

MIDDLEMOUNT COAL MINE
WESTERN EXTENSION PROJECT (EPBC 2017/8130)
EPBC Act Preliminary Assessment Documentation

Attachment E
Groundwater Assessment





Australasian Groundwater and
Environmental Consultants Pty Ltd



Report on

Middlemount Coal Mine Western Extension Project

Groundwater Assessment

Prepared for
Middlemount Coal Pty Ltd

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Middlemount Coal Mine Western Extension Project

Groundwater Assessment

1 Introduction

Middlemount Coal Pty Ltd (MCPL) currently operates the Middlemount Coal Mine located approximately 3 kilometres (km) to the south-west of the Middlemount township within the Isaac Regional Local Government Area, Queensland. MCPL propose to seek Queensland Government and Commonwealth Government approval for changes to the approved Middlemount Coal Mine, herein referred to as the Western Extension Project (the Project). The location of Middlemount Coal Mine is shown in Figure 1.1.

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

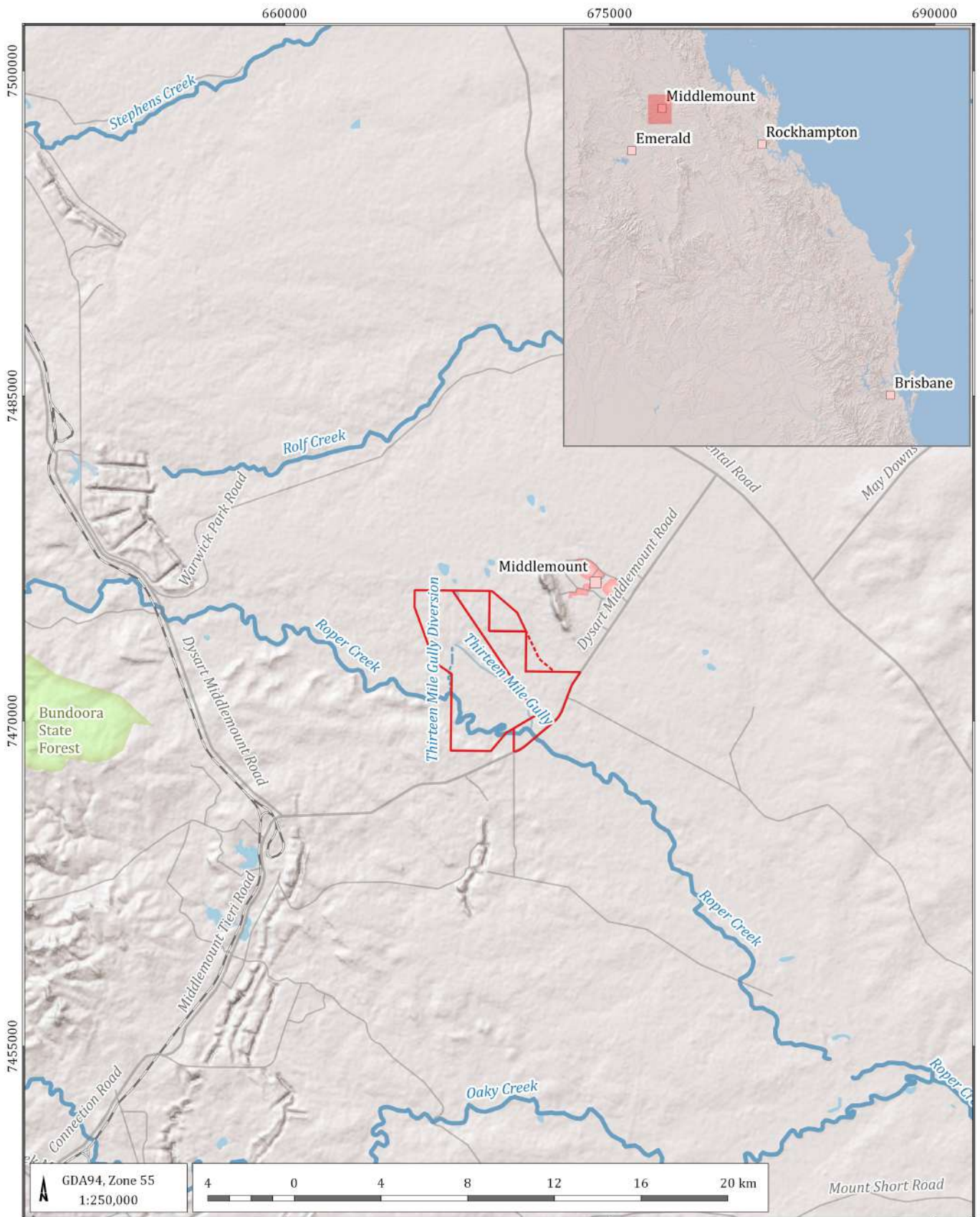
- extension of the open cut pit within ML 70379 to the north-west;
- continued extraction of run of mine (ROM) coal up to approximately 5.7 million tonnes per annum (Mtpa) using conventional open cut mining equipment;
- placement of waste rock in existing emplacements, expanded emplacements (including the Eastern Dump) and within the mined-out void;
- continued backfilling of coarse rejects into the pit within spoil, and temporary storage of fine rejects from coal crushing and washing in existing tailings storage facility cells for drying and reclaim for in-pit co-disposal;
- progressive development of sediment dams, pipelines and other water management equipment and structures (including levees and realignment of an existing diversion structure);
- progressive development of new haul roads and internal roads;
- continued development of soil stockpiles, laydown areas and borrow areas;
- continued use of existing and approved supporting mine infrastructure (including a coal handling and preparation plant [CHPP] and ROM and product stockpiles);
- continued rail transport of coal products to the Dalrymple Bay Coal Terminal, Abbott Point Coal Terminal or Wiggins Island Coal Export Terminal for export;
- extension of the approved mine life by approximately six years (to 2037); and
- a change to the final landform at the Middlemount Coal Mine for the end of the mine life to include two final voids.

The following groundwater assessment report has been produced by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to support the groundwater assessment for an EA amendment to 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.

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 groundwater assessment (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.



LEGEND

- | | |
|---|---|
| Populated place | Reserve |
| Mining Lease boundary (ML) | Road |
| Mining Lease Application boundary (MLA) | Watercourse |
| Built up area | Drainage feature |
| Water area | Rail |

Middelmount Coal Mine Western Extension Project
(G1840D)

Middelmount Coal mine location



DATE
05/04/2018

FIGURE No:
1.1

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.

1.2 Background to the report

A groundwater assessment was previously undertaken in 2010 (Parsons Brinkerhoff, 2010a) to support the Middlemount Mine Stage 2 project. Site specific hydrogeological, geological, and climatic data were used to inform the groundwater assessment. Additional data from the surrounding region was sourced from the Queensland Department of Natural Resources and Mines (DNRM) groundwater database (GWDB) and the Lake Lindsay Environmental Study – groundwater assessment (Parsons Brinkerhoff, 2010b), which was conducted immediately to the south of ML 70379 in 2005.

The groundwater data obtained from site were used to develop an eight-layer numerical groundwater flow model in 2010 (Parsons Brinkerhoff, 2010a). The model was used during the Middlemount Mine Stage 2 groundwater assessment to predict the rate of groundwater inflow to the open pit and the drawdown associated with mine dewatering.

The 2010 groundwater assessment concluded that shallow groundwater flow and recharge is expected to be limited by significant clay deposits within the alluvium and Tertiary units. Groundwater aquifers were identified with more sandy units where present within the Tertiary units, where groundwater was brackish to saline. Similarly, groundwater within the Permian strata is brackish to saline.

The 2010 groundwater model predicted:

- drawdown within the weathered Tertiary and weathered Permian zone would be limited in extent and during the active mining period is expected to remain within the Project boundaries;
- drawdown within the coal seams would propagate much further and was estimated to extend south of the Stage 2 mine area by up to 10 km during and post-mining; and
- the nearby creeks interact only intermittently with the groundwater system.

1.3 Report structure

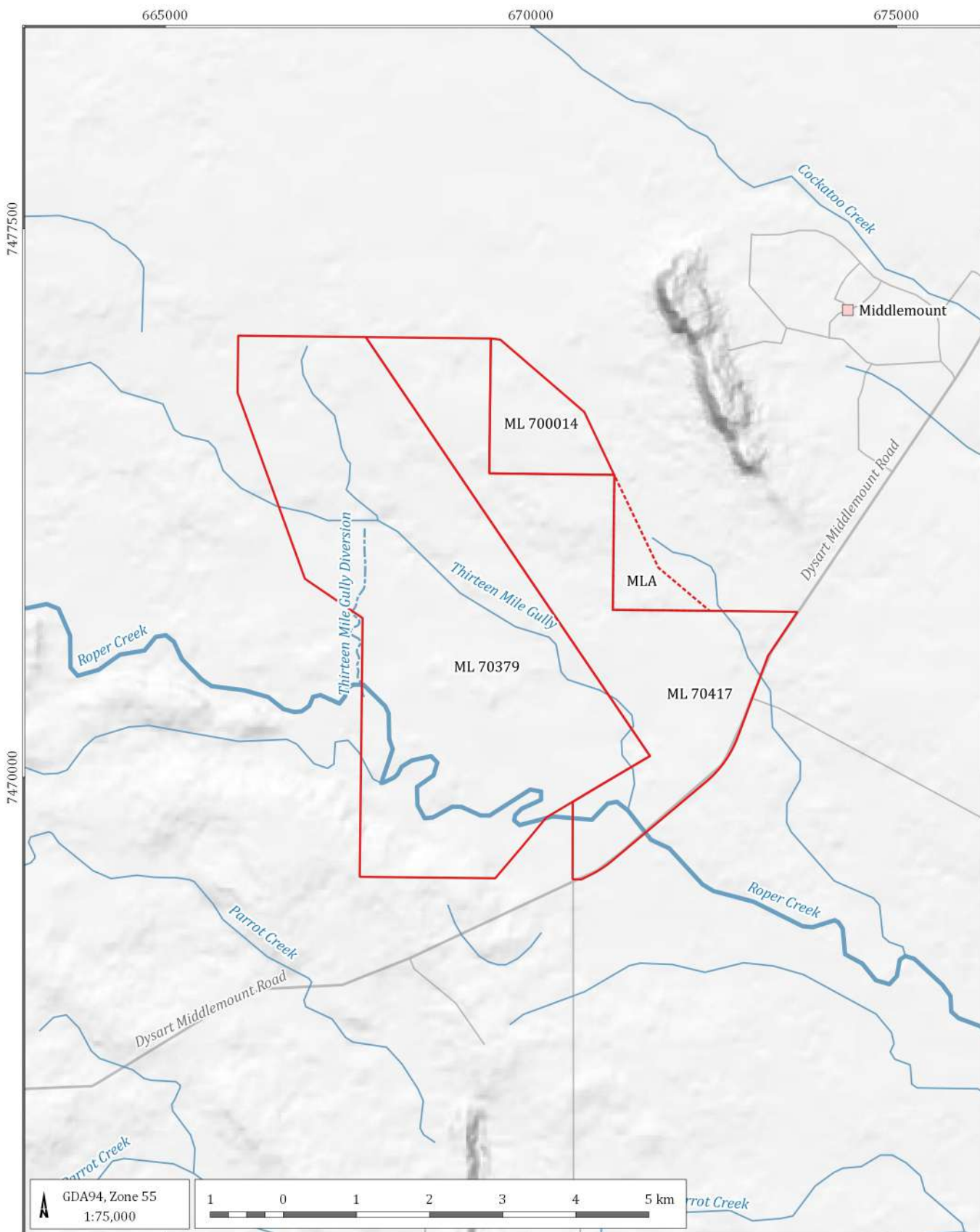
This report is structured as follows:

- **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 MLA 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 Western Extension 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 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. 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

- PopPlaces-clipped
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- ▬ Major road
- ▬ Watercourse
- - - Drainage feature

Middelmont Coal Mine Western Extension Project
(G1840D)

Middelmont Coal Mine-mining leases



DATE
05/04/2018

FIGURE No:
2.1

3 Queensland regulatory framework for groundwater

The following sections summarise Queensland groundwater legislation and policy relevant to the Middelmount 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 Resource Plans (WRP). A WRP 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 WRP.

Groundwater Management Areas (GMAs) and their component Groundwater Management Units (GMUs) are defined within a WRP. Authorisation is required from the DNRM to take water from a regulated GMA or GMU for specified purposes. The specified purposes are defined under a WRP, 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 DEHP 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 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 (associated water).

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.

The aim of the Associated Water Licence (AWL) is to facilitate the management of the resource in terms of monitoring and mitigation requirements. In addition, AWLs also provide security (via make good clauses) to other parties potentially affected by the removal of groundwater from the aquifers.

3.2 Fitzroy Basin water resource and operation plans

The Middlemount Coal Mine is located within 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 WRP 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).



LEGEND

- Mining Lease (ML70379, ML700014, ML70379, MLA)
- Fitzroy Basin
- ▲ Weir
- △ Dam

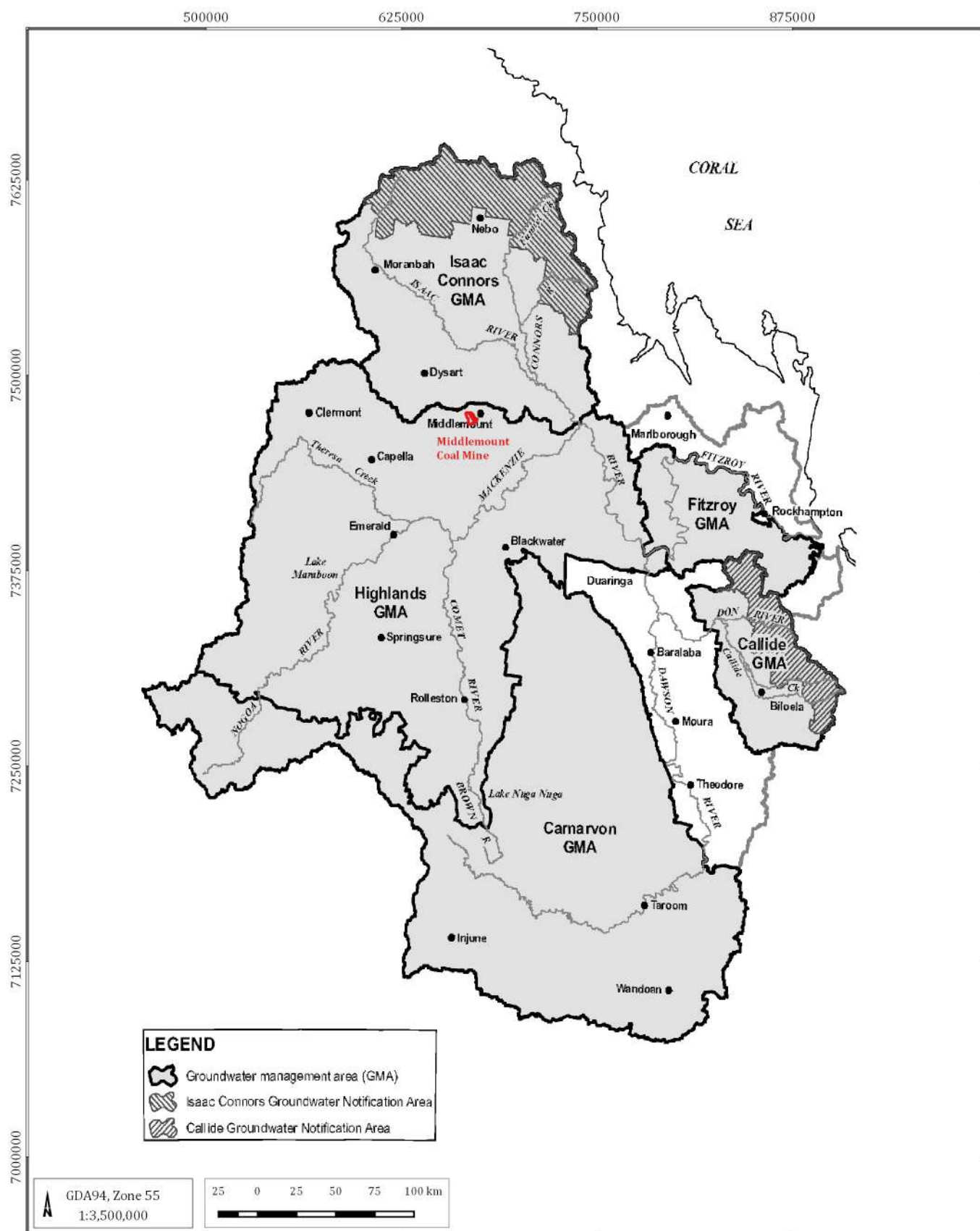
Middlemount Coal Mine Western Extension Project
(G1840D)

Water Plan (Fitzroy Basin) 2011



DATE
05/04/2018

FIGURE No:
3.1



LEGEND

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

Middelmount Coal Mine Western Extension
Project(G1840D)

**Highlands groundwater management
area**



DATE
05/04/2018

FIGURE No:
3.2

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) Policy 2009 (EPP Water, [Queensland Government, 2009]) 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.

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

Depth (±30 m)	Deep > 30 m			Shallow < 30 m		
Percentile	20 th	50 th	80 th	20 th	50 th	80 th
Electrical Conductivity (µS/cm)	3,419	6,100	16,000	498	2,150	8,910
Hardness (as CaCO₃)	359	919	3,208	163	674	2,228
pH	7.4	7.8	8.03	7.1	7.75	8.1
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 CaCO₃	188	330	650	187	536	878
Nitrate	0.01	2.15	14.92	0	0.95	5.3

Depth (±30 m)	Deep > 30 m			Shallow < 30 m		
Percentile	20 th	50 th	80 th	20 th	50 th	80 th
Silica	16	25	36	21	36	52
Fluorine	0.02	0.155	0.4	0.1	0.28	0.5
Iron	0	0.05	0.246	0	0.03	0.14
Manganese	0	0.05	0.291	0	0.01	0.16
Zinc	0.01	0.025	0.317	0	0.015	0.06
Copper	0.017	0.03	0.03	0	0.01	0.03
Sodium Absorption Ratio	10.5	15.6	24.65	4.37	10.85	18.21
Residual Alkali Hazard (meq/L)	0	0.24	6.25	0	0	2.3
Redox (mV)	ID	ID	ID	ID	ID	ID

Notes: All values as milligrams per litre (mg/L) unless specified.
 $\mu\text{S}/\text{cm}$ = microsiemens per centimetre
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 21 May 2018. 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 (C33 to C41) 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
C32	Groundwater Groundwater 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 .
C33	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.
C34	Subject to requirements of Condition C32 , 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 within twenty-eight (28) days of receiving the analysis result.

Condition number	Condition
C35	Groundwater levels affected by the mining activities must be monitored at the locations and frequencies defined in Table C9: Groundwater Levels .
C36	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.
C37	If the results of the investigation undertaken in accordance with Condition C36 identify that the groundwater fluctuations are a result of mining activities, the holder of the environmental authority must notify the administering authority and provide a copy of a report detailing the findings and outcomes of the investigation within seven (7) days of completing the investigation.
C38	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.
C39	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.
C40	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 <i>Water Quality Sampling Manual</i> .

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 the Environment and Energy (DoEE). The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance (MNES). Under the 2013 amendment to the EPBC Act, impacts on groundwater resources were included, and are known as the 'water trigger'. The Project has been referred to the Commonwealth Minister for the Environment and has been determined to be a 'controlled action' under the water trigger provisions and will be assessed by preliminary documentation for approval under the EPBC Act.

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 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 Project.

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 Queensland Department of Science, Information Technology and Innovation (DSITI), 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 in December and February. The mean annual rainfall is 616 millimetres (mm), while the evaporation rate is 2,027 mm and the potential evapotranspiration rate is 1,659 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 - 2017

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total annual
Mean max temp (°C)	33.4	32.7	31.6	29.3	26.2	23.4	23.3	25.1	28.1	30.8	32.4	33.5	-
Mean rainfall (mm) -	111.8	98.1	65.8	32.1	28.9	29.9	23.7	18.0	17.4	34.9	57.0	98.0	615.7
Mean evaporation (mm)	224.6	183.4	190.8	150.1	117.7	96.3	104.2	131.2	170.4	208.0	219.2	230.5	2,026.5
Potential Evapotranspiration (mm)	175.1	144.6	147.2	120.9	98.3	80.8	89.4	111.2	138.3	170.1	177.5	185.7	1639.1

Figure 4.1 presents SILO rainfall data between 1901 and 2017, 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).

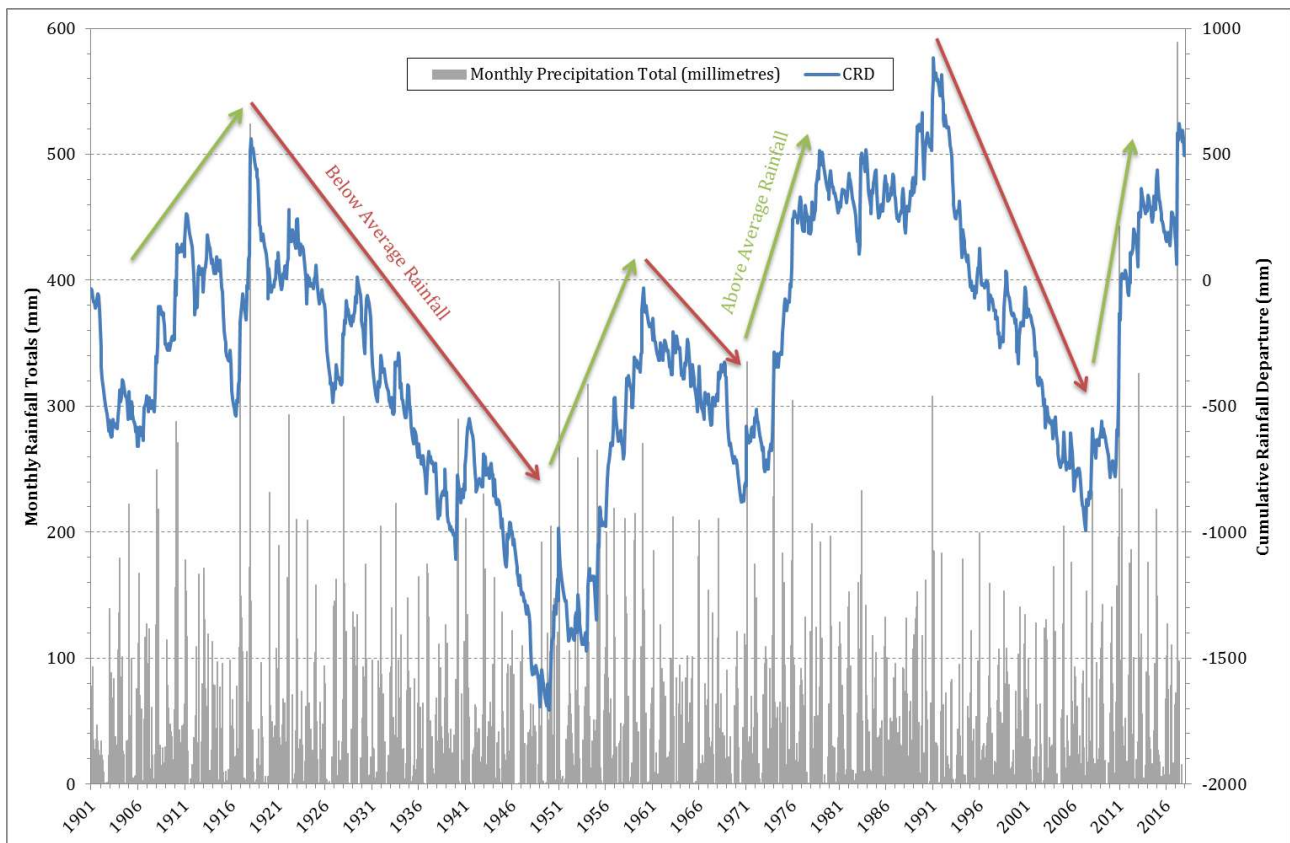


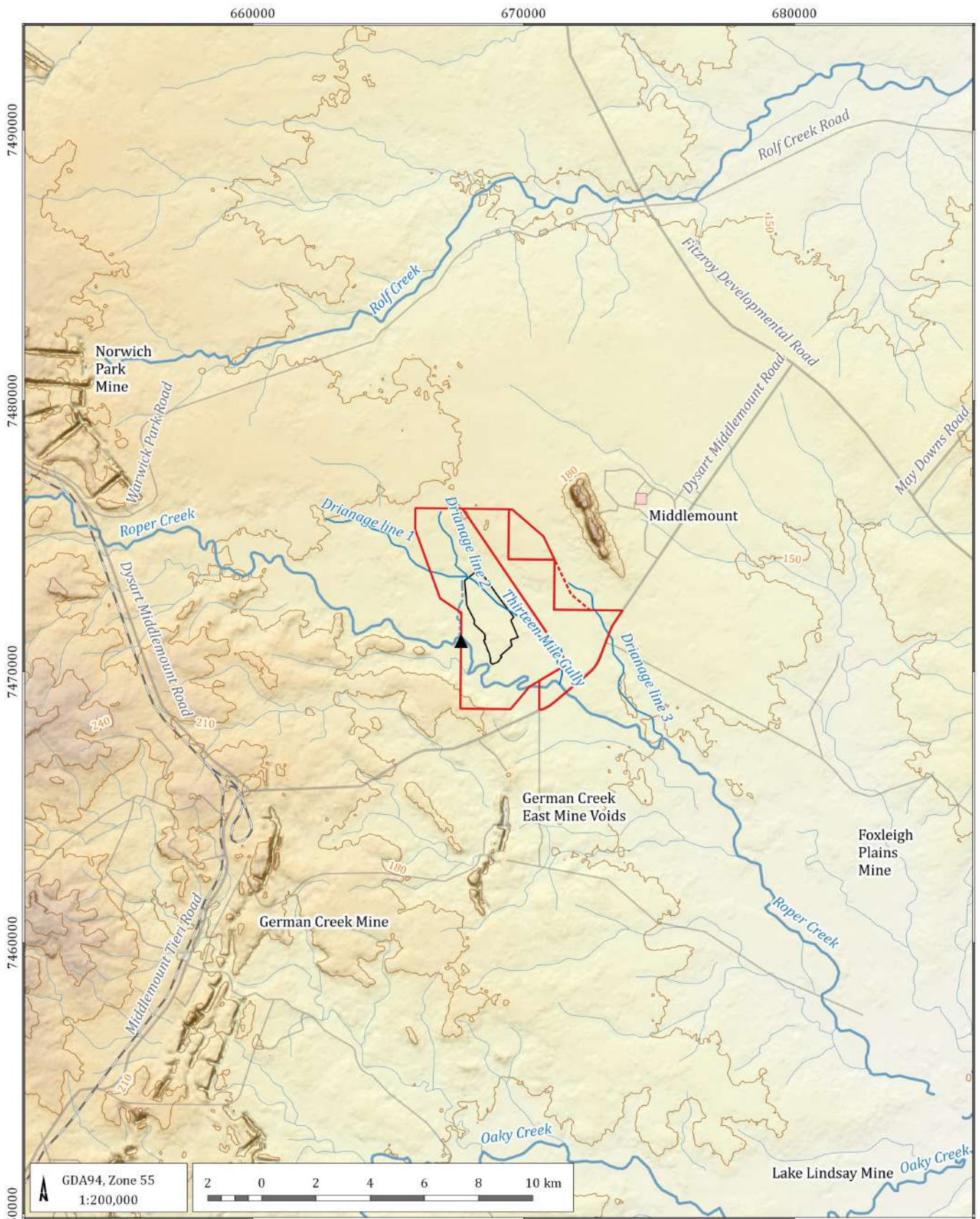
Figure 4.1 Monthly rainfall and cumulative rainfall departure – SILO Data for Middlemount Coal Mine 1901 - 2017

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 eastern boundary of ML 70379 in late 2014 (i.e. Thirteen Mile Gully Diversion). 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.

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.



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Mine pit footprint, 2017
- Road
- Watercourse
- Drainage feature
- Rail
- Stream gauge station

Terrain elevation (mAHD)

- 100
- 150
- 200
- 250
- 300
- 350
- Elevation contour (30 m interval)

Middelmont Coal Mine Western Extension Project (G1840D)

Terrain, drainage and stream gauge location within study area



DATE
10/04/2018

FIGURE No:
4.2

4.2.1 Surface water data availability

MCPL operate a gauging station (Ref 1) in Roper Creek, located just upstream of the confluence with the Thirteen Mile Gully diversion (Figure 4.2). The Ref 1 gauging station was installed in December 2012. Stream flow data is available for the period between July 2014 and August 2017. Details about the Ref 1 gauging station are provided below:

- data record commenced - 16/07/2014;
- coordinates and elevation – 667,484 mE; 7,471,112 mN (MGA94 Zone 55); 177 mAHD; and
- catchment area - 305.8 square kilometres (km²).

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.

DNRM 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.

The proponent owns all land within the footprint of the current and proposed open cut mining operations (ML 70379, ML 70417, and ML 700014). Portions of the land owned by the proponent are released for cattle grazing.

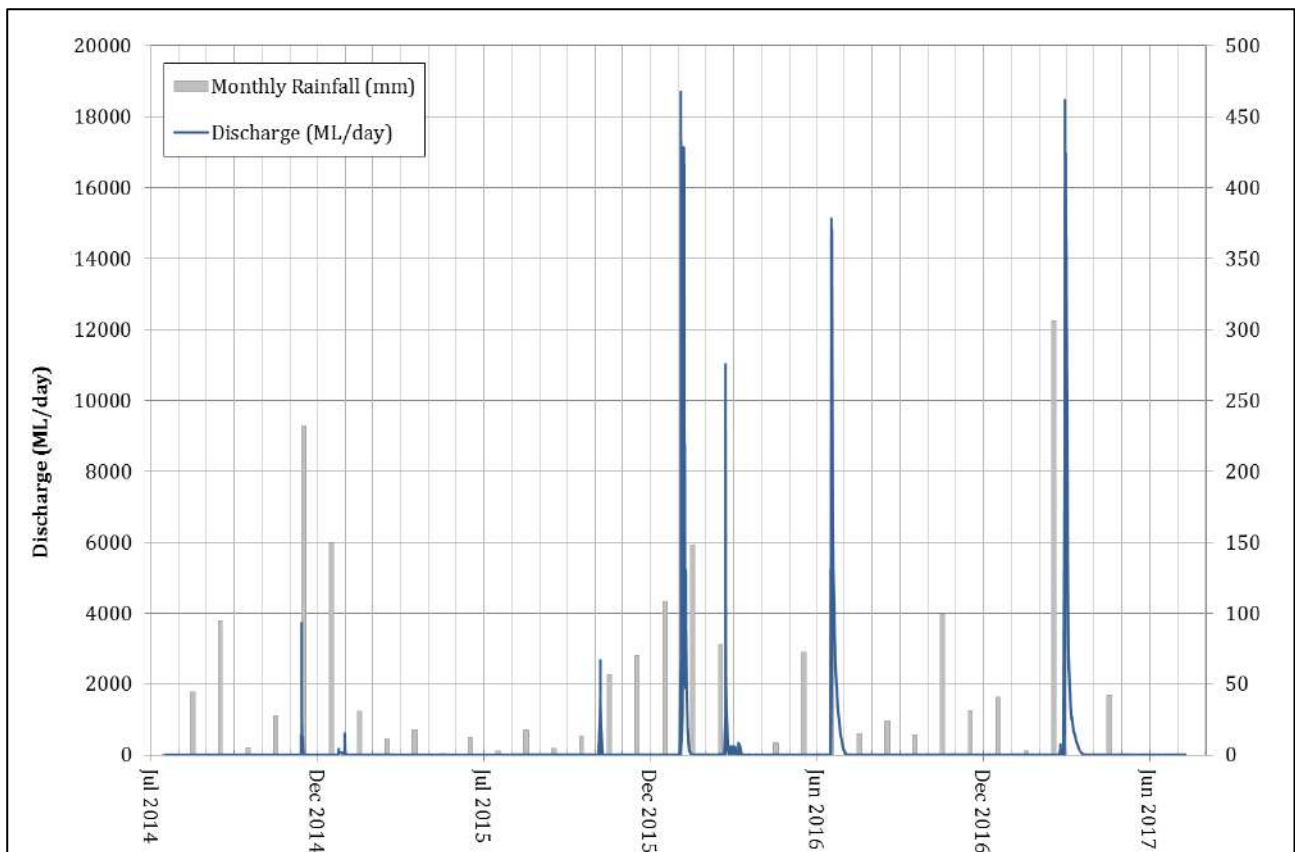


Figure 4.3 MCPL Roper Creek gauging station (Ref 1)

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;
- geological model surfaces for the Middlemount Coal Mine;
- geological data from registered bores held on the DNRM GWDB; and
- publicly available geological mapping (St Lawrence 1:250,000 map sheet) and reports.

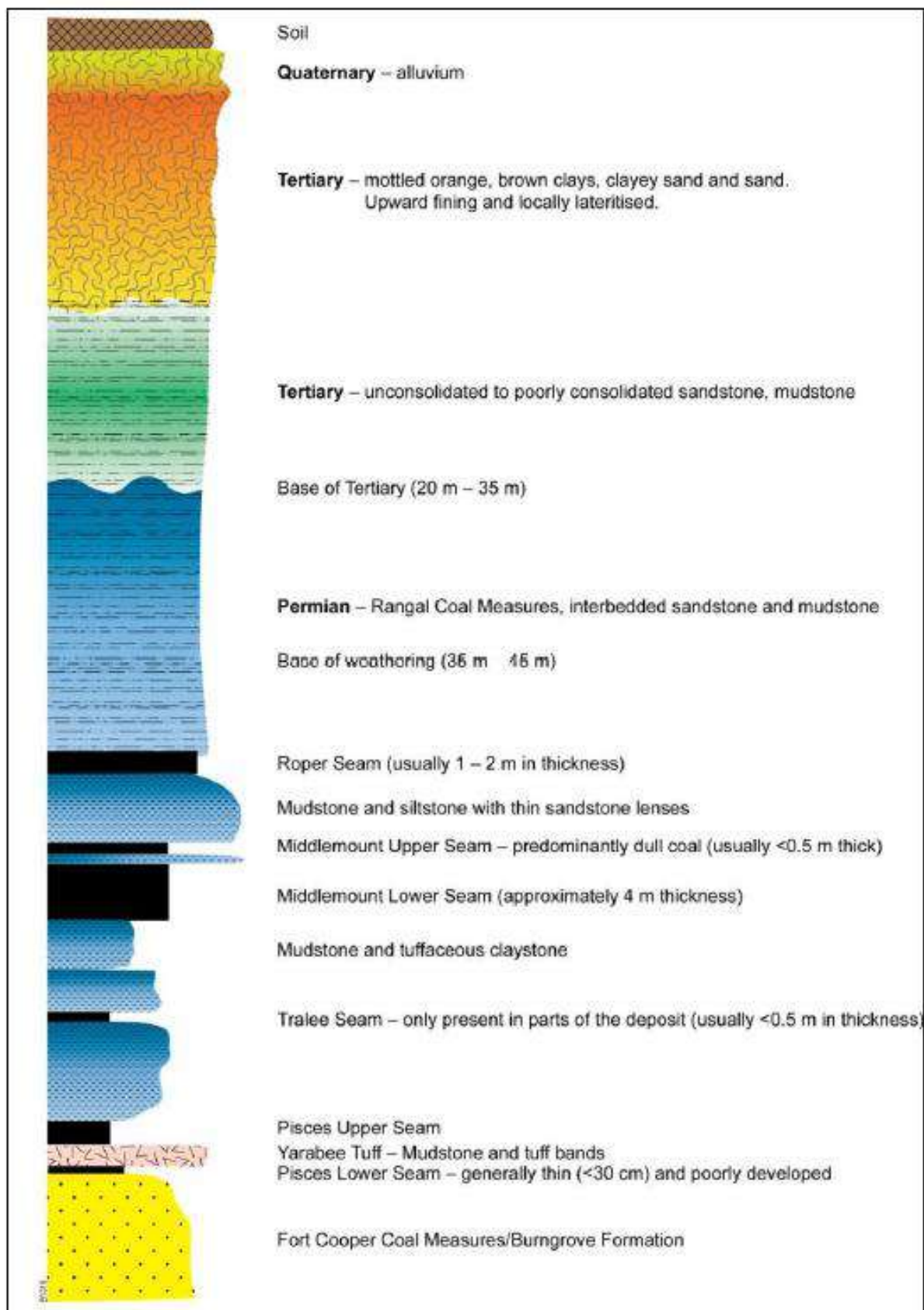
MCPL has undertaken exploration drilling across the Middlemount Coal Mine tenements. However, targeted exploration continues to define product coal structure and quality within the proposed expansion area. Exploration drilling has confirmed the geological units present in the ML areas and in the surrounds. 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 DNRM and MCPL for the modelled area were analysed to provide elevations of the major stratigraphic interfaces. The DNRM 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 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 collectively 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 surface 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 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 these units 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.

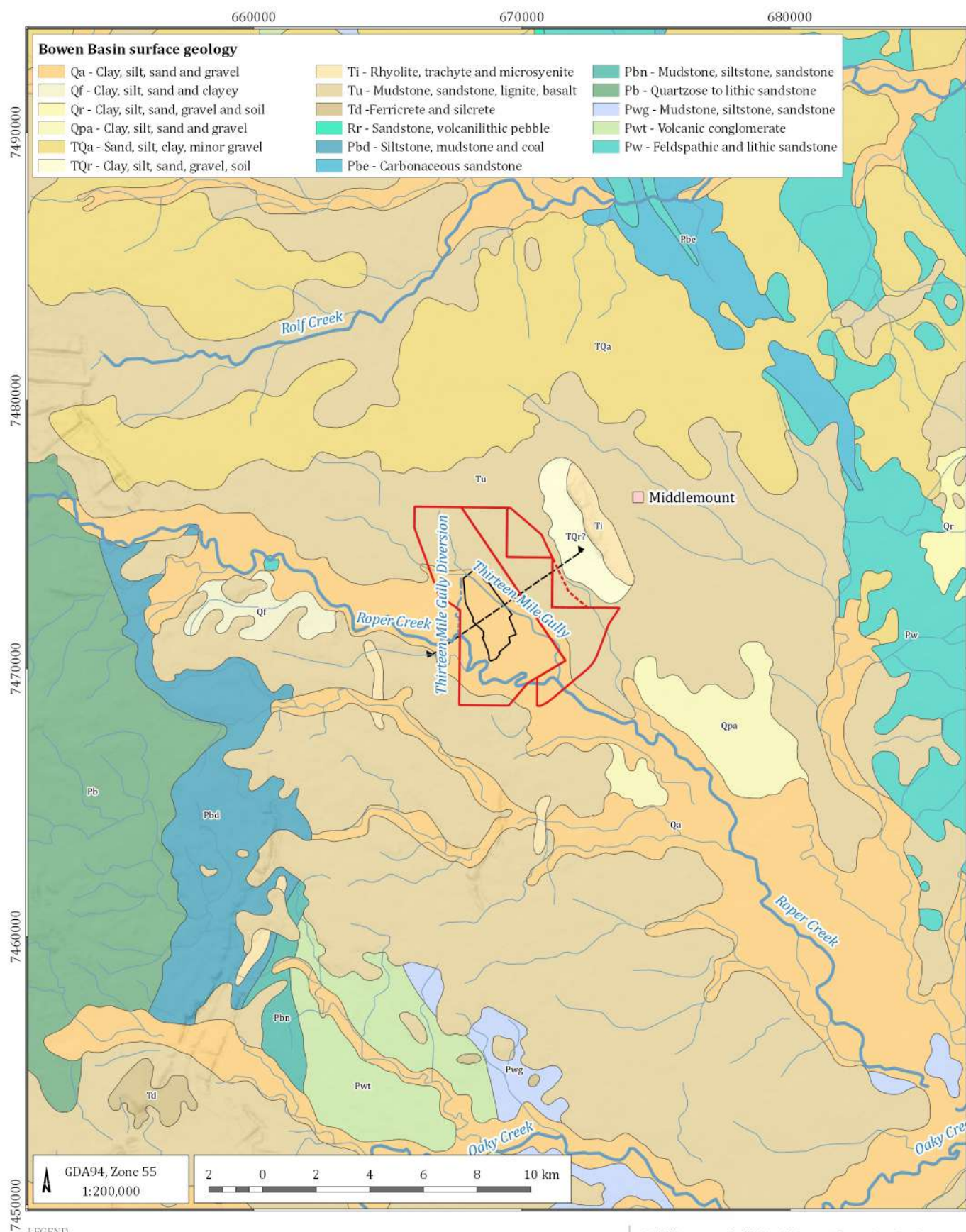
The Triassic Rewan Formation (Rr) does not outcrop within the study area, but does sub-crop within the study area beneath the Tertiary cover east of Middlemount township and southeast of the current mine footprint.

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 surface outcrop 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-north-west and dip towards the east-north-east, 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 northeast to southwest cross section in Figure 5.3.

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



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Mine pit footprint, 2017
- Geology cross-section in Figure 5.3
- Watercourse
- Drainage feature

Middlemount Coal Mine Western Extension Project
(G1840D)

Outcrop geology within study area



DATE
05/04/2018

FIGURE No:
5.2

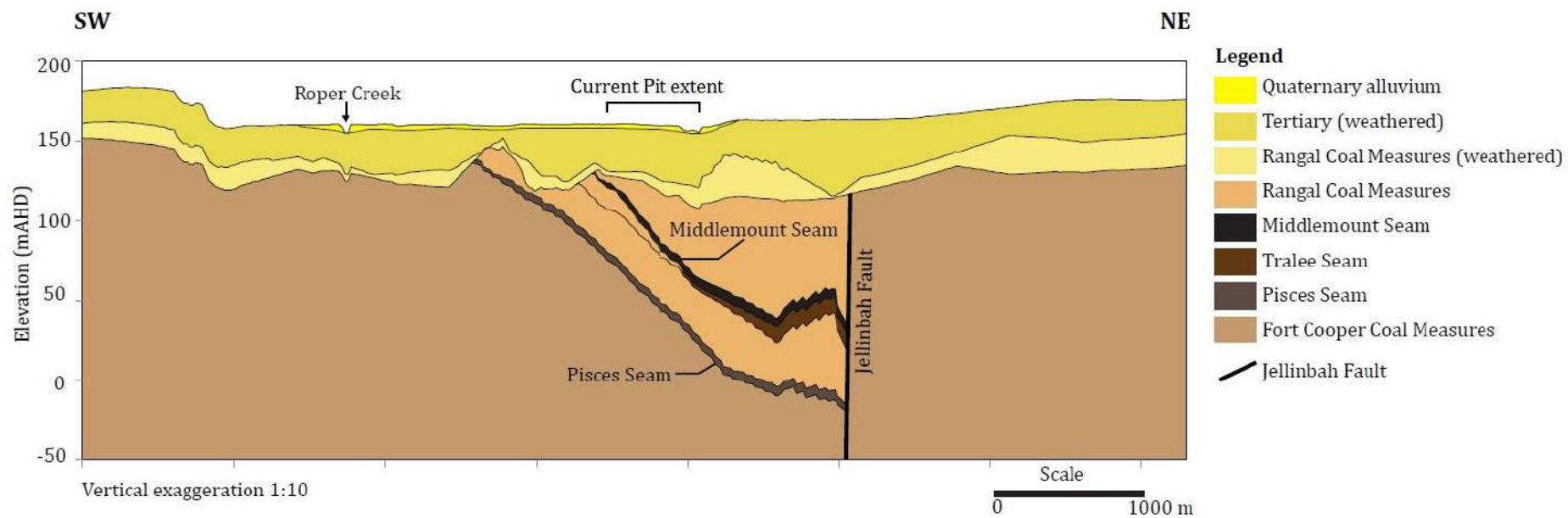


Figure 5.3 Northeast to southwest geological cross section

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 Mine. Additional limited occurrence east under Middlemount Township
		Roper seam	1 -2	
		Middlemount upper seam	<0.5	
		Middlemount lower seam	~4	
	Fort Cooper Coal Measures	Tralee coal seam	0.5 – 1	West of Rangal Coal Measures and east of Jellinbah Fault
		Pisces coal seam	2 - 6	
		Lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff	>100	
		Girrah coal seam	-	

(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 metres below ground level (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

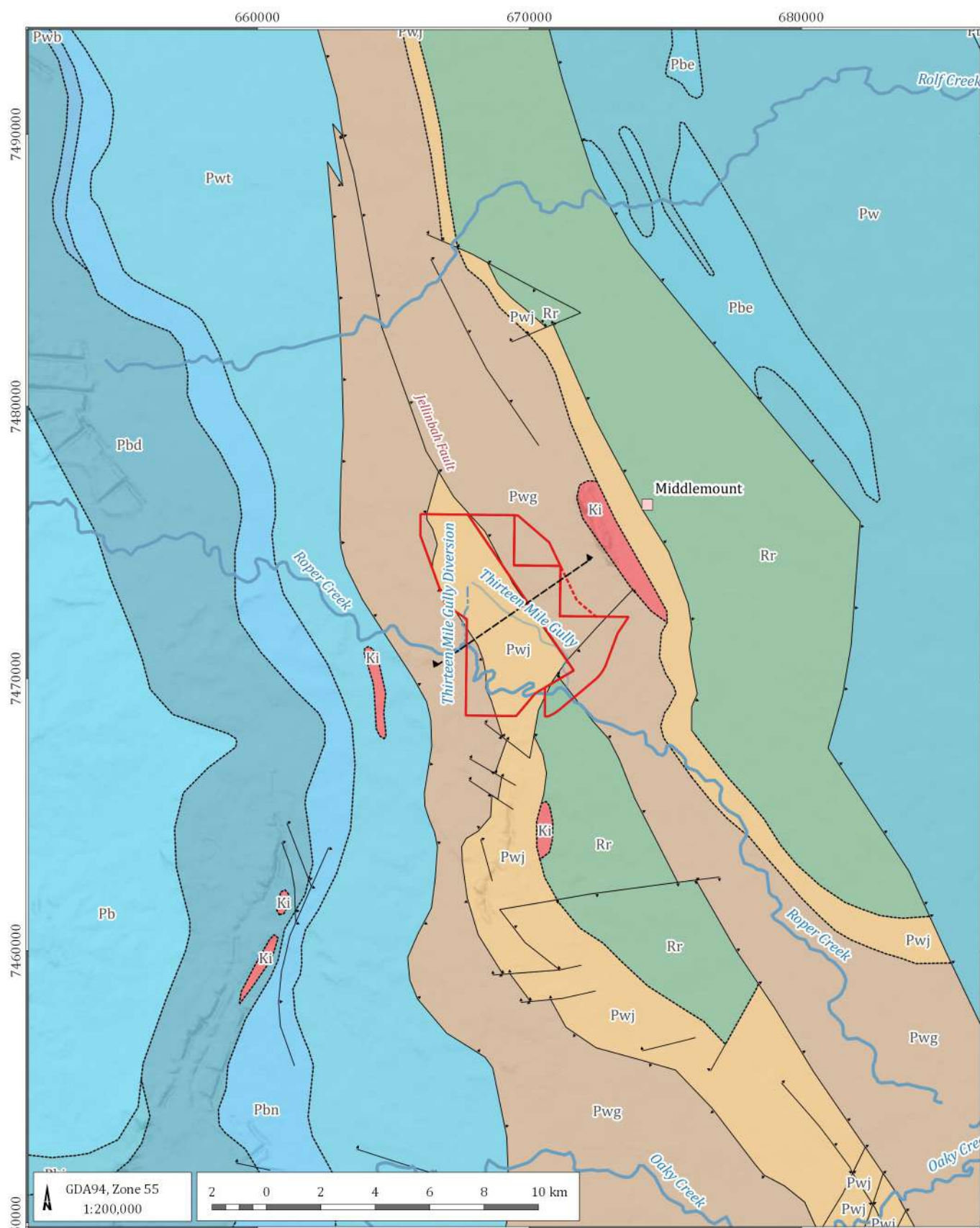
5.6.1 Rewan Formation

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 up to 800 m thick.

The Rewan Formation sub-crops beneath the Tertiary cover in the very southeastern 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.



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Regional mapped faults
- Contact
- ▲ Geology cross-section in figure 5.3
- Watercourse

Bowen Basin solid geology

- Ki-Ki-CQ
- Rr-Rewan Formation
- Pbd-German Creek Formation
- Pbe-Blenheim Subgroup
- Pbn-MacMillan Formation
- Pwg-Burngrove Formation
- Pwj-Rangal Coal Measures
- Pwt-Fair Hill Formation
- Pbi-Ingelara Formation
- Pw-Rannes beds

Middlemount Coal Mine Western Extension Project
(G1840D)

Bowen Basin solid geology with publicly available fault interpretation



DATE
05/04/2018

FIGURE No:
5.4

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 as a result of likely duplication from faulting. This occurrence is more evident nearer the Jellinbah Fault. These coal measures dip to the east between 3° and 7°, 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 inferred to sub-crop 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.

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 Geographical Information System* (GIS) dataset is a digital representation of the distribution of rock units and their structure in Queensland, which mirrors the DNRM'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 Stage 2 EIS Groundwater Technical Report (Parsons Brinkerhoff, 2010a) describes the Jellinbah Fault as a thrust fault that dips towards the east. The fault is interpreted as having a throw of over 300 m, with the western geological units being discontinuous across the fault with the stratigraphically older Girrah Coal Seam, which subcrops 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 southwest-northeast 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 truncates the Middlemount, Tralee, and Pisces coal seams along this eastern margin (Figure 5.3).

5.9 Geochemistry of coal, overburden, and interburden

Geochemical assessment (RGS, 2013) identified the majority of coal and mining waste materials (overburden and interburden) are classified as non-acid forming, have 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 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. The most used aquifer in the vicinity of Middlemount Coal Mine are the coal seams (i.e. neighbouring mine dewatering).

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 alluvium 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 would be completed at Middlemount Coal Mine in 2037, after which groundwater would flow into the open pit final voids. There are two final 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) is the same as the volume of void water lost through evaporation. This process typically does not result in groundwater levels that are fully recovered (or sometimes even partially recovered) to pre-mining conditions, as evaporation losses usually exceed inflows attributable to groundwater and rainfall.

6.4 Groundwater data availability

6.4.1 DNRM groundwater database bores

DNRM 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 43 bores within the study area. Table 6.1 provide a summary of the expected use of these bores. Of the 43 bores, only six were identified as landholder bores, 28 bores for mine groundwater monitoring purposes, and nine associated with petroleum (CSG) exploration. Details of the bores identified in the GWD are provided in Appendix B.

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

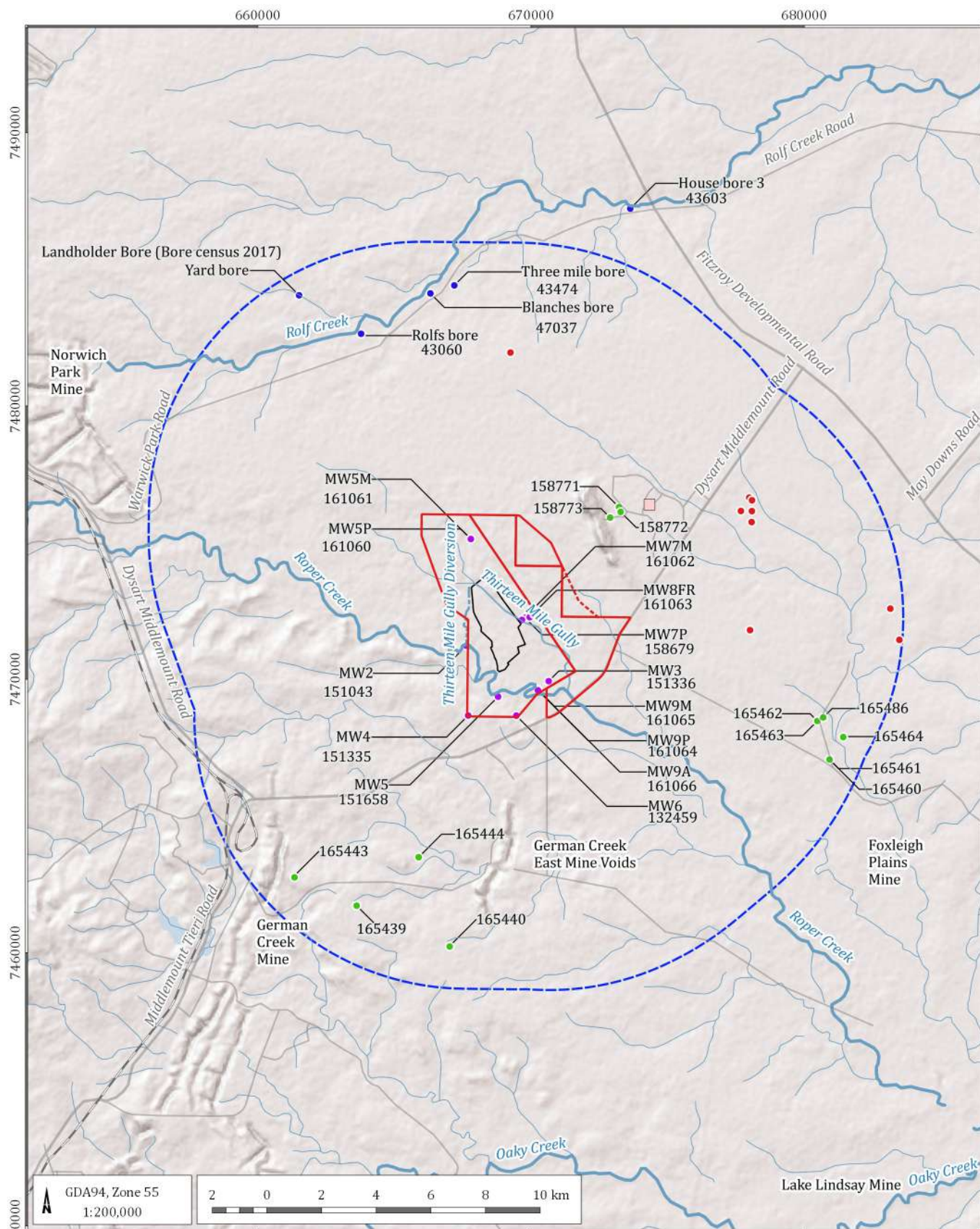
Roles of DNRM GWDB bores (2017)	Number of GWDB bores within the 10 km radius of MLs
Landholder water supply	
No specified role, but likely to be used for landholder water supply	6
Total number of bores used for landholder water supply	6
Monitoring bores	
Middlemount Landfill groundwater monitoring bores	3
Middlemount Mine groundwater monitoring bores	15
Foxleigh Mine groundwater monitoring bores	6
German Creek/Grasstree Mine groundwater monitoring bores	4
Total number of bores used for groundwater monitoring	28
Petroleum (CSG) exploration	
Petroleum or gas exploration	9
Total number of bores used for exploration	9
Total number of existing GWDB bores	43

Source: (DNRM, 2017)

The bore census undertaken by 4T Consultants Pty Ltd 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 [5] privately owned bores).

MCPL have also advised that two of the Middlemount Coal Mine groundwater monitoring bores (MW1 & MW1P) 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.



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Mine pit footprint, 2017
- 10 km buffer zone
- Road
- Drainage feature
- Watercourse
- Rail

- CSG well bores
- Landholder bores
- Mine monitoring bores
- Other mine Monitoring bores

Middlemount Coal Mine Western Extension Project (G1840D)

DNRM GWDB and census bores within study area



DATE
11/04/2018

FIGURE No:
6.1

6.4.2 Landholder bores – bore census data

A bore census of nearby groundwater users on privately owned properties was carried out by 4T Consultants Pty Ltd in September 2017 for the Western Extension Project. 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 km² 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 including the Project. Bores initially identified on the other two properties were subsequently assessed 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). No information relating to drawdown, recharge or seasonal variations in groundwater levels associated with abstraction was identified or provided during the census.

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 (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 Mine pit by significant faulting.

Table 6.2 Bore census landholder water supply bores

Monitoring bore	Property description	Registered number	Easting# (m)	Northing# (m)	Bore depth (m)	Screen depth (m)	Screen lithology	Standing water level (mbgl)
Yards Bore	Warwick Park	Not registered	661509	7484051	54	NA	NA	18.09
Rolfs Bore	Warwick Park	43060	663778	7482641	38.1	NA	NA	20.89
Blanches Bore	Warwick Park	43037	666941	7484987	35.7	NA	Back Creek Group	Not accessible
House Bore 3	Warwick Park	43063 *	673624 *	7487216 *	30.5 *	Open hole *	Sandstone *	11.61
Three Mile Bore	Hazelbrae	43474	666800	7484295	41	Open hole	Clay	Not accessible

Notes: # - Coordinates in GDA94, Zone 55

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

NA - Not available

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). Details of the groundwater monitoring network are 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. The current monitoring network consists of 17 bores 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.

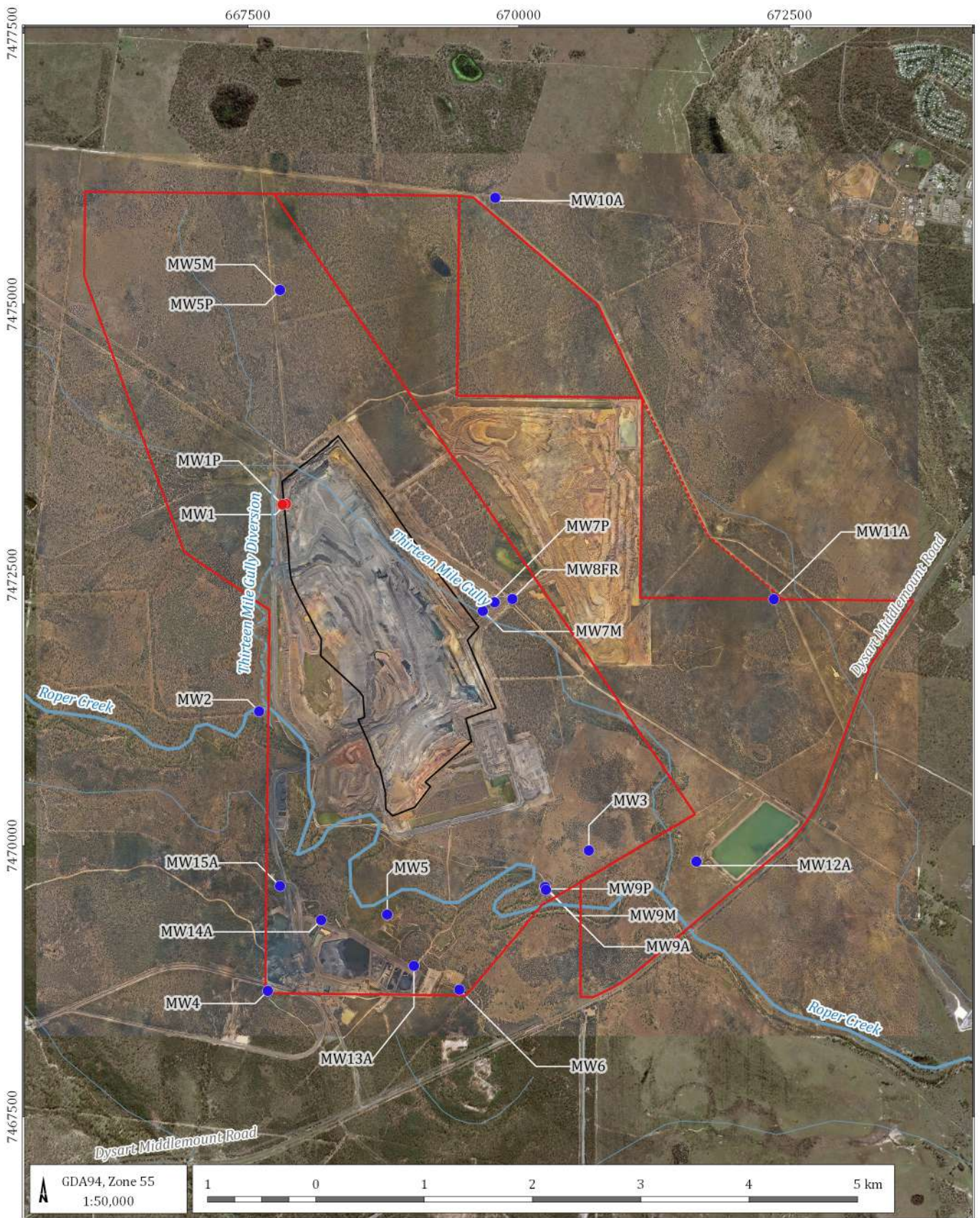
Groundwater monitoring has historically been conducted in accordance with the site's Plan of Operations and conditions within EA EPML00716913. The EA conditions are presented in Section 3.4.

Table 6.3 Mine monitoring bore network

Monitoring bore	Easting ¹ (m)	Northing ¹ (m)	Ground elevation (mAHD)	Bore depth (m)	Screen depth (m)	Screen lithology	Screen geology
MW1 (Mined out)	667851	7473155	161.5	30.0	21.0-29.0	Clay/sandy clay	Tertiary
MW1P (Mined out)	667818	7473149	161.1	77.2	72.0-75.0	Coal	Pisces coal seam
MW2	667603	7471239	163.12	30.0	21.0 – 29.0	Sandy Clay and Sand	Tertiary
MW3	670647	7469955	155.44	48.0	39.0 – 47.0	Clay and Sandy Clay	Tertiary
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)
MW5	668786	7469364	157.68	46.0	40.0 – 46.0	Coal	Pisces coal seam
MW6	669452	7468670	158.26	42.0	37.0 – 42.0	Clay	Tertiary
MW5M	667790	7475131	174.52	131.0	127.0 – 130.0	Coal	Middlemount coal seam
MW5P	667796	7745130	174.66	169.0	165.0 – 168.0	Coal	Pisces coal seam
MW7M	669668	7472167	161.15	135.5	132.0 – 134.5	Coal	Middlemount coal seam

Monitoring bore	Easting ¹ (m)	Northing ¹ (m)	Ground elevation (mAHD)	Bore depth (m)	Screen depth (m)	Screen lithology	Screen geology
MW7P	669777	7472247	163.87	194.5	189.5 – 193.5	Coal	Pisces coal seam
MW8FR	669941	7472277	164.33	151.0	147.0 – 150.0	Shale, Siltstone, and Sandstone	Fort Cooper Coal Measures
MW9A	670246	7469610	156.32	52.0	40.0 – 52.0	Sandstone and Siltstone	Tertiary
MW9M	670243	7469619	156.36	139.5	135.0 – 138.0	Coal	Middlemount coal seam
MW9P	670251	7469592	156.26	204.0	200.0 – 203.0	Coal	Pisces coal seam
MW10A	669783	7475981	175.75	12.0	6.0 – 12.0	Sand, Silty Sand, and Clay	Tertiary
MW11A	672355	7472275	156.21	13.5	10.5 – 13.5	Clay and Mudstone	Tertiary
MW12A	671640	7469853	158.28	10.55	6.0 – 10.55	Fine Sand and Mudstone	Tertiary
MW13A	669032	7468890	162.79	15.0	9.0 – 14.95	Sandstone	Tertiary
MW14A	668175	7469312	159.653	14.0	6.0 – 9.0	Sand, Clayey Sand and Mudstone	Tertiary
MW15A	667796	7469627	161.569	12.5	7.0 -10.0	Sand, Sandy Clay and Mudstone	Tertiary

Note: 1 – Coordinates in GDA94, Zone 55



LEGEND

- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Mine pit footprint, 2017
- Road
- Watercourse
- Drainage feature
- Abandoned/destroyed bores
- Middlemount Coal Mine monitoring bores

Middlemount Coal Mine Western Extension Project
(G1840D)

Middlemount Coal Mine monitoring bore locations



DATE
05/04/2018

FIGURE No:
6.2

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. However, the borehole logs make no reference to whether these were Quaternary or Tertiary sediments, indicating 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.

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} .

Literature values of specific storage range between 0.001 m^{-1} to 0.01 m^{-1} (i.e. $1.0\text{E-}3 \text{ m}^{-1}$ to $1.0\text{E-}2 \text{ m}^{-1}$) for clay and $5.0\text{E-}4 \text{ m}^{-1}$ to $1.0\text{E-}3 \text{ m}^{-1}$ for loose sand (Batu, 1998).

As a comparison, Arrow Energy (2012) assigned a specific storage value of $5.0\text{E-}4 \text{ m}^{-1}$ 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 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 $2.8\text{E-}8$ metres per second (m/s) or $2.4\text{E-}3$ 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 $1.0\text{E-}6$ m/day to $5.0\text{E-}4$ m/day and for sandstone (fresh) are about $3.0\text{E-}5$ m/day to $5.0\text{E-}1$ m/day (Domenico and Schwartz, 1990). A hydraulic conductivity range of $5.0\text{E-}2$ m/day to $5.0\text{E-}3$ 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 $5.0\text{E-}3$ 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.

Literature values of specific storage range between $1.0\text{E-}3$ m^{-1} to $1.0\text{E-}2$ m^{-1} for clay and $3.3\text{E-}6$ m^{-1} to $6.9\text{E-}5$ m^{-1} for competent to fractured rock (Batu, 1998), but could achieve lower values where clays occur at depth and are confined by overlying units. A geometric mean of about $5.0\text{E-}5$ m^{-1} would be considered a reasonable estimate for the bulk specific storage of the Tertiary Duaringa Formation within the study area.

