Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Middlemount Coal Mine Southern Extension Project Groundwater Impact Assessment

Prepared for
Middlemount Coal Pty Ltd

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Report on

Middlemount Coal Mine Southern Extension Project Groundwater Impact Assessment

1 Introduction

Middlemount Coal Pty Ltd (MCPL) owns and operates the Middlemount Coal Mine located approximately three kilometres (km) to the south-west of the Middlemount township within the Isaac Regional Local Government Area, Queensland. MCPL propose to seek Queensland Government approval for changes to the approved Middlemount Coal Mine, herein referred to as the Southern Extension Project (the Project). The Project provides for the continuation of open cut coal mining operations at the Middlemount Coal Mine. The location of Middlemount Coal Mine is shown in Figure 1.1.

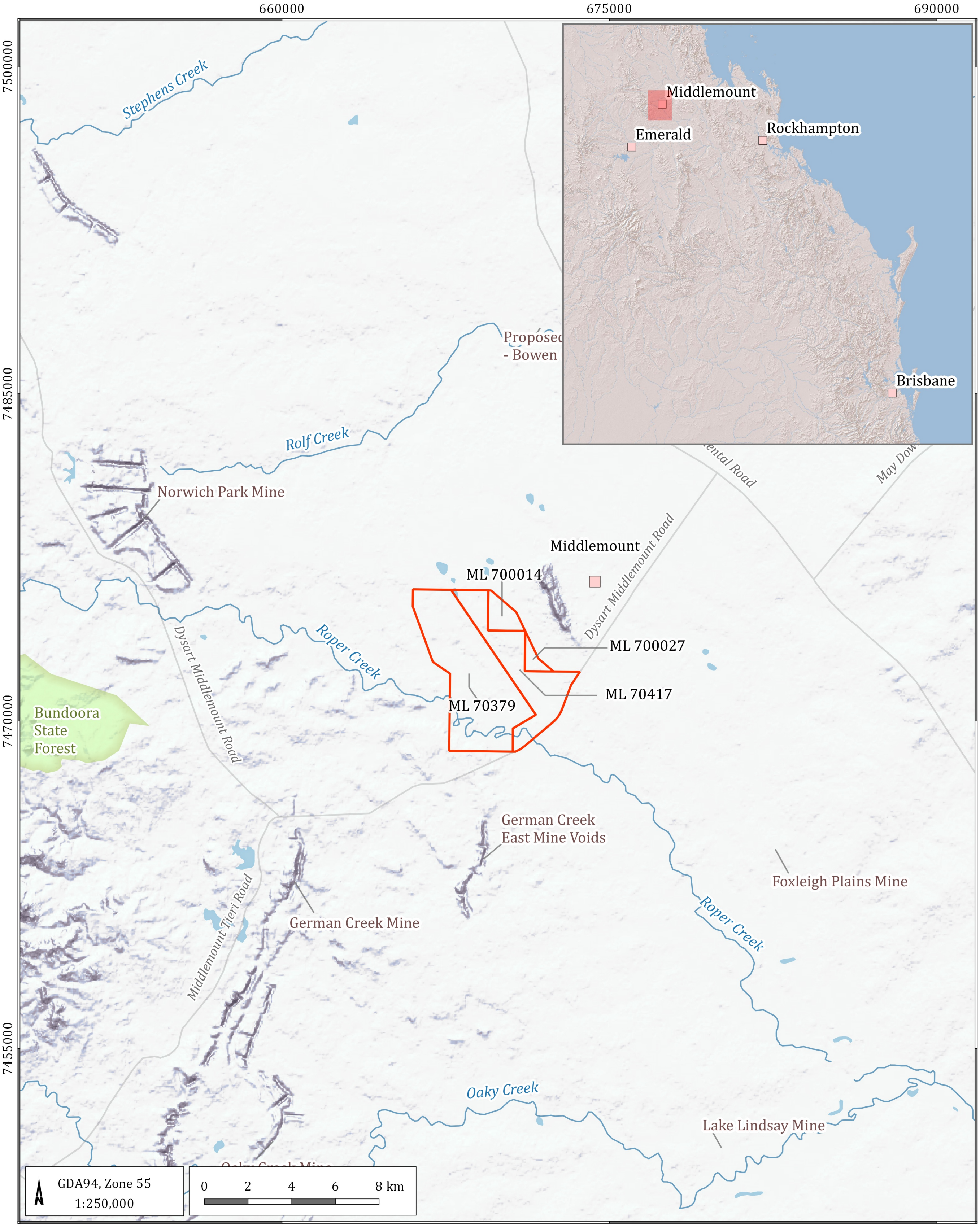
The Middlemount Coal Mine currently operates under Environmental Authority (EA) EPML00716913, dated 26 February 2020, which permits those activities associated with mining to be undertaken within Mining Lease (ML) 70379, ML 70417, ML 700014 and ML700027. The main activities associated with the development of the Project would include:

- extension of the open cut pit to the south within ML 70379 as shown in Figure 1.2;
- continued extraction of run-of-mine (ROM) coal up to approximately 5.7 million tonnes per annum (Mtpa) using conventional open cut mining equipment;
- placement of waste rock in existing emplacements, expanded emplacements (Eastern Dump) and within the mined out void;
- minor extensions to waste rock emplacement footprint;
- progressive development of sediment dams, pipelines and other water management equipment and structures;
- re-positioning of the approved southern flood levee and water management infrastructure;
- realignment and extension of the approved (but not yet constructed) eastern diversion of Roper Creek inside the ML;
- extension of the approved mine life by approximately seven years (to 2044); and
- a change to the final landform for the end of the mine life; and.

The following groundwater impact assessment (GIA) report has been produced by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to support the groundwater assessment of the Project.

1.1 Scope of work and objective of report

The objective of this groundwater assessment report is to support the EA amendment application made by MCPL, by providing sufficient technical information about the Project activities and the potential impact to environmental values and groundwater quality. Amendments introduced by the *Environmental Protection (Underground Water Management) and Other Legislation Amendment Act 2016* (EPOLA Act) have introduced new information requirements in the *Environmental Protection Act 1994* (EP Act), which require this groundwater assessment report to meet the requirements of sections 126A and 227AA of the EP Act.



LEGEND

- □ PopPlaces-clipped
- — Road
- — Watercourse
- ▨ Water area
- ▨ Reserve
- □ Mining Lease boundary (ML)

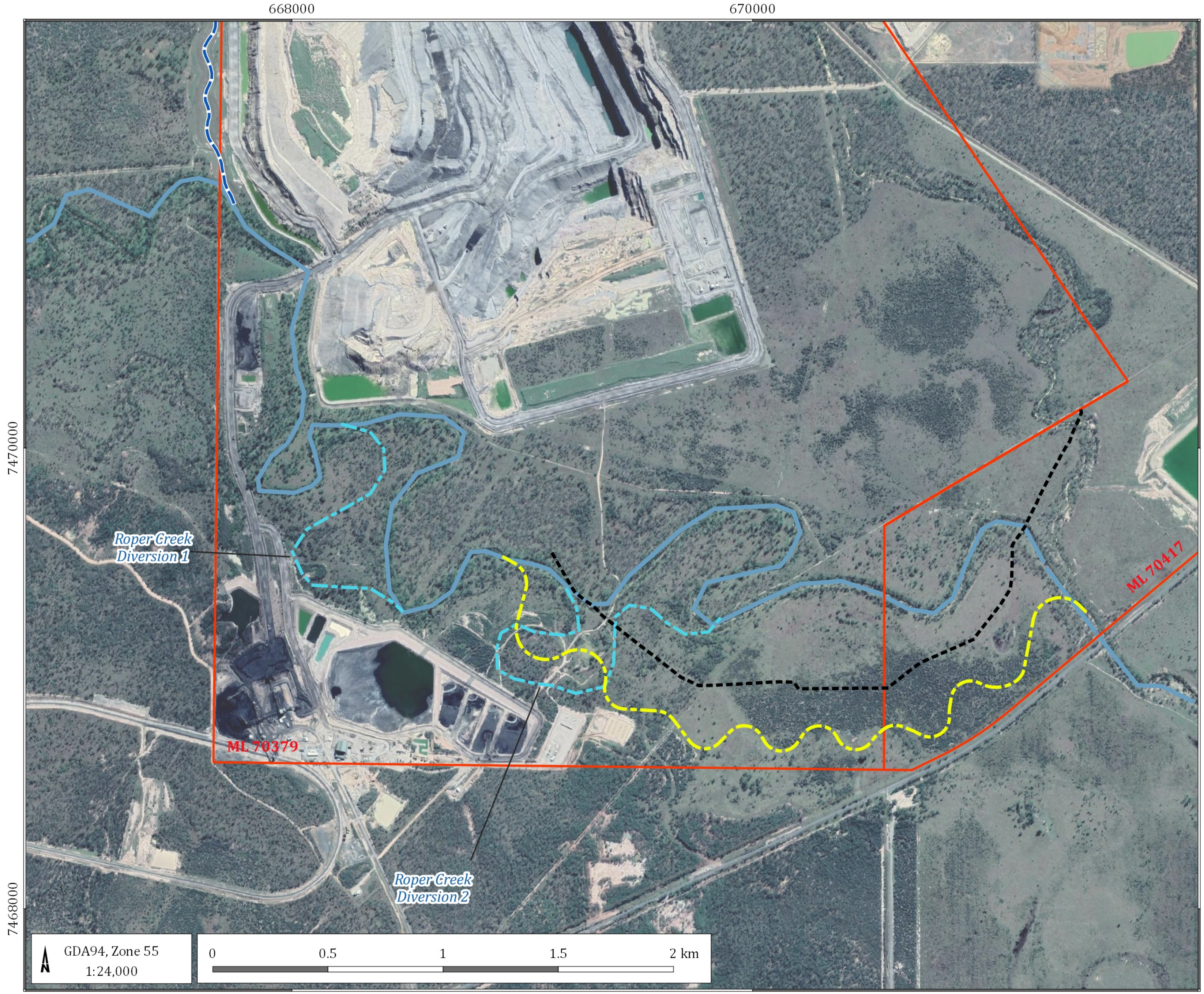
Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount Coal Mine location

DATE
21/08/2020

FIGURE No:
1.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\01.01_G1840P_Middlemount Coal Mine Location_v01.qgs



LEGEND

- Road
- Drainage feature
- Approved Roper Creek Diversion
- Conceptual Proposed Diversion
- Conceptual Open Cut Pit Extension
- Thirteen Mile Gully Diversion
- Mining Lease boundary (ML)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Conceptual Southern Extension Project Layout

DATE
31/08/2020

FIGURE No:
1.2

AGE

©2020 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au; Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\01.02_G1840P_Conceptual Southern Extension Project Layout.qgs

The Department of Environment and Heritage Protection (DEHP, now The Department of Environment and Science [DES]) have produced a guideline that details the mandatory information that is required by the GIA (DEHP, 2016). Section 126A of the EP Act outlines a list of information requirements that must accompany a site-specific application where the resource activity or project involves the exercise of underground water (groundwater) rights.

Section 126A of the EP Act requires the groundwater assessment to include the following mandatory information:

- *state any proposed exercise of underground water rights during the period in which resource activities will be carried out under the relevant tenure;*
- *describe the areas in which underground water rights are proposed to be exercised;*
- *for each aquifer affected, or likely to be affected by the exercise of underground water rights, include:*
    - *a description of the aquifer;*
    - *an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers and surface water;*
    - *a description of the area of the aquifer where the water level is predicted to decline because of the exercise of underground water rights; and*
    - *the predicted quantities of water to be taken or interfered with because of the exercise of underground water rights during the period in which resource activities are carried out.*
- *detail the environmental values that will, or may, be affected by the exercise of underground water rights and the nature and extent of the impacts on the environmental values;*
- *detail any impacts on the quality of groundwater that will, or may, happen because of the exercise of underground water rights during or after the period in which resource activities are carried out; and*
- *detail strategies for avoiding, mitigating or managing the predicted impacts on the environmental values or predicted impacts on the quality of groundwater.*

Section 227AA of the EP Act requires that this information also be included with an EA amendment application where the proposed amendment involves a change in the exercise of underground water rights.

The study area for this groundwater assessment includes the approved Middlemount Coal Mine, the Project area and the surrounding mining operations in the region shown on Figure 1.1.

1.2 Background

Two previous GIA’s have been undertaken for the Middlemount Coal Mine to date, namely by:

- Parsons Brinkerhoff (2010a) for the Middlemount Coal Project Stage 2 Environmental Impact Statement (EIS); and
- AGE (2018a) for the Middlemount Coal Mine Western Extension Project Major EA Amendment.

The Western Extension GIA report (AGE, 2018a) utilised site-specific hydrogeological, geological, and climatic data and additional data from the surrounding region sourced from the Queensland Department of Natural Resources, Mines and Energy (DNRME) groundwater database (GWDB). The Parsons Brinkerhoff GIA (2010a) also sourced data from the Lake Lindsay Environmental Study – groundwater assessment (Parsons Brinkerhoff, 2010b), which was conducted immediately to the south of ML 70379 in 2005.

Based on the data available at the time of the Western Extension GIA (AGE, 2018a), a 17 layer numerical groundwater flow model was developed and used to predict the rate of groundwater inflow to the open cut pit and the drawdown associated with mine dewatering. AGE (2018a) concluded that:

- *The primary groundwater units impacted by the Project are the Tertiary Duaringa Formation and weathered Permian Rangal Coal Measures where these sediments are saturated.*
- *There are no landholder water supply bores located within the predicted drawdown extents attributable to the proposed mine plan for the Project.*
- *The bore census undertaken for this assessment identified no use of groundwater from both the Tertiary Duaringa Formation and Permian Rangal Coal Measures surrounding the Project. This is due to the aquifers being either unsaturated or partially unsaturated in the vicinity of the Middlemount Coal Mine (as is the case with the shallower groundwater hosted within the Tertiary Duaringa Formation and weathered Permian Rangal Coal Measures), or saline as is the case for both the Tertiary Duaringa Formation and Permian Rangal Coal Measures.*
- *Assessment of the cumulative impacts with other nearby operating mines and the Bowen Gas Project activities does not predict any cumulative drawdown within the Tertiary and weathered Permian, but does predict the Middlemount Seam 1 m contour and Pisces Seam 2 m contour just intersecting roughly midway between the Project and the German Creek East voids.*
- *The assessment identifies that there are no watercourses with associated productive alluvial aquifers within the Project area and there will be no impact from mining on localised shallow alluvial or perched aquifers that may be associated with minor surface drainage features within the Project area.*
- *The Project is not predicted to impact any aquatic or terrestrial groundwater dependent ecosystems (GDEs), as mapped GDEs in the Project area are assessed unlikely to be restricted to areas where groundwater can potentially be accessed, the ephemeral nature of the drainage features, groundwater levels being in excess of 12 metres below ground level (mbgl), and there being no evidence of any vegetation dieback attributable to the existing operations.*
- *This assessment predicts the final voids will act as long-term groundwater sinks post mining, this will result in the long-term water quality within the final voids being affected by evaporative concentration and becoming more saline. However, flow of this water into the groundwater systems will be prevented as a consequence of the lower water level within the voids.*

1.3 Report structure

This report is structured as follows:

- **Section 1 – Introduction:** discusses the scope of the report and its objectives.
- **Section 2 – Mining history:** provides an overview of historical mining and the proposed mining activity within ML 70379, ML 70417, ML 700014, and ML 700027.
- **Section 3 – Queensland regulatory framework:** summarises the Queensland groundwater legislation and policy relevant to the Project.
- **Section 4 – Environmental setting:** describes the climate, terrain, drainage, and land use within the study area.
- **Section 5 – Geology within study area:** describes the geological setting of the study area including the regional geology and local stratigraphy.
- **Section 6 – Conceptual groundwater model:** describes the groundwater regime surrounding the Middlemount Coal Mine including the Project.
- **Section 7 – Environmental value of groundwater:** describes the environmental values of the groundwater regime surrounding the Middlemount Coal Mine including the Project.
- **Section 8 – Numerical Modelling:** details groundwater modelling completed for the assessment.

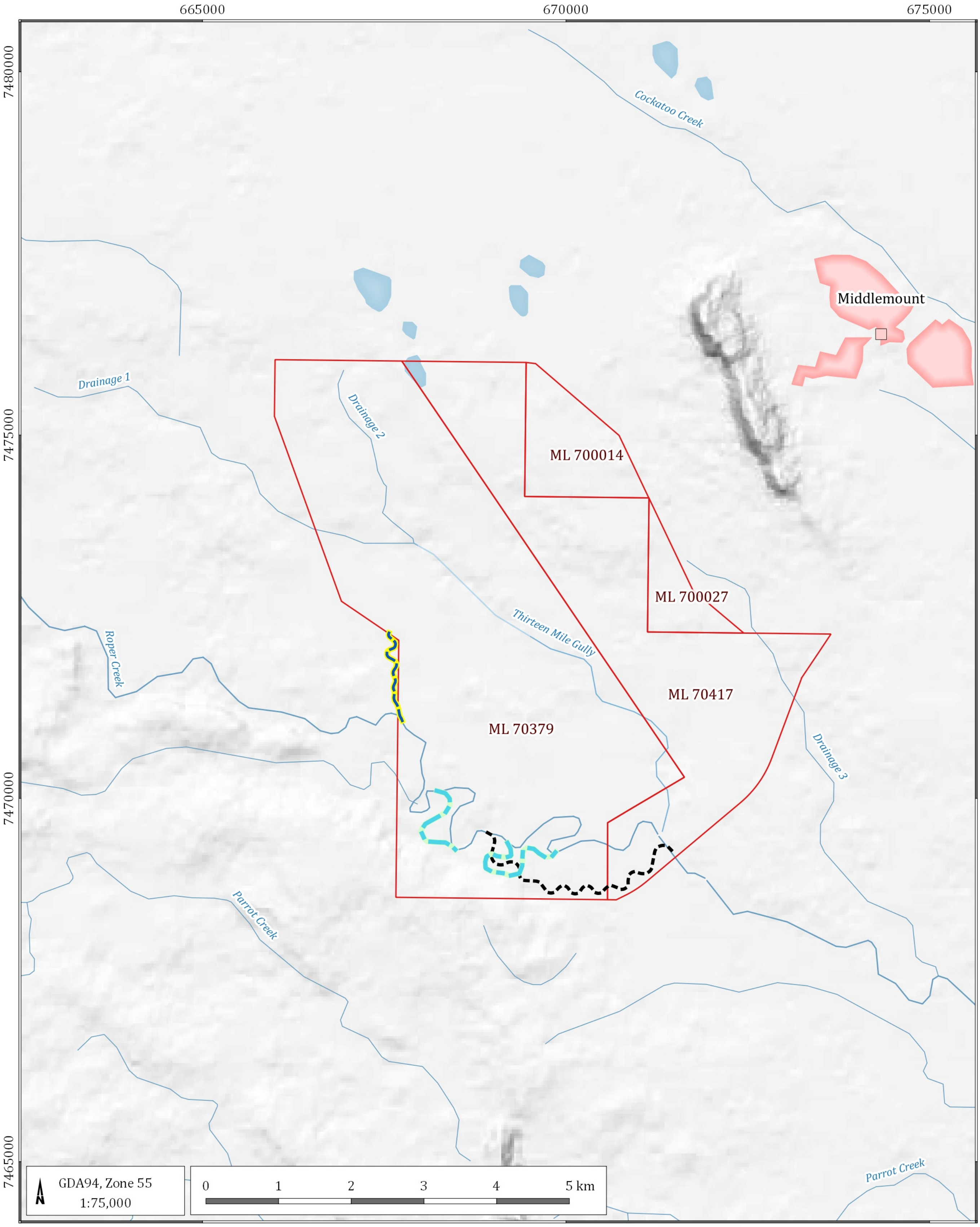
- **Section 9 – Groundwater monitoring strategy/program:** describes the proposed groundwater monitoring for the Project and provides recommendations for trigger levels.
- **Section 10 – Conclusions:** summarises the main aspects of the Project.
- **Section 11 – References:** lists the documents cited in this report.

2 Mining history

Stage 1 of the Middlemount Coal Mine was initially approved in 2009 for the production of 1.8 Mtpa of ROM coal from ML 70379. The Middlemount Coal Mine EA was amended in 2012 to approve the expansion of open cut mining operations within ML 70379 and ML 70417, referred to as Stage 2 of the Middlemount Coal Mine. A further major amendment to the EA was approved in March 2019 allowing a westward extension of the open cut operations. Subsequent minor EA amendments were approved in September 2019 and February 2020.

The currently approved Middlemount Coal Mine produces up to 5.7 Mtpa ROM coal.

Mining currently includes a single open cut operation within ML 70379 and an out of pit waste dump within ML 70417 and ML 700014 (Figure 2.1).



LEGEND

- 🟥 Populated place
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Approved Roper Creek Diversion
- Conceptual Proposed Diversion
- 🟥 Built up area
- 🟦 Water area
- ☐ Mining Lease boundary (ML)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount Coal Mine - mining leases

AGE

DATE
26/08/2020

FIGURE No:
2.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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3 Queensland regulatory framework for groundwater

The following sections summarise Queensland groundwater legislation and policy relevant to the Middlemount Coal Mine.

3.1 Acts, regulations, and plans

The *Water Act 2000*, supported by the subordinate *Water Regulation 2016* (Qld), is the primary legislation regulating groundwater resources in Queensland. The purpose of the *Water Act 2000* is to advance sustainable management and efficient use of water resources by establishing a system for planning, allocation, and use of water.

The water resource planning process provides a framework for development of catchment specific Water Plans. A Water Plan provides a management framework for water resources in a plan area, and includes outcomes, objectives, and strategies for maintaining balanced and sustainable water use in that area. A Resource Operations Plan (ROP) implements the outcomes and strategies of a Water Plan.

Groundwater Management Areas (GMAs) and their component Groundwater Management Units (GMUs) are defined within a Water Plan. Authorisation is required from the DNRME to take water from a regulated GMA or GMU for specified purposes. The specified purposes are defined under a Water Plan, the Water Regulation 2016, or a local water management policy.

The Water Reform and Other Legislation Amendment Act 2014 (Qld) (WROLA Act) was passed on 26 November 2014. The WROLA Act included a number of key changes to the *Water Act 2000*. However, commencement of these provisions was deferred under the *Water Reform and Other Legislation Amendment (Postponement) Regulation 2015* (Qld).

In November 2016, changes to the WROLA Act were made with the introduction of the *Water Legislation Amendment Act 2015* (Qld) and the EPOLA Act, which came into effect on 6 December 2016. The EPOLA Act amends the EP Act and *Water Act 2000* (Chapter 3), and aims to strengthen the powers of the DES in the environmental assessment process, as well as approval commitments to groundwater management.

The WROLA Act and the *Water Act 2000* bring the rights and obligations of ML and Mineral Development Licence (MDL) holders in respect of "associated water" in line with that existing for petroleum tenure holders under the petroleum legislation.

The changes establish a right for the holder of a MDL or ML to take or interfere with groundwater (associated water) in the area of the licence or lease where the taking or interference happens during the course of, or results from, the holder's authorised activities (and was occurring prior to the commencement of the *Water Legislation Amendment Act 2015*).

MDL and ML holders are required to measure and report the volume of associated water taken and also advise the chief executive of the exercise of the holder's underground water rights immediately after the holder starts exercising those rights.

The exercise of these underground water rights is also subject to the holder complying with the obligations in the amended Chapter 3 of the *Water Act 2000*, which previously only applied to petroleum tenure holders, and has been amended to now also apply to mining tenure holders.

3.2 Fitzroy Basin water resource and operation plans

The Middlemount Coal Mine is located within the area covered by the *Water Plan (Fitzroy Basin) 2011*. This Water Plan applies to watercourses and lakes, water in springs, overland flow water, and groundwater. The area covered by the *Water Plan (Fitzroy Basin) 2011* is shown on Figure 3.1.

The *Water Plan (Fitzroy Basin) 2011* is divided into five GMAs. The Middlemount Coal Mine is located in the Highlands GMA (Figure 3.2). The Water Plan further divides the Highlands GMA into the following groundwater units:

- Highlands Groundwater Unit 1, containing Quaternary alluvium aquifers of Sandy Creek; and
- Highlands Groundwater Unit 2, containing all sub-artesian aquifers within the Highlands GMA other than the aquifers included in Highlands Groundwater Unit 1.

The Middlemount Coal Mine is entirely located within Highlands Groundwater Unit 2.

Section 116 (f) of the *Water Plan (Fitzroy Basin) 2011* identifies that groundwater may be taken for stock and domestic purposes without an entitlement (i.e. water licence). Section 116 also identifies that an entitlement will be required for purposes other than stock or domestic purposes (i.e. mining use).

The Middlemount Coal Mine is not located within a declared Cumulative Management Area under the *Water Act 2000*.

3.3 Queensland Environmental Protection Act 1994

The EP Act provides a regulatory framework for the protection and management of the Queensland Environment. The objective of the EP Act is to protect Queensland's environment while allowing for sustainable development.

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water, [Queensland Government, 2019]) provides a framework to protect and/or enhance the environmental values and hence suitability of Queensland waters for various beneficial uses. Groundwater resources within the Project area lie within the Mackenzie River Sub-basin as listed in Schedule 1 of the EPP Water. Schedule 1, Column 2 makes reference to a subordinate document prepared by DEHP (2011), which states that the environmental values for groundwaters within the Mackenzie River Sub-basin that need to be considered are for aquatic ecosystems, irrigation, farm supply/use, stock water, drinking water, industrial use, and cultural and spiritual values. The relevant local groundwater uses, and associated values are described in Section 6.11.

The Water Quality Objectives (WQOs) specified by DEHP (2011) are *"numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated environmental values for those waters. They are based on scientific criteria or water quality guidelines but may be modified by other inputs"*.

The WQOs for Fitzroy Basin groundwaters are provided according to their chemistry zone and depth category (Table 14 of DEHP, 2011). In this instance, the chemistry zone that broadly covers the Project area, which covers up-stream catchments of tributaries to the Mackenzie River, are classified as chemistry Zone 34 – characterised as *"Sodic sequence – saline: Na, Cl"* type water.

The groundwater WQOs for aquatic ecosystems in Zone 34 are summarised in Table 3.1 below.

LEGEND

location

▲ Weir

△ Dam

▭ Mining Lease boundary (ML)

Middlemount Coal Mine Souther Extension Project - GIA (G1840P)

Water Plan (Fitzroy Basin) 2011

DATE 23/07/2020

FIGURE No: **3.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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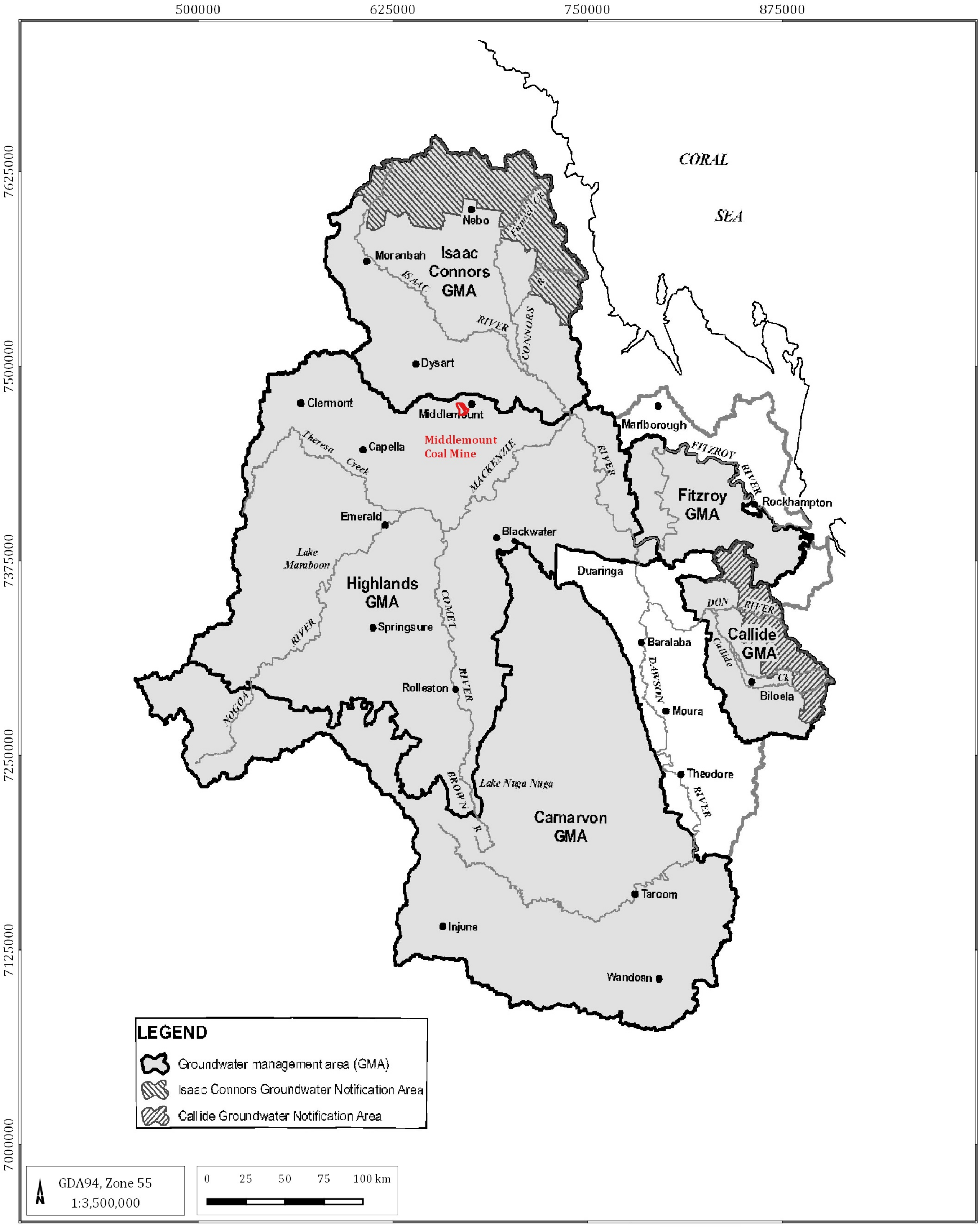

LEGEND

🟥 Mining Lease (ML70379, ML700014, ML70379, ML700027, MLA)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Highlands groundwater management area

DATE
23/07/2020

FIGURE No:
3.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\03.02_G1840P_Highlands groundwater managment area.qgs

Table 3.1 WQO (aquatic systems) for groundwaters in the Mackenzie River sub-catchment (Zone 34)

Depth (±30 m)	Deep > 30 m			Shallow < 30 m		
Percentile	**20th**	**50th**	**80th**	**20th**	**50th**	**80th**
Electrical Conductivity (µS/cm)	3,419	6,100	16,000	498	2,150	8,910
Hardness (as $CaCO_3$)	359	919	3,208	163	674	2,228
pH	7.40	7.80	8.03	7.10	7.75	8.10
Alkalinity	156	275	536	154	435	752
Calcium	46	145	442	18	84	215
Magnesium	35	115	491	27	108	389
Sodium	480	1100	2,565	135	747	1,500
Chloride	753	1,900	5,905	171	1,309	3,185
Sulfate	25	138	398	12	140	318
Bicarbonate Alkalinity as $CaCO_3$	188	330	650	187	536	878
Nitrate	0.01	2.15	14.92	0.00	0.95	5.30
Silica	16	25	36	21	36	52
Fluorine	0.020	0.155	0.400	0.100	0.280	0.500
Iron	0.00	0.05	0.246	0.000	0.030	0.140
Manganese	0.00	0.05	0.291	0.000	0.010	0.160
Zinc	0.010	0.025	0.317	0.000	0.015	0.060
Copper	0.017	0.030	0.030	0.000	0.010	0.030
Sodium Absorption Ratio	10.50	15.60	24.65	4.37	10.85	18.21
Residual Alkali Hazard (meq/L)	0.00	0.24	6.25	0.00	0.00	2.30
Redox (mV)	ID	ID	ID	ID	ID	ID

Notes: *All values as milligrams per litre (mg/L) unless specified.*

µS/cm = microsiemens per centimetre

$CaCO_3$ = Calcium Carbonate

meq/L = milliequivalents per litre

mV = millivolts

ID: insufficient data to perform statistical summaries, or the parameter was not tested

3.4 Environmental authority – groundwater conditions

Middlemount Coal Mine is currently authorised to operate as a mining project under the EA EPML00716913 dated 26 February 2020. The EA covers all of the Middlemount Coal Mine ML areas.

The purpose of the EA groundwater conditions is to ensure that any impacts of mining on the regional groundwater resources are appropriately monitored and managed. Groundwater conditions for Middlemount Coal Mine are contained in Schedule C (C34 to C45) of the EA, which are reproduced below in Table 3.2.

Table 3.2 Summary of the Middlemount Coal Mine EA groundwater conditions

Condition number	Condition
C34	**Groundwater** Groundwater quality affected by the mining activities must be monitored at the locations and frequencies specified in **Table C7: Groundwater Monitoring Locations and Frequency** for the parameters identified in **Table C8: Groundwater Investigation Trigger Levels**.
C35	The groundwater investigation trigger levels limit type "Median" referred to in **Table C8: Groundwater Investigation Trigger Levels** must be determined on the most recent three (3) consecutive routine monitoring samples.
C36	Subject to requirements of **Condition C34**, if the groundwater investigations trigger levels defined in **Table C8: Groundwater Investigation Trigger Levels** are exceeded then the environmental authority holder must complete an investigation into the potential for environmental harm and notify the administering authority via WaTERS within twenty-eight (28) days of receiving the analysis results.
C37	The exceedance investigation under condition C36 must be completed and submitted to the administering authority via WaTERs within **three (3) months** of the exceedance.
C38	Where it is identified that there is potential for environmental harm, an action plan to mitigate potential harm must be developed by a suitably qualified person and implemented within **three (3) months** of the completion of the investigation under condition C37.
C39	Groundwater levels affected by the mining activities must be monitored at the locations and frequencies defined in **Table C9: Groundwater Levels.**
C40	In the event that groundwater fluctuations exceed the groundwater level trigger values defined in **Table C10: Groundwater Level Trigger Values** at the groundwater monitoring locations nominated in **Table C9: Groundwater Levels**, an investigation must be undertaken within fourteen (14) days of detection to determine if the fluctuations are a result of: a) Mining activities; b) Pumping from licences bores; or c) Seasonal variation.
C41	If the results of the investigation undertaken in accordance with Condition C40 identify that the groundwater fluctuations are a result of mining activities, the holder of the environmental authority must notify the administering authority via WaTERS and provide a copy of a report detailing the findings and outcomes of the investigation within seven (7) days of completing the investigation.
C42	The groundwater monitoring data must be reviewed on an annual basis. The review must include the assessment of groundwater levels and quality data, and the suitability of the monitoring network. The assessment must be submitted to the administering authority within twenty-eight (28) days of receiving the report.
C43	**Groundwater monitoring** The following information must be recorded in relation to all water sampling: 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 results of all monitoring; e) Groundwater levels; and f) Sampling methodology.
C44	The method of water sampling required by this environmental authority must comply with that set out in the latest edition of the administering authority's *Water Quality Sampling Manual.*
C45	The construction, maintenance and management of groundwater bores (including 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.

Note: *Tables C7 to C10 are not provided here for brevity but can be viewed in EPML00716913.*

3.5 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Department of Agriculture, Water and the Environment (DAWE). The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance. Under the 2013 amendment to the EPBC Act, impacts on groundwater resources were included, and are known as the 'water trigger'.

The Western Extension Project was referred to the Commonwealth Department of Environment and Energy (DoEE) on 22 December 2017, and determined to be a controlled action 8 February 2018 with water as a controlling provision. The Western Extension Project was subsequently approved by the DoEE on 8 October 2019.

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) is a statutory body under the EPBC Act that provides scientific advice to the Commonwealth Environment Minister and relevant state ministers. Guidelines have been developed in order to assist the IESC in reviewing Coal Seam Gas (CSG) or large coal mining development proposals that are likely to have significant impacts on water resources. A summary of the IESC guidelines and where they are addressed within the report is included in Appendix A.

4 Environmental setting

4.1 Climate and weather

4.1.1 Climate and weather data availability

The study area which includes the Middlemount Coal Mine MLs and regionally the surrounding mine operations (as described in Section 4.3), has a semi-arid to sub-tropical climate, typical for Central Queensland. The nearest Bureau of Meteorology (BoM) weather recording station with rainfall and pan evaporation data is the Clermont Post Office located in the township of Clermont. This station (#035019) is still open and has been in operation since 1870. The nearest BoM rainfall station is Booroondarra (#035109) which is located approximately 17 km west of the Middlemount Coal Mine.

The Clermont Post Office weather dataset was complemented with data sourced from the Scientific Information for Land Owners (SILO) database. SILO is operated by the DES, with data contributions from BoM.

The SILO database provides a weather record dataset which utilises neighbouring stations to infill missing data and accumulated days. The SILO dataset includes long-term rainfall, temperature, and evaporation readings from 1889 to present.

4.1.2 Rainfall and evaporation

Monthly interpolated rainfall, temperature, pan evaporation and evapotranspiration data was obtained from SILO for Middlemount Coal Mine and is presented in Table 4.1. It shows that majority of the annual total rainfall occurs from December to February. The mean annual rainfall is 620.5 millimetres (mm), while the evaporation rate is 2,036.8 mm and the potential evapotranspiration rate is 1,631.8 mm. That is, mean evaporation and evapotranspiration rates exceed rainfall for all months of the year.

Table 4.1 SILO climate averages for Middlemount Coal Mine 1901 to 2019[1]

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total annual
Mean max temp (°C)	33.2	32.6	31.6	29.3	26.1	23.4	23.2	25.1	28.1	30.9	32.4	33.6	-
Mean rainfall (mm)	115.9	97.5	67.0	32.5	29.4	30.8	23.6	18.9	18.2	35.6	54.9	96.2	620.5
Mean evaporation (mm)	225.4	184.0	191.0	150.3	117.8	96.4	104.3	131.4	171.5	209.6	221.7	233.4	2,036.8
Potential Evapotranspiration (mm)	174.4	145.2	146.9	120.2	97.7	80.4	89.3	110.3	137.1	168.6	176.7	185.0	1,631.8

Figure 4.1 presents SILO rainfall data between January 1901 and December 2019, and the cumulative rainfall departure (CRD), also known as rainfall residual mass. The CRD can be used to identify periods of above average or below average rainfall for each month (cumulative departures from the arithmetic mean). A rising slope on the curve equates to a period of above average rainfall, while a falling slope shows to a period of lower than average rainfall. These trends indicate the cyclical nature of rainfall patterns for the Middlemount region. The CRD trends can also be used to assist in describing expected changes in regional groundwater levels.

For example, below average rainfall can result in a lower groundwater table [e.g. prolonged dry/drought conditions and often corresponding increased anthropogenic use of groundwater], whereas above average rainfall can result in recovery (recharge) of the groundwater table/systems (e.g. wetter/surface flow conditions and often corresponding less anthropogenic use of groundwater).

4.2 Terrain and drainage

The Middlemount Coal Mine is located in the Roper Creek catchment which drains into the Mackenzie River approximately 40 km to the south-east. The drainages in the area are shown on Figure 4.2.
In its natural state, Thirteen Mile Gully drained the runoff from upstream sub-catchments in a south-easterly direction across ML 70379 and ML 70417 and discharged into Roper Creek within ML 70417 about 350 m upstream of Dysart Middlemount Road. The upstream sub-catchments of Thirteen Mile Gully were diverted along the western boundary of ML 70379 in late 2014 (i.e. Thirteen Mile Gully Diversion, Figure 4.2). A licence to divert the flow of water of Thirteen Mile Gully was issued under the *Water Act 2000* in May 2013. All drainages overlying the current mine site and the proposed expansion area within ML 70379 are ephemeral, which means they do not permanently flow.

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[1] Data updated for the period up to and including 31 December 2019.

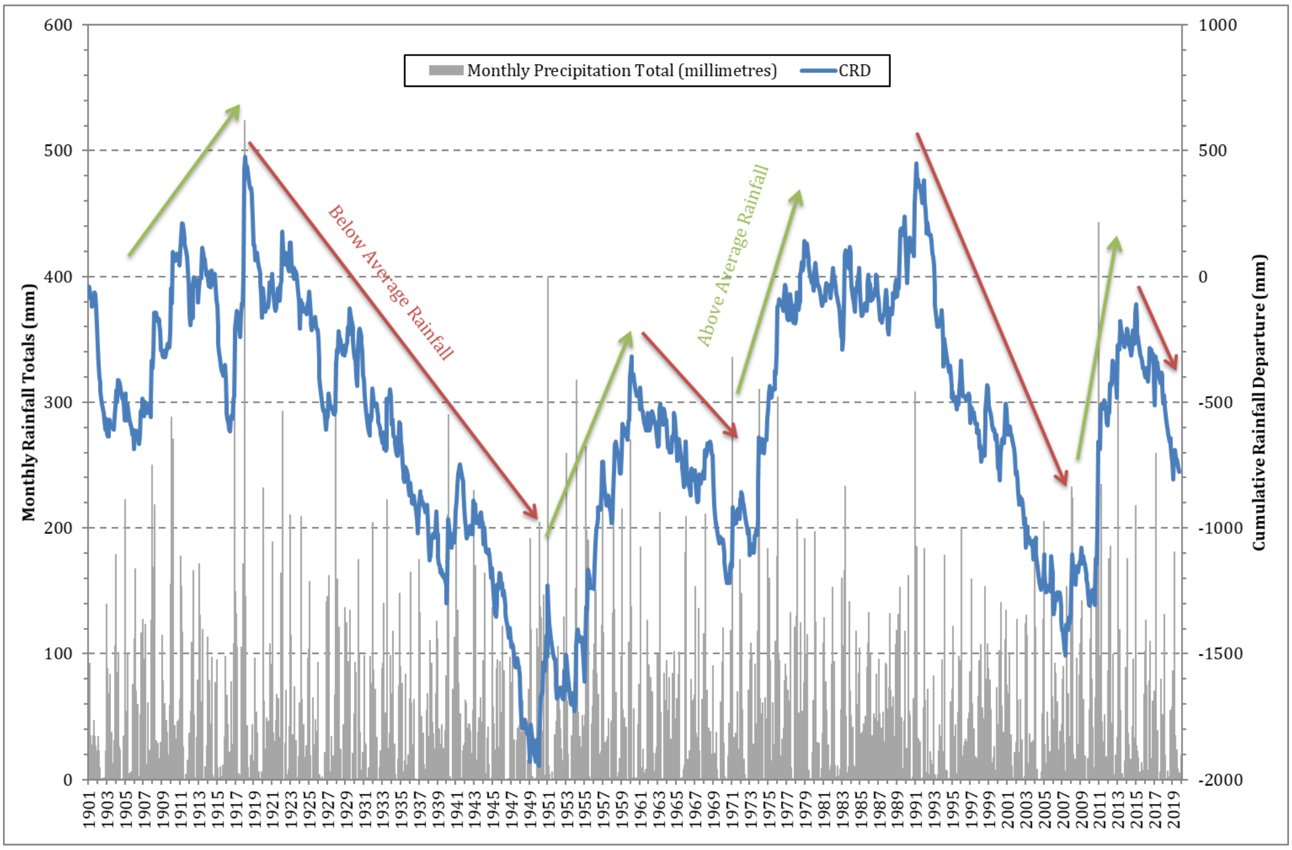
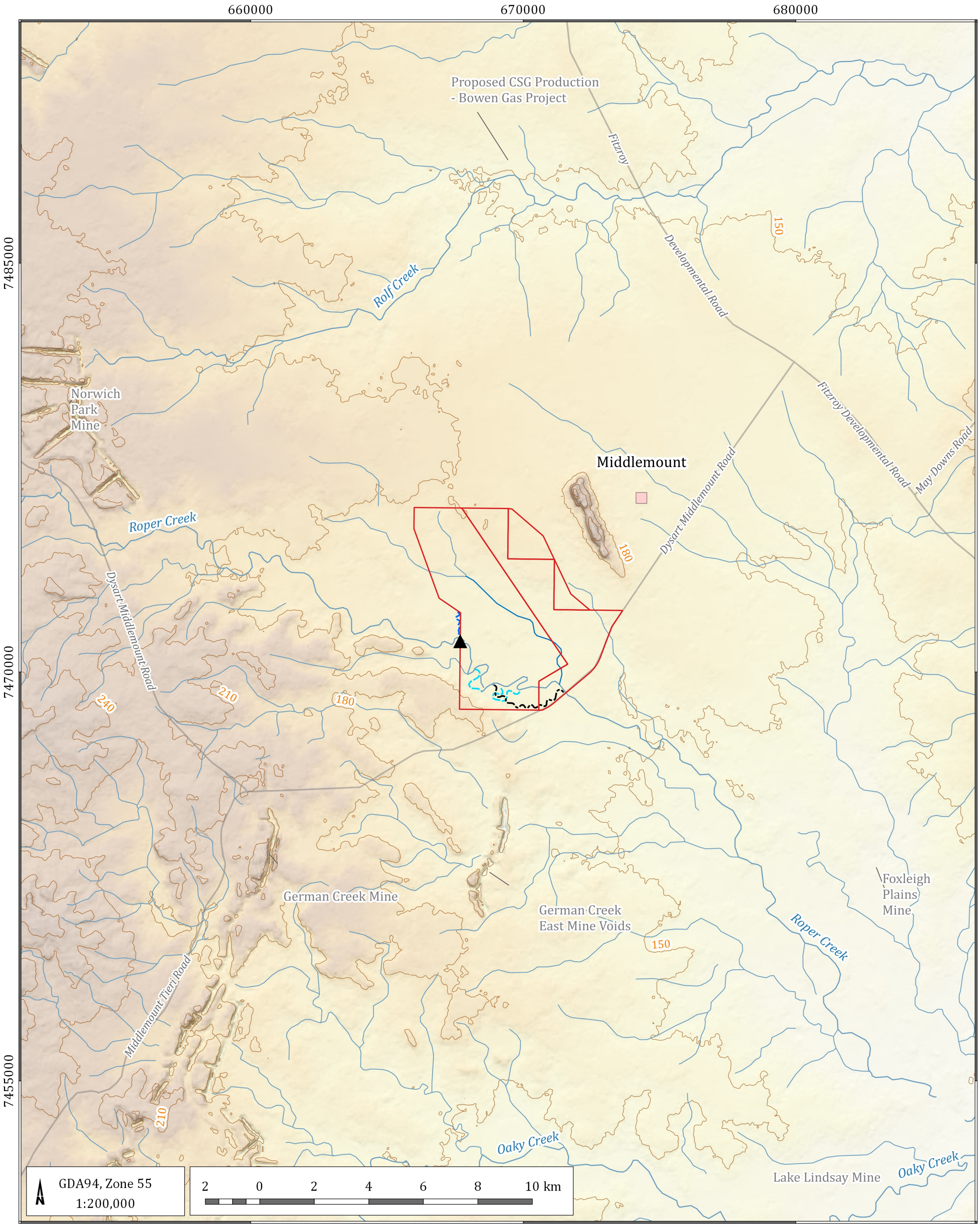


Figure 4.1 Monthly rainfall and cumulative rainfall departure – SILO Data for Middlemount Coal Mine 1901 to 2019



LEGEND

- 🟥 Populated place
- ▲ Stream gauge station
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Approved Roper Creek Diversion
- Conceptual Proposed Diversion
- Mining Lease boundary (ML)

Terrain elevation (mAHD)

- 100
- 125
- 150
- 175
- 200
- 250
- Elevation contour (30 m interval)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Terrain, drainage and stream gauge location within study area

AGE

DATE 26/08/2020

FIGURE No: **4.2**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\04.02_G1840P_Terrain, drainage, and stream gauge location within study area.qgs

Diversion of two reaches of Roper Creek within ML70379 between 2-5 km upstream of the confluence with Thirteen Mile Gully has also been previously approved although not yet constructed, namely Roper Creek Diversions 1 and 2 (Figure 1.2). As described in Section 1 and as shown in Figure 1.2, the Project will involve the realignment and extension of the of the existing Roper Creek diversions.

The topography surrounding Middlemount Coal Mine is gently undulating with elevations ranging from 178 m above the Australian Height Datum (mAHD) in the north, falling to 146 mAHD in the south along Roper Creek.

4.2.1 Surface water data availability

MCPL have a gauging station (Ref 1) in Roper Creek, located close the current boundary of ML 70379 and upstream of the proposed realignment of Roper Creek Diversion 2 described above (Section 4.2). The Ref 1 gauging station was installed in December 2012 and has been operational to August 2017. Details about the Ref 1 gauging station are provided below:

- stream flow data record is available between 16/07/2014 and 08/08/2017;
- coordinates and elevation – 667,484 mE; 7,471,112 mN (MGA94 Zone 55); 177 mAHD; and
- catchment area - 305.8 square kilometres (km^2).

Data from this gauging station is presented in Figure 4.3. This shows only periodic flows are recorded in Roper Creek which are in response to rainfall runoff flow events. These flows are then separated by long periods up to 11 months, of essentially zero flow within the creek.

DNRME had a gauging station on Roper Creek (#130107A at Barwon Park), which operated between August 1971 and September 1988 and is now closed. This gauging station was located approximately 30 km downstream of the Middlemount Coal Mine, which is outside of the study area and as such has not been considered any further for this assessment.

4.3 Regional land use

Mining and agriculture are the primary land uses within the vicinity of Middlemount Coal Mine. Private properties, which run cattle and conduct dryland cropping operations, are located to the north and east of the mine. Dryland cropping operations do not rely upon groundwater as confirmed during the Bore Census in 2017 (refer Section 6.4.2). Current mine operations include the German Creek and Lake Lindsay Mines (Anglo Coal [Capcoal Management Pty Ltd] Pty Limited), and Foxleigh Plains (Foxleigh Land Pty Ltd). These are underground and open coal mines located south and southeast of the Middlemount Coal Mine. Norwich Park Mine (BHP Billiton Mitsubishi Alliance) which is located north-west of the Middlemount Coal Mine ceased mining operations in 2012 and remains under care and maintenance.

MCPL owns all land within the footprint of the approved and proposed open cut mining operations (ML 70379, ML 70417, ML700014 and ML 700027). Portions of the land owned by MCPL are released for cattle grazing. A portion of the Project however is located within Lot 11, TT 443, owned by MCPL and Anglo American Coal, the majority of which is used for low intensity cattle grazing.

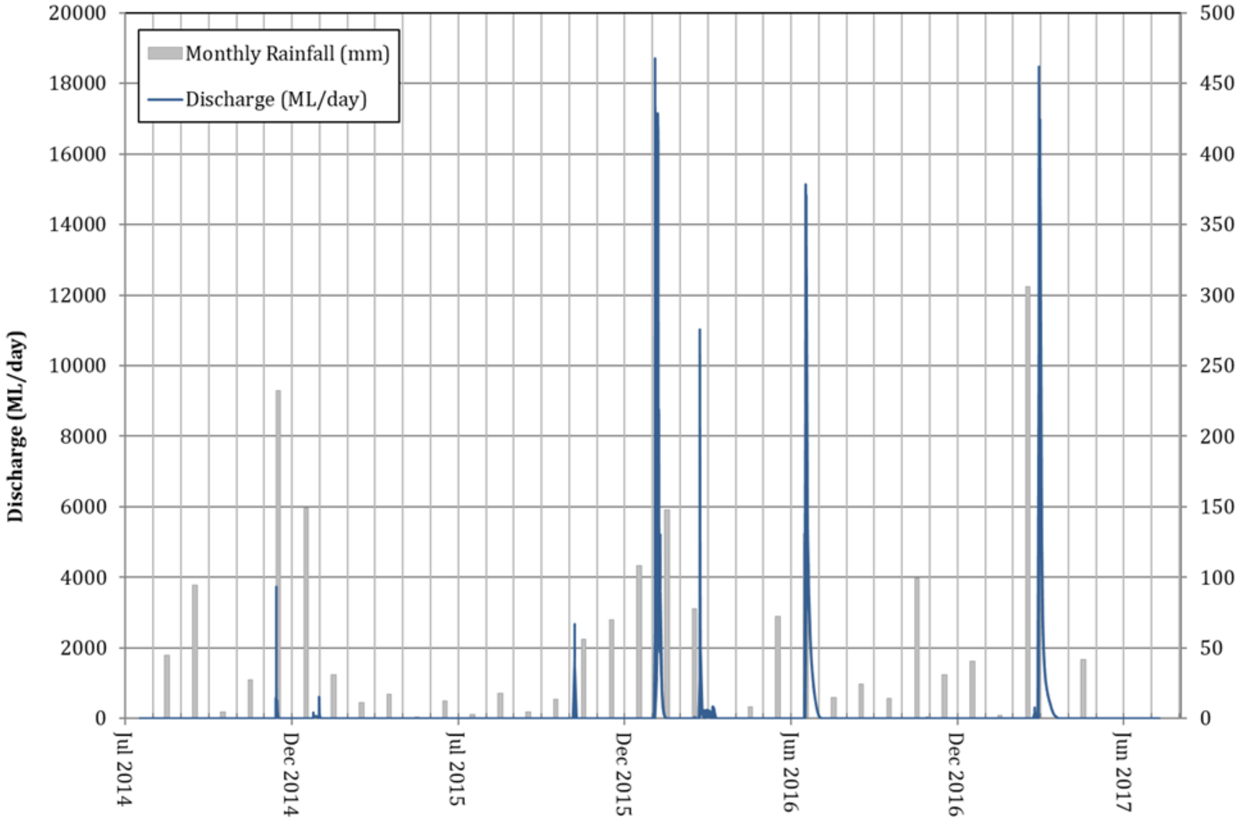


Figure 4.3 MCPL Roper Creek gauging station (Ref1)

5 Geology within the study area

5.1 Geology data availability

The geological understanding has been informed by the following data sources:

- geological logs, geophysical logs, and data compiled from exploration drilling across the Middlemount Coal Mine area including a series of bores drilled to investigate the Jellinbah Fault;
- geological model surfaces for the Middlemount Coal Mine;
- geological data from registered bores held on the DNRME GWDB; and
- publicly available geological mapping (St Lawrence 1:250,000 map sheet) and reports.

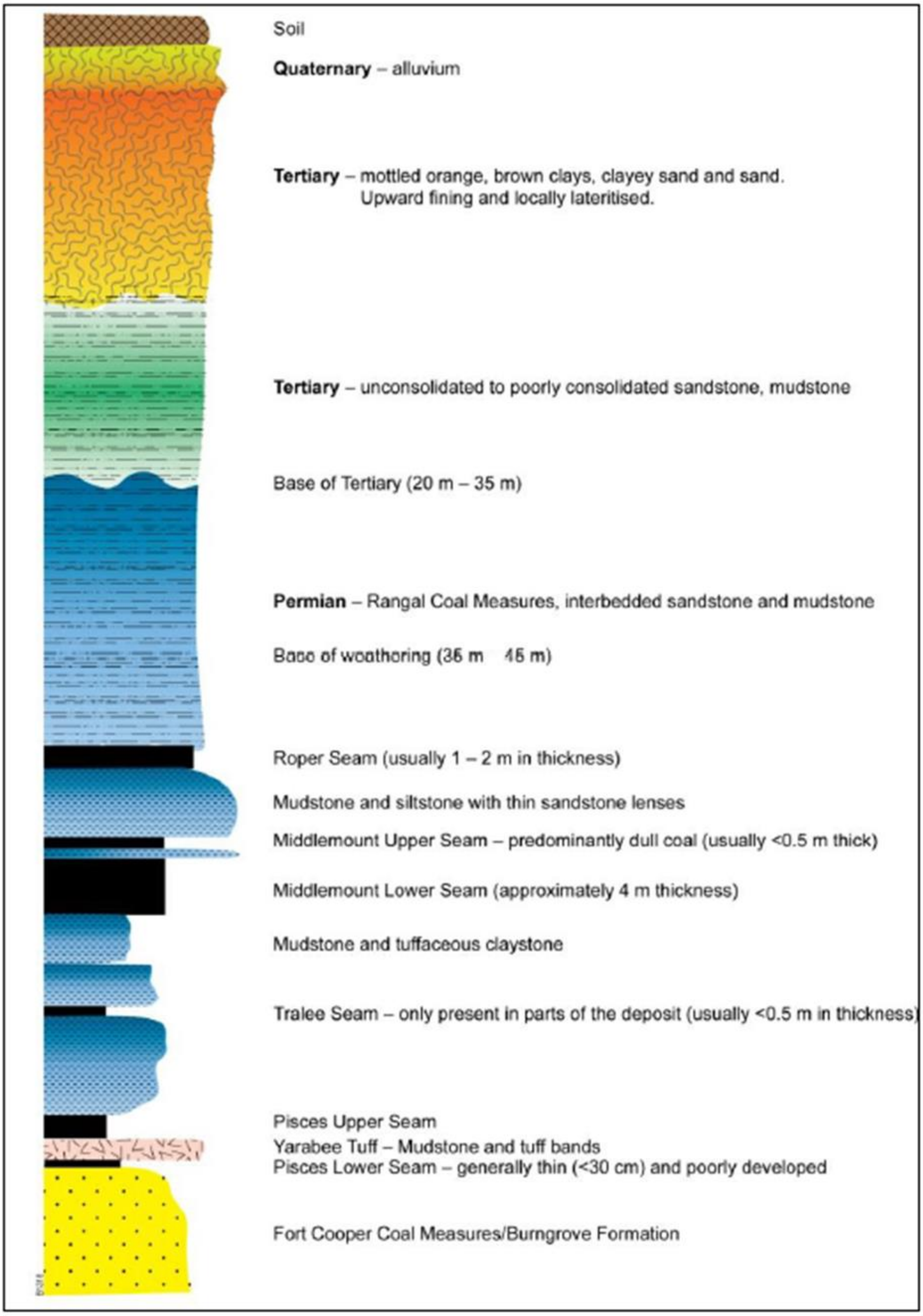
MCPL has undertaken exploration drilling across the Middlemount Coal Mine tenements. However, targeted exploration continues to define product coal structure and quality within the Project area. Exploration drilling has confirmed the geological units present in the ML areas and in the surrounds. MCPL has developed geological models from the exploration drilling data, which has been used to interpolate the stratigraphy and distribution of geological units across the Middlemount Coal Mine and immediate vicinity. The geological model provided the structural framework for developing the numerical groundwater model.

Geological data provided by DNRME and MCPL for the modelled area were analysed to provide elevations of the major stratigraphic interfaces. The DNRME data are important for developing the regional scale hydro-stratigraphic model. Ground elevations at many of the drill sites were not surveyed, and so ground elevations were estimated using a Geographical Information System (GIS) topographic database (Geoscience Australia, 2011).

5.2 Bowen Basin geology

The Middlemount Coal Mine is located within the Rangal Coal Measures of the Bowen Basin, which is a sedimentary basin comprising Triassic and Permian aged geology. Regionally, a veneer of more recent Tertiary geology and Quaternary geology typically overlies the Bowen Basin strata. The Permian Bowen Basin rocks depositional environment formed a regular layered sedimentary sequence, while the Tertiary and Quaternary geology is more complex and irregular.

The target seams at the Middlemount Coal Mine are the Middlemount, Tralee, and Pisces coal seams of the Rangal Coal Measures, a faulted and folded Permian sequence of calcareous sandstone, shale, mudstone, and coal. In the mine area, the Rangal Coal Measures dip gently to the northeast, underlain conformably by the Permian Fort Cooper Coal Measures / Burngrove Formation (herein referred to as the Fort Cooper Coal Measures). The Fort Cooper Coal Measures are Late Permian age sedimentary rocks that comprise feldspathic and lithic sandstone, siltstone, carbonaceous mudstone, siliceous siltstone, banded coal seams, and tuff. These rocks do not outcrop within the site and have only been encountered in the exploration boreholes. Collectively, these Permian age geological units, are referred to here as the Permian coal measures. The stratigraphy for Middlemount Coal Mine is shown Figure 5.1.



Source: *Stage 2 Environmental Impact Statement (EIS) (Parsons Brinkerhoff, 2010a)*

Figure 5.1 Stratigraphic sequence Middlemount Coal Mine

5.3 Mapped geology

The outcrop geology mapped across the study area (i.e. the geology that crops out at the ground surface) is shown in Figure 5.2. The majority of the study area is covered by Quaternary and Tertiary geological units. The Rangal Coal Measures do not outcrop within the Middlemount Coal Mine MLs or within the study area. The only Permian coal measure units that do outcrop within the study area are stratigraphically older than the Rangal Coal Measures, and are exposed south and west of the Middlemount Coal Mine MLs.

The characteristics of the superficial Quaternary alluvium (Qa) reflect the nature of the source rocks, weathering, transport, and depositional conditions. Poorly sorted clay, silt, sand, and gravel represent the thin flood-plain alluvium.

Other minor Quaternary units mapped northeast of the Middlemount Coal Mine MLs, consist of colluvial and residual deposits (TQr) of clay, silt, sand, gravel.

The Duaringa Formation (Tu) outcrops across the northern portions of the MLs and includes thick clay-rich laterite, a result of intensive and long-lasting weathering of the underlying parent rock (the Permian coal measures) during the Tertiary period. Other minor clay-rich Tertiary sediments (TQa) occur locally.

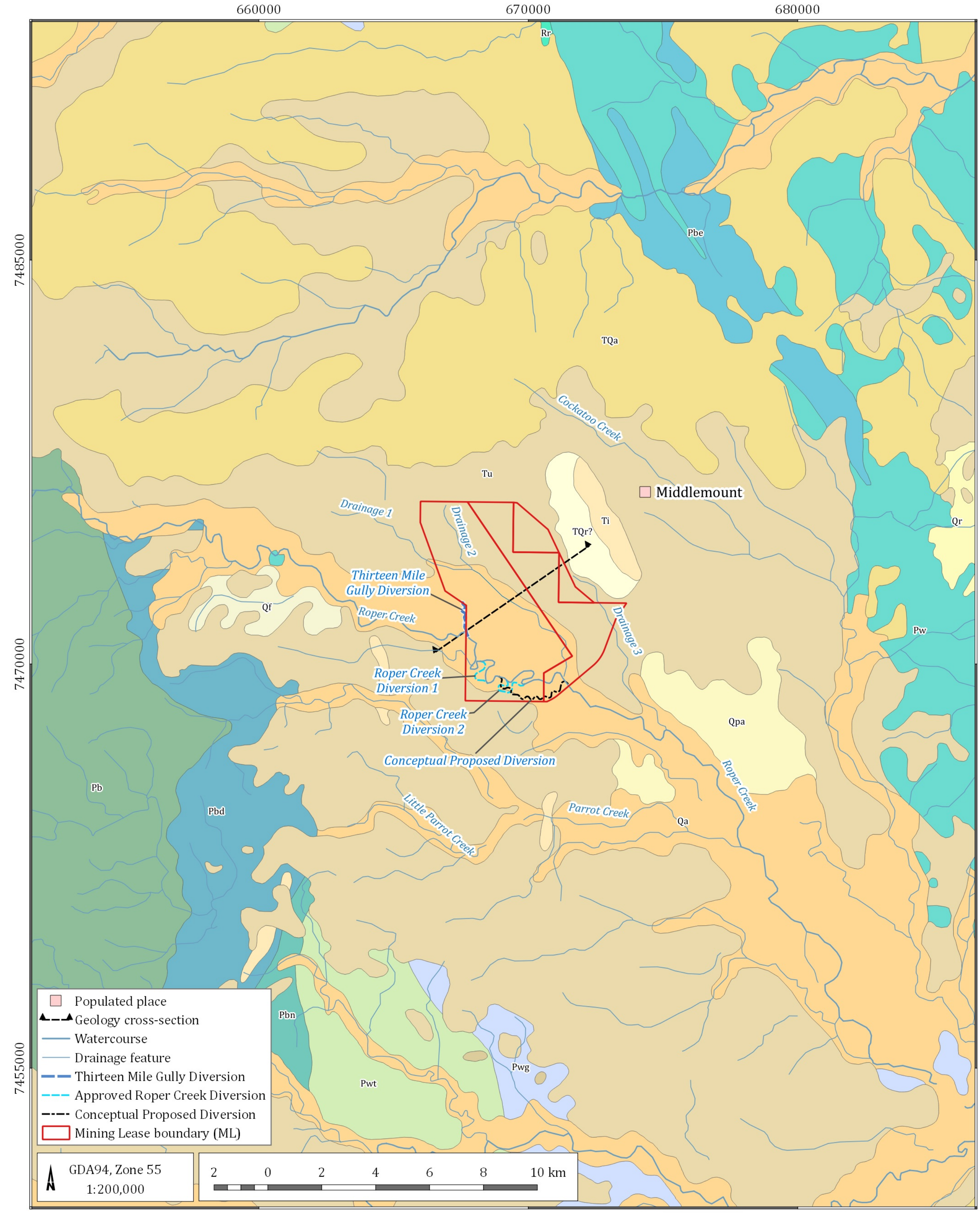
The Triassic Rewan Formation (Rr) does not outcrop within the study area, but does sub-crop within the study area beneath the Tertiary cover east of Middlemount township and southeast of the current mine footprint.

Outcrop of Permian coal measures are confined mainly to the western and southern parts of the study area and sub-crop beneath the Tertiary cover across the Middlemount Coal Mine MLs. The Permian coal measure units represented in outcrop geology include (from youngest to oldest) the:

- Burngrove Formation (Pwg);
- Fair Hill Formation (Pwt);
- MacMillan Formation (Pbn);
- German Creek Formation (Pbd);
- Blenheim Formation (Pbe); and
- Back Creek Group (Pb).

The Permian coal measures strike north-northwest and dip towards the east-northeast, generally at less than seven degrees. Local steeply dipping coals seams are anticipated to occur adjacent to the Jellinbah Fault. The extent of these geological features is shown conceptually as a north-east to south-west cross section in Figure 5.3.

The stratigraphy within the study area is summarised in Table 5.1.



LEGEND

Bowen Basin surface geology

Qa - Clay, silt, sand and gravel
Qf - Clay, silt, sand and clayey
Qr - Clay, silt, sand, gravel and soil
Qpa - Clay, silt, sand and gravel
TQa - Sand, silt, clay, minor gravel
TQr - Clay, silt, sand, gravel, soil
Ti - Rhyolite, trachyte and microsyenite
Tu - Mudstone, sandstone, lignite, basalt
Td -Ferricrete and silcrete
Rr - Sandstone, volcanilithic pebble
Pbd - Siltstone, mudstone and coal
Pbe - Carbonaceous sandstone
Pbn - Mudstone, siltstone, sandstone
Pb - Quartzose to lithic sandstone
Pwg - Mudstone, siltstone, sandstone
Pwt - Volcanic conglomerate
Pw - Feldspathic and lithic sandstone

Middlemount Coal Mine Southern Extension Project - GIA (G1840D)

Surface geology within study area

AGE

DATE
26/08/2020

FIGURE No:
5.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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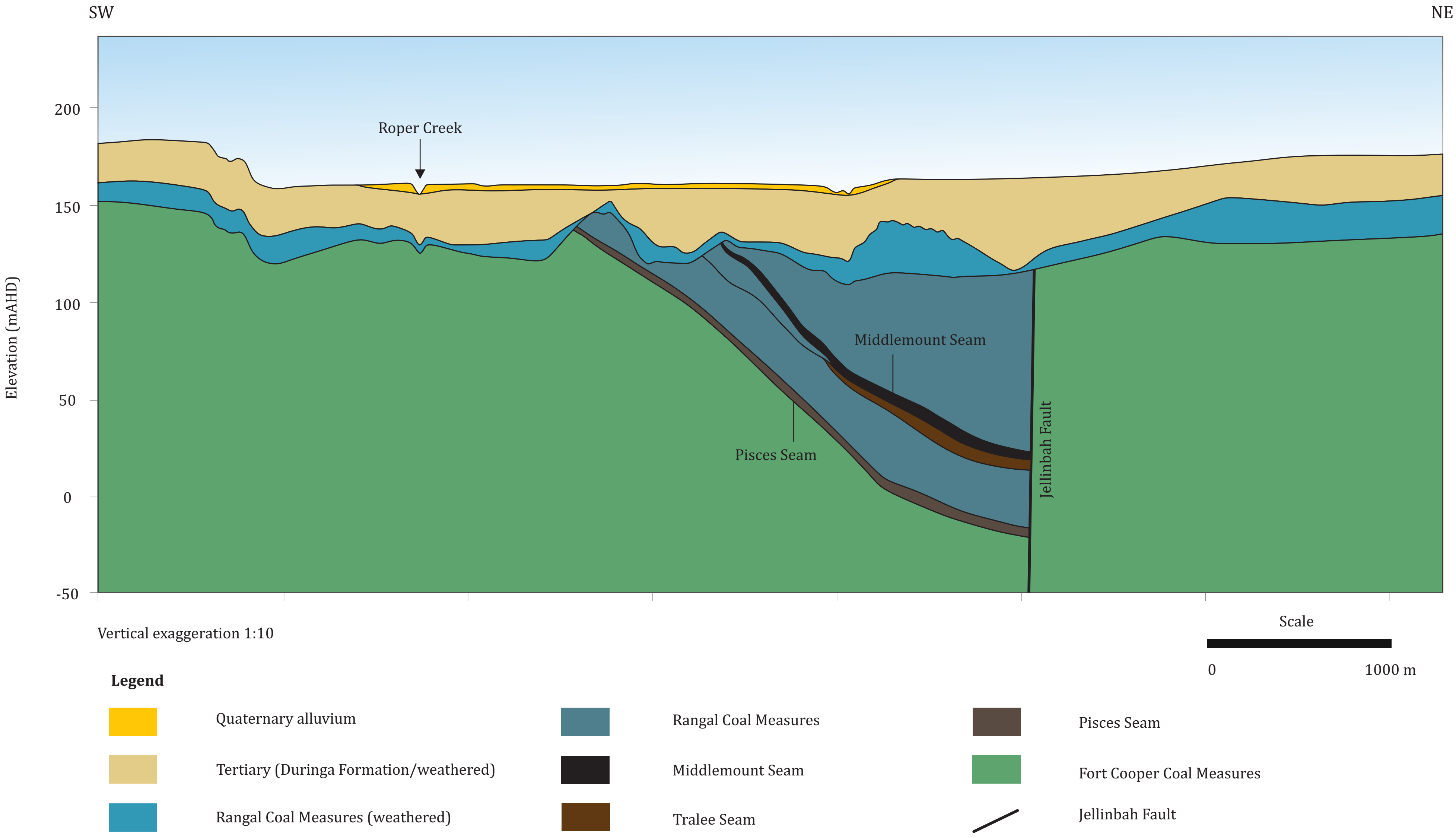


South-west to north-east geological cross section

Figure - 5.3

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\0_G1840P_E-W geological cross section.cdr

Table 5.1 Regional stratigraphy units

Age	Stratigraphic unit	Lithology description	Typical thickness (m)	Occurrence
Quaternary	alluvium	Clay, silts, sand, gravel, and floodplain alluvium	0 – 5	Confined to present day stream alignments and floodplains
Tertiary	Duaringa Formation	Claystone and siltstone, quartzose sandstone, pebbly sandstone, gravel, interbedded basalt; all deeply weathered	0 – 60	Surface covering that is extensive across the Middlemount Coal Mine MLs and much of the study area
Triassic	Rewan Formation	Green lithic sandstone, pebble conglomerate, red and green mudstone	-	Does not outcrop within study area and occurs east of Middlemount Township and southeast of current mining footprint.
Permian	Rangal Coal Measures	Calcareous sandstone, shale, mudstone, coal, limestone	0 - >150	Occurrence restricted to small area immediately west of the Jellinbah Fault, and extending south of the Middlemount Coal Mine. Additional limited occurrence east under Middlemount Township
		Roper seam Middlemount upper seam Middlemount lower seam Tralee coal seam Pisces coal seam	1 -2 <0.5 ~4 0.5 – 1 2 - 6	
	Fort Cooper Coal Measures	Lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff	>100	West of Rangal Coal Measures and east of Jellinbah Fault
		Girrah coal seam	-	

Source: *adapted from Stage 2 EIS, Parsons Brinkerhoff, 2010a.*

5.4 Quaternary aged geological units

5.4.1 Alluvial deposits

Within the study area, the Quaternary alluvial floodplain deposits (Qa) unconformably overlie the Duaringa Formation. The alluvial flood plain deposits are confined to present day stream alignments and floodplains, as shown in Figure 5.2.

The Quaternary alluvium is distributed within the ML from Roper Creek in the south to Thirteen Mile Gully in the north of the pit, and is comprised of clay, silt, and sand. Where it occurs, the alluvium is thin, usually less than 5 m (Parsons Brinkerhoff, 2010a).

Groundwater levels at the site are typically deeper than 10 mbgl, which is below the base of the Quaternary, indicating that the Quaternary sediments are typically unsaturated.

5.5 Tertiary aged geological units

5.5.1 Duaringa Formation

Tertiary sediments of the Duaringa Formation (Tu) cover the Middlemount Coal Mine MLs and much of the northern and southern parts of study area. The Duaringa Formation consists of deeply weathered mudstone, sandstone, pebbly sandstone/conglomerate and siltstone, gravel, and some interbedded oil shale and basalt. This formation unconformably overlies the Permian coal measures.

The thickness of the Duaringa Formation in the study area ranges from 0 m to 60 m and generally ranges between 25 m and 35 m within the MLs (Parsons Brinkerhoff, 2010a). Within the southwest portion of ML 70379, the Duaringa Formation is lateritised with a hard caprock that forms a topographic high in this area.

5.6 Triassic aged geology

5.6.1 Rewan Formation

The Rewan Formation (Rr) comprises lithic sandstone, pebbly lithic sandstone, and green to reddish brown mudstone, siltstone, quartz sandstone, shale, and some volcanolithic pebble conglomerate at the base. The thickness of the Rewan Formation varies across the Bowen Basin and is up to 800 m thick.

The Rewan Formation sub-crops beneath the Tertiary cover in the very south-eastern part of the Middlemount Coal Mine MLs and east of the Middlemount Township.

5.7 Permian aged geology

Figure 5.4 presents a map of the Bowen Basin Permian / Triassic geology located within the study area. Maps such as these are commonly referred to as showing the “solid geology” when the overlying Quaternary and Tertiary geology is not shown.

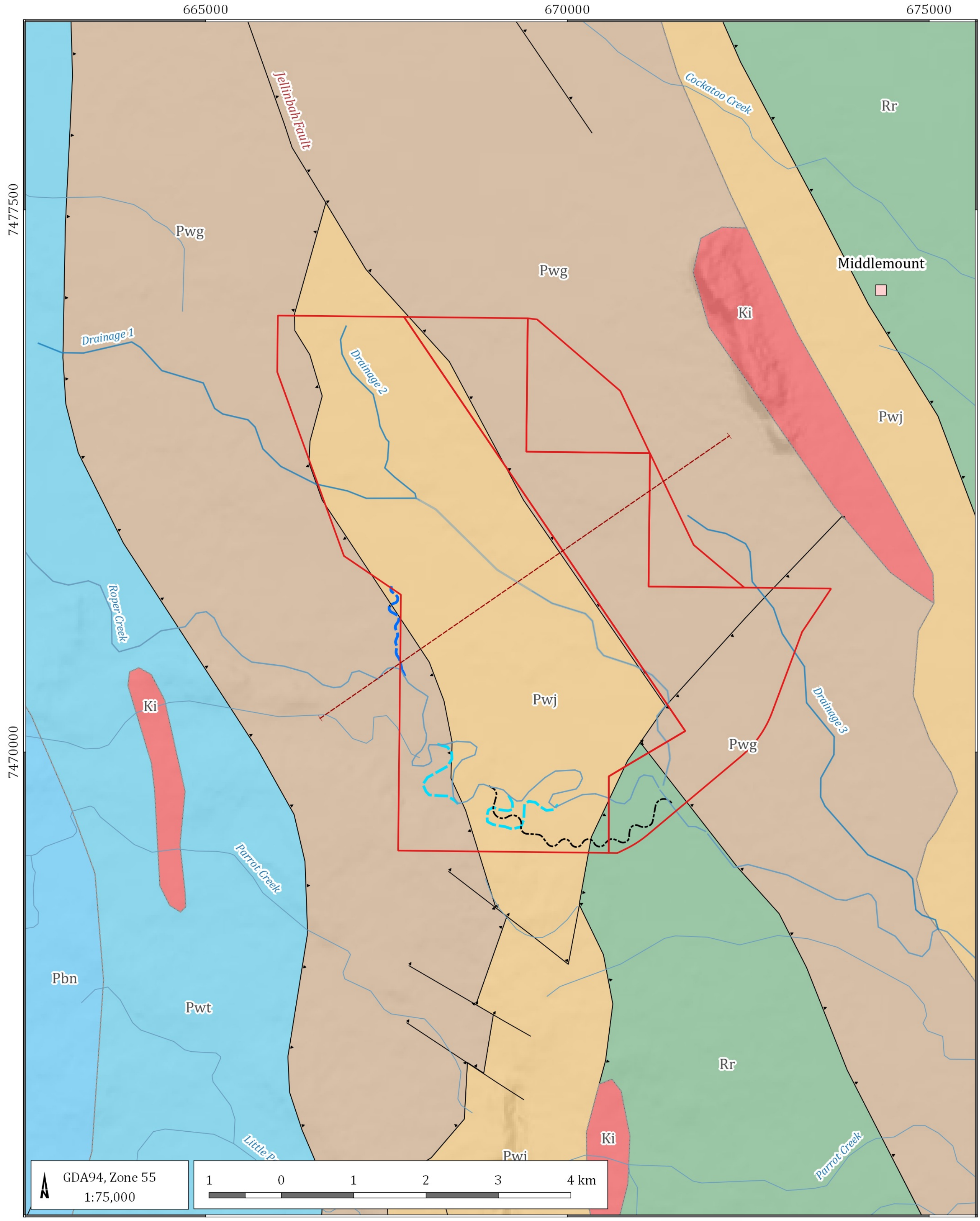
5.7.1 Rangal Coal Measures

The Rangal Coal Measures include the economic coal seams targeted at Middlemount Coal Mine. The Middlemount and Pisces seams are the thickest coal seams, which sometime double in thickness, likely as a result of duplication from faulting. This occurrence is more evident nearer the Jellinbah Fault. These coal measures dip to the east between 3º and 7º, and are truncated by the Jellinbah Fault, which has been mapped roughly coincident with the north-eastern boundary of ML 70379.

The entire sequence was intruded by igneous rocks (gabbro, diorite, granodiorite, rhyolite, and trachyte) in the Cretaceous, and several sub-crops of these intrusions (Ki) are mapped in the solid geology (Figure 5.4). However, only one instance of igneous rocks was recorded in the drilling of monitoring bores at Middlemount Coal Mine in bore MW4 (Phi Ground Innovations, 2015).

Beyond the extent of exploration drilling, the structure of the Rangal Coal Measures has been extrapolated. As such, the extent of the coal seams adopted for the conceptual and numerical groundwater models show the coal seams dip towards the east, and are inferred to sub-crop the area beneath the Tertiary sediments and terminate at the Jellinbah Fault line.

The interburden between the various coal seams is dominated by weathered and fresh interbedded carbonaceous mudstone, siltstone, feldspathic and lithic sandstone, and tuff sequences. The depth of weathering is generally between about 35 m and 45 m.



LEGEND

- ▫ Populated place
- — Regional mapped faults
- ----- Contact
- ⊢---⊣ Geology cross-section in figure 5.3
- — Watercourse
- — — Thirteen Mile Gully Diversion
- — — Approved Roper Creek Diversion
- -·-· Conceptual Proposed Diversion
- ▭ Mining Lease boundary (ML)

Bowen Basin solid geology

- 🟥 Ki-Ki-CQ
- 🟩 Rr-Rewan Formation
- 🟦 Pbd-German Creek Formation
- 🟦 Pbn-MacMillan Formation
- 🟫 Pwg-Burngrove Formation
- 🟨 Pwj-Rangal Coal Measures
- 🟦 Pwt-Fair Hill Formation

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Bowen Basin solid geology with publicly available fault interpretation

AGE

DATE
26/08/2020

FIGURE No:
5.4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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5.7.2 Fort Cooper Coal Measures

Drilling along the eastern side of the Jellinbah Fault has intersected the Fort Cooper Coal Measures. The Fort Cooper Coal Measures are dominated by siltstone and alternating layers of very fine grained and fine grained sandstone, with numerous calcite veins and layers of coal and tuff. The Fort Cooper Coal Measures stratigraphically underlie the Rangal Coal Measures, including the Middlemount and Pisces seams.

5.8 Geological structure

5.8.1 Publicly available fault data

Geological structure (i.e. faults, folds, etc.) for the Bowen Basin is publicly available from the Queensland Government. The Queensland geology and structural framework GIS dataset is a digital representation of the distribution of rock units and their structure in Queensland, which mirrors the DNRME's hard copy Queensland Geology map published in 2012.

The publicly available geological structure data is typically based on broad scale geological mapping interpretation. The result of this regional scale interpretation within the study area is shown in Figure 5.4. This data shows a series of northwest - southeast trending faults have previously been interpreted to exist:

- between the Burngrove Formation and underlying Fairhill Formation that trend southwest - northeast, west of the Middlemount Coal Mine MLs;
- roughly coincident with the north-eastern boundary of ML 70379 and referred to as the Jellinbah Fault;
- to the east between the Rangal Coal Measures and Rewan Formation beneath Middlemount Township; and
- further east of Middlemount Township between the Rewan Formation and Blackwater Group.

The mapping also shows a series of significantly shorter east-west and northeast-southwest cross faults that intersect these longer, more dominant northwest-southeast trending faults. Commonly, the accuracy of this publicly available data is improved greatly by site specific geological exploration. As such, the publicly available fault interpretation is considered within this report to be a useful guide for regional context, but is superseded where site specific fault interpretation exists.

5.8.2 Jellinbah Fault interpretation

The Jellinbah Fault is described as a thrust fault that dips towards the east (Parsons Brinkerhoff 2010a, AGE 2018a). The fault is interpreted as having a throw of over 300 m, where the western geological units are discontinuous across the fault with the stratigraphically older Fort Cooper Coal Measures and Girrah Coal Seam, which subcrop on the eastern side (upthrown block) of the fault. Secondary faulting is present on both sides of the Jellinbah Fault as part of the thrust complex, resulting in extensive brittle deformation, fractures, and faulting. A south-west to north-east cross-section through the site (Figure 5.3) shows the stratigraphic sequence and the Jellinbah Fault. This geological cross-section is oriented southwest-northeast, sub-perpendicular to the dip of the coal seams. The geological cross-section shows the Fort Cooper Coal Measures are thrust up against the Rangal Coal Measures by the Jellinbah Fault near the northeastern limit of the approved open cut. The Jellinbah Fault therefore truncates the Middlemount, Tralee, and Pisces coal seams along this eastern margin (Figure 5.3).

6 Conceptual groundwater model

An understanding of the groundwater regime is presented in this section which provides the basis for the hydrogeological conceptualisation for the study area. The conceptual model describes the groundwater system and how it operates given the available data and represents the natural system in a simplified way.

The following sections describe the conceptual groundwater model for the Middlemount Coal Mine. The conceptual groundwater model was based on publicly available geological and topographical maps, geological information from exploration bores drilled across MLs and its surrounds, groundwater level and quality data from monitoring bores and results from previous hydrogeological investigations.

6.1 Hydro-stratigraphic units

As previously discussed, the geology within the study area/model domain comprises a Quaternary and Tertiary age sequence overlying older Permian age coal measures. These geological units can be separated into three key hydro-stratigraphic units based on their hydraulic properties and lithology. From youngest to oldest, these units are:

- Quaternary aged units:
    - Alluvial aquifer – consists of localised stream channel deposits and associated flood plain deposits. These units comprise a temporary (rainfall dependent) aquifer that is limited to the immediate vicinity of Roper Creek, Thirteen Mile Gully and drainages within the MLs. Neither Roper Creek or Thirteen Mile Gully is targeted for water supply within the near vicinity of the Middlemount Coal Mine.
- Tertiary aged units:
    - Duaringa Formation – consists of thick clay-rich laterite which is sourced from highly weathered Permian sandstones and siltstones, and occasional basalt. The Duaringa Formation is not typically targeted for agricultural water supply and is (at best) a low yielding aquifer that would more commonly be regarded as an aquitard.
- Permian aged units:
    - Interburden/overburden - the bulk of the Permian coal measure strata is sandstone, siltstone, and mudstone that typically have low permeability and generally form aquitards.
    - Coal seams (principally the Middlemount and Pisces Seams) - form low to moderate yielding aquifers confined by interburden/overburden units.

6.2 Groundwater resources and concepts of groundwater flow

Groundwater is the component of the hydrological cycle that is stored below the earth's surface. If a geologic formation is capable of storing and transmitting groundwater in usable quantities it is called an aquifer. The groundwater sourced from aquifers within the study area are typically hosted within two general types of geologic formations:

- porous media – such as sand, gravel, and some sandstone; and
- fractured rock – such as fractured basalt (very limited occurrence in the study area), fractured/faulted/jointed sandstone and fractured coal seams.

Aquifers of both porous media and fractured rock occur within the study area.

In sand and gravel, water is stored in the pore spaces between the soil grains and can move quite freely in any direction. However, in a fractured rock aquifer water is stored in the fractures or crevices in an otherwise solid rock. A bore drilled into fractured rock has to intersect a fracture before water becomes available to the bore. For this reason, there is a greater chance of drilling an unsuccessful bore in fractured rock than in porous media.

Because the volume of the fractures is quite small compared with the total volume of the rock, fractured rock aquifers do not hold large volumes of water. They are also subject to large fluctuations in groundwater level both as a result of pumping and recharge.

A shallow Quaternary alluvial sand or gravel aquifer is generally unconfined, meaning that its upper surface (i.e. the water table) is open to the atmosphere through permeable material. The water table in an unconfined aquifer system has no overlying impervious rock layer to separate it from the atmosphere.

An unconfined aquifer is one in which the permeable geologic formation storing the water is only partly filled with water and it overlies a relatively impervious layer. An unconfined aquifer contains water which is not subjected to any pressure other than its own weight (i.e. hydrostatic pressure). If a bore penetrates such an aquifer the water will rise within the bore no higher than the depth at which it was first encountered. The level at which water stands in a bore penetrating an unconfined aquifer (i.e. the standing water level) is known as the water table and is the depth at which water in the aquifer is at atmospheric pressure.

By contrast, the Tertiary Duaringa Formation and Permian coal seam aquifers are confined, meaning that they are overlain by a confining bed. The confining bed has a significantly lower permeability than the aquifer. A confined aquifer is a completely saturated permeable formation of which the upper and lower boundaries greatly restrict the vertical movement of groundwater. In a confined aquifer, groundwater is under sufficient pressure to cause it to rise above the top of the aquifer if given the opportunity (e.g. if penetrated by a bore). The level to which the water rises is referred to as the potentiometric head.

Groundwater in geologic formations flows from areas where the standing water level (or potentiometric head) is higher, to areas where it is lower, in much the same way that surface water flows from areas of higher elevation to areas of lower elevation. The difference in groundwater levels is generally referred to as the hydraulic gradient. However, unlike surface water, groundwater flows slowly, through pores and fractures in formations.

The flow of groundwater is controlled primarily by two hydraulic parameters of the material through which it flows; the permeability and the storativity. Permeability is a measure of the ease with which water can flow through the material. The term hydraulic conductivity is another term used for the coefficient of permeability. Storativity is a measure of the capacity of the material to store or release water in response to a pressure change.

Highly permeable materials, such as sand, let groundwater flow relatively easily, resulting in a gentle hydraulic gradient in response to groundwater extraction. In contrast, lower-permeability materials such as clay, although yielding relatively small amounts of water, result in much steeper hydraulic gradients.

Geologic formations with higher hydraulic conductivity/permeability are known as aquifers and formations with lower hydraulic conductivity/permeability are known as aquitards. The remainder of this report will refer to hydraulic conductivity for consistency.

Within a geologic formation, groundwater typically flows more easily along bedding planes (the surfaces that separate different layers) than vertically through them. As a result, horizontal hydraulic conductivity is normally substantially higher than vertical hydraulic conductivity.

In addition to extraction from bores, groundwater also flows naturally to surrounding formations, springs, and watercourses. At any given time, water pressure in a geologic formation reflects a balance, or in the case of rising or falling water levels, an imbalance between the volume of water entering the system (recharge) and the volume of water flowing out of the system (discharge).

Regular measurement of groundwater levels in monitoring bores enables a history of groundwater level response to various stresses to be documented and analysed. Such stresses could result in groundwater level rises resulting from recharge events or groundwater level declines resulting from groundwater extraction. If water levels are measured in a number of monitoring bores at the same time and reduced to the same datum, it is possible to draw a set of groundwater level contours which reflect the groundwater hydraulic gradient at that time. It is possible to use such contours to determine the direction of groundwater flow and to obtain an aerial response to stresses on the system.

6.3 General aspects of groundwater and mining

The Middlemount Coal Mine currently includes a single open cut pit from which mining activities take place and interfere with groundwater by intersecting and dewatering (removing water) as part of the mining process.

6.3.1 Mine dewatering impacts

During mining, the rate of groundwater seepage into the open cut pit from the coal seam (which is subsequently removed by pumping to dewater the pit) exceeds the rate of groundwater flow to the mined region and consequently the coal seam aquifer experiences a reduction in groundwater pressure. This pressure decline is quantified in terms of groundwater level drawdown. Drawdown radiates outwards from the mined areas to create a cone of depression. The area affected by such pumping is called the area of influence. The outer limit of the area of influence at a particular time is called the radius of influence. The radius of influence continues to expand as the time of pumping increases. Beyond the radius of influence the drawdown effect is zero.

The radius of influence at any particular time depends only on the ability of the aquifer to store and to transmit water. It is independent of the pumping rate. However, the magnitude of the drawdown within the cone of depression does depend on the pumping rate and on the ability of the aquifer to store water and to allow the water to move through it. The lower the hydraulic conductivity of the aquifer, the steeper the resulting drawdown. Accordingly, in the study area, where three aquifers occur and each has different storage and transmitting capabilities, the radius of influence of pumping will vary significantly depending on which aquifer the water is being extracted from.

Hence, modelling of this complex relationship is required to understand the potential for impact in the surrounding aquifers.

6.3.2 Post-mining groundwater recovery

Mining (incorporating the Project) would be completed at Middlemount Coal Mine in 2043, after which groundwater would flow into the open pit residual voids. There are two residual voids proposed at the end of mining, the North Void and South Void (refer to Section 8.4). This filling process in each void will reduce the hydraulic gradient and magnitude of groundwater level drawdown immediately surrounding the mined areas. This process is referred to as “recovery”. The recovery process continues until the groundwater level and void water level reach an equilibrium where the volume of groundwater inflow and rainfall (runoff) equals the volume of void water lost through evaporation. This process typically results in groundwater levels that do not fully recover (or sometimes even partially recover) to pre-mining conditions, as evaporation losses usually exceed inflows attributable to groundwater and rainfall.

6.4 Groundwater data availability

6.4.1 DNRME groundwater database bores

DNRME maintains information on water bores across Queensland in its GWDB. A search of the GWDB up to 10 km from the Middlemount Coal Mine indicated a potential 56 bores within the study area. Table 6.1 provide a summary of the expected use of these bores. Of the 56 bores, only six were identified as landholder bores, 41 bores for mine groundwater monitoring purposes, and nine associated with petroleum (CSG) exploration. Details of the bores identified in the GWDB are provided in Appendix B.

Table 6.1 Summary of DNRME groundwater database bores in the study area

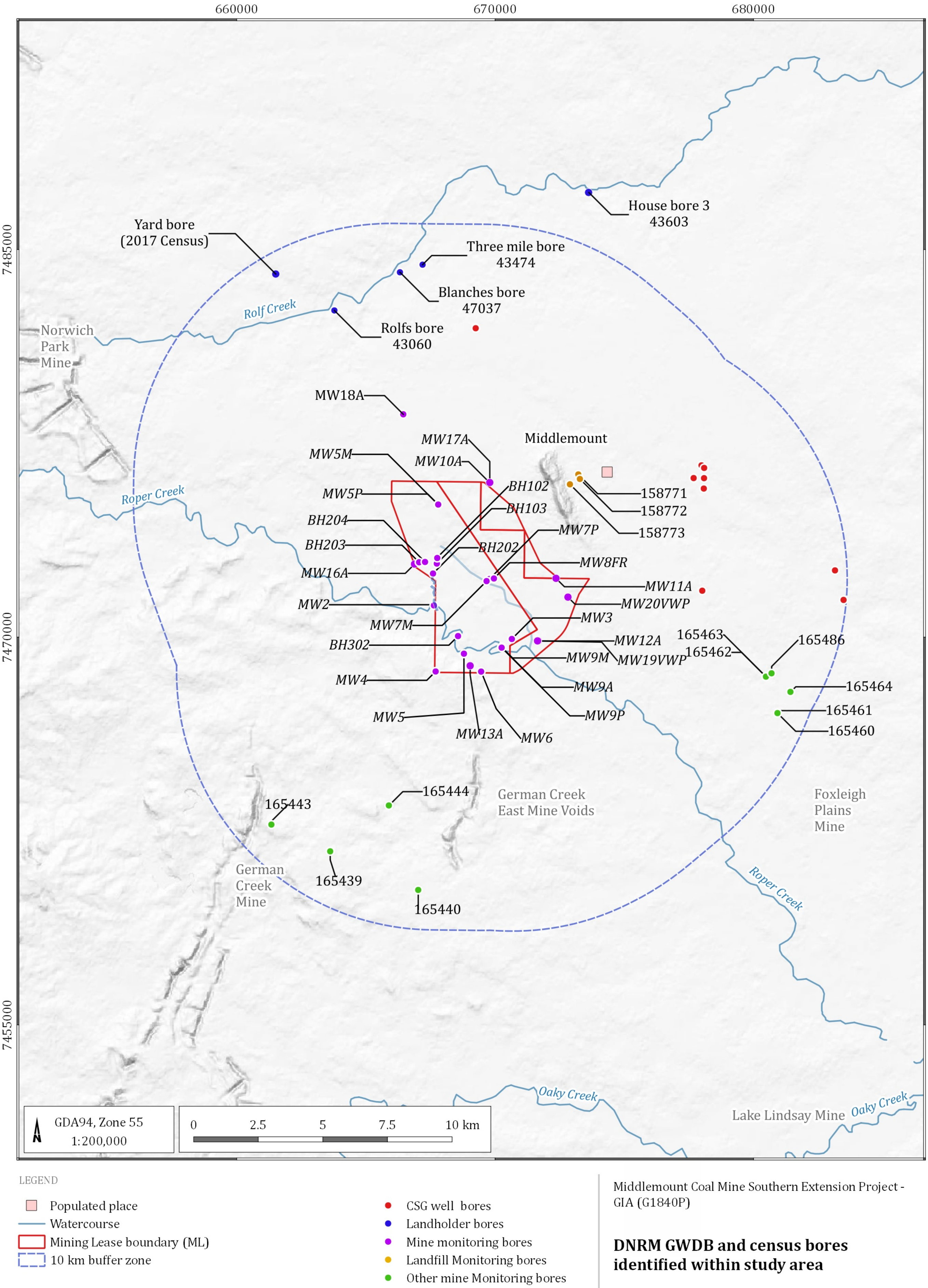
Roles of DNRME GWDB bores (2020)	Number of GWDB bores within the 10 km radius of MLs
Landholder water supply	
No specified role, but likely to be used for landholder water supply	6
Total number of bores used for landholder water supply	**6**
Monitoring bores	
Middlemount Landfill groundwater monitoring bores	3
Middlemount Coal Mine groundwater monitoring bores	28
Foxleigh Mine groundwater monitoring bores	6
German Creek/Grasstree Mine groundwater monitoring bores	4
Total number of bores used for groundwater monitoring	**41**
Petroleum (CSG) exploration	
Petroleum or gas exploration	9
Total number of bores used for exploration	**9**
Total number of existing GWDB bores	**56**

Source: *DNRME, 2020*

A bore census undertaken by 4T Consultants Pty Ltd (4T) in 2017 on surrounding privately owned land in September 2017 (refer Section 6.4.2) identified that two of the six landholder bores identified in the GWDB were no longer in use, and one additional bore was identified (i.e. a total of five privately owned bores). Review of the contemporary GWDB indicates that no additional landholder bores have been established since the bore census was undertaken in September 2017.

MCPL have also advised that three of the Middlemount Coal Mine groundwater monitoring bores (MW1, MW1P, and MW7M) have since been consumed by the planned advance of the mining pit.

Based on this review, there are five landholder bores used for water supply purposes. The rest of the bores are either mine or landfill monitoring bores, or associated with petroleum (CSG) exploration. The locations of these GWDB bores are shown on Figure 6.1. Middlemount's groundwater monitoring network is displayed via the mine designated nomenclature (e.g. MW3) in Figure 6.1; the registered bore numbers (RN) for the monitoring bore network are provided in Table 6.3.



Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

DNRM GWDB and census bores identified within study area

AGE

DATE 21/08/2020

FIGURE No: **6.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.01_G1840P_DNRM registered bores.qgs

6.4.2 Landholder bores – bore census data

A bore census of nearby groundwater users on privately owned properties was carried out by 4T in September 2017 for the Western Extension Project (AGE, 2018a). A copy of the bore census is provided in Appendix C.

The bore census assessed six privately-owned properties, the Middlemount landfill and the Middlemount Jockey Club covering an area of approximately 457 km^2 that surrounds the Middlemount Coal Mine. Following initial contact and establishing the presence of bores on four of the properties and Middlemount landfill, these properties were visited, and the bores inspected and assessed.

A total of five landholder water supply bores were assessed on two of the privately owned properties (of which four were listed on the GWDB within 10 km of ML70379). Details of these bores are provided in Table 6.2 and their locations are shown in Figure 6.1. All five bores are located in excess of 5 km from the Middlemount Coal Mine. Bores listed in the GWDB for the other two properties were determined to no longer exist.

The bore census also confirmed the three bores located at the Middlemount Landfill to be groundwater monitoring bores established for the landfill operation. All three monitoring bores were dry when assessed for the bore census.

The depth to groundwater in the landholder water supply bores inspected during the bore census was found to range between 11 m and 21 m below ground level (Table 6.2).

The drilling and construction logs for these bores were not made available for the bore census. However, review of the GWDB bore cards for the registered bores was used to identify the target aquifers (i.e. screen lithology, where available) for these bores. A geological map of the area, shown in Figure 5.2 and Figure 5.4, suggests that these bores are separated from the Middlemount Coal Mine pit by significant faulting.

Table 6.2 Bore census landholder water supply bores

Bore	Property description	Registered number	Easting# (m)	Northing# (m)	Bore depth (m)	Usage	Screen lithology and Yield (L/s)	Standing water level (mbgl)
Yards Bore	Warwick Park	Not registered	661509	7484051	54	Stock Water^	NA	18.09
Rolfs Bore	Warwick Park	43060	663778	7482641	38.1	Stock Water^	NA	20.89
Blanches Bore	Warwick Park	47037	666941	7484987	35.7	Stock Water	Back Creek Group (0.39 L/s)	Not accessible
House Bore 3	Warwick Park	43063 *	673624 *	7487216 *	30.5 *	Stock & Domestic	Sandstone (1.5 L/s)*	11.61
Three Mile Bore	Hazelbrae	43474	666800	7484295	41	Stock Water^	Clay (0.29 L/s)	Not accessible

Notes: *# - Coordinates in GDA94, Zone 55.*

** - Details for original House Bore 1, which was replaced with House Bore 3.*

NA – Not available.

^ Not in use at time of inspection. Used as emergency stock water supply during dry conditions.

6.4.3 Mine groundwater monitoring bore networks

MCPL has implemented an extensive groundwater monitoring bore network, located both within and outside of the Middlemount Coal Mine MLs. The groundwater monitoring focuses on the Tertiary Duaringa Formation aquifer and the Permian Rangal Coal Measures aquifer.

The first monitoring bores (MW1 to MW6) were installed in June 2008 for Stage 1 of the Middlemount Coal Mine. The monitoring network was subsequently expanded as part of the Stage 2 assessment for the EA amendment in 2012. This included installing nine monitoring bores principally into the Permian coal measures at four locations (MW1P, MW5M/P, MW7M/P and MW8FR, and MW9A/M/P). Six additional monitoring bores (MW10A, MW11A, MW12A, MW13A, MW14A, MW15A,) were installed into the Tertiary aquifer in December 2015 to augment the existing monitoring network and facilitate the mine development plan (Phi Ground Innovations, 2015) in early 2019. Details of the groundwater monitoring network are a summarised in Table 6.3, and the locations of these monitoring bores are shown in Figure 6.2. Copies of the monitoring bore logs are provided in Appendix D.

Monitoring bores MW1 and MW1P were consumed in mid-2015 as mining progressed northwards within the current open cut footprint, and MW7M was mined out in late 2019. The current monitoring network consists of 21 bores and two vibrating wire piezometers (VWPs) both on lease and surrounding the MLs for the purpose of monitoring the groundwater response due to mining. The monitoring bores are located around the current mining area and target the Tertiary aquifer and the Permian coal measures.

Groundwater monitoring has historically been conducted in accordance with the site's Plan of Operations and conditions within EA EPML00716913. The EA conditions are presented in Section 3.4.

Table 6.3 Mine monitoring bore network

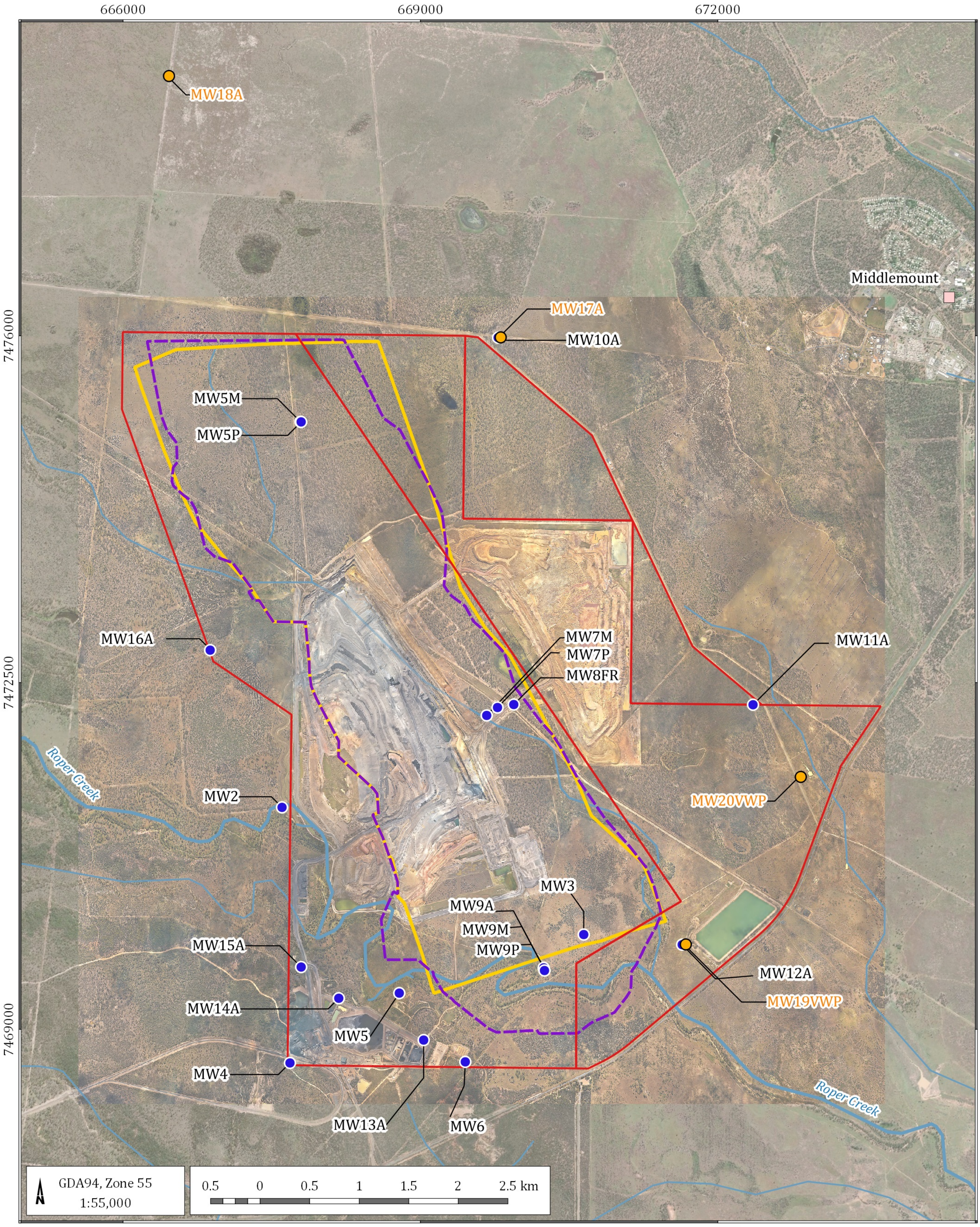
RN	Monitoring bore	Easting ^{1} (m)	Northing ^{1} (m)	Ground elevation (mAHD)	Bore depth (m)	Screen depth (m)	Screen lithology	Screen geology
151334	MW1 (Mined out)	667851	7473155	161.5	30.0	21.0-29.0	Clay/sandy clay	Tertiary
161059	MW1P (Mined out)	667818	7473149	161.1	77.2	72.0-75.0	Coal	Pisces coal seam
151043	MW2	667603	7471239	163.12	30.0	21.0 – 29.0	Sandy Clay and Sand	Tertiary
151336	MW3	670647	7469955	155.44	48.0	39.0 – 47.0	Clay and Sandy Clay	Tertiary
151335	MW4	667683	7468659	183.11	50.0	41.0 – 50.0	Weathered igneous rock, Coal, and Sandy Coal	Intrusives and Girrah coal seam (Fort Cooper Coal Measures)
151658	MW5	668786	7469364	157.68	46.0	40.0 – 46.0	Coal	Pisces coal seam
161060	MW5M	667790	7475131	174.52	131.0	127.0 – 130.0	Coal	Middlemount coal seam
161061	MW5P	667796	7475130	174.66	169.0	165.0 – 168.0	Coal	Pisces coal seam
132459	MW6	669452	7468670	158.26	42.0	37.0 – 42.0	Clay	Tertiary

RN	Monitoring bore	Easting [1] (m)	Northing [1] (m)	Ground elevation (mAHD)	Bore depth (m)	Screen depth (m)	Screen lithology	Screen geology
161062	MW7M (Mined out)	669668	7472167	161.15	135.5	132.0 – 134.5	Coal	Middlemount coal seam
158679	MW7P	669777	7472247	163.87	194.5	189.5 – 193.5	Coal	Pisces coal seam
161063	MW8FR	669941	7472277	164.33	151.0	147.0 – 150.0	Shale, Siltstone, and Sandstone	Fort Cooper Coal Measures
161064	MW9A	670246	7469610	156.32	52.0	40.0 – 52.0	Sandstone and Siltstone	Tertiary
161065	MW9M	670243	7469619	156.36	139.5	135.0 – 138.0	Coal	Middlemount coal seam
161066	MW9P	670251	7469592	156.26	204.0	200.0 – 203.0	Coal	Pisces coal seam
ND[3]	MW10A	669783	7475981	175.75	12.0	6.0 – 12.0	Sand, Silty Sand, and Clay	Tertiary
ND[3]	MW11A	672355	7472275	156.21	13.5	10.5 – 13.5	Clay and Mudstone	Tertiary
ND[3]	MW12A	671640	7469853	158.28	10.55	6.0 – 10.55	Fine Sand and Mudstone	Tertiary
ND[3]	MW13A	669032	7468890	162.79	15.0	9.0 – 14.95	Sandstone	Tertiary
ND[3]	MW14A	668175	7469312	159.653	14.0	6.0 – 9.0	Sand, Clayey Sand and Mudstone	Tertiary
ND[3]	MW15A	667796	7469627	161.569	12.5	7.0 - 10.0	Sand, Sandy Clay and Mudstone	Tertiary
ND[3]	MW16A	666878	7472826	163	50	44-50	Sandstone	Tertiary and weathered FCCM
ND[3]	MW17A	669791	7475983	169	42.5	42.5	Carbonaceous claystone and sandstone	Weathered and fresh FCCM
165615	MW18A	666444	7478622	189	24.5	18.5 – 24.5	Silty clay and siltstone	Tertiary and weathered FCCM
ND[3]	MW19VWP–3 MW19VWP–2 MW19VWP–1	671659	7469856	161	163	• 50 • 109 • 150	• Carbonaceous siltstone • Sandstone • Sandstone	• Weathered FCCM • FCCM • FCCM
ND[3]	MW20VWP-2 MW20VWP-1	672817	7471547	154	157	• 88 • 131.5[2]	• Carbonaceous siltstone • Coal	•FCCM •FCCM

Notes: *1 – Coordinates in GDA94, Zone 55.*

2 – Sensor believed to be faulty.

