MIDDLEMOUNT COAL MINE
PROGRESSIVE REHABILITATION AND CLOSURE PLAN

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3 REHABILITATION PLANNING PART

3.1 PROJECT PLANNING

On 27 May 2021, the Queensland (QLD) Department of Environment and Science (DES), pursuant to section 754 of the *Environmental Protection Act 1994* (the EP Act), issued Ribfield Pty Ltd and Middlemount Coal Pty Ltd (MCPL) a Progressive Rehabilitation and Closure Plan Transition Notice (PRCP Transition Notice). The PRCP Transition Notice requires the preparation of a Progressive Rehabilitation and Closure (PRC) Plan for the Middlemount Coal Mine that satisfies the requirements of sections 126C and 126D of the EP Act by 30 June 2022.

The Middlemount Coal Mine is an existing open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and approximately 3 km to the south-west of the Middlemount Township, QLD (Figure 1). MCPL owns and operates the Middlemount Coal Mine on behalf of the incorporated joint venture between Peabody Energy Australia Pty Ltd and Yancoal Australia Ltd.

In 2020, MCPL prepared and submitted a Major EA Amendment for the Middlemount Coal Mine Southern Extension Project (and associated Environmental Values Assessment [EVA]). The Southern Extension Project was approved in 2021. Figure 2 provides an overview of the approved layout of the Middlemount Coal Mine (i.e., including the Southern Extension Project). As part of the Southern Extension Project, MCPL defined the post-mining land uses (PMLUs) and non-use management areas (NUMAs) that would be achieved for the Middlemount Coal Mine.

In accordance with the *Guideline - Progressive rehabilitation and closure plans* (ESR/2019/4964) (DES, 2021) (the PRCP Guideline), the approved PMLUs, NUMAs and associated rehabilitation requirements (including outcomes for the land and associated criteria for achieving these outcomes) from the Southern Extension Project have been transitioned into this PRC Plan and the Progressive Rehabilitation Closure Plan Schedule (PRCP Schedule).

The objective of this PRC Plan is to provide a roadmap for progressive rehabilitation and closure of the Middlemount Coal Mine to achieve a safe, stable and non-polluting final landform which satisfies the requirements of sections 126C and 126D of the EP Act and other relevant legislation.

This PRC Plan and the associated PRCP Schedule supersede the existing *Rehabilitation Management Plan* (MCPL, 2012), *Rehabilitation Management Plan Addendum* (GT Environmental, 2018) and *Plan of Operations Middlemount Coal Mine* (1 April 2019 to 31 March 2021) (MCPL, 2019).

3.1.1 Project Description

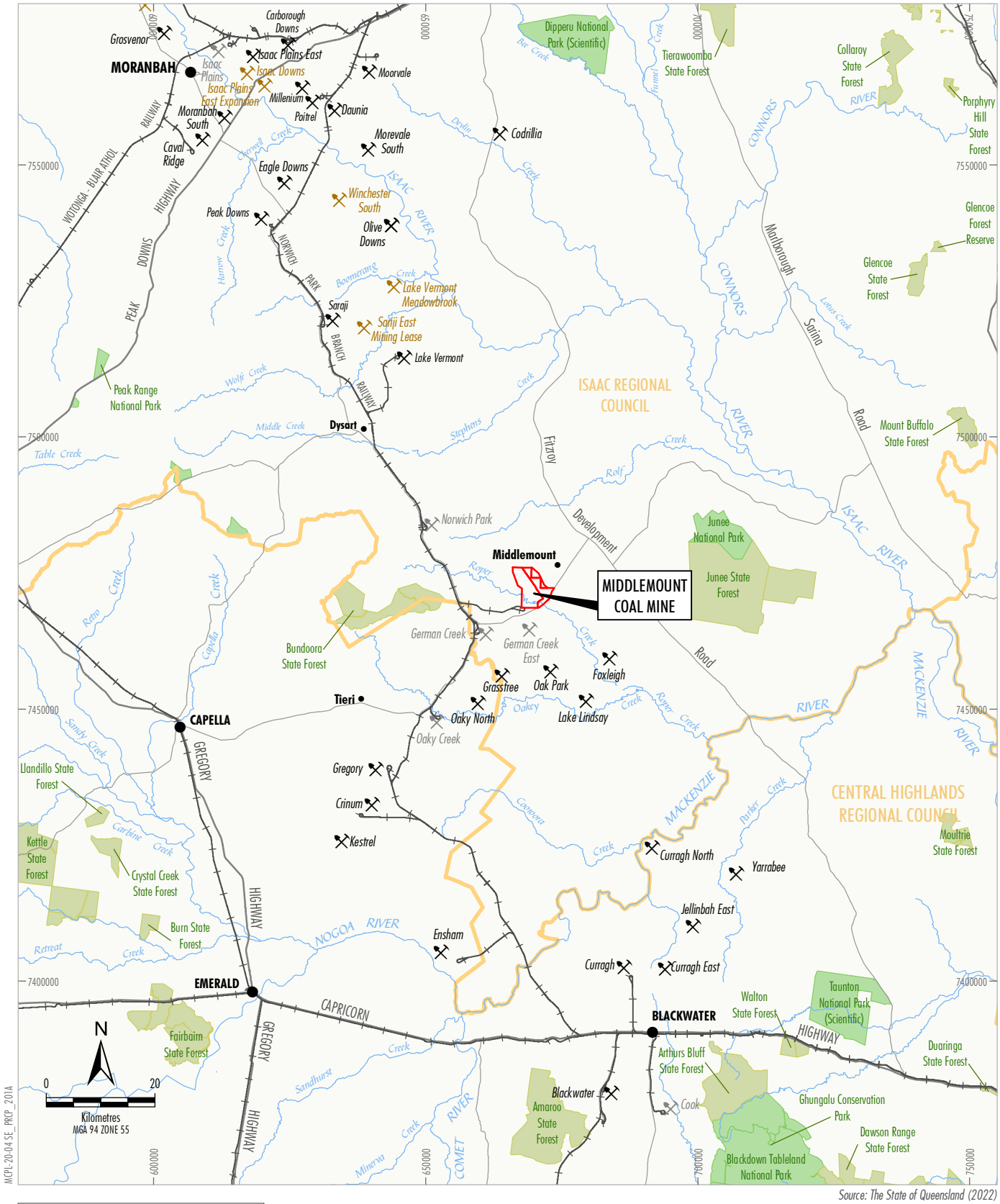
3.1.1.1 Type of Mining Operation

The Middlemount Coal Mine is an open cut coal mine, with truck and shovel operations.

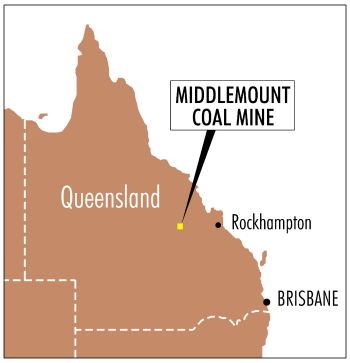
3.1.1.2 Duration of Mining Operations

The Middlemount Coal Mine has been operating for approximately 10 years, with full scale operations commencing in July 2011.

Operations are approved to continue until 2044.



Source: The State of Queensland (2022)



LEGEND

- National Park/Conservation Area
- State Forest
- LGA_Boundaries
- Railway
- Major Road
- Minor Road
- Major River
- Mining Lease Boundary
- Approved/Operating Coal Mine
- Proposed Coal Operation
- Under Care and Maintenance

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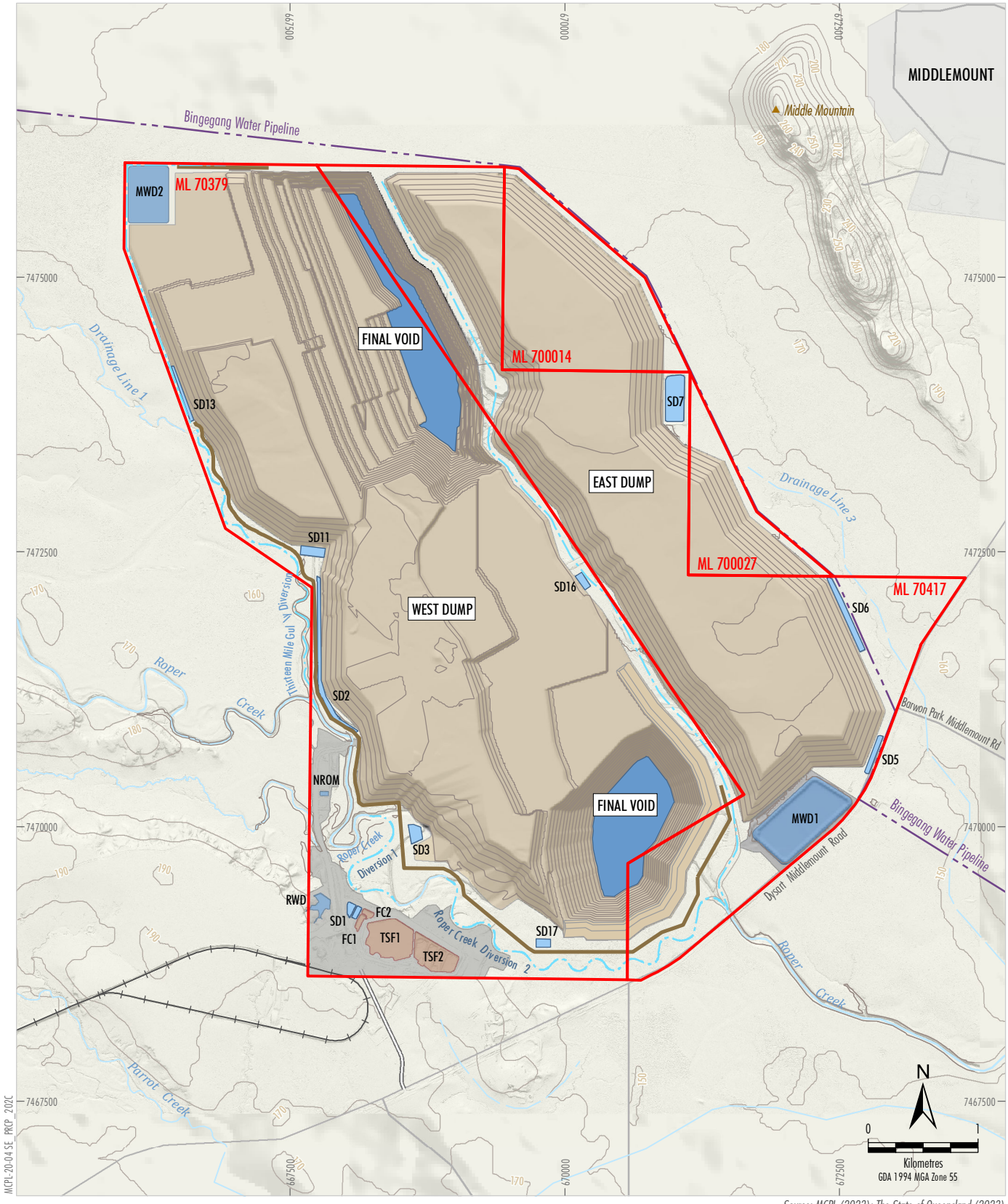
MIDDLEMOUNT COAL MINE

Regional Location

Figure 1



Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Mine Pit and Spoil
- Mine Infrastructure Area
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee

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MIDDLEMOUNT COAL MINE

Project General Arrangement

Figure 2

3.1.1.3 Mining Tenements

Table 1 identifies the Middlemount Coal Mine tenements and their status, and identifies the overlapping Exploration Permit for Coal (EPC) tenure.

Table 1
Relevant Mining Tenements

Permit	Holder	Granted	Expiry	Area (hectare [ha])	Overlapping Mining Tenure
Mining Lease (ML) 70379	MCPL	10 September 2009	30 September 2031	2,128	EPC 855
ML 70417	MCPL	8 December 2011	30 September 2031	1,082	EPC 855
ML 700014	MCPL	6 January 2017	30 Sep 2031	197.5	-
ML 700027	MCPL	5 June 2019	30 Sep 2031	95.5	-

MCPL has an agreement in place with Foxleigh Coal for the overlapping EPC tenure.

In addition to an overlapping mining tenure, the Middlemount Coal Mine also has overlapping petroleum tenements (Table 2).

Table 2
Overlapping Petroleum Tenements

Petroleum Tenure	Holder	Granted	Expiry	Overlapping Mining Lease
ATP 1103	CH4 Pty Ltd	23 December 2010	31 December 2025	ML 70379, ML 70417, ML 700014, ML 700027
PCA 135	CH4	4 December 2014	3 December 2029	ML 70379, ML 70417, ML 700014
PCA 136	CH4	4 December 2014	3 December 2029	ML 70379, ML 70417, ML 700027
EPC 855	Foxleigh Coal Pty Ltd	20 October 2003	19 October 2022	ML 70379, ML 70417

3.1.1.4 Primary Mine Features and Infrastructure

The primary mine features and infrastructure associated with the Middlemount Coal Mine include:

- open cut truck and shovel mining operations at a mining rate of 5.7 million tonnes per annum run of mine (ROM) coal;
- processing of ROM coal at the CHPP;
- disposal of waste rock, comprising of overburden and interburden, in-pit or in out-of-pit waste rock emplacements as mining progresses;
- disposal of coarse coal reject material within in-pit waste emplacements;
- storage of fine coal reject material in existing tailings storage facility (TSF) cells;
- loading of product coal using rail loading infrastructure;
- transport of product coal via the existing rail system from the Middlemount Coal Mine to the Dalrymple Bay Coal Terminal, Abbot Point Port or Wiggins Island Coal Export Terminal for export;

- construction and operation of ancillary infrastructure in support of mining operations, including:
  - haul and access roads;
  - electricity supply and communications infrastructure; and
  - water management infrastructure.
- diversion of Roper Creek and Thirteen Mile Creek;
- development of soil stockpiles, laydown areas and borrow areas;
- 24-hour seven-days per week operations until 2044;
- peak operational workforce of over 500 personnel;
- ongoing exploration activities within mining tenements;
- other associated minor infrastructure, plant and activities, where required; and
- progressive rehabilitation, as well as ultimate rehabilitation of the entire Middlemount Coal Mine area once the site has been decommissioned.

3.1.1.5 Environmentally Relevant Activities

Environmentally Relevant Activities (ERAs) (defined under the EP Act) are activities that will, or have the potential to, release contaminants into the environment which may cause environmental harm.

In accordance with EA EPML00716913, the Middlemount Coal Mine is approved to conduct the ERAs described within Table 3 until 2044.

Table 3
Approved Environmentally Relevant Activities

Relevant Mining Lease	Environmentally Relevant Activity	Description
ML 70379 ML 70417 ML 700014 ML 700027	ERA 8	**Ancillary – Chemical Storage 3** Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c).
	ERA 13	**Schedule 3 – Mining Black Coal**
	ERA 15	**Ancillary – Fuel burning** Using fuel burning equipment that is capable of burning at least 500 kg of fuel in an hour.
	ERA 31	**Ancillary – Mineral processing 2** Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000 t.
	ERA 63	**Ancillary – Sewage Treatment 1** Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-i) 21 to 100 EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.

3.1.1.6 Relevant Legislation and Guidelines

Environmental Protection Act 1994

Table 4 provides a reconciliation of the relevant requirements of sections 126C (Requirements for PRC Plan) and 126D (Requirements for Proposed PRCP Schedule) of the EP Act and where they have been addressed in this PRC Plan.

Table 4
Reconciliation of Sections 126C and 126D of the Environmental Protection Act

Sections 126C and 126D of the EP Act	Section of this PRC Plan
Section 126C – Requirements for PRC Plan	
(1) A proposed PRC plan must	-
(a) be in the approved form; and	This PRC Plan
(b) describe the following –	-
(i) each resource tenure, including the area of each tenure, to which the application relates;	Section 3.1.1.3
(ii) the relevant activities to which the application relates;	Section 3.1.4.1
(iii) the likely duration of the relevant activities; and	Section 3.1.4.1
(c) include –	-
(i) a proposed PRCP schedule that complies with section 126D; and	Attachment 1
(ii) a detailed description, including maps, of how and where the relevant activities are to be carried out; and	Sections 3.1.3 and 3.1.4, Figures 10 to 15 and Attachment 1
(iii) details of the consultation undertaken by the applicant in developing the proposed PRC plan; and	Section 3.2.1
(iv) details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan; and	Section 3.2.2
(d) state the extent to which each proposed post-mining land use for land, or non-use management area, identified in the proposed PRCP schedule for the plan is consistent with –	-
(i) the outcome of consultation with the community in developing the plan; and	Sections 3.3.1 and 3.4.1
(ii) any strategies or plans for the land of a local government, the State or the Commonwealth; and	Sections 3.3.2 and 3.4.2
(e) for each proposed post-mining land use for land, state the applicant's proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule; and	Section 3.5
(f) identify the risks of a stable condition for land mentioned in paragraph (e) not being achieved, and how the applicant intends to manage or minimise the risks; and	Section 3.6
(g) for each proposed non-use management area, state the reasons the applicant considers the area can not be rehabilitated to a stable condition because of a matter mentioned in section 126D(2); and	NA[1]

Table 4 (continued)
Reconciliation of Sections 126C and 126D of the Environmental Protection Act

Sections 126C and 126D of the EP Act	Section of this PRC Plan
(h) for each matter mentioned in paragraph (g), include copies of reports or other evidence relied on by the applicant for each proposed non-use management area; and	NA[1]
(i) for each proposed non-use management area, state the applicant's proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area; and	Section 3.5
(j) include the other information the administering authority reasonably considers necessary to decide whether to approve the PRCP schedule for the plan.	This PRC Plan
(2) The matters mentioned in subsection (1), other than the matter mentioned in subsection (1)(c)(i), are the rehabilitation planning part of the proposed PRC Plan.	-
Section 126D – Requirements for proposed PRCP schedule	
(1) A proposed PRCP schedule must—	Attachment 1
(a) for the area of each resource tenure described in the PRC plan, state—	
(i) the proposed post-mining land use for the land; or	
(ii) that the applicant considers the land to be a non-use management area; and	
(b) for each proposed post-mining land use mentioned in paragraph (a)(i), state—	
(i) each rehabilitation milestone required to achieve a stable condition for the land; and	
(ii) when each rehabilitation milestone is to be achieved; and	
(c) for each non-use management area mentioned in paragraph (a)(ii), state—	
(i) each management milestone for the area; and	
(ii) when each management milestone is to be achieved; and	
(d) include maps showing the land mentioned in paragraphs (a), (b) and (c).	
(2) The PRCP schedule may state that land is a non-use management area only if—	NA[1]
(a) carrying out rehabilitation of the land would cause a greater risk of environmental harm than not carrying out the rehabilitation; or	NA[1]
(b) both of the following apply—	NA[1]
(i) the risk of environmental harm as a result of not carrying out rehabilitation of the land is confined to the area of the relevant resource tenure;	NA[1]
(ii) the applicant considers, having regard to each public interest consideration, that it is in the public interest for the land not to be rehabilitated to a stable condition.	NA[1]
(3) Despite subsection (2), if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for rehabilitation of the land to a stable condition.	NA[1, 2]
(4) For subsection (1)(b)(ii), the PRCP schedule must provide for each rehabilitation milestone to be achieved as soon as practicable after the land to which it relates becomes available for rehabilitation.	Section 3.5.1 and Attachment 1

Table 4 (continued)
Reconciliation of Sections 126C and 126D of the Environmental Protection Act

Sections 126C and 126D of the EP Act	Section of this PRC Plan
*(5) For subsection (4), land is **available for rehabilitation** if the land is not being mined, unless—*	Attachment 1
(1) the land is being used for operating infrastructure or machinery for mining, including, for example, a dam or water storage facility; or	
(2) the land is identified in the proposed PRCP schedule or the application for an environmental authority for relevant activities to which the schedule relates as containing a probable or proved ore reserve that is to be mined within 10 years after the land would otherwise have become available for rehabilitation; or	
(ba) the land is required for the mining of a probable or proved ore reserve mentioned in paragraph (b); or	
(3) the land contains permanent infrastructure identified in the proposed PRCP schedule as remaining on the land for a post-mining land use.	
…	

[1] In accordance with section 754(3) of the EP Act, MCPL is not required to comply with a requirement under section 126C(1)(g) or (h) or 126D(2) or (3) for the proposed PRCP Schedule for the plan in relation to land as an outcome for the land has been identified under a land outcome document (EA EPML00716913), and the outcome for the land is the same as, or substantially similar to, the outcome for the land if it were a NUMA under a PRCP Schedule.

[2] The Middlemount Coal Mine in accordance with EA EPML00716913 and section 126C(1)(i)) of the EP Act has pre-approved NUMA's and therefore Section 126D (3) does not apply to this PRCP.

Environmental Protection Regulation 2019

Schedule 8A of the *Environmental Protection Regulation 2019* (the EP Regulation) provides details of the objective assessment for particular PRCP Schedule decisions. The administering authority must consider whether the PRCP Schedule achieves each objective stated in Part 3 of Schedule 8A of the EP Regulation.

Based on the definitions provided in section 750 of the EP Act, the EA for the Middlemount Coal Mine (EA EPML00716913) is the land outcome document. Accordingly, section 213 of the EP Regulation outlines the following transitional provisions that apply:

(213) Carrying out PRCP objective assessment for particular PRCP schedule decision

(1) This section applies if, under section 754 of the Act, the administering authority has given a mining EA holder a notice requiring the holder to give the administering authority a proposed PRC plan.

(2) Schedule 8A, part 3, table 1 does not apply for conducting a PRCP objective assessment of the proposed PRCP schedule for the plan to the extent that—

(a) a land outcome document provides for an outcome for the land the subject of the proposed PRCP schedule; and

(b) the outcome for the land is the same as or substantially similar to the outcome for the land as if it were a post-mining land use or non-use management area under the plan.

(3) Also, the PRCP objective and PRCP performance outcomes stated in schedule 8A, part 3, table 2, entry for 'Rehabilitation Milestones' do not apply for conducting a PRCP objective assessment of the proposed PRCP schedule for the plan to the extent that—

(a) a land outcome document states criteria for achieving an outcome provided for in the document for land; and

(b) the same or substantially similar criteria are proposed in the plan for the outcome.

(4) In addition, the PRCP objective and PRCP performance outcomes stated in schedule 8A, part 3, table 3, entry for 'Management Milestones' do not apply for conducting a PRCP objective assessment of the proposed PRCP schedule for the plan to the extent that—

(a) a land outcome document states criteria for achieving an outcome provided for in the document for land; and

(b) the same or substantially similar criteria are proposed in the plan for the outcome.

…

Progressive Rehabilitation and Closure Plans Guideline

The PRCP Guideline assists applicants in developing a PRC Plan as part of a site-specific application for a new mining activity and for existing EA holders who will be required to develop a PRC Plan under section 754 of the EP Act.

The PRC Plan (the rehabilitation planning part) must meet the information requirements in sections 126C and 126D of the EP Act (unless otherwise stated) (Table 4) and must be written in accordance with the PRCP Guideline. The PRCP Schedule (Attachment 1) operates separately to the EA and contains milestones and conditions that relate to the completion of progressive rehabilitation and mine closure. Both the EA and the PRCP Schedule apply to the entire life of the mining activities, irrespective of when the underlying tenure expires. As per section 202E of the EP Act, where there is an inconsistency between an EA and a PRCP Schedule, the EA prevails to the extent of the inconsistency.

Section 126C(1)(a) of the EP Act requires that '*A PRC Plan must be in the approved form'.* The approved form for a PRC Plan is provided by the DES Application Form *Submission of a progressive rehabilitation and closure plan* (ESR/2019/4957) (herein referred to as the PRCP Application Form). Section 6 of the PRCP Application Form provides a checklist which has been reproduced in Table 5.

This PRC Plan has been structured to be consistent with the requirements outlined in Appendix 1 of the PRCP Application Form. The structure of this PRC Plan is summarised below:

Section 3.1: Provides an overview of the objective of this PRC Plan, details of relevant legislation and an introduction to the Middlemount Coal Mine, including site location details and a description of the Middlemount Coal Mine.

Section 3.2: Provides information on stakeholder consultation, including a community consultation register and community consultation plan.

Section 3.3: Describes the justification for the PMLU and details of each nominated PMLU.

Section 3.4: Describes the justification for the NUMA and details of each nominated NUMA.

Section 3.5: Includes information describing how the proposed rehabilitation and management methodologies have been developed and will be implemented.

Section 3.6: Provides details of the risk assessment undertaken to identify the risk of a stable condition for land not being achieved and also provides a risk treatment plan outlining how the risks will be managed or minimised.

Section 3.7: Provides a monitoring and maintenance program that identifies and describes the monitoring systems that will be undertaken to demonstrate a milestone and milestone criteria have been achieved.

Section 3.8: Lists the references cited in this PRC Plan.