As a comparison, Arrow Energy (2012) assigned a specific storage value of $5.0\text{E-}5$ m^{-1} to their base case numerical groundwater model to represent the Tertiary Duaringa Formation within the Bowen Basin.

6.6.3 Groundwater levels, recharge, and flow

Recharge to the Tertiary 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 162.9 mAHD (MW10A) at the northern side of the ML area to 131.0 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 20.4 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 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. No groundwater level data have been recorded in MW12A and MW13A as these bores have been dry following construction.

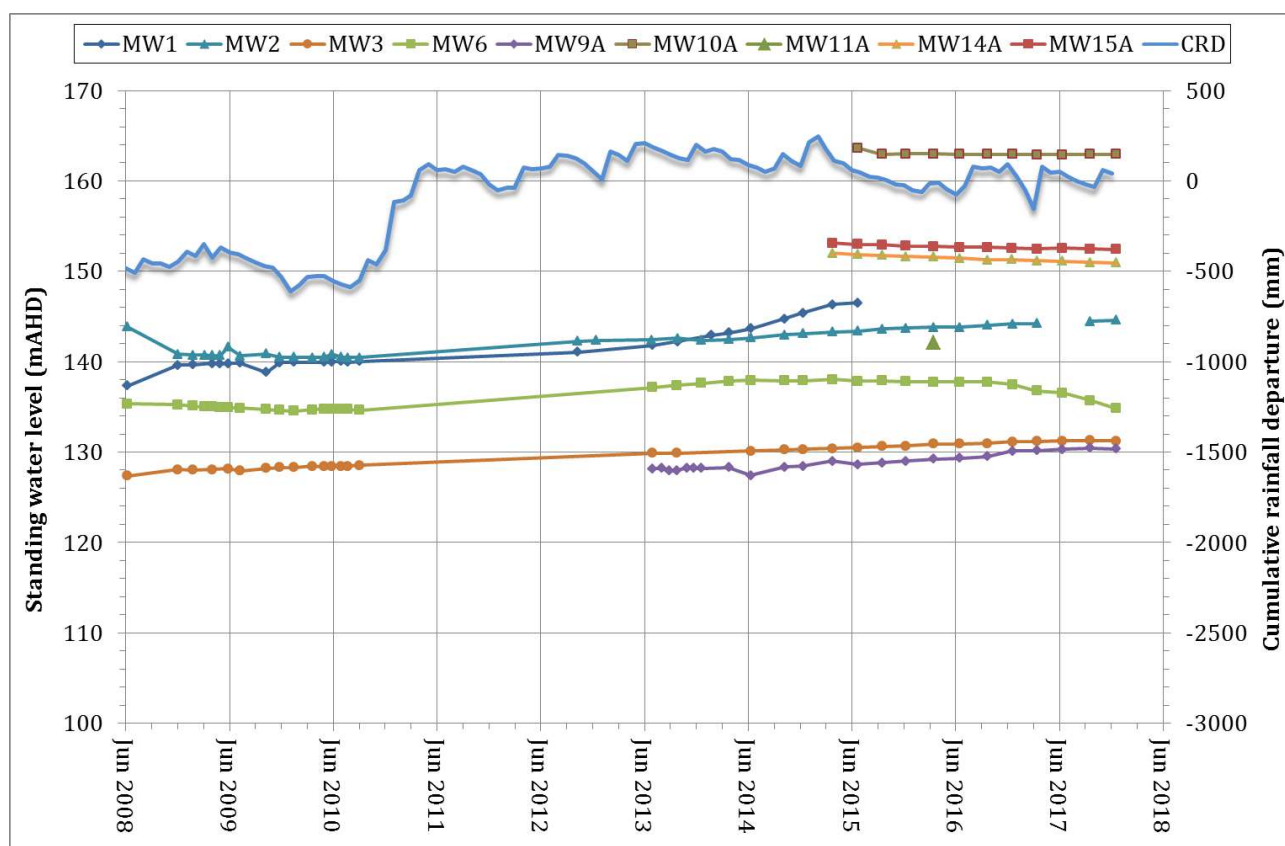


Figure 6.3 Measured groundwater levels in Tertiary aquifer monitoring bores

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 $\mu\text{S}/\text{cm}$ to ~10,500 $\mu\text{S}/\text{cm}$). 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 $\mu\text{S}/\text{cm}$)
- Brackish 500 to 7,000 mg/L (~750 to ~10,500 $\mu\text{S}/\text{cm}$)
- Saline 7,000 to 35,000 mg/L (~10,750 to ~53,000 $\mu\text{S}/\text{cm}$)
- Hypersaline (brine) >35,000 mg/L (> ~53,000 $\mu\text{S}/\text{cm}$)

Table 6.4 summarises the maximum, minimum, and average values of groundwater chemical parameters for the Tertiary Duaringa Formation aquifer sampled between May 2013 and December 2017. This data indicates the Tertiary aquifer water quality is:

- slightly acidic to alkaline with field pH values ranging from 6.5 to 8.5;
- dominated by sodium and chloride; and
- brackish to saline with total dissolved solids ranging from 900 mg/L to 25,700 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)		
					20 th	50 th	80 th
Field EC (µS/cm)	28,000	32,700	30,482	-	498	2,150	8,910
Laboratory EC (µS/cm)	1,370	35,000	19,730	-	498	2,150	8,910
Field pH	6.5	8.5	7.2	-	7.1	7.75	8.1
Laboratory pH	6.9	8.6	7.7	-	7.1	7.75	8.1
Total Dissolved Solids (mg/L)	919	25,700	13,071	4,000 (beef) 2,500 (dairy) 5,000 (sheep) 4,000 (horses) 4,000 (pigs) 2,000 (poultry)	-	-	-
Carbonate Alkalinity (mg/L)	<1	84	3.1	-	163	674	2,228
Bicarbonate Alkalinity (mg/L)	255	1,320	522	-	187	536	878
Total Alkalinity (mg/L)	258	829	525	-	154	435	752
Chloride (mg/L)	248	12,200	6,875	-	171	1,309	3,185
Calcium (mg/L)	33	771	317	1,000	18	84	215
Magnesium (mg/L)	16	838	468	2,000	27	108	389
Potassium (mg/L)	3	44	14	-	-	-	-
Sodium (mg/L)	213	7,390	3,575	-	135	747	1,500
Sulfate (mg/L)	23	2,060	568	1,000	12	140	318
<i>Dissolved metals</i>							
Aluminium (mg/L)	<0.001	0.18	0.18	5	-	-	-
Antimony (mg/L)	<0.001	<0.001	<0.001	-	-	-	-
Arsenic (mg/L)	<0.001	0.006	0.004	0.5	-	-	-
Iron (mg/L)	<0.05	8.19	0.75	-	0	0.03	0.14
Mercury (mg/L)	<0.0001	0.0011	0.0007	0.002	-	-	-
Molybdenum (mg/L)	<0.001	0.002	0.002	0.15	-	-	-
Selenium (mg/L)	<0.001	<0.001	<0.001	0.02	-	-	-

Parameter	Min	Max	Average	Stock water (ANZECC)	WQO Zone 34 Shallow <30 m (percentile)		
					20 th	50 th	80 th
Silver (mg/L)	<0.001	0.006	0.002	-	-	-	-
Total metals							
Aluminium (mg/L)	<0.001	286	24.2	5	-	-	-
Antimony (mg/L)	<0.001	0.002	0.002		-	-	-
Arsenic (mg/L)	<0.001	0.022	0.007	0.5	-	-	-
Iron (mg/L)	<0.48	494	31	-	0	0.03	0.14
Mercury (mg/L)	<0.0001	0.0912	0.016	0.002	-	-	-
Molybdenum (mg/L)	<0.001	0.018	0.008	0.15	-	-	-
Selenium (mg/L)	<0.001	0.02	0.02	0.02	-	-	-
Silver (mg/L)	<0.001	0.002	0.002	-	-	-	-
Total Petroleum Hydrocarbons							
C10 - C14 (µg/L)	<50	130	52	-	-	-	-
C15 - C28 (µg/L)	<100	540	114	-	-	-	-
C29 - C36 (µg/L)	<50	520	70	-	-	-	-
Sum of C10 - C36 (µg/L)	<50	2,390	502	-	-	-	-
C10 - C16 (µg/L)	<100	<100	<100	-	-	-	-
C16 - C34 (µg/L)	<100	1,950	499	-	-	-	-
C34 - C40 (µg/L)	<100	940	400	-	-	-	-
Sum of C10 - C40 (µg/L)	<100	2,890	670	-	-	-	-
BTEX hydrocarbons							
Benzene (µg/L)	<1	<1	<1	-	-	-	-
Toluene (µg/L)	<2	<2	<2	-	-	-	-
Ethylbenzene (µg/L)	<2	<2	<2	-	-	-	-
Total Xylenes (µg/L)	<2	<2	<2	-	-	-	-
Naphthalene (µg/L)	<2	<2	<2	-	-	-	-

Notes: - Not determined.

µg/L = micrograms per litre

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).
- Detectable levels of total and dissolved metals concentrations are reported for aluminium, antimony, arsenic, iron, mercury, molybdenum, selenium and silver.
- The average and maximum total aluminium and mercury concentrations both exceed the stock watering guidelines and total and dissolved concentrations for iron 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.
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX) concentrations for all Tertiary monitoring bores were all below the laboratory detection levels.

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, selenium and silver as data for these parameters is available for the period 2013 to 2017. Data collected for aluminium, antimony, arsenic and molybdenum is not presented as this was only collected between 2013 and 2014.

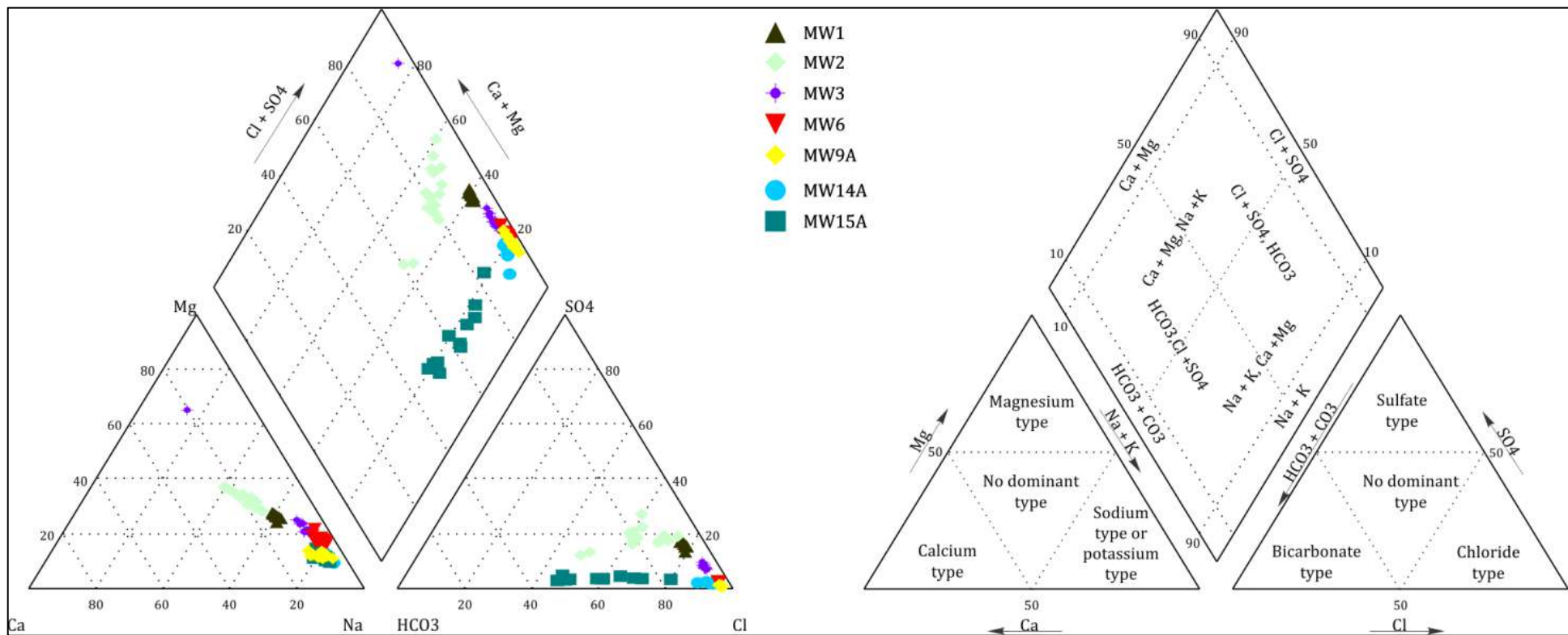


Figure 6.4 Piper diagram – Tertiary aquifer

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 DNRW GWDB and 2017 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.

Literature values of specific storage range between 1.0E-6 m⁻¹ to 1.0E-4 m⁻¹ for competent to fractured rock (Batu, 1998).

As a comparison, Arrow Energy (2012) assigned a specific storage value of 8.5E-5 m⁻¹ to their base case numerical groundwater model to represent the main coal seams within the Bowen Basin.

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 41 m in the Middlemount Seam and 25 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 5.9 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 0.2 m (MW9M) and 4 m (MW5).

The Permian monitoring bore within the Fort Cooper Coal Measures east of the mine pit (MW8FR) only shows a minor drawdown response of up to 5.7 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.

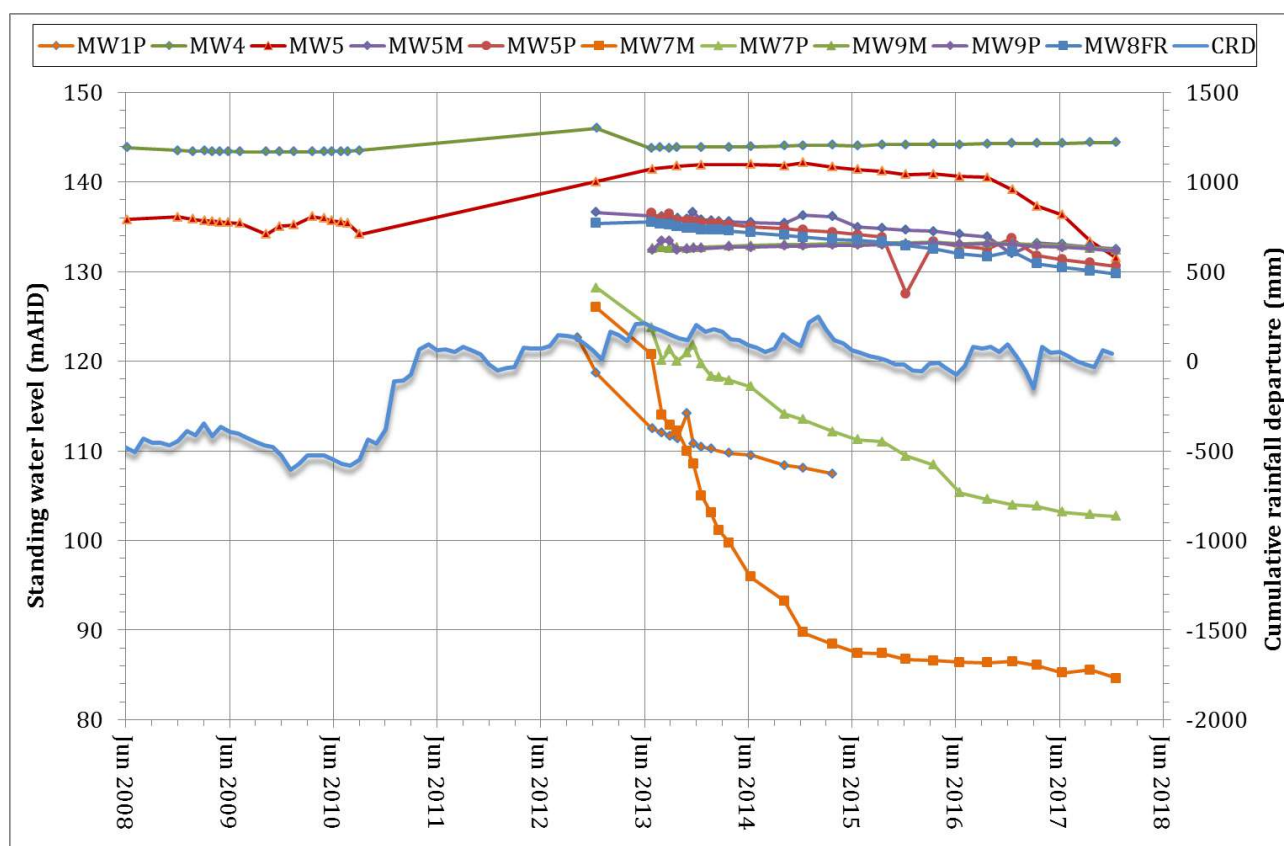


Figure 6.5 Measured groundwater levels in Permian coal measures monitoring bores

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, a common (Tertiary aquifer) recharge source to these coal seams. 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.

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 2017. This data indicates the Permian aquifer water quality is:

- slightly acidic to alkaline with field pH values ranging from 6.5 to 8.4;
- dominated by sodium and chloride; and
- brackish to saline with TDS ranging from 503 mg/L to 16,700 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)		
					20 th	50 th	80 th
Field EC# (µS/cm)	868	22,200	15,956	-	3,419	6,100	16,000
Laboratory EC# (µS/cm)	816	22,800	14,914		3,419	6,100	16,000
Field pH	6.5	8.4	7.0	-	7.4	7.8	8.03
Laboratory pH	6.9	8.3	7.6		7.4	7.8	8.03
TDS (mg/L)	503	16,700	9,758	4,000 (beef) 2,500 (dairy) 5,000 (sheep) 4,000 (horses) 4,000 (pigs) 2,000 (poultry)	-	-	-
Carbonate Alkalinity (mg/L)	<1	10	1.2	-	359	919	3,208
Bicarbonate Alkalinity (mg/L)	282	680	517	-	188	330	650
Total Alkalinity (mg/L)	243	878	501	-	156	275	536
Chloride (mg/L)	63	8,180	5,404	-	753	1,900	5,905
Calcium (mg/L)	37	489	271	1,000	46	145	442
Magnesium (mg/L)	26	578	358	2,000	35	115	491
Potassium (mg/L)	1	29	14	-	-	-	-
Sodium (mg/L)	57	4,050	2,666	-	480	1100	2,565
Sulfate (mg/L)	3	552	281	1,000	25	138	398
Dissolved metals							
Aluminium (mg/L)	<0.01	0.15	0.12	5	-	-	-
Antimony (mg/L)	<0.001	<0.001	<0.001	-	-	-	-
Arsenic (mg/L)	<0.001	0.028	0.004	0.5	-	-	-
Iron (mg/L)	<0.05	10.6	2.47	-	0	0.05	0.246
Mercury (mg/L)	<0.0001	<0.0001	<0.0001	0.002	-	-	-

Parameter	Min	Max	Average	Stock water (ANZECC)	WQO Zone 34 Deep >30 m (percentile)		
					20 th	50 th	80 th
Molybdenum (mg/L)	<0.001	0.007	0.002	0.15	-	-	-
Selenium (mg/L)	<0.001	<0.001	<0.001	0.02	-	-	-
Silver (mg/L)	<0.001	0.002	0.001	-	-	-	-
Total metals							
Aluminium (mg/L)	<0.01	16.7	0.63	5	-	-	-
Antimony (mg/L)	<0.001	0.003	0.003		-	-	-
Arsenic (mg/L)	<0.001	0.028	0.003	0.5	-	-	-
Iron (mg/L)	0.09	63.9	4.7	-	0	0.05	0.246
Mercury (mg/L)	<0.0001	0.0009	0.0004	0.002	-	-	-
Molybdenum (mg/L)	<0.001	0.007	0.003	0.15	-	-	-
Selenium (mg/L)	<0.01	<0.01	<0.01	0.02	-	-	-
Silver (mg/L)	<0.001	0.01	0.003	-	-	-	-
Total Petroleum Hydrocarbons							
C10 - C14 (µg/L)	<50	340	63	-	-	-	-
C15 - C28 (µg/L)	<100	1,870	202	-	-	-	-
C29 - C36 (µg/L)	<50	2,060	134	-	-	-	-
Sum of C10 - C36 (µg/L)	<50	4,010	793	-	-	-	-
C10 - C16 (µg/L)	<100	470	470	-	-	-	-
C16 - C34 (µg/L)	<100	2,990	700	-	-	-	-
C34 - C40 (µg/L)	<100	1,390	570	-	-	-	-
Sum of C10 - C40 (µg/L)	<100	4,850	1,063	-	-	-	-
BTEX hydrocarbons							
Benzene (µg/L)	<1	<1	<1	-	-	-	-
Toluene (µg/L)	<2	<2	<2	-	-	-	-
Ethylbenzene (µg/L)	<2	<2	<2	-	-	-	-
Total Xylenes (µg/L)	<2	<2	<2	-	-	-	-
Naphthalene (µg/L)	<2	<2	<2	-	-	-	-

Notes: # EC – Electrical conductivity.

- Not determined.

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 for samples collected from the Permian aquifer. These values are compared against the Australian and New Zealand Environment and Conservation Council (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).
- Detectable levels of total and dissolved metals concentrations are reported for aluminium, antimony, arsenic, iron, mercury, molybdenum and silver.
- The maximum total aluminium concentrations exceed the stock watering guidelines and total and dissolved concentrations for iron exceed the 50th and 80th percentile water quality objectives for deep aquifers (>30 m depth).
- Detectable levels of TPH have been recorded in MW4, MW5, and MW7P.
- BTEX concentrations for all Permian monitoring bores were all below the laboratory detection levels.

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, selenium and silver as data for these parameters is available for the period 2013 to 2017. Data collected for aluminium, antimony, arsenic and molybdenum is not presented as this was only collected between 2013 and 2014.

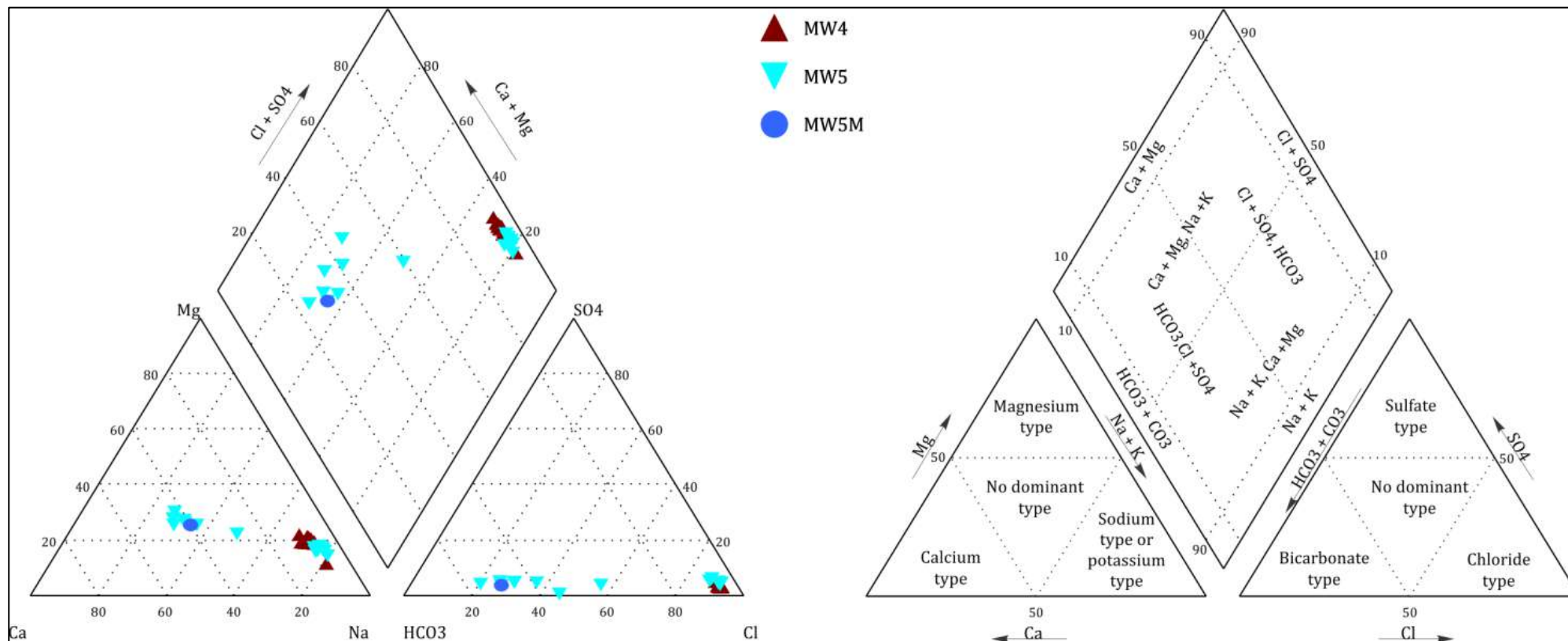


Figure 6.6 Piper diagram – Permian coal measures aquifer

6.8 Groundwater dependent ecosystems

A Groundwater Dependent Ecosystem (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, 2017). 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.

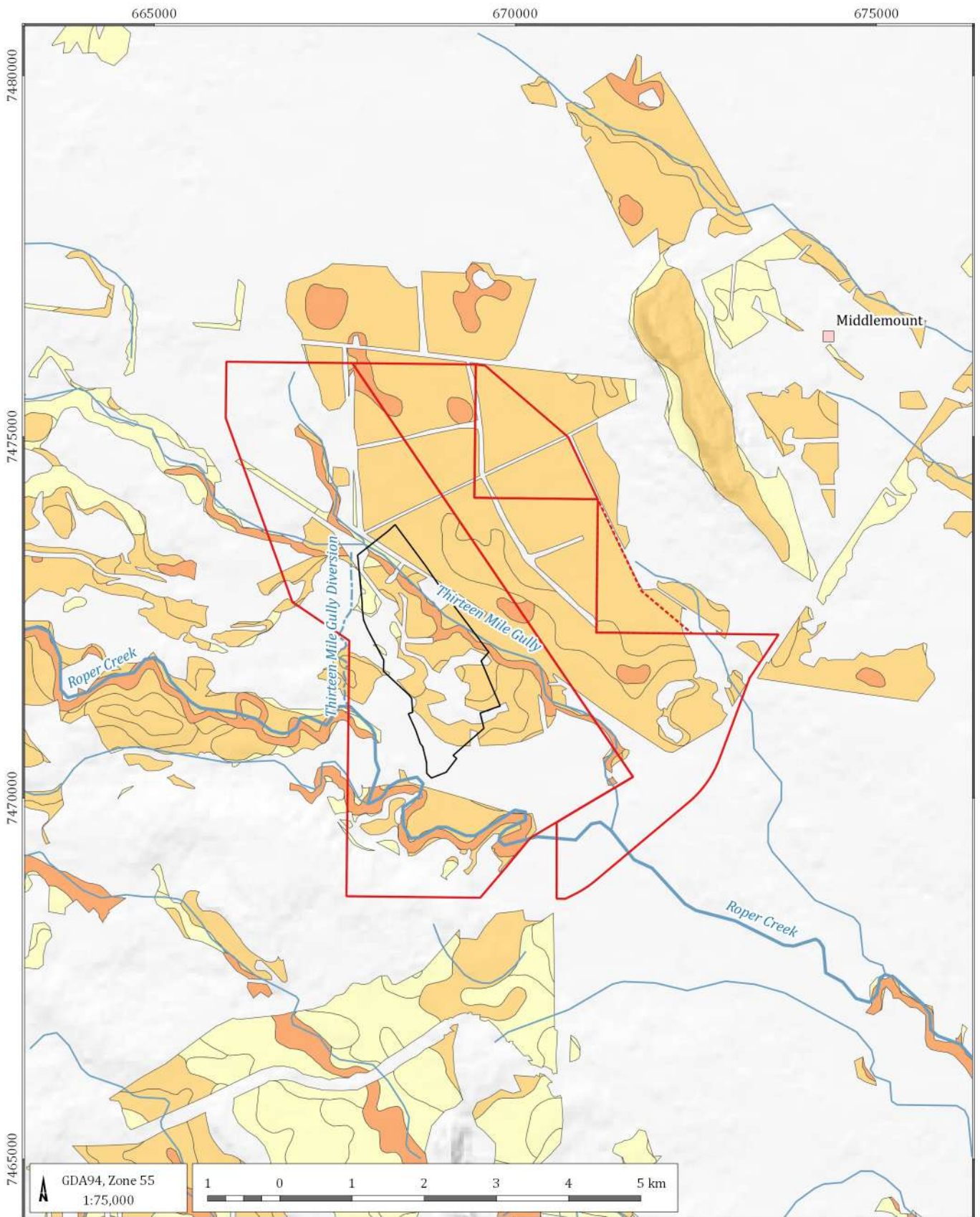
Figure 6.7 shows the potential GDE's identified by the BoM GDE mapping within and around Middelmount Coal Mine. This shows much of the surrounding land that is still treed has been mapped as a "terrestrial" GDE, and appears to be based heavily upon the extent of this existing treed vegetation within this area, which includes:

- Terrestrial vegetation associated with Thirteen Mile Gully and Roper Creek which is mapped as a high potential GDE that is *"marginally more likely to access an additional source of water than rely solely on rainfall"*;
- Terrestrial vegetation, tree swamps (Melaleuca and Eucalypt) associated with palustrine wetlands which is mapped as a high potential GDE that *"is possibly likely to access an additional source of water than rely solely on rainfall"* outside the MLs (ML 700417 and ML 70379); and
- Aquatic wetland/riverine habitat within watercourses associated with Thirteen Mile Gully and Roper Creek, which is mapped as a moderate potential GDE that is *"likely to access an additional source of water than rely solely on rainfall"*.

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 18.9 mbgl and 22.7 mbgl. Based on the depth to groundwater within the Tertiary sediments being in excess of 10 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 entirely dependent on groundwater interaction.

Desktop mapping of potential GDEs throughout Queensland (BoM, 2017¹) indicates that areas of with possible high, moderate and low potential for groundwater interaction occur within the Project locality (Figure 6.7).

¹ DSITI (2017) GDE mapping covers a portion of the Project area, however contains data gaps in the surrounding area. The two data sources show consistent mapping for the extent which they overlap.



LEGEND

- PopPlaces-clipped
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- ▬ Mine pit footprint, 2017
- ▬ Watercourse
- ▬ Drainage feature

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

- High potential for groundwater interaction
- Moderate potential for groundwater interaction
- Low potential for groundwater interaction

Middlemount Coal Mine Western Extension Project (G1840D)

Groundwater Dependent Ecosystems - GDE Atlas



DATE
06/04/2018

FIGURE No:
6.7

The desktop GDE mapping (BoM, 2017) indicates:

- Terrestrial vegetation associated with watercourses (Roper Creek) and a drainage line (Drainage Line 1) is mapped as having a high potential to be associated with subsurface presence of groundwater.
- Aquatic habitat associated with watercourses (Roper Creek) and a drainage line (Drainage Line 1) is mapped as having a moderate potential to be reliant on surface expression of groundwater.
- Terrestrial vegetation and aquatic habitat associated with palustrine wetlands outside of ML 70417 and ML 70379 is mapped as having a high potential to be associated with subsurface presence of groundwater.

All other terrestrial vegetation (Regional Ecosystems mapped by DSITI, 2017), is broadly mapped as having a low to moderate potential of being associated with subsurface presence of groundwater (BoM, 2017).

The following conclusions can be made in relation to the presence/absence of GDEs in the Project locality based on the desktop review of the GDE mapping (BoM, 2017):

- The majority of the terrestrial vegetation associated with Roper Creek and Drainage Line 1 is 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 18.9 mbgl and 22.7 mbgl. Based on the depth to groundwater surrounding Roper Creek being around 20 mbgl it is unlikely that these communities would be reliant on access to groundwater (Naturecall Environmental, 2018).
- Aquatic habitat associated with Roper Creek and Drainage Line 1 is unlikely to be dependent on groundwater given the ephemeral nature of the drainage features (Plates 1 and 2).
- Terrestrial vegetation and aquatic habitat associated with palustrine wetlands north of ML 70417 and ML 70379 could potentially be reliant on groundwater given the regional ecosystem mapped in these areas by DSITI (2017). DSITI (2017) has mapped these areas 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. 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 $\mu\text{S}/\text{cm}$ for unconsolidated sediments and 5,000 $\mu\text{S}/\text{cm}$ for fractured rock aquifers; and
- pH of approximately 6.5 – 8.5.

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

The Stygofauna assessment for the Foxleigh Plains Project EIS (ALS, 2012) 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 <2,000 $\mu\text{S}/\text{cm}$. 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.

A desktop review of the likely potential for stygofauna at the Middlemount Coal Mine based on the optimal conditions for stygofauna habitat is summarised in Table 6.7. This would suggest that the potential for optimal stygofauna habitat at Middlemount Coal Mine is unlikely given that average salinity in both the Tertiary and Permian aquifers exceeds 20,000 $\mu\text{S}/\text{cm}$, and the average depth to groundwater in the Permian aquifer is greater than 30 mbgl. This is in line with findings of similar studies undertaken for the Foxleigh Plains Project and the Bowen Gas Project.

Despite stygofauna being unlikely to be found at the Middlemount Coal Mine due to poor groundwater quality and otherwise lack of groundwater, a number of bores around the Middlemount Coal Mine were sampled for stygofauna in 2011. The sampling found what was likely a naturally low diversity of stygofauna (taxa from two Families² – 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).

² The taxa could not be identified to species level.

Table 6.7 Potential stygofauna habitat at Middlemount Coal Mine

Aquifer	EC range and average EC ($\mu\text{S}/\text{cm}$)	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	2,970 to 32,400. Average 21,139	6.5 to 8.5. Average 7.2	7.7 to 25.3. Average depth 17.5	Unconsolidated sediments	Unlikely due to elevated EC levels > 2,000 $\mu\text{S}/\text{cm}$
Permian	1,072 to 30,900. Average 20,055	6.5 to 7.9. Average 7.1	23.53 to 75.06. Average depth 41.01	Consolidated sediments	Possible where EC levels < 5,000 $\mu\text{S}/\text{cm}$, and depth to water is less than 30 m. Unlikely due to elevated average EC levels > 5,000 $\mu\text{S}/\text{cm}$, and depth to water is greater than 30 m

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

Limited details for landholder bores are available for construction, equipment, and operation, and landholder water requirements are not registered. For this reason, it is not possible to accurately determine the total landholder extraction rates. However, an estimate of groundwater extraction (based on DNRM GWDB bore reports and the bore census) was made by Parsons Brinkerhoff (2010a).

Available registered landholder bore yields obtained from the DNRM GWDB identifies these bores are mostly constructed into the Permian strata which indicates that the landholder bores take groundwater ranges between <0.1 L/s to 0.5 L/s. The hydrocensus undertaken for unregistered landholder bores indicated the three bores identified were only used in emergencies for stock watering. Whilst all could be used as a water supply, only one was equipped with a pump. The maximum estimated pumping usage for these bores was approximately 45 cubic metres per day (m³/day) which converts to about 0.5 L/s (when pumping for 24 hours per day). The depth to water in these bores ranged between 15 mbgl and 41 mbgl. No information was provided regarding geology or source aquifer, bore construction, drawdown, and seasonal variations in pumping water levels, or recharge. All bores were identified to be located east of the Jellinbah Fault. The bore census has identified there are five number of active bores east of the Jellinbah Fault

The Stage 2 EIS groundwater model did not include landholder extraction (Parsons Brinckerhoff, 2010a).

6.11.2 Mine groundwater extraction

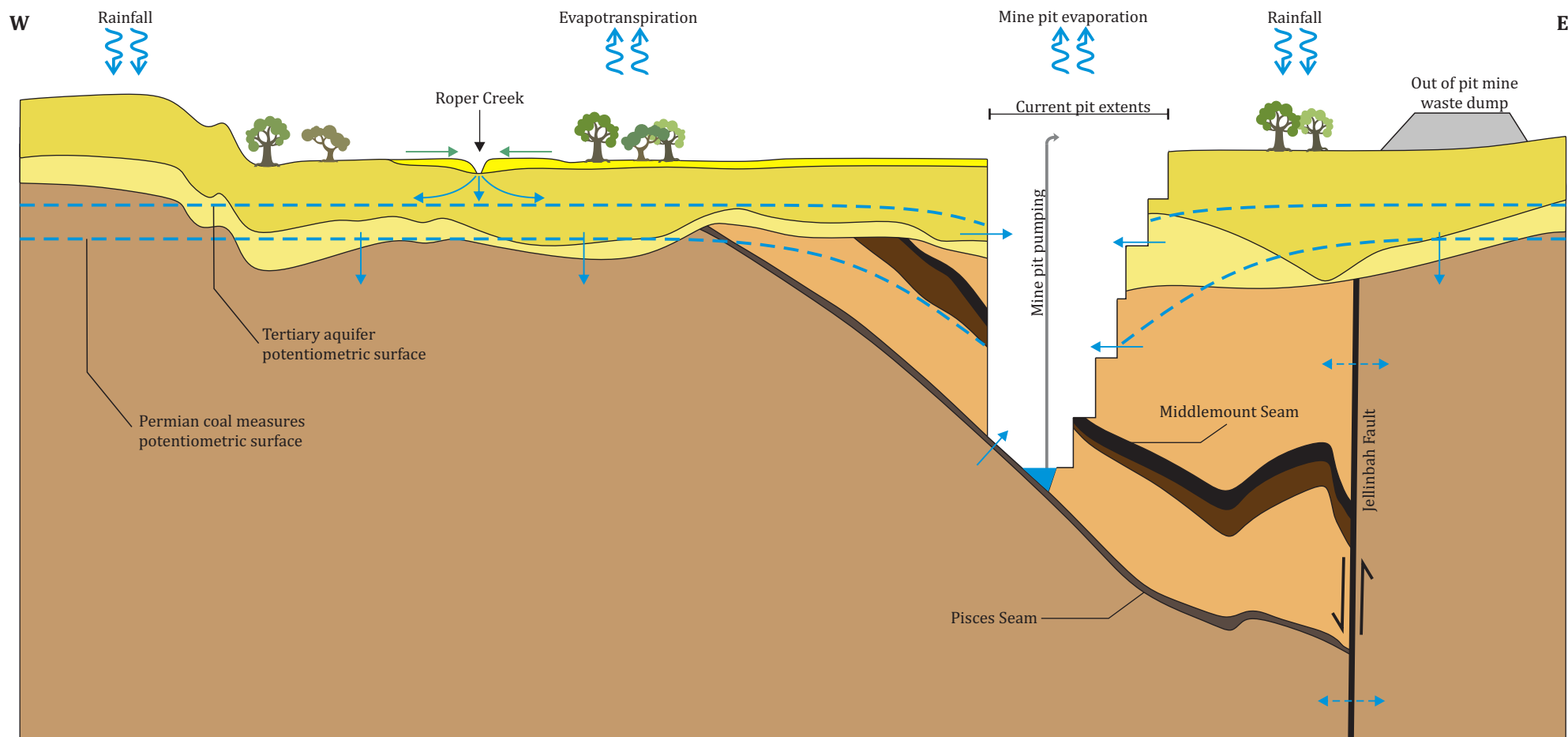
An assessment of the of the estimated monthly groundwater inflows to the Middlemount Coal Mine was undertaken by WRM Pty Ltd (WRM)(memorandum dated 5 October, 2017) for a 10 month period which includes data assessed for October 2015, May 2016 and between February and September 2017. Groundwater inflows have been 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 Summary of conceptual groundwater model

The conceptual groundwater model for the Middlemount Coal Mine is presented graphically in Figure 6.8. 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).

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 (Duarina 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.



Legend

- | | |
|--|---|
| Quaternary alluvium | Fault |
| Tertiary (weathered) | Surface runoff direction |
| Rangal Coal Measures (weathered) | Groundwater flow direction |
| Rangal Coal Measures | Uncertain groundwater flow direction |
| Middlemount Seam | Potentiometric surface |
| Tralee Seam | |
| Pisces Seam | |
| Fort Cooper Coal Measures | |

East to West Hydrogeological Conceptualisation

Figure 6.8

Middlemount Coal Mine Western Extension Project (G1840D)

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.

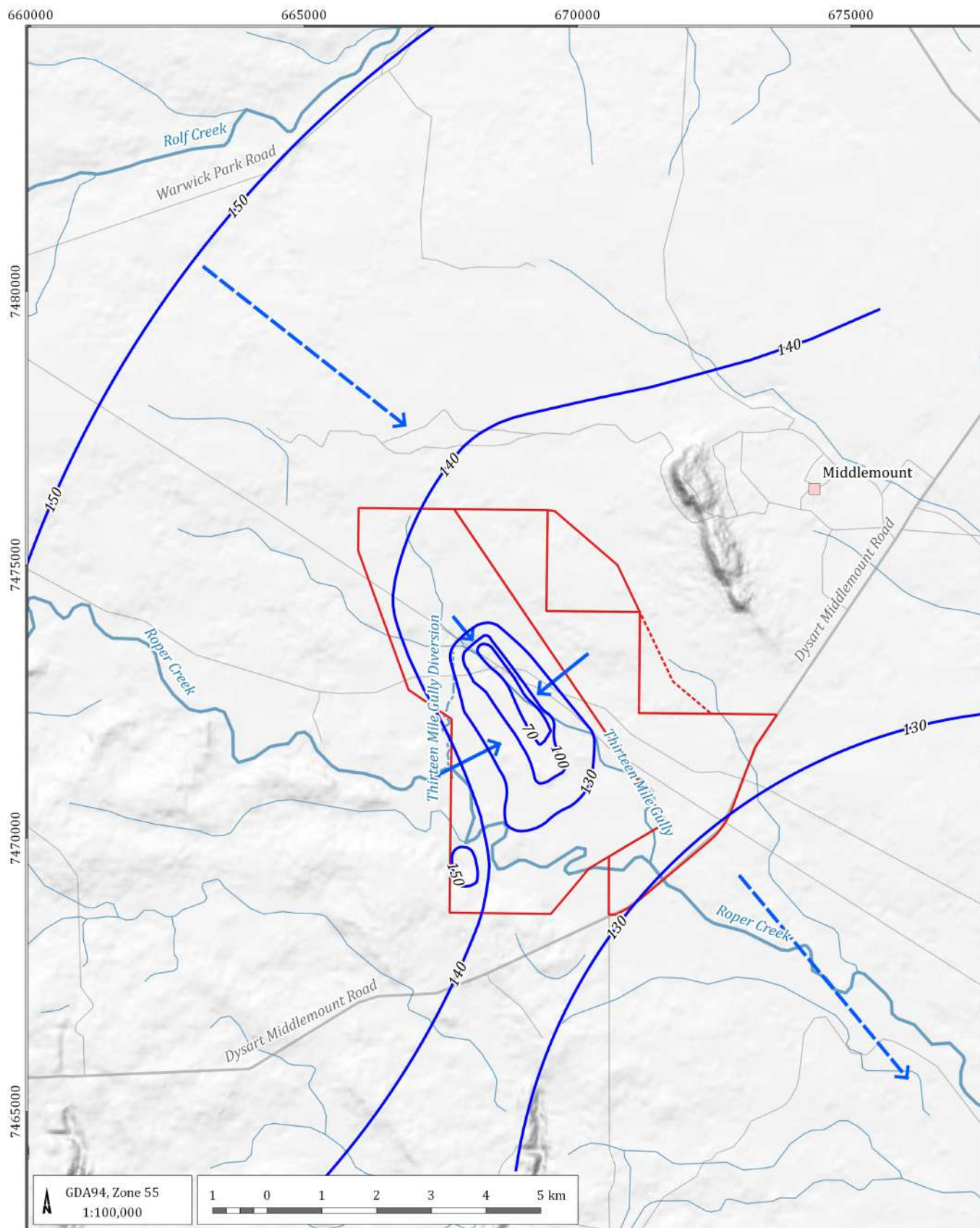
Recharge of the Tertiary aquifer occurs by direct infiltration of rainfall, via slow leakage through the overlying Tertiary clay sediments. Ephemeral watercourses such as Roper Creek would also contribute a proportion of recharge into the Tertiary aquifer through infiltration during periods of stream 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 6.9 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 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 6.10 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.



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Road
- Watercourse
- Drainage feature
- Inferred groundwater contours (mAHd)
- Regional groundwater flow direction
- Local mine induced groundwater flow direction

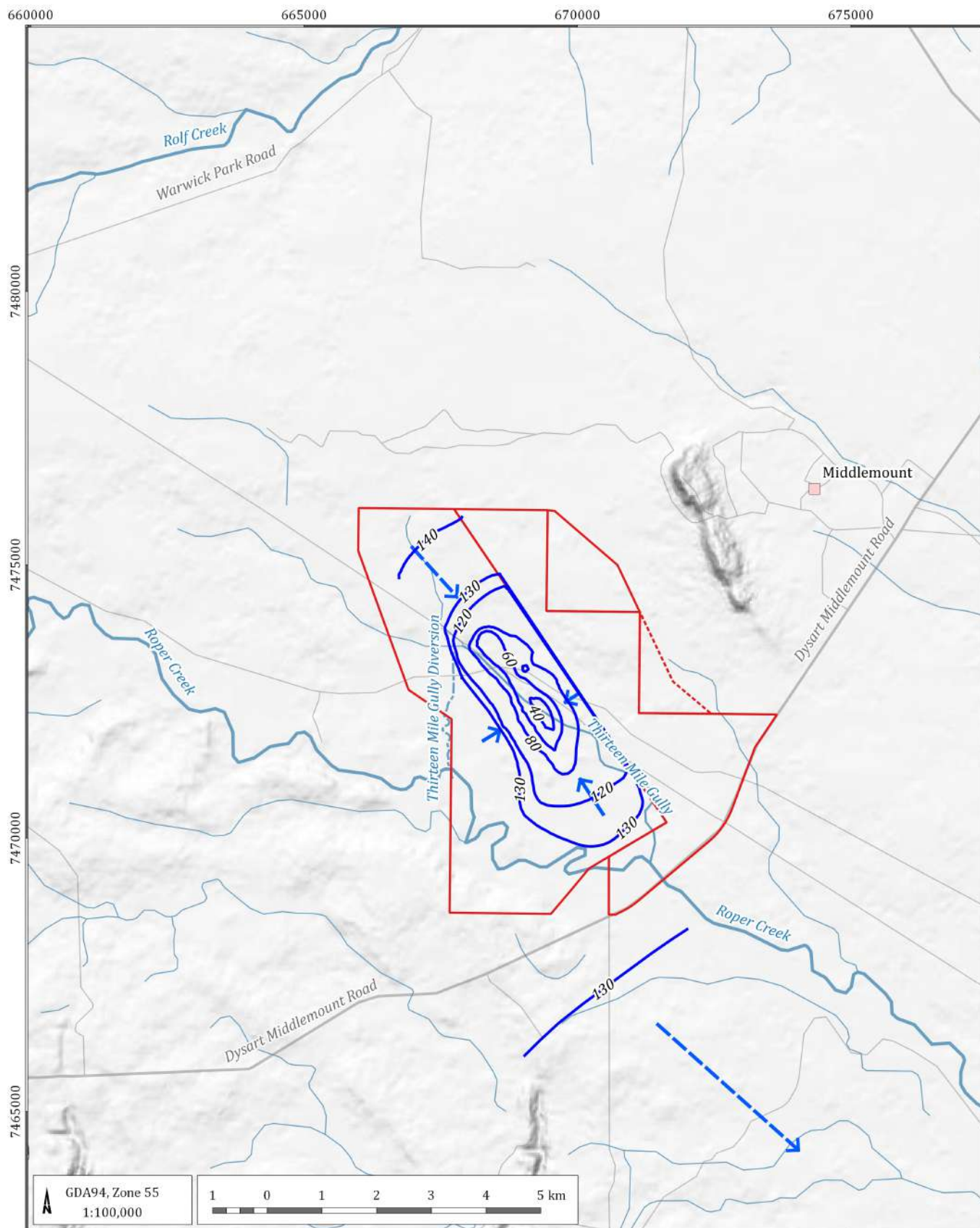
Middlemount Coal Mine Western Extension Project (G1840D)

Inferred 2017 Tertiary aquifer groundwater levels



DATE
04/06/2018

FIGURE No:
6.9



LEGEND

- | | |
|--|--|
| Populated place | Inferred groundwater contours (mAHd) |
| Mining Lease boundary (ML) | Regional groundwater flow direction |
| Mining Lease Application boundary (MLA) | Local mine induced groundwater flow direction |
| Road | |
| Watercourse | |
| Drainage feature | |

Middelmont Coal Mine Western Extension Project (G1840D)

Inferred 2017 Permian Rangal Coal Measures groundwater levels



DATE
04/06/2018

FIGURE No:
6.10

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 Project site.

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 or 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 water¹

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 Project 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)
Beryllium	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 Project will 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 three-dimensional numerical groundwater flow model was developed for the Project and was designed to account for the current and 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 final 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 groundwater model was developed as part of the groundwater assessment of the EIS for Stage 2 of the Middlemount Mine in 2010 (Parsons Brinckerhoff, 2010a). The model was constructed using MODFLOW SURFACT and comprised eight layers as shown in Table 8.1. In MODFLOW SURFACT, the model layers have to be continuous across the model domain. Where layers pinch out, the model cells are assigned the properties of the unit that is present in that area. The spatial extent of the model is approximately 38.8 km x 30 km, using a uniform grid of 100 m x 100 m cells.

The impact of geological structures, especially faulting, within the Project area was not considered due to limited data being available on their hydrogeological characteristics. The model was calibrated to steady state conditions. Transient calibration was not conducted as there was no suitable dataset to calibrate to. A sensitivity analysis was conducted on all model parameters and showed that the model was sensitive to several parameters. The resulting uncertainties in model predictions were considered to be acceptable although several recommendations were made for future model improvements.

With the level of information available at the time the model was given a complexity rating of low-medium according to the Murray-Darling Basin Commission (2000) modelling guidelines.

Table 8.1 2010 model layering

Layer	Hydrogeological unit
1	Tertiary
2	Weathered zone
3	Aquitard #1
4	Middlemount Coal Seams
3 - 5	Aquitard #2
6	Pisces Coal Seams
3 - 7	Fort Cooper Coal Measures
3 - 8	Fort Cooper Coal Measures/Fair Hill Formation

8.2 Overview of groundwater modelling

8.2.1 Model software and code selection

The industry standard in groundwater modelling is MODFLOW, which is released by the United States Geological Survey. The latest version, called MODFLOW-USG (USG), 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 geological units) and the model maintains its connections for layers above and below where the model layer has ceased. 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 numerical model.

8.2.2 Proposed mine plan

The Project involves the extension of open cut mining operations to the north-west, into ML 70379 (Figure 2.1) at the current maximum approved rate of 5.7 Mtpa until 2037, thereby allowing for a period of mining continuing for another 20 years. 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 Project 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 6.12, 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 8.6% 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 2037. 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.

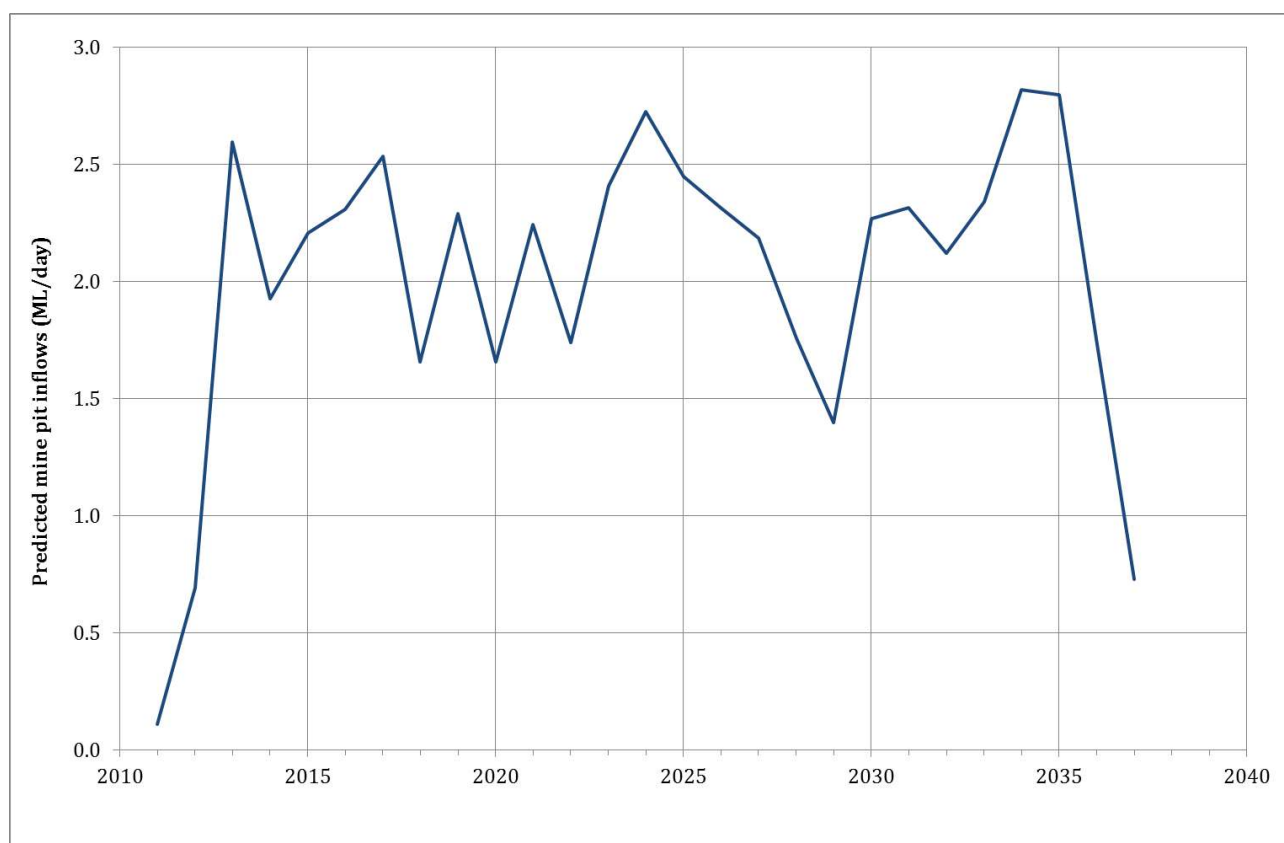


Figure 8.1 Predicted average annual pit inflows

Table 8.2 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 2037. The average daily predicted pit inflows between 2013 to 2017 are approximately 2.3 ML/day which is generally 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 8.2 Predicted groundwater inflow – 2011 to 2037

Calendar year	Combined (approved and proposed) predicted mine inflow	
	(ML/day)	(ML/year)
2011*	0.1	40
2012*	0.7	253
2013*	2.6	948
2014*	1.9	704
2015*	2.2	807
2016*	2.3	843
2017*	2.5	927
2018	1.7	605
2019	2.3	837
2020	1.7	605

Calendar year	Combined (approved and proposed) predicted mine inflow	
	(ML/day)	(ML/year)
2021	2.2	819
2022	1.7	635
2023	2.4	879
2024	2.7	995
2025	2.5	895
2026	2.3	845
2027	2.2	799
2028	1.8	642
2029	1.4	510
2030	2.3	828
2031	2.3	846
2032	2.1	775
2033	2.3	855
2034	2.8	1,030
2035	2.8	1,022
2036	1.8	640
2037	0.7	266

ML/year = megalitres per year

** Predictions from 2011 to 2017 that are for mining approved to date*

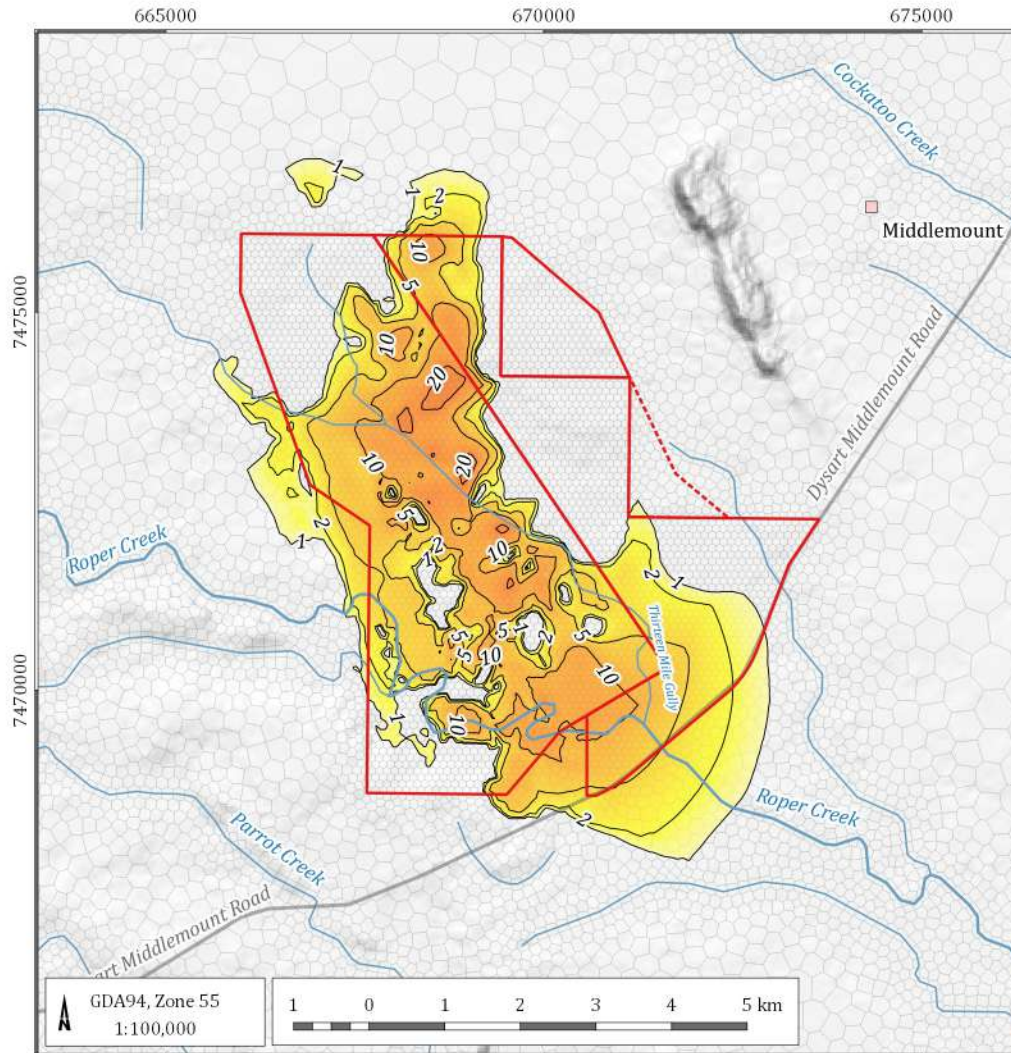
The predicted inflow rates presented in Figure 8.1 represent the take of water over the duration of the Project. Overall, the inflow rates are typically in line with the inflow rates currently experienced at the mine. It is noted that a proportion of these predicted groundwater inflows may be lost as 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

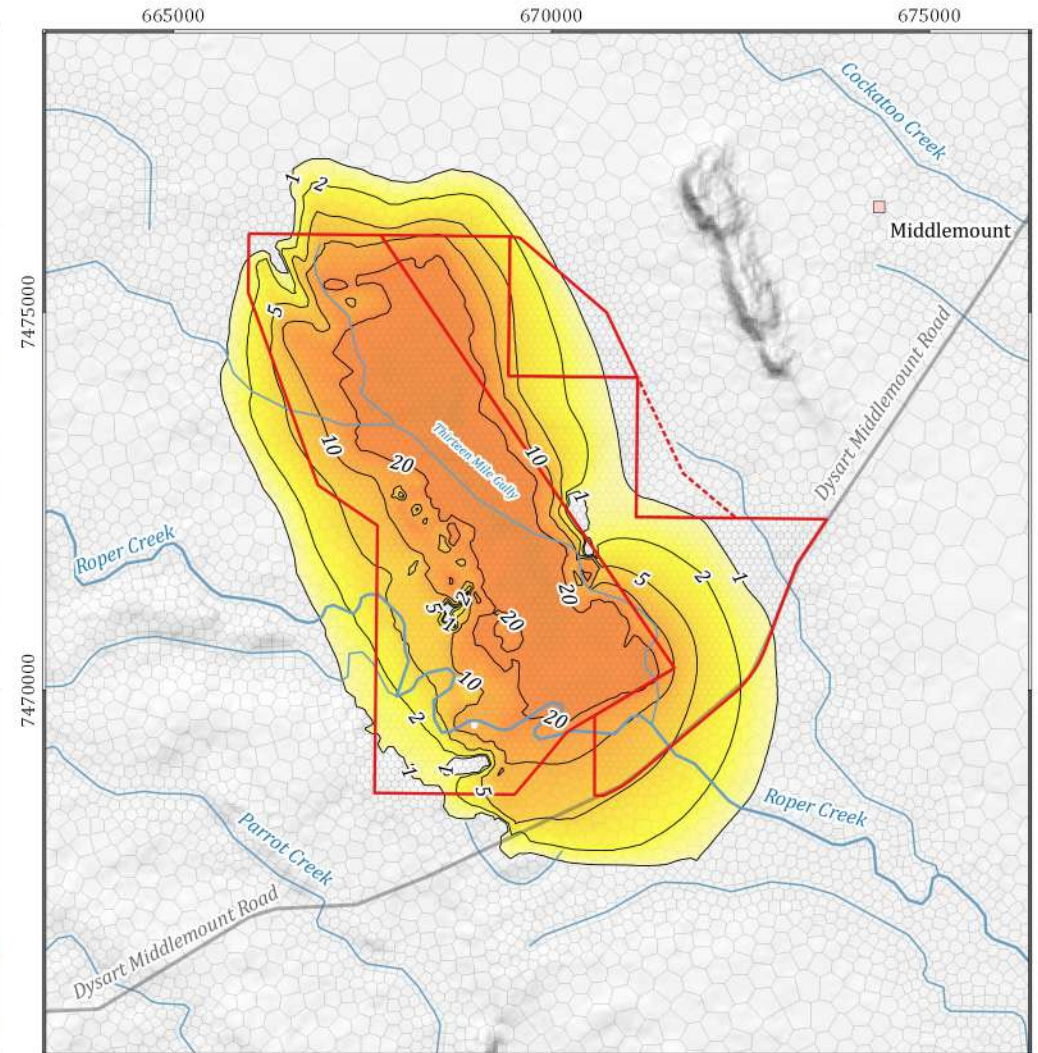
The zone of depressurisation due to the Project within the Tertiary and Weathered Permian (Layers 2 and 3), Middlemount Seam (layer 5), Pisces Seam (layer 7) and Fort Cooper Coal Measures (Layers 16 and 17), are shown in Figure 8.2, Figure 8.3, Figure 8.4, and Figure 8.5 respectively. The maximum drawdown 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 mining leases. 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 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 1.4 km to the north-west and south-east of the Project. 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 and Figure 8.4). Figure 8.5 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 8.5). The maximum extent of this drawdown during mining is largely contained within the ML boundaries.