3 – No details available on Queensland Globe.



LEGEND

- ● Existing monitoring bore network
- ● Newly installed monitoring bores
- ─ Watercourse
- ─ Drainage feature
- ▭ Approved open cut footprint
- ▭ Proposed open cut footprint
- ▭ Mining Lease boundary (ML)

Middlemount Coal Mine Southern Extension Project - GIA(G1840P)

Middlemount Coal Mine monitoring bore locations

AGE

DATE 26/08/2020

FIGURE No: **6.2**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.02_G1840P_Middlemount Coal Mine monitoring bore locations.qgs

6.5 Quaternary alluvial aquifer

6.5.1 Groundwater yield

The Quaternary alluvial aquifers are not well developed within much of the study area, and are regionally mapped across the central to southern parts of ML 70379 and the southern end of ML 70417 along Roper Creek and Thirteen Mile Gully. Drilling intersected sand in monitoring bores MW2, MW3, MW7M, MW7P, MW8FR and MW9A, between 0.5 mbgl and 14.5 mbgl. The borehole logs do not differentiate between Quaternary or Tertiary sediments, but it is understood that the Quaternary sediments are most likely localised around the drainage alignments and not laterally extensive. No groundwater was intersected in these boreholes, other than the moist sand intersected in MW7M and MW8FR. No significant groundwater extraction areas are known elsewhere within the study area.

The Quaternary alluvium is not targeted by landholders as a groundwater supply within the study area. This outcome supports the general understanding that the Quaternary alluvium is not a productive aquifer within the study area.

Similarly, no monitoring bores have been installed within the Quaternary alluvium.

Given the groundwater levels at the site are typically below the base of the Quaternary alluvium (i.e. are typically unsaturated) (Section 5.4.1), and the Quaternary sediments are most likely localised around the drainage alignments and not laterally extensive, groundwater monitoring of the Quaternary alluvium would not materially increase understanding of potential groundwater impacts associated with the Middlemount Coal Mine.

6.5.2 Hydraulic parameters

The Quaternary alluvium is estimated to have a highly variable range of hydraulic conductivity values owing to its variable lithology of sand, clay, and occasional gravel bands. The sandy to gravelly creek beds are expected to have higher values of hydraulic conductivity compared to the flood-plain deposits, because the latter would be expected to have a more clayey nature.

In lieu of site data, literature references can be used as useful guides for the expected range of hydraulic parameters for rocks and unconsolidated sediments. Literature values can be found in commonly cited references such as Fetter (1994), Kruseman and De Ridder (1994), Driscoll (1986), and Freeze and Cherry (1979), Domenico and Schwartz (1990).

Literature values of hydraulic conductivity for clayey sand are about 0.1 metres per day(m/day) and fine gravel are about 100 m/day. A geometric mean of about 1 m/day would be considered a reasonable estimate for the bulk hydraulic conductivity of the Quaternary alluvium within the study area.

As a comparison, Arrow Energy (2012) assigned a hydraulic conductivity value of 2 m/day to their base case numerical groundwater model to represent flood plain alluvium within the Bowen Basin.

In the field of hydrogeology, "storage properties" are physical properties that characterise the capacity of an aquifer to release groundwater.

Specific yield is primarily used to define the storage capacity of unconfined aquifers. Specific yield is also known as the drainable porosity, and is the volumetric fraction of the bulk aquifer volume that a given aquifer will yield when all the water is allowed to drain out of it under the forces of gravity.

In lieu of site data, literature references of specific yield range between 2% to 5% (i.e. 0.02 and 0.05) for clay, and 10% to 25% (i.e. 0.1 and 0.25) for sand/fine gravel. A geometric mean of about 10% (0.1) would be considered a reasonable estimate for the bulk specific yield of the Quaternary alluvium within the study area.

Specific storage is primarily used to define the storage capacity of confined aquifers. Specific storage is the volume of water that an aquifer releases from storage, per volume of aquifer, per unit decline in hydraulic head (Freeze and Cherry, 1979). Specific storage uses the dimension of m^{-1}.

Recent literature (Rau, 2018) suggests the plausible range of specific storage is limited to between 2.3E-07 m^{-1} and 1.3E-05m^{-1}. The unconsolidated nature of the alluvial aquifer means the upper bound (around 1.3E-05 m^{-1}) of this range is most likely for the alluvium.

As a comparison, Arrow Energy (2012) assigned a specific storage value of 5.0E-4 m^{-1} to their base case numerical groundwater model to represent flood plain alluvium within the Bowen Basin.

6.5.3 Groundwater recharge, levels, and flow

Groundwater level data is not available for the Quaternary alluvium within the vicinity of the Middlemount Coal Mine, as it is understood the regional groundwater table is below the depth of the alluvial sediments (i.e. greater than 10 mbgl) within the MLs.

Where saturated, recharge to the alluvium would occur as either:

- via direct rainfall on to the alluvium; or
- via seepage through the stream bed, when the creeks are flowing.

Stream gauging data for Roper Creek indicates surface water flow along this creek dissipates quickly after flow events. Therefore, recharge from stream flow would occur over short time periods as the water infiltrates relatively rapidly into the alluvium. When saturated, the groundwater flow direction in the alluvium would be expected to be generally from north-west to south-east, following the regional topography and drainage network.

In the vicinity of the Middlemount Coal Mine, discharge could occur from the alluvium via seepage to the underlying Tertiary sediments. However, this would only occur in areas where the alluvium is saturated and a downward vertical hydraulic gradient to the underlying strata occurs.

6.5.4 Groundwater quality

Groundwater quality data is not available for the Quaternary alluvium within the vicinity of the Middlemount Coal Mine, as the groundwater table is understood to be below the depth of the alluvial sediments (i.e. greater than 10 mbgl) within the MLs.

6.6 Tertiary Duaringa Formation aquifer/aquitard

6.6.1 Groundwater yield

The presence of significant clay within the Tertiary Duaringa Formation suggests that shallow groundwater flow and recharge from rainfall is likely to be minimal across much of these deposits. However, sandy/gravel layers within the Duaringa Formation deposits are likely to provide local aquifers, with the capacity to transmit and contain groundwater. However, the Duaringa Formation surrounding the Middlemount Coal Mine is not targeted for stock and domestic water supplies.

The degree of hydraulic connectivity between different sand units within the Duaringa Formation cannot be established from the available data. Importantly, determining the interface between the weathered sediments of the Duaringa Formation and the weathered profile of the Permian coal measures is not easily identified in the field. However, review of the borelogs for monitoring bores MW7M and MW7P indicate the groundwater discharge observed along the highwall in this portion of the Middlemount Coal Mine is from a perched water table that exists within the Duaringa Formation.

Intragranular flow is likely to be the dominant flow mechanism in the weathered Tertiary aquifer, which is likely to vary in nature between confined, semi-confined and confined across the Project area.

The results of the bore census by 4T in 2017 indicate that no registered or existing bores are screened within the Duaringa Formation within the 10 km search radius of the MLs.

6.6.2 Hydraulic parameters

Site derived hydraulic parameters for the Tertiary Duaringa Formation are only available for MW9A. This indicates a hydraulic conductivity value for Tertiary sandstone around 2.8E-8 metres per second (m/s) or 2.4E-3 m/day.

The Duaringa Formation is estimated to have a wide range, but typically low hydraulic conductivity because it consists of deeply weathered claystone and siltstone, quartzose sandstone, pebbly sandstone, and gravel. The higher values of hydraulic conductivity will be associated with isolated sand units and gravel deposits, located in a predominantly low hydraulic conductivity bulk unit.

Literature values of hydraulic conductivity for clay are about 1.0E-6 m/day to 5.0E-4 m/day and for sandstone (fresh) are about 3.0E-5 m/day to 5.0E-1 m/day (Domenico and Schwartz, 1990). A hydraulic conductivity range of 5.0E-2 m/day to 5.0E-3 m/day would be considered a reasonable estimate for the bulk hydraulic conductivity of the Tertiary Duaringa Formation within the study area.

As a comparison, Arrow Energy (2012) assigned a hydraulic conductivity value of 5.0E-3 m/day to their base case numerical groundwater model to represent the Tertiary Duaringa Formation within the Bowen Basin.

Literature values of specific yield range between 0.02 and 0.06 for clay and 0.06 and 0.2 for sandstone (fresh) (Heath, 1983; Morris and Johnson, 1967). A geometric mean of about 0.05 would be considered a reasonable estimate for the bulk specific yield of the Tertiary Duaringa Formation within the study area.

As with the alluvium, the unconsolidated nature of the Tertiary Duaringa Formation within the study area would be at the upper bound (1.3E-05 m^{-1}) of the possible specific storage values determined by Rau (2018).

As a comparison, Arrow Energy (2012) assigned a specific storage value of 5.0E-5 m^{-1} to their base case numerical groundwater model to represent the Tertiary Duaringa Formation within the Bowen Basin. This is not significantly different to the upper bound of the refined plausible range of Rau (2018) that obviously postdates the earlier Arrow work.

6.6.3 Groundwater levels, recharge, and flow

Recharge to the Tertiary Duaringa Formation occurs via direct infiltration from rainfall in areas where the unit crops out and via seepage from the overlying Quaternary flood plain alluvium, where present. However, recharge is expected to be low due to the predominately clayey nature of the formation.

The regional groundwater flow direction in the Tertiary Duaringa Formation is expected to be coincident with the regional surface drainage, being towards the southeast.

Middlemount Coal Mine monitoring bores installed within the Duaringa Formation indicate groundwater levels ranging from 163.64 mAHD (MW10A) at the northern side of the ML area to 127.42 mAHD (MW9A) adjacent to Roper Creek where this creek exits the MLs. Depth to water in the monitoring bores ranges from 7.7 mbgl (MW14A) to 28.9 mbgl (MW9A), with an average depth of 17.3 mbgl. Figure 6.3 presents hydrographs for monitoring bores in the Tertiary Duaringa Formation at the Middlemount Coal Mine. The water level data for bore MB10A indicate that this bore is has been dry since March 2017 (AGE, 2017a). A single water level was measured in MW11A in March 2016, after which this bore was dry. Water was measured in MW12A from March 2019. No groundwater level data have been recorded in MW13A as this bore has been dry following construction. Groundwater levels in MW6 increased in response to wetter conditions between 2011 and 2014, before stabilising until mid-2016. After mid-2016 MW6 has declined at rates of 1-4 metres per year.

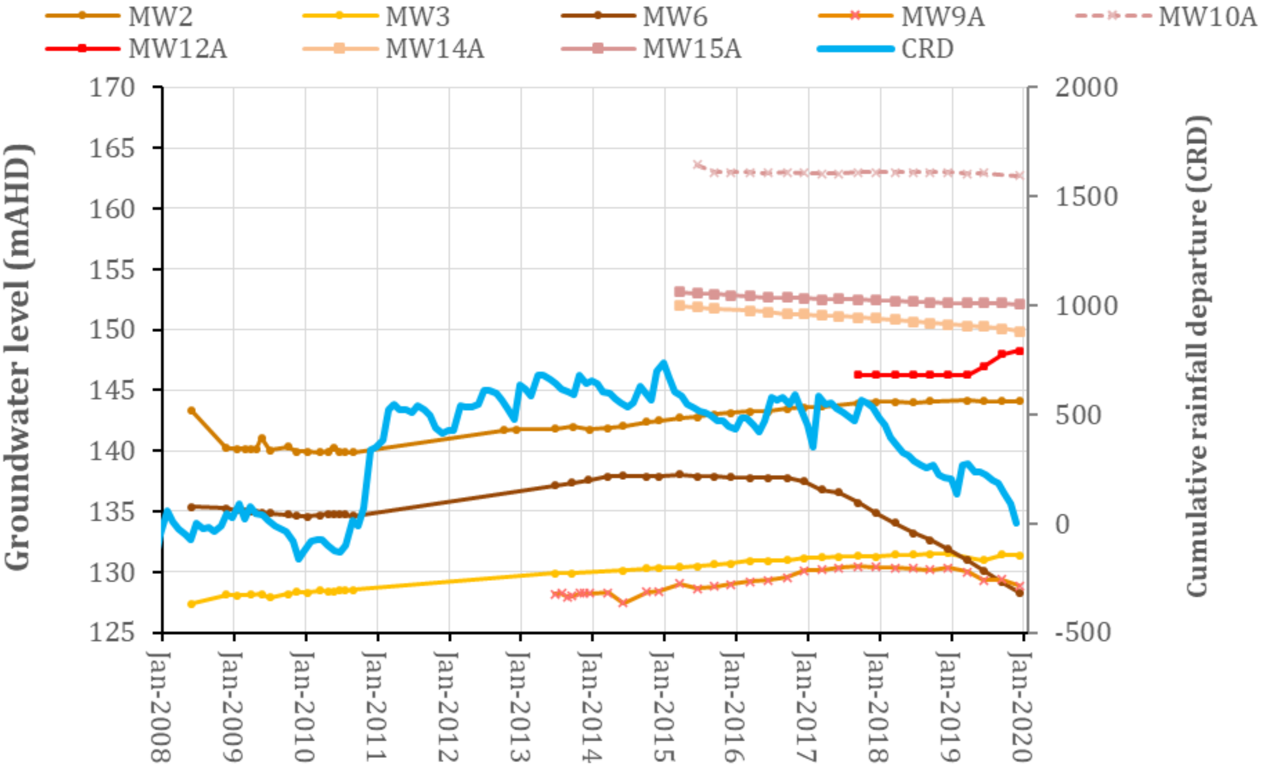


Figure 6.3 Measured groundwater levels in Tertiary aquifer monitoring bores

6.6.4 Groundwater quality

Salinity is a key constraint to water management and groundwater use, and can be classified by total dissolved solid (TDS) concentrations. Hence, salinity can be categorised based on the following TDS concentrations (Food and Agriculture Organization of the United Nations, 2013) for groundwater:

Fresh water	<500 mg/L
Brackish (slightly saline)	500 to 1,500 mg/L
Moderately saline	1,500 to 7,000 mg/L
Saline	7,000 to 15,000 mg/L
Highly saline	15,000 to 35,000 mg/L
Brine	>35,000 mg/L

The National Water Commission (December 2011) more broadly defines brackish water as "*water that has a higher salt content than fresh water but a lower content than seawater*". Based on this definition brackish water is considered that having a TDS concentration between 500 mg/L and 7,000 mg/L (equivalent to an EC of ~750 µS/cm to ~10,500 µS/cm). For the purpose of this groundwater assessment, a combination both definitions have been adopted providing for the following salinity classification for groundwaters intersected:

Fresh water	<500 mg/L (< ~750 µS/cm)
Brackish	500 to 7,000 mg/L (~750 to ~10,500 µS/cm)
Saline	7,000 to 35,000 mg/L (~10,750 to ~53,000 µS/cm)
Hypersaline (brine)	>35,000 mg/L (> ~53,000 µS/cm)

Table 6.4 summarises the maximum, minimum, and average values of groundwater chemical parameters listed on the current EA for the Tertiary Duaringa Formation aquifer sampled between May 2013 and December 2019. This data indicates the Tertiary aquifer water quality is:

- slightly acidic to alkaline with field pH values ranging from 6.3 to 8.5;
- dominated by sodium and chloride; and
- brackish to saline with TDS ranging from 920 mg/L to 31,100 mg/L, with the majority of samples being saline.

Table 6.4 Summary of groundwater quality analyses – Tertiary aquifers

Parameter	Min	Max	Average	Stock water (ANZECC)	WQO Zone 34 Shallow <30 m (percentile)		
					20th	50th	80th
Field EC (µS/cm)	3,270	**33,150**	**19,500**	-	498	2,150	8,910
Laboratory EC (µS/cm)	1,370	**35,000**	**18,900**	-	498	2,150	8,910
Field pH	6.3	**8.5**	7.2	-	7.10	7.75	8.10
Laboratory pH	6.9	**8.6**	7.6	-	7.10	7.75	8.10
Total Dissolved Solids (mg/L)	920	**31,100**	**13,500**	4,000 (beef) 2,500 (dairy) 5,000 (sheep) 4,000 (horses) 4,000 (pigs) 2,000 (poultry)	-	-	-
Carbonate Alkalinity (mg/L)	<1	84	2.8*	-	163	674	2,228
Bicarbonate Alkalinity (mg/L)	240	**1,320**	550	-	187	536	878
Chloride (mg/L)	248	**12,200**	**7,030**	-	171	1,309	3,185
Calcium (mg/L)	23	**771**	**330**	1,000	18	84	215
Magnesium (mg/L)	16	**1,180**	**480**	2,000	27	108	389
Potassium (mg/L)	3	44	14	-	-	-	-
Sodium (mg/L)	213	**7,390**	**3,700**	-	135	747	1,500
Sulfate (mg/L)	23	**2,060**	**510**	1,000	12	140	318
Dissolved metals							
Iron (mg/L)	<0.05	**9.7**	**0.89***	-	0.000	0.030	0.140
Mercury (mg/L)	<0.0001	0.0011	0.00012*	0.002	-	-	-
Selenium (mg/L)	0.002	0.05	0.016	0.02	-	-	-

Parameter	Min	Max	Average	Stock water (ANZECC)	WQO Zone 34 Shallow <30 m (percentile)		
					20th	50th	80th
Total Petroleum Hydrocarbons							
C10 - C14 (µg/L)	<50	130	53*	-	-	-	-
C15 – C28 (µg/L)	<100	540	130*	-	-	-	-
C29 - C36 (µg/L)	<50	520	88*	-	-	-	-

Notes: *- Not determined.*

µg/L = micrograms per litre

**included samples at the limit of reporting*

***LOR: Limit of Reporting, all samples are at limit of reporting.*

***Red bold** values exceed the Stock water guidelines values.*

***Black bold** values exceed the 80th % water quality objectives (WQO) values*

These values are compared against the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines for stock watering (ANZECC, 2000), and the WQOs for the Mackenzie River Sub-basin shallow aquifers (<30 m depth)(DEHP, 2011). The following observations can be made with regard to the Tertiary aquifer water quality:

- The elevated maximum levels of sodium, calcium, magnesium, chloride, sulphate and alkalinity exceed the 80th percentile water quality objectives for shallow aquifers (<30 m depth), and the maximum sulfate level exceeds the ANZECC stock water guideline.
- Detectable levels of dissolved metals concentrations are reported for iron and mercury, and selenium.
- The average and maximum iron concentrations exceed the 80th percentile water quality objectives for shallow aquifers (<30 m depth).
- Detectable levels of total petroleum hydrocarbon (TPH) have been recorded in MW2, MW3, MW4, MW9A, and MW14A.

The proportions of the major anions and cations were analysed to determine the hydrochemical facies of the Tertiary aquifer. The anion-cation balance is shown on the Piper diagram in Figure 6.4. The data shows that groundwater within the Tertiary aquifer ranges from a no dominant water to a sodium-chloride (Na-Cl) type water. The change in water type reflects a natural progression of water moving from a recharge zone into the shallow Tertiary aquifer.

Time series water quality data for the Tertiary aquifer bores are presented in Appendix E. Note that total and dissolved metals water quality is only presented for iron, mercury, and selenium as data for these parameters is available for the period 2013 to 2019. Data collected for aluminium, antimony, arsenic and molybdenum is not presented as this was only collected between 2013 and 2014.

In summary, water from the Tertiary aquifers would be unsuitable for human consumption or stock watering based on the naturally elevated TDS levels.

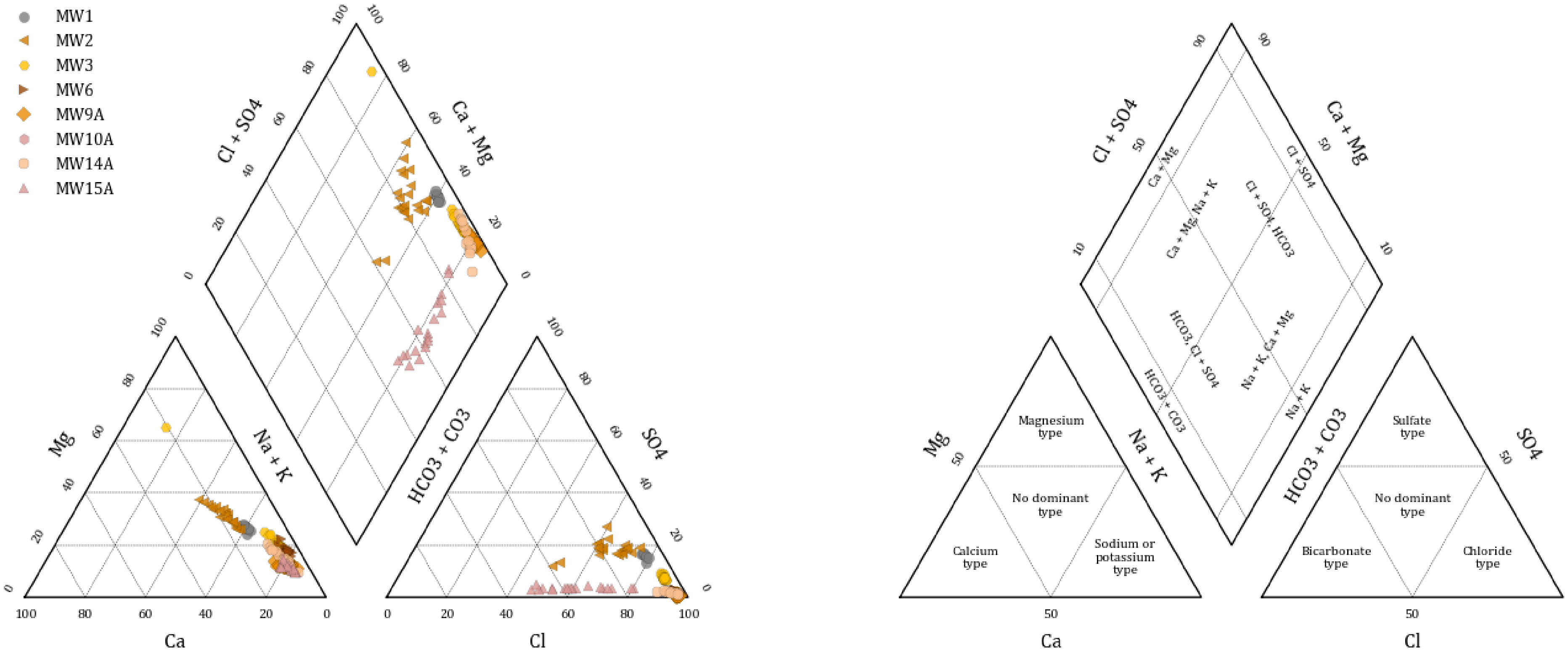


Figure 6.4 Piper diagram – Tertiary aquifer

6.7 Permian coal measures aquifer

6.7.1 Groundwater yield

The Permian strata includes coal seams interbedded with less permeable rock units such as sandstone, siltstone, and mudstones that are typically 'tight' and low yielding.

Bores do not commonly access the Permian aquifer due to the depth of water bearing strata and the typical high salinity of this type of water. However, where more attractive aquifers do not exist, bores are installed on occasion into the Permian coal measures where yield and water quality meet the intended purpose.

The DNRME GWDB and bore census indicates the potential for the Permian coal measures to be able to be moderately productive, and provide groundwater yields ranging between 0.04 litres per second (L/s) (Yard Bore) and 0.7 L/s (RN47037 – Blanches Bore). However, the Stage 2 EIS reported airlift yields in the Permian bores during drilling to be typically low and less than 1 litre per minute (L/min) (Parsons Brinkerhoff, 2010a).

6.7.2 Hydraulic parameters

The hydraulic parameters of the Permian coal seams have been determined at the Middlemount Coal Mine by in-situ falling and rising head slug tests that were performed by Parsons Brinkerhoff (2010a) on the Permian monitoring bores drilled for the Stage 2 EIS.

The tests indicated a hydraulic conductivity range of 4.9E-4 m/day to 1.6 m/day for the Middlemount Seam and 8.2E-2 m/day to 0.15 m/day for the Pisces Seam. This encompasses the generally accepted hydraulic conductivity for coal seams in the Bowen Basin of 1.0E-1 m/day near the coal seam sub-crop. The hydraulic parameter data obtained from these tests are summarised in Table 6.5.

Table 6.5 Summary of hydraulic parameters of Permian coal measures

Permian lithology	Hydraulic conductivity (m/day)		Number of tests
	Range	Average	
Middlemount Seam	4.9E-4 – 1.6	5.6E-2	6
Pisces Seam	8.2E-2 – 0.15	0.12	2
Fort Cooper Coal Measures	5.7E-5	5.7E-5	1

No assessment of aquifer storage parameters has been undertaken for Middlemount Coal Mine and literature values of specific yield for Bowen Basin coal seams are not common. Research undertaken by Mackie (2009) in the Hunter Valley estimated the specific yield in the Sydney Basin to range from less than 0.01 in dull weakly cleated coal to more than 0.03 in bright strongly cleated coal. Literature values of specific yield for siltstone and sandstone range between 0.06 and 0.2 (Heath, 1983; Morris and Johnson, 1967). A geometric mean of about 0.01 would be considered a reasonable estimate for the bulk specific yield of the Permian coal measure overburden/interburden within the study area.

Specific storage of the coal measures will be varied since the coal measure comprise coal seams and much tighter interburden materials. Rau (2018) suggests plausible specific storage values range from 2.3E-07 m^{-1} to 1.3E-05 m^{-1}.

6.7.3 Groundwater recharge, levels, and flow

Recharge of the Permian coal measures occurs in areas where they sub-crop beneath the Tertiary cover. The coal seams all sub-crop within the western portions of the Middlemount Coal Mine MLs.

Figure 6.5 presents hydrographs for a series of monitoring bores in the Permian coal measures at the Middlemount Coal Mine. The bores located nearest to the mining area (MW7M/7P, less than 300 m to east of the mine pit), show the greatest drawdown response was around 50 m in the Middlemount Seam and 27 m in the Pisces Seam. A 15 m drawdown was measured in MW1P before this bore was mined out in 2015. Permian coal measure monitoring bores MW5M/5P, which are located approximately 1,500 m north of the current mine area, show only a minor drawdown response of up to 9 m, whilst monitoring bores MW5 and MW9M/9P located between 900 m and 1,500 m south of the mining area show a drawdown to mining ranging between 4.75 m (MW9M) and 24 m (MW5).

The Permian monitoring bore within the Fort Cooper Coal Measures (Figure 6.6) east of the mine pit (MW8FR) only shows a minor drawdown response of up to 8.4 m, whilst monitoring bore MW4 located between approximately 2,000 m south-west of the mining area shows no drawdown response to mining.

The variable decline observed in groundwater levels in these Permian monitoring bores provides an example of groundwater depressurisation that would be expected to be due to mining.

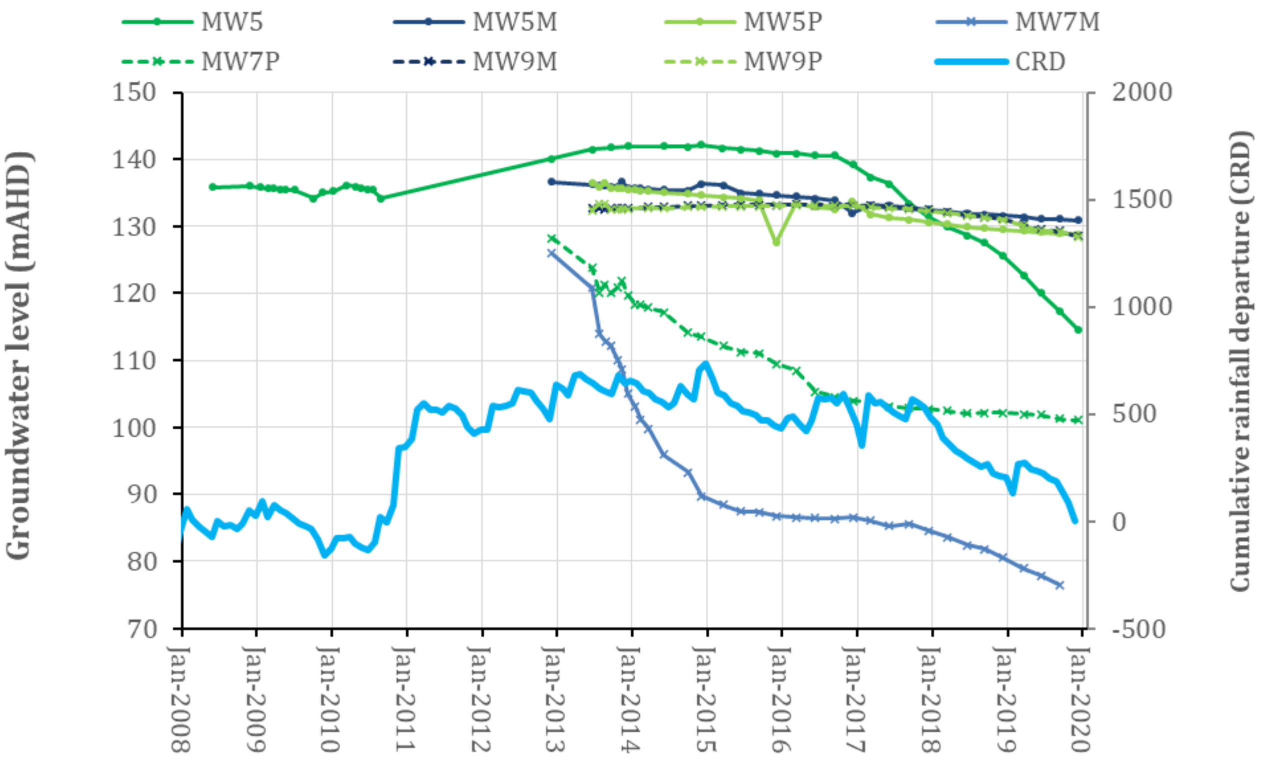


Figure 6.5 Measured groundwater levels in Rangal coal measures monitoring bores

The similar groundwater levels observed in the paired monitoring bores MW5M/5P and MW9M/9P indicate no hydraulic gradient between the Middlemount and Pisces coal seams where located away from the current mine area. The diverging groundwater levels observed in MW7M/7P located nearest to the mining area suggest an initial depressurisation has occurred within the shallower Middlemount seam, followed by a more gradual depressurisation within the deeper Pisces seam as mining has progressed deeper.

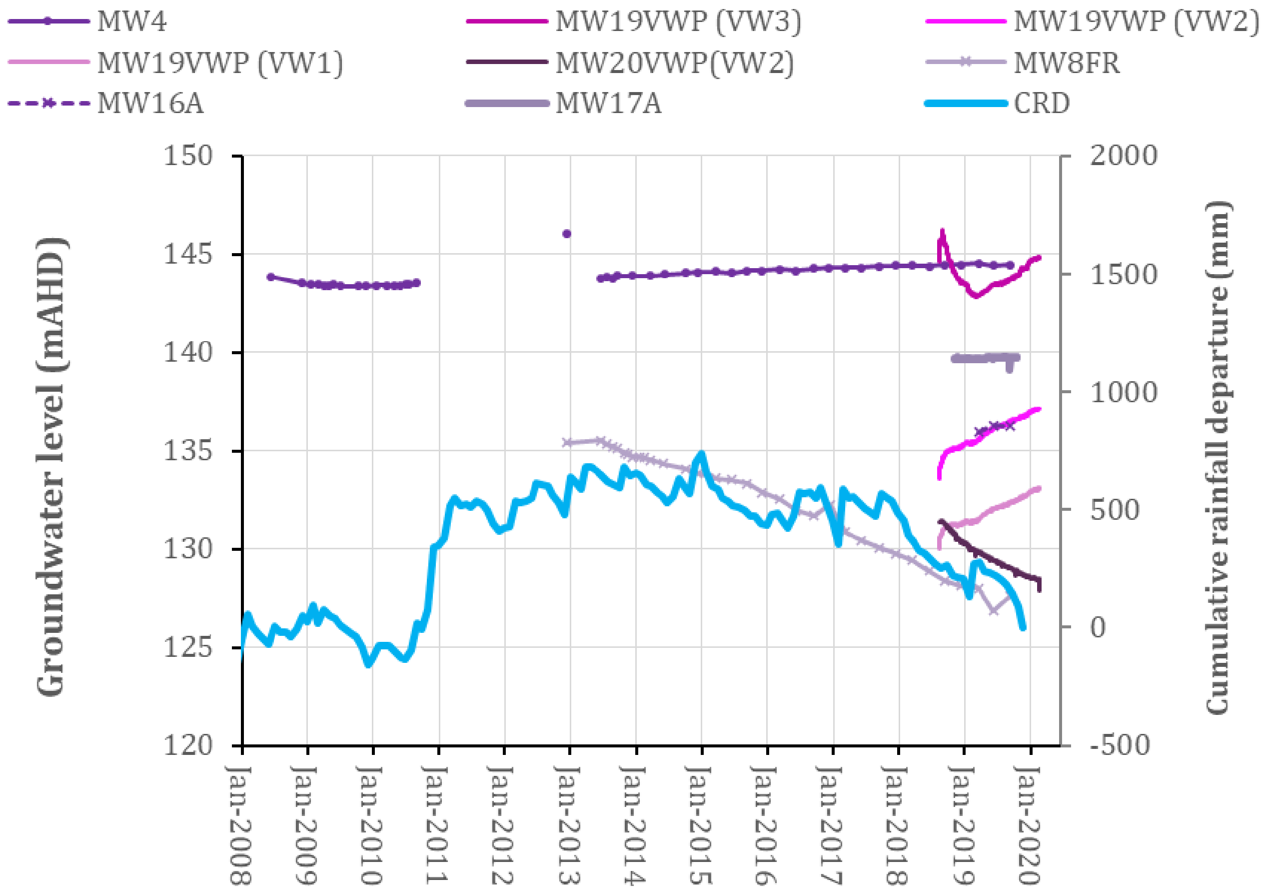


Figure 6.6 Measured groundwater levels in Fort Cooper coal measures monitoring bores

6.7.4 Groundwater quality

The Permian coal measures water quality data identifies a similar quality groundwater to the overlying Tertiary aquifers. Table 6.6 summarises the maximum, minimum, and average values of groundwater chemical parameters for the Permian aquifer sampled between May 2013 and December 2019. This data indicates the Permian aquifer water quality is:

- slightly acidic to alkaline with field pH values ranging from 6.4 to 10.5;
- dominated by sodium and chloride; and
- brackish to saline with TDS ranging from 503 mg/L to 25,700 mg/L, with the majority of samples being saline.

Table 6.6 Summary of water quality analyses – Permian aquifers

Parameter	Min	Max	Average	Stock water (ANZECC)	WQO Zone 34 Deep >30 m (percentile)		
					20th	50th	80th
Field EC$^{\#}$ (µS/cm)	5,600	**31,600**	**19,510**	-	3,419	6,100	16,000
Laboratory EC$^{\#}$ (µS/cm)	900	**32,400**	**17,440**		3,419	6,100	16,000
Field pH	6.4	**10.47**	7.13	-	7.40	7.80	8.03
Laboratory pH	7.0	**10.3**	7.6		7.40	7.80	8.03
TDS (mg/L)	503	**25,700**	**15,020**	4,000 (beef) 2,500 (dairy) 5,000 (sheep) 4,000 (horses) 4,000 (pigs) 2,000 (poultry)	-	-	-
Carbonate Alkalinity (mg/L)	<1	552	4.1*	-	359	919	3,208
Bicarbonate Alkalinity (mg/L)	13	**1200**	512	-	188	330	650
Chloride (mg/L)	63	**1,220**	**8,190**	-	753	1,900	5,905
Calcium (mg/L)	37	**489**	271	1,000	46	145	442
Magnesium (mg/L)	26	**578**	311	2,000	35	115	491
Potassium (mg/L)	1	228	20	-	-	-	-
Sodium (mg/L)	57	**7,390**	**4,190**	-	480	1100	2,565
Sulfate (mg/L)	3	**1,180**	223	1,000	25	138	398
Dissolved metals							
Iron (mg/L)	<0.05	**13.2**	**2.44***	-	0.000	0.050	0.246
Mercury (mg/L)	<0.0001	0.0011	<0.0001	0.00011*	-	-	-
Selenium (mg/L)	0.002	0.05	0.017	0.02	-	-	-
Total Petroleum Hydrocarbons							
C10 - C14 (µg/L)	<50	1220	75*	-	-	-	-
C15 – C28 (µg/L)	<100	12,800	292*	-	-	-	-
C29 - C36 (µg/L)	<50	2,060	83*	-	-	-	-

Notes: *# EC – Electrical conductivity.*

- Not determined.

** Included samples at the limit of reporting.*

***LOR: Limit of Reporting, all samples are at limit of reporting.*

***Red bold** values exceed the Stock water guidelines values.*

***Black bold** values exceed the 80th % water quality objectives (WQO) values.*

Table 6.6 summarises the maximum, minimum, and average values of groundwater chemical parameters listed on the current EA for samples collected from the Permian aquifer. These values are compared against the ANZECC guidelines for stock watering (ANZECC, 2000) and the Mackenzie River Sub-basin water quality objectives for deep aquifers (>30 m depth)(DEHP, 2011). The following observations can therefore be made with regard to the Permian aquifer water quality:

- The elevated maximum levels of sodium, calcium, magnesium, chloride, sulphate, bicarbonate and alkalinity exceed the 80th percentile water quality objectives for deep aquifers (>30 m depth), and the maximum sulfate level exceeds the ANZECC stock water guideline.
- Detectable levels of dissolved metals concentrations are reported for iron and mercury, and selenium.
- Detectable levels of total and dissolved metals concentrations are reported for iron and mercury.
- The dissolved concentrations for iron exceed the 80th percentile water quality objectives for deep aquifers (>30 m depth).
- Detectable levels of TPH have been recorded in MW4, MW5, MW7P, and MW16A.

The proportions of the major anions and cations were analysed to determine the hydrochemical facies of the Permian aquifer. The anion-cation balance is shown on the Piper diagram in Figure 6.6. The data shows that groundwater within the Permian coal seams ranges from a no dominant water type to a sodium-chloride type water, with both water types identified in bore MW5. Bore MW5 intersects the Pisces Seam where it subcrops below the Tertiary sediments. The change in water type most likely reflects a natural progression of carbonate dissolution in the shallow unsaturated zone during recharge, followed by precipitation of carbonates as groundwater moves downwards through the Tertiary sediments into the deeper coal seam.

Time series water quality data for the Permian aquifer bores are presented in Appendix E. Note that total and dissolved metals water quality is only presented for iron, mercury, and selenium. Data collected for aluminium, antimony, arsenic and molybdenum is not presented as this was only collected between 2013 and 2014.

In summary, water from the Permian aquifers would be unsuitable for human consumption or stock watering based on the naturally elevated TDS levels.

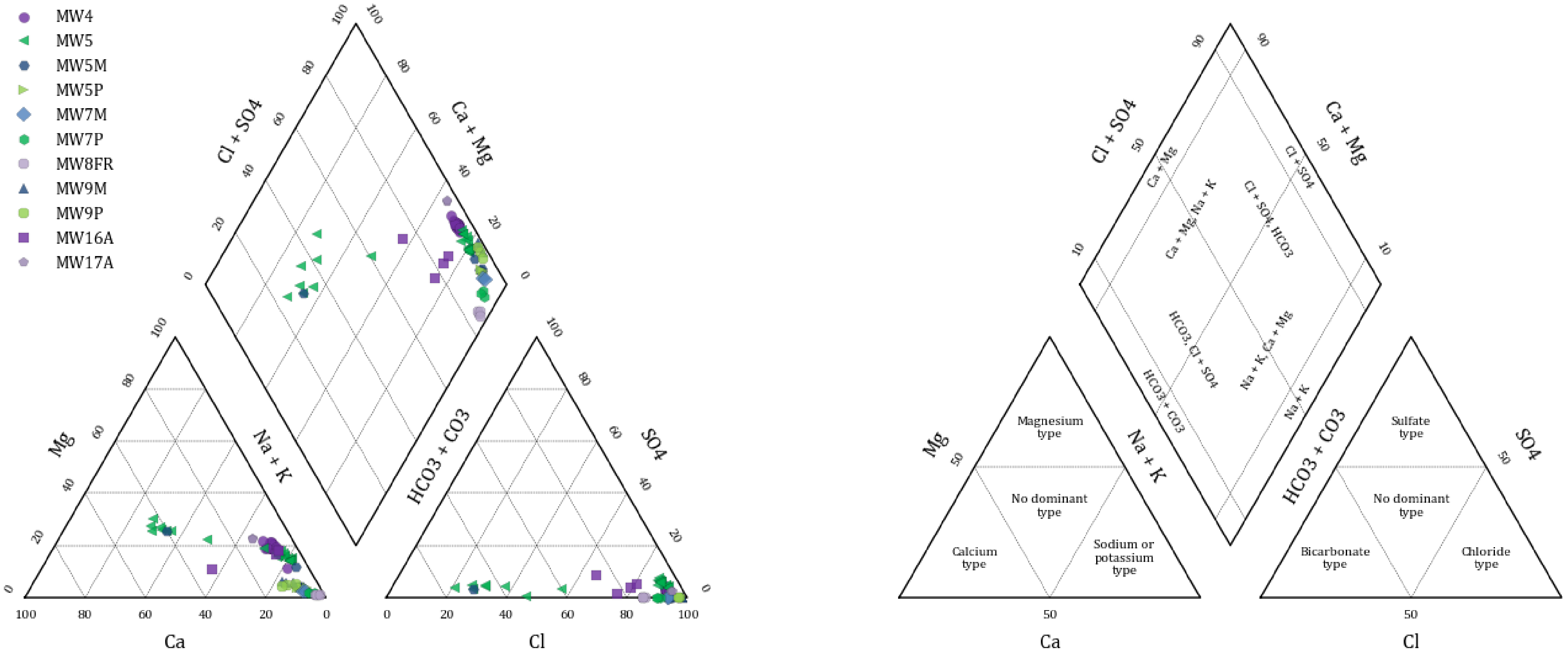


Figure 6.7 Piper diagram – Permian coal measures aquifer

6.8 Groundwater dependent ecosystems

A GDE is one in which the plant and animal community is dependent on the availability of groundwater to maintain its structure and function. The BoMs GDE Atlas shows ecosystems including springs, wetlands, rivers, and vegetation that interact with the subsurface presence of groundwater, or the surface expression of groundwater (BoM, 2020). The Atlas categorises GDEs into two classes in Queensland. These are ecosystems that potentially rely on the:

- surface expression of groundwater - this includes all the surface water ecosystems which may have a groundwater component, such as rivers, wetlands, and springs; and
- subsurface presence of groundwater - this includes all vegetation ecosystems.

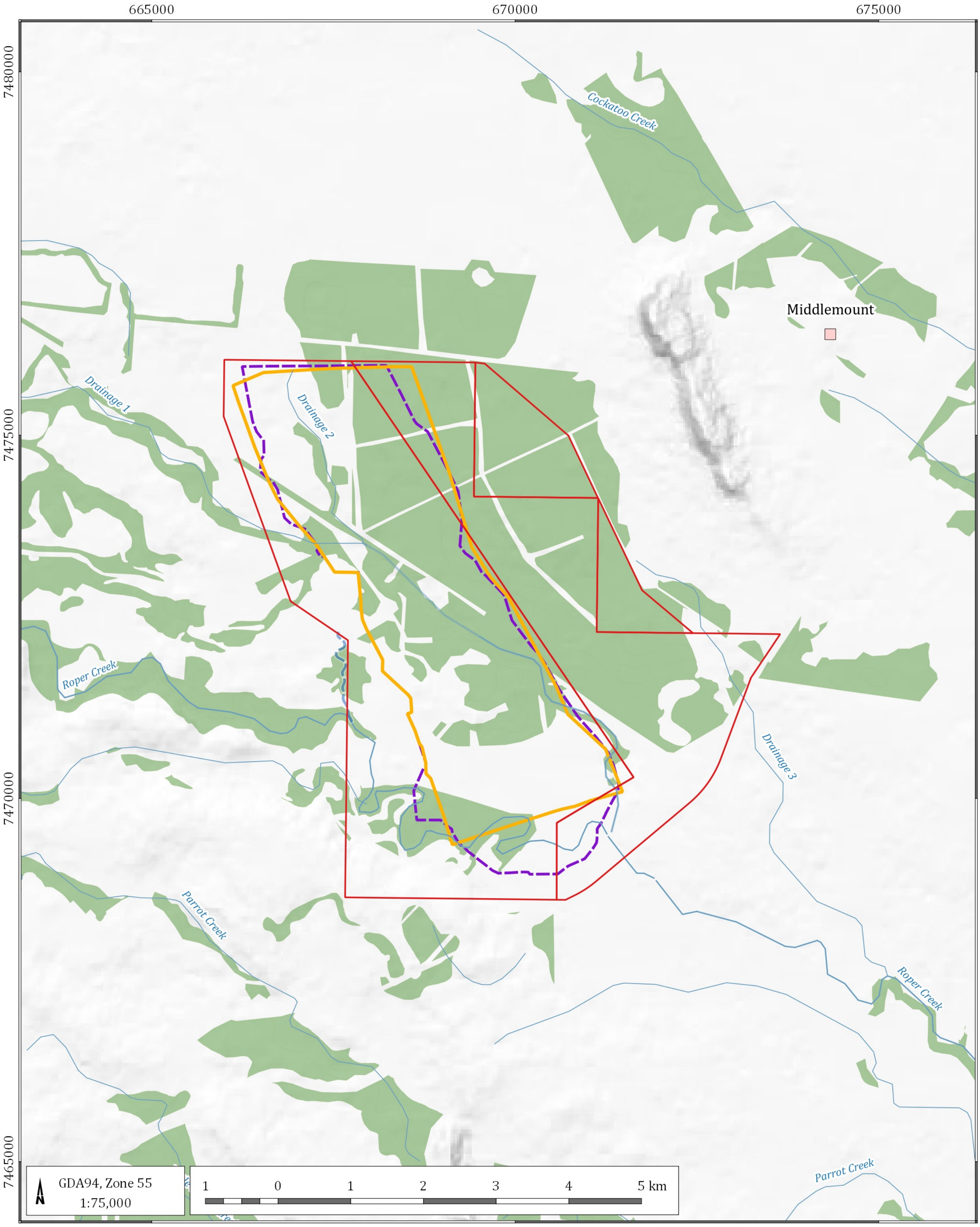
Figure 6.8 shows the potential GDE's identified by the BoM GDE mapping within and around Middlemount Coal Mine.

This shows much of the surrounding land that is still treed has been mapped as a low potential "terrestrial" GDE, and appears to be based heavily upon the extent of this existing treed vegetation within this area, which includes:

- Terrestrial vegetation associated with the Thirteen Mile Gully drainage alignments and Roper Creek; and
- Terrestrial vegetation, tree swamps (Melaleuca and Eucalypt) associated with palustrine wetlands that exist to the north of the MLs.

The depth to groundwater within the Tertiary sediments in these areas ranges between 12 mbgl (MW10A) and 40 mbgl (MW4), with an average depth of 25.5 mbgl. Groundwater levels within the Tertiary sediments at MW2 adjacent to Roper Creek have ranged between 18.4 mbgl and 22.7 mbgl. Based on the depth to groundwater within the Tertiary sediments being in excess of 12 mbgl, and around 20 mbgl adjacent to Roper Creek, and the ephemeral nature of Roper Creek and Thirteen Mile Gully, these mapped areas are considered as not being dependent on groundwater interaction.

Based on this information, the desktop GDE mapping (BoM, 2020) indicates terrestrial vegetation associated with watercourses (Roper Creek) and drainage lines associated with Thirteen Mile Gully (Drainage Lines 1 and 2), and the palustrine wetlands outside of ML 70417 and ML 70379 are mapped as having a low potential to be associated with subsurface presence of groundwater.



LEGEND

- 🟥 Populated place
- — Watercourse
- — Drainage feature
- ▭ Mining Lease boundary (ML)
- ▭ Approved open cut footprint
- ▭ Proposed open cut footprint

GDE Atlas - Surface GDEs that rely on the subsurface presence of groundwater

🟩 Low potential GDE - from regional studies

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Groundwater Dependent Ecosystems - GDE Atlas

AGE

DATE 26/08/2020

FIGURE No: **6.8**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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In summary, this desktop assessment of the GDE mapping (BoM, 2020) is consistent with the findings provided for the Western Extension GIA (AGE, 2018) which concluded:

- The majority of the terrestrial vegetation associated with Roper Creek and drainage lines associated with Thirteen Mile Gully are unlikely to be dependent on groundwater given the vegetation along these drainage features also occurs more widely across the landscape and is not restricted to areas where it could potentially access groundwater (Naturecall Environmental, 2018). There are small areas of RE 11.3.25 along Roper Creek which contains Queensland Blue Gum (*Eucalyptus tereticornis*) and River Oak (*Casuarina cunninghamiana*) which are sometimes reliant on access to groundwater, however, the groundwater levels adjacent to Roper Creek range between 18.4 mbgl and 22.7 mbgl. Based on the depth to groundwater surrounding Roper Creek being around 20 mbgl and the ephemeral nature of this drainage features, it is unlikely that these communities would be reliant on access to groundwater (Naturecall Environmental, 2018).
- Terrestrial vegetation associated with palustrine wetlands north of ML 70417 and ML 70379 could potentially have some reliance on groundwater given the regional ecosystem mapped in these areas (BoM, 2020). These areas were mapped as RE 11.3.27, which contains River Red Gum (*Eucalyptus camaldulensis*) and Queensland Blue Gum (*Eucalyptus tereticornis*), both species that could be reliant on subsurface expression of groundwater to some degree (Naturecall Environmental, 2018). However, groundwater levels in this area have been identified as being in excess of 12 mbgl, it is unlikely that these communities would be reliant on groundwater (Naturecall Environmental, 2018).
- All other terrestrial vegetation is unlikely to be dependent on groundwater given that there is no evidence that any vegetation surrounding the Project area has experienced any impacts (i.e. dieback) from the existing operations.

6.9 Stygofauna

Stygofauna are small specialised subterranean aquatic invertebrates that are found in aquifers across Australia and the rest of the world. Stygofauna are predominantly found in aquifers with large (mm or greater) pore spaces, especially alluvial aquifers, and less frequently fractured rock aquifers (Hose *et al*., 2015). Stygofauna have occasionally been recorded in coal seam aquifers, notably in coal seams that are hydraulically connected to a shallow alluvial aquifer.

The majority of stygofauna are found in locations where food supply and oxygen are more plentiful. The optimal conditions for stygofauna have been identified as:

- alluvial systems with large pore spaces;
- water levels within 20 m of ground surface for unconsolidated sediments and within 30 m for fractured rock aquifers;
- EC of less than 2,000 µS/cm for unconsolidated sediments and 5,000 µS/cm for fractured rock aquifers; and
- pH of approximately 6.5 – 8.5.

Hence, there is the potential for mining activities to impact on stygofauna habitats if they are present in the aquifer units near to the mines.

Sampling for Stygofauna was undertaken in a number of bores around the Middlemount Coal Mine in 2011 (4T Consultants, 2012). The sampling found what was likely a naturally low diversity of stygofauna taxa from two Families[2] – Copepoda [a crustacean] and Oligochaeta [a worm]) from bores in and outside the maximum zone of drawdown (e.g. some 5-7 km north-west and south-east).

As recommended by the IESC in its assessment of the Western Extension Project, further Stygofauna sampling has been conducted at the Middlemount Coal Mine by DPM Envirosciences (2020) as part of its Aquatic Ecology Assessment for the Project (included as Appendix F of the Environmental Assessment Report). The sampling included dry season sampling of 10 monitoring bores and wet season sampling of 11 monitoring bores in late 2019 and early 2020. However, no stygofauna were found in any bore during the sampling program.

The Western Extension GIA (AGE, 2018a) referenced two other Stygofauna assessments that were undertaken for the nearby Foxleigh Plains Project EIS (ALS, 2012), and the Bowen Gas Project (4T Consultants, 2012). The Stygofauna assessment undertaken for the Foxleigh Plains Project EIS included a desktop review of the likely potential and subsequent sampling for Stygofauna. The assessment concluded that water quality and depth to water limited the potential for Stygofauna habitat. Stygofauna sampling did not detect any Stygofauna species, and the site assessment confirmed the project was unlikely to impact on endemic Stygofauna species within the geology targeted by the project.

The Stygofauna assessment for the Bowen Gas Project (4T Consultants, 2012) identified that Roper Creek provided the best opportunity for suitable habitat for Stygofauna species in the region adjacent to Middlemount Coal Mine. That is, stygofauna could be more likely to occur in aquifers with a pH value between 6.5 and 8.5 and the EC is less than 2,000 µS/cm. However, given the shallow Quaternary alluvium is considered to be predominantly dry in the vicinity of Middlemount Coal Mine, it is therefore unlikely to support any Stygofauna. Similarly, Stygofauna in coal seams was considered rare due to the low permeability and reduced connectivity to recharge and water quality.

Based on these Stygofauna assessments, the potential for Stygofauna at the Middlemount Coal Mine is considered unlikely based on the optimal conditions for stygofauna habitat as summarised in Table 6.7.

Table 6.7 Potential stygofauna habitat at Middlemount Coal Mine

Aquifer	EC range and average EC (µS/cm)	pH range and average pH	Groundwater depth and average depth (m)	Strata	Stygofauna potential
Alluvial deposits	dry	dry	dry	Unconsolidated sediments	Unlikely as sediments are generally assessed to be dry
Tertiary	3,270 to 33,150. Average 19,500	6.9 to 8.6. Average 7.6	12 to 40. Average depth 25.5	Unconsolidated sediments	Unlikely due to elevated EC levels > 2,000 µS/cm
Permian	5,600 to 31,600. Average 19,510	7.0 to 10.3. Average 7.6	22.6 to 67.5. Average depth 38.2	Consolidated sediments	Unlikely due to elevated average EC levels > 5,000 µS/cm, and depth to water is greater than 30 m

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[2] The taxa could not be identified to species level.

6.10 Hydraulic influence of faults

The regional tectonic setting of the Bowen Basin is largely compressive and as a consequence faults and folds are more likely to be hydraulic barriers than conduits to lateral groundwater flow (Arrow Energy, 2012). Some faults may also limit flow by vertical displacement of strata (aquifers with aquitards) or by infilling within the fractures. The Stage 2 EIS (Parsons Brinkerhoff, 2010a) identified the Jellinbah Fault as being a barrier to groundwater flow east of the fault and mining area as a result of the 300 m displacement.

Fault delineation drilling by MCPL in 2017 included 36 boreholes drilled along the Jellinbah Fault which intersected sedimentary units from both the Rangal Coal Measures and Fort Cooper Coal Measures. Groundwater was intersected at 17 sites within either the base of the Tertiary sediments or the underlying Permian coal measures. Generally minor groundwater flows were intersected with measurable flows up to 0.2 L/s. Two boreholes that did intersect higher groundwater yields (0.4 L/s and 1.8 L/s) were considered to be associated with localised fracture zones of limited groundwater storage.

It is generally agreed amongst hydrogeologists that faults should not necessarily be represented in a groundwater flow model if there is evidence that they do not act as a barrier to groundwater flow. In the natural groundwater system, for example, a fault may act as a barrier to groundwater flow where the vertical offset results in coal seams (i.e. the main groundwater conduit) being truncated against lower-permeability interburden. However, where the vertical offset results in one coal seam being fully or partially connected to another coal seam, the hydraulic connection across the fault may be unimpeded with the potential for groundwater seepage (hydraulic loading) from the adjacent offset coal measures.

Hence, groundwater flow within the Permian coal measures may, or may not, be influenced by the hydraulic parameters of the Jellinbah Fault and the associated secondary faulting to the east and west as part of this thrust complex. These faults are orientated northwest-southeast, with the Middlemount Coal Mine open pit located southwest of the Jellinbah Fault (Figure 5.4).

6.11 Groundwater use and extraction

6.11.1 Landholder groundwater use

Landholder groundwater use in the region is very limited, with only five landholder water supply bores located within 10 km of the Middlemount Coal Mine, all of which are located greater than 5 km from the Middlemount Coal Mine (Sections 6.4.1 and 6.4.2).

Only two of these bores (Blanches Bore and House Bore 3) were equipped an in use at the time of the bore census inspection. The three other bores that were identified would only be used in emergencies for stock watering. Whilst all could be used as a water supply, only one of these three bores was equipped with a pump.

6.11.2 Mine groundwater extraction

An assessment of the of the estimated monthly groundwater inflows to the Middlemount Coal Mine was undertaken by WRM Pty Ltd (WRM)(memorandum dated 5 October, 2017) for a 10 month period which includes data assessed for October 2015, May 2016 and between February and September 2017. Groundwater inflows were assessed from metered pit dewatering data and a site water balance model.

The assessed groundwater inflows were calculated as the balance of the pumped volume after accounting for inflows from surface runoff and evaporation from the mining face. The calculated groundwater inflows exclude any losses due to evaporation and are therefore representative of groundwater seepage from the aquifer reporting to the pit face. Over the 10 month (304 days) reporting period, the total groundwater inflows were estimated at 697.2 megalitres (ML). The average daily pit inflows ranged from 1 megalitre per day (ML/day) to 5 ML/day, with an average inflow of 2.3 ML/day.

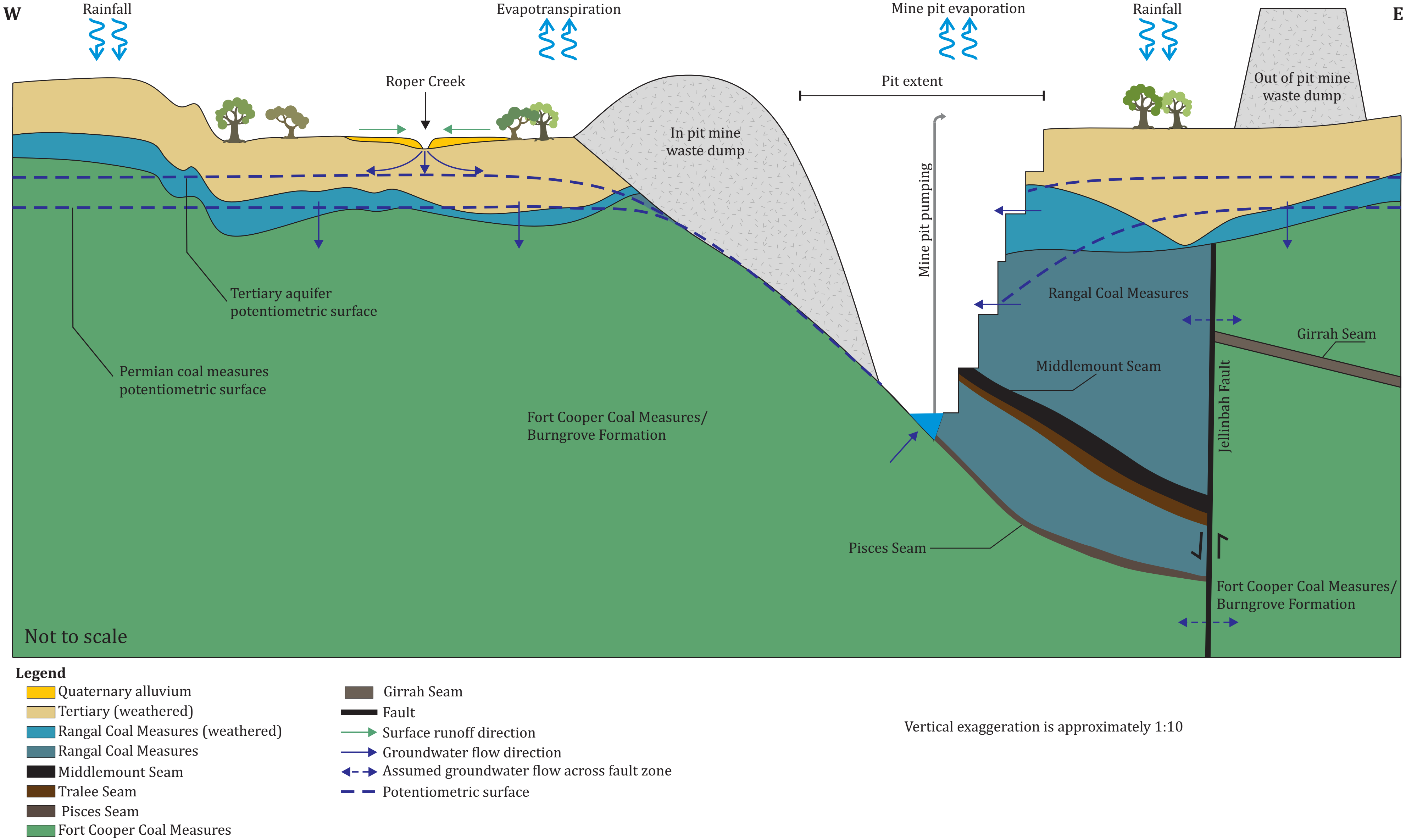
6.12 Groundwater geochemistry from coal, overburden, and interburden

A geochemical assessment undertaken at the Middlemount Coal Mine (RGS, 2013) classified the majority of coal and mining waste materials (overburden and interburden) as non-acid forming, having excess acid buffering capacity, and a high factor of safety with respect to potential for acid generation. Heavy metal concentrations in all overburden samples tested for the Stage 2 project (Parsons Brinkerhoff, 2010c) were below environmental investigation levels. The excavation and dumping of overburden was predicted to have a low risk of producing heavy metal contamination from leachate seepage or surface water runoff from the overburden dumps.

The overburden and interburden within the Project area includes the same types of sedimentary units that occur within the current Middlemount Coal Mine area, and as such are considered to have the same geochemistry characteristics. Therefore, no additional geochemical assessment has been undertaken for the Project area, with the existing geochemical assessments valid for the overburden and interburden sequences that will be mined in the Project portion of the site.

6.13 Summary of conceptual groundwater model

The conceptual groundwater model for the Middlemount Coal Mine is presented graphically in Figure 6.9. The conceptual groundwater model section illustrates the main hydrogeological processes and mechanisms within the Middlemount Coal Mine, including recharge, flow directions, discharge, and anthropogenic activities (i.e. mine dewatering).



South-west to north-east hydrogeological conceptualisation

Figure - 6.9

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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The geology surrounding the Middlemount Coal Mine comprises a relatively thin cover of Quaternary and Tertiary sediments overlying Permian coal measures which dip to the east. The main groundwater bearing units at the Middlemount Coal Mine are the Tertiary (Duaringa Formation) aquifer, and the Rangal Coal Measures coal seams. The Quaternary alluvium is limited in extent to Roper Creek and part of Thirteen Mile Gully.

Where saturated, recharge to the Quaternary alluvium can occur via direct rainfall onto the alluvium, and seepage through the stream bed, when the creeks are flowing.

Recharge of the Tertiary aquifer occurs by direct infiltration of rainfall, via slow leakage through the overlying Tertiary clay sediments. Ephemeral watercourses such as Roper Creek would also contribute a proportion of recharge into the Tertiary aquifer through infiltration during periods of stream flow. Recharge of the Permian coal measures occurs in areas where the coal seams sub-crop beneath the Tertiary cover.

The depth to groundwater within the Tertiary sediments being in excess of 10 mbgl, and around 20 mbgl adjacent to Roper Creek, indicates Roper Creek to be a losing stream with limited to nil potential for a baseflow contribution from the Tertiary aquifer. This correlates with the extended periods of zero flow observed within Roper Creek (refer Section 4.2.1). Similarly, groundwater uptake by terrestrial vegetation from the Tertiary aquifer and loss through evapotranspiration is also considered unlikely, with the take of any water by vegetation most likely to be from soil moisture within the unsaturated zone.

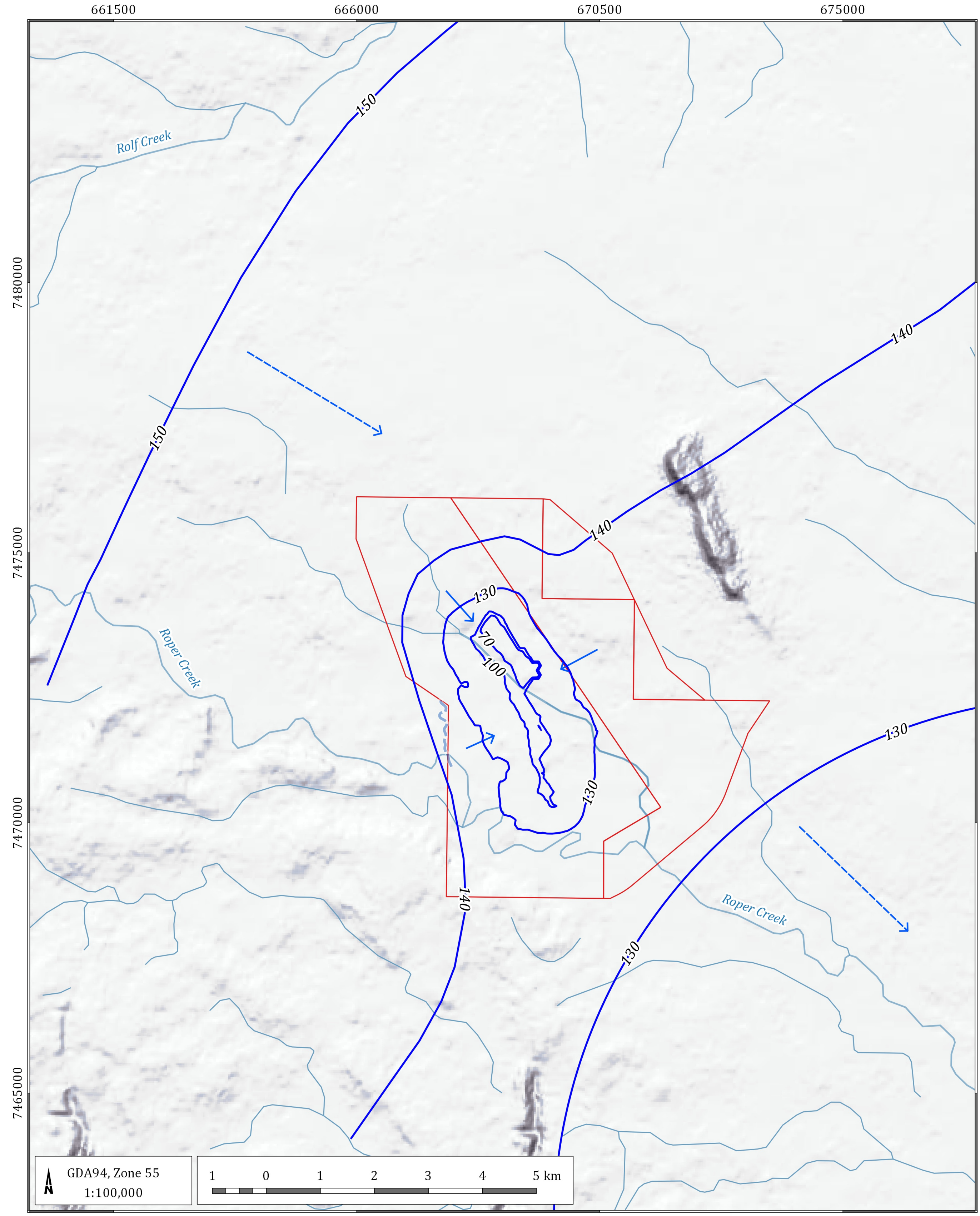
The regional water table within the Tertiary aquifer is a subdued reflection of topography with a general flow towards the south-east. The exception to this is immediately around the mine where groundwater levels would have declined due to localised depressurisation resulting from mining. Figure 6.10 presents current groundwater levels inferred for the Tertiary aquifer.

The coal measures form confined groundwater systems and they sub-crop beneath the Tertiary aquifers. The direction of groundwater flow for the Permian coal measures is influenced by the local geomorphology and structural geology (i.e. faults), and around the mine where groundwater levels have declined as a result of depressurisation from mining. The regional water table within the Permian Rangal Coal Measures aquifer is therefore constrained within the lateral extents of these coal measures west of the Jellinbah Fault and within ML 70379 as shown in Figure 5.4. Where unaffected by mining, groundwater flow is assessed to be roughly coincident with the Tertiary aquifer and generally towards the southeast. Similarly, the exception to this is immediately around the mine where groundwater levels have declined due to localised depressurisation resulting from mining. Figure 6.11 presents current groundwater levels inferred for the Permian Rangal Coal Measures aquifer.

Based on the fault delineation drilling by MCPL in 2017 (Section 6.10), it is assessed that vertical displacement along the Jellinbah Fault alignment has resulted in the Rangal Coal Measures coal seams being truncated against lower permeability Fort Cooper Coal Measures interburden. That is groundwater flow/movement to the east across the Jellinbah Fault is not halted, rather it is slowed as a result of the lower permeability Fort Cooper Coal Measures interburden sediments.

The northern, eastern and western boundaries of the groundwater model are located sufficiently distant from the Middlemount Coal Mine to avoid potential boundary effects. Accordingly, it is considered appropriate to simulate these as no flow boundaries. Where these boundaries coincide with regional mining or CSG operations, these are simulated with drain packages.

The model southern boundary has been revised and changed to include a general head boundary that allows interactive flow condition with the nearby regional mine operations. This is considered appropriate given the location of this boundary is effectively arbitrary, where the hydrogeological units represented within the model are likely to be continuous beyond this boundary towards the south.



LEGEND

- ▨ Populated place
- Watercourse
- Drainage feature
- ☐ Mining Lease boundary (ML)
- Inferred groundwater contours (mAHD)

Flow directions

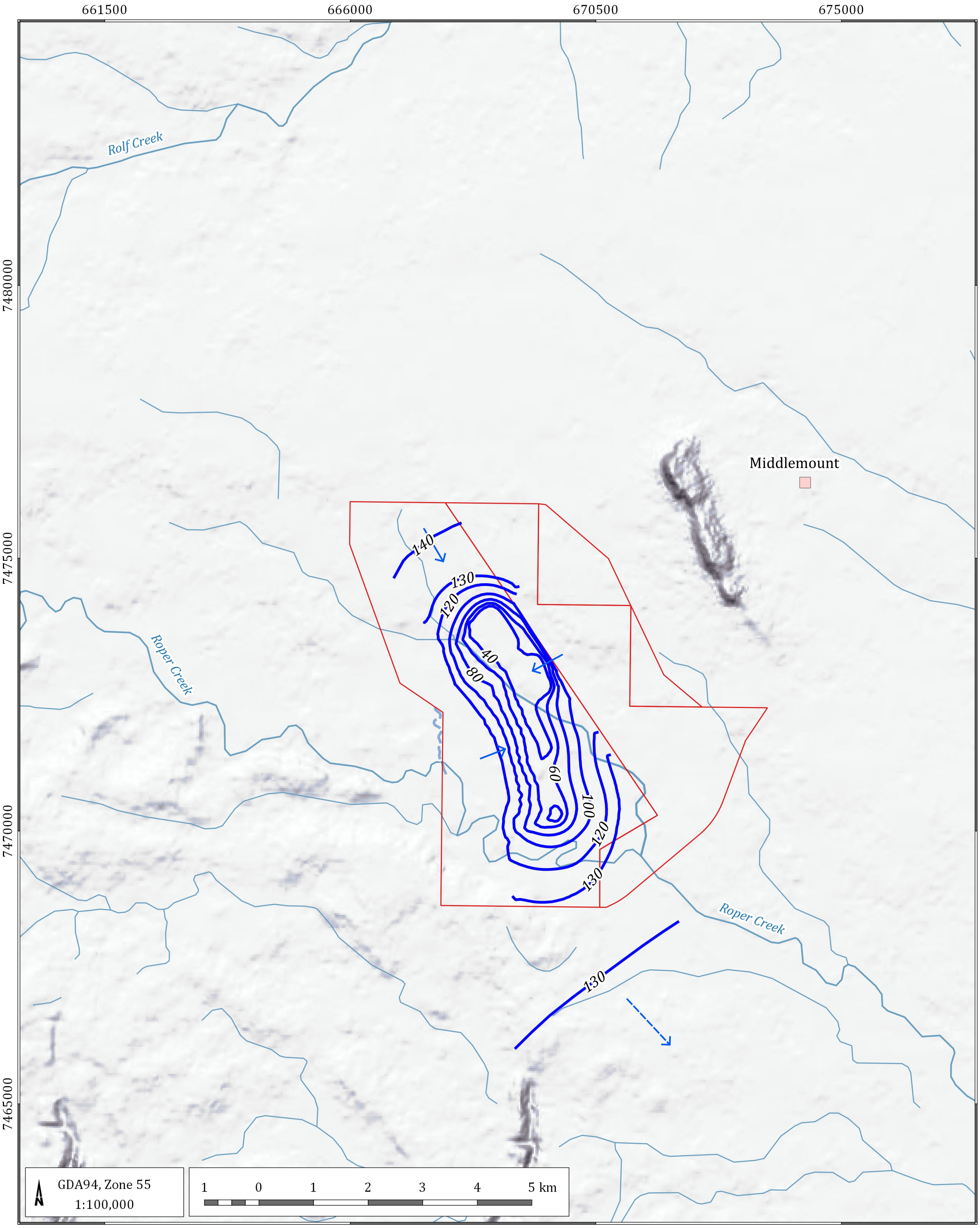
- ⇢ Regional groundwater flow direction
- → Local mine induced groundwater flow direction

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Inferred 2020 Tertiary aquifer groundwater levels

DATE	FIGURE No:
21/08/2020	**6.10**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.10_G1840P_Inferred 2020 Tertiary aquifer groundwater levels.qgs



LEGEND

- 🟥 Populated place
- Watercourse
- Drainage feature
- ▭ Mining Lease boundary (ML)
- Inferred groundwater contours (mAHD)

Flow directions

- --→ Regional groundwater flow direction
- → Local mine induced groundwater flow direction

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Inferred 2020 Permian Coal Measures groundwater levels

AGE

DATE	FIGURE No:
31/07/2020	**6.11**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.11_G1840P_Inferred 2017 Permian Rangal Coal Measures groundwater levels.qgs

7 Environmental value of groundwater

The EPP Water (Section 3.3) provides a framework to protect and/or enhance the environmental values and hence suitability of Queensland waters (including groundwater) for various beneficial uses. Groundwater resources within the Project area lie within the Mackenzie River Sub-basin (DEHP, 2011), in which the environmental values for groundwaters that need to be considered include:

- aquatic ecosystems;
- irrigation;
- farm supply/use;
- stock water;
- drinking water;
- industrial purposes; and
- cultural and spiritual values.

The *Mackenzie River Sub-basin Environmental Values and Water Quality Objectives* (DEHP, 2011) provides general WQO to support and protect the various environmental values identified for waters. The WQO are long-term goals for water quality management. Each of the environmental values listed above are discussed below to identify those that are relevant to the Project.

7.1 Aquatic ecosystem

As discussed in Section 6.8, there are no known springs or seeps within the Project area and no obligatory GDEs have been identified in within the Project area. The nearest mapped spring is associated with the Blackdown Tablelands National Park approximately 100 km south of the Middlemount Coal Mine.

Regionally, groundwater flow within the underlying aquifers is towards the south-east. Groundwater levels are generally in excess of 25 mbgl and separated from surface waters, limiting potential to support GDEs. There are no springs from these deep confined aquifers within the Project area or surrounds that would support GDEs.

7.2 Irrigation and farm supply/use

Groundwater is not used for irrigation or farm supply within (and neighbouring) the Project area. There are no known irrigation bores located within 10 km of the Project area.

7.3 Stock water

As discussed in Section 6.4, there is no significant groundwater usage within (and neighbouring) the Project area. The primary agricultural purpose of land within and surrounding the Project area has been low intensity cattle grazing.

The WQOs for Mackenzie River Sub-basin groundwaters are provided for tolerances of livestock to TDS (salinity) in drinking water and are adapted based on the guidelines presented in ANZECC (2000). Table 7.1 presents the tolerance of livestock to TDS in drinking water. The groundwater quality data for the site monitoring bores identifies this water would be unsuitable for stock watering based on the naturally elevated TDS levels (refer Section 6.6.4 and Section 6.7.4).

Table 7.1 Stock watering environmental values: Tolerance of livestock to TDS in drinking water

Livestock	No adverse effects on animals expected	Animals may have initial reluctance to drink or there may be some scouring, but stock should adapt without loss of production	Loss of production and decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually
Beef cattle	0 – 4,000 mg/L	4,000 mg/L – 5,000 mg/L	5,000 mg/L – 10,000 mg/L
Dairy cattle	0 – 2,500 mg/L	2,500 mg/L – 4,000 mg/L	4,000 mg/L – 7,000 mg/L
Sheep	0 – 5,000 mg/L	5,000 mg/L – 10,000 mg/L	10,000 mg/L – 13,000 mg/L[2]
Horses	0 – 4,000 mg/L	4,000 mg/L – 6,000 mg/L	6,000 mg/L – 7,000 mg/L
Pigs	0 – 4,000 mg/L	4,000 mg/L – 6,000 mg/L	6,000 mg/L – 8,000 mg/L
Poultry	0 – 2,000 mg/L	2,000 mg/L – 3,000 mg/L	3,000 mg/L – 4,000 mg/L

Notes: *1 - From ANZECC (1992), adapted to incorporate more recent information.*

2 - Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production.

Water quality objectives are also provided for trace metal (heavy metals and metalloids) concentrations in livestock drinking water, these are summarised in Table 7.2. Water quality data for dissolved metals reported for the Middlemount Coal Mine monitoring bores is below these WQOs.

Table 7.2 Stock watering environmental values: Low risk trigger values for heavy metals and metalloids in livestock drinking water

Element	Trigger value (low risk)[1] (mg/L)
Aluminium	5
Arsenic	0.5 (up to 5[2])
Berylium	ND[3]
Boron	5
Cadmium	0.01
Chromium	1
Cobalt	1
Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
Fluoride	2
Iron	Not sufficiently toxic
Lead	0.1
Manganese	Not sufficiently toxic
Mercury	0.002
Molybdenum	0.15
Nickel	1
Selenium	0.02

Element	Trigger value (low risk)[1] (mg/L)
Uranium	0.2
Vanadium	ND[3]
Zinc	20

Notes: *1 - Higher concentrations may be tolerated in some situations (details provided in AWQG, Volume 3, Section 9.3.5).*

2 - May be tolerated if not provided as a food additive and natural levels in the diet are low.

3 - ND – not determined, insufficient background data to calculate.

Metal values relate to the total concentration of the constituent.

7.4 Drinking water

Data indicates that groundwater quality in the Project area is brackish to saline and not suitable for human consumption.

7.5 Industrial purposes

The Middlemount Coal Mine will continue to recycle groundwater that seeps into the open cut pit. The water will be pumped to holding dams, where it will be incorporated into the mine water balance.

No WQOs are provided for industrial use as water quality requirements for industry vary within and between industries. Similarly, ANZECC (2000) does not provide guidelines for industry, and indicates that industrial water quality requirements need to be considered on a case-by-case basis. Based on this approach, groundwater accessed by the Project would provide a beneficial industrial use.

7.6 Cultural and spiritual values

No WQOs are provided for cultural and spiritual values, would need to be such that they "*protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans*" (DEHP, 2011). There are no known environmental values in relation to cultural and spiritual values of groundwater within the Project area.

8 Numerical modelling

A contemporary three-dimensional numerical groundwater flow model developed for the Western Extension Project has been reviewed and updated to account for the proposed mine plan. The objective of modelling this groundwater system was to simulate the progressive development of the proposed open pit and provide a tool to predict potential groundwater level drawdown, aquifer depressurisation, and groundwater inflow to the open cut pits. The groundwater model has also been used to simulate the cumulative progression of the Project and the existing Middlemount Coal Mine, and the neighbouring mines.

The predictive model scenarios have been designed to estimate:

- ranges of groundwater inflow to the Project area as a function of mine position and timing, for operational and post mining phases for each aquifer;
- the extent of the zone of aquifer depressurisation due to:
    - the incremental impacts associated with the Project; and
    - the combined impacts associated with the Project, CSG operations and nearby existing mines.
- the level and rate of groundwater level drawdown (incremental and cumulative) surrounding the residual voids; and
- incremental and cumulative impacts to the interaction of groundwater with surface water such as baseflow within Roper Creek.

8.1 Previous modelling

A contemporary groundwater model was developed for the Western Extension Project, which was approved in 2018 (AGE, 2018a). The groundwater model included a 17 layer numerical groundwater flow model that was developed and used to predict the rate of groundwater inflow to the open cut pit and the drawdown associated with mine dewatering. This groundwater model used MODFLOW-USG (USG) which had some significant advantages over the previous MODFLOW SURFACT for simulating the groundwater systems at Middlemount. These key features include the truncation of model layers and the ability to connect across layers through the non-neighbour connections (i.e. across the fault).

8.2 Overview of groundwater modelling

8.2.1 Model software and code selection

The groundwater model used for this assessment was the same USG groundwater model developed for the Western Extension Project. This latest version allows for the model to have an unstructured grid which means that model cell refinement can occur in areas within the model without requiring extended refinement to the edge of the model. This creates the opportunity to reduce the number of model cells in each model layer. Another key advantage of USG is the fact that model layers can be truncated where they cease to exist (such as sub-cropping and fault terminated geological units) and maintain the hydraulic connections for layers above and below where the model layer has ceased to exist. USG can also simulate unsaturated flow. These attributes have allowed the USG code using the model grid made up of Voronoi (polygon) cells particularly effective for the Middlemount Coal Mine numerical model.

8.2.2 Proposed mine plan

The Project involves the extension of open cut mining operations to the south, within ML 70379 (Figure 2.1) at the current maximum approved rate of 5.7 Mtpa until 2044, thereby allowing for mining to continue for another seven years beyond the approved mine life. The mine plan, which includes the extension to the approved open cut operation for the Project, is presented in Figure F 4.3 in Appendix F.

Open cut mining will result in progressive depressurisation of the surrounding strata and subsequent recovery post mining. Appendix F describes how the groundwater model simulated the proposed mining and groundwater recovery.

8.2.3 Model design and calibration

Where appropriate, natural hydrogeological boundaries such as geological units and regional catchment boundaries, have been adopted in the model. The groundwater model was developed to include the proposed mine plan and potential for cumulative impact from nearby operational mines such as German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park. CSG production as part of the Bowen Gas Project (Arrow, 2012) within the Rangal Coal Measures approximately 7 km to the north of the Middlemount Coal Mine in 2034 is also incorporated into the groundwater model.

The model represents the key geological units within the model domain as 17 layers, and extends approximately 30 km from north-west to south-east, and 21 km from north-east to south-west, and was divided into variable sized cells comprising up to 19,412 cells per layer. The model was developed around the conceptual groundwater model summarised in Section 6.13, and this development is detailed in Appendix F. The model was calibrated and verified to existing groundwater levels, using reliable measurements from representative bores within the model domain. A detailed description of the calibration method is provided in Appendix F. The objective of the calibration was to replicate the observed groundwater levels in accordance with the modelling guidelines developed by Barnett et al., (2012). The transient calibration achieved an 9.1% scaled root mean square (SRMS) error, which is less than the 10% SRMS error suggested by the modelling guidelines as constituting a calibrated model. Comparison of the predicted and observed hydrographs shows a good qualitative match in groundwater level trends.

Once calibrated, the model was used to predict the groundwater level response to the Project, including simulated mining of the open cut pit in accordance with the proposed mine plan. The model simulated mining to the base of the Pisces Seam within the Rangal Coal Measures, defined as layer seven in the groundwater model.

The following sections describe the predictions of the groundwater model.

8.3 Groundwater modelling predictions

8.3.1 Groundwater inflow to mining areas

The transient development of the mine was simulated initially on a quarterly basis for seven years between 2011 and 2017 for the simulation (and calibration) of mining to date, and then annually for the predictions between 2018 and 2044. The pit inflows determined from the calibration and predictive simulations are shown graphically in Figure 8.1. These predicted inflows represent seepage as time weighted averages of the annual totals for each stress period reporting to the open cut pits over the life of the proposed mine operations.

These groundwater inflows are considered ‘associated water’ in accordance with MCPL’s underground water rights under ML 70739 and ML 70417. MCPL will measure and report the volume of associated water taken in accordance with the requirements of the *Water Act 2000*.

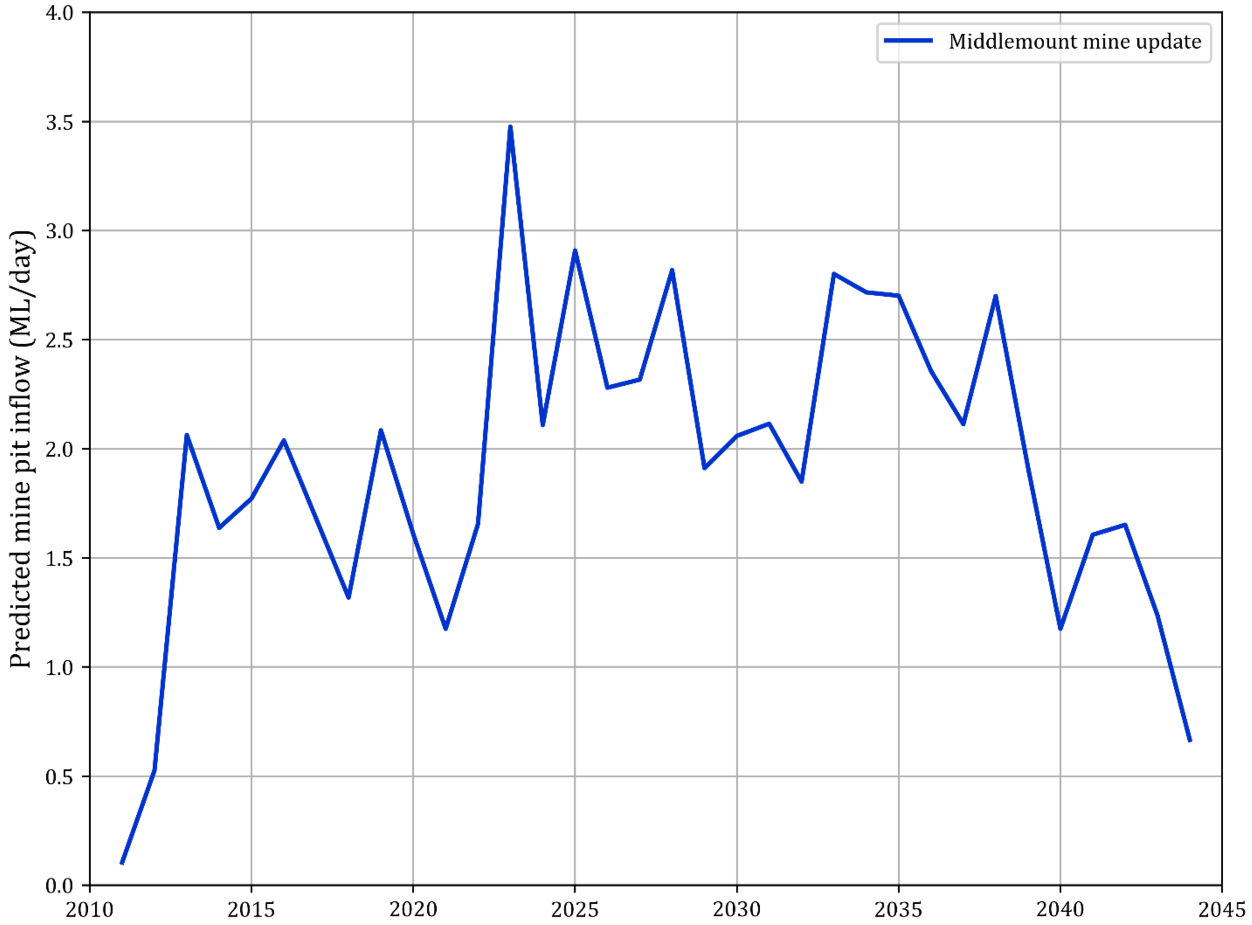


Figure 8.1 Predicted average annual pit inflows

Table 8.1 presents the predicted combined groundwater extraction as seepage reporting to the open pit for both the approved and proposed mine plans for each mining year between 2011 to 2044. The average daily predicted pit inflows between 2013 to 2017 are approximately 1.8 ML/day with a maximum inflow of 3.5 ML/day, which is consistent with the estimated monthly groundwater inflow ranges between approximately 1 ML/day and 5 ML/day during a 10 month period assessed for October 2015, May 2016 and between February and September 2017 (WRM, 2017).

Table 8.1 Predicted groundwater inflow – 2011 to 2044

Calendar year	Approved predicted mine inflow^		Proposed predicted mine inflow		Difference
	(ML/day)	(ML/year)	(ML/day)	(ML/year)	(ML/day)
2011*	0.1	40	0.1	38.0	0
2012*	0.7	253	0.5	192.3	-0.2
2013*	2.6	948	2.1	753.1	-0.5
2014*	1.9	704	1.6	597.7	-0.3
2015*	2.2	807	1.8	646.9	-0.4
2016*	2.3	843	2.0	746.0	-0.3
2017*	2.5	927	1.7	612.8	-0.8

Calendar year	Approved predicted mine inflow^		Proposed predicted mine inflow		Difference
	(ML/day)	(ML/year)	(ML/day)	(ML/year)	(ML/day)
2018*	1.7	605	1.3	481.1	-0.4
2019*	2.3	837	2.1	761.0	-0.2
2020*	1.7	605	1.6	588.9	-0.1
2021*	2.2	819	1.2	428.8	-1.0
2022*	1.7	635	1.7	604.4	0
2023*	2.4	879	3.5	1268.9	1.1
2024*	2.7	995	2.1	771.8	-0.6
2025*	2.5	895	2.9	1061.8	0.4
2026*	2.3	845	2.3	832.2	0
2027*	2.2	799	2.3	845.8	0.1
2028*	1.8	642	2.8	1031.6	1.0
2029*	1.4	510	1.9	697.8	0.5
2030*	2.3	828	2.1	751.5	-0.2
2031*	2.3	846	2.1	771.9	-0.2
2032*	2.1	775	1.8	677.0	-0.3
2033*	2.3	855	2.8	1022.6	0.5
2034*	2.8	1,030	2.7	991.8	-0.1
2035*	2.8	1,022	2.7	986.1	-0.1
2036*	1.8	640	2.4	862.6	0.6
2037*	0.7	266	2.1	771.3	1.4
2038	-	-	2.7	985.5	2.7
2039	-	-	1.9	698.5	1.9
2040	-	-	1.2	430.1	1.2
2041	-	-	1.6	586.2	1.6
2042	-	-	1.7	602.8	1.7
2043	-	-	1.2	451.5	1.2
2044	-	-	0.7	243.6	0.7

<u>Notes:</u> *ML/year = megalitres per year*

^ Approved inflow rates derived from the Western Extension GIA (AGE, 2018a)

** Predictions from 2011 to 2037 that are for mining approved to date*

The predicted inflow rates presented in Figure 8.1 represent the take of water over the duration of the Project. Overall, the inflow rates are typically in line with the inflow rates previously predicted and experienced at the mine. It is noted that a proportion of these predicted groundwater inflows may be lost as moisture in the coal (entrained water), and at times, from direct evaporation from the exposed coal seam. However, given the variabilities in the extent of coal seams exposed at any one time, highwall angle and the height of exposed coal seams, in comparison to the surface area of the mine water storages to which the direct groundwater inflows would be pumped to, such losses are considered negligible for the purposes of this assessment. As the groundwater model inflow predictions are based on annual snapshots, such instantaneous losses are considered to be within the bounds of reasonable accuracy of the averaged groundwater model predicted inflow ranges.

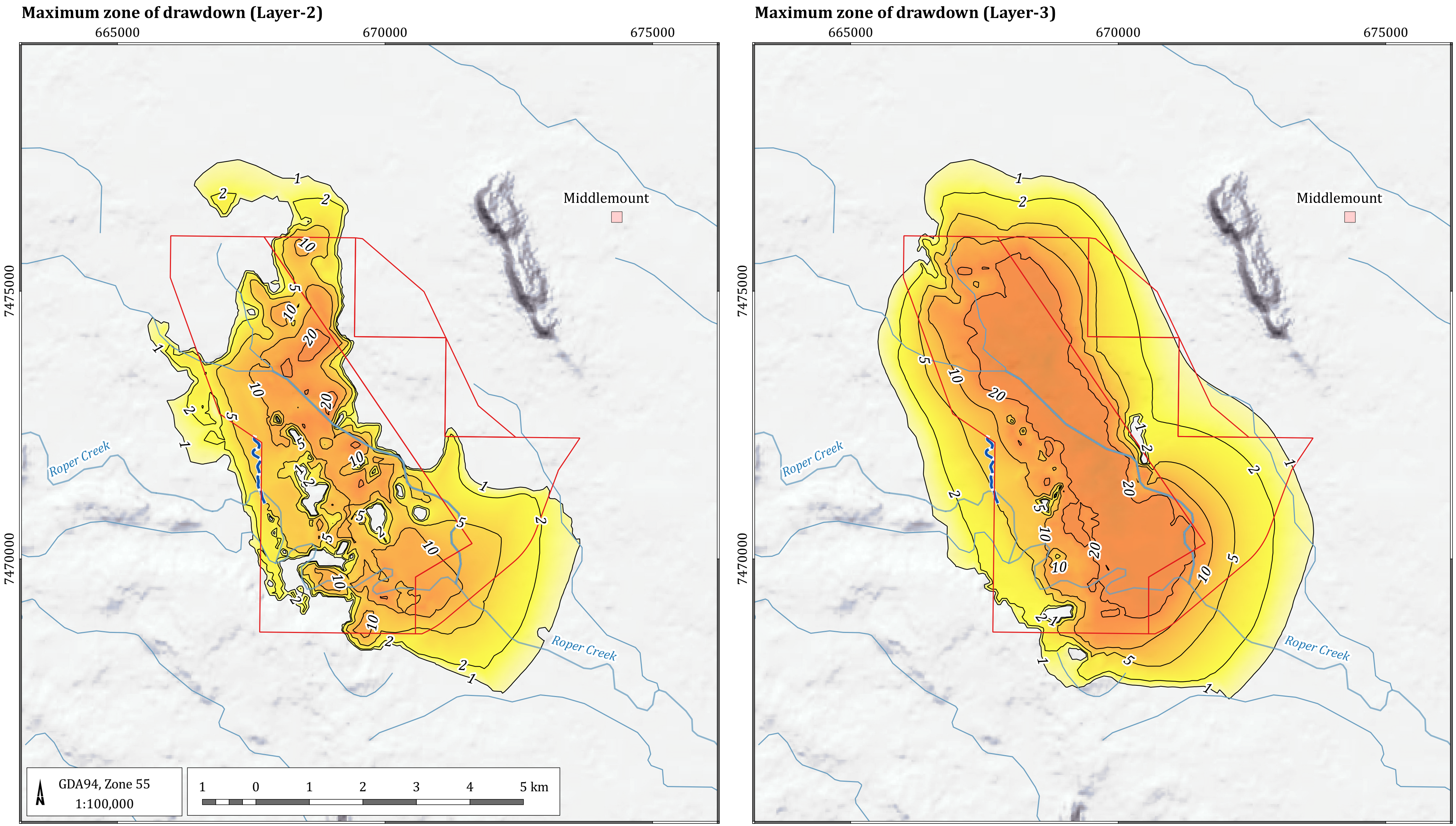
8.3.2 Drawdown and depressurisation during mining operations

The zone of depressurisation due to the Middlemount Coal Mine (incorporating the Project) within the Tertiary and Weathered Permian (Layers 2 and 3), Middlemount Seam (layer 5), Pisces Seam (layer 7) and Fort Cooper Coal Measures (Layers 16 and 17), are shown in Figure 8.2, Figure 8.3, and Figure 8.4 respectively. The maximum drawdown for these layers during mining was determined from the 2011 pre-mining groundwater heads. These show that the overall drawdown extent is greatest within the Weathered Permian. The drawdown within the shallower Tertiary sediments is less and is constrained within that for the Weathered Permian due to this layer being partially saturated within and surrounding the MLs. The drawdown extent generally decreases within the underlying layers, which is not unexpected given the presence of lower permeability interburden strata (aquitards) between these geological units, and the reduced lateral extents of these Middlemount and Pisces coal seam aquifer units within the Rangal Coal Measures. As discussed in Section 6.1, the sandstone and siltstone interburden and overburden of the Rangal Coal Measures form a confining aquitard over the floor and roof of the depressurised coal seams.

The resultant zone of depressurisation within the Weathered Permian (Rangal Coal Measures and Fort Cooper Coal Measures) from the Middlemount Coal Mine (incorporating the Project) is predicted to extend to the north, south-east and west beyond the ML boundaries (Figure 8.2). The maximum drawdown extents during mining are up to 1.7 km to the north-west and south-east of the Middlemount Coal Mine. The extent of drawdown within the Rangal Coal Measures (Middlemount and Pisces Seams, Layers 5 and 7) is constrained by the limited lateral extents of the coal measures. These sub-crop just within the western ML70379 boundary and dip towards the north-east where they are truncated by the Jellinbah Fault, roughly coincident with the western ML70379 boundary (Figure 8.3). Figure 8.4 shows the Jellinbah Fault is not assessed to be a barrier to groundwater flow, rather propagation of groundwater drawdown is limited east of the fault by the lower permeability Fort Cooper Coal Measures (Burngrove Formation, layer 16). Whilst mining does intersect the Fort Cooper Coal Measures (Burngrove Formation, layer 9) underlying the mine pit, vertical hydraulic connection between the Rangal Coal Measures and the Fort Cooper Coal Measures does result in drawdown extending downwards in layer 9 (Figure 8.4). The maximum extent of this drawdown during mining is largely contained within the ML boundaries.

The predicted extent of drawdown and depressurisation to the north, east and west of the Middlemount Coal Mine (incorporating the Project) is largely consistent with the extent of drawdown predicted for the Western Extension Project. The extent of depressurisation in the Fort Cooper Coal Measures is predicted to extend approximately 2 km further south than what was predicted for the Western Extension Project.

The timing of maximum predicted drawdown for any given location is dependent on the location relative to the progress of the open cut pit and in-pit waste emplacement and could occur anytime during mining.



LEGEND

- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)
- ☐ Mining Lease boundary (ML)

Drawdown (m)

☐ 0	🟧 20
☐ 1	🟫 50
🟨 2	🟫 100
🟨 5	🟫 200
🟧 10	🟫 500

Middlemount Coal Mine Southern Extension Project -
GIA (G1840P)

Tertiary and Weathered Permian (Layers 2 & 3) – Maximum zone of drawdown

DATE
31/07/2020

FIGURE No:
8.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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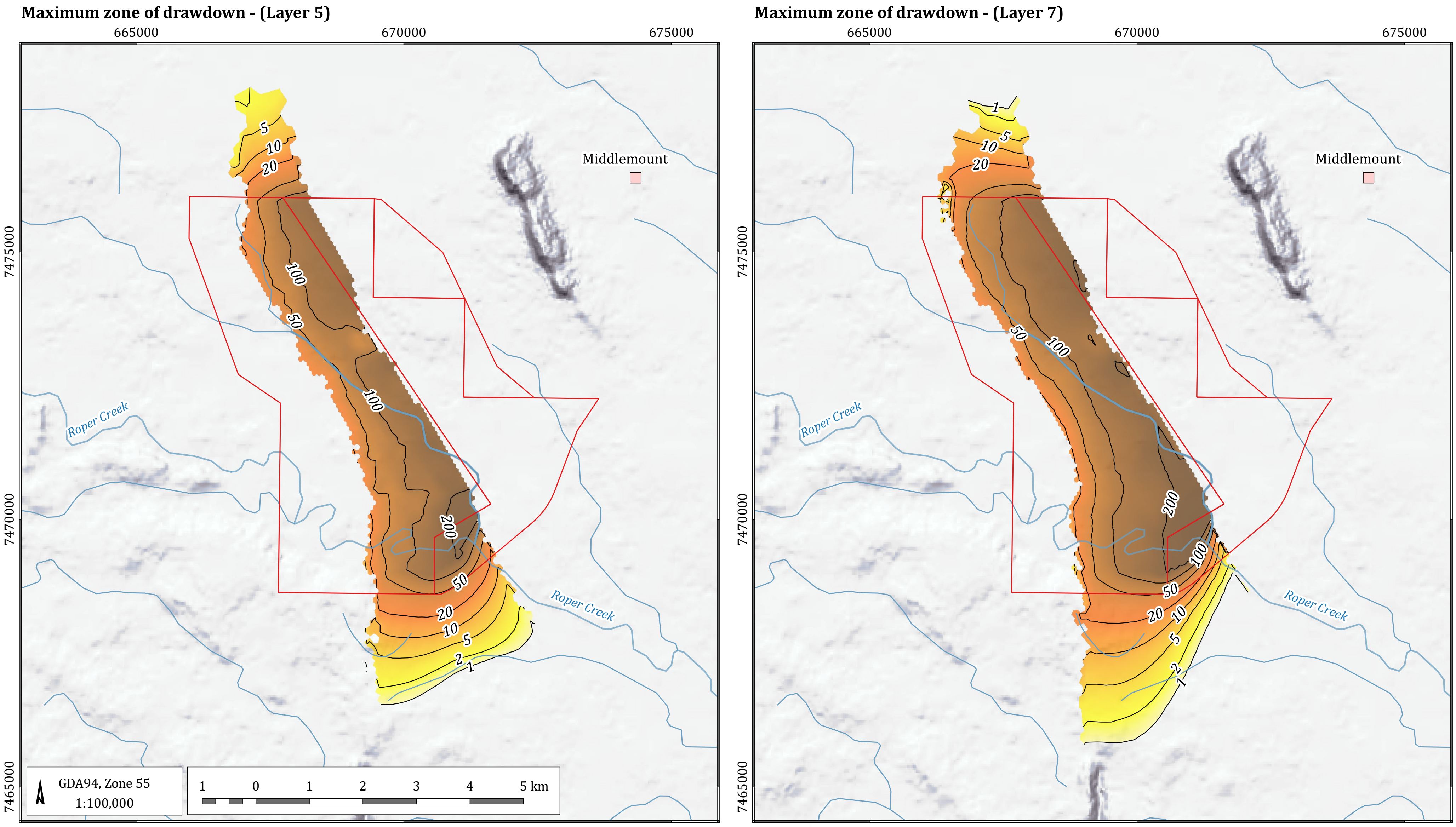

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount and Pisces Seam (Layer 5 & 7) - Maximum zone of drawdown

DATE
21/08/2020

FIGURE No:
8.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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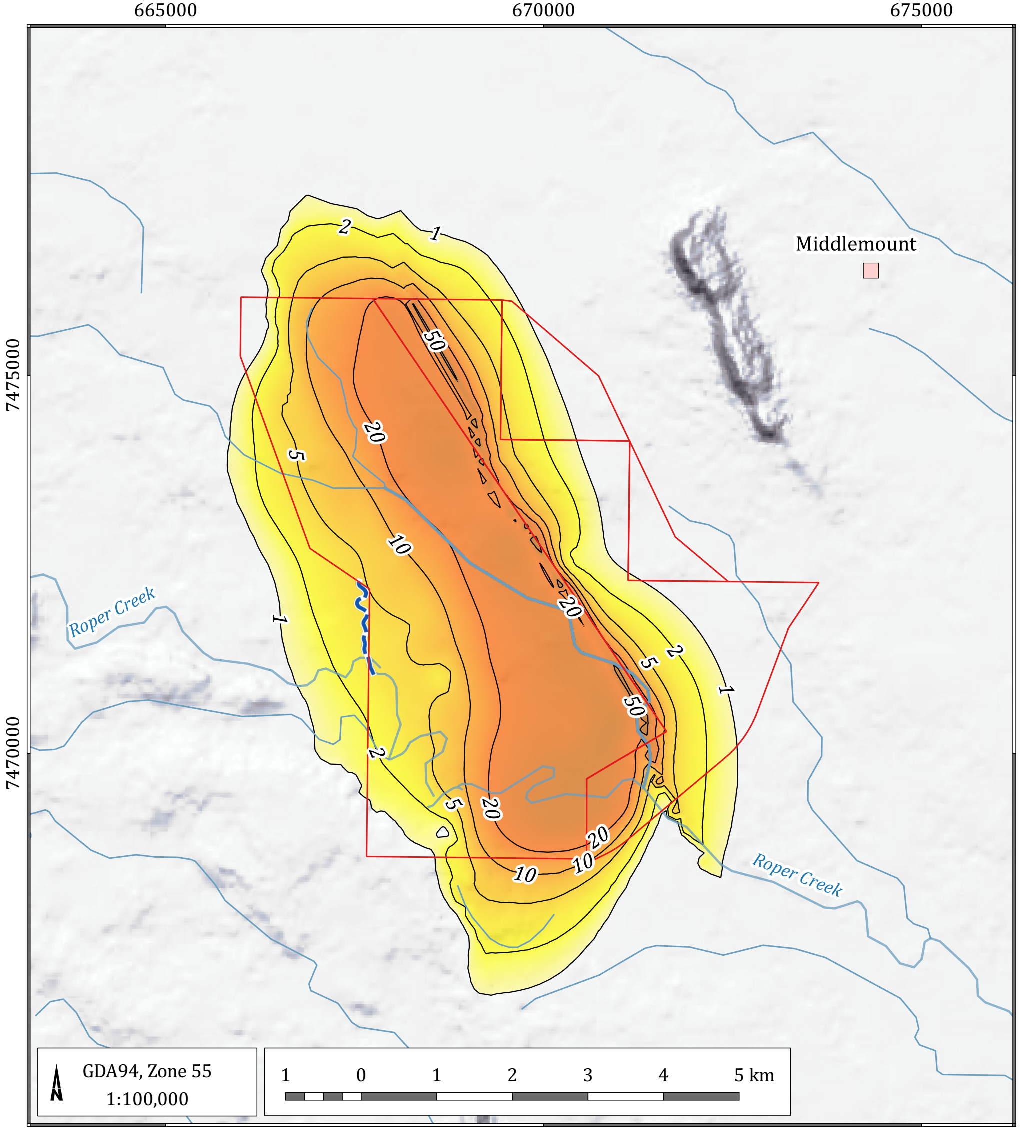
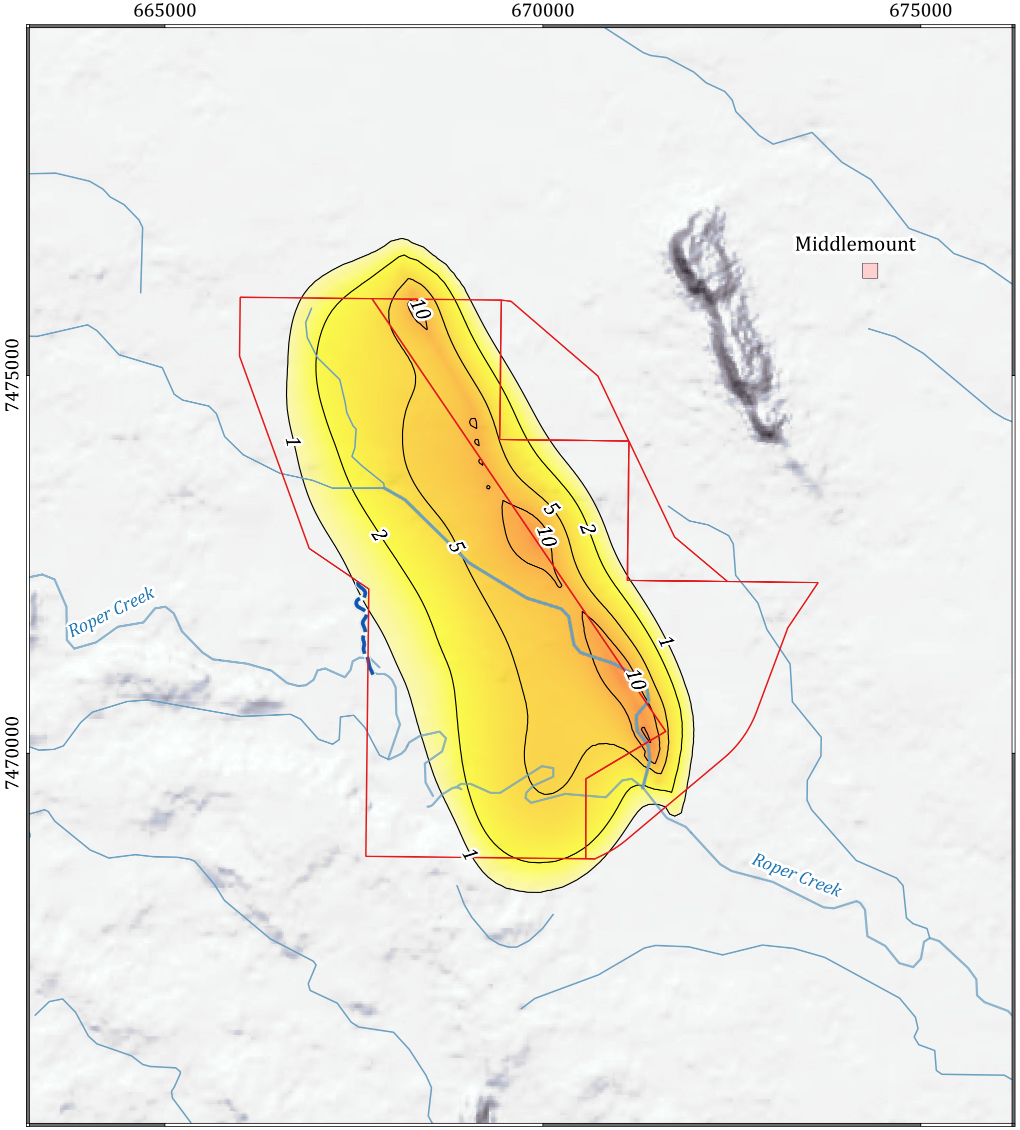
Maximum zone of drawdown (Layer-9 & 16)



Maximum zone of drawdown (Layer-10 & 17)



LEGEND
- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- Mining Lease boundary (ML)

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project -
GIA (G1840P)

Fort Cooper Coal Measures (Layers 9 &16, 10 & 17) – Maximum zone of drawdown

DATE
24/08/2020

FIGURE No:
8.4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.04_G1840P_Fort Cooper Coal Measures (Layers 9 &16, 10 & 17) – Maximum zone of drawdown.qgs

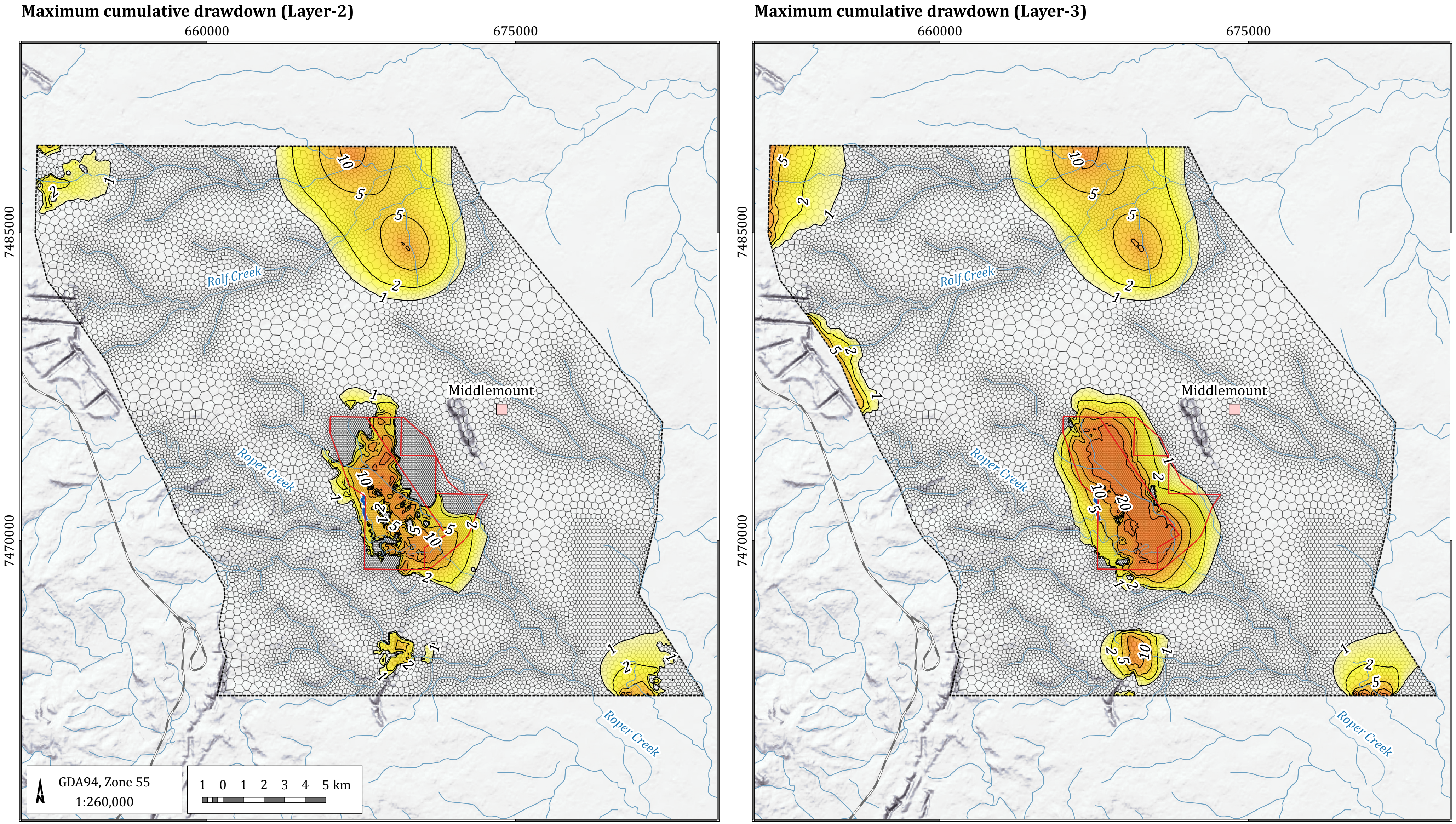
8.3.3 Cumulative impacts

The numerical groundwater model was used to assess the cumulative impact between the Middlemount Coal Mine (incorporating the Project) and nearby operational and closed mines which include German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park. CSG production as part of the Bowen Gas Project (Arrow, 2012) was also simulated where this is proposed within the Rangal Coal Measures approximately 7 km to the north of the Middlemount Coal Mine from 2034. Associated groundwater removed from the coal seams as a by-product of the CSG production, resulted in depressurisation of the Rangal Coal Measures to the north of the Middlemount Coal Mine.