Table 5
Progressive Rehabilitation and Closure Plan – Checklist

PRC Plan Requirement[1]	Requirement Met? (Yes/NA)	Relevant Section Number	Justification[2]
Project Description			
Describe the following:	-	-	-
• each resource tenure, including the area of each tenure to which the application relates;	Yes	Section 3.1.1.3	-
• the relevant activities to which the application relates;	Yes	Section 3.1.4.1	-
• the likely duration of the relevant activities.	Yes	Section 3.1.4.1	-
Include a detailed description, including maps, of how and where the relevant activities are to be carried out.	Yes	Sections 3.1.3 and 3.1.4, Figures 10 to 15 and Attachment 1	-
Consultation			
Include details of the consultation undertaken by the applicant in developing the proposed PRC plan.	Yes	Section 3.2.1	-
Include details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.	Yes	Section 3.2.2	-
PMLU			
State the extent to which each proposed PMLU identified in the proposed PRCP schedule for the plan is consistent with the outcome of consultation with the community in developing the PRC plan.	Yes	Section 3.3.1 and Attachments 1 and 2	The PMLU identified in the PRCP Schedule is compatible with existing surrounding land uses, would enable a productive land use for the site, and is consistent with EA EPML00716913.
State the extent to which each proposed PMLU identified in the proposed PRCP schedule for the plan is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.	Yes	Section 3.3.2 and Attachments 1 and 2	

Table 5 (Continued)
Progressive Rehabilitation and Closure Plan – Checklist

PRC Plan Requirement[1]	Requirement Met? (Yes/NA)	Relevant Section Number	Justification[2]
NUMA[3]			
State the extent to which each proposed NUMA identified in the PRCP schedule for the plan is consistent with the outcome of consultation with the community in developing the PRC plan.	Yes	Section 3.4.1 and Attachments 1 and 2	The NUMAs identified in the PRCP Schedule are consistent with EA EPML00716913.
State the extent to which each NUMA identified in the PRCP schedule for the plan is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.	Yes	Section 3.4.2 and Attachments 1 and 2	
For each proposed NUMA, state the reasons the applicant considers the area cannot be rehabilitated to a stable condition because of a matter mentioned in section 126D(2).	NA	Attachments 1 and 2	
For each matter mentioned in the requirement above, include copies of reports or other evidence relied on by the proponent for each proposed NUMA.	NA	Attachments 1 and 2	
Rehabilitation and Management Methodology[4]			
For each PMLU, state the applicant's proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.	Yes	Section 3.5.1	-
For each NUMA, state the applicant's proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.	Yes	Section 3.5.1	-
Risk Assessment			
Identify the risks of a stable condition for land described as a PMLU not being achieved, and how the applicant intends to manage or minimise the risks.	Yes	Section 3.6	-
PRCP Guideline			
Include any other information prescribed by the administering authority in the PRCP Guideline.	Yes	This PRC Plan	-
Include the spatial information required in the PRCP Guideline.	Yes	Section 3.1.3 and Figures 10 to 15	-
Other Information			
Include the other information the administering authority reasonably considers necessary to decide whether to approve the PRCP schedule.	Yes	This PRC Plan	-

Table 5 (Continued)
Progressive Rehabilitation and Closure Plan – Checklist

PRC Plan Requirement[1]	Requirement Met? (Yes/NA)	Relevant Section Number	Justification[2]
PRCP Schedule[5]			
Include a PRCP schedule prepared using the *PRCP schedule template* (ESR/2019/5103).	Yes	Attachment 1	-
Include maps showing all of the land mentioned in the PRCP schedule, as it relates to being progressively rehabilitated.	Yes	Section 3.1.3 and Figures 10 to 17	-

1 As per the requirements of *Submission of a Progressive Rehabilitation and Closure Plan* (ESR/2019/4957).

2 Justification must be provided for any requirements for which the response is Not Applicable (NA).

3 Note for Transitional PRC plans: The holder is not required to comply with the requirements under section 126C(1)(g) or (h) or 126D(2) or (3) for the proposed PRCP schedule for the plan in relation to land if a land outcome document identifies the outcome for the land as the same, or substantially similar to, the outcome for the land if it were a NUMA.

4 Note: section 3.5 of the PRCP Guideline outlines the range of information that must be included as appendices to the rehabilitation planning part of the PRC plan.

5 The proposed PRCP schedule must comply with section 126D of the EP Act, and be written in accordance with the PRCP Guideline. The administering authority will assess the proposed PRCP schedule in conjunction with the rehabilitation planning part of the PRC plan and other application documents, and decide whether to approve the proposed PRCP schedule, with or without conditions, or refuse the proposed PRCP schedule.

3.1.2 Baseline Information

In 2020, MCPL completed the *Middlemount Coal Mine Southern Extension Project Environmental Values Assessment* (MCPL, 2020a). Studies undertaken for the EVA that are relevant to this PRC Plan include:

- Surface Water Assessment (WRM Water & Environment [WRM], 2020) (Appendix A).
- Groundwater Assessment (Australasian Groundwater and Environmental Consultants Pty Ltd [AGE], 2020) (Appendix B).
- Terrestrial Ecology Assessment (Biodiversity Australia, 2020) (Appendix C).
- Aquatic Ecology Assessment (DPM Envirosciences, 2020) (Appendix D).

To further support the studies undertaken for the EVA and to address the requirements of the PRCP Guideline, a contemporary Mine Waste Geochemical Characterisation (Geo-Environmental Management Pty Ltd [GEM], 2021) and a laboratory rock armour investigation (Landloch Pty Ltd, 2019) was undertaken.

3.1.2.1 Site Topography

The natural topography of the Middlemount Coal Mine is relatively flat, with an elevation ranging from approximately 160 to 170 metres (m) Australian Height Datum (AHD). Approximately 1.5 km to the east of the Middlemount Coal Mine, Middle Mountain rises to an elevation of approximately 280 m AHD (Figure 2) (MCPL, 2020a).

Overall, topography of the region is gently undulating. The local terrain is predominantly non-remnant vegetation and cleared land, with patches (varying in size) of remnant vegetation (MCPL, 2020a).

3.1.2.2 Climate

The Middlemount Coal Mine site has a sub-humid and semi-arid climate, with hot and wet summers, and cool and dry winters. The average daily minimum and maximum temperatures at Emerald Airport (located approximately 90 km south-west of the Middlemount Coal Mine) range between approximately 9 degrees Celsius (°C) (in July) and 35°C (in January).

The average monthly rainfall at the Middlemount Coal Mine exhibits distinctly wet (October to March) and dry (April to September) seasons during the year, with a dry season average low of 16 millimetres (mm) in September and a wet season high of 110 mm in January (BOM, 2021). The wet season average monthly rainfalls (41 mm to 110 mm) are significantly higher than the equivalent dry season average monthly rainfalls (16 mm to 34 mm) (BOM, 2021). The recorded mean annual rainfall at Booroondarra (located approximately 15 km west of the Middlemount Coal Mine) over the 91-year period is approximately 633 mm (BOM, 2021).

The average annual evaporation at Clermont Post Office (approximately 100 km west of the Middlemount Coal Mine) is 2,000 mm to 2,400 mm, which is greater than three times the average annual rainfall. The evaporation rate is high throughout the year, with the highest evaporation rates occurring in the months between October and March. Evaporation rates are typically much higher than rainfall in all months.

Although understanding of climate change has improved markedly over the past several decades, climate change projections are still subject to uncertainties such as (Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2015):

> *…scenario uncertainty, due to the uncertain future emissions and concentrations of greenhouse gases and aerosols; response uncertainty, resulting from limitations in our understanding of the climate system and its representation in climate models; and natural variability uncertainty, the uncertainty stemming from unperturbed variability in the climate system.*

In Australia, the climate is projected to become warmer and drier.

Climate change may result in changes to rainfall patterns, runoff patterns and river flow. Based on the *Climate Change Projections for the east coast cluster* (CSIRO, 2015) the following changes are predicted at the Middlemount Coal Mine from 2090 onwards based on the RCP8.5 results:

- 80 percent (%) of climate change models predicted that annual rainfall would change by between -25 % (reduce by approximately 158 mm) and 14 % (increase by approximately 89 mm); and
- 80 % of climate change models predicted that annual evapotranspiration would change by between 9 % (increase by approximately 190 mm) and 18 % (increase by approximately 400 mm).

The potential implications of climate change to the residual void water balance and on design flood levels were considered in the Middlemount Coal Mine Southern Extension Project EVA (MCPL, 2020a).

3.1.2.3 Geological Setting

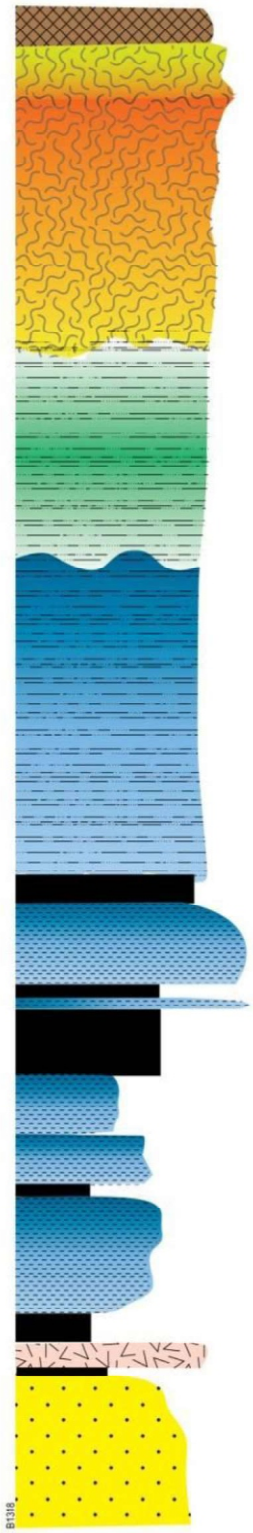
The coal resource at the Middlemount Coal Mine is located within the Permian age Rangal Coal Measures of the Bowen Basin. The Rangal Coal Measures form a relatively narrow (approximately 3 km wide) structure, striking from the north-northwest to south-southeast within and adjacent to the Middlemount Coal Mine tenements. In the locality, a veneer of more recent Tertiary geology and Quaternary geology typically overlies the Bowen Basin strata.

The target coal seams are the Middlemount and Pisces coal seams of the Rangal Coal Measures. These coal seams dip to the east-northeast at between 3 and 7 degrees (°), where they are truncated by the Jellinbah Fault, mapped to be generally coincident with the north-eastern boundary of ML 70379.

The main stratigraphic units occurring within the Middlemount Coal Mine and immediate surrounds, from youngest to oldest, including corresponding hydrogeological systems, are (Figure 3):

- Quaternary – Alluvial aquifer consisting of localised stream channel deposits and associated flood plain deposits.
- Tertiary – Duaringa Formation, consisting of thick, clay-rich laterite sourced from highly weathered Permian sandstones and siltstones, and occasional basalt. The Duaringa Formation is, at best, a low-yielding aquifer that would more commonly be regarded as an aquitard.
- Permian – Inter/overburden is predominantly sandstone, siltstone and mudstone. Coal seams (principally the Middlemount and Pisces Seams) for low to moderate yielding aquifers confined by inter/overburden units.

The physical and chemical properties of each of the above hydrogeological systems (where available) are described in the following subsections and are discussed further in Appendix B.



Soil

Quaternary – alluvium

Tertiary – mottled orange, brown clays, clayey sand and sand.
Upward fining and locally lateritised.

Tertiary – unconsolidated to poorly consolidated sandstone, mudstone

Base of Tertiary (20 m – 35 m)

Permian – Rangal Coal Measures, interbedded sandstone and mudstone

Base of weathering (35 m – 45 m)

Roper Seam (usually 1 – 2 m in thickness)

Mudstone and siltstone with thin sandstone lenses

Middlemount Upper Seam – predominantly dull coal (usually <0.5 m thick)

Middlemount Lower Seam (approximately 4 m thickness)

Mudstone and tuffaceous claystone

Tralee Seam – only present in parts of the deposit (usually <0.5 m in thickness)

Pisces Upper Seam
Yarabee Tuff – Mudstone and tuff bands
Pisces Lower Seam – generally thin (<30 cm) and poorly developed

Fort Cooper Coal Measures/Burngrove Formation

B1318

MCPL-20-04_SE_PRCP_001A

Source: MCPL (2022)

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Indicative Stratigraphy
of the Middlemount Coal Mine

Figure 3

Quaternary Sediments

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 floodplain deposits, because the latter would be expected to have a more clayey nature.

Where saturated, recharge to the alluvium would occur 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 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 in the Quaternary alluvium would 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.

The Quaternary alluvium is not targeted by landholders in the vicinity of the Middlemount Coal Mine as a groundwater supply, which supports the general understanding that the Quaternary alluvium is not a productive aquifer within and surrounding the Project area (Section 3.1.2.5).

Tertiary Sediments

Tertiary sediments of the Duaringa Formation cover large areas of the Middlemount Coal Mine MLs and surrounds. The Duaringa Formation consists of deeply weathered mudstone, sandstone, pebbly sandstone/conglomerate and siltstone, gravel, and some interbedded shale and basalt. This formation unconformably overlies the Permian coal measures.

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 where present and saturated. However, recharge is expected to be low due to the predominately clayey nature of the formation.

Permian Sediments

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.

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.

Private landholder bores do not commonly access the Permian aquifer due to the increased depth to water bearing strata and the typically high salinity of the contained water.

3.1.2.4 Site Hydrology and Fluvial Networks

The Middlemount Coal Mine is located within the Roper Creek catchment, within the Mackenzie River sub-basin of the greater Fitzroy Basin. The Middlemount Coal Mine lies within the area of the *Water Plan (Fitzroy Basin) 2011* (within the Upper Mackenzie Sub-catchment).

Local drainage in the vicinity of the Middlemount Coal Mine includes (Figure 4):

- Roper Creek and its approved (but not fully constructed) diversions;
- the Thirteen Mile Gully Diversion (including associated upstream drainage features, namely Drainage Lines 1 and 2) which diverts the upstream sub-catchments of Thirteen Mile Gully to Roper Creek; and
- an unnamed tributary of Roper Creek (designated 'Drainage Line 3') located immediately east of the Middlemount Coal Mine, which joins Roper Creek approximately 4.2 km downstream of Dysart Middlemount Road (Figure 4).

Roper Creek is an ephemeral watercourse that flows for short time periods following rainfall. The catchment commences about 35 km to the west of the Middlemount Coal Mine. Roper Creek flows into the Mackenzie River some 40 km to the south-east of the Middlemount Coal Mine.

The total catchment area of Roper Creek to the downstream boundary of the Middlemount Coal Mine tenements, including the Thirteen Mile Gully catchment, is approximately 389 square km (km^2).

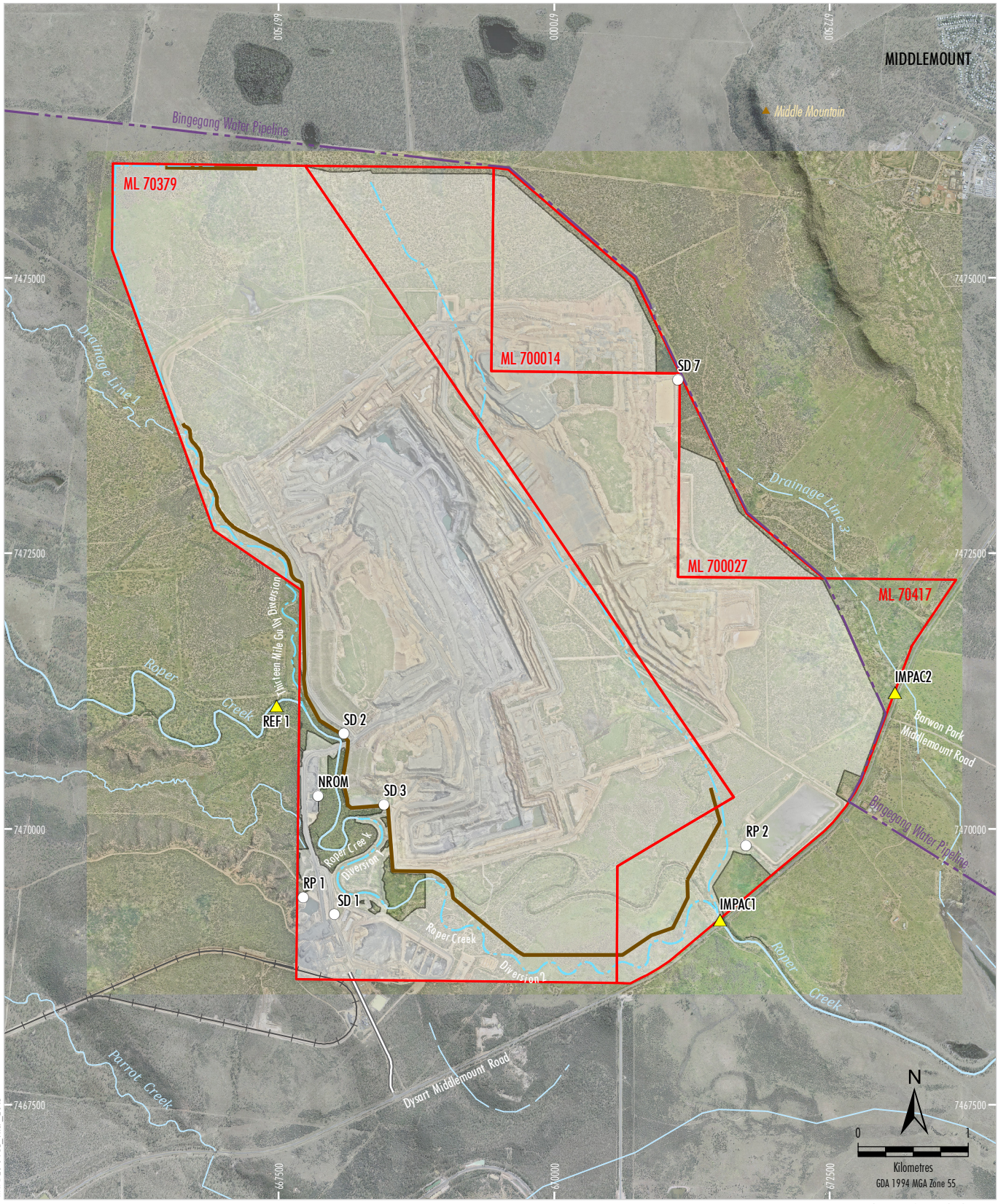
The upstream sub-catchments of Thirteen Mile Gully were diverted along the western boundary of ML 70379 in late 2014. The Thirteen Mile Gully Diversion is authorised under a Water Licence (No. 608025) under the QLD *Water Act 2000* (the Water Act) and two Development Permits under the QLD *Planning Act 2016* (the Planning Act). The existing Thirteen Mile Gully Diversion is shown on Figure 4.

Upstream of the diversion, the sub-catchments of Thirteen Mile Gully drain via two drainage features; Drainage Line 1 (to the north-west) and Drainage Line 2 (to the north) (Figure 4). The former Department of Natural Resources and Mines (DNRM) confirmed that these drainage lines are not watercourses, but rather drainage features defined under the Water Act that facilitate overland flow (DNRM, 2017).

A small portion of Thirteen Mile Gully (approximately 1 km) remains in its pre-mining location (within ML 70417) to the south-east of the Middlemount Coal Mine, which drains south to Roper Creek (Figure 4).

No water resource developments, such as dams or major irrigation infrastructure, are located within the Roper Creek catchment.

Extensive groundwater modelling was undertaken for the Southern Extension Project EVA (MCPL, 2020a) as well as for the Surface Water Assessment (WRM Water, 2020) and Groundwater Impact Assessment (AGE, 2020), to assess the likely long-term water level behaviour of the final voids within the Middlemount Coal Mine. The 0.1 % annual exceedance probability (AEP) design flood model was used to assess the immunity of the residual voids under final landform conditions. Residual void modelling indicated that the final landform void structures are stable and remain as long-term groundwater sinks with the ability to prevent floodwater overflow in a 0.1 % AEP event. It is noted that the work undertaken for the Southern Extension Project EVA refines the QLD Floodplain Assessment Overlay.



MCPL-20-04 SE_PRCP_2048

Source: MCPL (2022); The State of Queensland (2022)
Orthophoto Mosaic: 2021, 2015

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee
- Surface Water Reference Site
- Surface Water Release Point

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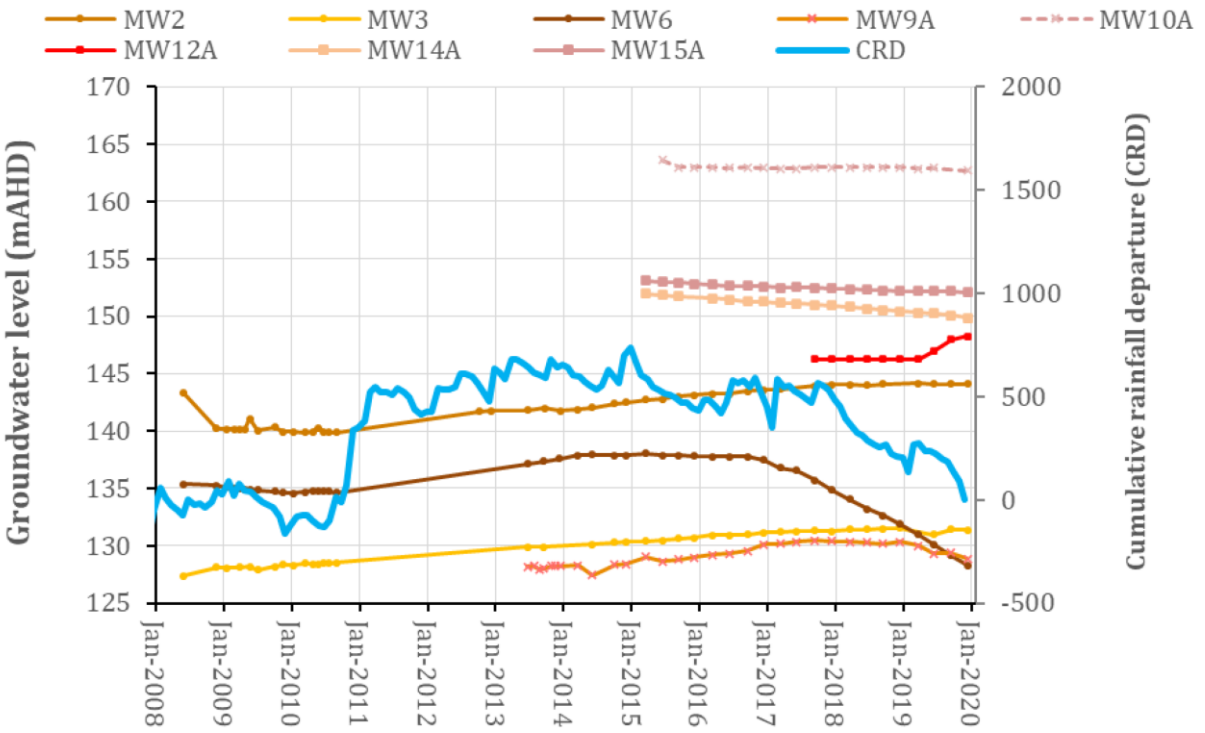
Surface Water Features

Figure 4

3.1.2.5 Groundwater Levels and Properties

Groundwater Levels

Groundwater level data has been collected from the groundwater monitoring bores within the vicinity of the Middlemount Coal Mine from 2008 to present. Plate 1 presents the groundwater level hydrograph for the groundwater monitoring bores.



Source: Figure 6.3 in AGE (2020).

Plate 1 - Groundwater Level Hydrographs

Groundwater levels are between 164.6 m AHD (MW10A) in the north to 127.4 m AHD (MW9A) adjacent to Roper Creek. Depth to water in the monitoring bores ranges from 7.7 m below ground level (mbgl) (MW14A) to 28.9 mbgl (MW9A), with an average depth of 17.3 mbgl.

Groundwater Quality

A review of groundwater quality samples taken between May 2013 and December 2019 was completed by AGE (2020) for the Middlemount Coal Mine Southern Extension EVA.

The review indicated that groundwater in the Tertiary aquifers is brackish to saline, with average electrical conductivity of 19,500 microSiemens per centimetre (mS/cm). On this basis, the groundwater is generally unsuitable for livestock watering. In regard to dissolved metals, selenium and mercury were detected, though levels were below the livestock watering and drinking water guidelines (AGE, 2020). The average concentration of iron was found to exceed the 80th percentile water quality objectives for shallow aquifers (AGE, 2020). Similarly, the average levels of sodium, calcium, magnesium, chloride and sulfate exceed the 80th percentile water quality objectives for shallow aquifers, with the maximum sulfate levels exceeding the stock watering guideline (AGE, 2020).

Bore Census

A bore census (4T Consultants, 2017) was conducted in a study area covering approximately 457 km² across six privately-owned properties, the Middlemount Landfill and the Middlemount Jockey Club (the bore census area). The bore census sought to identify and validate the presence of groundwater bores/features within the bore census area.

The bore census identified that there is limited groundwater use of brackish to saline groundwater in the locality.