Maximum zone of drawdown (Layer-2)



Maximum zone of drawdown (Layer-3)



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- Model grid
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)

Drawdown (m)

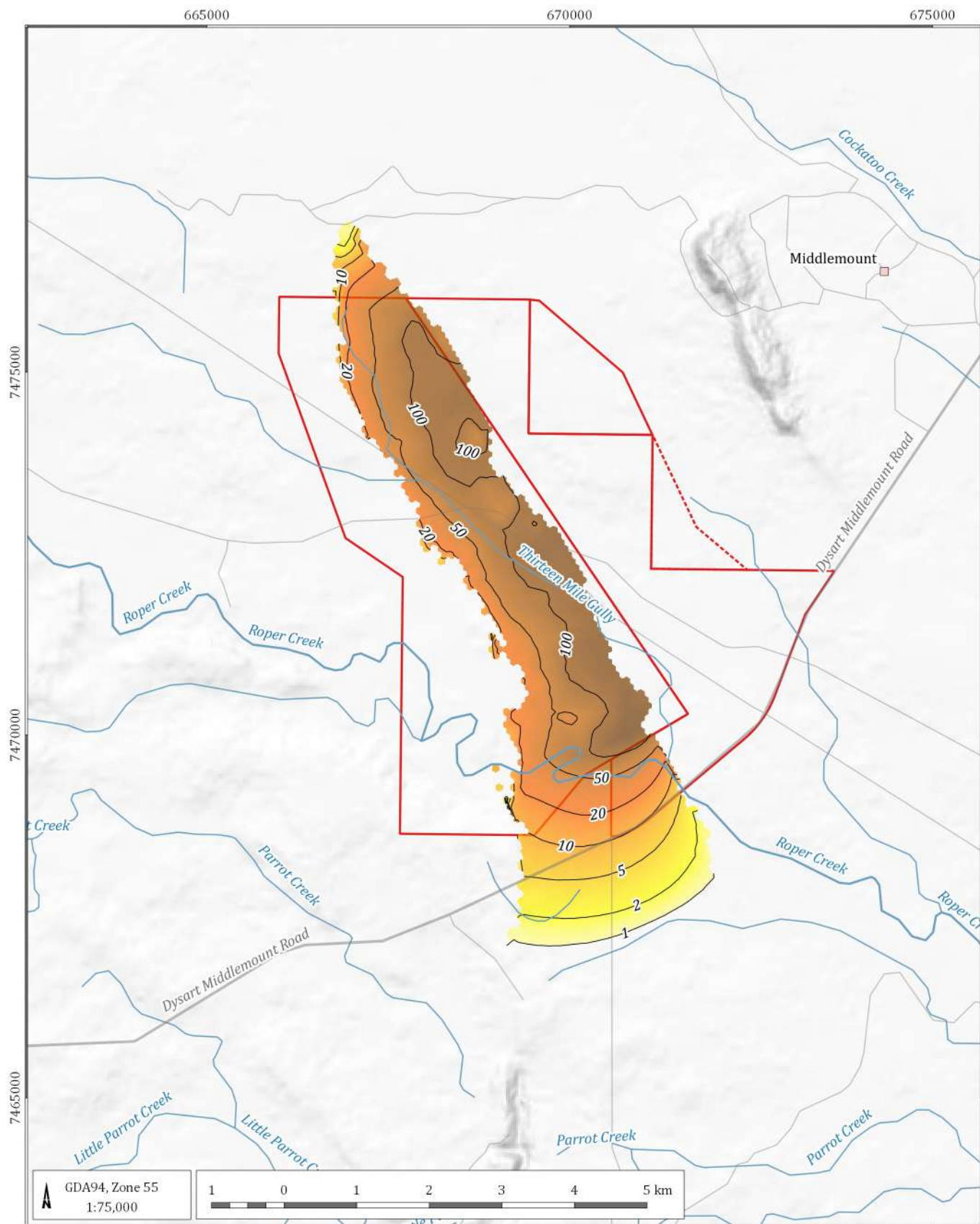
- 0
- 1
- 2
- 5
- 10
- 20

Middlemount Coal Mine Western Extension Project
(G1840D)

**Tertiary and Weathered Permian (Layer
2 & 3) - Maximum zone of drawdown
during mining**

DATE
27/04/2018

FIGURE No:
8.2



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- Road
- Watercourse
- Drainage feature

Drawdown (m)

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

— Drawdown contour (m)

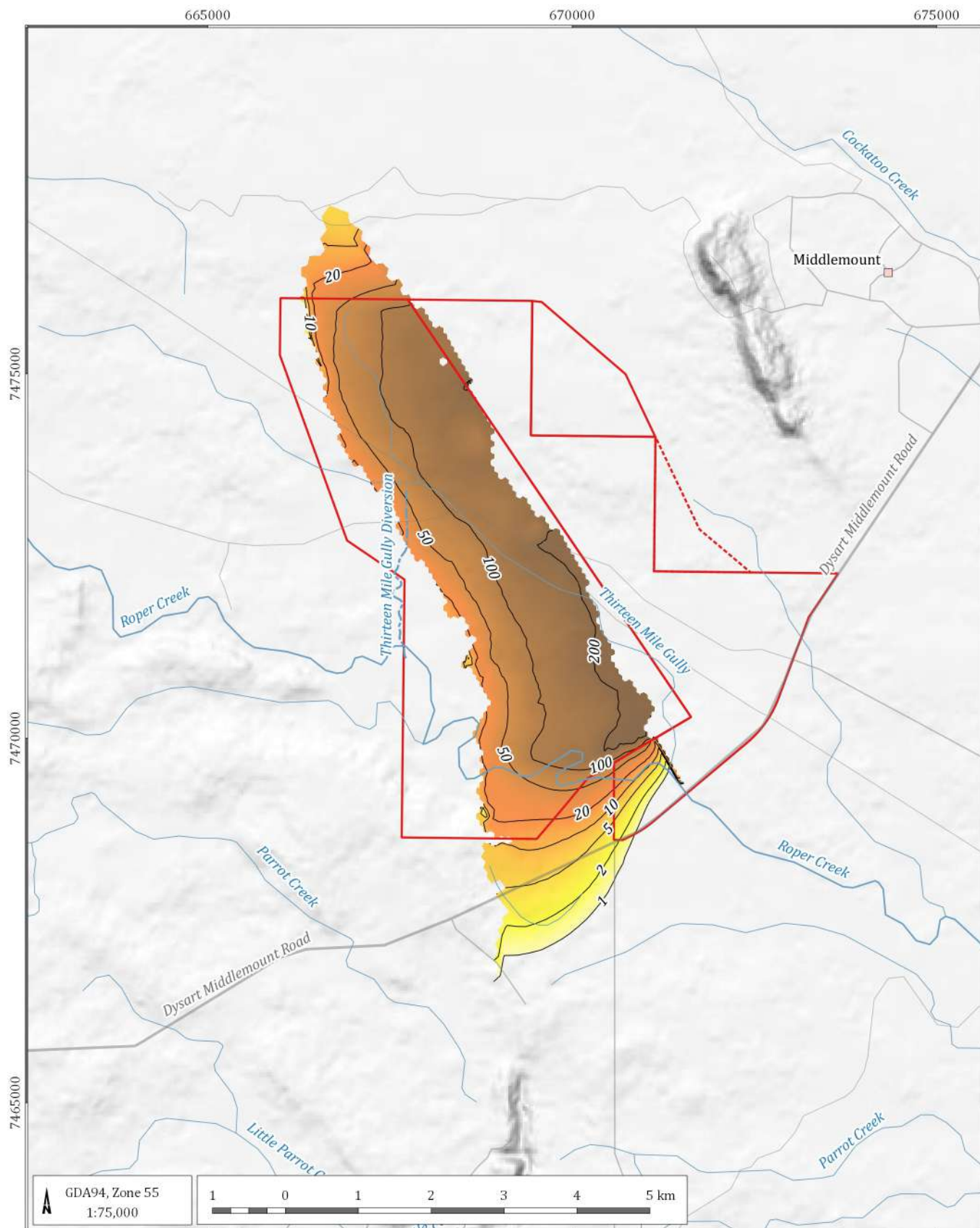
Middlemount Coal Mine Western Extension Project
(G1840D)

Middlemount Seam (Layer 5) - Maximum zone of drawdown during mining



DATE
27/04/2018

FIGURE No:
8.3



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- Road
- Watercourse
- Drainage feature

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- Drawdown contour (m)

Middlemount Coal Mine Western Extension Project
(G1840D)

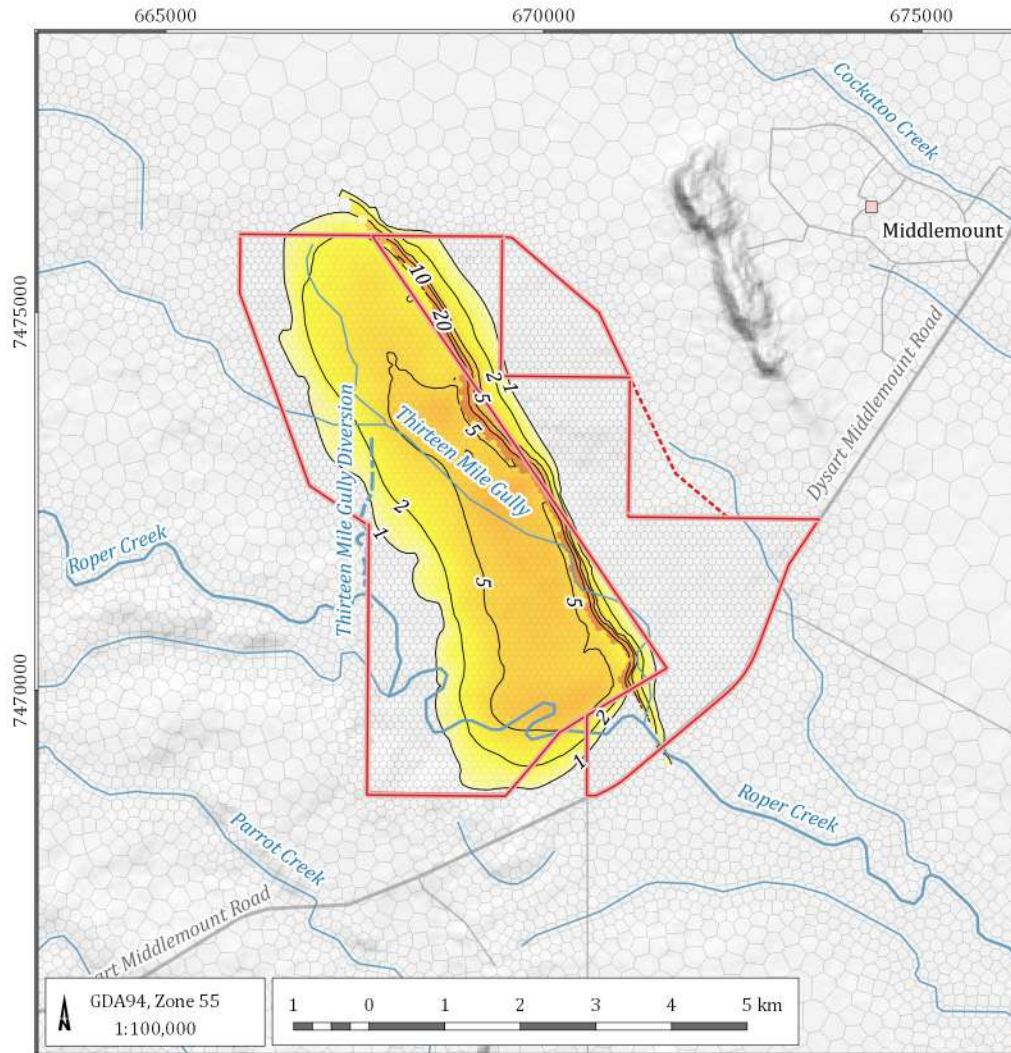
Pisces Seam (Layer 7) - Maximum zone of drawdown during mining



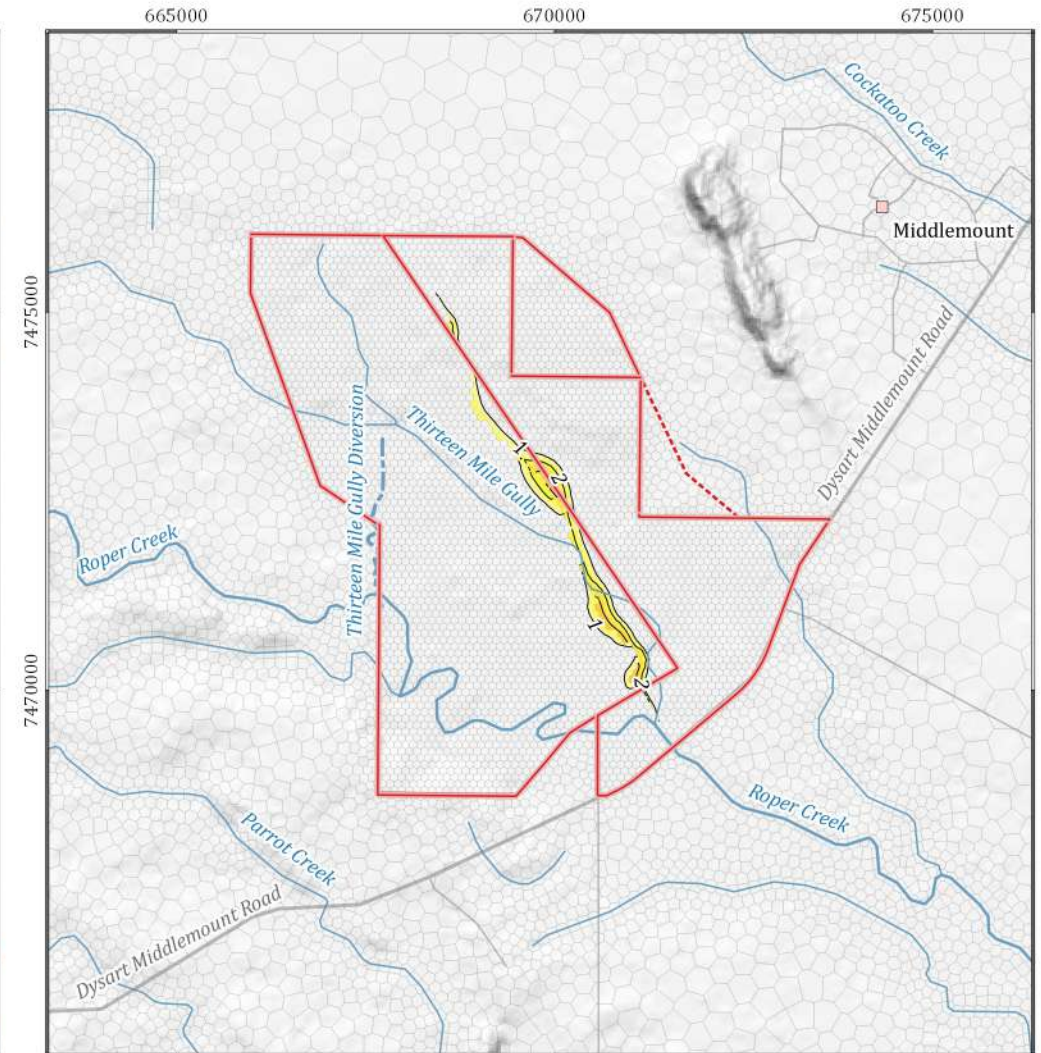
DATE
27/04/2018

FIGURE No:
8.4

Maximum zone of drawdown (Layer-9 & 16)



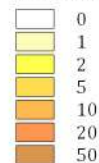
Maximum zone of drawdown (Layer-10 & 17)



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- Model grid
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)

Drawdown (m)



Middlemount Coal Mine Western Extension Project
(G1840D)

**Fort Cooper Coal Measures (Layers 9, 16
& 10, 17) - Maximum zone of drawdown
during mining**

DATE
27/04/2018

FIGURE No:
8.5

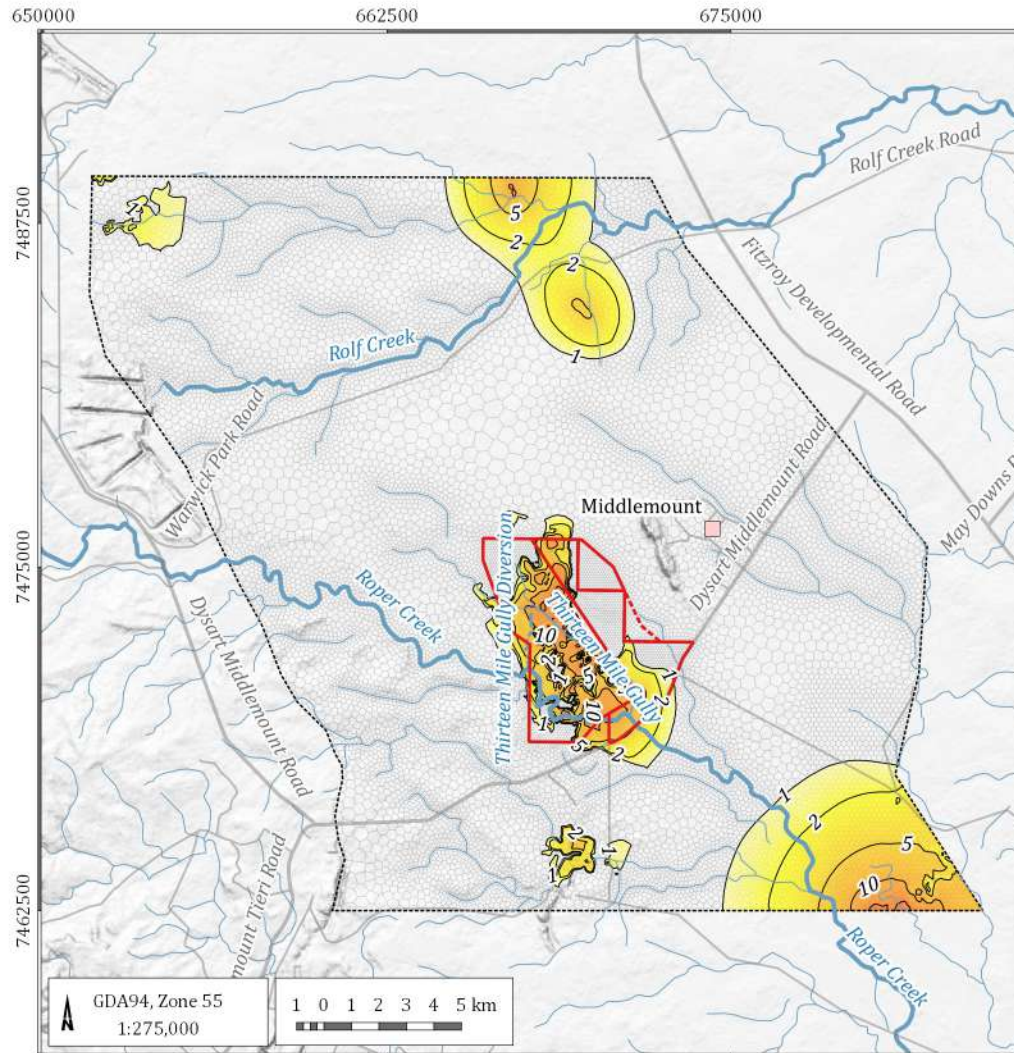
8.3.3 Cumulative impacts

The numerical groundwater model was used to assess the cumulative impact between 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 Project 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 Project area.

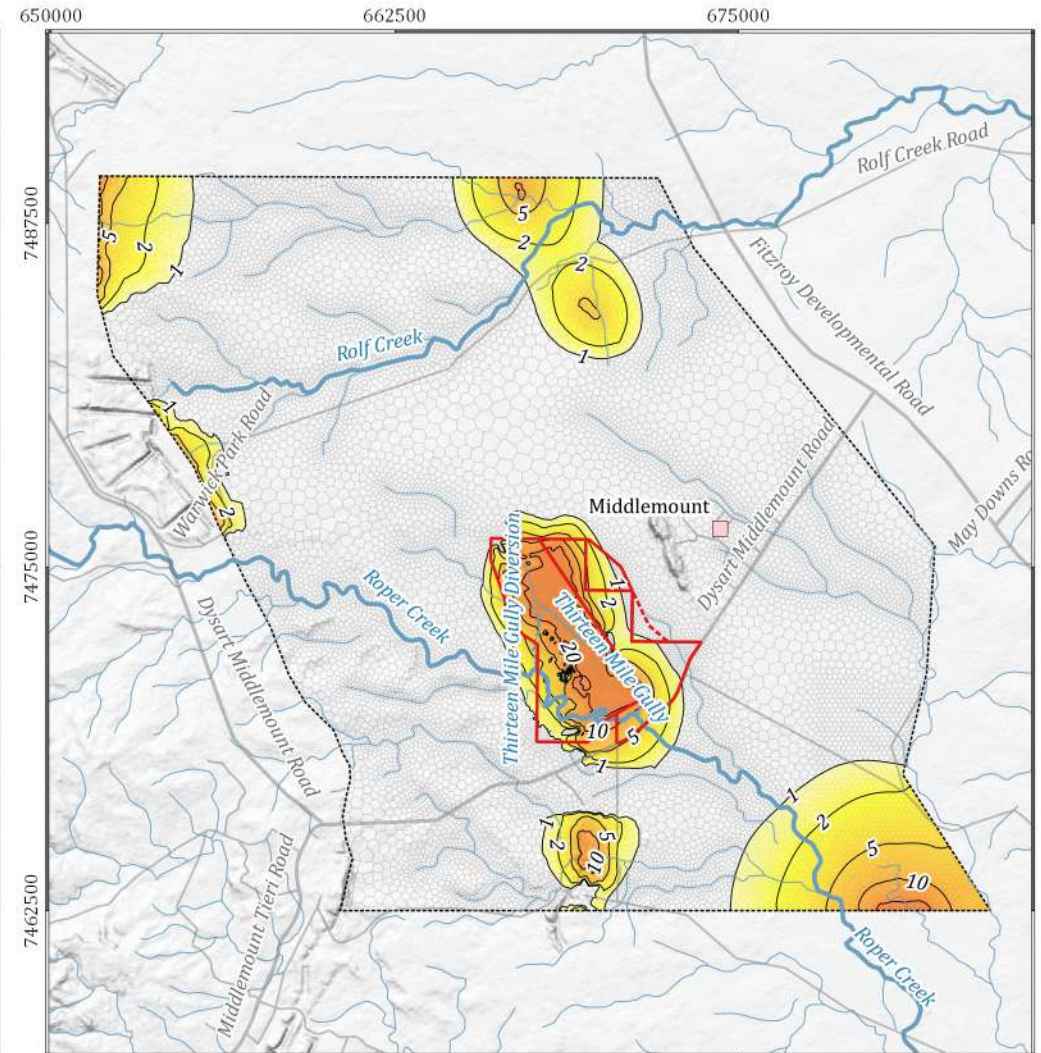
Figure 8.6 to Figure 8.9 show predicted drawdown extents for each of the adjacent mine and CSG projects. These show the maximum drawdown extents during mining:

- Within the Tertiary and Weathered Permian (Figure 8.6) for each site do not overlap resulting in there being no cumulative drawdown within model layers 2 and 3.
- For the Middlemount Seam (layer 5) 1 m contour, just intersects roughly midway between the Project and the German Creek East voids (Figure 8.7), 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 Project and the German Creek East voids (Figure 8.8), 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.
- Within the Fort Cooper Coal Measures (Figure 8.9) for each site do not overlap resulting in no cumulative drawdown within model layers 9, 10, 16 and 17.

Maximum cumulative drawdown (Layer-2)



Maximum cumulative drawdown (Layer-3)



LEGEND

- Populated place
- ▭ Mining Lease boundary (ML)
- ▭ Mining Lease Application boundary (MLA)
- ▭ Model boundary
- ▭ Model grid
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)

Drawdown (m)

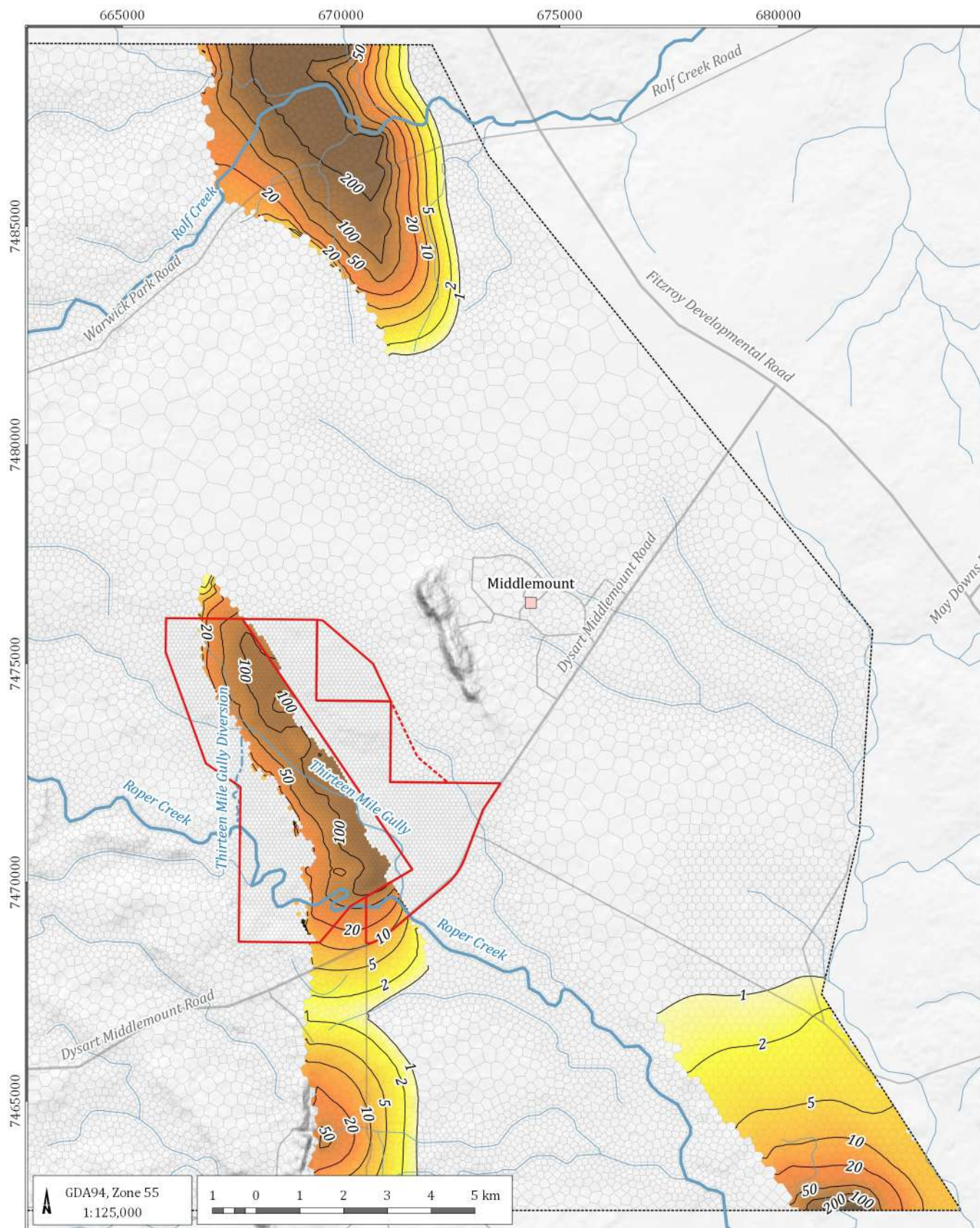
- 0
- 1
- 2
- 5
- 10
- 20

Middlemount Coal Mine Western Extension Project
(G1840D)

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

DATE
27/04/2018

FIGURE No:
8.6



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Model boundary
- Model grid
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)

Drawdown (m)

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

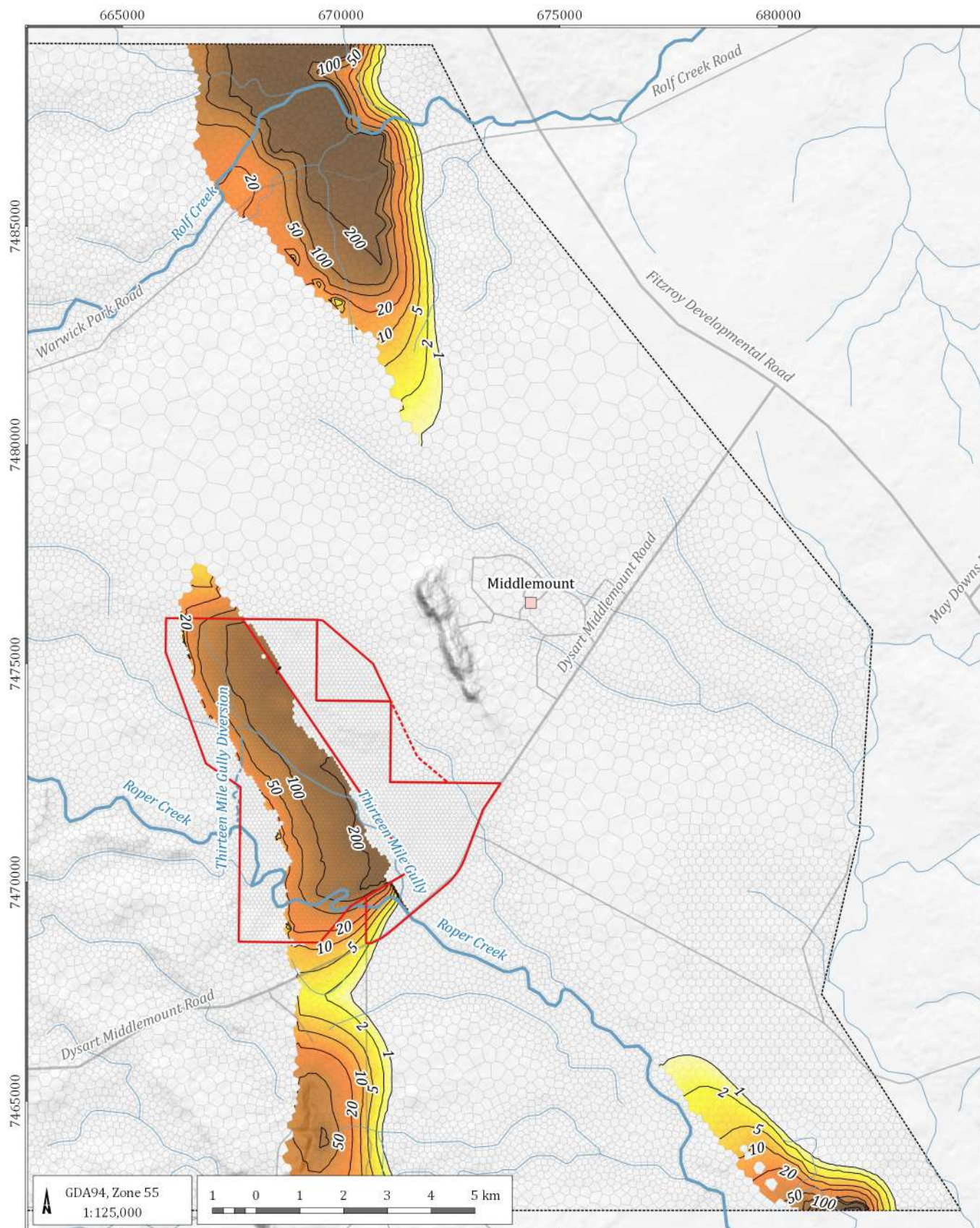
Middlemount Coal Mine Western Extension Project
(G1840D)

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



DATE
27/04/2018

FIGURE No:
8.7



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Model boundary
- Model grid
- Road
- Watercourse
- Drainage feature
- Drawdown contour (m)

Drawdown (m)

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

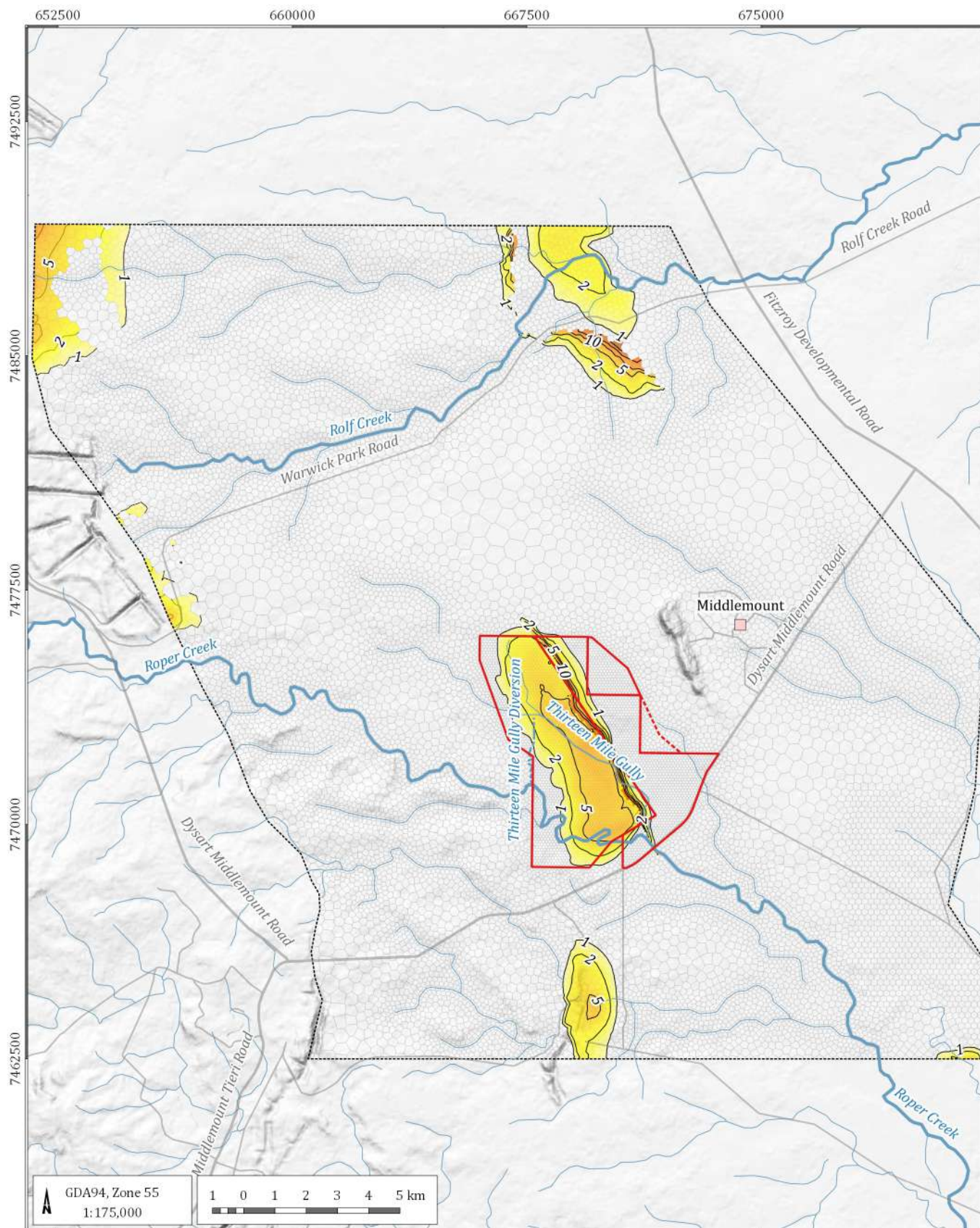
Middlemount Coal Mine Western Extension Project
(G1840D)

**Maximum cumulative drawdown Pisces
and Vermont Seam during mining -
Layer 7 & Layer 14 (CSG extraction,
Foxleigh Mine, German Creek East Mine)**



DATE
27/04/2018

FIGURE No:
8.8



LEGEND

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

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20

Middlemount Coal Mine Western Extension Project (G1840D)

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



DATE
27/04/2018

FIGURE No:
8.9

8.3.4 Water licensing

Under the *Water Act 2000* (current at 1 March 2017), the Project will require an AWL for this EA amendment application. The purpose of an AWL is provided in section 1250C, division 2 of the *Water Act* which states “An associated water licence authorises the taking of or interference with underground water in the area of a mining tenure if the taking or interference happens during the course of, or results from, the carrying out of an authorised activity for the tenure.”

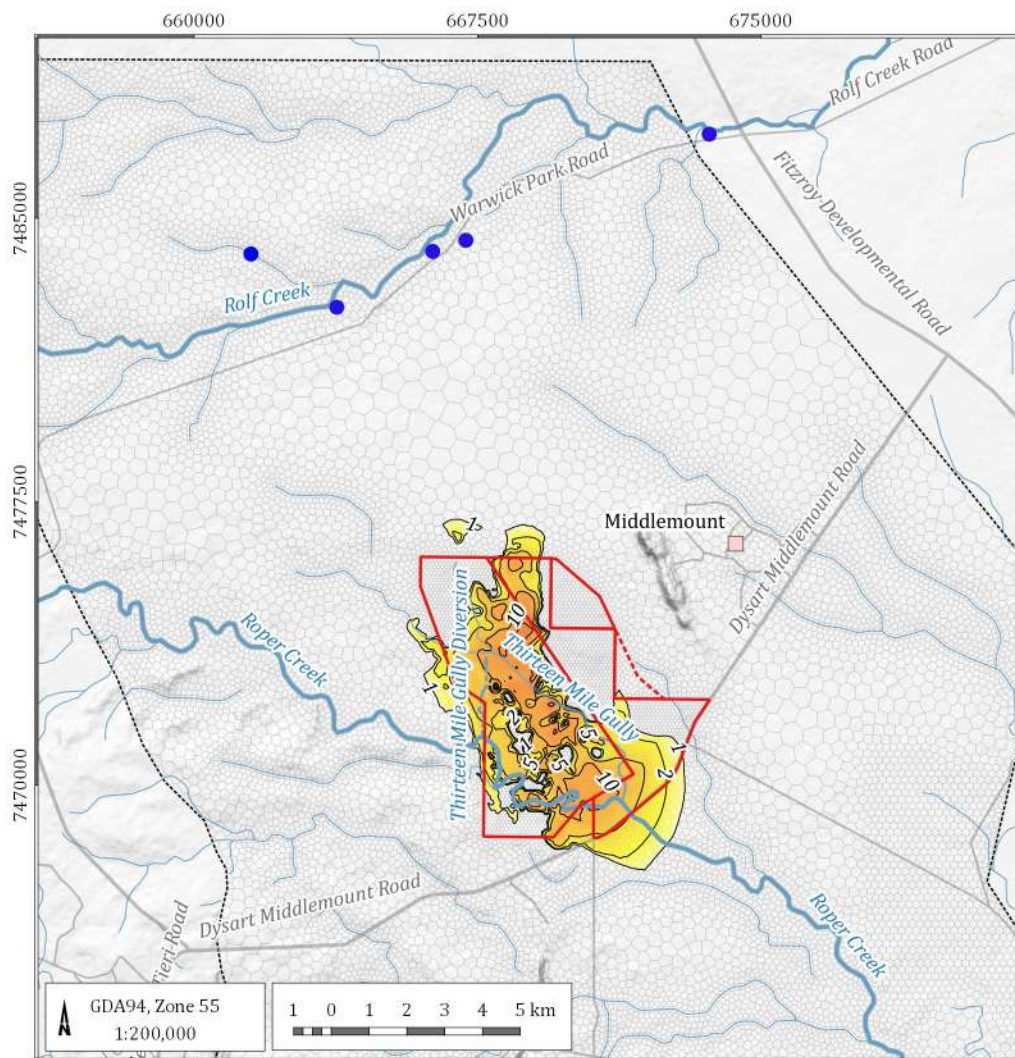
8.3.5 Impacts on groundwater users

As discussed in Section 8.3.2, the depressurised zone as a result of the Project in the Tertiary and Weathered Permian, and the Rangal Coal Measures extends up to 1.4 km towards the north-west and south-east of the Project area.

Figure 8.10 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 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.

Maximum zone of drawdown (Layer-2)



LEGEND

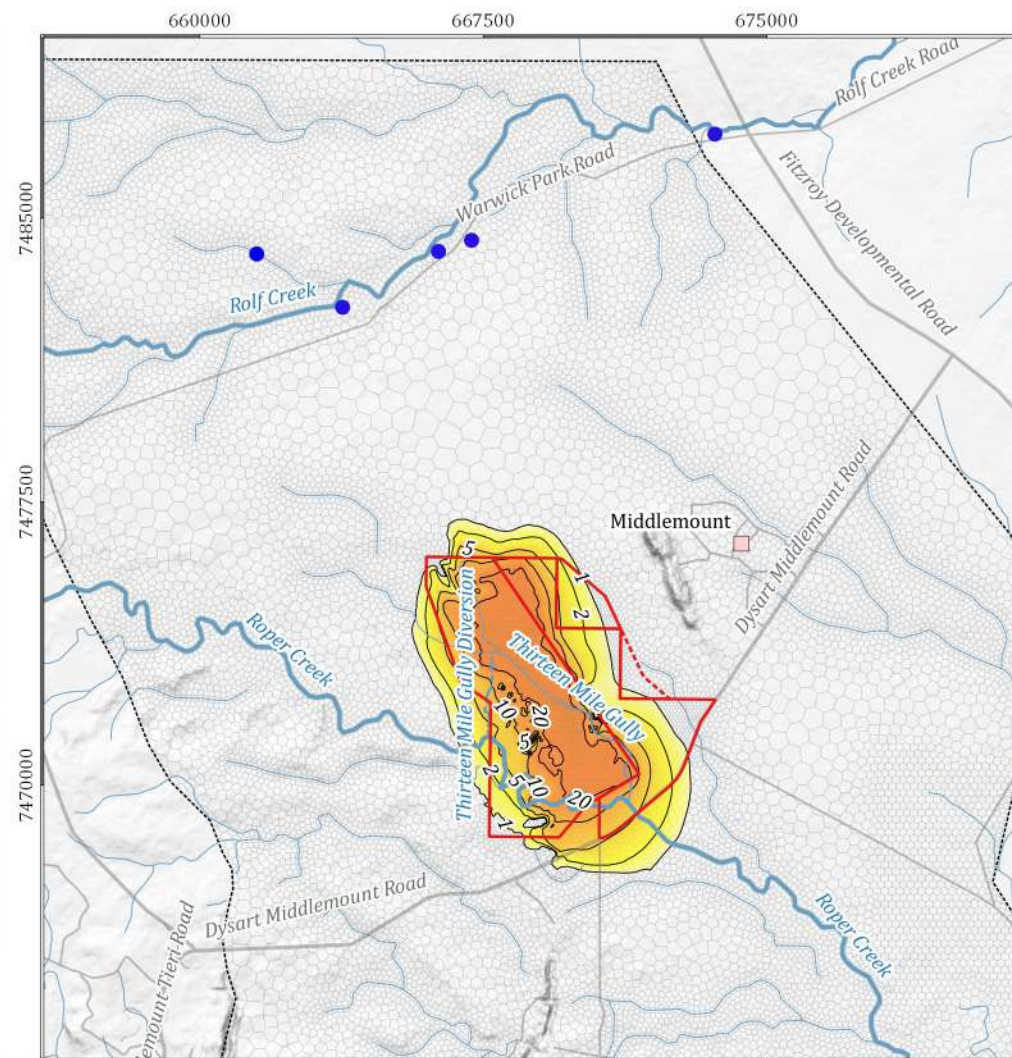
- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Model grid
- Road
- Watercourse
- Drainage feature

- Landholder bores
- Drawdown contour (m)

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20

Maximum zone of drawdown (Layer-3)



Middlemount Coal Mine Western Extension Project
(G1840D)

**Landholder bores within predicted
maximum zone of drawdown during
mining**

DATE
17/05/2018

FIGURE No:
8.10

8.3.6 Impacts on groundwater dependent ecosystems

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 Project area (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 $\mu\text{S}/\text{cm}$, 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 approved mine and Project (e.g. some 5-7 km north-west and south-east).

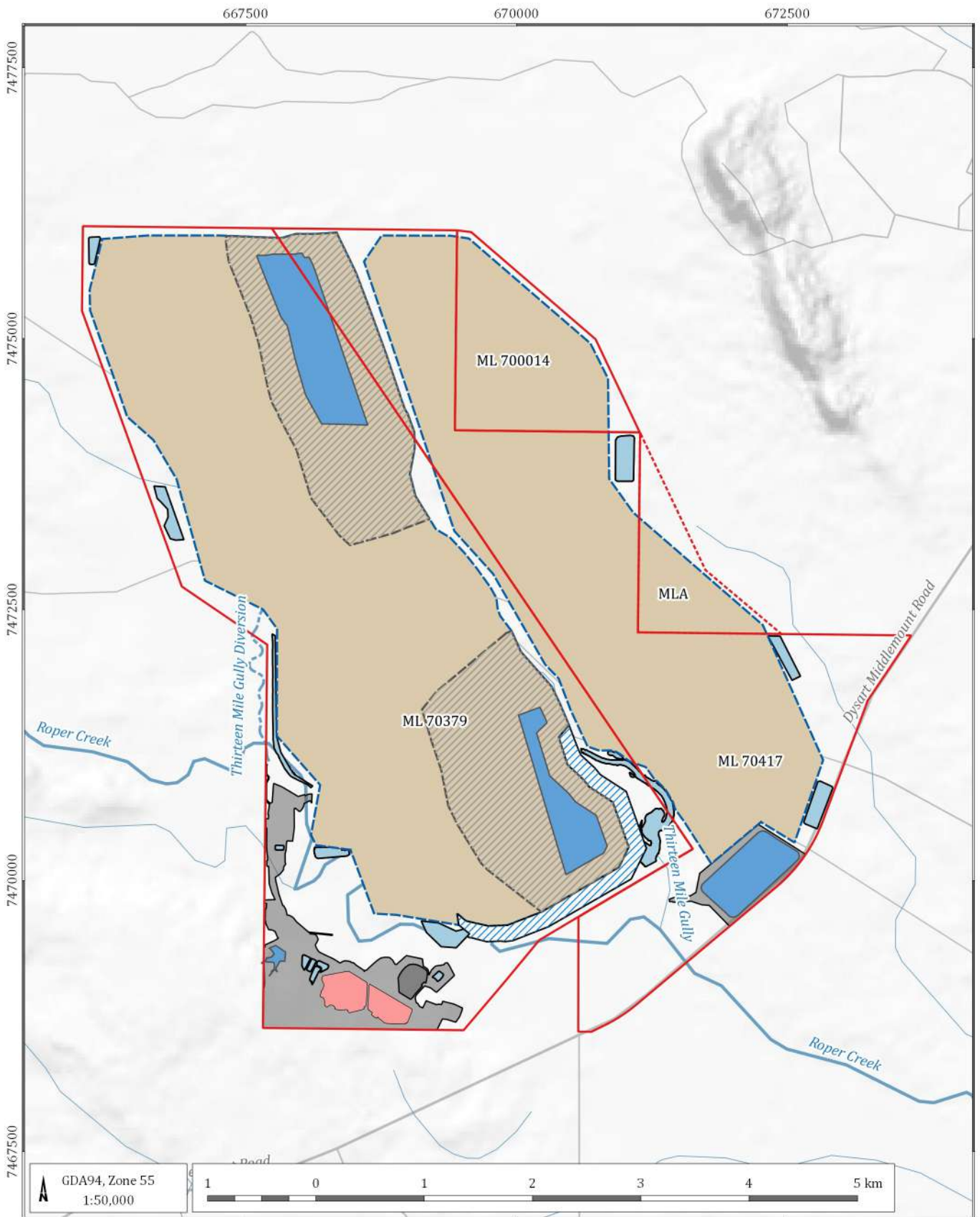
The Project is not predicted to significantly impact stygofauna considering the Project would only incrementally increase the groundwater drawdown from the approved mine, the groundwater aquifer (similar stygofauna habitat) is extensive outside of the maximum zone of drawdown, and the sampling indicates there is a low diversity of stygofauna in and outside the maximum zone of drawdown.

8.4 Post mining recovery conditions

Post mining conditions were also simulated using the numerical groundwater flow model. The locations of the final voids are shown in Figure 8.11 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 Project development 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 180 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. The simulation results show the North Void becoming saturated and the development of a void lake at the northern end of the void, and a larger void lake developing in the South Void. The difference in equilibrium water level for each void produces a gradient from the North Void into the South Void resulting in the North Void remaining mostly dry. 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.



LEGEND

- | | |
|---|--|
| Mining Lease boundary (ML) | Flood Bund |
| Mining Lease Application boundary (MLA) | Final Void |
| Road | Established Rehabilitation |
| Watercourse | Infrastructure Extent |
| Drainage feature | Tailings Storage Facility |
| | Water Management Dams |
| | Sediment Dam |

Middlemount Coal Mine Western Extension Project
(G1840D)

Western Extension Project final voids



DATE
11/04/2018

FIGURE No:
8.11

8.4.1 Post closure groundwater recovery

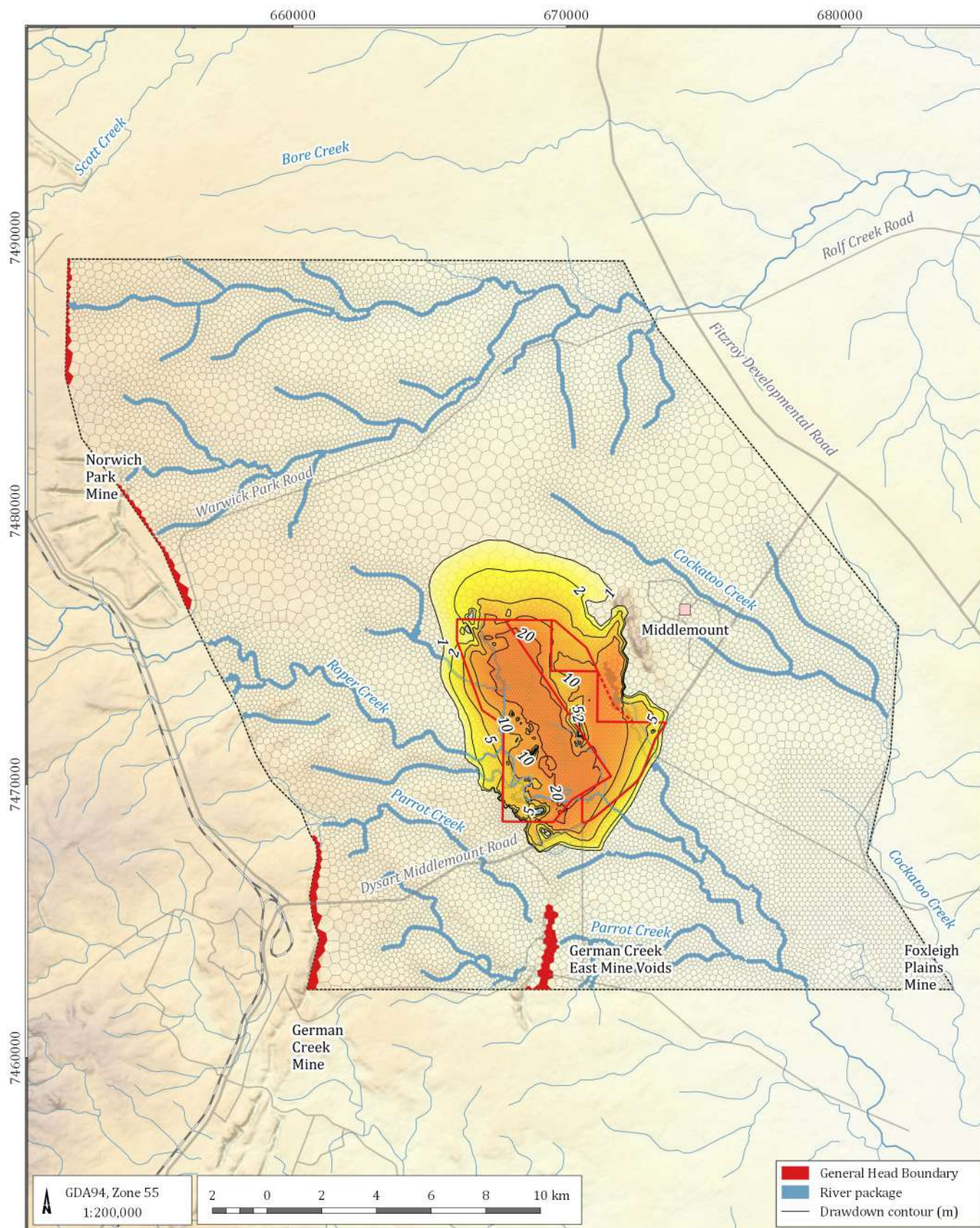
Post closure conditions were simulated over a period of 500 years by WRM to predict the extent of void lake level recovery following cessation of mining. WRM modelling indicates that the final voids would gradually fill over time from direct rainfall occurring across each void and groundwater seepage. Utilising the WRM modelling results, representative pit lake levels of approximately 65 mAHD in the northern portion of the North Void, and -39 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 final voids. This was achieved in a steady state simulation using the representative pit lake levels, consistent with the WRM modelling results, in each void.

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 8.12 to Figure 8.15 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 final voids remaining as groundwater sinks in perpetuity and the depth to the equilibrium level for the two final void lakes, the drawdown extents depicted by the 1 m contour is predicted to generally remain constrained around the mine footprint and mining leases. Predicted drawdown within the Tertiary and weathered Permian extends up to 2 km from the northern mining lease 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 mining lease, 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 mining lease boundaries towards Middlemount township.

It should be noted that this drawdown extent was determined by steady state simulation, which creates predicted water levels that represent the ultimate long-term situation. 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 equilibrium groundwater drawdown predicted by the steady state groundwater model is conservative and provides a worst case scenario of the potential drawdown extents.



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Active model outline
- Model grid
- Road
- Rail
- Watercourse
- Drainage feature

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20

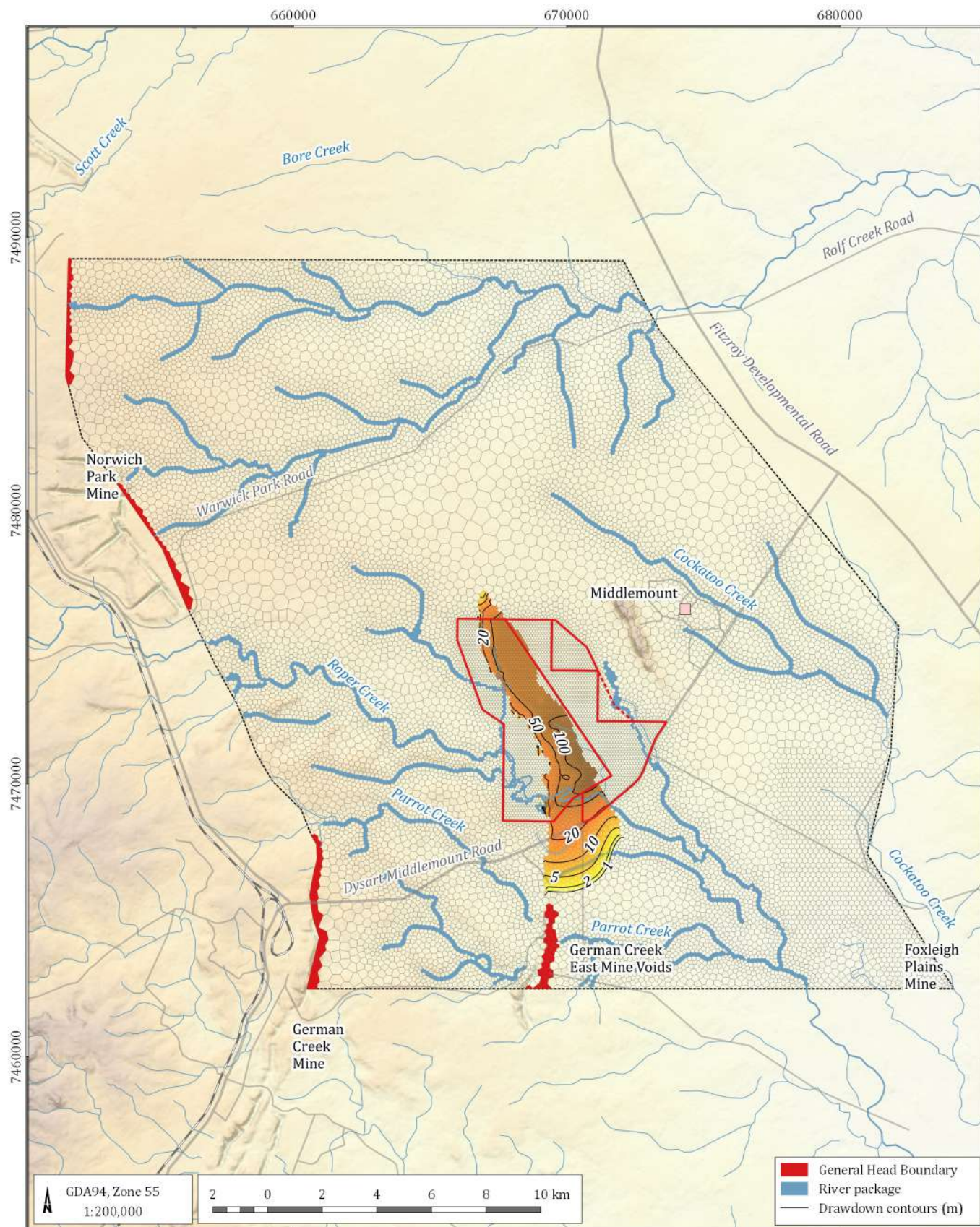
Middlemount Mine Extension (G1840D)

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



DATE
04/06/2018

FIGURE No:
8.12



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Active model outline
- Model grid
- Road
- Watercourse
- Drainage feature
- Rail

Drawdown (m)

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

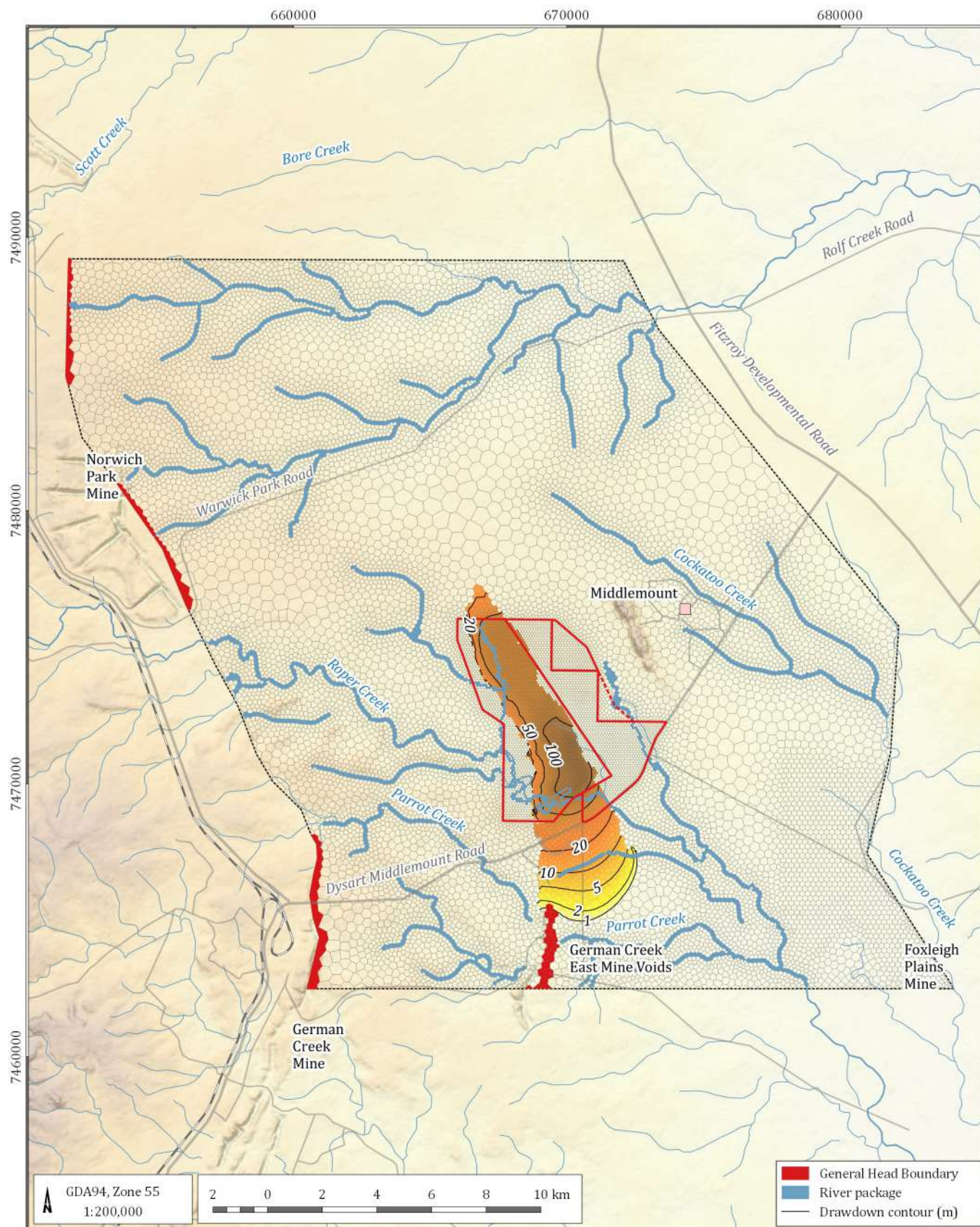
Middlemount Mine Extension (G1840D)

Post mining equilibrium drawdown - Middlemount Seam (Layer 5)



DATE
04/06/2018

FIGURE No:
8.13



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Active model outline
- Model grid
- Road
- Watercourse
- Drainage feature
- Rail

Drawdown (m)

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

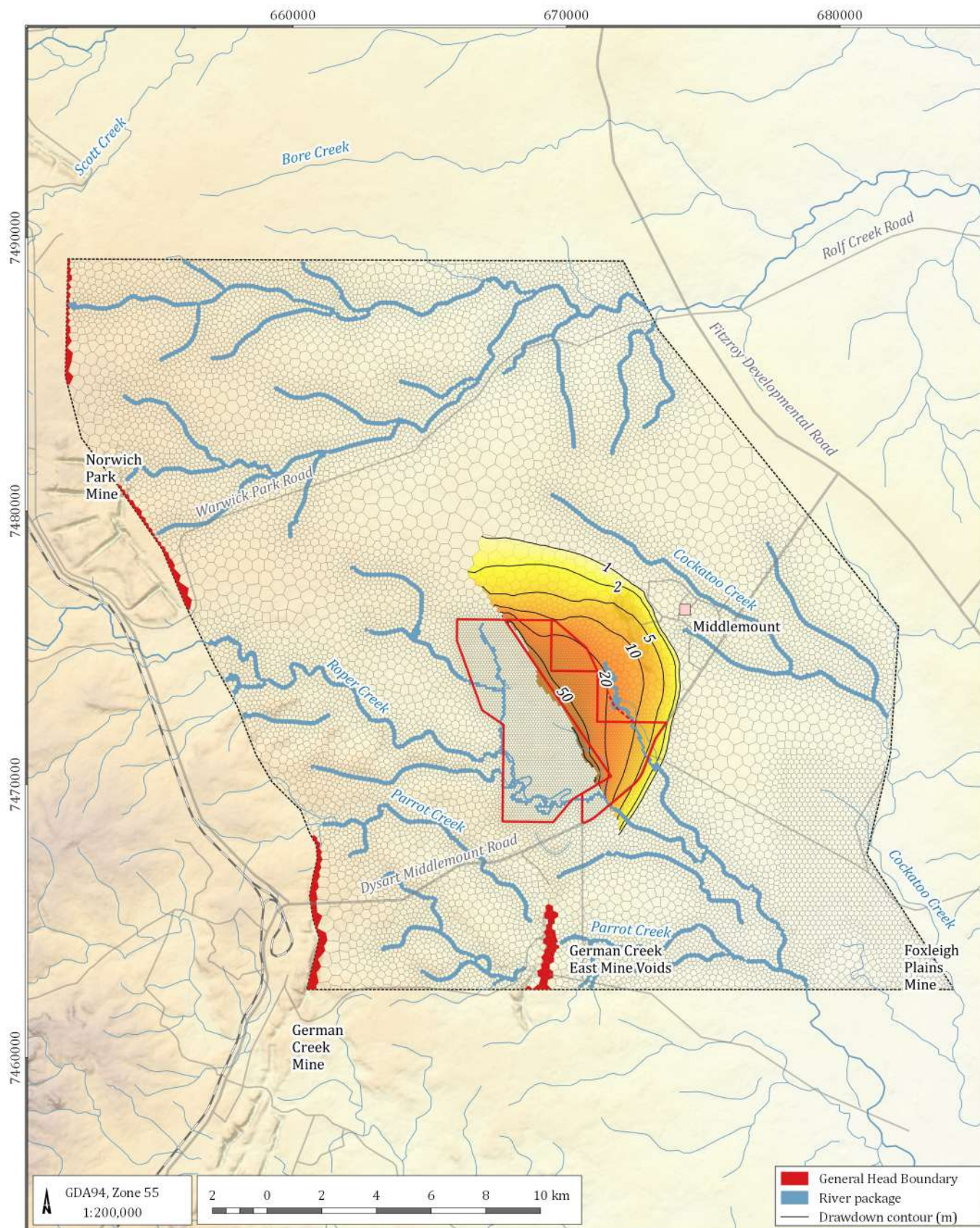
Middlemount Mine Extension (G1840D)

Post mining equilibrium drawdown - Pisces Seam (Layer 7)



DATE
04/06/2018

FIGURE No:
8.14



LEGEND

- Populated place
- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Active model outline
- Model grid
- Road
- Watercourse
- Drainage feature
- Rail

Drawdown (m)

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

Middlemount Mine Extension (G1840D)

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



DATE
04/06/2018

FIGURE No:
8.15

8.4.2 Groundwater intercepted post mining

The WRM modelling indicates the final voids will gradually fill with water over time and representative pit lake levels of approximately 65 mAHD in the northern portion of the North Void, and -39 mAHD in the South Void have been used for the purpose 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 Project is estimated to intercept approximately 0.07 ML/day (24 ML/year) of groundwater inflow to the final 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.

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 final 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. Under 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 final void 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 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 Project will continue over the Project life.

As such, coal rejects will need to be managed to control formation and release of any acid drainage. For example, where it is anticipated that placement of coarse and fine reject materials occurs hydraulically up-gradient of the final void, any resultant seepage from the emplaced rejects will need to report to the final voids. As the final voids are predicted to become sinks, any resultant seepage from the emplaced rejects will be captured and contained within the final voids. Similarly, utilisation of the final voids for in-pit rejects emplacement will be managed to ensure a groundwater sink post closure, provided that any in-pit rejects emplacement remains below the surrounding regional groundwater table.

As detailed in Section 8.4.1, the final voids would gradually fill over time from direct rainfall occurring across each void and groundwater seepage, however the water level in the final voids would remain well below the surrounding groundwater levels. As a result, it is predicted that the final voids would act as sinks to groundwater flow. Any poor quality water within the in-pit rejects emplacement would be captured in the final pit void lakes. Evaporation from the final 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 70, 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 final void.

The Project would recycle groundwater that seeps into the open cut pit. 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 the Project.

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 Project and a proactive indicator of any adverse impacts on the groundwater regime.