Figure 8.5 to Figure 8.8 show predicted drawdown extents for each of the adjacent mine and CSG projects. Consistent with the outcomes of the modelling for the Western Extension Project, these show the maximum drawdown extents during mining:

- Within the Tertiary and Weathered Permian (Figure 8.5) do not show overlap between Middlemount and Foxleigh mines resulting in no cumulative drawdown between model layers 2 and 3.
- For the Middlemount Seam (layer 5) 1 m contour, just intersects roughly midway between the Middlemount Coal Mine and the German Creek East voids (Figure 8.6), but does not overlap or intersect the drawdown from the Leichhardt Seam (layer 12) from Foxleigh and Foxleigh Plains mines, and the Bowen Gas Project CSG production.
- For the Pisces Seam (layer 7) 2 m contour, overlaps roughly midway between the Middlemount Coal Mine and the German Creek East voids (Figure 8.7), but does not overlap or intersect the drawdown from the Vermont Seam (layer 14) from Foxleigh and Foxleigh Plains mines, and the Bowen Gas Project CSG production.

As a result of the proposed southern extension, predicted drawdown in the Fort Cooper Coal Measures (Figure 8.8) overlaps between the Project and the German Creek East mine. This was not predicted to occur for the Western Extension Project. Notwithstanding, cumulative drawdown within model layers 9, 10, 16 and 17 remains limited with no other overlap with drawdown from other regional mining operations predicted to occur.



LEGEND

- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion

- Drawdown contour (m)
- Mining Lease boundary (ML)
- Model grid
- Model boundary

Drawdown (m)

⬜	0	🟧	20
🟨	1	🟫	50
🟨	2	🟫	100
🟨	5	🟫	200
🟧	10	🟫	500

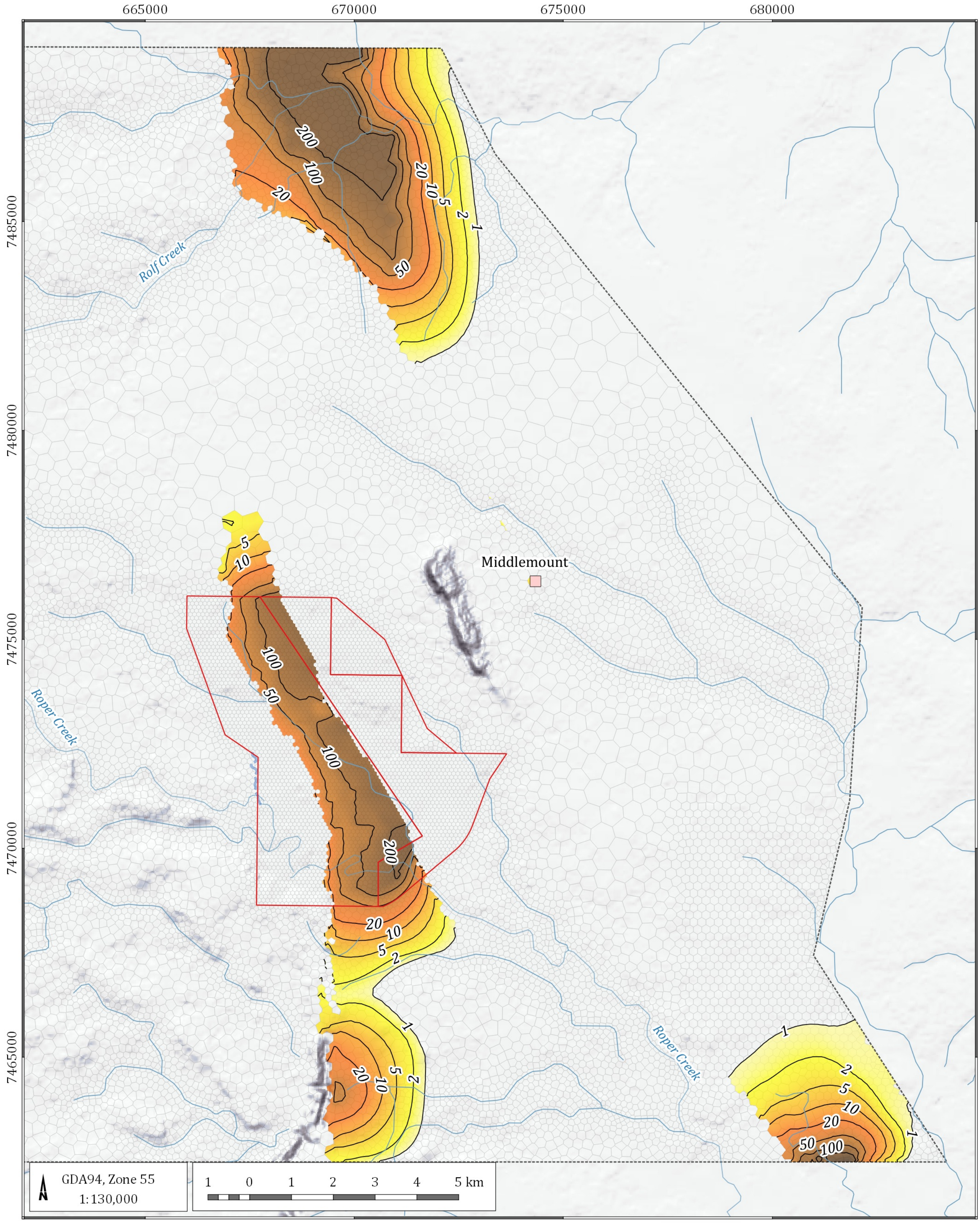
Middlemount Coal Mine Southern Extension Project -
GIA (G1840P)

Maximum cumulative drawdown Tertiary and Weathered Permian – Layers 2 & 3 (CSG extraction, Foxleigh Mine, German Creek East Mine)

DATE
24/08/2020

FIGURE No:
8.5

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.05_G1840P_Maximum cumulative drawdown Tertiary and Weathered Permian – Layers 2 & 3 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- ▭ Mining Lease boundary (ML)
- ▭ Model grid
- ⬚ Model boundary

Drawdown (m)

- ☐ 0
- 🟨 1
- 🟨 2
- 🟨 5
- 🟧 10
- 🟧 20
- 🟫 50
- 🟫 100

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

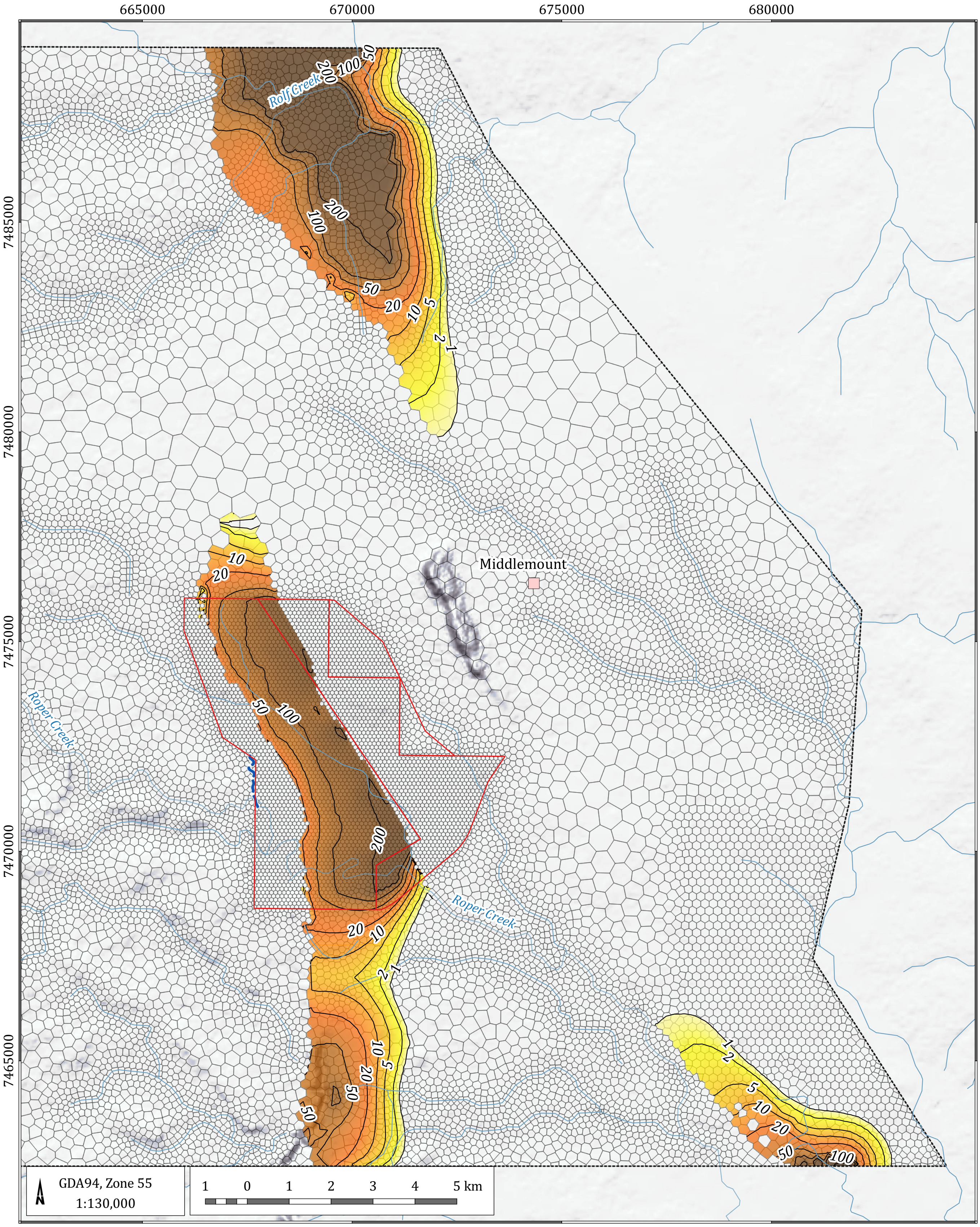
Maximum cumulative drawdown Middlemount Seams and Leichhardt – Layer 5 & Layer 12 (CSG extraction, Foxleigh Mine, German Creek East Mine)

AGE

DATE 31/08/2020

FIGURE No: **8.6**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.06_G1840P_Maximum cumulative drawdown Middlemount Seams and Leichhardt – Layer 5 & Layer 12 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- 🟥 Mining Lease boundary (ML)
- ☐ Model grid
- ☐ Model boundary

Drawdown (m)

- ☐ 0
- 🟨 1
- 🟨 2
- 🟨 5
- 🟧 10
- 🟧 20
- 🟫 50
- 🟫 100

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

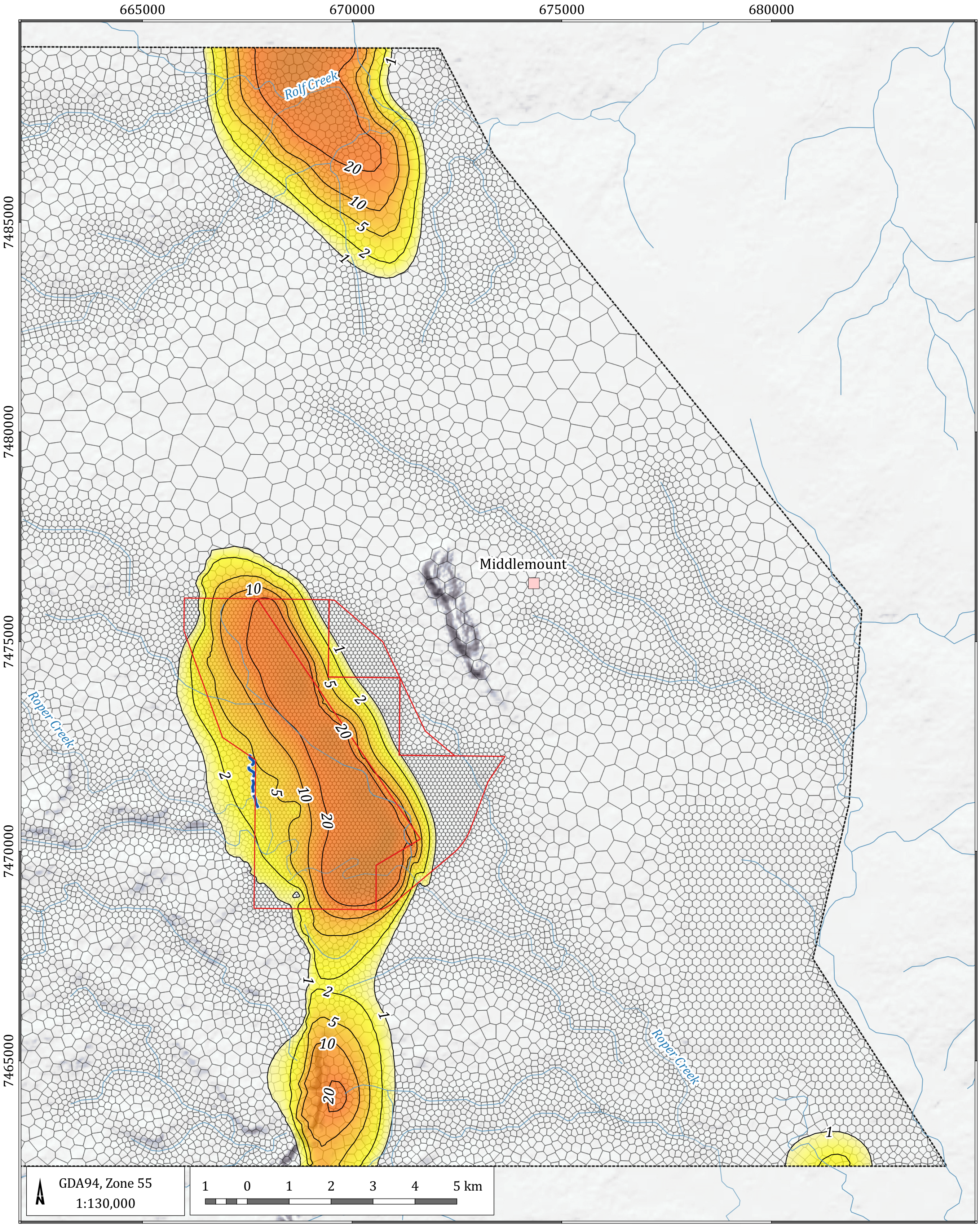
Maximum cumulative drawdown Pisces and Vermount Seam – Layer 7 & Layer 14 (CSG extraction, Foxleigh Mine, German Creek East Mine)

AGE

DATE 24/08/2020

FIGURE No: **8.7**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.07_G1840P_Maximum cumulative drawdown Pisces and Vermount Seam – Layer 7 & Layer 14 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

- 🟥 Populated place
- Road
- Watercourse
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- Mining Lease boundary (ML)
- Model grid
- Model boundary

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Maximum cumulative drawdown Fort Cooper Coal Measures – Layers 9,10,16 & 17 (CSG extraction, Foxleigh Mine, German Creek East Mine)

AGE

DATE	FIGURE No:
24/08/2020	**8.8**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.08_G1840P_Maximum cumulative drawdown Fort Cooper Coal Measures – Layers 9,10,16 & 17 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs

8.3.4 Impacts on groundwater users

As discussed in Section 8.3.2, the depressurised zone as a result of the Middlemount Coal Mine (incorporating the Project) in the Tertiary and Weathered Permian, and the Rangal Coal Measures extends up to 1.7 km towards the north-west and south-east of the Middlemount Coal Mine.

Figure 8.9 shows the locations of the registered bores identified in the DNRM GWDB in relation to the predicted zone of depressurisation for the Tertiary and Weathered Permian sediments. None of the existing registered bores on the DNRM GWDB are identified within this predicted zone of depressurisation. Therefore, no landholder water supply bores are located within the predicted drawdown extents attributable to the proposed mine plan for the Middlemount Coal Mine (incorporating the Project). This is consistent with the findings of the Western Extension Project.

It is important to note that a conservative approach has been adopted in the modelling, and the zone of influence is not expected to develop to the full extent predicted by the numerical modelling. That is, the model does not include any hydraulic heterogeneities in the area and simulates a continuous hydraulically connected aquifer system. Minor faults offset the coal seams and heterogeneities can act as barriers to groundwater flow, which limits the expansion of the zone of depressurisation.

8.3.5 Impacts on groundwater dependent ecosystems

The Middlemount Coal Mine (incorporating the Project) is not predicted to impact any aquatic or terrestrial GDEs, as GDEs are assessed as being unlikely to occur within and surrounding the Middlemount Coal Mine (Section 6.8), on the basis that:

- the majority of the terrestrial vegetation associated with Roper Creek and Drainage Line 1 also occurs more widely across the landscape and is not restricted to areas where it could potentially access groundwater;
- Roper Creek and Drainage Line 1 are ephemeral and the depth to groundwater in these areas is typically around 20 m;
- the depth to groundwater within the palustrine wetlands north of ML 70417 and ML 70379 exceeds of 12 m depth; and
- there is no evidence of vegetation dieback resulting from existing operations.

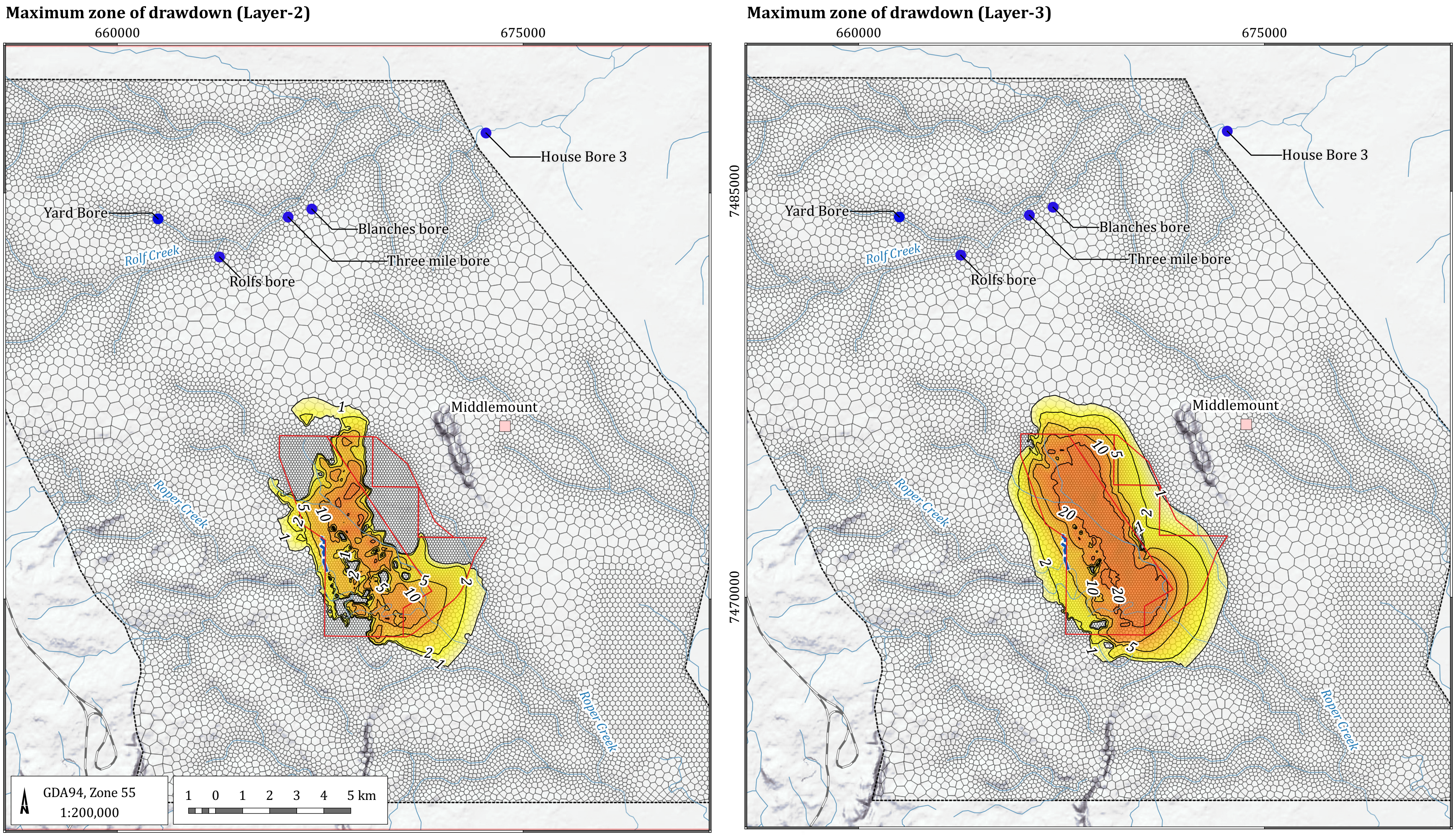
The presence of stygofauna in groundwater within the Project area was assessed from a desktop review of optimal conditions for stygofauna habitat and results of sampling. The review concluded that the potential for optimal stygofauna habitat at Middlemount Coal Mine is unlikely given to average salinity in both the Tertiary and Permian aquifers being in excess of 20,000 µS/cm, and the average depth to groundwater in the Permian aquifer being greater than 30 mbgl.

As discussed in Section 6.9, sampling in 2011 found a naturally low diversity of stygofauna (taxa from two Families). Stygofauna from the same two Families were found in bores that were located both in and outside the maximum zone of drawdown associated with the Middlemount Coal Mine (incorporating the Project) (e.g. some 5 km to 7 km north-west and south-east). However, a subsequent wet and dry season sampling program in selected monitoring bores in late 2019 and early 2020 found no stygofauna in any bore.

The Project is not predicted to significantly impact stygofauna considering the Project would only incrementally increase the groundwater drawdown from the approved mine, the groundwater aquifer (similar stygofauna habitat) is extensive outside of the maximum zone of drawdown, and the sampling to date indicates there is either a low diversity of stygofauna or no stygofauna present in and outside the maximum zone of drawdown. This is consistent with the findings of the Western Extension Project.

8.3.6 Roper Creek Diversion

The proposed realignment and extension of the Roper Creek diversions is unlikely to impact on shallow groundwater or terrestrial vegetation as the alluvium is largely unsaturated, and Roper Creek is ephemeral with no existing baseflow in the vicinity of the Middlemount Coal Mine.



LEGEND

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

AGE

Landholder bores within predicted maximum zone of drawdown during mining

DATE
24/08/2020

FIGURE No:
8.9

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.09_G1840P_Landholder bores within predicted maximum zone of drawdown during mining.qgs

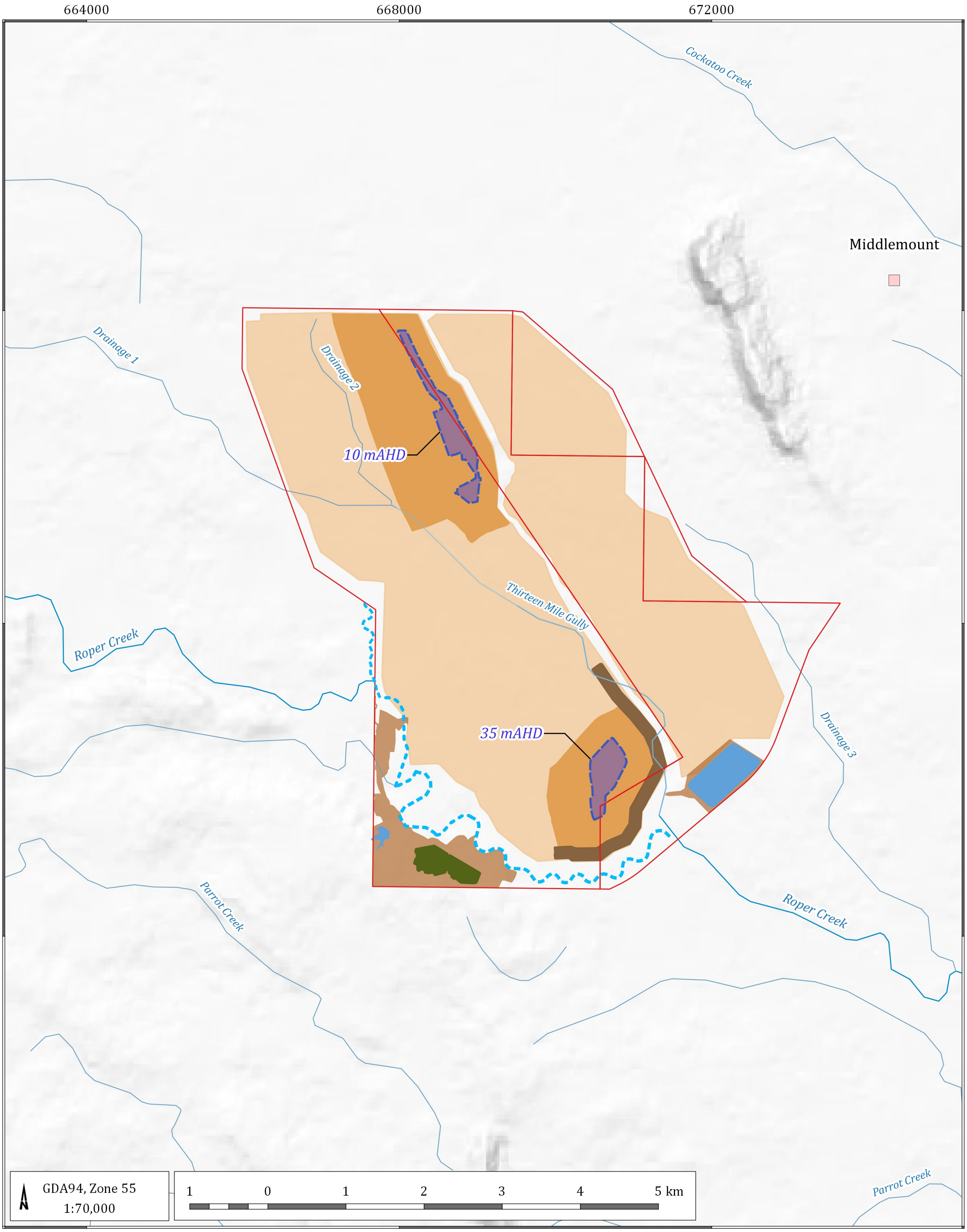
8.4 Post mining recovery conditions

Post mining conditions were also simulated using the numerical groundwater flow model. The locations of the residual voids are shown in Figure 8.10, and Appendix F provides details of the model set up.

The sections below describe the post mining predictions of the pit lake levels, potentiometric surface and water table recovery, and water quality variation. These predictions are based on the residual landform at the end of mining, which includes the North Void and South Void. The depths of each void at the end of mining vary from north to south across both mine pits, with pit floor elevation extending to the base of the coal seams mined within each void. The two voids are separated by spoil backfill that rises up to 200 mAHD.

The recovery process is driven by inputs from groundwater seepage, direct rainfall across the void, and rainfall runoff from the catchment associated with each void. These inputs are eventually balanced against losses from evaporation, with the pit lake elevation reaching a stable equilibrium level approximately 100 to 200 years post-mining (WRM, 2020). The simulation results show both the North and South Voids becoming saturated and the development of a void lake in each void. The difference in equilibrium water level for each void is predicted to be 25 m producing a gradient from the South Void into the North Void. Surface water runoff from rainfall is the principal filling mechanism that contributes to development of the void lake levels in each void, the extent of which is dominated by evaporation. As such, the volume of groundwater into the void lakes is a minor contributor to the equilibrium void recovery water levels.

An assessment of the impact of storm events on the water level in the residual voids has been undertaken by WRM (2020). The storm event analysis shows that the 72-hour, 1 in 1,000 AEP design event only increases the residual void water levels by 3.4 m (North Void) and 2.1 m (South Void) (WRM, 2020). These temporary and modest increases in water level would not affect the groundwater recovery assessment in the following subsections.



LEGEND

- ■ Populated place
- — Watercourse
- — Drainage feature
- - - Watercourse Diversion
- ☐ Mining Lease boundary (ML)

Mine infrastructures

- ■ Mine Infrastructure Area
- ■ Flood Protection Landform
- ▨ Final Void
- ■ Final Void Batter
- ■ Established Rehabilitation
- ■ Tailings Storage Facilities
- ■ Water Management Dams

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Southern Extension Project residual voids

DATE	FIGURE No:
27/08/2020	**8.10**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.10_G1840P_Southern Extension Project residual voids.qgs

8.4.1 Post closure groundwater recovery

Post closure conditions were simulated over a period of 500 years by WRM to predict the extent of void lake level recovery following cessation of mining. WRM modelling indicates that the residual voids would gradually fill over time from direct rainfall occurring across each void and groundwater seepage. Utilising the WRM modelling results, representative pit lake levels of approximately 10 mAHD in the North Void, and 35 mAHD in the South Void have been used for the purposes of post closure groundwater recovery modelling.

The representative pit lake levels were used to determine the long-term residual drawdown in the surrounding aquifers and establish a new equilibrium groundwater level around the residual voids. This was achieved by applying the representative pit lake levels, consistent with the WRM modelling results, in each void and running the model forward from the end of mining for 500 years.

Based on these predictions, the voids would act as sinks in perpetuity with no escape of contained void water into the Rangal Coal Measures or Fort Cooper Coal Measures.

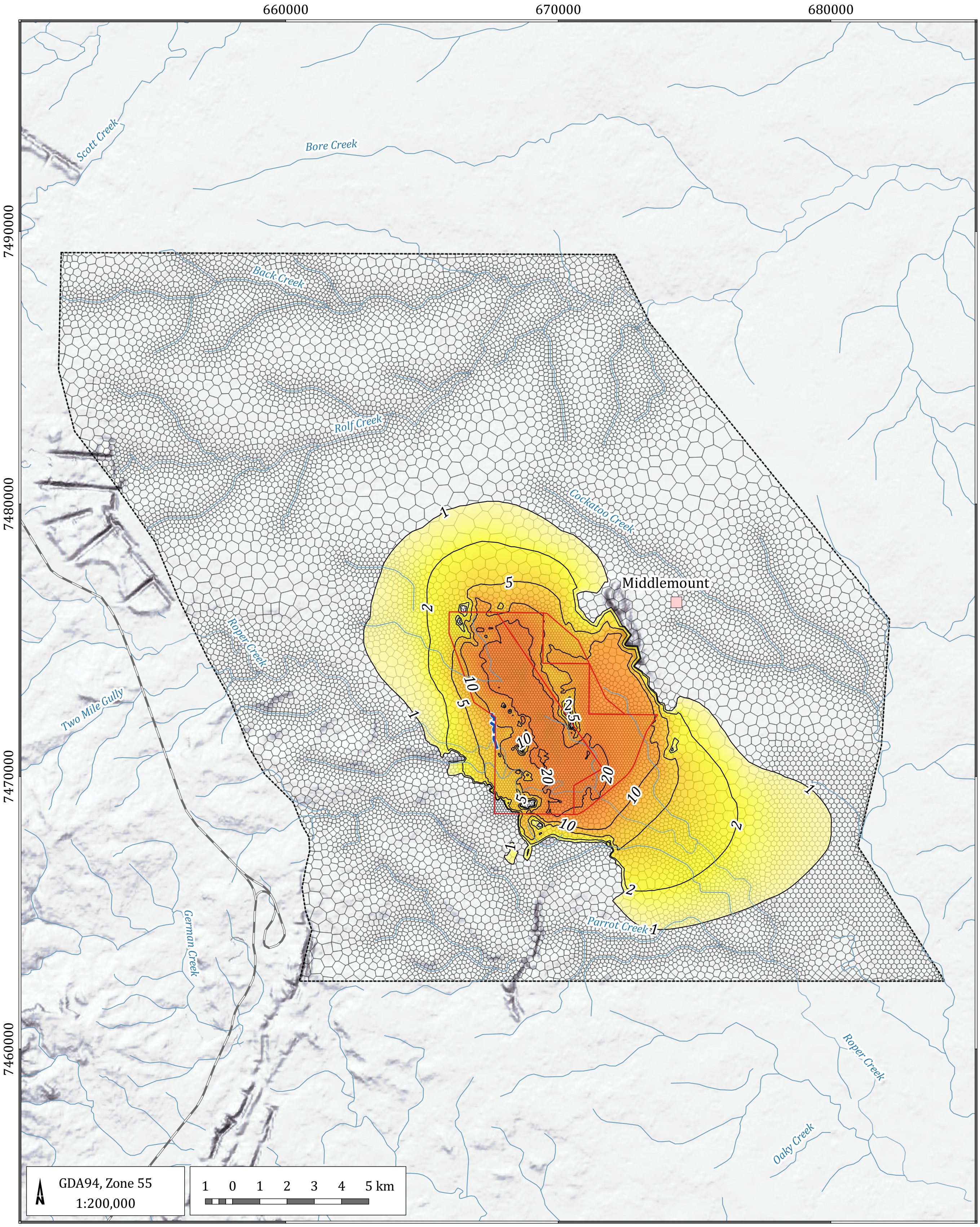
Figure 8.11 to Figure 8.14 show the predicted extent and magnitude of post mining drawdown in the Tertiary and Weathered Permian (layer 3), Middlemount Seam (layer 5), Pisces Seam (layer 7) and the Fort Cooper Coal Measures (layer 16), respectively. As a result of the residual voids remaining as groundwater sinks in perpetuity and the depth to the equilibrium level for the two residual void lakes, the drawdown extents depicted by the 1 m contour is predicted to generally remain constrained around the mine footprint and MLs. Predicted drawdown within the Tertiary and weathered Permian extends up to 2 km from the northern ML boundary. Conversely, predicted drawdown with the Middlemount Seam (layer 5) and Pisces Seam (layer 7) remains constrained by the limited lateral extents of the coal measures within the ML, and only extending up to 3.5 km southwards within the Rangal Coal Measures. This drawdown within the Rangal Coal Measures is predicted to continue to be propagated east of the Jellinbah Fault within the Fort Cooper Coal Measures, where it is predicted to extend up to 3 km to the north and northeast of the ML boundaries towards Middlemount township. No landholder water supply bores are located within the predicted post-mining drawdown extents for the Middlemount Coal Mine (incorporating the Project).

It should also be noted that the model has been setup so there is a continuous and uninhibited hydraulic connection across the model domain for each model layer. In reality, this condition is unlikely to occur given the heterogeneity that most probably naturally occurs with each aquifer unit, and the potential for geological structures to inhibit groundwater movement. It is therefore assessed that the groundwater drawdown predicted at 500 years post mining is conservative and provides a worst case scenario of the potential drawdown extents.

8.4.2 Groundwater intercepted post mining

The WRM modelling indicates the residual voids will gradually fill with water over time and representative pit lake levels of approximately 10 mAHD in the North Void, and 35 mAHD in the South Void have been used for the purposed of post closure groundwater recovery modelling. As the predicted pit lake levels are below pre-mining groundwater levels, the voids would act as a sink and would have a long term ‘water take’.

The Middlemount Coal Mine (incorporating the Project) is estimated to intercept approximately 0.11 ML/day (39.5 ML/year) of groundwater inflow to the residual voids at equilibrium conditions (i.e. based on the modelled representative pit lake levels). This inflow supplements the rainfall and runoff in balancing the pit water level at an equilibrium level. This inflow is only a small component of the overall water balance on the void which is dominated by rainfall, runoff and evaporation.



LEGEND

🟥 Populated place
Drainage feature
Thirteen Mile Gully Diversion
Drawdown contour (m)
Mining Lease boundary (ML)
Model grid
Model boundary

Drawdown (m)

☐	0
🟨	1
🟨	2
🟨	5
🟧	10
🟧	20
🟫	50

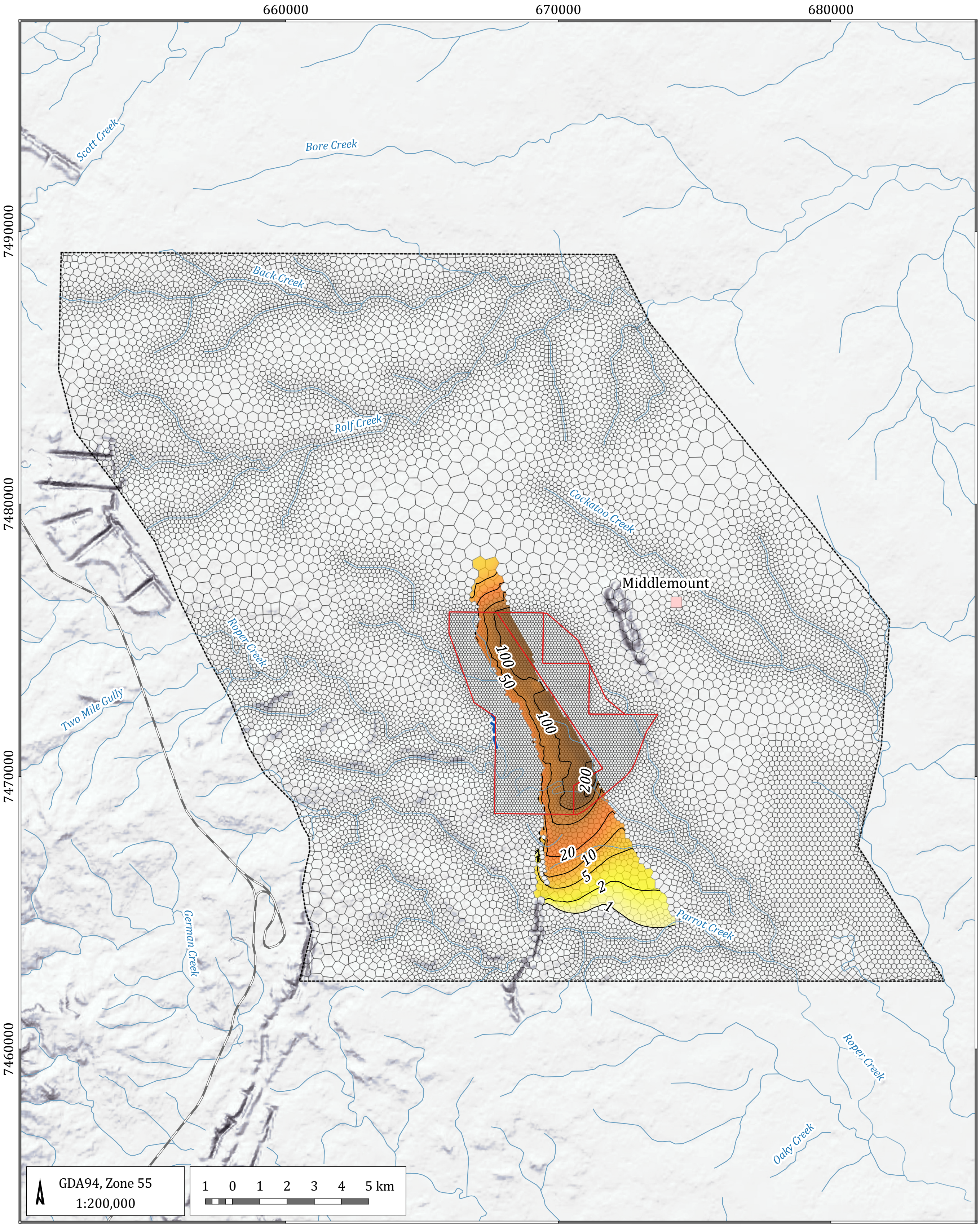
Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Post mining equilibrium drawdown – Tertiary and Weathered Permian (Layer 3)

DATE
24/08/2020

FIGURE No:
8.11

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.11_G1840P_Post mining equilibrium drawdown – Tertiary and Weathered Permian (Layer 3).qgs



LEGEND

- 🟥 Populated place
- — Drainage feature
- – – Thirteen Mile Gully Diversion
- — Drawdown contour (m)
- ☐ Mining Lease boundary (ML)
- ☐ Model grid
- ☐ Model boundary

Drawdown (m)

- ☐ 0
- 🟨 1
- 🟨 2
- 🟨 5
- 🟧 10
- 🟧 20
- 🟧 50
- 🟫 100
- 🟫 200
- 🟫 500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

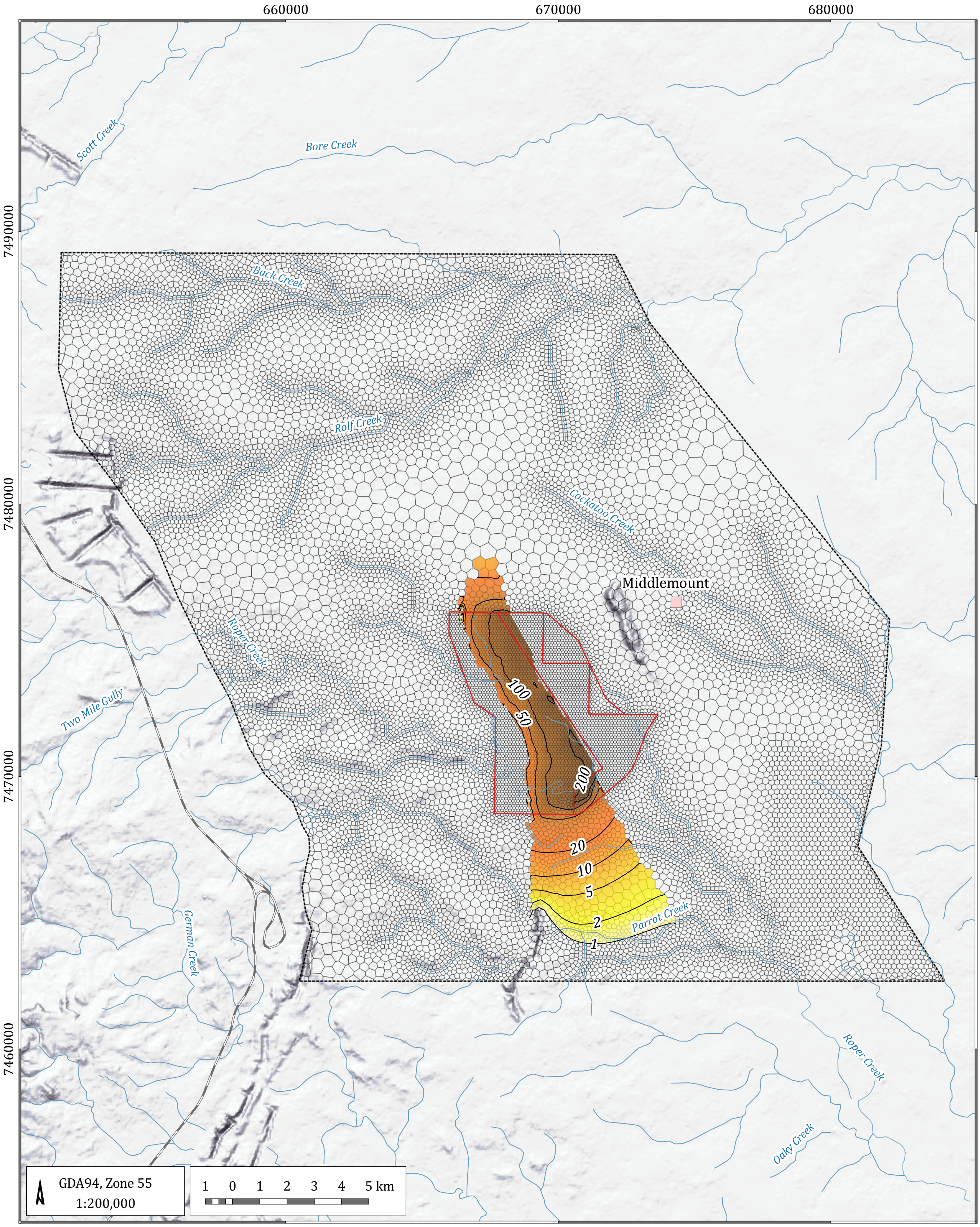
Post mining equilibrium drawdown – Middlemount Seam (layer 5)

AGE

DATE
24/08/2020

FIGURE No:
8.12

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.12_G1840P_Post mining equilibrium drawdown – Middlemount Seam (layer 5).qgs



LEGEND

- 🟥 Populated place
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- Mining Lease boundary (ML)
- Model grid
- Model boundary

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- 500

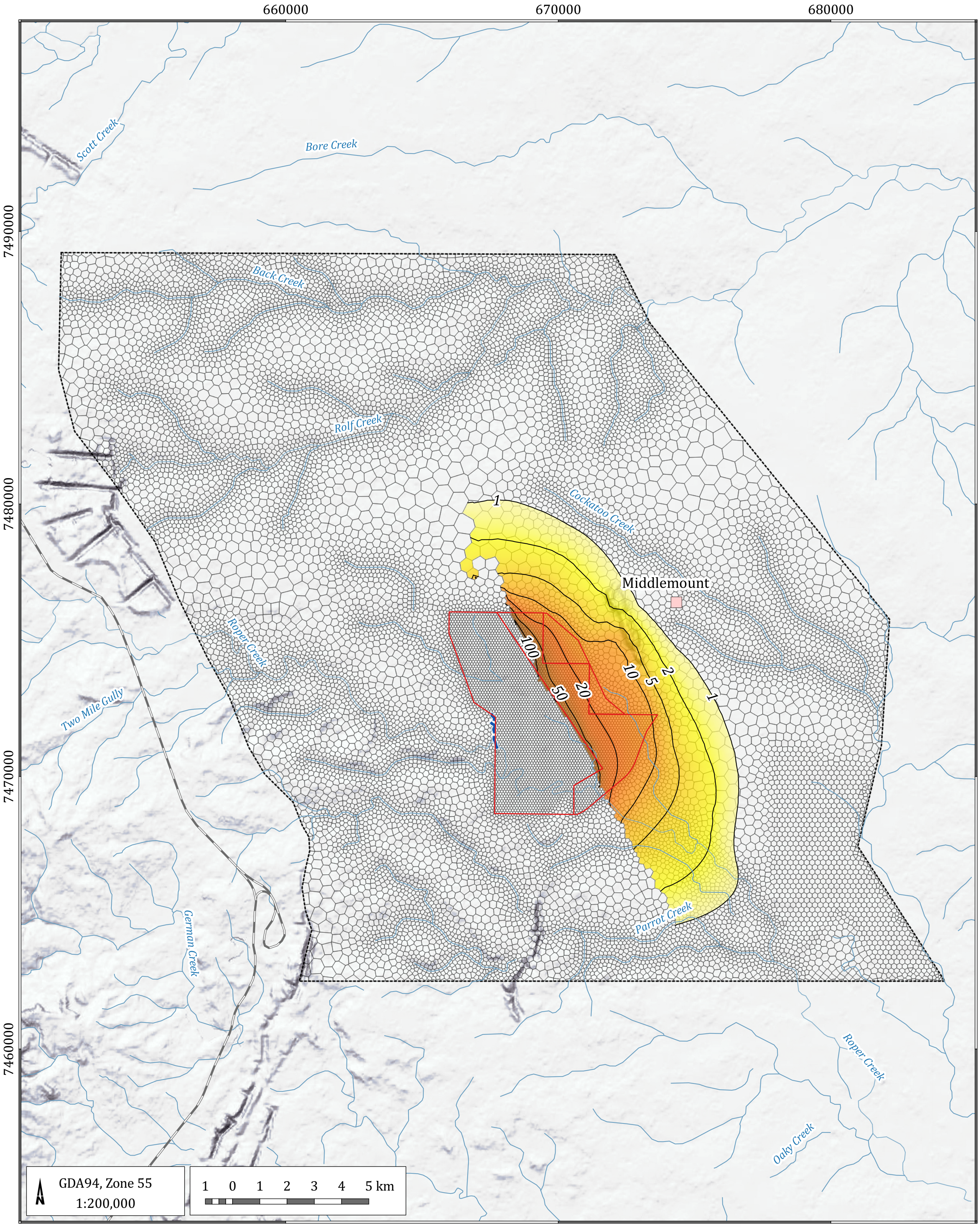
Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Post mining equilibrium drawdown – Pisces Seam (Layer 7)

DATE
24/08/2020

FIGURE No:
8.13

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.13_G1840P_Post mining equilibrium drawdown – Pisces Seam (Layer 7).qgs



LEGEND

- 🟥 Populated place
- Drainage feature
- Thirteen Mile Gully Diversion
- Drawdown contour (m)
- 🟥 Mining Lease boundary (ML)
- ☐ Model grid
- ☐ Model boundary

Drawdown (m)

- ☐ 0
- 🟨 1
- 🟨 2
- 🟨 5
- 🟧 10
- 🟧 20
- 🟫 50
- 🟫 100
- 🟫 200
- 🟫 500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Post mining equilibrium drawdown – Fort Cooper Coal Measures (Layer 16)

AGE

DATE
24/08/2020

FIGURE No:
8.14

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.14_G1840P_Post mining equilibrium drawdown – Fort Cooper Coal Measures (Layer 16).qgs

8.5 Impacts on groundwater quality

This section describes the potential sources of groundwater quality changes associated with the Project.

8.5.1 Overburden emplacement areas and residual void lakes

Although the majority of overburden could be managed as non-acid forming material, there is a risk that some of the coal rejects may have a capacity to generate acid over time if left unmanaged during mining operations (RGS, 2016). The Mining By-Products Management Plan (MCPL, 2013a) and Mining By-Products In-Pit Disposal Site Practice (MCPL, 2013b) describe how mining waste, coarse rejects and tailings will be managed during mining operations. Overburden will continue to be placed within the open cut pits and progressively rehabilitated during mining. Over the life of the Project, surface water runoff and accumulated rainfall seepage will drain towards the voids. Similarly, groundwater will also be drawn in from the surrounding geological units towards the voids. Evaporation from the void lake surfaces will maintain a water level below the surrounding aquifer water levels, forming a groundwater sink in the local environment. Evaporation from the lake surfaces will also slowly concentrate salts in the pit lake over time. The increasing salinity will not pose a risk to other aquifers and surface water features as the residual voids will remain a permanent sink.

8.5.2 Hydrocarbons

There is limited potential for groundwater contamination to occur as a result of hydrocarbon and chemical contamination with provision for immediate clean-up of spills. All chemicals will be transported, handled and stored in accordance with relevant Australian Standards. These controls represent standard practice and a legislated requirement at mine sites for preventing contamination.

8.5.3 Coal rejects storage

Coarse rejects generated at the Middlemount Coal Mine are co-disposed with fine rejects in-pit and encapsulated with waste rock. Fine rejects are currently pumped to one of four tailings cells operated under a rotating place/dry/excavate cycle before being reclaimed by excavators and trucks and trucked to in-pit disposal locations (RGS, 2016). Water from the fine rejects stream is decanted and returned to the site water management system for re-use. This process of managing coarse and fine rejects generated at the Middlemount Coal Mine will continue over the Project life.

As detailed in Section 8.4.1, the residual voids would gradually fill over time from direct rainfall occurring across each void and groundwater seepage, however the water level in the residual voids would remain well below the surrounding groundwater levels. As a result, it is predicted that the residual voids would act as sinks to groundwater flow. Any poor quality water within the in-pit rejects emplacement would be captured in the residual pit void lakes. Evaporation from the residual pit voids would concentrate salts slowly over time. Therefore, there would be little potential for interaction of pit void water with other aquifers or surface water features.

8.5.4 Impacts on environmental values

As discussed in Section 7, the environmental values for groundwaters within the Mackenzie River Sub-basin (DEHP, 2011) that need to be considered include:

- aquatic ecosystems;
- irrigation;
- farm supply/use;
- stock water;
- drinking water;
- industrial purposes; and
- cultural and spiritual values.

The primary agricultural purpose of land within and surrounding the Project area has been for low intensity cattle grazing. However, the groundwater quality data identifies this water would be unsuitable for stock watering based on the naturally elevated TDS levels (Section 7.3). As discussed in Section 8.4.1 the predicted void levels are below pre-mining groundwater levels, and will therefore act as a sink to groundwater flow. Any increase in salinity due to the Project (as a result of evaporation, or from acid generation of rejects or overburden material) will be contained within the residual voids.

Groundwater that seeps into the open cut pit would continue to be recycled. The water would be pumped to holding dams, where it will be incorporated into the mine water balance. Therefore, the Project would provide a beneficial industrial use by supplying water for ongoing operations at the Middlemount Coal Mine.

9 Groundwater monitoring strategy/program

This section of the report provides a recommended groundwater monitoring program that will provide both an on-going assessment of the impact of the Middlemount Coal Mine (incorporating the Project) and a proactive indicator of any adverse impacts on the groundwater regime.

9.1 Monitoring bore network

The MCPL currently maintains a groundwater monitoring program for the approved mining operations in accordance with EA (EPML00716913). With the updates to the mine plan, some of the monitoring bores will be destroyed over the life of the Project. The existing bores will provide a good indication of groundwater response to mining and should be monitored while they are accessible. These monitoring bores will be used to verify predicted groundwater model drawdown responses in these areas that are attributable to mining and the data used in any future model updates.

Details of the groundwater monitoring network are provided in Table 9.1 with their locations shown in Figure 6.2.

Table 9.1 Proposed Middlemount Coal Mine groundwater monitoring network

Monitoring bore	Easting (m)	Northing (m)	Bore depth (m)	Screen depth (m)	Screen lithology	Frequency
MW2	667603	7471239	30.0	21.0 – 29.0	Tertiary	SWL: quarterly * Quality: quarterly
MW3^	670647	7469955	48.0	39.0 – 47.0	Tertiary	SWL: quarterly * Quality: quarterly
MW4	667683	7468659	50.0	41.0 – 50.0	Intrusives and Girrah coal seam (Fort Cooper Coal Measures)	SWL: quarterly * Quality: quarterly
MW5	668786	7469364	46.0	40.0 – 46.0	Pisces coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW6	669452	7468670	42.0	37.0 – 42.0	Tertiary	SWL: quarterly Quality: quarterly
MW5M^	667790	7475131	131.0	127.0 – 130.0	Middlemount coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW5P^	667796	7475130	169.0	165.0 – 168.0	Pisces coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW7P^	669777	7472247	194.5	189.5 – 193.5	Pisces coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW8FR^	669941	7472277	151.0	147.0 – 150.0	Fort Cooper Coal Measures	SWL: quarterly * Quality: quarterly
MW9A^	670246	7469610	52.0	40.0 – 52.0	Tertiary	SWL: quarterly * Quality: quarterly
MW9M^	670243	7469619	139.5	135.0 – 138.0	Middlemount coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW9P^	670251	7469592	204.0	200.0 – 203.0	Pisces coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly
MW10A	669783	7475981	12.0	6.0 – 9.0	Tertiary	SWL: quarterly Quality: quarterly

Monitoring bore	Easting (m)	Northing (m)	Bore depth (m)	Screen depth (m)	Screen lithology	Frequency
MW11A	672355	7472275	13.5	10.5 – 13.5	Tertiary	SWL: quarterly Quality: quarterly
MW12A	671640	7469853	10.55	6.0 – 10.55	Tertiary	SWL: quarterly Quality: quarterly
MW13A	669032	7468890	15.0	9.0 – 14.95	Tertiary	SWL: quarterly * Quality: quarterly
MW16A#	666878	7472826	50	44-50	Tertiary and weathered FCCM	SWL: quarterly * Quality: quarterly
MW17A#	669791	7475983	42.5	42.5	Weathered and fresh Fort Cooper Coal Measures	SWL: quarterly * Quality: quarterly
MW18A#	666444	7478622	24.5	18.5 – 24.5	Tertiary and weathered Fort Cooper Coal Measures	SWL: quarterly * Quality: quarterly
MW19 VWP#	671659	7469856	163	• 50 • 109 • 150	Weathered to fresh Fort Cooper Coal Measures	SWL: quarterly
MW20 VWP#	672817	7471547	157	• 88 • 131.5#	Fort Cooper Coal Measures	SWL: quarterly

Notes: *Coordinates in GDA94Z55*

** recommend installation of a datalogger in addition to manual quarterly water level measurements*

 # Sensor believed to be faulty.

^Indicates bore will be mined out during the Project life.

9.2 Water level monitoring plan

It is recommended that groundwater level monitoring continue to be undertaken quarterly to establish baseline data for groundwater levels in each monitoring bore. Manual monitoring is suitable for identification of long term trends in groundwater levels but does not provide data on short term events such as rainfall recharge that can occur within a monthly monitoring cycle.

Electronic water level loggers have been installed in monitoring bores MW16A, MW17A and MW18A and the VWPs. It is therefore recommended that for the long term monitoring of groundwater levels, electronic water level loggers are installed in additional selected monitoring bores and set to record groundwater level measurements at regular intervals (i.e. at least daily or even every six-hours). This will enable continuous measurement of groundwater level fluctuations to determine to what extent these are attributable to rainfall recharge or from declining water level from depressurisation resulting from open cut mining. Quarterly manual measurements should still be conducted to verify the electronic water level data.

It is recommended that the groundwater level monitoring program be reviewed throughout the life of the Project to determine any updates required to the monitoring network as monitoring bores are mined through (Table 9.1).

9.3 Water quality monitoring plan

Groundwater quality sampling of existing monitoring bores should continue in order to provide long-term groundwater quality dataset, and to detect any changes in groundwater quality during and post mining.

The full groundwater quality suite should continue to include:

- physio-chemical parameters – pH, EC, TDS;
- major ions – calcium, magnesium, sodium, potassium, chloride, sulphate, alkalinity (carbonate and bicarbonate);
- total and dissolved metals –iron, mercury, and selenium; and
- TPHs – C10-14, C15-28, and C29-36.

All groundwater monitoring, water level measurements and sample collection, storage and transportation should be undertaken in accordance with the procedures outlined by the Murray Darling Basin Commission (1997) and the DES (2018).

9.4 Groundwater triggers

The aim of trigger levels is to provide advanced warning of water quality and water level trends that may be departing from historical or predicted values. Once groundwater monitoring data has been accepted, processed, and input into the relevant GWDB, the data will be compared against the trigger limit values and thresholds for the various parameters prescribed by the EA conditions.

9.4.1 Groundwater quality trigger values

Groundwater quality trigger values developed for the Middlemount Coal Mine (incorporating the Project) provide a threshold, above which some further consideration of the data should be given. The trigger values are not a pass or fail assessment, but act as a warning system that initiates further investigation and response.

The water quality datasets collected between May 2013 and December 2019 identifies the water is typically saline making it unsuitable for stock watering, and supports the 2017 bore census which identified no significant use of groundwater by landholders surrounding the Middlemount Coal Mine. Review of the environmental values identifies that groundwater accessed by the Middlemount Coal Mine (incorporating the Project) would only provide a beneficial use for industrial purposes.

Similar to water level trigger thresholds, groundwater quality triggers are defined in Table C8 of the EA EPML00716913 (dated 26 February 2020). These groundwater triggers are presented in Table 9.2.

Table 9.2 Groundwater investigation trigger levels

Parameter^	Unit	Trigger value	Limit type	Recommended amendments	
				Trigger value	Limit type
pH	pH units	6.5-8.5	Minimum / Maximum	6.5-8.5	Minimum of median/ Maximum of median
EC	µS/cm	35,000	Maximum	35,000	Median
TDS	mg/L	23,550	Maximum	23,550	Median
Calcium	mg/L	1,000	Median	1,000	Median
Magnesium	mg/L	2,000	Median	2,000	Median
Sodium	mg/L	6,700	Median	6,700	Median

Parameter^	Unit	Trigger value	Limit type	Recommended amendments	
				Trigger value	Limit type
Potassium	mg/L	43	Median	43	Median
Chloride	mg/L	12,700	Median	12,700	Median
Sulfate (SO_4)	mg/L	2,000	Median	2,000	Median
Carbonate (CO_3)	mg/L	7.7	Median	7.7	Median
Bicarbonate (HCO_3)	mg/L	800	Median	800	Median
Iron	mg/L	14	Maximum	14	Median
Mercury	mg/L	0.002	Maximum	0.002	Median
Selenium	mg/L	0.034*	Maximum	Revise to 0.05	Median
TPHs (C10-C14)	µg/L	50	Maximum	50	Median
TPHs (C15-C28)	µg/L	185	Maximum	185	Median
TPHs (C29-C36)	µg/L	90	Maximum	90	Median

Notes: ^ *Silver was removed from Table C8 of EA EMPL00716913 in a minor amendment dated 21 May 2018.*

* *Trigger value changed from 0.02 to 0.034 in a minor amendment dated 21 May 2018.*

In 2017, a review of the EA triggers (i.e. in the EA dated 22 August 2017) identified several inappropriate or unsuitable conditions in the EA in relation to the groundwater triggers, and recommended changes that would ensure a greater level of compliance, while maintaining the protection of environmental values (AGE, 2017a). Recommendation was provided for adopting the median-type trigger value for all other parameters (except pH) which would be more appropriate for eliminating false exceedances that are isolated occurrences. Since the 2017 review, the number of bores to which water quality triggers apply was expanded to include all bores listed on Table 9.1. Additions to the water quality network includes the recently installed bores (MW16A, MW17A, and MW18A) and five additional bores that are screened in the Pisces and Middlemount Coal Seams (MW5P, MW5M, MW7P, MW7M, MW8FR, MW9P, MW9M). Investigations of trigger exceedances (AGE, 2017c; AGE, 2018b; AGE, 2018c; AGE, 2019; AGE, 2020) since the 2017 review of the EA triggers, evaluated the potential causes of the exceedances and the potential for any resultant environmental harm.

These reports indicated the exceedances in relation to:

- TDS, bicarbonate and sodium that are related to high salinity and would have no change in the environmental values of the groundwater.
- Selenium that are related to a higher limit of reporting value (0.05 mg/L) for samples that require a five-fold dilution for laboratory analysis due to their salinity.
- TPH were short term and probably not representative of petrogenic hydrocarbons linked to mining activities. These exceedances have decreased following the use of the silica-gel clean-up method recommended by Australian Laboratory Services Pty Ltd (ALS code EP071-SG) and also following additional purging of one of the newly installed bores.

The exceedances in these parameters were not expected to have any impact on the potential groundwater use or environmental values, and AGE, 2020 provided recommendation for:

- increasing the trigger value for selenium to 0.05 mg/L, which is equivalent to the limit of reporting for samples that require a five-fold dilution due to high salinity;
- amending the EC and TDS to "median-type" and pH to maximum and minimum of the median values; and
- revisiting the triggers for EC, bicarbonate, and sodium after two full years of data becomes available from the expanded water quality monitoring regime.

9.4.2 Groundwater level trigger thresholds

The existing monitoring bore network is located both within and surrounding the approved and proposed mining footprint. These bores are therefore expected to measure drawdown that will range from a few metres to tens of metres. Drawdown compared to the predictions of groundwater drawdown for the Middlemount Coal Mine (incorporating the Project) will be used to identify divergence between predicted and observed measurements, and assess the likely causes of these discrepancies.

Table 9.3 presents the current groundwater level trigger thresholds as defined in Table C10 of the EA EPML00716913 (dated 26 February 2020) for the existing monitoring bores, outside of normal seasonal fluctuations. These are provided either as a change in water level per year, or as a total change in the groundwater elevation (mAHD) as determined from the total predicted drawdown from the initial water level at for bores MW3, MW6 and MW9A. If the results, when compared to the groundwater level trigger thresholds, do not exceed the level trigger thresholds, then no further action is required. If they exceed the trigger level thresholds; an exceedance investigation and response will be initiated.

Table 9.3 Groundwater level trigger thresholds

Monitoring location	Current EA-EPML00716913 trigger level threshold [a]	Predicted maximum drawdown from groundwater model (m) [a]	Recommended amendments to trigger threshold
MW2	> 2 metres per year	4.17	No change to trigger
MW3[b]	Total groundwater level of < 115.39 metres AHD	11.9	No change to trigger
MW4	> 2 metres per year	0.0	No change to trigger or remove from EA
MW5	Total groundwater level of < 116.9 metres AHD	15.1	Bore is currently dry in line with model predictions - remove from EA
MW6	> 2 metres per year	11.6	Total groundwater level of < 122.15 metres AHD
MW9A[b]	Total groundwater level of < 118.17 metres AHD	13.6	Total groundwater level of < 113.17 metres AHD
MW10A	> 2 metres per year	0.0	No change to trigger
MW11A	> 2 metres per year	0.0	No change to trigger
MW12A	> 2 metres per year	7.7	No change to trigger
MW13A	> 2 metres per year	0.0	No change to trigger
MW16A	Total groundwater level of < 129.2 metres AHD	3.0	No change to trigger

Monitoring location	Current EA-EPML00716913 trigger level threshold [a]	Predicted maximum drawdown from groundwater model (m) [a]	Recommended amendments to trigger threshold
MW17A	Total groundwater level of < 135.6 metres AHD	2.1	No change to trigger
MW18A	> 2 metres per year	0.1	No change to trigger
MW19 VWP-VW3	Total groundwater level of < 130.8 metres AHD	10.2	No change to trigger
MW19 VWP-VW2	> 2 metres per year	5.8	No change to trigger
MW19 VWP-VW1	> 2 metres per year	5.8	No change to trigger
MW20 VWP-VW2	> 2 metres per year	0.4	No change to trigger

Notes: *a: The level trigger threshold is equal to the groundwater level drawdown observed within each monitoring bore measured from the commencement of mining.*

b: Will continue to be monitored until progression prevents monitoring. MW9A was installed as a replacement well for MW3.

Review of the maximum drawdown levels for the monitoring bores listed in the EA (dated 26 February 2020) indicates the trigger level for MW6 and MW9A would need to be revised to reflect the predicted change in groundwater elevation (mAHD) at these locations. Bore MW5 should be removed from the EA as this bore has become dry. This is in line with the groundwater model predictions for the Pisces coal seam becoming dry in this part of the mine between 2020 and 2025. Since MW5 is located at the western extents of the Pisces coal seam sub-crop, consideration for a replacement bore should be to the south where the Pisces coal seam is likely to be saturated.

9.5 Mine groundwater inflow monitoring

MCPL currently assess groundwater pit inflows through review of pumping records of pit de-watering and the site water balance model to identify inflow/seepage rates. Water samples should also be collected of any pumped seepage and include laboratory analysis for same suite of parameters for the groundwater monitoring bores to assist in identifying the source of groundwater inflows. The groundwater pit inflow monitoring program should include:

- recording of any unexpected or significantly increased groundwater inflows directly to the pits;
- metered measurement of water pumped from the pits;
- sampling of water quality pumped from the pits;
- monitoring of rainfall (to allow for correlation with pumping/pit inflow records); and
- records of ROM and product coal moisture content.

9.6 Data management and reporting

MCPL would continue to prepare an annual groundwater monitoring report in accordance with Condition C42 of Environmental Authority EPML00716913. The annual monitoring report includes:

- records of groundwater levels and quality in the monitoring network bores; and
- details of any review undertaken of the groundwater model since the previous annual monitoring report.

10 Conclusions

This report has evaluated the impact of the Middlemount Coal Mine (incorporating the Project). The Project involves extending the continued operation of the Middlemount Coal Mine for approximately seven years at the currently approved rate of 5.7 Mtpa, which requires an EA amendment. The study has built on results from the previous groundwater assessments (AGE, 2018a), groundwater level data, groundwater chemistry data and the geological data available for the Project area. The conclusions of the assessment of the Project on the groundwater resources are listed below:

- The primary groundwater units impacted by the Project are the Tertiary Duaringa Formation and weathered Permian Rangal Coal Measures where these sediments are saturated.
- There are no landholder water supply bores located within the predicted drawdown extents attributable to the proposed mine plan for the Project.
- The bore census undertaken for the previous groundwater assessment for the Western Extension Project identified no use of groundwater from both the Tertiary Duaringa Formation and Permian Rangal Coal Measures surrounding the Project. This is due to the aquifers being either unsaturated or partially unsaturated in the vicinity of the Middlemount Coal Mine (as is the case with the shallower groundwater hosted within the Tertiary Duaringa Formation and weathered Permian Rangal Coal Measures), or saline as is the case for both the Tertiary Duaringa Formation and Permian Rangal Coal Measures.
- Assessment of the cumulative impacts with other nearby operating mines and the Bowen Gas Project CSG activities predicts cumulative drawdown within the Tertiary and weathered Permian between the Project and Foxleigh Mine, and the Middlemount Seam (1 m contour), Pisces Seam (5 m contour), and Fort Cooper Coal Measures (1 m contour) intersecting roughly midway between the Project and the German Creek East voids.
- There are no watercourses with associated productive alluvial aquifers within the Project area and there will be no impact from mining on localised shallow alluvial or perched aquifers that may be associated with minor surface drainage features within the Project area.
- The residual voids will act as long-term groundwater sinks post mining, this will result in the long-term water quality within the residual voids being affected by evaporative concentration and becoming more saline. However, flow of this water into the groundwater systems will be prevented as a consequence of the lower water level within the voids.
- Although the overburden consists primarily of non-acid forming material, coal rejects and overburden material will be contained within in-pit storage emplacements, which will act as a sink to groundwater flow. As such, any resultant impact to void water quality will be contained at the site.

These findings are generally consistent with the findings of the Western Extension Project Groundwater Assessment (AGE, 2018). Accordingly, the Project would have a negligible incremental impact on groundwater resources.

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Appendix A IESC Guidelines

A1 Independent Expert Scientific Committee guidelines

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development has information guidelines for advice on coal seam gas and large coal mining development proposals. The following section specifies where the IESC information requirements for individual proposals have been addressed within this report.

A1.1 Description of the proposal

Project Information	Addressed in section
Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, present and reasonably foreseeable coal mining and CSG developments.	Sections 1, 2, 4, 5, & 6
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies or regulations..	Sections 1.1, 3, & 7
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Sections 1, 6 & 8
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 3 & 7

A1.2 Risk Assessment

Project Information	Addressed in section
Identify and assess all potential environmental risks to water resources and water-related assets, and their possible impacts. In selecting a risk assessment approach consideration should be given to the complexity of the project, and the probability and potential consequences of risks.	Sections 6, 7, 8 & Appendix F
Assess risks following the implementation of any proposed mitigation and management options to determine if these will reduce risks to an acceptable level based on the identified environmental objectives.	Section 8 & Appendix F
Incorporate causal mechanisms and pathways identified in the risk assessment in conceptual and numerical modelling. Use the results of these models to update the risk assessment.	Section 8 & Appendix F
The risk assessment should include an assessment of: • all potential cumulative impacts which could affect water resources and water-related assets; and, • mitigation and management options which the proponent could implement to reduce these impacts..	Sections 8 & 9

A1.3 Groundwater – Context and conceptualisation

Project Information	Addressed in section
Describe and map geology at an appropriate level of horizontal and vertical resolution including: • definition of the geological sequence(s) in the area, with names and descriptions of the formations and accompanying surface geology, cross-sections and any relevant field data. • geological maps appropriately annotated with symbols that denote fault type, throw and the parts of sequences the faults intersect or displace.	Section 5 Section 5
Define and describe or characterise significant geological structures (e.g. faults, folds, intrusives) and associated fracturing in the area and their influence on groundwater – particularly groundwater flow, discharge or recharge. • Site-specific studies (e.g. geophysical, coring / wireline logging etc.) should give consideration to characterising and detailing the local stress regime and fault structure (e.g. damage zone size, open/closed along fault plane, presence of clay/shale smear, fault jogs or splays). • Discussion on how this fits into the fault's potential influence on regional-scale groundwater conditions should also be included.	Section 5.8, 6.10 & 6.12
Provide site-specific values for hydraulic parameters (e.g. vertical and horizontal hydraulic conductivity and specific yield or specific storage characteristics including the data from which these parameters were derived) for each relevant hydrogeological unit. In situ observations of these parameters should be sufficient to characterise the heterogeneity of these properties for modelling.	Section 6
Provide time series level and water quality data representative of seasonal and climatic cycles.	Section 6 & Appendix E
Provide data to demonstrate the varying depths to the hydrogeological units and associated standing water levels or potentiometric heads, including direction of groundwater flow, contour maps, and hydrographs. All boreholes used to provide this data should have been surveyed.	Section 6
Provide hydrochemical (e.g. acidity/alkalinity, electrical conductivity, metals, and major ions) and environmental tracer (e.g. stable isotopes of water, tritium, helium, strontium isotopes, etc.) characterisation to identify sources of water, recharge rates, transit times in aquifers, connectivity between geological units and groundwater discharge locations	Section 6
Describe the likely recharge, discharge and flow pathways for all hydrogeological units likely to be impacted by the proposed development.	Section 6
Assess the frequency (and time lags if any), location, volume and direction of interactions between water resources, including surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water	Section 6

A1.4 Groundwater – Numerical modelling

Project Information	Addressed in section
Provide a detailed description of all analytical and/or numerical models used, and any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Section 8 & Appendix F
Undertaken groundwater modelling in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), including independent peer review.	Appendix F1.1
Calibrate models with adequate monitoring data, ideally with calibration targets related to model prediction (e.g. use baseflow calibration targets where predicting changes to baseflow).	Section 8.2.3 & Appendix F
Describe each hydrogeological unit as incorporated in the groundwater model, including the thickness, storage and hydraulic characteristics, and linkages between units, if any.	Appendix F4.4
Describe the existing recharge/discharge pathways of the units and the changes that are predicted to occur upon commencement, throughout, and after completion of the proposed project.	Appendix F4.8
Describe the various stages of the proposed project (construction, operation and rehabilitation) and their incorporation into the groundwater model. Provide predictions of water level and/or pressure declines and recovery in each hydrogeological unit for the life of the project and beyond, including surface contour maps for all hydrogeological units..	Sections 8.3 & Appendix F
Identify the volumes of water predicted to be taken annually with an indication of the proportion supplied from each hydrogeological unit.	Section 8.3
Undertake model verification with past and/or existing site monitoring data.	Appendix F4
Provide an explanation of the model conceptualisation of the hydrogeological system or systems, including multiple conceptual models if appropriate. Key assumptions and model limitations and any consequences should also be described.	Section 6 & Appendix F2.3
Consider a variety of boundary conditions across the model domain, including constant head or general head boundaries, river cells and drains, to enable a comparison of groundwater model outputs to seasonal field observations.	Appendix F4.2
Undertake sensitivity analysis and uncertainty analysis of boundary conditions and hydraulic and storage parameters, and justify the conditions applied in the final groundwater model (see Middlemis and Peeters [in press]).	Appendix F7
Provide an assessment of the quality of, and risks and uncertainty inherent in, the data used to establish baseline conditions and in modelling, particularly with respect to predicted potential impact scenarios.	Section 6
Undertake an uncertainty analysis of model construction, data, conceptualisation and predictions (see Middlemis and Peeters [in press]).	Appendix F7
Provide a program for review and update of models as more data and information become available, including reporting requirements.	Section 9
Provide information on the magnitude and time for maximum drawdown and post-development drawdown equilibrium to be reached.	Sections 8.3 & 8.4

A1.5 Groundwater – Impacts on water resources and water dependent assets

Project Information	Addressed in section
Provide an assessment of the potential impacts of the proposal, including how impacts are predicted to change over time and any residual long-term impacts. Consider and describe:	
• any hydrogeological units that will be directly or indirectly dewatered or depressurised, including the extent of impact on hydrological interactions between water resources, surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water.	Section 8.3.2
• the effects of dewatering and depressurisation (including lateral effects) on water resources, water-dependent assets, groundwater, flow direction and surface topography, including resultant impacts on the groundwater balance.	Section 8.3
• the potential impacts on hydraulic and storage properties of hydrogeological units, including changes in storage, potential for physical transmission of water within and between units, and estimates of likelihood of leakage of contaminants through hydrogeological units.	N/A
• the possible fracturing of and other damage to confining layers.	N/A
• For each relevant hydrogeological unit, the proportional increase in groundwater use and impacts as a consequence of the proposed project, including an assessment of any consequential increase in demand for groundwater from towns or other industries resulting from associated population or economic growth due to the proposal	N/A
Describe the water resources and water-dependent assets that will be directly impacted by mining or CSG operations, including hydrogeological units that will be exposed/partially removed by open cut mining and/or underground mining..	Section 8.3.3
For each potentially impacted water resource, provide a clear description of the impact to the resource, the resultant impact to any water-dependent assets dependent on the resource, and the consequence or significance of the impact.	Section 8.3
Describe existing water quality guidelines, environmental flow objectives and other requirements (e.g. water planning rules) for the groundwater basin(s) within which the development proposal is based.	Sections 7
Provide an assessment of the cumulative impact of the proposal on groundwater when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 8.3.3
Describe proposed mitigation and management actions for each significant impact identified, including any proposed mitigation or offset measures for long-term impacts post mining.	Section 9
Provide a description and assessment of the adequacy of proposed measures to prevent/minimise impacts on water resources and water-dependent assets.	Section 9 and refer to Receiving Environment Monitoring Program

A1.6 Groundwater – Data and monitoring

Project Information	Addressed in section
Provide sufficient data on physical aquifer parameters and hydrogeochemistry to establish pre-development conditions, including fluctuations in groundwater levels at time intervals relevant to aquifer processes.	Sections 6 & 9
Develop and describe a robust groundwater monitoring program using dedicated groundwater monitoring wells – including nested arrays where there may be connectivity between hydrogeological units – and targeting specific aquifers, providing an understanding of the groundwater regime, recharge and discharge processes and identifying changes over time.	Section 9
Develop and describe proposed targeted field programs to address key areas of uncertainty, such as the hydraulic connectivity between geological formations, the sources of groundwater sustaining GDEs, the hydraulic properties of significant faults, fracture networks and aquitards in the impacted system, etc., where appropriate.	Section 9
Provide long-term groundwater monitoring data, including a comprehensive assessment of all relevant chemical parameters to inform changes in groundwater quality and detect potential contamination events.	Section 9
Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 9

A1.7 Water dependent assets – Context and conceptualisation

Project Information	Addressed in section
Identify water-dependent assets, including: • water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). • public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Sections 6.8, 6.9 & 7
Identify GDEs in accordance with the method outlined by Eamus *et al*. (2006). Information from the GDE Toolbox (Richardson *et al*. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody *et al*. [in press]).	Section 6.8
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Section 6. 8
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody *et al*. [in press]).	Section 6. 8
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody *et al*. [in press]).	Section 6. 8
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 8.3.5
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 8.3.5

A1.8 Water dependent assets – Impacts, risk assessment and management of risks

Project Information	Addressed in section
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody *et al*. [in press]).	Section 8.3.5
Describe the potential range of drawdown at each affected bore, and clearly articulate of the scale of impacts to other water users.	Section 8.3.4
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Sections 8.5
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 8.4
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Refer to Surface Water Assessment
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 8.3.5
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 8.3.5
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 9

A1.9 Water dependent assets – Data and monitoring

Project Information	Addressed in section
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody *et al*. [in press]).	Section 9
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody *et al*. [in press]).	Section 9
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody *et al*. [in press]).	Section 9
Describe the proposed process for regular reporting, review and revisions to the monitoring program.	Section 9
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna [QLD Government 2015]).	Refer to Receiving Environment Monitoring Program

A1.10 Water and salt balance and water management strategy

Project Information	Addressed in section
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Refer to Surface Water Assessment
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Refer to Surface Water Assessment
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Refer to Surface Water Assessment
Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	Refer to Surface Water Assessment

A1.11 Cumulative Impacts – Context and conceptualisation

Project Information	Addressed in section
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 8.3.3
Consider all past, present and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 8.3.3

A1.12 Cumulative Impacts – Impacts

Project Information	Addressed in section
Provide an assessment of the condition of affected water resources which includes: • identification of all water resources likely to be cumulatively impacted by the proposed development; • a description of the current condition and quality of water resources and information on condition trends; • identification of ecological characteristics, processes, conditions, trends and values of water resources; • adequate water and salt balances; and, • identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	Section 8.3.3
Assess the cumulative impacts to water resources considering: • the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally; • all stages of the development, including exploration, operations and post closure / decommissioning; • appropriately robust, repeatable and transparent methods; • the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and, • opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	Sections 8.3 & 8.4

A1.13 Cumulative Impacts – Mitigation, monitoring and management

Project Information	Addressed in section
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided..	Refer to Surface Water Assessment
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Refer to Surface Water Assessment
Identify cumulative impact environmental objectives.	Refer to Surface Water Assessment
Describe appropriate reporting mechanisms.	Refer to Surface Water Assessment
Propose adaptive management measures and management responses.	Refer to Surface Water Assessment

A1.14 Final landform and voids – coal mines

Project Information	Addressed in section
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 8.4
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	Section 8.4
Provide an evaluation of stability of void slopes where failure during extreme events or over the long term (for example due to aquifer recovery causing geological heave and landform failure) may have implications for water quality.	Section 8.5
Evaluate mitigating inflows of saline groundwater by planning for partial backfilling of final voids.	Section 8.5
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: • groundwater behaviour – sink or lateral flow from void. • water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). • seepage – geochemistry and potential impacts. • long-term water quality, including salinity, pH, metals and toxicity. • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Sections 8.4 & 8.5
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	Sections 8.4 & 8.5

A1.15 Acid-forming materials and other contaminants of concern

Project Information	Addressed in section
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	Sections 5.9 & 8.5
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	Section 8.5
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	Sections 6.6.4 & 6.7.4
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, and encapsulation).	Section 8.5.3
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	Section 8.3.5
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	Section 8.5

Appendix B **DNRME groundwater data base bores**

Table B.1 Summary of DNRME existing registered bores within a 10 km buffer zone

RN	Bore name	Date drilled	Screen/perforation/ open hole (from... mbGL to... mbGL)	Drilling depth (mbGL)	SWL (mbGL)	Yield (L/s)	Water quality (µS/cm)	Aquifer
43060	Rolfs bore	1/02/1973	-	54	21.2	0.7	14,360	-
43474	Three mile bore	2/07/1965	Open hole 21.3 - 41.0m	41.1	18.1	no data	no data	Clay[a]
43063	House Bore 3*	-	-	-	12.09	0.7	4,430	Coal *
47037	Blanches bore	19/11/1972	Open hole 23.2 - 35.7m	35.7	15.1	0.38	2,290	Back Creek Group
132459	MW6	3/06/2008	37.0 – 42.0 (screen)	42.0	43.5	1.0	Potable	Duaringa Formation
151043	MW2	5/06/2006	21.0 – 29.0 (screen)	30.0	no data	no data	no data	Duaringa Formation
151335	MW4	4/06/2008	41.0 – 50.0 (screen)	50.0	no data	no data	no data	Fort Cooper Coal Measures
151336	MW3	4/06/2008	39.0 – 47.0 (screen)	48.0	no data	no data	no data	Duaringa Formation
151658	MW5	4/06/2008	40.0 – 46.0 (screen)	46.0	no data	no data	no data	Pisces coal seam
158679	MW7P	24/07/2010	189.5 – 193.5 (screen)	194.5	no data	no data	no data	Pisces coal seam
158771	no data	17/04/2014	23.5 – 26.5 (screen)	27.0	no data	no data	no data	Sandstone/siltstone
158772	no data	18/04/2014	9.2 – 12.2 (screen)	12.2	no data	no data	no data	Sandstone
158773	no data	17/04/2014	37.5 – 40.5 (screen)	41.0	no data	no data	no data	Granite
161060	MW5M	24/07/2010	127.0 – 130.0 (screen)	131.0	43.5	1.0	Potable	Middlemount coal seam
161061	MW5P	24/07/2010	165.0 – 168.0 (screen)	169.0	no data	no data	no data	Pisces coal seam
161062	MW7M	19/06/2010	132.0 – 134.5 (screen)	135.5	no data	no data	no data	Middlemount coal seam
161063	MW8FR	25/07/2010	147.0 – 150.0 (screen)	151.0	no data	no data	no data	Fort Cooper Coal Measures
161064	MW9A	27/07/2010	40.0 – 52.0 (screen)	52.0	no data	no data	no data	Duaringa Formation

RN	Bore name	Date drilled	Screen/perforation/ open hole (from... mbGL to... mbGL)	Drilling depth (mbGL)	SWL (mbGL)	Yield (L/s)	Water quality (µS/cm)	Aquifer
161065	MW9M	27/07/2010	135.0 – 138.0 (screen)	139.5	no data	no data	no data	Middlemount coal seam
161066	MW9P	28/07/2010	200.0 – 203.0 (screen)	201.0	24.4	0.2	-	Pisces coal seam
165439	MB2	30/06/2017	50.0 – 62.0 (screen)	62.0	no data	no data	14,020	Coal / Sandstone
165440	MB3	2/07/2017	38.0 – 50.0 (screen)	50.0	37.0	no data	no data	Coal / Sandstone
165443	MB6	7/07/2017	45.0 – 54.0 (screen)	54.0	no data	no data	no data	Sandstone / Coal / Diorite (intrusion)
165444	-	8/07/2017	21.0 – 36.0 (screen)	36.0	22.2	0.41	Salty	Coal / Sandstone
165460	RDF1047_P2	5/08/2017	24.0 – 51.0 (screen)	51.0	no data	no data	3,074	Duaringa Formation
165461	RDF1047_P1	6/08/2017	181.0 – 190.0 (screen)	201.0	no data	7.1	3,072	Blackwater Group
165462	RDF1033 P1	8/08/2017	156.0 – 162.0 (screen)	170.0	no data	7.1	Salty	Blackwater Group
165463	RDF1033_P2	8/08/2017	12.0 – 30.0 (screen)	27.0	12.0	0.1	3,125	Duaringa Formation
165464	RDF1056_P1	9/08/2017	129.0 – 138.0 (screen)	138.0	no data	0.2	3,970	Blackwater Group
165486	-	31/10/2017	35.0 – 101.0 (screens)	115.0	no data	0.5	3,240	Blackwater Group
165615	-	19/08/2018	18.8 – 24.5 (screens)	24.5	no date	no date	no date	Duaringa Formation

***Notes**:* *Table A.1 excludes CSG bores*

mbGL metres below ground level

\- *no information provided*

* *details for original House Bore 1, which was replaced with House Bore 3*

Appendix C Bore census

Middlemount Coal Mine Western Extension Project

Groundwater Bore Census

September 2017

Contents

1 Executive Summary

4T Consultants Pty Ltd was contracted by Middlemount Coal Pty Ltd (MCPL) to undertake a census of existing bores surrounding the Middlemount Coal Mine, verified by ground-truthing, to support the groundwater modelling and impact assessment process for the Western Extension Project.

A total of six (6) landholder properties and the Middlemount landfill sites were assessed.

These are summarised in Table 1.

Table 1: Properties and possible bore sites identified during the census.

Property	Lot/Plan	Bore (RN)	Bore name	Located	Recorded	Sampled
Gundabah	L1 RP620006	RN44080	NA	✗	✗	✗
Gundabah	L1 RP620006	RN38997	Bore No 2	✗	✗	✗
Tuon Downs	L5 CNS232	NA	TD1	✗	✗	✗
Tuon Downs	L5 CNS232	NA	TD2	✗	✗	✗
Tuon Downs	L5 CNS232	NA	TD3	✗	✗	✗
Hazelbrae	L2 RP620006	RN43474	Three Mile Bore	✓	✓	✗
Warwick Park	L4 CNS38	NA	Yards Bore	✓	✓	✗
Warwick Park	L4 CNS38	RN43060	Rolfs Bore	✓	✓	✓
Warwick Park	L4 CNS38	RN47037	Blanches Bore	✓	✓	✓
Warwick Park	L4 CNS38	RN43063	House Bore 3*	✓	✓	✓
Middlemount Landfill	L49 CNS281	RN158771	MB03	✓	✓	✗
Middlemount Landfill	L49 CNS281	RN158772	MB02	✓	✓	✗
Middlemount Landfill	L49 CNS281	RN158773	MB01	✓	✓	✗

* Original House Bore recorded as RN3063 has been replaced with House Bore 3.

2 Introduction and Purpose

The purpose of this report is to present the findings of a census of existing bores surrounding the Middlemount Coal Mine, verified by ground-truthing, to support the groundwater modelling and impact assessment process for the Western Extension Project.

The bore census was conducted by 4T Consultants Pty Ltd (4T) with general consideration of the QLD DEHP (2017) *Guideline Baseline Assessments* for the minimum requirements for undertaking a baseline assessment on water bores.

3 Scope of Works

The following Scope of Works (SoW) was provided to 4T Consultants Pty Ltd (4T) by Middlemount Coal Pty Ltd (MCPL) and Resource Strategies Pty Ltd (RS).

3.1 Objectives

The overall purpose of this project is to complete a census of existing bores in the project area verified by ground truthing to support the groundwater modelling process.

Complete a borehole census for the above project with general consideration of the QLD DEHP (2017) minimum requirements for undertaking a baseline assessment on a water bore.

Preliminary review of existing groundwater bore records for the project area indicated the following properties were to be assessed during the census, (including but not limited to):

- Baker property
- Murphy property
- Singleton property
- Curran property (south side of Rolf Creek / 10 km radius)
- Middlemount Township (c. 3-5 bores).

The following assumptions were made as part of the SoW:

- The existing groundwater monitoring network on Middlemount Coal owned land will not be recorded as part of the bore census (only privately-owned bores).
- That there are no other known (historic) groundwater bores on the Middlemount Coal owned land.

- Other mine owned land (Foxleigh, Anglo, BHP) were not to be inspected (assumed validated by desktop means or email correspondence with mining companies).

3.2 Desktop Bore Census, Data Collation and Gap Analysis

Compile desktop maps and bore database supported by reviews of project records, landowner records, previous reports, government databases, regional topographic maps, and available groundwater data for the project area.

Identify data gaps to determine where supplementary site works are required.

Confirm the extent of the area to be covered by the census in context of the hydrogeological setting, bore distribution, site access, and the proposed mine operations in consultation with the client. Commence with 5 km radius and expand to 10 km as required.

3.2.1 Landowner Notification

Liaise with Middlemount Coal to contact landowners. Where landowner liaison confirms no bores are present, the specified land parcels may be removed from the register of sites requiring ground truthing.

This task is required to inform the extent of field truthing.

3.2.2 Field Validation and Bore Census

Conduct site visit with landholders in order to confirm:

- Bore site information;
- Bore construction details;
- Bore equipment and condition details;
- Photograph the bore and equipment;
- Bore supply information (e.g. use, licence, purpose, pump regime, capacity;
- Water level measurement and bore head measurements;
- Water quality assessment (sample, field testing, submit for laboratory analysis for suite of parameters); and
- Other general comments from discussions with the landholder (e.g. yield, extraction history, previous water level readings, construction details, etc.)

4 Bore Census Methodology

4.1 Identification of bore locations for assessment

Bores were initially identified surrounding the Middlemount Coal Mine based on desktop details extracted from the Queensland Department of Natural Resources and Mines (DNRM) database of registered groundwater bores (2012) are shown on Figure 1.

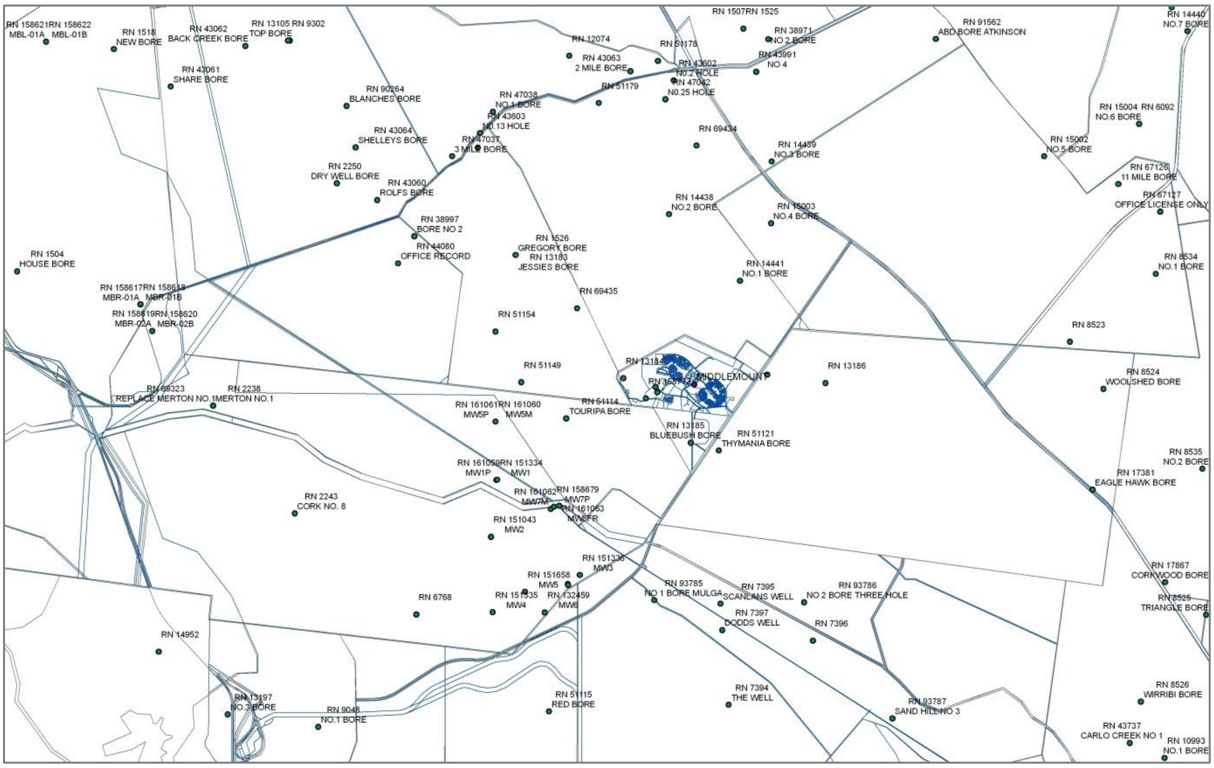

Figure 1: Draft map based on the 2012 DNRM database of registered groundwater bores.

Field surveys and a review of the DNRM data showed that a number of these bores were, in fact, in GDA Zone 54 (western Queensland), and not in Zone 55 (Area of Interest).

Bores that were ultimately identified and assessed (or discussed with landholders) within the 10 Km are shown in Figure 2. Bores TD1, TD2 and TD3 on Tuon Downs were discussed with the landholder, but the bores are not registered, and no coordinates were available to 4T to map the locations (Refer Section 5.5).

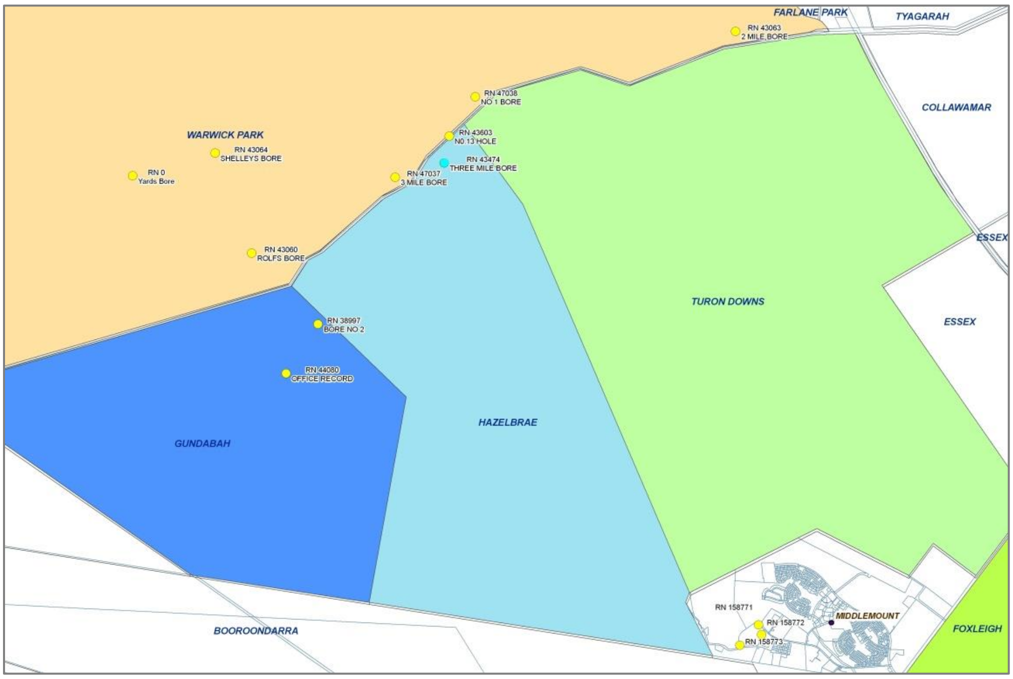

Figure 2: Bores that were assessed in the census.

4.2 Prior notice to landholders

All landholders were contacted by telephone, prior to field visits (when approval was obtained) and whilst accessing their properties (if personal contact was not possible during the field work).

4T met with John Baker (Gundabah), Jim Curran (Warwick Park) and John Singleton (Tuon Downs) during the field survey period to discuss the census.

4T visited the Isaac Regional Council offices in Middlemount and they contacted the responsible person in Moranbah to provide authorisation for access to the three monitoring bores at the Middlemount landfill site.

Telephone conversations were held with Ted Murphy (“Hazelbrae”), John Campion (“Foxleigh”), Matt Kenny (“Tralee”), and Don Black (Middlemount Jockey Club).

Details of the field assessment visits are in the following bore records for each property.

4.3 Location of bores

Initially the DNR database records were discussed with individual landholders, who indicated whether there were existing bores, abandoned bores or any collective recollection of previously existing bores.

Information provided by landholders is included in the detailed data sheets from each property.

In the field, bore coordinates were loaded into a vehicle GPS tracking system (GDA94 UTM) and this system used the map in Figure 2: Bores that were assessed in the census.**Error! Reference source not found.** as the basis to locate bores.

4.4 Bore census records

At each located bore, a field record based on the DEHP (2017) minimum requirements for undertaking a baseline assessment on a water bore were completed, and photographs were taken.

Any other general observations were recorded, and these are included in this report under individual property sections.

4.5 Sampling and analysis

Where water samples were obtained, they were sampled in accordance with the DERM Monitoring and Sampling Manual 2009 Version 2 (September 2010).

Samples for laboratory analysis were sent to Australian Laboratory Services (ALS) in Brisbane. ALS is a NATA accredited laboratory for all analytes required under the minimum requirements as indicated in the DEHP (2017) minimum requirements for undertaking a baseline assessment on a water bore.

5 Bore census information

The bores that were recorded during the census are listed in Table 2.

5.1 Summary of field surveys

Table 2: Bores that were recorded during the census

Property	Lot/Plan	Bore (RN)	Bore name	Located	Recorded	Sampled
Gundabah	L1 RP620006	RN44080	NA	✗	✗	✗
Gundabah	L1 RP620006	RN38997	Bore No 2	✗	✗	✗
Tuon Downs		Refer to comments in report regarding bores TD1, TD2 and TD3				
Hazelbrae	L2 RP620006	RN43474	Three Mile Bore	✓	✓	✗
Warwick Park	L4 CNS38	NA	Yards Bore	✓	✓	✗
Warwick Park	L4 CNS38	RN43060	Rolfs Bore	✓	✓	✓
Warwick Park	L4 CNS38	RN47037	Blanches Bore	✓	✓	✓
Warwick Park	L4 CNS38	RN43063	House Bore 3*	✓	✓	✓
Middlemount Landfill	L49 CNS281	RN158771	MB03	✓	✓	✗
Middlemount Landfill	L49 CNS281	RN158772	MB02	✓	✓	✗
Middlemount Landfill	L49 CNS281	RN158773	MB01	✓	✓	✗

*Initial bore recorded as RN3063 has been replaced with House Bore 3.

Property	Bore Name	RN	Easting	Northing	Total depth (m)	Screen (m)	TOC_GL (m)	SWL (mBTOC)	SWL (mBGL)	Casing material	Casing size (mm)	Notes
Warwick Park	Yards Bore	NA	0661509	7484051	54.0 *	NA	0.33	18.42	18.09	Steel	150	* estimated by owner
Warwick Park	Rolfs Bore	43060	0663778	7482641	38.1	NA	0.32	21.21	20.89	Steel	125	
Warwick Park	Blanches Bore	47037	0666941	7484987	35.7	NA	0.32	NA		Steel	125	Could not insert depth sensor.
Warwick Park	House Bore 1	43063	0673624	7487216	30.5	Open hole	0.19	11.15	10.96	Steel	125	Open hole at 30.5
Warwick Park	House Bore 2	NA	0673615	7487207	NA	NA	0.70	12.1	11.4	Steel/PVC	150/125	125 mm PVC casing insert.
Warwick Park	House Bore 3	NA	0673625	7487204	NA	NA	0.48	12.09	11.61	Steel	150	Current house bore
Warwick Park	Shellys Bore	43064	0663042	7484421	79.3	Open hole	No longer exists refer to bore log for historical data.					
Warwick Park	No 13 Hole	43603	0667263	7484901	No longer exists. Owner has no recollection of bore location.							
Warwick Park	No 1 Bore	47038	0667707	7485630	42.7	Open hole	No longer exists refer to bore log for historical data.					
Gundabah	Bore No 2	38997	0665032	7481405	106.7	Open hole	No longer exists refer to bore log for historical data.					
Gundabah	NA	44080	0664487	7480492	64.6	Open hole	No longer exists refer to bore log for historical data.					
Hazelbrae	Three Mile Bore	43474	0666800	7484295	41.0	Open hole	0.17	NA	-	Steel	125	Open hole 21.3 - 41.0m
Tuon Downs	TD1	NA			Owner indicated that bore has been capped and abandoned.							
Tuon Downs	TD2	NA			Owner indicated that bore has been capped and abandoned.							
Tuon Downs	TD3	NA			Owner indicated that bore has been capped and abandoned.							
Middlemount Landfill	MB01	158773	0672779	7475733	31.6	37.5 - 40.5	0.66	Dry		PVC	60	Depth tape hit bottom at 31.63m
Middlemount Landfill	MB02	158772	0673170	7475942	12.5	9.2 - 12.2	0.73	Dry		PVC	60	Depth tape hit bottom at 12.51m
Middlemount Landfill	MB03	158771	0673109	7476116	26.6		0.65	Dry		PVC	60	Depth tape hit bottom at 26.57m

Figure 3: Base information summary - Bores in the area of interest (Source: DNRM database)

Property	Bore Name	RN	Sampled	Temp (°C)	pH	EC (uS/cm)	Lab analysis	Colour	Odour	CO_2 (%)	CH_4 (%)	H_2S (ppm)	Notes
Warwick Park	Yards Bore	NA	Not sampled	-	-	-	-	-	-	-	-	-	-
Warwick Park	Rolfs Bore	43060	Yes	27.9	7.00	14,360	Yes	Clear	H_2S smell	0.00	0.00	0.02	No particles in sample.
Warwick Park	Blanches Bore	47037	Yes	24.4	7.08	2,290	Yes	Clear	Nil	0.00	0.00	0.00	Near Rolf Creek.
Warwick Park	House Bore 3	43063	Yes	30.4	6.91	4,430	Yes	Clear	Nil	0.00	0.00	0.00	Two abandoned bores nearby.
Warwick Park	Shellys Bore	43064	Does not exist	-	-	-	-	-	-	-	-	-	-
Warwick Park	No 13 Hole	43603	Does not exist	-	-	-	-	-	-	-	-	-	-
Warwick Park	No 1 Bore	47038	Does not exist	-	-	-	-	-	-	-	-	-	-
Gundabah	Bore No 2	38997	Does not exist	-	-	-	-	-	-	-	-	-	-
Gundabah	NA	44080	Does not exist	-	-	-	-	-	-	-	-	-	-
Hazelbrae	Three Mile Bore	43474	Not sampled	-	-	-	-	-	-	-	-	-	-
Tuon Downs	TD1	NA	Not sampled	-	-	-	-	-	-	-	-	-	-
Tuon Downs	TD2	NA	Not sampled	-	-	-	-	-	-	-	-	-	-
Tuon Downs	TD3	NA	Not sampled	-	-	-	-	-	-	-	-	-	-
Middlemount Landfill	MB01	158773	Dry	-	-	-	-	-	-	-	-	-	-
Middlemount Landfill	MB02	158772	Dry	-	-	-	-	-	-	-	-	-	-
Middlemount Landfill	MB03	158771	Dry	-	-	-	-	-	-	-	-	-	-

Figure 4: In-situ water quality results – Bores in the area of interest that no longer exist [1]

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[1] Excludes bores that were identified as located in Zone 54 during the census.