The bore census indicated a total of five landholder water supply bores which were across two of the six privately-owned properties within the study area. All five identified water supply bores are located in excess of 5 km from the Middlemount Coal Mine and are located at depths of more than 30 mgbl.

The bore census also confirmed three groundwater monitoring bores located at the Middlemount Landfill established for the landfill operation. All three monitoring bores were dry when assessed for the bore census (4T Consultants, 2017).

3.1.2.6 Soil Types, Properties and Productivity

Soil Types and Properties

Soil types at the Middlemount Coal Mine (within ML 70379, 70417, 700014 and 700027) were described by Parsons Brinkerhoff (2010b). Based on the soil mapping presented in Parsons Brinkerhoff (2010a), six soil units have been identified at the Middlemount Coal Mine (Figure 5):

- Yellow Duplex – sandy loam or sand soils on the flat plains away from drainage lines and on very gently inclined slopes with neutral to moderate acidity, very low salinity and very low organic carbon content.
- Grey-Brown Duplex – sandy to clay loam soils on the flat plains and on the very gently inclined slopes with neutral to slight acidity, very low salinity and low organic carbon content. The subsoils of Grey-Brown Duplex soils are saline.
- Brown Uniform Clay – sandy clay with high clay content that is mildly to moderately alkaline and very low salinity.
- Alluvial Soils – clay loam soils along drainage features with very low salinity and medium organic carbon content.
- Red Lithosol – clay sandy loam to clay loam soils with neutral to strong acidity and very low salinity.
- Warwick – sandy clay to clay (high clay content) with neutral to very strong acidity and very low salinity.

The Yellow Duplex and Grey-Brown Duplex soils have moderate alkalinity, sodicity within the subsoils and are moderately to highly dispersive. The Brown Uniform Clay has poor workability when wet and the Red Lithosol and Warwick soils have negligible to slight potential for dispersion. The Alluvial soils are neutral, have very low salinity and are considered to have a negligible potential for dispersion (Parsons Brinkerhoff, 2010b).

Parsons Brinkerhoff (2010b) concluded that there is a low to negligible risk of acid mine drainage from the overburden at the Middlemount Coal Mine.

Soil Productivity

The Middlemount Coal Mine was assessed for suitability for dry-land cropping and beef cattle grazing on improved pasture land uses (Parsons Brinckerhoff, 2010b) and assigned land suitability classes as outlined in the *Guidelines for Agricultural Land Evaluation in Queensland* (Department of Science, Information Technology and Innovation [DSITI] and DNRM, 2015). The five-class system is based on physical and chemical limiting factors applied directly to specific uses, as described below (DSITI and DNRM, 2015):

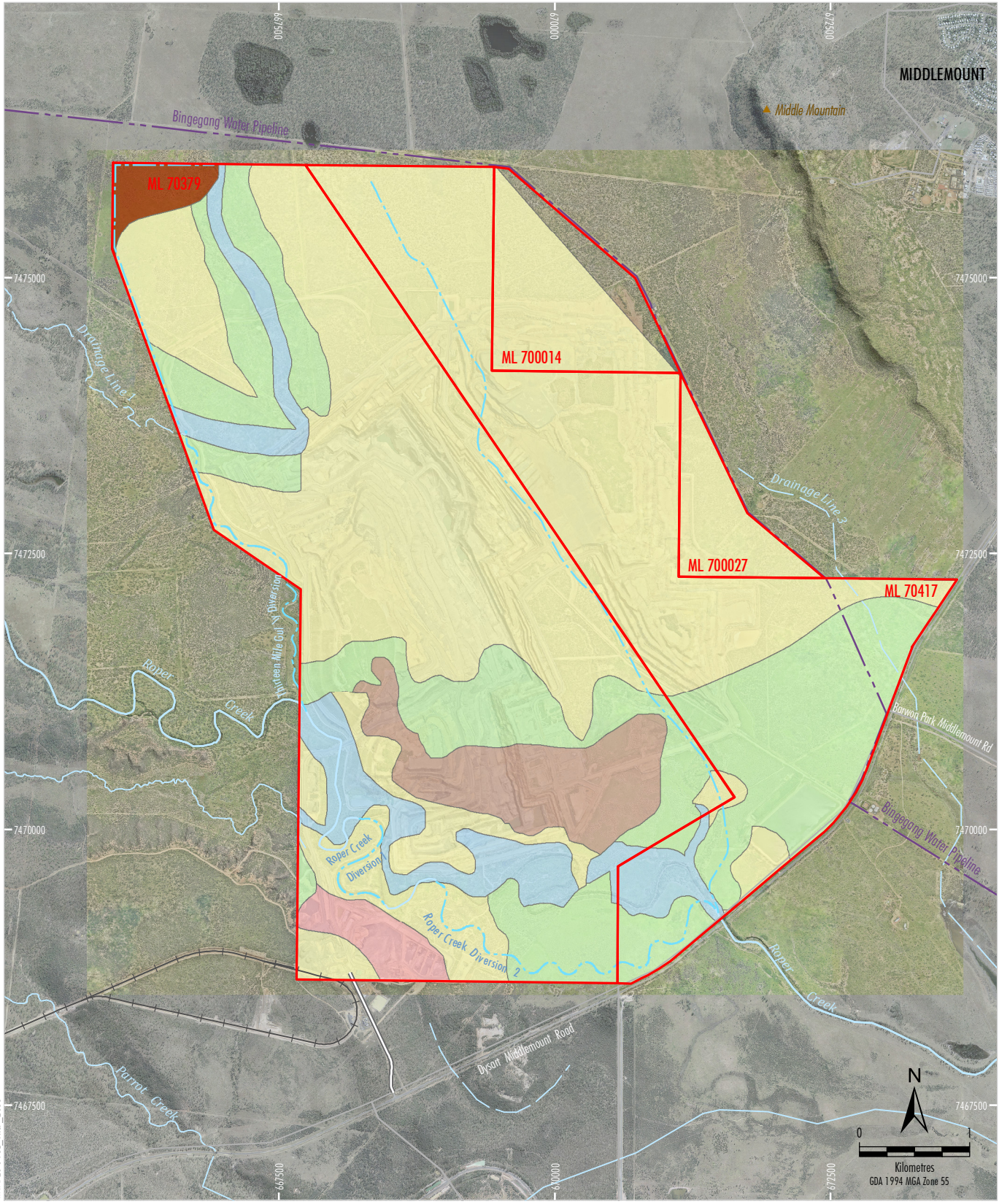
- Class 1 – Suitable land with negligible limitations and is highly productive requiring only simple management practices to maintain economic production.
- Class 2 – Suitable land with minor limitations which either constrain production or require more than the simple management practices of class 1 land to maintain economic production.
- Class 3 – Suitable land with moderate limitations that either further constrain production, or require more than those management practices of class 2 land to maintain economic production.
- Class 4 – Unsuitable land with severe limitations that the sustainable use of the land in the proposed manner is precluded. In some circumstances, the limitations may be surmountable with changes to knowledge, economics or technology.
- Class 5 – Unsuitable land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

The land suitability classification identifies limitations of the different soil types present and identifies suitable uses. Land suitability class is determined by the highest-ranking limiting factor or a combination of a number of factors. In this survey, the main limiting factors which determined low-density beef cattle grazing suitability class include:

- plant available water capacity;
- water erosion;
- nutrient deficiency;
- salinity; and
- soil physical factors.

Table G2 of EA EMPL00716913 specifies the proposed post-mining land use of low density beef cattle grazing with native ecosystem, including the recreation of RE's. Recreating RE's is beneficial for restoring ecological communities and can be applied as an effective post-mining land use. However, the challenge with recreating RE's as suggested by the EA, is the ability to provide a compatible soil structure and composition to allow for the establishment and longevity of these vegetation communities.

Based on the results from the Middlemount Coal Project, Stage 2 Geology, Soils and Land Resource Assessment (Parsons Brinckerhoff, 2010b), the pre-mining land use suitability for the Middlemount Coal Mine comprise classes between Class 2 and Class 4 for both dry land cropping and cattle grazing land uses, with the majority of the Middlemount Coal Mine classified as Class 3 for beef cattle grazing and Class 4 for dry land cropping. It is recognised that the wider Middlemount Coal Mine may contain small areas of Class 5 land.



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure

Soil Type

- Alluvial Soils
- Brown Uniform Clay
- Grey-brown Duplex
- Red Lithosol
- Warwick Soils
- Yellow Duplex

Source: MCPL (2022); The State of Queensland (2022) Orthophoto Mosaic: 2021, 2015

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Soil Unit Mapping

Figure 5

Acid Sulphate Soils

The *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines* (Department of Science, Information Technology, Innovation and the Arts, 2014) states that Acid Sulphate Soils (ASS) are coastal soils and sediments containing iron sulphides (predominately pyrite) which occur naturally over extensive area of low-lying coastal land, commonly below 5 m AHD.

The natural topography is relatively flat, with an elevation ranging from approximately 160 to 170 m AHD. In addition, soil investigations undertaken for the *Middlemount Coal Project Stage 2 Geology, Soils and Land Resource Assessment* (Parsons Brinckerhoff, 2010b) indicated that the topsoil over majority of the Middlemount Coal Mine naturally has low salinity, low organic matter, low nutrient content and neutral to slightly acidic pH. Overburden materials and subsoils were mildly alkaline to very strongly alkaline (pH values above 7.6).

In terms of overburden acid production potential, Parson Brinckerhoff (2010b) undertook overburden assessments for the Middlemount Coal Mine Stage 2 EIS and concluded that selected overburden samples have near zero or negative net acid producing potential in the range of 0.8 to 122-kilogram (kg) H_2SO_4 per tonne (H_2SO_4/t). In addition, net acid generation results of overburden samples indicated that when exposed to oxidising conditions the spoil material does not generate acid and/or the generated acid will be neutralised by other materials present.

Contaminated Land

Lot 3, SP282156 and Lot 2, SP248577, which partially overlap the Middlemount Coal Mine, are listed on the Environmental Management Register (EMR) (DES, 2018) as having livestock dips or spray races. However, plans of these lots indicate that the Middlemount Coal Mine is not likely to disturb areas where evidence of contamination or historical contaminating activities occur as the closest record (a dip site) located approximately 2 km west of the Middlemount Coal Mine (DES, 2018).

Lot 5, SP210524 which partially overlaps the Middlemount Coal Mine, is listed on the EMR as having a livestock dip or spray race. A review of aerial photography, historical registered plans and conversations with land-owners show that the cattle dips associated with these lots are not located within the Middlemount Coal Mine (Parsons Brinkerhoff, 2010b).

Lot 11, TT443, which also partially overlaps the Middlemount Coal Mine, is listed on the EMR as having mine wastes related to (DES, 2018):

- storing hazardous mine or exploration wastes, (e.g. tailings dams, overburden or waste rock dumps containing hazardous contaminants); or
- exploring for, mining, or processing minerals in a way that exposes faces or releases groundwater containing hazardous contaminants.

During site inspections carried out by MCPL, no mine wastes were identified in the portion of Lot 11, TT443 which overlap the Middlemount Coal Mine.

3.1.2.7 Land Stability

The pre-mining land use at the Middlemount Coal Mine is predominantly low-density cattle grazing on native vegetation. The stability and level of degradation of the existing site is consistent with other similar land uses in the area.

The waterways in the vicinity of the Middlemount Coal Mine (including Roper Creek and Thirteen Mile Gully) are ephemeral, experiencing flow only following sustained or intense rainfall in the catchment. Bank stability is generally good, with greater than 50 % of the stream banks covered with vegetation (Appendix D).

There is some potential for erosion within the system during extreme flooding. Riparian zone widths range from 10-35 m throughout the Middlemount Coal Mine (Appendix D).

3.1.2.8 Vegetation Communities and Ecological Data

The Middlemount Coal Mine is located in the Isaac-Comet Downs subregion of the Brigalow Belt North Bioregion. This bioregion extends from Townsville in QLD to the south of Dubbo in central-western New South Wales (NSW).

The closest protected area is Junee National Park which is located approximately 30 km to the east of the Middlemount Coal Mine. Bundoora State Forest is located approximately 25 km to the south-west of the Middlemount Coal Mine.

Clearing for cattle grazing in the region has been extensive, and, as such, the Middlemount Coal Mine contains cleared areas that are currently grazed or have been grazed in the past. Cattle grazing has also resulted in the establishment of fences and stock dams within the Middlemount Coal Mine (Appendix C).

Due to past and ongoing agricultural activities (e.g., clearing, grazing, logging and thinning), it is estimated that approximately 1,876 ha and 1,626 ha of the Middlemount Coal Mine was previously comprised of remnant vegetation and regrowth vegetation (non-remnant) (i.e., prior to mining activities).

The terrestrial flora and fauna in the vicinity of the Middlemount Coal Mine and surrounds have been subject to multiple studies since 2009. Field surveys were undertaken by Parsons Brinkerhoff (2010a) for the Middlemount Coal Mine Stage 2 Project during November 2009 and February/March 2010.

These surveys have since been supplemented by surveys over the existing offset areas undertaken by Ecology and Heritage Partners (2012) in July and August 2012, and across the Middlemount Coal Mine area and adjacent offset areas by Naturecall Environmental (Naturecall) (2014a; 2015a).

Biodiversity Australia (2018a) undertook flora and fauna surveys in the Western Extension Project area and surrounds, with additional surveys conducted in 2020 for the Southern Extension Project (Biodiversity Australia, 2020).

Naturecall (2013; 2014b; 2015b; 2016; 2017) and Biodiversity Australia (2018b; 2019) have also conducted annual monitoring in the existing MCPL offset areas to the west of the Middlemount Coal Mine, which provides additional information on the likely occurrence of flora and fauna within the Middlemount Coal Mine.

Flora surveys were conducted in accordance with the QLD Herbarium vegetation survey methods described in Neldner *et al.* (2020). Survey techniques included a combination of secondary and quaternary surveys, ground-truthing of regional ecosystems (REs), identification of threatened ecological communities under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), targeted searches for conservation significant species listed under the QLD *Nature Conservation Act 1992* (NC Act) and EPBC Act, and random meanders. Terrestrial habitat quality data was also collected in accordance with the *Guide to Determining Terrestrial Habitat Quality Version 1.3* (DES, 2020a).

Fauna surveys were conducted in consideration of the relevant QLD and Commonwealth survey guidelines (Eyre *et al.*, 2018; Department of Sustainability, Environment, Water, Populations and Communities [DSEWPaC], 2011a, 2011b, 2011c; Department of the Environment, Water, Heritage and the Arts [DEWHA], 2010a, 2010b; Department of the Environment [DotE], 2014). Survey methods included spotlighting, microbat call recording and analysis, herpetofauna surveys, diurnal bird surveys, passive infrared camera stations, koala surveys and scat, track and secondary evidence searches (Appendix C).

Targeted searches for threatened fauna species listed under the NC Act and EPBC Act were also conducted (Appendix C).

Endangered and Of Concern Regional Ecosystems

A total of 18 individual REs have been recorded within ML 70379, ML 70417, ML 700027 and ML 700014 and progressively refined through successive surveys since 2010 (undertaken for the Middlemount Coal Project Stage 2 [Parsons Brinckerhoff, 2010a], Western Extension Project [Biodiversity Australia, 2018a] and Southern Extension Project [Biodiversity Australia, 2020]) (Table 6; Figure 6). Ground-truthed REs are generally represented by Eucalypt woodlands and small patches of Acacia dominated woodlands.

The most dominant RE is *Eucalyptus populnea +/- E.melanophloia +/- Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces (RE 11.5.3) encompassing approximately 1,118 ha of the Middlemount Coal Mine.

Of the 18 REs identified, three[1] have a conservation status of 'Endangered' and six have a conservation status of 'Of Concern' under the *Vegetation Management Act 1999* (VM Act) (Table 6, Figure 7).

Conservation Significant Flora Species

Two 'Near Threatened' (under the NC Act) species of plant (*Cerbera dumicola* and *Desmodium macrocarpum*) were located during surveys undertaken by Parsons Brinckerhoff (2010a) for the Middlemount Coal Project Stage 2.

No additional threatened flora species were recording during the field surveys undertaken by Biodiversity Australia for the Western Extension (Biodiversity Australia, 2018a) and Southern Extension (Biodiversity Australia, 2020).

[1] Areas of RE 11.3.1, 11.3.1b, 11.4.9 (which conform to *Acacia hypophylla* Dominant and Co-dominant Threatened Ecological Community [Brigalow TEC] and areas of RE 11.3.21 (which conform to Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin) are listed under the EPBC as 'Endangered'.

Table 6
Ground-truthed Regional Ecosystems

Regional Ecosystem	Short Description	VM Act Status
11.3.1 (BVG 25a)	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plain	Endangered
11.3.1b* (BVG 25a)	*Acacia harpophylla* and/or *Casuarina cristata* open forest.	Endangered
11.3.2 (BVG 17a)	*Eucalyptus populnea* woodland on alluvial plains.	Of Concern
11.3.2b (BVG 17a)	*Eucalyptus camaldulensis* (sometimes *E. populnea* and or *E. tereticornis)* woodland on drainage depressions.	Of Concern
11.3.2c (BVG 17a)	*Eucalyptus populnea* woodlands on floodplains.	Of Concern
11.3.2/11.3.4 (BVG 17a/16c)	*Eucalyptus populnea* woodland on alluvial plains/*Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains.	Of Concern
11.3.7 (BVG 9e)	*Corymbia* spp. open woodland on alluvial plains	Least Concern
11.3.21 (BVG 30a)	*Dichanthium sericeum* and/or *Astrebla* spp. grassland on alluvial plains. Cracking clay soils.	Of Concern^
11.3.25 (BVG 16a)	*Eucalyptus tereticornis* or *E.camaldulensis* woodland fringing drainage lines.	Least Concern
11.3.25e (BVG 16a)	*Eucalyptus camaldulensis*, *E. tereticornis* woodland fringing larger, permanent water courses.	Least Concern
11.3.27d (BVG 34a)	*Eucalyptus camaldulensis* and/or *E. tereticornis woodland.*	Least Concern
11.4.9 (BVG 25a)	*Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains.	Endangered
11.5.3 (BVG 17a)	*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces.	Least Concern
11.5.3b (BVG 17a)	*Eucalyptus populnea* woodland on closed depressions.	Least Concern
11.5.9d (BVG 10a)	*Corymbia citriodora* and/or *E. crebra* woodland	Least Concern
11.5.18 (BVG 29b)	*Micromyrtus capricornia* open shrubland on Cainozoic sand plains and/or remnant surfaces.	Of Concern
11.7.1 (BVG 25a)	*Acacia harpophylla* and/or *Casuarina cristata* and *Eucalyptus thozetiana* or *E. microcarpa* woodland on lower scarp slopes on Cainozoic lateritic duricrust.	Least Concern
11.7.2 (BVG 24a)	*Acacia* spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone.	Least Concern
11.7.4 (BVG 12a)	*Eucalyptus decorticans* and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* woodland on Cainozoic lateritic duricrust	Least Concern

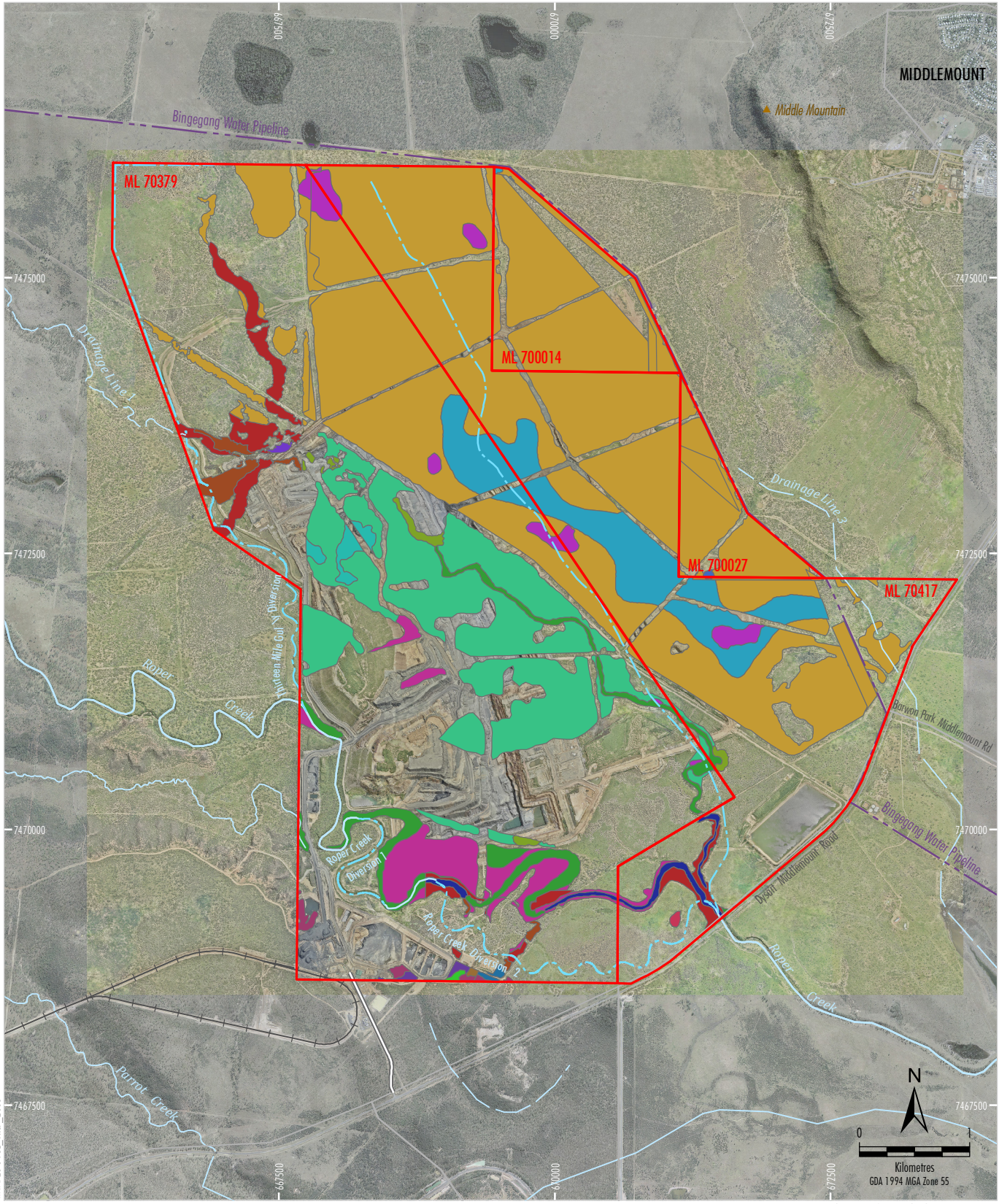
* Listed as Brigalow *(Acacia harpophylla* Dominant and Co-dominant*)* Threatened Ecological Community under the EPBC Act.

^ Current *Vegetation Management Act* status

BVG = Broad Vegetation Group.

VM Act = *Vegetation Management Act 1999*.