9.1 Monitoring bore network

The proponent currently maintains a groundwater monitoring program for the approved mining operations in accordance with under 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. Installation of additional bores (MW16A, MW17A, MW18A, MW19VWP, and MW20VWP) outside of the current mine area, is proposed to provide groundwater data within the:

- Tertiary/Weathered Permian strata west of the proposed extension area;
- Tertiary/Weathered Permian strata adjacent to MW10A where groundwater levels have declined below the base of MW10A;
- Tertiary/Weathered Permian strata north of the Project between the northern boundaries for ML 70379 and ML 70417 and existing landholder bores along Rolf Creek; and
- Fort Cooper Coal Measures east of the Jellinbah Fault to assess groundwater drawdown response and the potential for hydraulic loading within these Permian sediments.

The installation of these additional bores will serve to capture additional groundwater monitoring where data gaps within the current monitoring network have been identified. 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 existing and proposed groundwater monitoring network are provided in Table 9.1 with their locations shown in Figure 9.1

Table 9.1 Proposed Middlemount Mine groundwater monitoring network

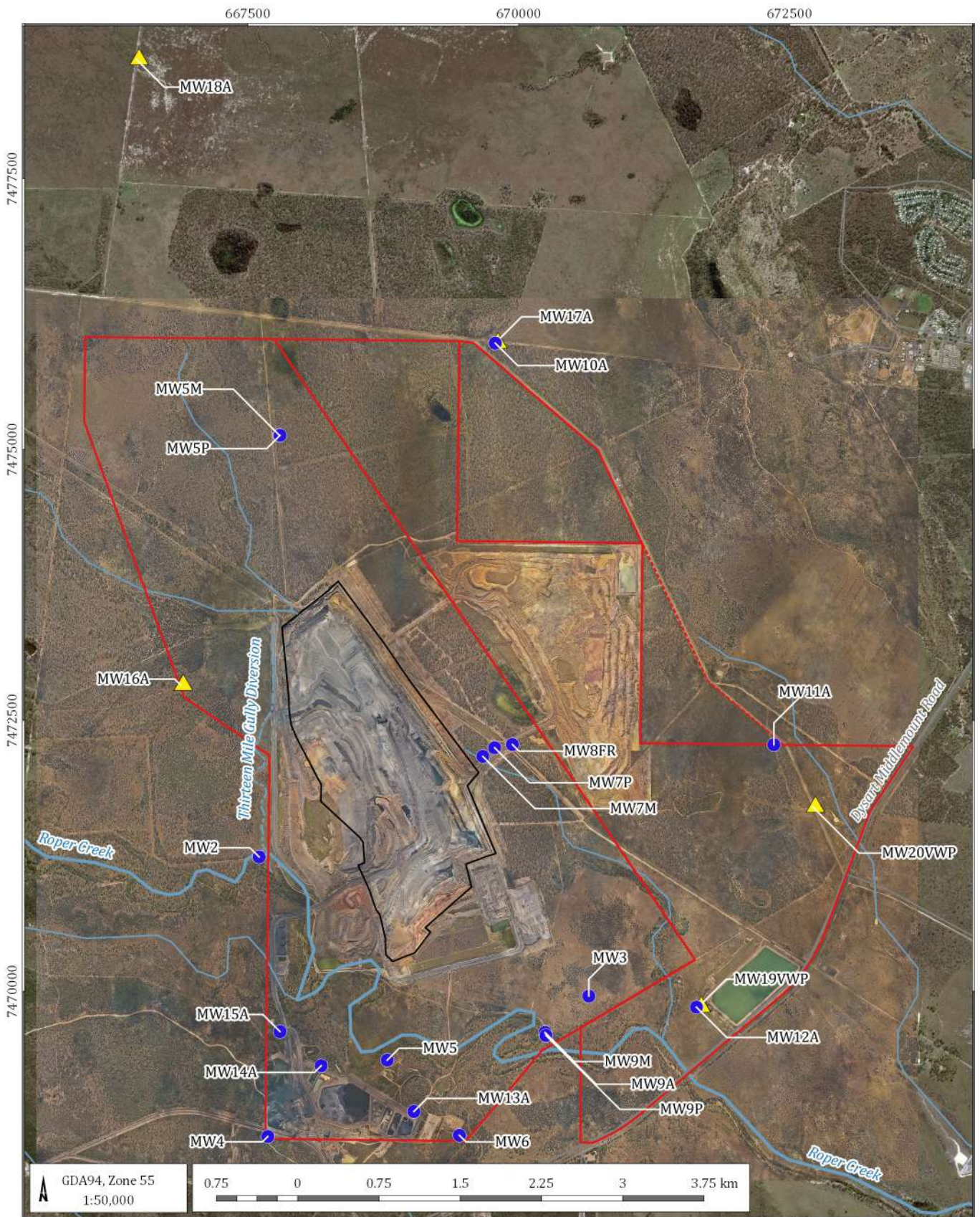
Monitoring bore	Easting (m)	Northing (m)	Bore depth (m)	Screen depth (m)	Screen lithology	Frequency
MW2	667603	7471239	30.0	21.0 – 29.0	Tertiary	SWL: quarterly * Quality: quarterly
MW3	670647	7469955	48.0	39.0 – 47.0	Tertiary	SWL: quarterly * Quality: quarterly
MW4	667683	7468659	50.0	41.0 – 50.0	Intrusives 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
MW7M	669668	7472167	135.5	132.0 – 134.5	Middlemount coal seam (Rangal Coal Measures)	SWL: quarterly * Quality: quarterly

Monitoring bore	Easting (m)	Northing (m)	Bore depth (m)	Screen depth (m)	Screen lithology	Frequency
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 – 12.0	Tertiary	SWL: quarterly Quality: quarterly
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	~30	~15 - 30	Tertiary/Weathered Permian	SWL: quarterly * Quality: quarterly
MW17A [#]	669783	7475981	~30	~15 – 30	Tertiary/Weathered Permian	SWL: quarterly * Quality: quarterly
MW18A [#]	666470	7478600	~30	~15 – 30	Tertiary/Weathered Permian	SWL: quarterly * Quality: quarterly
MW19 VWP [#]	671660	7469855	~331.2	TBC	Girrah coal seam (Fort Cooper Coal Measures)	SWL: quarterly
MW20 VWP [#]	672714	7471701	~317.5	TBC	Girrah coal seam (Fort Cooper Coal Measures)	SWL: quarterly

Notes: Coordinates in GDA94Z55

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

[#] proposed additional monitoring bores to address gaps in monitoring network



LEGEND

- Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- Mine pit footprint, 2017
- Road
- Watercourse
- Drainage feature
- Middlemount Coal Mine monitoring bores
- ▲ Proposed monitoring bores

Middlemount Coal Mine Western Extension Project
(G1840D)

Proposed Middlemount Coal Mine groundwater monitoring network



DATE
30/04/2018

FIGURE No:
9.1

9.2 Water level monitoring plan

It is recommended that groundwater level monitoring is initially undertaken at a quarterly frequency 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.

It is therefore recommended that for the long term monitoring of groundwater levels, electronic water level loggers are installed in 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.

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 include:

- physio-chemical parameters – pH, EC, TDS;
- major ions – calcium, magnesium, sodium, potassium, chloride, sulphate, alkalinity (carbonate and bicarbonate);
- total and dissolved metals –iron, silver, mercury, nickel, 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 DEHP (2009).

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 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 June 2017 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 Project. Review of the environmental values identifies that groundwater accessed by 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 21 May 2018). 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 / Maximum
EC	µS/cm	35,000	Maximum	35,000	Median
TDS	mg/L	23,548	Maximum	24,000	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
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	7.65	Median	7.7	Median
Bicarbonate (HCO ₃)	mg/L	798	Median	800	Median
Iron	mg/L	13.984	Maximum	14.0	Median
Mercury	mg/L	0.002	Maximum	0.002	Median
Selenium	mg/L	0.034*	Maximum	Remove parameter	Remove parameter
TPHs (C10-C14)	µg/L	50	Maximum	50	Median
TPHs (C15-C28)	µg/L	184.8	Maximum	185.0	Median
TPHs (C29-C36)	µg/L	89.2	Maximum	90.0	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. The most recent review of recent trigger exceedances (AGE, 2017b) included analysis of the potential causes of the exceedances and the potential for any resultant environmental harm, and indicated the exceedances in relation to:

- TDS and sodium were a result of naturally occurring fluctuations that were most likely attributable to changes in climate that would have no change in the environmental values of the groundwater.
- Silver and selenium were related to sample dilution and at very low concentrations.
- TPH were short term that were probably not represent of petrogenic hydrocarbons linked to mining activities, and were therefore were false exceedances that would probably be removed using the silica-gel clean-up method recommended by Australian Laboratory Services Pty Ltd (ALS code EP071-SG). This was subsequently confirmed with the groundwater monitoring undertaken in December 2017 (AGE, 2018).

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

- removing silver as there is no ANZECC/ARMCANZ guideline for this parameter;
- removing selenium as the water is unsuitable for stock watering due to high TDS; and
- keeping the EC and TDS trigger values at their current levels but amending these to “median-type”.

This assessment also recommended rounding off the trigger levels for TDS, carbonate, bicarbonate, iron and TPH (C15-28 and C29-36).

It is noted that a minor amendment to EA EMPL00716913 dated 21 May 2018 (i.e. subsequent to AGE [2017a; 2017b]) resulted in changes to Table C8 of the EA to reflect some of these recommendations (i.e. the removal of silver as a monitoring parameter, and modification of the selenium trigger value). The remaining recommendations from AGE (2017a) that were not implemented at the time of the minor amendment have been included in Table 9.2.

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 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 21 May 2018) 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, MW5 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	3.8	No change to trigger
MW3 ^b	Total groundwater level of < 115.39 metres AHD	11.8	No change to trigger
MW4	> 2 metres per year	0.0	No change to trigger or remove from EA
MW5	Total groundwater level of < 140.4 metres AHD	17.3	Total groundwater level of < 116.9 metres AHD
MW6	> 2 metres per year	8.2	No change to trigger
MW9A	Total groundwater level of < 118.17 metres AHD	13.5	No change to trigger
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	6.6	No change to trigger
MW13A	> 2 metres per year	0.0	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: MW3 will continue to be monitored until progression prevents monitoring. MW9A installed as a replacement well for MW3.

Review of the maximum drawdown levels for the monitoring bores listed in the EA (dated 21 May 2018) indicates the trigger level for MW5 would need to be revised to reflect the predicted change in groundwater elevation (mAHD) at this location. AGE (2017a) also recommended bore MW4 should not be subject to groundwater level change restrictions (in EA Table C10) as it is not screened in the Tertiary unit and therefore be removed from the EA. This recommendation is included in Table 9.3. Groundwater level triggers for the proposed monitoring bores MW16A, MW17A and MW18A will be determined after these bores are installed, and their locations and aquifer intersected confirmed.

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. The groundwater pit inflow monitoring program should include:

- recording of any unexpected or significantly increased groundwater inflows directly to the pits;
- 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

It is recommended that data management and reporting by the proponent includes an annual monitoring report which should include:

- 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 (NB: A review of the groundwater model should be undertaken within five years of commencement of the Project by a suitably qualified hydrogeologist).

10 Conclusions

This report has evaluated the impact of the Project. The Project involves extending the continued operation of the Middlemount Coal Mine for approximately six 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 (PB, 2010a; PB, 2010c; AGE, 2017a; and AGE, 2017b), 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 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 CSG 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 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 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.
- 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.
- Removing the selenium water quality trigger and adopting the median-type trigger value for all other parameters (except pH) to eliminate false exceedances that are isolated occurrences and, given the groundwater is unsuitable for stock watering, the overall lack of groundwater use by landholders surrounding the Project, and the only beneficial use of the groundwater being for industrial purposes.
- Revising the trigger level for MW5 to reflect the predicted change in groundwater elevation at this location.

- Removing bore MW4 from the EA as this bore is not screened in the Tertiary unit and should not be subject to groundwater level change restrictions in Table C10 of the EA.
- Rounding off the trigger levels for selected parameters.

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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, & 8.3.4
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. - 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. - 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. - the possible fracturing of and other damage to confining layers. - 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	Section 8.3.2 Section 8.3 N/A N/A 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 <i>et al.</i> [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 <i>et al.</i> (2006). Information from the GDE Toolbox (Richardson <i>et al.</i> 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody <i>et al.</i> [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 <i>et al.</i> [in press]).	Section 6. 8
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody <i>et al.</i> [in press]).	Section 6. 8

Project Information	Addressed in section
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 8.3.6
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 8.3.6

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 <i>et al.</i> [in press]).	Section 8.3.6
Describe the potential range of drawdown at each affected bore, and clearly articulate of the scale of impacts to other water users.	Section 8.3.5
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 8.3.6
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 8.3.6
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 <i>et al.</i> [in press]).	Section 9

Project Information	Addressed in section
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 <i>et al.</i> [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 <i>et al.</i> [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

Project Information	Addressed in section
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 8.3.6
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	Section 8.5

Appendix B **DNRM 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

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



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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 Middelmount 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.)

4.2 Prior notice to landholders

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

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

4.3 Location of bores

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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 (mBTC)	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: DNRN database)

Property	Bore Name	RN	Sampled	Temp (°C)	pH	EC (uS/cm)	Lab analysis	Colour	Odour	CO ₂ (%)	CH ₄ (%)	H ₂ S (ppm)	Notes
Warwick Park	Yards Bore	NA	Not sampled	-	-	-	-	-	-	-	-	-	-
Warwick Park	Rolfs Bore	43060	Yes	27.9	7.00	14,360	Yes	Clear	H ₂ S 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 Rolfs 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

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.

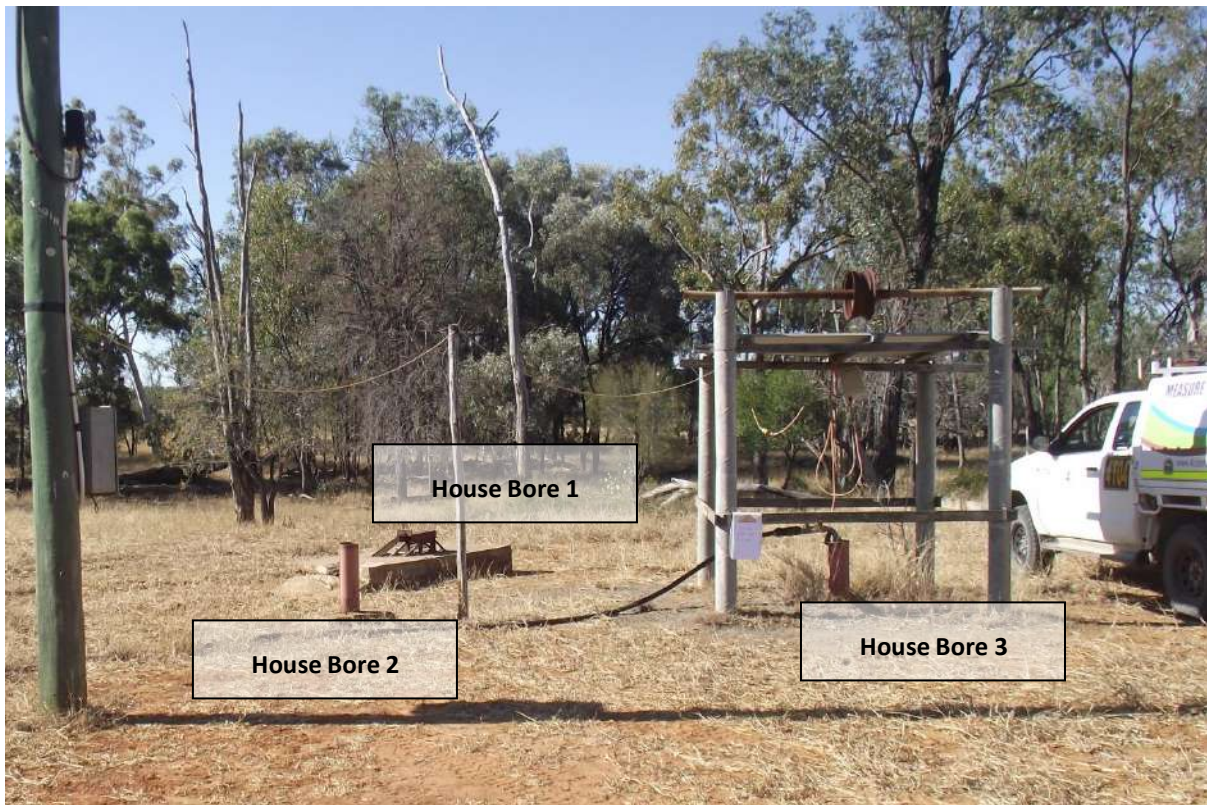


Figure 5: Bores at the original Warwick Park House Bore location.

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 in Figure 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 – Middelmount Landfill

Three monitoring bores have been installed at the Middelmount 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

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:	Submersible		
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 ($\mu\text{S}/\text{cm}$): -		Hydroxide: -	
Temperature ($^{\circ}\text{C}$): -		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



BORE REPORT

REG NUMBER 43060

REGISTRATION DETAILS

OFFICE Rockhampton	BASIN 1304	LATITUDE 22-45-20	MAP-SCALE 104
DATE LOG RECD	SUB-AREA	LONGITUDE 148-35-43	MAP-SERIES M
D/O FILE NO. 50-1371	SHIRE 3980-ISAAC REGIONAL	EASTING 663778	MAP-NO 8652
R/O FILE NO. C598/E272	LOT	NORTHING 7482641	MAP NAME WINDEYERS HILL
H/O FILE NO. L40772B	PLAN	ZONE 55	PROG SECTION
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	
		DATA OWNER	
FACILITY TYPE Sub-Artesian Facility	DATE DRILLED 01/02/1973		
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

BORE REPORT

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 E	DATE	RD	ANALYST	QAN	DEPT H (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 ****

BORE REPORT

REG NUMBER 43060

SPECIAL WATER ANALYSIS

*** NO RECORDS FOUND ***

BORE REPORT

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**** 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



BORE REPORT

REG NUMBER 47037

REGISTRATION DETAILS

OFFICE	Rockhampton	BASIN	1304	LATITUDE	22-44-31	MAP-SCALE	104
DATE LOG RECD		SUB-AREA		LONGITUDE	148-37-11	MAP-SERIES	M
D/O FILE NO.	50-1371	SHIRE	3980-ISAAC REGIONAL	EASTING	666315	MAP-NO	8652
R/O FILE NO.	C598/E272	LOT	4	NORTHING	7484118	MAP NAME	WINDEYERS HILL
H/O FILE NO.	L40772B	PLAN	CNS38	ZONE	55	PROG SECTION	
		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	
						DATA OWNER	
FACILITY TYPE	Sub-Artesian Facility	DATE DRILLED	19/11/1972				
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

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 RN OF NO. 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

BORE REPORT

REG NUMBER 47037

**** NO RECORDS FOUND ****

WATER ANALYSIS PART1

PIPE E	DATE	RD ANALYST	QAN	DEPT H (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

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**** 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 currently 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 taken from House bore 3 which is currently in use and only c.10m away from this bore. SWL indicate that this bore is 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



BORE REPORT

REG NUMBER 43063

REGISTRATION DETAILS

OFFICE	Rockhampton	BASIN	1304	LATITUDE	22-42-55	MAP-SCALE	104
DATE LOG RECD		SUB-AREA		LONGITUDE	148-40-42	MAP-SERIES	M
D/O FILE NO.	50-1371	SHIRE	3980-ISAAC REGIONAL	EASTING	672366	MAP-NO	8652
R/O FILE NO.	C598/E272	LOT		NORTHING	7487004	MAP NAME	WINDEYERS HILL
H/O FILE NO.	L40772B	PLAN		ZONE	55	PROG SECTION	
		ORIGINAL DESCRIPTION	L4 CNS38	ACCURACY		PRES EQUIPMENT	JP
				GPS ACC			
GIS LAT	-22.715383774	PARISH NAME	2684-KIRKCALDY			ORIGINAL BORE NO	2 MILE BORE
GIS LNG	148.678312259	COUNTY	CAIRNS			BORE LINE	-
CHECKED	N						
						POLYGON	
						RN OF BORE REPLACED	
						DATA OWNER	
FACILITY TYPE	Sub-Artesian Facility	DATE DRILLED	01/02/1973				
STATUS	Existing	DRILLERS NAME	G SHELLEY				
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	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

BORE REPORT

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	DEPT H (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

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
X	01/01/1969	-24.40		N	NR

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
------	------	----------------	-----	-----	--------------

PIPE	DATE	MEASURE (m)	N/R	RMK	MEAS TYPE
------	------	----------------	-----	-----	--------------

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: 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 (mBTC):	-		
SWL at assessment (mBTC):	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 taken from House bore 3 which is currently in use and only c.10m away from this bore. SWL indicate that this bore is 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 (mBTC):	-		
SWL at assessment (mBTC):	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 (mBTC):	99.99		
SWL at assessment (mBTC):	-		
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

BORE REPORT

REG NUMBER 38997

REGISTRATION DETAILS

OFFICE	Rockhampton	BASIN	1301	LATITUDE	22-46-00	MAP-SCALE	104
DATE LOG RECD		SUB-AREA		LONGITUDE	148-36-27	MAP-SERIES	M
D/O FILE NO.	50-0044	SHIRE	3980-ISAAC REGIONAL	EASTING	665032	MAP-NO	8652
R/O FILE NO.	C2706/E397	LOT		NORTHING	7481405	MAP NAME	WINDEYERS HILL
H/O FILE NO.	L40357B	PLAN		ZONE	55	PROG SECTION	
		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	
						DATA OWNER	
FACILITY TYPE	Sub-Artesian Facility	DATE DRILLED	23/11/1972				
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

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
			SHLE								
2	76.20	80.80		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 E	DATE	RD ANALYST	QAN	DEPT H (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 ****

BORE REPORT

REG NUMBER 38997

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 01:39:50 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 DNR 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 (mBTC):	-		
SWL at assessment (mBTC):	-		
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

BORE REPORT

REG NUMBER 44080

REGISTRATION DETAILS

OFFICE	Rockhampton	BASIN	1301	LATITUDE	22-46-30	MAP-SCALE	104
DATE LOG RECD		SUB-AREA		LONGITUDE	148-36-08	MAP-SERIES	M
D/O FILE NO.	50-0044	SHIRE	3980-ISAAC REGIONAL	EASTING	664487	MAP-NO	8652
R/O FILE NO.	C2796.E397	LOT		NORTHING	7480492	MAP NAME	WINDEYERS HILL
H/O FILE NO.	L40357B	PLAN		ZONE	55	PROG SECTION	
		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	
						DATA OWNER	
FACILITY TYPE	Sub-Artesian Facility	DATE DRILLED	23/11/1972				
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 ($\mu\text{S}/\text{cm}$):	-	Hydroxide:	-
Temperature ($^{\circ}\text{C}$):	-	Total alkalinity:	-
		Bore head gas tests	
Colour:	-	CO ₂	0.00%
Odour:	-	CH ₄	0.00%
Particles:	-	H ₂ S	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



BORE REPORT

REG NUMBER 47037

REGISTRATION DETAILS

OFFICE	Rockhampton	BASIN	1304	LATITUDE	22-44-31	MAP-SCALE	104
DATE LOG RECD		SUB-AREA		LONGITUDE	148-37-11	MAP-SERIES	M
D/O FILE NO.	50-1371	SHIRE	3980-ISAAC REGIONAL	EASTING	666315	MAP-NO	8652
R/O FILE NO.	C598/E272	LOT	4	NORTHING	7484118	MAP NAME	WINDEYERS HILL
H/O FILE NO.	L40772B	PLAN	CNS38	ZONE	55	PROG SECTION	
		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	
						DATA OWNER	
FACILITY TYPE	Sub-Artesian Facility	DATE DRILLED	19/11/1972				
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

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 RN OF NO. 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

BORE REPORT

REG NUMBER 47037

**** NO RECORDS FOUND ****

WATER ANALYSIS PART1

PIPE E	DATE	RD ANALYST	QAN	DEPT H (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

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**** 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 ($\mu\text{S}/\text{cm}$):	-	Hydroxide:	-
Temperature ($^{\circ}\text{C}$):	-	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



BORE REPORT

REG NUMBER 158773

REGISTRATION DETAILS

OFFICE Emerald	BASIN 1301	LATITUDE 22-48-56	MAP-SCALE
DATE LOG RECD 22-APR-14	SUB-AREA	LONGITUDE 148-41-05	MAP-SERIES
D/O FILE NO. LON/515/000(1733	SHIRE 3980-ISAAC REGIONAL	EASTING 672894	MAP-NO
R/O FILE NO.	LOT 49	NORTHING 7475913	MAP NAME
H/O FILE NO.	PLAN CNS281	ZONE 55	PROG SECTION
	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 ($\mu\text{S}/\text{cm}$):	-	Hydroxide:	-
Temperature ($^{\circ}\text{C}$):	-	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



BORE REPORT

REG NUMBER 158772

REGISTRATION DETAILS

OFFICE Emerald	BASIN 1301	LATITUDE 22-48-49	MAP-SCALE
DATE LOG RECD 22-APR-14	SUB-AREA	LONGITUDE 148-41-18	MAP-SERIES
D/O FILE NO. LON/515/000(1733	SHIRE 3980-ISAAC REGIONAL	EASTING 673279	MAP-NO
R/O FILE NO.	LOT 49	NORTHING 7476120	MAP NAME
H/O FILE NO.	PLAN CNS281	ZONE 55	PROG SECTION
	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 ****

BORE REPORT

REG NUMBER 158772

FIELD MEASUREMENTS

**** NO RECORDS FOUND ****

SPECIAL WATER ANALYSIS

**** NO RECORDS FOUND ****

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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 ($\mu\text{S}/\text{cm}$):	-	Hydroxide:	-
Temperature ($^{\circ}\text{C}$):	-	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



BORE REPORT

REG NUMBER 158773

REGISTRATION DETAILS

OFFICE Emerald	BASIN 1301	LATITUDE 22-48-56	MAP-SCALE
DATE LOG RECD 22-APR-14	SUB-AREA	LONGITUDE 148-41-05	MAP-SERIES
D/O FILE NO. LON/515/000(1733	SHIRE 3980-ISAAC REGIONAL	EASTING 672894	MAP-NO
R/O FILE NO.	LOT 49	NORTHING 7475913	MAP NAME
H/O FILE NO.	PLAN CNS281	ZONE 55	PROG SECTION
	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
			DATA OWNER
FACILITY TYPE Sub-Artesian Facility	DATE DRILLED 17/04/2014		
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 ****

APPENDIX 2

Bore Assessment – Water Quality Results

CERTIFICATE OF ANALYSIS

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 5
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 09:20
Date Analysis Commenced : 19-Sep-2017
Issue Date : 25-Sep-2017 15:54



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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
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	----	----

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	Page	: 1 of 11
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
Order number	: ----	Date Analysis Commenced	: 19-Sep-2017
C-O-C number	: ----	Issue Date	: 25-Sep-2017
Sampler	: ----		
Site	: ----		
Quote number	: BNBQ/001/16		
No. of samples received	: 3		
No. of samples analysed	: 3		



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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
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



Sub-Matrix: **WATER**

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**

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**

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

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 Work Order : EB1719214
 Client : 4T CONSULTANTS PTY LTD
 Project : 745 GWQ



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 (%)
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**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
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 Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
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				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
						LCS	Low	High
CAS Number	LOR	Unit	Result					
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				Matrix Spike (MS) Report			
				Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
					MS	Low	High
Client sample ID	Method: Compound	CAS Number					
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**

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: Mercurv	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.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

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.

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,	----	----	----	19-Sep-2017	13-Sep-2017	6
Blanches Bore							

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

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, Blanches Bore	House Bore,	13-Sep-2017	----	----	----	19-Sep-2017	13-Sep-2017	✖
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Rolf's Bore, Blanches Bore	House 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, Blanches Bore	House Bore,	13-Sep-2017	----	----	----	20-Sep-2017	20-Sep-2017	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P) Rolf's Bore, Blanches Bore	House 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, Blanches Bore	House Bore,	13-Sep-2017	----	----	----	22-Sep-2017	11-Oct-2017	✓
ED045G: Chloride by Discrete Analyser								
Clear Plastic Bottle - Natural (ED045G) Rolf's Bore, Blanches Bore	House Bore,	13-Sep-2017	----	----	----	22-Sep-2017	11-Oct-2017	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) Rolf's Bore, Blanches Bore	House 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, Blanches Bore	House 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, Blanches Bore	House 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, Blanches Bore	House Bore,	13-Sep-2017	20-Sep-2017	12-Mar-2018	✓	20-Sep-2017	12-Mar-2018	✓

Page : 4 of 8
 Work Order : EB1719214
 Client : 4T CONSULTANTS PTY LTD
 Project : 745 GWQ



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	
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 liberated 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 0.45um 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 (SnCl ₂)(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 SnCl ₂ 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 (SnCl ₂)(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 SnCl ₂ 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**

Monitoring Well **MW1**

Page: 1 of 1

Project	<u>MEMS</u>		Owner	<u>Middlemount Coal Pty Ltd</u>	
Location	<u>Middlemount Mine</u>		Proj. No.	<u>ENV/NEWS08629AA</u>	
Surface Elev.	<u>NA</u>	Total Hole Depth	<u>30.0 m.</u>	North	<u> </u>
Top of Casing	<u>NA</u>	Water Level Initial	<u>▽ 26.0 m.</u>	Static	<u>▽ 24.0 m.</u>
Screen: Dia	<u>NA</u>	Length	<u>NA</u>	Type/Size	<u>Class 18 UPVC</u>
Casing: Dia	<u>NA</u>	Length	<u>NA</u>	Type	<u>Class 18 UPVC</u>
Fill Material	<u> </u>		Rig/Core	<u> </u>	
Drill Co.	<u>QLD Drilling</u>		Method	<u>Air Rotary</u>	
Driller	<u>Corey Evetts</u>	Log By	<u>M Weir</u>	Date	<u>5/6/08</u>
Checked By	<u> </u>		License No.	<u>NA</u>	

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.
0							
2						CL	Sandy CLAY - non plastic, brown, dry, stiff, heterogeneous.
4						CL	Sandy CLAY - non plastic, grey, heterogeneous, sandy brown lenses, dry.
6						CL	CLAY - non plastic, orange, dry, stiff, homogeneous.
8						CL	
10						CL	
12						CL	Sandy CLAY - orange, soft, dry.
14						CL	CLAY - non plastic, brown, dry, stiff, heterogeneous.
16						SP	SAND - grey, moist.
18						CL	CLAY - non plastic, brown, dry, stiff, heterogeneous.
20						CL	
22						CL	CLAY - non plastic, grey, stratified, orange lenses, dry, very stiff.
24						CL	
26						CL	Sandy CLAY - moderate plasticity, grey sand, orange clay, wet, heterogeneous.
28						CL	
30							End of hole at 30.0m - Limit of investigation.



GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW1P

SHEET 1 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: **UKR**

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	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			TOC 1 m									
			Monument cover with PVC cap, Cement 0 to 5m bgl (below ground level)	160	2				SC	Clayey SAND: fine to medium grained, orange brown, dry.	D	171mm Diameter, 0 to 44m bgl
			50mm ID, Class 18 uPVC casing, 0 to 72m bgl	158.300	4				CL	Sandy CLAY: grey, medium grained, sand component, soft, bands of iron staining.		
			Backfill, 5 to 67m bgl	156.500	6				CL	CLAY: grey, stiff, bands of iron staining.		
				154	8				SP	SAND: fine to medium grained, yellow, dry.		
				152	10					medium grained, yellow and red, with clay, dry.		
				150.100	12				CL	CLAY: grey and brown, stiff, banded.		
				148	14							
				146	16							
				144.700	18				CL/SP	grey, pink and orange, stiff and SAND: fine to medium grained, pink.		
				142	20							
				140.700	22				CL	CLAY: grey, pink and orange, stiff.		
				138.300	24				SC	Clayey SAND: fine to medium grained, orange red, soft, dry.		
				136	26				CL	CLAY: grey, pink and orange, soft to firm.		
				134	28							
				132	30							
				130	32				CL	Sandy CLAY: grey, fine grained sand component, soft.		
				128	34							
				126.500	36					COAL: black, distinctly weathered, (Middlemount Seam).		
				124	38							
				122.000	40					SANDSTONE: fine to medium grained, dark grey, carbonaceous, distinctly weathered.		
				120.000	42				CL	Sandy CLAY: pale grey, fine to medium grained sand component, soft.		
				118	44				CL/SP	CLAY: grey, soft and SAND: fine to medium grained, yellow.		
				116	46					SANDSTONE: fine to medium grained, yellow, distinctly weathered.		
				114	48					fine to medium grained, grey, distinctly weathered, dry.		
				112	50					very fine to fine grained, grey, distinctly weathered, dry.		
121mm Diameter, 44 to 77.2m bgl												

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:

Drill Model/Mounting: IRTM 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:

Local Co-ords:

E 667818 N 7473149 MGA94 Zone 55

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FB VL JL MD SL ST D H	
RAB				110						very fine to fine grained, grey, distinctly weathered, dry. (continued)	D	
				52								
				108.00						medium grained, grey, distinctly weathered, dry.		
				54								
				106.00						medium grained, grey, fresh, dry.		
				56								
				104								
				58								
				102								
				60								
				100								
				62.00						very fine grained, grey brown, fresh.		
				98.00						SHALE: dark grey.		
				64.00						SANDSTONE: fine grained, grey, fresh.		
				96								
				66								
				94								
				68								
				92								
				70.00						COAL: black, moist, soft. (Pisces Seam)	M	
				90								
				72								
				88								
				74								
				86.00						CLAY: black, carbonaceous, firm.		
				76.00						SILTSTONE: grey, carbonaceous, fresh.		
				84								
				78						END OF BOREHOLE AT 77.20 m		
				82								
				80								
				82								
				78								
				84								
				76								
				86								
				74								
				88								
				72								
				90								
				70								
				92								
				68								
				94								
				66								
				96								
				64								
				98								
				62								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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.

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.
0						SC	Clayey SAND - brown, dry, loose.
2						SP	SAND - brown, compacted, dry.
4							
6							Sandy CLAY - non plastic, grey, dry, stratified, yellow/orange, hard.
8							
10							
12							
14						CL	
16							
18							
20							
22							
24						SP	SAND - grey, wet.
26						CL	Sandy CLAY - red/brown, moist.
28						CL	Sandy CLAY - black.
30						SP	SAND - grey, wet.
							End of hole at 30.0m - Limit of investigation.

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.
0							
5						CL	CLAY - non plastic, orange/grey, stratified, dry, very stiff.
10						SP	SAND - orange, dry, medium density, medium to coarse sand.
15						CL	CLAY - low plasticity, brown, stratified, dry, stiff.
20						CL	CLAY - low plasticity, grey, white/orange mottles, damp, firm/soft.
25						CL	Silty CLAY - grey, damp, firm, heterogeneous.
30						CL	Silty CLAY - grey, dry, firm, heterogeneous.
35						CL	Silty CLAY - low plasticity, orange, damp, soft, heterogeneous.
40						CL	CLAY - non plastic, orange with grey lenses, friable, hard, dry.
45						CL	Sandy CLAY - grey, damp.
48							End of hole at 48.0m - Limit of investigation.

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.

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.
0							TOPSOIL. GRANITE ROCK.
5						CL	CLAY - brown, hard, friable, dry. CLAYSTONE - brown, rock, dry. CLAY - non plastic, grey/white, very hard, friable, dry.
10						CL	
15						CL	CLAY - non plastic, brown/white/orange mottled, stiff, dry, laminated.
20						CL	CLAY - non plastic, orange/white/grey/black, stratified, dry, damp.
25							Weathered GRANITE/CLAYSTONE.
30							Weathered BASALT - blue/grey, dry.
35							
40						CL	CLAY - non plastic, brown, damp, stiff. Weathered BASALT - dry.
45							
50						SP	COAL - hard, dry. Sandy COAL - wet. End of hole at 50.0m - Limit of investigation.

Project MEMS Owner Middlemount Coal Pty Ltd
 Location Middlemount Mine Proj. No. ENVINEWS08629AA
 Surface Elev. NA Total Hole Depth 46.0 m. North NA East NA
 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 NA Rig/Core NA
 Drill Co. QLD Drilling Method Air Rotary
 Driller Corey Evetts Log By M Weir Date 3/6/08 Permit # NA
 Checked By NA License No. NA

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.
0							TOPSOIL.
5						CL	CLAY - non plastic, brown, hard, dry.
10						CL	CLAY - non plastic, dark grey, hard, dry.
15						CL	CLAY - non plastic, red/brown, hard, dry.
20						CL	CLAY - non plastic, brown, hard, dry.
25						CL	CLAY - non plastic, brown, hard, dry.
30						CL	CLAY - non plastic, brown, hard, dry.
35						CL	CLAY - non plastic, grey, dry, friable.
40						CL	COAL - black, moist.
45						CL	COAL - wet slurry.
45							End of hole at 45.0m - Limit of investigation.



GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5M

SHEET 1 OF 3

Client: MACARTHUR COAL
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW5M - MIDDLEMOUNT MINE
Project Number: 2117076B

PB Borehole No.:

Date Commenced: 10.07.2010

Date Completed: 24.07.2010

Recorded By: Malcolm Graham

Log Checked By: *UAR*

Drill Model/Mounting: IRTB 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 667790 N 7475131 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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								RELATIVE DENSITY CONSISTENCY	
RB			Monument cover with PVC cap, Cement 0 to 6.5m bgl (below ground level) 50mm ID, Class 18 uPVC casing, 0 to 127m bgl	172	2				CL	Silty CLAY: brown, firm, moist.	M	200mm Diameter, 0 to 46m bgl
				170	4				CL/SP	CLAY: grey, pink and brown, firm, moist and SAND: fine grained, brown, moist.		
				168.60	6					Clayey SANDSTONE: fine grained, brown, extremely weathered, moist.		
				166	8							
				164.00	10					SANDSTONE: fine to medium grained, brown, distinctly weathered, moist.		
				162	12							
				160.40	14					SILTSTONE: yellow, distinctly weathered, moist.		
				158	16							
				156	18					SANDSTONE: fine grained, brown, distinctly weathered, moist.		
				154.00	20					CLAYSTONE: brown, distinctly weathered, moist, calcite alteration, grey and pink, extremely weathered, moist.		
				152	22							
				150.40	24					Sandy CLAYSTONE: black, grey and red, distinctly weathered, moist.		
				148	26					SANDSTONE: very fine grained, yellow, distinctly weathered, moist.		
				146.80	28					Sandy CLAYSTONE: grey, brown and pink, distinctly weathered, moist.		
				144	30					SANDSTONE: very fine grained, brown, distinctly weathered, moist.		
				142	32					Silty CLAYSTONE: grey and orange, distinctly weathered, moist.		
				140	34							
				138	36					SANDSTONE: very fine grained, red brown, distinctly weathered, moist.		
				136	38							
				134.00	40					SILTSTONE: red brown, distinctly weathered, moist.		
				132.20	42					SANDSTONE: very fine grained, red brown, distinctly weathered, moist.		
				130.40	44					grey and orange.		
				128.60	46					SILTSTONE: red, distinctly weathered, moist.		
				126	48					CLAYSTONE: grey and red, slightly weathered, moist.		
										SILTSTONE: grey and brown, distinctly weathered, moist.		
										grey, slightly weathered.		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 1 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: *WJR*

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	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			Monument cover with PVC cap. Cement 9 to 6.5m bgl (below ground level) 80mm ID. Class 18 uPVC casing, 9 to 165m bgl									
			Backfill 6.5 to 160.5m bgl									
				172.00	2				CL	Silty CLAY: brown, moist, firm.	M	200mm Diameter, 0 to 52m bgl
				170.00	4				CL	CLAY: grey and red, moist, firm.		
				168.00	6				CL/SP	CLAY: grey and red, moist, firm and SAND: fine grained, brown.		
				166.00	8					SANDSTONE very fine grained, brown, extremely weathered, moist.		
				164.00	10					distinctly weathered		
				162.00	12							
				160.00	14							
				158.00	16					SILTSTONE: yellow-brown, distinctly weathered, moist.		
				156.00	18					SANDSTONE: fine grained, brown, distinctly weathered, moist.		
				154.00	20					CLAYSTONE: grey and red, distinctly weathered, moist.		
				152.00	22							
				150.00	24					Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.		
				148.00	26					SANDSTONE: fine grained, brown, distinctly weathered.		
				146.00	28					Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.		
				144.00	30					SANDSTONE: fine grained, yellow, extremely weathered, moist.		
				142.00	32					Clayey SANDSTONE: fine grained, yellow, extremely weathered, moist.		
				140.00	34					Silty CLAYSTONE: grey and brown, distinctly weathered, moist.		
				138.00	36							
				136.00	38					SANDSTONE: fine grained, red-brown, distinctly weathered, moist.		
				134.00	40							
				132.00	42					SILTSTONE: red-brown, distinctly weathered, moist.		
				130.00	44					SANDSTONE: fine grained, red-brown, distinctly weathered, moist.		
				128.00	46					grey		
				126.00	48					red		
										CLAYSTONE: grey and brown, distinctly weathered, moist.		
										SANDSTONE: fine grained, grey, slightly weathered, moist.		
										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: *WJR*

Drill Model/Mounting: IRTM 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	6	7	8	9	10	11	12	13	
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			TOC 1 m								VS FB VL LD ST HT		
RB										SILTSTONE: grey, slightly weathered, dry. (continued)	D		
RAB				122.20	52					SANDSTONE: fine grained, grey, slightly weathered, dry.		140mm Diameter, 52 to 174m bgl	
				53.00						SILTSTONE: grey, slightly weathered, dry.			
				120	54					SANDSTONE: fine grained, grey, fresh, dry.			
				55.00						SILTSTONE: grey, fresh, dry.			
				118	56					SANDSTONE: fine grained, grey, fresh, dry.			
				57.00						SILTSTONE: grey, fresh, dry.			
				116	58					SANDSTONE: fine grained, grey, fresh, dry.			
				114	60					SILTSTONE: grey, fresh, dry.			
				112	62					SANDSTONE: very fine grained, grey, fresh, dry.			
				63.00						SILTSTONE: grey, fresh, dry.			
				110	64					SANDSTONE: fine grained, grey, dry.			
				108	66					SILTSTONE: grey, fresh, dry.			
				106	68					SANDSTONE: fine grained, grey, fresh, dry.			
				69.00						SILTSTONE: grey, fresh, dry.			
				104	70					SANDSTONE: fine grained, grey, dry.			
				102	72					SILTSTONE: grey, fresh, dry.			
				73.00						SANDSTONE: fine grained, grey, fresh, dry.			
				100	74					SILTSTONE: grey, fresh, wet.			
				98	76					SANDSTONE: fine grained, grey, fresh, dry.			
				96	78					slightly weathered, wet.	W		
				94	80					fresh, wet.			
				92	82					SILTSTONE: grey, fresh, wet.			
				90	84					SANDSTONE: fine grained, fresh, wet.			
				88	86					SILTSTONE: dark grey, fresh, wet.			
				87.00						SANDSTONE: fine grained, grey, fresh, wet.			
				86	88					SILTSTONE: dark grey, fresh, wet.			
				84	90					SANDSTONE: fine grained, grey, fresh, wet.			
				82	92					SILTSTONE: dark grey, fresh, wet.			
				80	94					SANDSTONE: fine grained, grey, fresh, wet.			
				78	96					SILTSTONE: dark grey, fresh, wet.			
				76	98					SANDSTONE: fine grained, grey, fresh, wet.			
				76	99					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:

Drill Model/Mounting: IRTM 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	6	7	8	9	10	11	12	13		
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
			TOC 1 m								VS FB VS LV VS L VS MO VS ST VS D VS H			
RAB				101.00						SANDSTONE: fine grained, grey, fresh, wet. (continued)	W			
				72 102						SILTSTONE: dark grey, fresh, wet.				
				70 104										
				105.00						CLAYSTONE: black, fresh, carbonaceous, wet.				
				68 106						SANDSTONE: fine grained, grey, fresh, wet.				
				66 108										
				64 110										
				62 112										
				113.00						SILTSTONE: dark grey, fresh, wet.				
				60 114						SANDSTONE: fine grained, grey, fresh, wet.				
				58 116										
				56 118						fine grained.				
				54 120										
				52 122										
				50 124										
				125.00						SILTSTONE: dark grey, fresh, wet.				
				48 126						CLAYSTONE: black, fresh, carbonaceous, wet.				
				127.00						SILTY COAL: black, fresh, wet, (Middlemount Seam).			Airlift yield: 0.12 L/S	
				46 128						COAL: black, fresh, wet.				
				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.

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**
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: *[Signature]*

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	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL (m) AHD	DEPTH (m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FB VL ND ST DO	
RAB				22	152					SILTSTONE: black, fresh, wet. (continued)	W	
				20	154							
				18	156					SANDSTONE: fine grained, dark grey, fresh, wet.		
				16	158							
				14	160							
				12	162							
				10	164					CLAYSTONE: black, fresh, carbonaceous, wet.		Airlift yield: 0.29 L/S
				8	166					COAL: black, fresh, wet. (Pisces Seam).		Airlift yield: 0.31 L/S
				6	168					SILTSTONE: dark grey, fresh, carbonaceous, wet.		
				4	170					SANDSTONE: very fine grained, grey, fresh, wet.		
				2	172							Airlift yield: 0.34 L/S
				0	174					END OF BOREHOLE AT 174.00 m		
				-2	176							
				-4	178							
				-6	180							
				-8	182							
				-10	184							
				-12	186							
				-14	188							
				-16	190							
				-18	192							
				-20	194							
				-22	196							
				-24	198							

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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.	Description (Color, Texture, Structure) Geologic descriptions are based on ASTM Standard D 2487-93 and the USCS.
0						CL	TOPSOIL - vegetation.
5						CL	CLAY - non plastic, brown, hard, dry, homogeneous.
10						CL	CLAY - non plastic, brown/grey, hard, dry.
15						CL	CLAY - low plasticity, red, dry, homogeneous.
20						CL	CLAY - low plasticity, white, damp, firm, stiff.
25						CL	CLAY - low plasticity, white/brown, firm, dry, homogeneous.
30						CL	CLAY - non plastic, black/grey, dry, friable.
35						CL	CLAY - non plastic, brown/white, dry, friable.
40						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**
Project: **MIDDLEMOUNT COAL PROJECT**
Borehole Location: **MW7M - MIDDLEMOUNT MINE**
Project Number: **2117076B**

PB Borehole No.:

Date Commenced: **15.06.2010**Date Completed: **19.06.2010**Recorded By: **Malcolm Graham**

Log Checked By:

Drill Model/Mounting: **IRTH 60**
Borehole Diameter: **171mm to 121mm**

Driller: **S Baker**
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							Field Material Description						
1	2	3	4	5	6	7	8	9	10	11	12	13	
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m										
RAB			Monument cover with PVC cap, Corment 0 to 5m bgl (below ground level) 50mm ID uPVC, Class 12 casing, 0 to 132m bgl		2.00 2				CL	Sandy CLAY: brown, fine grained, sand component, firm, dry.	D		* Elevations inferred from DTM 171mm Diameter, 0 to 55.5m bgl
					3.00				SP	Clayey SAND: fine to medium grained, orange, moist.	M		
					4.00 4				SP	SAND: fine to medium grained, orange, with clay, medium grained, yellow, moist, loose.			
					5.00					medium grained, yellow, moist, trace coarse sand and gravel, loose.			
					6.00 6					brown clay bands.			
					7.00				SP	Clayey SAND: fine to medium grained, orange and grey, bands of firm, grey clay, moist.			
					8								
					10								
					12.00 12				SP	SAND: medium grained, orange, with clay, moist.			
					13.00					bands of firm, brown clay.			
					14.00 14					medium to coarse grained, bands of firm, grey clay, moist.			
					16								
					17.00								
					18				CL/ SP	CLAY: grey and brown, firm and SAND: fine grained, yellow.			
					20								
					22.00 22				SP/ CL	SAND: medium grained, orange and CLAY: grey, firm.			
					24								
					25.00				SP	SAND: medium grained, yellow.			
					26.00 26				CL	CLAY: brown and grey, soft, trace fine grained sand.			
					27.00				CL	Silty CLAY: grey and brown, firm.			
					28.00 28				CL	Sandy CLAY: grey and orange, fine to medium grained sand component, firm.			
					29.00				CL	CLAY: grey and brown, firm.			
					30								
					32.00 32				SP	SAND: medium grained, yellow, bands of firm, grey clay.			
					34								
					35.00				CL	CLAY: brown and grey, firm.			
					36.00 36				CL/ SP	CLAY: brown and grey, firm and SAND: fine to medium grained, yellow.			
					38.00 38				SP	SAND: medium grained, pale grey.			
					40								
					42								
					44								
					45.00				SP/ CL	SAND: medium grained, pale grey and Sandy CLAY: grey and brown, soft.			
					46.00 46				SP	SAND: medium grained, pale grey.			
					48								

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW7M - MIDDLEMOUNT MINE
Project Number: 2117076B

PB Borehole No.:

Date Commenced: 15.06.2010

Date Completed: 19.06.2010

Recorded By: Malcolm Graham

Log Checked By: *UJR*

Drill Model/Mounting: IRTM 60
Borehole Diameter: 171mm to 121mm

Driller: S Baker
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							Field Material Description						
1	2	3	4	5	6	7	8	9	10	11	12	13	
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			TOC 1 m										
				50.00						medium to coarse grained, pale grey, trace gravel.	M		121mm Diameter, 55.5 to 143m bgl
				52.00									
				54.00	54				SC	SAND: medium to coarse grained, pale grey, trace gravel and			
				56.00	56					Sandy CLAY: grey, soft.			
				57.00						SANDSTONE: very fine grained, dark grey, distinctly weathered, soft, moist.			
				58.00						fine grained, pale grey, slightly weathered, moist.			
				59.00						very fine grained, dark grey, distinctly weathered, bands of dark grey clay, moist.			
				60.00	60					very fine grained, grey, slightly weathered, moist.			
				62.00									
				64.00									
				65.00						distinctly weathered.			
				66.00									
				68.00	68					slightly weathered, dry.	D		
				69.00						fine grained, dark grey, slightly weathered, dry.			
				70.00									
				71.00						moist.	M		
				72.00	72					dry, fresh.	D		
				74.00									
				75.00									
				76.00						SILTSTONE: dark grey, fresh, dry.			
				78.00									
				80.00									
				81.00									
				82.00	82					SANDSTONE: fine grained, grey, fresh, dry.			
										very fine grained, dark grey.			
				84.00	84					fine grained.			
				85.00						very fine grained.			
				86.00	86					fine grained.			
				88.00	88					very fine grained, wet.	W		
				90.00	90					fine grained, grey, wet.			
				91.00						very fine grained, dark grey, wet.			
				92.00	92					SILTSTONE: dark grey, fresh, wet.			
				93.00						SANDSTONE: very fine grained, dark grey, fresh, wet.			
				94.00	94					SILTSTONE: dark grey, fresh, wet.			
				95.00						SANDSTONE: very fine grained, grey, fresh, wet.			
				96.00									
				98.00									
				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
Project: MIDDLEMOUNT COAL PROJECT
Borehole Location: MW7M - MIDDLEMOUNT MINE
Project Number: 2117076B

PB Borehole No.:

Date Commenced: 15.06.2010

Date Completed: 19.06.2010

Recorded By: Malcolm Graham

Log Checked By: *UKR*

Drill Model/Mounting: IRTM 60
Borehole Diameter: 171mm to 121mm

Driller: S Baker
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 Diameter: 177 mm to 122 mm													TOC (RL): 161 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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION				MOISTURE	RELATIVE DENSITY / CONSISTENCY				STRUCTURE AND ADDITIONAL OBSERVATIONS																			
			TOC 1 m																																			
RAB				100.00						SANDSTONE: very fine grained, grey, fresh, wet.				W																								
				101.00						SILTSTONE: dark grey, fresh, wet.																												
				102.00									SANDSTONE: very fine grained, grey, fresh, wet.																									
				103.00									SILTSTONE: dark grey, fresh, wet.																									
				104.00									SANDSTONE: very fine grained, dark grey, fresh, wet.																									
				105.00																																		
				106.00																																		
				108.00																																		
				110.00																																		
				112.00																																		
				114.00										SILTSTONE: dark grey, fresh, wet.																								
				115.00										SANDSTONE: very fine grained, grey, fresh, wet.																								
				116.00																																		
				118.00																																		
				119.00										SILTSTONE: dark grey, fresh, wet.																								
				120.00																																		
				121.00										SANDSTONE: very fine grained, dark grey, fresh, wet.																								
				122.00																																		
				124.00																																		
				125.00										SILTSTONE: dark grey, fresh, wet.																								
126.00																																						
128.00										carbonaceous.																												
129.00										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).																												
133.00																																						
134.00										CLAYSTONE: black, fresh, carbonaceous, wet.																												
135.00																																						
136.00										SANDSTONE: very fine grained, grey, fresh, wet.																												
137.00																																						
138.00																																						
140.00										fine grained.																												
142.00																																						
144.00										END OF BOREHOLE AT 143.00 m																												
146.00																																						
148.00																																						

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
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: *UW*

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					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m									
RB			Monument cover with PVC cap, Content: 0 to 5m bgl (below ground level) 60mm ID, Class 1B uPVC casing, 0 to 189.5m bgl	162	2				CL	Silty CLAY: brown, firm, moist.	M	254mm Diameter, 0 to 45m bgl
			Backfill 5 to 186.5m bgl	160	4							
				158.600	6				SP	SAND: medium, grained, orange, moist.		
				156.800	8				SC	Clayey SAND: very fine grained, pale brown, moist.		
				154	10				SP	SAND: medium grained, orange, moist.		
				152.200	12					fine grained, pale grey.		
				150	14					medium grained, orange.		
				148.600	16				CL	CLAY: grey and brown, firm, moist.		
				146	18				CL/SP	CLAY: grey, black and orange, firm, moist and SAND: medium grained, orange, moist.		
				144.200	20				SP	SAND: medium grained, orange, moist.		
				142.200	22				CL/SP	Sandy CLAY: grey and brown, firm, moist and SAND: medium grained, grey and brown, moist.		
				138	26				CL	CLAY: grey and brown, firm, moist.		
				136.800	28					wet.	W	
				134	30					with fine grained brown sand.		
				132.200	32				CL/SP	Sandy CLAY: grey and brown, firm, wet and SAND: fine grained, brown, wet.		
				130	34					medium grained, yellow sand component.		
				128.600	36				SC	SAND: coarse grained, yellow, with firm grey clay, wet.		
				126	38					medium grained, pale yellow, trace gravel.		
				122	42					SANDSTONE: fine to medium grained, yellow, extremely weathered, wet.		
				120	44							
RAB				118	46							200mm Diameter, 45m to 66m bgl
				116	48							

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					
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 VS FB VL MD %L ST VST D H	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				51.00						fresh, with very fine grained, pale yellow, sandstone, distinctly weathered, iron staining.	W	
				112.20	52					SANDSTONE: very fine grained, grey and brown, slightly weathered, minor black carbonaceous siltstone, iron staining and quartz veins, wet.		
				110	54							
				108	56							
				106	58							
				104	60							
				61.00								
				102	62					SILTSTONE: dark grey, fresh, iron staining and calcite veins, wet.		
				100	64							
				98	66							
				96	68							
				94.70	70					SANDSTONE: very fine grained, grey, slightly weathered, pyrite alteration, wet.		
				92.20	72					fresh, no pyrite		
				90.40	74					fresh, calcite veins, no pyrite		
				75.00						fine grained, fresh, calcite veins.		
				88	76							
				86.30	78					very fine grained, fresh, calcite veins.		
				84	80							
				82	82							
				80.40	84					fine grained, fresh.		
				85.00						very fine grained, black, fresh, carbonaceous.		
				78	86							
				87.00						SHALE: dark brown, fresh, carbonaceous, calcite alteration.		
				76.00	88					SANDSTONE: very fine grained, pale brown, fresh, slightly metamorphosed, minor soft sandstone - fault gouge material.		
				74.00	90					grey, fresh, no evidence of metamorphism or fault gouge material.		
				72.20	92					COAL: black, fresh, (Roper Seam).		
				93.00						SILTSTONE: grey, fresh.		
				70.40	94					pale, grey.		
				68	96							
				66	98							
				99.00						COAL: black, fresh, (Middlemount Seam fault capped).		

140mm Diameter, 66 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 3 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					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FB VL J MD VS ST VST D V H	
RAB				100.00						SILTSTONE: grey, fresh.	W	
				101.00						COAL: black, fresh, (Middlemount Seam fault repeated).		
				62 102								
				60 104								
				58 106								
				56 108								
				54 110								
				52 112						SILTSTONE: grey, fresh, carbonaceous.		
				50 114						non-carbonaceous.		
				48 116						SANDSTONE: very fine grained, grey, fresh, slightly carbonaceous.		
				46 118								
				44 120								
				42 122						SILTSTONE: grey, fresh.		
				40 124								
				38 126						SANDSTONE: very fine grained, grey, fresh.		
				36 128						SILTSTONE: grey, fresh.		
				34 130						COAL: black, fresh, (Middlemount Seam).		
				32 132								
				30 134								
				28 136								
				26 138								
				24 140						SILTSTONE: grey, fresh.		
				22 142						SANDSTONE: fine to medium grained, grey, fresh.		
				20 144								
				18 146								
				16 148						black, carbonaceous.		
				14 150						grey, non-carbonaceous.		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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: *UKR*
 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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FB VL MD ST D YST H		
RAB					-38 202					SANDSTONE: fine grained, grey. (continued)	W		
					-40 204					END OF BOREHOLE AT 203.00 m			
					-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.: 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: *UAR*

Drill Model/Mounting: IRTM 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							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								FB VS VL MD ST VD	
RB			Monument cover with PVC cap. Cement 0 to 7m bgl (below ground level) 80mm ID, Class 18 uPVC casing. 0 to 94m bgl	100					SC	CLAYEY SAND: fine grained, yellow brown, dry	D	200mm Diameter, 0 to 40m bgl
				162	2				CL	SANDY CLAY: orange brown, firm, fine grained sand component, dry.		
				160	4				SC	CLAYEY SAND: fine to medium grained, brown, dry.		
				158	6				SP	SAND: fine grained, orange brown, with clay, dry.		
			Backfill, 7 to 91m bgl	156	8					medium to coarse grained grained, trace of clay fines, pale yellow to orange, moist.	M	
				154	10					fine to medium grained, yellow, moist.		
				152	12							
				150	14				SC	CLAYEY SAND: fine grained, grey, moist.		
				148	16				CL	CLAY: grey, firm, moist.		
				146	18							
				144	20				OL	Silty CLAY: brown, with organics, firm, moist.		
				142	22				SC	CLAYEY SAND: fine grained, pale grey, moist.		
				140	24					SANDSTONE: fine to medium grained, yellow grey, extremely weathered, moist.		
				138	26					clayey, fine grained, grey, extremely weathered, moist.		
				136	28					very fine to fine grained, orange, extremely weathered.		
				134	30					very fine grained, yellow-grey, distinctly weathered.		
				132	32					fine grained		
				130	34					SILTSTONE: brown, slightly weathered, moist.		
				128	36					yellow and grey, moist.		
				126	38					grey, fresh		
				124	40							143mm Diameter, 40 to 153m bgl
				122	42							
				120	44					calcite veins.		
				118	46					SANDSTONE: fine grained, pale grey, calcite veins, dry.	D	
				116	48					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**
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:

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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
											VS	FB	
RAB			TOC 1 m							fine grained.	D		
				112	52								
				110	54								
				108	56								
				106	58								
				104	60								
				102	62								
				100	64								
				98	66								
				96	68								
				94	70								
				71.00									
				92.20	72					moist	M		
				90	74					dry	D		
				88	76								
				77.00									
				86.80	78					moist	M		
				79.00						SILTSTONE: grey, fresh, calcite alteration, dry.	D		
				84.00	80					SANDSTONE: fine grained, grey, fresh, calcite alteration.			
				82.20	82					very fine grained.			
				83.00						fine grained.			
				80.40	84					moist	M		
				85.00						very fine grained, dry.	D		
				78	86					fine grained.			
				76	88								
				89.00									
				74.00	90					SHALE: dark grey to black, fresh, moist.	M		
				72	92					SANDSTONE: fine grained, dark grey, fresh, carbonaceous and calcite alteration, moist.			
				70.40	94								
				68	96					SHALE: dark grey to black, fresh, carbonaceous and calcite alteration, wet.	W		
				66	98								
				39.00						SILTSTONE: dark grey, fresh, carbonaceous, calcite alteration, dry.	D		

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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 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: *U&R*

Drill Model/Mounting: IRTM 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							Field Material Description												
1	2	3	4	5	6	7	8	9	10	11	12	13							
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS						
RAB			TOC 1 m							SANDSTONE: very fine grained, dark grey, fresh, calcite alteration, carbonaceous, wet.	W	VS FB VL JL ST VD							
			80mm ID, Class 18 uPVC casing from 100 to 123.5m bgl	62	102														
				60	104														
				58	106														
				56	108														
				54	110														
				52	112														
				50	114														
				48	116														
				46	118														
				44	120														
				42	122														
				40	124	80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 123.5 to 129.5m bgl	38	126											
				36	128														
				34	130	80mm ID, Class 18 uPVC casing from 129.5 to 147m bgl	32	132											
				30	134														
				28	136														
				26	138														
				24	140														
				22	142														
	20	144																	
	18	146																	
	16	148	80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 147 to 150.1m bgl, 0.2m uPVC sump																
Airlift yield: 0.004 L/S																			
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:

Drill Model/Mounting: IRTM 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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FB VL JL MD ST OD H	
RAB				12.2 162						SANDSTONE: very fine grained, dark grey, fresh, calcite alteration, wet. (continued)	W	114mm Diameter, 153 to 189m bgl
				153.00						SILTSTONE: grey, fresh, with calcite alteration, wet.		
				10 154						SANDSTONE: very fine grained, dark grey, fresh, wet.		
				8 156								
				6 158								
				4 160								
				2 162								
				0 164								
				-2 166								
				-4 168								
				-6 170						fine grained.		
				-8 172						very fine grained.		
				-10 174						fine grained.		
				-12 176						very fine grained.		
				-14 178						COAL: black, fresh, wet.		
				-16 180						TUFF: pale grey, fresh, wet.		
				-18 182						COAL: black, fresh, wet.		
				-20 184						TUFF: white, fresh, wet.		
				-22 186						COAL: black, fresh, wet and TUFF: white, fresh, wet. COAL: black, fresh, wet.		Airlift yield: 0.07 L/S
				-24 188								
				-26 190						END OF BOREHOLE AT 189.00 m		
				-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**
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:

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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								RELATIVE DENSITY VS FB VL AD ST VD VS FB VL AD ST VD	
RB			Monument cover with PVC cap, Coromant 0 to 6.5m bgl (below ground level) 50mm ID, Class 12 uPVC casing, 0 to 40m bgl	154.200	2				CL	Silty CLAY: brown, dry, firm.	D	143mm Diameter, 0 to 52m bgl
					3.00					moist	M	
				152	4				CL	CLAY: brown	D	
				150.600	6				SC	Clayey SAND: fine grained, pale brown, moist	M	
				148.800	8				SP	SAND: fine grained, pale brown, dry.	D	
				146	10				SC	with clay, moist.	M	
				144	12				CL	CLAY: pale grey, moist, firm		
				142	14				SC	Sandy CLAY: brown, fine grained sand, moist.		
				140.600	15				CL/ML	CLAY: grey, moist, firm and Clayey SAND: fine to medium grained, grey and orange, moist.		
				138	18				CL	CLAY: grey, moist, firm and Clayey SAND: fine grained, orange, moist.		
				136	20				CL	CLAY: grey, orange and pink, firm, trace very fine grained pink sand, moist.		
				134	22				CL/ML	Clay: pale grey, pink and orange, moist, firm and SAND: very fine grained, pink, moist.		
				132	24							
				130	26							
				128	28							
				126	30							
				124.200	32				ML/CL	SAND: very fine grained, yellow, moist and CLAY: yellow brown, moist, firm.		
				122.400	34				CL	CLAY: brown, with pale brown silt, moist, firm.		
				120.600	36				ML	SILT: yellow, with firm grey clay, moist.		
				118	38					SANDSTONE: very fine grained, yellow brown, extremely weathered, moist.		
				116	40							
				114	42							
				112.400	44					grey, distinctly weathered, moist.		
				110	46							
				108.400	48					SILTSTONE: dark grey, slightly weathered, moist.		