5.2 Bore census – 'Warwick Park'

The following bores were located and recorded:

Yards Bore	RN not available – not registered.
Rolfs Bore	RN43060
Blanches Bore	RN47037

This bore is incorrectly named as 3 Mile Bore in the DNRM database. This may have been due to confusion with the Three Mile Bore across the road in Hazelbrae. Mr. Jim Curran advised that this bore has always been called Blanches Bore.

House Bore 1	RN43063

This bore is incorrectly named as 2 Mile Bore in the DNRM database.

Mr. Jim Curran advised that this bore is the original house bore. House Bore 1 was subsequently replaced by House Bore 2, followed by House Bore 3, which is currently in use. SWL indicates that the original bore is in the same aquifer as House Bore 3.

House bore 3 at Warwick Park is the currently active bore. The registered bore details for RN43063 refers to the original bore drilled at this site in 1973. The size and construction material of the bore casing (125mm steel) are consistent with the DNRM bore log for RN43063. The bore plinth has 1980 inscribed in the concrete. Discussions with the landholder indicated that yield from this bore reduced to a point where supply was inadequate.

Two other bores have been drilled very close to the original site. House bore 2 was drilled to replace the original bore which had stopped producing, but yield from this bore also subsequently reduced to a point where it could not be used. The casing in this bore was also 125mm steel but discussions with the landholder and the date inscribed on the plinth (1990) confirm that it was drilled later than 1973. When the bore performance reduced, it was sleeved with PVC but ultimately it was abandoned.

House Bore 3 was then installed to replace House Bore 2. This bore has 150mm steel casing and is the currently active bore (installed electric submersible pump).

Based on the observations and available information, House Bore 2 and House Bore 3 are not registered. Refer to Figure 5 for bore proximity.

Figure 5: Bores at the original Warwick Park House Bore location.

Mr Curran also advised 4T that:

- RN43603 and RN 47038 had existed a long time ago but were now destroyed and no longer in existence. He indicated that these were not producing bores and were close to the Warwick Park road fence and had therefore likely been bulldozed and destroyed when fire breaks were pushed along the fence. No evidence of these bores was found during field assessments.
- Mr Curran did not have any recollection of RN43064 (Shelley's Bore) ever existing. He indicated that the paddock had been blade ploughed so if there was a bore there, it would have been destroyed during the blade ploughing.

An additional bore (Yards Bore) was located close to where RN2250 is indicated on Warwick Park (Figure 2).

5.3 Gundabah

Mr John Baker indicated that he had no knowledge of the existence of RN44080 and RN 38997. Detailed field surveys confirmed this and no evidence of these bores was located.

The conclusion from the survey is that these bores on Gundabah do not exist. The original bore logs are included in Appendix 1 for record only.

5.4 Hazelbrae

During discussions with Mr Ted Murphy, he indicated that he was only aware of Three Mile Bore (RN43474). This bore was located and recorded. Headworks prevented sampling for water quality.

Mr Murphy indicated that he had not seen any evidence of RN13183, RN1526, RN51154 or RN51149 on the property. Field surveys confirmed that these bores did not exist on Hazelbrae, and further investigations revealed that these bores were actually in (UTM) Zone 54 (Western Queensland).

5.5 Tuon Downs

During in-field discussions with 4T (Ian Rankine and Patrick Hopper), Mr John Singleton "Tuon Downs" indicated the following:

- TD3 has been filled and sealed.
- TD1 and TD2 have been capped and are unlikely to ever be used. The quality is poor and Mr Singleton believes that the bores were compromised in the past during exploration activities by Norton Gold.

There were no other bores on the property that were within approximately 10 km of the Middlemount Coal Mine.

Based on discussions with (and requests from) the landholder, these sites were not visited.

5.6 Foxleigh

Mr John Campion was contacted regarding possible bores on 'Foxleigh'. He indicated that he had no knowledge of bore in the vicinity of RN51121. This was confirmed by field survey.

5.7 Tralee

Mr Matt Kenny was contacted regarding possible location of bores on his property near RN93785 as indicated inFigure 2. He indicated that they had no knowledge of bores in that area. Field surveys confirmed this.

5.8 Middlemount Jockey Club and Racecourse

Mr Don Black from the Middlemount Jockey Club was contacted regarding RN13185 (**Error! Reference source not found.**) which was located adjacent to the Middlemount Racecourse.

Don indicated that there was no bore there and that he had no knowledge of a pre-existing bore. The field survey confirmed that there was no bore at that location.

5.9 Isaac Regional Council – Middlemount Landfill

Three monitoring bores have been installed at the Middlemount landfill to monitor leachate and potential groundwater impacts.

The three bores (RN158771, RN158772, and RN158773) were located and inspected.

None of the bores had free water available for sampling, so no samples were sent for laboratory analysis.

6 Census Information and Bore Logs

Census records and bore logs are shown in Appendix 1 - assembled by property name.

7 Laboratory analysis data

Sample analysis records from ALS are included in this report in Appendix 2.

8 Additional test reports

There were no additional tests (e.g. pump tests) conducted on the identified bores.

9 Health, Safety and Environment (HSE) summary.

There were no health, safety or environmental issues or incidents during the bore assessments.

APPENDIX 1

Bore Assessment Information and Bore Logs [2]

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[2] Bore logs - as available from the DNRM Groundwater Database.

WARWICK PARK

1. Property and bore owner

Bore name:	Yards Bore	Property name:	Warwick Park
Registered No.:	NA	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:
500 Warwick Park Road
Middlemount 4746
Queensland
Australia

Postal address:
As above

Additional information:
Next to the back cattle yards at Warwick Park.
Currently used by Warwick Park as emergency water supply during dry conditions.
Could not sample on 13/9/17 as generator set required. Warwick Park generator set deployed elsewhere.

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0661509	EPE (m):	4
North:	7484051		
Zone:	55K	Photographs:	Yes
Elevation (m):	182		

Bore information:

Total depth:	NA	Date drilled:	NA
TOC to GL (m):	0.33	Driller name:	NA
Screened interval (m):	NA	Drilling company:	NA
SWL when drilled (mBTOC):	NA		
SWL at assessment (mBTOC):	18.42		
Pressure at assessment (psi)*:	-	Bore log:	No
Yield at drilling (l/sec):	NA	Geological formation:	NA
Historical level records:	No	Construction details:	NA
		Casing material:	Steel
Installed equipment:	Submersible pump	Casing diameter(mm):	150
		Casing length (m):	NA
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Submersible	Stock:	Cattle
Operational / non operational:	-	Stock type:	Beef
Currently in use:	Occasional	No. of stock:	100
Not in use but still usable:	Requires gen set	Grazing/intensive:	Grazing
Abandoned:	-		Short term while cattle in yards.
Pump type:	Subm ersible		
Make/model:	Grundfos MA2P	Domestic use:	No
Power source:	Gen set	No. of houses:	-
Depth in bore (m):			
Av. pump rate (L/sec)	0.4	Irrigation:	No
Max. pump capacity (L/sec)	1.0	Town/camp supply:	No
Meter fitted:	No	Industrial use:	No
Meter type:	-	Other:	No
Maintenance log available:	No		
Logger installed:	No		
Logger data available:	No		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	30		
Discharge line size (mm):	30		
Distribution lines (mm):	30		

Equipment and maintenance notes:

Pump requires gen set to operate. Equipment in fair condition and only used occasionally if other water sources unavailable. Owner indicated that water was slightly brackish.

Headworks include Grundfos bore cover plate, pressure switch, one-way valve, blue oine poly 300mm delivery line.

Pump has s/s safety wire.

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	0.10%
Odour:	-	CH4	0.00%
Particles:	-	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional notes:

Sample could not be taken because pump requires generator set and none available.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

Incorrectly labelled as RN2250 (Dry Well Bore) in photos.

6. Photographs

1. Property and bore owner

Bore name:	Rolfs Bore	Property name:	Warwick Park
Registered No.:	43060	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:	500 Warwick Park Road Middlemount 4746 Queensland Australia
Postal address:	As above
Additional information:	

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0663778	EPE (m):	4
North:	7482641		
Zone:	55K	Photographs:	Yes
Elevation (m):	182		

Bore information:

Total depth:	39.31	Date drilled:	01/02/1973
TOC to GL (m):	0.33	Driller name:	H D Rickert
Screened interval (m):	-	Drilling company:	
SWL when drilled (mBTOC):	18.30		
SWL at assessment (mBTOC):	21.21		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	0.7	Geological formation:	N/A
Historical level records:	No	Construction details:	N/A
		Casing material:	Steel
Installed equipment:	Submersible pump	Casing diameter(mm):	125
		Casing length (m):	0 - 38.10m
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: ** Artesian*

3. Bore equipment / use

Equipment		Use	
Equipment installed:	None	Stock:	Cattle
Operational / non operational:	N/A	Stock type:	Beef
Currently in use:	-	No. of stock:	-
Not in use but still usable:	Requires pump installation	Grazing/intensive:	Grazing
Abandoned:	-		Only used if water shortage.
Pump type:	None		
Make/model:	-	Domestic use:	No
Power source:	-	No. of houses:	-
Depth in bore (m):	54		
Av. pump rate (L/sec)	0.6	Irrigation:	No
Max. pump capacity (L/sec)	1.0	Town/camp supply:	No
Meter fitted:	No	Industrial use:	No
Meter type:	No	Other:	No
Maintenance log available:	No		
Logger installed:	No		
Logger data available:	No		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	-		
Discharge line size (mm):	-		
Distribution lines (mm):	-		

Equipment and maintenance notes:

No pumping infrastructure. Bore only used in emergencies (e.g. extreme drought). Very infrequently required.

4. Water quality

In-situ tests

Date:	13/09/2017	**Alkalinity**	
Time:	11:15	Bicarbonate:	735
pH:	7.00	Carbonate:	0
EC (µS/cm):	14360	Hydroxide:	0
Temperature (°C):	27.9	Total alkalinity:	735
		Bore head gas tests	
Colour:	Clear	CO2	0.10%
Odour:	H2S smell	CH4	0.00%
Particles:	Nil	H2S	0.0 ppm
Sampling point:	Top of casing	Sampled for analysis:	Yes
Equipment:	QED micropurge pump	Sent to lab:	Yes
Purge method:	Low flow / stabilisation	NATA laboratory:	ALS Brisbane

Additional notes:

Sample taken using low flow purge pump with stabilisation before sampling.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 43060

REGISTRATION DETAILS

		BASIN	1304	**LATITUDE**	22-45-20	**MAP-SCALE**	104
OFFICE	Rockhampton	**SUB-AREA**		**LONGITUDE**	148-35-43	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	663778	**MAP-NO**	8652
D/O FILE NO.	50-1371	**LOT**		**NORTHING**	7482641	**MAP NAME**	WINDEYERS HILL
R/O FILE NO.	C598/E272	**PLAN**		**ZONE**	55	**PROG SECTION**	
H/O FILE NO.	L40772B	**ORIGINAL DESCRIPTION**	L4 CNS38	**ACCURACY**		**PRES EQUIPMENT**	WL
				GPS ACC			
GIS LAT	-22.755660646	**PARISH NAME**	2684-KIRKCALDY			**ORIGINAL BORE NO**	ROLFS BORE
GIS LNG	148.595258528	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	N						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	01/02/1973			**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**					
ROLES		**DRILL COMPANY**					
		METHOD OF CONST.					

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	01/02/1973	1	Steel Casing		WT	127	0.00	38.10

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	39.31	NO STRATA DETAILS AVAILABLE
2			DRILLER H D RICKERT
902			00/00/0000 SWL -18.30 M
903			00/00/0000 DISCH 60.0 M3D ESTIMAT

STRATIGRAPHY DETAILS

****** NO RECORDS FOUND ******

AQUIFER DETAILS

REG NUMBER **43060**

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

PIPE	DATE	RD	ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	18/11/1972	1	GCL	054777	27.00	PU	GB	8800	7.5		5946.17	5599.00	1521	560	0.4	17.7	

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	18/11/1972	1	1586.0		312.0	180.0		683.0			2960.0	0.17		225.0				

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
X	01/01/1969	-18.30	N		NR												

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

REG NUMBER 43060

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

**** End of Report. Produced:** 10/09/2017 12:46:36 PM ******

1. Property and bore owner

Bore name:	Blanches Bore	Property name:	Warwick Park
Registered No.:	47037	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:
500 Warwick Park Road
Middlemount 4746
Queensland
Australia

Postal address:
As above

Additional information:
Recorded in DNRM as 3 mile bore. Confirmed with Jim Curran that this is Blanches Bore.
Arrow Energy photos

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0666941	EPE (m):	4
North:	7484987		
Zone:	55K	Photographs:	Yes
Elevation (m):	166		

Bore information:

Total depth:	35.7	Date drilled:	19/11/1972
TOC to GL (m):	0.32	Driller name:	N/A
Screened interval (m):	Open hole 23.2 - 35.7m	Drilling company:	N/A
SWL when drilled (mBTOC):	15.10		
SWL at assessment (mBTOC):	N/A Fixed cover plate		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	0.38	Geological formation:	Blenheim formation
Historical level records:	Limited	Construction details:	Rotary rig
		Casing material:	Steel
Installed equipment:	Submersible	Casing diameter(mm):	125
		Casing length (m):	0 - 23.2
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Submersible	Stock:	Cattle
Operational / non operational:	Operational	Stock type:	Beef
Currently in use:	Yes	No. of stock:	350
Not in use but still usable:	-	Grazing/intensive:	Grazing
Abandoned:	-		
Pump type:	Franklin		
Make/model:	-	Domestic use:	No
Power source:	Solar	No. of houses:	-
Depth in bore (m):			
Av. pump rate (L/sec)	0.7	Irrigation:	No
Max. pump capacity (L/sec)	1.0	Town/camp supply:	No
Meter fitted:	No	Industrial use:	No
Meter type:	No	Other:	No
Maintenance log available:	No		
Logger installed:	No		
Logger data available:	No		
Headworks:	See photos	Usage per day (Hrs):	
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	30		
Discharge line size (mm):	30		
Distribution lines (mm):	30		

Equipment and maintenance notes:

Submersible (electric) pump. C. 600W solar panels.

4. Water quality

In-situ tests

Date:	13/09/2017	**Alkalinity**	
Time:	13:30	Bicarbonate:	574
pH:	7.08	Carbonate:	0
EC (µS/cm):	2290	Hydroxide:	0
Temperature (°C):	24.4	Total alkalinity:	574
		Bore head gas tests	
Colour:	Clear	CO2	0.00%
Odour:	Nil	CH4	0.00%
Particles:	Nil	H2S	0.0 ppm
Sampling point:	Discharge line 3m from pump	Sampled for analysis:	Yes
Equipment:	Installed pump	Sent to lab:	Yes
Purge method:	Discharge was operating	NATA laboratory:	ALS Brisbane
	Purged 10 Lt then		

Additional notes:

Sample taken from coupling in discharge line about 3 m from bore head. Submersible pumping at time of sampling.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER **47037**

REGISTRATION DETAILS

		BASIN	1304	**LATITUDE**	22-44-31	**MAP-SCALE**	104
OFFICE	Rockhampton	**SUB-AREA**		**LONGITUDE**	148-37-11	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	666315	**MAP-NO**	8652
D/O FILE NO.	50-1371	**LOT**	4	**NORTHING**	7484118	**MAP NAME**	WINDEYERS HILL
R/O FILE NO.	C598/E272	**PLAN**	CNS38	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.	L40772B	**ORIGINAL DESCRIPTION**	P4	**ACCURACY**		**PRES EQUIPMENT**	WL
				GPS ACC			
GIS LAT	-22.742049746	**PARISH NAME**	2684-KIRKCALDY			**ORIGINAL BORE NO**	3 MILE BORE
GIS LNG	148.619702353	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	N						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	19/11/1972			**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**					
ROLES	WS	**DRILL COMPANY**					
		METHOD OF CONST.	ROTARY RIG				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	19/11/1972	1	Steel Casing		WT	127	0.00	23.20
A	19/11/1972	2	Open Hole				35.70	35.70
A	19/11/1972	3	Grout					

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	2.40	SANDY SOIL
2	2.40	7.90	SANDY CLAY
3	7.90	14.90	SHALE AND SANDSTONE
4	14.90	16.20	PUG CLAY
5	16.20	16.50	SHALE
6	16.50	16.80	PUG SHALE

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 47037

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
7	16.80	18.30	SHALE
8	18.30	31.10	GREY SHALE
9	31.10	35.70	GREY SANDSTONE HARD AT BOTTOM

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1			BLENHEIM FORMATION

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	21.00	24.00	SHLE SILT MDST	19/11/1972	-15.10	N	8850 US/CM	0.39	Y	FR	BACK CREEK GROUP

PUMP TEST DETAILS PART 1

PIPE	DATE	REC NO.	RN OF PUMP-BORE	TOP (m)	BOTTOM (m)	DIST (m)	METH	TEST TYPES	PUMP TYPE	SUCTION SET (m)	Q PRIOR TO TEST (l/s)	DUR OF Q PR (min)	PRES ON ARRIV (m)	Q ON ARRIV (l/s)
A	19/11/1972	1	47037	0.00	35.70		PUM							

PUMP TEST DETAILS PART 2

PIPE	DATE	REC	TEST DUR (mins)	SWL (m)	RECOV. TIME (mins)	RESID. DD (m)	MAX DD or P RED (m)	Q at MAX DD (l/s)	TIME TO MAX DD (mins)	Max Q (l/s)	CALC STAT HD (m)	DESIGN YIELD (l/s)	DESIGN BP (m)	SUCT. SET (m)	TMSY (m2/DAY)	STOR
A	19/11/1972	1	<1440	-15.10			24.40	0.38				0.38	24.40			

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

REG NUMBER 47037

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

PIPE	DATE	RD ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	19/11/1972	1 GCL	054776	26.00	PU	GB	8850	7.5		5816.20	5438.02	1446	610	0.4	18.2	

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	19/11/1972	1	1590.0		154.0	258.0		744.0			2970.0	0.20		100.0				

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
X	19/11/1972	-15.10	N		NR												

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

BORE REPORT

**** End of Report. Produced:** 10/09/2017 12:48:05 PM ******

1. Property and bore owner

Bore name:	House Bore 1	Property name:	Warwick Park
Registered No.:	43063	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:
500 Warwick Park Road
Middlemount 4746
Queensland
Australia

Postal address:
As above

Additional information:
Recorded in DNRM database as 2 mile bore.
Confirmed with Jim Curran that this is the original House Bore.
Arrow Energy photos.
Bore log RN43063 is for this original house bore (House bore 1) - casing is 125mm but current bore in use (and other abandoned bore) have 150mm PVC casings.

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673624	EPE (m):	4
North:	7487216		
Zone:	55K	Photographs:	Yes
Elevation (m):	151		

Bore information:

Total depth:	30.5	Date drilled:	18/11/1972
TOC to GL (m):	0.20	Driller name:	G Shelley
Screened interval (m):	Open hole 2.40m - 30.50m	Drilling company:	Shelly Well Boring Co
SWL when drilled (mBTOC):	24.40		
SWL at assessment (mBTOC):	11.15		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	1.5	Geological formation:	Blenheim formation
Historical level records:	Limited	Construction details:	Rotary rig
		Casing material:	Steel
Installed equipment:	None	Casing diameter(mm):	125
		Casing length (m):	0 - 2.40m
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: ** Artesian*

Depth tape stopped at 18.26m during test on 13/09/2017 indicating that bore had collapsed. There was water detected at 11.15m.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	-	Stock:	No
Operational / non operational:	Non operational.	Stock type:	-
Currently in use:	No	No. of stock:	-
Not in use but still usable:	-	Grazing/intensive:	-
Abandoned:	Yes		
Pump type:	-		
Make/model:	-	Domestic use:	No
Power source:	-	No. of houses:	-
Depth in bore (m):	-		
Av. pump rate (L/sec)	-	Irrigation:	No
Max. pump capacity (L/sec)	-	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	No
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	See photos	Usage per day (Hrs):	
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	-		
Discharge line size (mm):	-		
Distribution lines (mm):	-		

Equipment and maintenance notes:

Original house bore.

Collapsed and was replaced by House bore 2 nearby. Same aquifer. House bore 2 subsequently replaced by House bore 3 which is current;y in use.

4. Water quality

In-situ tests

Date:	13/09/2017	**Alkalinity**	
Time:	16:45	Bicarbonate:	-
pH:	Not tested	Carbonate:	-
EC (µS/cm):	Not tested	Hydroxide:	-
Temperature (°C):	Not tested	Total alkalinity:	-
		Bore head gas tests	
Colour:	NA	CO2	0.00%
Odour:	NA	CH4	0.00%
Particles:	NA	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-
	-		

Additional notes:

Sample takne from House bore 3 which is currently in use and only c.10m away from this bore. SWL indicate that this bore in same aquifer as House Bore 3.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 43063

REGISTRATION DETAILS

OFFICE Rockhampton
DATE LOG RECD
D/O FILE NO. 50-1371
R/O FILE NO. C598/E272
H/O FILE NO. L40772B

GIS LAT -22.715383774
GIS LNG 148.678312259
CHECKED N

BASIN 1304
SUB-AREA
SHIRE 3980-ISAAC REGIONAL
LOT
PLAN
ORIGINAL DESCRIPTION L4 CNS38

PARISH NAME 2684-KIRKCALDY
COUNTY CAIRNS

LATITUDE 22-42-55
LONGITUDE 148-40-42
EASTING 672366
NORTHING 7487004
ZONE 55
ACCURACY
GPS ACC

MAP-SCALE 104
MAP-SERIES M
MAP-NO 8652
MAP NAME WINDEYERS HILL
PROG SECTION
PRES EQUIPMENT JP

ORIGINAL BORE NO 2 MILE BORE
BORE LINE -

POLYGON
RN OF BORE REPLACED
DATA OWNER

FACILITY TYPE Sub-Artesian Facility
STATUS Existing
ROLES WS

DATE DRILLED 01/02/1973
DRILLERS NAME G SHELLEY
DRILL COMPANY SHELLEY WELL BORING CO
METHOD OF CONST. ROTARY

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	01/02/1973	1	Steel Casing		WT	127	0.00	2.40
A	01/02/1973	2	Open Hole				30.50	30.50

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	2.43	WHITE SANDSTONE
2	2.43	6.09	YELLOW SANDSTONE
3	6.09	6.40	HARD WHITE SANDSTONE
4	6.40	7.01	SOFT BROWN SANDSTONE
5	7.01	8.22	WHITE SANDSTONE
6	8.22	9.14	BROWN SANDSTONE
7	9.14	23.16	BLUE SANDSTONE

REG NUMBER **43063**

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
8	23.16	24.38	SHALE
9	24.38	26.82	BROKEN SANDSTONE WATER

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1			BLENHEIM FORMATION

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	24.00	26.00	SDST	01/02/1973	-24.40	N	890 US/CM	1.50	Y	FR	TERTIARY - UNDEFINED

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

PIPE	DATE	ELEVATION	PRECISION	DATUM	MEASUREMENT POINT	SURVEY SOURCE
X	04/10/2006	156.72	EST	AHD	N	9 SECOND DEM

WATER ANALYSIS PART1

PIPE	DATE	RD	ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	18/11/1972	1	GCL	054774	26.00	PU	GB	890	7.6		765.05	499.72	340	428	2.0	1.8	1.77

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER **43063**

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	18/11/1972	1	77.0		70.0	40.0		522.0			56.0	0.05		0.0				

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
X	01/01/1969	-24.40	N		NR												

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

**** End of Report. Produced:** 05/10/2017 05:35:05 PM ******

1. Property and bore owner

Bore name:	House Bore 2	Property name:	Warwick Park
Registered No.:	43063	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:
500 Warwick Park Road
Middlemount 4746
Queensland
Australia

Postal address:
As above

Additional information: Confirmed with Jim Curran that this is the 'second' House Bore which was drilled after the original House Bore collapsed.
Arrow Energy photos.

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673615	EPE (m):	4
North:	7487207		
Zone:	55K	Photographs:	Yes
Elevation (m):	151		

Bore information:

Total depth:	-	Date drilled:	24/12/1980*
TOC to GL (m):	0.7	Driller name:	NA
Screened interval (m):	-	Drilling company:	NA
SWL when drilled (mBTOC):	-		
SWL at assessment (mBTOC):	12.10		
Pressure at assessment (psi)*:	-	Bore log:	NA
Yield at drilling (l/sec):	-	Geological formation:	-
Historical level records:	-	Construction details:	-
		Casing material:	Steel **
Installed equipment:	None	Casing diameter(mm):	150
		Casing length (m):	-
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: ** Artesian*

* 24/12/80 was date on monument plinth.

** 125mm inner PVC casing.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	-	Stock:	No
Operational / non operational:	Non operational.	Stock type:	-
Currently in use:	No	No. of stock:	-
Not in use but still usable:	-	Grazing/intensive:	-
Abandoned:	Yes		
Pump type:	-		
Make/model:	-	Domestic use:	No
Power source:	-	No. of houses:	-
Depth in bore (m):	-		
Av. pump rate (L/sec)	-	Irrigation:	No
Max. pump capacity (L/sec)	-	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	No
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	See photos	Usage per day (Hrs):	
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	-		
Discharge line size (mm):	-		
Distribution lines (mm):	-		

Equipment and maintenance notes:
Second house bore drilled after original collapsed - Jim Curran. Same aquifer.
House bore 2 subsequently replaced by House bore 3 which is currently in use.

4. Water quality

In-situ tests

Date:	13/09/2017	**Alkalinity**	
Time:	16:37	Bicarbonate:	-
pH:	Not tested	Carbonate:	-
EC (µS/cm):	Not tested	Hydroxide:	-
Temperature (°C):	Not tested	Total alkalinity:	-
		Bore head gas tests	
Colour:	NA	CO2	0.00%
Odour:	NA	CH4	0.00%
Particles:	NA	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-
	-		

Additional notes:

Sample takne from House bore 3 which is currently in use and only c.10m away from this bore. SWL indicate that this bore in same aquifer as House Bore 3.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

1. Property and bore owner

Bore name:	House Bore	Property name:	Warwick Park
Registered No.:	43063	Owner/Contact:	Jim Curran
Lot/Plan:	L4 CNS38	Telephone:	07 49858250
Parish:		Mobile:	0429 858250
County:	Cairns	eMail:	

Residential address:
500 Warwick Park Road
Middlemount 4746
Queensland
Australia

Postal address:
As above

Additional information: Confirmed with Jim Curran that this is current House Bore. Nominated in this survey as House Bore 3 to distinguish it from the other two (abandoned) bores. All in same aquifer.
Arrow Energy photos.

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673625	EPE (m):	4
North:	7487204		
Zone:	55K	Photographs:	Yes
Elevation (m):	151		

Bore information:

Total depth:	-	Date drilled:	NA
TOC to GL (m):	0.48	Driller name:	N/A
Screened interval (m):	-	Drilling company:	N/A
SWL when drilled (mBTOC):	-		
SWL at assessment (mBTOC):	12.09		
Pressure at assessment (psi)*:	-	Bore log:	-
Yield at drilling (l/sec):	-	Geological formation:	-
Historical level records:	-	Construction details:	-
		Casing material:	Steel
Installed equipment:	-	Casing diameter(mm):	150
		Casing length (m):	-
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: ** Artesian*

Refer to House bore 1 (RN43063) bore log for depths, original SWL and aquifer details.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Submersible	Stock:	Cattle
Operational / non operational:	Operational	Stock type:	Beef
Currently in use:	Yes	No. of stock:	350
Not in use but still usable:	-	Grazing/intensive:	Grazing
Abandoned:	-		
Pump type:	Franklin		
Make/model:	-	Domestic use:	Yes
Power source:	Solar	No. of houses:	2
Depth in bore (m):			
Av. pump rate (L/sec)	0.7	Irrigation:	No
Max. pump capacity (L/sec)	1.0	Town/camp supply:	No
Meter fitted:	No	Industrial use:	No
Meter type:	No	Other:	No
Maintenance log available:	No		
Logger installed:	No		
Logger data available:	No		
Headworks:	See photos	Usage per day (Hrs):	
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	30		
Discharge line size (mm):	30		
Distribution lines (mm):	30		

Equipment and maintenance notes:

Mains powered submersible pump.

4. Water quality

In-situ tests

Date:	13/09/2017	**Alkalinity**	
Time:	15:45	Bicarbonate:	639
pH:	6.91	Carbonate:	0
EC (µS/cm):	4430	Hydroxide:	0
Temperature (°C):	30.4	Total alkalinity:	639
		Bore head gas tests	
Colour:	Clear	CO2	0.00%
Odour:	Nil	CH4	0.00%
Particles:	Nil	H2S	0.0 ppm
Sampling point:	Connection in discharge line 3m from pump	Sampled for analysis:	Yes
Equipment:	Installed pump	Sent to lab:	Yes
Purge method:	Pump operational.	NATA laboratory:	ALS Brisbane
	Purged 10 Lt then		
	Currently used for stock		

Additional notes:

Sample taken from coupling in discharge line about 3 m from bore head. Submersible pumping at time of sampling.

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GUNDABAH

1. Property and bore owner

Bore name:	Bore No 2	Property name:	Gundabah
Registered No.:	38997	Owner/Contact:	John Baker
Lot/Plan:	L1 RP620006	Telephone:	07 49857970
County/Parish:	Cairns	Mobile:	0428 857970
		eMail:	

Residential address:	1295 Warwick Park Road Middlemount 4746 Queensland Australia
Postal address:	"Booroondarra" 67 Booroondarra Capella Road Dysart 4745 Queensland
Additional information:	Landholder indicated that this bore no longer existed. Bore log indicates that bore was cased to 11.6m with open hole to 106.7m. Log indicates that bore was abandoned and destroyed. Bore or original site not located at coordinates indicated in DNRM database. Search conducted by 4T in AGD66 and GDA94 datum but no evidence of bore found.

2. Bore - Base information

Geographic location

Datum:	Unknown	GPS:	Garmin GPS76 handheld
East:	0665032	EPE (m):	4
North:	7481405		
Zone:	55K	Photographs:	No
Elevation (m):			

Bore information:

Total depth:	106.7	Date drilled:	23/11/1972
TOC to GL (m):	-	Driller name:	Shelley Well Boring Company
Screened interval (m):	Open hole 11.6 - 106.7m	Drilling company:	L Bell
SWL when drilled (mBTOC):	99.99		
SWL at assessment (mBTOC):	-		
Pressure at assessment (psi)*:	-	Bore log:	No
Yield at drilling (l/sec):	0.3	Geological formation:	NA
Historical level records:	-	Construction details:	Rotary drill
		Casing material:	NA
Installed equipment:	-	Casing diameter(mm):	NA
		Casing length (m):	NA
Artesian/Sub-artesian:	-		

Additional notes: * *Artesian*

Refer to field survey method for search procedure.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Bore no longer exists	Stock:	-
Operational / non operational:	Non-operational	Stock type:	-
Currently in use:		No. of stock:	-
Not in use but still usable:		Grazing/intensive:	-
Abandoned:	Yes		
No longer in existence:	Yes		
Pump type:			
Make/model:		Domestic use:	-
Power source:		No. of houses:	-
Depth in bore (m):			
Av. pump rate (L/sec)		Irrigation:	-
Max. pump capacity (L/sec)		Town/camp supply:	-
Meter fitted:	-	Industrial use:	-
Meter type:	-	Other:	-
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	-	Usage per day (Hrs):	-
Photo of headworks:	-	Pump test done:	-
Pump outlet size (mm):	-		
Discharge line size (mm):	-		
Distribution lines (mm):	-		

Equipment and maintenance notes:
NA

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	-
Odour:	-	CH4	-
Particles:	-	H2S	-
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional notes:

5. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 38997

REGISTRATION DETAILS

		BASIN	1301	**LATITUDE**	22-46-00	**MAP-SCALE**	104
OFFICE	Rockhampton	**SUB-AREA**		**LONGITUDE**	148-36-27	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	665032	**MAP-NO**	8652
D/O FILE NO.	50-0044	**LOT**		**NORTHING**	7481405	**MAP NAME**	WINDEYERS HILL
R/O FILE NO.	C2706/E397	**PLAN**		**ZONE**	55	**PROG SECTION**	
H/O FILE NO.	L40357B	**ORIGINAL DESCRIPTION**	L1 RP620006	**ACCURACY**		**PRES EQUIPMENT**	NE
				GPS ACC			
GIS LAT	-22.76677166	**PARISH NAME**	5200-WYNDHAM			**ORIGINAL BORE NO**	BORE NO 2
GIS LNG	148.607480691	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	N						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	23/11/1972			**DATA OWNER**	
STATUS	Abandoned and Destroyed	**DRILLERS NAME**	L BELL				
ROLES	WS	**DRILL COMPANY**	SHELLEY WELL BORING CO				
		METHOD OF CONST.	ROTARY				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	23/11/1972	1	Steel Casing	4.760	WT	152	0.00	11.60
A	23/11/1972	2	Open Hole				11.60	106.70

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	0.60	SOIL
2	0.60	0.91	SAND
3	0.91	6.09	SANDY CLAY
4	6.09	6.40	CLAY & BOULDERS
5	6.40	7.62	SANDY CLAY
6	7.62	7.92	WHITE SANDSTONE
7	7.92	9.14	CLAY

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 38997

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
8	9.14	11.58	SHALE
9	11.58	12.80	SANDSTONE
10	12.80	14.32	SHALE
11	14.32	24.38	SANDSTONE
12	24.38	24.68	SHALE
13	24.68	28.65	SANDSTONE
14	28.65	30.48	SHALE
15	30.48	30.78	SANDSTONE
16	30.78	32.00	SANDY SHALE
17	32.00	34.13	SANDSTONE
18	34.13	39.31	SHALE
19	39.31	39.62	COAL
20	39.62	74.37	SHALE & COAL BROKEN 26 M3D
21	74.37	76.50	COAL 33 M3D
22	76.50	76.81	SHALE
23	77.11	81.99	COAL & SHALE
24	81.99	83.51	BROWN SHALE
25	83.51	94.79	COAL & SHALE
26	94.79	97.84	SANDSTONE
27	97.84	98.45	HARD SHALE
28	98.45	106.68	SANDSTONE

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1	7.60		BLACKWATER GROUP

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	40.50	76.50	COAL	23/11/1972	-99.99	N		0.30	Y	FR	BLACKWATER GROUP

BORE REPORT

REG NUMBER 38997

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
2	76.20	80.80	SHLE	23/11/1972	-99.99	N	12500 US/CM	0.38	Y	FR	BLACKWATER GROUP

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

PIPE	DATE	ELEVATION	PRECISION	DATUM	MEASUREMENT POINT	SURVEY SOURCE
X	04/10/2006	179.37	EST	AHD	N	9 SECOND DEM

WATER ANALYSIS PART1

PIPE	DATE	RD ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	22/11/1972	1 DPI	054582		PU	GB				9911.90	9604.89	4790	495	1.2	11.9	
A	23/11/1972	1 GCL	54901	76.00	AI	GB	10500	7.4		9753.14	9604.21	4512	240	1.1	12.8	
A	23/11/1972	2 GCL	54902	80.00	AI	GB	12500	7.6		9733.12	9578.09	4849	250	1.2	11.5	

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	22/11/1972	1	1889.6		717.4	728.4		604.0			5948.5			24.0				
A	23/11/1972	1	1970.0		755.0	638.0		293.0	0.00	0.0	5980.0	0.14	4.0	113.0				
A	23/11/1972	2	1839.0		725.0	738.0		305.0	0.00		6020.0	0.12		106.0				

WATER LEVEL DETAILS

****** NO RECORDS FOUND ******

REG NUMBER 38997

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

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**** End of Report. Produced:** 10/09/2017 01:39:50 PM ******

1. Property and bore owner

Bore name:	Unnamed bore	Property name:	Gundabah
Registered No.:	44080	Owner/Contact:	John Baker
Lot/Plan:	L1 RP620006	Telephone:	07 49857970
County/Parish:	Cairns	Mobile:	
		eMail:	

Residential address:	1295 Warwick Park Road Middlemount 4746 Queensland Australia
Postal address:	"Booroondarra" 67 Booroondarra Capella Road Dysart 4745 Queensland
Additional information:	Landowner indicated that this bore no longer existed. Bore log indicates that no water was found. Bore was not screened and was abandoned and destroyed. Bore or original site not located at coordinates indicated in DNRM database. Search conducted by 4T in AGD66 and GDA94 datum but no evidence of bore found.

2. Bore - Base information

Geographic location

Datum:	Unknown	GPS:	Garmin GPS76 handheld
East:	0664487	EPE (m):	4
North:	7480492		
Zone:	55K	Photographs:	No
Elevation (m):			

Bore information:

Total depth:	52.73	Date drilled:	23/11/1972
TOC to GL (m):	-	Driller name:	Shelley Well Boring Company
Screened interval (m):	Not screened	Drilling company:	NA
SWL when drilled (mBTOC):	-		
SWL at assessment (mBTOC):	-		
Pressure at assessment (psi)*:	-	Bore log:	No
Yield at drilling (l/sec):	-	Geological formation:	NA
Historical level records:	-	Construction details:	Rotary drill
		Casing material:	NA
Installed equipment:	-	Casing diameter(mm):	NA
		Casing length (m):	NA
Artesian/Sub-artesian:	-		

Additional notes: * *Artesian*

Refer to field survey method for search procedure.

.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Bore no longer exists	Stock:	-
Operational / non operational:	Non-operational	Stock type:	-
Currently in use:		No. of stock:	-
Not in use but still usable:		Grazing/intensive:	-
Abandoned:	Yes		
No longer in existence:	Yes		
Pump type:			
Make/model:		Domestic use:	-
Power source:		No. of houses:	-
Depth in bore (m):			
Av. pump rate (L/sec)		Irrigation:	-
Max. pump capacity (L/sec)		Town/camp supply:	-
Meter fitted:	-	Industrial use:	-
Meter type:	-	Other:	-
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	-	Usage per day (Hrs):	-
Photo of headworks:	-	Pump test done:	-
Pump outlet size (mm):	-		
Discharge line size (mm):	-		
Distribution lines (mm):	-		

Equipment and maintenance notes:

NA

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	-
Odour:	-	CH4	-
Particles:	-	H2S	-
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional notes:

4. Assessment date and details:

Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

5. Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

DATE 10/09/2017

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 44080

REGISTRATION DETAILS

		BASIN	1301	**LATITUDE**	22-46-30	**MAP-SCALE**	104
OFFICE	Rockhampton	**SUB-AREA**		**LONGITUDE**	148-36-08	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	664487	**MAP-NO**	8652
D/O FILE NO.	50-0044	**LOT**		**NORTHING**	7480492	**MAP NAME**	WINDEYERS HILL
R/O FILE NO.	C2796.E397	**PLAN**		**ZONE**	55	**PROG SECTION**	
H/O FILE NO.	L40357B	**ORIGINAL DESCRIPTION**	L1 RP620006	**ACCURACY**		**PRES EQUIPMENT**	NE
				GPS ACC			
GIS LAT	-22.775104855	**PARISH NAME**	5200-WYNDHAM			**ORIGINAL BORE NO**	OFFICE RECORD
GIS LNG	148.602203152	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	N						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	23/11/1972			**DATA OWNER**	
STATUS	Abandoned and Destroyed	**DRILLERS NAME**					
ROLES	WS	**DRILL COMPANY**	SHELLEY WELLBORING CO				
		METHOD OF CONST.	ROTARY				

CASING DETAILS

****** NO RECORDS FOUND ******

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	0.61	SOIL
2	0.61	7.32	SANDY CLAY
3	7.32	11.58	SOFT SANDSTONE
4	11.58	12.50	WHITE SANDY CLAY
5	12.50	18.90	SANDSTONE
6	18.90	19.81	SANDY CLAY
7	19.81	21.95	PUG CLAY
8	21.95	24.99	SHALE
9	24.99	25.30	RED SHALE
10	25.30	25.91	SHALE
11	25.91	32.31	HARD SHALE

BORE REPORT

REG NUMBER 44080

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
12	32.31	41.76	GREY SANDSTONE
13	41.76	42.98	SHALE
14	42.98	45.42	COAL SOAK
15	45.42	52.73	SHALE AND COAL SOAK
16	52.73	64.62	HARD SANDSTONE - ABANDONED

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1	7.30		BLACKWATER GROUP

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	43.00	52.70	COAL			N		0.01	Y	FR	BLACKWATER GROUP

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

BORE REPORT

REG NUMBER **44080**

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

****** NO RECORDS FOUND ******

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

BORE REPORT

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**** End of Report. Produced:** 10/09/2017 01:40:33 PM ******

HAZELBRAE

1. Property and bore owner

Bore name:	Three Mile Bore	Property name:	Hazelbrae
Registered No.:	43474	Owner/Contact:	Ted Murphy
Lot/Plan:	L2 RP620006	Telephone:	07 4958 1533
County/Parish:	Cairns	Mobile:	0419 653593
		eMail:	

Residential address:	905 Warwick Park Road Middlemount 4746 Queensland Australia
Postal address:	"TayGlen" Lot 81 / Dysart Connection Road Dysart 4745 Queensland
Additional information:	Comet windmill - not operational. See notes and photographs

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0666800	EPE (m):	4
North:	7484295		
Zone:	55K	Photographs:	Yes
Elevation (m):	158		

Bore information:

Total depth:	41.14	Date drilled:	N/A
TOC to GL (m):	0.17	Driller name:	N/A
Screened interval (m):	Open hole 21.3 - 41.0m	Drilling company:	N/A
SWL when drilled (mBTOC):	18.06		
SWL at assessment (mBTOC):	N/A		
Pressure at assessment (psi)*:	-	Bore log:	Yes
Yield at drilling (l/sec):	0.35	Geological formation:	N/A
Historical level records:	No	Construction details:	Rotary drill
		Casing material:	Steel
Installed equipment:	Windmill pump	Casing diameter(mm):	125
		Casing length (m):	0 - 21.3m
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

Windmill pump rods broken (photographs). Appeared to have been broken for some time. Tank had water in it but highly unlikely to have originated from the bore because the windmill equipment was disconnected. Headworks prevented use of sampling pumps, and no installed equipment to use to obtain sample. Tried to measure SWL but obstruction at c. 2.8m (packer/centraliser?) prevented SWL sensor from descending - multiple attempts but SWL could not be measured during visit.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Windmill pump	Stock:	Cattle
Operational / non operational:	Non-operational	Stock type:	Beef
Currently in use:		No. of stock:	250
Not in use but still usable:		Grazing/intensive:	Grazing
Abandoned:	Yes		
Pump type:	Comet windmill		
Make/model:		Domestic use:	No
Power source:	Wind	No. of houses:	-
Depth in bore (m):	Unknown		
Av. pump rate (L/sec)	N/A	Irrigation:	No
Max. pump capacity (L/sec)	N/A	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	No
Maintenance log available:	-		
Logger installed:	No		
Logger data available:	No		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	30		
Discharge line size (mm):	30		
Distribution lines (mm):	30		

Equipment and maintenance notes:

Windmill in run down condition. Pump rods currently not attached to mill pump. Windmill head requires maintenance but still operational.

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	0.00%
Odour:	-	CH4	0.00%
Particles:	-	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional notes:

Sample could not be taken as headworks prevented use of sampling pumps/equipment. No installed equipment for sampling.

5. Assessment date and details:

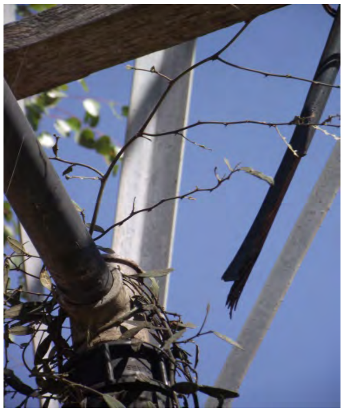
Date of assessment:	14/09/2001		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs



GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 47037

REGISTRATION DETAILS

OFFICE Rockhampton
DATE LOG RECD
D/O FILE NO. 50-1371
R/O FILE NO. C598/E272
H/O FILE NO. L40772B

GIS LAT -22.742049746
GIS LNG 148.619702353
CHECKED N

BASIN 1304
SUB-AREA
SHIRE 3980-ISAAC REGIONAL
LOT 4
PLAN CNS38
ORIGINAL DESCRIPTION P4

PARISH NAME 2684-KIRKCALDY
COUNTY CAIRNS

LATITUDE 22-44-31
LONGITUDE 148-37-11
EASTING 666315
NORTHING 7484118
ZONE 55
ACCURACY
GPS ACC

MAP-SCALE 104
MAP-SERIES M
MAP-NO 8652
MAP NAME WINDEYERS HILL
PROG SECTION
PRES EQUIPMENT WL

ORIGINAL BORE NO 3 MILE BORE
BORE LINE -

POLYGON
RN OF BORE REPLACED
DATA OWNER

FACILITY TYPE Sub-Artesian Facility
STATUS Existing
ROLES WS

DATE DRILLED 19/11/1972
DRILLERS NAME
DRILL COMPANY
METHOD OF CONST. ROTARY RIG

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	19/11/1972	1	Steel Casing		WT	127	0.00	23.20
A	19/11/1972	2	Open Hole				35.70	35.70
A	19/11/1972	3	Grout					

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	2.40	SANDY SOIL
2	2.40	7.90	SANDY CLAY
3	7.90	14.90	SHALE AND SANDSTONE
4	14.90	16.20	PUG CLAY
5	16.20	16.50	SHALE
6	16.50	16.80	PUG SHALE

REG NUMBER 47037

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
7	16.80	18.30	SHALE
8	18.30	31.10	GREY SHALE
9	31.10	35.70	GREY SANDSTONE HARD AT BOTTOM

STRATIGRAPHY DETAILS

SOURCE	RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
DNR	1			BLENHEIM FORMATION

AQUIFER DETAILS

REC	TOP BED(M)	BOTTOM BED(M)	BED LITHOLOGY	DATE	SWL (m)	FLOW	QUALITY	YIELD (l/s)	CTR	CONDIT	FORMATION NAME
1	21.00	24.00	SHLE SILT MDST	19/11/1972	-15.10	N	8850 US/CM	0.39	Y	FR	BACK CREEK GROUP

PUMP TEST DETAILS PART 1

PIPE	DATE	REC NO.	RN OF PUMP-BORE	TOP (m)	BOTTOM (m)	DIST (m)	METH	TEST TYPES	PUMP TYPE	SUCTION SET (m)	Q PRIOR TO TEST (l/s)	DUR OF Q PR (min)	PRES ON ARRIV (m)	Q ON ARRIV (l/s)
A	19/11/1972	1	47037	0.00	35.70		PUM							

PUMP TEST DETAILS PART 2

PIPE	DATE	REC	TEST DUR (mins)	SWL (m)	RECOV. TIME (mins)	RESID. DD (m)	MAX DD or P RED (m)	Q at MAX DD (l/s)	TIME TO MAX DD (mins)	Max Q (l/s)	CALC STAT HD (m)	DESIGN YIELD (l/s)	DESIGN BP (m)	SUCT. SET (m)	TMSY (m2/DAY)	STOR
A	19/11/1972	1	<1440	-15.10			24.40	0.38				0.38	24.40			

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

REG NUMBER 47037

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

PIPE	DATE	RD	ANALYST	QAN	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	19/11/1972	1	GCL	054776	26.00	PU	GB	8850	7.5		5816.20	5438.02	1446	610	0.4	18.2	

WATER ANALYSIS PART 2

PIPE	DATE	RD	Na	K	Ca	Mg	Mn	HCO3	Fe	CO3	Cl	F	NO3	SO4	Zn	Al	B	Cu
A	19/11/1972	1	1590.0		154.0	258.0		744.0			2970.0	0.20		100.0				

WATER LEVEL DETAILS

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE	PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
X	19/11/1972	-15.10	N		NR												

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

**** End of Report. Produced:** 10/09/2017 12:48:05 PM ******

ISAAC REGIONAL COUNCIL

1. Property and bore owner

Bore name:	MB01	Property name:	Middlemount Landfill
Registered No.:	158773	Owner/Contact:	Isaac Regional Council
Lot/Plan:	L49 CNS281	Telephone:	1300472227
Parish:	Wyndham	Mobile:	
County:	Cairns	eMail:	

Residential address:	c/o Isaac Regional Council Middlemount Shopping Centre Middlemount 4746 Queensland
Postal address:	PO Box 97 Moranbah 4744 Queensland
Additional information:	Bore had moist mud in bottom. Moisture registered on depth sensor, but insufficient water to take a sample.

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0672779	EPE (m):	4
North:	7475733		
Zone:	55K	Photographs:	Yes
Elevation (m):	183		

Bore information:

Total depth (m):	41	Date drilled:	17/04/2017
TOC to GL (m):	0.66	Driller name:	Malcolm Scott
Screened interval (m):	37.5 - 40.50	Drilling company:	M & J Drilling
SWL when drilled (mBTOC):	NA		
SWL at assessment (mBTOC):	31.63		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	NA	Geological formation:	NA
Historical level records:	No	Construction details:	Landfill monitoring bore
		Casing material:	PVC
Installed equipment:	Nil	Casing diameter(mm):	60
		Casing length (m):	26.5
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

Total depth from bore log.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Nil	Stock:	No
Operational / non operational:	-	Stock type:	No
Currently in use:	Landfill monitoring bore	No. of stock:	No
Not in use but still usable:	-	Grazing/intensive:	No
Abandoned:	-		
Pump type:	NA		
Make/model:	NA	Domestic use:	No
Power source:	NA	No. of houses:	-
Depth in bore (m):	-		
Av. pump rate (L/sec)	-	Irrigation:	No
Max. pump capacity (L/sec)	-	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	Landfill monitoring bore
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	NA		
Discharge line size (mm):	NA		
Distribution lines (mm):	NA		

Equipment and maintenance notes:

No equipment. Bore is used to monitor leachate and/or potential impact on GW near Middlemount Landfill

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	0.00%
Odour:	-	CH4	0.02%
Particles:	-	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional inotes:

No sample taken. Wet mud in bottom of bore but not enough water to take a sample. Three attempts to take sample but not successful.

5. Assessment date and details:

Date of assessment:	15/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

DATE **10/09/2017**

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER **158773**

REGISTRATION DETAILS

		BASIN	1301	**LATITUDE**	22-48-56	**MAP-SCALE**	
OFFICE	Emerald	**SUB-AREA**		**LONGITUDE**	148-41-05	**MAP-SERIES**	
DATE LOG RECD	22-APR-14	**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	672894	**MAP-NO**	
D/O FILE NO.	LON/515/000(1733	**LOT**	49	**NORTHING**	7475913	**MAP NAME**	
R/O FILE NO.		**PLAN**	CNS281	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**		**PRES EQUIPMENT**	
				GPS ACC			
GIS LAT	-22.81554792	**PARISH NAME**	5200-WYNDHAM			**ORIGINAL BORE NO**	
GIS LNG	148.6846234	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	Y						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	17/04/2014			**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**	MALCOLM, SCOTT				
ROLES	SM	**DRILL COMPANY**	M & J DRILLING				
		METHOD OF CONST.	ROTARY AIR				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	17/04/2014	1	Polyvinyl Chloride	4.950	WT	60	0.00	41.00
A	17/04/2014	2	Perforated or Slotted Casing			60	37.50	40.50
A	17/04/2014	3	Gravel Pack	3.000	GR	125	36.00	41.00
X	17/04/2014	4	Grout			125	0.00	35.50
X	17/04/2014	5	Bentonite Seal			125	35.50	36.00
X	17/04/2014	6	Centraliser			125	7.00	35.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	0.40	CLAY, GRAVELLY, FILL
2	0.40	1.20	CLAY, PALE BROWN
3	1.20	11.00	GRANITE, PINK

BORE REPORT

REG NUMBER **158773**

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
4	11.00	23.00	GRANITE, ORANGE
5	23.00	25.00	GRINITE, PINK
6	25.00	41.00	GRANITE, ORANGE

STRATIGRAPHY DETAILS

****** NO RECORDS FOUND ******

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

****** NO RECORDS FOUND ******

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

BORE REPORT

REG NUMBER 158773

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

BORE REPORT

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**** End of Report. Produced:** 10/09/2017 01:16:20 PM ******

1. Property and bore owner

Bore name:	MB02	Property name:	Middlemount Landfill
Registered No.:	158772	Owner/Contact:	Isaac Regional Council
Lot/Plan:	L49 CNS281	Telephone:	1300472227
Parish:	Wyndham	Mobile:	
County:	Cairns	eMail:	

Residential address:	c/o Isaac Regional Council Middlemount Shopping Centre Middlemount 4746 Queensland
Postal address:	PO Box 97 Moranbah 4744 Queensland
Additional information:	Dry. Depth tape stopped at 12.51m

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673170	EPE (m):	4
North:	7475942		
Zone:	55K	Photographs:	Yes
Elevation (m):	181		

Bore information:

Total depth (m):	12.7	Date drilled:	18/04/2017
TOC to GL (m):	0.73	Driller name:	Malcolm Scott
Screened interval (m):	9.20 - 12.20	Drilling company:	M & J Drilling
SWL when drilled (mBTOC):	NA		
SWL at assessment (mBTOC):	Dry		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	NA	Geological formation:	NA
Historical level records:	No	Construction details:	Landfill monitoring bore
		Casing material:	PVC
Installed equipment:	Nil	Casing diameter(mm):	60
		Casing length (m):	12.2
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

Total depth from bore log. Depth sensor stopped at 12.51m.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Nil	Stock:	No
Operational / non operational:	-	Stock type:	No
Currently in use:	Landfill monitoring bore	No. of stock:	No
Not in use but still usable:	-	Grazing/intensive:	No
Abandoned:	-		
Pump type:	NA		
Make/model:	NA	Domestic use:	No
Power source:	NA	No. of houses:	-
Depth in bore (m):	-		
Av. pump rate (L/sec)	-	Irrigation:	No
Max. pump capacity (L/sec)	-	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	Landfill monitoring bore
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	NA		
Discharge line size (mm):	NA		
Distribution lines (mm):	NA		

Equipment and maintenance notes:

No equipment. Bore is used to monitor leachate and/or potential impact on GW near Middlemount Landfill.

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (μS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	0.00%
Odour:	-	CH4	0.00%
Particles:	-	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional inotes:

No sample taken. Bore dry.

5. Assessment date and details:

Date of assessment:	15/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER **158772**

REGISTRATION DETAILS

		BASIN	1301	**LATITUDE**	22-48-49	**MAP-SCALE**	
OFFICE	Emerald	**SUB-AREA**		**LONGITUDE**	148-41-18	**MAP-SERIES**	
DATE LOG RECD	22-APR-14	**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	673279	**MAP-NO**	
D/O FILE NO.	LON/515/000(1733	**LOT**	49	**NORTHING**	7476120	**MAP NAME**	
R/O FILE NO.		**PLAN**	CNS281	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**		**PRES EQUIPMENT**	
				GPS ACC			
GIS LAT	-22.81363908	**PARISH NAME**	5200-WYNDHAM			**ORIGINAL BORE NO**	
GIS LNG	148.6883504	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	Y						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	18/04/2014			**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**	MALCOLM, SCOTT				
ROLES	SM	**DRILL COMPANY**	M & J DRILLING				
		METHOD OF CONST.	ROTARY AIR				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	18/04/2014	1	Polyvinyl Chloride	10.000	WT	60	0.00	12.70
A	18/04/2014	2	Perforated or Slotted Casing			60	9.20	12.20
A	18/04/2014	3	Gravel Pack			60	8.00	12.70
X	18/04/2014	4	Grout			150	0.00	7.00
X	18/04/2014	5	Bentonite Seal			150	7.00	8.00
X	18/04/2014	6	Centraliser			150	5.00	9.20

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	1.00	CLAY, DARK BROWN
2	1.00	3.50	CLAY, GREY SANDY
3	3.50	6.00	CLAY, ORANGE

BORE REPORT

REG NUMBER **158772**

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
4	6.00	12.50	SAND
5	12.50	12.70	SNADSTONE WITH QUARTZ GRAINS

STRATIGRAPHY DETAILS

****** NO RECORDS FOUND ******

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

****** NO RECORDS FOUND ******

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

REG NUMBER **158772**

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

BORE REPORT

**** End of Report. Produced:** 10/09/2017 01:18:42 PM ******

1. Property and bore owner

Bore name:	MB03	Property name:	Middlemount Landfill
Registered No.:	158771	Owner/Contact:	Isaac Regional Council
Lot/Plan:	L49 CNS281	Telephone:	1300472227
Parish:	Wyndham	Mobile:	
County:	Cairns	eMail:	

Residential address:
c/o Isaac Regional Council
Middlemount Shopping Centre
Middlemount 4746
Queensland

Postal address:
PO Box 97
Moranbah 4744
Queensland

Additional information: Dry. Depth tape stopped at 26.57m

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673109	EPE (m):	4
North:	7476116		
Zone:	55K	Photographs:	Yes
Elevation (m):	177		

Bore information:

Total depth (m):	27	Date drilled:	18/04/2017
TOC to GL (m):	0.65	Driller name:	Malcolm Scott
Screened interval (m):	23.5 - 26.5	Drilling company:	M & J Drilling
SWL when drilled (mBTOC):	NA		
SWL at assessment (mBTOC):	Dry		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	NA	Geological formation:	NA
Historical level records:	No	Construction details:	Landfill monitoring bore
		Casing material:	PVC
Installed equipment:	Nil	Casing diameter(mm):	60
		Casing length (m):	12.2
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: ** Artesian*

Total depth from bore log. Depth sensor stopped at 26.57m.

3. Bore equipment / use

Equipment		Use	
Equipment installed:	Nil	Stock:	No
Operational / non operational:	-	Stock type:	No
Currently in use:	Landfill monitoring bore	No. of stock:	No
Not in use but still usable:	-	Grazing/intensive:	No
Abandoned:	-		
Pump type:	NA		
Make/model:	NA	Domestic use:	No
Power source:	NA	No. of houses:	-
Depth in bore (m):	-		
Av. pump rate (L/sec)	-	Irrigation:	No
Max. pump capacity (L/sec)	-	Town/camp supply:	No
Meter fitted:	-	Industrial use:	No
Meter type:	-	Other:	Landfill monitoring bore
Maintenance log available:	-		
Logger installed:	-		
Logger data available:	-		
Headworks:	See photos	Usage per day (Hrs):	N/A
Photo of headworks:	Yes	Pump test done:	No
Pump outlet size (mm):	NA		
Discharge line size (mm):	NA		
Distribution lines (mm):	NA		

Equipment and maintenance notes:

No equipment. Bore is used to monitor leachate and/or potential impact on GW near Middlemount Landfill.

4. Water quality

In-situ tests

Date:	-	**Alkalinity**	
Time:	-	Bicarbonate:	-
pH:	-	Carbonate:	-
EC (µS/cm):	-	Hydroxide:	-
Temperature (°C):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO2	0.00%
Odour:	-	CH4	0.00%
Particles:	-	H2S	0.0 ppm
Sampling point:	-	Sampled for analysis:	No
Equipment:	-	Sent to lab:	-
Purge method:	-	NATA laboratory:	-

Additional inotes:

No sample taken. Bore dry.

5. Assessment date and details:

Date of assessment:	15/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

Contact name:	Shane Flint	ACN:	
Occupation:	Environmental Manager	Activity:	Coal Mining
Company:	Middlemount Coal Pty Ltd		
Street address:		Telephone:	07 49850059
Postal address:	PO Box 24	Mobile:	0427 204083
Suburb:	Middlemount 4726	eMail:	sflint@middlemountcoal.com.au
State:	Queensland:		
Country:	Australia		

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 158773

REGISTRATION DETAILS

OFFICE Emerald
DATE LOG RECD 22-APR-14
D/O FILE NO. LON/515/000(1733
R/O FILE NO.
H/O FILE NO.

GIS LAT -22.81554792
GIS LNG 148.6846234
CHECKED Y

BASIN 1301
SUB-AREA
SHIRE 3980-ISAAC REGIONAL
LOT 49
PLAN CNS281
ORIGINAL DESCRIPTION

PARISH NAME 5200-WYNDHAM
COUNTY CAIRNS

LATITUDE 22-48-56
LONGITUDE 148-41-05
EASTING 672894
NORTHING 7475913
ZONE 55
ACCURACY
GPS ACC

MAP-SCALE
MAP-SERIES
MAP-NO
MAP NAME
PROG SECTION
PRES EQUIPMENT

ORIGINAL BORE NO
BORE LINE -

POLYGON
RN OF BORE REPLACED
DATA OWNER

FACILITY TYPE Sub-Artesian Facility
STATUS Existing
ROLES SM

DATE DRILLED 17/04/2014
DRILLERS NAME MALCOLM, SCOTT
DRILL COMPANY M & J DRILLING
METHOD OF CONST. ROTARY AIR

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	17/04/2014	1	Polyvinyl Chloride	4.950	WT	60	0.00	41.00
A	17/04/2014	2	Perforated or Slotted Casing			60	37.50	40.50
A	17/04/2014	3	Gravel Pack	3.000	GR	125	36.00	41.00
X	17/04/2014	4	Grout			125	0.00	35.50
X	17/04/2014	5	Bentonite Seal			125	35.50	36.00
X	17/04/2014	6	Centraliser			125	7.00	35.00

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	0.40	CLAY, GRAVELLY, FILL
2	0.40	1.20	CLAY, PALE BROWN
3	1.20	11.00	GRANITE, PINK

BORE REPORT

REG NUMBER **158773**

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
4	11.00	23.00	GRANITE, ORANGE
5	23.00	25.00	GRINITE, PINK
6	25.00	41.00	GRANITE, ORANGE

STRATIGRAPHY DETAILS

****** NO RECORDS FOUND ******

AQUIFER DETAILS

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 1

****** NO RECORDS FOUND ******

PUMP TEST DETAILS PART 2

****** NO RECORDS FOUND ******

BORE CONDITION

****** NO RECORDS FOUND ******

ELEVATION DETAILS

****** NO RECORDS FOUND ******

WATER ANALYSIS PART1

****** NO RECORDS FOUND ******

WATER ANALYSIS PART 2

****** NO RECORDS FOUND ******

WATER LEVEL DETAILS

****** NO RECORDS FOUND ******

WIRE LINE LOG DETAILS

****** NO RECORDS FOUND ******

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 158773

FIELD MEASUREMENTS

****** NO RECORDS FOUND ******

SPECIAL WATER ANALYSIS

****** NO RECORDS FOUND ******

**** End of Report. Produced:** 10/09/2017 01:16:20 PM ******

APPENDIX 2

Bore Assessment – Water Quality Results

CERTIFICATE OF ANALYSIS

Work Order	: **EB1719214**	Page	: 1 of 5
Client	: **4T CONSULTANTS PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR IAN RANKINE	Contact	: Jenny Bevan
Address	: PO BOX 1946 EMERALD QLD, AUSTRALIA 4720	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 7 49824100	Telephone	: +61-7-3243 7222
Project	: 745 GWQ	Date Samples Received	: 19-Sep-2017 09:20
Order number	: ----	Date Analysis Commenced	: 19-Sep-2017
C-O-C number	: ----	Issue Date	: 25-Sep-2017 15:54
Sampler	: ----		
Site	: ----		
Quote number	: BNBQ/001/16		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Sydney Organics, Smithfield, NSW
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- **Methane analysis will be conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**Rolf's Bore**	**House Bore**	**Blanches Bore**	**----**	**----**
			Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1719214-001**	**EB1719214-002**	**EB1719214-003**	**--------**	**--------**
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.23**	**7.25**	**7.37**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**13600**	**4330**	**2270**	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**9280**	**2510**	**1370**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**764**	**719**	**614**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**764**	**719**	**614**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**21**	**168**	**196**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**5200**	**1090**	**342**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**311**	**196**	**93**	----	----
Magnesium	7439-95-4	1	mg/L	**496**	**135**	**86**	----	----
Sodium	7440-23-5	1	mg/L	**2070**	**582**	**286**	----	----
Potassium	7440-09-7	1	mg/L	**3**	**5**	**3**	----	----
ED093F: SAR and Hardness Calculations								
Total Hardness as CaCO3	----	1	mg/L	**2820**	**1040**	**586**	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	**0.213**	**0.192**	**0.115**	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.012**	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	**0.006**	**0.007**	**0.019**	----	----
Manganese	7439-96-5	0.001	mg/L	**1.80**	**0.019**	**0.003**	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**Rolf's Bore**	**House Bore**	**Blanches Bore**	**----**	**----**
			Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1719214-001**	**EB1719214-002**	**EB1719214-003**	**--------**	**--------**
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.006**	**0.002**	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Boron	7440-42-8	0.05	mg/L	**0.30**	**0.40**	**0.19**	----	----
Iron	7439-89-6	0.05	mg/L	**19.7**	<0.05	<0.05	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.03**	<0.01	<0.01	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	**0.240**	**0.210**	**0.122**	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	**0.0001**	----	----
Chromium	7440-47-3	0.001	mg/L	**0.001**	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.015**	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	**0.007**	<0.005	**0.017**	----	----
Manganese	7439-96-5	0.001	mg/L	**1.80**	**0.022**	**0.004**	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	**0.005**	**0.002**	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Boron	7440-42-8	0.05	mg/L	**0.32**	**0.44**	**0.22**	----	----
Iron	7439-89-6	0.05	mg/L	**19.8**	<0.05	<0.05	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	**0.5**	**0.2**	----	----
EK084: Un-ionized Hydrogen Sulfide								
Unionized Hydrogen Sulfide	----	0.1	mg/L	<0.1	<0.1	<0.1	----	----
EN055: Ionic Balance								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**Rolf's Bore**	**House Bore**	**Blanches Bore**	**----**	**----**
			Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1719214-001**	**EB1719214-002**	**EB1719214-003**	**--------**	**--------**
				Result	Result	Result	----	----
EN055: Ionic Balance - Continued								
Total Anions	----	0.01	meq/L	**162**	**48.6**	**26.0**	**----**	**----**
Total Cations	----	0.01	meq/L	**146**	**46.3**	**24.2**	**----**	**----**
Ionic Balance	----	0.01	%	**5.16**	**2.40**	**3.50**	**----**	**----**
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**6790**	<10	<10	**----**	**----**

QUALITY CONTROL REPORT

Work Order : **EB1719214**

Client : **4T CONSULTANTS PTY LTD**
Contact : MR IAN RANKINE
Address : PO BOX 1946
EMERALD QLD, AUSTRALIA 4720
Telephone : +61 7 49824100
Project : 745 GWQ
Order number : ----
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : BNBQ/001/16
No. of samples received : 3
No. of samples analysed : 3

Page : 1 of 11

Laboratory : Environmental Division Brisbane
Contact : Jenny Bevan
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 19-Sep-2017
Date Analysis Commenced : 19-Sep-2017
Issue Date : 25-Sep-2017

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Sydney Organics, Smithfield, NSW
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to hig

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 1122177)									
EB1719153-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	6.87	6.83	0.584	0% - 20%
EB1719214-001	Rolf's Bore	EA005-P: pH Value	----	0.01	pH Unit	7.23	7.24	0.138	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 1122175)									
EB1719153-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	4140	4090	1.22	0% - 20%
EB1719214-001	Rolf's Bore	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	13600	13600	0.00	0% - 20%
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 1123893)									
EB1719208-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	662	672	1.55	0% - 20%
EB1719234-004	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	3360	3380	0.505	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 1122176)									
EB1719153-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	465	468	0.738	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	465	468	0.738	0% - 20%
EB1719214-001	Rolf's Bore	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	764	765	0.00	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	764	765	0.00	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1128258)									
EB1719100-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	13	13	0.00	0% - 50%
EB1719214-002	House Bore	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	168	168	0.00	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 1128259)									
EB1719100-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	4	5	0.00	No Limit
EB1719214-002	House Bore	ED045G: Chloride	16887-00-6	1	mg/L	1090	1090	0.346	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1123833)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
ED093F: Dissolved Major Cations (QC Lot: 1123833) - continued									
EB1719140-012	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EB1718574-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	5	5	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	1	1	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	10	10	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123830)									
EB1719140-012	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1718574-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.028	0.027	0.00	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.009	0.009	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.032	0.022	36.9	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.55	0.55	0.00	0% - 20%
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123830) - continued									
EB1718574-001	Anonymous	EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.27	0.28	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123831)									
EB1718574-001	Anonymous	EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1123839)									
EB1719202-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.010	0.010	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.010	0.011	0.00	0% - 50%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.04	0.02	83.8	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1719204-009	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.013	0.013	0.00	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.043	0.044	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.011	0.011	0.00	0% - 50%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.007	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	3.13	3.13	0.147	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.007	0.008	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.029	0.029	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2.62	2.59	1.26	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.07	2.10	1.75	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	7.77	7.86	1.06	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 1123840)									
EB1719202-001	Anonymous	EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EB1719204-009	Anonymous	EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.007	0.007	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1123841)									
EB1719214-003	Blanches Bore	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.122	0.125	2.16	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.015	0.016	0.00	0% - 50%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.017	0.018	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.22	0.23	5.37	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1719263-004	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.022	0.022	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.185	0.186	0.00	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.007	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.030	0.030	0.00	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.899	0.905	0.650	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.19	0.20	0.00	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 1123834)									
EB1719140-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1719278-013	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1123844)									
EB1719186-066	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1719204-007	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 1122174)									
EB1719153-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	4.6	4.6	0.00	0% - 20%
EB1719214-001	Rolf's Bore	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.2	0.2	0.00	No Limit
EP033: C1 - C4 Hydrocarbon Gases (QC Lot: 1127457)									
EB1719214-001	Rolf's Bore	EP033: Methane	74-82-8	10	µg/L	6790	6740	0.762	0% - 20%
EM1712836-009	Anonymous	EP033: Methane	74-82-8	10	µg/L	<10	<10	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA005P: pH by PC Titrator (QCLot: 1122177)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98	102
				----	7 pH Unit	101	98	102
EA010P: Conductivity by PC Titrator (QCLot: 1122175)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	220 µS/cm	98.2	91	107
				<1	12890 µS/cm	95.2	91	107
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 1123893)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	293 mg/L	99.8	88	112
				<10	2000 mg/L	94.6	88	112
ED037P: Alkalinity by PC Titrator (QCLot: 1122176)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	102	80	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1128258)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	103	85	118
				<1	100 mg/L	99.0	85	118
ED045G: Chloride by Discrete Analyser (QCLot: 1128259)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	104	90	115
				<1	1000 mg/L	110	90	115
ED093F: Dissolved Major Cations (QCLot: 1123833)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	97.5	79	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	88	116
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	98.6	81	117
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	110	70	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	99.8	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	101	87	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.4	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	96.0	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	89.3	89	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	95.5	89	120
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	97.3	89	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	101	89	113

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830) - continued								
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	99.8	83	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	104	88	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	96.6	87	113
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	105	81	125
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	95.6	82	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123831)								
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1123839)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	103	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	101	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	111	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	96.9	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	100	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.3	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	105	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	103	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	98.6	88	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	102	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	97.1	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	101	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	106	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	91.6	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	111	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.8	82	118
EG020T: Total Metals by ICP-MS (QCLot: 1123840)								
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1123841)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	108	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.9	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	107	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	114	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	98.9	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	100	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	96.0	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	102	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	102	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	102	88	114

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 1123841) - continued								
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	99.7	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	94.7	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.2	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	111	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	90.8	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	121	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	82	118
EG035F: Dissolved Mercury by FIMS (QCLot: 1123834)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	94.1	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1123844)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	100	84	118
EK040P: Fluoride by PC Titrator (QCLot: 1122174)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.5 mg/L	100	80	117
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 1127457)								
EP033: Methane	74-82-8	10	µg/L	<10	28.48 µg/L	91.4	86	114

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1128258)							
EB1719100-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 1128259)							
EB1719100-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	110	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830)							
EB1718574-002	Anonymous	EG020A-F: Aluminium	7429-90-5	0.5 mg/L	# Not Determined	70	130
		EG020A-F: Arsenic	7440-38-2	1 mg/L	97.5	70	130
		EG020A-F: Beryllium	7440-41-7	1 mg/L	97.4	70	130
		EG020A-F: Barium	7440-39-3	5 mg/L	108	70	130
		EG020A-F: Cadmium	7440-43-9	1 mg/L	97.7	70	130
		EG020A-F: Chromium	7440-47-3	1 mg/L	92.4	70	130
		EG020A-F: Cobalt	7440-48-4	1 mg/L	97.6	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830) - continued							
EB1718574-002	Anonymous	EG020A-F: Copper	7440-50-8	2 mg/L	96.4	70	130
		EG020A-F: Lead	7439-92-1	1 mg/L	81.7	70	130
		EG020A-F: Manganese	7439-96-5	0.1 mg/L	# Not Determined	70	130
		EG020A-F: Molybdenum	7439-98-7	1 mg/L	85.8	70	130
		EG020A-F: Nickel	7440-02-0	1 mg/L	99.7	70	130
		EG020A-F: Selenium	7782-49-2	1 mg/L	96.3	70	130
		EG020A-F: Vanadium	7440-62-2	1 mg/L	99.6	70	130
		EG020A-F: Zinc	7440-66-6	2 mg/L	95.2	70	130
		EG020A-F: Boron	7440-42-8	5 mg/L	101	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1123839)							
EB1719186-067	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	97.4	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	102	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	107	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	93.1	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	97.2	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	102	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	103	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	113	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	97.4	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	93.9	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	96.4	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	93.3	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1123841)							
EB1719218-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	100.0	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	108	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	119	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	98.2	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	93.8	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	95.6	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	94.9	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	110	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	92.8	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	87.8	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	95.8	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	90.1	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 1123834)							
EB1719140-004	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	82.0	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1123844)							
EB1719186-067	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	88.4	70	130
EK040P: Fluoride by PC Titrator (QCLot: 1122174)							
EB1719174-001	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	99.8	70	130
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 1127457)							
EM1712836-001	Anonymous	EP033: Methane	74-82-8	28.48 µg/L	126	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1719214**	Page	: 1 of 8
Client	: **4T CONSULTANTS PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR IAN RANKINE	Telephone	: +61-7-3243 7222
Project	: 745 GWQ	Date Samples Received	: 19-Sep-2017
Site	: ----	Issue Date	: 25-Sep-2017
Sampler	: ----	No. of samples received	: 3
Order number	: ----	No. of samples analysed	: 3

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EB1719100--002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EB1718574--002	Anonymous	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EB1718574--002	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	**Days overdue**	*Date analysed*	*Due for analysis*	**Days overdue**
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural Rolf's Bore, House Bore, Blanches Bore	----	----	----	19-Sep-2017	13-Sep-2017	**6**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Dissolved Metals by ICP-MS - Suite B	0	3	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	0	10	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**19-Sep-2017**	13-Sep-2017	✗
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**19-Sep-2017**	11-Oct-2017	✓
EA015: Total Dissolved Solids dried at 180 ± 5 °C							
Clear Plastic Bottle - Natural (EA015H) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**20-Sep-2017**	20-Sep-2017	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**19-Sep-2017**	27-Sep-2017	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**22-Sep-2017**	11-Oct-2017	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**22-Sep-2017**	11-Oct-2017	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	11-Oct-2017	✓
ED093F: SAR and Hardness Calculations							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	11-Oct-2017	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	12-Mar-2018	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**20-Sep-2017**	12-Mar-2018	✓	**20-Sep-2017**	12-Mar-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*		*Sample Date*	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F)								
Rolf's Bore, Blanches Bore	House Bore,	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	11-Oct-2017	✓
EG035T: Total Recoverable Mercury by FIMS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T)								
Rolf's Bore, Blanches Bore	House Bore,	**13-Sep-2017**	**----**	----	----	**20-Sep-2017**	11-Oct-2017	✓
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P)								
Rolf's Bore, Blanches Bore	House Bore,	**13-Sep-2017**	**----**	----	----	**19-Sep-2017**	11-Oct-2017	✓
EP033: C1 - C4 Hydrocarbon Gases								
Amber VOC Vial - Sulfuric Acid (EP033)								
Rolf's Bore, Blanches Bore	House Bore,	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	27-Sep-2017	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	16	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	0	3	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	0	10	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Total Dissolved Solids (High Level)	EA015H	WATER	In house: Referenced to APHA 2540C. A gravimetric procedure that determines the amount of \`filterable\` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Un-ionized Hydrogen Sulfide	EK084	WATER	In house: Referenced to APHA 4500-S2- H. Sulfide in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
C1 - C4 Gases	EP033	WATER	Technical Guidance for the Natural Attenuation Indicators: Methane, Ethane, and Ethene, US EPA - Region 1, EPA New England, July 2001. Automated static headspace, dual column GC/FID. A 12 mL sample is pipetted into a 20 mL headspace vial containing 3g of sodium chloride and sealed. Each sample is equilibrated with shaking at 40 degrees C for 10 minutes prior to analysis by GC/FID using a pair of PLOT columns of different polarity.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

Appendix D **Monitoring bores**

coffey environments

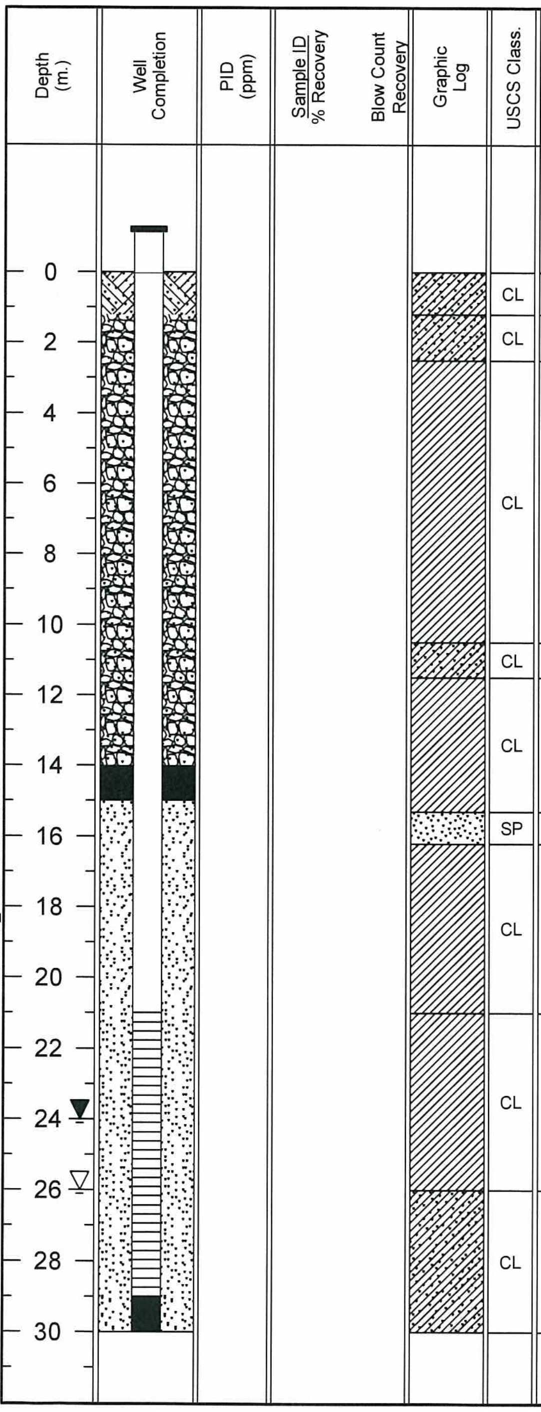
Drilling Log

Monitoring Well **MW1**

Page: 1 of 1

Project *MEMS*
Owner *Middlemount Coal Pty Ltd*
Location *Middlemount Mine*
Proj. No. *ENVINEWS08629AA*
Surface Elev. *NA*
Total Hole Depth *30.0 m.*
North
East
Top of Casing *NA*
Water Level Initial ∇ *26.0 m.*
Static ▼ *24.0 m.*
Diameter *125 mm.*
Screen: Dia *NA*
Length *NA*
Type/Size *Class 18 UPVC*
Casing: Dia *NA*
Length *NA*
Type *Class 18 UPVC*
Fill Material
Rig/Core
Drill Co. *QLD Drilling*
Method *Air Rotary*
Driller *Corey Evetts*
Log By *M Weir*
Date *5/6/08*
Permit # *NA*
Checked By
License No.

COMMENTS
Backfill used above bentonite plug.



USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
CL	Sandy CLAY - non plastic, brown, dry, stiff, heterogeneous.
CL	Sandy CLAY - non plastic, grey, heterogeneous, sandy brown lenses, dry.
CL	CLAY - non plastic, orange, dry, stiff, homogeneous.
CL	Sandy CLAY - orange, soft, dry.
CL	CLAY - non plastic, brown, dry, stiff, heterogeneous.
SP	SAND - grey, moist.
CL	CLAY - non plastic, brown, dry, stiff, heterogeneous.
CL	CLAY - non pastic, grey, stratified, orange lenses, dry, very stiff.
CL	Sandy CLAY - moderate plasticity, grey sand, orange clay, wet, heterogeneous.
	End of hole at 30.0m - Limit of investigation.

GROUNDWATER BOREHOLE LOG

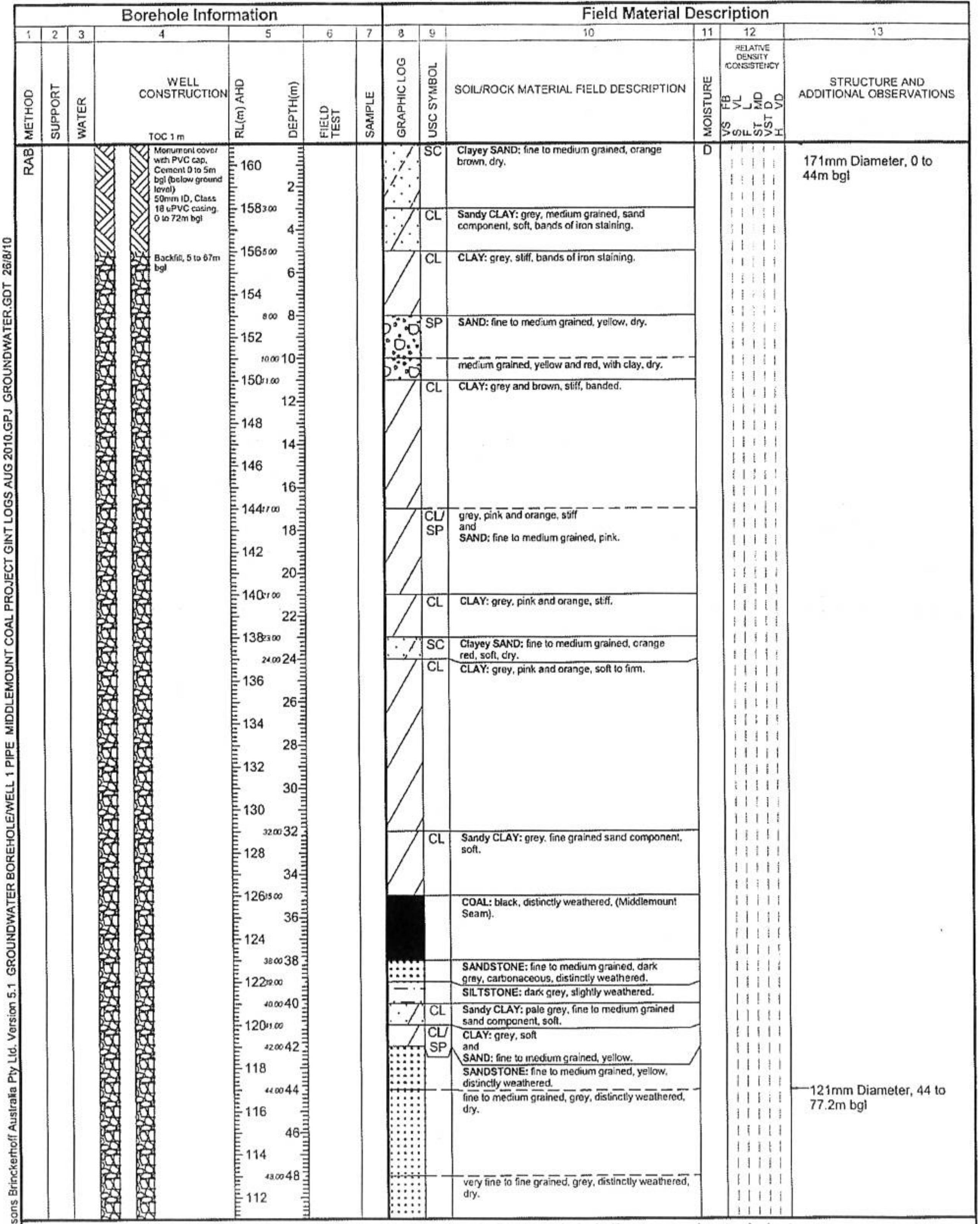
BOREHOLE NO.

MW1P

SHEET 1 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	12.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	19.06.2010
Borehole Location:	MW1P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	WAR
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	161 m AHD
		Driller Lic No:	3046	Co-ords:	E 667818 N 7473149 MGA94 Zone 55
Borehole Diameter:	171mm to 121mm	TOC (RL):	162 m AHD	Local Co-ords:	

Borehole Information / Field Material Description



WELL CONSTRUCTION (TOC 1 m):

Monument cover with PVC cap, Cement 0 to 5m bgl (below ground level)
50mm ID, Class 18 uPVC casing, 0 to 72m bgl

Backfill, 5 to 67m bgl

DEPTH(m)	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
	SC	**Clayey SAND:** fine to medium grained, orange brown, dry.	D	171mm Diameter, 0 to 44m bgl
3.00	CL	**Sandy CLAY:** grey, medium grained, sand component, soft, bands of iron staining.		
5.00	CL	**CLAY:** grey, stiff, bands of iron staining.		
8.00	SP	**SAND:** fine to medium grained, yellow, dry.		
10.00		medium grained, yellow and red, with clay, dry.		
11.00	CL	**CLAY:** grey and brown, stiff, banded.		
17.00	CL/ SP	grey, pink and orange, stiff and **SAND:** fine to medium grained, pink.		
21.00	CL	**CLAY:** grey, pink and orange, stiff.		
23.00	SC	**Clayey SAND:** fine to medium grained, orange red, soft, dry.		
24.00	CL	**CLAY:** grey, pink and orange, soft to firm.		
32.00	CL	**Sandy CLAY:** grey, fine grained sand component, soft.		
35.00		**COAL:** black, distinctly weathered, (Middlemount Seam).		
38.00		**SANDSTONE:** fine to medium grained, dark grey, carbonaceous, distinctly weathered.		
39.00		**SILTSTONE:** dark grey, slightly weathered.		
40.00	CL	**Sandy CLAY:** pale grey, fine to medium grained sand component, soft.		
41.00	CL/ SP	**CLAY:** grey, soft and **SAND:** fine to medium grained, yellow.		
42.00		**SANDSTONE:** fine to medium grained, yellow, distinctly weathered.		
44.00		fine to medium grained, grey, distinctly weathered, dry.		121mm Diameter, 44 to 77.2m bgl
48.00		very fine to fine grained, grey, distinctly weathered, dry.		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

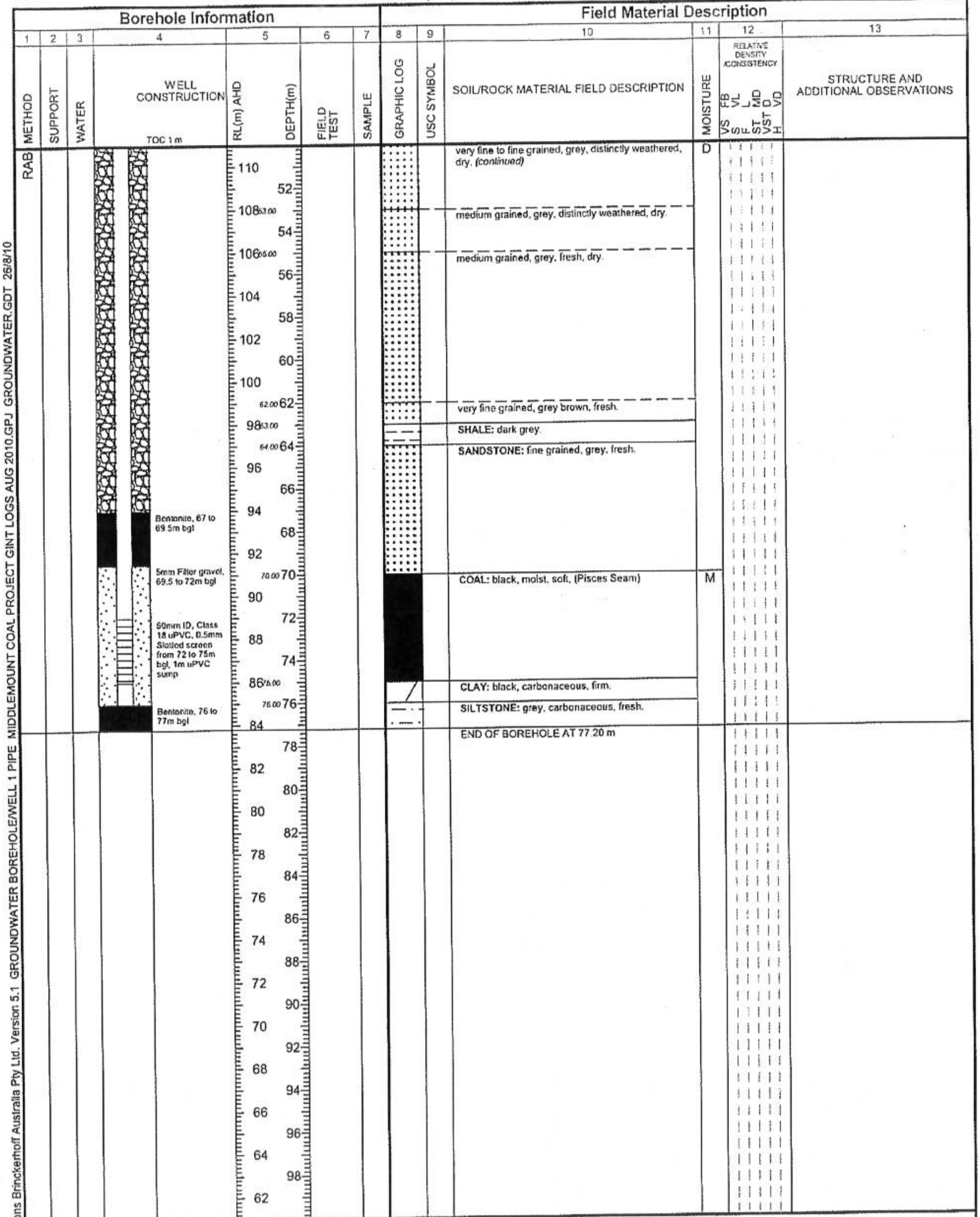
BOREHOLE NO.

MW1P

SHEET 2 OF 2

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW1P - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 12.06.2010
Date Completed: 19.06.2010
Recorded By: Malcolm Graham
Log Checked By: MR

Drill Model/Mounting: IRTH 60
Borehole Diameter: 171mm to 121mm
Driller: S Baker
Driller Lic No: 3046
TOC (RL): 162 m AHD
Surface RL: 161 m AHD
Co-ords: E 667818 N 7473149 MGA94 Zone 55
Local Co-ords:



Borehole Information

Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB							very fine to fine grained, grey, distinctly weathered, dry. *(continued)*	D		
				53.00			medium grained, grey, distinctly weathered, dry.			
				55.00			medium grained, grey, fresh, dry.			
				62.00			very fine grained, grey brown, fresh.			
				63.00			**SHALE:** dark grey.			
				64.00			**SANDSTONE:** fine grained, grey, fresh.			
			Bentonite, 67 to 69.5m bgl							
			5mm Filter gravel, 69.5 to 72m bgl	70.00			**COAL:** black, moist, soft, (Pisces Seam)	M		
			50mm ID, Class 18 uPVC, 0.5mm Slotted screen from 72 to 75m bgl, 1m uPVC sump							
				75.00			**CLAY:** black, carbonaceous, firm.			
			Bentonite, 76 to 77m bgl	76.00			**SILTSTONE:** grey, carbonaceous, fresh.			
							END OF BOREHOLE AT 77.20 m			

coffey environments

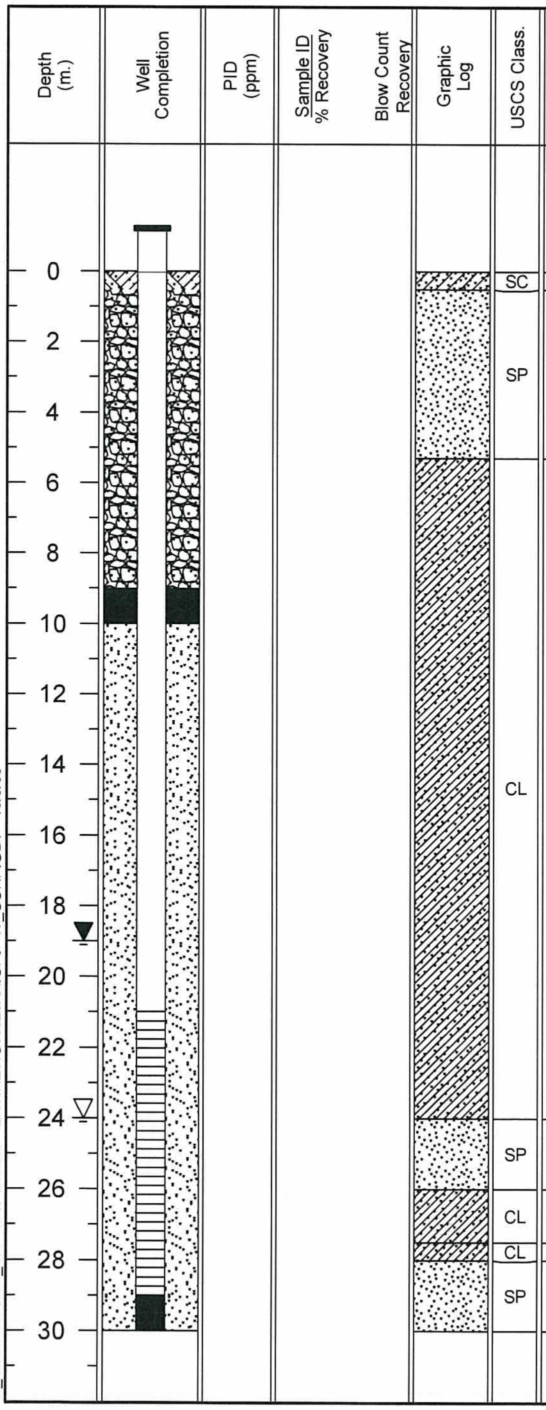
Drilling Log

Monitoring Well **MW2**

Page: 1 of 1

Project *MEMS* Owner *Middlemount Coal Pty Ltd*
Location *Middlemount Mine* Proj. No. *ENVINEWS08629AA*
Surface Elev. *NA* Total Hole Depth *30.0 m.* North ____ East ____
Top of Casing *NA* Water Level Initial ▽ *24.0 m.* Static ▼ *19.0 m.* Diameter *125 mm.*
Screen: Dia *NA* Length *NA* Type/Size *Class 18 UPVC*
Casing: Dia *NA* Length *NA* Type *Class 18 UPVC*
Fill Material ____ Rig/Core ____
Drill Co. *QLD Drilling* Method *Air Rotary*
Driller *Corey Evetts* Log By *M Weir* Date *5/6/08* Permit # *NA*
Checked By ____ License No. ____

COMMENTS
Backfill used above bentonite plug.



Description

(Color, Texture, Structure)

Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.

Clayey SAND - brown, dry, loose.

SAND - brown, compacted, dry.

Sandy CLAY - non plastic, grey, dry, stratified, yellow/orange, hard.

SAND - grey, wet.

Sandy CLAY - red/brown, moist.

Sandy CLAY - black.

SAND - grey, wet.

End of hole at 30.0m - Limit of investigation.

Drilling Log

Monitoring Well **MW3**

Page: 1 of 1

Project *MEMS*
Owner *Middlemount Coal Pty Ltd*
Location *Middlemount Mine*
Proj. No. *ENVINEWS08629AA*
Surface Elev. *NA*
Total Hole Depth *48.0 m.*
North
East
Top of Casing *NA*
Water Level Initial ▽ *45.0 m.*
Static ▼ *22.0 m.*
Diameter *125 mm.*
Screen: Dia *NA*
Length *NA*
Type/Size *Class 18 UPVC*
Casing: Dia *NA*
Length *NA*
Type *Class 18 UPVC*
Fill Material
Rig/Core
Drill Co. *QLD Drilling*
Method *Air Rotary*
Driller *Corey Evetts*
Log By *M Weir*
Date *4/6/08*
Permit # *NA*
Checked By
License No.

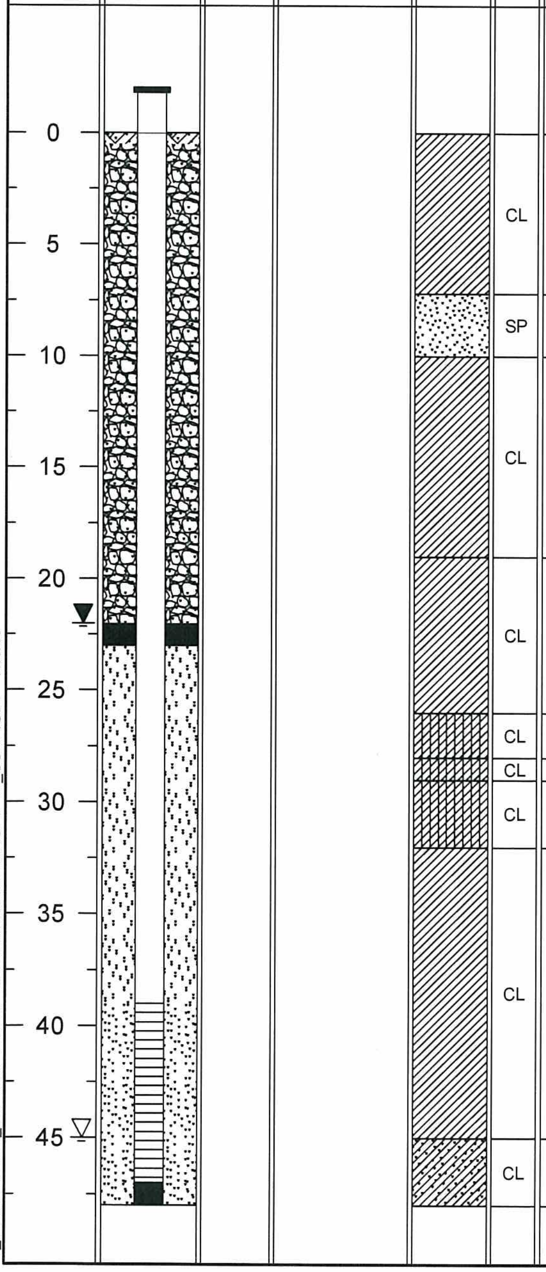
COMMENTS
Backfill used above bentonite plug.

Depth (m.) | Well Completion | PID (ppm) | Sample ID % Recovery | Blow Count Recovery | Graphic Log | USCS Class.

Description

(Color, Texture, Structure)

Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.



USCS Class.	Description
CL	CLAY - non plastic, orange/grey, stratified, dry, very stiff.
SP	SAND - orange, dry, medium density, medium to coarse sand.
CL	CLAY - low plasticity, brown, stratified, dry, stiff.
CL	CLAY - low plasticity, grey, white/orange mottles, damp, firm/soft.
CL	Silty CLAY - grey, damp, firm, heterogeneous.
CL	Silty CLAY - grey, dry, firm, heterogeneous.
CL	Silty CLAY - low plasticity, orange, damp, soft, heterogeneous.
CL	CLAY - non plastic, orange with grey lenses, friable, hard, dry.
CL	Sandy CLAY - grey, damp.
	End of hole at 48.0m - Limit of investigation.

Drilling Log

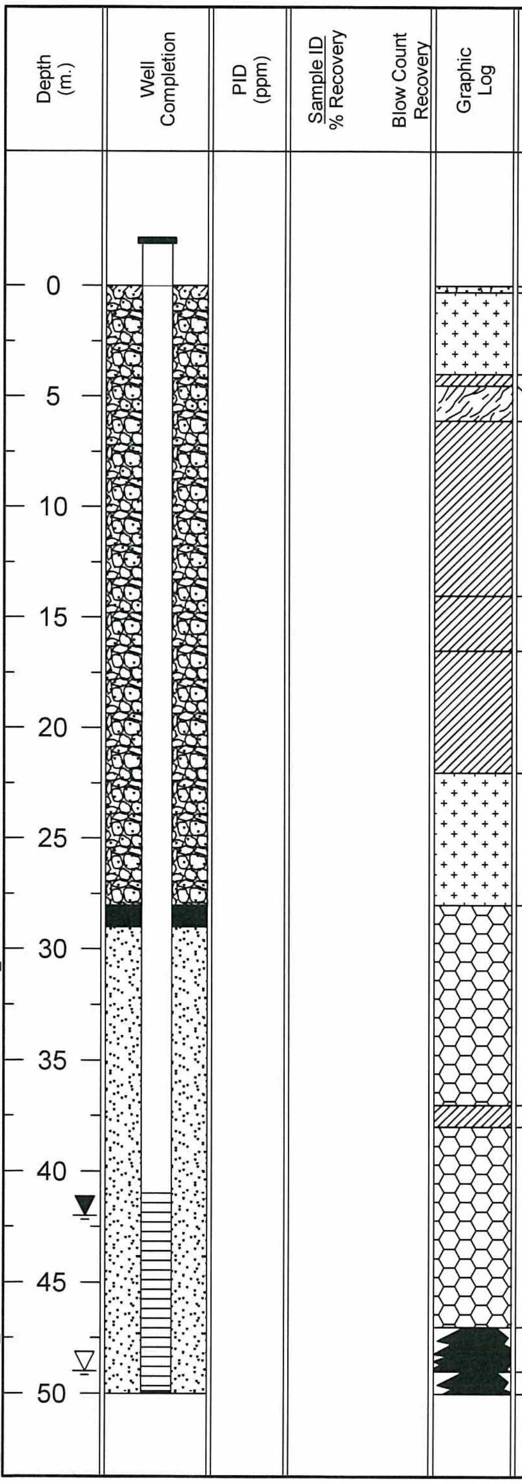
coffey environments

Monitoring Well MW4

Page: 1 of 1

Project: *MEMS*
Owner: *Middlemount Coal Pty Ltd*
Location: *Middlemount Mine*
Proj. No.: *ENVINEWS08629AA*
Surface Elev.: *NA*
Total Hole Depth: *50.0 m.*
North:
East:
Top of Casing: *NA*
Water Level Initial: ∇ *49.0 m.*
Static: ▼ *42.0 m.*
Diameter: *125 mm.*
Screen: Dia: *NA*
Length: *NA*
Type/Size: *Class 18 UPVC*
Casing: Dia: *NA*
Length: *NA*
Type: *Class 18 UPVC*
Fill Material:
Rig/Core:
Drill Co.: *QLD Drilling*
Method: *Air Rotary/Air Hammer*
Driller: *Corey Evetts*
Log By: *M Weir*
Date: *4/6/08*
Permit #: *NA*
Checked By:
License No.:

COMMENTS
Backfill used above bentonite plug.



Description
(Color, Texture, Structure)
Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.

USCS Class.	Description
	TOPSOIL.
	GRANITE ROCK.
CL	CLAY - brown, hard, friable, dry.
	CLAYSTONE - brown, rock, dry.
CL	CLAY - non plastic, grey/white, very hard, friable, dry.
CL	CLAY - non plastic, brown/white/orange mottled, stiff, dry, laminated.
CL	CLAY - non plastic, orange/white/grey/black, stratified, dry, damp.
	Weathered GRANITE/CLAYSTONE.
	Weathered BASALT - blue/grey, dry.
CL	CLAY - non plastic, brown, damp, stiff.
	Weathered BASALT - dry.
	COAL - hard, dry.
SP	Sandy COAL - wet.
	End of hole at 50.0m - Limit of investigation.

coffey environments

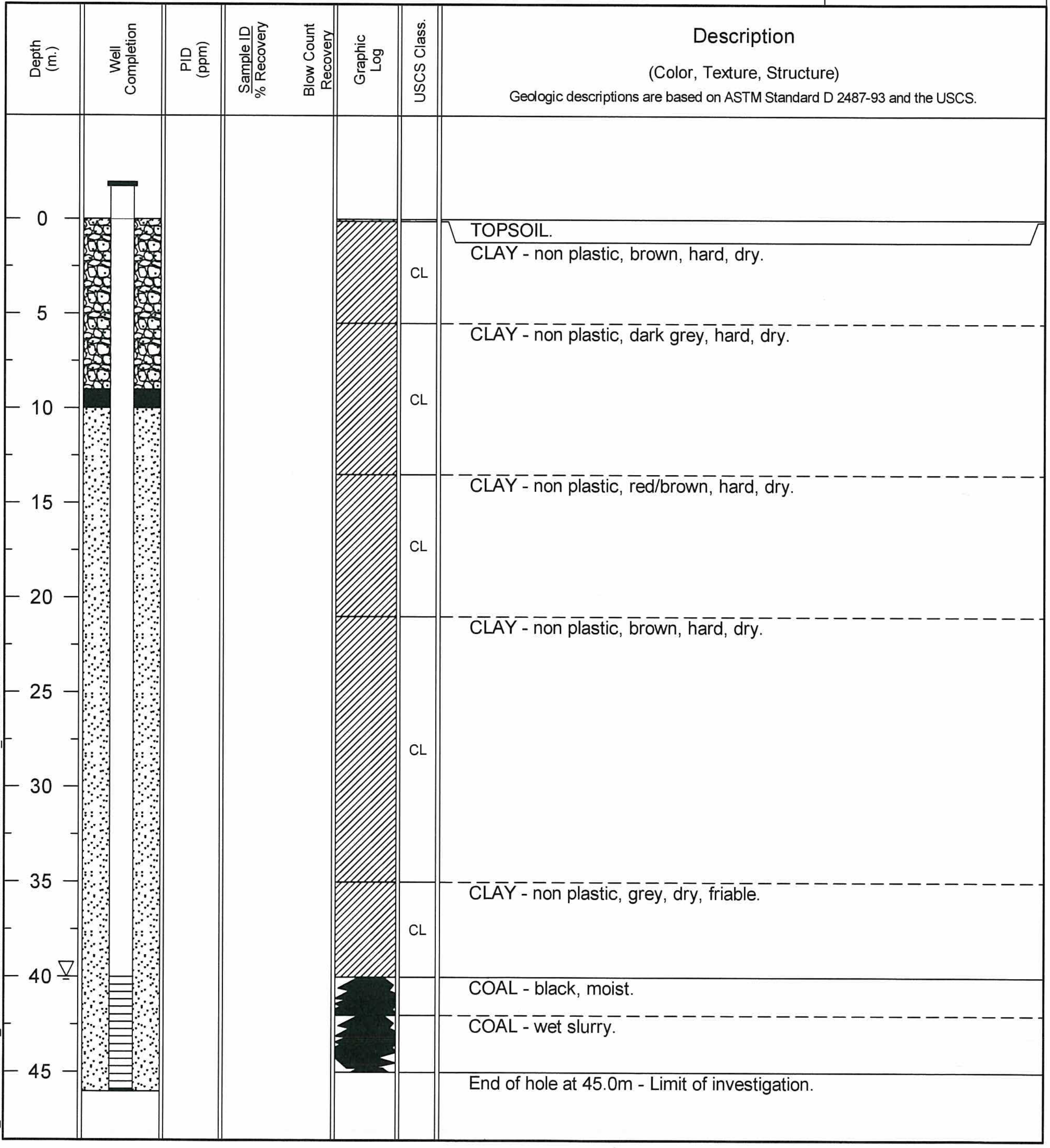
Drilling Log

Monitoring Well **MW5**

Page: 1 of 1

Project MEMS
Owner Middlemount Coal Pty Ltd
Location Middlemount Mine
Proj. No. ENVINEWS08629AA
Surface Elev. NA
Total Hole Depth 46.0 m.
North
East
Top of Casing NA
Water Level Initial ⊻ 40.0 m.
Static NA
Diameter 125 mm.
Screen: Dia NA
Length NA
Type/Size Class 18 UPVC
Casing: Dia NA
Length NA
Type Class 18 UPVC
Fill Material
Rig/Core
Drill Co. QLD Drilling
Method Air Rotary
Driller Corey Evetts
Log By M Weir
Date 3/6/08
Permit # NA
Checked By
License No.

COMMENTS
Backfill used above bentonite plug.