After: Parsons Brinckerhoff (2010a), Naturecall (2016) and Biodiversity Australia (2018a; 2020)



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure

Ground-truthed Regional Ecosystems

- 11.3.1
- 11.3.1b
- 11.3.2
- 11.3.2/11.3.4
- 11.3.21
- 11.3.25
- 11.3.25e
- 11.3.27d
- 11.3.2b
- 11.3.2c
- 11.3.7
- 11.4.9
- 11.5.18
- 11.5.3
- 11.5.3b
- 11.5.9d
- 11.7.1
- 11.7.2
- 11.7.4

Source: MCPL (2022); The State of Queensland (2022); Biodiversity Australia (2018; 2020); Parsons Brinkerhoff (2014); Naturecall (2016)
Orthophoto Mosaic: 2021, 2015

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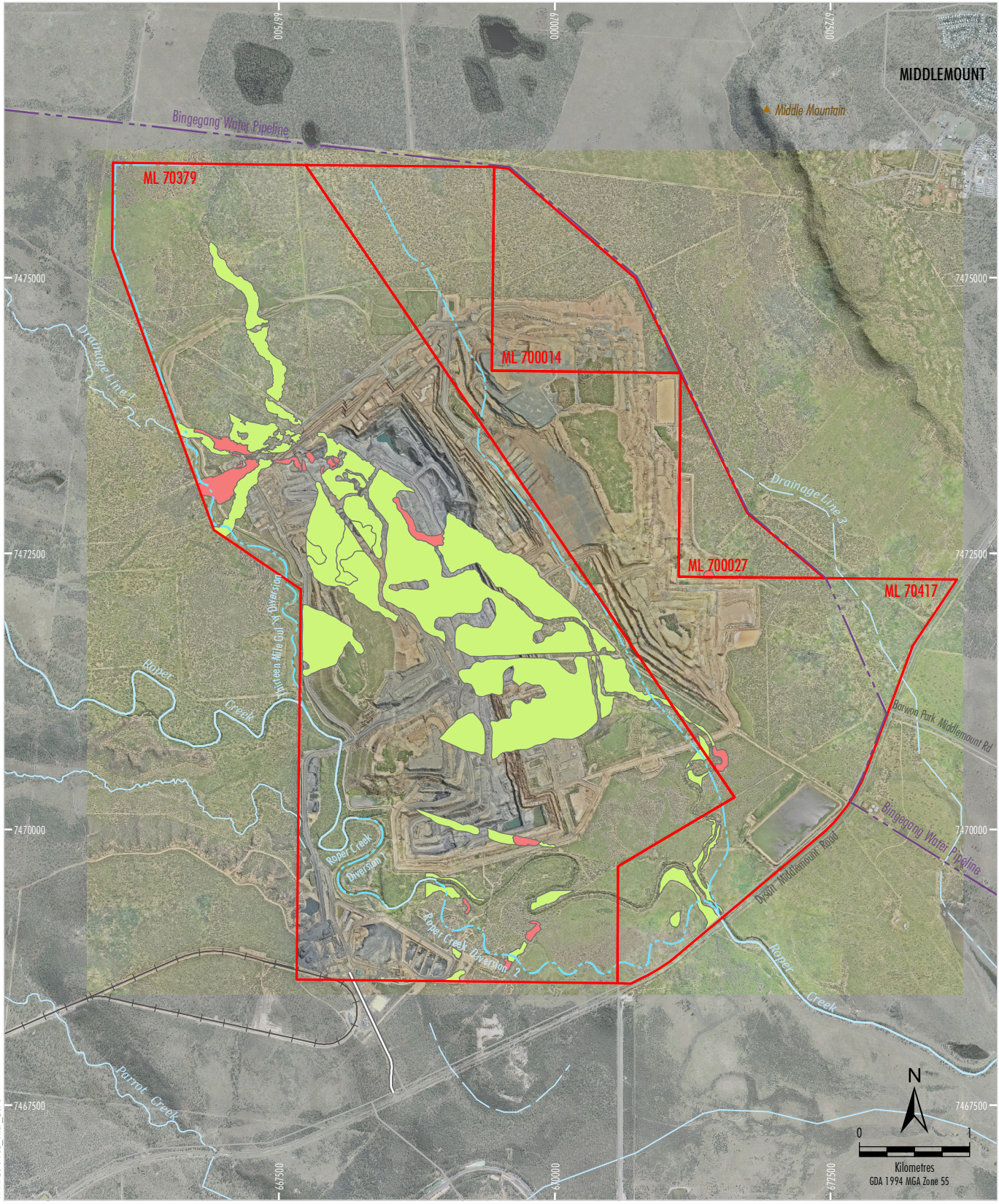
Ground-truthed Regional Ecosystem Mapping

Figure 6



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure

Nature Conservation Act Listing Status

- Endangered Regional Ecosystem
- Of concern Regional Ecosystem

Source: MCPL (2022); The State of Queensland (2022) Orthophoto Mosaic: 2021, 2015

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Endangered and Of Concern Regional Ecosystems

Figure 7

Aquatic Flora

Wet season aquatic ecology surveys were previously undertaken at nine locations within the Middlemount Coal Mine area by FRC Environmental over the periods 7 to 11 December 2009 and 22 to 26 February 2010 (FRC Environmental, 2010). Supplementary aquatic ecology surveys were undertaken at five locations by DPM Enviros ciences (2020) over the periods 14 to 16 October 2019 (a dry season survey aligning with the AusRivAS 'early wet' sampling season of October to December) and 18 to 21 February 2020.

Survey techniques implemented by DPM Enviros ciences (2020) included a combination of AusRivAS protocols to establish descriptions of aquatic habitats and macroinvertebrate communities; presence/absence surveys for aquatic plants (macrophytes); and assessment of aquatic habitat attributes, measurement of in-situ physico chemical water quality, fish survey, turtle survey, and ground truthing mapped lacustrine waterbodies. DPM Enviros ciences (2020) identified one habitat type within the Middlemount Coal Mine area, Riverine Habitat.

Lacustrine and Palustrine Wetlands

Five palustrine wetlands associated with RE 11.3.2d (freshwater wetlands) were ground-truthed by Parsons Brinckerhoff in 2010 as part of the Middlemount Coal Mine Stage 2 EIS (Parsons Brinkerhoff, 2010a) (Figure 8).

Riverine Habitats

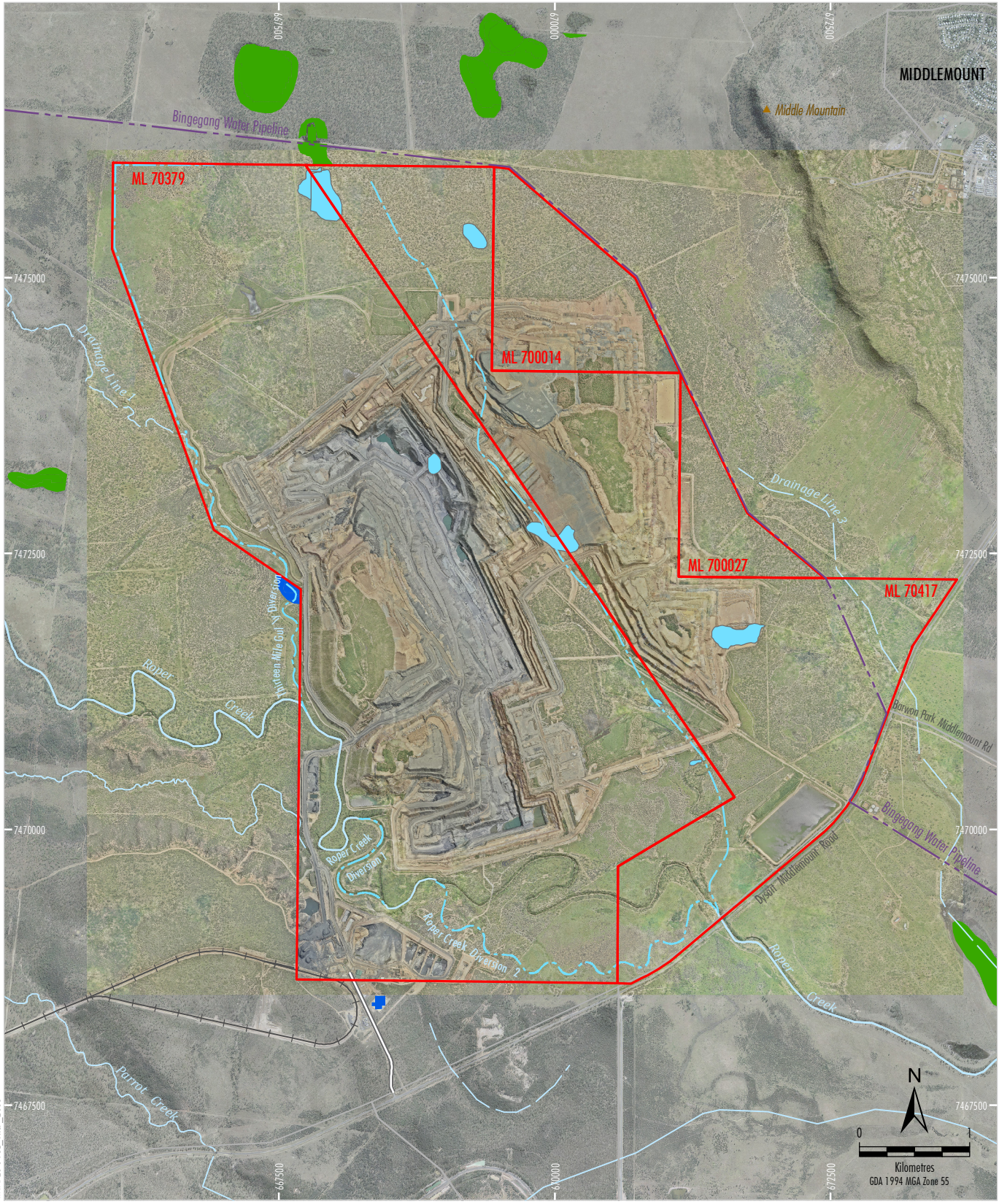
All waterways in the Middlemount Coal Mine area are ephemeral (Appendix D). DPM Enviros ciences (Appendix D) describes that the waterways in the Middlemount Coal Mine area provide only marginal aquatic habitat, with habitat assessment scores of 'poor' or 'fair'. Notwithstanding these habitat assessment scores, Roper Creek was attributed an aquatic value rating of moderate due to its importance as a regional conduit for fish passage.

Groundwater Dependent Ecosystems – Terrestrial Vegetation

Regionally, groundwater flow within the underlying aquifers is towards the south-east of the Middlemount Coal Mine. Groundwater levels are generally in excess of 25 mbgl and separated from surface waters, limiting potential to support Groundwater Dependent Ecosystems (GDEs). There are no surface expressions of these deep confined aquifers within the Middlemount Coal Mine or surrounds that would support GDEs (Appendix B).

Desktop mapping of potential GDEs throughout QLD (Bureau of Meteorology [BoM], 2020) indicated that areas of terrestrial vegetation and aquatic ecosystems in the Middlemount Coal Mine and surrounds had potential to be GDEs (mapped as low potential terrestrial GDE).

Based on the findings of site surveys, it has been established that aquatic GDEs are unlikely to occur in the Middlemount Coal Mine or surrounds (Appendix D).



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Ground-truthed Wetlands

Government Mapped Wetlands

- Lacustrine
- Palustrine

Source: MCPL (2022); The State of Queensland (2022)
Orthophoto Mosaic: 2021, 2015

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Wetlands

Figure 8

Environmentally Sensitive Areas

The Environmentally Sensitive Areas (ESA) mapping tool (DEHP, 2014a) does not identify any Category A or C ESAs within the Middlemount Coal Mine. However, as described above, three 'Endangered' REs, constituting Category B ESAs, were ground-truthed by Parsons Brinckerhoff (2010a) and Biodiversity Australia (2018a) (i.e., RE 11.3.1, RE 11.3.1b and RE 11.4.9).

Matters of State Environmental Significance

Matters of State Environmental Significance (MSES) are defined under Schedule 2 of the Environmental Offsets Regulation 2009 and include REs listed as 'Endangered' and 'Of Concern' under the VM Act and Connectivity Areas (i.e. non-remnant vegetation, Regional Ecosystems which intersect mapped wetlands and waterways etc.) (Table 7).

Table 7
Matters of State Environmental Significance – Flora

Matters of State Environmental Significance			Relevance to the Middlemount Coal Mine
Regulated Vegetation	'Endangered' or 'of concern' regional ecosystems[1]	RE 11.3.1, 11.3.1b 'Endangered'	Approximately 22.5 ha of remnant RE 11.3.1 and 11.3.1b occurs in the west and south of the Middlemount Coal Mine (Figure 7)
		RE 11.4.9 'Endangered'	RE 11.4.9 constitutes a small patch (approximately 0.5 ha) of vegetation to the east of the Middlemount Coal Mine.
		RE 11.3.2, 11.3.2b, 11.3.2c 'Of Concern'	RE 11.3.2 occurs to the west and south of the Middlemount Coal Mine. RE 11.3.2b was recorded to the south adjacent Roper Creek Diversion 2, and RE 11.3.2c occurs within the centre of the Middlemount Coal Mine. All three RE encompasses a combined area of approximately 384 ha.
		RE 11.3.2/11.3.4 'Of Concern'	RE 11.3.2/11.3.4 occurs as small patches (approximately 1.5 ha) to the south and west of the Middlemount Coal Mine.
		RE 11.5.18 'Of Concern'	RE 11.5.18 occurs as a single patch (approximately 1.2 ha) of open shrubland to the south of the Middlemount Coal Mine.
		RE 11.3.21 'Of Concern'	RE 11.3.21 occurs as small patches (approximately 11 ha) to the west of the Middlemount Coal Mine.
	Regional ecosystems within mapped vegetation management wetlands		The Middlemount Coal Mine does not contain any mapped vegetation management wetlands.
	Regional ecosystems within the defined distance of a vegetation management watercourse		RE 11.3.2 and 11.3.25, 11.3.25e occur along Roper Creek and associated Diversion 1 and 2.
Connectivity Areas			The *Landscape Fragmentation and Connectivity Tool* (DES, 2020b) was applied to the Middlemount Coal Mine and concluded that the Middlemount Coal Mine exceeded the threshold for an impact on connectivity and fragmentation (MCPL, 2020a).
Wetlands and Watercourses			No wetlands or watercourses of high ecological significance were recorded within the Middlemount Coal Mine.
Designated Precinct in a Strategic Environmental Area			The Middlemount Coal Mine is not in a designated precinct in a strategic environmental area.

Table 7 (continued)
Matters of State Environmental Significance – Flora

Matters of State Environmental Significance	Relevance to the Middlemount Coal Mine
Protected Areas	There are no protected areas in the Middlemount Coal Mine.
Highly Protected Zones of State Marine Parks	There are no State marine parks in the Middlemount Coal Mine.
Marine Plants	Marine plants do not occur in the Middlemount Coal Mine.
Legally Secured Offset Areas	There are no legally secured offset areas located within the Middlemount Coal Mine.

Source: Appendices C and D.

Matters of National Environmental Significance

Patches of RE 11.3.1, RE 11.3.1b and RE 11.4.9 within the Middlemount Coal Mine ML's were assessed as part of the Western and Southern Extension Projects against the relevant threshold criteria for Brigalow (*Acacia harpophylla* dominant and co-dominant). Following assessment, approximately 26 ha were determined to meet the requirements of Brigalow TEC. Brigalow TEC is listed as 'Endangered' under EPBC Act and constitutes a Matter of National Environmental Significance (MNES).

3.1.2.9 Fauna Presence and Populations

Terrestrial Fauna Habitat

Due to past and ongoing agricultural activities, the Middlemount Coal Mine area predominantly consists of non-remnant regrowth vegetation and cleared land. Patches of remnant vegetation, most of which likely was disturbed by previous land use practices, are present within the largely disturbed landscape.

Biodiversity Australia (2020) concluded that the southern portion of the Middlemount Coal Mine provides small patches of suitable habitat for the *Denisonia maculate* (Ornamental Snake) in the form of Brigalow habitats with gilgai and drainage depressions providing habitat for preferred prey species (i.e. frogs).

Given that a number of targeted surveys undertaken by Biodiversity Australia (2020) and other consultants since 2010 have not detected this species within the Southern Extension, it is considered to be a low to fair chance of occurrence within the potential habitat in Middlemount Coal Mine. Removal of a relatively small extent of potential habitat for the Southern Extension while a negative impact, was concluded to unlikely lead to a long-term decrease in the local population.

Most of the regrowth comprises of the dominant species, which occurred prior to the clearing and fast-growing species like exotic grasses.

Broad fauna habitats identified at the Middlemount Coal Mine include (Parsons Brinckerhoff 2010a, Naturecall, 2014, Biodiversity Australia 2018 and 2020a):

- Eucalypt woodland/forest.
- Riparian Eucalypt woodland.
- Acacia harpophylla woodland/forest.
- Acacia shirleyi forest.
- Regrowth vegetation.
- Wetlands (natural/artificial).

- Brigalow forest.
- Lancewood forest.
- Micromyrtus shrubland.
- Cleared grassland.

Conservation Significant Fauna Species Listed under the NC Act

Fauna surveys have recorded four listed threatened fauna species under the NC Act at the Middlemount Coal Mine (Figure 9):

- Squatter Pigeon (southern) (*Geophaps scripta scripta*) – Vulnerable (EPCB Act), Threatened (NC Act);
- Ornamental Snake (*Denisonia maculata*) – Vulnerable (EPCB Act), Vulnerable (NC Act);
- Koala (*Phascolarctos cinereus*) – Vulnerable (EPBC Act), Threatened (NC Act); and,
- Greater Glider (*Petauroides Volans*) - Vulnerable (EPBC Act), Vulnerable (NC Act).

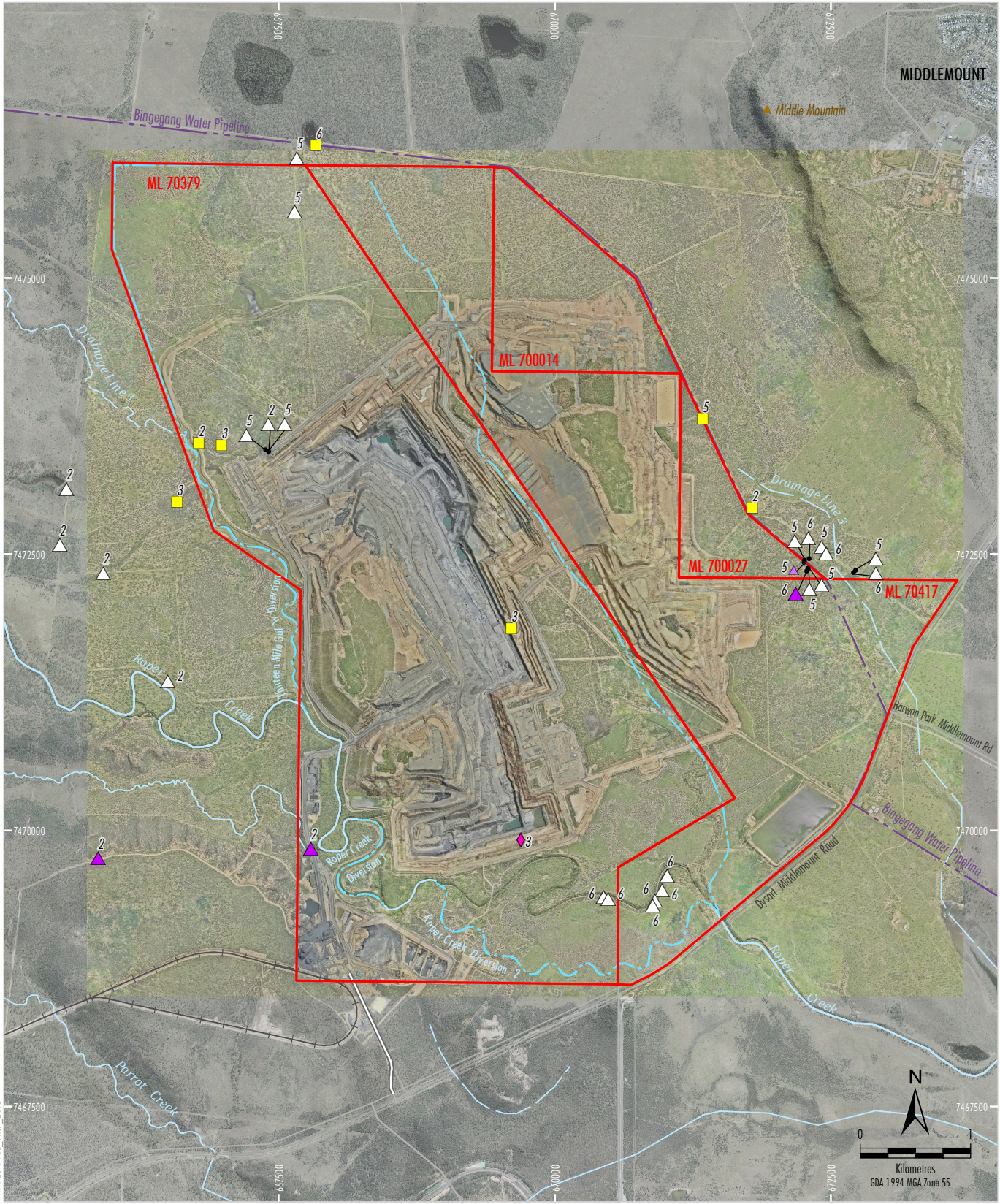
Matters of State Environmental Significance

Two species which constitute MSES were recorded during field surveys at the Middlemount Coal Mine undertaken by Parsons Brinckerhoff (2010a), the Ornamental Snake and Squatter Pigeon. During fauna surveys undertaken by Biodiversity Australia for the Western Extension Project (Biodiversity Australia, 2018a) and Southern Extension Project (Biodiversity Australia (2020), the Greater Glider and the Koala were additional species recorded that constitute MSES (Table 8). The Echidna was also recorded which is a Special Least Concern species.

Table 8
Matters of State Environmental Significance – Fauna

Matters of State Environmental Significance		Relevance to the Middlemount Coal Mine Area
Protected Wildlife Habitat[1]	Ornamental Snake	Small area of potential habitat within the Middlemount Coal Mine area.
	Greater Glider	Multiple recordings of the Greater Glider in the Middlemount Coal Mine area.
	Koala	The Koala has had few recordings within the project area, however primary food resources for this species are associated with riparian vegetation.
	Squatter Pigeon (Southern)	Squatter Pigeon is present in Middlemount Coal Mine area.
Regulated Vegetation	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	This vegetation is present in the Middlemount Coal Mine area.
	Eucalyptus populnea woodland on alluvial plains	
	Remnant vegetation within 5m of the defining bank of Roper Creek	
	Riparian vegetation	
Waterways Providing for Fish Passage		During the wet season Roper Creek is considered a waterway for fish. Roper Creek and Thirteen Mile Gully diversion channels are expected to maintain the waterways for fish passage during the mining stage.

Source: Appendices C and D.



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure

Conservation Significant Species Records

- Squatter Pigeon (Southern)
- Ornamental Snake
- Greater Glider
- Koala
- Koala Scats

Reference:
2 Naturecall Environmental (2014)
3 Parsons Brinkerhoff (2010)
5 Naturecall Environmental (2017)
6 Biodiversity Australia (2020)

Source: MCPL (2022); The State of Queensland (2022)
Orthophoto Mosaic: 2021, 2015

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Conservation Significant Species Records

Figure 9

Matters of National Environmental Significance

Two species (Ornamental Snake and Squatter Pigeon) were recorded by Parsons Brinckerhoff (2010a) during the Middlemount Coal Project Stage 2 surveys. Additional MNES recorded during the Western and Southern Extension surveys (Biodiversity Australia, 2018a; 2020) included the Ornamental Snake, Squatter Pigeon, Greater Glider and Koala. The Echidna was recorded outside the Western and Southern study areas and is not listed as a MNES.

On the 21 December 2017, MCPL lodged a referral for the Western Extension with the Department of Environment and Energy (DEE) to determine whether the Western Extension needed formal assessment and approval under the EPBC Act. An action requires approval under the EPBC Act if the action is likely to have a significant impact on MNES. On 8 February 2018, a delegate of the Commonwealth Minister declared the Western Extension to be a 'Controlled Action' for the purposes of the EPBC Act, with the following controlling provisions:

- Listed threatened species and communities (sections 18 and 18A).
- A water resource, in relation to coal seam gas development and large coal mining development (sections 24D and 24E).

In addition, on 20 May 2021, MCPL lodged a referral for the Southern Extension with the Department of Agriculture, Water and the Environment (DAWE) to determine whether the Southern Extension needed formal assessment and approval under the EPBC Act. On 17 June 2021, a delegate of the Commonwealth Minister declared the Southern Extension to be a "Controlled Action" for the purposes of the EPBC Act, with the following controlling provisions:

- Listed threatened species and communities (sections 18 and 18A).
- A water resource (sections 24D and 24E).

3.1.2.10 Pre-mining Land Use

Major land use within the entire region is primarily known for agricultural, forestry and fishery activities and coal mining. The pre-mining land use of the project site is agriculture (grazing and cropping) and coal mining.

In addition, the Middlemount Coal Mine area has been identified as having key resource and coal/mineral resource attributes. No Strategic Cropping Land (SCL) is mapped within, or in the vicinity of the Project (DNRME, 2020).

3.1.2.11 Underlying Landholders

Tenements

As described in section 3.1.1.3, four Mining Leases exist within the Middlemount Coal Mine, ML 70379, ML 70417, ML 700014 and ML 700027 all of which are held by MCPL.

Several overlapping Petroleum tenures exist within the Middlemount Coal Mine, including, one overlapping EPC tenure, EPC 855 held by Foxleigh Coal, two PCA's, PCA 135 and PCA 136 both held by CH4 Pty Ltd and one ATP tenure, ATP 1103, also held by CH4 Pty Ltd.

Native Title Claims/Applications

There are two Native Title claimants within the Middlemount Coal Mine area:

- Barada Barna People – who have an active registered native title claim (Queensland QC08/11 QUD380/08)

- Barada Barana, Kanalbara & Yetimarla People #4 (BBKY #4) – who have a finalised (dismissed) native title claim (Queensland QC01/25 QUD6023/01).

Landholders

Table 9 below identifies the Lots on Plan which intersect the Middlemount Coal Mine. The majority of the Middlemount Coal Mine is located on freehold land owned by Middlemount Coal Pty Ltd. A small portion of the Middlemount Coal Mine is located on Lot 11, TT443, which is owned by Anglo Coal Pty Ltd.