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 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:

Drill Model/Mounting: IRTN 60 Driller: S Baker Surface RL: 156 m AHD
Borehole Diameter: 143mm Driller Lic No: 3046 Co-ords: E 670246 N 7469610 MGA94 Zone 55
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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS	
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**
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:

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	12	13	
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m										
RB			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	154	2				CL	Silty CLAY: brown, dry, firm.	D		200mm Diameter, 0 to 51m bgl
		152		4			SL	CLAY: brown, dry, firm.					
		150		6			SC	Clayey SAND: medium grained, brown, moist	M				
		148		8			CL/SC	CLAY: grey, moist, firm and Sandy CLAY: brown, fine grained sand, moist.					
		146		10			SC	Clayey SAND: fine to medium grained, grey and orange, moist.					
		144		12			CL/ML	CLAY: grey, moist, firm and Clayey SAND: fine grained, orange, moist.					
		142		14			CL	CLAY: pale grey, orange and pink, moist, firm, trace very fine grained pink sand.					
		140		16			CL/ML	CLAY: grey, pink and orange, moist, firm and SAND: very fine grained, pink, moist					
		138		18									
		136		20									
		134		22									
		132		24									
		130		26									
		128		28									
		126		30									
		124		32									
		122		34				CL	CLAY: brown, moist, firm.				
		120		36				ML	SILT: yellow-brown, with firm grey clay, moist.				
		118		38					SANDSTONE: very fine grained, yellow-brown, extremely weathered, moist.				
		116		40									
		114		42									
		112		44					red, distinctly weathered.				
		110		46					CLAYSTONE: brown and orange, distinctly weathered, moist.				
		108		48					SILTSTONE: grey-brown, distinctly weathered, carbonaceous, moist.				
									SANDSTONE: very fine grained, grey, slightly weathered, moist.				

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: *WGR*

Drill Model/Mounting: IRTM 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	12	13	
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			TOC 1 m								VS FB VL L MD ST VD H		
				50.00						CLAYSTONE: grey, distinctly weathered, moist.	M		
RAB				104 52									140mm Diameter, 51 to 144m bgl
				53.00						SANDSTONE: very fine grained, grey, fresh, dry.	D		
				102 54									
				100 56									
				57.00						CLAYSTONE: dark grey, fresh, dry.			
				98 58						SILTSTONE: dark grey, fresh, carbonaceous, dry.			
				96 60									
				94 62									
				92 64						SANDSTONE: very fine grained, dark grey, fresh, carbonaceous, dry			
				90 66						SILTSTONE: dark grey, fresh, carbonaceous, dry.			
				88 68									
				86 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						SILTSTONE: dark grey, fresh, carbonaceous, dry.			
				80 76									
				77.00						extremely weathered, clayey, wet.	W		
				78 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						fine grained.			
				66 90									
				64 92									
				62 94									
				60 96						very fine grained.			
				97.00						SILTSTONE: dark grey, fresh, wet.			
				58 98						SANDSTONE: very fine grained, dark grey, fresh, wet.			

This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m									
RB			Monument cover with PVC cap. Cement 0 to 5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 200m bgl	1.00	2				ML	Clayey SILT: brown, dry.	D	
				154	2				CL	Silty CLAY: brown and orange, moist, firm.	M	
				152	4							
				5.00					SC	SAND: fine grained, orange, with clay, moist.		
			Backfill, 5 to 194m bgl	150.00	6					fine to medium grained, brown.		
				148.00	8					medium grained, orange.		
				146	10				CL	CLAY: grey and orange, moist, firm, with medium grained, orange sand.		
				144	12							
				142.00	14					pink, orange and grey, no sand.		
				140	16							
				138	18							
				19.00					CL/SP	Sandy CLAY: pink and grey, moist, firm and SAND: fine, grained, pink, moist.		
				136	20							
				134	22							
				132	24							
				130.00	26				CL	CLAY: pink and grey, moist, firm.		
				128.00	28					orange and grey.		
				126.00	30				CL	Silty CLAY: grey, orange and dark brown, moist, firm.		
				124	32							
				33.00								
				122	34					SANDSTONE: very fine grained, yellow, extremely weathered, moist.		
				35.00								
				120.00	36					SILTSTONE: yellow, distinctly weathered, moist.		
				118	38					SANDSTONE: very fine grained, yellow and brown, extremely weathered, moist.		
				39.00								
				116.00	40					SILTSTONE: yellow, distinctly weathered, moist.		
				41.00						SANDSTONE: fine grained, grey, distinctly weathered, moist.		
				114.00	42					very fine grained.		
				112.00	44					brown, clayey in places.		
				110.00	46					SILTSTONE: grey and brown, slightly weathered, moist.		
RAB				108.00	48					SANDSTONE: fine grained, grey, slightly weathered, moist.		140mm Diameter, 46 to 203m bgl
				49.00						CLAYSTONE: grey, slightly weathered, minor silt, moist.		
										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**
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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS		
RAB			TOC 1m							SILTSTONE: grey, slightly weathered, moist. (continued)	M				
				104	52										
				102	54										
				100	56					SANDSTONE: very fine grained, grey, slightly weathered, moist.					
				98	58										
				96	60										
				94	62										
				92	64					SILTSTONE: grey, fresh, moist.					
				90	66					SANDSTONE: very fine grained, grey, fresh, moist.					
				88	68					SILTSTONE: grey, fresh, moist.					
				86	70					SANDSTONE: grey, fresh, moist.					
				84	72					SILTSTONE: grey, fresh, moist.					
				82	74										
				80	76										
				78	78					SANDSTONE: very fine grained, grey, fresh, moist.					
				76	80					fine grained.					
				74	82										
				72	84										
				70	86										
				68	88										
				66	90					very fine grained.					
				64	92					SILTSTONE: dark grey, fresh, moist.					
				62	94					SANDSTONE: fine grained, grey, fresh, wet.	W				
				60	96					SILTSTONE: dark grey, wet.					
58	98					SANDSTONE: very fine grained, dark gray, fresh, wet.									

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:

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m							VS	FB	
RAB									SANDSTONE: very fine grained, dark grey, fresh, wet. (continued)	W		
				54	102							
				52	104				calcite veins.			
				50	106				no calcite veins			
				48	108							
				46	110							
				44	112				SILTSTONE: grey, fresh, wet.			
				42	114				SANDSTONE: very fine grained, grey, fresh, wet.			
				40	116				SILTSTONE: grey, fresh, wet.			
				38	118				SANDSTONE: very fine grained, grey, fresh, wet.			
				36	120				fine grained.			
				34	122				very fine grained.			
				32	124							
				30	126							
				28	128							
				26	130				fine grained.			
				24	132				very fine grained.			
				22	134							
				20	136				SILTSTONE: dark grey, fresh, carbonaceous, wet.			
				18	138				Silty COAL: dark brown, fresh, wet, (Middlemount Seam).			
				16	140				COAL: black, fresh, wet, (Middlemount Seam).			
				14	142				SANDSTONE: very fine grained, brown, fresh, wet.			
				12	144				fine grained, grey.			
				10	146							
				8	148				very fine grained, brown, carbonaceous.			

Airlift yield: 0.03 L/S

Airlift yield: 0.03 L/S

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
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: *UKR*

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	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FL VL JL ML SL ST VST D H		
RAB				152.00						fine grained, grey.	W		
				452.452						very fine grained, bands of carbonaceous siltstone.			
				153.00						fine grained.			
				2 154									
				055.456						brown			
				-255.458						grey			
				-455.460						brown.			
				-655.462						grey.			
				163.00						very fine grained.			
				-855.464						fine grained.			
				-1055.466						very fine grained.			
				-12 168									
				169.00						fine grained.			
				-1475.470						brown			
				171.00						grey			
				-16 172									
				173.00						brown.			
				-1875.474						grey.			
				175.00						brown.			
				-20 176									
				177.00						calcite veins.			
				-22 178									
				-24 180									
				-2652.482							very fine grained, dark grey, no calcite veins.		
				-28 184									
			185.00						fine grained.				
			-3055.486							SILTSTONE: dark grey, fresh, wet.			
			187.00							SANDSTONE: very fine grained, grey, fresh, calcite veins, wet.			
			-32 188										
			189.00							SILTSTONE: dark grey, fresh, wet.			
			-34 190										
			-36 192										
			-38 194										
			-40 196										
			-4255.498							Silty COAL: dark brown, fresh, wet, (Pisces Seam)			
				199.00									

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**Driller: **E Schumacher**Surface RL: **156 m AHD**Borehole Diameter: **200mm to 140mm**Driller Lic No: **3127**Co-ords: **E 670251 N 7469592 MGA94 Zone 55**TOC (RL): **157 m AHD**

Local Co-ords:

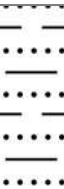
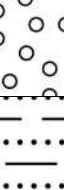
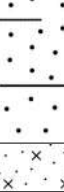
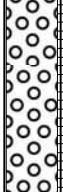
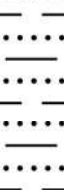
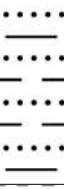
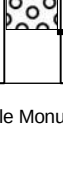
Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	STRUCTURE AND ADDITIONAL OBSERVATIONS
			TOC 1 m								VS FL ST H	
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 (Fishes Seam). (continued)	W	
			Bentonite, 204 to 207m bgl	-48	204					SILTSTONE: dark brown, fresh, carbonaceous, wet, with very fine grained, white tuff.		Airlift yield: 0.15 L/S
			Backfill, 207 to 210m bgl	-50	206					no tuff present.		
				-52	208					tuff presents.		Airlift 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							

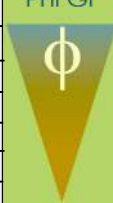
This borehole log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

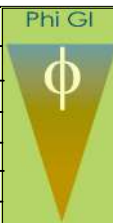


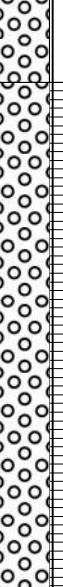
APPENDIX C

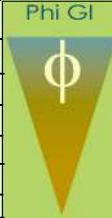
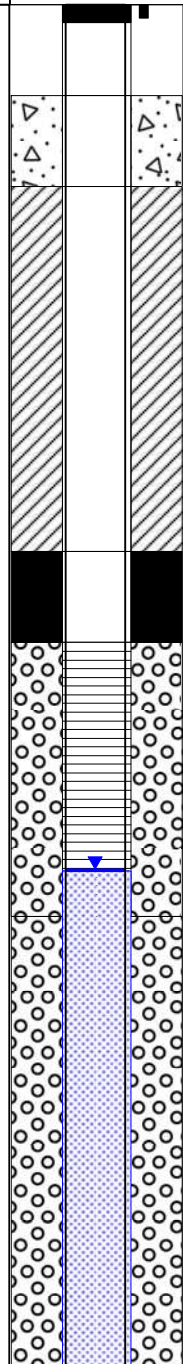
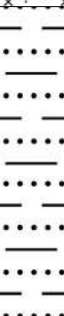
2014 / 2015 EXPLORATORY HOLE RECORDS

				Exploratory Hole Details					
				Hole No.	MW10A	Co-ordinate System	GDA94 Zone 55		
Project Middlemount Coal - Monitoring Wells				Start Date	22/12/2014	Easting	669782.88		
				Completion Date	22/12/2014	Northing	7475981.12		
Client	MCPL	Driller	L. Dahler	Ground Level	175.75mAHD				
Project No.	PGC1214004	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	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					
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au 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					
				Hole No.	MW11A	Co-ordinate System	GDA94 Zone 55		
Project	Middlemount Coal - Monitoring Wells	Start Date	25/03/2015	Easting	672355.00				
Client	MCPL	Completion Date	25/03/2015	Northing	7472275.10				
Project No.	PGC1214004	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)	Sampling and Testing	Installation Details / Groundwater Levels		
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				0.00 to 1.00m: Concrete	
	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				1.00 to 7.70m: Bentonite Grout	
	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				7.70 to 9.70m: Bentonite Seal	
	143.73	12.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil				2mm Gravel Pack	
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au Web: www.nqphigi.com.au				Remarks 50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.					

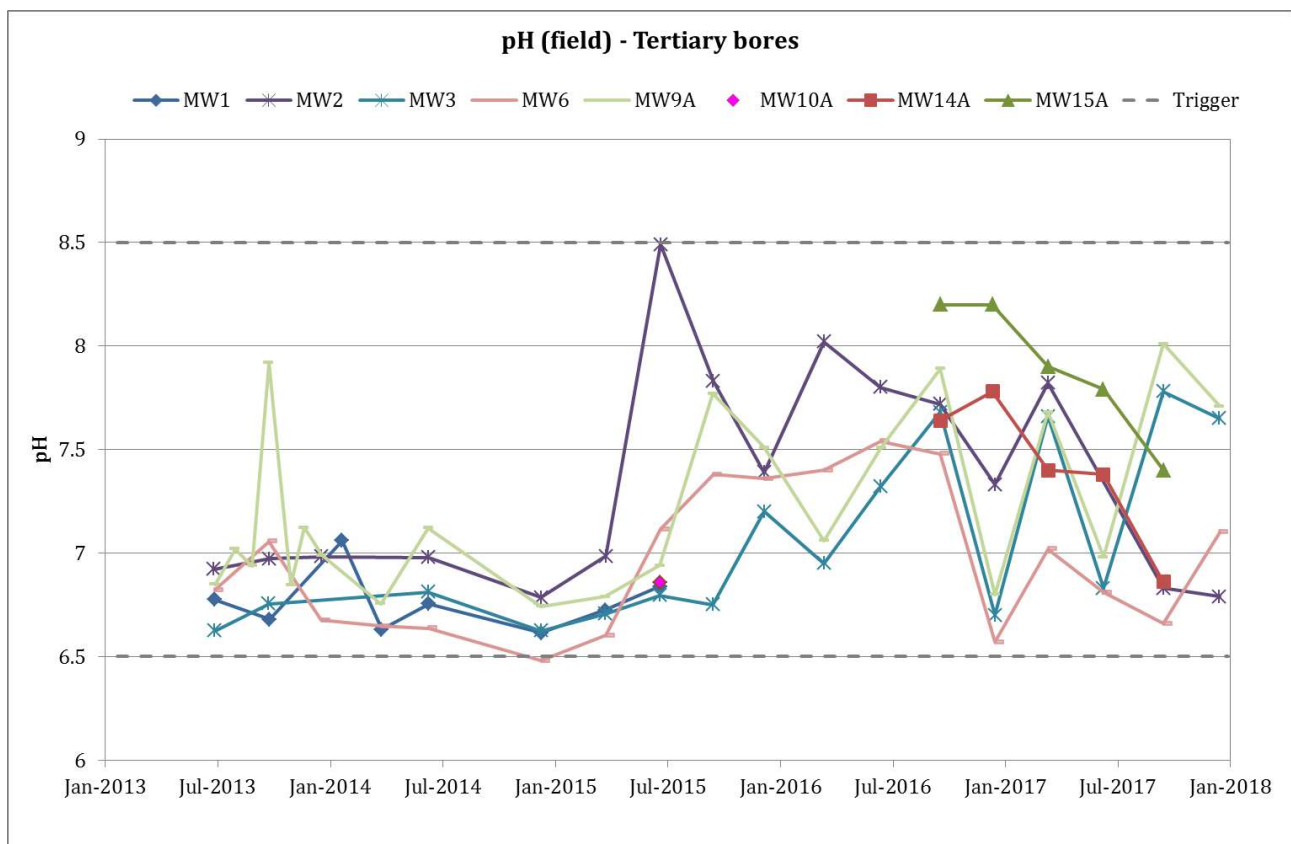
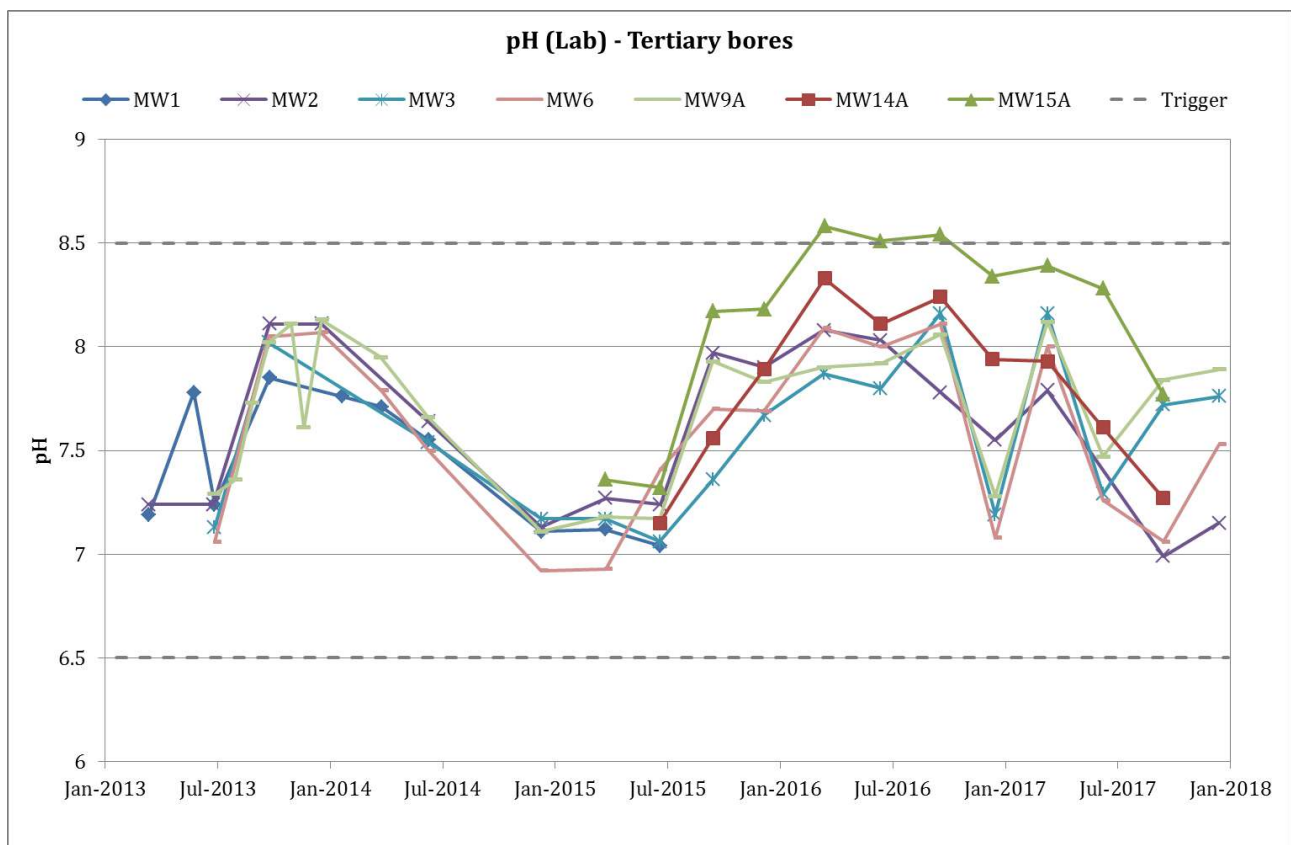
				Exploratory Hole Details					
				Hole No.	MW12A	Co-ordinate System	GDA94 Zone 55		
Project	Middlemount Coal - Monitoring Wells <th>Start Date</th> <td>15/12/2014<th>Easting</th><td>671639.97</td></td>	Start Date	15/12/2014 <th>Easting</th> <td>671639.97</td>	Easting	671639.97				
Client	MCPL	Completion Date	15/12/2014 <th>Northing</th> <td>7469852.68</td>	Northing	7469852.68				
Project No.	PGC1214004	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)	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				0.00 to 1.00m: Concrete	
	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.				1.00 to 5.00m: Bentonite Grout	
	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				5.00 to 6.00m: Seal	
	150.78	7.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil				2mm Gravel Pack	
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au Web: www.nqphigi.com.au				Remarks 50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.					

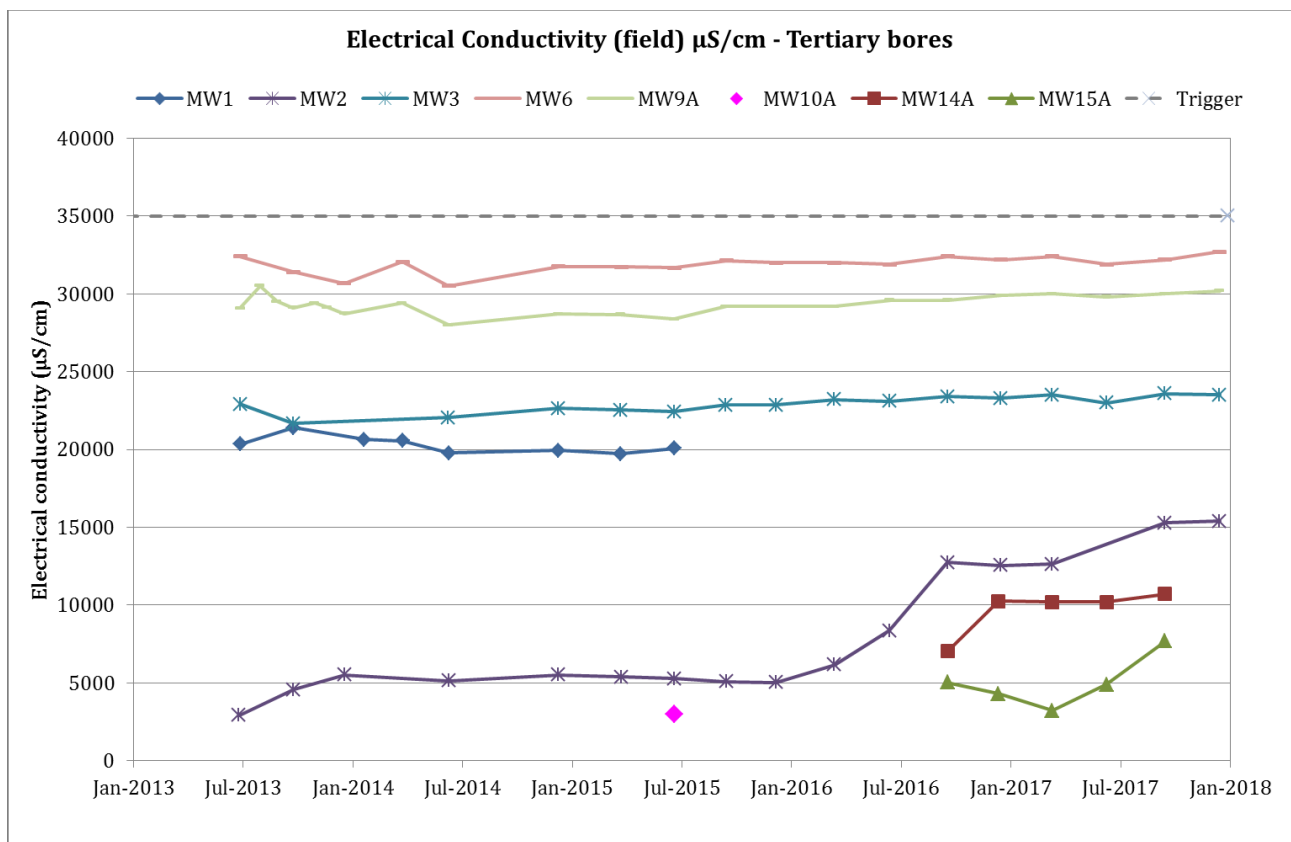
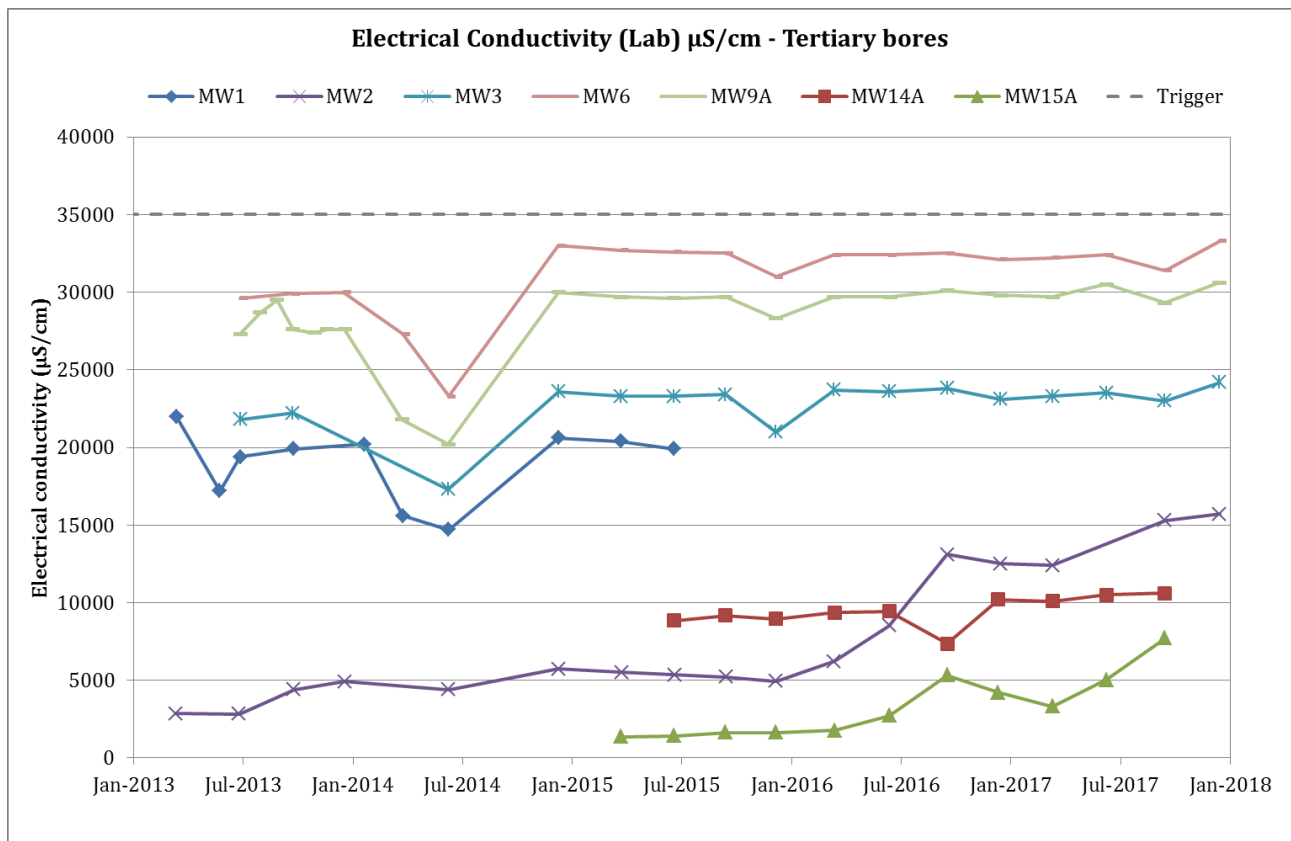
 ProjectMiddlemount Coal - Monitoring Wells ClientMCPL Project No.PGC1214004				Exploratory Hole Details				 Page 1 of 1
				Hole No.	MW13A	Co-ordinate System	GDA94 Zone 55	
				Start Date	12/12/2014	Easting	669032.15	
				Completion Date	12/12/2014	Northing	7468889.81	
				Driller	L. Dahler	Ground Level	162.79mAHD	
				Supervisor	P. Rogers			
				Licence No.	Class 2 / 2517			
				Logged By	A. Horspool	Checked By	S. Flux	
Drilling Method	R.L. (mAHD)	Depth (m)	Legend	Material Description	SPT (blows/300mm)	Sampling and Testing	Installation Details / Groundwater Levels	
Open Hole / Air Flush								
	162.79	0.00		SM: silty SAND, trace rootlets, dry. (TOPSOIL)			 Monument 0.00 to 1.00m: Concrete	
	161.79	1.00		CI: CLAY intermediate plasticity, trace sand, dark brown, dry.			 1.00 to 7.00m: Bentonite Grout	
	161.29	1.50		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			 7.00 to 8.00m: Seal	
	154.79	8.00		SANDSTONE, grey banded yellowish brown, very low strength, extremely to distinctly weathered			 2mm Gravel Pack	
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au Web: www.nqphigi.com.au				Remarks 50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.				

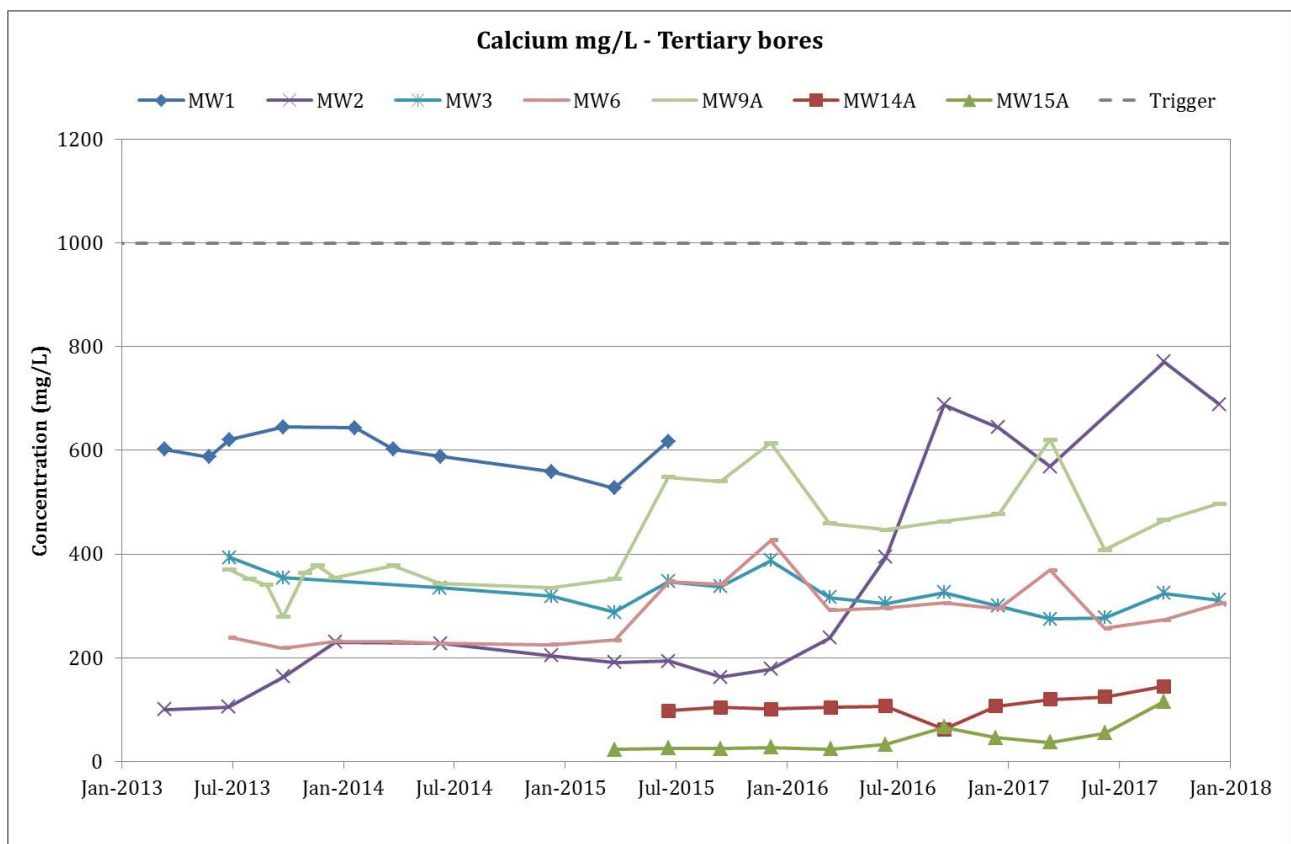
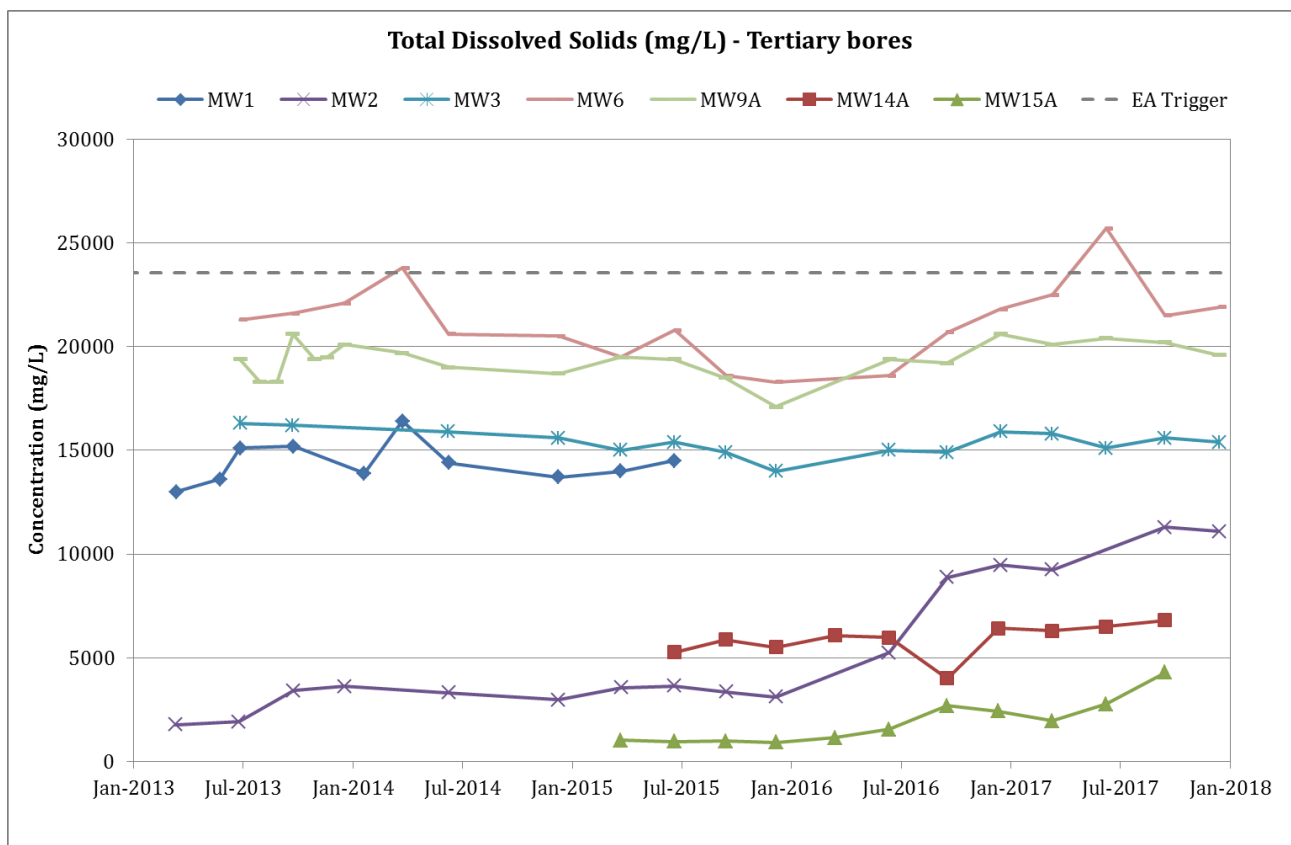
				Exploratory Hole Details					
				Hole No.	MW14A	Co-ordinate System	GDA94 Zone 55		
Project Middlemount Coal - Monitoring Wells				Start Date	14/12/2014	Easting	668175.46		
				Completion Date	14/12/2014	Northing	7469311.96		
Client MCPL				Driller	L. Dahler	Ground Level	159.65mAHD		
Project No. PGC1214004				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	Installation Details / Groundwater Levels		
Open Hole / Air Flush									
	159.65	0.00		SM: silty SAND, fine and medium, reddish brown, dry			Monument		
	158.65	1.00		SM: silty SAND, fine and medium, light brown, dry.			0.00 to 1.00m: Concrete		
	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.					
	150.9	8.75		SC: very clayey SAND, fine to coarse, dark grey, moist.			GWL 8.50m		
	149.9	9.75		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			2mm Gravel Pack		
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au Web: www.nqphigi.com.au				Remarks 50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.					

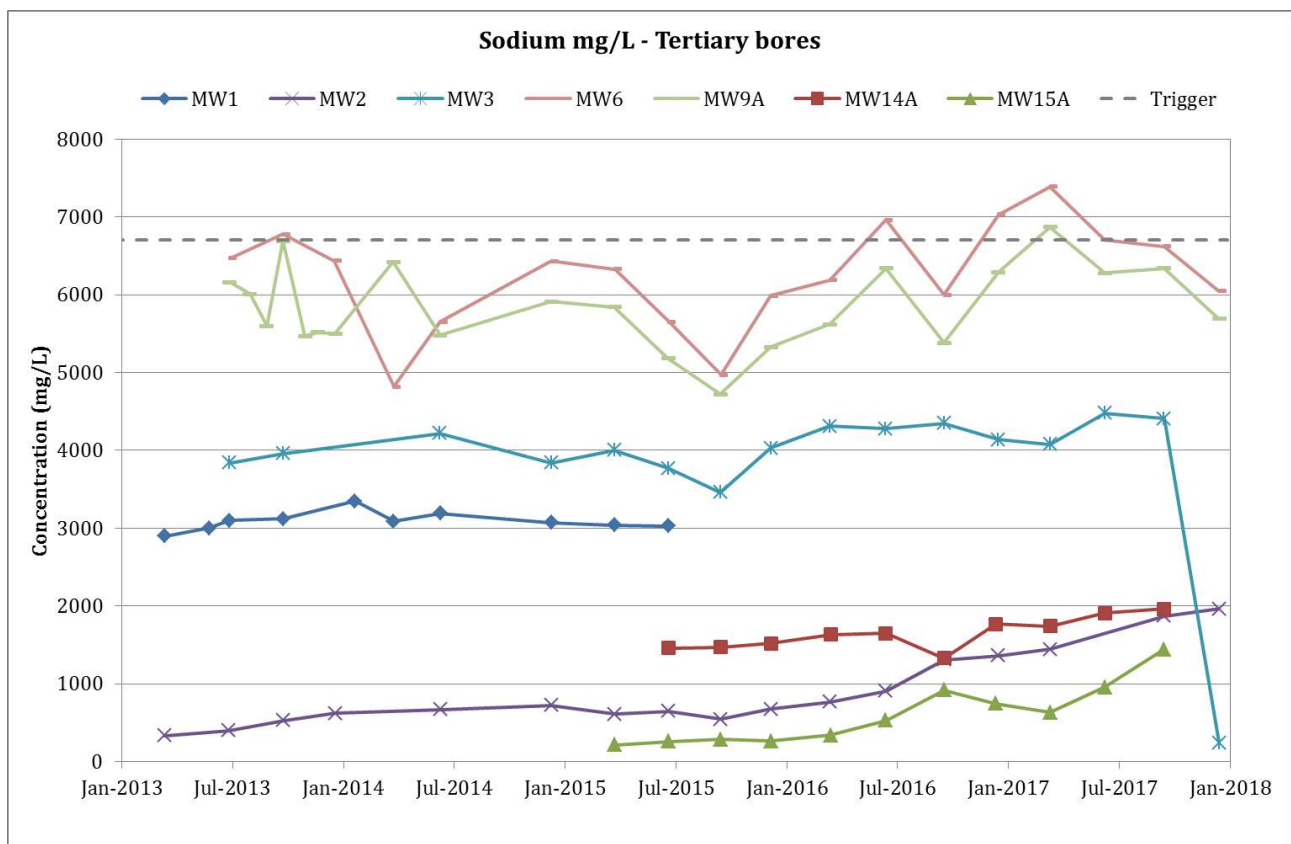
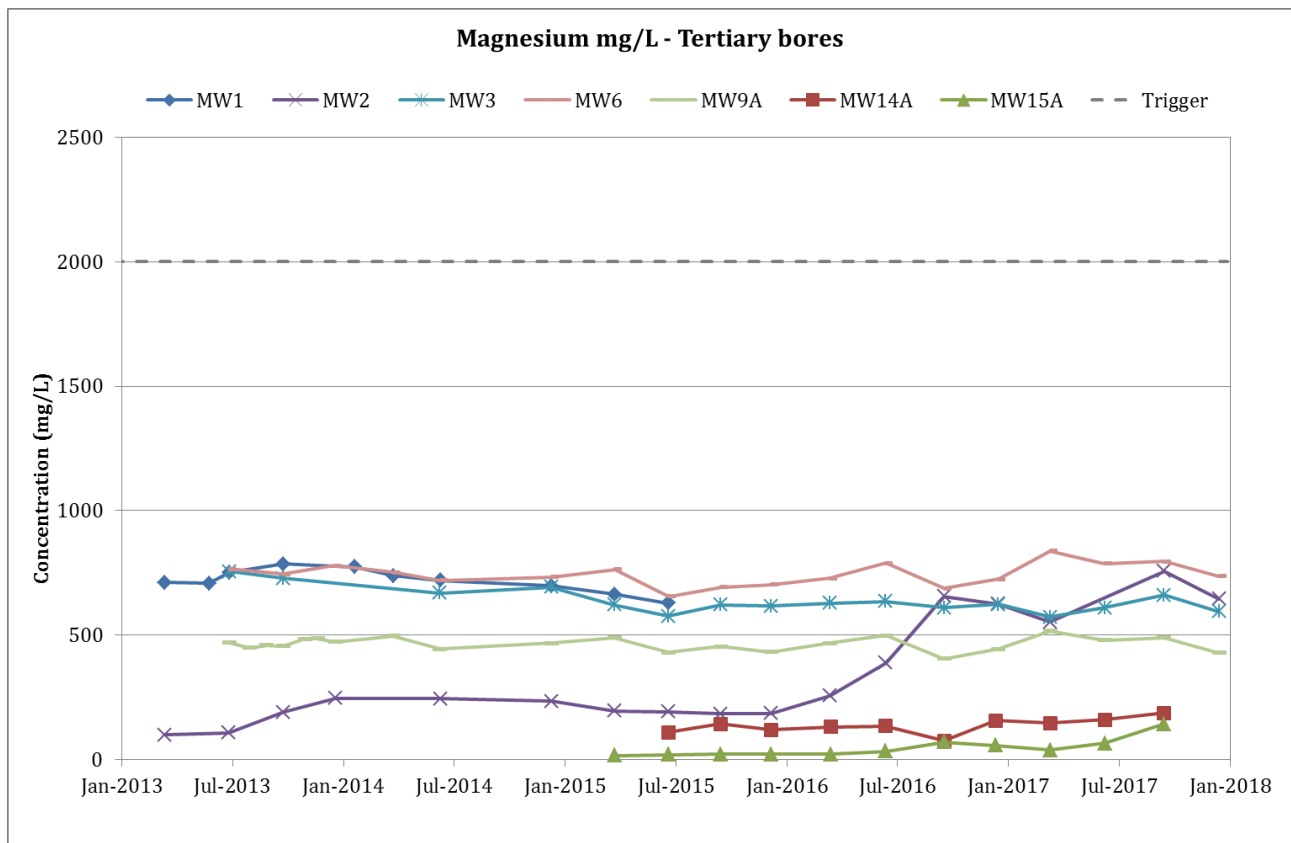
				Exploratory Hole Details					
				Hole No.	MW15A	Co-ordinate System	GDA94 Zone 55		
ProjectMiddlemount Coal - Monitoring Wells				Start Date	15/12/2014	Easting	667795.96		
				Completion Date	15/12/2014	Northing	7469627.08		
ClientMCPL				Driller	L. Dahler	Ground Level	161.57mAHD		
				Supervisor	P. Rogers				
Project No. PGC1214004				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	Installation Details / Groundwater Levels		
Open Hole / Air Flush								Monument	
	161.57	0.00		CH: CLAY with boulders, high plasticity, stiff, dry. FILL				0.00 to 1.00m: Concrete	
	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.				0.00 to 1.00m: Concrete	
	157.77	3.80		SW: SAND, fine to coarse, dry				5.00 to 6.00m: Seal	
	153.57	8.00		CI: Very sandy CLAY, intermediate plasticity, grey, moist.				GWL 7.20m 2mm Gravel Pack	
	150.57	11.00		MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil				Hole Collapsed	
Phi Ground Innovations Pty. Ltd. Ground Engineering Services 60 William Street, West End Queensland 4810 Tel: 0438985494 E-mail:enquiries@nqphigi.com.au Web: www.nqphigi.com.au				Remarks 50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.					

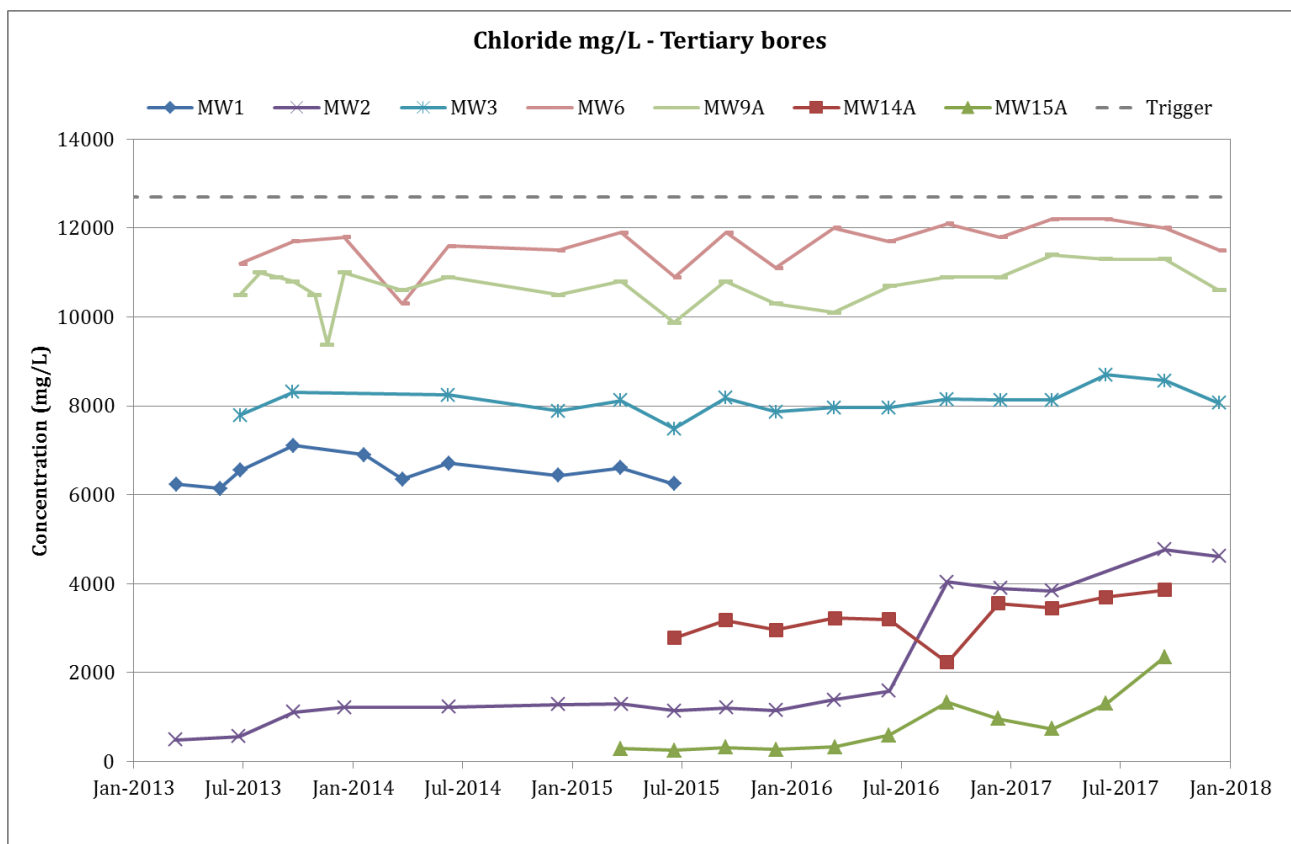
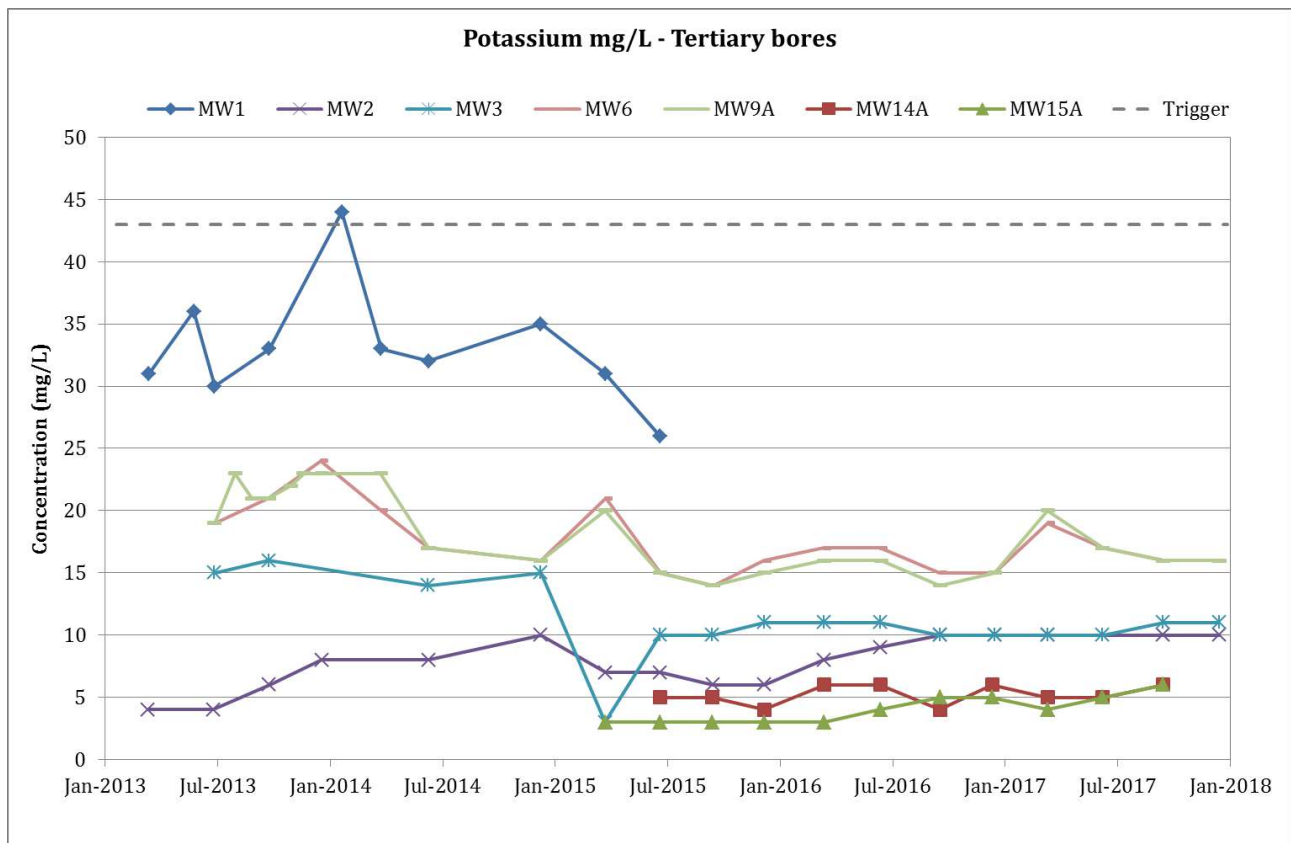
Appendix E **Tertiary and Permian water quality data**

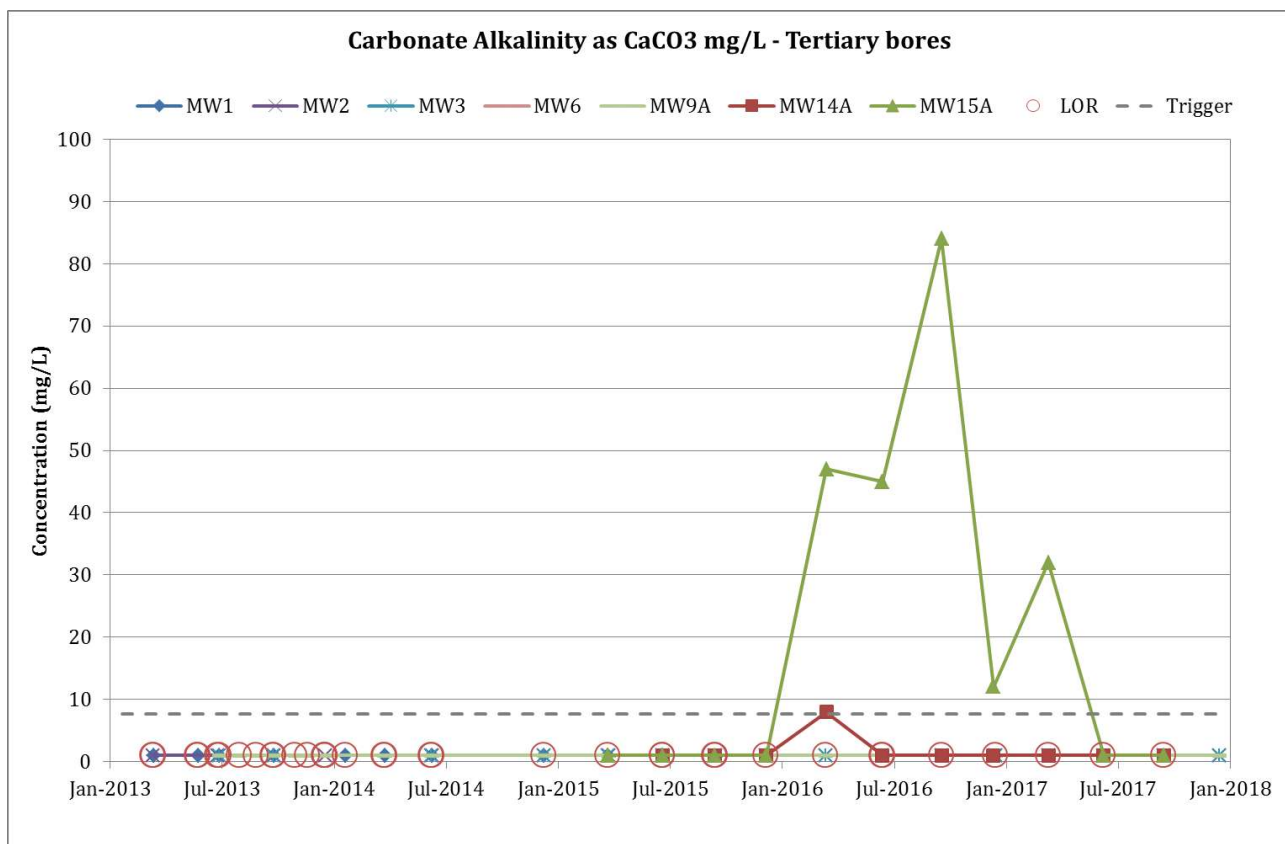
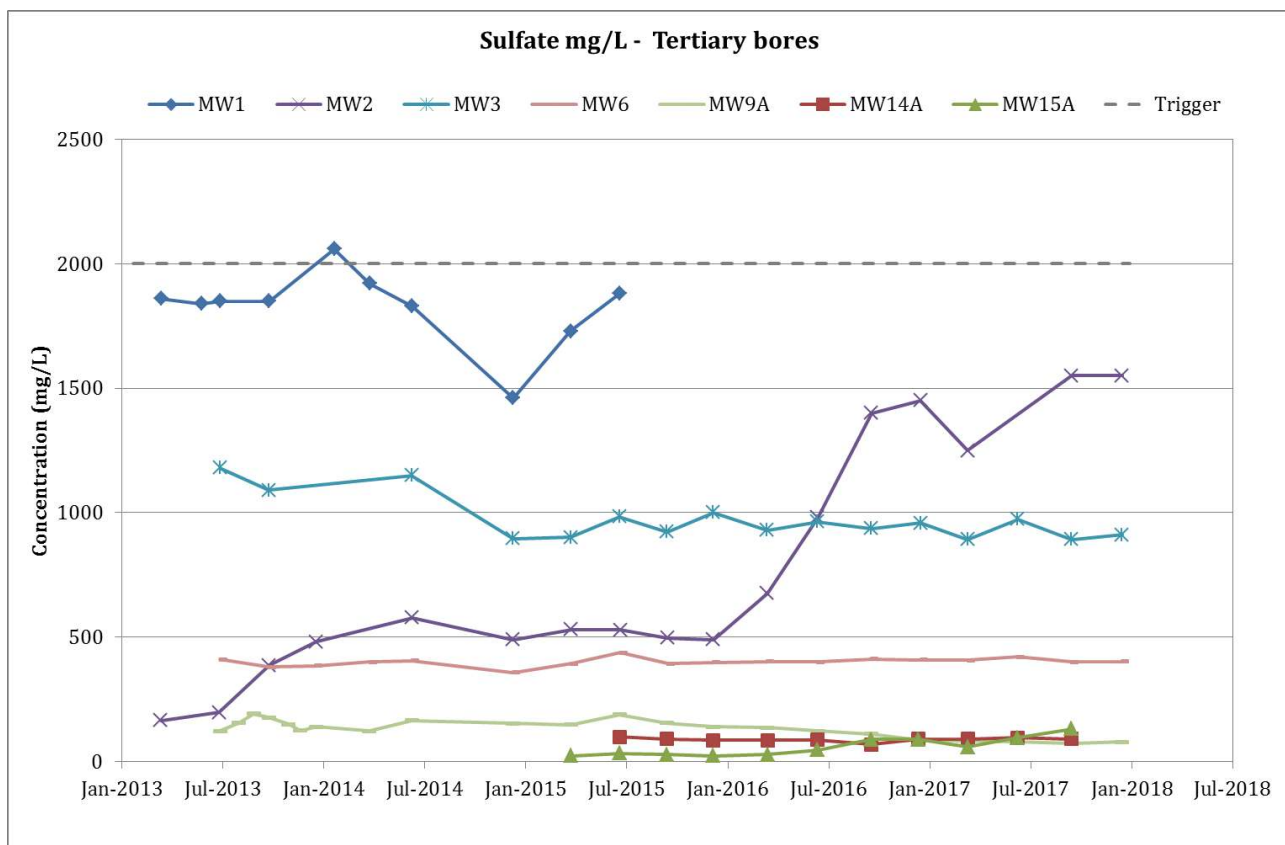


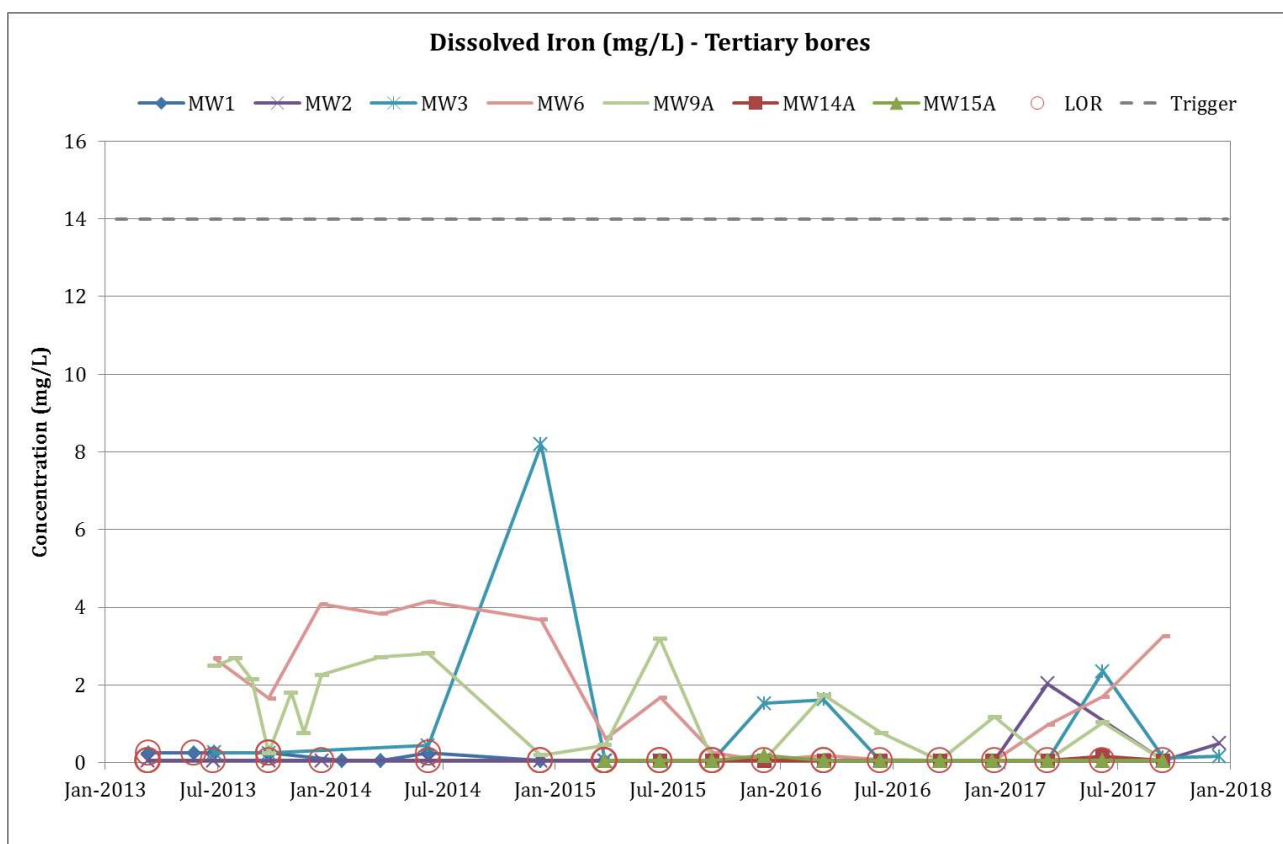
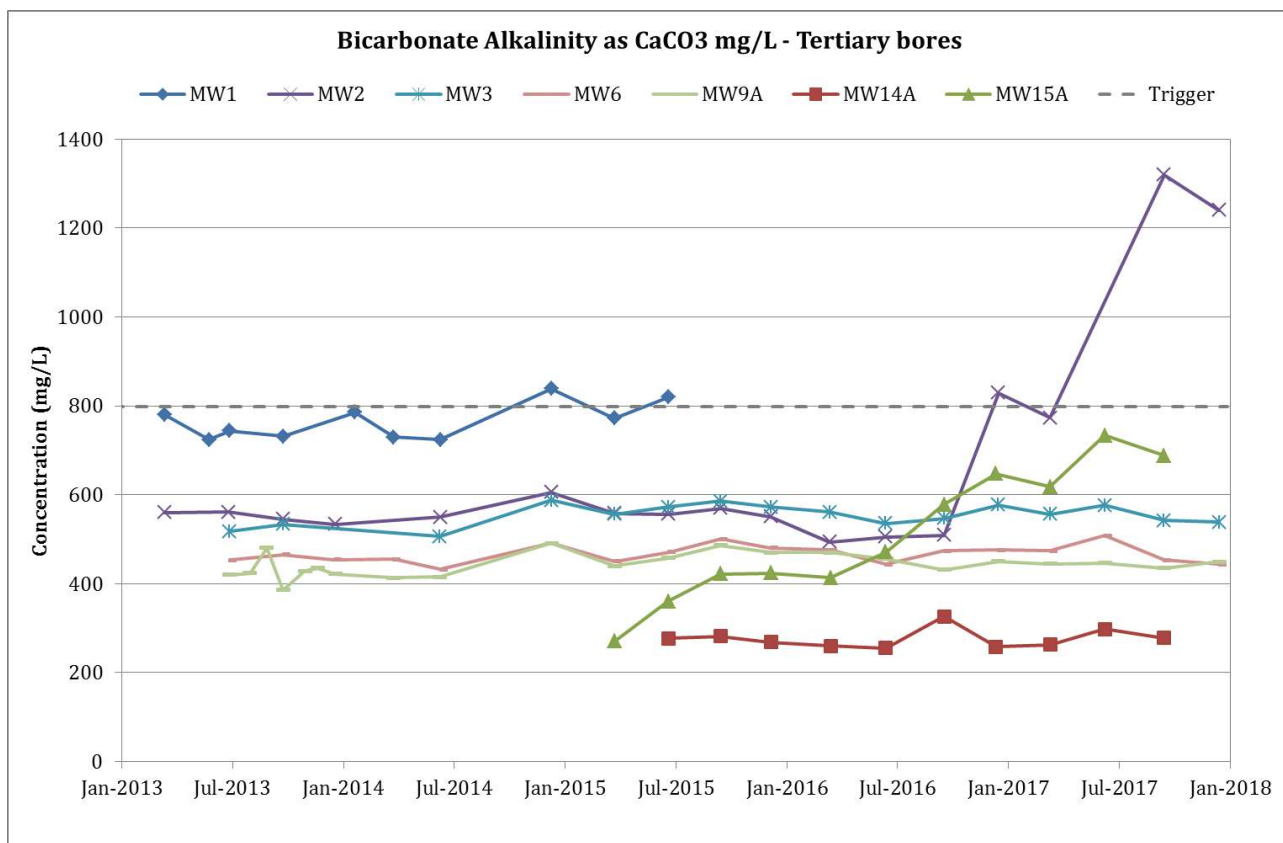