Description

(Color, Texture, Structure)

Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.

TOPSOIL.

CLAY - non plastic, brown, hard, dry.

CLAY - non plastic, dark grey, hard, dry.

CLAY - non plastic, red/brown, hard, dry.

CLAY - non plastic, brown, hard, dry.

CLAY - non plastic, grey, dry, friable.

COAL - black, moist.

COAL - wet slurry.

End of hole at 45.0m - Limit of investigation.

GROUNDWATER BOREHOLE LOG

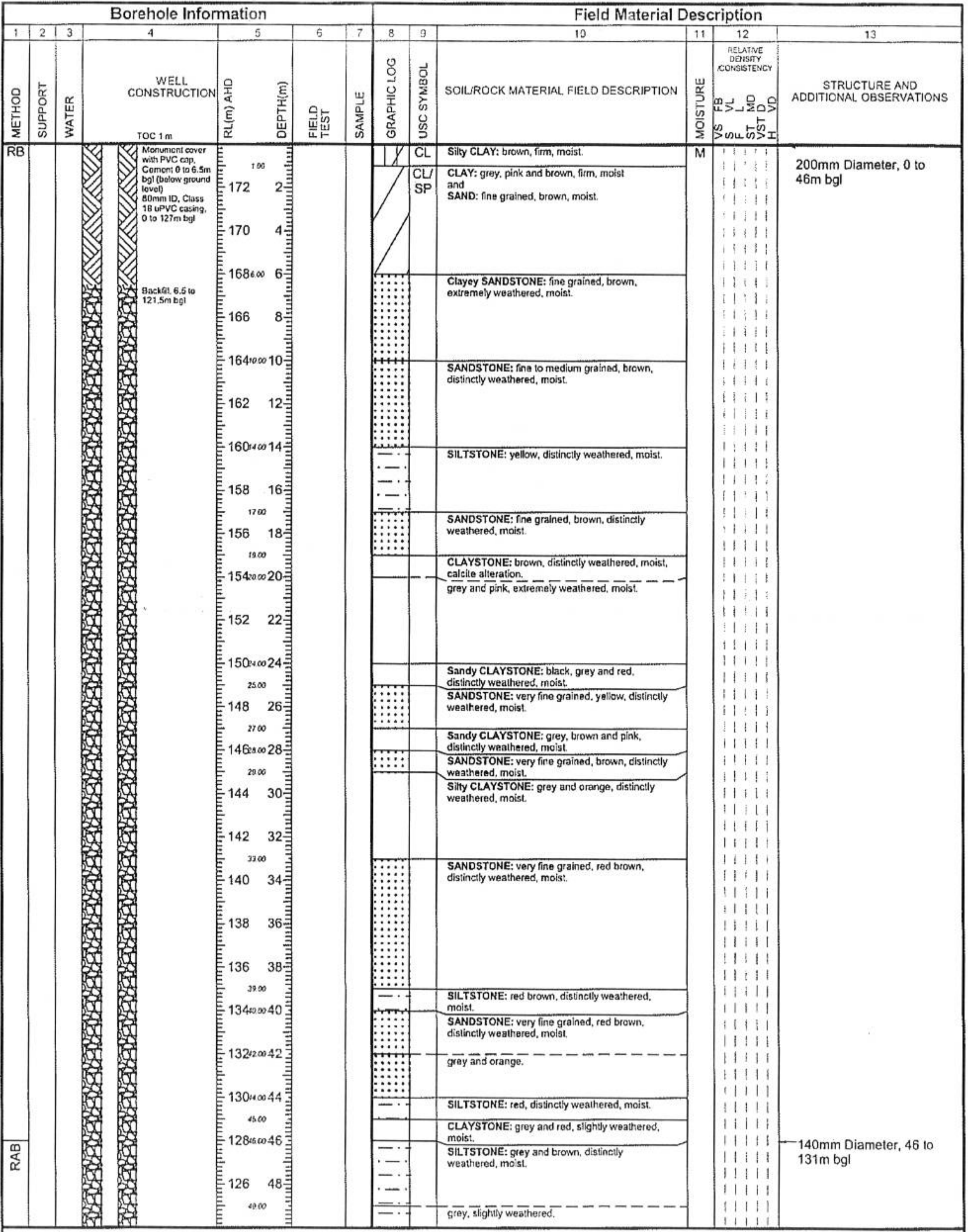
BOREHOLE NO.

MW5M

SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced:	10.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed:	24.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE		Recorded By:	Malcolm Graham
Project Number:	2117076B		Log Checked By:	MAR

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667790 N 7475131 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	



Well construction:

Monument cover with PVC cap, Cement 0 to 6.5m bgl (below ground level)
80mm ID, Class 18 uPVC casing, 0 to 127m bgl

Backfill, 6.5 to 121.5m bgl

METHOD	DEPTH(m)	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB		CL	**Silty CLAY:** brown, firm, moist.	M	200mm Diameter, 0 to 46m bgl
	1.00	CL/ SP	**CLAY:** grey, pink and brown, firm, moist and **SAND:** fine grained, brown, moist.		
	6.00		**Clayey SANDSTONE:** fine grained, brown, extremely weathered, moist.		
	10.00		**SANDSTONE:** fine to medium grained, brown, distinctly weathered, moist.		
	14.00		**SILTSTONE:** yellow, distinctly weathered, moist.		
	17.00		**SANDSTONE:** fine grained, brown, distinctly weathered, moist.		
	19.00		**CLAYSTONE:** brown, distinctly weathered, moist, calcite alteration.		
	20.00		grey and pink, extremely weathered, moist.		
	24.00		**Sandy CLAYSTONE:** black, grey and red, distinctly weathered, moist.		
	25.00		**SANDSTONE:** very fine grained, yellow, distinctly weathered, moist.		
	27.00		**Sandy CLAYSTONE:** grey, brown and pink, distinctly weathered, moist.		
	28.00		**SANDSTONE:** very fine grained, brown, distinctly weathered, moist.		
	29.00		**Silty CLAYSTONE:** grey and orange, distinctly weathered, moist.		
	33.00		**SANDSTONE:** very fine grained, red brown, distinctly weathered, moist.		
	39.00		**SILTSTONE:** red brown, distinctly weathered, moist.		
	40.00		**SANDSTONE:** very fine grained, red brown, distinctly weathered, moist.		
	42.00		grey and orange.		
	44.00		**SILTSTONE:** red, distinctly weathered, moist.		
	45.00		**CLAYSTONE:** grey and red, slightly weathered, moist.		
RAB	46.00		**SILTSTONE:** grey and brown, distinctly weathered, moist.		140mm Diameter, 46 to 131m bgl
	49.00		grey, slightly weathered.		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5M

SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	
Project:	MIDDLEMOUNT COAL PROJECT	Date Commenced:	10.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE	Date Completed:	24.07.2010
Project Number:	2117076B	Recorded By:	Malcolm Graham
		Log Checked By:	

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667790 N 7475131 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information								Field Material Description					
1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION TOC 1 m	5 RL(m) AHD	DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY VS S F FB VL ST L MD VST D H VD	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB										grey, slightly weathered. *(continued)*	M		
				122	52								
				120	54								
				118	56.00 56					fresh.			
					57.00					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				116	58								
				114	60								
					61.00					**SILTSTONE:** grey, fresh, moist.			
				112	62								
					63.00					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				110	64								
				108	66								
				106	68.00 68					**SILTSTONE:** grey, fresh, moist.			
				104	70.00 70					**SANDSTONE:** very fine grained, grey, fresh, moist.			
					71.00					**SILTSTONE:** grey, fresh, moist.			
				102	72.00 72					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				100	74.00 74					**SILTSTONE:** grey, fresh, moist.			
					75.00					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				98	76								
				96	78								
				94	80								
				92	82								
					83.00					distinctly weathered, wet.	W		
				90	84.00 84					fine grained.			
				88	86.00 86					very fine grained, dark grey.			
				86	88.00 88					fine grained.			
					89.00					very fine grained.			
				84	90.00 90					**SILTSTONE:** dark grey, fresh, wet.			
				82	92								
				80	94								
				78	96.00 96					**SANDSTONE:** very fine grained, dark, grey, fresh, wet.			
				76	98.00 98					**SILTSTONE:** dark grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	10.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	24.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	MAR

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667790 N 7475131 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information / Field Material Description

METHOD: RAB

MOISTURE: W

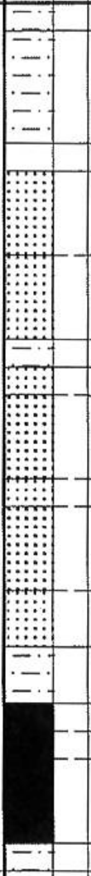
WELL CONSTRUCTION (TOC 1 m):

Bentonite, 121.5 to 126m bgl

3mm Filter gravel, 126 to 131m bgl

80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 127 to 130m bgl, 1m uPVC sump

GRAPHIC LOG:



RL(m) AHD	DEPTH(m)	SOIL/ROCK MATERIAL FIELD DESCRIPTION	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SILTSTONE: dark grey, fresh, wet. *(continued)*	
	101.00	SILTSTONE: dark grey, fresh, wet.	
72	102		
70	104		
	105.00	CLAYSTONE: black, fresh, carbonaceous, wet.	
68	106.00 / 106	SANDSTONE: fine grained, dark, grey, fresh, wet.	
66	108		
	109.00	medium grained.	
64	110		
62	112.00 / 112	SILTSTONE: dark grey, fresh, wet.	
	113.00	SANDSTONE: medium grained, dark, grey, fresh, wet.	
60	114.00 / 114	very fine grained.	
58	116		
	117.00	fine grained.	
56	118.00 / 118	very fine grained.	
54	120		
	121.00	fine grained.	
52	122		
	123.00	SILTSTONE: dark grey, fresh, wet.	
50	124		
	125.00	COAL: black, fresh, wet, (Middlemount Seam).	Airlift yield: 0.21 L/S
48	126.00 / 126	silty.	
	127.00	non-silty.	
46	128		
44	130.00 / 130	SILTSTONE: black, fresh, carbonaceous, wet.	Airlift yield: 0.76 L/S
		END OF BOREHOLE AT 131.00 m	
42	132		
40	134		
38	136		
36	138		
34	140		
32	142		
30	144		
28	146		
26	148		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 1 OF 4

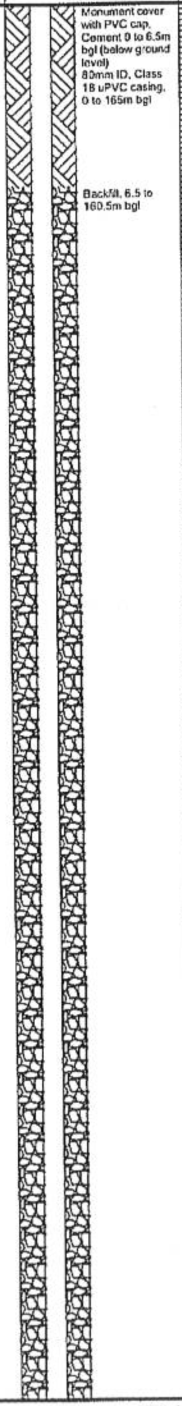
Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
		Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
Borehole Diameter:	200mm to 140mm	TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

1 METHOD · 2 SUPPORT · 3 WATER · 4 WELL CONSTRUCTION · 5 RL(m) AHD / DEPTH(m) · 6 FIELD TEST · 7 SAMPLE

WELL CONSTRUCTION

TOC 1 m



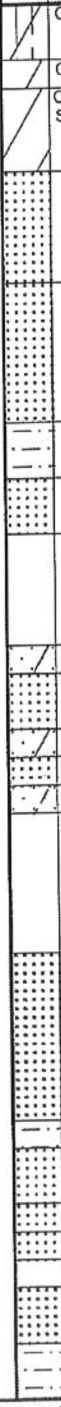
Monument cover with PVC cap.
Cement 0 to 6.5m bgl (below ground level)
80mm ID, Class 18 uPVC casing, 0 to 165m bgl

Backfill, 6.5 to 160.5m bgl

RL(m) AHD	DEPTH(m)
172	2
170	4
168	6
166	8
164	10
162	12
160	14
158	16
156	18
154	20
152	22
150	24
148	26
146	28
144	30
142	32
140	34
138	36
136	38
134	40
132	42
130	44
128	46
126	48

Field Material Description

8 GRAPHIC LOG · 9 USC SYMBOL · 10 SOIL/ROCK MATERIAL FIELD DESCRIPTION · 11 MOISTURE · 12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD) · 13 STRUCTURE AND ADDITIONAL OBSERVATIONS



METHOD	DEPTH(m)	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB		CL	**Silty CLAY:** brown, moist, firm.	M	200mm Diameter, 0 to 52m bgl
	2.00	CL	**CLAY:** grey and red, moist, firm.		
	3.00	CL/ SP	**CLAY:** grey and red, moist, firm and **SAND:** fine grained, brown.		
	6.00		**SANDSTONE** very fine grained, brown, extremely weathered, moist.		
	10.00		distinctly weathered		
	15.00		**SILTSTONE:** yellow-brown, distinctly weathered, moist.		
	17.00		**SANDSTONE:** fine grained, brown, distinctly weathered, moist.		
	19.00		**CLAYSTONE:** grey and red, distinctly weathered, moist.		
	23.00		**Sandy CLAYSTONE:** brown, distinctly weathered, very fine grained sand.		
	24.00		**SANDSTONE:** fine grained, brown, distinctly weathered.		
	25.00		**Sandy CLAYSTONE:** brown, distinctly weathered, very fine grained sand.		
	27.00		**SANDSTONE:** fine grained, yellow, extremely weathered, moist.		
	28.00		**Clayey SANDSTONE:** fine grained, yellow, extremely weathered, moist.		
	29.00		**Silty CLAYSTONE:** grey and brown, distinctly weathered, moist.		
	34.00		**SANDSTONE:** fine grained, red-brown, distinctly weathered, moist.		
	40.00		**SILTSTONE:** red-brown, distinctly weathered, moist.		
	41.00		**SANDSTONE:** fine grained, red-brown, distinctly weathered, moist.		
	43.00		grey		
	44.00		red		
	45.00		**CLAYSTONE:** grey and brown, distinctly weathered, moist.		
	46.00		**SANDSTONE:** fine grained, grey, slightly weathered, moist.		
	48.00		**SILTSTONE:** grey, slightly weathered, dry.	D	

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 2 OF 4

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW5P - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 06.07.2010
Date Completed: 24.07.2010
Recorded By: Malcolm Graham
Log Checked By:
Drill Model/Mounting: IRTH 60
Borehole Diameter: 200mm to 140mm
Driller: S Baker
Driller Lic No: 3046
TOC (RL): 175 m AHD
Surface RL: 174 m AHD
Co-ords: E 667796 N 7475130 MGA94 Zone 55
Local Co-ords:

Borehole Information								Field Material Description					
1	2	3	4	5	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F St VSt H VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB										**SILTSTONE:** grey, slightly weathered, dry. *(continued)*	D		
RAB				122	52.00 52					**SANDSTONE:** fine grained, grey, slightly weathered, dry.			140mm Diameter, 52 to 174m bgl
					53.00					**SILTSTONE:** grey, slightly weathered, dry.			
				120	54								
					55.00					**SANDSTONE:** fine grained, grey, fresh, dry.			
				118	56								
					57.00					**SILTSTONE:** grey, fresh, dry.			
				116	58.00 58					**SANDSTONE:** fine grained, grey, fresh, dry.			
				114	60								
				112	62.00 62					**SILTSTONE:** grey, fresh, dry.			
					63.00					**SANDSTONE:** very fine grained, grey, fresh, dry.			
				110	64								
				108	66								
				106	68								
					69.00					**SILTSTONE:** grey, fresh, dry.			
				104	70								
				102	72								
					73.00					**SANDSTONE:** fine grained, grey, dry.			
				100	74.00 74					**SILTSTONE:** grey, fresh, dry.			
				98	76								
				96	78.00 78					**SANDSTONE:** fine grained, grey, fresh, dry.			
				94	80.00 80					slightly weathered, wet.	W		
				92	82								
				90	84.00 84					fresh, wet.			
				88	86								
					87.00					**SILTSTONE:** grey, fresh, wet.			
				86	88.00 88					**SANDSTONE:** fine grained, fresh, wet.			
				84	90.00 90					**SILTSTONE:** dark grey, fresh, wet.			
				82	92								
				80	94								
				78	96.00 96					**SANDSTONE:** fine grained, grey, fresh, wet.			
				76	98.00 98					**SILTSTONE:** dark grey, fresh, wet.			
					99.00					**SANDSTONE:** fine grained, grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 3 OF 4

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW5P - MIDDLEMOUNT MINE
Project Number: 2117076B

PB Borehole No.:

Date Commenced: 06.07.2010
Date Completed: 24.07.2010
Recorded By: Malcolm Graham
Log Checked By: MG

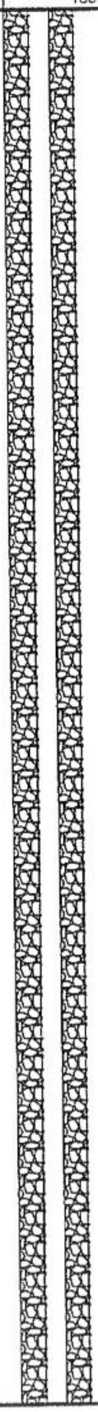
Drill Model/Mounting: IRTH 60
Borehole Diameter: 200mm to 140mm

Driller: S Baker
Driller Lic No: 3046
TOC (RL): 175 m AHD

Surface RL: 174 m AHD
Co-ords: E 667796 N 7475130 MGA94 Zone 55
Local Co-ords:

Borehole Information

Field Material Description



1 METHOD	2 SUPPORT	3 WATER	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB							**SANDSTONE:** fine grained, grey, fresh, wet. *(continued)*	W	
				101.00			**SILTSTONE:** dark grey, fresh, wet.		
			72	102					
			70	104					
				105.00			**CLAYSTONE:** black, fresh, carbonaceous, wet.		
			68	106 106.00			**SANDSTONE:** fine grained, grey, fresh, wet.		
			66	108					
			64	110					
			62	112 112.00			**SILTSTONE:** dark grey, fresh, wet.		
				113.00			**SANDSTONE:** fine grained, grey, fresh, wet.		
			60	114					
			58	116 116.00			fine grained.		
			56	118					
			54	120					
			52	122					
			50	124 124.00			**SILTSTONE:** dark grey, fresh, wet.		
				125.00			**CLAYSTONE:** black, fresh, carbonaceous, wet.		
			48	126 126.00			**SILTY COAL:** black, fresh, wet, (Middlemount Seam).		Airlift yield: 0.12 L/S
				127.00			**COAL:** black, fresh, wet.		
			46	128					
			44	130					
				131.00			**SILTSTONE:** dark grey, fresh.		Airlift yield: 0.14 L/S
			42	132					
				133.00			**SANDSTONE:** fine grained, grey, fresh, wet.		
			40	134					
			38	136					
			36	138					Airlift yield: 0.14 L/S
			34	140					
			32	142					
			30	144					
			28	146					
			26	148					
				149.00			**SILTSTONE:** black, fresh, wet.		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

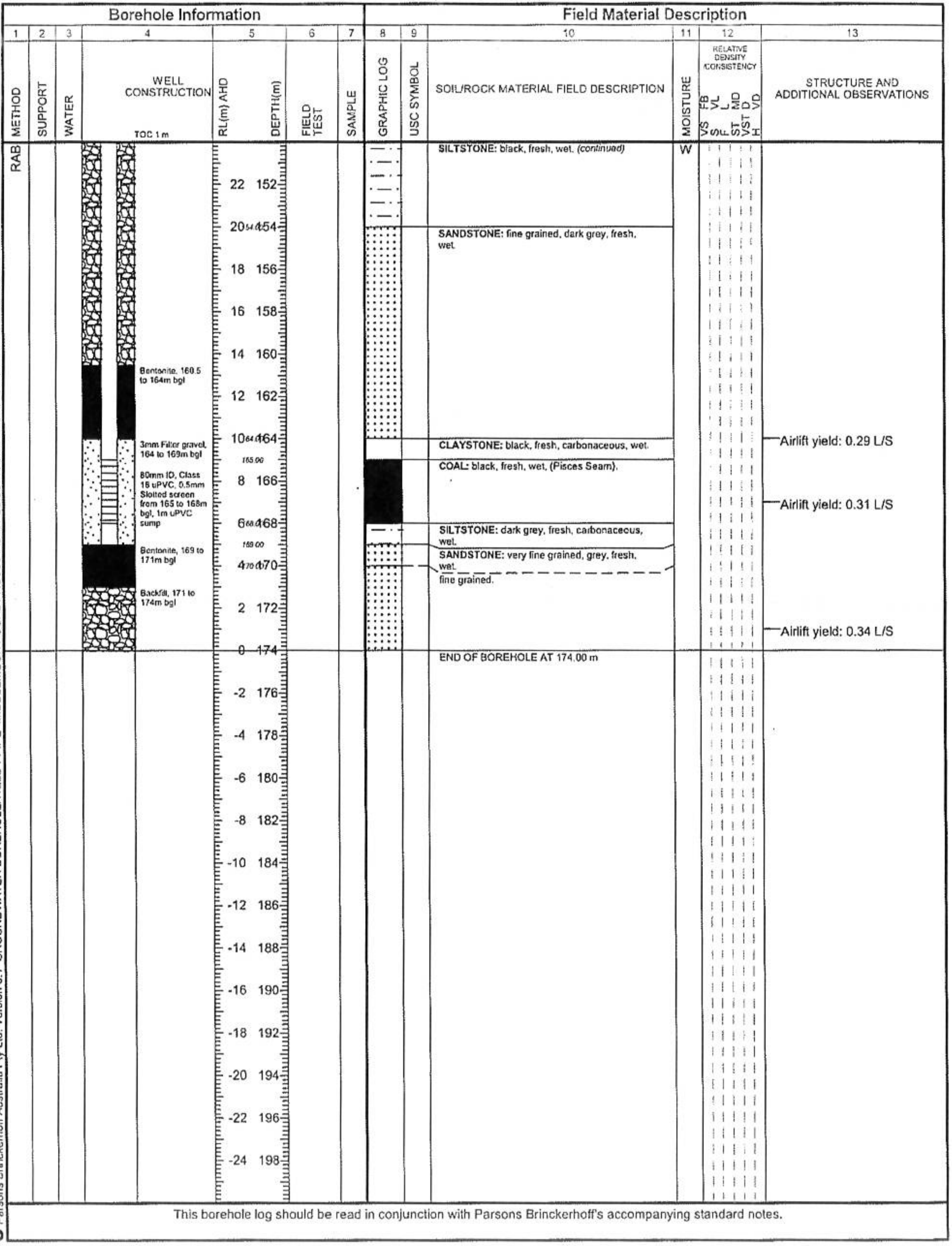
GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 4 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	MGR
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
		Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
Borehole Diameter:	200mm to 140mm	TOC (RL):	175 m AHD	Local Co-ords:	



Bentonite, 160.5 to 164m bgl

3mm Filter gravel, 164 to 169m bgl

80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 165 to 168m bgl, 1m uPVC sump

Bentonite, 169 to 171m bgl

Backfill, 171 to 174m bgl

SILTSTONE: black, fresh, wet. *(continued)*

SANDSTONE: fine grained, dark grey, fresh, wet

CLAYSTONE: black, fresh, carbonaceous, wet.

COAL: black, fresh, wet, (Pisces Seam).

SILTSTONE: dark grey, fresh, carbonaceous, wet.

SANDSTONE: very fine grained, grey, fresh, wet.

fine grained.

END OF BOREHOLE AT 174.00 m

Airlift yield: 0.29 L/S

Airlift yield: 0.31 L/S

Airlift yield: 0.34 L/S

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

coffey environments

Drilling Log

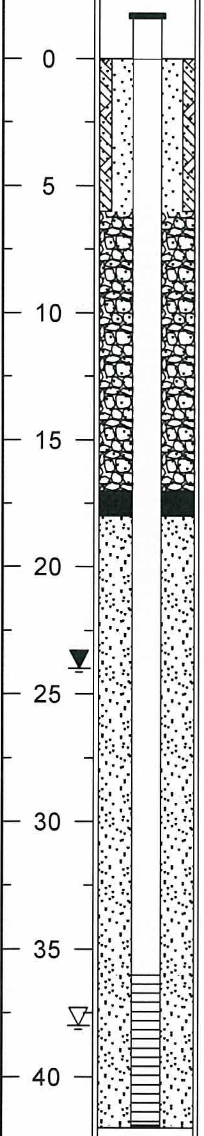
Monitoring Well **MW6**

Page: 1 of 1

Project *MEMS* Owner *Middlemount Coal Pty Ltd*
Location *Middlemount Mine* Proj. No. *ENVINEWS08629AA*
Surface Elev. *NA* Total Hole Depth *42.0 m.* North East
Top of Casing *NA* Water Level Initial ▽ *38.0 m.* Static ▼ *24.0 m.* Diameter *125 mm.*
Screen: Dia *NA* Length *NA* Type/Size *Class 18 UPVC*
Casing: Dia *NA* Length *NA* Type *Class 18 UPVC*
Fill Material Rig/Core
Drill Co. *QLD Drilling* Method *Air Rotary*
Driller *Corey Evetts* Log By *M Weir* Date *3/6/08* Permit # *NA*
Checked By License No.

COMMENTS
Backfill used above bentonite plug.

Depth (m.) | Well Completion | PID (ppm) | Sample ID % Recovery | Blow Count Recovery | Graphic Log | USCS Class.



USCS Class.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
	TOPSOIL - vegetation.
CL	CLAY - non plastic, brown, hard, dry, homogeneous.
CL	CLAY - non plastic, brown/grey, hard, dry.
CL	CLAY - low plasticity, red, dry, homogeneous.
CL	CLAY - low plasticity, white, damp, firm, stiff.
CL	CLAY - low plasticity, white/brown, firm, dry, homogeneous.
CL	CLAY - non plastic, black/grey, dry, friable.
CL	CLAY - non plastic, brown/white, dry, friable.
CL	CLAY - grey, hard, damp.
CL	CLAY - non plastic, grey, wet, hard.
	End of hole at 42.0m - Limit of investigation.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7M

SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	
Project:	MIDDLEMOUNT COAL PROJECT	Date Commenced:	15.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE	Date Completed:	19.06.2010
Project Number:	2117076B	Recorded By:	Malcolm Graham
		Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046
		TOC (RL):	161 mAHD*
		Surface RL:	160 mAHD*
		Co-ords:	E 669668 N 7472167 MGA94 Zone 55
		Local Co-ords:	

Borehole Information

1 METHOD: RAB

2 SUPPORT

3 WATER

4 WELL CONSTRUCTION (TOC 1 m):
- Monument cover with PVC cap, Cement 0 to 5m bgl (below ground level) 50mm ID uPVC, Class 12 casing, 0 to 132m bgl
- Backfill, 9 to 129m bgl

5 RL(m) AHD / DEPTH(m)

6 FIELD TEST

7 SAMPLE

Field Material Description

8 GRAPHIC LOG; 9 USC SYMBOL; 10 SOIL/ROCK MATERIAL FIELD DESCRIPTION; 11 MOISTURE; 12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD); 13 STRUCTURE AND ADDITIONAL OBSERVATIONS

DEPTH(m)	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE
	CL	**Sandy CLAY:** brown, fine grained, sand component, firm, dry.	D
2.00	SP	**Clayey SAND:** fine to medium grained, orange, moist.	M
3.00	SP	**SAND:** fine to medium grained, orange, with clay.	
4.00		medium grained, yellow, moist, loose.	
5.00		medium grained, yellow, moist, trace coarse sand and gravel, loose.	
6.00		brown clay bands.	
7.00	SP	**Clayey SAND:** fine to medium grained, orange and grey, bands of firm, grey clay, moist.	
12.00	SP	**SAND:** medium grained, orange, with clay, moist.	
13.00		bands of firm, brown clay.	
14.00		medium to coarse grained, bands of firm, grey clay, moist.	
17.00	CL/ SP	**CLAY:** grey and brown, firm and **SAND:** fine grained, yellow.	
22.00	SP/ CL	**SAND:** medium grained, orange and **CLAY:** grey, firm.	
25.00	SP	**SAND:** medium grained, yellow.	
26.00	CL	**CLAY:** brown and grey, soft, trace fine grained sand.	
27.00	CL	**Silty CLAY:** grey and brown, firm.	
28.00	CL	**Sandy CLAY:** grey and orange, fine to medium grained sand component, firm.	
29.00	CL	**CLAY:** grey and brown, firm.	
32.00	SP	**SAND:** medium grained, yellow, bands of firm, grey clay.	
35.00	CL	**CLAY:** brown and grey, firm.	
36.00	CL/ SP	**CLAY:** brown and grey, firm and **SAND:** fine to medium grained, yellow.	
38.00	SP	**SAND:** medium grained, pale grey.	
45.00	SP/ CL	**SAND:** medium grained, pale grey and **Sandy CLAY:** grey and brown, soft.	
46.00	SP	**SAND:** medium grained, pale grey.	

STRUCTURE AND ADDITIONAL OBSERVATIONS:

*** Elevations inferred from DTM**

171mm Diameter, 0 to 55.5m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7M

SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	15.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	19.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	160 mAHD*
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046	Co-ords:	E 669668 N 7472167 MGA94 Zone 55
		TOC (RL):	161 mAHD*	Local Co-ords:	

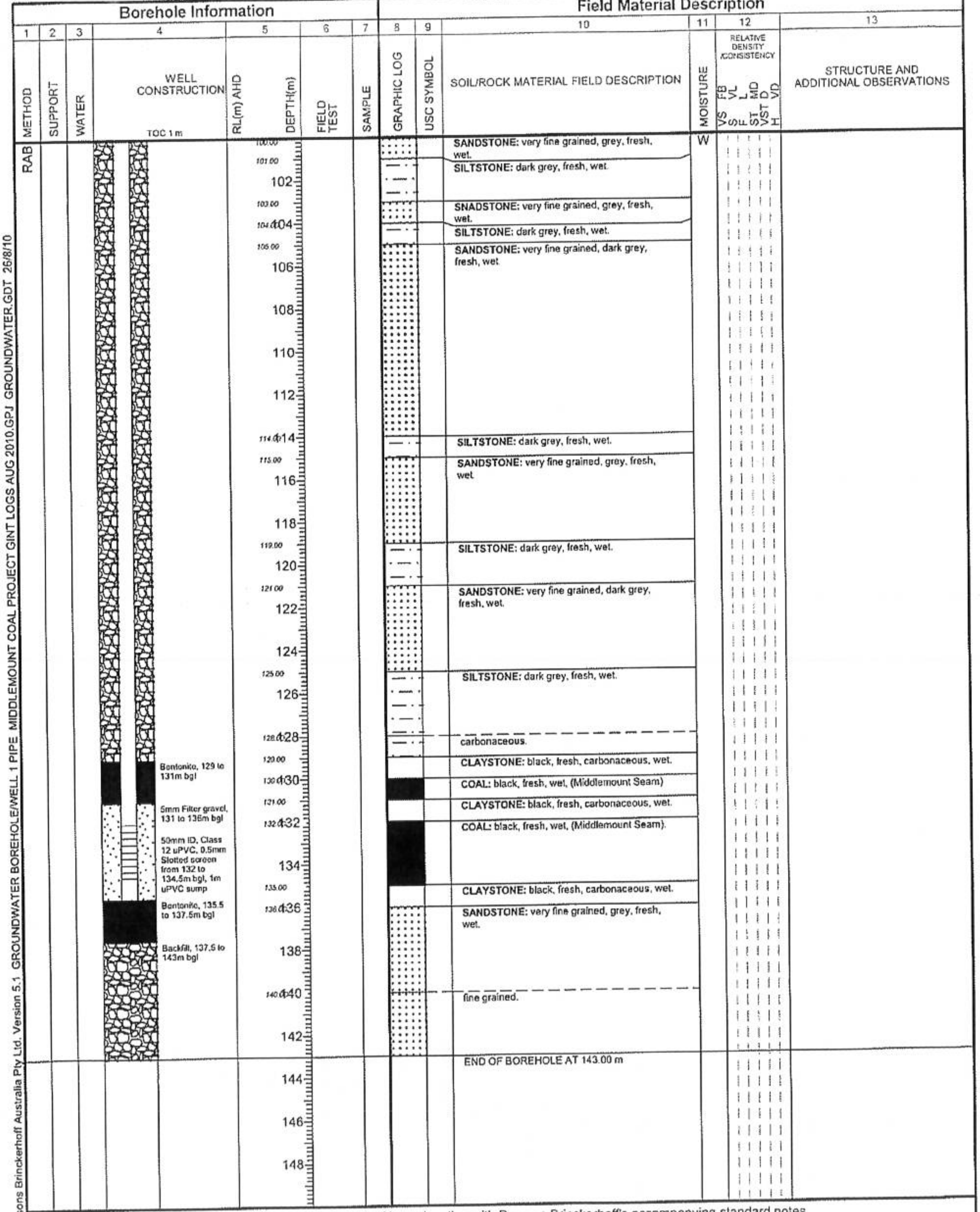
Borehole Information								Field Material Description					
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB					50.00					medium to coarse grained, pale grey, trace gravel.	M		
					54.00				SC	**SAND:** medium to coarse grained, pale grey, trace gravel and **Sandy CLAY:** grey, soft.			
					56.00					**SANDSTONE:** very fine grained, dark grey, distinctly weathered, soft, moist.			121mm Diameter, 55.5 to 143m bgl
					57.00					fine grained, pale grey, slightly weathered, moist.			
					59.00					very fine grained, dark grey, distinctly weathered, bands of dark grey clay, moist.			
					60.00					very fine grained, grey, slightly weathered, moist.			
					65.00					distinctly weathered.			
					68.00					slightly weathered, dry.	D		
					69.00					fine grained, dark grey, slightly weathered, dry.			
					71.00					moist.	M		
					72.00					dry, fresh.	D		
					75.00					**SILTSTONE:** dark grey, fresh, dry.			
					81.00					**SANDSTONE:** fine grained, grey, fresh, dry.			
					82.00					very fine grained, dark grey.			
					84.00					fine grained.			
					86.00					very fine grained.			
					86.00					fine grained.			
					88.00					very fine grained, wet.	W		
					90.00					fine grained, grey, wet.			
					91.00					very fine grained, dark grey, wet.			
					92.00					**SILTSTONE:** dark grey, fresh, wet.			
					93.00					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			
					94.00					**SILTSTONE:** dark grey, fresh, wet.			
					95.00					**SANDSTONE:** very fine grained, grey, fresh, wet.			
					99.00					**SILTSTONE:** dark grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW7M
SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	15.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	19.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	MSR
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	160 mAHD*
		Driller Lic No:	3046	Co-ords:	E 669668 N 7472167 MGA94 Zone 55
Borehole Diameter:	171mm to 121mm	TOC (RL):	161 mAHD*	Local Co-ords:	



DEPTH(m)	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE
100.00	**SANDSTONE:** very fine grained, grey, fresh, wet.	W
101.00	**SILTSTONE:** dark grey, fresh, wet.	
103.00	**SNADSTONE:** very fine grained, grey, fresh, wet.	
104.00	**SILTSTONE:** dark grey, fresh, wet.	
105.00	**SANDSTONE:** very fine grained, dark grey, fresh, wet	
114.00	**SILTSTONE:** dark grey, fresh, wet.	
115.00	**SANDSTONE:** very fine grained, grey, fresh, wet	
119.00	**SILTSTONE:** dark grey, fresh, wet.	
121.00	**SANDSTONE:** very fine grained, dark grey, fresh, wet.	
125.00	**SILTSTONE:** dark grey, fresh, wet.	
128.00	carbonaceous.	
120.00	**CLAYSTONE:** black, fresh, carbonaceous, wet.	
130.00	**COAL:** black, fresh, wet, (Middlemount Seam)	
131.00	**CLAYSTONE:** black, fresh, carbonaceous, wet.	
132.00	**COAL:** black, fresh, wet, (Middlemount Seam).	
135.00	**CLAYSTONE:** black, fresh, carbonaceous, wet.	
136.00	**SANDSTONE:** very fine grained, grey, fresh, wet.	
140.00	fine grained.	
	END OF BOREHOLE AT 143.00 m	

WELL CONSTRUCTION:
- Bentonite, 129 to 131m bgl
- 5mm Filter gravel, 131 to 136m bgl
- 50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 132 to 134.5m bgl, 1m uPVC sump
- Bentonite, 135.5 to 137.5m bgl
- Backfill, 137.5 to 143m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

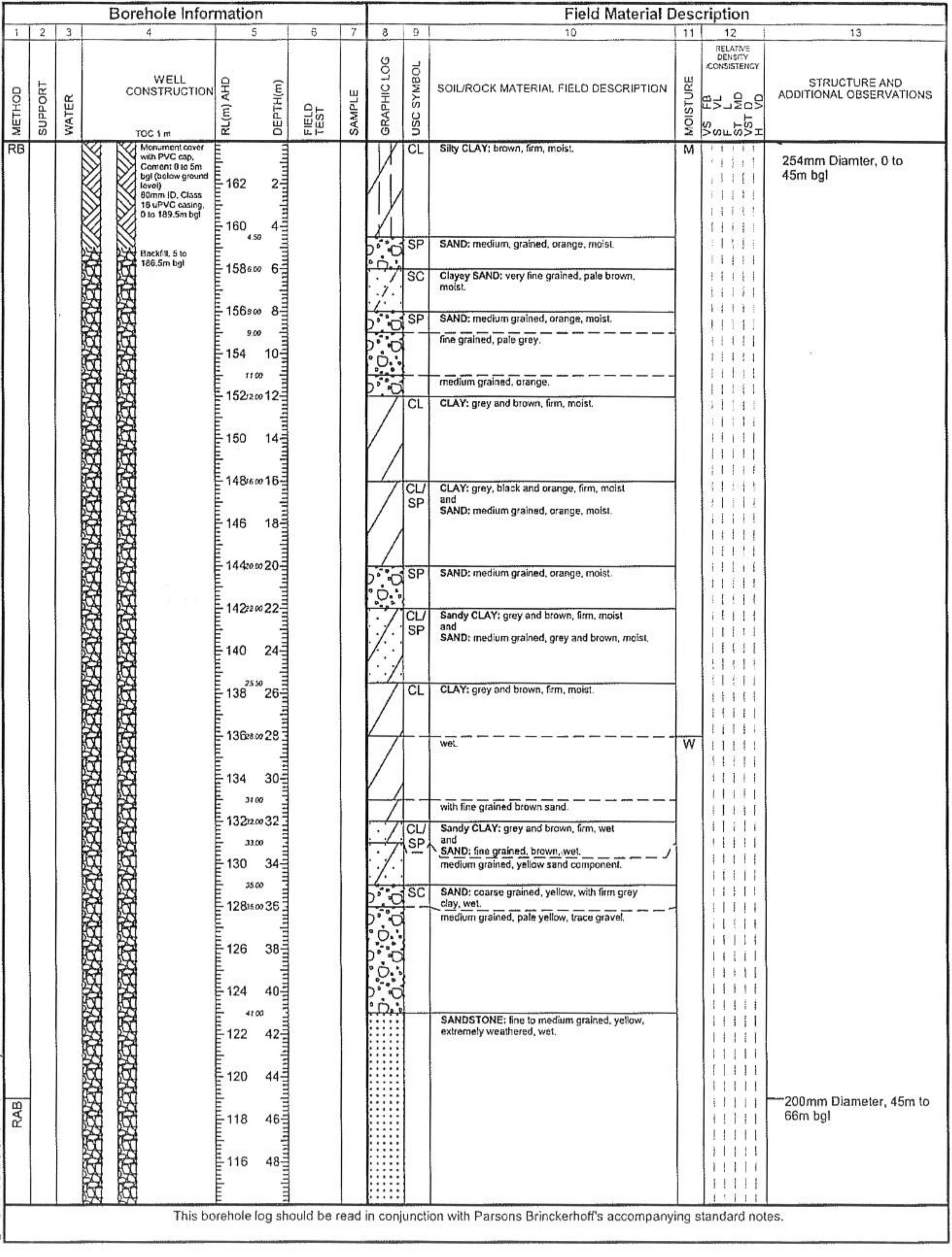
GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 1 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	



Well construction:

Monument cover with PVC cap, Cement 0 to 5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 189.5m bgl

Backfill, 5 to 186.5m bgl

Depth (m)	USC Symbol	Soil/Rock Material Field Description	Moisture
	CL	Silty CLAY: brown, firm, moist.	M
4.50	SP	SAND: medium, grained, orange, moist.	
6.00	SC	Clayey SAND: very fine grained, pale brown, moist.	
8.00	SP	SAND: medium grained, orange, moist.	
9.00		fine grained, pale grey.	
11.00		medium grained, orange.	
12.00	CL	CLAY: grey and brown, firm, moist.	
16.00	CL/ SP	CLAY: grey, black and orange, firm, moist and SAND: medium grained, orange, moist.	
20.00	SP	SAND: medium grained, orange, moist.	
22.00	CL/ SP	Sandy CLAY: grey and brown, firm, moist and SAND: medium grained, grey and brown, moist.	
25.50	CL	CLAY: grey and brown, firm, moist.	
28.00		wet.	W
31.00		with fine grained brown sand.	
32.00	CL/ SP	Sandy CLAY: grey and brown, firm, wet and SAND: fine grained, brown, wet.	
33.00		medium grained, yellow sand component.	
35.00	SC	SAND: coarse grained, yellow, with firm grey clay, wet.	
36.00		medium grained, pale yellow, trace gravel.	
41.00		SANDSTONE: fine to medium grained, yellow, extremely weathered, wet.	

Structure and additional observations:

254mm Diamter, 0 to 45m bgl

200mm Diameter, 45m to 66m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW7P
SHEET 2 OF 5

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW7P - MIDDLEMOUNT MINE
Project Number: 2117076B

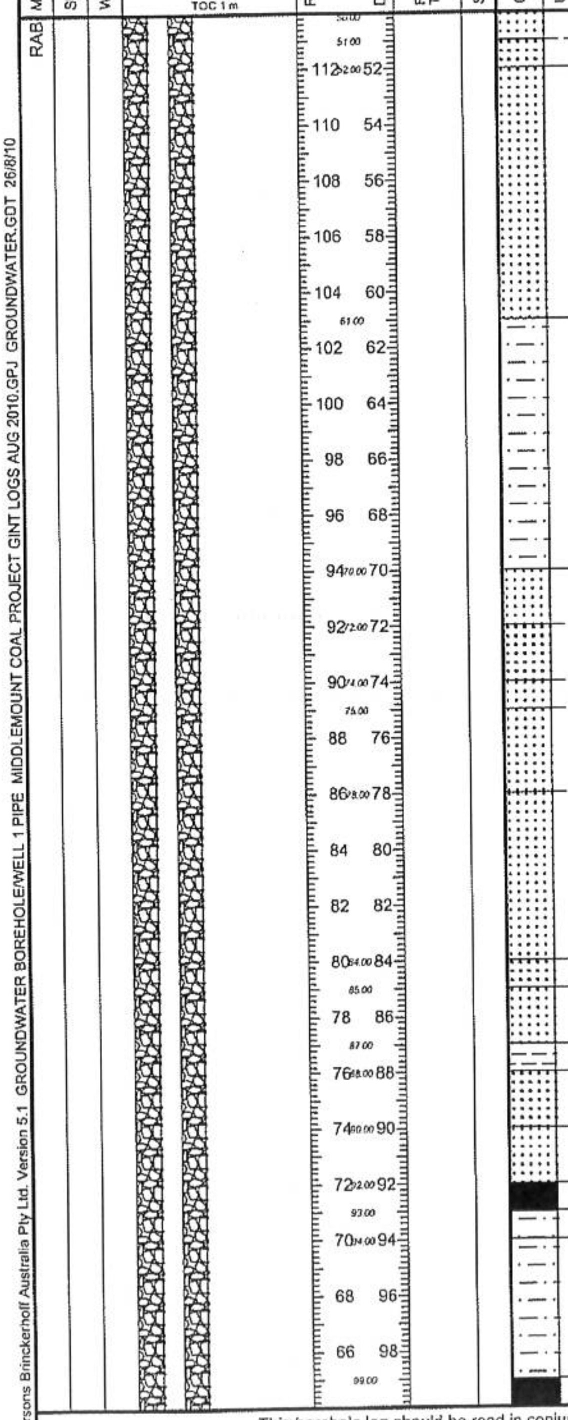
PB Borehole No.:

Date Commenced: 21.07.2010
Date Completed: 28.07.2010
Recorded By: Malcolm Graham
Log Checked By:

Drill Model/Mounting: HYDROPOWER SCOUT
Borehole Diameter: 254mm to 140mm
Driller: E Schumacher
Driller Lic No: 3127
TOC (RL): 165 m AHD
Surface RL: 164 m AHD
Co-ords: E 669777 N 7472247 MGA94 Zone 55
Local Co-ords:

Borehole Information

Field Material Description



DEPTH(m)	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY CONSISTENCY VS S F St VSt H / VL L MD D VD	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
50.00	fresh, with very fine grained, pale yellow, sandstone.	W		
51.00	distinctly weathered, iron staining.			
52.00	**SANDSTONE:** very fine grained, grey and brown, slightly weathered, minor black carbonaceous siltstone, iron staining and quartz veins, wet.			
61.00	**SILTSTONE:** dark grey, fresh, iron staining and calcite veins, wet.			140mm Diameter, 66 to 203m bgl
70.00	**SANDSTONE:** very fine grained, grey, slightly weathered, pyrite alteration, wet.			
72.00	fresh, no pyrite.			
74.00	fresh, calcite veins, no pyrite			
75.00	fine grained, fresh, calcite veins.			
78.00	very fine grained, fresh, calcite veins.			
84.00	fine grained, fresh.			
85.00	very fine grained, black, fresh, carbonaceous.			
87.00	**SHALE:** dark brown, fresh, carbonaceous, calcite alteration.			
88.00	**SANDSTONE:** very fine grained, pale brown, fresh, slightly metamorphosed, minor soft sandstone - fault gouge material.			
90.00	grey, fresh, no avidence of metamorphosis or fault gouge material.			
92.00	**COAL:** black, fresh, (Roper Seam).			
93.00	**SILTSTONE:** grey, fresh.			
94.00	pale, grey.			
99.00	**COAL:** black, fresh, (Middlemount Seam fault repeated)			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 3 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information / Field Material Description

Columns: 1 METHOD · 2 SUPPORT · 3 WATER · 4 WELL CONSTRUCTION (TOC 1 m) · 5 RL(m) AHD, DEPTH(m) · 6 FIELD TEST · 7 SAMPLE · 8 GRAPHIC LOG · 9 USC SYMBOL · 10 SOIL/ROCK MATERIAL FIELD DESCRIPTION · 11 MOISTURE · 12 RELATIVE DENSITY /CONSISTENCY (VS S F St VSt H / FB VL L MD D VD) · 13 STRUCTURE AND ADDITIONAL OBSERVATIONS

METHOD: RAB — MOISTURE: W

RL(m) AHD	DEPTH(m)
62	102
60	104
58	106
56	108
54	110
52	112
50	114
48	116
46	118
44	120
42	122
40	124
38	126
36	128
34	130
32	132
30	134
28	136
26	138
24	140
22	142
20	144
18	146
16	148

DEPTH(m)	SOIL/ROCK MATERIAL FIELD DESCRIPTION
100.00	**SILTSTONE:** grey, fresh.
101.00	**COAL:** black, fresh, (Middlemount Seam fault repeated).
112.00	**SILTSTONE:** grey, fresh, carbonaceous.
114.00	non-carbonaceous.
115.00	**SANDSTONE:** very fine grained, grey, fresh, slightly carbonaceous.
122.00	**SILTSTONE:** grey, fresh.
125.00	**SANDSTONE:** very fine grained, grey, fresh.
128.00	**SILTSTONE:** grey, fresh.
130.00	**COAL:** black, fresh, (Middlemount Seam).
140.00	**SILTSTONE:** grey, fresh.
142.00	**SANDSTONE:** fine to medium grained, grey, fresh.
148.00	black, carbonaceous.
149.00	grey, non-carbonaceous.

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

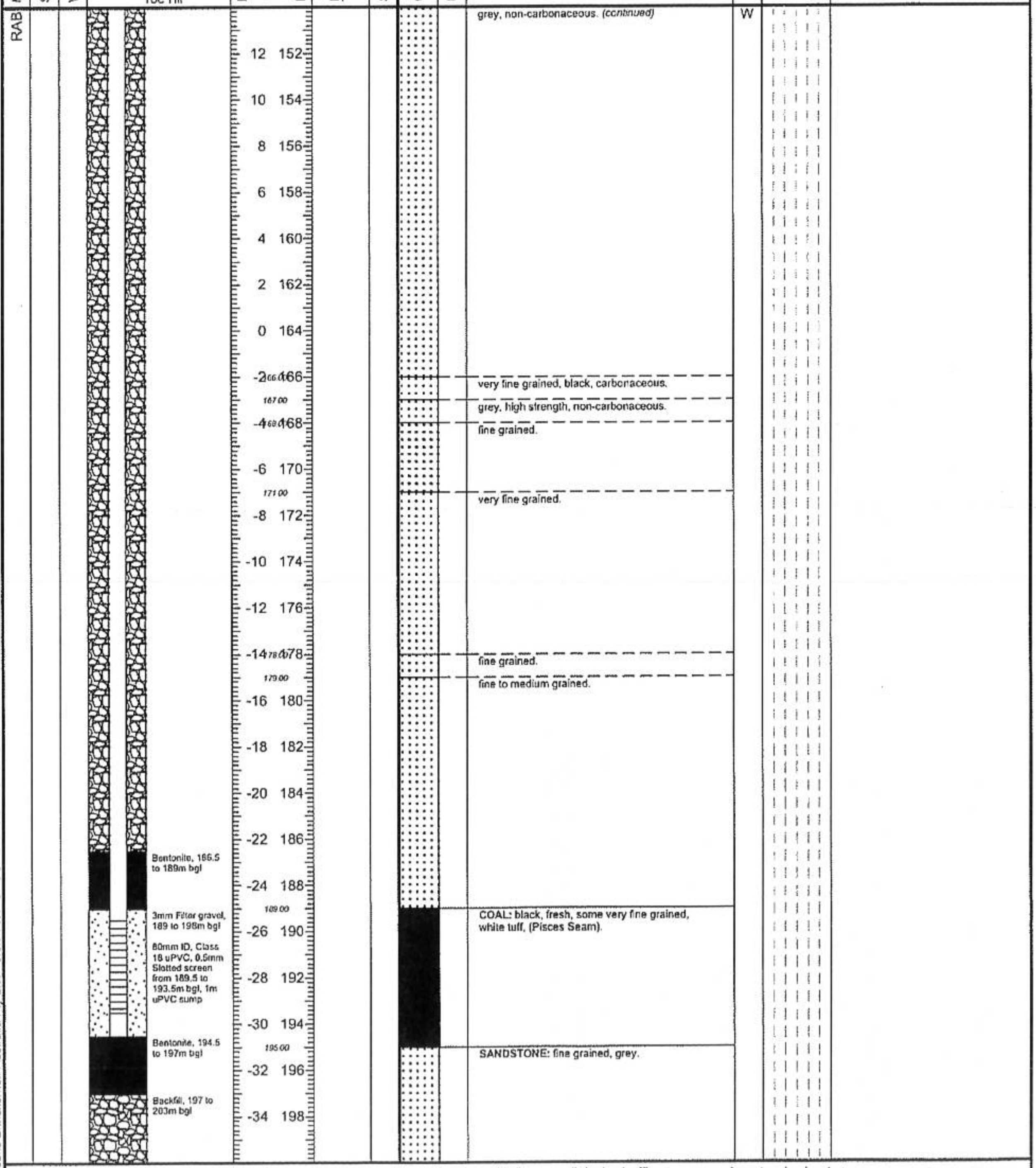
MW7P

SHEET 4 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	MSR
Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information | **Field Material Description**

1	2	3	4	5	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F St VSt H VL L MD D VD FB	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB										grey, non-carbonaceous. *(continued)*	W		



very fine grained, black, carbonaceous.

grey, high strength, non-carbonaceous.

fine grained.

very fine grained.

fine grained.

fine to medium grained.

COAL: black, fresh, some very fine grained, white tuff, (Pisces Seam).

SANDSTONE: fine grained, grey.

Bentonite, 186.5 to 189m bgl

3mm Filter gravel, 189 to 198m bgl

80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 189.5 to 193.5m bgl, 1m uPVC sump

Bentonite, 194.5 to 197m bgl

Backfill, 197 to 203m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 5 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information								Field Material Description					
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				-38	202					**SANDSTONE:** fine grained, grey. *(continued)*	W		
										END OF BOREHOLE AT 203.00 m			
				-40	204								
				-42	206								
				-44	208								
				-46	210								
				-48	212								
				-50	214								
				-52	216								
				-54	218								
				-56	220								
				-58	222								
				-60	224								
				-62	226								
				-64	228								
				-66	230								
				-68	232								
				-70	234								
				-72	236								
				-74	238								
				-76	240								
				-78	242								
				-80	244								
				-82	246								
				-84	248								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW8FR

SHEET 1 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	
Project:	MIDDLEMOUNT COAL PROJECT	Date Commenced:	10.06.2010
Borehole Location:	MW8MR MIDDLEMOUNT MINE	Date Completed:	25.07.2010
Project Number:	2117076B	Recorded By:	Malcolm Graham
		Log Checked By:	

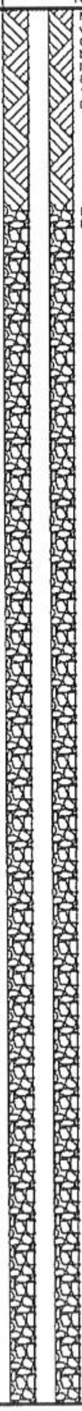
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information

WELL CONSTRUCTION — TOC 1 m

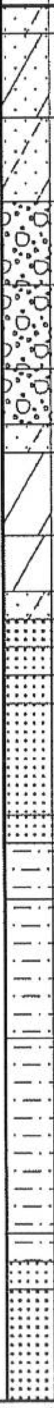
Monument cover with PVC cap, Cement 0 to 7m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 94m bgl

Backfill, 7 to 91m bgl



RL(m) AHD	DEPTH(m)
162	2
160	4
158	6
156	8
154	10
152	12
150	14
148	16
146	18
144	20
142	22
140	24
138	26
136	28
134	30
132	32
130	34
128	36
126	38
124	40
122	42
120	44
118	46
116	48

Field Material Description



1 METHOD	2 SUPPORT	3 WATER	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB						SC	**CLAYEY SAND:** fine grained, yellow brown, dry	D		200mm Diameter, 0 to 40m bgl
			1.00			CL	**SANDY CLAY:** orange brown, firm, fine grained sand component, dry.			
			4.00			SC	**CLAYEY SAND:** fine to medium grained, brown, dry.			
			7.00			SP	**SAND:** fine grained, orange brown, with clay, dry.			
			10.00				medium to coarse grained grained, trace of clay fines, pale yellow to orange, moist.	M		
			13.00				fine to medium grained, yellow, moist.			
			15.00			SC	**CLAYEY SAND:** fine grained, grey, moist.			
			16.00			CL	**CLAY:** grey, firm, moist			
			19.00			OL	**Silty CLAY:** brown, with organics, firm, moist.			
			21.00			SC	**CLAYEY SAND:** fine grained, pale grey, moist			
			22.00				**SANDSTONE:** fine to medium grained, yellow grey, extremely weathered, moist.			
			23.00				clayey, fine grained, grey, extremely weathered, moist.			
			24.00				very fine to fine grained, orange, extremely weathered.			
			25.00				very fine grained, yellow-grey, distinctly weathered			
			29.00				fine grained			
			30.00				**SILTSTONE:** brown ,slightly weathered, moist.			
			32.00				yellow and grey, moist.			
			37.00				grey, fresh			
RAB										143mm Diameter, 40 to 153m bgl
			44.00				calcite veins.			
			45.00				**SANDSTONE:** fine grained, pale grey, calcite veins, dry.	D		
			46.00				very fine grained.			

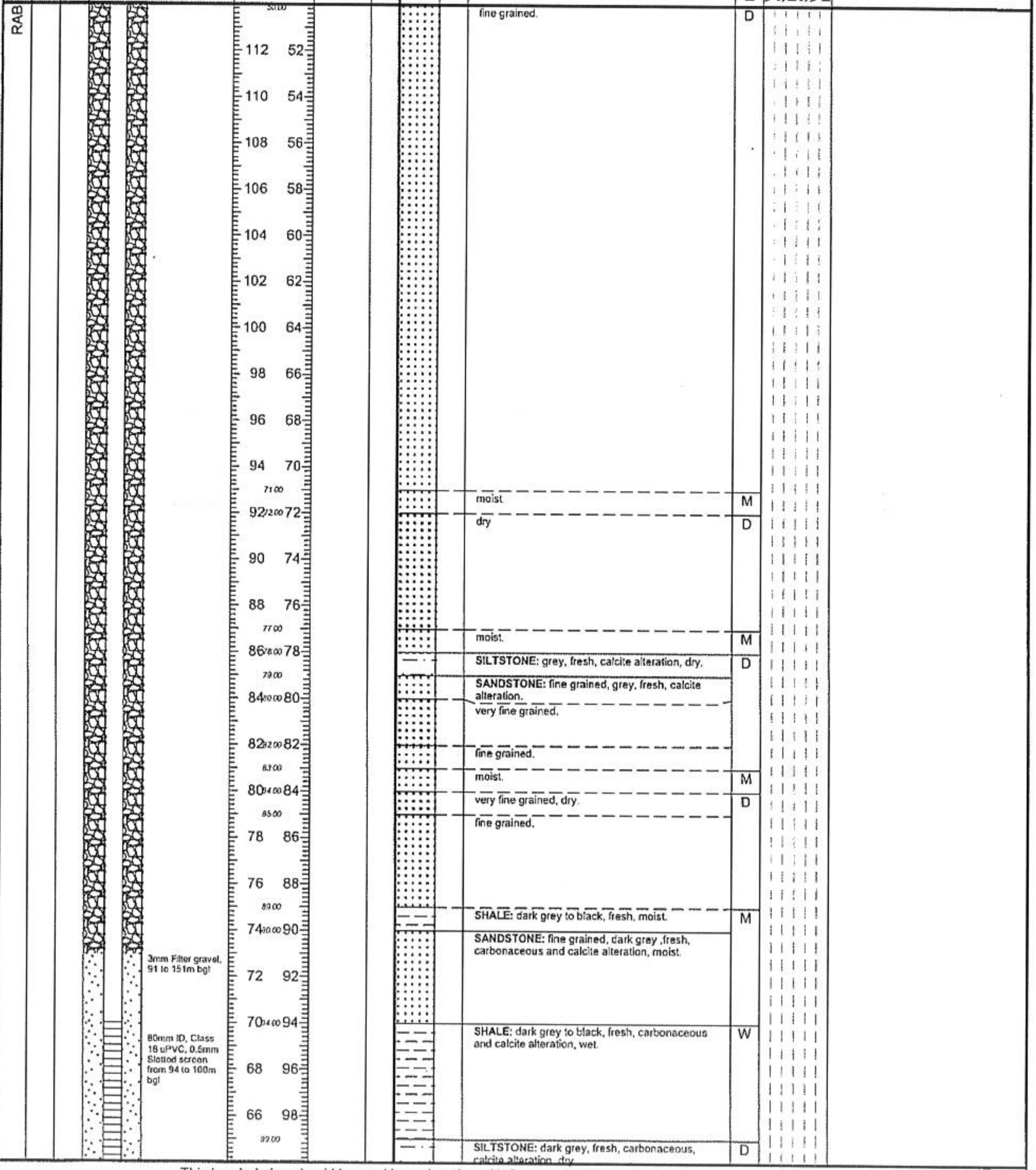
This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW8FR
SHEET 2 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	10.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	25.07.2010
Borehole Location:	MW8MR MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information (1 METHOD, 2 SUPPORT, 3 WATER, 4 WELL CONSTRUCTION TOC 1 m, 5 RL(m) AHD DEPTH(m), 6 FIELD TEST, 7 SAMPLE) — **Field Material Description** (8 GRAPHIC LOG, 9 USC SYMBOL, 10 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 11 MOISTURE, 12 RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD, 13 STRUCTURE AND ADDITIONAL OBSERVATIONS)



3mm Filter gravel, 91 to 151m bgl

80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 94 to 100m bgl

DEPTH(m)	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE
50.00	fine grained.	D
71.00	moist.	M
72.00	dry	D
77.00	moist.	M
78.00	**SILTSTONE:** grey, fresh, calcite alteration, dry.	D
79.00	**SANDSTONE:** fine grained, grey, fresh, calcite alteration.	
80.00	very fine grained.	
82.00	fine grained.	
83.00	moist.	M
84.00	very fine grained, dry.	D
85.00	fine grained.	
89.00	**SHALE:** dark grey to black, fresh, moist.	M
90.00	**SANDSTONE:** fine grained, dark grey ,fresh, carbonaceous and calcite alteration, moist.	
94.00	**SHALE:** dark grey to black, fresh, carbonaceous and calcite alteration, wet.	W
99.00	**SILTSTONE:** dark grey, fresh, carbonaceous, calcite alteration, dry	D

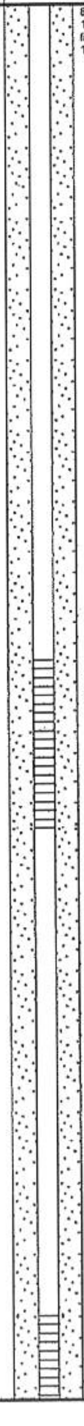
This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW8FR
SHEET 3 OF 4

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW8MR MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 10.06.2010
Date Completed: 25.07.2010
Recorded By: Malcolm Graham
Log Checked By: Wbk

Drill Model/Mounting: IRTH 60
Borehole Diameter: 200mm to 114mm
Driller: S Baker
Driller Lic No: 3046
TOC (RL): 165 m AHD
Surface RL: 164 m AHD
Co-ords: E 669941 N 7472277 MGA94 Zone 55
Local Co-ords:



Borehole Information								Field Material Description					
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			80mm ID, Class 18 uPVC casing from 100 to 123.5m bgl		100.00					**SANDSTONE:** very fine grained, dark grey, fresh, calcite alteration, carbonaceous, wet.	W		
				62	102								
				60	104								
				58	106								
				56	108								
				54	110								
				52	112								
				50	114								
				48	116								
				46	118								
				44	120								
				42	122								
			80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 123.5 to 129.5m bgl	40	124								
				38	126								
				36	128								
			80mm ID, Class 18 uPVC casing from 129.5 to 147m bgl	34	130								
				32	132					**SILTSTONE:** dark grey, fresh, calcite alteration, wet.			
				30	134					**SANDSTONE** : very fine grained, dark grey, fresh, calcite alteration, wet.			
				28	136								Airlift yield: 0.004 L/S
				26	138								
				24	140								
				22	142								
				20	144								
				18	146								
			80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 147 to 150.1m bgl, 0.9m vPVC sump	16	148								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW8FR
SHEET 4 OF 4

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW8MR MIDDLEMOUNT MINE
Project Number: 2117076B

PB Borehole No.:

Date Commenced: 10.06.2010
Date Completed: 25.07.2010
Recorded By: Malcolm Graham
Log Checked By: WGK

Drill Model/Mounting: IRTH 60
Borehole Diameter: 200mm to 114mm

Driller: S Baker
Driller Lic No: 3046
TOC (RL): 165 m AHD

Surface RL: 164 m AHD
Co-ords: E 669941 N 7472277 MGA94 Zone 55
Local Co-ords:

Borehole Information								Field Material Description				
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F St VSt H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB										**SANDSTONE** : very fine grained, dark grey, fresh, calcite alteration, wet. *(continued)*	W		
			Bentonite, 151 to 153m bgl	12	152					**SILTSTONE:** grey, fresh, with calcite alteration, wet.			
			Backfill, 153 to 189m bgl		153.00					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			114mm Diameter, 153 to 189m bgl
				10	154								
				8	156								
				6	158								
				4	160								
				2	162								
				0	164								
				-2	166								
				-4	168								
					169.00					fine grained.			
				-6	170					very fine grained.			
				-8	172					fine grained.			
					173.00					very fine grained.			
				-10	174					**COAL:** black, fresh, wet.			
					175.00					**TUFF:** pale grey, fresh, wet.			
				-12	176								
					177.00					**COAL:** black, fresh, wet.			
				-14	178								
				-16	180								
					181.00					**TUFF:** white, fresh, wet.			
				-18	182								
				-20	184					**COAL:** black, fresh, wet and **TUFF:** white, fresh, wet.			Airlift yield: 0.07 L/S
					185.00					**COAL:** black, fresh, wet.			
				-22	186								
				-24	188								
										END OF BOREHOLE AT 189.00 m			
				-26	190								
				-28	192								
				-30	194								
				-32	196								
				-34	198								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

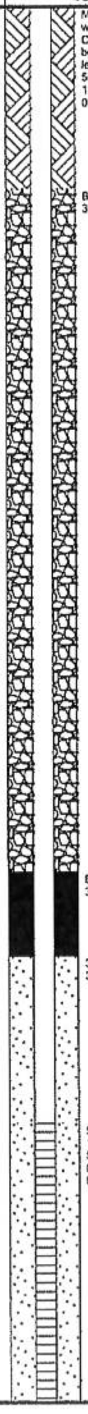
SHEET 1 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced:	05.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed:	27.07.2010
Borehole Location:	MW9A -MIDDLEMOUNT MINE		Recorded By:	Malcolm Graham
Project Number:	2117076B		Log Checked By:	WR

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
		Driller Lic No:	3046	Co-ords:	E 670246 N 7469610 MGA94 Zone 55
Borehole Diameter:	143mm	TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1 METHOD: RB | 2 SUPPORT | 3 WATER | 4 WELL CONSTRUCTION (TOC 1 m) | 5 RL(m) AHD / DEPTH(m) | 6 FIELD TEST | 7 SAMPLE



Well construction:
- Monument cover with PVC cap, Cemeht 0 to 6.5m bgl (below ground level)
- 50mm ID, Class 12 uPVC casing, 0 to 40m bgl
- Backfill, 6.5 to 31m bgl
- Bentonite, 31 to 34m bgl
- 3mm Filter gravel, 34 to 52m bgl
- 50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 40 to 52m bgl

RL(m) AHD		DEPTH(m)
154	2.00	2
	3.00	
152		4
	5.00	
150	6.00	6
	7.00	
148	8.00	8
	9.00	
146		10
	11.00	
144		12
	13.00	
142		14
140	16.00	16
138		18
136		20
134		22
132		24
130		26
128		28
126		30
124	32.00	32
	33.00	
122	34.00	34
120	36.00	36
118		38
116		40
114		42
112	44.00	44
110		46
108	48.00	48

Field Material Description

9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE
CL	**Silty CLAY:** brown, dry, firm.	D
	moist	M
CL	**CLAY:** brown	D
SC	**Clayey SAND:** fine grained, pale brown, moist	M
SP	**SAND:** fine grained, pale brown, dry.	D
SC	with clay, moist.	M
CL	**CLAY:** pale grey, moist, firm and	
SC	**Sandy CLAY:** brown, fine grained sand, moist.	
	Clayey SAND: fine to medium grained, grey and orange, moist.	
CL/ ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.	
CL	**CLAY:** grey, orange and pink, firm, trace very fine grained pink sand, moist.	
CL/ ML	**Clay:** pale grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist.	
ML/ CL	**SAND:** very fine grained, yellow, moist and **CLAY:** yellow brown, moist, firm.	
CL	**CLAY:** brown, with pale brown silt, moist, firm.	
ML	**SILT:** yellow, with firm grey clay, moist.	
	SANDSTONE: very fine grained, yellow brown, extremely weathered, moist.	
	grey, distinctly weathered, moist.	
	SILTSTONE: dark grey, slightly weathered, moist.	

12 RELATIVE DENSITY /CONSISTENCY: VS S F ST VST H / FB VL L MD D VD

13 STRUCTURE AND ADDITIONAL OBSERVATIONS: 143mm Diameter, 0 to 52m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

SHEET 2 OF 2

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW9A -MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 05.07.2010
Date Completed: 27.07.2010
Recorded By: Malcolm Graham
Log Checked By: MGR

Drill Model/Mounting: IRTH 60
Borehole Diameter: 143mm
Driller: S Baker
Driller Lic No: 3046
TOC (RL): 157 m AHD
Surface RL: 156 m AHD
Co-ords: E 670246 N 7469610 MGA94 Zone 55
Local Co-ords:

Borehole Information								Field Material Description					
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB										**SILTSTONE:** dark grey, slightly weathered, moist. *(continued)*	M		Airlift yield: 0.01 L/S
				104	52					END OF BOREHOLE AT 52.00 m			
				102	54								
				100	56								
				98	58								
				96	60								
				94	62								
				92	64								
				90	66								
				88	68								
				86	70								
				84	72								
				82	74								
				80	76								
				78	78								
				76	80								
				74	82								
				72	84								
				70	86								
				68	88								
				66	90								
				64	92								
				62	94								
				60	96								
				58	98								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 1 OF 3

Client:	MACARTHUR COAL	Date Commenced:	30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT	Date Completed:	27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE	Recorded By:	Malcolm Graham
Project Number:	2117076B	Log Checked By:	UbR

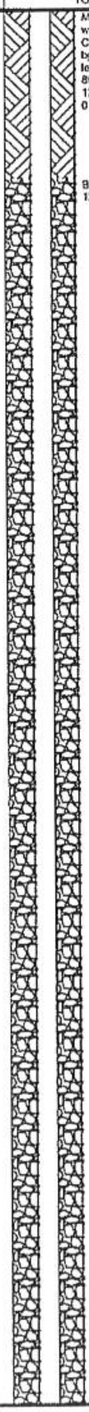
PB Borehole No.:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information (1–7) — **Field Material Description** (8–13)

1 METHOD: RB

4 WELL CONSTRUCTION (TOC 1 m):
- Monument cover with PVC cap, Cement 0 to 6m bgl (below ground level) 80mm ID, Class 12 uPVC casing, 0 to 135m bgl
- Backfill, 6 to 129m bgl



5 RL(m) AHD	DEPTH(m)
154	2
152	4
150	6
148	8
146	10
144	12
142	14
140	16
138	18
136	20
134	22
132	24
130	26
128	28
126	30
124	32
122	34
120	36
118	38
116	40
114	42
112	44
110	46
108	48

Depth	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE
	CL	Silty CLAY: brown, dry, firm.	D
3.00	SL	CLAY: brown, dry, firm.	
5.00	SC	Clayey SAND: medium grained, brown, moist	M
8.00	CL/SC	CLAY: grey, moist, firm and Sandy CLAY: brown, fine grained sand, moist.	
9.00	SC	Clayey SAND: fine to medium grained, grey and orange, moist.	
11.00	CL/ML	CLAY: grey, moist, firm and Clayey SAND: fine grained, orange, moist.	
13.00	CL	CLAY: pale grey, orange and pink, moist, firm, trace very fine grained pink sand.	
16.00	CL/ML	CLAY: grey, pink and orange, moist, firm and SAND: very fine grained, pink, moist	
33.00	CL	CLAY: brown, moist, firm.	
34.00	ML	SILT: yellow-brown, with firm grey clay, moist.	
36.00		SANDSTONE: very fine grained, yellow-brown, extremely weathered, moist.	
43.00		red, distinctly weathered.	
44.00		CLAYSTONE: brown and orange, distinctly weathered, moist.	
46.00		SILTSTONE: grey-brown, distinctly weathered, carbonaceous, moist.	
48.00		SANDSTONE: very fine greained, grey, slightly weathered, moist.	

12 RELATIVE DENSITY /CONSISTENCY: VS S F ST VST H / FB VL L MD D VD

13 STRUCTURE AND ADDITIONAL OBSERVATIONS: 200mm Diameter, 0 to 51m bgl

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 2 OF 3

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW9M - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 30.06.2010
Date Completed: 27.07.2010
Recorded By: Malcolm Graham
Log Checked By: UdR

Drill Model/Mounting: IRTH 60
Borehole Diameter: 200mm to 140mm
Driller: S Baker
Driller Lic No: 3046
TOC (RL): 157 m AHD
Surface RL: 156 m AHD
Co-ords: E 670244 N 7469619 MGA94 Zone 55
Local Co-ords:

Borehole Information							Field Material Description					
1	2	3	4	5		6	7	8	9	10	11	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB					50.00					**CLAYSTONE:** grey, distinctly weathered, moist.	M	
RAB												140mm Diameter, 51 to 144m bgl
				104	52							
					53.00					**SANDSTONE:** very fine grained, grey, fresh, dry.	D	
				102	54							
				100	56							
					57.00					**CLAYSTONE:** dark grey, fresh, dry.		
				98	58.00 58					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.		
				96	60							
				94	62							
				92	64.00 64					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry		
				90	66.00 66					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.		
				88	68							
				86	70.00 70					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.		
					71.00					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.		
				84	72							
					73.00					**CLAYSTONE:** dark grey, distinctly weathered, carbonaceous, dry.		
				82	74.00 74					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.		
				80	76							
					77.00					extremely weathered, clayey, wet.	W	
				78	78.00 78					slightly weathered, clayey, wet.		
				76	80							
				74	82							
				72	84							
				70	86							
					87.00					**SANDSTONE:** very fine grained, dark grey, fresh, wet.		
				68	88.00 88					fine grained.		
				66	90							
				64	92							
				62	94							
				60	96.00 96					very fine grained.		
					97.00					**SILTSTONE:** dark grey, fresh, wet.		
				58	98.00 98					**SANDSTONE:** very fine grained, dark grey, fresh, wet.		

Column 12: RELATIVE DENSITY /CONSISTENCY VS S F St VSt H / VL L MD D VD

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

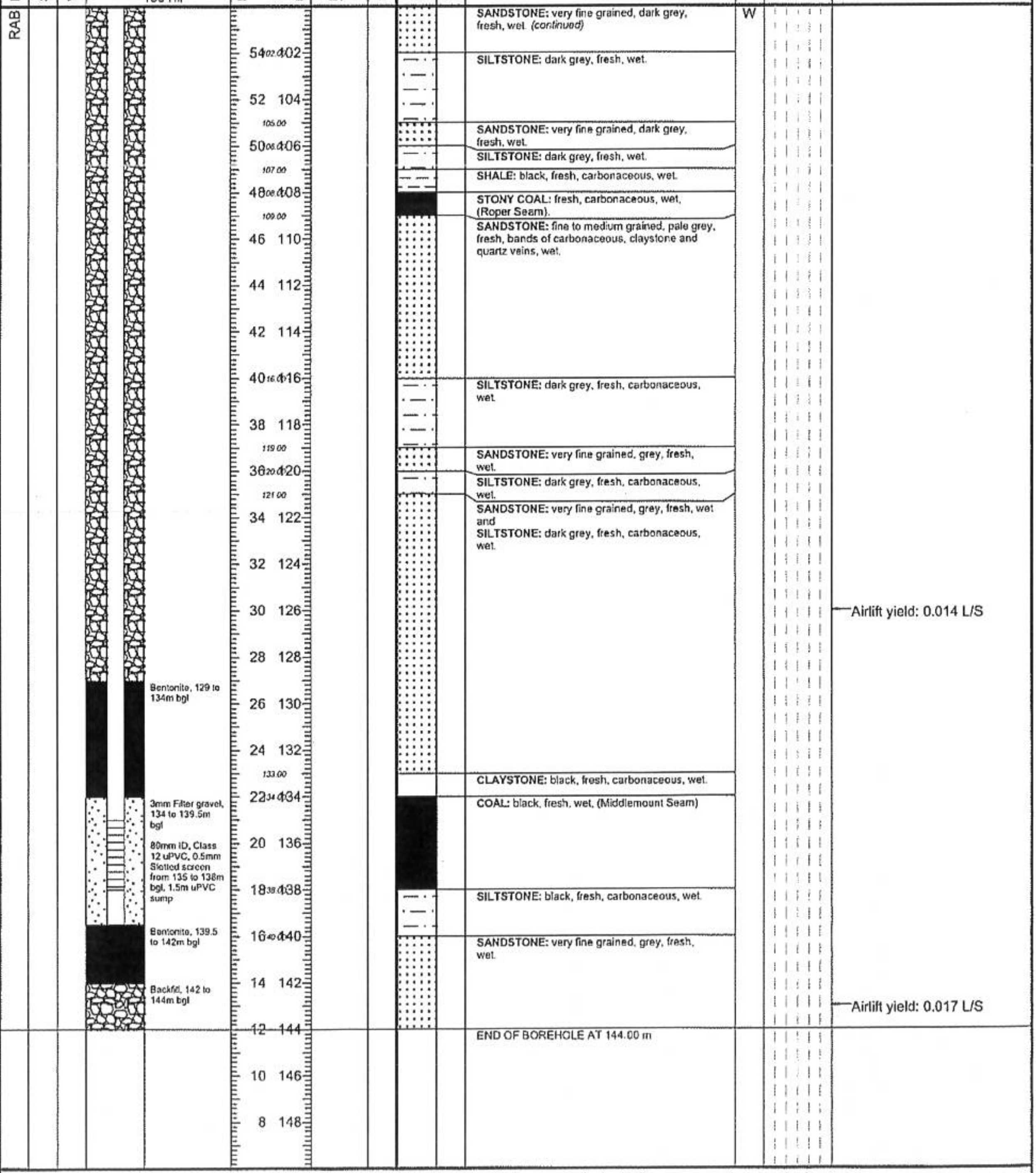
GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
		Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
Borehole Diameter:	200mm to 140mm	TOC (RL):	157 m AHD	Local Co-ords:	



Borehole Information				Field Material Description		
1 METHOD	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				**SANDSTONE:** very fine grained, dark grey, fresh, wet. *(continued)*	W	
		54	102.00	**SILTSTONE:** dark grey, fresh, wet.		
			105.00	**SANDSTONE:** very fine grained, dark grey, fresh, wet.		
		50	106.00	**SILTSTONE:** dark grey, fresh, wet.		
			107.00	**SHALE:** black, fresh, carbonaceous, wet.		
		48	108.00	**STONY COAL:** fresh, carbonaceous, wet, (Roper Seam).		
			109.00	**SANDSTONE:** fine to medium grained, pale grey, fresh, bands of carbonaceous, claystone and quartz veins, wet.		
		40	116.00	**SILTSTONE:** dark grey, fresh, carbonaceous, wet.		
			119.00	**SANDSTONE:** very fine grained, grey, fresh, wet.		
		36	120.00	**SILTSTONE:** dark grey, fresh, carbonaceous, wet.		
			121.00	**SANDSTONE:** very fine grained, grey, fresh, wet and **SILTSTONE:** dark grey, fresh, carbonaceous, wet.		
		30	126			Airlift yield: 0.014 L/S
	Bentonite, 129 to 134m bgl					
			133.00	**CLAYSTONE:** black, fresh, carbonaceous, wet.		
	3mm Filter gravel, 134 to 139.5m bgl	22	134.00	**COAL:** black, fresh, wet, (Middlemount Seam)		
	80mm ID, Class 12 uPVC, 0.5mm Slotted screen from 135 to 138m bgl, 1.5m uPVC sump					
		18	138.00	**SILTSTONE:** black, fresh, carbonaceous, wet.		
	Bentonite, 139.5 to 142m bgl	16	140.00	**SANDSTONE:** very fine grained, grey, fresh, wet.		
	Backfill, 142 to 144m bgl					Airlift yield: 0.017 L/S
		12	144	END OF BOREHOLE AT 144.00 m		

RL(m) AHD	DEPTH(m)
54	102
52	104
50	106
48	108
46	110
44	112
42	114
40	116
38	118
36	120
34	122
32	124
30	126
28	128
26	130
24	132
22	134
20	136
18	138
16	140
14	142
12	144
10	146
8	148

Columns: 2 SUPPORT, 3 WATER, 6 FIELD TEST, 7 SAMPLE, 8 GRAPHIC LOG, 9 USC SYMBOL, 12 RELATIVE DENSITY CONSISTENCY (VS S F St VSt H / VL L MD D VD)

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 1 OF 5

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW9P - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 25.07.2010
Date Completed: 28.07.2010
Recorded By: Malcolm Graham
Log Checked By:
Drill Model/Mounting: HYDROPOWER SCOUT
Borehole Diameter: 200mm to 140mm
Driller: E Schumacher
Driller Lic No: 3127
TOC (RL): 157 m AHD
Surface RL: 156 m AHD
Co-ords: E 670251 N 7469592 MGA94 Zone 55
Local Co-ords:

Borehole Information								Field Material Description					
1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION TOC 1 m	5 RL(m) AHD	DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			Monument cover with PVC cap, Cement 0 to 5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 200m bgl						ML	Clayey SILT: brown, dry.	D		200mm Diameter, 0 to 46m bgl
				154 152	1.00 2 4				CL	Silty CLAY: brown and orange, moist, firm.	M		
			Backfill, 5 to 194m bgl		5.00				SC	SAND: fine grained, orange, with clay, moist.			
				150	6.00 6					fine to medium grained, brown.			
					7.00					medium grained, orange.			
				148 146 144	8.00 8 10 12				CL	CLAY: grey and orange, moist, firm, with medium grained, orange sand.			
				142 140 138	14.00 14 16 18					pink, orange and grey, no sand.			
				136 134 132	19.00 20 22 24				CL/ SP	Sandy CLAY: pink and grey, moist, firm and SAND: fine, grained, pink, moist.			
				130	26.00 26				CL	CLAY: pink and grey, moist, firm.			
				128	28.00 28					orange and grey.			
				126 124	30.00 30 32				CL	Silty CLAY: grey, orange and dark brown, moist, firm.			
				122	33.00 34					SANDSTONE: very fine grained, yellow, extremely weathered, moist.			
					35.00					SILTSTONE: yellow, distinctly weathered, moist.			
				120 118	36.00 36 38					SANDSTONE: very fine grained, yellow and brown, extremely weathered, moist.			
					39.00					SILTSTONE: yellow, distinctly weathered, moist.			
				116	40.00 40					SANDSTONE: fine grained, grey, distinctly weathered, moist.			
					41.00					very fine grained.			
				114	42.00 42					brown, clayey in places.			
				112	44.00 44					SILTSTONE: grey and brown, slightly weathered, moist.			
RAB				110	46.00 46					SANDSTONE: fine grained, grey, slightly weathered, moist.			140mm Diameter, 46 to 203m bgl
				108	48.00 48					CLAYSTONE: grey, slightly weathered, minor silt, moist.			
					49.00					SILTSTONE: grey, slightly weathered, moist.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

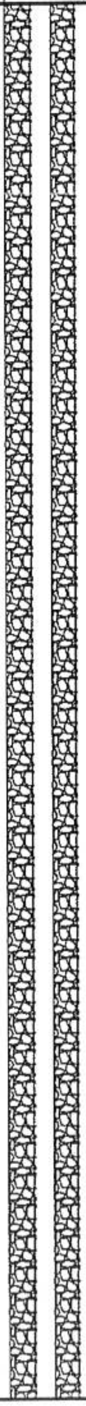
BOREHOLE NO.
MW9P
SHEET 2 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	
Project:	MIDDLEMOUNT COAL PROJECT	Date Commenced:	25.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE	Date Completed:	28.07.2010
Project Number:	2117076B	Recorded By:	Malcolm Graham
		Log Checked By:	

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
		Driller Lic No:	3127	Co-ords:	E 670251 N 7469592 MGA94 Zone 55
Borehole Diameter:	200mm to 140mm	TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information — 1 METHOD, 2 SUPPORT, 3 WATER, 4 WELL CONSTRUCTION (TOC 1 m), 5 RL(m) AHD / DEPTH(m), 6 FIELD TEST, 7 SAMPLE

Field Material Description — 8 GRAPHIC LOG, 9 USC SYMBOL, 10 SOIL/ROCK MATERIAL FIELD DESCRIPTION, 11 MOISTURE, 12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD), 13 STRUCTURE AND ADDITIONAL OBSERVATIONS



METHOD	RL(m) AHD	DEPTH(m)	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE
RAB			**SILTSTONE:** grey, slightly weathered, moist. *(continued)*	M
	104	52		
	102	54		
		55.00	**SANDSTONE:** very fine grained, grey, slightly weathered, moist.	
	100	56		
	98	58		
	96	60		
	94	62		
		63.00	**SILTSTONE:** grey, fresh, moist.	
	92	64		
		65.00	**SANDSTONE:** very fine grained, grey, fresh, moist.	
	90	66.00 66	**SILTSTONE:** grey, fresh, moist.	
	88	68		
		69.00	**SANDSTONE:** grey, fresh, moist.	
	86	70		
		71.00	**SILTSTONE:** grey, fresh, moist.	
	84	72		
	82	74		
	80	76		
		77.00	**SANDSTONE:** very fine grained, grey, fresh, moist.	
	78	78		
		79.00	fine grained.	
	76	80		
	74	82		
	72	84		
	70	86		
	68	88		
		89.00	very fine grained.	
	66	90.00 90	**SILTSTONE:** dark grey, fresh, moist.	
		91.00	**SANDSTONE:** fine grained, grey, fresh, wet.	W
	64	92		
		93.00	**SILTSTONE:** dark grey, wet.	
	62	94		
		95.00	**SANDSTONE:** very fine grained, dark gray, fresh, wet.	
	60	96		
	58	98		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW9P
SHEET 3 OF 5

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW9P - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 25.07.2010
Date Completed: 28.07.2010
Recorded By: Malcolm Graham
Log Checked By:
Drill Model/Mounting: HYDROPOWER SCOUT
Borehole Diameter: 200mm to 140mm
Driller: E Schumacher
Driller Lic No: 3127
TOC (RL): 157 m AHD
Surface RL: 156 m AHD
Co-ords: E 670251 N 7469592 MGA94 Zone 55
Local Co-ords:

Method	RL(m) AHD	Depth(m)	Soil/Rock Material Field Description	Moisture	Structure and Additional Observations
RAB			SANDSTONE: very fine grained, dark grey, fresh, wet. *(continued)*	W	
	54	102			
	52	104.00	calcite veins.		
		105.00	no calcite veins		
	50	106			
	48	108			
	46	110			
		111.00	SILTSTONE: grey, fresh, wet.		
	44	112.00	SANDSTONE: very fine grained, grey, fresh, wet.		
		113.00	SILTSTONE: grey, fresh, wet.		
	42	114.00	SANDSTONE: very fine grained, grey, fresh, wet.		
	40	116.00	SILTSTONE: dark grey, fresh, wet.		
		117.00	SANDSTONE: very fine grained, grey, fresh, wet.		
	38	118			
	36	120.00	fine grained.		
	34	122.00	very fine grained.		
	32	124			
	30	126			
	28	128			
	26	130			
		131.00	fine grained.		
	24	132.00	very fine grained.		Airlift yield: 0.03 L/S
	22	134			
	20	136.00	SILTSTONE: dark grey, fresh, carbonaceous, wet.		
		137.00	Silty COAL: dark brown, fresh, wet, (Middlemount Seam).		
	18	138.00	COAL: black, fresh, wet, (Middlemount Seam).		
	16	140			
		141.00	SANDSTONE: very fine grained, brown, fresh, wet.		
	14	142.00	fine grained, grey.		
	12	144			Airlift yield: 0.03 L/S
	10	146			
		147.00	very fine grained, brown, carbonaceous.		
	8	148			

TOC 1 m

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

GROUNDWATER BOREHOLE LOG

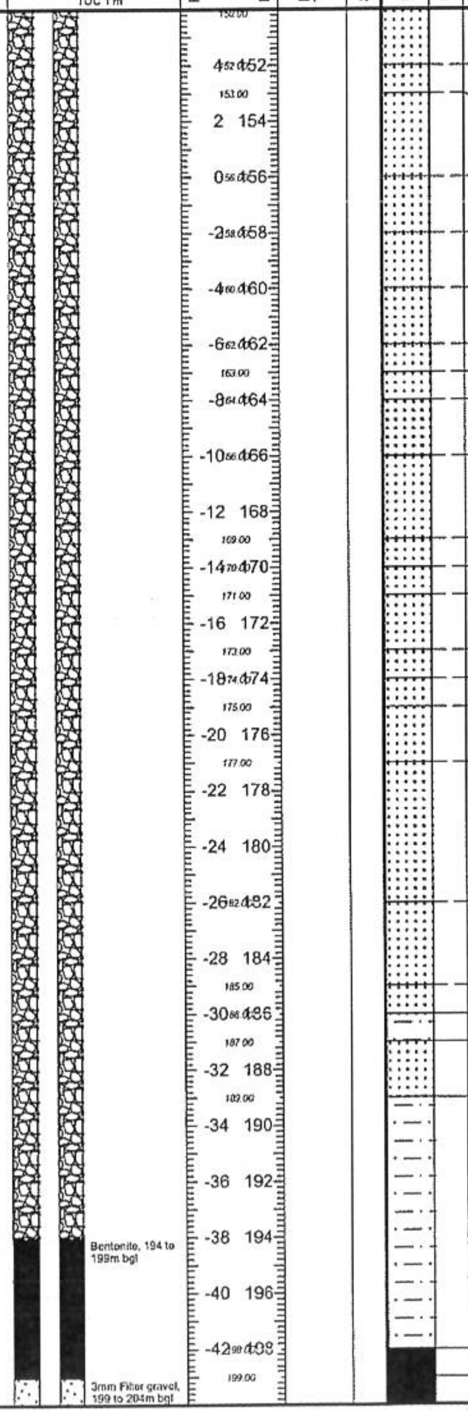
BOREHOLE NO.

MW9P

SHEET 4 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
		Driller Lic No:	3127	Co-ords:	E 670251 N 7469592 MGA94 Zone 55
Borehole Diameter:	200mm to 140mm	TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB										W		



fine grained, grey.

very fine grained, bands of carbonaceous siltstone.

fine grained.

brown

grey

brown.

grey.

very fine grained.

fine grained.

very fine grained.

fine grained.

brown

grey

brown.

grey.

brown.

calcite veins.

very fine grained, dark grey, no calcite veins.

fine grained.

SILTSTONE: dark grey, fresh, wet.

SANDSTONE: very fine grained, grey, fresh, calcite veins, wet.

SILTSTONE: dark grey, fresh, wet.

Silty COAL: dark brown, fresh, wet, (Pisces Seam)

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

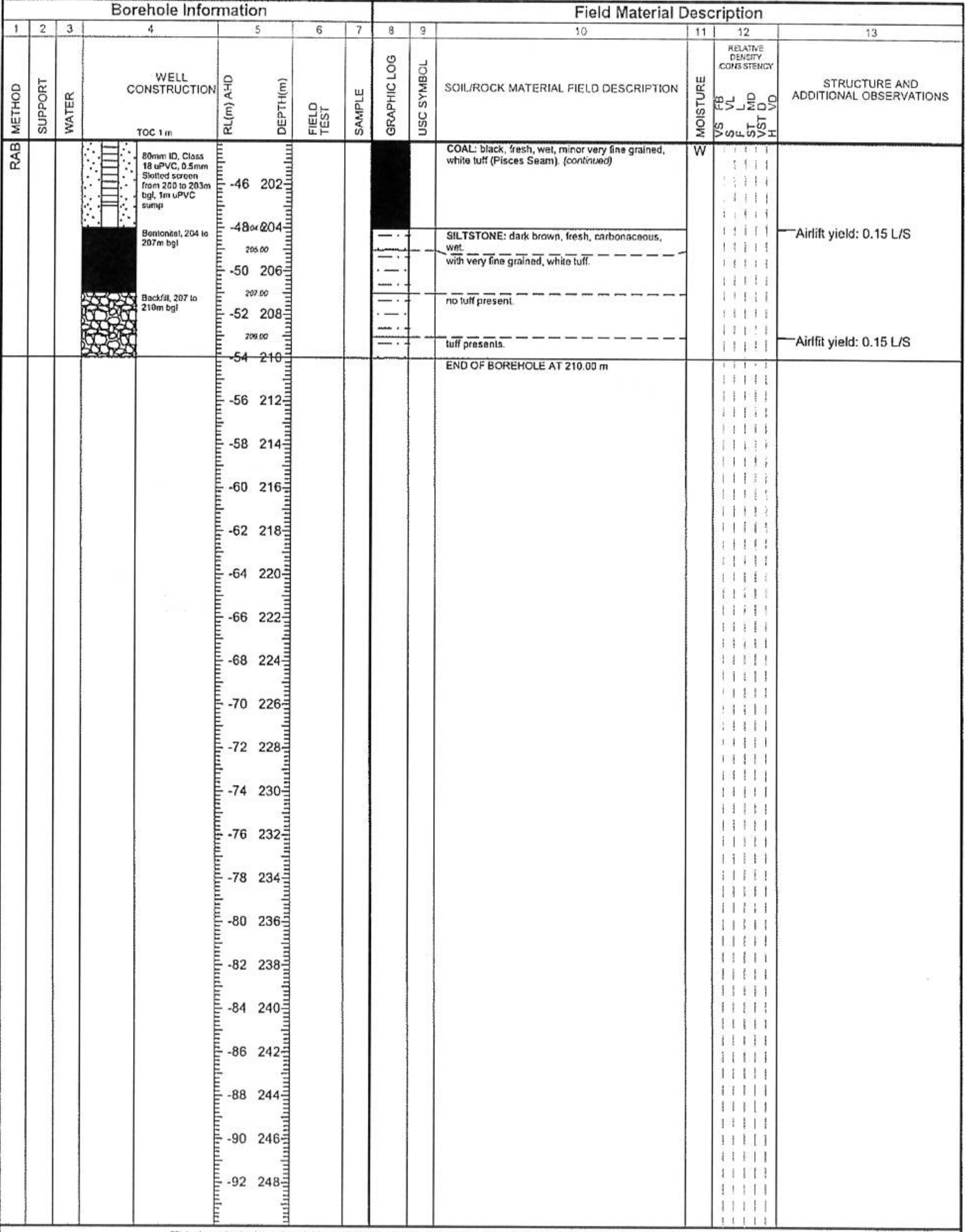
GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 5 OF 5

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW9P - MIDDLEMOUNT MINE
Project Number: 2117076B
PB Borehole No.:
Date Commenced: 25.07.2010
Date Completed: 28.07.2010
Recorded By: Malcolm Graham
Log Checked By:
Drill Model/Mounting: HYDROPOWER SCOUT
Borehole Diameter: 200mm to 140mm
Driller: E Schumacher
Driller Lic No: 3127
TOC (RL): 157 m AHD
Surface RL: 156 m AHD
Co-ords: E 670251 N 7469592 MGA94 Zone 55
Local Co-ords:



Borehole Information								Field Material Description				
1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 200 to 203m bgl, 1m uPVC sump	-46	202					COAL: black, fresh, wet, minor very fine grained, white tuff (Pisces Seam). *(continued)*	W		
			Bentonitel, 204 to 207m bgl	-48	204.00 204					SILTSTONE: dark brown, fresh, carbonaceous, wet.			Airlift yield: 0.15 L/S
					205.00					with very fine grained, white tuff.			
				-50	206								
			Backfill, 207 to 210m bgl		207.00					no tuff present.			
				-52	208								
					209.00					tuff presents.			Airlfit yield: 0.15 L/S
				-54	210					END OF BOREHOLE AT 210.00 m			
				-56	212								
				-58	214								
				-60	216								
				-62	218								
				-64	220								
				-66	222								
				-68	224								
				-70	226								
				-72	228								
				-74	230								
				-76	232								
				-78	234								
				-80	236								
				-82	238								
				-84	240								
				-86	242								
				-88	244								
				-90	246								
				-92	248								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

APPENDIX C

2014 / 2015 EXPLORATORY HOLE RECORDS

middlemount coal

Exploratory Hole Details

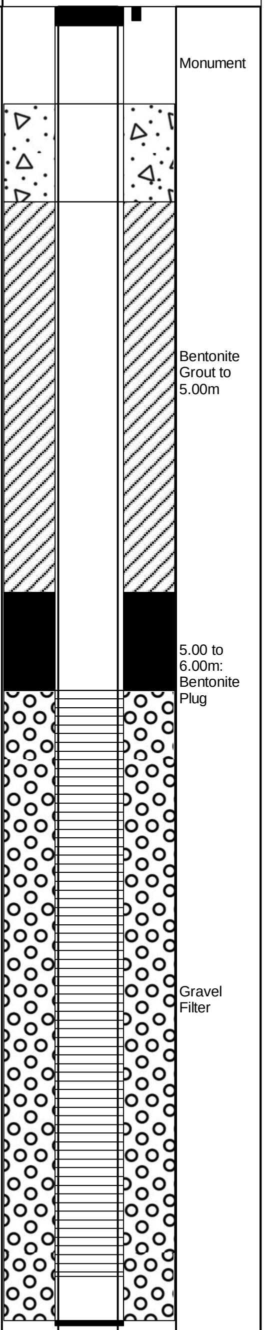
Phi GI

Project	**Middlemount Coal - Monitoring Wells**
Client	**MCPL**
Project No.	**PGC1214004**

Hole No.	**MW10A**	**Co-ordinate System**	GDA94 Zone 55
Start Date	22/12/2014	Easting	**669782.88**
Completion Date	22/12/2014	Northing	**7475981.12**
Driller	L. Dahler	Ground Level	**175.75mAHD**
Supervisor	P. Rogers		
Licence No.	Class 2 / 2517		
Logged By	A. Horspool	Checked By	S. Flux

Page 1 of 1

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm) 0 10 20 30 40 50	Sampling and Testing	Installation Details / Groundwater Levels
Open Hole / Air Flush	175.75	0.00		CI: CLAY, intermediate plasticity, brown and reddish brown slightly sandy, trace gravel,dry			
	173.75	2.00		SP: SAND light grey and yellowish brown, dry			
	171.75	4.00		GP: GRAVEL, fine and medium subrounded, dry			
	170.75	5.00		CI: CLAY, intermediate plasticity, brown and reddish brown slightly sandy, trace gravel,dry			
	169.75	6.00		SC: SAND, fine and medium grained, clayey to very clayey, reddish brown, dry			
	168.25	7.50		Silty SAND, fine to medium, fairly uniform, low plasticity			
	167.75	8.00		CI: CLAY, intermediate plasticity, grey and reddish brown slightly sandy, trace gravel,dry			
	163.75	12.00		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			



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Web: www.nqphigi.com.au

Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

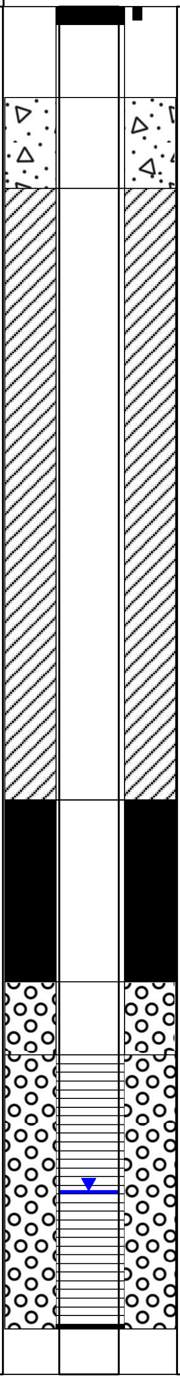
Exploratory Hole Details

Project	**Middlemount Coal - Monitoring Wells**	Hole No.	**MW11A**	**Co-ordinate System**	GDA94 Zone 55
Client	**MCPL**	Start Date	25/03/2015	Easting	**672355.00**
Project No.	**PGC1214004**	Completion Date	25/03/2015	Northing	**7472275.10**
		Driller	L. Dahler	Ground Level	**156.20mAHD**
		Supervisor	R. Goldsworthy		
		Licence No.	Class 2 / 2894		
		Logged By	A. Horspool	Checked By	S.Flux

Page 1 of 1

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm) 0 10 20 30 40 50	Sampling and Testing
Continuous Flight Auger	156.2	0.00		SM: silty SAND, trace rootlets, dry. (TOPSOIL)		
	155.9	0.30		CI: CLAY, intermediate plasticity, stiff, brown and reddish brown slightly sandy, trace gravel,dry		
	154.2	2.00		CI:sandy CLAY, intermediate plasticity, brown and reddish brown, trace gravel,dry		
	151.7	4.50		CH: CLAY, high plasticity, brown and reddish brown slightly sandy, trace gravel,dry		
	149.2	7.00		CI: CLAY, intermediate plasticity, brown and reddish brown slightly sandy, trace gravel,dry		
	146.2	10.00		CI: CLAY, intermediate plasticity, brown and reddish brown mottled white, slightly sandy, trace gravel,dry		
	143.73	12.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil		

Installation Details / Groundwater Levels



Monument

0.00 to 1.00m: Concrete

1.00 to 7.70m: Bentonite Grout

7.70 to 9.70m: Bentonite Seal

2mm Gravel Pack

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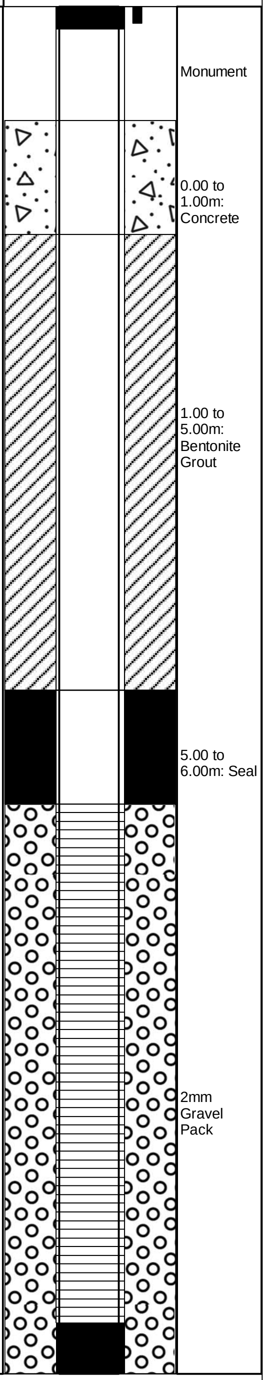
Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Exploratory Hole Details

Project	**Middlemount Coal - Monitoring Wells**	Hole No.	**MW12A**	**Co-ordinate System**	GDA94 Zone 55
Client	**MCPL**	Start Date	15/12/2014	Easting	**671639.97**
Project No.	**PGC1214004**	Completion Date	15/12/2014	Northing	**7469852.68**
		Driller	L. Dahler	Ground Level	**158.28mAHD**
		Supervisor	P. Rogers		
		Licence No.	Class 2 / 2517		
		Logged By	A. Horspool	Checked By	S. Flux

Page 1 of 1

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm) 0 10 20 30 40 50	Sampling and Testing	Installation Details / Groundwater Levels
Open Hole / Air Flush	158.28	0.00		SM: silty SAND, trace rootlets, dry. (TOPSOIL)			
	157.98	0.30		SC: clayey SAND, low plasticity, reddish brown, dry			
	156.78	1.50		CI: sandy CLAY, low plasticity, reddish brown,dry.			
	156.28	2.00		SC: fine and medium SAND with trace clay, yellowish brown, dry.			
	155.28	3.00		CI: CLAY intermediate plasticity, trace sand, dark brown, dry.			
	152.78	5.50		SP: fine SAND with some fine and medium platy gravel, dry			
	150.78	7.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			



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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

middlemount coal

Project	**Middlemount Coal - Monitoring Wells**
Client	**MCPL**
Project No.	**PGC1214004**

Exploratory Hole Details

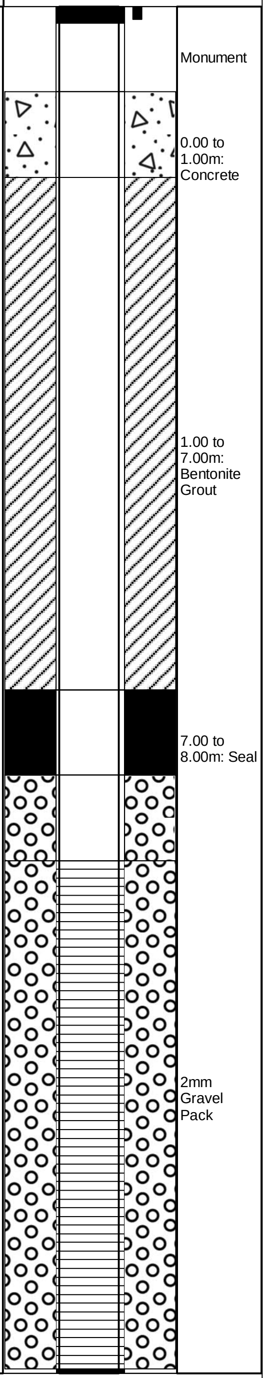
Hole No.	**MW13A**	**Co-ordinate System**	GDA94 Zone 55
Start Date	12/12/2014	Easting	**669032.15**
Completion Date	12/12/2014	Northing	**7468889.81**
Driller	L. Dahler	Ground Level	**162.79mAHD**
Supervisor	P. Rogers		
Licence No.	Class 2 / 2517		
Logged By	A. Horspool	Checked By	S. Flux

Phi GI φ

Page 1 of 1

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm) 0 10 20 30 40 50	Sampling and Testing
Open Hole / Air Flush	162.79	0.00		SM: silty SAND, trace rootlets, dry. (TOPSOIL)		
	161.79	1.00		CI: CLAY intermediate plasticity, trace sand, dark brown, dry.		
	161.29	1.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil		
	154.79	8.00		SANDSTONE, grey banded yellowish brown, very low strength, extremely to distinctly weathered		

Installation Details / Groundwater Levels



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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Exploratory Hole Details

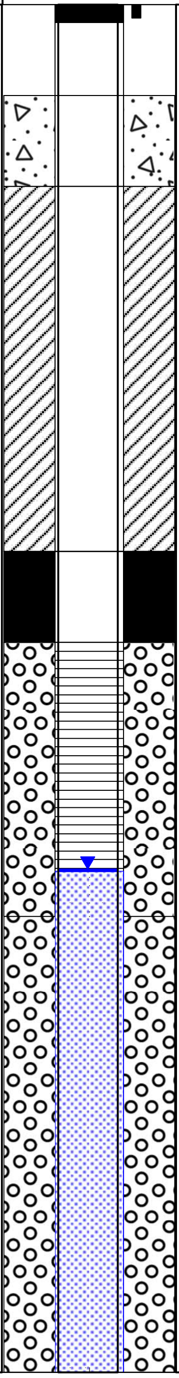
Phi GI

Project	**Middlemount Coal - Monitoring Wells**
Client	**MCPL**
Project No.	**PGC1214004**

Hole No.	**MW14A**	**Co-ordinate System**	GDA94 Zone 55
Start Date	14/12/2014	Easting	**668175.46**
Completion Date	14/12/2014	Northing	**7469311.96**
Driller	L. Dahler	Ground Level	**159.65mAHD**
Supervisor	P. Rogers		
Licence No.	Class 2 / 2517		
Logged By	A. Horspool	Checked By	S. Flux

Page **1 of 1**

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm) 0 10 20 30 40 50	Sampling and Testing	Installation Details / Groundwater Levels
							Monument
Open Hole / Air Flush	159.65	0.00		SM: silty SAND, fine and medium, reddish brown, dry			0.00 to 1.00m: Concrete
	158.65	1.00		SM: silty SAND, fine and medium, light brown, dry.			
	158.15	1.50		CI: Sandy CLAY,intermediate plasticity, brown, dry.			0.00 to 1.00m: Concrete
	154.65	5.00		SP: fine to coarse SAND, yellowish brown, dry.			5.00 to 6.00m: Seal
	152.65	7.00		SC: Clayey SAND, fine to coarse, dark grey, moist.			
	151.65	8.00		SP: fine and medium SAND, yellowish brown, moist.			GWL 8.50m
	150.9	8.75		SC: very clayey SAND, fine to coarse, dark grey, moist.			
	149.9	9.75		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			2mm Gravel Pack



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Remarks

50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Project	**Middlemount Coal - Monitoring Wells**
Client	**MCPL**
Project No.	**PGC1214004**

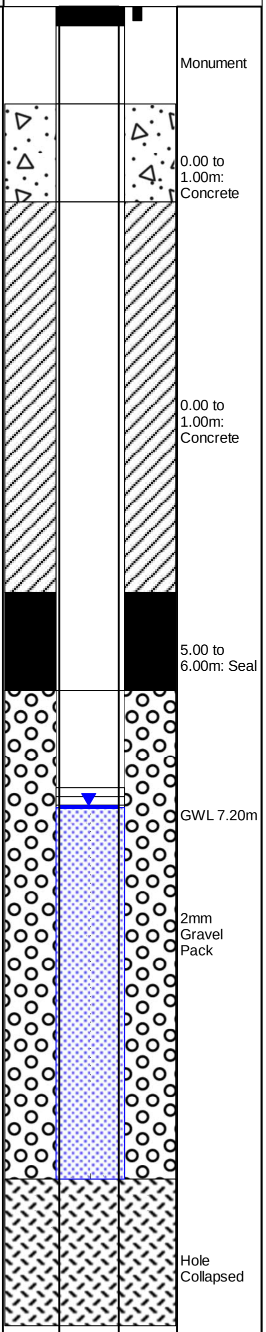
Exploratory Hole Details

Hole No.	**MW15A**	**Co-ordinate System**	GDA94 Zone 55
Start Date	15/12/2014	Easting	**667795.96**
Completion Date	15/12/2014	Northing	**7469627.08**
Driller	L. Dahler	Ground Level	**161.57mAHD**
Supervisor	P. Rogers		
Licence No.	Class 2 / 2517		
Logged By	A. Horspool	Checked By	S. Flux