Table 9
Landholders (Lot and DP) within the Middlemount Coal Mine

Lot/Plan	Reference Number	Tenure
2/SP248577	50896228	Middlemount Coal Pty Ltd
3/SP282156	51052854	Middlemount Coal Pty Ltd
5/SP210524	50716193	Middlemount Coal Pty Ltd
11/TT443	40075759	Anglo Coal (Capcoal Management) Pty Ltd

3.1.3 Designing for Closure

The Middlemount Coal Mine rehabilitation strategy will aim on establishing non-polluting, safe, stable, and able to support a self-sustaining PMLU. The Middlemount Coal Mine has been designed to:

- Be rehabilitated to a safe final landform to humans and wildlife:
  - A safety bund wall will be constructed out of competent rock and/or fencing with a minimum height of 2 m base width of 4 m and be located at least 10 m beyond any area potentially affected by any final void instability.
- Have a non-polluting final landform:
  - Both residual voids are not predicted to spill under any of the simulated climatic sequences.
  - Both residual voids will remain as long-term groundwater sinks, preventing the flow of hyper saline final void water out of the voids.
- Ensure that the final landform is stable:
  - In-pit and out-of-pit waste rock emplacements will be contoured to an angle of less than (<) 18.5% and will utilise rock mulch to achieve greater stability if greater than (>) 16 %.
  - Residual void highwalls would be treated (e.g. benched or blasted) so that they are geotechnically stable.
- Able to sustain a PLMU:
  - The areas proposed to be disturbed by the Project would be rehabilitated to sustain native ecosystem, consistent with EA EPML00716913.
  - Rehabilitation towards the PMLU of native ecosystem at the Middlemount Coal Mine is undertaken progressively within two years of areas becoming available within the operational land.

3.1.4 Rehabilitation/Improvement Planning

Consistent with EA EPML00716913, the approved PMLU of the Middlemount Coal Mine is low-intensity beef cattle grazing with native ecosystem. As part of the PRC Plan, MCPL is proposing to transition the approved EA PMLU into the PRC Plan PMLU (Section 3.5).

Condition G9 of the EA EPML00716913 (reproduced below) provides the overall rehabilitation objective for the Middlemount Coal Mine:

> *All areas significantly disturbed by mining activities must be rehabilitated to a safe, stable and non-polluting landform, with a self-sustaining vegetation cover (except for the residual voids), in accordance with:*
>
> - *Table G1: Landform Design Criteria;*
> - *Table G2: Final Land Use and Rehabilitation Approval Schedule;*
> - *Table G3: Residual Void Design;*
> - *Table G4: Rehabilitation Schedule;*
> - *Attachment C: Final Landform;*
> - *Attachment F: Rehabilitation Requirements; and*
> - *As otherwise detailed in Condition G21.*

Further detail on the approved PMLU and NUMAs for the Middlemount Coal Mine is provided in Sections 3.3 and 3.4.

Mine planning is a structured process that takes into account a range of key variables that may influence a potential mining operation and its viability. Aspects that are considered within the mining process includes safety, resource recovery, geotechnical constraints, management of potential environmental impacts (e.g. noise, air quality, water, coal rejects), community issues, risks to the operation, mining methods and rates, equipment requirements and economics (i.e capital and operating costs).

To facilitate rehabilitation at the Middlemount Coal Mine, progressive rehabilitation has been undertaken at different areas across the Middlemount Coal Mine. Progressive rehabilitation is undertaken on land that is able to be actively rehabilitated, with relative mining activities ceasing within the area. The progressive development of the Middlemount Coal Mine is evident on Figures 10 to 15.

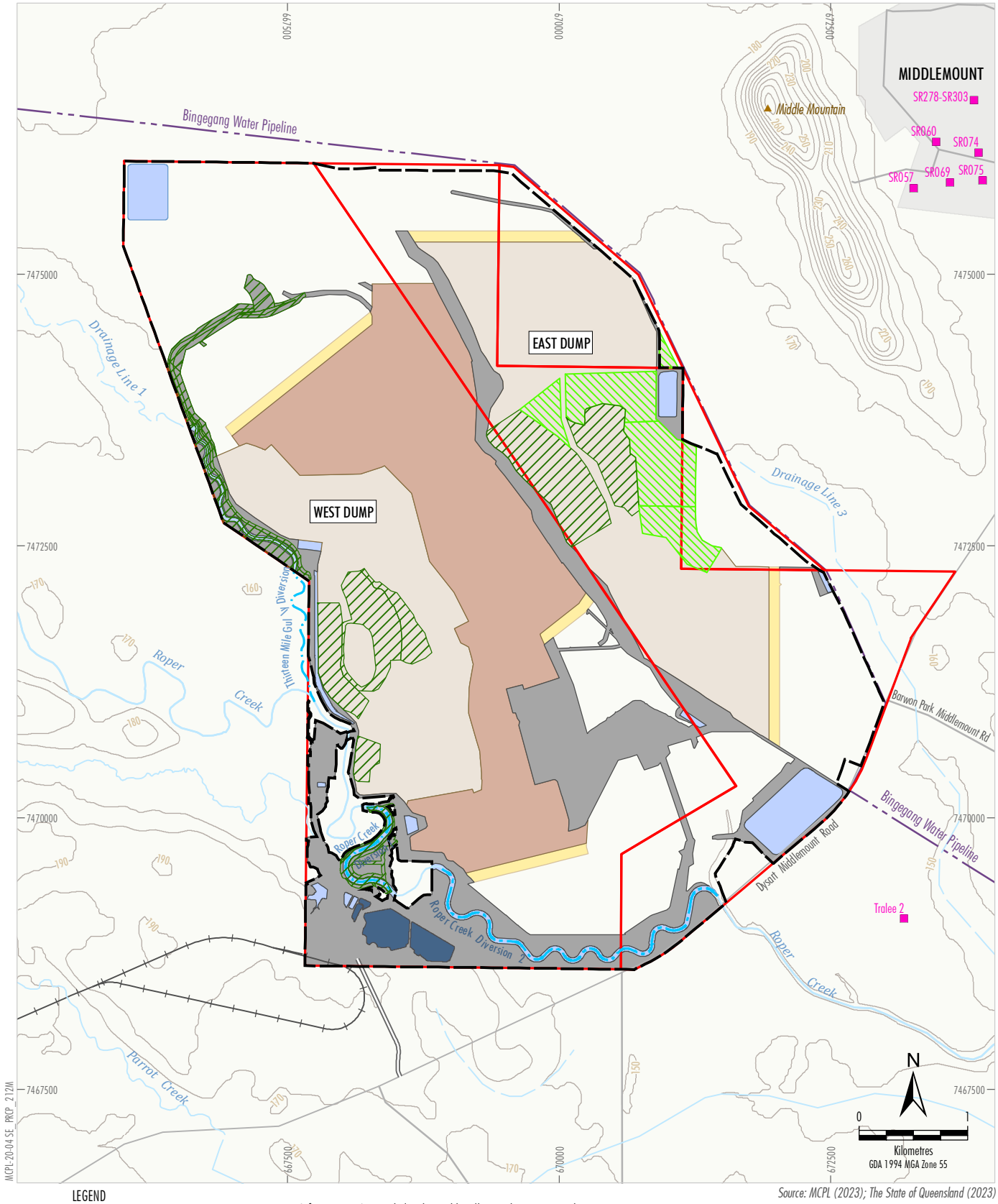
3.1.4.1 Relevant Activities

The PMLU is shown on Figure 16. For the purpose of this PRC Plan, MCPL has defined Rehabilitation Areas and Improvement Areas as outlined on Figure 17. These areas are based upon the progressive development and rehabilitation plans provided within Figures 10 to 14, and the approved final landform in Figure 15. Progressive stage plans will continue to be developed at regular intervals to inform rehabilitation and operational activities over the life of the Middlemount Coal Mine.

Table 10 provides details of the relevant activities (i.e predicted duration, size/extent and ability to progressively rehabilitate during the activity) that will be undertaken at each of the Rehabilitation Areas and Improvement Areas throughout the life of the Middlemount Coal Mine.

Table 10
Relevant Mining Activities

Area	Relevant Activity	Size (ha)	Date of Activity Commencement	Date of Activity Completion	Able to Progressively Rehabilitate?
Rehabilitation Areas					
RA1	Waste Rock Emplacement	819	Already Commenced	2043	Yes
RA2	Waste Rock Emplacement	32	Already Commenced	2021	Yes
RA3	Waste Rock Emplacement	1,341	Already Commenced	2043	Yes
RA4	Tailings Storage Facility	23	Already Commenced	2043	Yes
RA5	Infrastructure Area	415	Already Commenced	2043	Yes
RA6	Water Management Infrastructure (Mine Water Dams)	57	Already Commenced	2043	No (Section 3.5.7)
RA7	Water Management Infrastructure (Sediment Dams)	23	Already Commenced	2043	No (Section 3.5.7)
RA8	Water Management Infrastructure (Diversions)	75	Already Commenced	2043	No (Section 3.5.7)
Improvement Areas					
IA1	Residual Void	358	Already Commenced	2044	No
IA2	Residual Void	163	2023	2044	No



Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Diversion Structure
- Sensitive Receiver

Project Domains

- Topsoil Stripping
- Open Cut Mining Area
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Rehabilitation Domains

- Indicative Area Available for Rehabilitation *
- Active Rehabilitation Area **

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power reticulation, temporary offices, other ancillary works (e.g. exploration activities) and construction disturbance.

* Areas considered "Available for Rehabilitation" are indicative only based on estimated rates of rehabilitation. The location of rehabilitation undertaken in a given year may vary although the total areas would remain consistent with the PRCP Schedule.

** Areas considered "Active Rehabilitation" are those in which rehabilitation has commenced.

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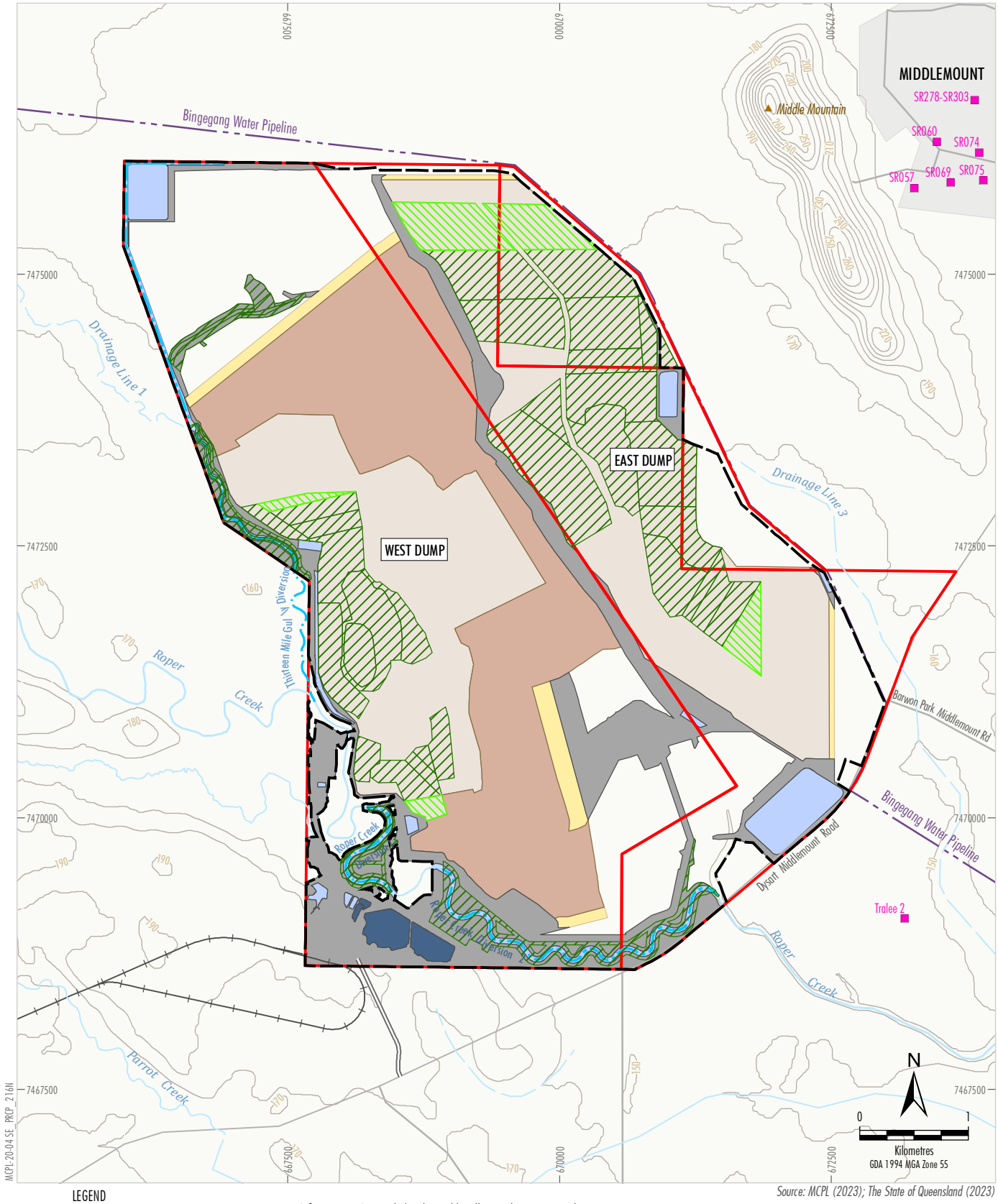
Progressive Development and Rehabilitation 2023

Figure 10



MCPL-20-04 SE_PRCP_216N

Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Diversion Structure
- Sensitive Receiver

Project Domains

- Topsoil Stripping
- Open Cut Mining Area
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Rehabilitation Domains

- Indicative Area Available for Rehabilitation *
- Active Rehabilitation Area **

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power reticulation, temporary offices, other ancillary works (e.g. exploration activities) and construction disturbance.

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** Areas considered "Active Rehabilitation" are those in which rehabilitation has commenced.

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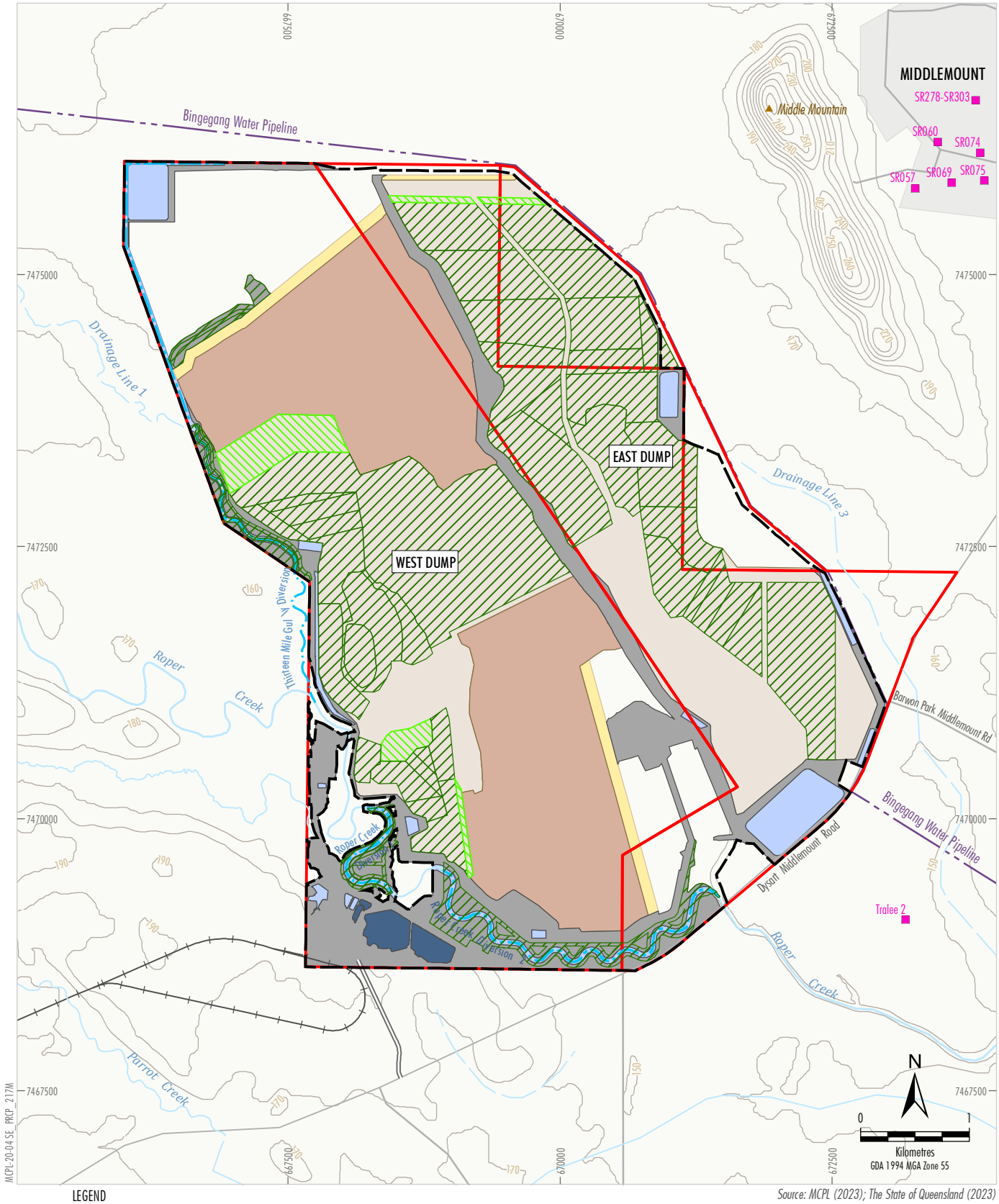
Progressive Development and Rehabilitation 2028

Figure 11



Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Diversion Structure
- Sensitive Receiver

Project Domains

- Topsoil Stripping
- Open Cut Mining Area
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Rehabilitation Domains

- Indicative Area Available for Rehabilitation *
- Active Rehabilitation Area **

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power reticulation, temporary offices, other ancillary works (e.g. exploration activities) and construction disturbance.

* Areas considered "Available for Rehabilitation" are indicative only based on estimated rates of rehabilitation. The location of rehabilitation undertaken in a given year may vary although the total areas would remain consistent with the PRCP Schedule.

** Areas considered "Active Rehabilitation" are those in which rehabilitation has commenced.

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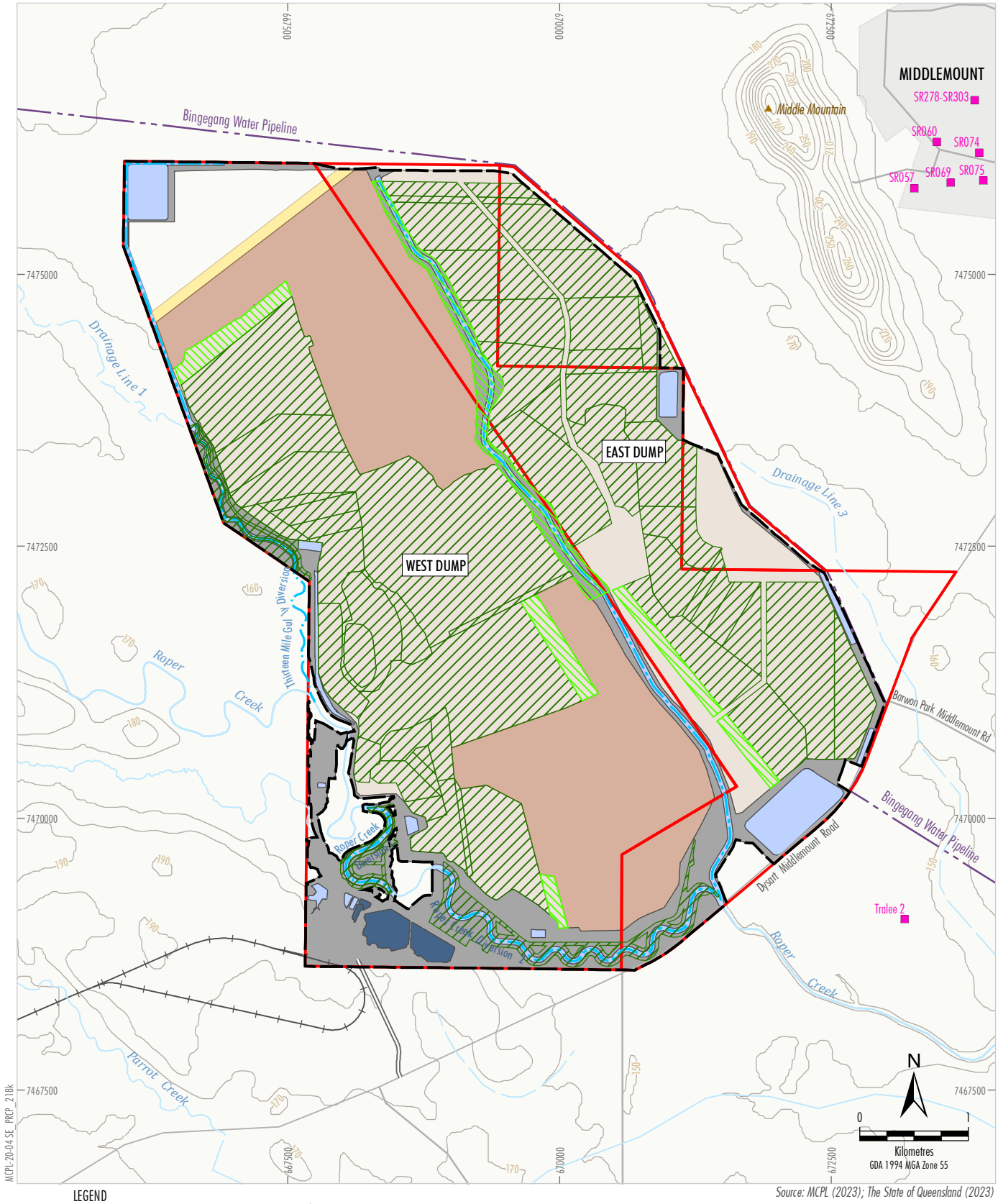
MIDDLEMOUNT COAL MINE

Progressive Development and Rehabilitation 2032

Figure 12

MCPL-20-04 SE_PRCP_217M



Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Diversion Structure
- Sensitive Receiver

Project Domains

- Topsoil Stripping
- Open Cut Mining Area
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Rehabilitation Domains

- Indicative Area Available for Rehabilitation *
- Active Rehabilitation Area **

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power reticulation, temporary offices, other ancillary works (e.g. exploration activities) and construction disturbance.

* Areas considered "Available for Rehabilitation" are indicative only based on estimated rates of rehabilitation. The location of rehabilitation undertaken in a given year may vary although the total areas would remain consistent with the PRCP Schedule.

** Areas considered "Active Rehabilitation" are those in which rehabilitation has commenced.

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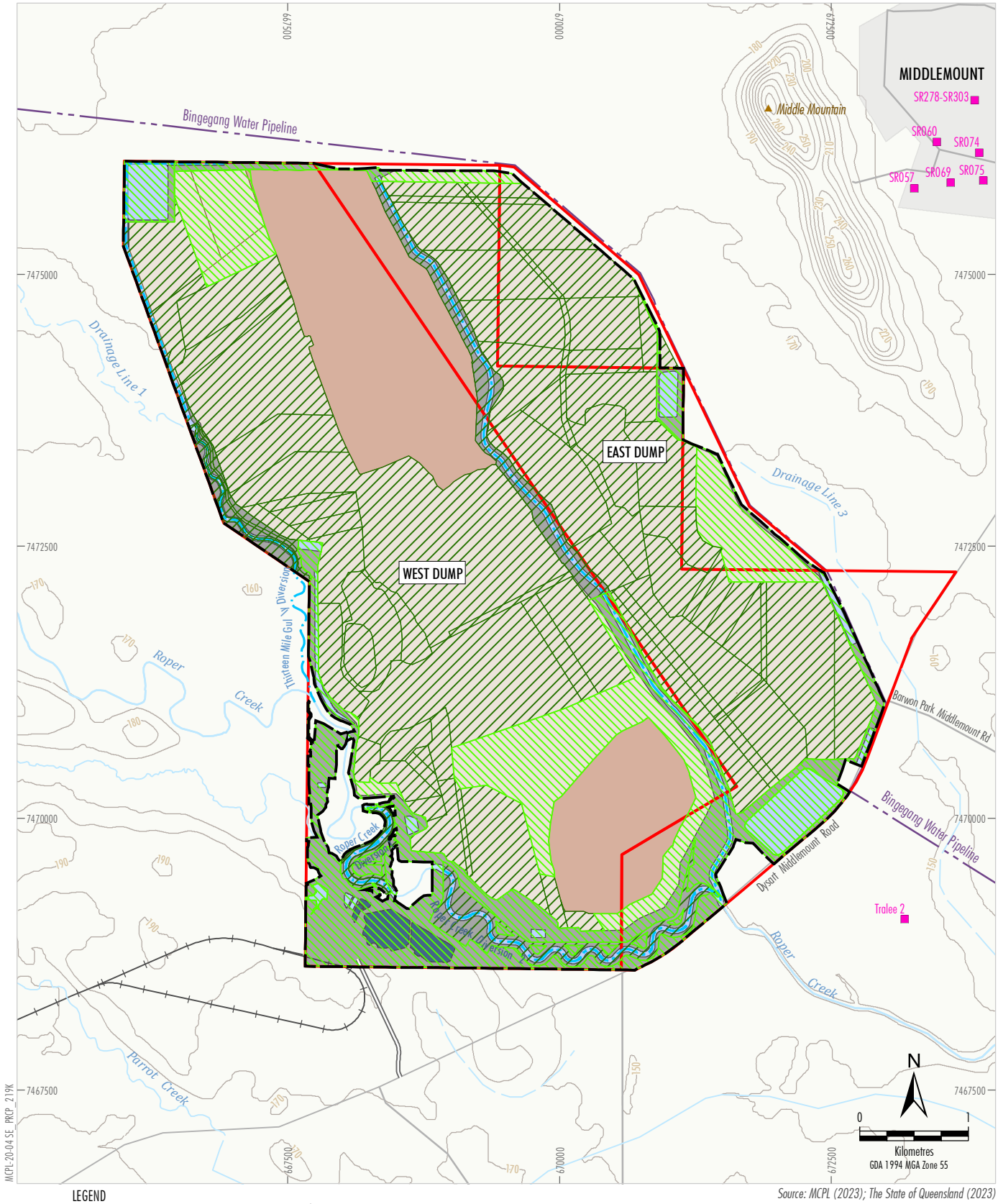
MIDDLEMOUNT COAL MINE

Progressive Development and Rehabilitation 2037

Figure 13

MCPL-20-04 SE_PRCP_218k



Source: MCPL (2023); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Diversion Structure
- Sensitive Receiver

Project Domains

- Open Cut Mining Area
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Rehabilitation Domains

- Indicative Area Available for Rehabilitation *
- Active Rehabilitation Area **

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power reticulation, temporary offices, other ancillary works (e.g. exploration activities) and construction disturbance.