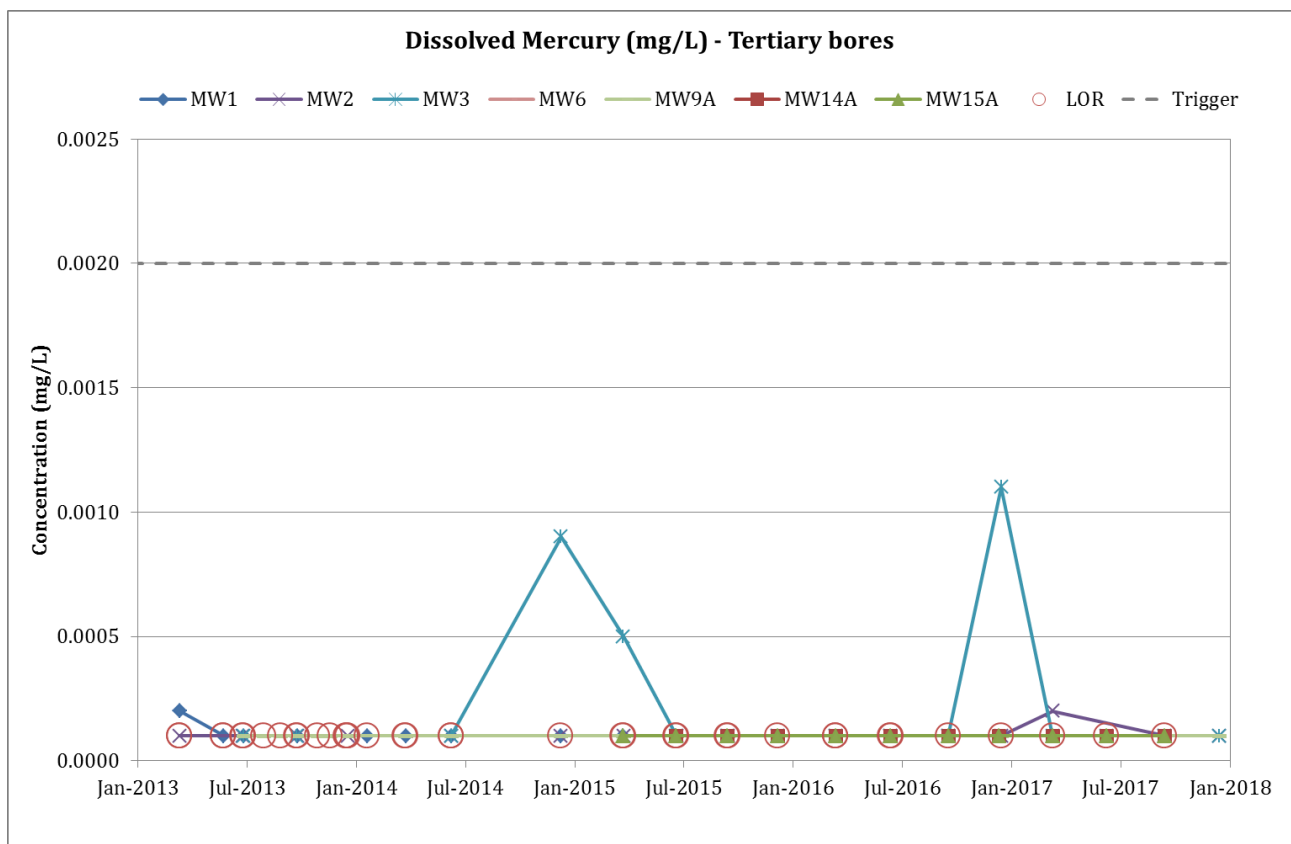
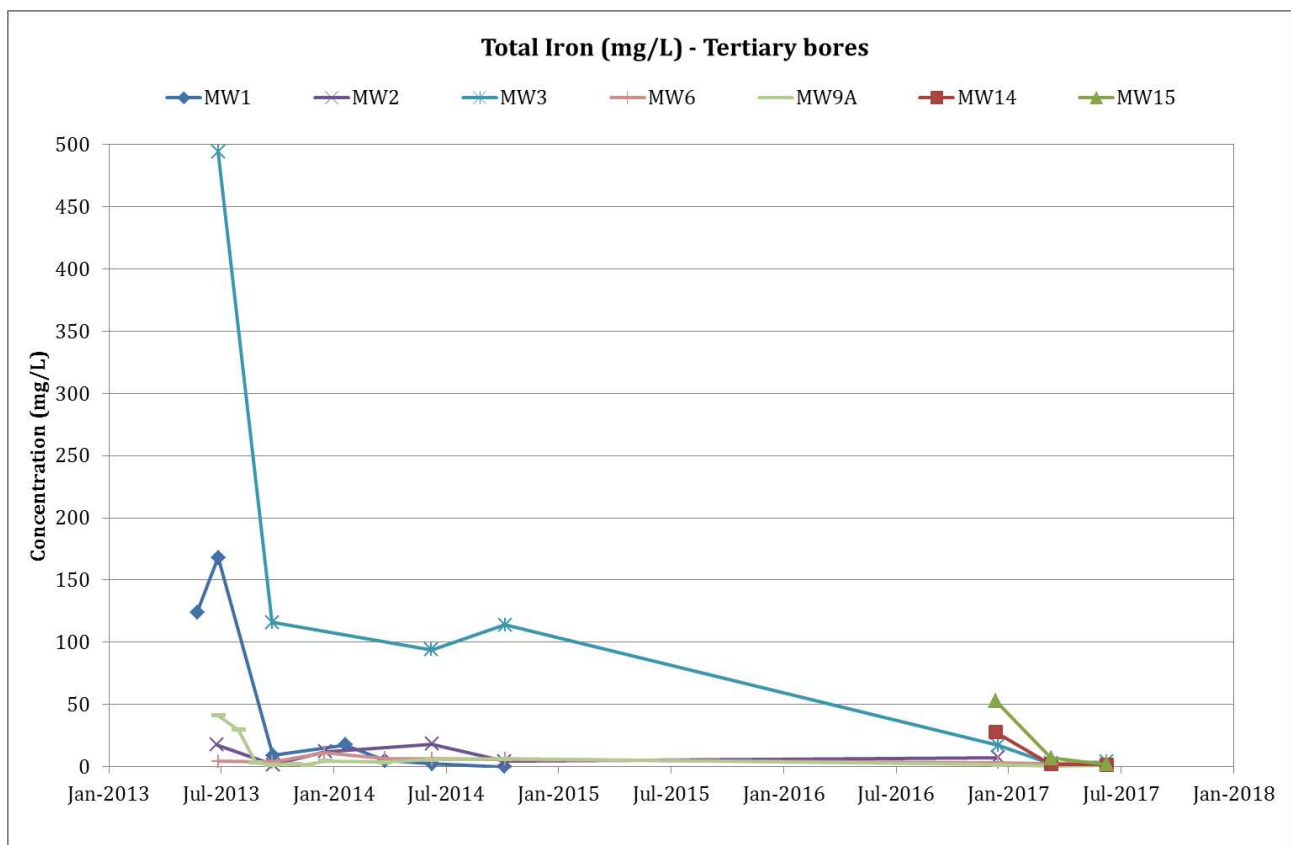


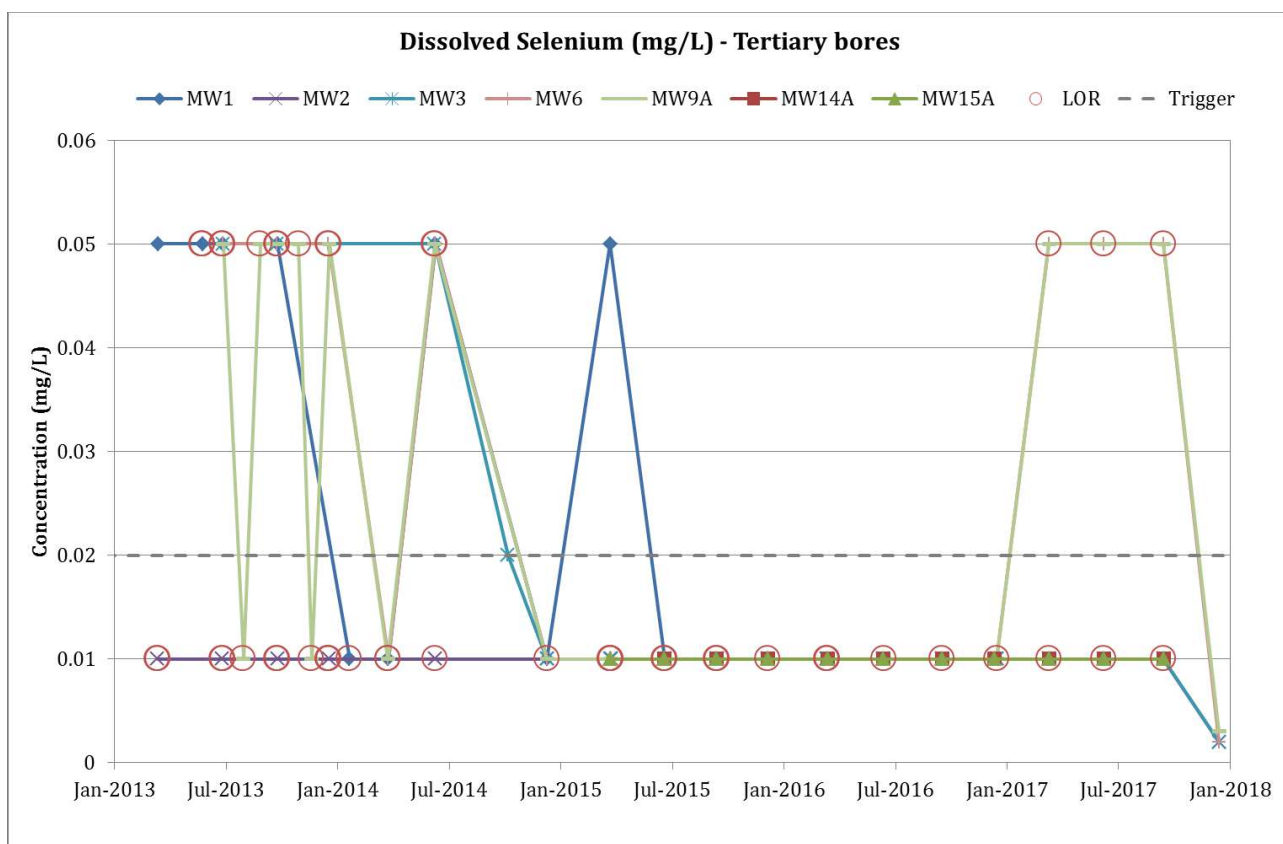
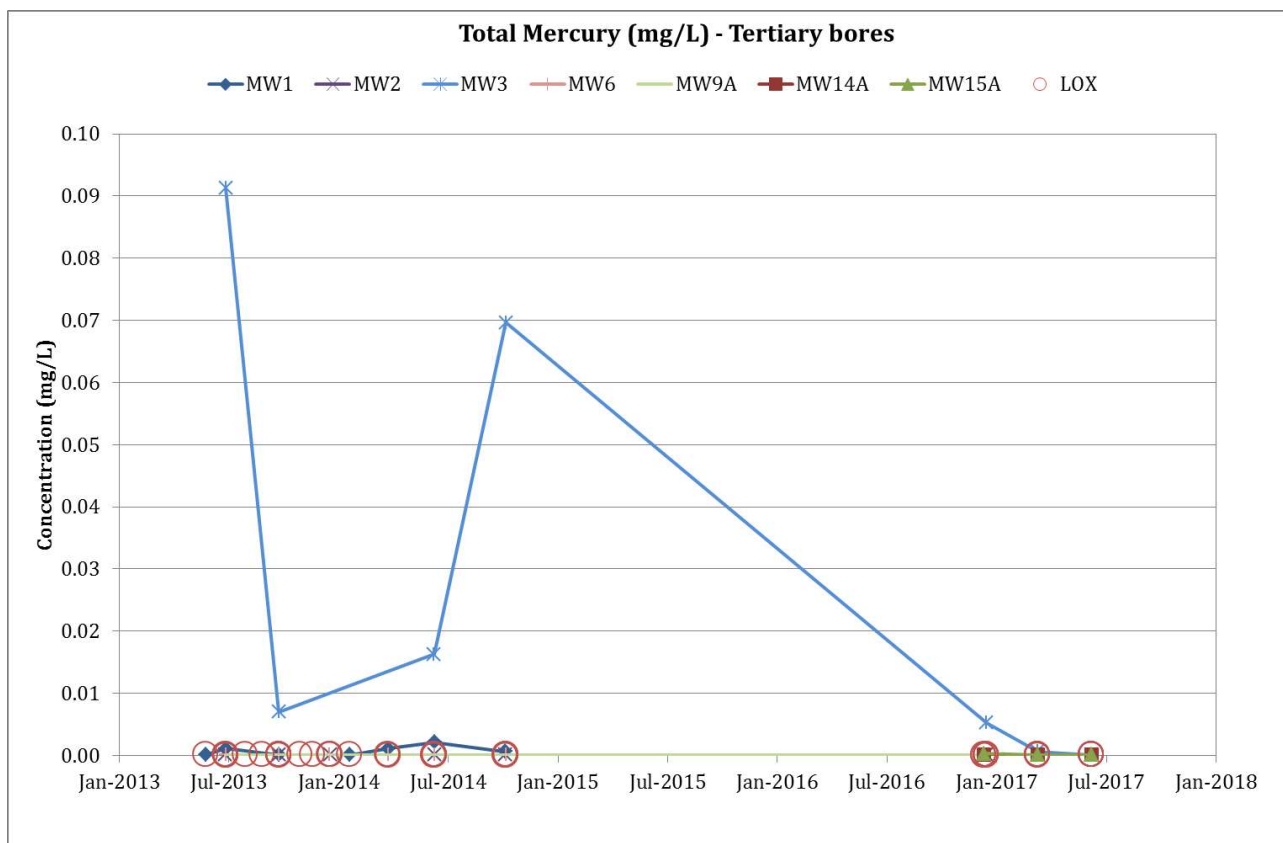


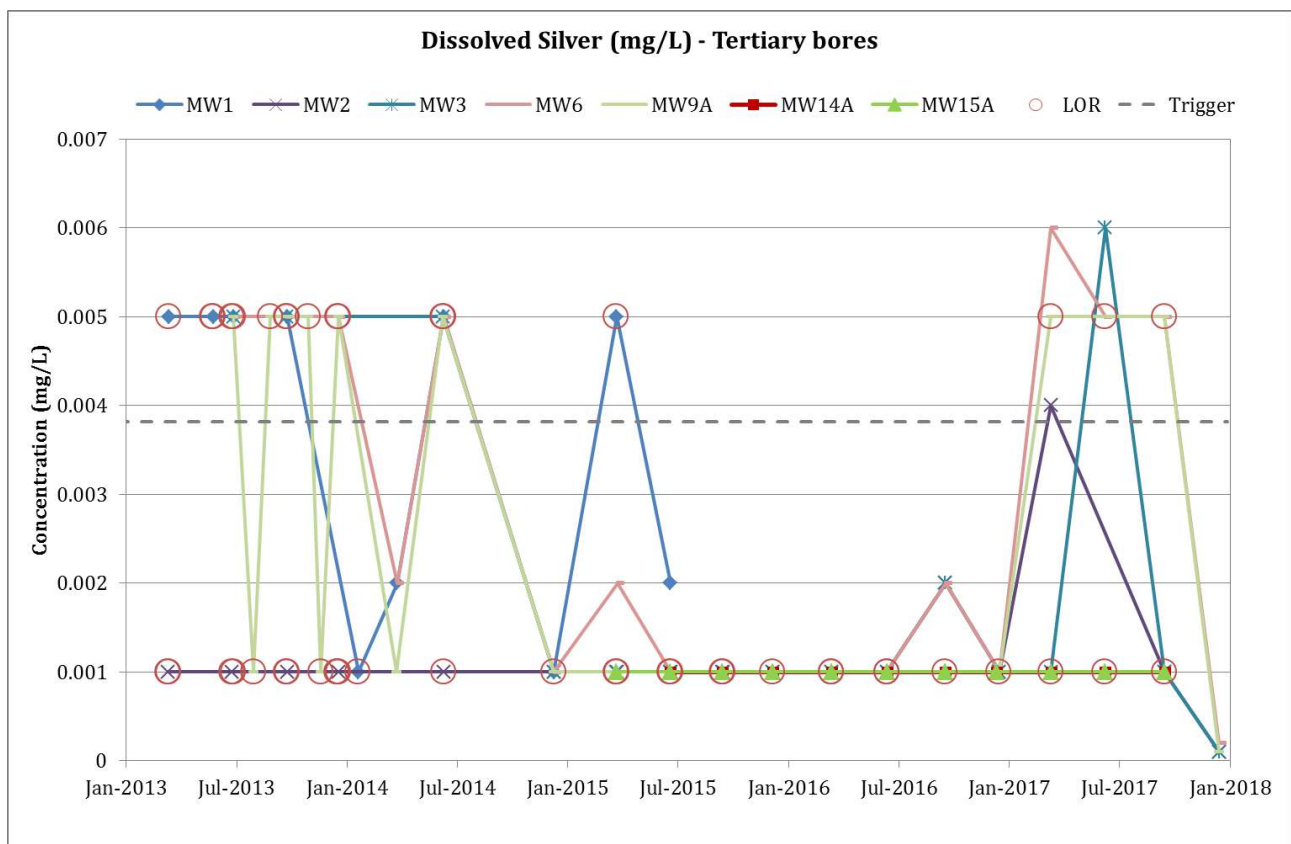
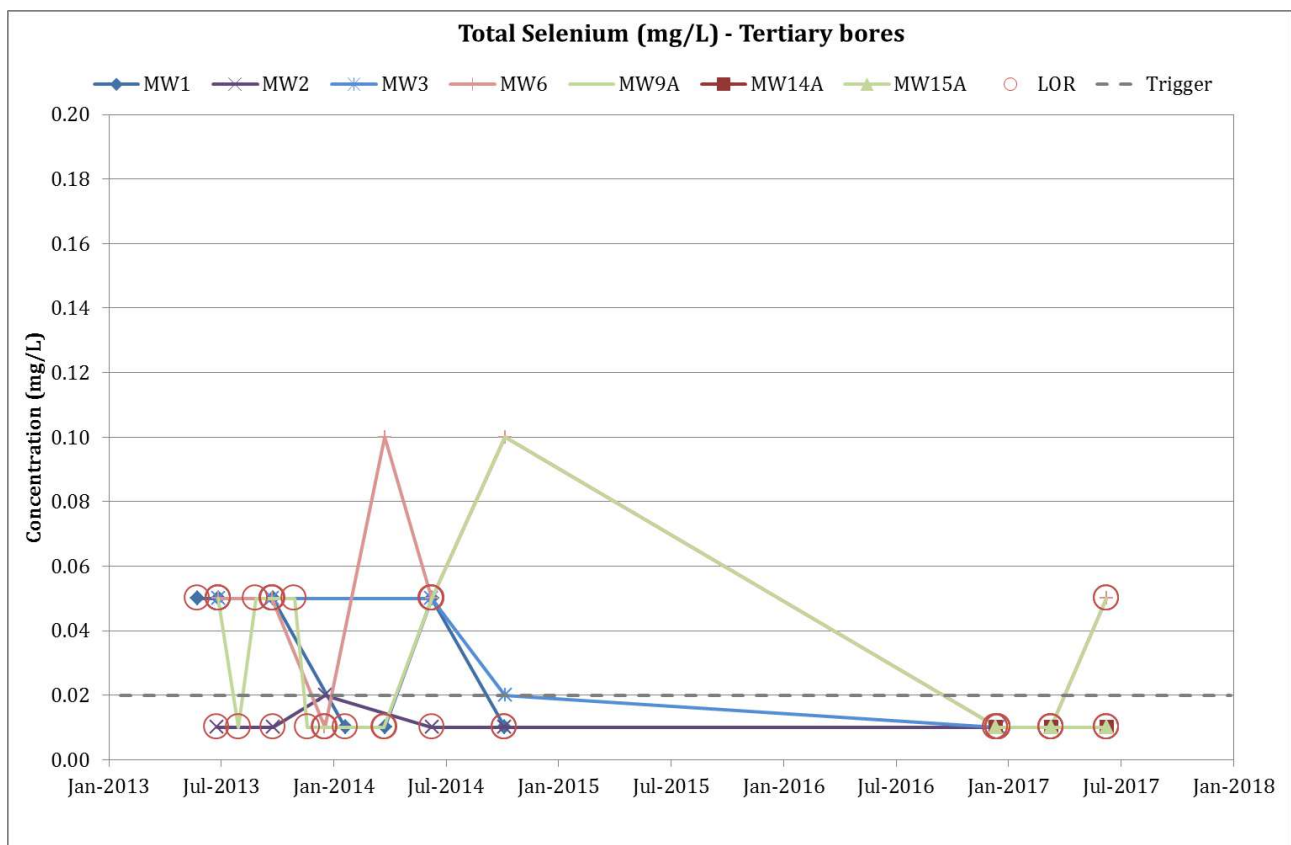


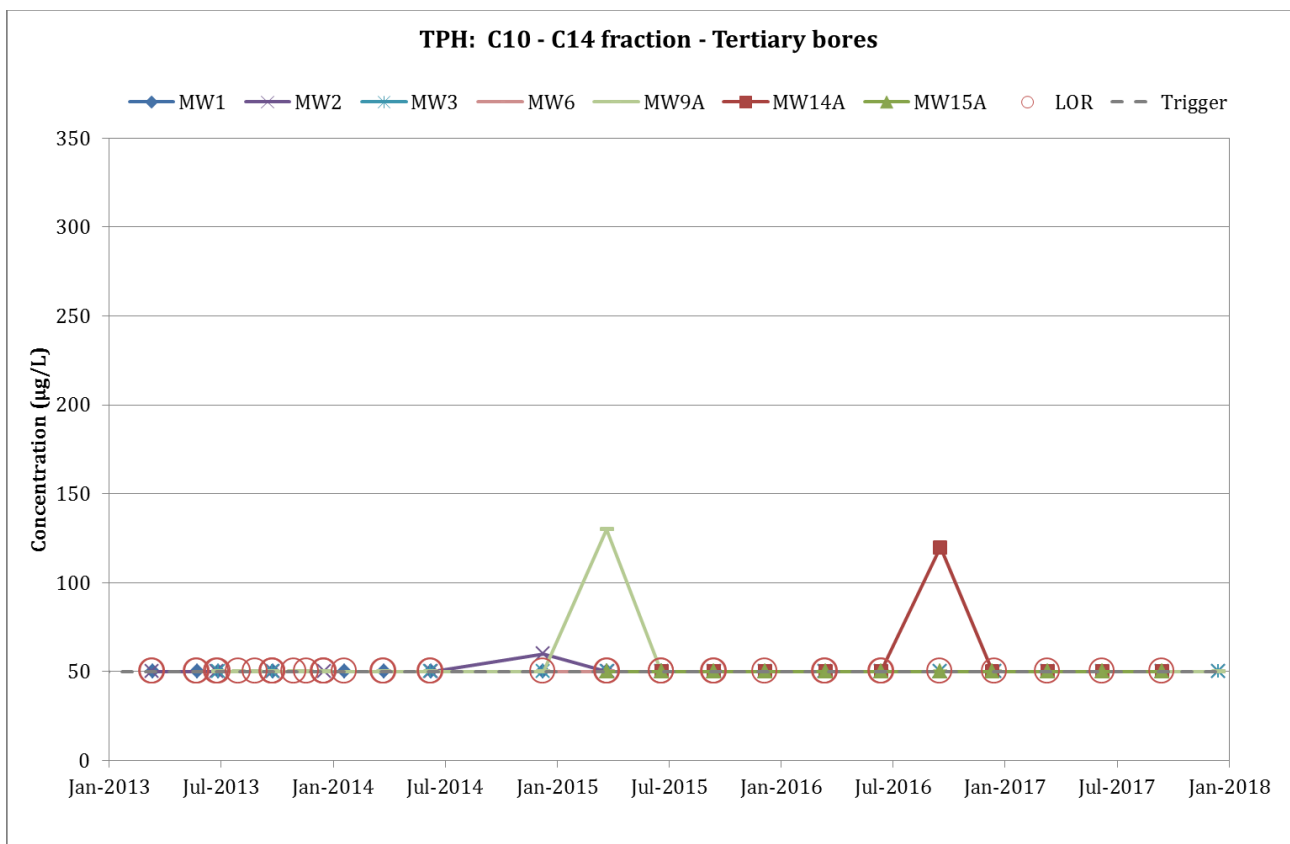
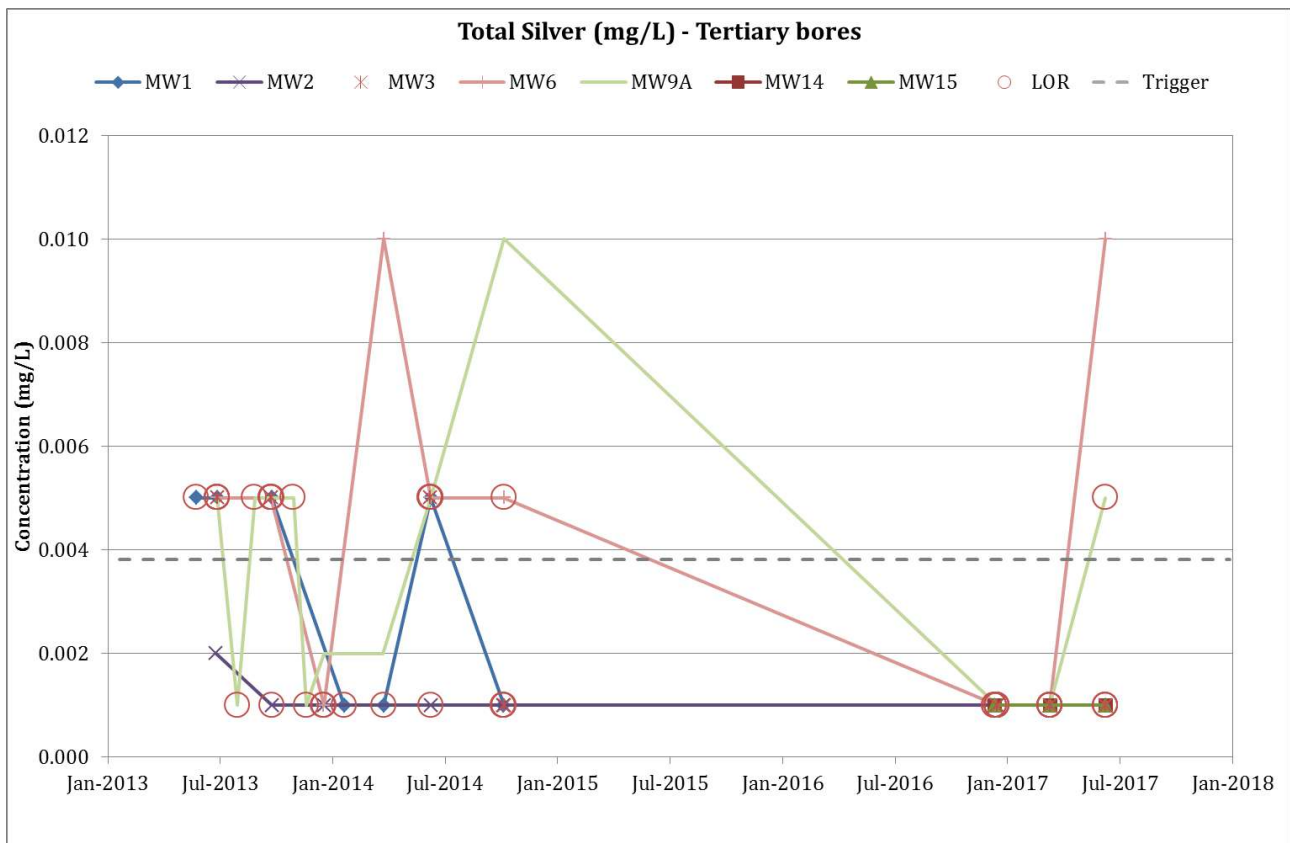


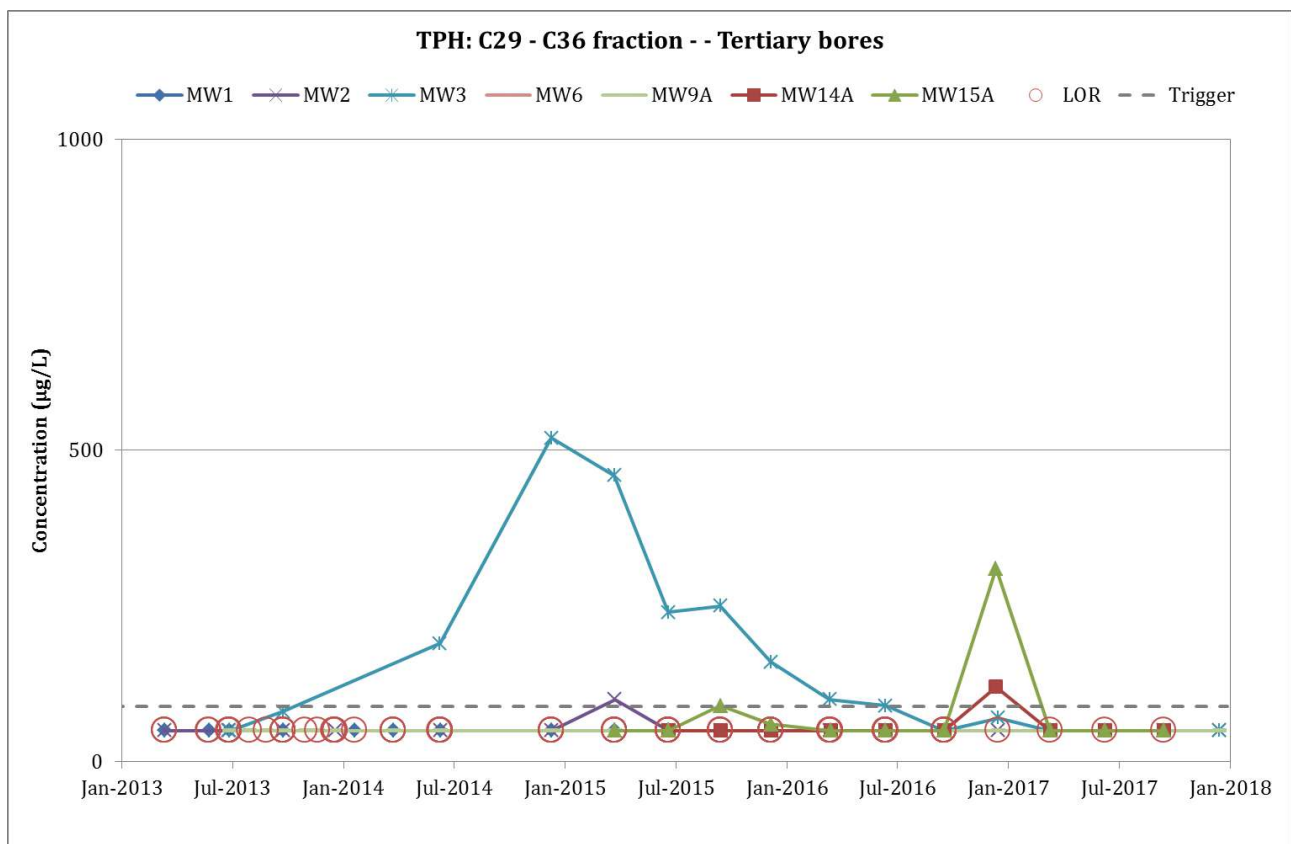
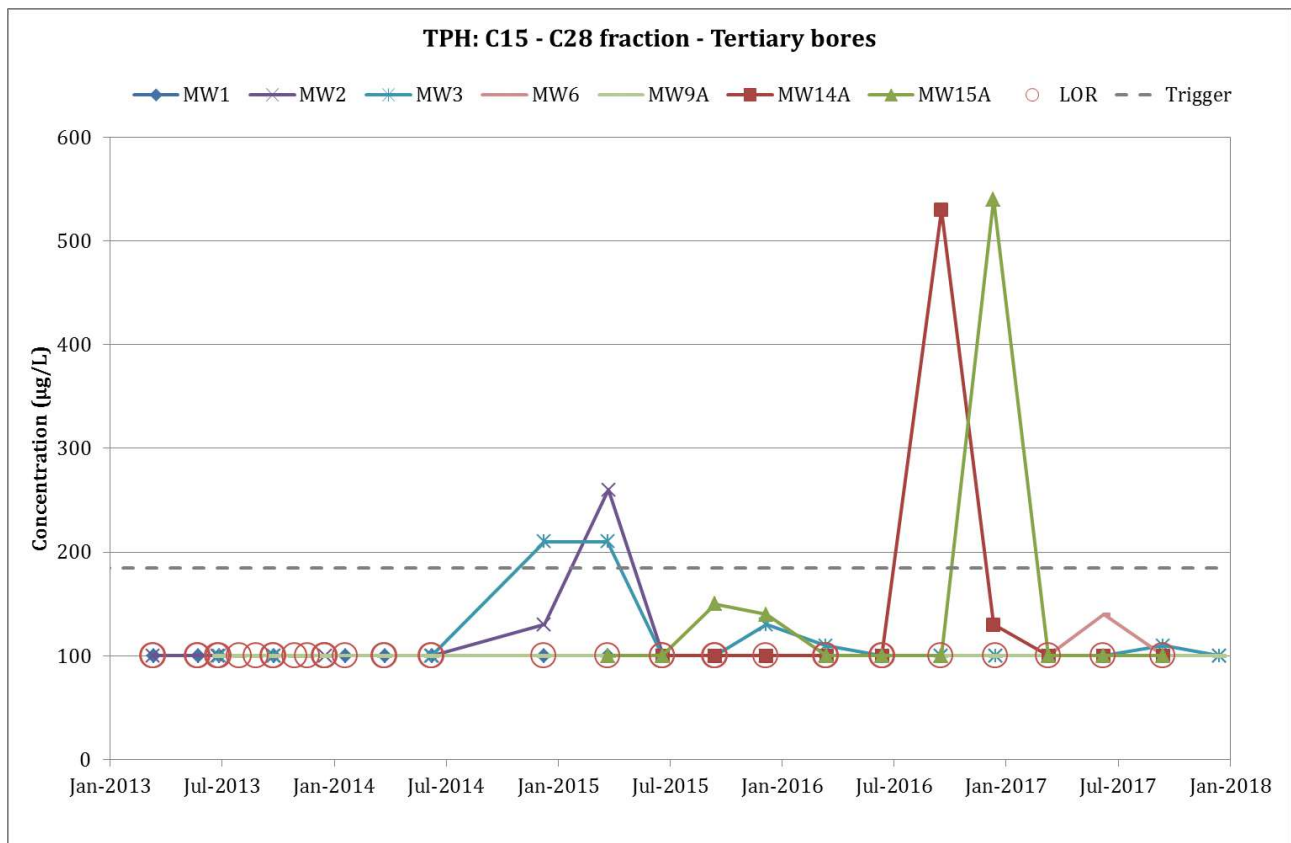


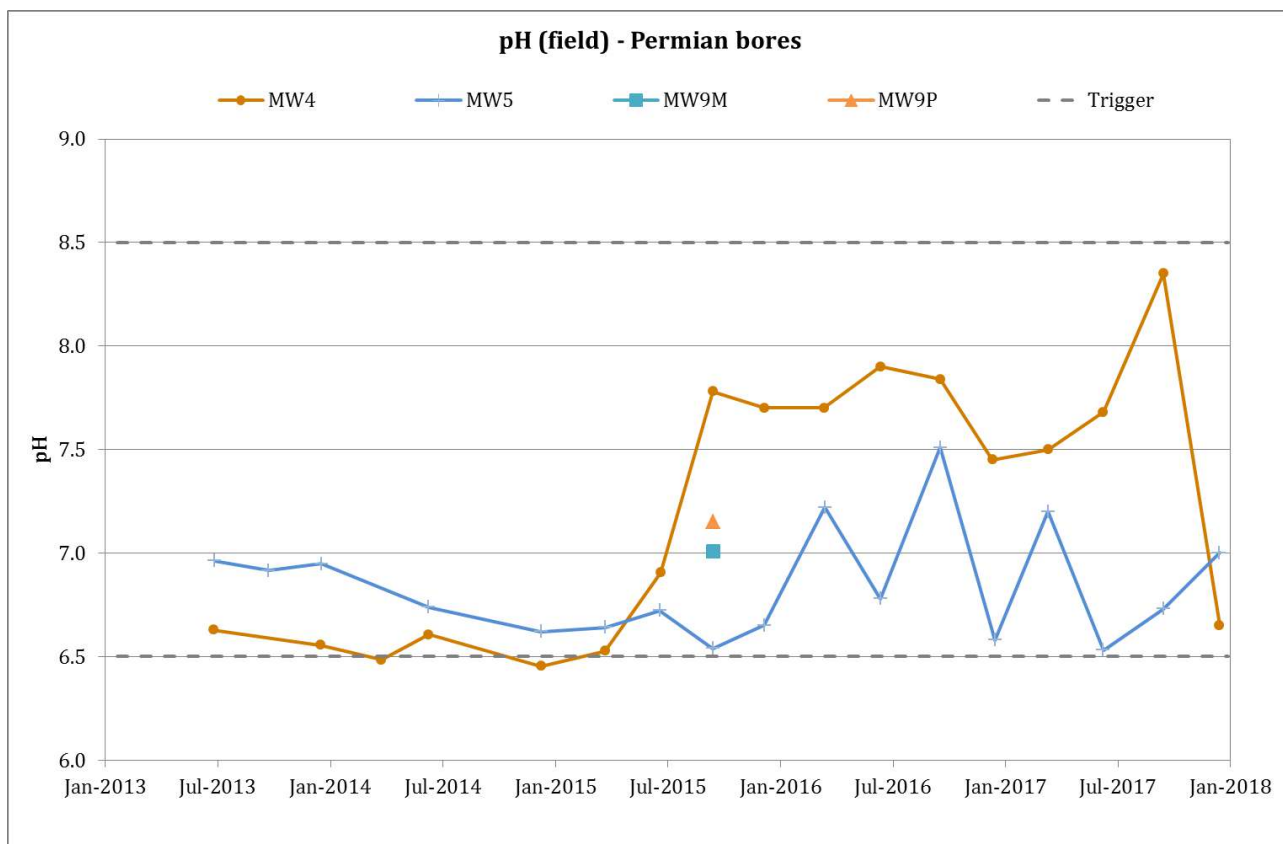
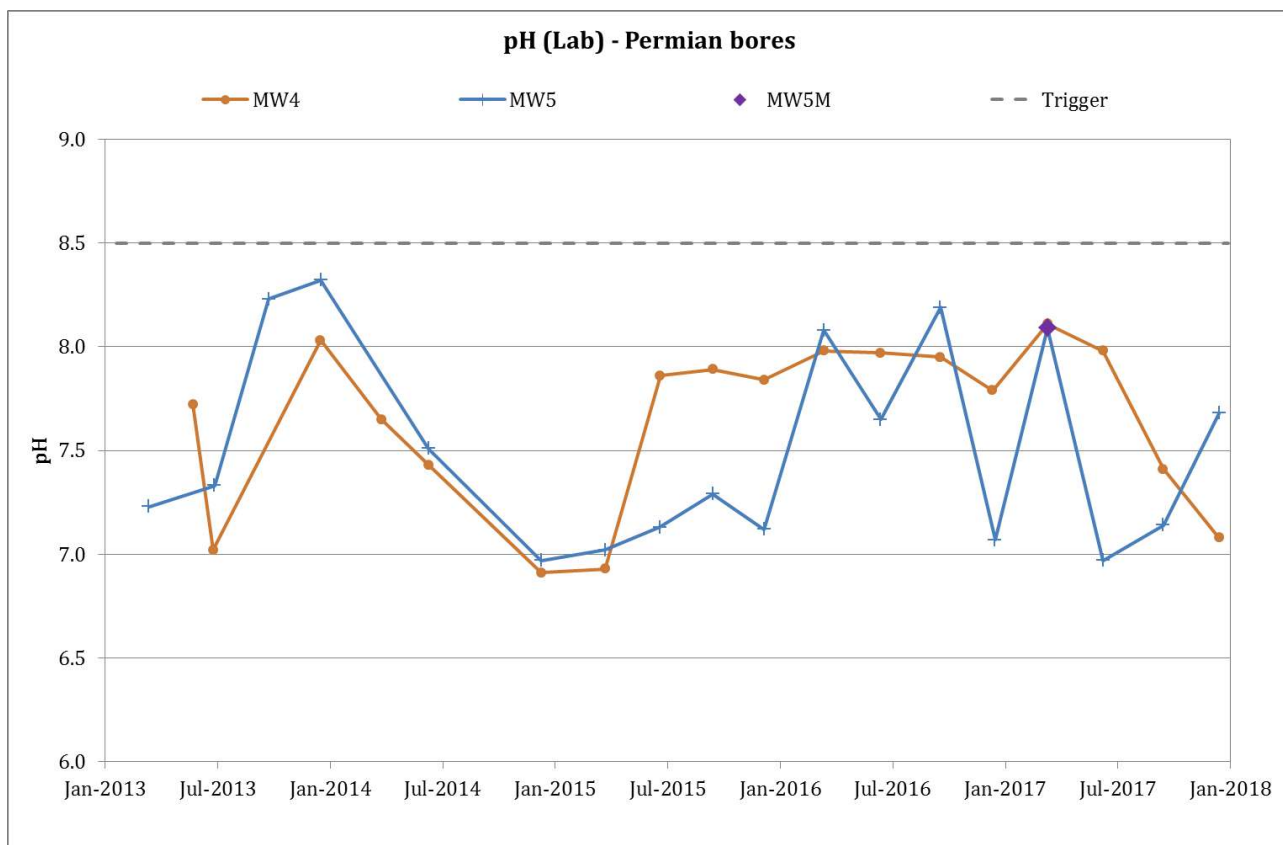


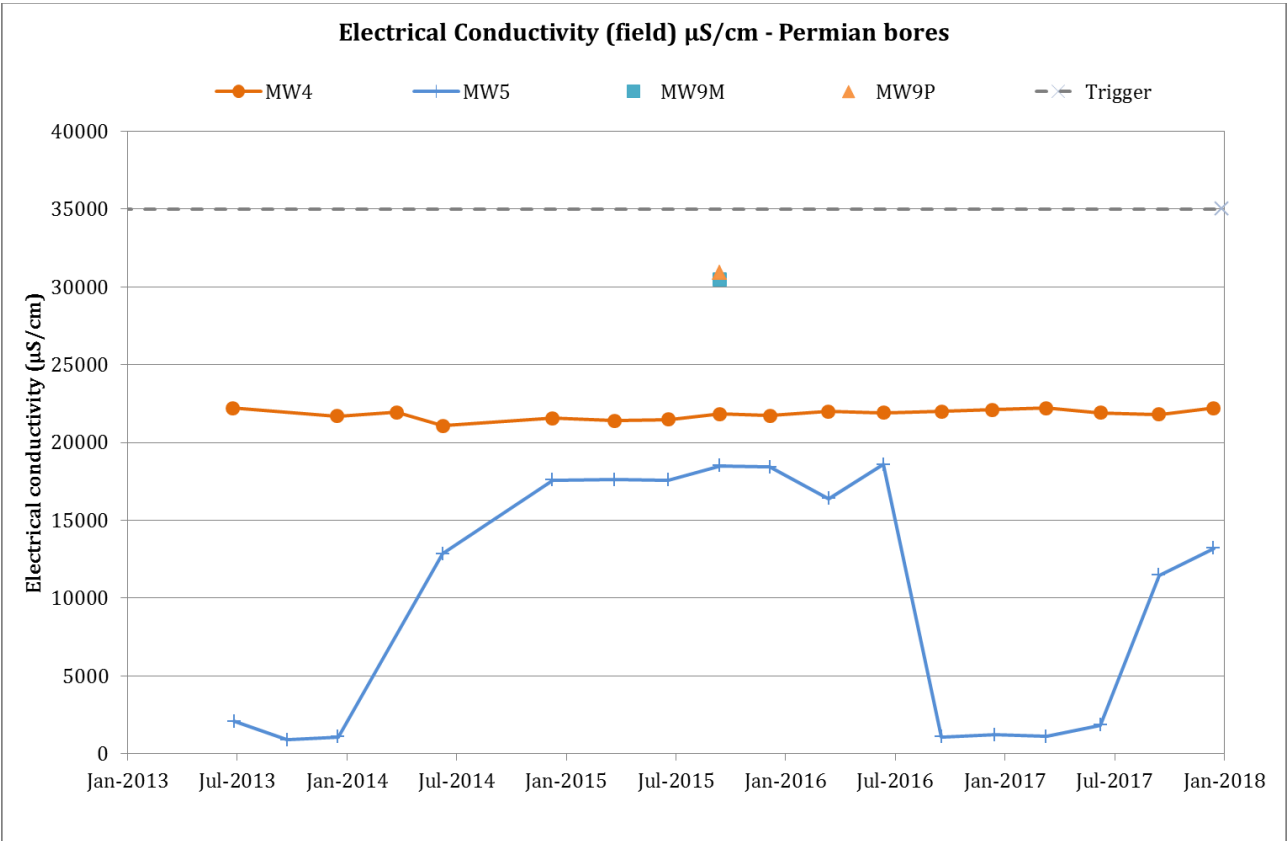
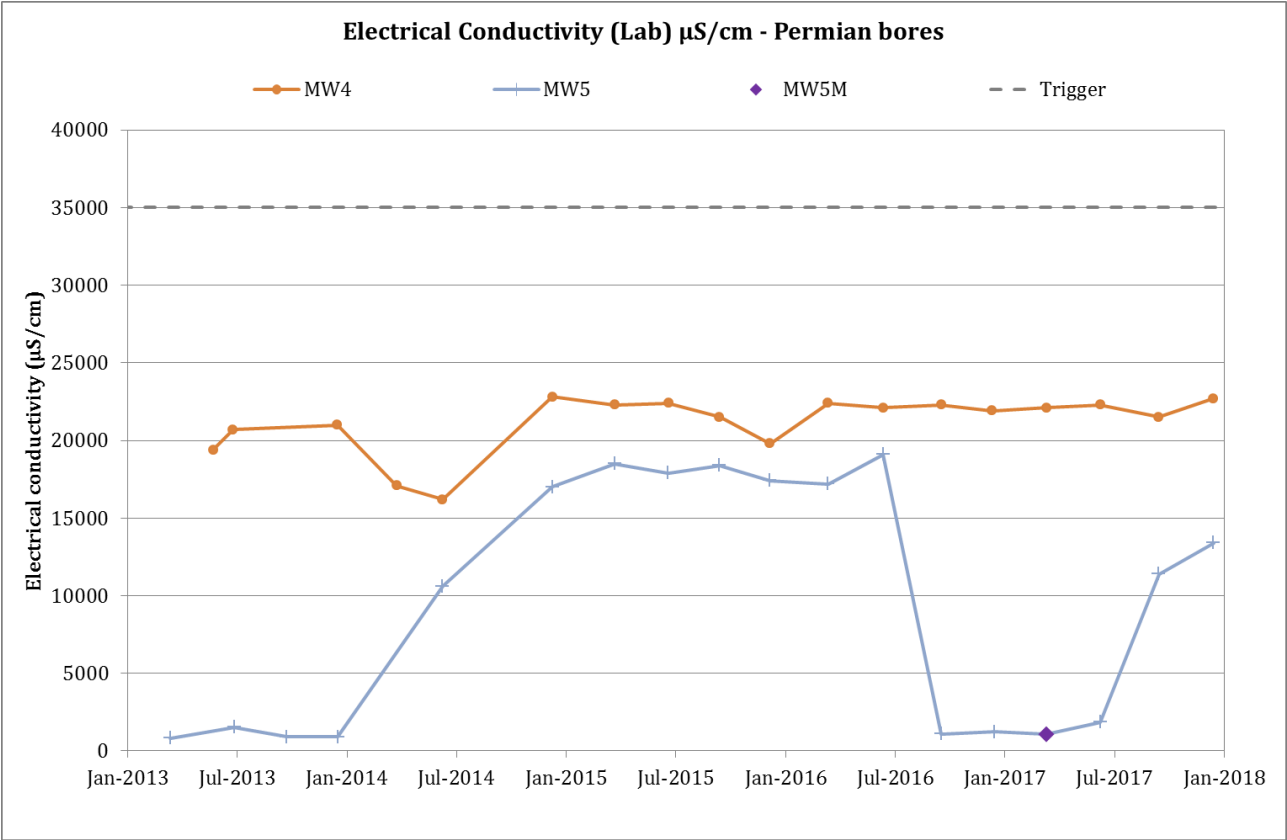


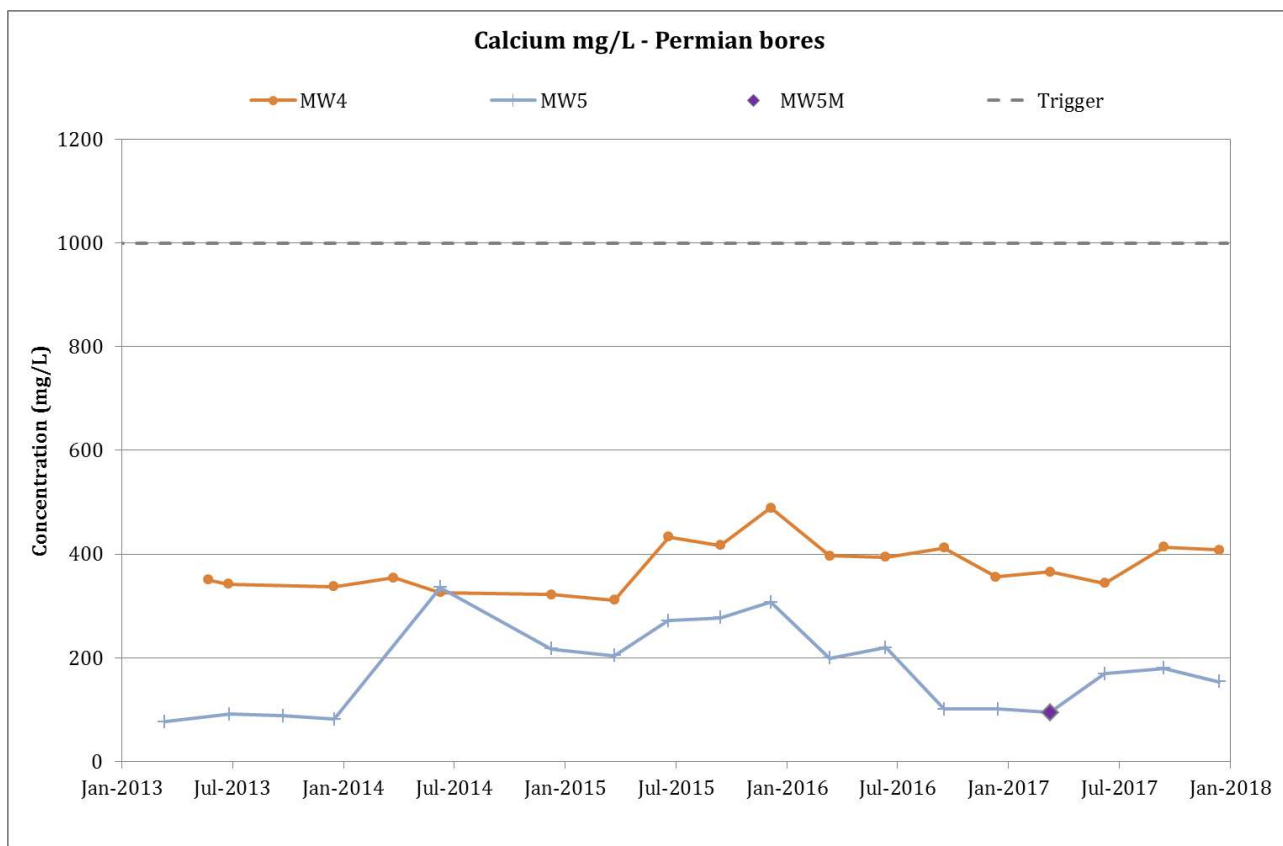
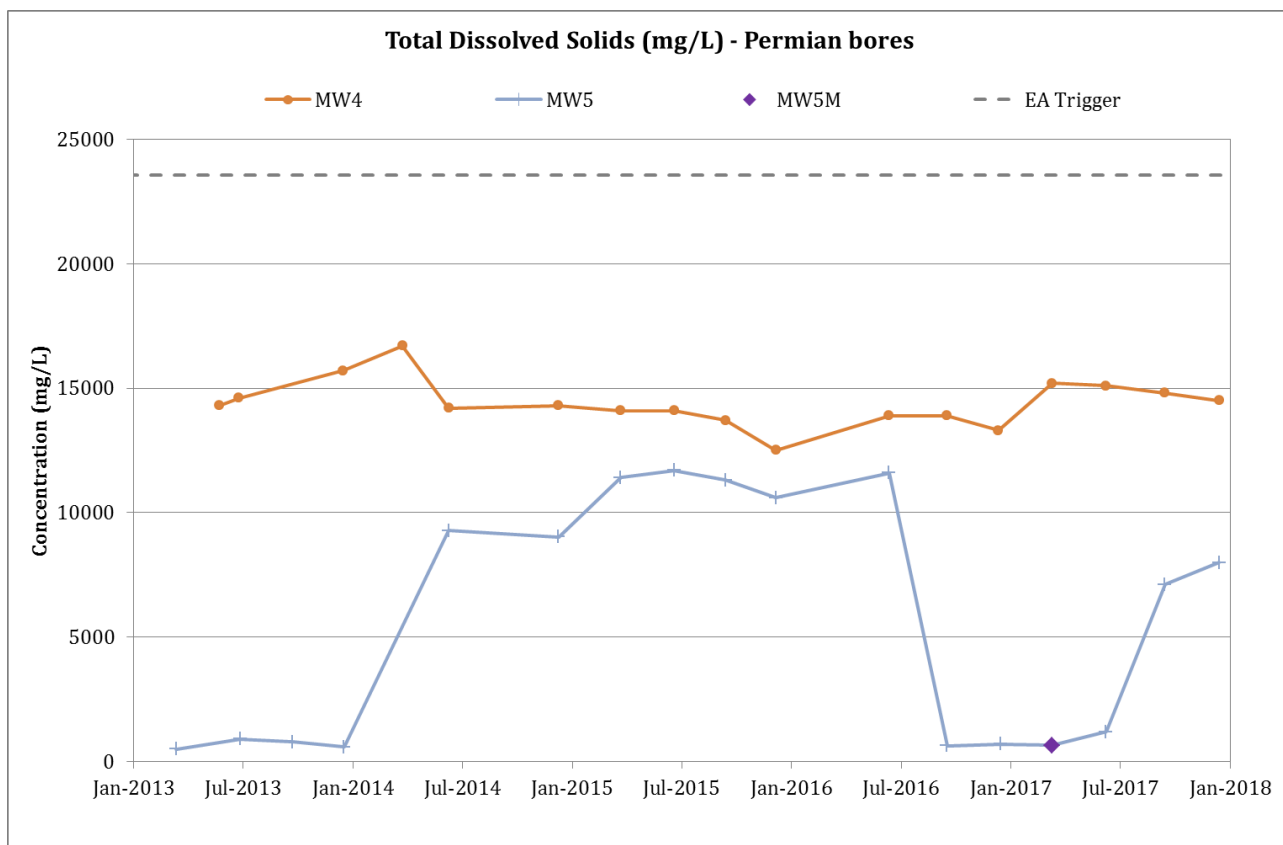


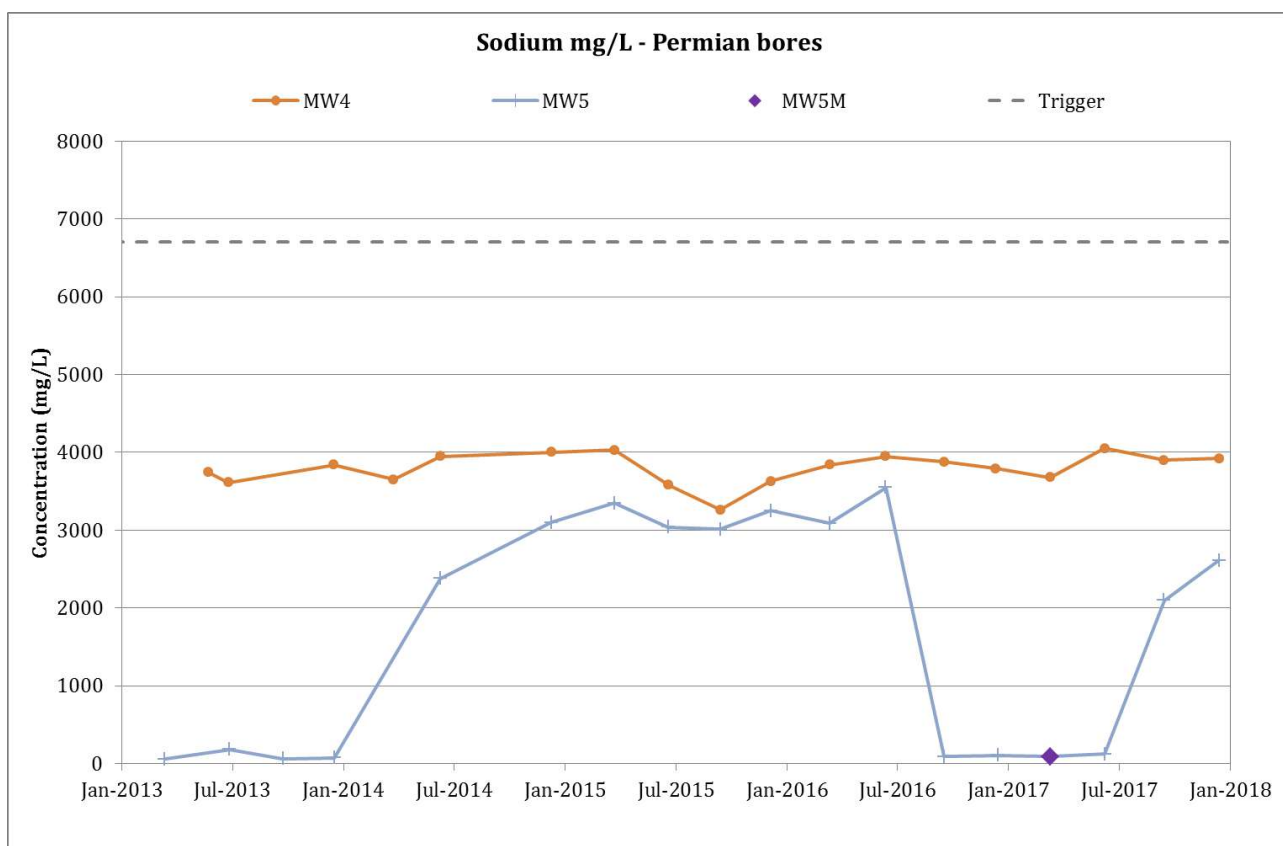
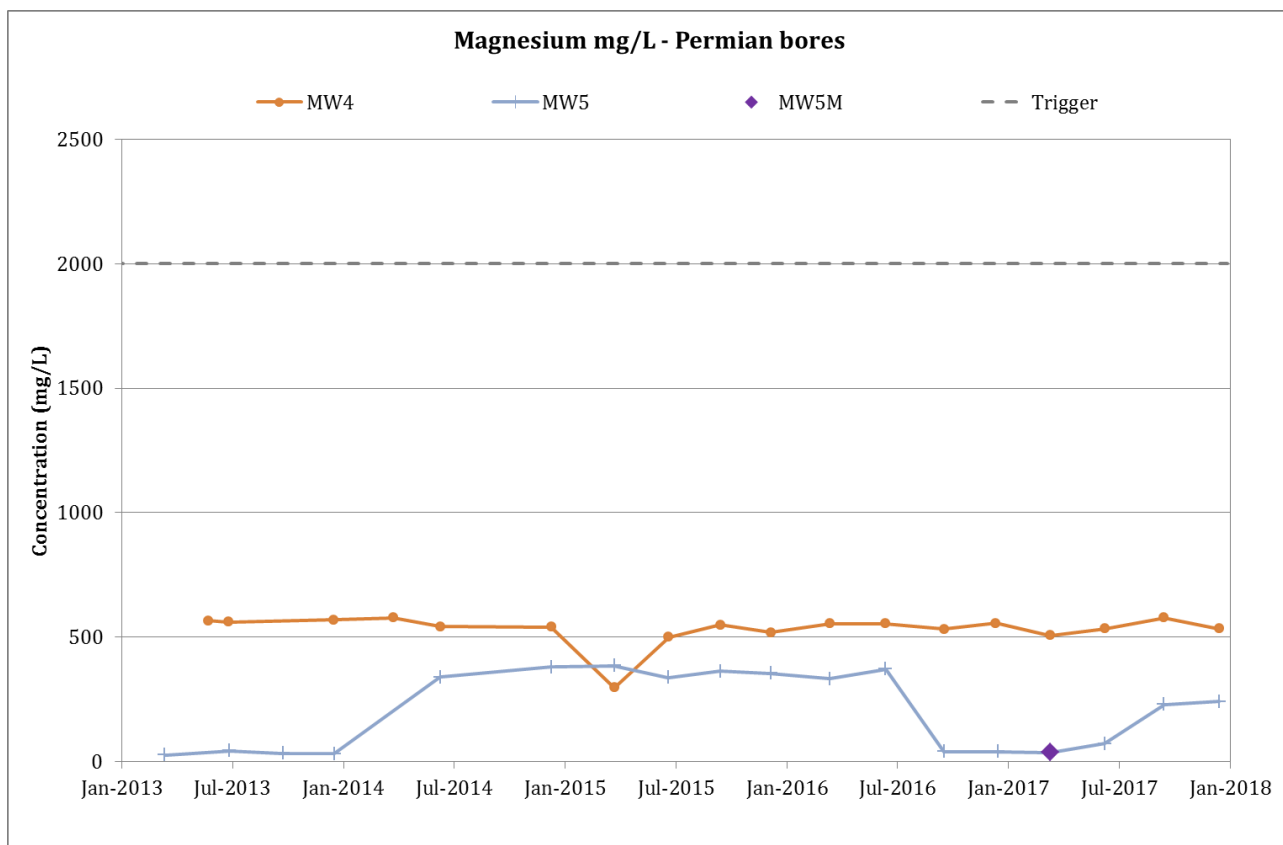


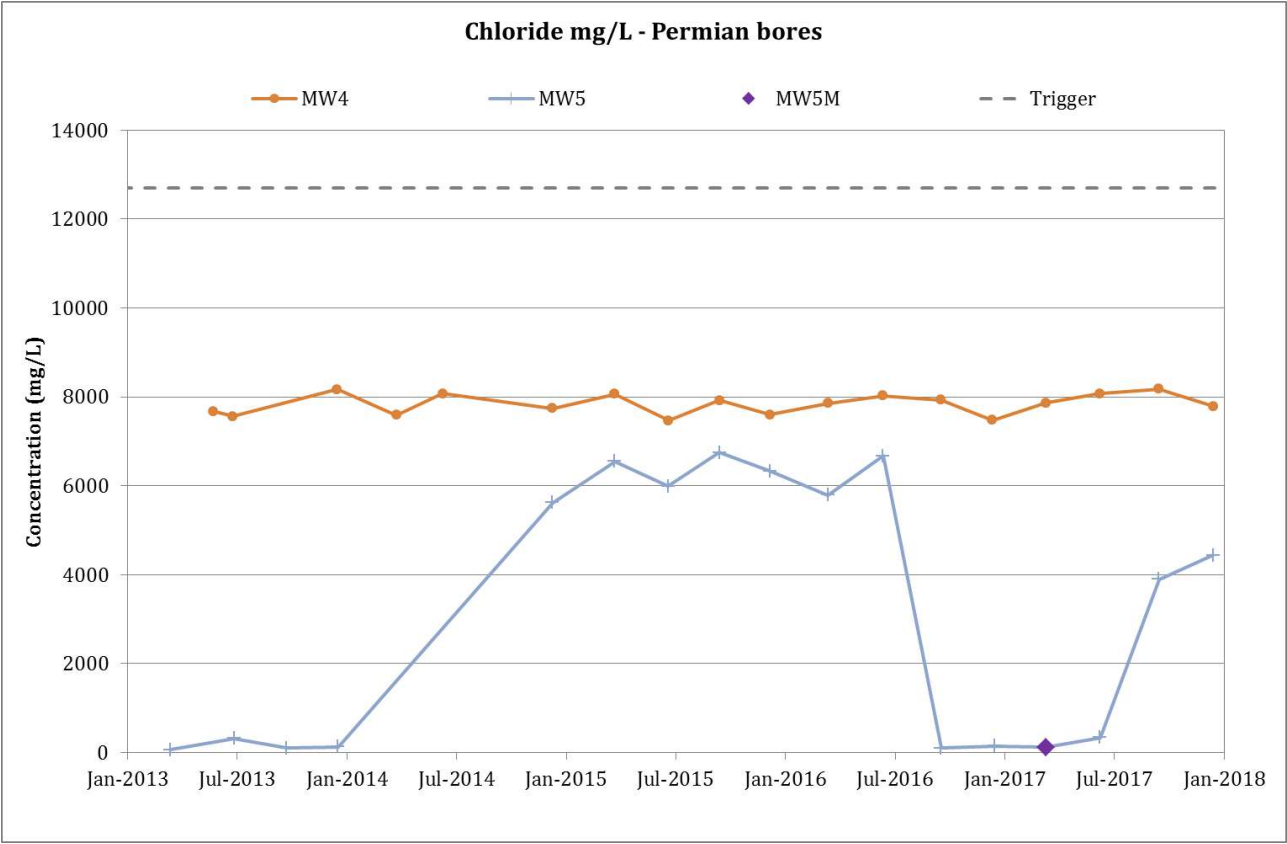
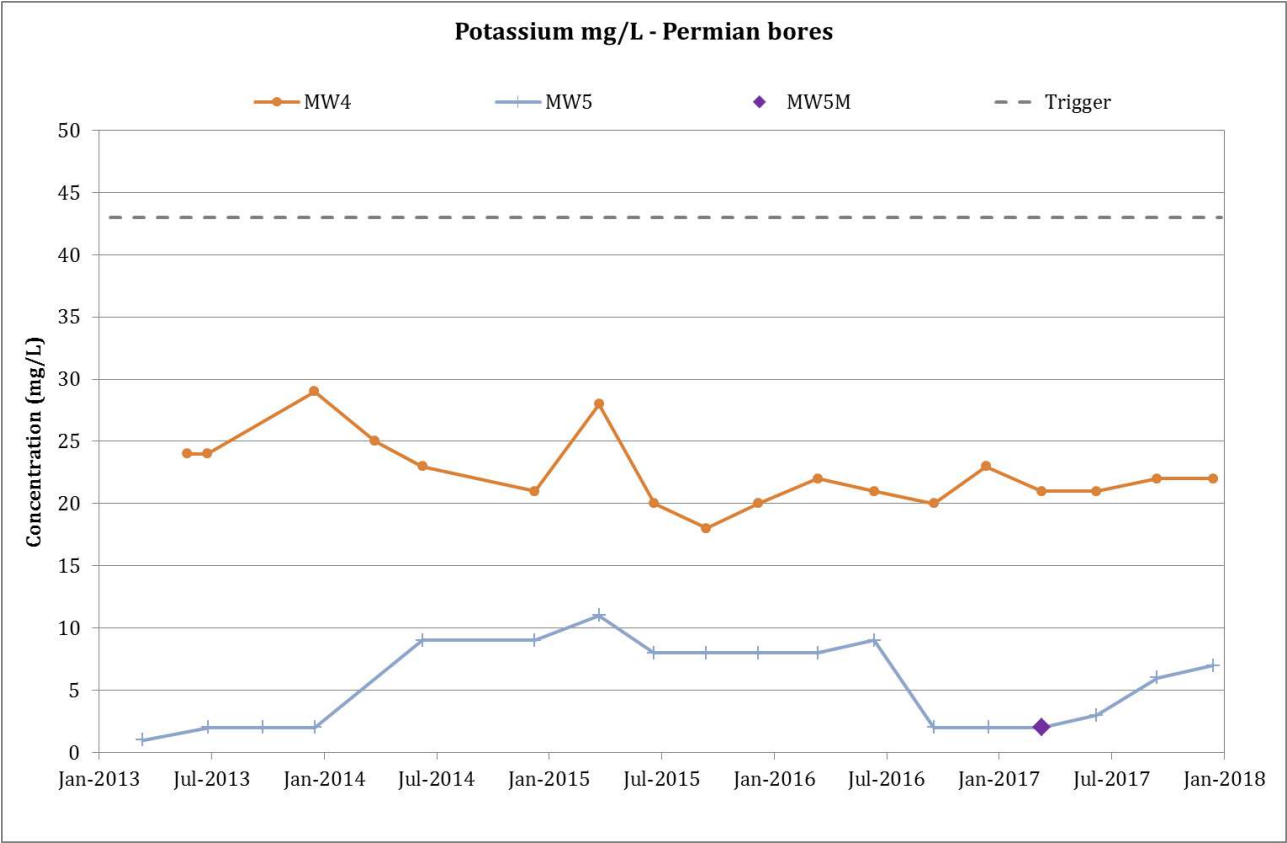