Page **1 of 1**

Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm)	Sampling and Testing
Open Hole / Air Flush	161.57	0.00		CH: CLAY with boulders, high plasticity, stiff, dry. FILL		
	160.57	1.00		SM: Silty SAND, fine and medium, with trace organic matter (TOPSOIL)		
	160.27	1.30		SM: Silty SAND, dark brown , dry.		
	159.77	1.80		CI: CLAY with trace cobbles, dark brown, very stiff, iontermediate plastcity, dry		
	158.87	2.70		CI: CLAY, dark brown, intermediate plasticity, very stiff, dry.		
	157.77	3.80		SW: SAND, fine to coarse, dry		
	153.57	8.00		CI: Very sandy CLAY, intermediate plasticity, grey, moist.		
	150.57	11.00		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil		

Installation Details / Groundwater Levels



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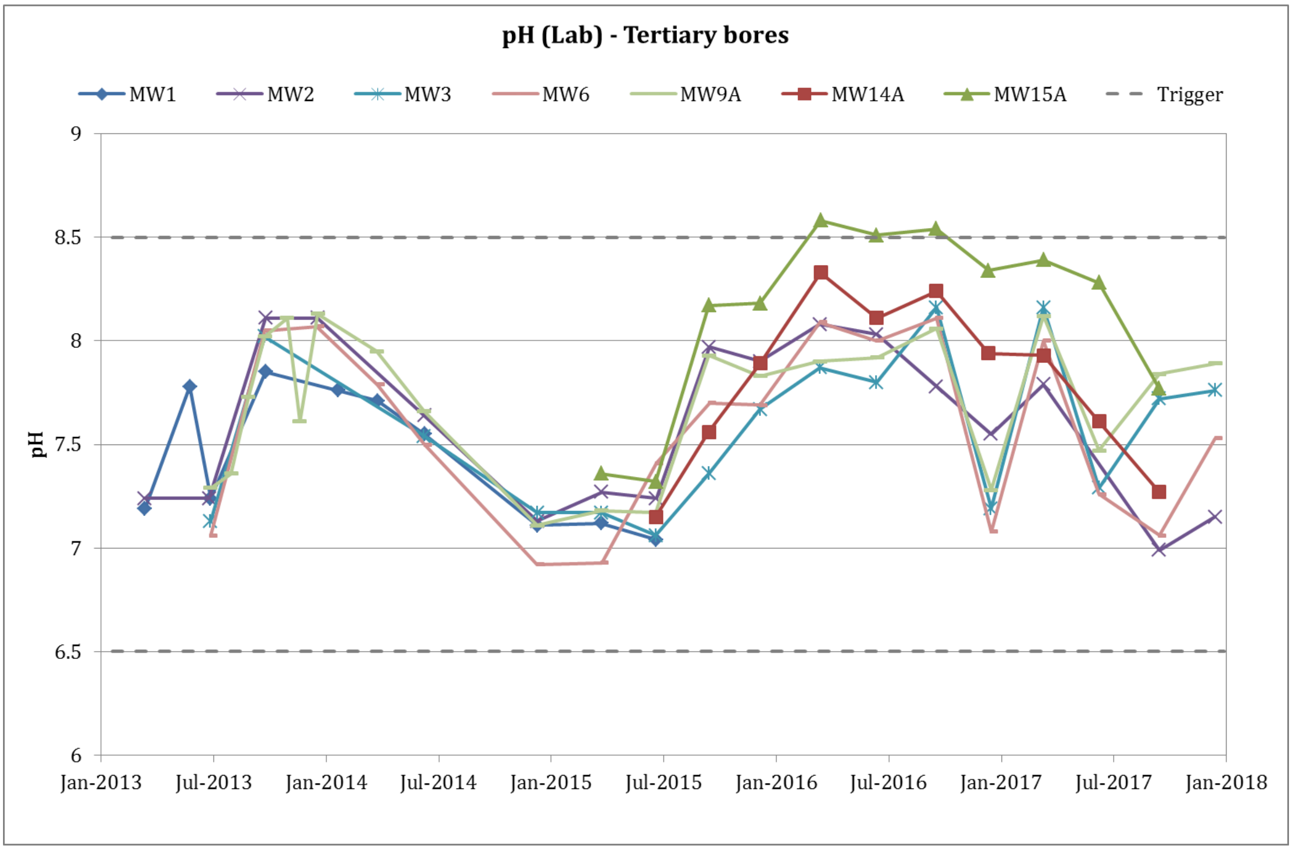
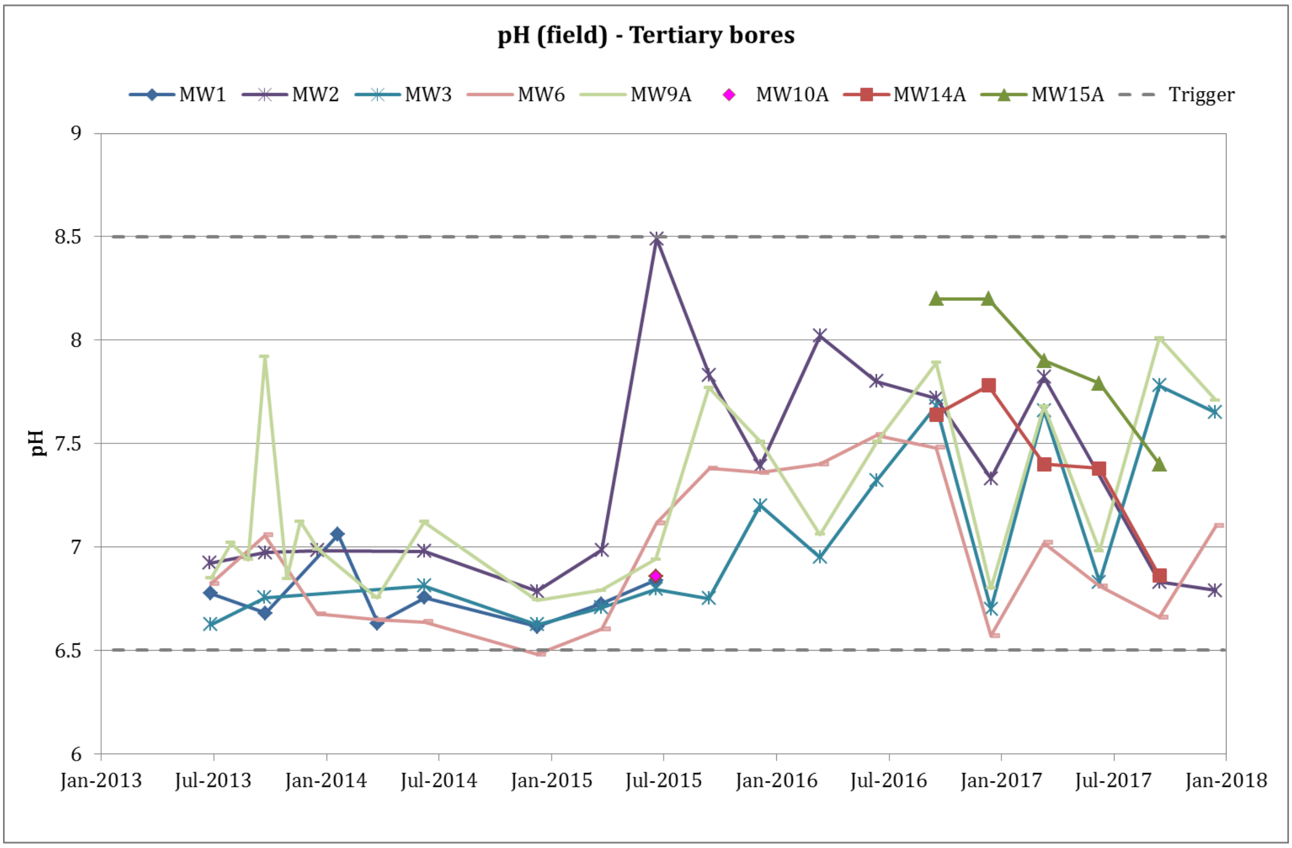
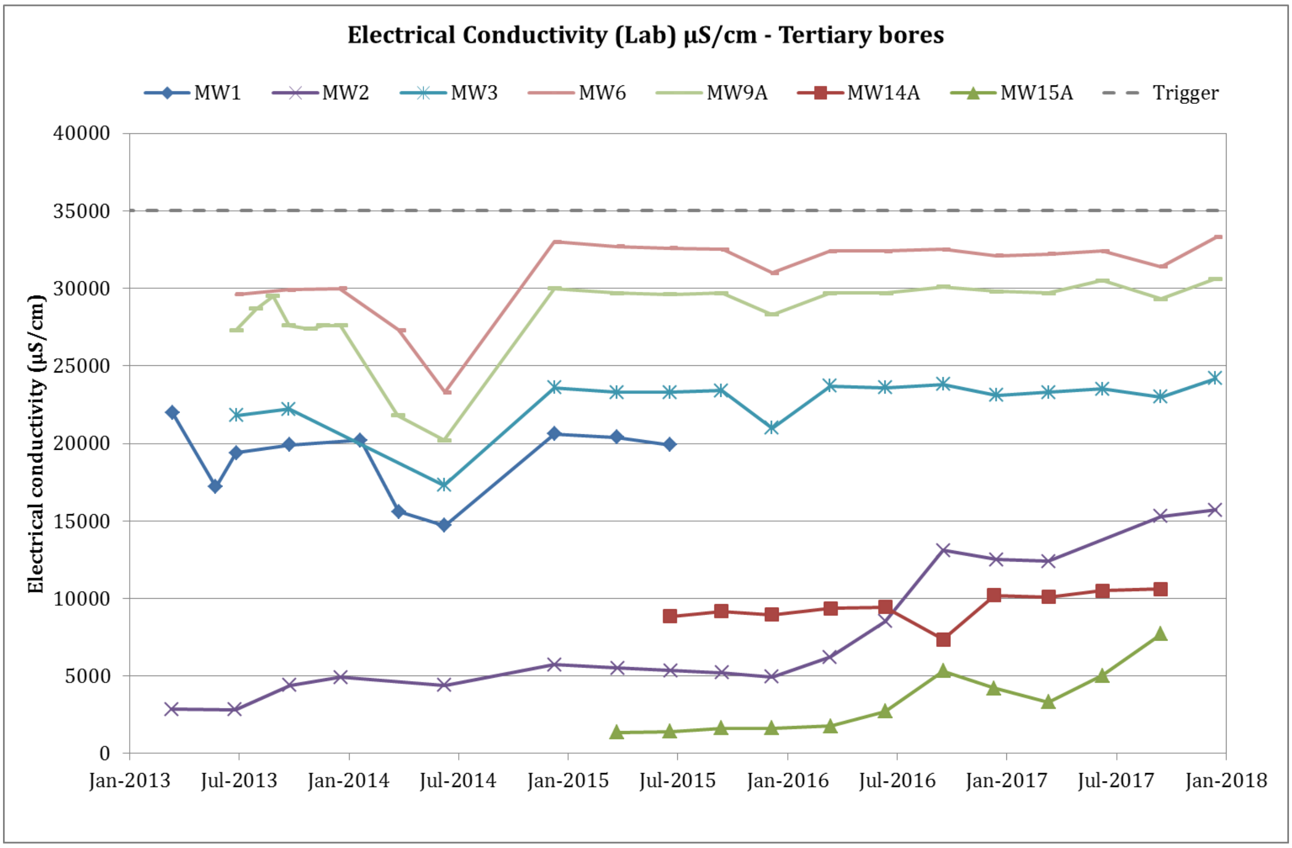
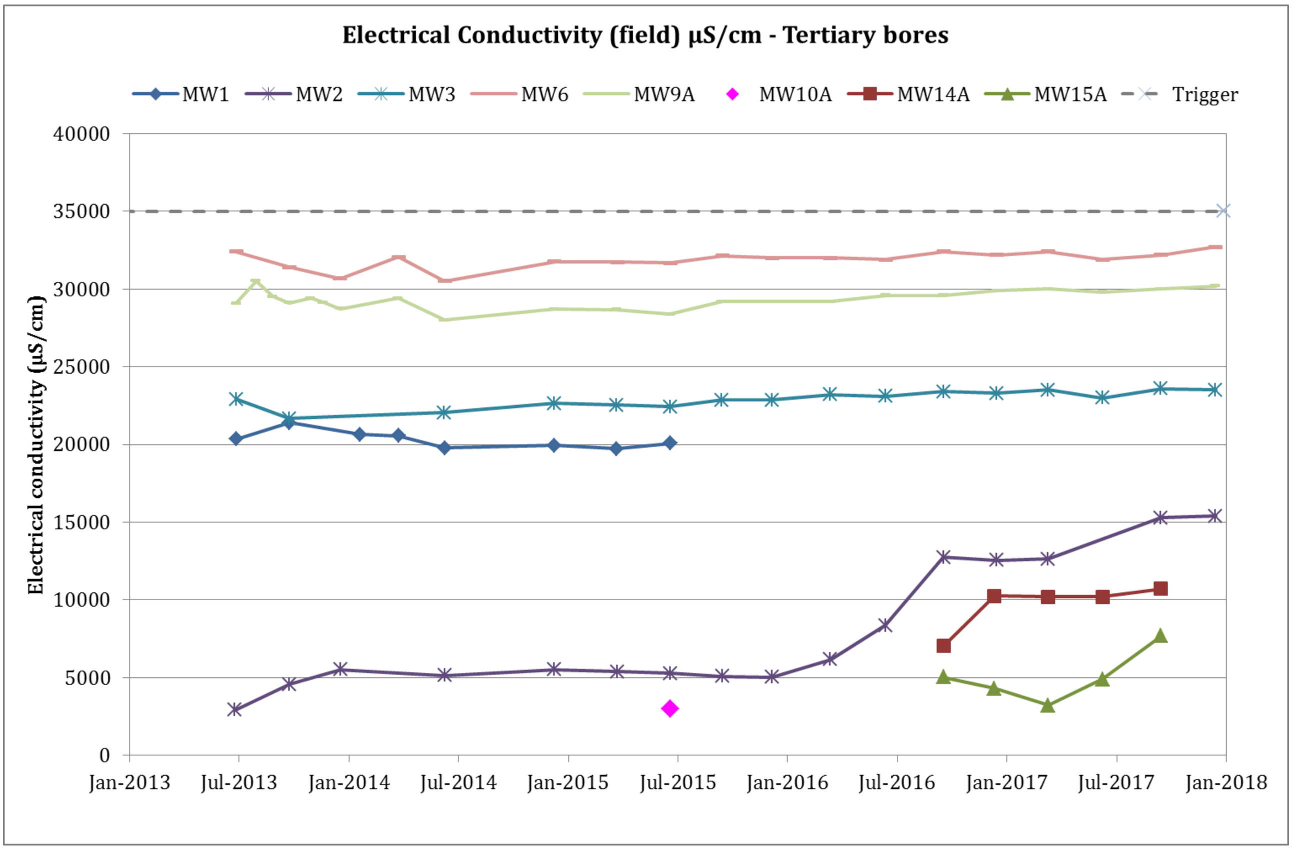
Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

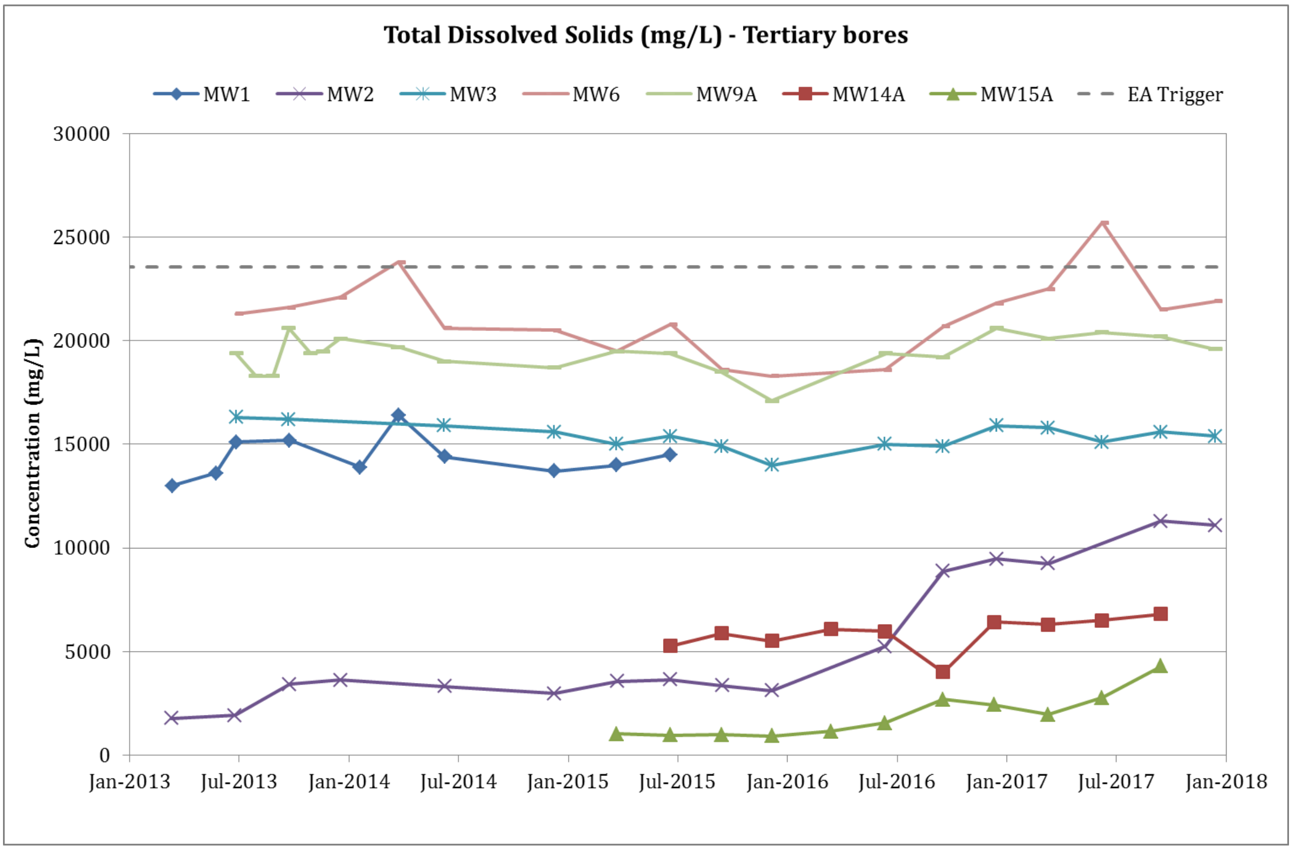
Appendix E Tertiary and Permian water quality data

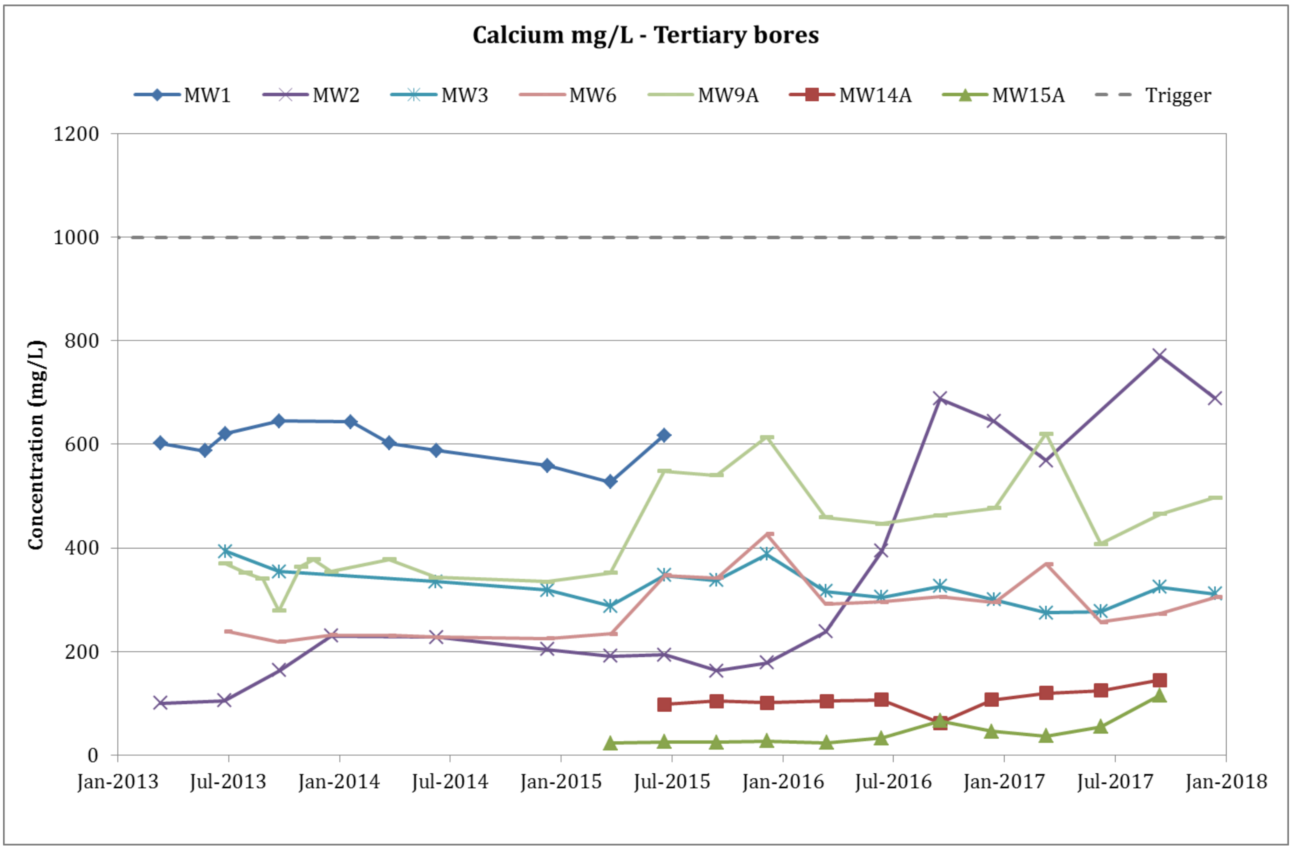

pH (Lab) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
9
8.5
8
7.5
7
6.5
6
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

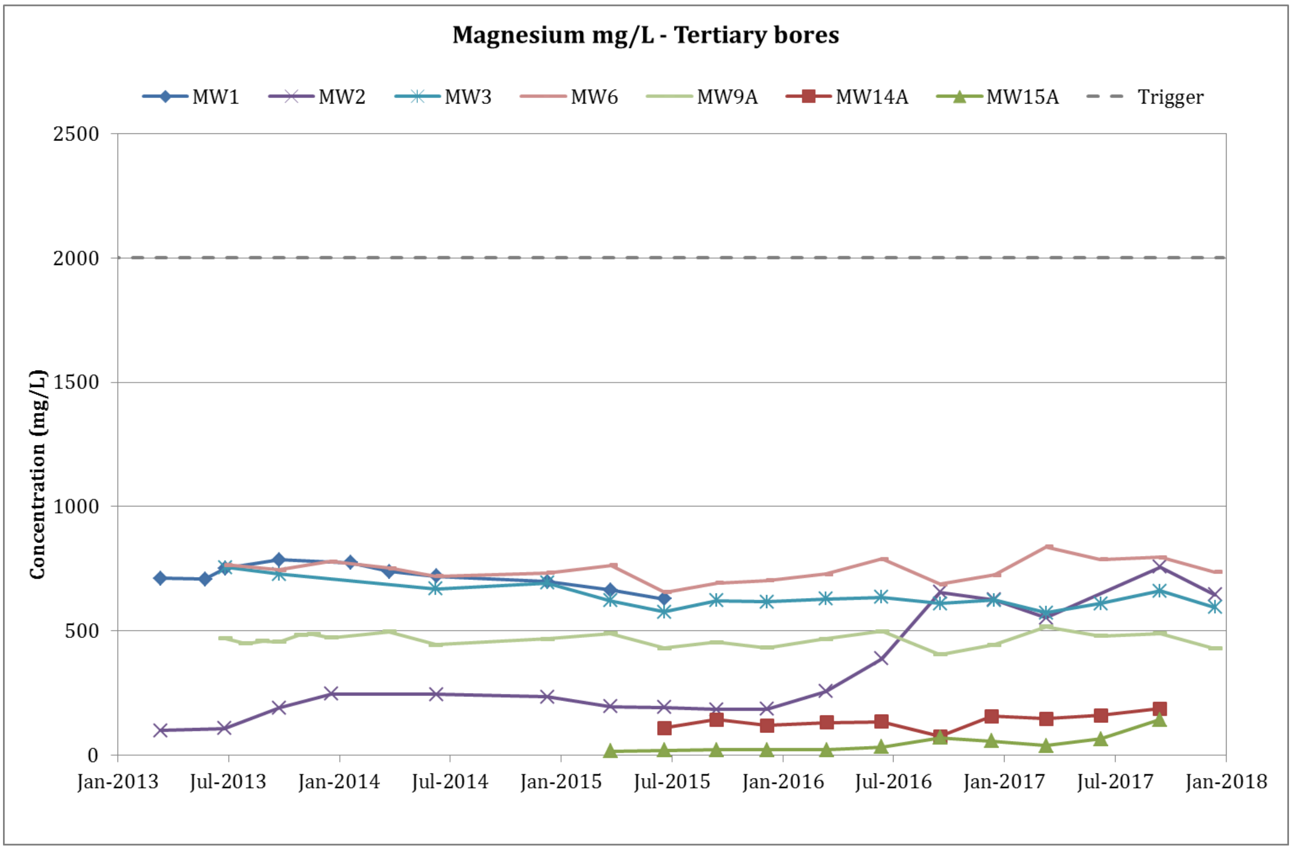

pH (field) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW10A
MW14A
MW15A
Trigger
9
8.5
8
7.5
7
6.5
6
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

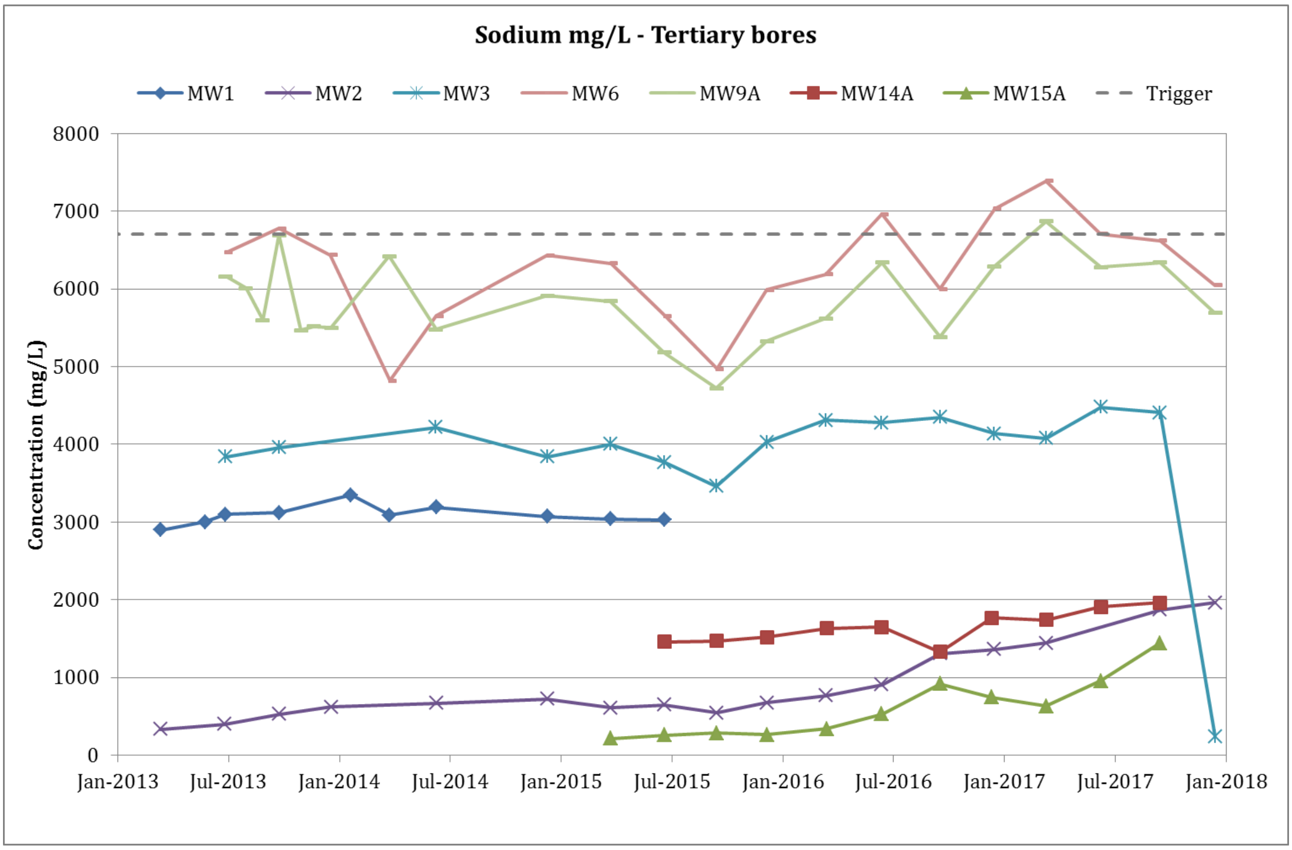

Electrical Conductivity (Lab) µS/cm - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

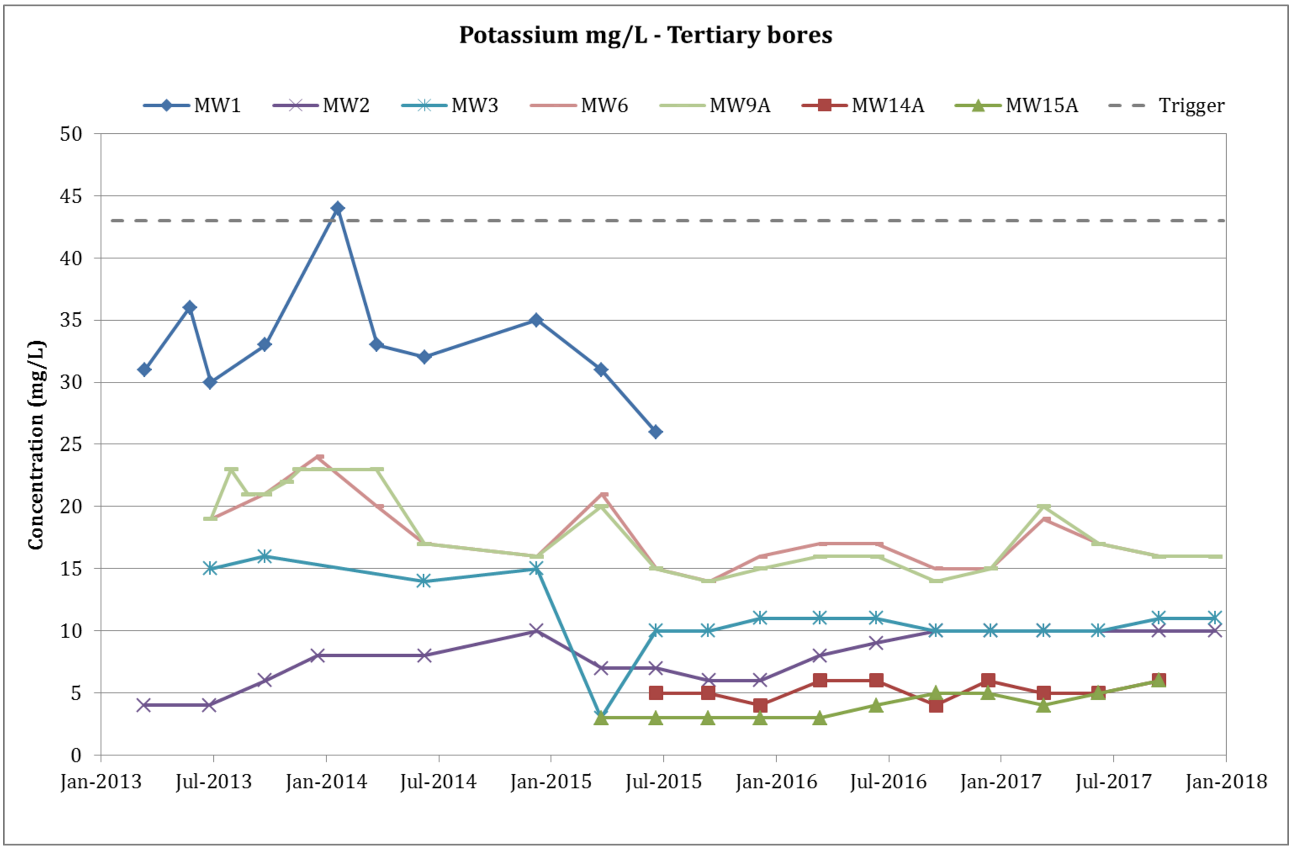

Electrical Conductivity (field) µS/cm - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW10A
MW14A
MW15A
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

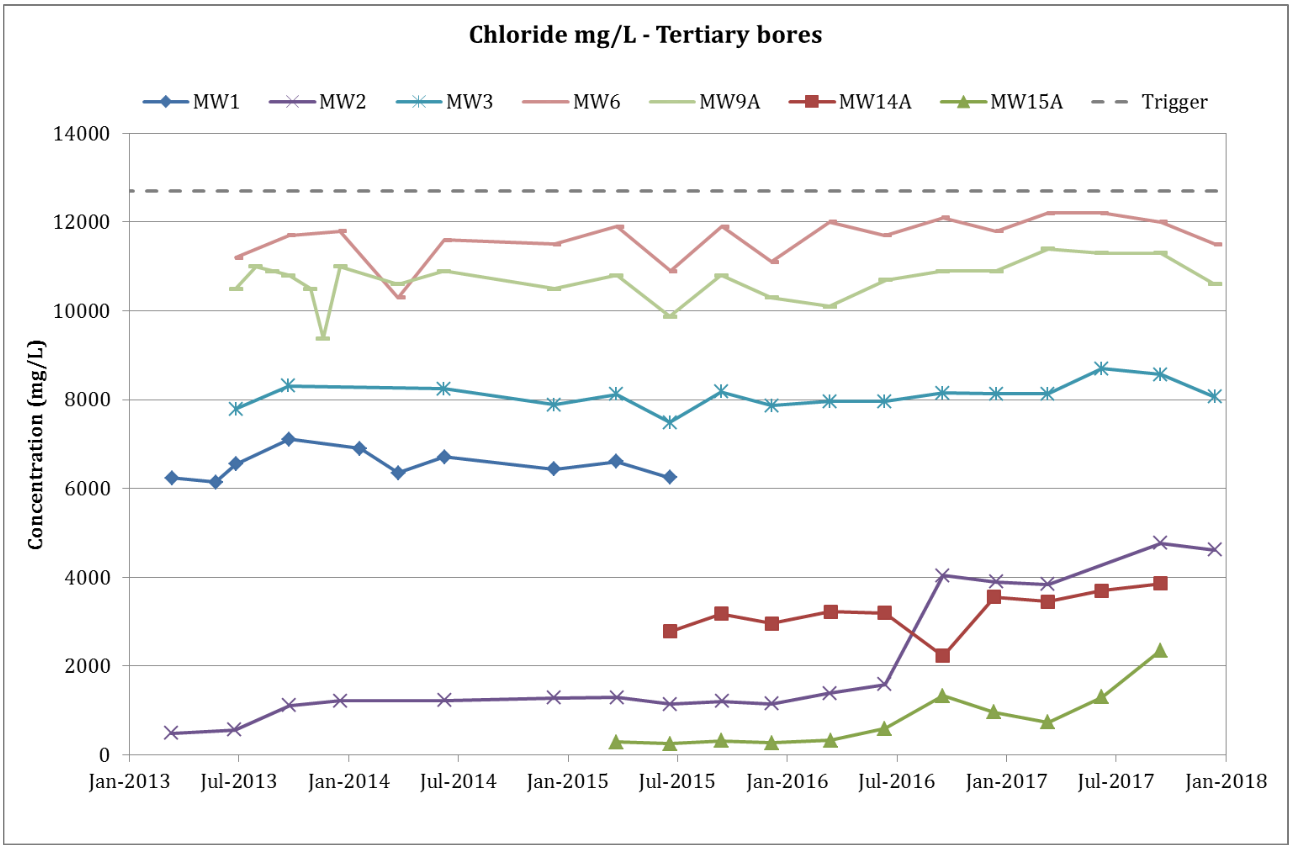

Total Dissolved Solids (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
EA Trigger
Concentration (mg/L)
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

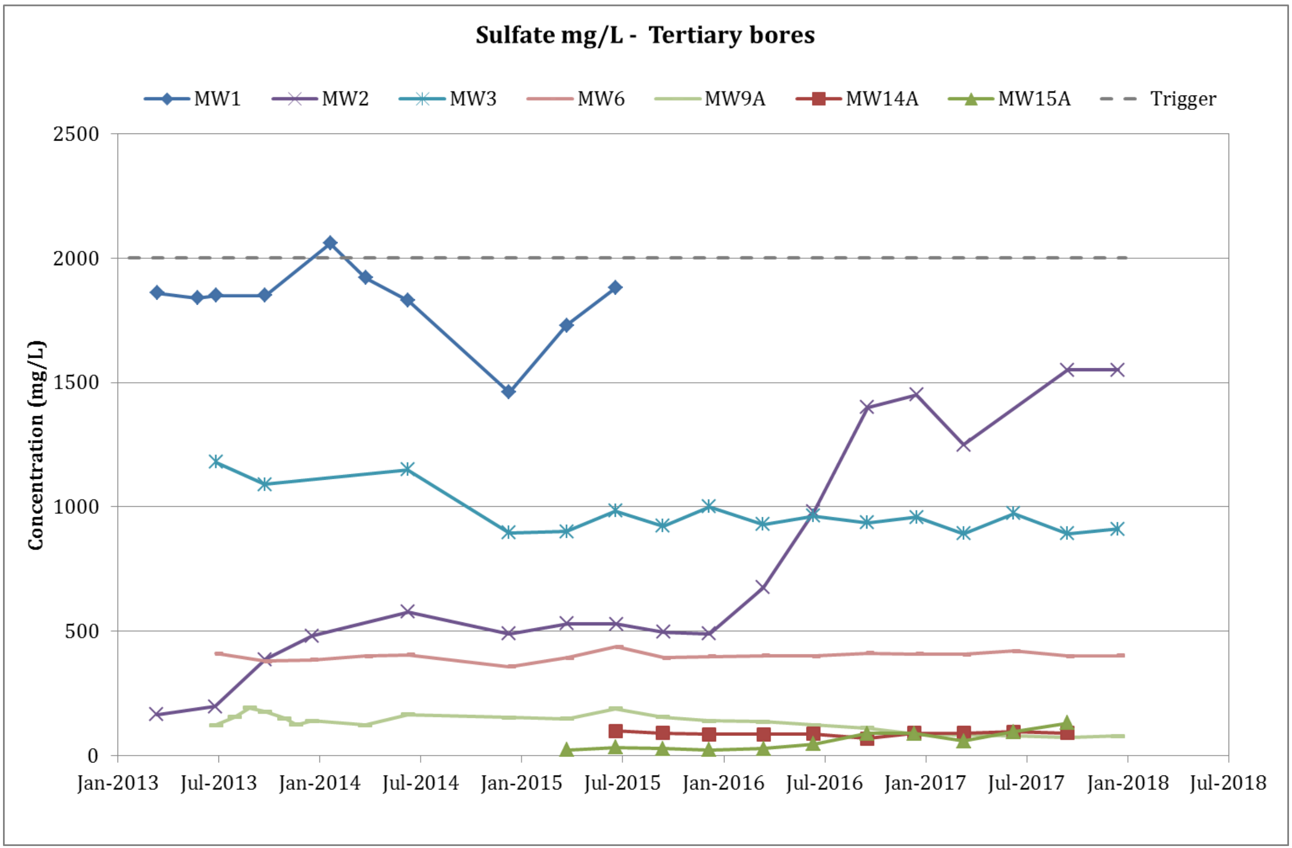

Calcium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

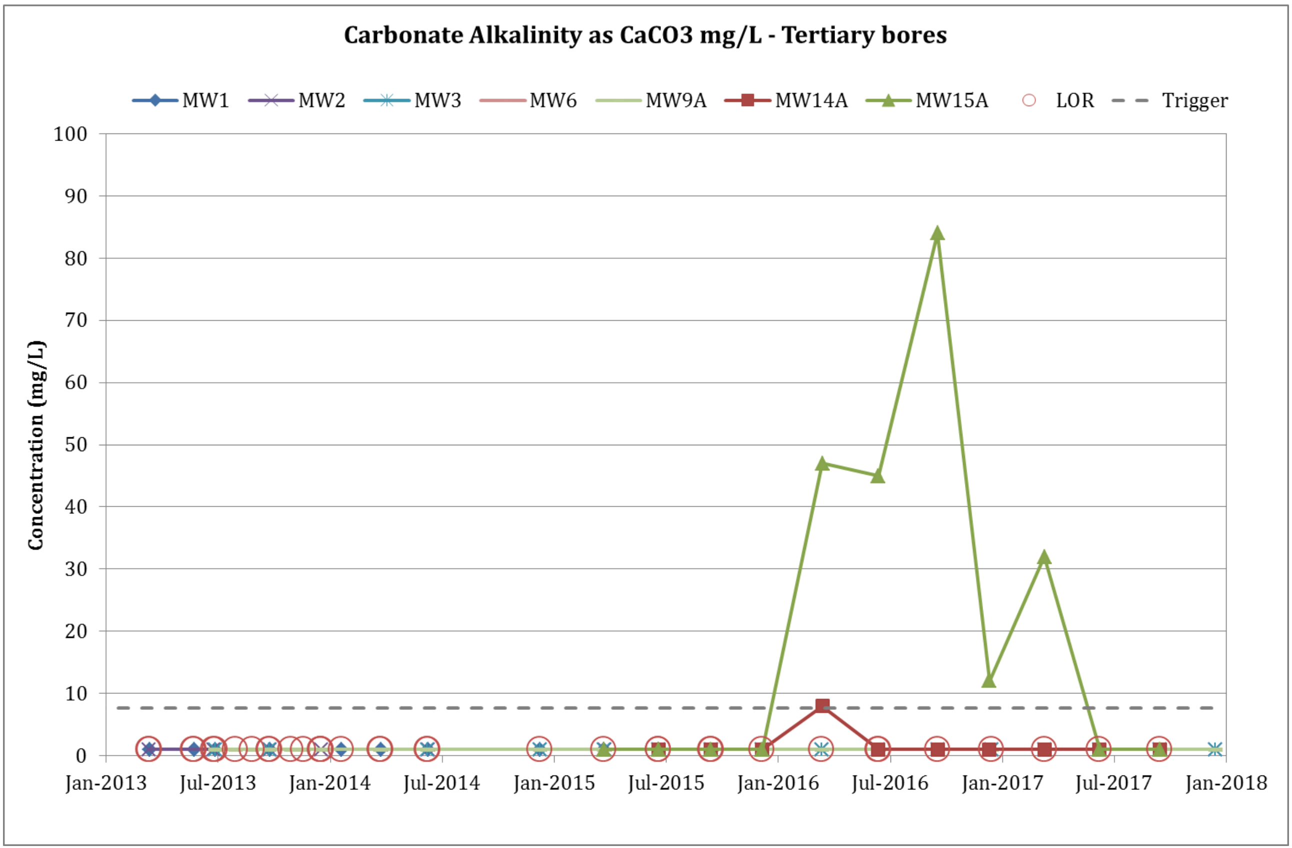

Magnesium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

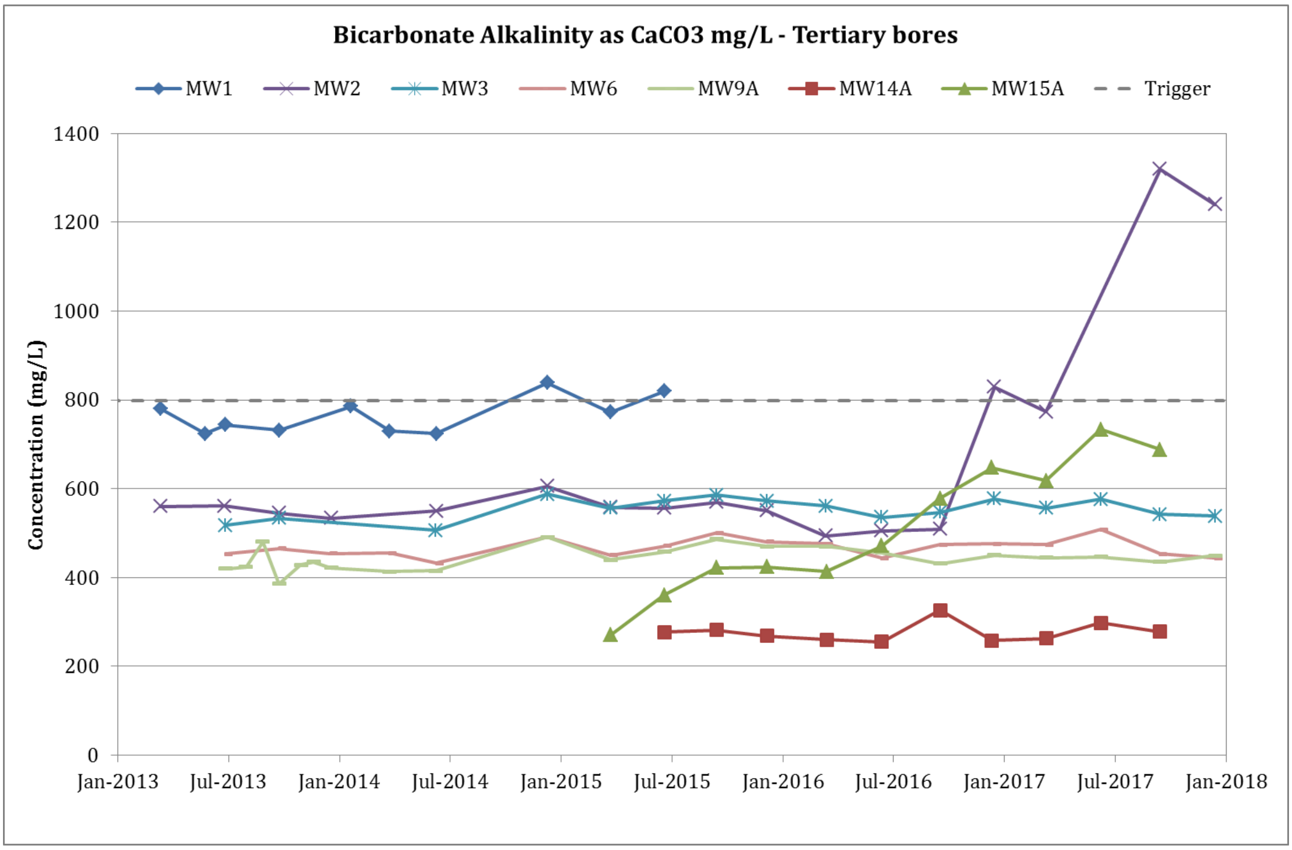

Sodium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

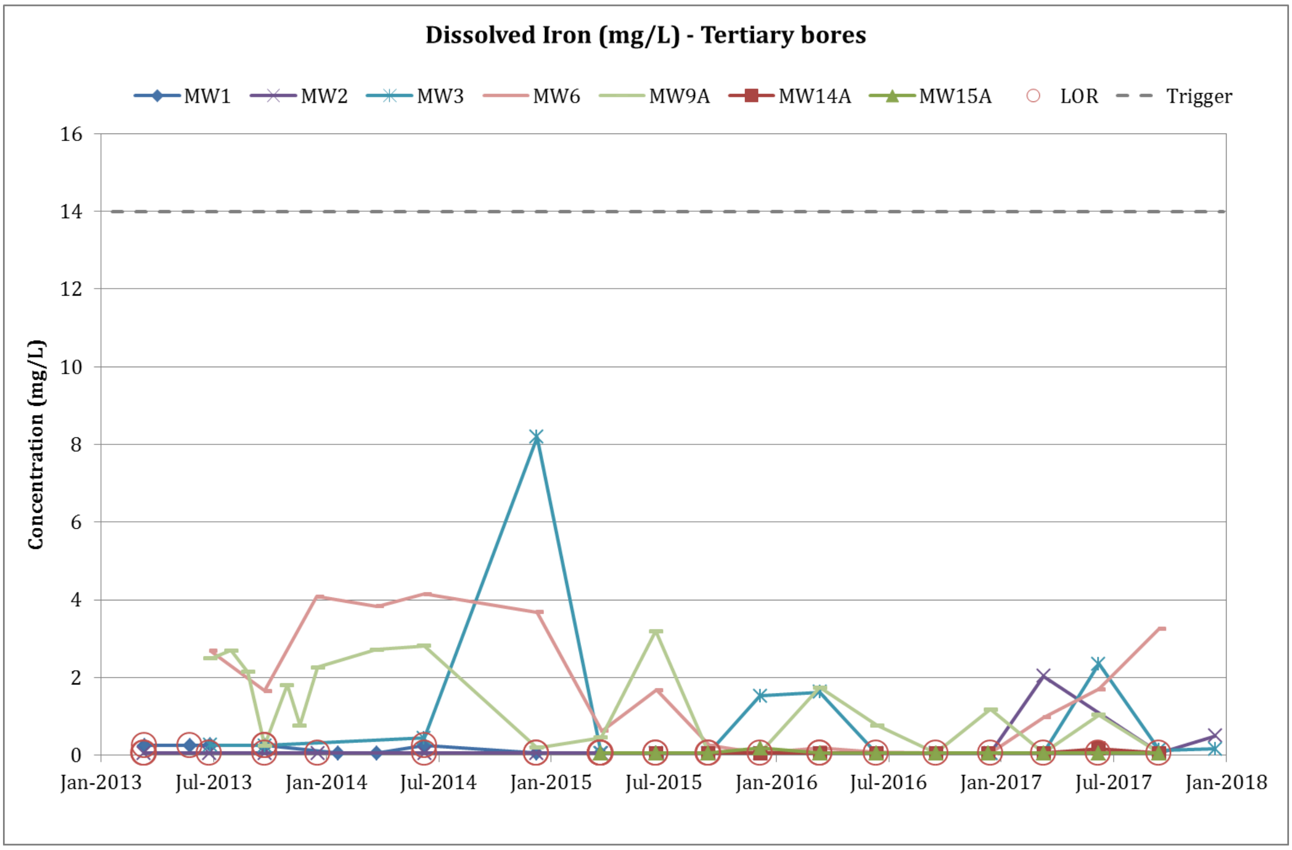

Potassium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

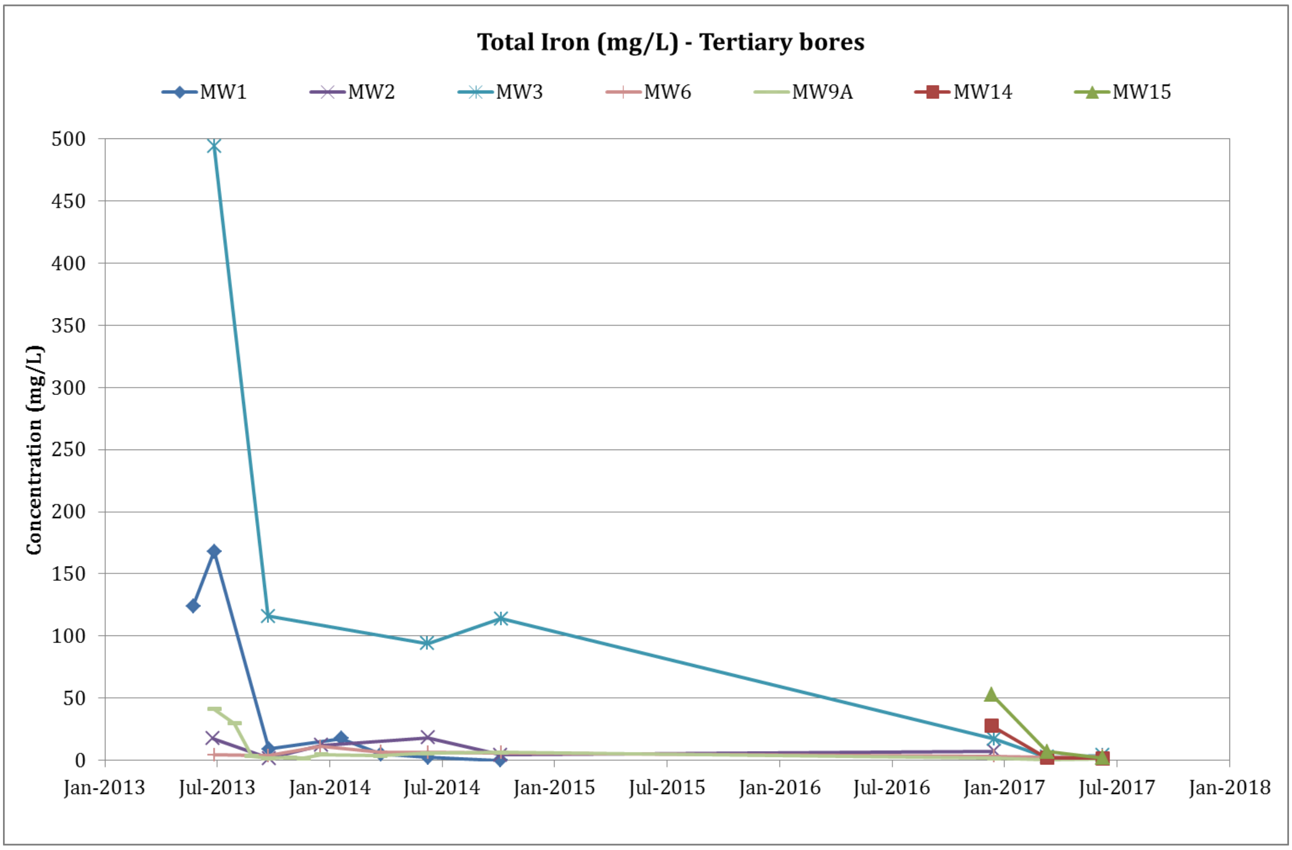

Chloride mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
0
2000
4000
6000
8000
10000
12000
14000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

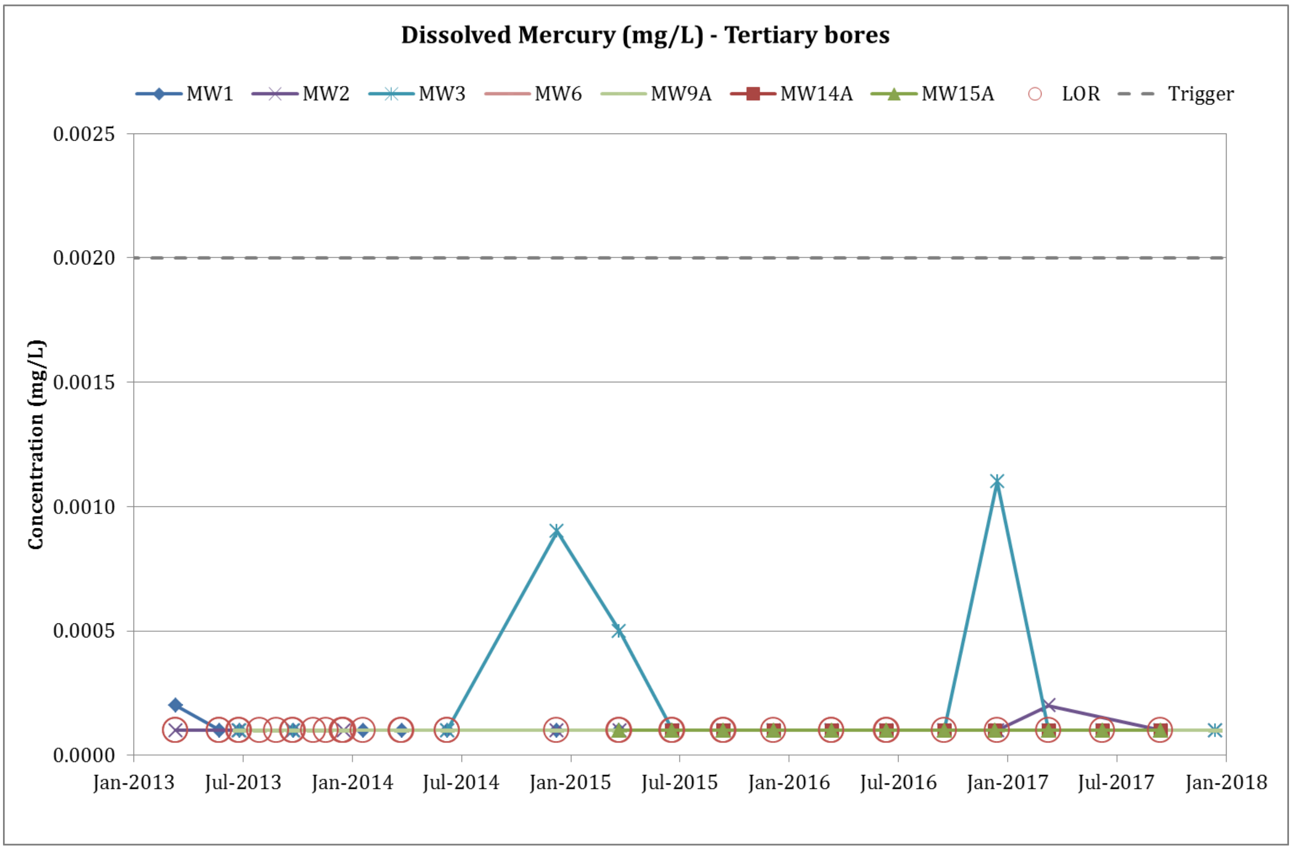

Sulfate mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018
Jul-2018

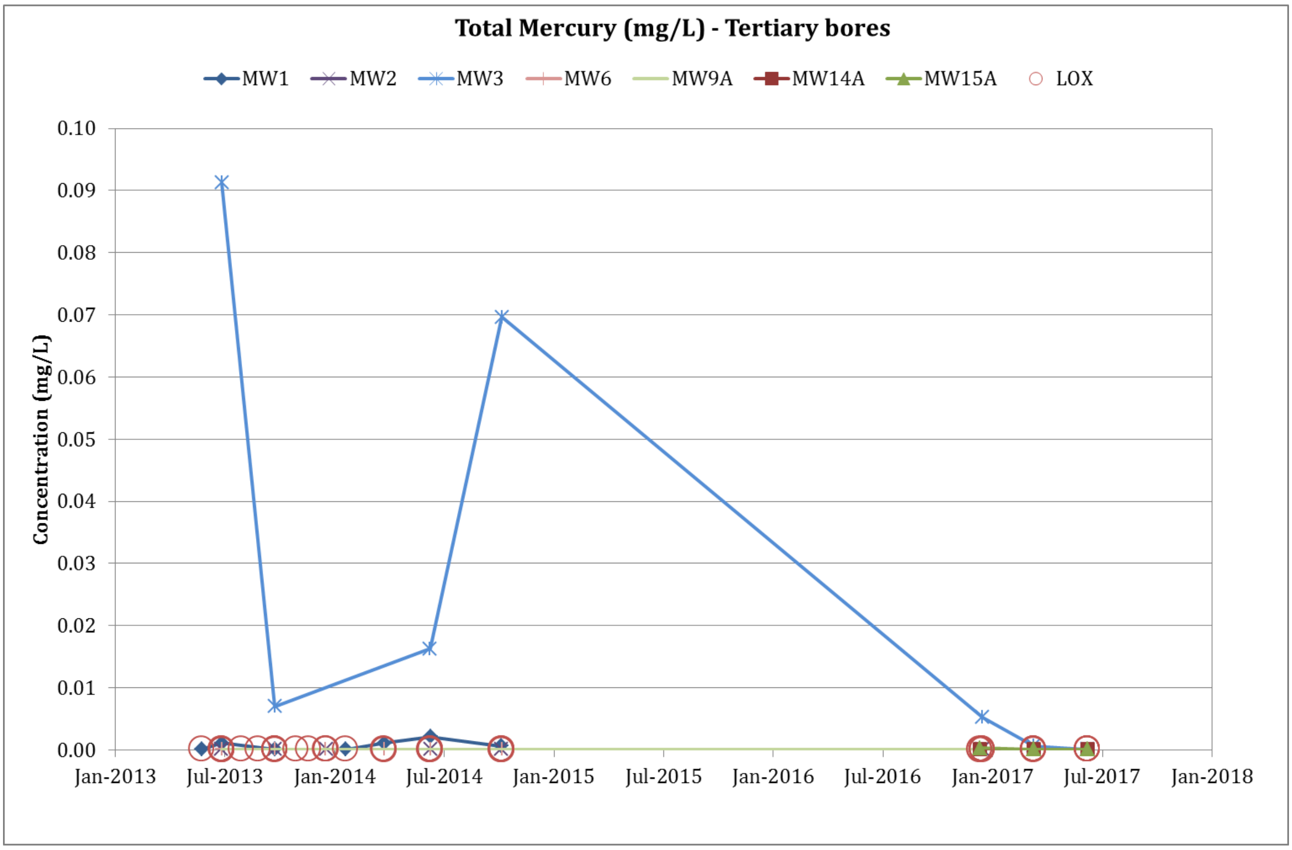

Carbonate Alkalinity as CaCO3 mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

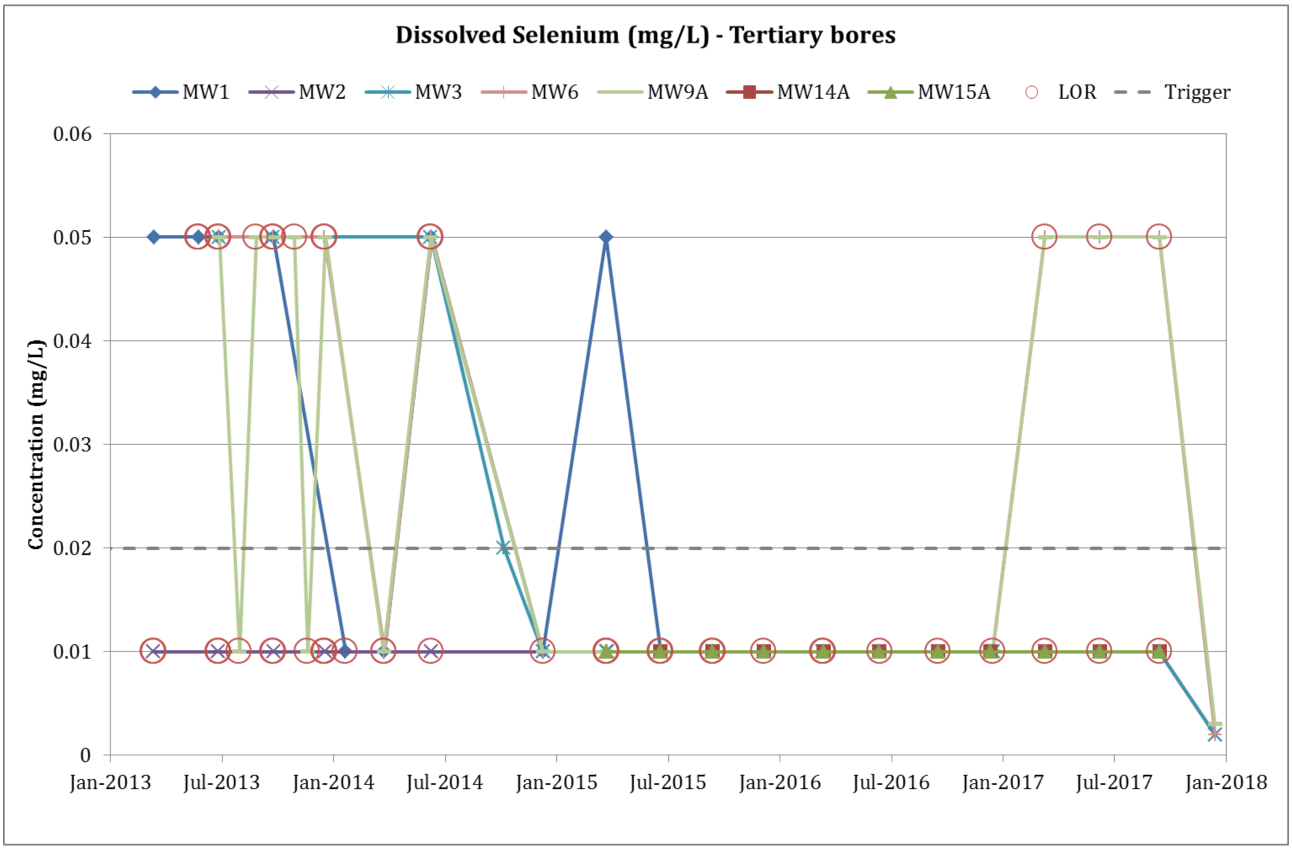

Bicarbonate Alkalinity as CaCO3 mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

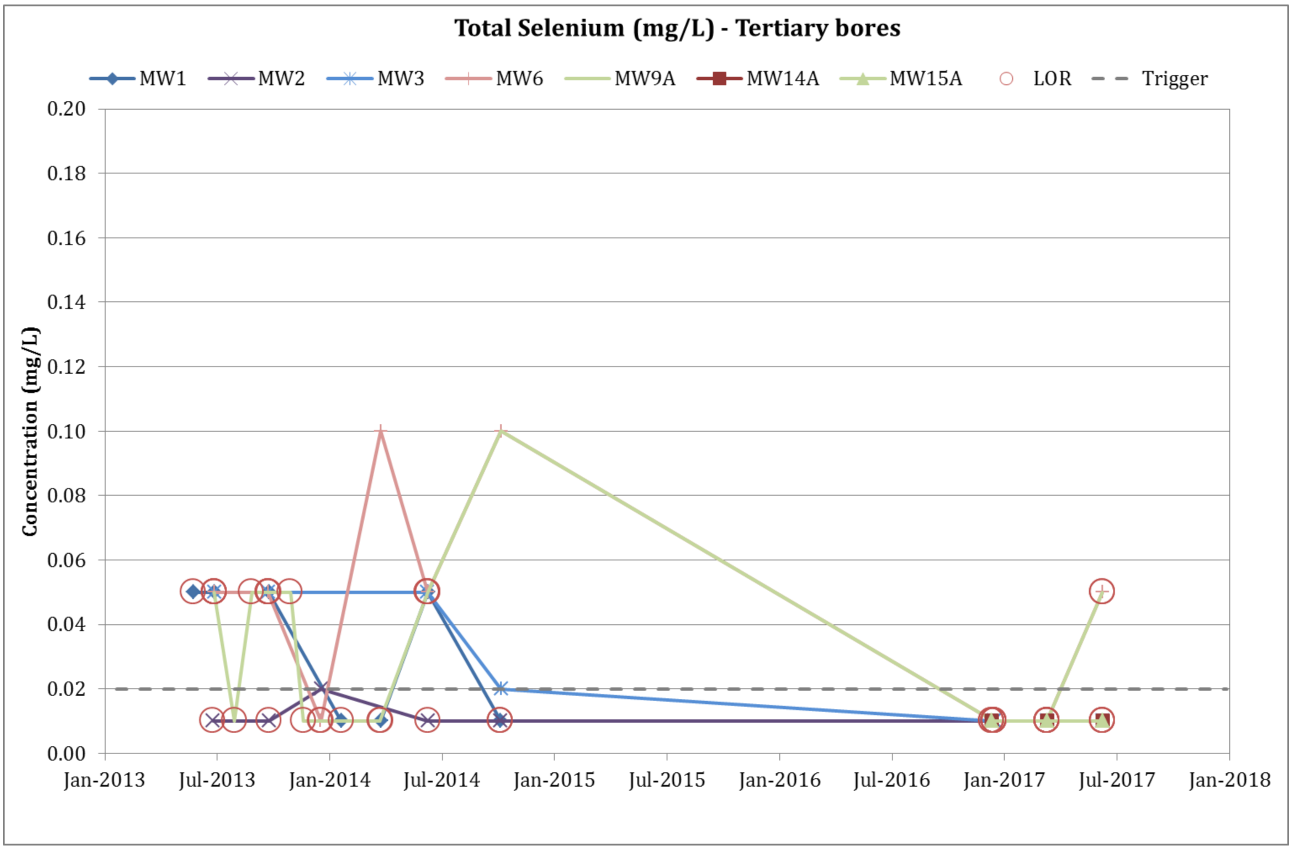

Dissolved Iron (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

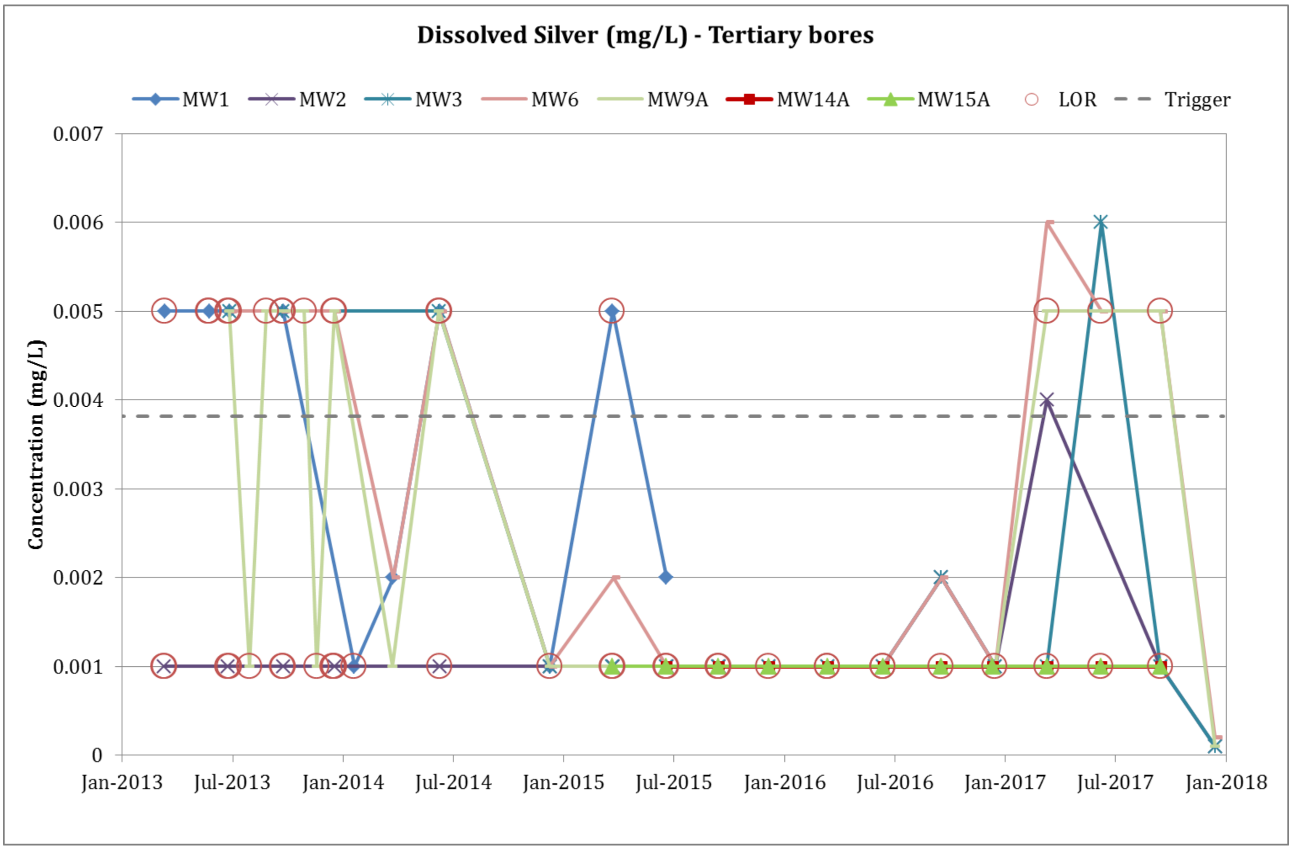

Total Iron (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14
MW15
Concentration (mg/L)
500
450
400
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

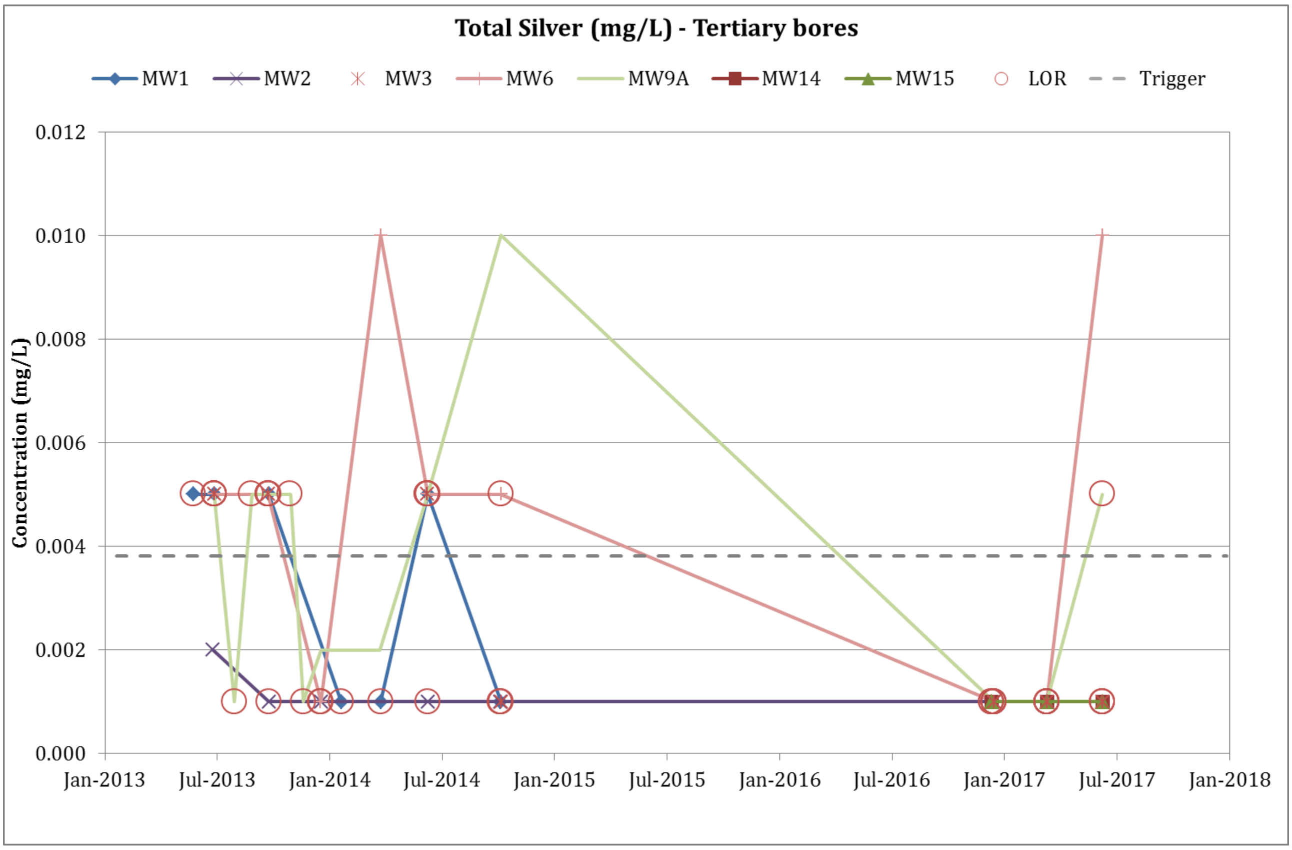

Dissolved Mercury (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

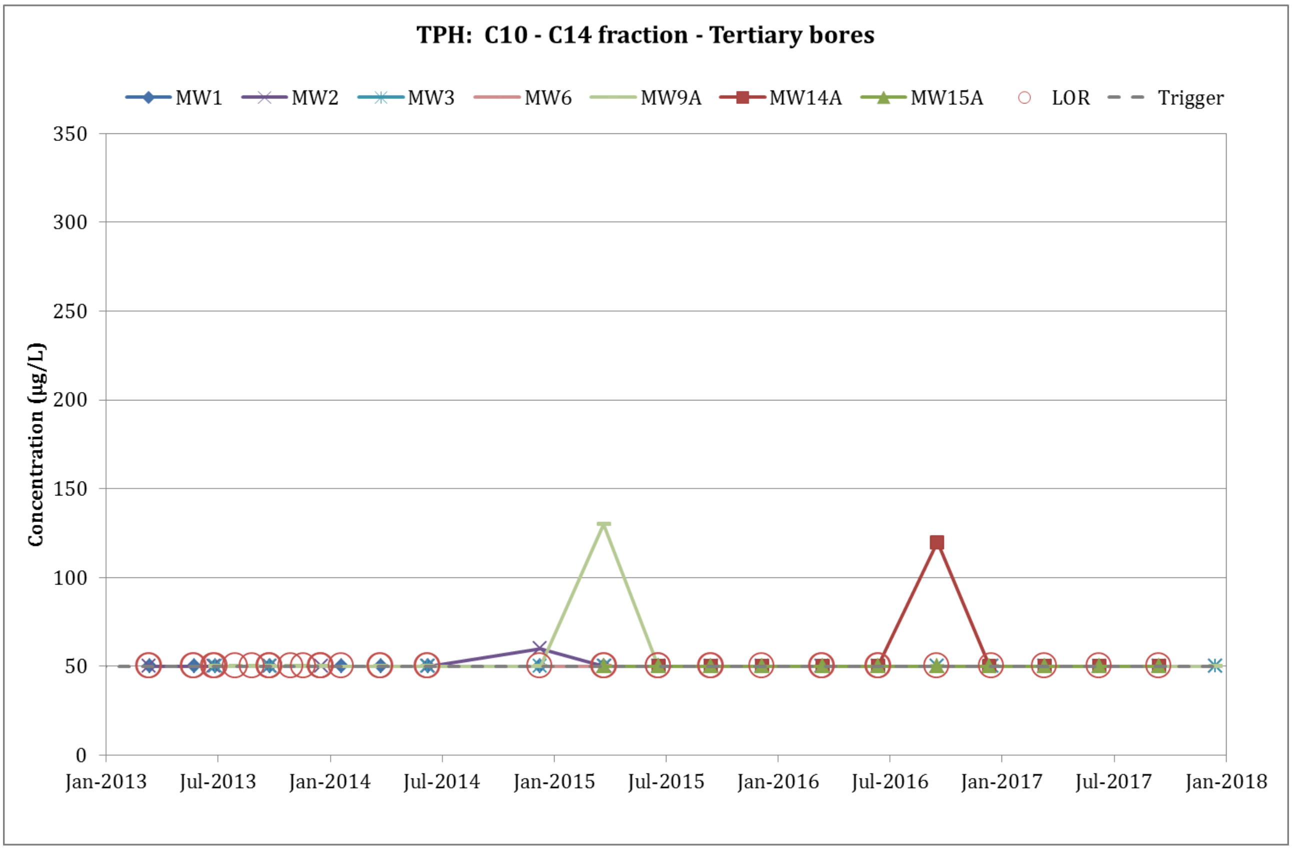

Total Mercury (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOX
Concentration (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

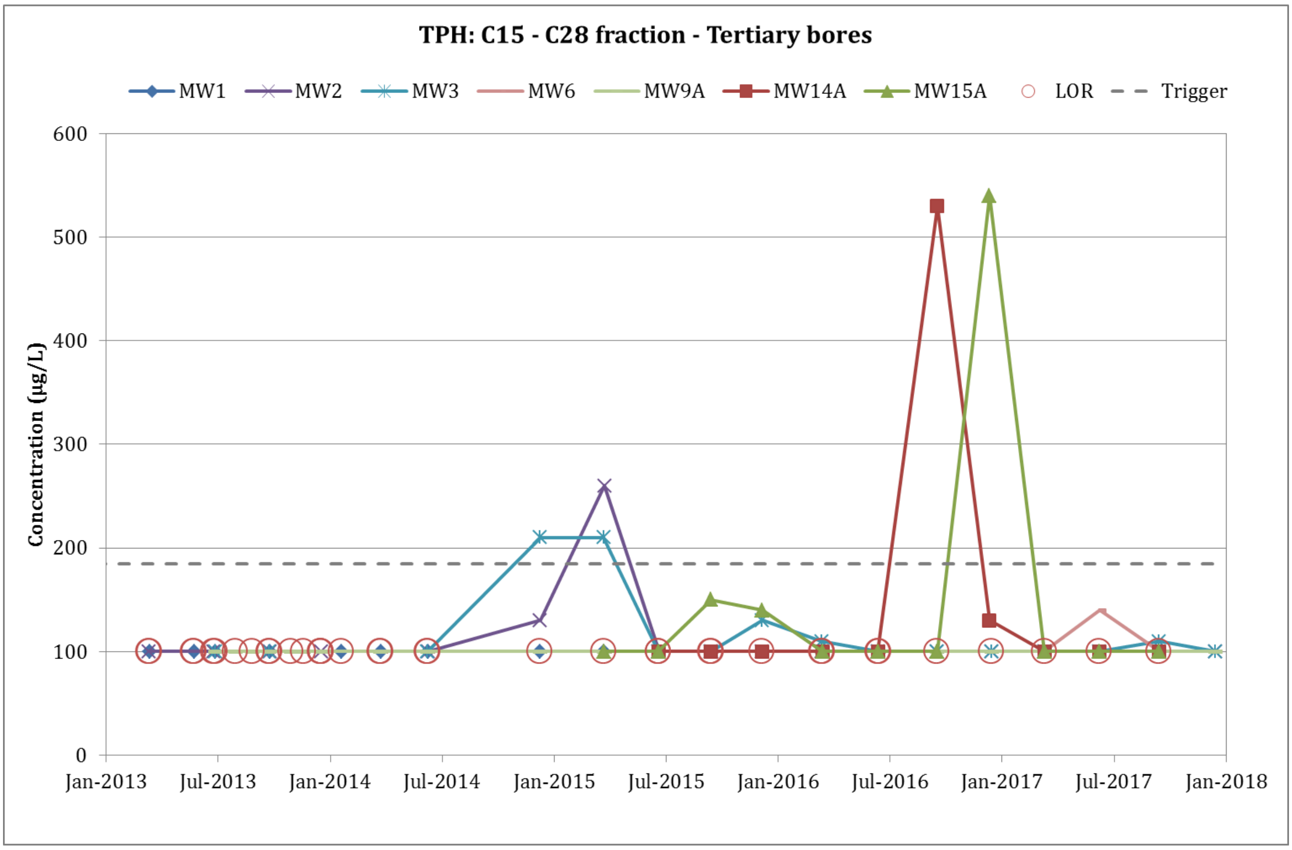

Dissolved Selenium (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

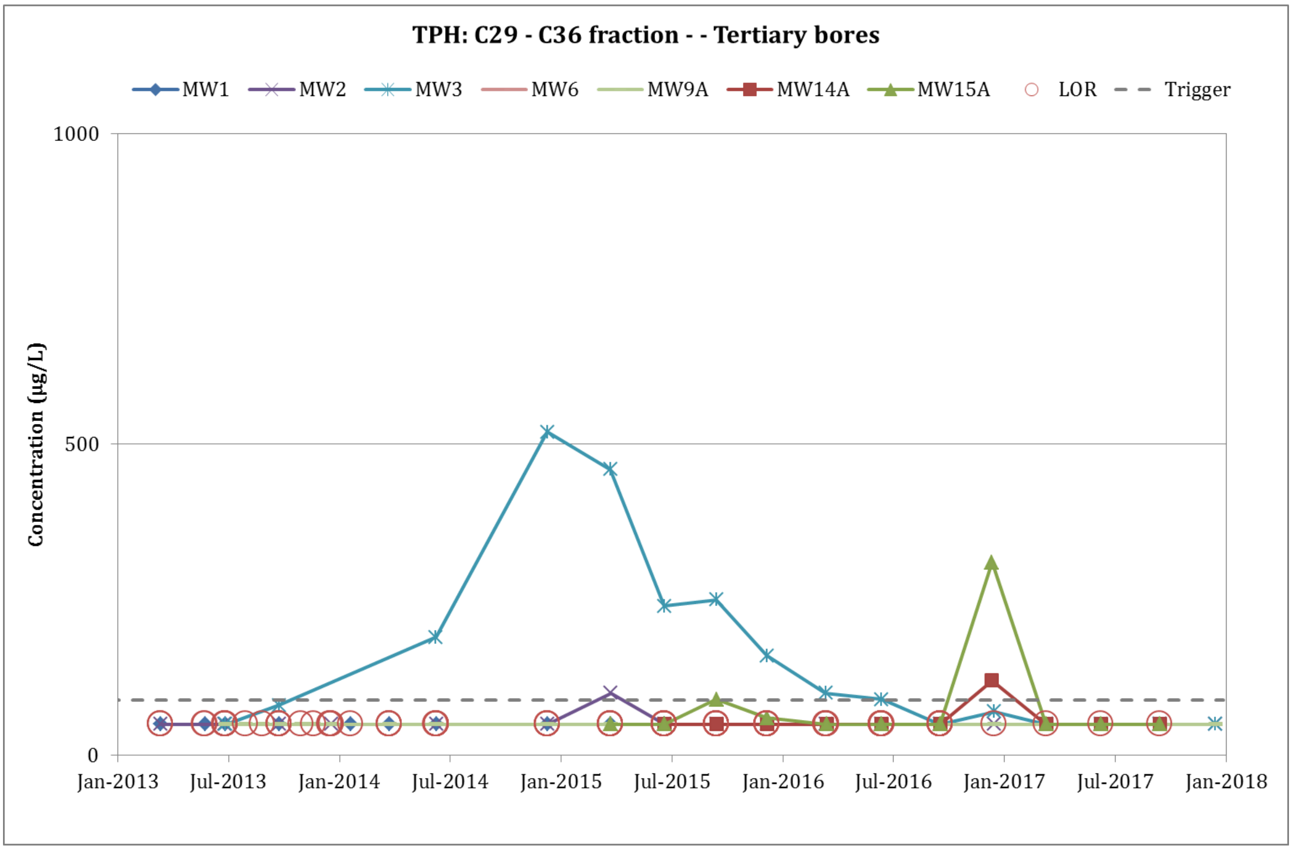

Total Selenium (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

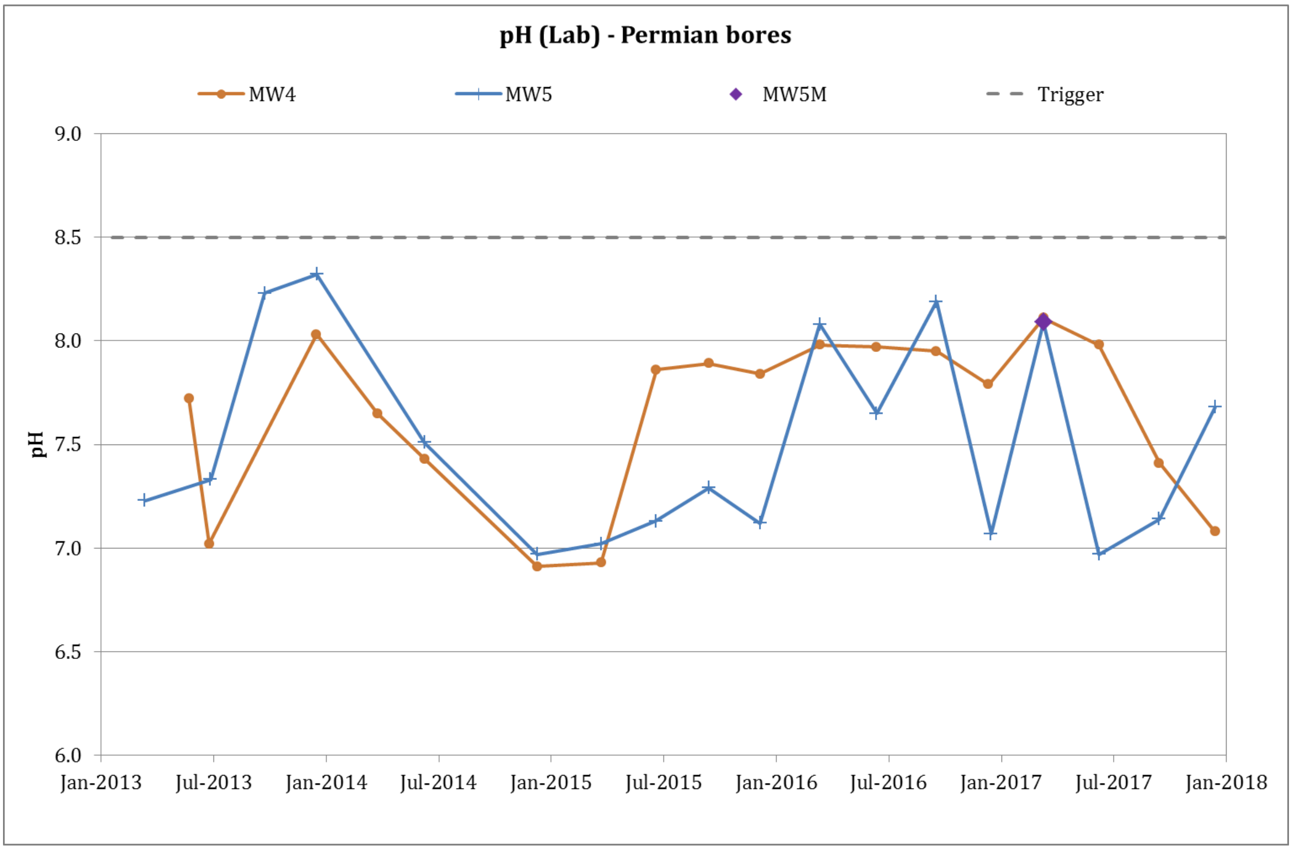

Dissolved Silver (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

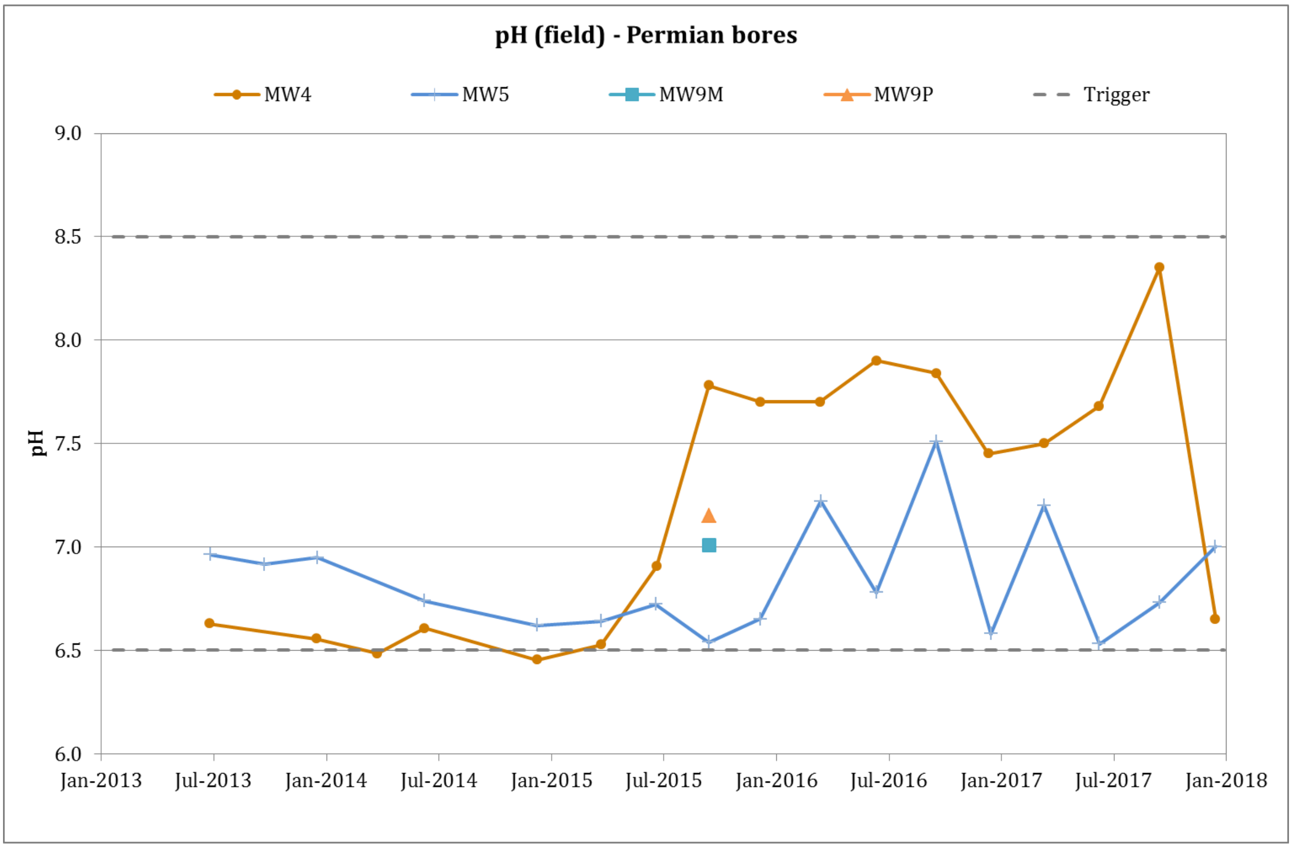

Total Silver (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14
MW15
LOR
Trigger
Concentration (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

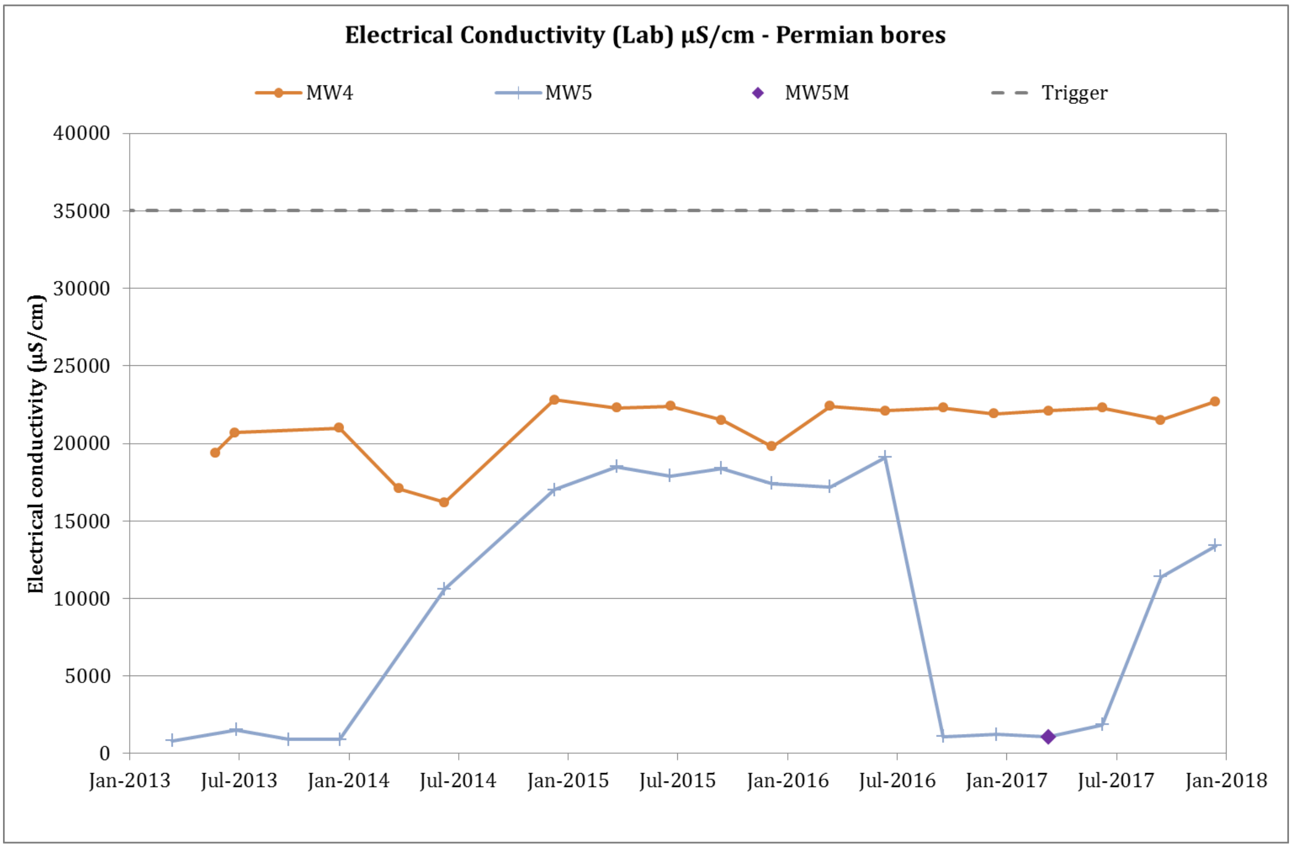

TPH: C10 - C14 fraction - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

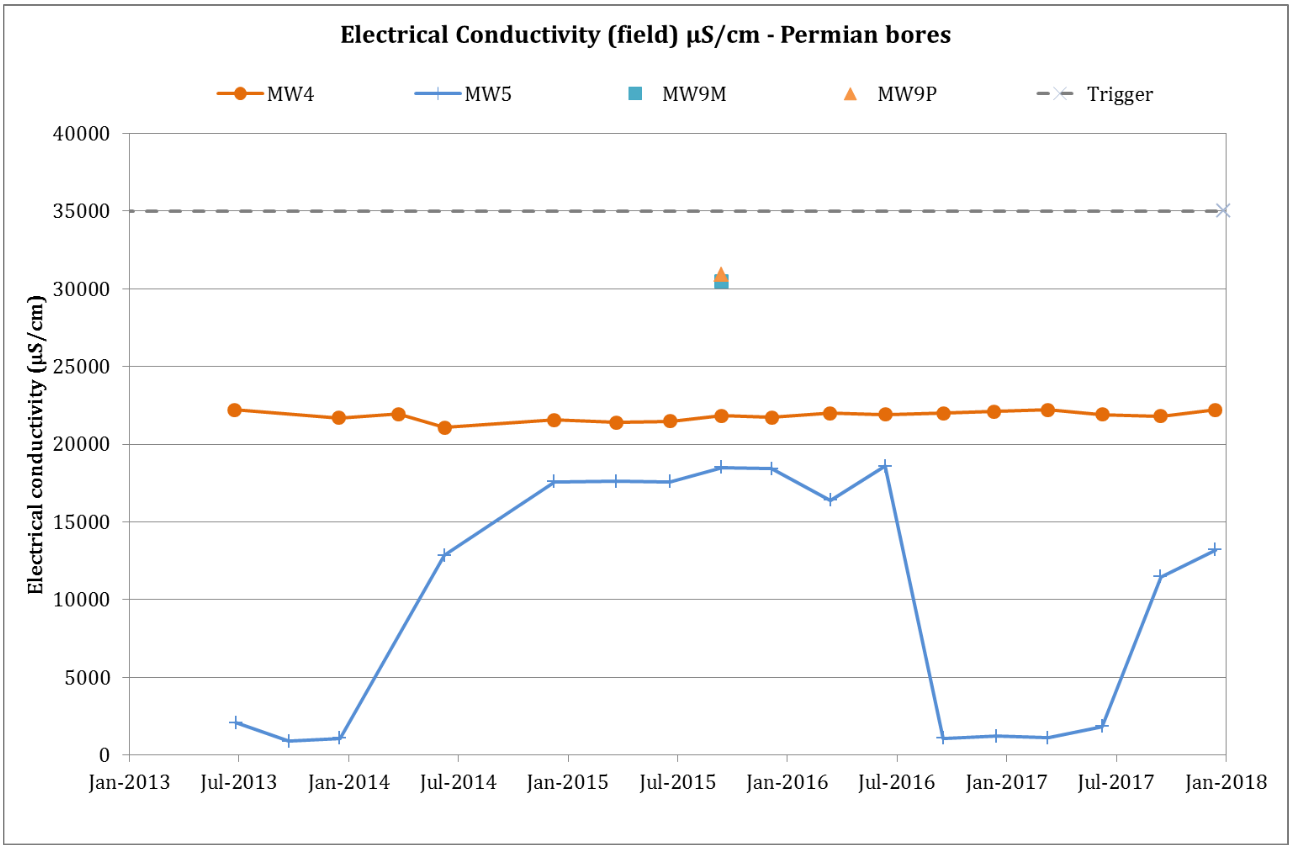

TPH: C15 - C28 fraction - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
600
500
400
300
200
100
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

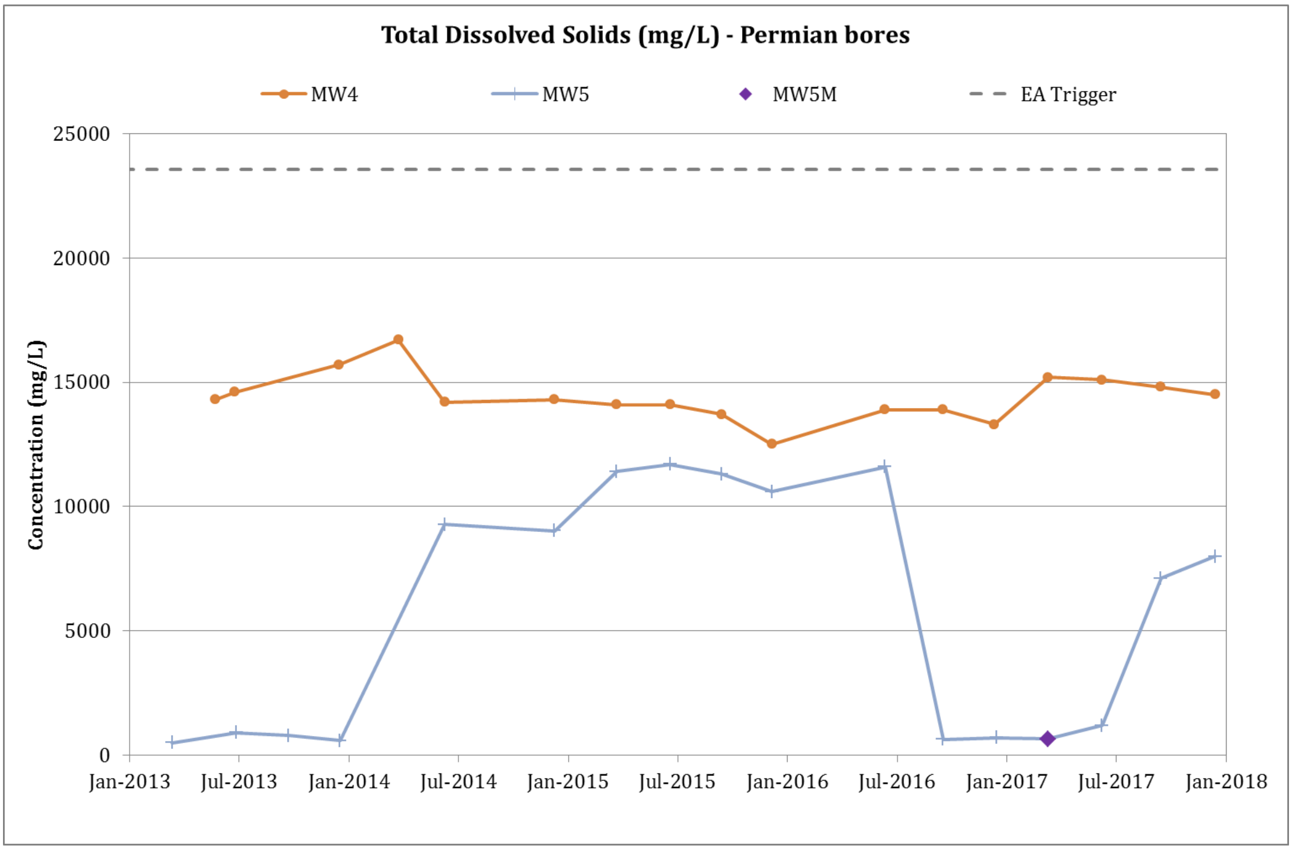

TPH: C29 - C36 fraction - - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

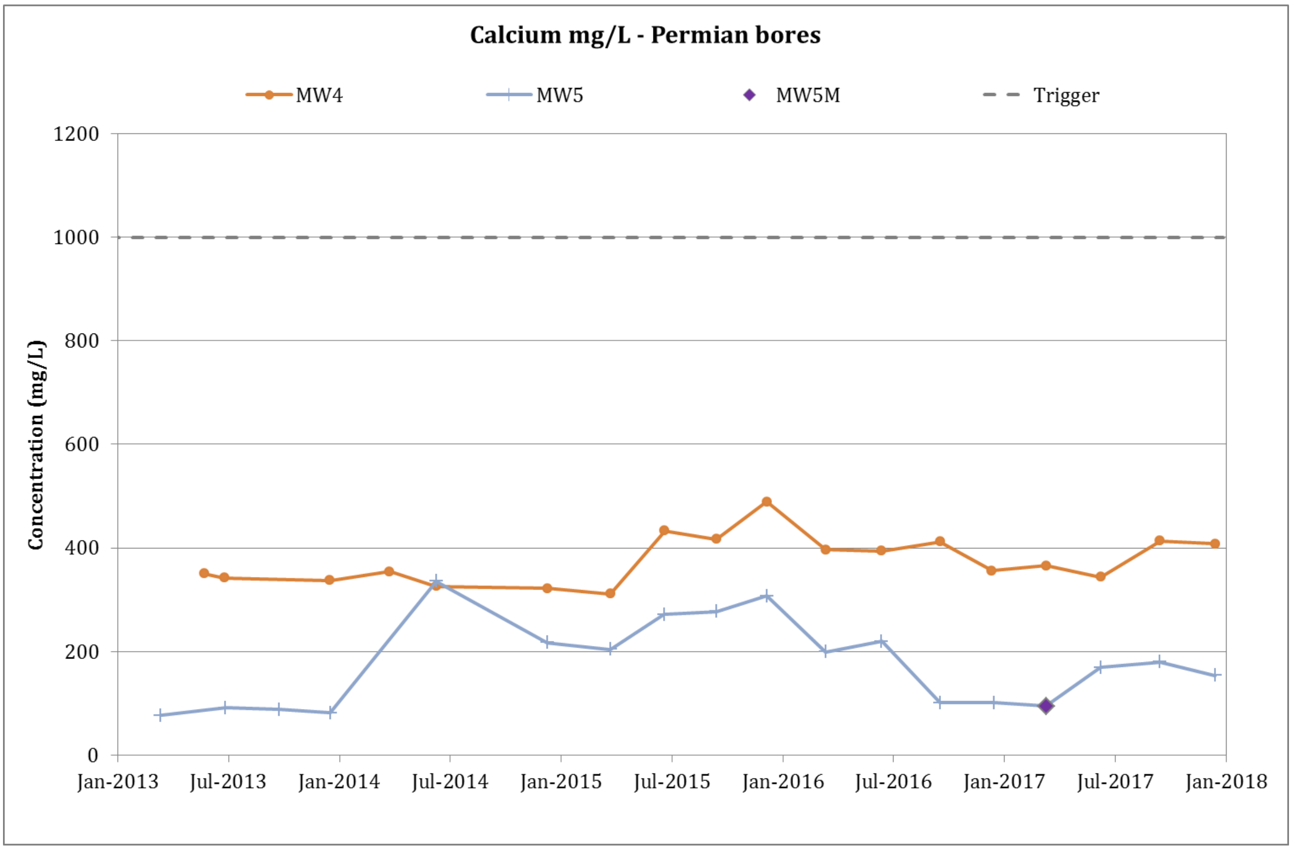

pH (Lab) - Permian bores
MW4
MW5
MW5M
Trigger
9.0
8.5
8.0
7.5
7.0
6.5
6.0
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