* Areas considered "Available for Rehabilitation" are indicative only based on estimated rates of rehabilitation. The location of rehabilitation undertaken in a given year may vary although the total areas would remain consistent with the PRCP Schedule.

** Areas considered "Active Rehabilitation" are those in which rehabilitation has commenced.

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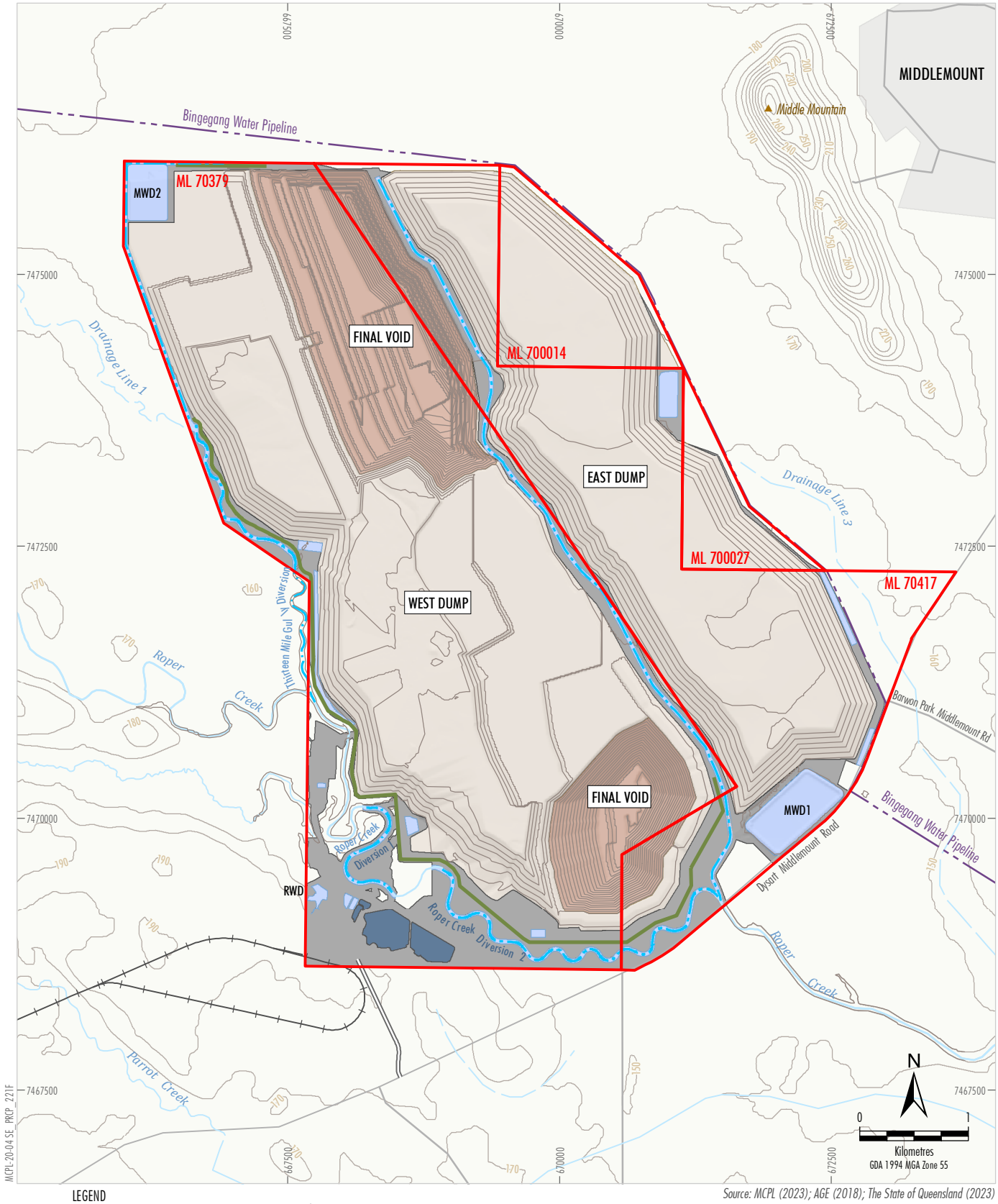
MIDDLEMOUNT COAL MINE

Progressive Development and Rehabilitation 2044

Figure 14



MCPL-20-04 SE_PRCP_221F

Source: MCPL (2023); AGE (2018); The State of Queensland (2023)

LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop (Retained or Rehabilitated)
- Mine Access Road
- Diversion Structure
- Levee (Rehabilitated)
- Final Landform Contour (10 m)

Project Domains

- Final Void
- Waste Rock Emplacement
- Infrastructure Area #
- Tailings Storage Facility
- Water Management

Infrastructure Area includes the coal handling and preparation plant, coal stockpiles, administration buildings, rail loop, rail load-out infrastructure, haul roads, bunding, hardstands, minor water management infrastructure, access tracks, topsoil stockpiles, explosives magazine, power

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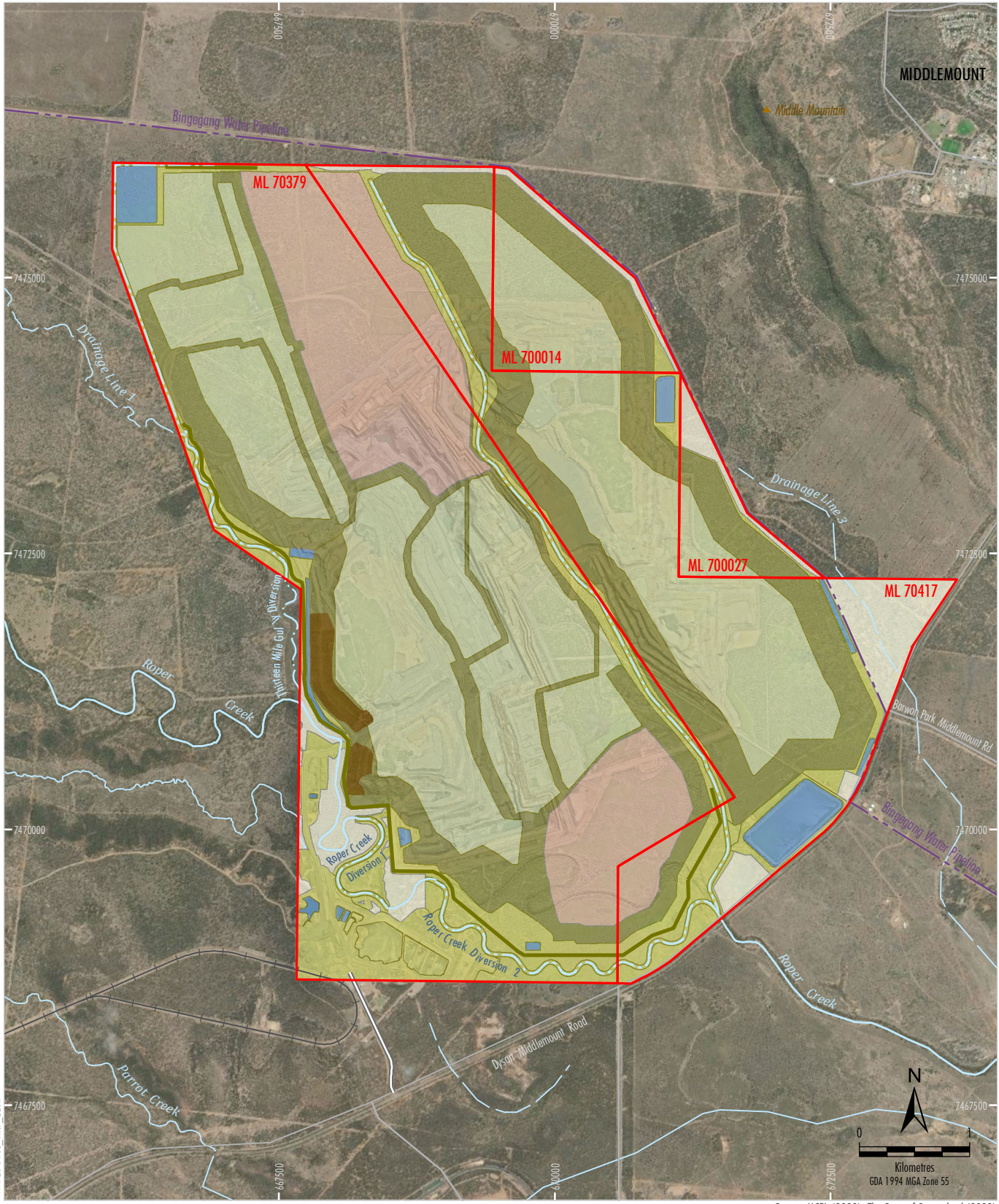
MIDDLEMOUNT COAL MINE

Progressive Development and Final Landform

Figure 15



Source: MCPL (2023); The State of Queensland (2023)

MCPL-20-04 SE_PKP_223H

LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee (Rehabilitated)

Post-mining Land Use Areas

- Native Ecosystem
- Native Ecosystem (Flat/Undulating)
- Native Ecosystem (Slope <16%)
- Native Ecosystem (Slope >16%)
- Grazing (Retained Water Management Infrastructure)
- Existing Grazing Pasture

Non-use Management Area

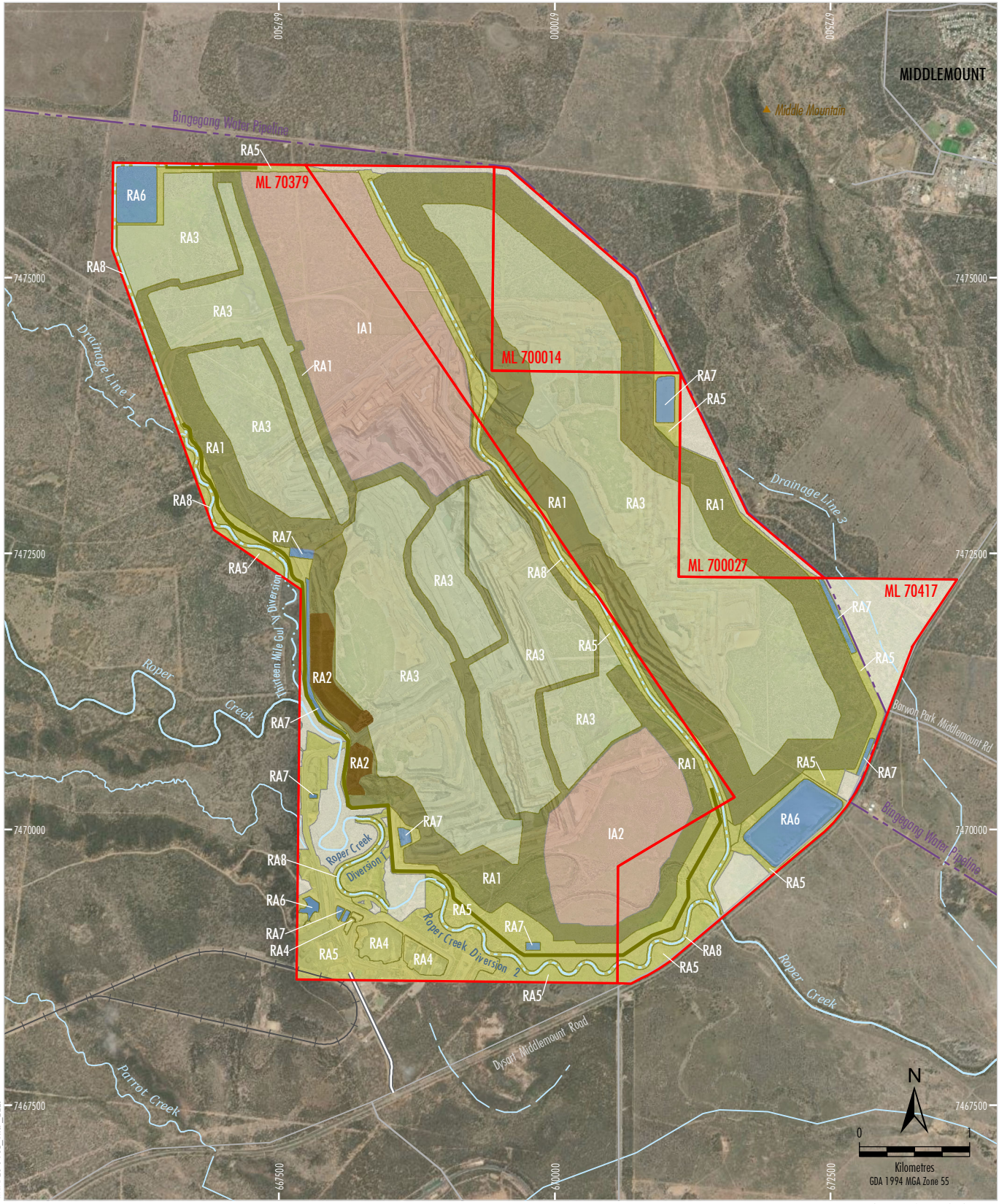
- Residual Void

middlemount coal PTY LTD

MIDDLEMOUNT COAL MINE

Proposed Post-mining Land Uses and Non-use Management Areas

Figure 16



MCPL-20-04 SE_PRCP_222J

LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee (Rehabilitated)

Post-mining Land Use Areas

- Native Ecosystem
- Native Ecosystem (Flat/Undulating)
- Native Ecosystem (Slope <16%)
- Native Ecosystem (Slope >16%)
- Grazing (Retained Water Management Infrastructure)
- Existing Grazing Pasture

Non-use Management Area

- Residual Void

Source: MCPL (2023); The State of Queensland (2022)
Orthophoto Mosaic: 2021, 2015

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MIDDLEMOUNT COAL MINE

Rehabilitation Areas and Improvement Areas

Figure 17

3.1.4.2 Rehabilitation Undertaken to Date

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

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

Rehabilitation at the Middlemount Coal Mine (Plate 2) has been progressively undertaken since 2015. Progressive rehabilitation to date (i.e. up to December 2021) has commenced across approximately 194 ha at the Middlemount Coal Mine (Figure 10, Table 11). All areas of rehabilitation at the Middlemount Coal Mine are subject to ongoing monitoring and maintenance activities including reporting within the annual Rehabilitation Monitoring Programme.

Plate 2: Cover Crop species present on 5 month old rehabilitation at the Middlemount Coal Mine.

Plate 3: Intermediate pasture with emerging Acacia species present at the Middlemount Coal Mine.

Existing rehabilitation at the Middlemount Coal Mine whilst commenced, has not yet been assessed against the proposed rehabilitation milestones presented in this PRC Plan. Following approval of this PRC Plan areas of existing rehabilitation will be assessed against the approved rehabilitation milestones and success criteria to determine which milestone each area is currently up to and if any rework is required.

Table 11
Progressive Rehabilitation Undertaken to Date

Area	PMLU	Size of Area (ha)	Rehabilitation Milestone[1]	Progression of Rehabilitation Undertaken to Date (ha)[1]
RA1	Native Ecosystem (slopes <16%)	819	RM1	4
			RM3	4
			RM4	4
			RM5	-
			RM6	-
			RM7	-
			RM8	-
RA2	Native Ecosystem (slopes >16%)	32	RM1	28
			RM3	28
			RM4	28
			RM5	-
			RM6	-
			RM7	-
			RM8	-
RA3	Native Ecosystem	1,341	RM1	94
			RM3	94
			RM4	94
			RM5	-
			RM6	-
			RM7	-
			RM8	-
RA5	Native Ecosystem	415	RM1	29
			RM2	29
			RM4	29
			RM5	-
			RM6	-
			RM7	-
			RM8	-
RA8	Native Ecosystem	75	RM1	16
			RM4	16
			RM5	-
			RM6	-
			RM7	-
			RM8	-

[1] Rehabilitation only reported once all milestone criteria for a given rehabilitation milestone are completed.

The PRCP Schedule (Attachment 1) includes the status of the rehabilitation activities undertaken so far. Work undertaken to date is generally limited to the completion of activities associated with RM1, RM2 RM3 and RM4 which primarily relate to decommissioning, remediation of contaminated land and landform development and reshaping/re-profiling. Activities associated with other rehabilitation milestones (e.g. RM5 and RM6) have also commenced at the Middlemount Coal Mine, however they have not yet progressed to a point where these milestones are considered to be completed. Rehabilitation activities undertaken prior to the preparation of the PRC Plan and PRCP Schedule were completed in accordance with the methodologies outlined in the Rehabilitation Management Plan (MCPL, 2012), which is the approved land outcome document (and has been superseded by this PRC Plan).

Future rehabilitation activities will continue to progress through the remaining rehabilitation milestones relevant to each area (e.g. RM5 to RM9). MCPL has not yet applied for, or received, progressive certification from DES for any of the rehabilitation completed to date

3.2 COMMUNITY CONSULTATION

3.2.1 Community Consultation Register

MCPL has undertaken extensive consultation with key stakeholders regarding the PMLU of the Middlemount Coal Mine. Consultation to date has been conducted with the neighbouring landholders, local community, Aboriginal stakeholders, key State and Commonwealth government agencies, Isaac Regional Council and relevant infrastructure owners.

Consultation with the above relevant stakeholders was undertaken for:

- Middlemount Coal Mine Southern Extension Project;
- Middlemount Coal Mine Western Extension Project; and
- Middlemount Coal Mine Stage 2 EIS.

Consultation has also been undertaken with the relevant groups during the preparation of the PRC Plan and PRCP Schedule and will continue to be undertaken for the life of the Middlemount Coal Mine.

A summary of the consultation undertaken to date (where relevant to the PRC Plan) is provided below. Details of any issues raised during consultation regarding rehabilitation and PMLU at the Middlemount Coal Mine and how the issues were considered during the preparation of the PRC Plan and PRCP Schedule are provided in Table 12.

3.2.1.1 Local Community

Community Reference Group

A Community Reference Group (CRG) was established for the Middlemount Coal Mine comprising representatives from the local communities, neighbouring landholders, Isaac Regional Council and MCPL. The CRG provides a mechanism for ongoing communication between MCPL and the local community. MCPL consulted with the CRG on a regular basis throughout the preparation of the Middlemount Coal Mine Southern Extension Project and Western Extension Project.

During the preparation of the PRC Plan and PRCP Schedule, MCPL has arranged consultation with the CRG in Q2 2022 to provide an overview of the PRC Plan and PRCP Schedule process and a summary of key elements including overall timing, PMLU, NUMAs and the additional assessments being undertaken. MCPL will continue to liaise with the CRG throughout the preparation and finalisation of the PRCP.

Adjacent/Underlying Landholders

During the preparation of the PRC Plan and PRCP Schedule, MCPL distributed a briefing to neighbouring (and other local) landholders in Q1 2022, to provide an overview of the PRC Plan and PRCP Schedule process and as summary of key elements including overall timing, PMLU, NUMAs and the additional assessments being undertaken. No responses to the overview have been received to date.

MCPL undertakes regular consultation with the neighbouring landholders regarding mitigation of potential impacts through mechanisms such as negotiated agreements or property acquisitions.

Table 12
Community Consultation Register

Stakeholder	Key Objectives and Information to be Provided	Consultation Activities and Engagement Method	Consultation Date	Issues Raised	How Issues Have Been Considered	Outcomes, Decisions and/or Commitments
Government Agencies						
Department of Environment and Science (DES)	Summary of key elements including overall timing, community consultation plan, PMLUs, NUMAs, completion criteria and supporting assessments being undertaken.	Pre-lodgement Meeting (videoconference) /Email	10 May 2021	-	MCPL considered the feedback provided by DES and has used this feedback to develop the PRC Plan and PRCP Schedule, consistent with previous commitments in EA EPML00716913 and the EVA.	
	Draft PRC Plan and PRCP Schedule provided to DES for review and feedback.	Email	May 2022			
	Final PRC Plan and PRCP Schedule submitted to DES for assessment.	Email	June 2022			
Department of Resources (DoR)	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLUs, NUMAs and supporting assessments being undertaken.	Email/Letter	May 2022	No issues raised to date.	-	-
Local Government						
Isaac Regional Council	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLUs, NUMAs and supporting assessments being undertaken.	Letter/Presentation	21 June 2022	No issues raised to date.	-	-
Surrounding Landholders						
Affected (Underlying and Adjoining) Landholders	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLUs, NUMAs and supporting assessments being undertaken.	Email/Letter	May 2022	No issues raised to date.	-	-

Table 12 (Continued)
Community Consultation Register

Stakeholder	Key Objectives and Information to be Provided	Consultation Activities and Engagement Method	Consultation Date	Issues Raised	How Issues Have Been Considered	Outcomes, Decisions and/or Commitments
Local Community Groups						
Community Reference Group	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLU, NUMAs and assessments being undertaken.	Letter/Presentation	May 2022	No issues raised to date.	-	-
Local Community and Groups	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLU, NUMAs and assessments being undertaken.	Community Newsletter/Website	Dec 2021	No issues raised to date.	-	-
Other Community Members	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLU, NUMAs and assessments being undertaken.	Website	Dec 2021	No issues raised to date.	-	-
Traditional Owners						
Aboriginal Community	Overview of PRC Plan and PRCP Schedule process and summary of key elements including overall timing, PMLU, NUMAs and assessments being undertaken.	Email/Letter	Dec 2021	No issues raised to date.	-	-

Other Local Community Members

A dedicated Middlemount Coal Mine community information line (07 4985 0000) has been established for community members (including neighbouring landholders) to contact MCPL with any questions they may have, and relevant information has been, or will be, made publicly available on the Middlemount Coal Mine website.

3.2.1.2 Aboriginal Community

Cultural Heritage Management Plans (CHMPs) have been formed with the Barada Barna People, the Barada Barna Aboriginal Corporation (as the prescribed body corporate for the Barada Barna People) and the Barada Barna Kabalbara and Yetimarla People #4 (BBKY #4).

As part of the Middlemount Coal Mine Stage 2 Environmental Impact Statement (EIS), CHMPs were formed in consultation with the Barada Barna People in May 2010 and with the BBKY #4 in September 2010. The CHMPs covered MCPL and Ribfield Pty Ltd as tenement holders. The CHMP formed with Barada Barna People covered the northern portions of ML 70379, MLA 70417, MDL 282 and EPC 1225 and the CHMP formed with the BBKY #4 covered the remaining (southern) portions including ML 70379, MLA 70417 and MDL 282.

As part of the Middlemount Coal Mine Western Extension Project, MCPL met with the Barada Barna People to form a new CHMP for the additional area that was not covered by the existing CHMPs.

As part of the Middlemount Coal Mine Southern Extension Project, consultation with the Aboriginal Community was undertaken during preparation of the EVA.

In Q1 2022, during the preparation of the PRC Plan and PRCP Schedule, MCPL distributed a briefing to the Barada Barna People, the Barada Barna Aboriginal Corporation and the BBKY #4 to provide an overview of the PRC Plan and PRCP Schedule process and a summary of key elements including overall timing, PMLUs, NUMAs and the supporting assessments being undertaken. No responses to the briefing have been received to date.

3.2.1.3 Queensland State Government Agencies

MCPL consults with relevant QLD State Government agencies on a regular basis in relation to the current operations at the Middlemount Coal Mine. MCPL undertook extensive consultation with the QLD State Government regarding the Southern Extension Project in 2020.