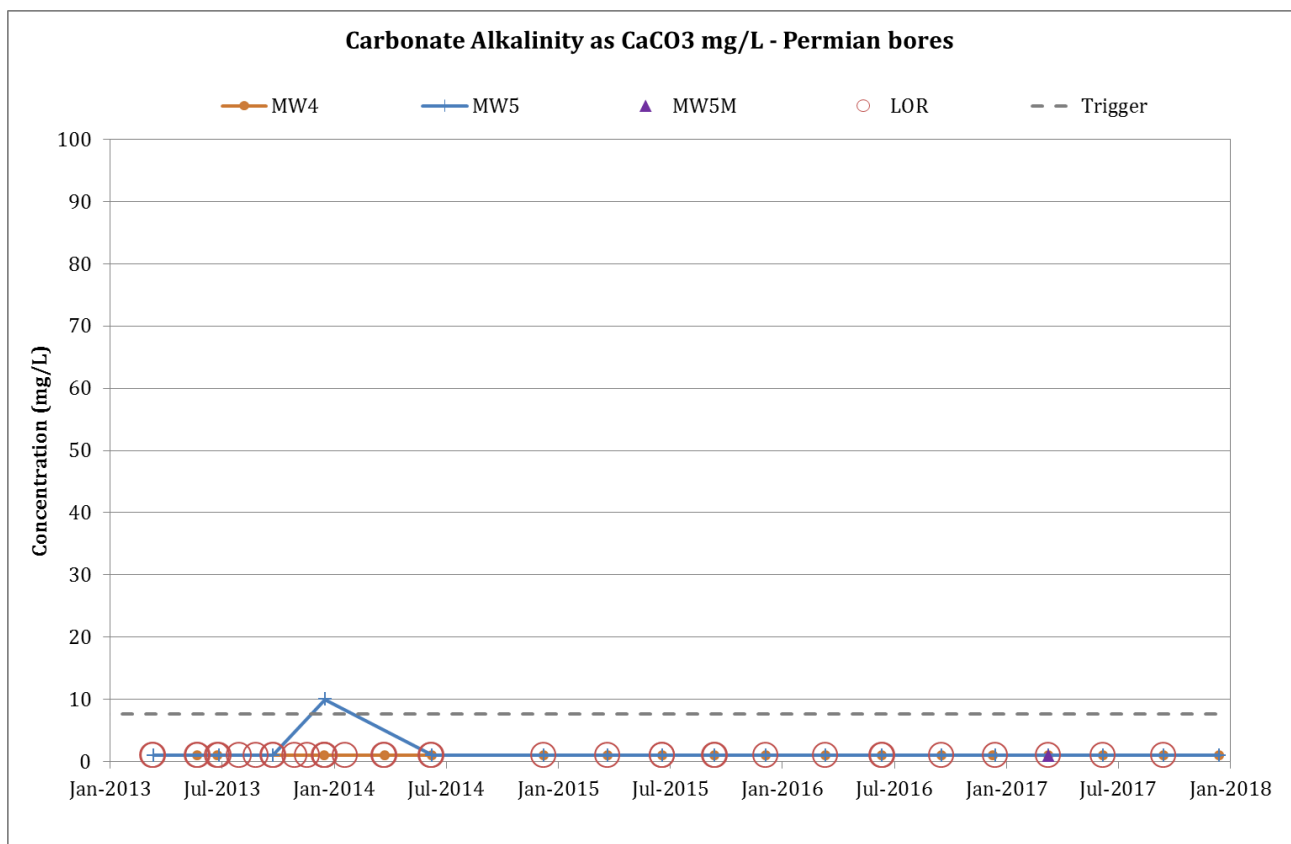
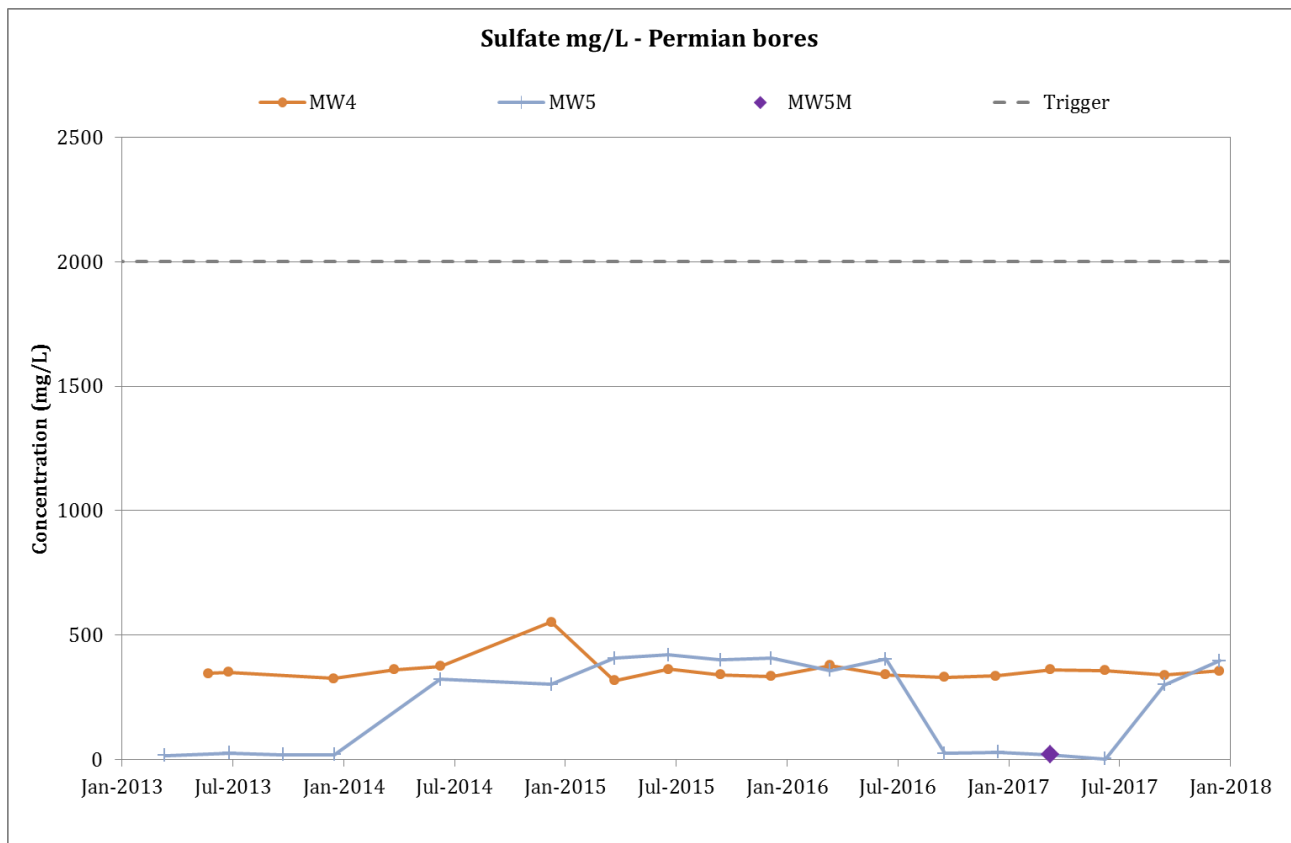


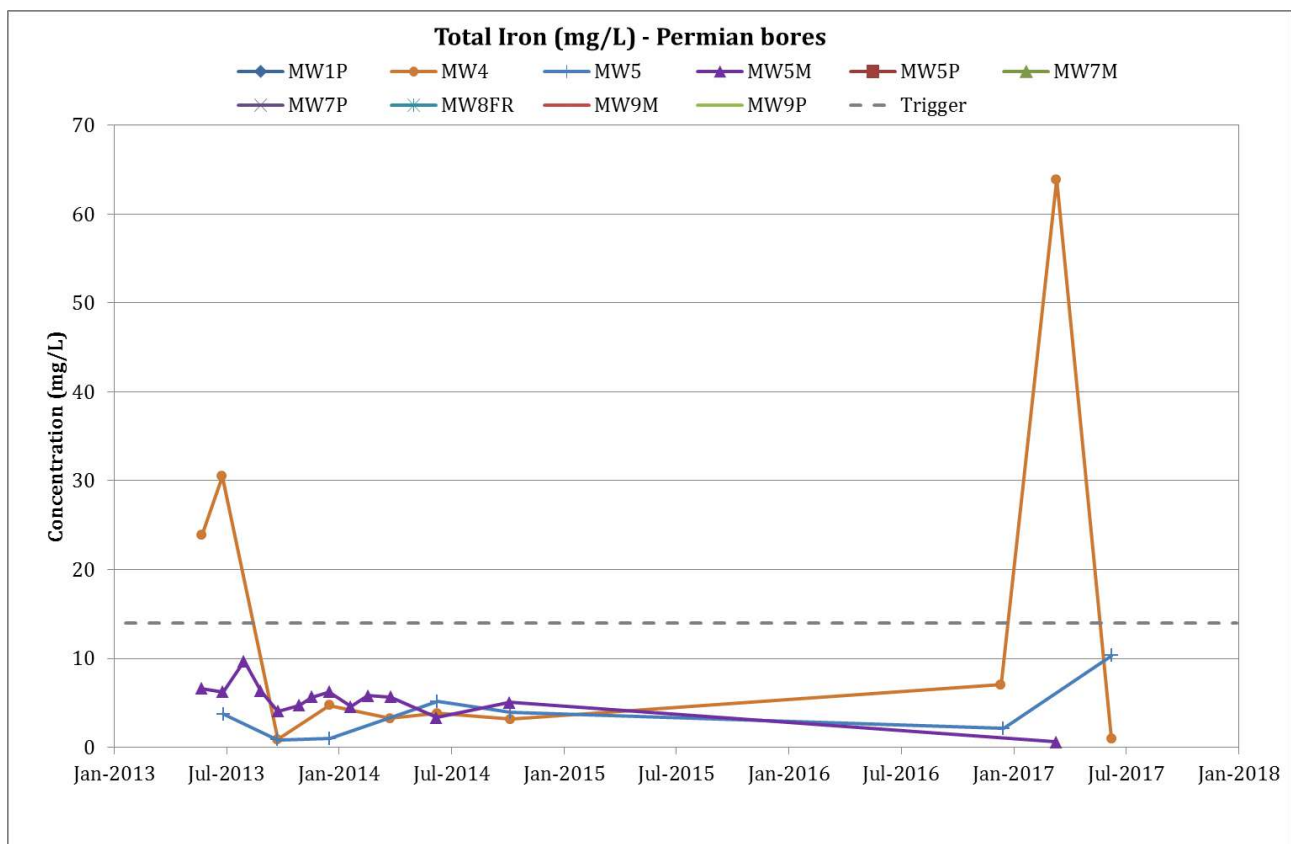
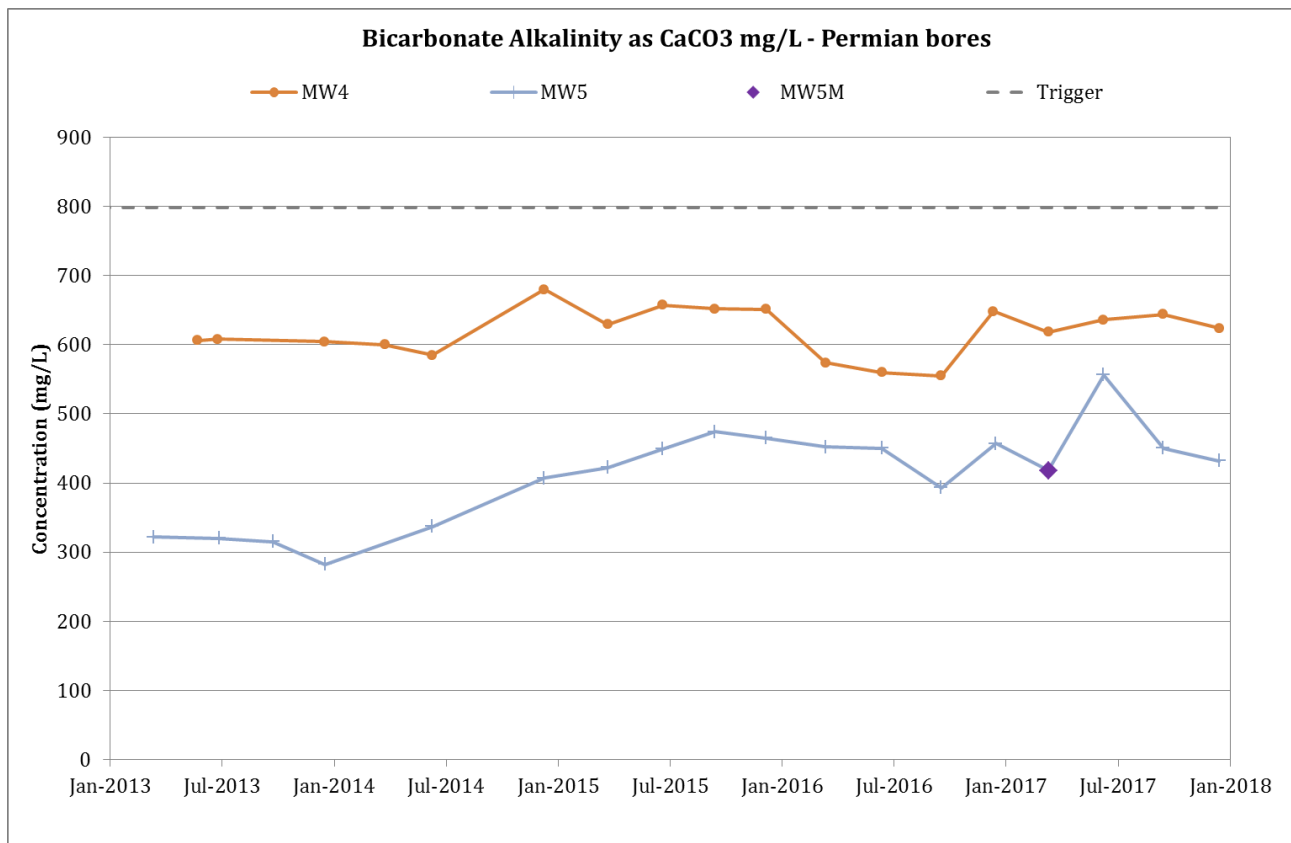


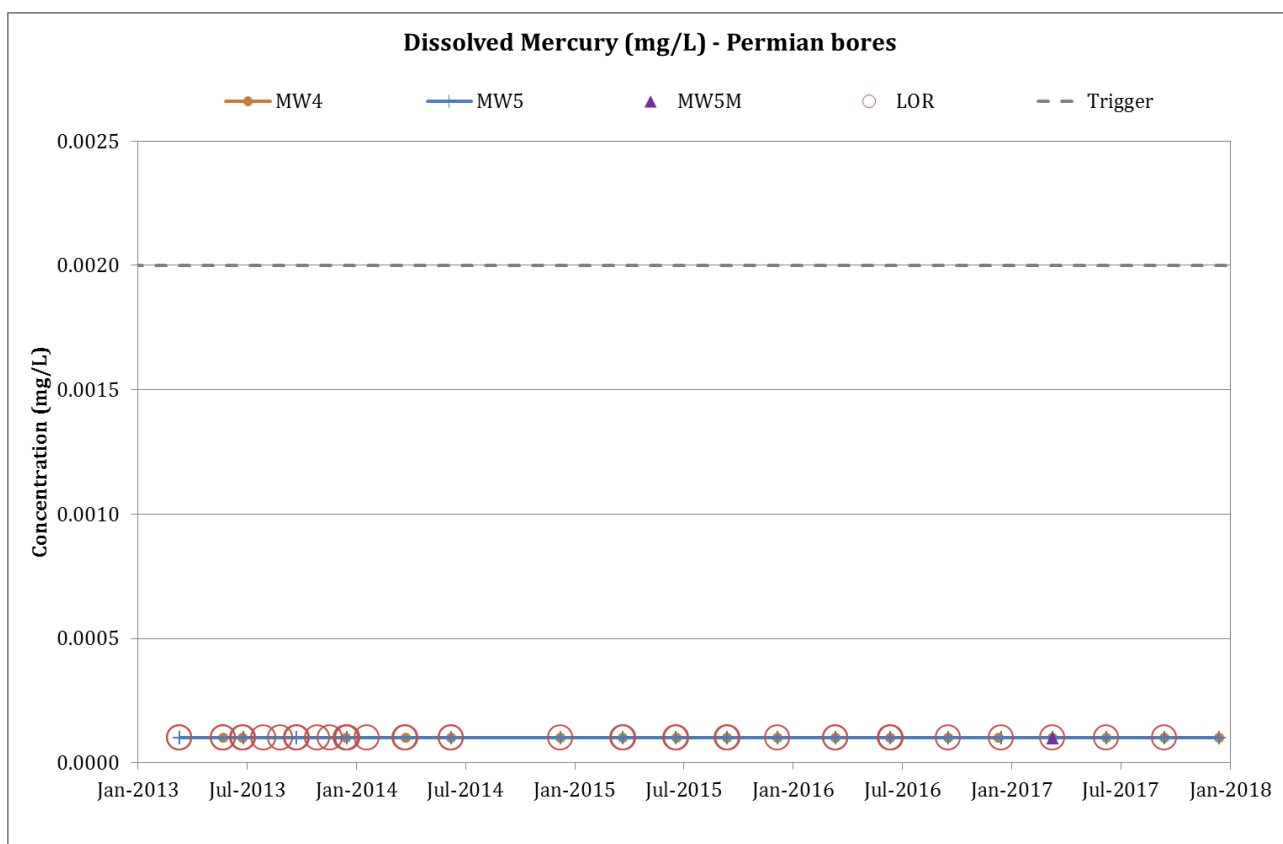
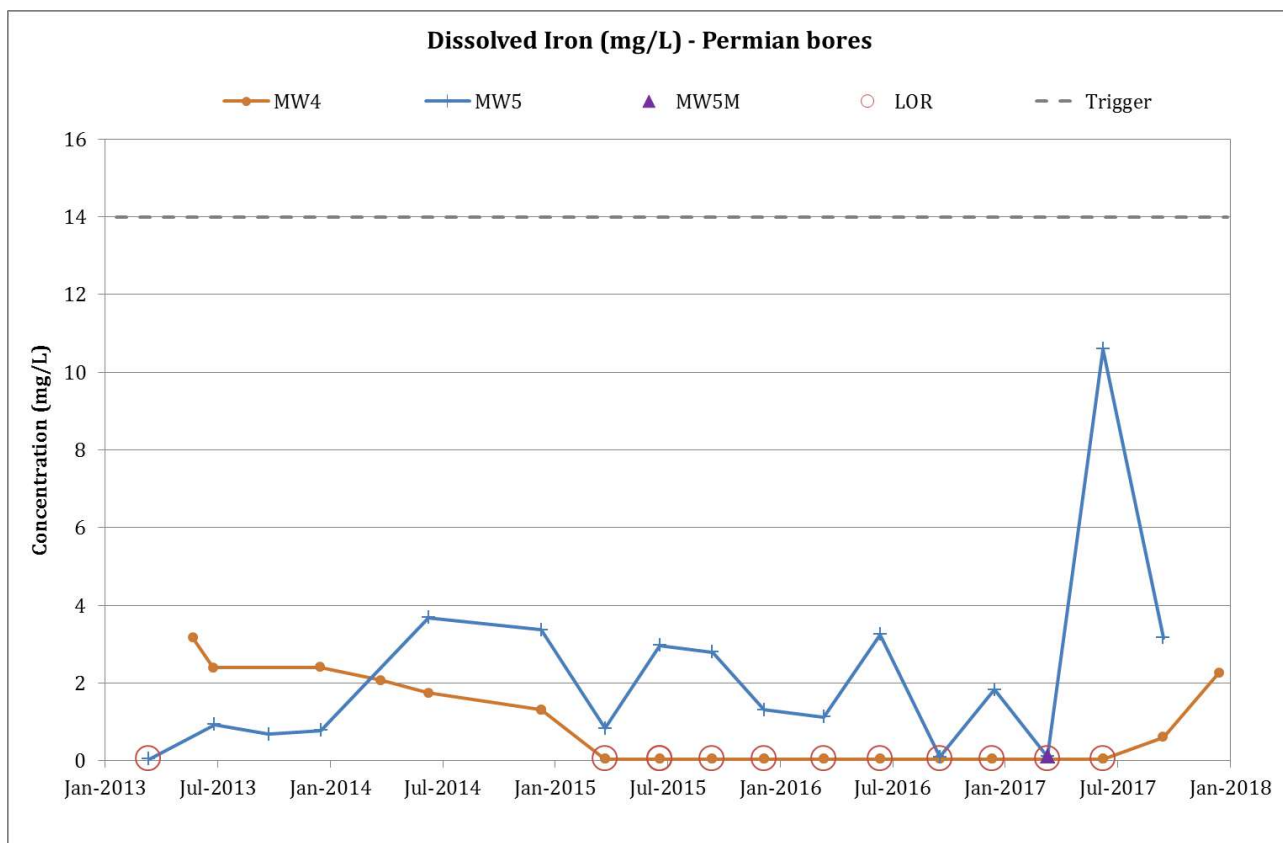


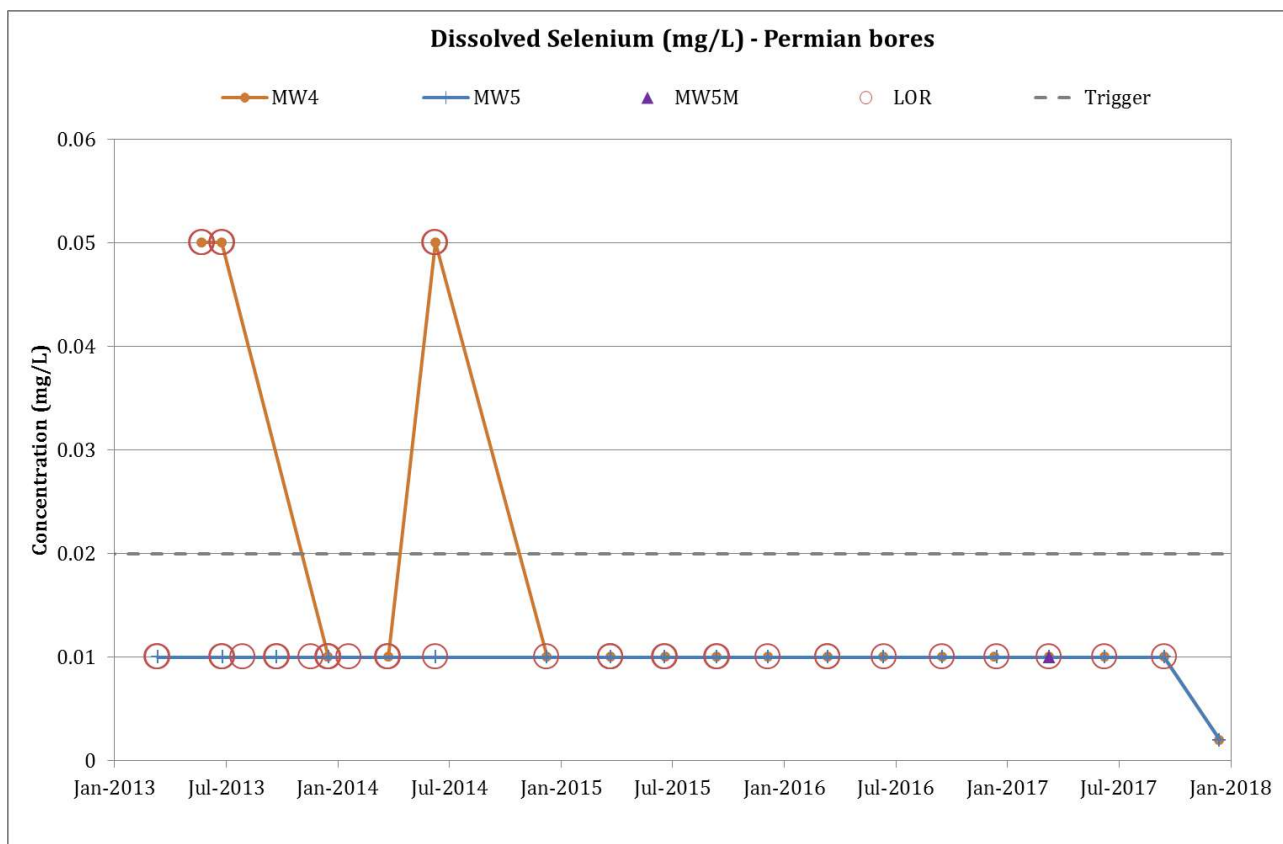
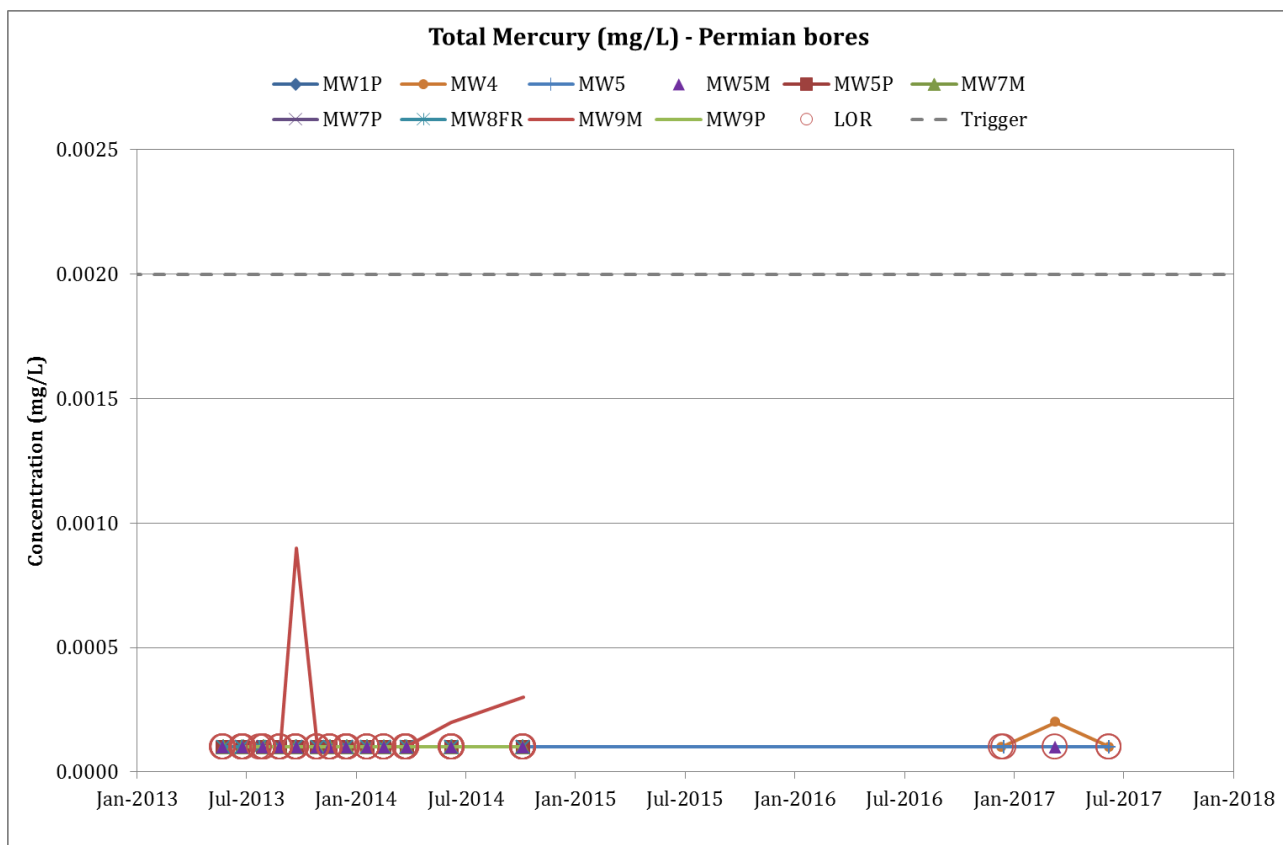


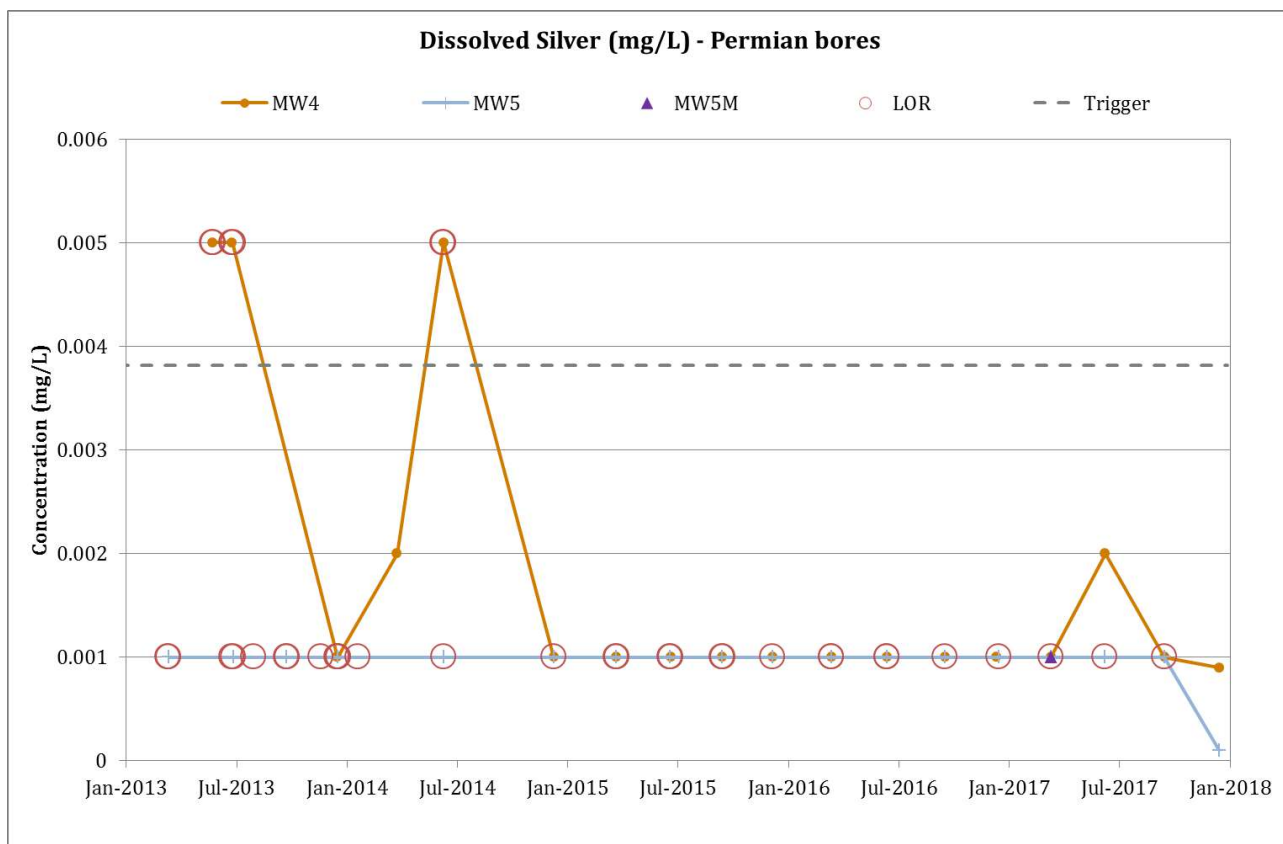
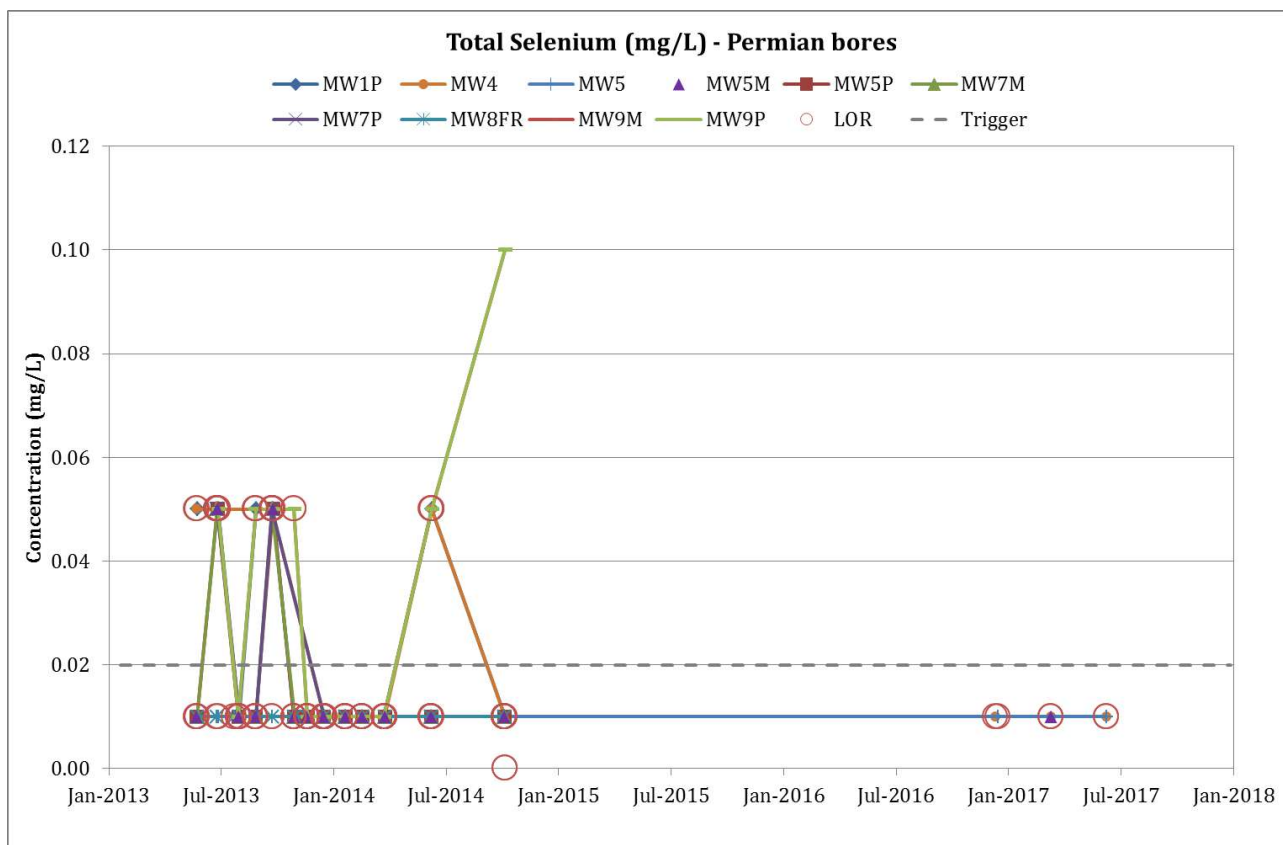


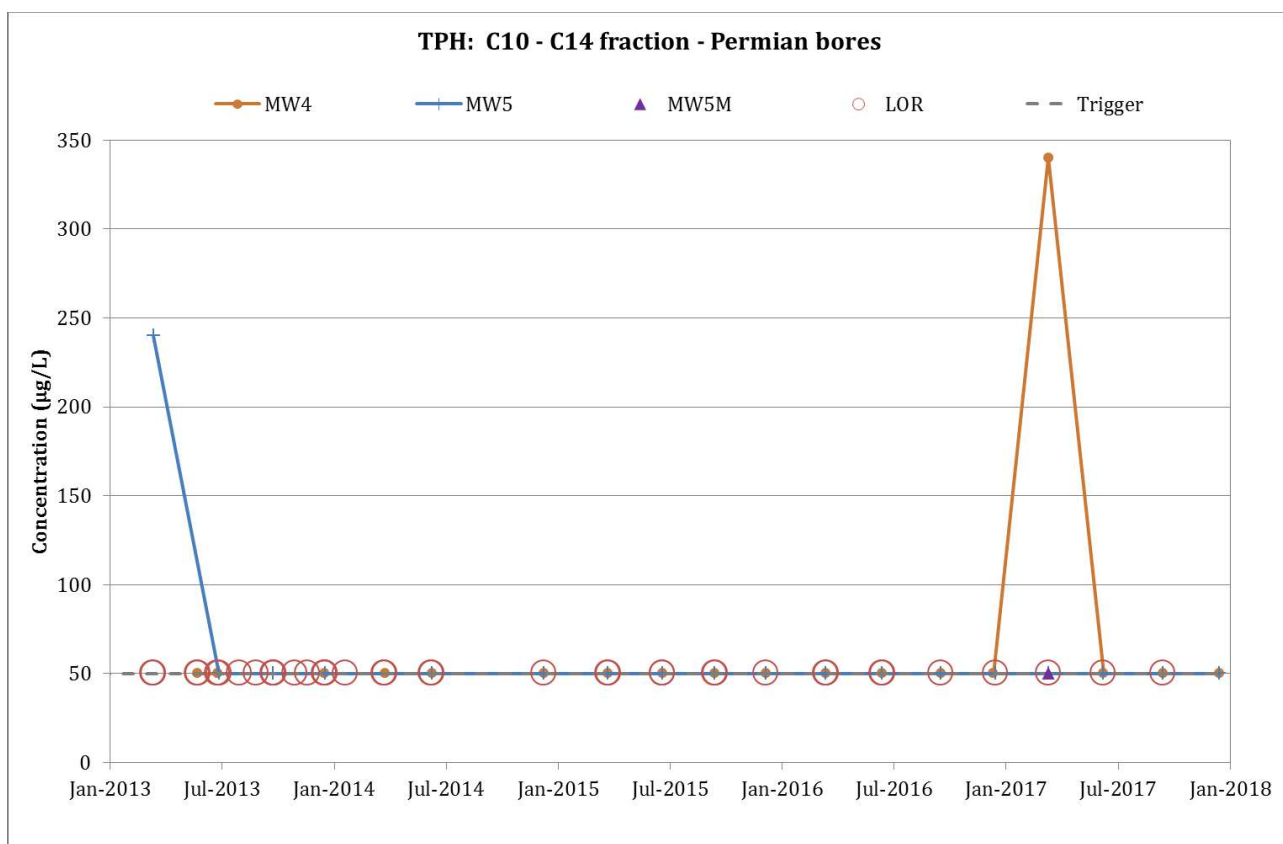
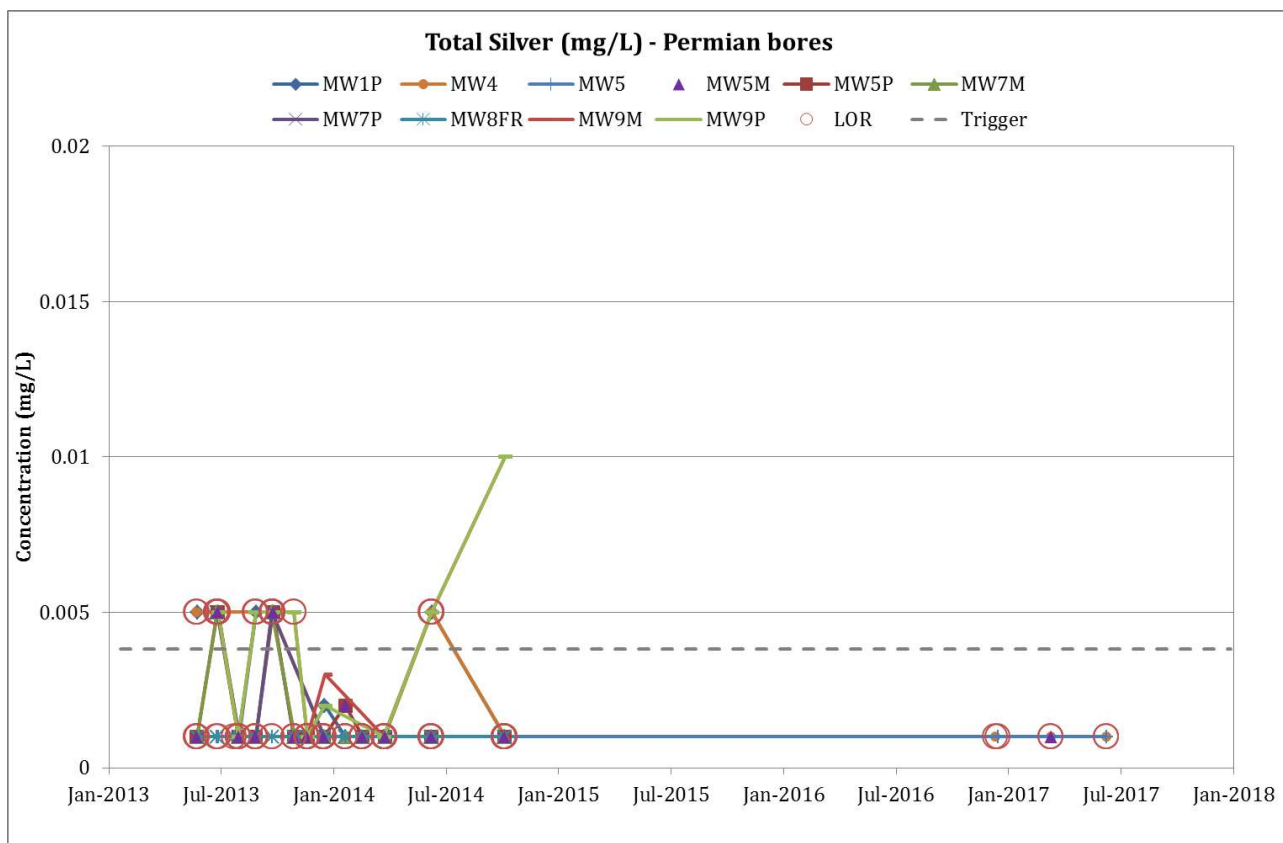


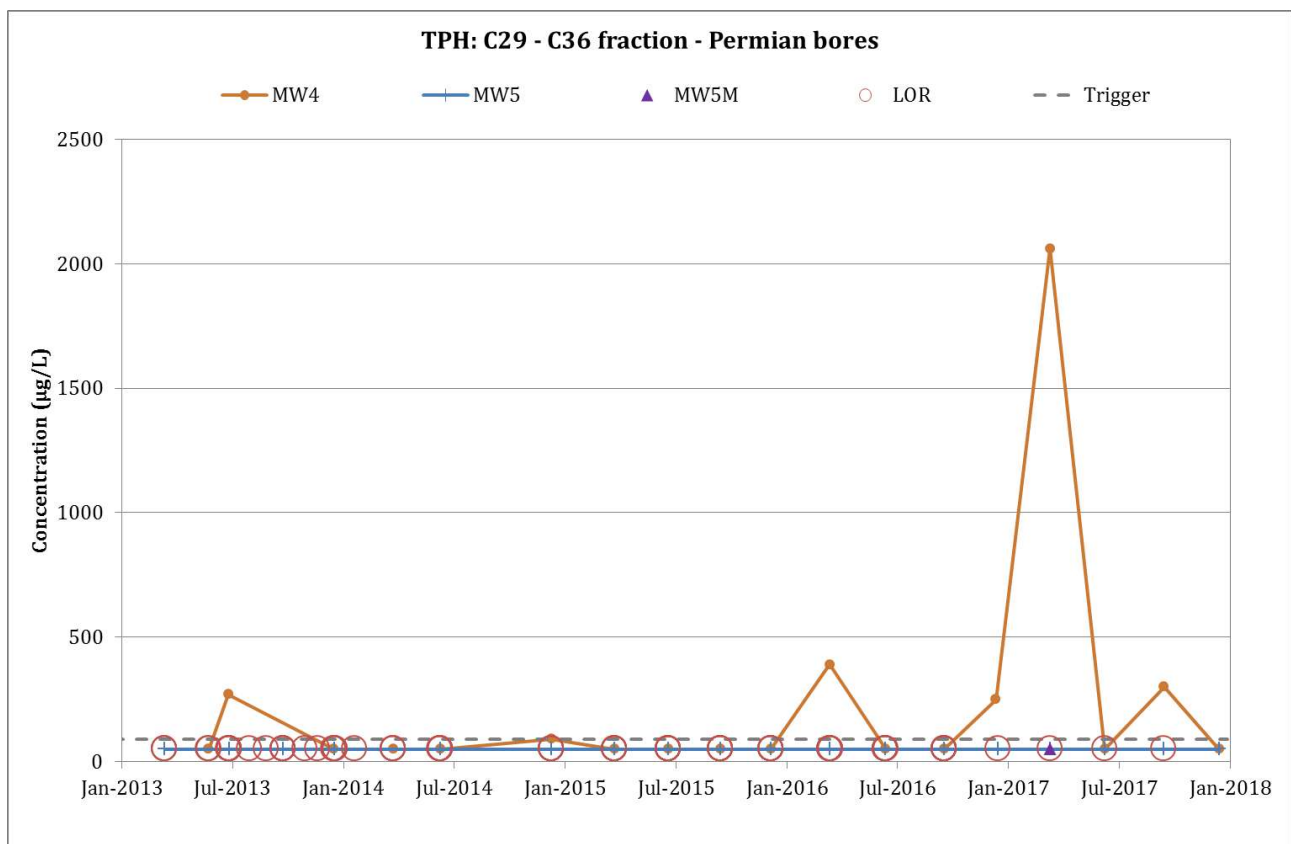
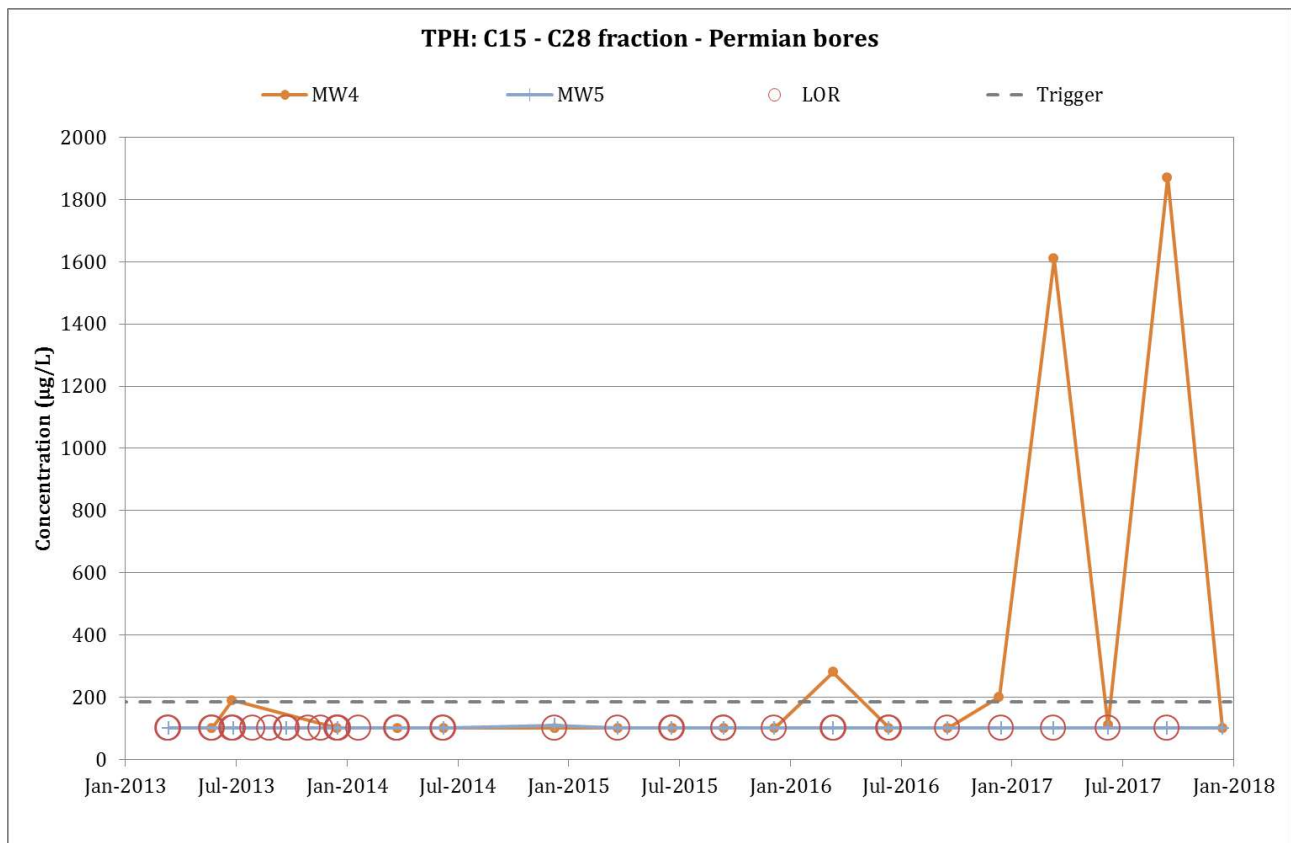












Appendix F **Numerical model report**

Middlemount Western Extension Project

Numerical Modelling Report

F1 Introduction and objectives

Numerical modelling was undertaken to assess the impact of the proposed Middlemount Western 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 Western Extension Project groundwater model is classified between a Class 2 and Class 3 model. That is, the model classification identifies:

- 4 out 18 (22%) performance indicators align with a Class 1 model;
- 12 out 22 (60%) performance indicators align with a Class 2 model; and
- 11 out 21 (52%) 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

A groundwater model was developed as part of the groundwater component of the Environmental Impact Assessment for Stage 2 of the Middlemount Mine in 2010 (PB, 2010). The model was constructed using MODFLOW SURFACT and comprised eight layers as shown in Table F 2.1. In MODFLOW SURFACT the model layers have to be continuous across the model domain. The spatial extent of the model was approximately 38.8 km x 30 km, using a uniform grid of 100 m x 100 m cells.

The impact of geological structures, especially faulting, within the Project area was not considered in the 2010 modelling due to limited data being available on their hydrogeological characteristics. The model was calibrated to steady state conditions. Transient calibration was not conducted as there was no suitable time series dataset at the time for calibration. A sensitivity analysis was conducted on all model parameters and showed that the model was sensitive to several parameters. The resulting uncertainties in model predictions were considered to be acceptable although several recommendations were made for future model improvements.

With the level of information available at the time the model was given a complexity rating of low-medium according to the MDBC (2000) modelling guidelines.

Table F 2.1 2010 model layering

Layer	Hydrogeological unit
1	Tertiary
2	Weathered zone
3	Aquitard #1
4	Middlemount Coal Seams
3 - 5	Aquitard #2
6	Pisces Coal Seams
3 - 7	Fort Cooper Coal Measures
3 - 8	Fort Cooper Coal Measures/Fair Hill Formation

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, Oak Park, German Creek, German Creek East, Foxleigh and Foxleigh Plains, and Norwich Park. 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 most 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 Western Extension Project is presented in Section 6 of the main report. This graphically presents and illustrates the main hydrogeological processes and mechanisms within the Middlemount Coal Mine, 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 (Duaranga 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 geological units), and the model maintains its connections for layers above and below where the model layer has ceased. 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 108,554 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).

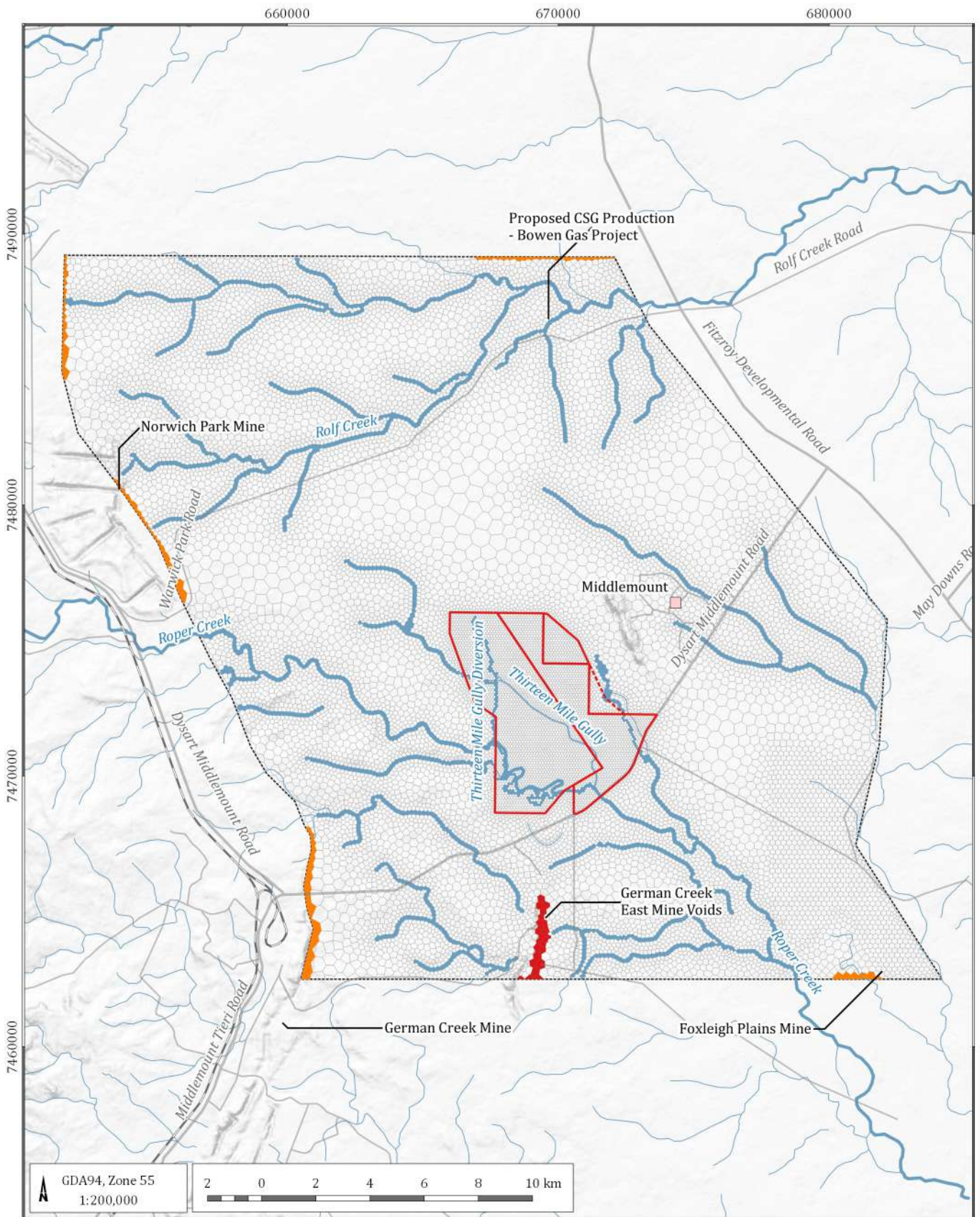
The model extents have been revised from the Stage 2 EIS model due to the following considerations:

- 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.

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.



LEGEND

- | | |
|---|---|
| Populated place | General Head Boundary |
| Mining Lease boundary (ML) | River package |
| Mining Lease Application boundary (MLA) | Drain package |
| Active model outline | |
| Model grid | |
| Road | |
| Watercourse | |
| Drainage feature | |
| Rail | |

Middlemount Coal Mine Western Extension Project (G1840D)

Extent of the modelling domain - model grid



DATE
06/04/2018

FIGURE No:
F 4.1

F4.1 Time discretisation – stress periods

The time discretisation adopted for the calibration and prediction periods incorporated a variable time step ranging between 30 days and 365 days.

F4.2 Boundary conditions

Areal recharge from rainfall infiltration has been estimated as a percentage of rainfall and applied across the model domain. Evapotranspiration has not been applied in the model due to the depth of water below the ground surface. However, an evaporation boundary condition was applied over the mine voids footprint for the void recovery analyses. The pan evaporation rate was used for the voids to simulate the take of water from an open surface water body.

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 2037 (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. 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 2037 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 m²/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 Rangel 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	6.40E-05	2.00E-02
2	Tertiary	0.75	5.47E-02	No	1.76E-05	2.00E-02
3	Weathered Zone (Rangal Coal Measures)	0.1	1.30E-02	No	5.00E-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	8.42E-05	1.00E-02
10	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	8.21E-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	8.42E-05	1.00E-02
17	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	8.21E-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).

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.

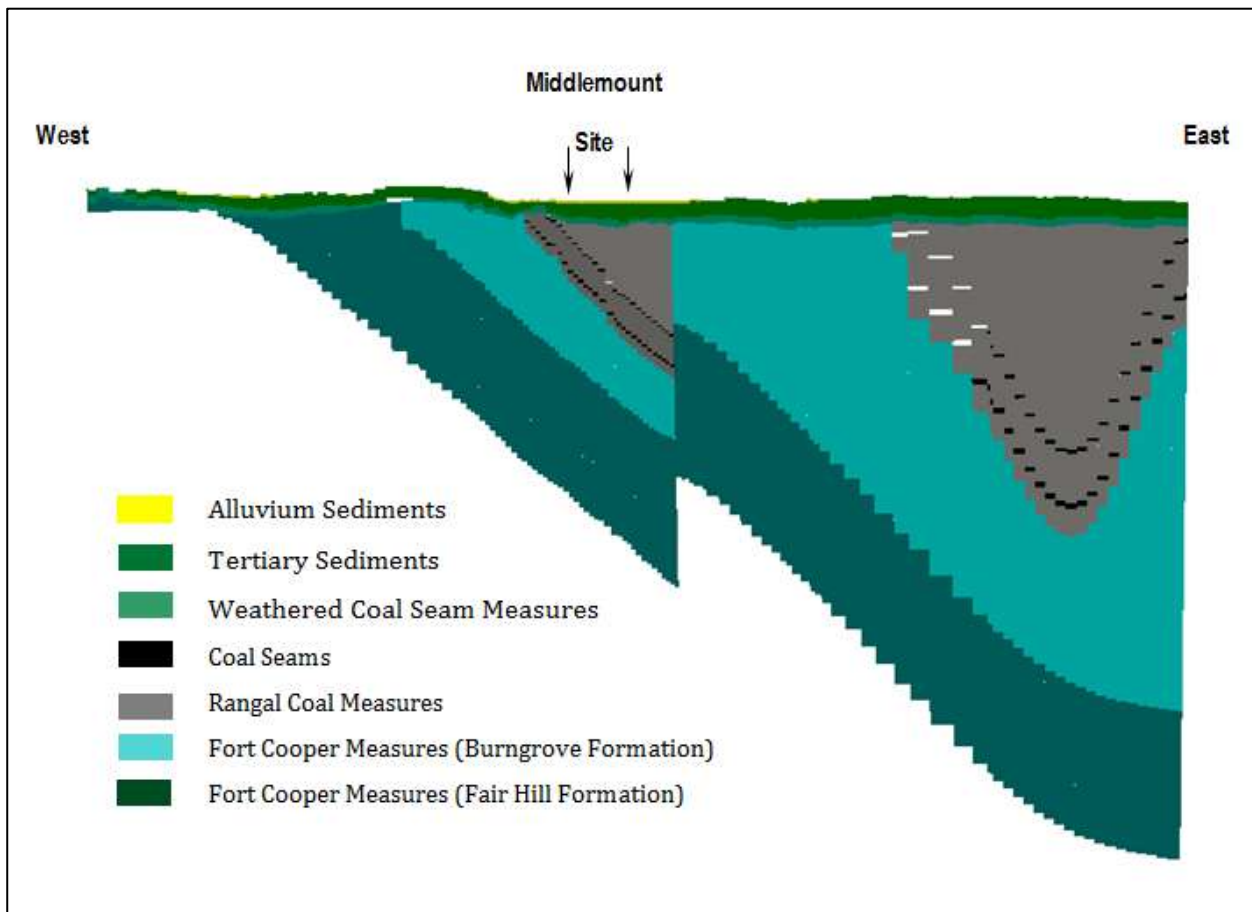


Figure F 4.2 Section through groundwater model showing layer design

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 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 (K_h) of each coal seam with depth according to the following relationship:

- *Middlemount and Leichhardt seam* $K_h = 0.3731 \times e^{(-0.021 \times \text{depth})}$
- *Pisces and Vermont seam* $K_h = 0.1504 \times e^{(-0.021 \times \text{depth})}$

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 2037. 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

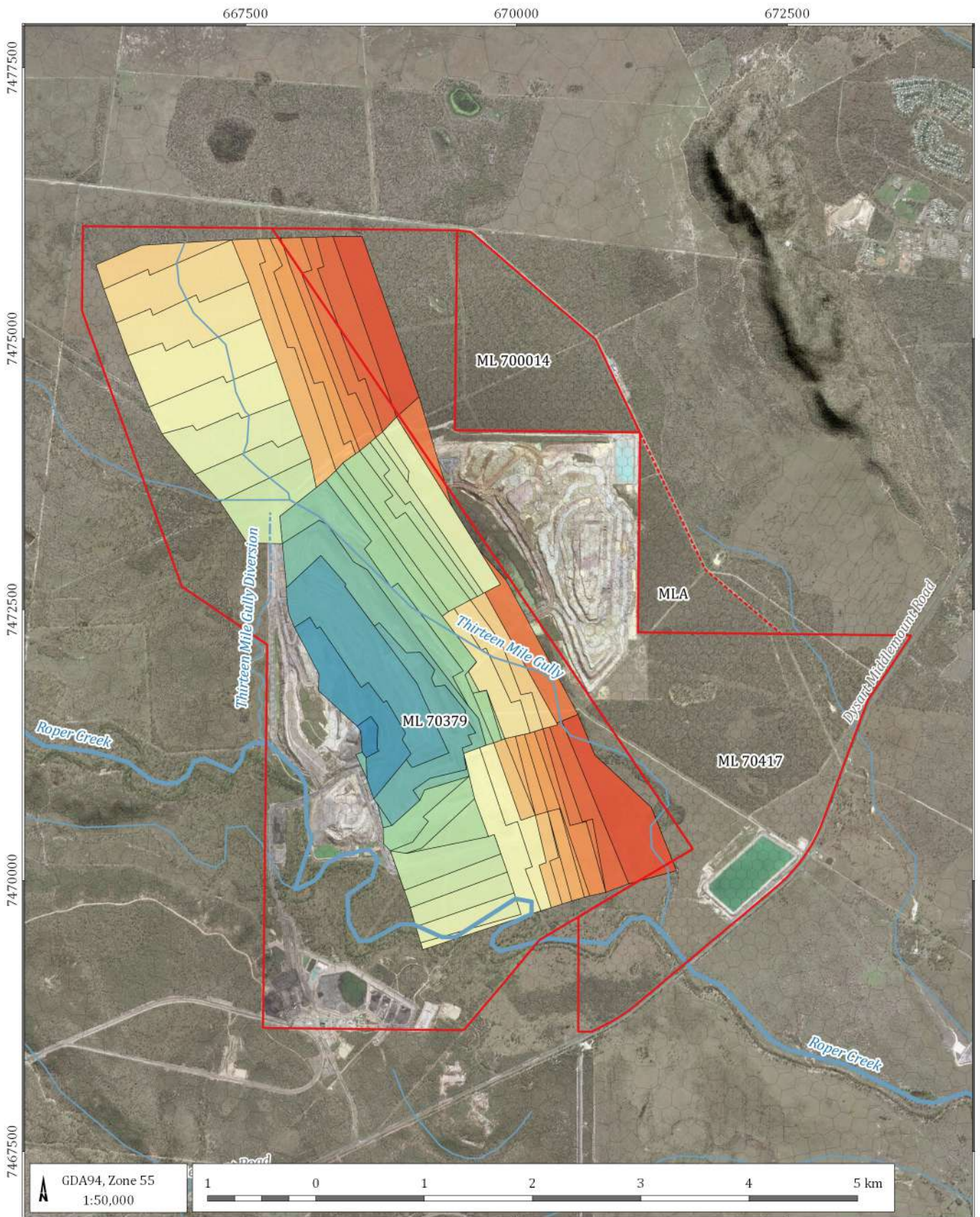
During the predictive run, a drain boundary condition (DRN) was used to simulate the effect of mine operations. A nominally high drain conductance of 100 m²/day was applied to the drain cells and the elevation of the base of the modelled layer was used as the drain level. The drain cells were moved within 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

- Mining Lease boundary (ML)
- Mining Lease Application boundary (MLA)
- Road
- Watercourse
- Drainage feature

Mine Progression (Year)

2011	2020	2029
2012	2021	2030
2013	2022	2031
2014	2023	2032
2015	2024	2033
2016	2025	2034
2017	2026	2035
2018	2027	2036
2019	2028	2037

Middlemount Coal Mine Western Extension Project
(G1840D)

Proposed continued operations project mine plan



DATE
11/04/2018

FIGURE No:
F 4.3

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 2037.