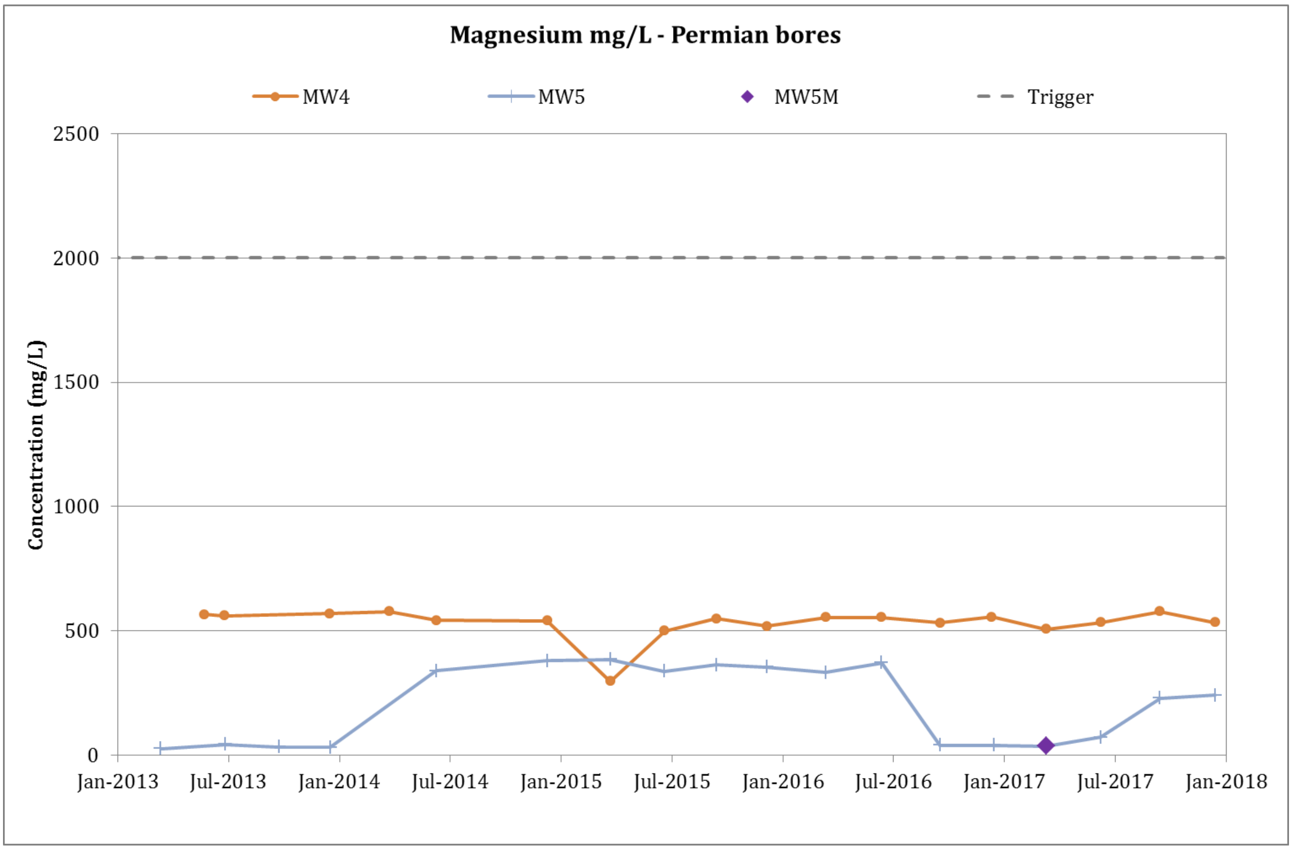

pH (field) - Permian bores
MW4
MW5
MW9M
MW9P
Trigger
9.0
8.5
8.0
7.5
7.0
6.5
6.0
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

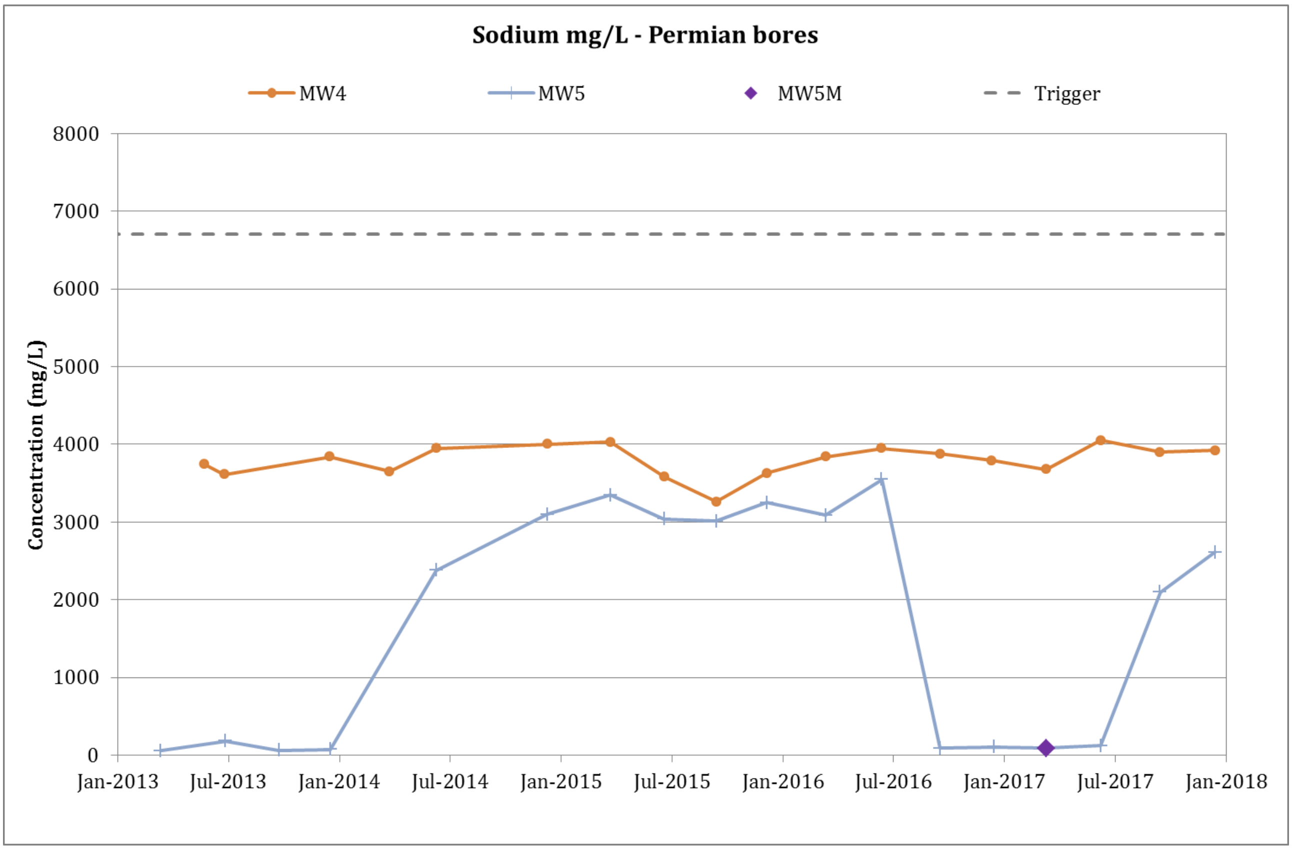

Electrical Conductivity (Lab) µS/cm - Permian bores
MW4
MW5
MW5M
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

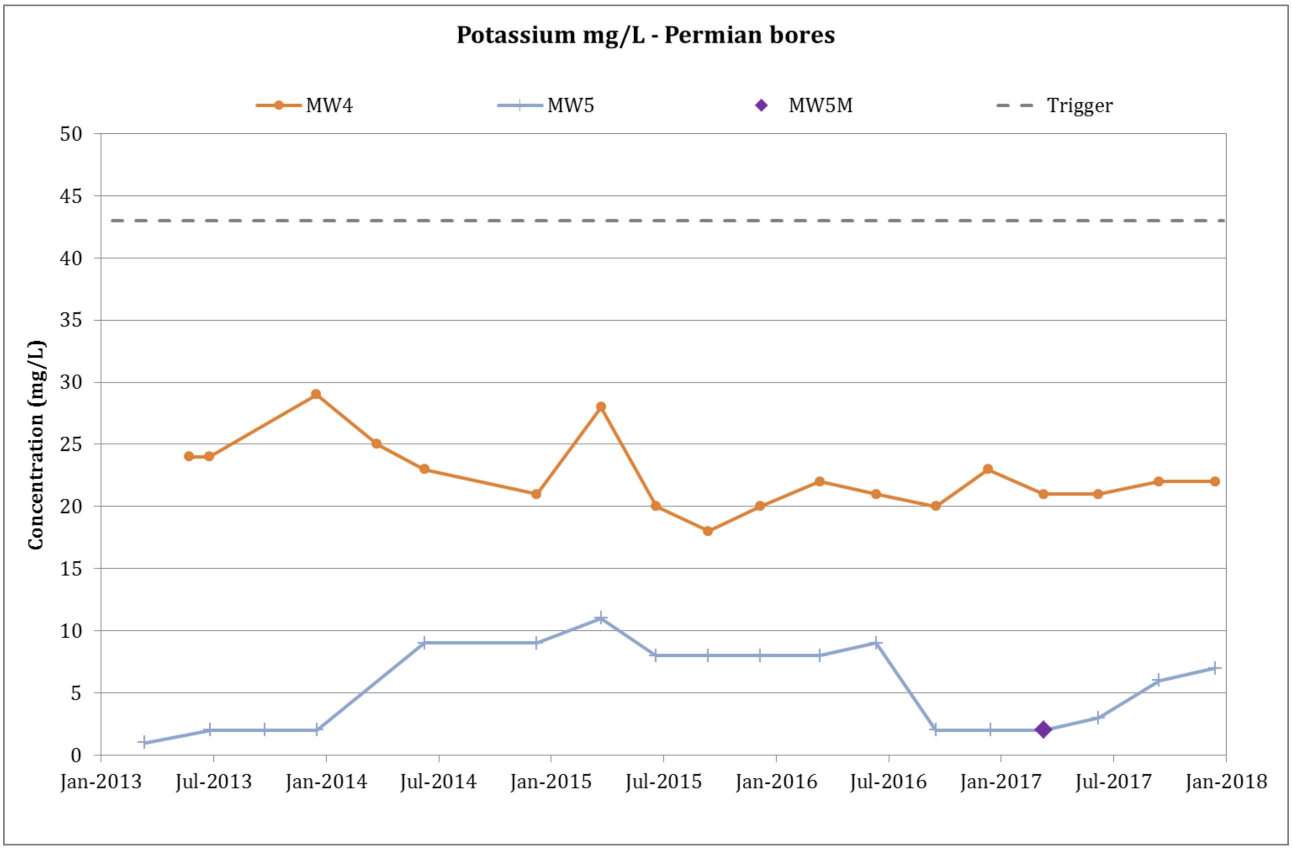

Electrical Conductivity (field) µS/cm - Permian bores
MW4
MW5
MW9M
MW9P
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

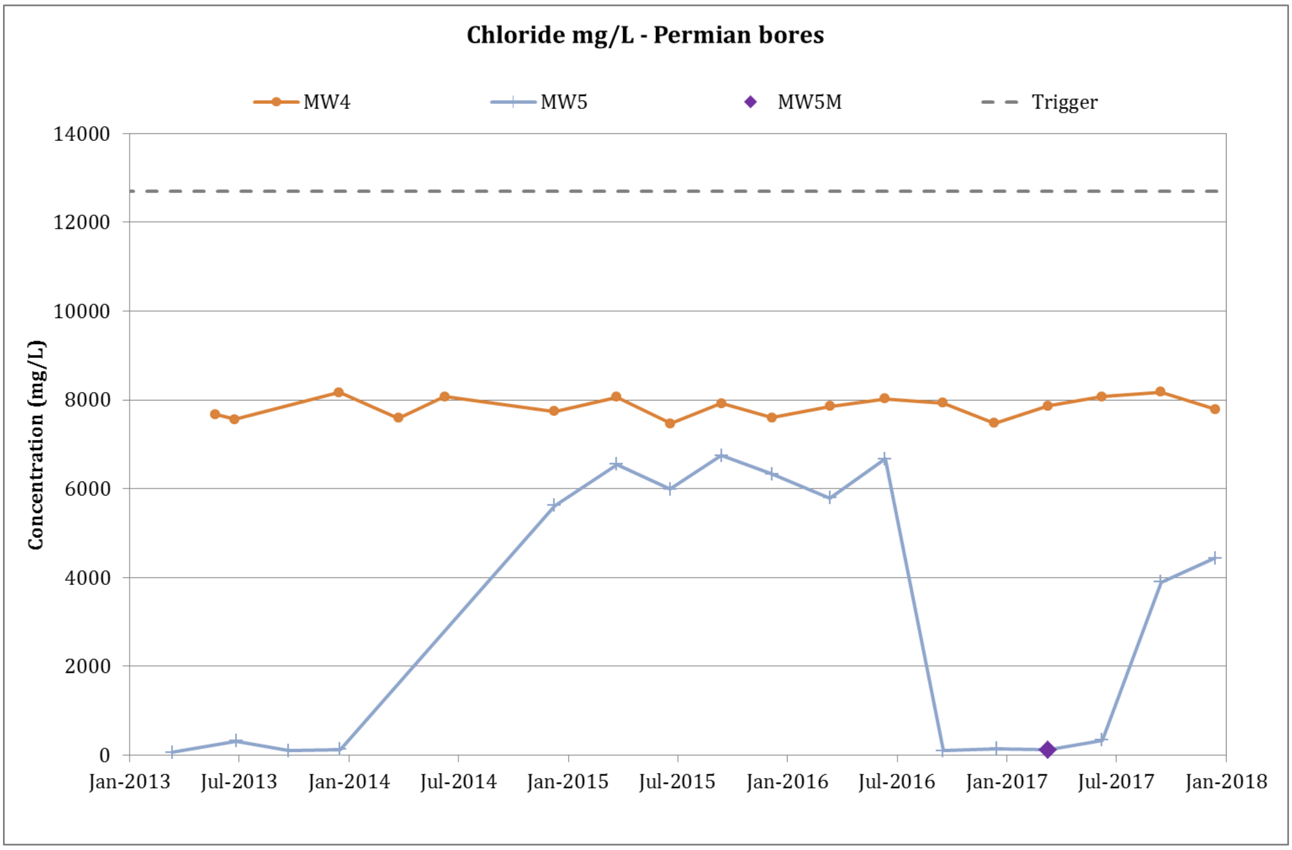

Total Dissolved Solids (mg/L) - Permian bores
MW4
MW5
MW5M
EA Trigger
Concentration (mg/L)
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

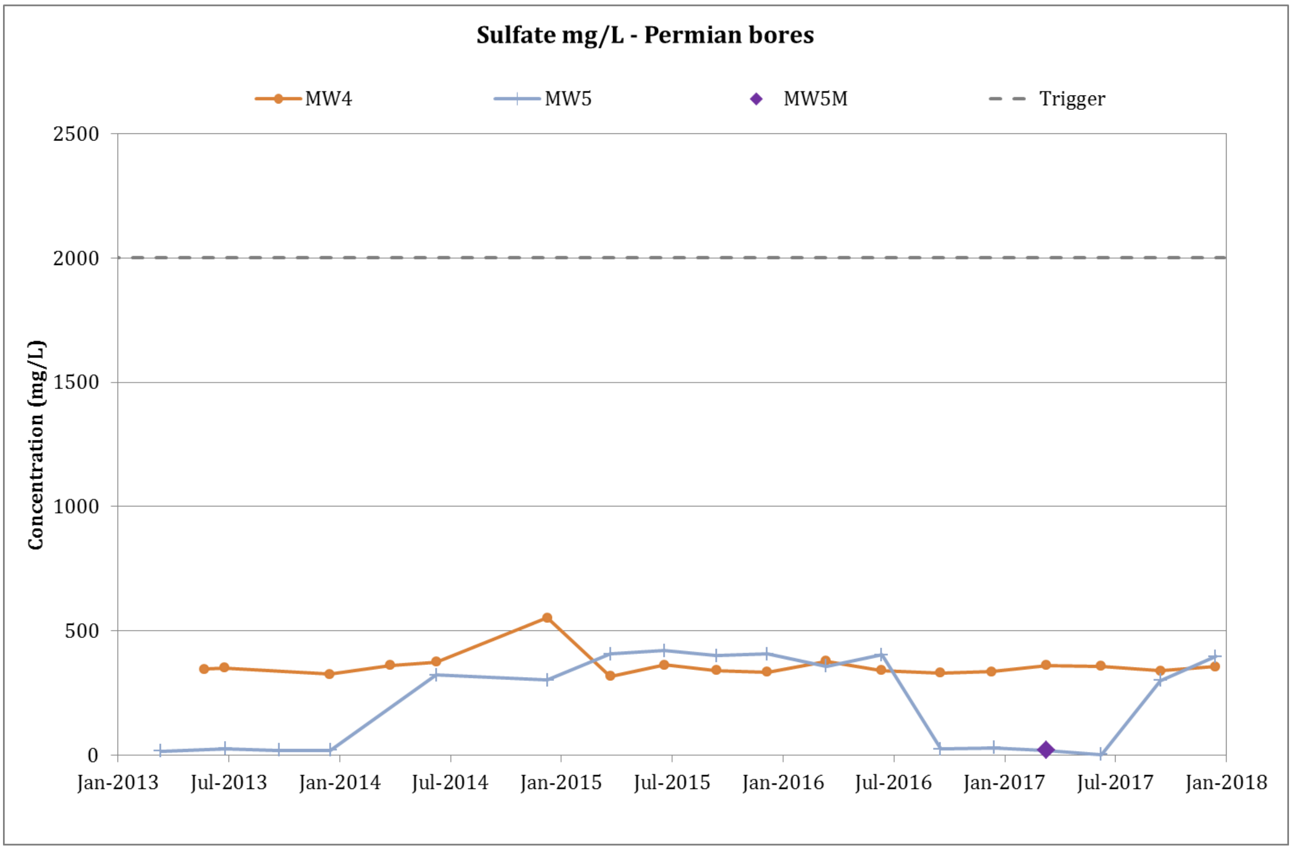

Calcium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

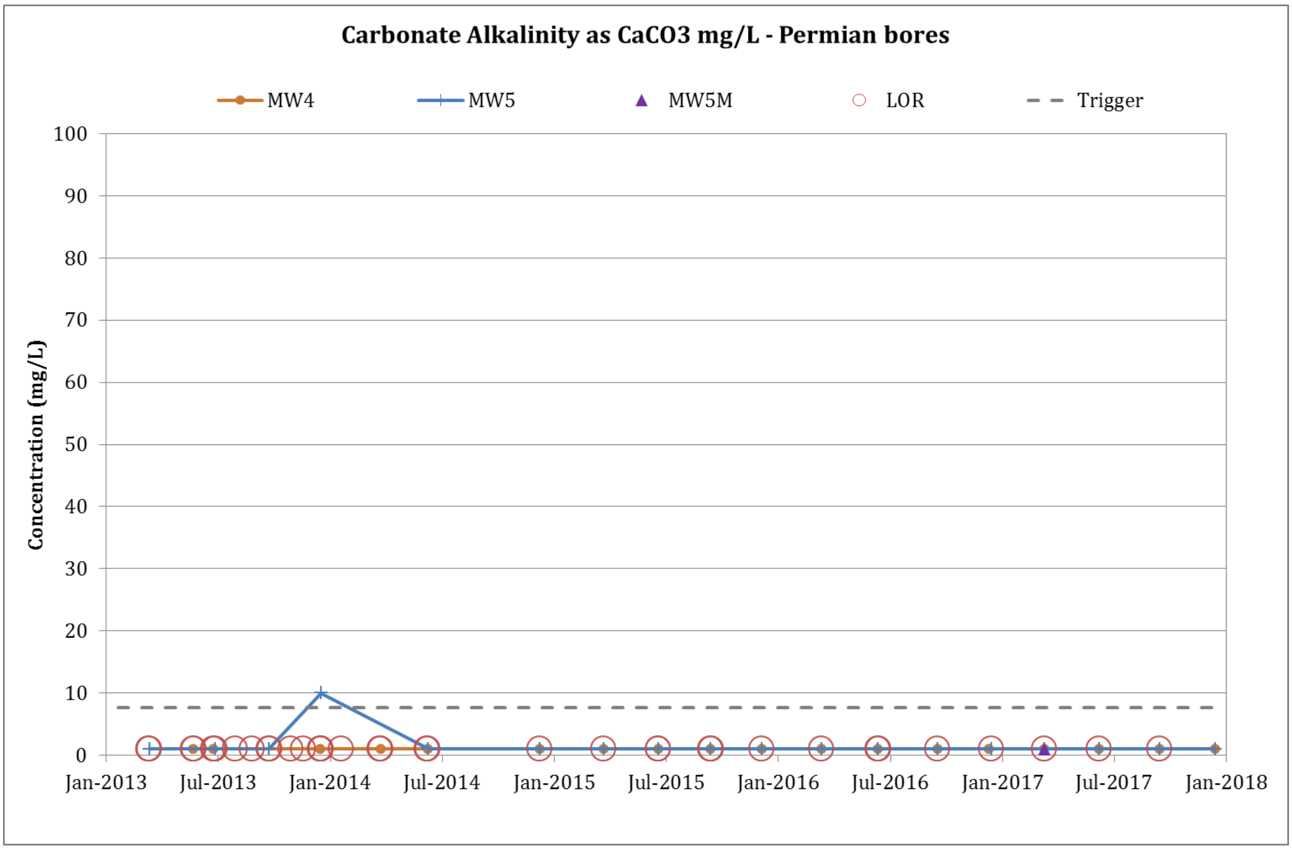

Magnesium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

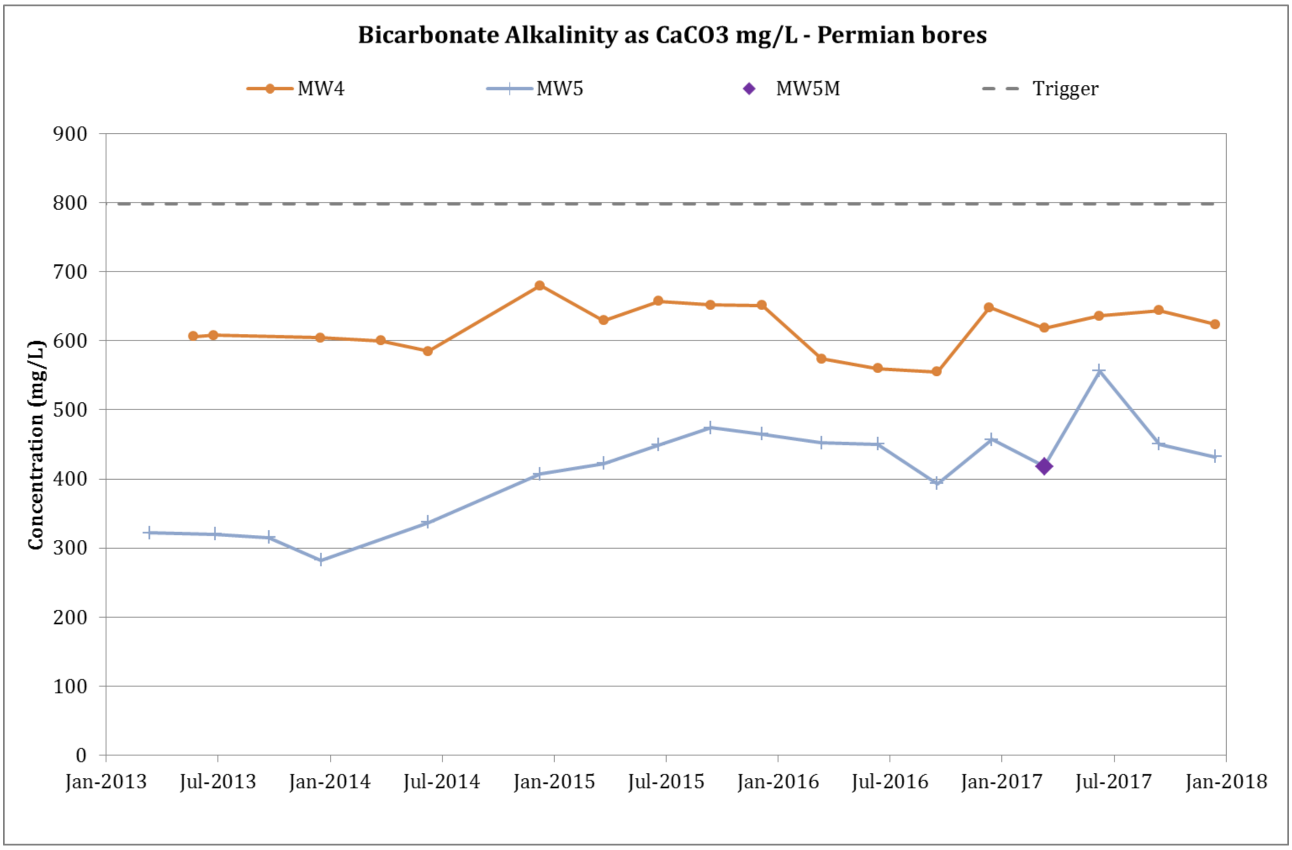

Sodium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

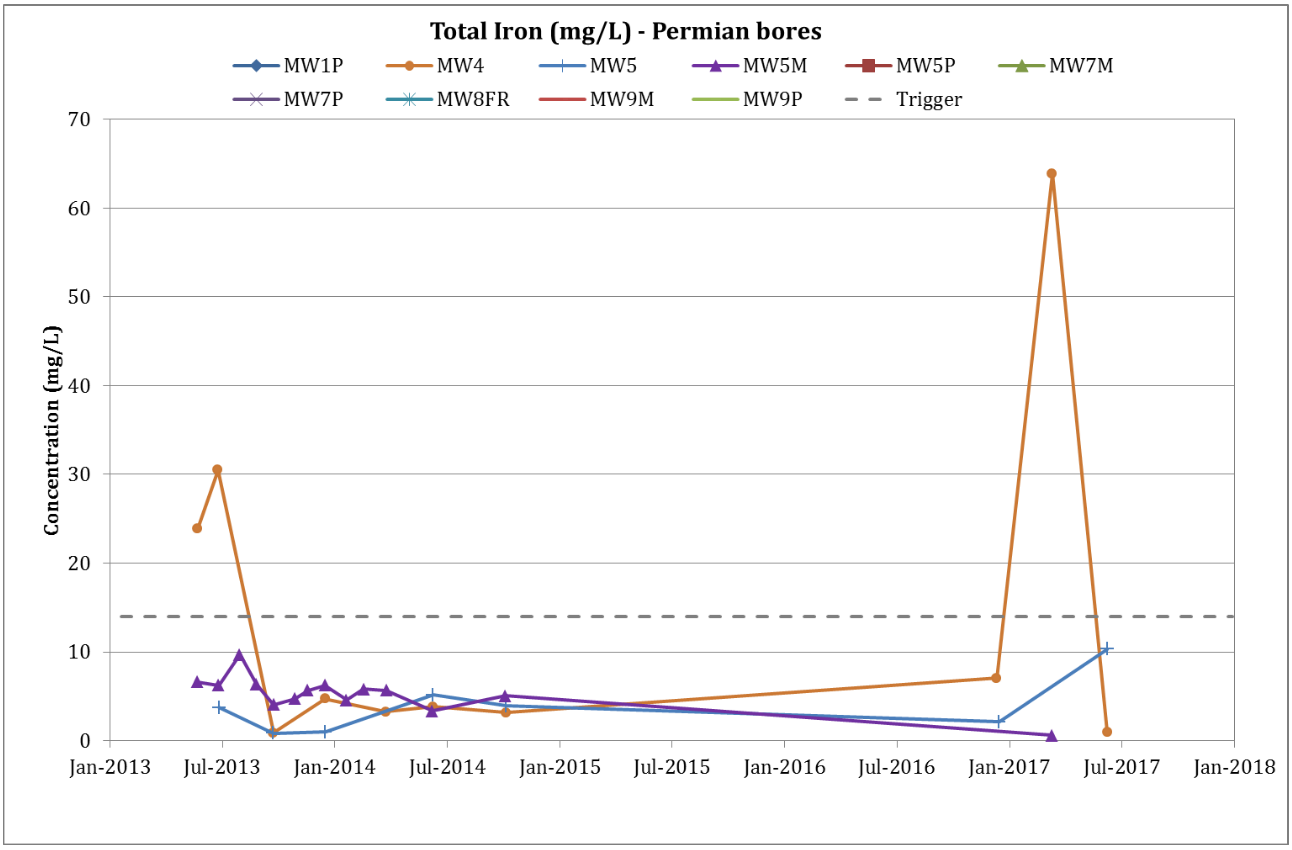

Potassium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
0
5
10
15
20
25
30
35
40
45
50
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

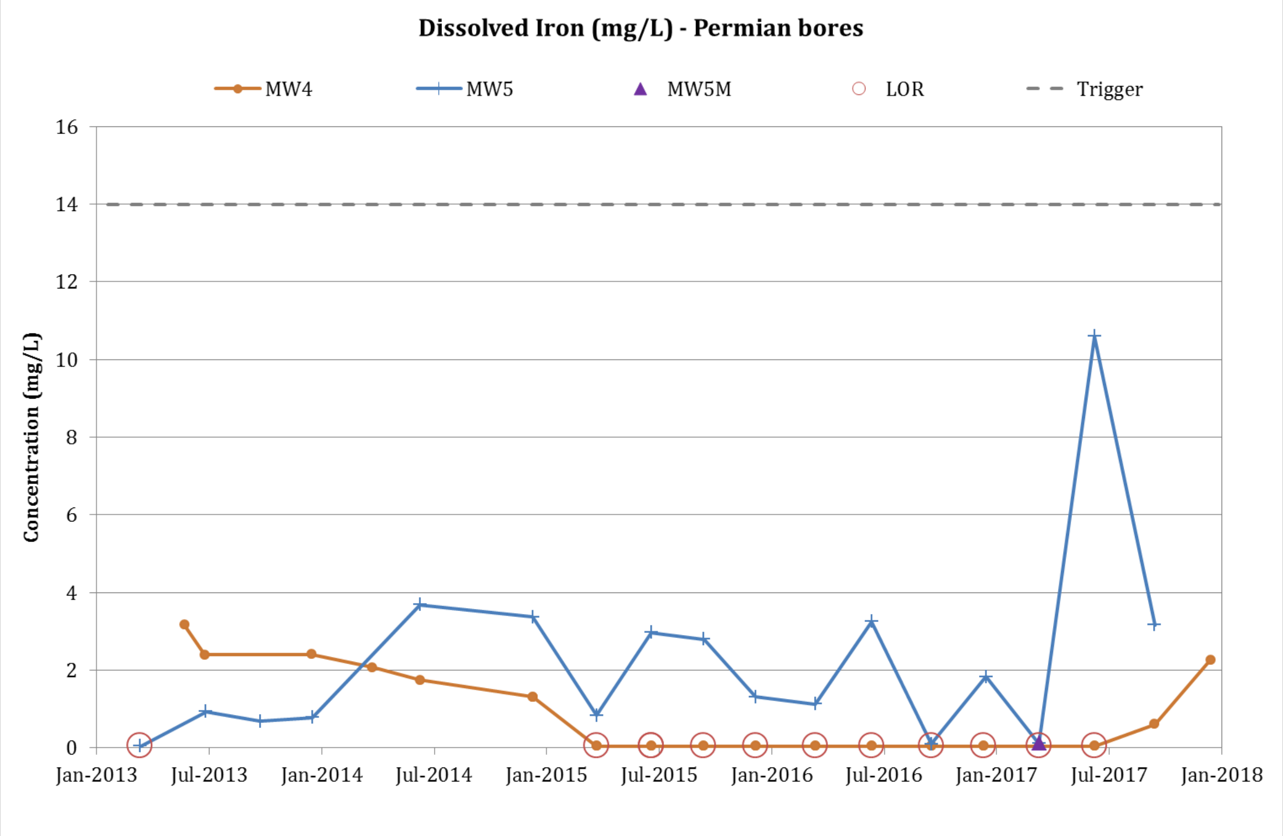

Chloride mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
0
2000
4000
6000
8000
10000
12000
14000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

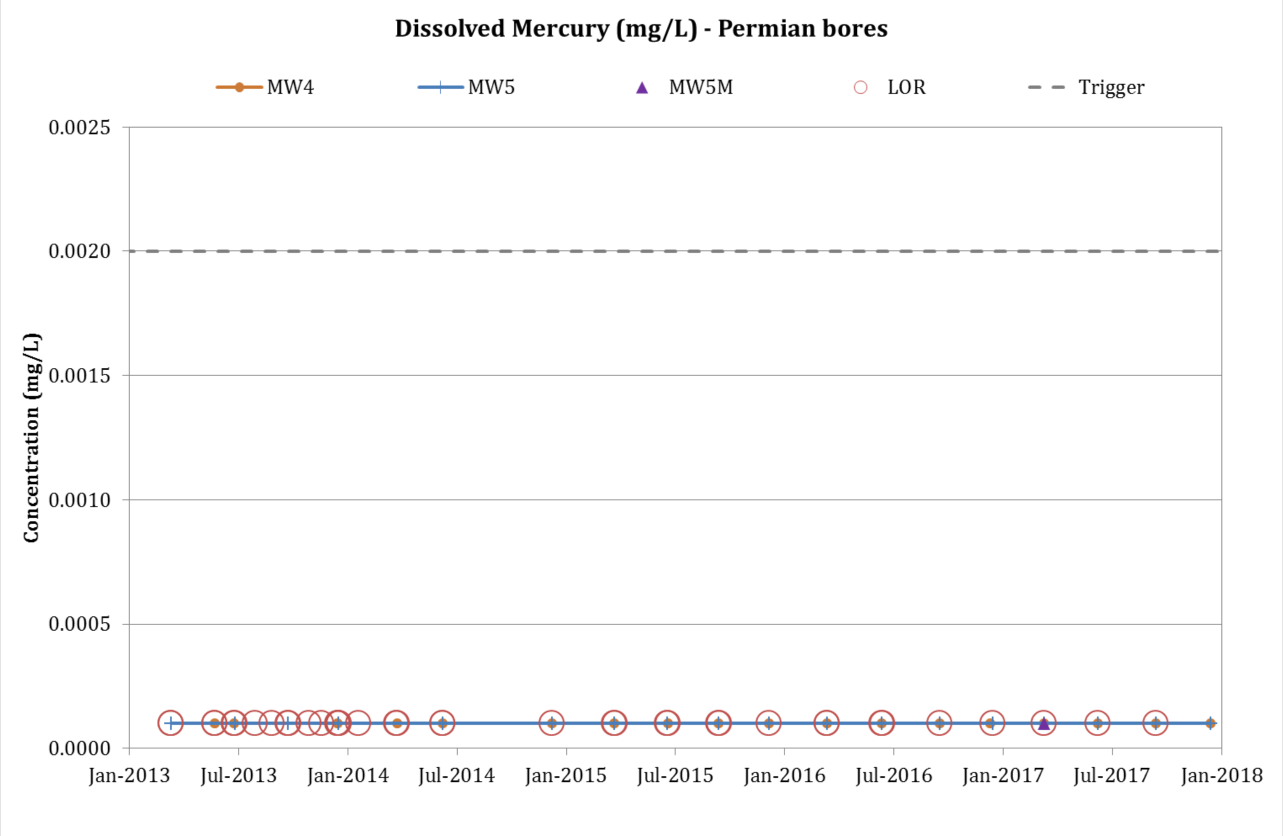

Sulfate mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

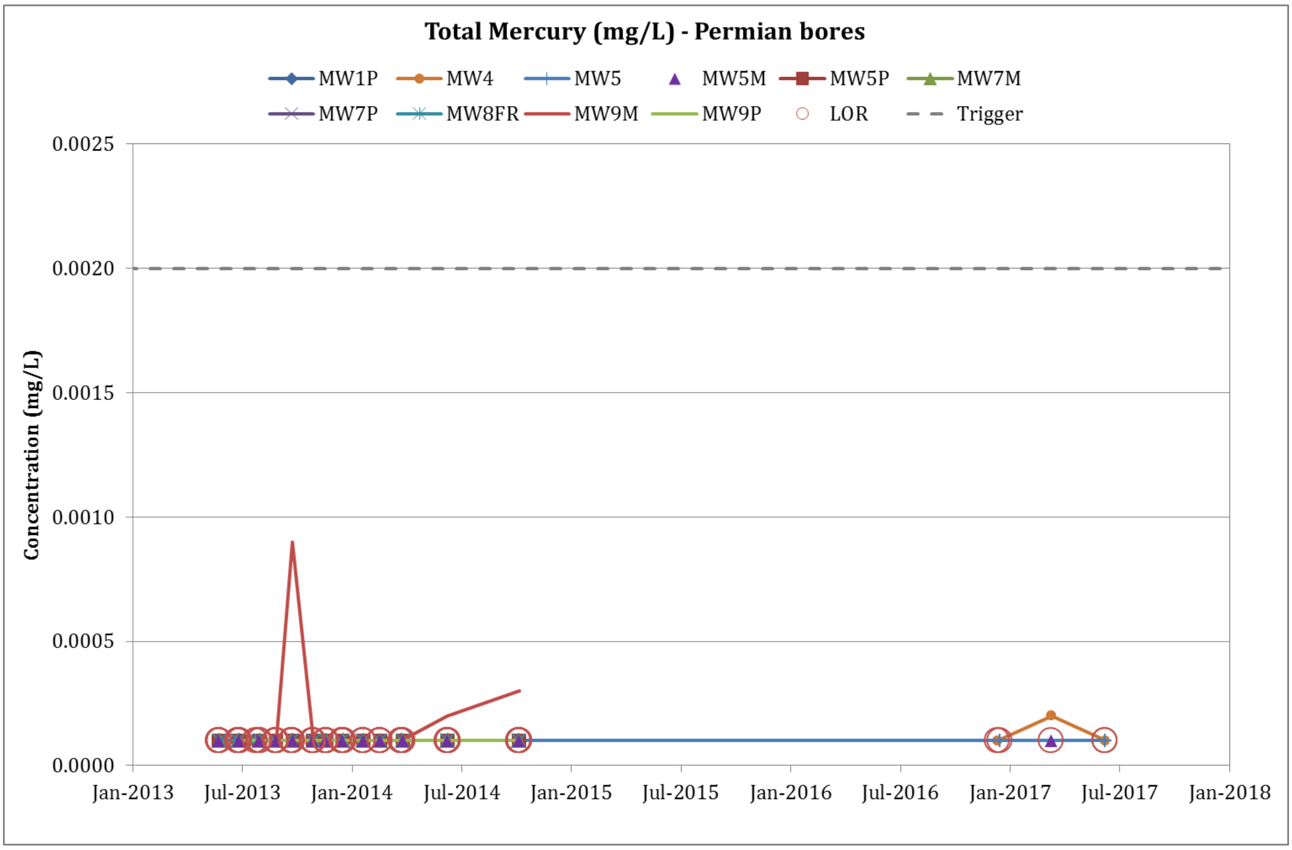

Carbonate Alkalinity as CaCO3 mg/L - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

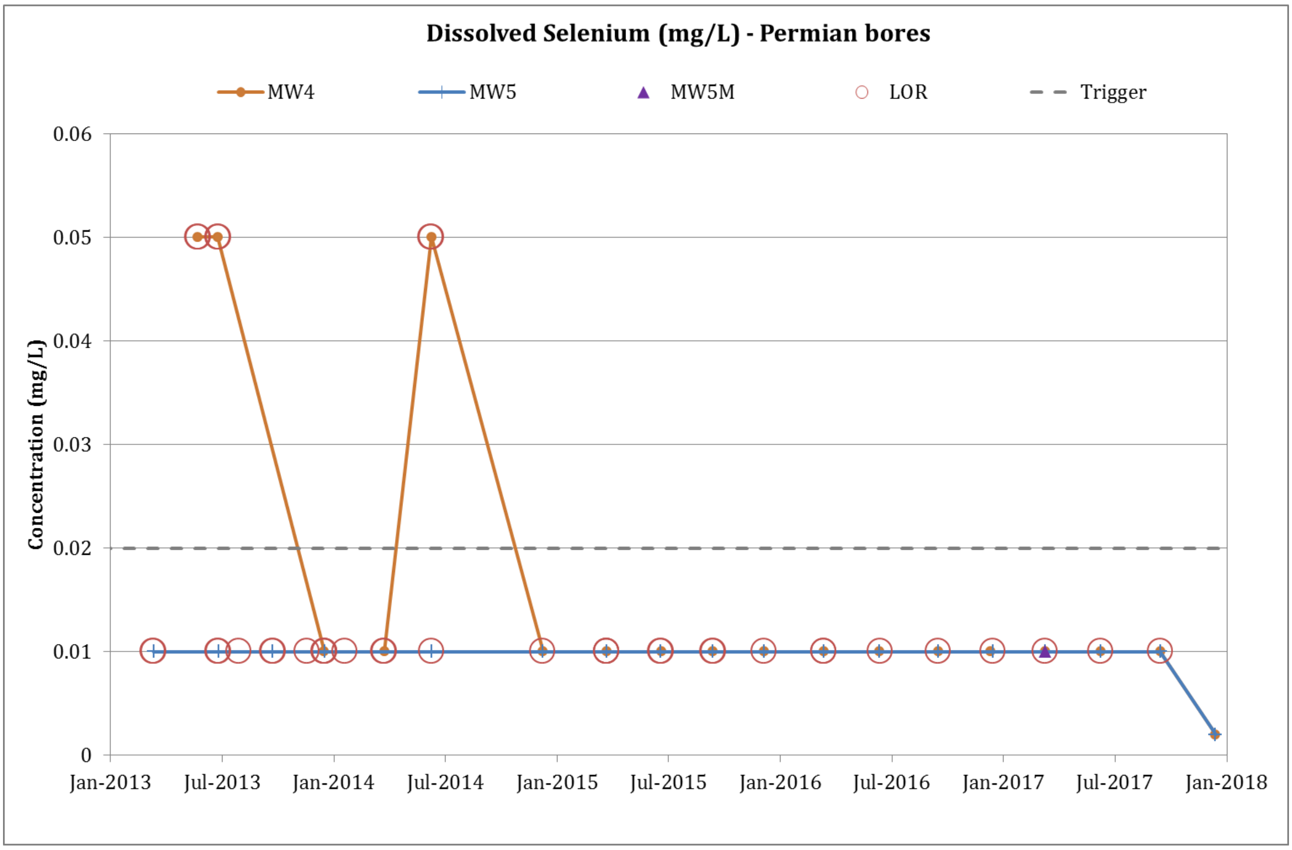

Bicarbonate Alkalinity as CaCO3 mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
0
100
200
300
400
500
600
700
800
900
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

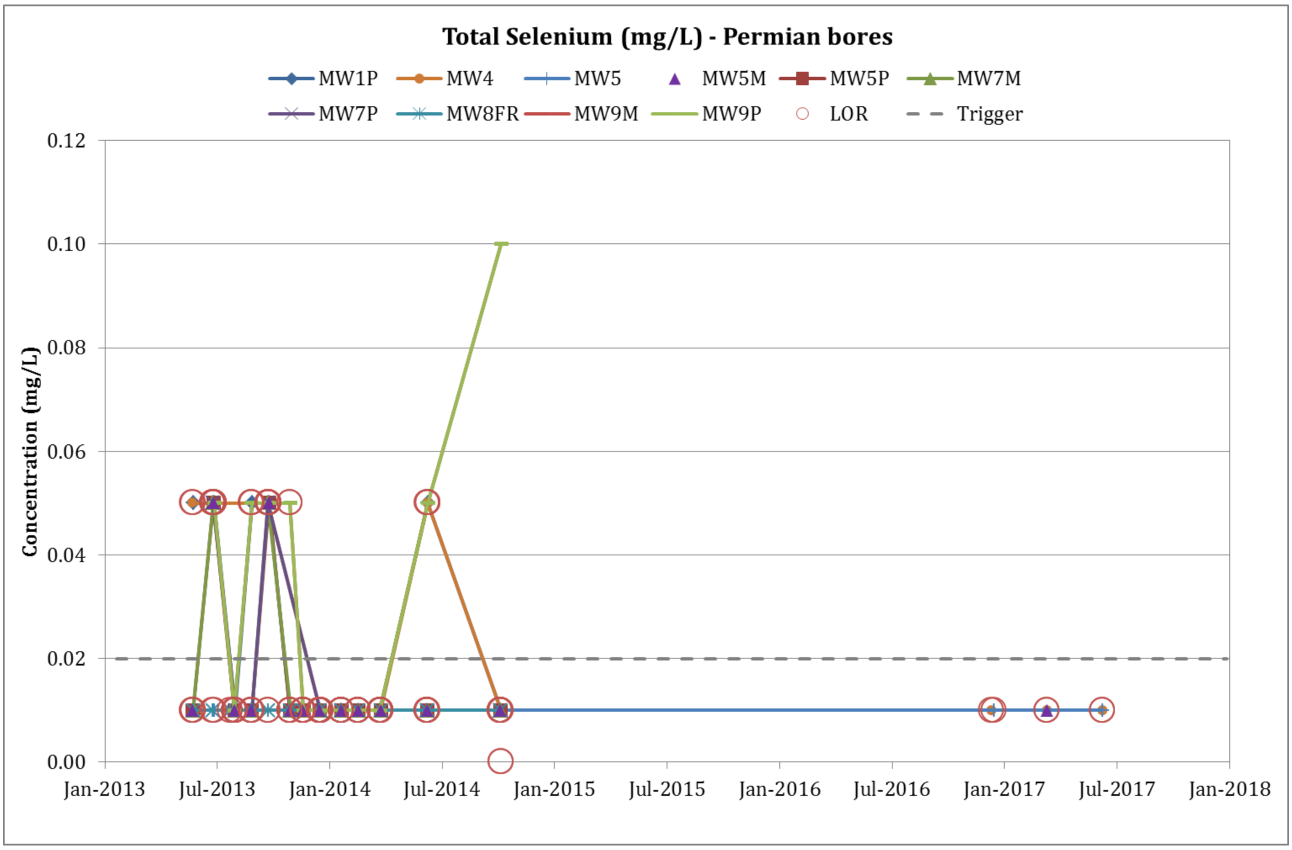

Total Iron (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
Trigger
Concentration (mg/L)
0
10
20
30
40
50
60
70
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

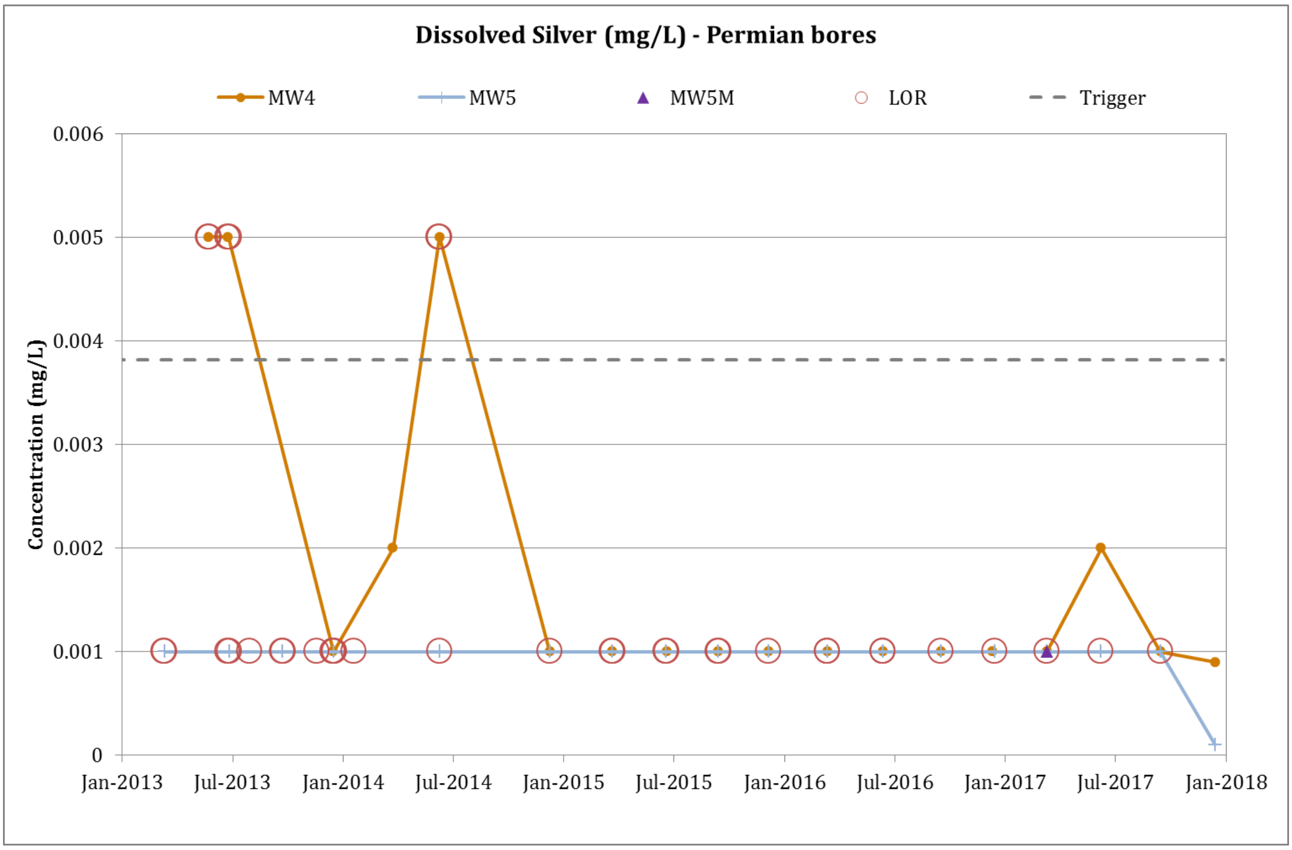

Dissolved Iron (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

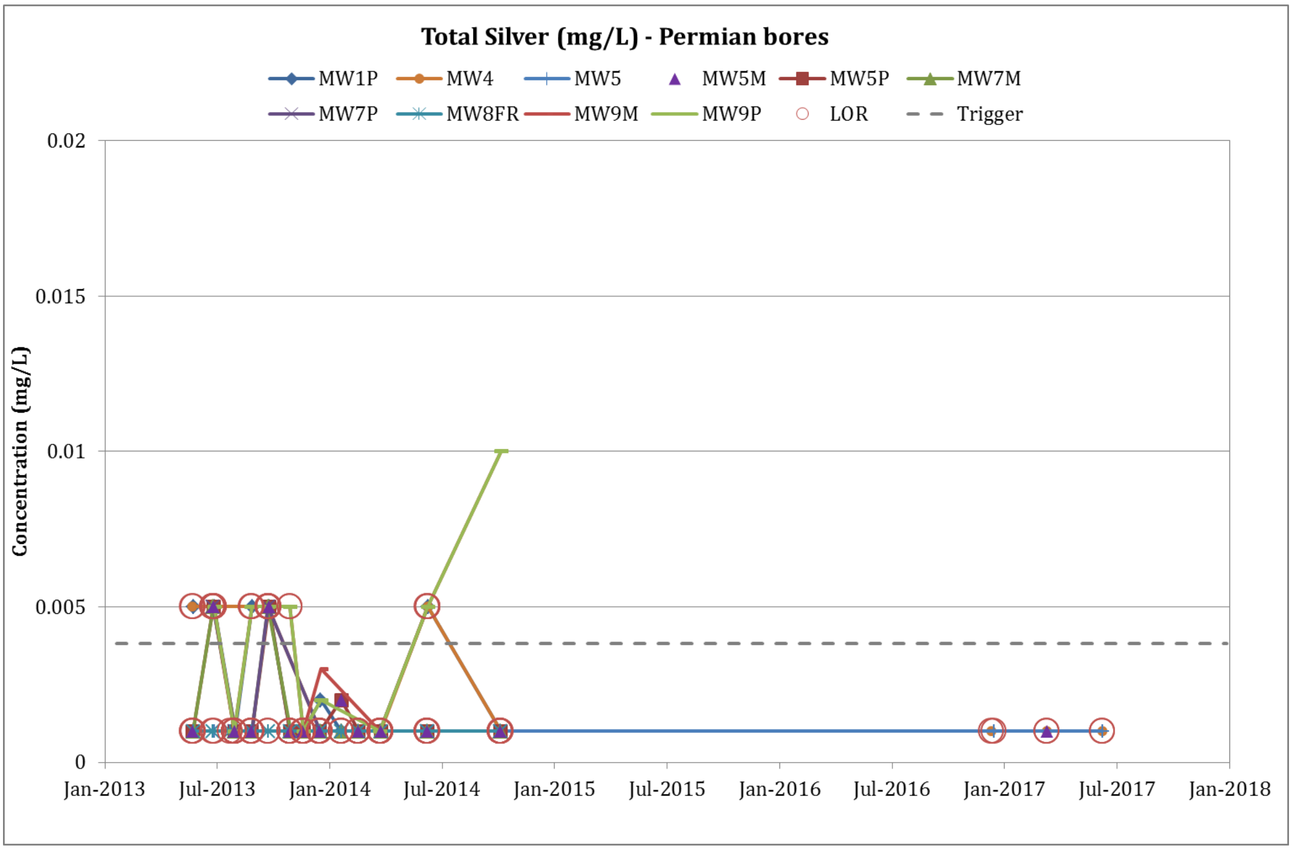

Dissolved Mercury (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

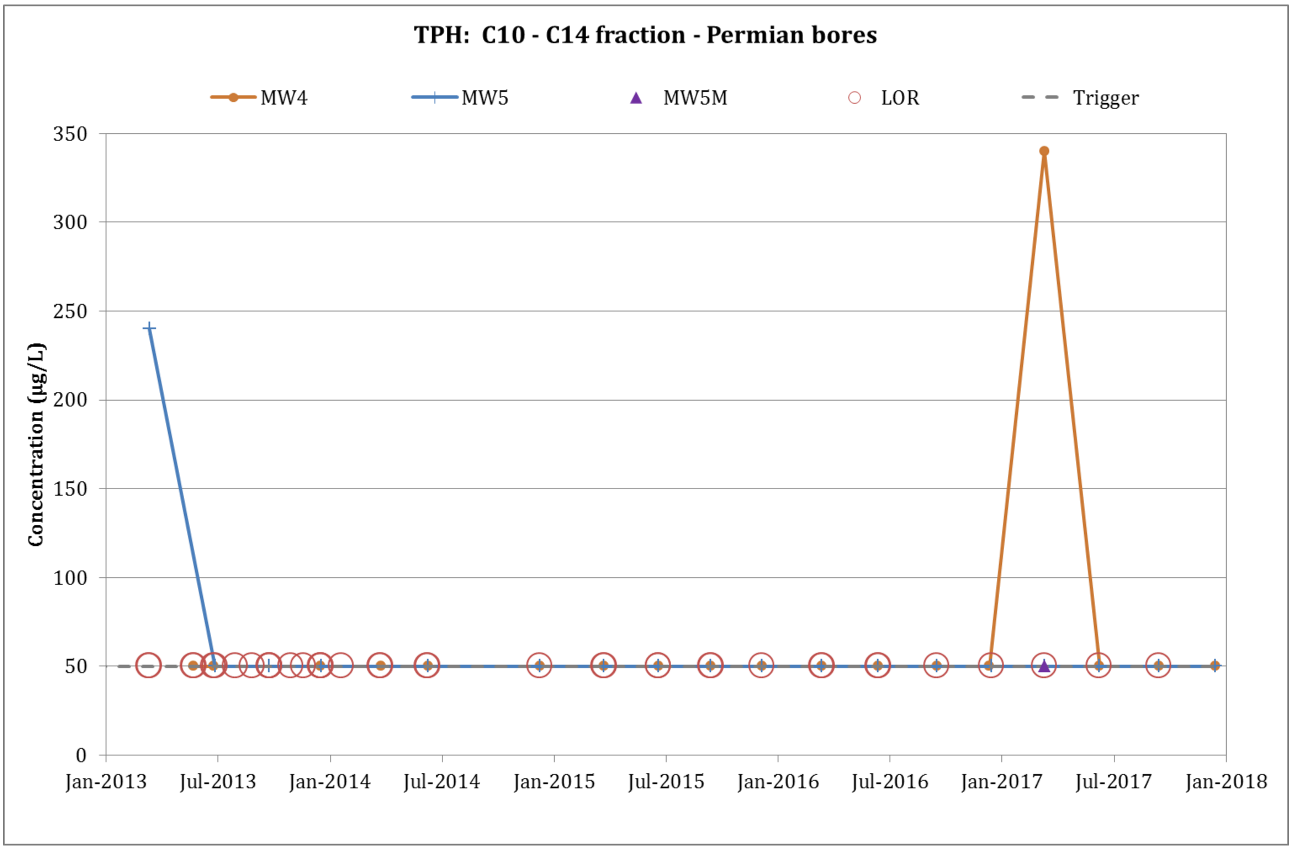

Total Mercury (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

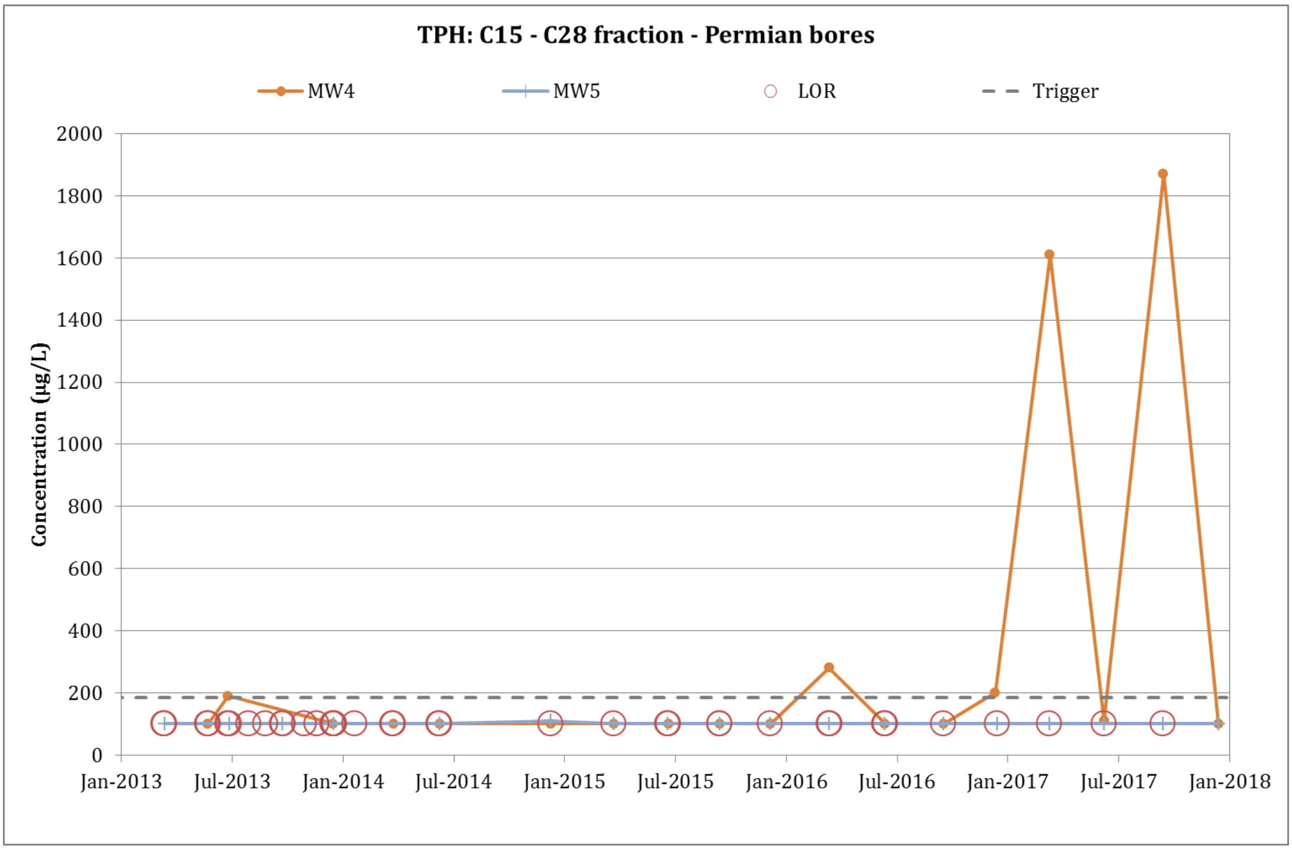

Dissolved Selenium (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

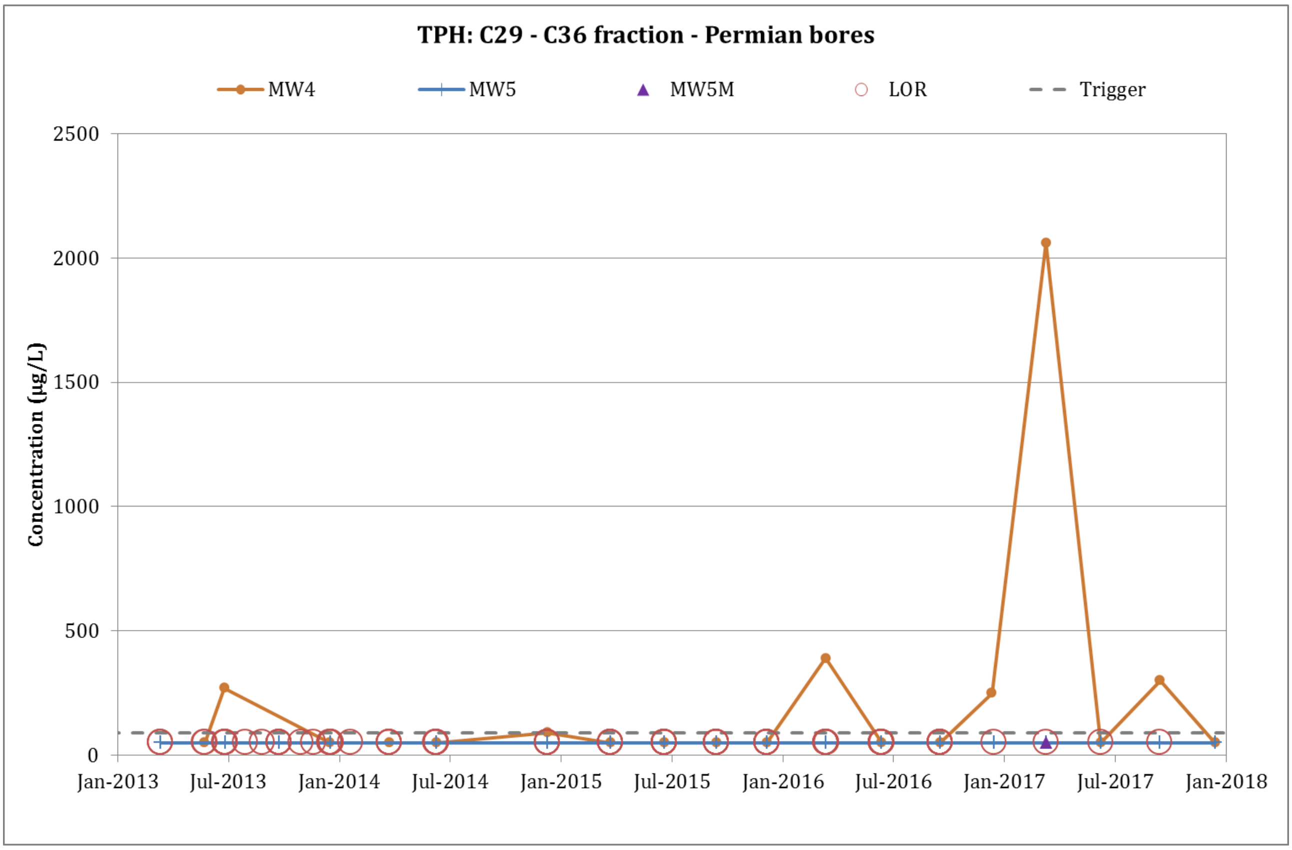

Total Selenium (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Dissolved Silver (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Total Silver (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.02
0.015
0.01
0.005
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C10 - C14 fraction - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (µg/L)
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C15 - C28 fraction - Permian bores
MW4
MW5
LOR
Trigger
Concentration (µg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C29 - C36 fraction - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (µg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

Appendix F **Numerical model report**

Middlemount Southern Extension Project
Numerical Modelling Report

F1 Introduction and objectives

Numerical modelling was undertaken to assess the impact of the proposed Middlemount Southern Extension Project (the Project) on the groundwater regime. The objectives of the modelling were to estimate with a high level of confidence:

1. potential mine inflows for water licencing; and
2. potential drawdown impacts on the surrounding environment due to mining.

This has been achieved by:

- simulating groundwater flow within the Quaternary, Tertiary, and Permian strata;
- calibrating the model under steady state and transient conditions;
- predicting future mine inflows and surrounding drawdown under the current hydrogeological conditions;
- predicting the volumetric take of groundwater, changes in regional groundwater levels and impacts on private bore water levels due to the Project and cumulatively;
- undertaking uncertainty analysis to capture range of predictions within the uncertainty in model parameters; and
- assessing the rate of groundwater recovery and long term impacts occurring on cessation of mining.

F1.1 Model confidence level classification

A high level of confidence in model predictions is required for the Project. Barnett *et al*., (2012) developed a system to classify the confidence-level for groundwater models. Models are classified as either Class 1, Class 2 or Class 3 in order of increasing confidence. Several factors are considered in determining the model confidence-level:

- available data;
- calibration procedures;
- consistency between calibration and predictive analysis; and
- level of stresses.

A Class 3 model is often referred to as an aquifer simulator, in that it encapsulates a very detailed and well understood conceptualisation. Despite the use of all available data for the model inputs, it is difficult to obtain all of the Class 3 descriptors, and an appropriate and achievable level is somewhere between an aquifer simulator and an impact model. Barnett *et al*., (2012) consistently suggest "*it is not expected that any individual model will have all the defining characteristics of Class 1, 2 or 3 models*".

Comparison against the performance indicators for individual model classes are presented in Table F 1.1.

Table F 1.1 Model classification – model performance indicators

Class	Data	Calibration	Prediction	Quantitative Indicators
1 (Simple)	× Not much	× Not possible	✓ Timeframe >> Calibration	× Timeframe > 10x
	✓ Sparse coverage	× Large error statistic	× Long stress periods	✓ Stresses < 5x
	✓ No metered usage	× Inadequate data spread	× Poor/no validation	× Mass balance > 1% (or one-off 5%)
	× Low resolution	× Targets incompatible with model purpose.	× Transient prediction but steady-state calibration	~ Properties < > field values
	× Poor aquifer geometry			× No review by Hydro/Modeller
2 (Impact Assessment)	✓ Some	× Partial performance	✓ Timeframe > Calibration	× Time frame = 3-10x
	✓ Ok coverage	× Some long term trends wrong.	× Long stress periods	✓ Stresses = 2-5x
	~ Some usage data/ low volumes	✓ Short term record.	✓ Ok validation	✓ Mass balance <1%
	~ Baseflow estimates. Some K & S measurements	✓ Weak seasonal match.	✓ Transient calibration and prediction	✓ Some properties < > field values. Review by Hydrogeologist
	✓ Some high resolution topographic DEM &/or some aquifer geometry	× No use of targets compatible with model purpose (heads & fluxes)	✓ New stresses not in calibration	× Some coarse discretisation in key areas of grid or at key times
3 (Complex Simulator)	✓ Lots, with good coverage.	✓ Good performance stats	× Timeframe ~ calibration	✓ Timeframe < 3x
	× Good metered usage info.	✓ Most long term trends matched	~ Similar stress periods	× Stresses < 2x
	~ Local climate data	× Most seasonal matches ok.	✓ Good validation	✓ Mass balance < 0.5%
	~ Kh, Kv & Sy measurements from range of tests	✓ Present day data targets	✓ Calibration & prediction consistent (transient or steady state).	~ Properties ~field measurements
	~ High resolution DEM all areas.	✓ Head & Flux targets used to constrain calibration	~ Similar stresses to those in calibration.	✓ No coarse discretisation in key areas (grid or time)
	✓ Good aquifer geometry.			✓ Review by experienced Modeller

This shows the Southern Extension Project groundwater model is classified between a Class 2 and Class 3 model. That is, the model classification identifies:

- 12 out 22 (55%) performance indicators align with a Class 2 model; and
- 12+ out 21 (57%) performance indicators align with a Class 3 model.

The above indicates the groundwater model has been developed to be suitable for predicting groundwater responses to changes in applied stress or hydrological conditions, and the evaluation and management of potential impacts.

F2 Model background

F2.1 Previous modelling for Middlemount Coal Mine

The most recent numerical groundwater model developed for the Middlemount Coal Mine was for the Middlemount Western Extension Project which was approved in 2018 (AGE, 2018). The groundwater model comprised 17 layers representing the geological units at the Middlemount Coal Mine. The numerical groundwater flow model was used to predict the rate of groundwater inflow to the open cut pit and the resultant drawdown in the surrounding geological units. This 2018 modelling for the Western Expansion Project has been utilised as the starting point for the Southern Expansion Project.

F2.2 Other nearby sites

There are a number of other mine sites in the vicinity of the Middlemount Coal Mine. The nearest mines include Lake Lindsay (approximately 20 km south), Oak Park (approximately 9 km south), German Creek (in care and maintenance) (approximately 8 km south-west), German Creek East (in care and maintenance) (approximately 2.5 km south), Foxleigh and Foxleigh Plains (approximately 12 km south-east), and Norwich Park (in care and maintenance) (approximately 11 km north-west). Of these, German Creek East, Lake Lindsay and Oak Park are the only mines that target coal from the same Rangal Coal Measures sub-basin as Middlemount Coal Mine. Mining at German Creek East mine ceased in 2007 and the voids are now used as mine water storage facilities, which will effectively mask the northwards propagation of any impacts from Lake Lindsay and Oak Park mines. On this basis, the only nearby mine operations considered likely to have a cumulative interaction with the Project will include German Creek East and Foxleigh mines.

The Bowen Gas Project (Arrow Energy, 2012b) identifies coal seam gas (CSG) production commencing in the Rangal Coal Measures approximately 7 km to the north of the Project in 2034 and within the Project area in the Moranbah Coal Measures in 2039. Groundwater drawdown from CSG production is predicted to extend within the Rangal Coal Measures into the northern portion of the model domain approximately 4.5 km from the Project.

However, detail of this drawdown is only provided for the end of CSG production in 2072 (Arrow Energy, 2012). Groundwater drawdown from the CSG production in the Moranbah Coal Measures is not predicted to extend vertically upwards into the overlying Rangal Coal Measures. Therefore, the only CSG production considered likely to have any cumulative interaction with the Project would be that within the Rangal Coal Measures north of the Project.

F2.3 Conceptual model

The conceptual model of the groundwater systems at Middlemount Coal Mine and Western Extension Project assumes the following key processes for water movement.

Inflow:

- recharge from rainfall infiltration (deep drainage);
- recharge from streamflow; and
- up-gradient inflow from surrounding strata.

Outflow:

- groundwater extraction from the existing mine operations;
- evapotranspiration;
- baseflow to surface drainages; and
- down-gradient outflow to surrounding strata.

The conceptual groundwater model for the Middlemount Coal Mine and Southern Extension Project is presented in Section 6 of the main report. This graphically presents and illustrates the main hydrogeological processes and mechanisms thought to be operating in the area, including recharge, flow directions, discharge, and anthropogenic activities (i.e. mine dewatering).

The geology surrounding the Middlemount Coal Mine comprises a relatively thin cover of Quaternary and Tertiary sediments overlying Permian coal measures which dip to the east. The main groundwater bearing units at the Middlemount Coal Mine are the Tertiary (Duaringa Formation) aquifer, and the Rangal Coal Measures coal seams. The Quaternary alluvium is limited in extent.

Where saturated, recharge to the Quaternary alluvium can occur via direct rainfall on to the alluvium, and seepage through the stream bed, when the creeks are flowing.

Recharge of the Tertiary aquifer occurs by direct infiltration of rainfall, via slow leakage through the overlying Tertiary clay aquitard. Ephemeral watercourses such as Roper Creek would also contribute a proportion of recharge into the Tertiary aquifer through infiltration during periods of stream flow. Recharge of the Permian coal measures occurs in areas where the coal seams sub-crop beneath the Tertiary cover.

The regional water table within the Tertiary aquifer is a subdued reflection of topography with a general flow towards the southeast. The exception to this is immediately around the mine where groundwater levels will have declined due to localised depressurisation resulting from mining.

The depth to groundwater within the Tertiary sediments in excess of 10 mbgl, indicates Roper Creek to be a losing stream with limited to nil potential for a baseflow contribution from the Tertiary aquifer. This correlates with the extended periods of zero flow observed within Roper Creek. Similarly, groundwater uptake by terrestrial vegetation from the Tertiary aquifer and loss through evapotranspiration is also considered unlikely, with the take of any water by vegetation most likely to be from soil moisture within the unsaturated zone.

The coal measures form confined groundwater systems and they sub-crop beneath the Tertiary aquifers. The direction of groundwater flow for the Permian coal measures is influenced by the local geomorphology and structural geology (i.e. faults), and around the mine where groundwater levels have declined as a result of depressurisation from mining.

The presence of the Jellinbah Fault has been considered in the conceptual model. It is assumed that vertical displacement along the fault alignment has resulted in the Rangal Coal Measures coal seams being truncated against lower permeability Fort Cooper Coal Measures/Burngrove Formation interburden. That is groundwater flow/movement to the east across the Jellinbah Fault is not halted, rather it is slowed as a result of the lower permeability Fort Cooper Coal Measures/Burngrove Formation interburden sediments.

F3 Model software

F3.1 Code selection

The industry standard in groundwater modelling is MODFLOW. This software is freely available from the United States Geological Survey (USGS). The base MODFLOW code is a finite difference model that relies on an orthogonal model grid of rows and columns (and layers) of model cells.

The USGS have released their new version called MODFLOW-USG (USG) that allows for the model to have an unstructured grid. This allows for model cell refinement within specific areas of the model without requiring extended refinement to the edge of the model. This creates the opportunity to reduce the number of model cells in each model layer. Another key advantage of USG is the fact that model layers can be truncated where they cease to exist (such as sub-cropping and fault terminated geological units), and maintain the hydraulic connections with layers above and below where the model layer has ceased to exist. USG can also simulate unsaturated flow. The USG code is particularly effective when the model grid is made up of Voronoi (polygon) cells, which has been implemented for the Middlemount numerical model.

F3.1.1 Pre and post processing

In-house FORTRAN and Python codes have also been used to process the raw data into the model input file formats, as well as extracting the model results from the binary model output files. QGIS and Surfer software were also used to implement the layer interpolation and visualise the modelling outcomes.

F4 Model design

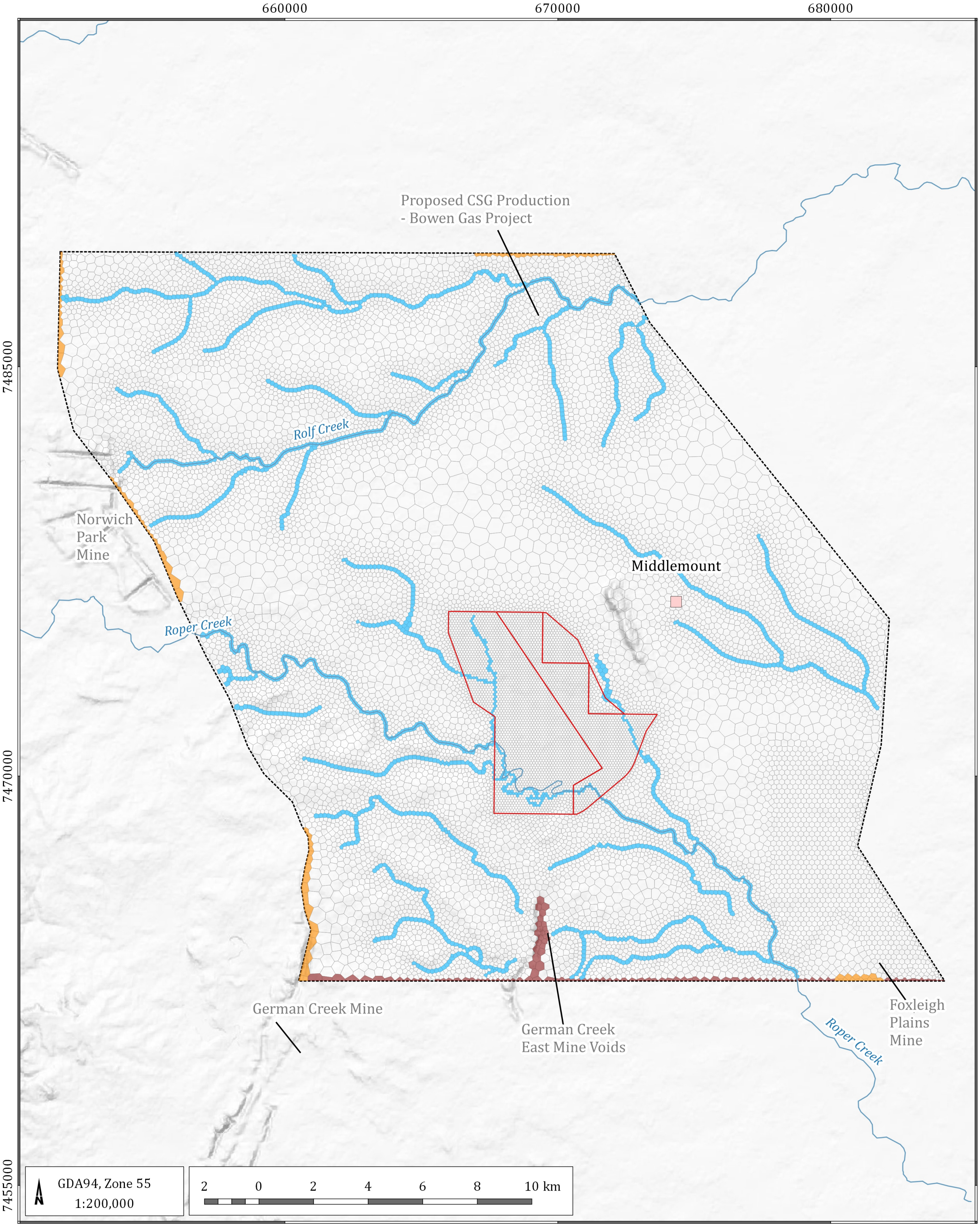
The model grid domain was designed to account for the current and future likely drawdown attributable to the Project. The model boundaries are sufficiently distant to the area of interest, such that there is no undue influence on the model predictions from the boundary assumptions. Where necessary, natural hydrogeological boundaries such as geological units and regional catchment boundaries, have been adopted in the model.

The model cell dimensions have been optimised to replicate the historical and future mining progressions and associated groundwater level responses. Grid spacing across the model domain is variable, with refinement around the mine site and locations of groundwater level observations. The model cell size becomes larger away from these key areas. The model domain was discretised into 19,412 cells per layer, and a total of 109,147 cells for the whole model. Layers 4 to 17 pinch out where these layers sub-crop beneath the weathered zone, or are truncated by the Jellinbah Fault. Cell sizes range from 100 m by 100 m within the mining area and up to 700 m by 700 m outside the Project area (Figure F 4.1).

The model extents have been revised from the Stage 2 EIS model due to the following considerations:

- the drawdown observed from the current approved coal operations;
- cumulative impacts given the proximity of the Project to the nearest operational mines which include Lake Lindsay, Oak Park, German Creek, German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park;
- inclusion of the areas targeted for the bore census for the Project; and
- adequacy to capture the predicted drawdown attributable to the Project.

The current model extent is shown by the dashed line in Figure F 4.1.



LEGEND

- 🟥 Populated place
- ― Watercourse
- ‒ ‒ Thirteen Mile Gully Diversion
- ▭ Mining Lease boundary (ML)
- ▭ Model boundary
- 🟫 General Head Boundary
- 🟦 River package
- 🟧 Drain package

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Extent of the modelling domain - model grid

DATE
21/08/2020

FIGURE No:
F 4.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-4.1_G1840P_Extent of the modelling domain - model grid.qgs

The vertical discretisation of the model is described by the geological layers. Geological surfaces have been developed for the Middlemount Coal mining area from the mine geology model, and have been extrapolated across the entire proposed numerical model extent from interpretation of the regional geological mapping and layering for the Bowen Gas Project (Arrow Energy, 2012). The model layering is similar to the 2010 numerical model, and includes the Quaternary alluvium as a separate layer to represent recharge from ephemeral surface water flows and rainfall in these areas.

The hydraulic properties of the model are based on the initial parameters established for the 2010 groundwater model (Parsons Brinkerhoff, 2010). These initial parameters were based on available field data, which includes site permeability tests conducted at bores on site. The parameters have been calibrated for a better fit to the available data. In addition, the range of parameters used for the Bowen Gas Project (Arrow Energy, 2012), were used as a reference to set the valid ranges of the model calibration.

F4.1 Time discretisation – stress periods

The time discretisation adopted for the calibration and prediction periods incorporated a variable stress period ranging between 90 days and 365 days.

F4.2 Boundary conditions

Areal recharge from rainfall infiltration has been estimated as a percentage of rainfall (namely, 0.01%) and applied across the model domain. Evapotranspiration has not been applied in the model due to the depth of water below the ground surface.

The surface drainages are represented by the RIV package. The focus of representing Roper Creek in the model is to capture its potential interaction with the underlying groundwater regime. Due to the creek predominantly being a losing stream, the key feature requiring simulation is recharge from the creek to the water table during flow events. The water table is generally located well below the creek bed, and as such, baseflow is assessed to not occur, meaning there is no need to route the baseflow downstream.

The western model boundary has been established coincident with the generally north-south extents of the German Creek and Norwich Park open cut mine voids. Review of aerial imagery provided through Queensland Globe (DNRME, 2017) shows these mine voids are no longer operational mines and are used for either water storage or tailings disposal. Similarly, the model southern boundary intersects the German Creek East Mine voids. Mining is understood to have commenced operations in 1991 and ceased mining around 2007, with the mine voids subsequently used as mine water storage facilities, which includes provision of process water to Middlemount Coal Mine. For the purposes of assessment, it has been assumed (based on advice from Middlemount Coal Mine) that the void water level in the German Creek East Mine voids is maintained coincident with the base of Tertiary in these pits. This being the case, the German Creek and Norwich Park open cut mine voids are represented as drains using the Drain package. Similarly, the German Creek East Mine voids are initially represented as drains between 1991 and 2005 (during mining), and then by the General Head Boundary (GHB) between 2005 to 2044 (when used for mine water storage). In both instances, a reference level was set to the base of the Tertiary layer for the southern and western model extents.

The south-eastern corner of the model boundary is located at the northern extents of the Foxleigh Mine. The Drain package has been applied to model cells along this boundary where the mine exists, and remain active up to 2034. The levels for the Drain cells were set at the base of the Rangal Coal Measures to represent depressurisation from this mine operation, beyond which groundwater drawdown from the Project would not be able to propagate.

The northern boundary is situated sufficient distant from drawdown predicted from the Project and is simulated as a no flow boundary for model calibration.

However, inclusion of CSG production commencing in the Rangal Coal Measures approximately 7 km to the north of the Project in 2034 is represented as drains along the eastern end of the northern model boundary from 2034 to 2044 prediction simulation. The levels for the Drain cells were set 30 m above the base of the Leichhardt and Vermont Seams within the Rangal Coal Measures to represent depressurisation from this activity. The drain conductance was set to 100 m^2/day.

The model's eastern boundary is approximately 10 km east of the Project, and extends northwest from the south-eastern model corner boundary until it intersects the model's northern boundary. The model's eastern extents are assumed to be a no-flow boundary. The no-flow status of the model extent is considered appropriate as this part of the model is sufficiently distant to the area of interest for the Project, that being the Middlemount Extension area and the existing Middlemount mining area.

Mine progression is extrapolated from the mine plan data provided by Middlemount Coal Mine and implemented into the model using DRN cells.

Pumping from private bores is limited in both location and volume. Groundwater data has been sourced from the NRM groundwater database and bore census for the Project. The NRM database does not include pumping data and the bore census identified that usage of groundwater is limited to an as-required basis if an emergency water supply during dry conditions is needed. As no actual pumping details were determined from the bore census or the NRM database, abstraction from the active bores identified within the model domain is not represented within the groundwater model.

F4.3 Initial conditions

A steady state model was created to represent pre-mining groundwater levels at Middlemount Mine. This has formed the starting heads for a simulation representing mine development in surrounding mines from 1974 to the end of 2010. The final predicted water levels from that model run become the starting heads for the historical transient simulation covering the period from 2011 to present.

F4.4 Hydraulic parameters

The fieldwork completed for the monitoring bores at the site has provided measurements of hydraulic parameters within the different hydrogeological units. Where available, these values were compared to published values for the same strata both regionally and for nearby areas.

Storage properties have not been determined on site as these are typically obtained from a pumping test with observation bores, which has not been performed for this site. As such, storage parameters have been adapted from the previous study undertaken for the Stage 2 EIS model and the CSG production for the Bowen Gas Project (Arrow Energy, 2012). Where required, estimates for hydraulic parameters have also been sourced from text book references and nearby projects to guide the parameter range for the calibration of different hydrogeological units. Table F 4.1 shows the layer details as well as the hydraulic property values assigned to each layer.

Layers 1 to 3 occur stratigraphically above the geology displaced by the Jellinbah Fault and as such are not assessed to be impacted by this fault, and are therefore consistent across the model domain. However, layers 4 to 17 includes replicated layers to represent strata (i.e Rangal Coal Measures and Fort Cooper Coal Measures) displaced east and west of the Jellinbah Fault northwest–southeast strike alignment.

Table F 4.1 Summary of groundwater model parameters

Layer	Layer name	Hydraulic conductivity (K m/day)			Specific storage (m^{-1})	Specific yield
		Horizontal (Kh)	Vertical (Kv)	Depth dependency		
Model Domain						
1	Alluvium	0.75	6.37E-02	No	1.30E-05	2.00E-02
2	Tertiary	0.75	5.47E-02	No	1.30E-05	2.00E-02
3	Weathered Zone (Rangal Coal Measures)	0.1	1.30E-02	No	1.30E-05	1.00E-02
Permian Geology West of Jellinbah Fault						
4	Rangal Coal Measures – overburden	1.00E-04	2.10E-05	No	1.00E-06	1.00E-02
5	Rangal Coal Measures – Middlemount coal seam	0.22 to 1.00E-05#	1.48E-01	Yes	1.00E-06	1.00E-02
6	Rangal Coal Measures – interburden	6.03E-06	3.24E-08	No	1.00E-06	1.00E-02
7	Rangal Coal Measures – Permian Pisces coal seam	0.09 to 1.00E-05#	1.29E-01	Yes	1.00E-06	1.00E-02
8	Rangal Coal Measures – strata underlying Pisces coal seam	5.43E-05	4.18E-06	No	1.00E-06	1.00E-02
9	Fort Cooper Coal Measures – Burngrove Formation	7.20E-05	6.48E-05	No	1.30E-05	1.00E-02
10	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	1.30E-05	1.00E-02
Permian Geology East of Jellinbah Fault						
11	Rewan Formation	1.00E-04	2.10E-05	No	1.00E-06	1.00E-02
12	Rangal Coal Measures – Leichhardt coal seam	0.18 to 1.00E-05#	1.48E-01	Yes	1.00E-06	1.00E-02
13	Rangal Coal Measures – interburden	6.03E-06	3.24E-08	No	1.00E-06	1.00E-02
14	Rangal Coal Measures – Vermont coal seam	0.06 to 1.00E-05#	1.29E-01	Yes	1.00E-06	1.00E-02
15	Rangal Coal Measures – strata underlying the Vermont coal seam	5.43E-05	4.18E-06	No	1.00E-06	1.00E-02
16	Fort Cooper Coal Measures – Burngrove Formation	7.20E-05	6.48E-05	No	1.30E-05	1.00E-02
17	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	1.30E-05	1.00E-02

Note: *# Range of horizontal hydraulic conductivity (Kh) values based on the depth dependence equations used for each coal seam (refer Section F4.4.1).*

The previous modelling utilised some specific storage values that were outside of what is now considered to be plausible ranges (Rau et. al., 2018) for the unconsolidated alluvium and Tertiary units and for the Fort Cooper Coal Measures. The specific storage for these units has been adjusted to be more consistent with the findings of Rau (2018) than was calibrated in the previous modelling (AGE, 2018).

It is acknowledged that whilst heterogeneity exists within the geological units, there is not enough data to support fully defining this in the model layers. The Jellinbah Fault is the main structural feature within the model domain, and is represented by offsetting the Rangal Coal Measures against the underlying Fort Cooper Coal Measures where this geology strata has been vertically displaced east of the Middlemount Mine area. Whilst there is likely to be other minor faults within the model domain, the nature of these faults is unknown and therefore have not been incorporated into the groundwater model to slow or halt groundwater flow / movement. This approach in conjunction with the available model inputs, has necessitated simplifications to the numerical model that are considered to create conservative predictions of the impacts from groundwater depressurisation. This simplified conceptualisation and representation of the groundwater model is presented in the cross section in Figure F 4.2.

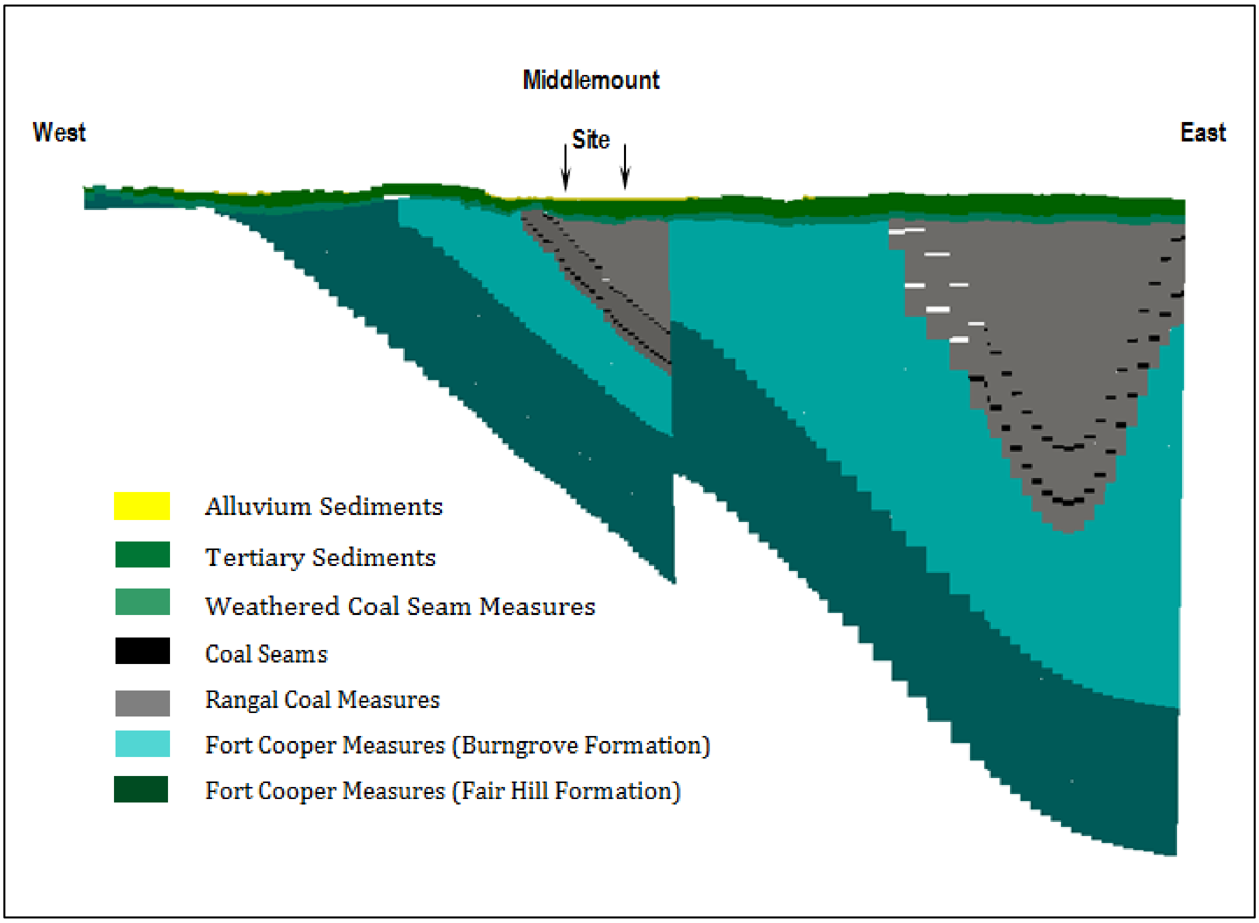


Figure F 4.2 Section through groundwater model showing layer design

Hence, the numerical model provides for a lateral, horizontal hydraulic connection across the Jellinbah Fault where different layers are juxtaposed on the eastern and western sides of the fault plane as represented in Figure F 4.2 and summarised in (Table F 4.2) below. This was achieved using the Algomesh software to provide non-neighbour connections which hydraulically connect model cells (nodes) within the different model layers positioned on either side of the Jellinbah Fault.

Table F 4.2 Model layer horizontal hydraulic connection as shown east and west of the Jellinbah Fault in Figure F 4.2

Model Layer (Geology) West of Jellinbah Fault	Model Layer (Geology) East of Jellinbah Fault
Rangal Coal Measures – overburden – layer 4	Fort Cooper Coal Measures – Burngrove Formation – layer 16
Rangal Coal Measures – Middlemount coal seam – layer 5	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – interburden – layer 6	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – Permian Pisces coal seam – layer 7	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – strata underlying Pisces coal seam – layer 8	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Fort Cooper Coal Measures – Burngrove Formation – layer 9	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Fort Cooper Coal Measures – Fair Hill Formation – layer 10	Fort Cooper Coal Measures – Fair Hill Formation – layer 17

F4.4.1 Depth dependence of hydraulic conductivity in coal seam

It is known that seam permeability typically reduces with depth within the Bowen Basin (Arrow Energy, 2012). The decrease occurs as increased pressure from the overlying strata closes up cleats in the coal and mineral precipitates seal fractures.

The model simulates a reduced (horizontal) hydraulic conductivity (Kh) of each coal seam with depth according to the following relationship:

- $Middlemount\ and\ Leichhardt\ seam\ Kh = 0.3731\ x\ e^{(-0.021\ x\ depth)}$
- $Pisces\ and\ Vermont\ seam\ Kh = 0.1504\ x\ e^{(-0.021\ x\ depth)}$

The above relationship was obtained using the available coal permeability measurements from the Middlemount Mine. This results in an order of magnitude reduction in the hydraulic conductivity over 110 m depth. The lower bound of coal seam horizontal conductivity was capped to two orders of magnitude lower than the upper bound value.

F4.5 Timing – proposed mining run

The model was run in three stages: the pre-mining starts from January 1974 to December 2010, followed by a transient lead-in period from January 2011 to December 2017, and then the prediction simulation of the proposed extension from January 2018 up to December 2044. The lead-in period was used to compare the model performance with observed field data (i.e. model calibration).

F4.6 Timing – post-mining

The post-mining conditions were simulated using a steady state model. The stabilised water levels for each void, obtained from the WRM void water level recovery (hydrological) modelling, were used to define the head in the voids, from which the steady state model defines the long term residual impacts from the Project. The Drain cells representing the Foxleigh Mine and CSG production were turned off, and the Drain cells along the model's western boundary representing German Creek Mine and Norwich Park open cut mines were changed to General Head Boundary cells coincident with the base of the Tertiary cover.

F4.7 Mine drainage

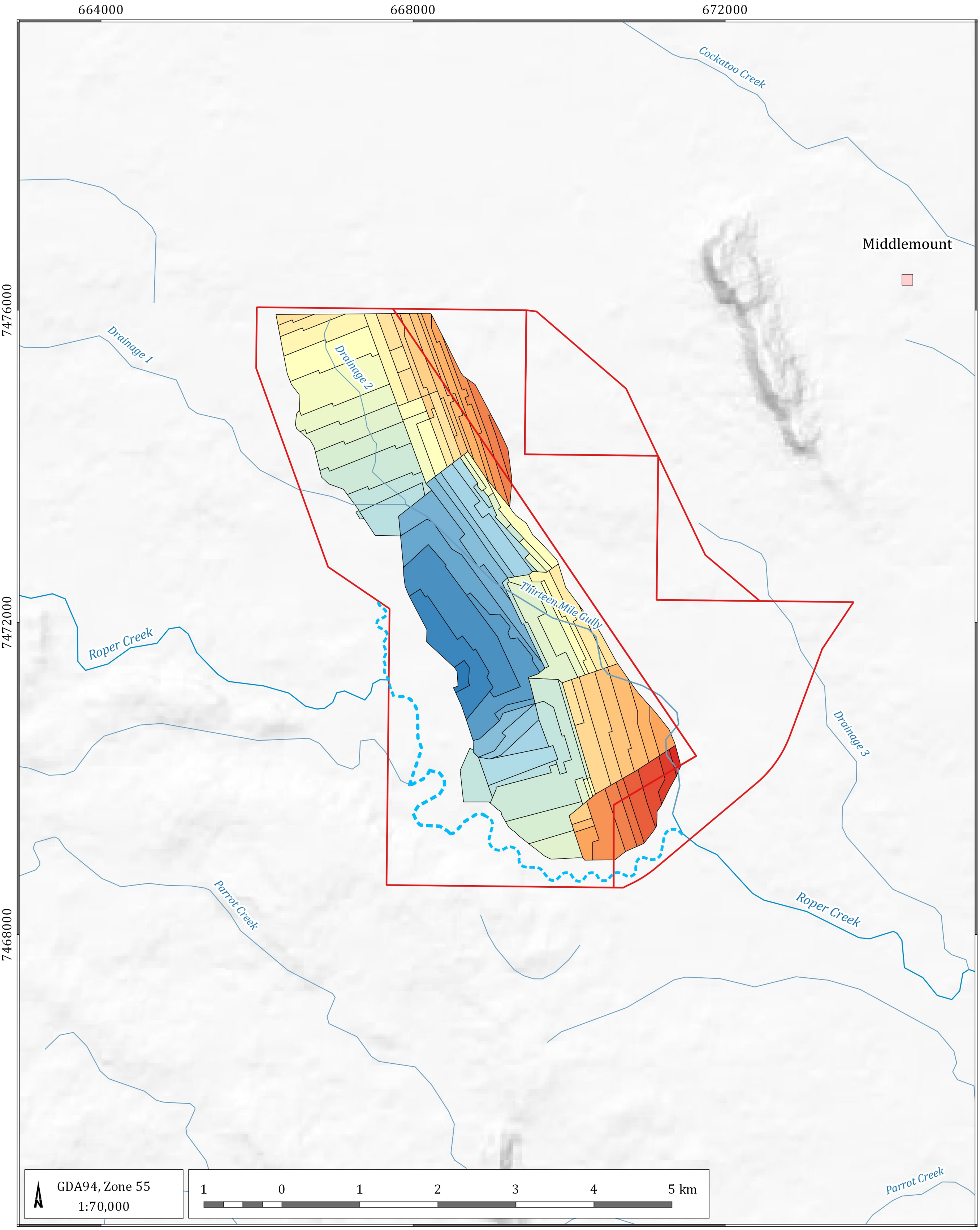
During the predictive run, a drain boundary condition (DRN) was used to simulate the effect of mine operations. A nominally high drain conductance of 100 m^2/day was applied to the drain cells and the elevation of the base of the modelled layer was used as the drain level. The drain cells were moved within the mine footprint in line with the proposed mine plan progression, simulating water removal from the active block for that particular stress period. The drain cell progression for both approved and proposed mining plans is presented in Figure F 4.3

At the completion of mining, drain cells were removed representing mining at Middlemount Coal Mine and the model simulated post-mining conditions.

F4.8 Recharge

Recharge to the groundwater system occurs through diffuse rainfall recharge across the land surface, leakage from surface water flows (i.e. perennial streams) and overland flow, as there are no specific bedrock outcrop areas that would form recharge zones within the model domain (PB, 2010). This is assumed to be via the Quaternary alluvium, Tertiary sediments, or weathered profile. These recharge mechanisms were condensed in a single package for the model using the recharge package (RCH) for MODFLOW-USG, and were applied to the uppermost layer.

For the steady-state modelling, a value of 0.06 mm/year has been adopted for recharge. This represents the proportion of rainfall that seeps through the predominantly clayey Tertiary and regolith surficial layers and becomes deep drainage to the water table.



LEGEND

- Populated place
- Watercourse
- Drainage feature
- Watercourse Diversion
- Mining Lease boundary (ML)

Mine progression (Year)

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2044

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Mining progression – proposed operations

DATE
27/08/2020

FIGURE No:
F 4.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-4.3_G1840P_Mining progression – proposed operations.qgs

F4.9 Water budget

Table F 4.3 shows the average rates of water transfer (flow into and out of the model) over the transient lead-in period (2011 to 2017). Table F 4.4 shows the average flow rates across model boundaries for the prediction period of 2018 to 2044.

Table F 4.3 Model budgets – transient lead-in period

Parameter	Average water transfer - 2011 – 2017 (ML/day)	
	Input	Output
Rainfall recharge	0.10	--
Drains	--	1.40
River	0.04	0.03
General head boundary	0.08	--

Table F 4.4 Model budgets – Prediction

Parameter	Average water transfer - 2018– 2044 (ML/day)	
	Input	Output
Rainfall recharge	0.10	--
Drains	--	2.05
River	--	0.04
General head boundary	0.04	--

Groundwater recharge during the transient and prediction periods is on average 0.1 ML/day. Mining is simulated via the DRN package with an average extraction rate of 1.40 ML/day for the calibration period. As mining progress to the deeper coal seams, the average rate of dewatering increases slightly to 2.05 ML/day (see Table F 4.4).

The mass balance error is a parameter used to quantify the quality of the internal numerical solution of the simulation, defined as the difference between the model inflows and outflows at the completion of calibration model run. The mass balance of the simulation was generally less than 0.41% indicating that the model was numerically stable and achieved an accurate numerical solution.

F5 Model calibration and verification

The groundwater model calibration was verified for the transient run (2011 to 2017) using available groundwater level data, including results of the 2017 bore census. The model was calibrated by adjusting aquifer hydraulic properties and recharge parameters to achieve the best match between the observed and simulated water levels. The modelled hydrographs were then compared to the observed water levels as well as modelled heads in previous report (PB, 2010).

F5.1 Calibration heads

The transient model simulated water levels at 26 site monitoring bores (MW1-18). The majority of monitoring bores are located within the footprint of the proposed mine and will be eventually destroyed as the mining progresses. Additional groundwater level data sourced from the Department of Natural Resources and Mines (DNRM) groundwater database identified that most DNRM registered bores were dry and only three bores (i.e. RN158617, RN158619 and RN158621) included water level data located further from the Project that was able to be used.

Figure F 5.1 presents the observed and simulated groundwater levels graphically as a scattergram. The calibration hydrographs for the site monitoring bores and regional registered bores are shown in Appendix F1, which present the calibration data in context with the overall predicted drawdown for each bore.

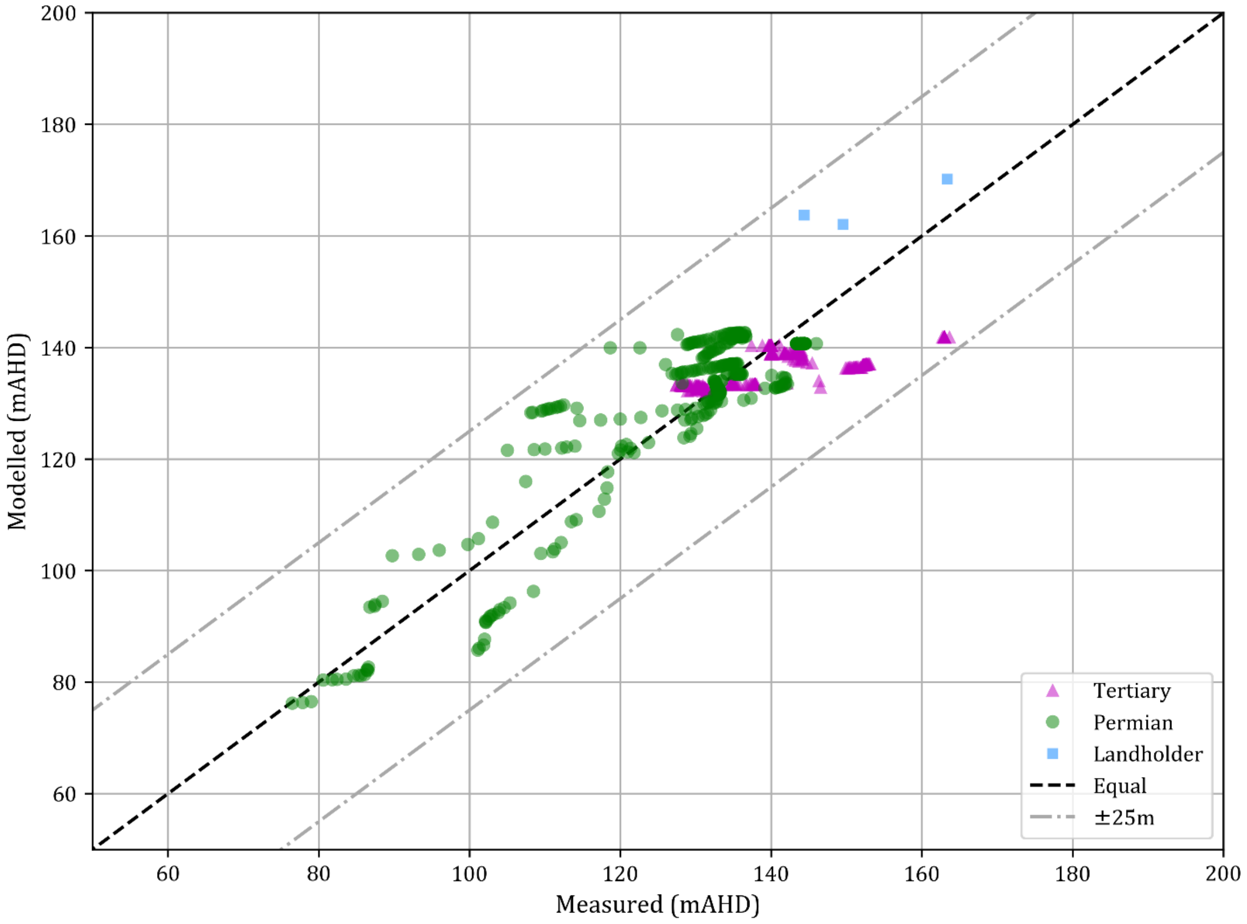


Figure F 5.1 Transient calibration – modelled vs observed groundwater levels

The root mean square (RMS) error calculated for the calibrated model was 7.9 m. The total measured head change across the model domain was 87.18 m, resulting in a scaled RMS (SRMS) of 9.1%. A lower SRMS would most likely be achieved through inclusion of heterogeneity to the aquifer parameters. However, the number and distribution of currently available observations would not support acalibrated parameter set that would also limit parameter non-uniqueness. That is, whilst it may be possible to find a set of parameter values that were able to match the observations almost perfectly, the required heterogeneity this creates would remove the model's predictive potential due to parameter non-uniqueness. The other critical aspect of the calibration is that all of the observation data is close to the mine and appears to have responded to historical mining. Incorporation of the historical mine progression has required it to be simplified to allow it to fit in with the model discretisation and transient progression, which in turn has impacted on the ability of the model to perfectly match the water level responses.