Consultation with QLD State Government agencies regarding the PRC Plan and PRCP Schedule is ongoing. Consultation undertaken to date are discussed below.

Department of Environment and Science

On 10 May 2021, MCPL met with DES to discuss the preparation of the PRC Plan and PRCP Schedule. MCPL provided a summary of the key elements including the overall timing, community consultation plan, PMLUs, NUMAs and supporting assessments being undertaken. The key objectives for the meeting were related to the final voids, public notification process, PRC Plan and PRCP Schedule scope and the proposed community consultation plan. Feedback from DES was used to inform the preparation of the PRC Plan and PRCP Schedule. In Q2 2022, MCPL provided a preliminary draft of the PRC Plan and PRCP Schedule to DES for their review. High-level advice with regards to the draft PRC Plan and PRCP Schedule was received from DES on 15 June 2022. The final PRC Plan and PRCP Schedule was submitted to DES in June 2022, whereby a site visit of the Middlemount Coal Mine was undertaken by DES to observe the existing rehabilitation and how it aligned with the submitted PRC Plan and PRCP Schedule. Further comments and advice were provided by DES in August 2022 and has been considered in this PRC Plan and the associated PRCP Schedule.

Department of Resources

In Q2 2022, MCPL provided DoR with a briefing letter on the PRC Plan and PRCP Schedule process and a summary of the key elements including overall timing, PMLUs, NUMAs and the supporting assessments being undertaken. No response to the briefing letter has been received to date.

3.2.1.4 Isaac Regional Council

Regular consultation has been undertaken with IRC providing an overview of the PRC Plan and PRCP Schedule process and a summary of key elements including overall timing, PMLUs, NUMAs and the supporting assessments being undertaken.

On 21 June 2022, MCPL engaged with the Isaac Regional Council to discuss the PRC Plan and PRCP Schedule, whereby the Isaac Regional Council were supportive of the amendment of the PMLU.

MCPL will continue to consult with the IRC regarding future outcomes of the PRCP and associated activities at the Middlemount Coal Mine.

3.2.2 Community Consultation Plan

Ongoing future consultation with key stakeholders to be undertaken with regard to the PRC Plan and PRCP Schedule is outlined in Table 13. Consultation and regular updates to the PRC Plan and PRCP Schedule where relevant will be provided at CRG meetings when held.

Table 13
Community Consultation Plan

Stakeholder	Key Objectives of Engagement	Proposed Engagement Method and Activities	Engagement Indicative Timing	Information to be Provided	Mechanism for Feedback Incorporation
Government Agencies					
DES	• To provide updates on rehabilitation progress.	Meetings or Email Rehabilitation Report Milestone Monitoring	Annually	Status of rehabilitation.	PRC Plan Amendments.
DoR	• To outline the status of MLs once rehabilitation is complete.	Email/Letter Report	Post-mining	Status of ML relinquishment.	Post-surrender Management Report.
Local Government					
IRC	• To provide updates on rehabilitation progress. • To ensure any desired changes to post-mining land uses are considered.	Meetings or Email	Annually	Status of rehabilitation.	PRC Plan Amendments.
Surrounding Landholders					
Affected (Underlying and Adjoining) Landholders	• To provide updates on rehabilitation progress. • To discuss retaining infrastructure or water storages/management areas.	Email/Letter	As required	Status of rehabilitation.	PRC Plan Amendments.
Local Community Groups					
CRG	• To provide updates on rehabilitation progress.	Meetings or Email	Annually	Status of rehabilitation.	PRC Plan Amendments.
Local Community and Groups	• To provide updates on rehabilitation progress.	Website	Annually	Status of rehabilitation.	PRC Plan Amendments.
Other Community Members	• To provide updates on rehabilitation progress.	Website	Annually	Status of rehabilitation.	PRC Plan Amendments.
Traditional Owners					
Aboriginal Community	• To provide updates on rehabilitation progress.	Website	Annually	Status of rehabilitation.	PRC Plan Amendments.

3.3 POST-MINING LAND USE

The relevant land outcome document for the Middlemount Coal Mine is EA EPML00716913.

PMLUs for the Middlemount Coal Mine were developed during the preparation of the *Middlemount Coal Project Stage 2 Environmental Impact Assessment* (MCPL, 2011) and further refined following consultation and presented in the *Middlemount Coal Project Stage 2 Supplementary Environmental Impact Statement* (MCPL, 2011). The PMLUs presented within these documents lacked clear and objective descriptions (e.g. nature conservation) however maintained the overall objective of native ecosystem (as existed prior to mining).

Since approval of the *Middlemount Coal Project Stage 2 Environmental Impact Assessment* (MCPL, 2011) the PMLUs for the Middlemount Coal Mine have been revised through subsequent approvals such as the *Middlemount Coal Mine Western Extension Project Environmental Assessment Report* (MCPL, 2018). Revisions to PMLUs since 2010 intended to increase clarity and objective descriptions whilst maintaining the overall optionality for native ecosystem (e.g. inclusion of flora comprising species characteristic of selective REs present within the pre-mining landscape, where practicable).

Consistent with the process outlined in the PRCP Guideline, MCPL has amended the approved PMLUs (described within the abovementioned documents) for the Middlemount Coal Mine into this PRC Plan and associated PRCP Schedule (Table 14).

Native ecosystem is the proposed PMLU for the majority of the Middlemount Coal Mine, as it is located within a rural area that is predominantly used for mixed activities including grazing on unimproved pasture. As per EA EPML00716913, native ecosystem is defined as recreating land to a natural ecosystem as similar as possible to the original ecosystem. As such, the Middlemount Coal Mine would be revegetated to a native ecosystem comprising species characteristic of selective RE's for each mining domain. Selected grazing would be applied as a land management tool to control ground cover/understorey growth. No horticulture or cropping occurs on the Middlemount Coal Mine site. The PMLU of native ecosystem will be supported by retained water management structures which will provide access to water for potential livestock. Any unnecessary water management structures at the cessation of operations at the Middlemount Coal Mine would be decommissioned and rehabilitated (Section 3.5.7).

The proposed change of PMLU is in the best interest of supporting a responsible and productive land use for the site in consideration of existing regional land uses.

Flora comprising species characteristic of particular REs present within the pre-mining landscape would be incorporated into the final landform, where practicable, to provide habitat corridors for wildlife, shelter belts for stock (from sun and wind) and visual enhancement. Endemic floral would contain species characteristics of REs which were present in the pre-mining landscape (i.e. these areas would not necessarily aim to recreate particular REs, rather contain species which are commonly present within the listed REs).

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

a) the outcome of consultation with the community in developing the plan, and

b) any strategies or plans for the land of a local government, the State or the Commonwealth.

This is addressed in the sub-sections below.

Table 14
Post-mining Land Use Transition

Domain	Area (ha)	Approved PMLU[1]	PRCP Transitioned PMLU	Justification for Transition
Overarching Footprint	3,350	Low-density beef cattle grazing, or native ecosystem as similar as possible to the original ecosystem.	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. The transitioned PMLU would seek to achieve the enduring long-term sustainability of the land post-mining.
MIA and CHPP Area	111	Low-density beef cattle grazing or recreated Regional Ecosystem (RE) 11.5.9 (*Eucalyptus crebra* and other *Eucalyptus spp*. and *Corymbia spp*. Woodland on Cainozoic sand plains/remnant surfaces.).	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. The transitioned PMLU would seek to achieve the enduring long-term sustainability of the land post-mining. Some infrastructure components may be retained for beneficial reuse where appropriate. Areas of native vegetation will include species which are characteristic of surrounding vegetation such as RE 11.5.9 (e.g. *Eucalyptus crebra*, other *Eucalyptus spp.* and *Corymbia spp.*), where practicable.

Table 14 (continued)
Post-Mining Land Use Transition

Domain	Area (ha)	Approved PMLU[1]	PRCP Transitioned PMLU	Justification for Transition
Roads including haul roads	46	Retained for beneficial reuse where appropriate, or a land use conducive to the surrounding land use including recreation of: • RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains). • RE 11.7.2 (*Acacia spp*. Woodland on Cainozoic lateritic duricrust. Scarp retreat zone). • RE 11.5.9 (*Eucalyptus crebra* and other *Eucalyptus spp*. and *Corymbia spp*. Woodland on Cainozoic sand plains/remnant surfaces).	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. The transitioned PMLU would seek to achieve the enduring long-term sustainability of the land post-mining. Roads (including haul roads) will be retained for beneficial reuse where appropriate (i.e. where agreed with the landholder and where it would support the PMLU). It is considered that native ecosystem is applied to the surrounding land uses. Areas of native vegetation will include species which are characteristic of surrounding vegetation such as REs 11.3.2, 11.7.2 and 11.5.9 (e.g. *Eucalyptus populnea*, other *Eucalyptus spp.*, *Acacia spp.* and *Corymbia spp.*), where practicable.
Creek diversion, drainage lines and levee banks	371	Retained, with recreated RE 11.3.25 (*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines). Thirteen Mile Gully Diversion would be revegetated with species characteristic of: • RE 11.3.1b (Open forest dominated by *Acacia harpophylla* and/or *Casuarina cristata*). • RE 11.3.2c (*Eucalyptus populnea* woodlands on floodplains). • RE 11.3.25 (*Eucalyptus tereticornis* or *Eucalyptus camaldulensis* woodland fringing drainage lines).	Native ecosystem is the transitioned PMLU for diversions and levee banks. Existing vegetation along drainage lines undisturbed by mining operations would be retained and improved where required. Existing vegetation along drainage lines would be retained where possible.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. The transitioned PMLU would seek to achieve the enduring long-term sustainability of the land post-mining. Areas of native vegetation on levee banks and diversions will include species which are characteristic of surrounding vegetation such as REs 11.3.1b, 11.3.2c and 11.3.25 (e.g. *Acacia harpophylla, Casuarina cristata* and suitable *Eucalyptus spp.*), where practicable.

Table 14 (continued)
Post-Mining Land Use Transition

Domain	Area (ha)	Approved PMLU[1]	PRCP Transitioned PMLU	Justification for Transition
In-pit and out-of-pit overburden spoil dumps (slopes)	691	Rock mulched surface with native grass, with exception of the slope of the southern overburden spoil dump relative to the Roper Creek Floodplain which would be native ecosystem with recreated RE 11.5.3 (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces).	Native ecosystem with selective grazing for land management purposes.	Rock mulching requirements have been reviewed by Verterra and advised that slopes ≤16% do not require rock mulching as a revegetation strategy (Section 3.5.3.8). Native vegetation will include species which are characteristic of surrounding vegetation such as RE 11.5.3 (e.g. *Eucalyptus spp.* and *Corymbia spp.*). The spoil dump slopes cannot be developed to achieve Cainozoic sand plains/remnant surfaces, so recreation of RE 1.5.3 is not possible in this domain. Rock mulching trials are demonstrating poor rehabilitation outcomes, such as limited vegetation cover and habitat value
In-pit and out-of-pit overburden spoil dumps (upper surface)	1,458	Native ecosystem[2] with recreated RE 11.5.3 (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces).	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. Areas of native vegetation will include species which are characteristic of surrounding vegetation such as RE 11.5.3 (e.g. *Eucalyptus spp.* and *Corymbia spp.*).
Low wall spoil (above natural ground level)	60	Native ecosystem[2] with recreated RE 11.5.3 on benches (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces).	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. Areas of native vegetation will include species which are characteristic of RE 11.5.3 (e.g. *Eucalyptus spp.* and *Corymbia spp.*), where practicable.
North residual void	358	Residual void.	NUMA.	No overall change.
South residual void	163	Residual void.	NUMA.	No overall change.

Table 14 (continued)
Post-Mining Land Use Transition

Domain	Area (ha)	Approved PMLU[1]	PRCP Transitioned PMLU	Justification for Transition
Water storage/water management dams	68	Retained for beneficial reuse where appropriate, or a land use conducive to the surrounding land use, including wetlands, recreated RE 11.3.27 (Freshwater wetlands).	Grazing (Retained Water Management Infrastructure).	The transitioned PMLU achieves a more supporting and productive land use outcome better suited to the surrounding land uses of the Middlemount Coal Mine. Water storages/water management dams will be retained for beneficial reuse where appropriate (i.e. where agreed with the landholder and where it would support the PMLU). It is considered that native ecosystem is conducive to the surrounding land uses. Areas of native vegetation will include species which are characteristic of surrounding vegetation such as RE 11.3.27 (e.g. *Eucalyptus camaldulensis* or *E. tereticornis*), where practicable.
TSF and TFC	24	RE 11.7.2 (*Acacia spp*. Woodland on Cainozoic lateritic duricrust. Scarp retreat zone).	Native ecosystem with selective grazing for land management purposes.	The transitioned PMLU achieves a more supporting and productive land use outcome conductive to the surrounding land uses of the Middlemount Coal Mine. Areas of native vegetation will include species which are characteristic of RE 11.7.2 (e.g. *Acacia spp.*).

[1] Approved PMLU as defined by EA EPML00716913.

[2] Where native ecosystem is defined as recreating land to a natural ecosystem as similar as possible to the original ecosystem.

Exploration Areas

Exploration areas are not classified as a stand-alone mining domain due to all exploration areas being within the current overall mining footprint, incorporated within the existing mining domains. All exploration areas contained within the current mining domains will be rehabilitated in accordance with Rehabilitation Milestone 1 (Table 15).

3.3.1 Community Consultation

As described in Section 3.2.1, during preparation of the Southern Extension Project EVA (MCPL, 2020a), consultation was conducted with the neighbouring landholders, the local community, Aboriginal stakeholders, key State and Commonwealth government agencies, IRC and relevant infrastructure owners. Consultation undertaken to date included summaries of overall timing, community consultation plan, PMLUs, NUMAs (i.e. residual voids), completion criteria and supporting assessments being undertaken.

Consultation has continued to be undertaken with the abovementioned groups during the preparation of this PRC Plan and PRCP Schedule. Where relevant, feedback has been addressed or incorporated.

The PMLU of native ecosystem is considered to be consistent with the outcomes of the community consultation undertaken to date as:

- No queries or issues with the PMLU have been raised by the CRG to date.
- No queries or issues with the PMLU have been raised by adjacent landholders or other members of the local community to date.
- No queries or issues with the PMLU have been raised by other relevant stakeholders.

3.3.2 Relevant Legislation, Plans and Strategies

3.3.2.1 Local and Regional Government

Relevant local and regional government plans/schemes have been considered in the preparation of this PRC Plan and the establishment of the proposed target PMLU.

The *Isaac 2035, Community Strategic Plan: Isaac's 20 year vision* (IRC, 2015) (the Community Plan) provides a long-term vision and strategic direction towards improving the future of the Isaac community in the midst of anticipated changes over the next two decades. The Community Plan is the over-arching document and key driver for the region's Strategic Planning Framework, particularly focusing on community, infrastructure, the economy and the environment. The Community Plan sets out what is important to the Isaac community, including the long standing agricultural industry.

The *Isaac Regional Planning Scheme* (IRC, 2021) (the Planning Scheme) was prepared in accordance with the *Planning Act 2016* as a framework for managing development. The Planning Scheme focuses on liveable communities, economic diversification, community infrastructure, the protection of natural resources and the environment, and safety from natural disasters. The Planning Scheme references the character and amenity that agriculture and grazing encompass in the Isaac region.

The *Mackay, Isaac and Whitsunday Regional Plan* (State of Queensland, 2012) (the Regional Plan) establishes a long-term vision and direction for the region to 2031. The Regional Plan provides an overarching certainty about where the region is heading and a framework to respond to any challenges and opportunities that may arise. The Regional Plan also references the importance that traditional industries like agriculture, fishing and tourism will have in contributing to the regional economy into the future.

The proposed target PMLU of native ecosystem with selected grazing is in line with, and keeping with, the vision of the Community Plan, the Planning Scheme, and the Regional Plan as:

- The region's natural environment and native species habitats will be recognised, maintained and enhanced, and the extent of weeds and pests impacting on the region will be minimised.
- The rehabilitated landform will be consistent with the region's character and amenity (e.g. agricultural land and the natural environment).
- The return to grazing areas will support the region's strategic plan and opportunities for global shortages and changing consumption patterns (i.e. increased beef, agriculture, fisheries and aquaculture), and will protect land used for rural production and other non-urban values from further fragmentation and excessive urban encroachment.

3.3.2.2 State and Commonwealth Governments

The State and Commonwealth legislation considered during the preparation of the Southern Extension Project EVA (MCPL, 2020a) and this PRC Plan includes:

- *Mineral Resources Act 1989.*
- EP Act 1994.
- EPBC Act 1999.
- *Environmental Offsets Act 2014.*
- *Nature Conservation Act 1992.*
- *Regional Planning Interests Act 2014.*
- *Planning Act 2016*.
- *Water Act 2000.*
- *Water Plan (Fitzroy Basin) 2011.*
- *Native Title Act 1993.*
- *Aboriginal Cultural Heritage Act 2003.*
- *Land Act 1994.*
- *Electricity Act 1994.*
- *Local Government Act 2009*.
- *Isaac Regional Planning Scheme 2021.*
- *Building Act 1975.*
- *Building Regulation 2021.*
- *Code for the Tendering and Performance of Building Work 2016.*

The proposed target PMLU is not considered to be inconsistent with any of the legislation identified above.

3.4 NON-USE MANAGEMENT AREAS

The relevant land outcome document for the Middlemount Coal Mine is EA EPML00716913. Two final voids are described in the land outcome document and have been transitioned into this PRC Plan and PRCP Schedule.

Consistent with the process outlined in the PRCP Guideline, MCPL is not required to comply with the requirements under section 126C(1)(g) or (h), or section 126D(2) or (3) of the EP Act and is not required to complete the information requirements under section 126C(1)(j) of the EP Act for the approved NUMAs.

Condition G19 of EA EPML00716913 requires MCPL to complete an investigation into residual voids and submit a report to the administering authority by 31 October 2021 proposing relevant acceptance criteria. Middlemount submitted a residual void study, addressing the requirements of Condition G19, whereby Plate 4 below details the proposed acceptance criteria as per the Middlemount Coal Mine Geotechnical – Final Void Study (Appendix K). There have been no changes to the final void maximum depth and volume compared to the approved layout in EA EPML00716913.

Table 5 Recommended slope geometry for the final voids

Material	Overall Slope Angle (°)	Bench Height (m)	Berm Width (m)	Batter Angle (°)
Surficial Soils	20	NA	NA	NA
Weathered Permian	NA	30	25	55
Fresh Permian	NA	60	60	60

Table 6 Recommended slope geometry for lowwalls

Material	Overall Slope Angle (°)~	Max. Bench Height (m)	Berm Width (m)*	Batter Angle (°)
Lowwall CAT3 Spoil	27	40	12 to 25	37

~This is the maximumOSA allowed for lowwall designs

*The bench geometries maybe changed to satisfy the OSA, this include bench height and berm width

Plate 4 – Table 5 and 6 from the Middlemount Coal Mine Geotechnical – Final Void Study

Notwithstanding, the legislative requirements under section 126C(1)(d) of the EP Act still apply. In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRC Plan must state the extent to which each NUMA identified in the PRCP Schedule is consistent with:

a) the outcome of consultation with the community in developing the plan; and

b) any strategies or plans for the land of a local government, the State or the Commonwealth.

This is addressed in the sub-sections below.

3.4.1 Community Consultation

As described in Section 3.2.1, during preparation of the Southern Extension Project EVA, consultation was conducted with the neighbouring landholders, the local community, Aboriginal stakeholders, key State and Commonwealth government agencies, IRC and relevant infrastructure owners.

Consultation has also been undertaken with the relevant groups during the preparation of this PRC Plan and PRCP Schedule, and their feedback has been addressed or incorporated.

The approved NUMAs (i.e. the residual voids) are considered to be consistent with the outcomes of the community consultation undertaken to date as:

- No queries or issues with NUMAs have been raised by the CRG to date.
- No queries or issues with NUMAs have been raised by adjacent landholders or other members of the local community.

3.4.2 Relevant Legislation, Plans and Strategies

3.4.2.1 Local Government

The approved NUMAs will be managed in such a way as to minimise any impacts on the vision outcomes in the Community Plan, the Planning Scheme and the Regional Plan, in particular:

- The region's natural environment and native species habitats will be recognised, maintained and enhanced, and the extent of weeds and pests impacting on the region will be minimised.
- The rehabilitated landform will be consistent with the region's character and amenity (e.g. agricultural land and the natural environment).
- The size of the NUMAs has been minimised to maximise the land to be returned to grazing, which will support the region's strategic plan and opportunities for global shortages and changing consumption patterns (i.e. increased beef, agriculture, fisheries and aquaculture), and will protect land used for rural production and other non-urban values from further fragmentation and excessive urban encroachment.

3.4.2.2 State and Commonwealth Governments

The proposed NUMAs were considered in accordance with relevant State and Commonwealth legislation during the preparation of the Southern Extension Project EVA (MCPL, 2020a). Relevant legislation considered is listed in Section 3.3.2.2.

The approved NUMAs are considered to be consistent with the relevant legislation identified in Section 3.3.2.2. The northern void is not located within the current floodplain of Roper Creek. The southern final void is located on the pre-mine floodplain of Roper Creek. At the completion of mining the flood protection levee in place during operation of the mine would be decommissioned and incorporated into the final landform to provide flood immunity up to the probable maximum flood (PMF).

Native vegetation cover between the final landform and Roper Creek would be retained.

3.5 REHABILITATION AND MANAGEMENT METHODOLOGY

In accordance with section 126C(1)(e) and (i) of the EP Act, the following section states:

- For each proposed PMLU for land, the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP Schedule.
- For each proposed NUMA, the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP Schedule for the area.

3.5.1 Rehabilitation and Management Milestones

Consistent with the Rehabilitation Requirements for the Middlemount Coal Mine (Attachment F of EA EPML00716913), MCPL in consultation with Verterra (2022) has developed a comprehensive suite of milestones for rehabilitation areas and improvement areas of the Middlemount Coal Mine. Tables 15 and 16 describe these milestones and how they relate to the proposed rehabilitation methodology for the Middlemount Coal Mine (Appendix H).

The sub-sections below provide further detail on how MCPL will manage the rehabilitation activities undertaken at the Middlemount Coal Mine to achieve the rehabilitation milestones.

The following guidelines and relevant information have been considered in development of these milestones:

- PRCP Guideline.
- DES (2014) *Guideline: Rehabilitation requirements for mining resource activities* (Historical).
- Australian Government (2016a) *Leading Practice Sustainable Development Program for the Mining Industry – Mine Rehabilitation*.
- Australian Government (2016b) *Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure*.

MCPL considers the management measures proposed for each rehabilitation area (RA) and improvement area (IA) to be consistent with current “best practice” measures at the time of preparing this PRC Plan and PRCP Schedule. If additional relevant information to this PRC Plan and PRCP Schedule becomes available, or the abovementioned guidelines are materially revised, this PRC Plan and PRCP Schedule would be reviewed and updated as required to ensure that “best practice” management measures are retained.

In addition, MCPL commissioned suitably qualified specialists to develop and refine a Revegetation Management Plan (Verterra, 2022; Appendix H), and to review and evaluate potential risks related to rehabilitation (Risk Mentor, 2021; Verterra, 2022). The Revegetation Management Plan (Verterra, 2022) and PRCP Risk Assessment (Risk Mentor, 2021, Appendix I) informed the rehabilitation management measures and maintenance/monitoring methodologies discussed in Sections 3.5 and 3.6.

The rehabilitation and management milestone progression proposed in this PRC Plan and PRCP Schedule (Table 15 and Table 16) has been developed in consideration of the risks that were attributed to each of the rehabilitation milestones timeframes (Risk Mentor, 2021, Appendix I) (discussed further in Section 3.6).