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	--	2.06
River	--	0.06
General head boundary	0.12	0.08

Table F 4.4 Model budgets – Prediction

Parameter	Average water transfer - 2018– 2037 (ML/day)	
	Input	Output
Rainfall recharge	0.10	--
Drains	--	2.28
River	--	0.06
General head boundary	0.12	0.09

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 2.06 ML/day for the calibration period. As mining progress to the deeper coal seams, the average rate of dewatering increases slightly to 2.28 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 0.5% 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.

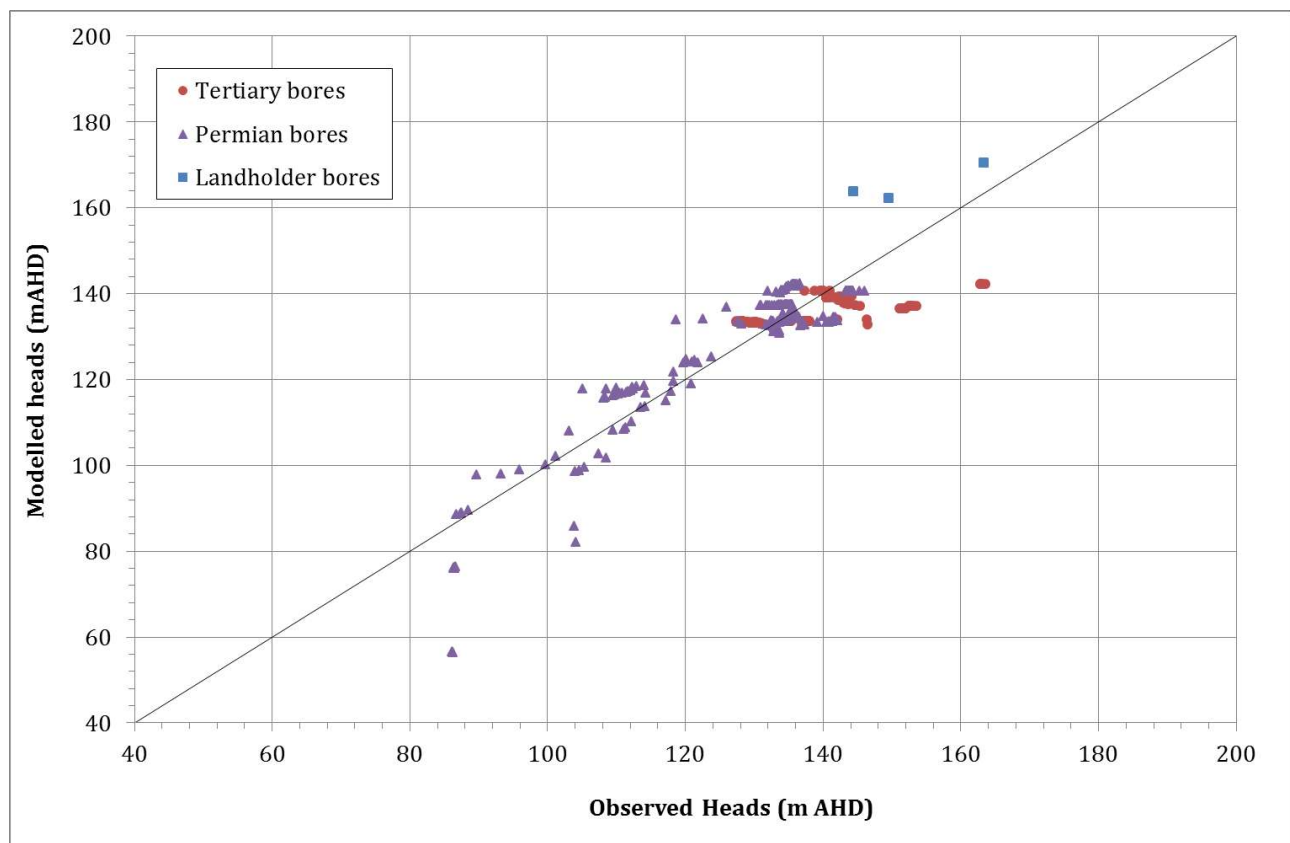


Figure F 5.1 Transient calibration – modelled vs observed groundwater levels

The root mean square (RMS) error calculated for the calibrated model was 6.69 m. The total measured head change across the model domain was 77.55 m, resulting in a scaled RMS (SRMS) of 8.6%. 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 a calibrated 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).

A combination of manual and automated calibration using PEST (Doherty, 2010) was undertaken to determine optimal hydraulic parameters and recharge rates to replicate observed groundwater level data. The software made iterative adjustments to the parameter set within pre-defined bounds to reduce the residual difference between the predicted results and the observed data. PEST adjusted the following properties in the model to achieve the steady-state and transient calibrations:

- horizontal and vertical hydraulic conductivity;
- recharge rate to each recharge zone; and
- storage parameters (specific yield and specific storage).

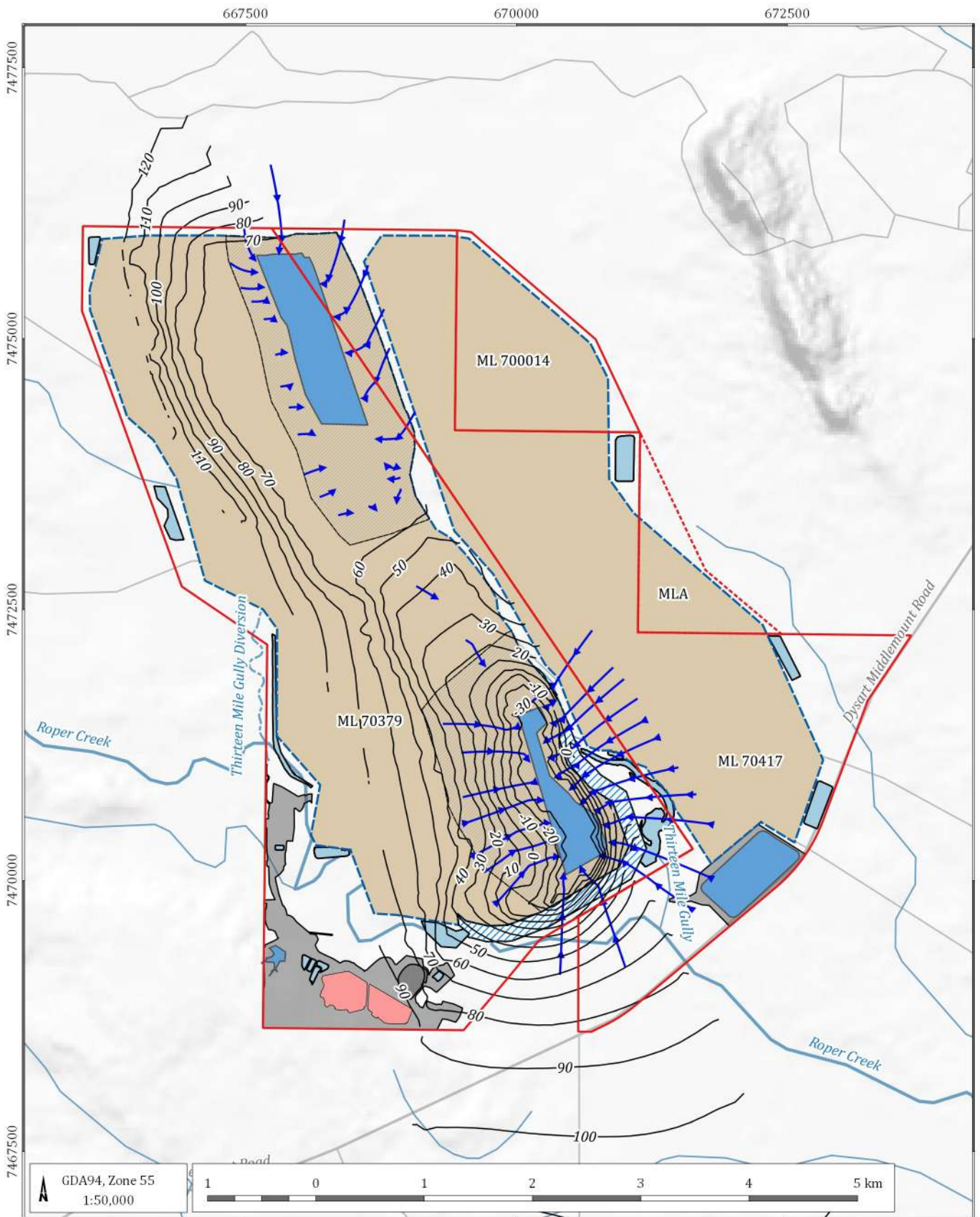
The manual process was used following initial automatic calibration given the relatively limited data available and the better judgement provided by the groundwater modeller's experience, which provides for a better assessment of observation trends and the overall behaviour of the system.

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 back simulated over a 50,000 year period 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 backwards radially away from 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

- | | |
|---|--|
| Mining Lease boundary (ML) | Flood Bund |
| Mining Lease Application boundary (MLA) | Final Void |
| Road | Spoil/Waste Dumps |
| → Particle trace | Infrastructure Extent |
| — Watercourse | Tailings Storage Facility |
| — Drainage feature | Sediment Dam |
| | Water Management Dam |

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Particle tracking-Steady state



DATE
11/04/2018

FIGURE No:
F 6.1

F7 Uncertainty analysis

Groundwater models represent complex environmental systems and processes in a simplified manner. This means that predictions from groundwater models, likely 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 m² 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.

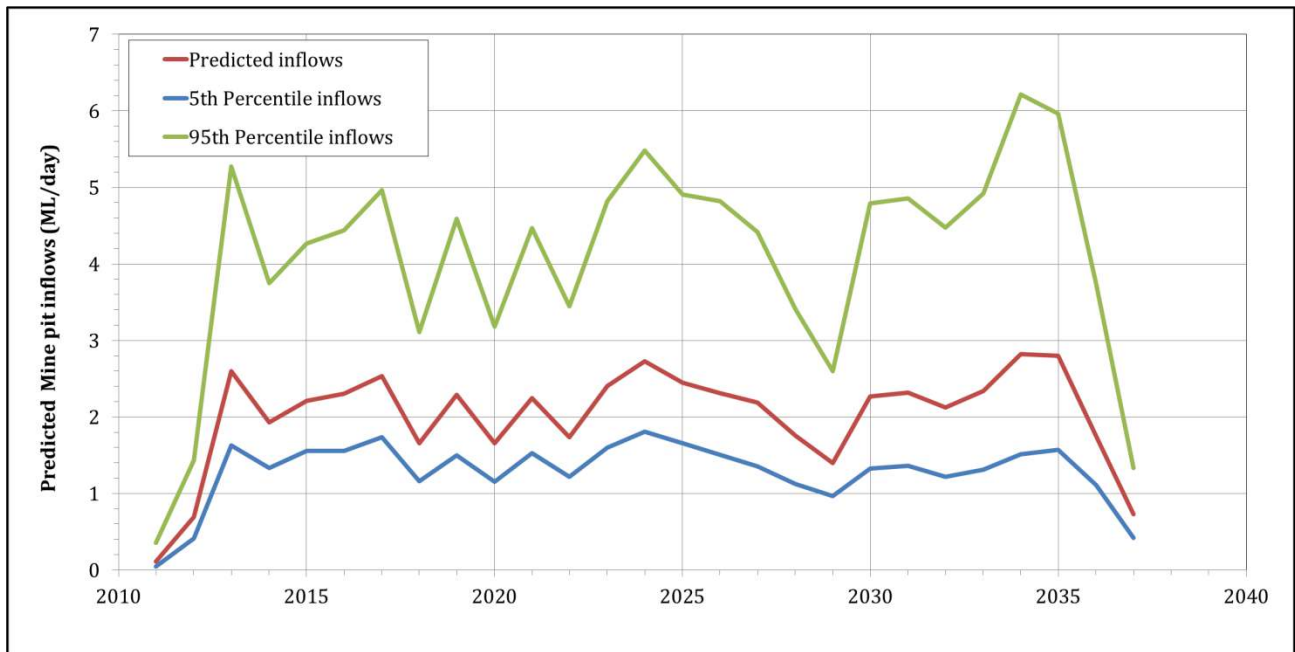


Figure F 7.1 Predicted Project groundwater inflow uncertainty

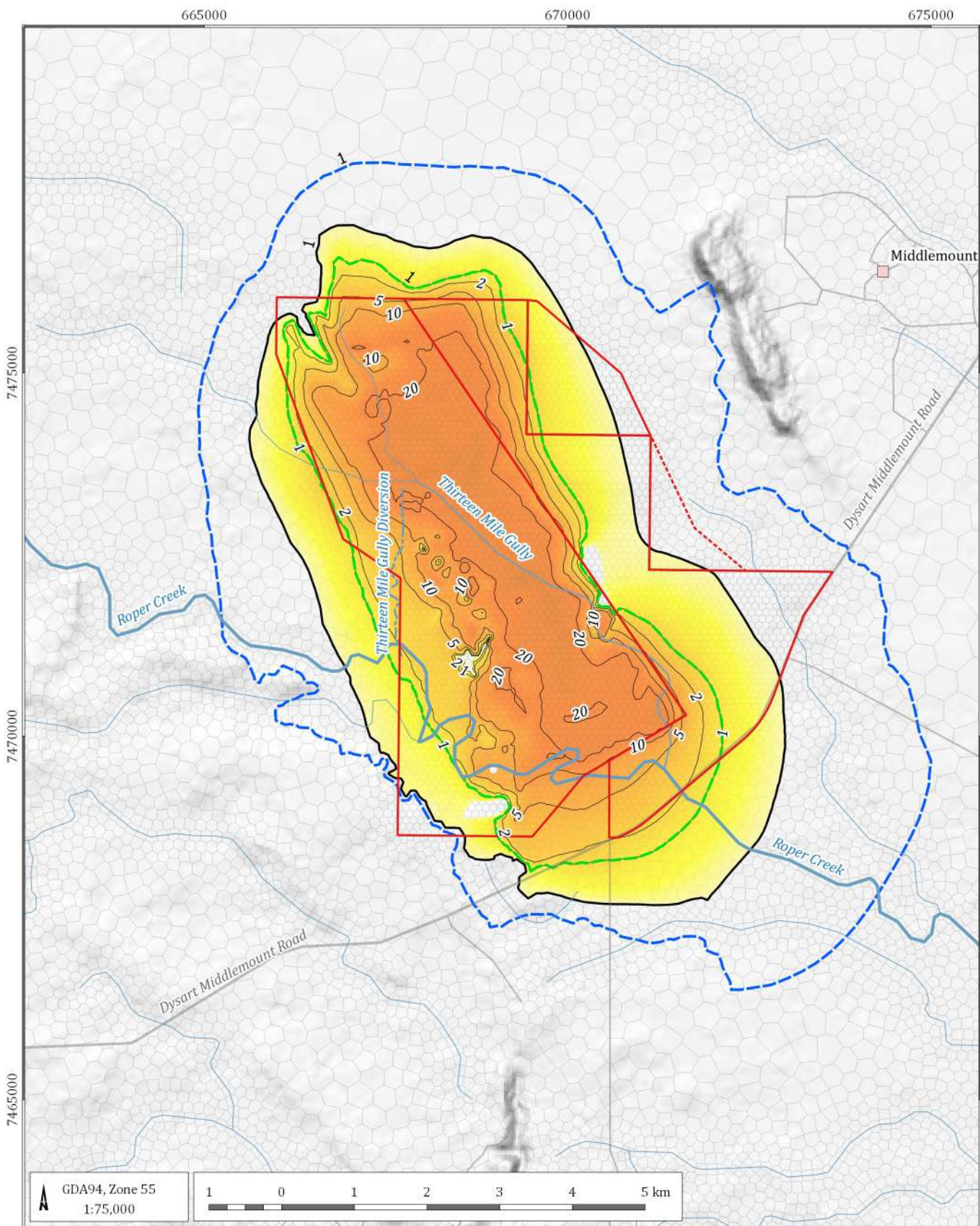
The uncertainty analysis indicated predicted the maximum inflows ranging between 1.81 ML/day (5th percentile) and 6.22 ML/day (95th percentile) in year 2024 and 2034 respectively. Table F 7.6 presents the uncertainty in the total inflow to the Project only for each year.

Table F 7.6 Predicted groundwater inflow – 2011 to 2037

Year	Groundwater inflow (P05)	Groundwater inflow (Calibration)	Groundwater inflow (P95)
2011	0.05	0.11	0.35
2012	0.41	0.69	1.44
2013	1.63	2.60	5.27
2014	1.33	1.93	3.75
2015	1.55	2.21	4.27
2016	1.55	2.31	4.44
2017	1.73	2.54	4.97
2018	1.16	1.66	3.11
2019	1.50	2.29	4.59
2020	1.15	1.66	3.18
2021	1.53	2.24	4.47
2022	1.22	1.74	3.45
2023	1.60	2.41	4.82
2024	1.81	2.72	5.48
2025	1.66	2.45	4.91
2026	1.50	2.31	4.82
2027	1.36	2.19	4.42
2028	1.12	1.76	3.41
2029	0.97	1.40	2.60
2030	1.33	2.27	4.79
2031	1.36	2.31	4.86
2032	1.22	2.12	4.47
2033	1.31	2.34	4.92
2034	1.51	2.82	6.22
2035	1.57	2.80	5.96
2036	1.11	1.75	3.74
2037	0.42	0.73	1.34
Max	1.81	2.82	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). 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.



LEGEND

- Populated place
- ▭ Mining Lease boundary (ML)
- ▭ Mining Lease Application boundary (MLA)
- ▭ Model grid
- Watercourse
- Drainage feature
- Road

Drawdown (m)

- ▭ 0
- ▭ 1
- ▭ 2
- ▭ 5
- ▭ 10
- ▭ 20
- Drawdown contour (1 m)
- P05 drawdown contour (1 m)
- P95 drawdown contour (1 m)

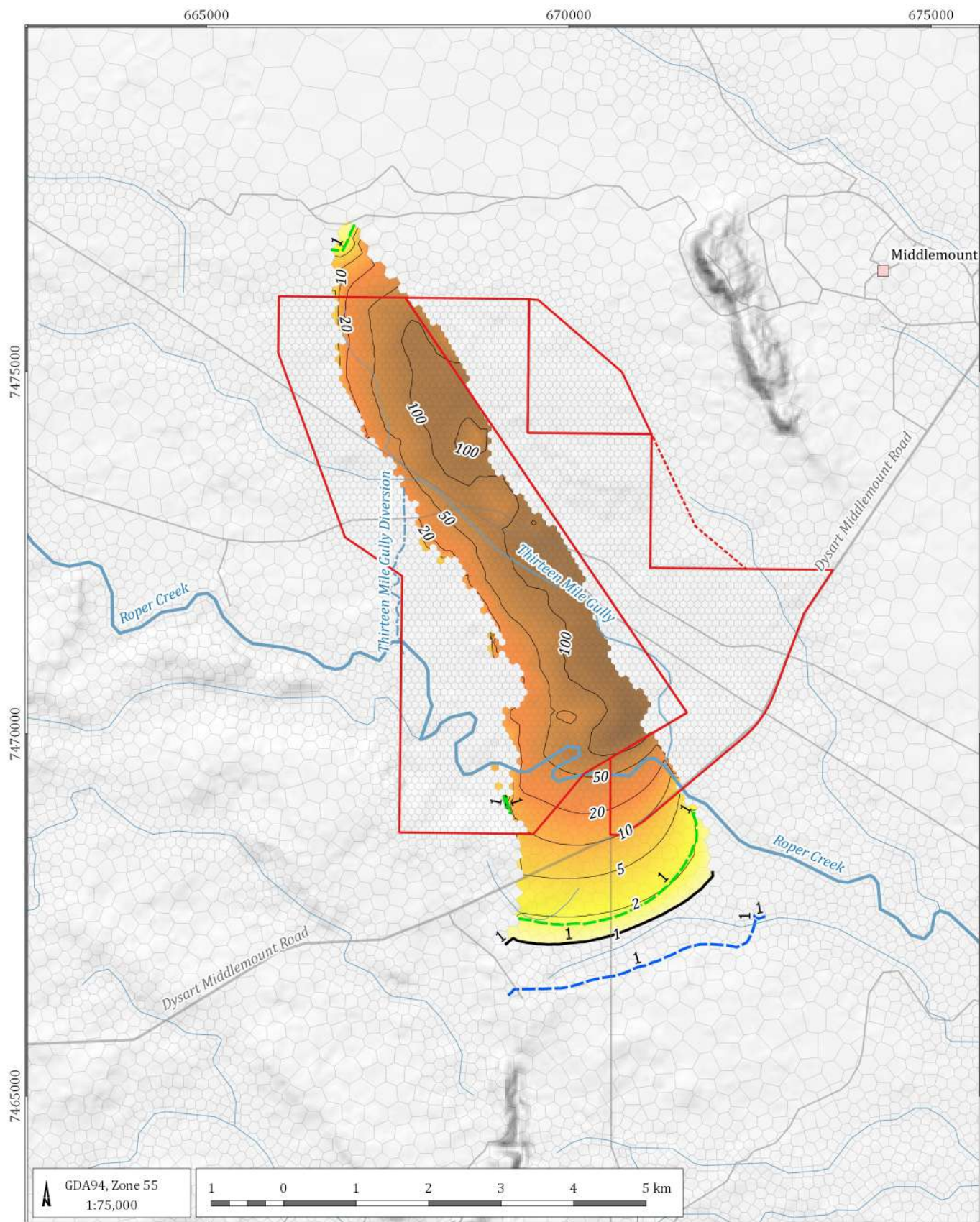
Middlemount Coal Mine Western Extension Project (G1840D)

Tertiary & Weathered Permian (Layers 2 & 3) - Uncertainty of maximum zone of drawdown during mining



DATE
27/04/2018

FIGURE No:
F 7.2



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary ()
- Model grid
- Road
- Watercourse
- Drainage feature

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- Drawdown contour (1 m)
- P05 drawdown contour (1 m)
- P95 drawdown contour (1 m)

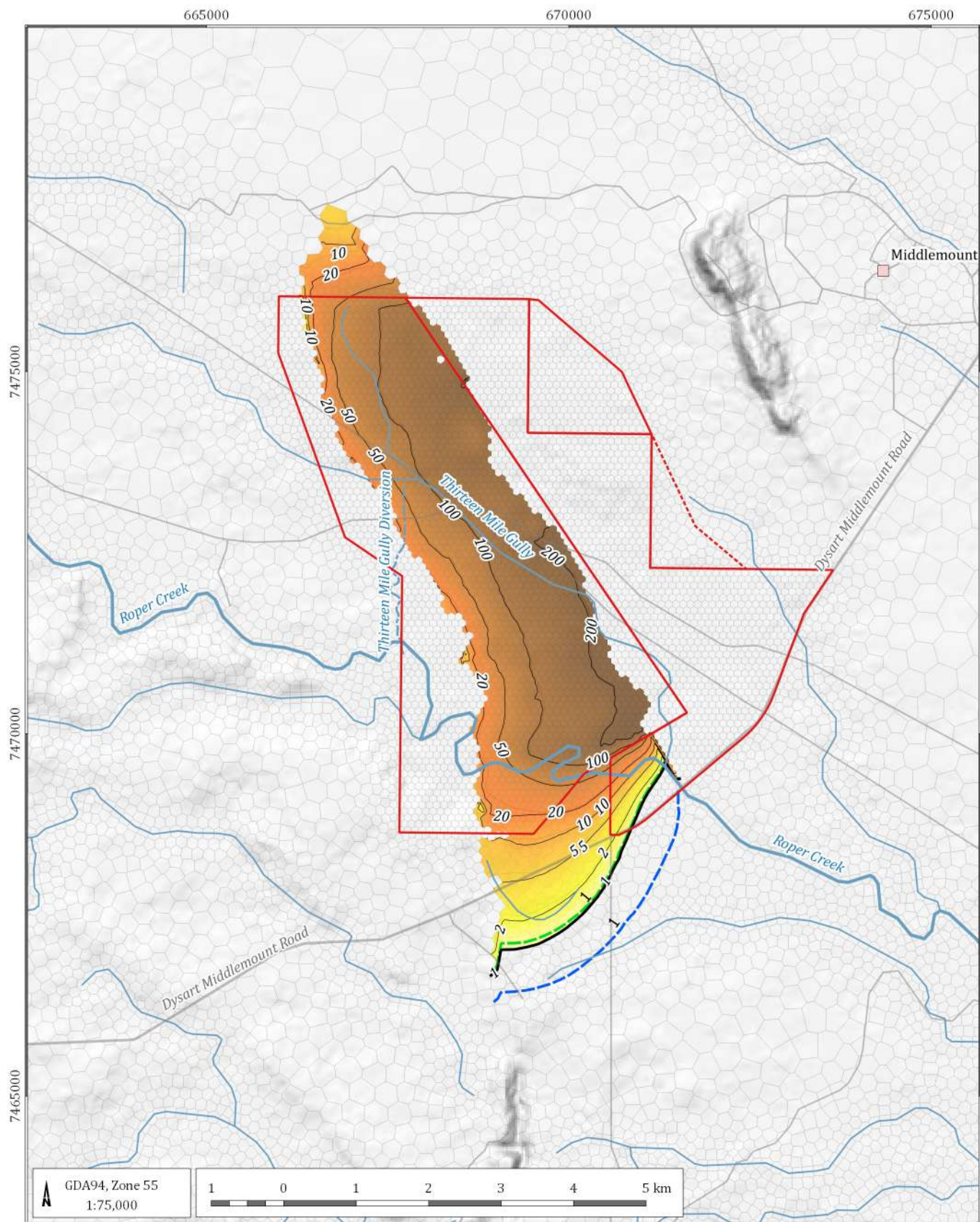
Middlemount Coal Mine Western Extension Project (G1840D)

Middlemount Seam (Layer 5) - Uncertainty of maximum zone of drawdown during mining



DATE
27/04/2018

FIGURE No:
F 7.3



LEGEND

- Populated place
- ▬ Mining Lease boundary (ML)
- - - Mining Lease Application boundary (MLA)
- ▬ Model grid
- ▬ Road
- ▬ Watercourse
- ▬ Drainage feature

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 Western Extension Project
(G1840D)

**Pisces Seam (Layer 7) – Uncertainty of
maximum zone of drawdown during
mining**



DATE
27/04/2018

FIGURE No:
F 7.4

F8 References

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Panday, S, Langevin, CD, Niswonger, RG, Ibaraki, M & Hughes, JD (2013), *“MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation”*; U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

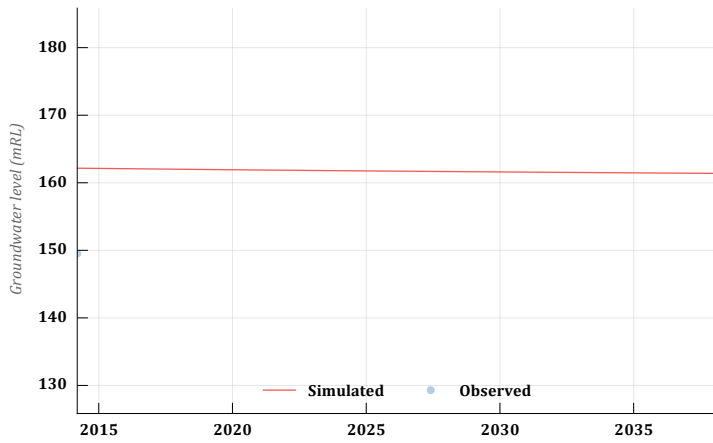
Parsons Brinkerhoff, (2010), *Middlemount Coal Project, Stage 2, Groundwater Technical Report*, Prepared for Middlemount Coal Pty Ltd.

Doherty, J., (2010), *“PEST Model-Independent Parameter Estimation User Manual: 5th Edition”*, Watermark Numerical Computing.

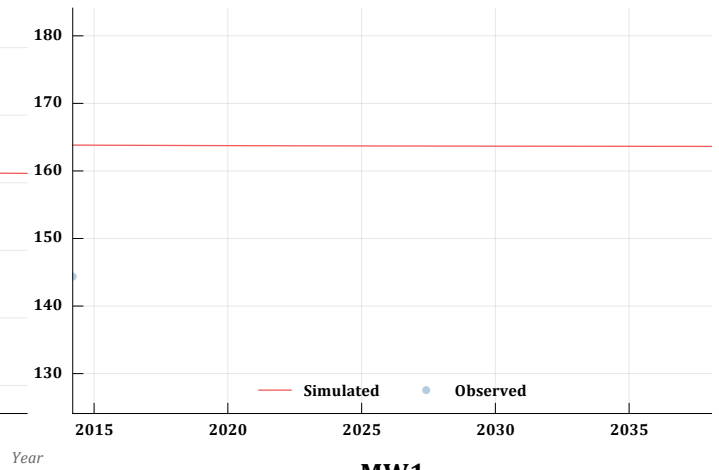
Appendix F1

Simulated and observed hydrographs

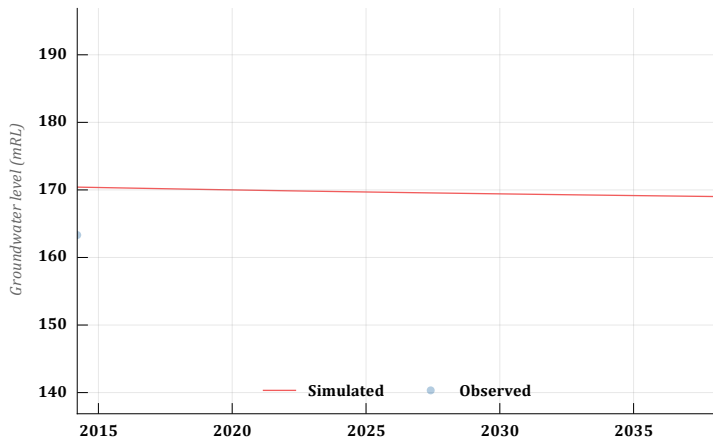
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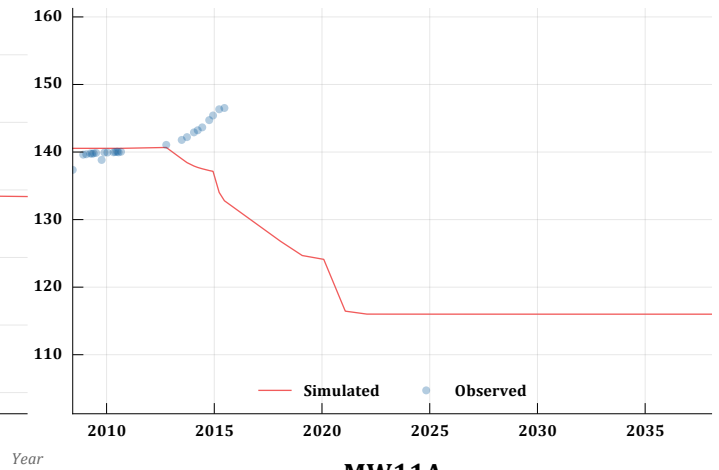
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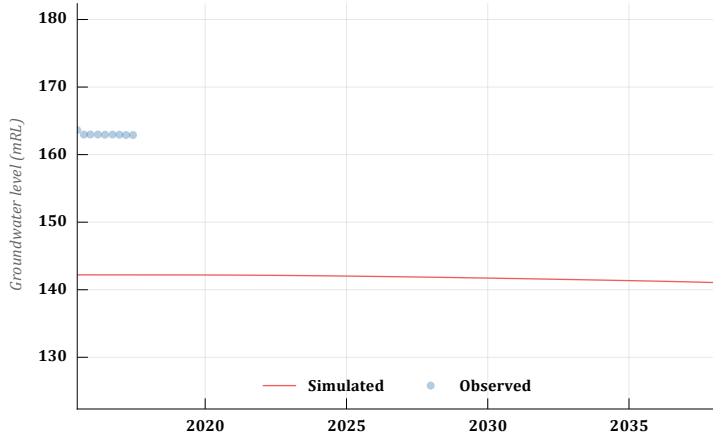
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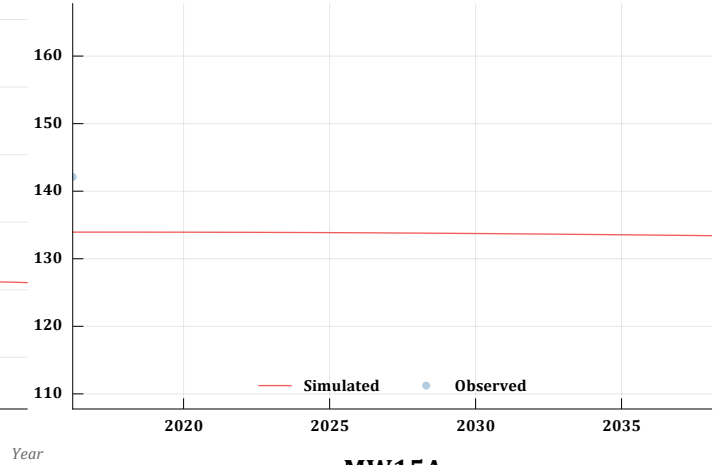
MW1



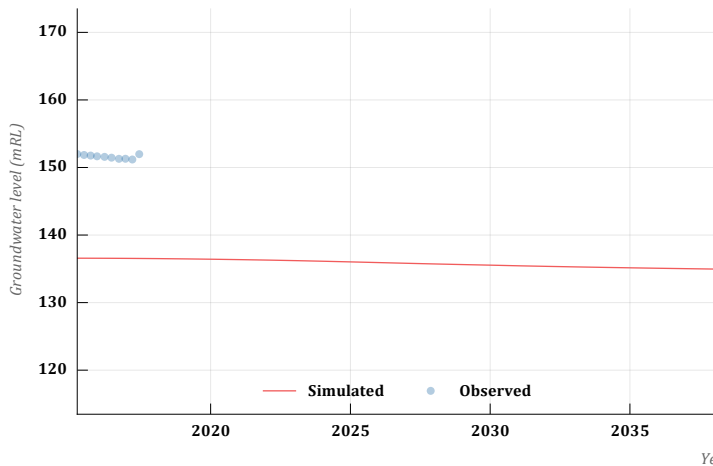
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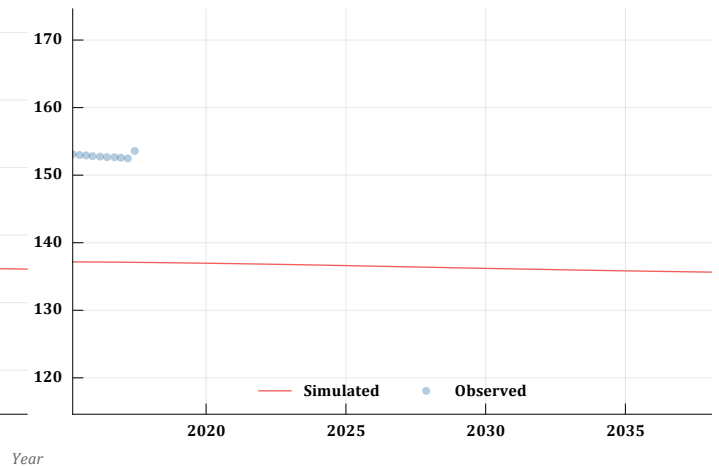
MW11A

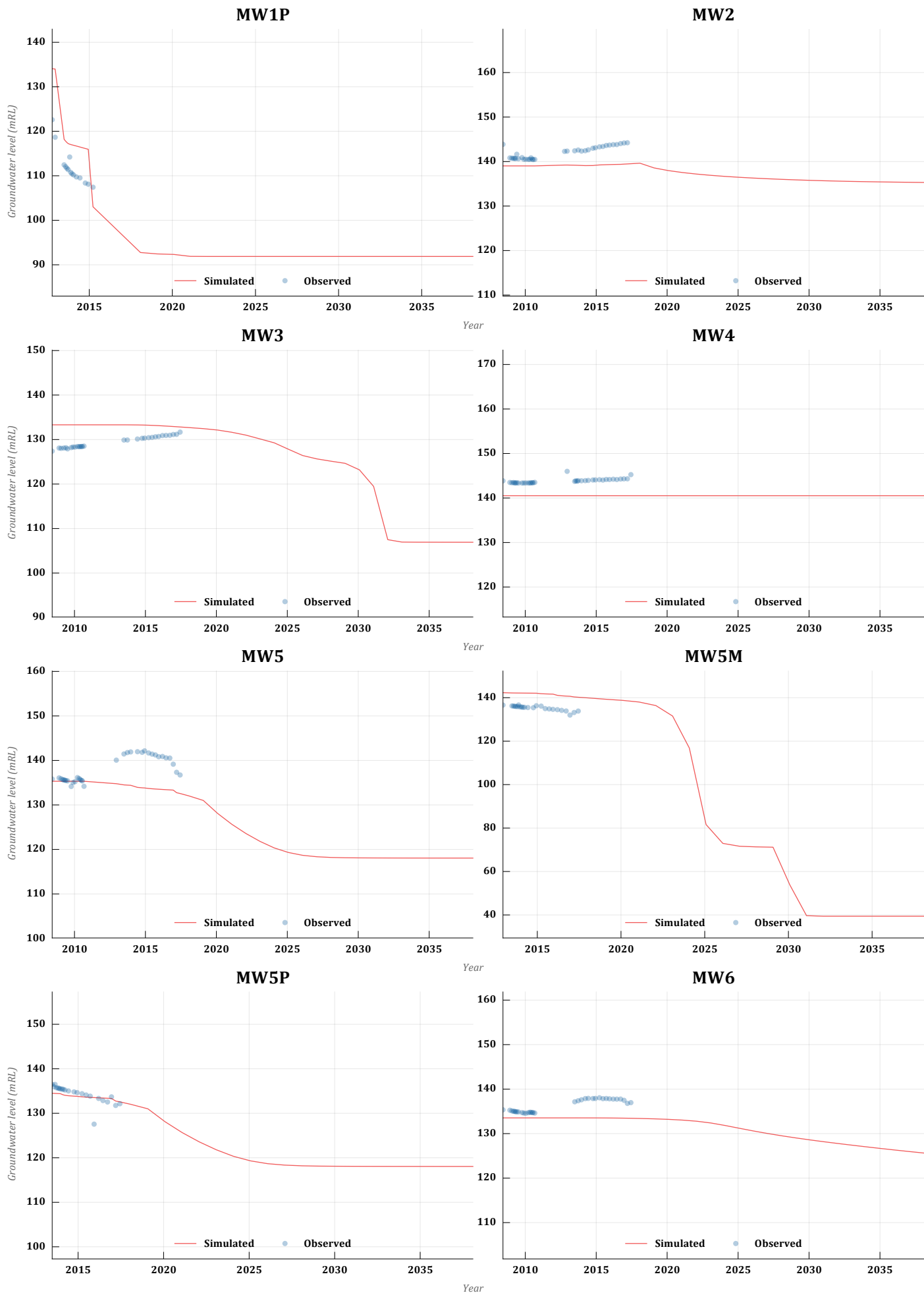


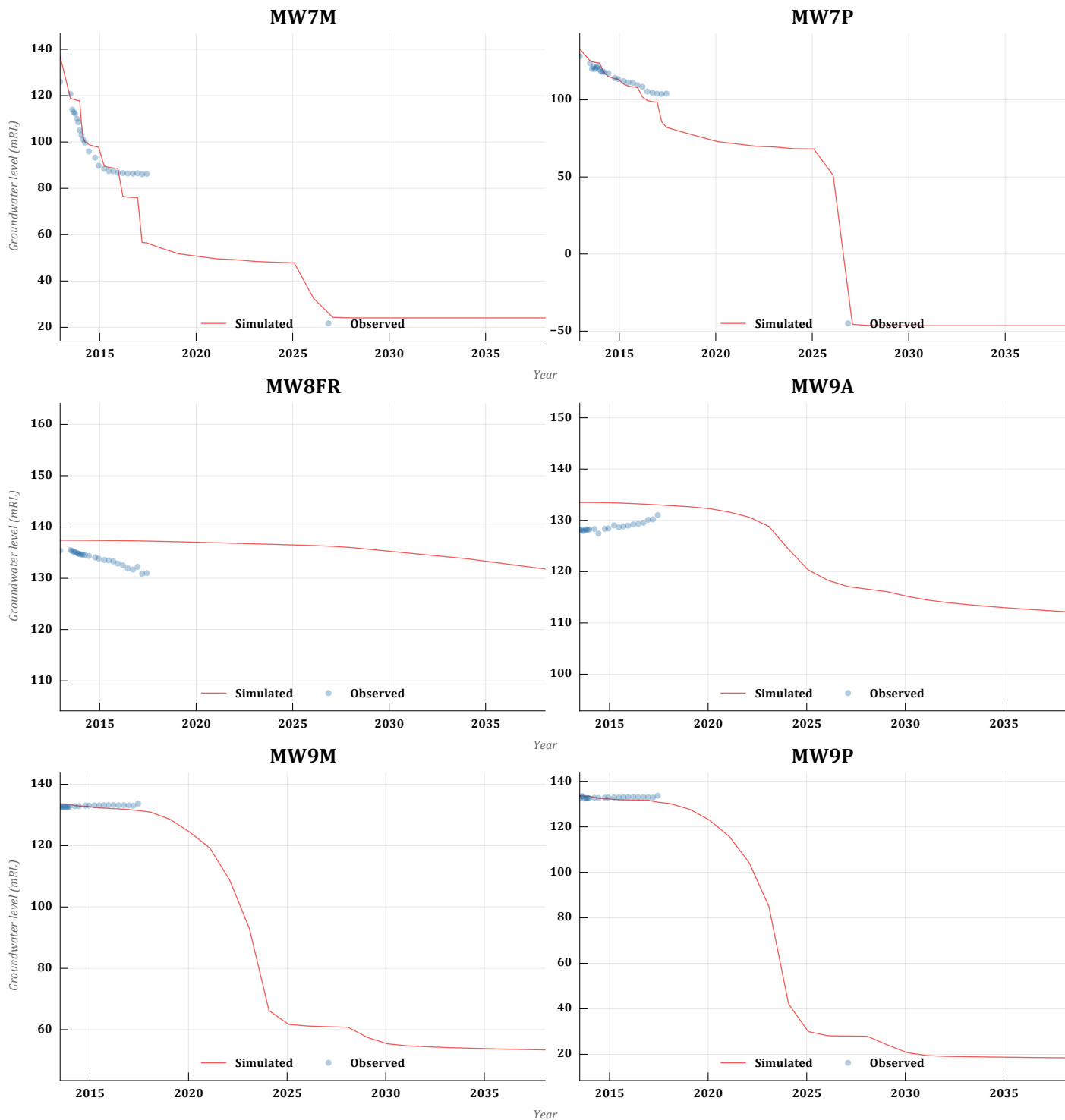
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MW15A

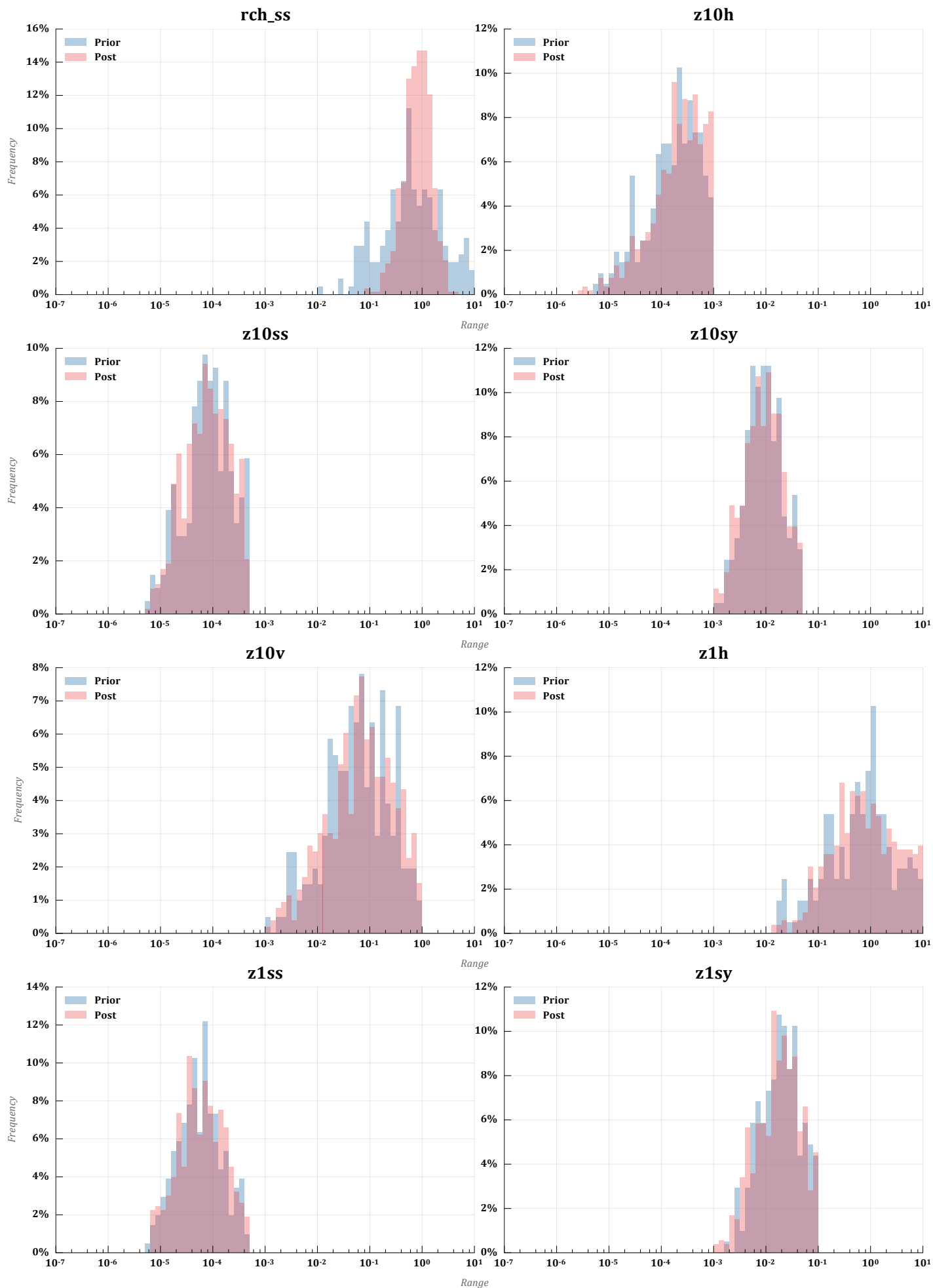


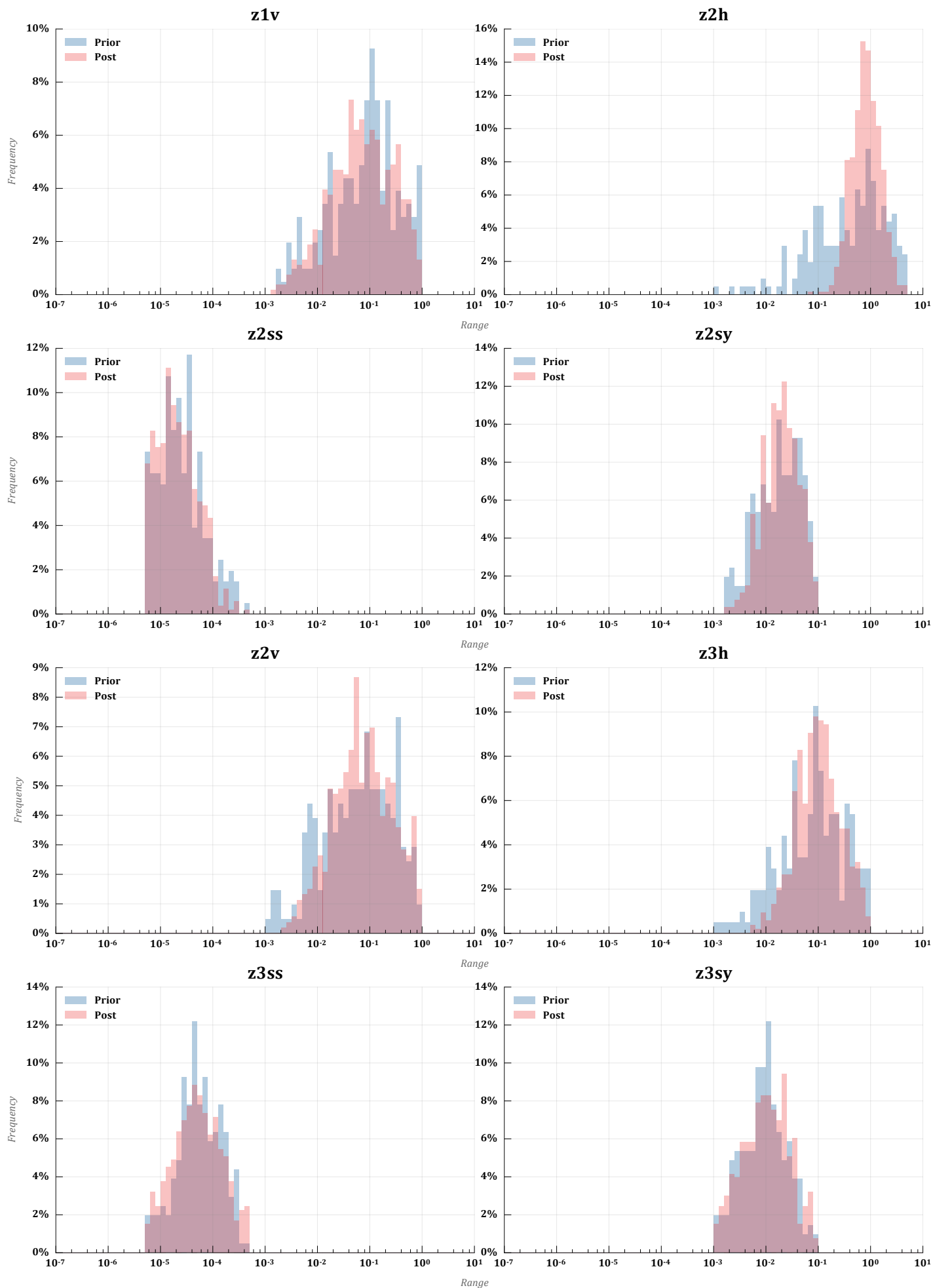


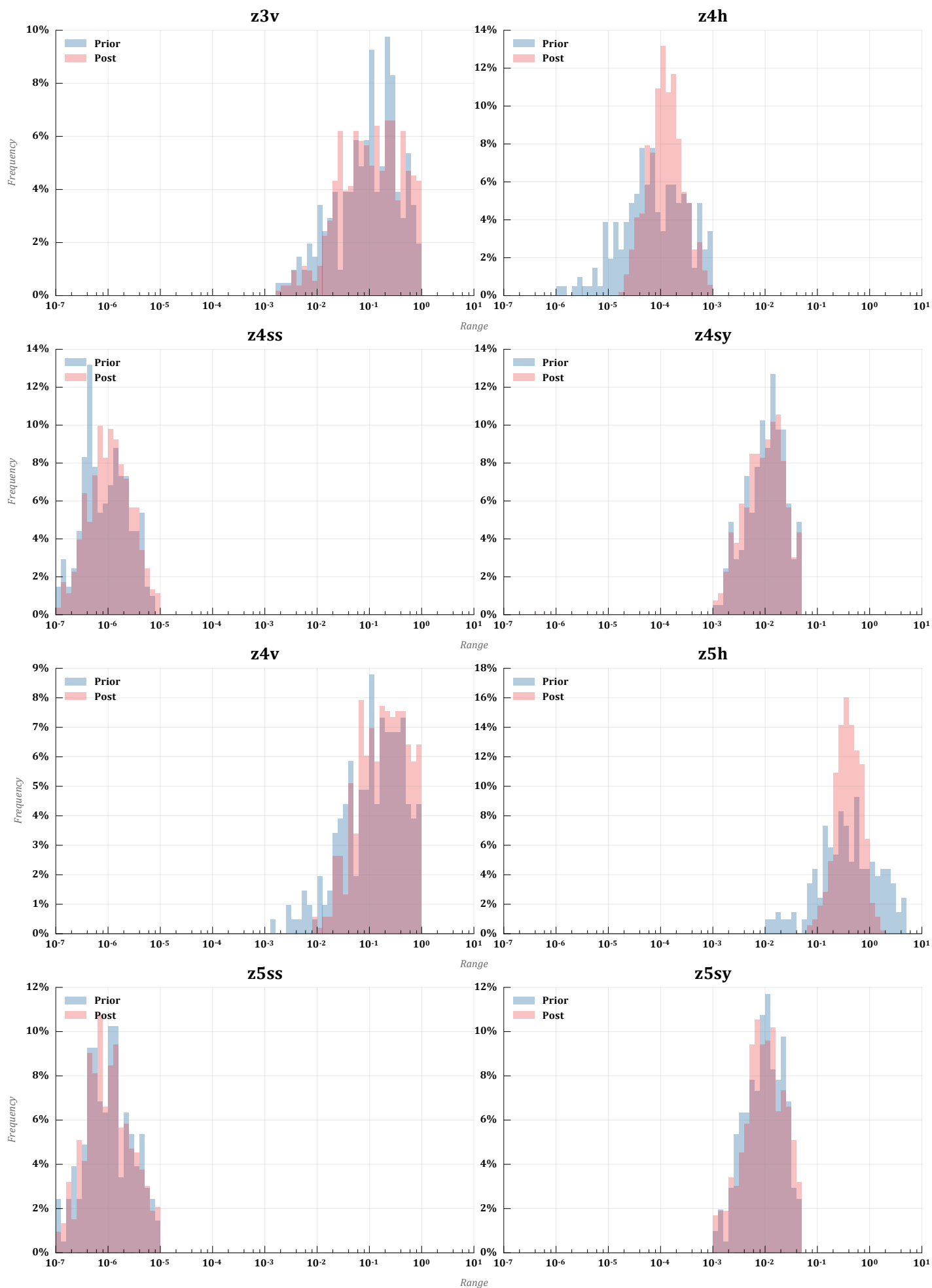


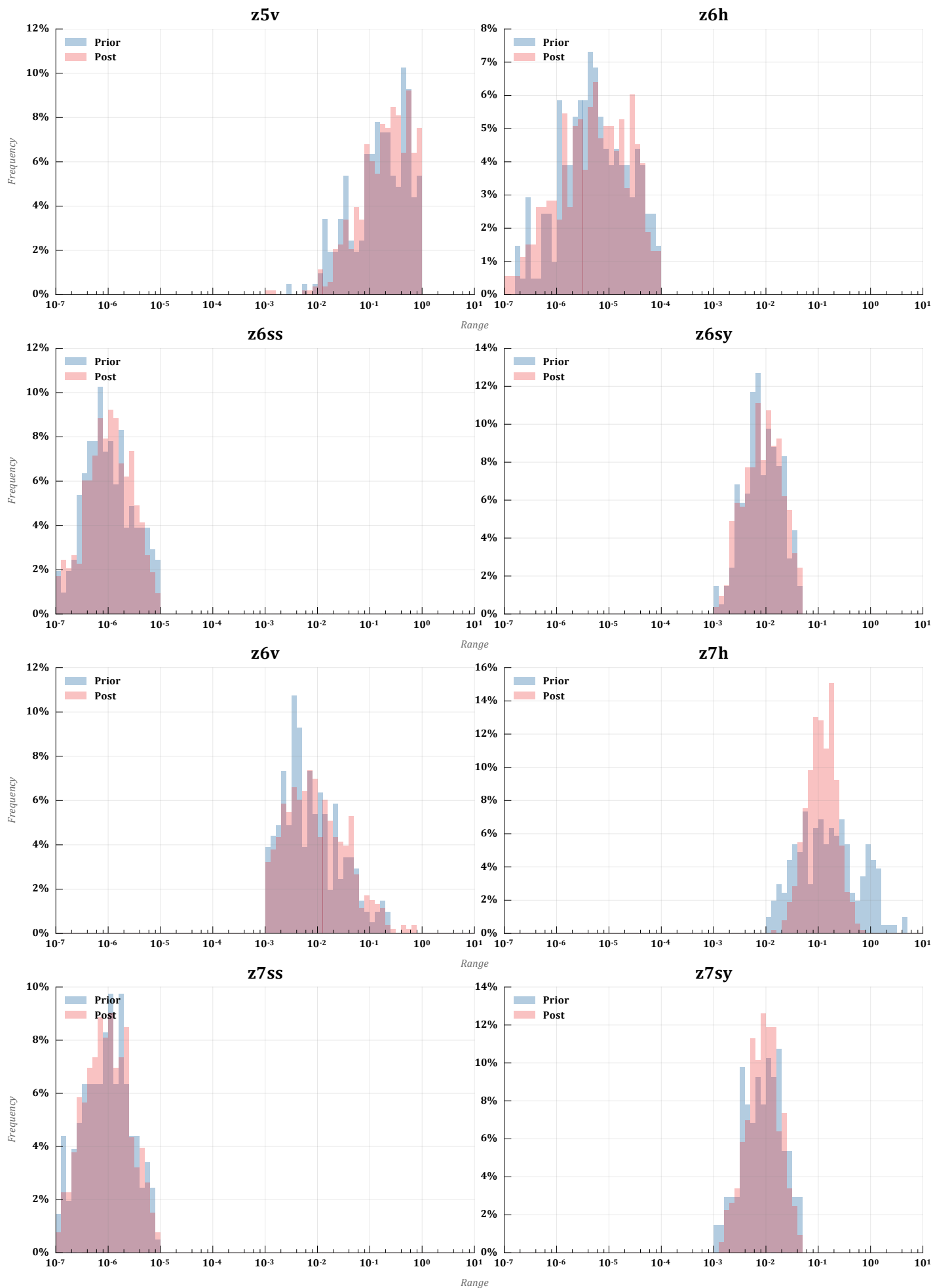
Appendix F2

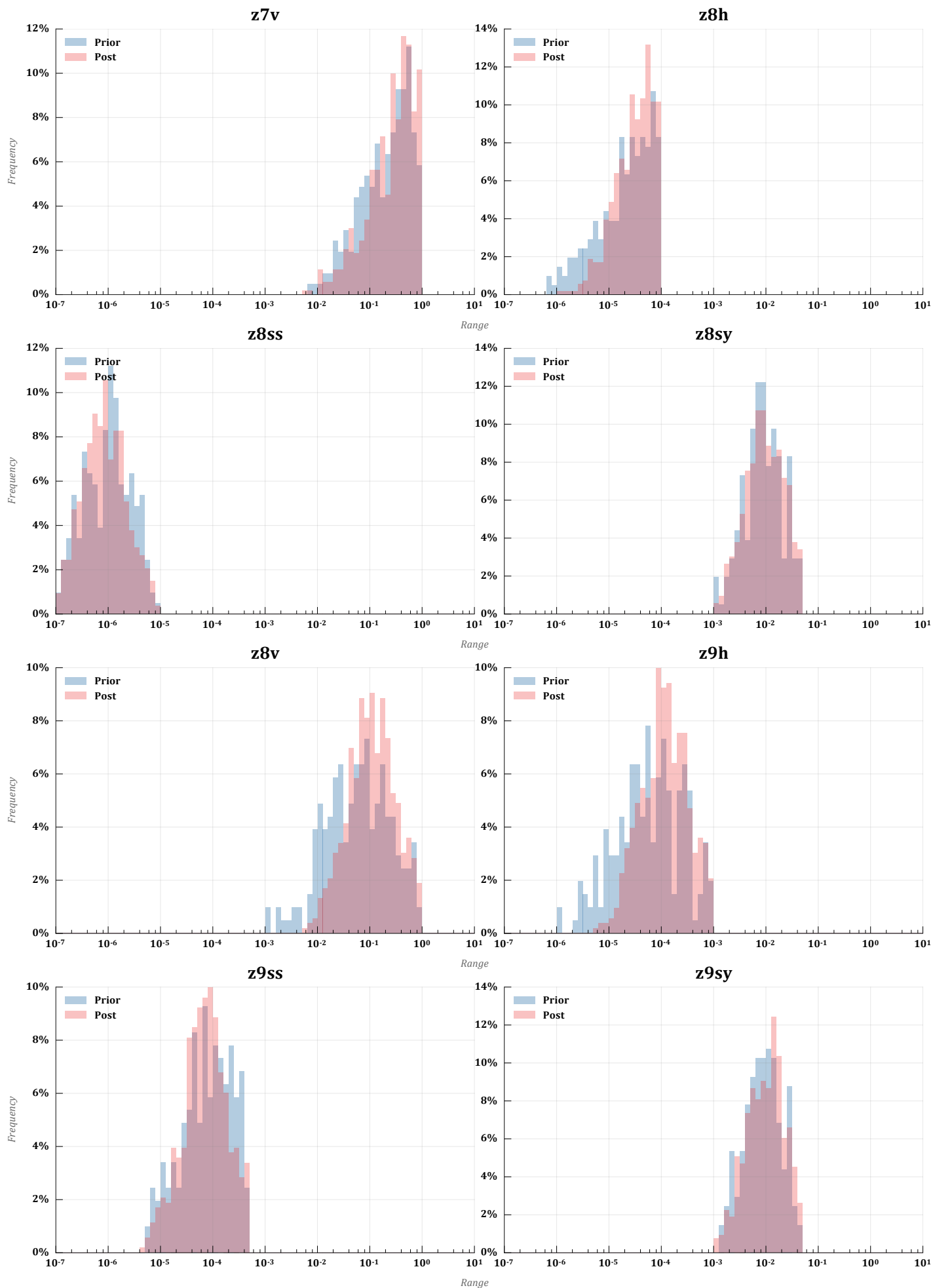
Prior and posterior parameter distributions

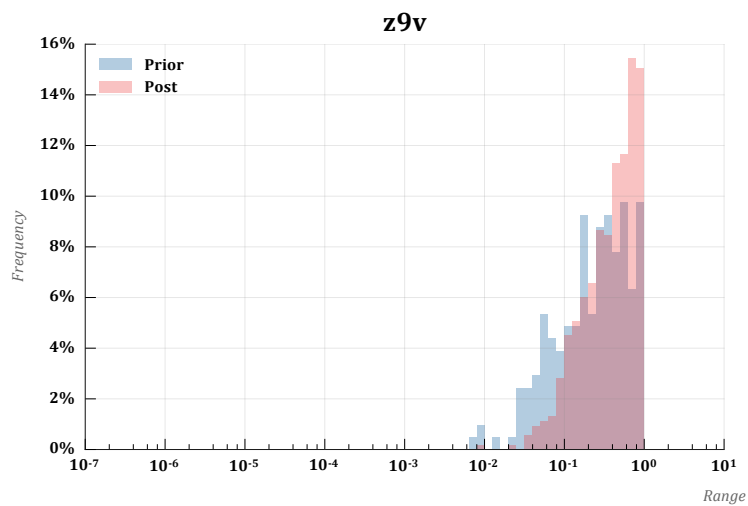












Appendix F3

Predictive uncertainty hydrographs