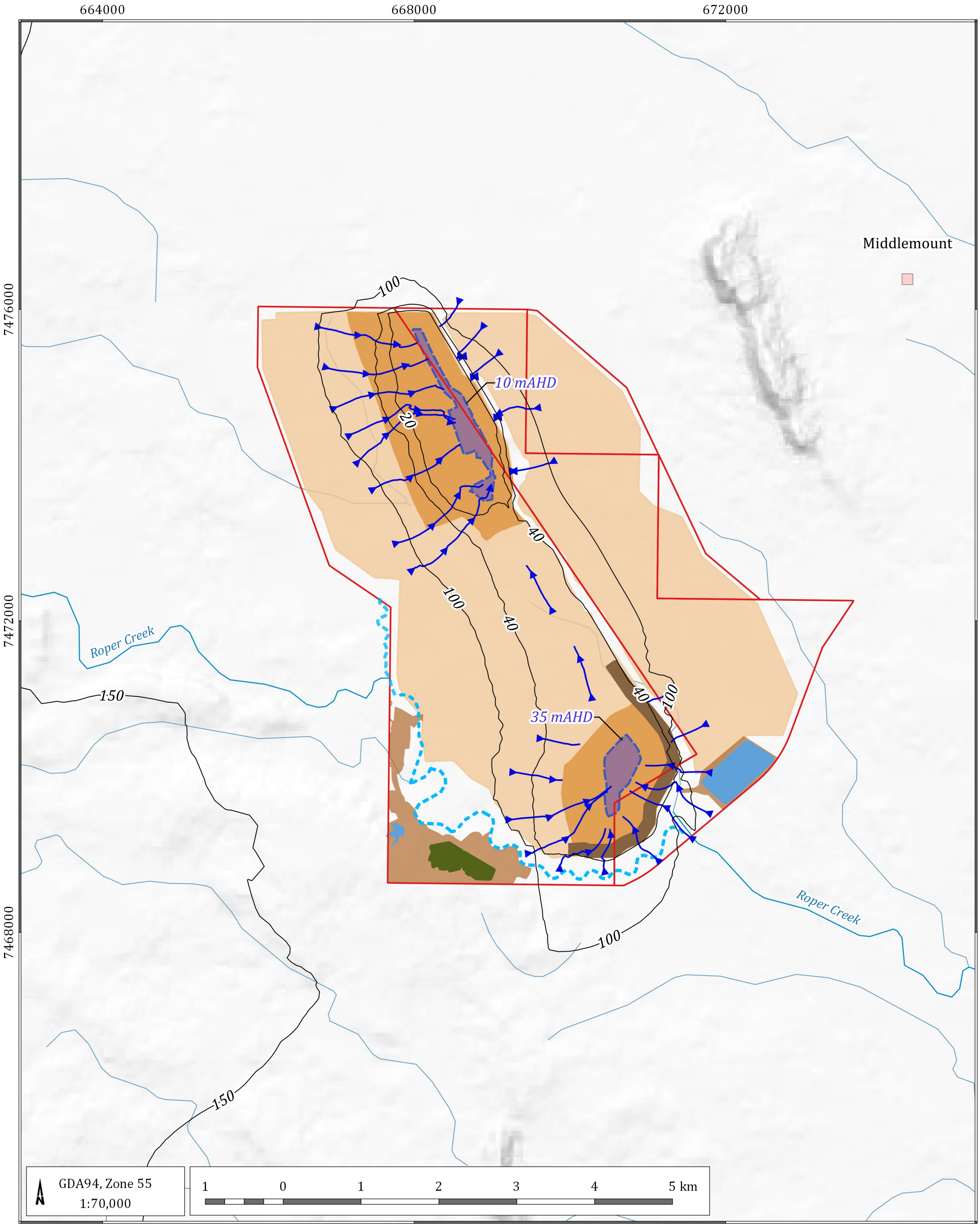
The calibration hydrographs for the site monitoring bores are shown in Appendix F1, which presents the calibration data in context with the overall predicted drawdown for each monitoring bore. These show a reasonably good match between the predicted and observed groundwater levels and trends with exception to bore MW01, where the predicted drawdown response did not replicate the observed rise in groundwater levels between 2013 and 2015 (when this bore was mined out and destroyed). This monitoring bore was located near the confluence of Drainage lines 1 and 2, in an area where surface water periodically ponds along the western side of the open cut pit. This interaction between surface water and groundwater (at a local scale) is not represented in the groundwater model as the creeks are ephemeral and the groundwater table is located generally below the creek bed (refer Section F4.2).

The Australian Modelling Guidelines (Barnett *et al*, 2012) suggest a SRMS of 10% or lower constitute a reasonably well calibrated model. This model meets this criterion. Additionally, the generally good match between the predicted and observed groundwater levels and trends suggests an acceptable model calibration. More widespread observation data around the model domain which could support the simulation of non-homogeneous hydraulic parameters would be necessary for a better match of the observed data while still retaining the prediction capacity.

F6 Groundwater fate modelling

Particle tracking was used to identify the likely travel paths of water particles surrounding the North and South Voids post closure for the Project. Points were placed around the two void lake footprints and simulated over a 10,000 year period (post mining) to simulate the path line a water particle would travel based on the gradients surrounding the final voids.

This analysis shows the particles positioned surrounding each void essentially track forwards radially towards each void (see Figure F 6.1), regardless of the length of the particle tracking timeframe. That is, the mine voids remain groundwater sinks in perpetuity post mining, with seepage draining from with the surrounding aquifers towards the two mine voids. No particles of water within the mine voids migrate away from the Project area.



LEGEND

- 🟥 Populated place
- Drainage feature
- Contour line
- Particle trace
- Watercourse Diversion
- ▭ Mining Lease boundary (ML)

Mine infrastructures

- 🟫 Mine Infrastructure Area
- 🟫 Flood Protection Landform
- 🟪 Final Void
- 🟧 Final Void Batter
- 🟧 Established Rehabilitation
- 🟩 Tailings Storage Facilities
- 🟦 Water Management Dams

Middlemount Coal Mine Southern Extension Project -
GIA (G1840P)

Particle tracking – Steady state

AGE

DATE	FIGURE No:
27/08/2020	**F 6.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-6.1_G1840P_Particle tracking – Steady state.qgs

F7 Uncertainty analysis

Uncertainty analysis was undertaken for the Middlemount Southern Extension Project. As the modelling for the Southern Extension merely involves a minor change to the mine footprint and utilises the same model parameters (except for the specific storage adjustments) and assumptions as the previous modelling, the uncertainty analysis that was previously undertaken is still considered a valid assessment. The previous analysis provides a reasonable assessment of the likely variability in model predictions, and so is reproduced below with the updated predicted basecase outputs superimposed.

Groundwater models represent complex environmental systems and processes in a simplified manner. This means that predictions from groundwater models, like so many other environmental models are inherently uncertain. The preceding sections highlight uncertainties in model inputs and the necessary simplifications within models to represent natural systems. National modelling guidelines encourage the acknowledgement of uncertainty and suggest methods to formulate predictions in which uncertainties are minimised. Barnett *et al* (2012) recommend uncertainty in model predictions can be quantified using linear or non-linear methods. The sections below describe the methodology and results of the uncertainty analysis.

F7.1 Methodology

A pseudo Null-space Monte Carlo uncertainty analysis was undertaken to quantify the magnitude of uncertainty in the future impacts predicted by the model. This type of analysis produces probability distributions for predictive impacts by assessing a composite likelihood of an impact occurring by assessing and ranking the predictions from hundreds of model 'realizations'. Each model realisation is informed by the observation dataset by using the relationship between the observations statistics to perturbations of each parameter in the groundwater model. The approach is described as a 'pseudo' Null-space Monte Carlo simply because this model did not utilise a 'highly parameterised inversion' approach, whereby pilot points are used extensively across the model as to not introduce artificial sensitivity (and consequently 'certainty') to small changes to homogenous aquifer units. To compensate, 'posterior' or post-calibration parameter ranges were informed by the Jacobian matrix, but were manually inspected and adjusted where posterior ranges appeared artificially constrained.

F7.2 Parameter generation

To undertake this type of analysis it is necessary to firstly quantify the parameter variability based on our prior knowledge about parameters. This requires specifying a distribution and range for each parameter, which is referred to as the "prior uncertainty range". Table F 7.1 to Table F 7.5 shows the 'prior' range explored for the Project. Each parameter is assumed to be log-normally distributed around the optimum value derived from calibration, and spreads gradually over the upper and lower bounds. The next step is to constrain the prior uncertainty range using information from the calibration matrix. This is achieved using Predunc7 utility from calibration and uncertainty software PEST (Doherty, 2010). In summary, PEST (Predunc7 utility) uses the prior parameter distribution and parameter sensitivities and provides a constrained parameter range which is known as "posterior uncertainty range". Appendix F2 presents the prior and posterior parameter distributions and ranges.

Table F 7.1 Prior uncertainty range - Horizontal hydraulic conductivity

Model layer	Lithology	Horizontal hydraulic K m/day (lower)	Horizontal hydraulic K m/day (optimum)	Horizontal hydraulic K m/day (upper)
1	Alluvium	0.01	0.75	10
2	Tertiary	0.001	0.75	5
3	Weathered Zone (Rangal Coal Measures)	0.001	0.1	1
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-6	1.00E-04	1.00E-03
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-2	0.37	5
6, 13	Rangal Coal Measures – interburden	1.00E-07	6.03E-06	1.00E-04
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-02	0.15	5
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-07	5.43E-05	1.00E-04
9, 16	Fort Cooper Coal Measures – Burngrove Formation	1.00E-06	7.20E-05	1.00E-03
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	1.00E-06	3.59E-04	1.00E-03

Table F 7.2 Prior uncertainty range - Vertical hydraulic conductivity

Model layer	Lithology	Vertical hydraulic conductivity (Kv) multiplier (lower)	Vertical hydraulic conductivity (Kv) multiplier (optimum)	Vertical hydraulic conductivity (Kv) multiplier (upper)
1	Alluvium	0.001	8.49E-02	1
2	Tertiary	0.001	7.29E-02	1
3	Weathered Zone (Rangal Coal Measures)	0.001	0.139	1
4, 11	Rangal Coal Measures – overburden Rewan Formation	0.001	0.217	1
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	0.001	0.405	1

Model layer	Lithology	Vertical hydraulic conductivity (Kv) multiplier (lower)	Vertical hydraulic conductivity (Kv) multiplier (optimum)	Vertical hydraulic conductivity (Kv) multiplier (upper)
6, 13	Rangal Coal Measures – interburden	0.001	5.38E-03	1
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	0.001	0.862	1
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	0.001	7.70E-02	1
9, 16	Fort Cooper Coal Measures – Burngrove Formation	0.001	0.901	1
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	0.001	5.74E-02	1

Table F 7.3 Prior uncertainty range - Specific yield

Model layer	Lithology	Specific yield - Sy (lower)	Specific yield - Sy (optimum)	Specific yield - Sy (upper)
1	Alluvium	0.001	2.00E-02	0.1
2	Tertiary	0.001	2.00E-02	0.1
3	Weathered Zone (Rangal Coal Measures)	0.001	1.00E-02	0.1
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-03	1.00E-02	5.00E-02
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-03	1.00E-02	5.00E-02
6, 13	Rangal Coal Measures – interburden	1.00E-03	1.00E-02	5.00E-02
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-03	1.00E-02	5.00E-02
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-03	1.00E-02	5.00E-02
9, 16	Fort Cooper Coal Measures – Burngrove Formation	1.00E-03	1.00E-02	5.00E-02
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	1.00E-03	1.00E-02	5.00E-02

Table F 7.4 Prior uncertainty range - Specific storage

Model layer	Lithology	Specific Storage m^{-1} (lower)	Specific Storage m^{-1} (optimum)	Specific Storage m^{-1} (upper)
1	Alluvium	5.00E-06	6.40E-05	5.00E-04
2	Tertiary	5.00E-06	1.76E-05	5.00E-04
3	Weathered Zone (Rangal Coal Measures)	5.00E-06	5.00E-05	5.00E-04
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-07	1.00E-06	1.00E-05
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-07	1.00E-06	1.00E-05
6, 13	Rangal Coal Measures – interburden	1.00E-07	1.00E-06	1.00E-05
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-07	1.00E-06	1.00E-05
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-07	1.00E-06	1.00E-05
9, 16	Fort Cooper Coal Measures – Burngrove Formation	5.00E-06	8.42E-05	5.00E-04
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	5.00E-06	8.21E-05	5.00E-04

Table F 7.5 Prior uncertainty range - Recharge

Model layer	Lithology	Recharge factor (lower)	Recharge factor (optimum)	Recharge factor (upper)
1, 2,	Alluvium and Tertiary	0.01	1	10

The posterior range and optimum values were used to generate random realisations. In summary, a total of 500 realisations were generated using a random parameter generator for which the model was run for each realisation. The 500 model runs were tested against the objective function to derive a threshold for model 'de-calibration'. Versions of the model that exceeded this threshold were assumed to be sufficiently un-calibrated, and hence were omitted from the uncertainty analysis. A threshold objective function of 1,200 m^2 was applied, which represented an increase of around 20% over the optimal solution. Of these 500 model runs, 304 versions had an objective function less than the threshold, which were included in the analysis. The remaining 196 simulations were removed from the analysis because they did not meet the criteria.

F7.3 Results

As discussed above, a total of 304 models achieved model convergence and produced acceptable calibration statistics. A summary of the calibration performance and predictive uncertainty is provided in Appendix F3. The hydrographs show the composite distribution of the heads across all 304 realisations and indicate that the majority of the models are acceptably calibrated.

F7.3.1 Predicted groundwater inflow

Figure F 7.1 presents the uncertainty of Permian groundwater inflow into the approved mining and the Project from 2011 to 2037. Added to this figure is the current predicted inflow for the Southern Extension Project. This demonstrates that while the uncertainty has not been simulated for this model update, the inflow has not varied significantly away from the Western Extension Project inflows (AGE, 2018) and the potential range arising from the updated inflows are likely to be very similar to the previous analysis.

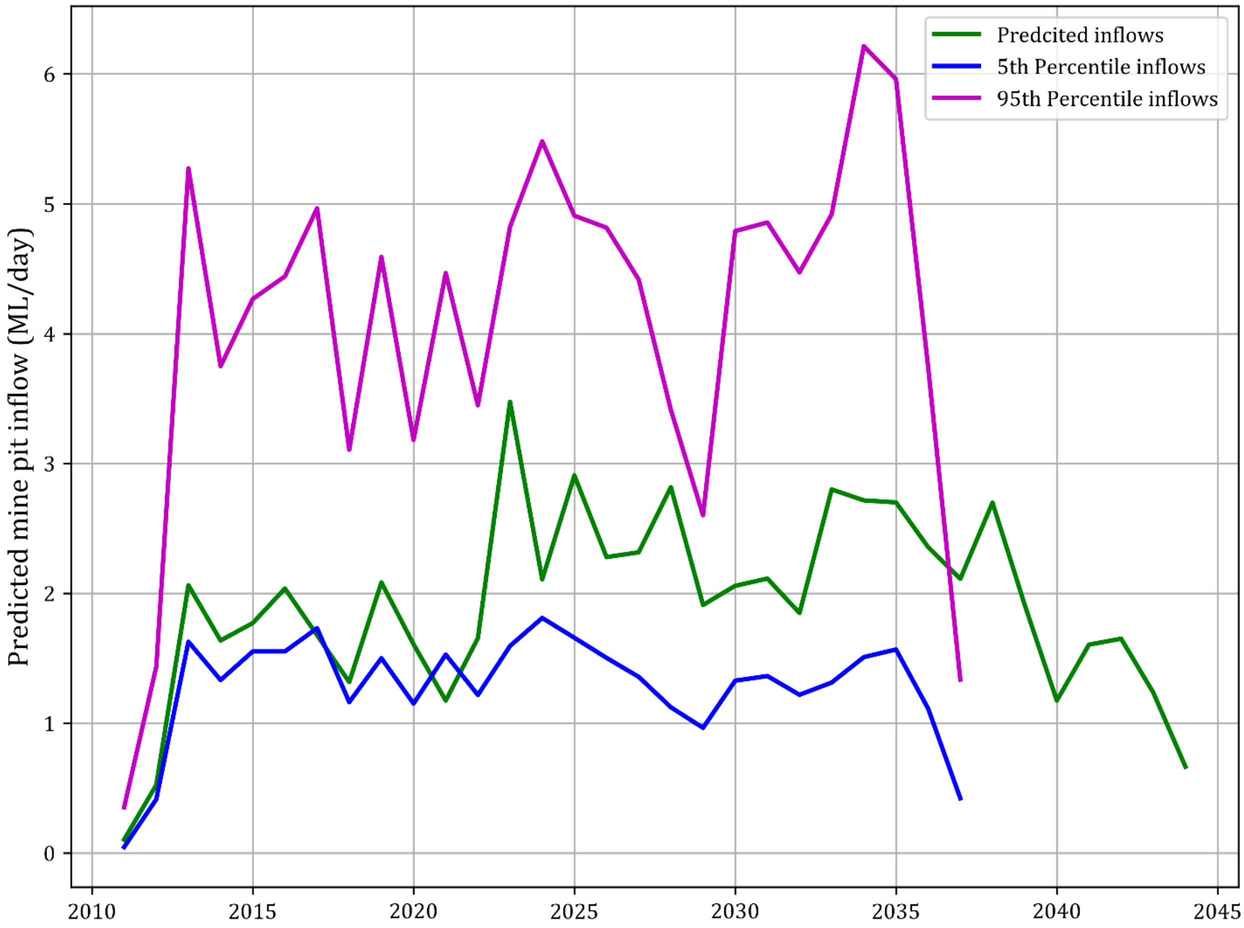


Figure F 7.1 Predicted Project groundwater inflow uncertainty

The uncertainty analysis indicated predicted the maximum inflows ranging between 1.81 ML/day (5th percentile) and 6.22 ML/day (95th percentile) in year 2024 and 2034 respectively. Table F 7.6 presents the uncertainty in the total inflow to the Project only for each year.

Table F 7.6 Predicted groundwater inflow – 2011 to 2037

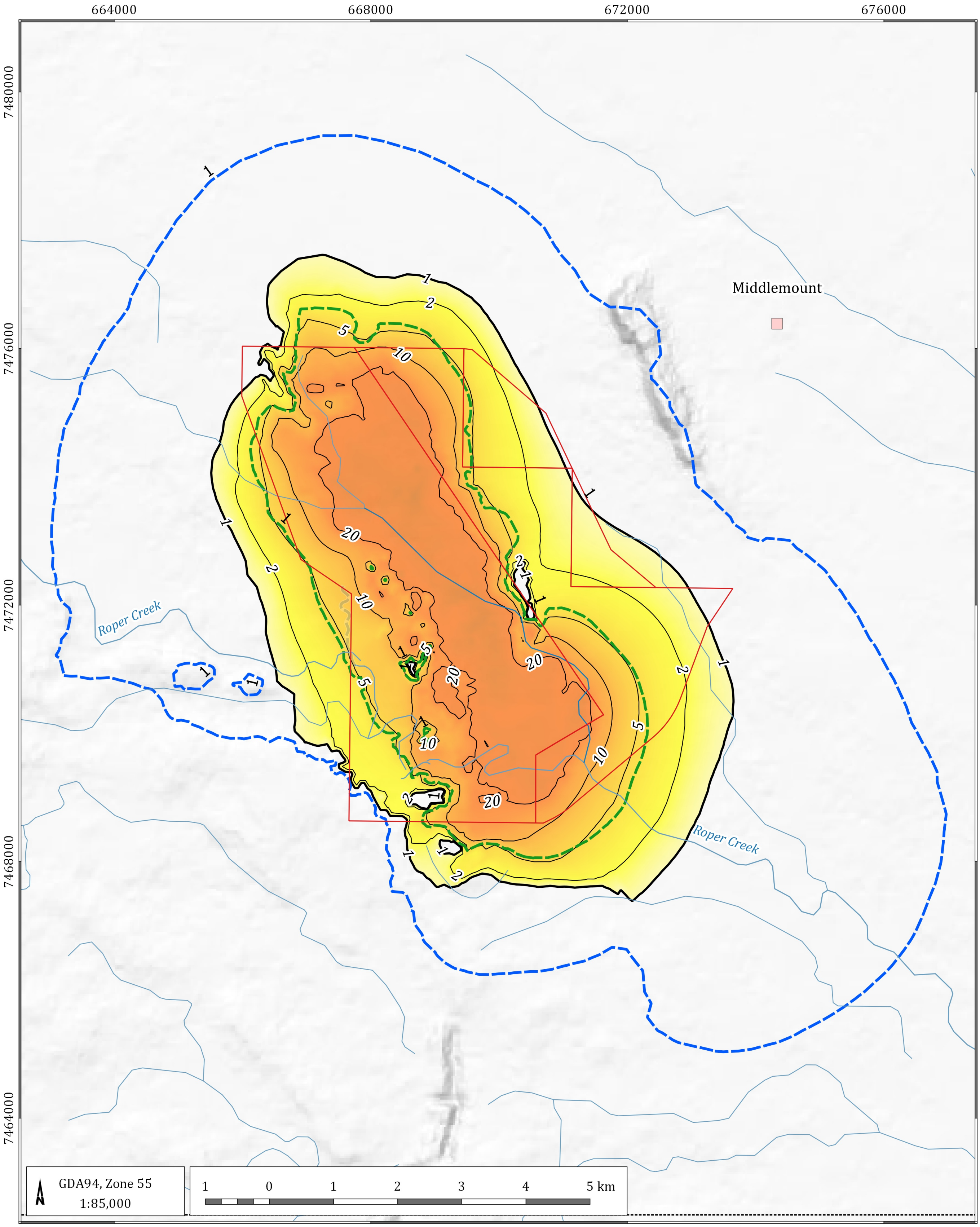
Year	Groundwater inflow (P05)	Groundwater inflow (Calibration)	Groundwater inflow (P95)
2011	0.05	0.1	0.35
2012	0.41	0.5	1.44
2013	1.63	2.1	5.27
2014	1.33	1.6	3.75
2015	1.55	1.8	4.27
2016	1.55	2.0	4.44
2017	1.73	1.7	4.97
2018	1.16	1.3	3.11
2019	1.50	2.1	4.59
2020	1.15	1.6	3.18
2021	1.53	1.2	4.47
2022	1.22	1.7	3.45
2023	1.60	3.5	4.82
2024	1.81	2.1	5.48
2025	1.66	2.9	4.91
2026	1.50	2.3	4.82
2027	1.36	2.3	4.42
2028	1.12	2.8	3.41
2029	0.97	1.9	2.60
2030	1.33	2.1	4.79
2031	1.36	2.1	4.86
2032	1.22	1.8	4.47
2033	1.31	2.8	4.92
2034	1.51	2.7	6.22
2035	1.57	2.7	5.96
2036	1.11	2.4	3.74
2037	0.42	2.1	1.34
2038	--	2.7	--
2039	--	1.9	--
2040	--	1.2	--
2041	--	1.6	--
2042	--	1.7	--
2043	--	1.2	--
2044	--	0.7	--
Max	**1.81**	**3.5**	**6.22**

F7.3.2 Groundwater drawdown

To assess the level of uncertainty in the extent of predicted drawdown, the calibrated drawdown extent was compared to the 1m drawdown extent for the 5th and 95th drawdown percentiles. Figure F 7.2 to Figure F 7.4 present the uncertainty in maximum groundwater drawdown at any time during mining within the Tertiary and Weathered Zone (layers 2 and 3), Middlemount and Pisces Seams (layers 5 and 7). These figures also show the predicted drawdown for the Southern Extension Project.

Figure F 7.2 shows that the 95th drawdown percentile has a larger drawdown extent within the weathered layer compared to the calibrated case. In particular, the 1 m drawdown extent was mainly contained around the mine area in the calibrated case and with the 95th drawdown; the drawdown extends approximately 3 km east of the mine extent and approximately 4 km west and south of the open cut. Figure F 7.3 and Figure F 7.4 show that 95th percentile drawdown in the Middlemount and Pisces Seams occurs up to 1 km further south of calibrated case.

Comparison of the updated 1m drawdown results with the previous 5th and 95th drawdown percentiles shows that except for Pisces coal seam, in all the other layers the calibrated model predictions are largely bound by the previous uncertainty predictions. The further expansion of the 1 m drawdown in the Pisces seam is due to extended mine plan to the South of the Middlemount mine and longer dewatering of the coal seam up to 2044.



LEGEND

▫ Populated place
— Drainage feature
☐ Mining Lease boundary (ML)
☐ Model boundary

Drawdown (m)

☐ 0
▨ 1
▨ 2
▨ 5
▨ 10
▨ 20
▨ 50
— Drawdown contour (1 m)
-- P05 drawdown contour (1 m)
-- P95 drawdown contour (1 m)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

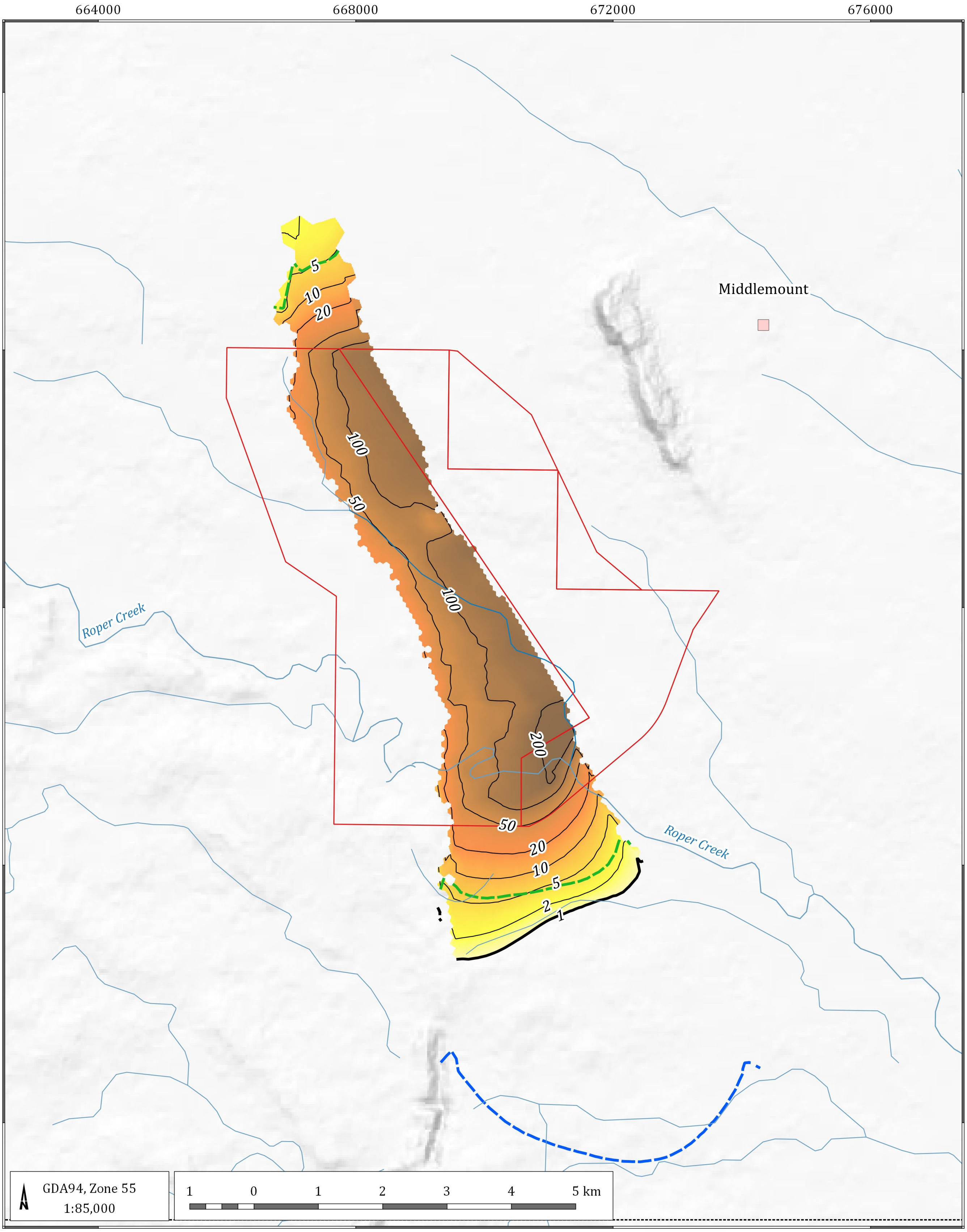
Tertiary and weathered Permian (Layers 2 and 3) – Uncertainty of maximum zone of drawdown during mining

AGE

DATE
27/08/2020

FIGURE No:
F 7.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-7.2_G1840P_Tertiary and weathered Permian (Layers 2 and 3) – Uncertainty of maximum zone of drawdown during mining.qgs



LEGEND

- 🟥 Populated place
- Drainage feature
- Mining Lease boundary (ML)
- Model boundary

Drawdown (m)

- ☐ 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- Drawdown contour (1 m)
- P05 drawdown contour (1 m)
- P95 drawdown contour (1 m)

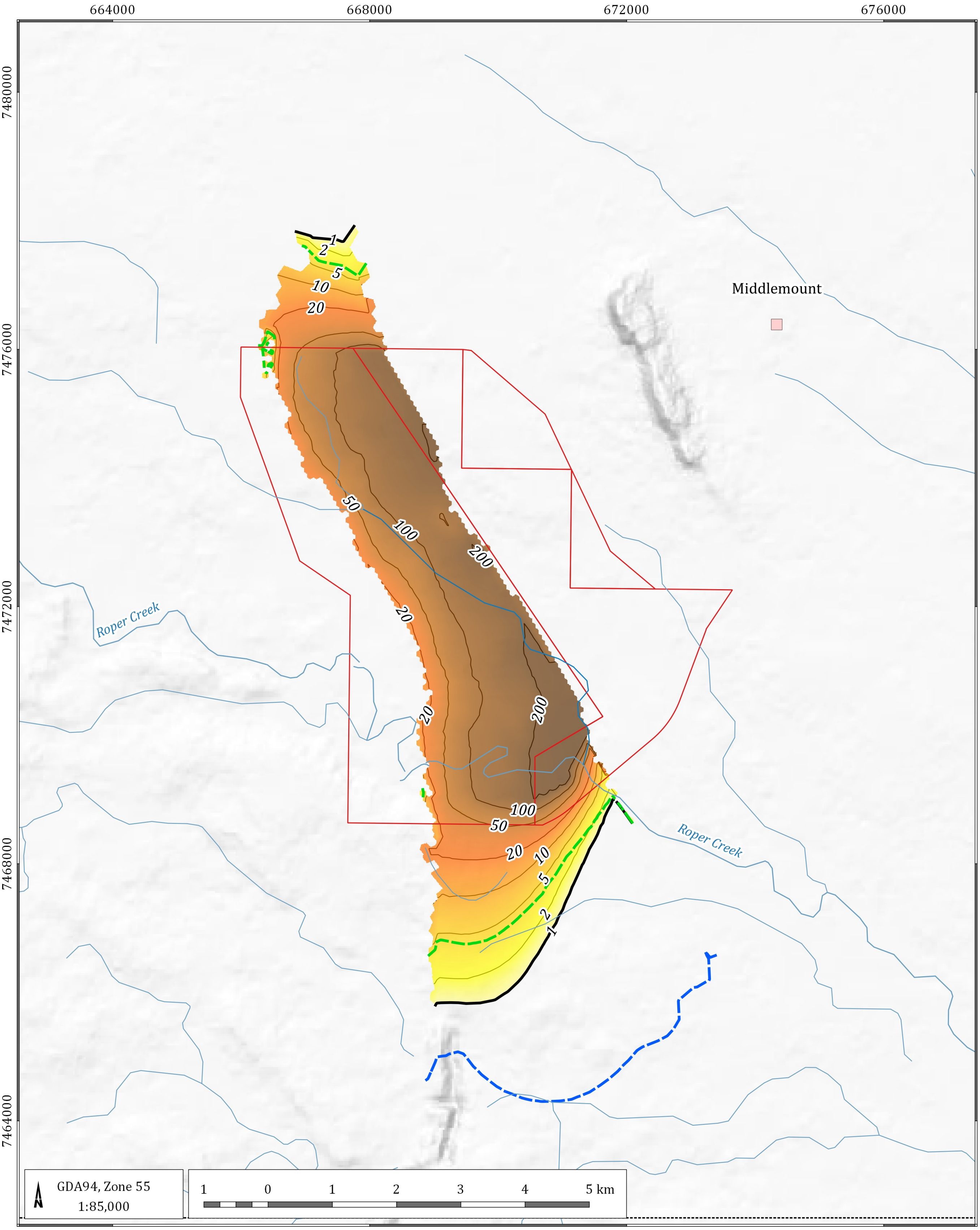
Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount Seam (Layer 5) – Uncertainty of maximum zone of drawdown during mining

DATE
27/08/2020

FIGURE No:
F 7.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F_7.3_G1840P_Middlemount Seam (Layer 5) – Uncertainty of maximum zone of drawdown during mining.qgs



LEGEND

- ▨ Populated place
- — Drainage feature
- ▭ Mining Lease boundary (ML)
- ⬚ Model boundary

Drawdown (m)

- □ 0
- ■ 1
- ■ 2
- ■ 5
- ■ 10
- ■ 20
- ■ 50
- ■ 100
- ■ 200
- — Drawdown contour (1 m)
- - - P05 drawdown contour (1 m)
- - - P95 drawdown contour (1 m)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Pisces Seam (Layer 7) – Uncertainty of maximum zone of drawdown during mining

DATE
27/08/2020

FIGURE No:
F 7.4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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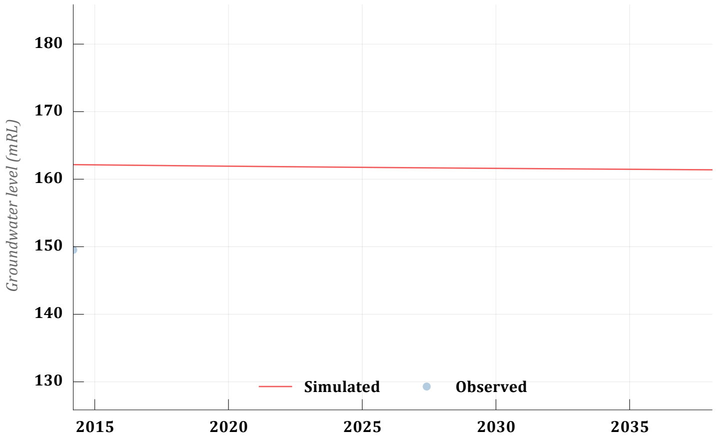
Appendix F1 Simulated and observed hydrographs

158617



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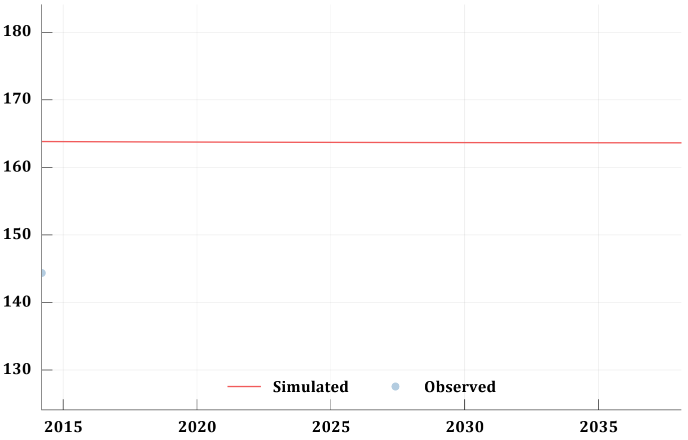

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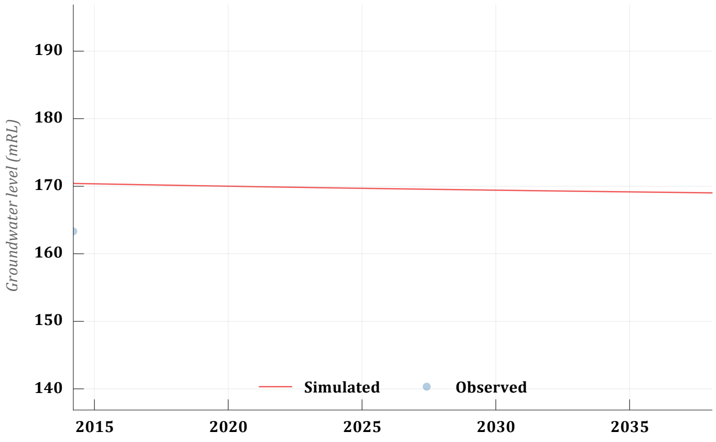
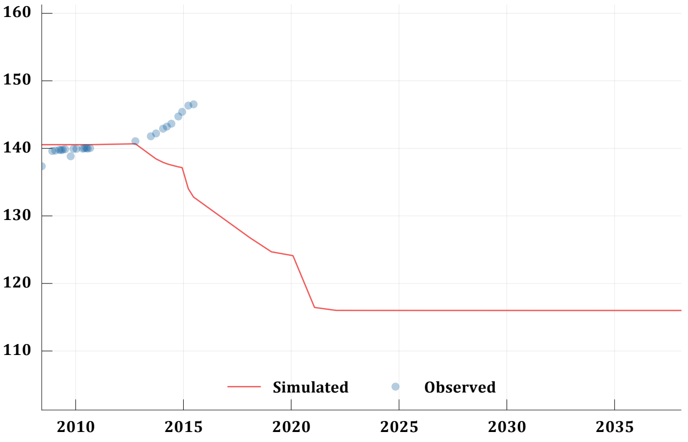


MW1



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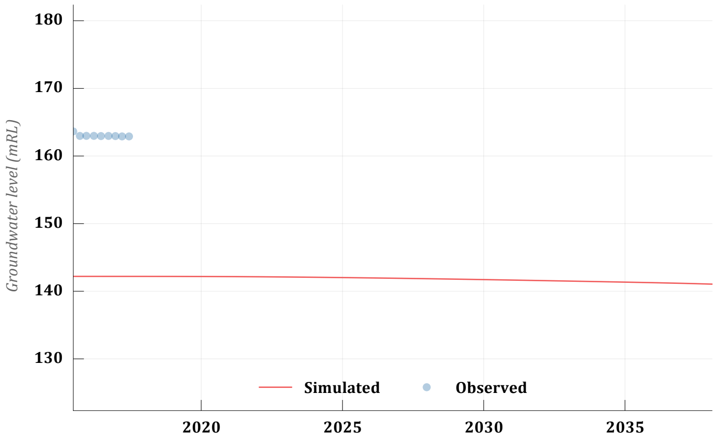
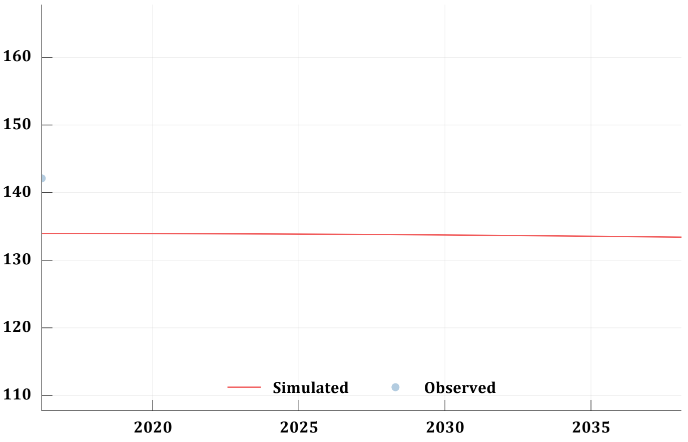
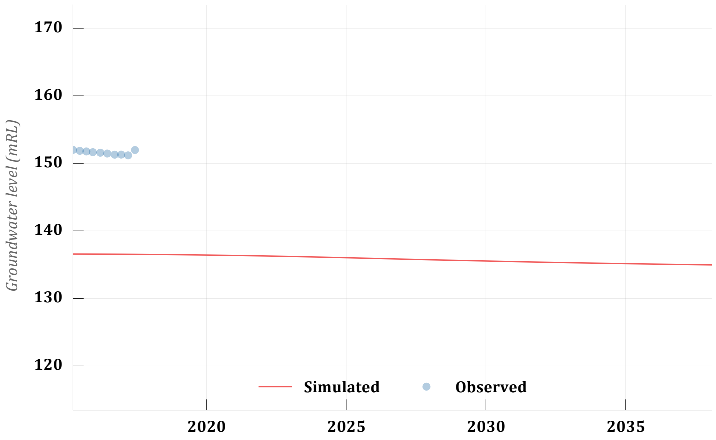


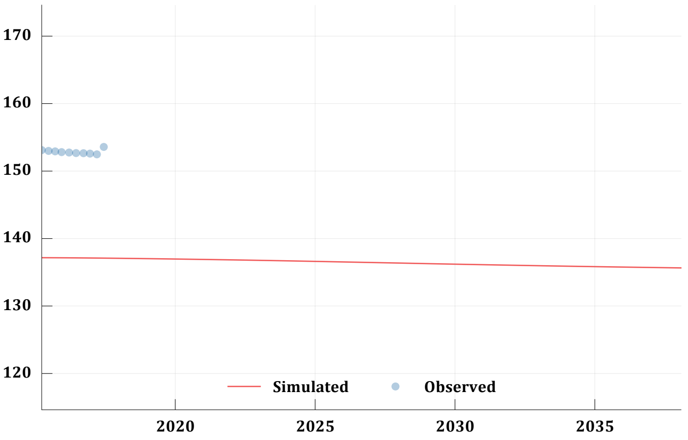
MW11A

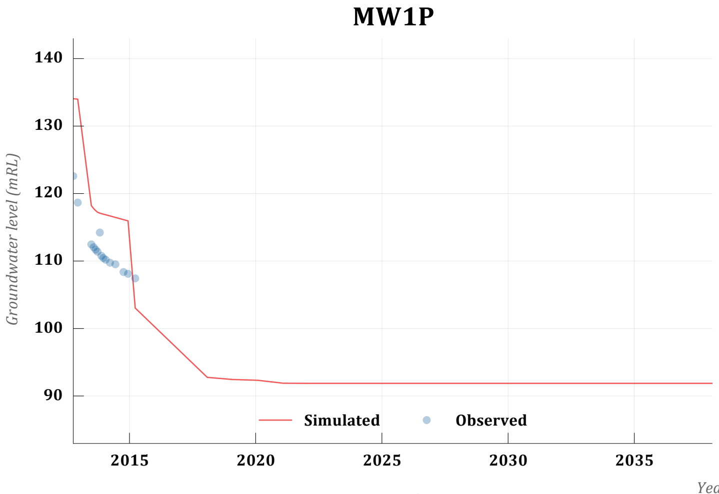


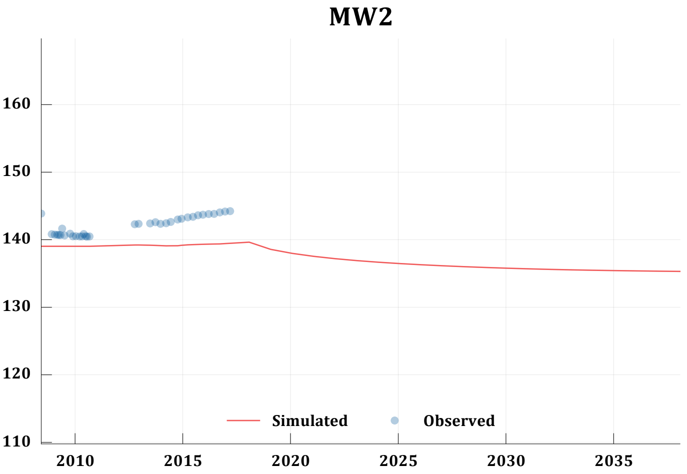
MW14A

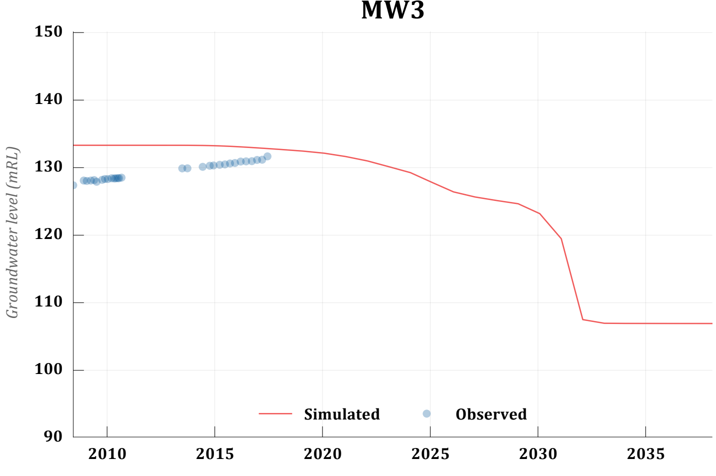


MW15A

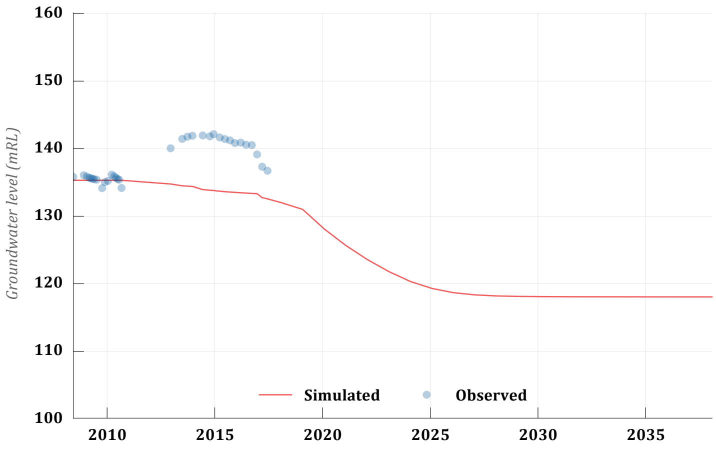


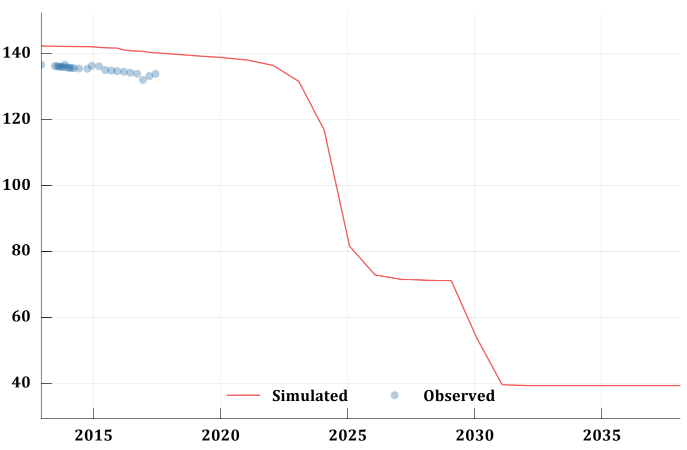

MW1P
Groundwater level (mRL)
140
130
120
110
100
90
2015
2020
2025
2030
2035
Year
Simulated
Observed

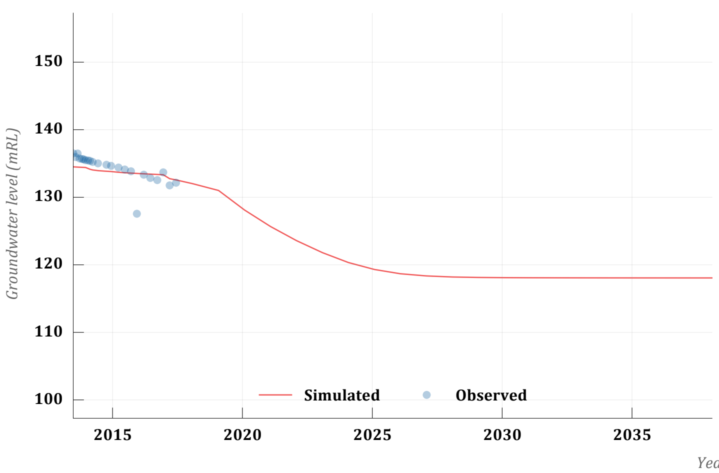

MW2
160
150
140
130
120
110
2010
2015
2020
2025
2030
2035
Simulated
Observed

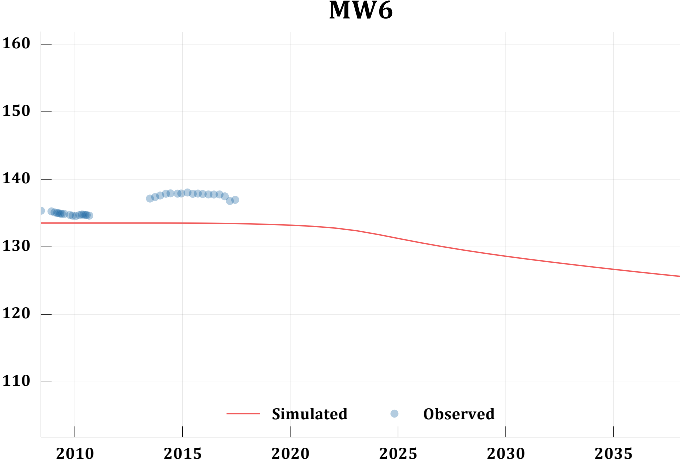

MW3
Groundwater level (mRL)
150
140
130
120
110
100
90
2010
2015
2020
2025
2030
2035
Year
Simulated
Observed

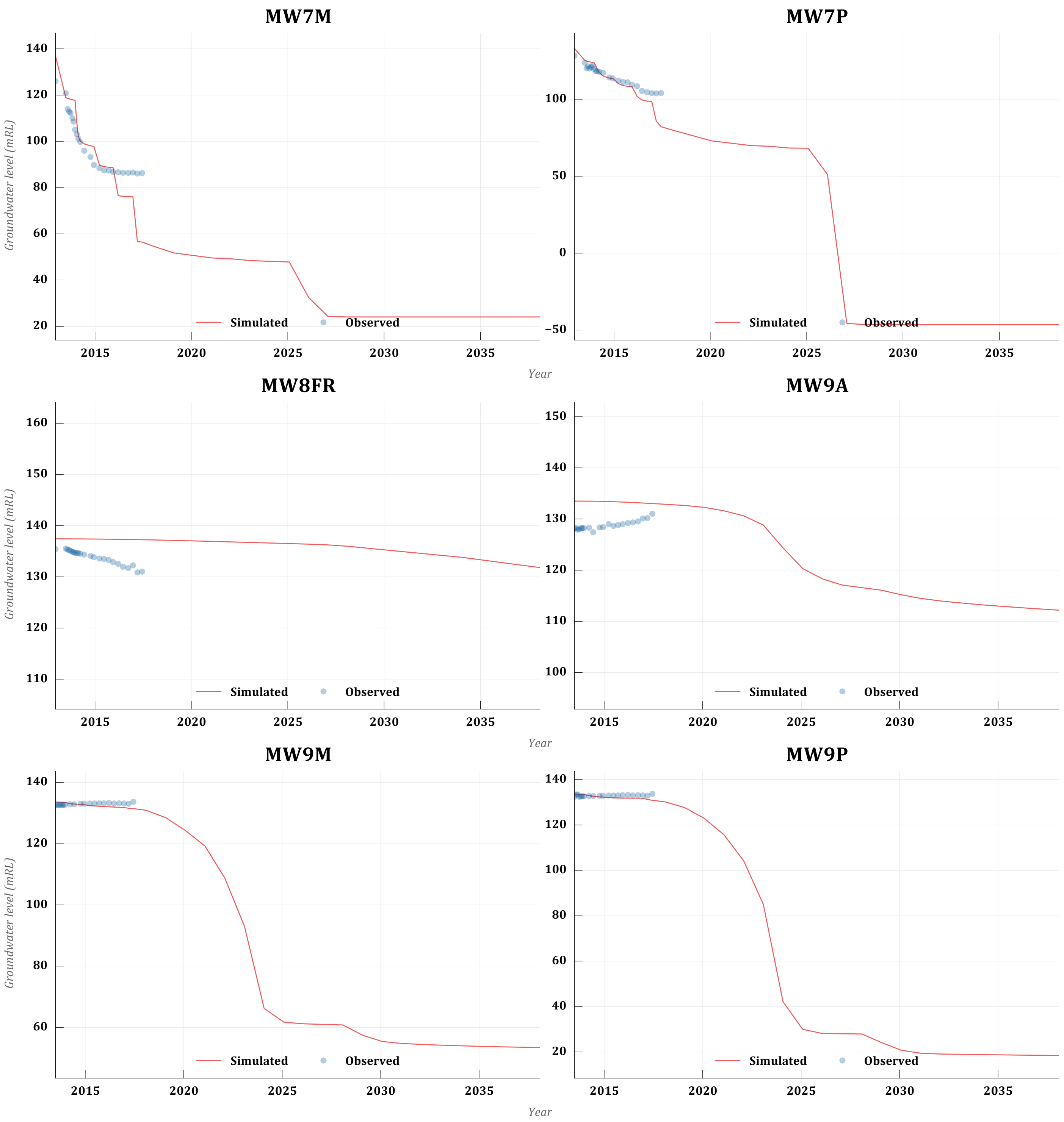

MW4
170
160
150
140
130
120
2010
2015
2020
2025
2030
2035
Simulated
Observed


MW5
Groundwater level (mRL)
160
150
140
130
120
110
100
2010
2015
2020
2025
2030
2035
Year
Simulated
Observed

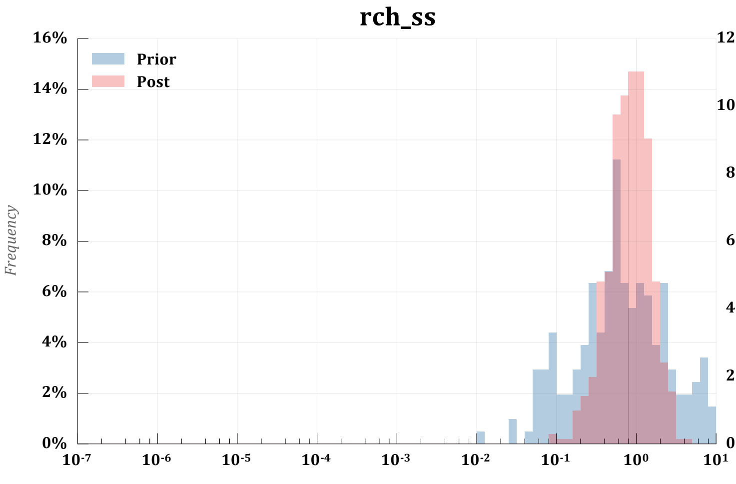

MW5M
140
120
100
80
60
40
2015
2020
2025
2030
2035
Simulated
Observed

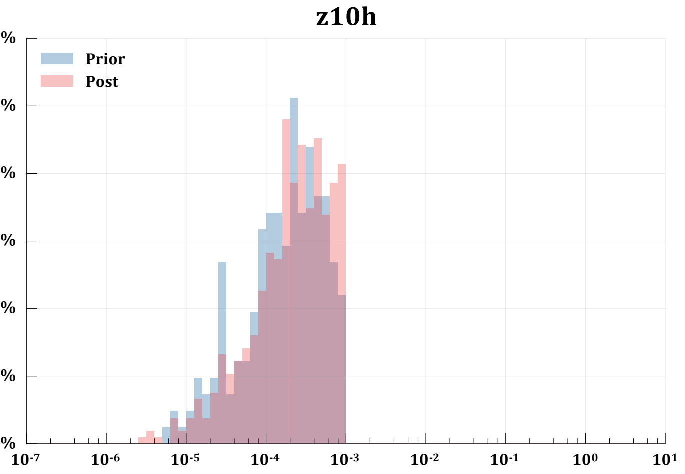

MW5P
Groundwater level (mRL)
150
140
130
120
110
100
2015
2020
2025
2030
2035
Year
Simulated
Observed

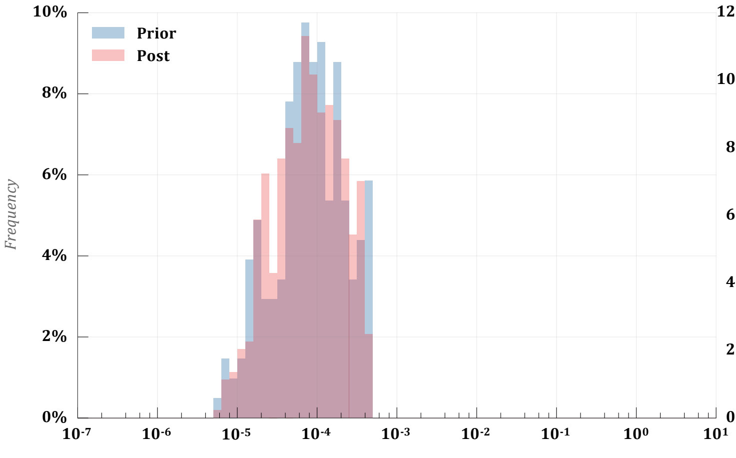

MW6
160
150
140
130
120
110
2010
2015
2020
2025
2030
2035
Simulated
Observed

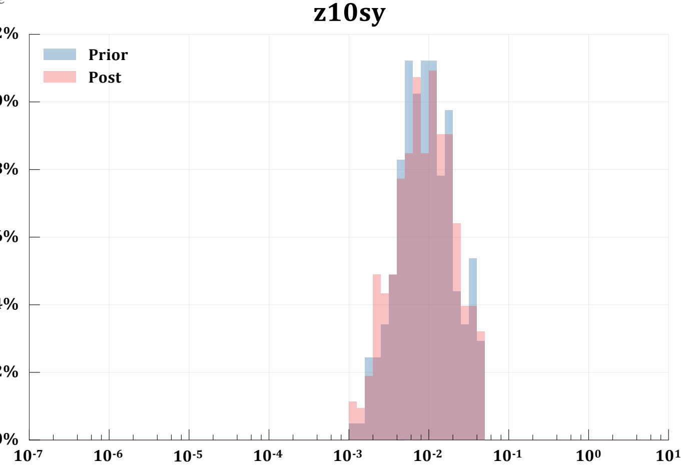

MW7M
Groundwater level (mRL)
140
120
100
80
60
40
20
2015
2020
2025
2030
2035
Simulated
Observed
MW7P
100
50
0
−50
2015
2020
2025
2030
2035
Simulated
Observed
Year
MW8FR
Groundwater level (mRL)
160
150
140
130
120
110
2015
2020
2025
2030
2035
Simulated
Observed
MW9A
150
140
130
120
110
100
2015
2020
2025
2030
2035
Simulated
Observed
Year
MW9M
Groundwater level (mRL)
140
120
100
80
60
2015
2020
2025
2030
2035
Simulated
Observed
MW9P
140
120
100
80
60
40
20
2015
2020
2025
2030
2035
Simulated
Observed
Year

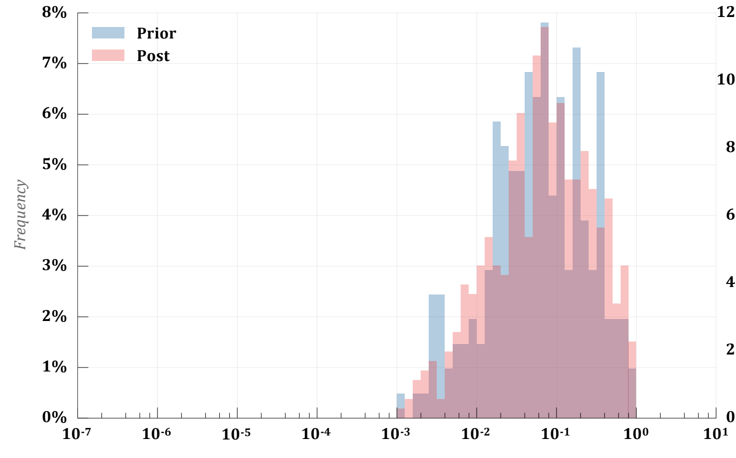
Appendix F2 Prior and posterior parameter distributions

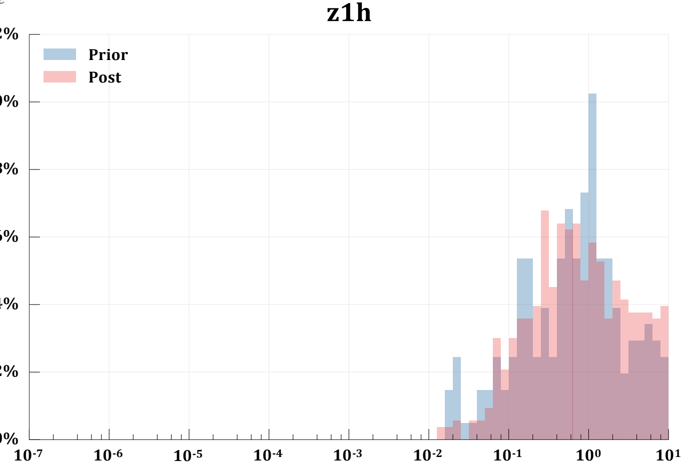

rch_ss
Prior
Post
Frequency
16%
14%
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}
Range

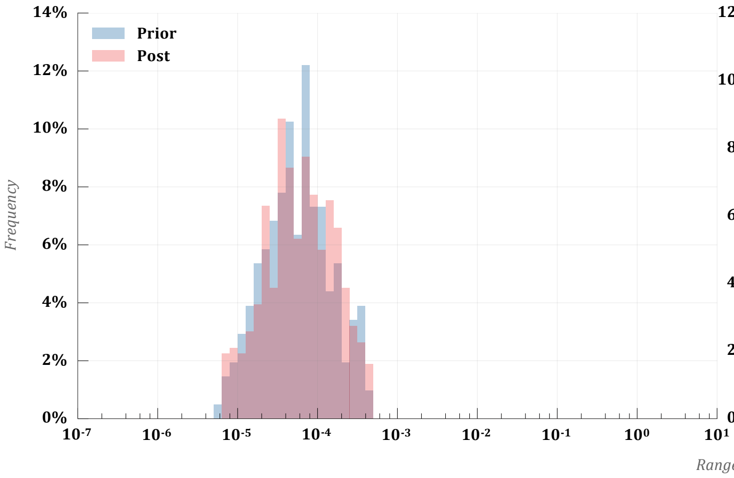

z10h
Prior
Post
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}

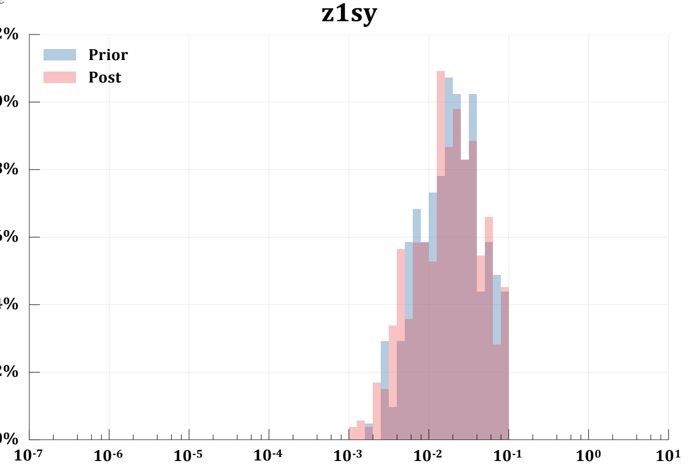

z10ss
Prior
Post
Frequency
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}
Range


z10sy
Prior
Post
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}

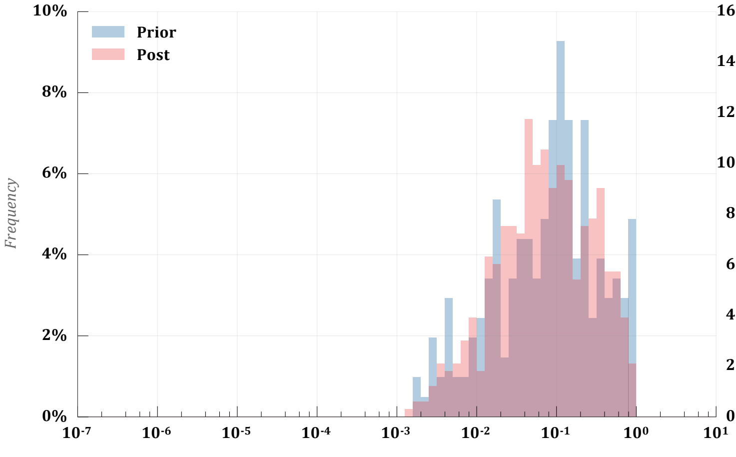

z10v
Prior
Post
Frequency
8%
7%
6%
5%
4%
3%
2%
1%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}
Range


z1h
Prior
Post
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}

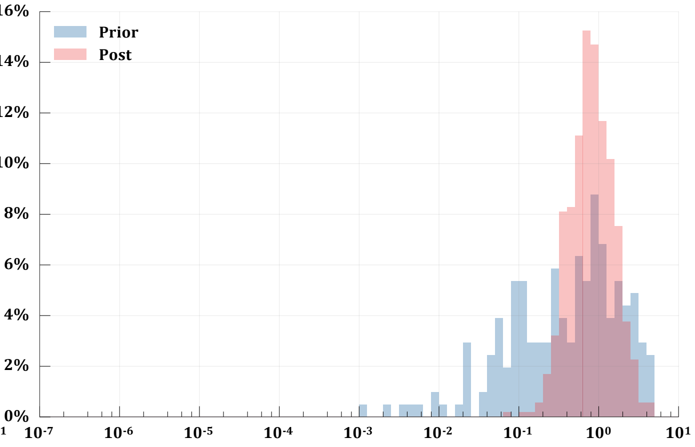

z1ss
Prior
Post
Frequency
14%
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}
Range


z1sy
Prior
Post
12%
10%
8%
6%
4%
2%
0%
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1}

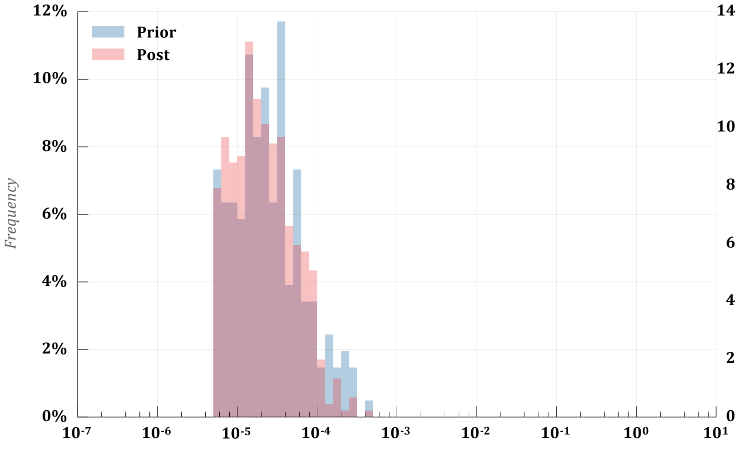
z1v



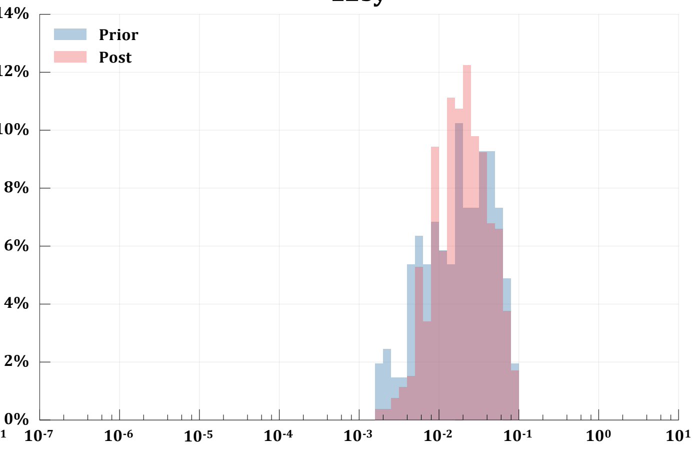
z2h



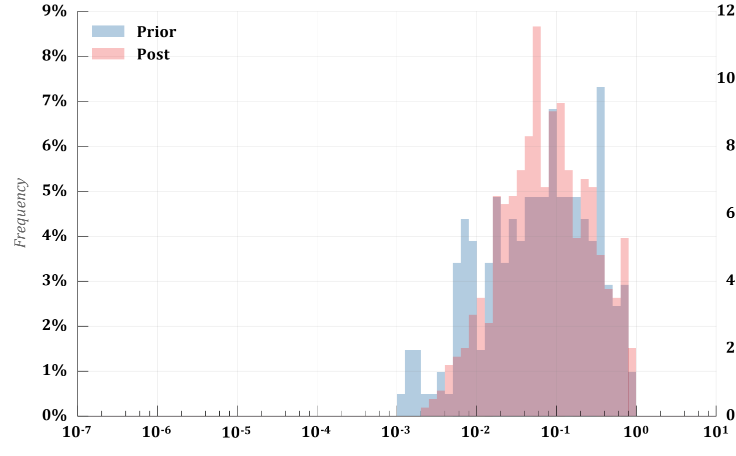
z2ss



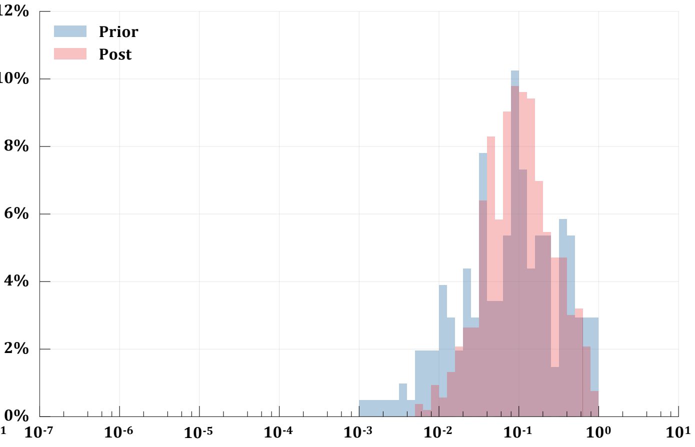
z2sy



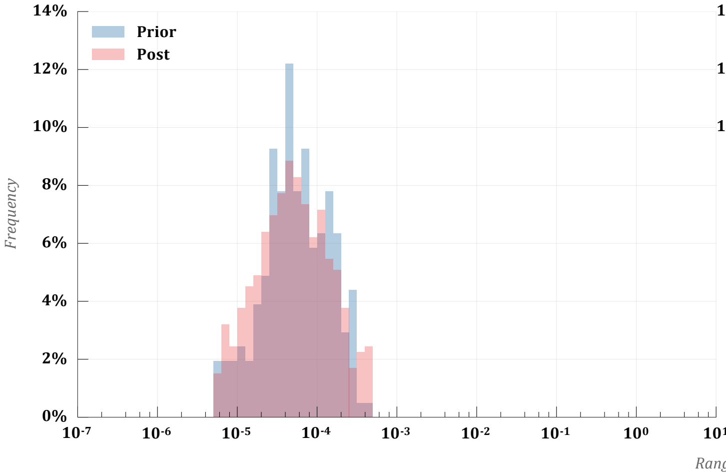
z2v



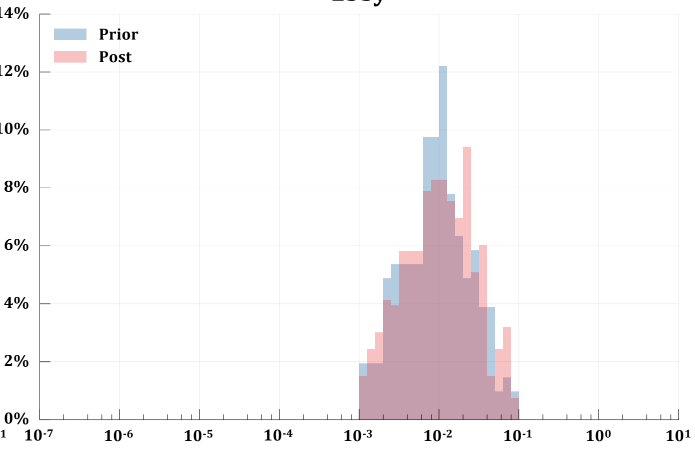
z3h

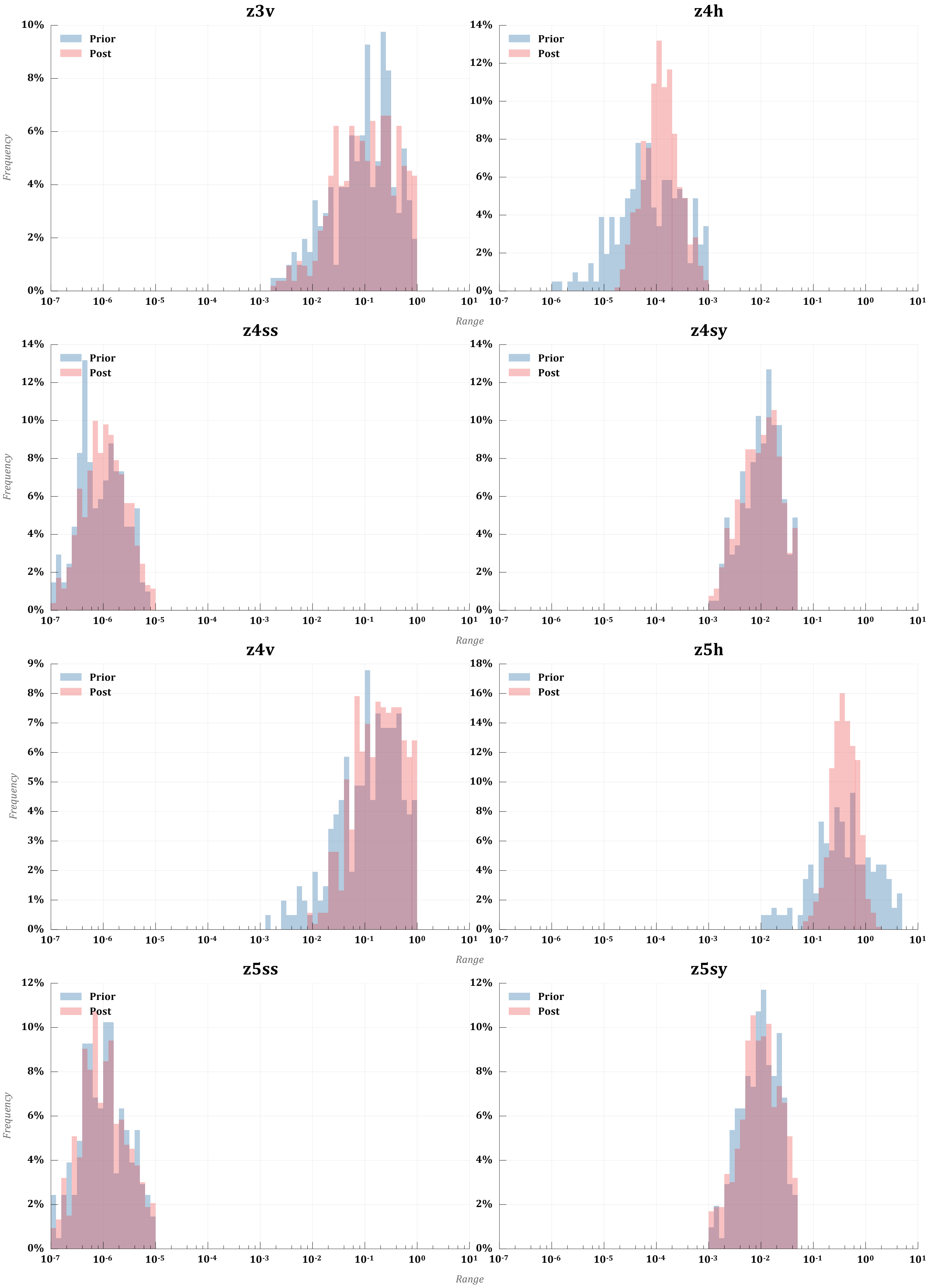


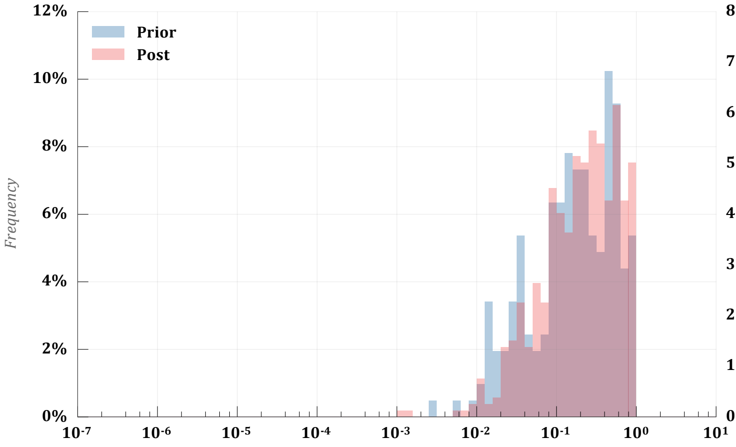
z3ss

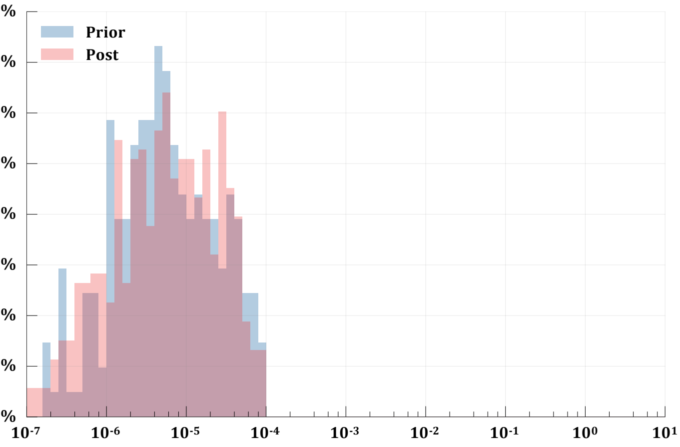


z3sy

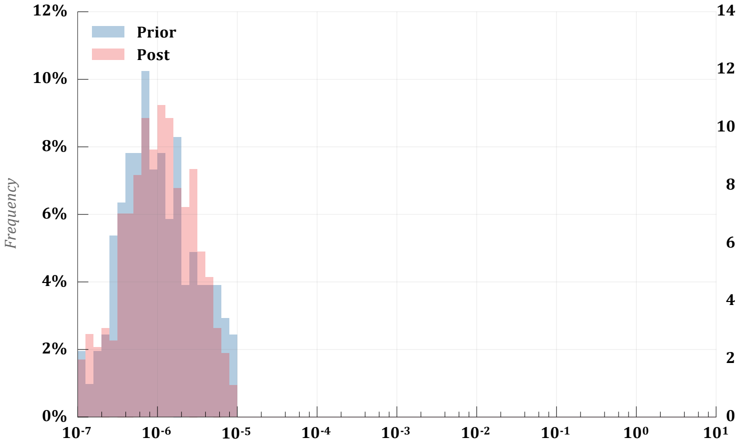


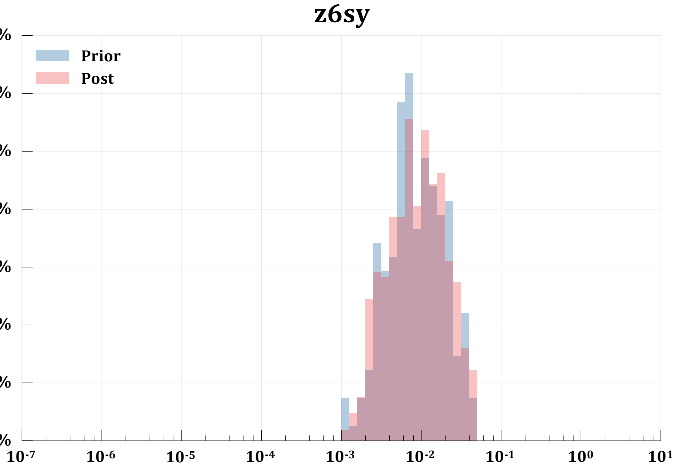

z3v
z4h
z4ss
z4sy
z4v
z5h
z5ss
z5sy
Prior
Post
Frequency
Range
0%
2%
4%
6%
8%
10%
12%
14%
16%
18%
1%
3%
5%
7%
9%
10-7
10-6
10-5
10-4
10-3
10-2
10-1
100
101


z5v

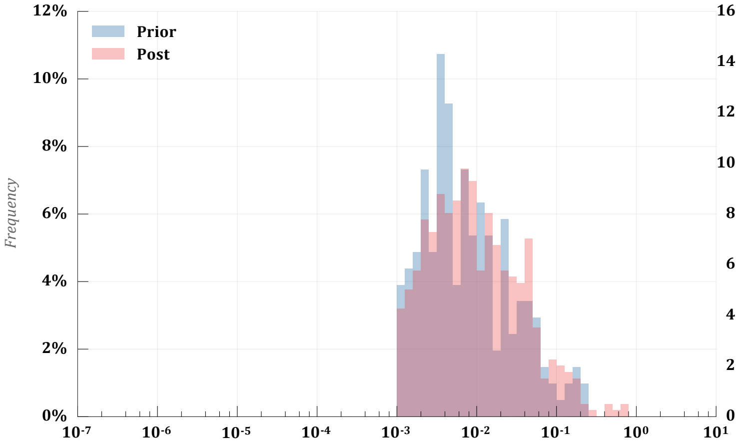

z6h

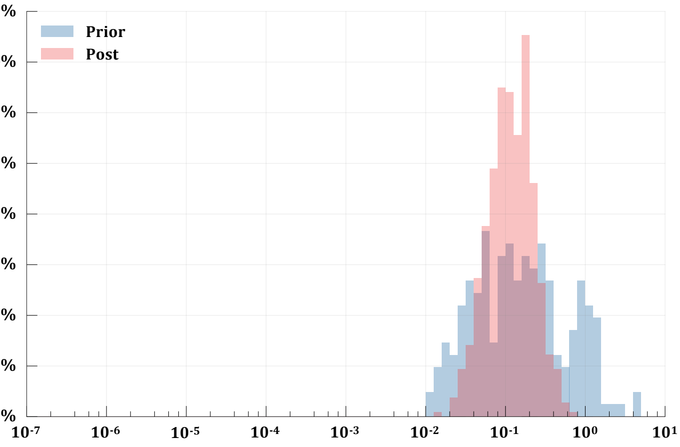
Range


z6ss

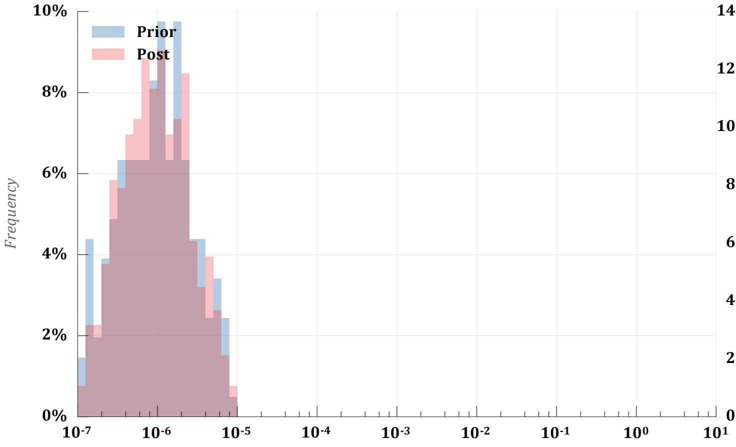

z6sy

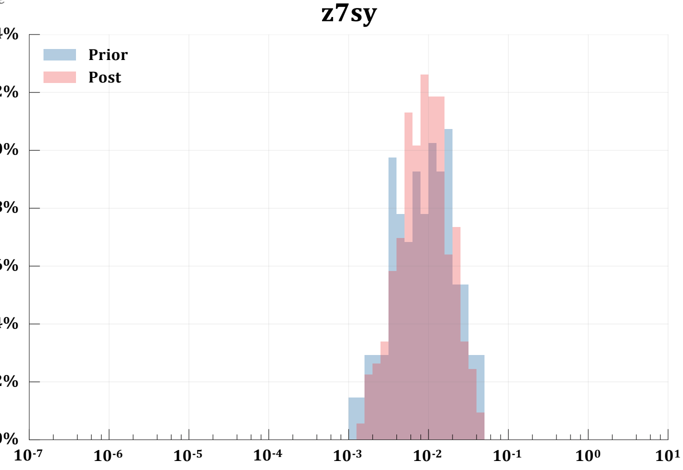
Range


z6v

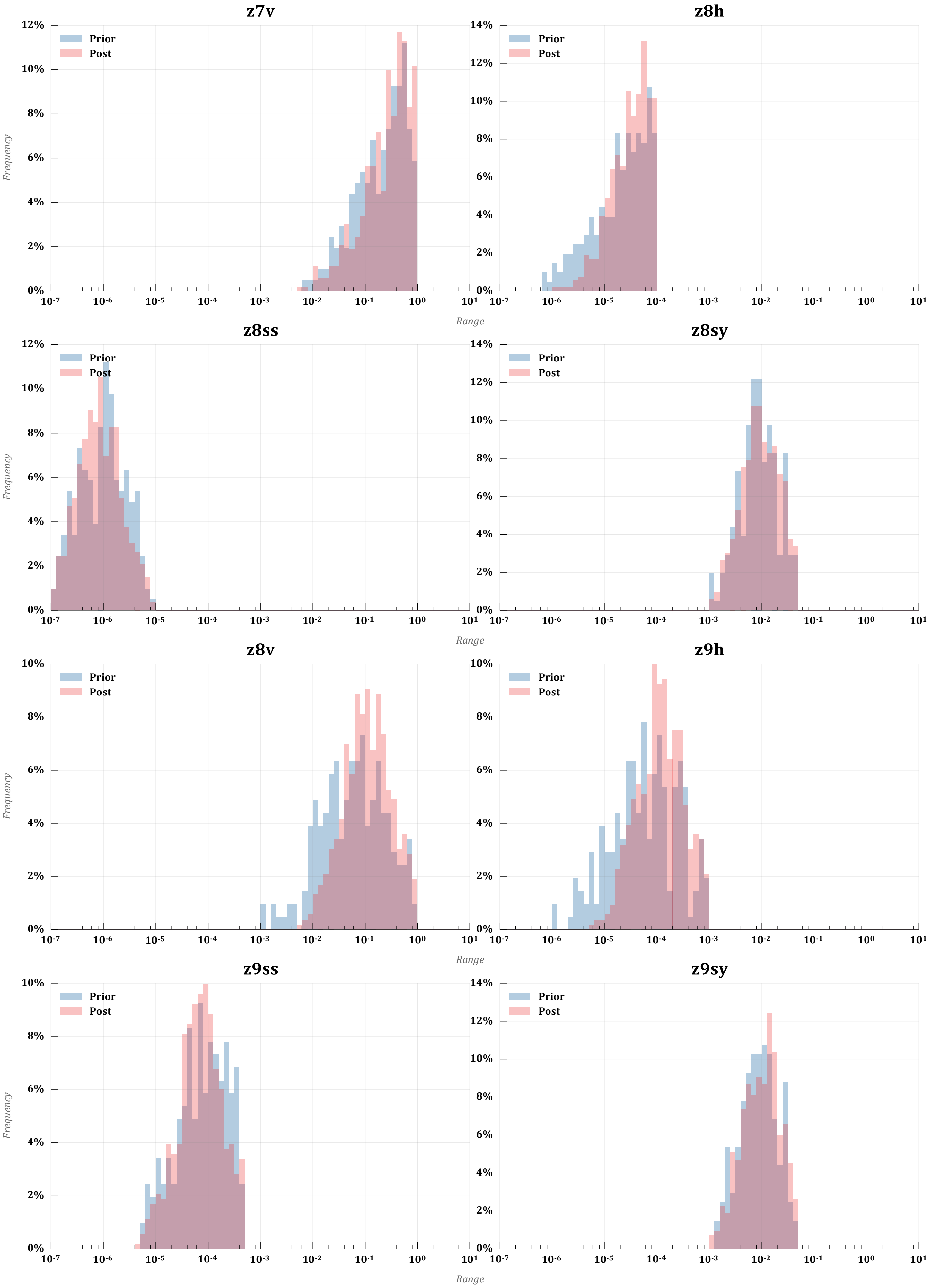

z7h

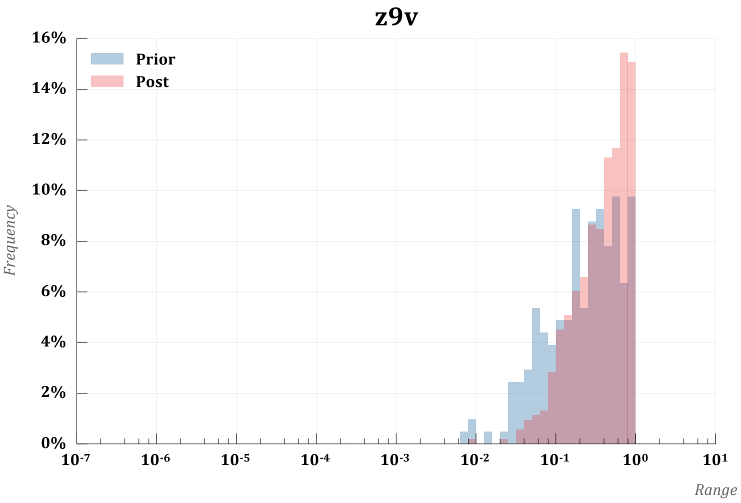
Range


z7ss

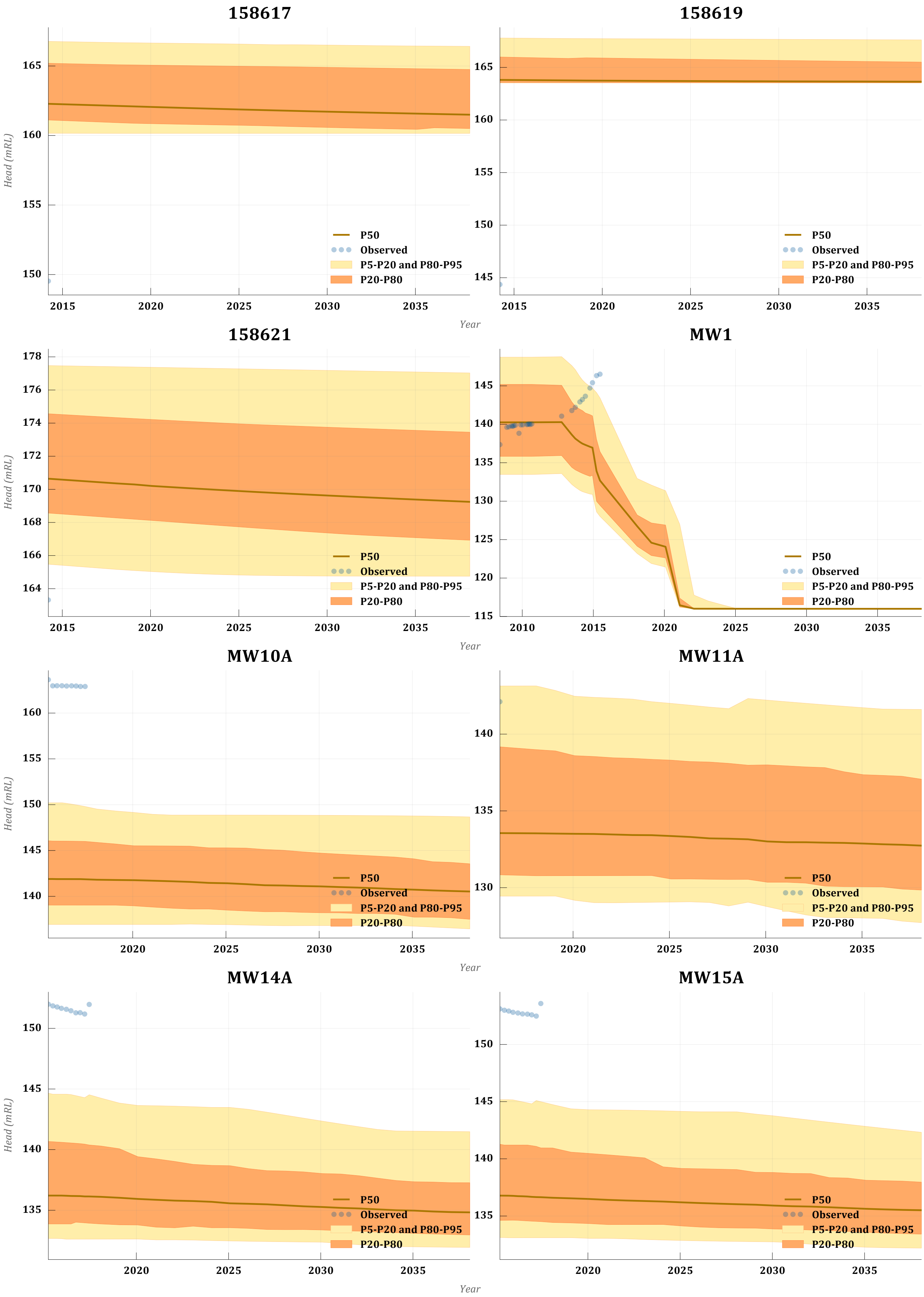

z7sy

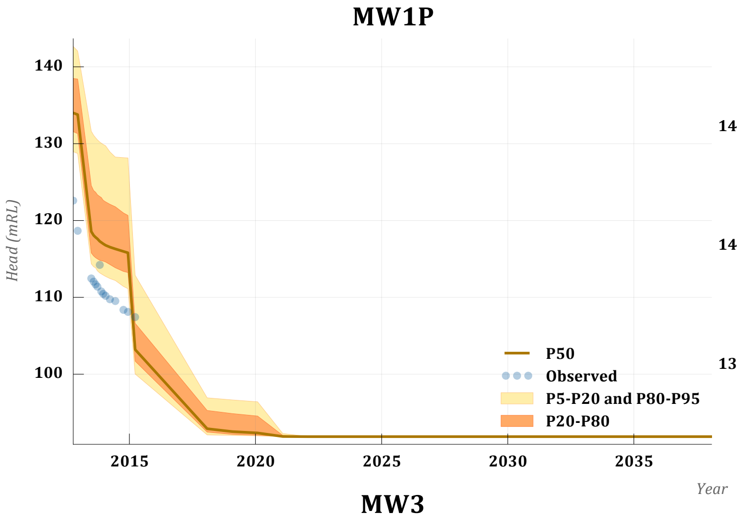
Range

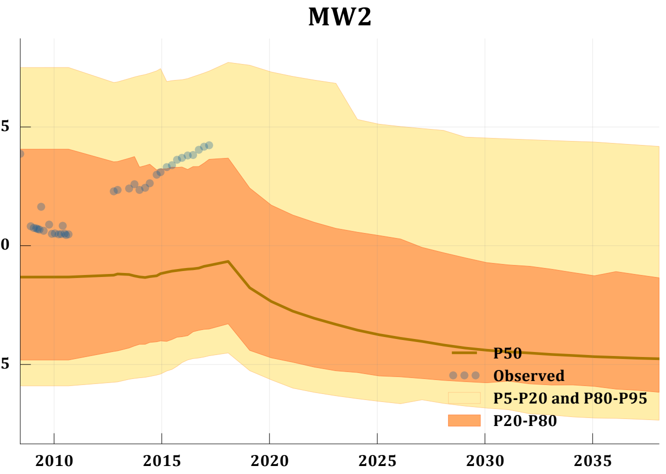

z7v
z8h
z8ss
z8sy
z8v
z9h
z9ss
z9sy
Prior
Post
Frequency
Range
0%
2%
4%
6%
8%
10%
12%
14%
10-7
10-6
10-5
10-4
10-3
10-2
10-1
100
101

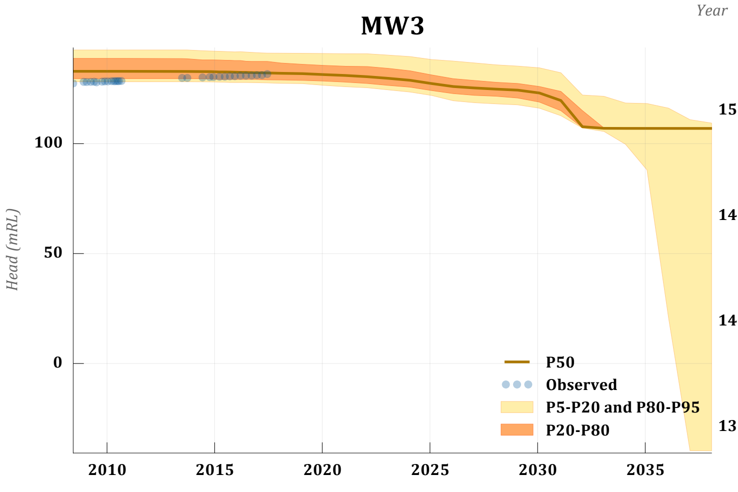

z9v
Prior
Post
Frequency
16%
14%
12%
10%
8%
6%
4%
2%
0%
10-7
10-6
10-5
10-4
10-3
10-2
10-1
100
101
Range

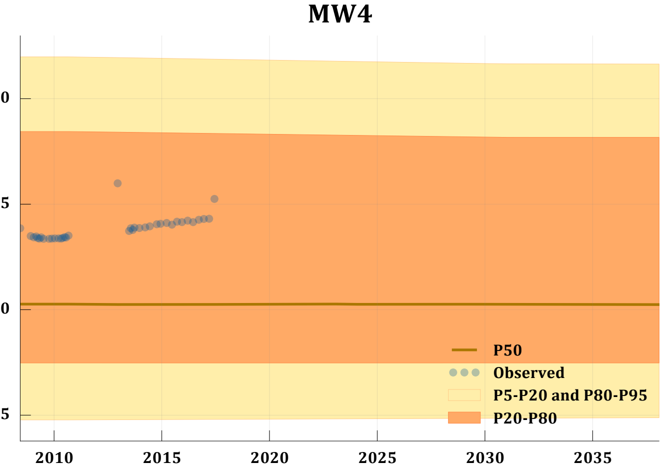
Appendix F3 Predictive uncertainty hydrographs

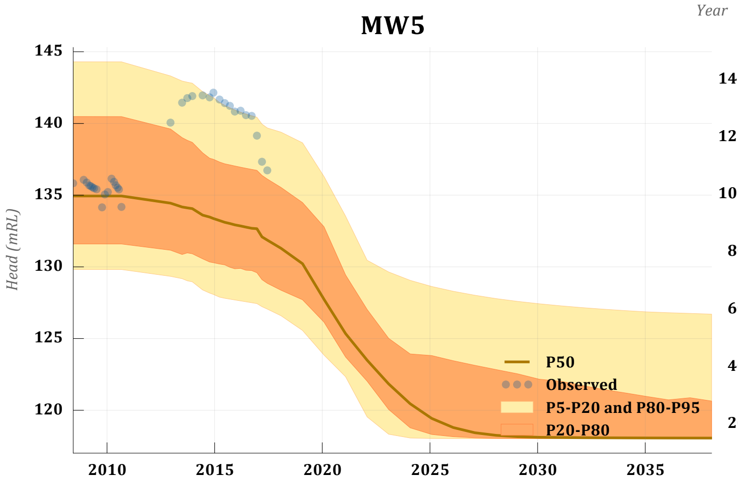

158617
165
160
155
150
2015
2020
2025
2030
2035
Head (mRL)
P50
Observed
P5-P20 and P80-P95
P20-P80
158619
165
160
155
150
145
2015
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80
Year
158621
178
176
174
172
170
168
166
164
2015
2020
2025
2030
2035
Head (mRL)
P50
Observed
P5-P20 and P80-P95
P20-P80
MW1
145
140
135
130
125
120
115
2010
2015
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80
Year
MW10A
160
155
150
145
140
2020
2025
2030
2035
Head (mRL)
P50
Observed
P5-P20 and P80-P95
P20-P80
MW11A
140
135
130
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80
Year
MW14A
150
145
140
135
2020
2025
2030
2035
Head (mRL)
P50
Observed
P5-P20 and P80-P95
P20-P80
MW15A
150
145
140
135
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80
Year

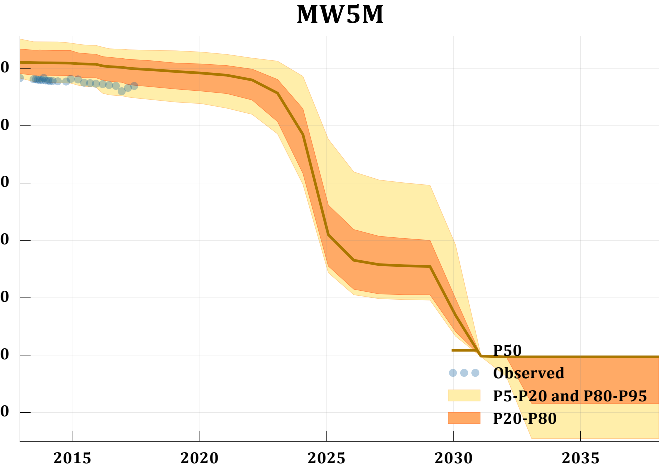

MW1P

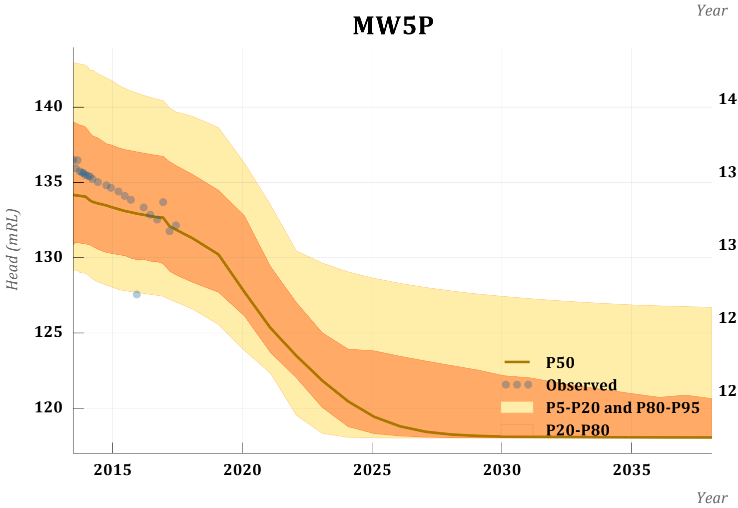

MW2

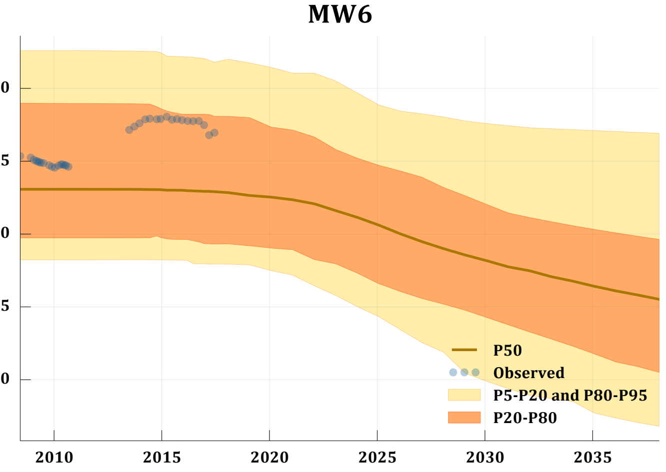

MW3

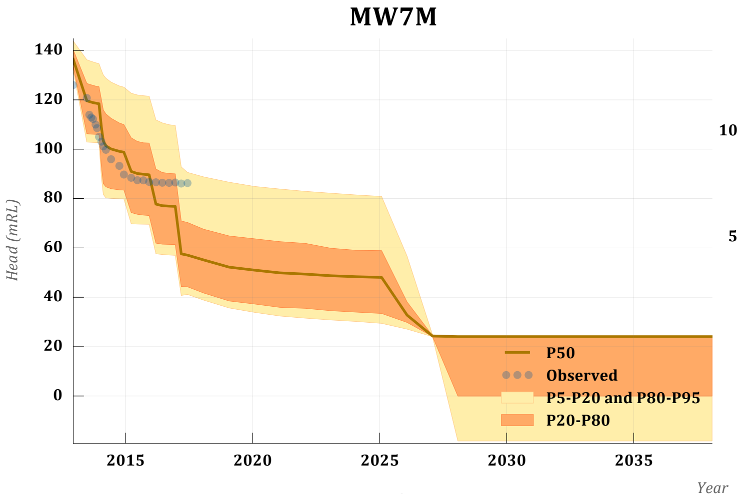

MW4

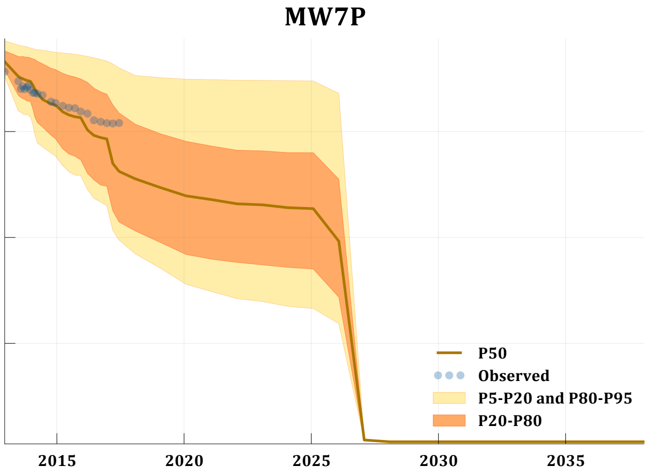

MW5

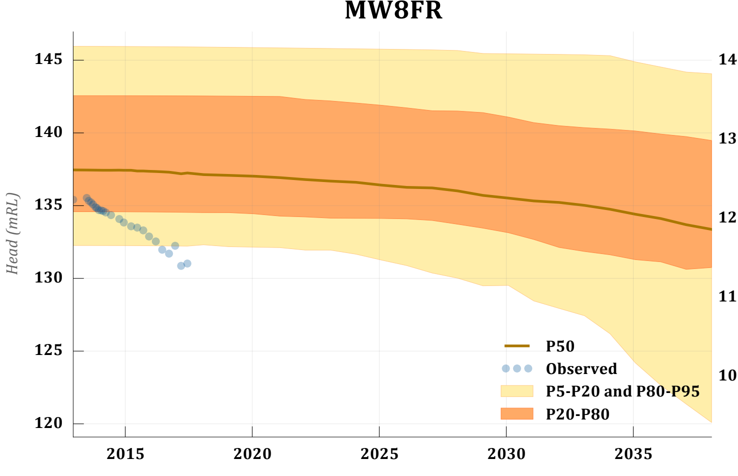

MW5M

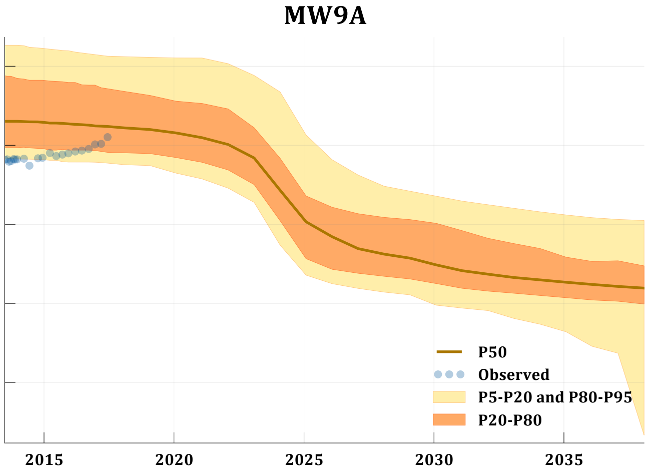

MW5P

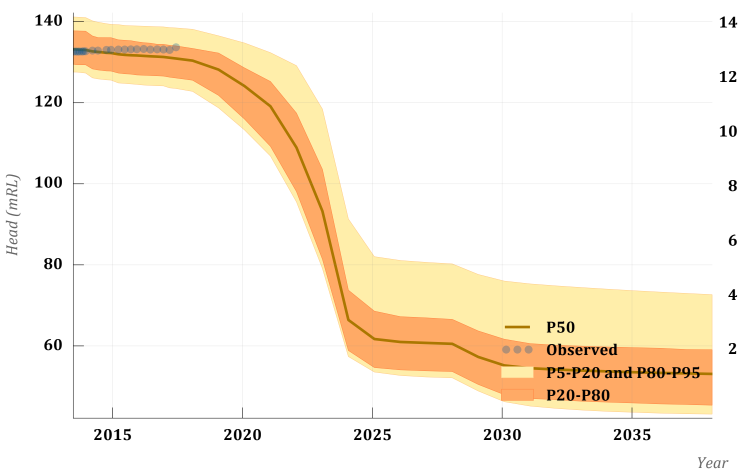

MW6

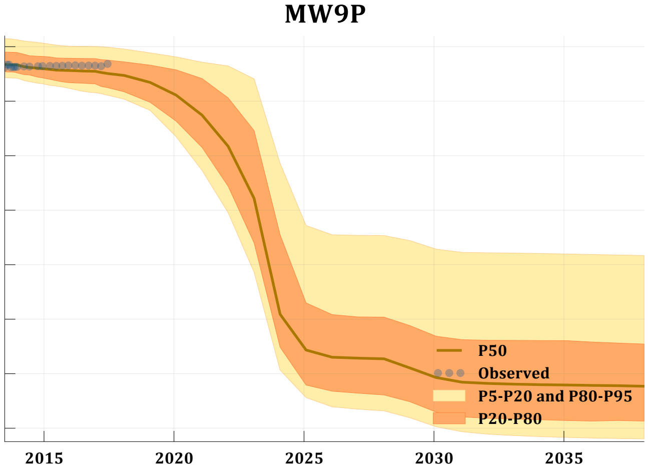

MW7M
Head (mRL)
140
120
100
80
60
40
20
0
2015
2020
2025
2030
2035
Year
P50
Observed
P5-P20 and P80-P95
P20-P80


MW7P
100
50
0
2015
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80


MW8FR
Head (mRL)
145
140
135
130
125
120
2015
2020
2025
2030
2035
Year
P50
Observed
P5-P20 and P80-P95
P20-P80


MW9A
140
130
120
110
100
2015
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80


MW9M
Head (mRL)
140
120
100
80
60
2015
2020
2025
2030
2035
Year
P50
Observed
P5-P20 and P80-P95
P20-P80


MW9P
140
120
100
80
60
40
20
0
2015
2020
2025
2030
2035
P50
Observed
P5-P20 and P80-P95
P20-P80