Table 15
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM1	Infrastructure Decommissioning and Removal	Zone 1	a) All services disconnected and decommissioned. b) Contaminated land and water (e.g. affected by hydrocarbons, metals, brine, etc) is treated to ensure consistency with upstream water quality characteristics, or removed off site. Upstream water quality parameters and monitoring sites would be consistent with those listed in Table 3.2 of Appendix A. c) All wastes removed from site and lawfully disposed. d) All infrastructure water storages demolished and removed, unless agreed in writing by the landholders and relevant agencies. e) All haul roads and access tracks to be ripped and removed to reduce compaction unless agreed in writing by landholders and relevant agencies. f) Risk assessment undertaken to ensure that all infrastructure has been appropriately disconnected and decommissioned. g) Certification that all exploration drill holes not agreed to in writing with the post-mining landholder to be converted to either a water bore or groundwater monitoring bore have been rehabilitated safe and stable, and will remain safe and stable.	3 months

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM2	Remediation of Contaminated Land (Characterisation)	Zone 1 Zone 2	a) Detailed site investigation report, as required under the *Environmental Protection Act 1994*, completed. b) Contaminated and hazardous materials (e.g. PCBs, Mercury, hydrocarbon contaminated soils, Dioxins etc). have been removed and appropriately disposed of or remediated. c) Hydrocarbon, heavy metal, or other contaminants are within allowable departmental limits (established in accordance with DES' *Queensland Auditor Handbook for Contaminated Land*) and has been certified by an appropriately qualified person. d) A site suitability statement confirms the uses or activities for which the land is suitable and aligns to the approved PMLUs for the site. e) Validation testing confirms that contaminated soils have been removed or remediated.	3 months
RM3	Remediation of Contaminated Land (Waste Rock Material Treatment)	Zone 1 Zone 2	a) Site added to the Environmental Management Register, if required. b) Remediation of contaminated soil materials such as hydrocarbon has been undertaken as required. c) Validation testing confirms that contaminated soils have been removed or remediated. d) No acid rock drainage is occurring or has the potential to occur. Acid rock drainage would be measured against the thresholds detailed in the Global Acid Rock Drainage Guide (INAP, 2009).	3 months

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM4	Landform Establishment (Capping, Development and Reshaping /Re-profiling)	Zone 1 Zone 2	a) Engineering and design plans for TSF and emplacement areas finalised. b) Tailings have settled before capping. c) NAF waste rock or other identified capping materials such as clay will be compacted with suitable oxygen diffusion control properties to reduce the minimum encapsulation thickness. d) All major earthworks completed. e) Landform recontoured to conform with adjacent landforms. f) Out-of-pit coal emplacement slopes no greater than 10%, or up to 18.5% where rock mulch or other stabilisation controls are used. Backfilled emplacement areas would follow the same landform design criteria to be considered geotechnically stable. g) Infrastructure area slope angles do not exceed 5%. For slopes over 2%, continuous slope length does not exceed 70 m. h) Slopes of >16% have been treated with rock mulch to assist with maintaining slope stability. i) Installation of contour or graded drains as per construction design which has been certified by an appropriately qualified person. j) Final voids certified by a suitably qualified and experienced person as geotechnically stable. k) Final landform is stable and has been certified by an appropriately qualified person. l) Engineering report on completed cover finalised, certifying that the capping system has been built/installed as per engineering design plan. m) Overburden is classified as NAF and is placed in any in-pit or ex-pit spoil dump. n) Interburden is preferentially placed in-pit to provide the acid neutralisation capacity for spot-dumping of Potentially Acid Forming (PAF) materials and creation of Permian caps and bunds on coal reject cells. o) PAF floor materials from the Middlemount seam should remain in the open pit and be covered with NAF spoil. p) Burial of PAF be lime dosed (at a rate of 10 t/ha or as confirmed by field trials) and kept at least 10 m away from the outer surfaces of final landforms by covering with Permian spoil. q) Consideration of leaching potential via leaching tests for PAF materials r) the maximum ratio of PAF coarse reject/tailings to Permian spoil at the out-of-pit spoil emplacement area be 1 to 10.	6 months

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM5	Growth Medium Application (Surface Preparation and application of ameliorants)	Zone 1 Zone 2	a) An assessment of soil health and suitability has been completed by an appropriately qualified person to confirm soil is suitable for target vegetation growth. b) Waste rock material ripped to a minimum of 300 mm depth via grader tyres or equivalent. c) Topsoil/growth medium placed to a minimum depth of 200 mm, to achieve 300 mm of amended subsoil. d) Topsoil amelioration and fertilisation process completed to minimise chemical and physical limitations of establishment and growth of vigorous vegetation cover. Approach involves the application of gypsum and organic matter prior to spreading of topsoil and chemical fertiliser (as required) (target Total N: >1,500 milligram [mg] per kg [mg/kg], Phosphate: >20 mg/kg). e) Topsoil to be ripped with a bulldozer or with tynes spaced at approximately 50 centimetre (cm) centres. f) Use of offset disc harrows to harrow gypsum and organic matter into full depth (maximum 200 mm) and on the contour. Use of scarifies or harrows (maximum less than 50 mm depth) to apply fertiliser and seed incorporation. g) Installation of fencing (if required) completed. h) Evidence, certified by an appropriately qualified person, that topsoil/growth medium has been spread to a suitable depth in rehabilitated areas to sustain the post mining land use. i) Amelioration of topsoil undertaken to minimise chemical and physical properties limiting establishment and growth of vegetation cover. j) For areas < 16 % slope, vertical rills and troughs removed, and topsoil applied to a minimum depth of 0.2 m. k) Seed and harrow applied to average depth of approximately 50 mm. l) For areas > 16 %, seed over rock mulch applied. m) Soil surface crusting occurs in less than 2 % of the rehabilitated domain area.	3 months

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM6	Revegetation (native ecosystem with selected grazing)	Zone 1 Zone 2 Zone 3	a) Direct seeding of cover crop, pasture species and native vegetation completed (seed mix proportions relevant to grazing and native ecosystem representative of relevant RE's, native shrubs and grasses are specified in Revegetation Management Plan [Table 9]). b) Seed incorporations to a depth of approximately 5 cm to ensure adequate soil moisture is stored before germination is initiated and so that the seed is not penetrated too deep in the soil surface. c) Use of tractor drawn, and dozer mounted seeding equipment to sow seed integrated with scarifies, harrows or tracking chains. d) Seed sourced from reputable seed suppliers with documented quality control procedures. e) Stock fencing to protect early stages of revegetation instalment. f) Germination and purity visual inspections by a certified professional undertaken (e.g. agronomist or reputable seed supplier). g) Topsoil ripped no more than three months later than placement. h) Till along the contour with a tyned implement with tyne spacing no greater than 0.5m. i) Non-vegetation cover (stones, rock cover, litter, logs, grass etc) does not cover greater than 30% of the total area. j) A minimum of 65% vegetation cover is present, and evidence of generational succession of trees and shrubs is apparent in rehabilitated areas. k) Pasture grass and native species are comparable in cover to designated vegetation reference sites. l) Bare surface areas are not to exceed 100 m^2 in area, and exceed a length of 10 m along slope, based on a five year average period. m) Target species number by stratum for each native and non-native species composition is consistent with Table 9 of the Revegetation Management Plan. n) Reseed/plant tube stocks with native shrub, tree and grass species, where required.	12 months

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM7	Surface Conditions	Zone 1 Zone 2	a) No evidence of slumping and erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. b) Hydraulic and geomorphic characteristics of rehabilitated portions of Roper Creek (Diversion 1 and 2), and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of undisturbed sections of Roper Creek and Thirteen Mile Gully channels. c) Target ranges for chemical and physico-chemical nutrients are considered to be at levels in which plant nutrient deficiencies are relieved and plant growth is encouraged (refer to Revegetation Management Plan). d) Hydrocarbon, heavy metals or other contamination levels are within appropriate DES limits.	5 years
RM8	Achievement of PMLU to Stable Condition (native ecosystem with selected grazing)	Zone 1 Zone 2 Zone 3	**Safe:** a) Certification that slopes are safe, and predicted to remain safe. b) Certification that the relevant specified cover thickness has been obtained. c) Evidence that any site contamination has been resolved and relevant measures implemented, resulting in removal of the site from the Environmental Management Register (if required). d) Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for an ongoing period of time. e) A Bushfire Management Plan developed in accordance with relevant Queensland Fire and Emergency Services is in place.	Up to 20 years

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM8 (continued)	As above	As above	**Stable:** f) Rehabilitation area has remained stable when comparing photographs from successive monitoring events, for a period of at least five years post-mining. g) Active erosion (t/ha/year) is less than 110% of the levels present in designated vegetation reference sites. h) Erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. i) Nutrient cycling processes are comparable to designated reference sites which are representative of the PMLU. j) Pest species abundance comparable to designated reference sites. k) Weed diversity and density less than 110% of the levels present in the designated reference sites, for a period of at least two years. l) Vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass. m) No evidence of severe erosion[2] n) Persistent groundcover greater than or equal to 65% established as assessed against comparable reference sites. o) Assessed hypothetical stocking rates in rehabilitated pasture areas are comparable to designated vegetation reference sites. p) Hydraulic and geomorphic characteristics of rehabilitated portions of Roper Creek (Diversion 1 and 2), and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of undisturbed sections of Roper Creek and Thirteen Mile Gully channels.	As above

[2] Severe erosion has any of the following characteristics – Loss of surface horizons, root exposure, etc. (sheet erosion), >30 rills and/or any >0.3 m deep (rill / gully erosion); presence of tunnel erosion; or evidence of mass soil movement.

Table 15 (continued)
Rehabilitation Milestones and Criteria for Rehabilitation Areas

Milestone Reference	Rehabilitation Milestone	Revegetation Scenario	Milestone Criteria	Approximate Timeframe
RM8 (continued)	As above	As above	**Self-sustaining land use:** q) Assessed hypothetical stocking rates in rehabilitated areas are comparable to designated vegetation reference sites. r) Litter density comparable to vegetation designated vegetation reference sites. s) Declared weed species cover is comparable to designated vegetation reference sites. t) Tree and shrub species are comparable to designated vegetation reference sites. u) Tree and shrub species show evidence of flowering, viable seed setting, germination and emergence. v) Persistent groundcover greater than or equal to 65% as assessed against comparable reference sites. w) Salinity levels of less than 0.6 dS/m in soil root zone or less than 110% of designated vegetation reference sites. x) Cation exchange capacity levels are greater than 8 to 10 in soil root zone or less than 110% of designated vegetation reference sites. **Non-polluting:** y) Hydrocarbon, heavy metal or other contamination levels are within relevant DES limits. z) Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for a period of at least two years. aa) Groundwater quality monitoring results comply with Table D2: Groundwater Quality Investigation Trigger Levels in EA EPML00716913, and are reviewed every two years.	As above
RM9	Retained Water Structures	Zone 1	a) Certification of structural integrity. b) Water quality within the retained water structures is comparable with upstream values. Upstream water quality parameters and monitoring sites would be consistent with those listed in Table 3.2 of Appendix A. c) Water quality monitoring results comply with EA EMPL00716913, and are reviewed every two years. d) All retained structures and landforms to be assessed and approved as safe and stable for post-mining use by an appropriate qualified person	2 years

Table 16
Management Milestones and Criteria for Improvement Areas

Milestone Reference	Management Milestone	Milestone Criteria	Approximate Timeframe
MM1	High and Low Wall Treatment	a) Certification from an appropriately qualified and experienced person that the final voids are safe. b) Factor of Safety to determine geotechnical stability as highwall competent rock slopes are no greater than 59°, and incompetent slopes no greater than 36°. c) Low wall slopes no greater than 30°. d) Low and high walls certified by a suitably qualified and experienced person as geotechnically stable. e) Slope geometry for the final voids is as follows: i. Surficial Soils – Overall slope angle does not exceed 20 degrees ii. Weathered Permian – Bench height does not exceed 30 m. – Berm width does not exceed 25 m – Batter Angle does not exceed 55 degrees. iii. Fresh Permian – Bench height does not exceed 60 m – Berm width does not exceed 60 m – Batter angle does not exceed 60 degrees. f) Northern Void does not exceed 358 ha in surface area and 285,870,000 m^3 in volume. g) Southern void does not exceed 163 ha in surface area and 157,960,000 m^3 in volume.	2 years
MM2	Achievement of surface condition requirements	a) Access is prohibited to final voids by a bund wall with a minimum height of 2 m, a minimum base width of 4 m and be located at least 10 m beyond the area potentially affected by any instability of the pit edge. b) Appropriate signage placed to clearly identify and convey the purpose (e.g. *EP Act 1994 Non- Use Management Area No Entry*).	12 months

Table 16 (continued)
Management Milestones and Criteria for Improvement Areas

Milestone Reference	Management Milestone	Milestone Criteria	Approximate Timeframe
MM3	Achievement of Sufficient Improvement	a) Bund wall remains in place. b) Appropriate signage remains in place. c) Final voids remain structurally stable, with no maintenance requirements and are predicted to remain stable. d) High walls and low walls certified by a suitably qualified and experienced person as geotechnically stable. e) Groundwater quality monitoring results comply with EA EPML00716913, ongoing and for a period of at least two years. f) Final void walls confirmed to drain internally to the final void. g) Review of final void water recovery confirms the void is predicted to act as a long-term groundwater sink.	2 years

3.5.2 Rehabilitation Area Commencement Dates

MCPL is committed to commencing rehabilitation in each of the Rehabilitation Areas progressively, as land becomes available. An overview of the anticipated commencement dates, and justification of these dates, is provided in Table 17.

3.5.3 General Rehabilitation Practices

The following sub-sections (Sections 3.5.3.1 to 3.5.3.8) outline the information that is necessary to underpin the development of the rehabilitation and management methodologies for the existing Middlemount Coal Mine.

3.5.3.1 Hydrogeology

Groundwater Occurrence

As described in Section 3.1.2.3, the stratigraphic units occurring within the Middlemount Coal Mine area and immediate surrounds from youngest to oldest, including corresponding hydrogeological systems are (Figure 18):

- Quaternary – Quaternary Alluvium. Alluvial aquifer consisting of localised stream channel deposits and associated flood plain deposits.
- Tertiary – Duaringa Formation. A low-yielding aquifer, more commonly regarded as an aquitard.
- Permian – Permian Coal Measures (principally the Middlemount and Pisces Seams). Low to moderate yielding aquifers confined by interburden/overburden units.

A groundwater bore census conducted by 4T consultants in 2017 (Section 3.1.2.5) concluded that the Quaternary alluvium is not targeted by landholders as a groundwater supply supporting the general understanding that the Quaternary alluvium is not a productive aquifer (Appendix B). The Duaringa formation (tertiary) unconformably overlays the Permian Coal Measures and is more commonly regarded as an aquitard due to its hydraulic properties (i.e. deeply weathered mudstone, sandstone, pebbly sandstone/conglomerate and siltstone, gravel and some interbedded shale and basalt). The underlying Permian Coal Measures are low yielding, and due to the depth to groundwater not commonly accessed by private landholders.

Groundwater Recharge and Discharge Locations

Where saturated, recharge to the Quaternary alluvium occurs via either direct rainfall onto the alluvium, or via seepage through stream beds when creeks are flowing. Stream gauging data for Roper Creek, located to the south of the Middlemount Coal Mine, indicates that surface water flow dissipates quickly following flow events. Recharge from stream flow into the Quaternary alluvium would occur over short time periods as water infiltrates rapidly into the alluvium. When saturated, the groundwater flow direction in the Quaternary alluvium would be expected to be generally 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 Quaternary 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.

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

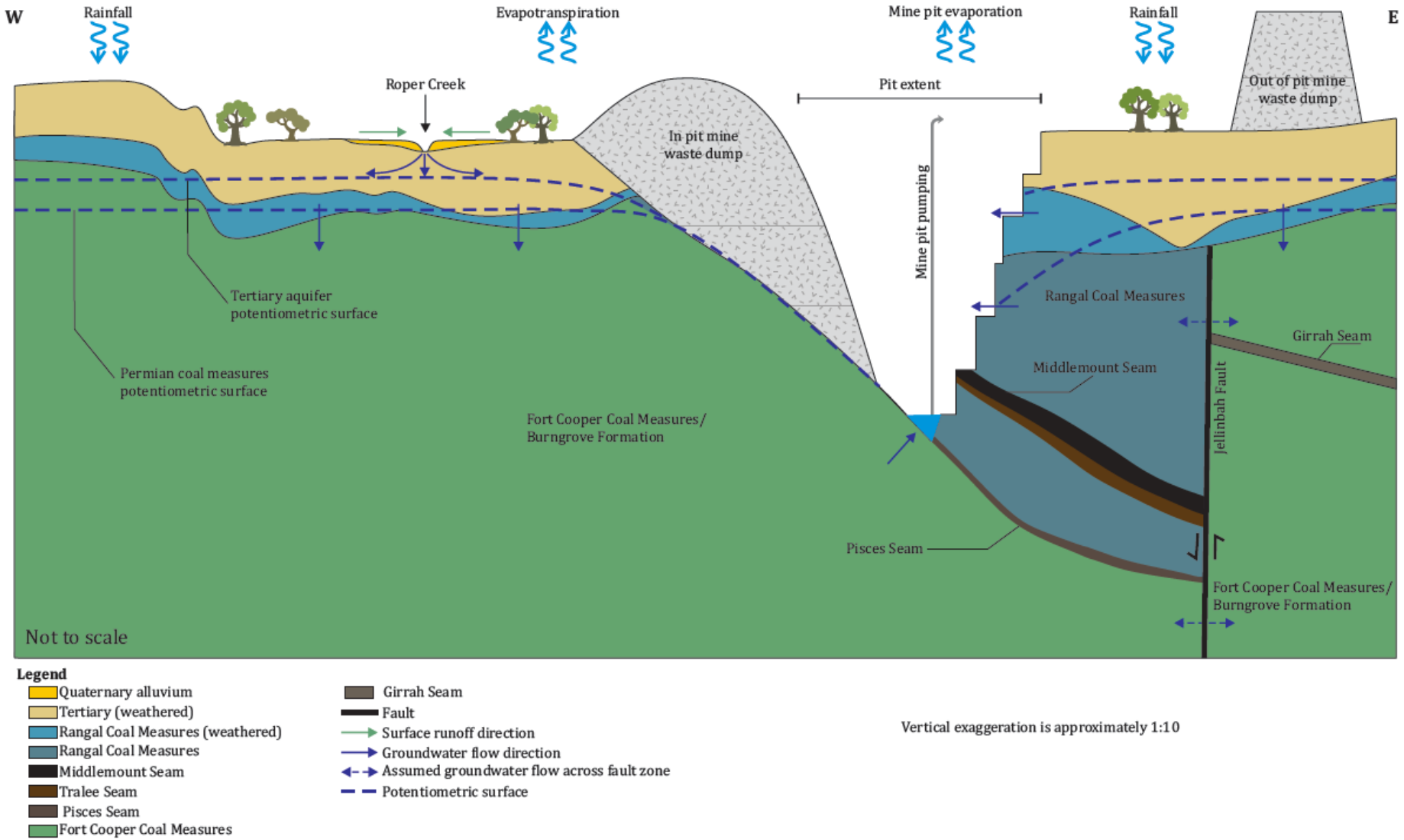


Figure 18: Hydrogeological Conceptual Model (South-west to North-east)

Table 17
Rehabilitation Area Commencement Dates and Justification

Rehabilitation Area	Relevant Activities	PMLU	Rehabilitation Commencement Date	Estimated Completion Date	Justification of Commencement Date
RA1	Waste Rock Emplacement	Native Ecosystem	Already Commenced	2064	Initial rehabilitation activities have already commenced in the western emplacement areas. Waste rock emplacement areas associated with RA1 will become available progressively over the life of the mine.
RA2	Waste Rock Emplacement	Native Ecosystem	Already Commenced	2049	Rehabilitation activities have already commenced on the steeper slopes of the western dump.
RA3	Waste Rock Emplacement	Native Ecosystem	Already Commenced	2064	Initial rehabilitation activities have already commenced in the western and eastern top emplacement areas, and will continue to be available for rehabilitation following open cut mining activities.
RA4	Tailings Storage Facility	Native Ecosystem	2044	2064	Tailings storage facilities 1 and 2 and associated flocc cells are intended to be operated throughout the life of the mine. At the cessation of mining, rehabilitation can be progressed.
RA5	Infrastructure	Native Ecosystem	Already commenced	2059	Infrastructure areas are typically anticipated to be required for the life of the mine. Some small areas of infrastructure adjacent the Roper Creek Diversion 1 and the Thirteen Mile Gully Diversion extension have already commenced rehabilitation.

Table 17 (Continued)
Rehabilitation Area Commencement Dates and Justification

Rehabilitation Area	Relevant Activities	PMLU	Rehabilitation Commencement Date	Estimated Completion Date	Justification of Commencement Date
RA6	Water Management Infrastructure (Mine Water Dams)	Grazing (Retained Water Management Infrastructure)	2044	2049	Water Management infrastructure will be required for the life of mining. MCPL has undertaken consultation with relevant stakeholders and confirmed various water management infrastructure to be retained at the completion of mining (Attachment 3). Due to the size and quantity of the water management dams, they are unlikely to be necessary to support the overall native ecosystem PMLU and are therefore proposed to be retained and rehabilitated to grazing pasture.
RA7	Water Management Infrastructure (Sediment Dams)				
RA8	Diversions	Native Ecosystem	Already Commenced	2054	Roper Creek Diversion 1 and Thirteen Mile Gully Diversion extension has already been constructed and rehabilitation commenced. Construction of Roper Creek Diversion 2 is scheduled to commenced in 2023, with rehabilitation progressing subsequently.

Groundwater Quality

Groundwater quality is described in Section 3.1.2.5.

Current and Potential Future Groundwater Uses

The bore census conducted in 2017 by 4T consultants (Section 3.1.2.5) concluded that there is limited groundwater use of brackish to saline groundwater, with all identified groundwater bores located in excess of 5 km of the Middlemount Coal Mine. Other users in the area surrounding the Middlemount Coal Mine include the Middlemount Landfill and other mining operations.

Given the availability and quality of groundwater in the area, it is expected that future groundwater uses would remain the same.

Groundwater Flow Direction and Potentiometric Profile

Figure 18 shows the conceptual groundwater model for the Middlemount Coal Mine and illustrates the main hydrogeological processes and mechanisms including flow directions, discharge, recharge, anthropogenic activities and the potentiometric surface (AGE, 2020).

Groundwater monitoring data was recorded for the three predominant aquifers present within the Middlemount Coal Mine, including the Quaternary alluvial aquifer, the Tertiary Duaringa Formation aquifer/aquitard and the Permian coal measures aquifer.

Firstly, given the groundwater levels at the site are typically below the base of the Quaternary alluvium, groundwater monitoring data is not available. However, using literature references as a guide, AGE (2020) estimated the Quaternary alluvium to have a highly variable range of hydraulic conductivity values because of its variable lithology. Sandy to gravelly creek beds within the alluvium are expected to possess higher values of hydraulic conductivity compared to the flood-plain deposits due to their clayey nature. Stream gauging data for Roper Creek indicates surface water flow 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 in the Quaternary alluvium would expect to be generally from north-west to south-east, following the regional topography and drainage network (AGE, 2020).

Within the Tertiary Duaringa formation aquifer, the presence of significant clay suggests shallow groundwater flow and recharge from rainfall is likely to be minimal. There is limited available data within the Tertiary Duaringa formation aquifer to establish a degree of hydraulic conductivity. Data from surrounding monitoring bores suggest that the Tertiary Duaringa Formation has a wide range, but commonly low hydraulic conductivity due to the weathered claystone and siltstone, sandstone and gravel that comprises the alluvium (AGE, 2020). The regional groundwater flow direction in the Tertiary Duaringa Formation is expected to be coincident with the regional surface drainage being towards the south-east.

Permian coal seams hydraulic parameters were derived from in-situ falling and rising head slug tests on the Permian monitoring bores drilled for the *Middlemount Coal Project Stage 2 Groundwater Technical Report* conducted by Parsons Brinckerhoff (2010c). The tests indicated the Permian coal measures encompassed the generally accepted hydraulic conductivity for coal seams in the Bowen Basin (0.1 m/day).

Groundwater Modelling

As described in Section 3.1.2, a comprehensive Groundwater Impact Assessment was completed for the Middlemount Coal Mine Southern Extension EVA (MCPL, 2020a) (Appendix B). As part of this Groundwater Impact Assessment, a 3D numerical groundwater flow model was developed for the Southern Extension Project based on the model developed for the Western Extension Project. The peer review of the Western Extension Groundwater Assessment (AGE, 2018) by HydroAlgorithmics (2018) concluded the model had an appropriate level of complexity, was generally in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and the groundwater impact assessment was 'fit-for-purpose'.

It is noted that there have been no significant changes to the approved Southern Extension Project since the Western Extension Project Groundwater Assessment (AGE, 2018) was prepared for the Middlemount Coal Mine.

The model has been designed to account for the current and proposed mine plan and potential for cumulative impact from nearby operational mines such as German Creek East, Foxleigh, Foxleigh Plains and Norwich Park. Coal Seam Gas (CSG) production as part of the Bowen Gas Project (Arrow Energy Pty Ltd [Arrow Energy], 2012) within the Rangal Coal Measures approximately 7 km to the north of the Middlemount Coal Mine 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.

The numerical groundwater model was used to assess the cumulative impact between the Middlemount Coal Mine and nearby operational and closed mines which include German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park as well as CSG production as part of the Bowen Gas Project (Arrow Energy, 2012). Modelling indicates that depressurisation/drawdown in the Tertiary and Weathered Permian and deeper Middlemount and Pisces seams has some (albeit limited) interaction with depressurisation/drawdown effects from other mines and proposed future CSG production activities (AGE, 2020).

3.5.3.2 Flooding

WRM (2020) completed hydrologic and hydraulic modelling of local catchments to:

- assess the existing and proposed flood behaviour at the Middlemount Coal Mine and surrounds at the completion of the operations;
- assist in the development of conceptual designs for clean water drains and drainage features diversions; and
- assess the conceptual design of flood protection measures for the open cut pits and mine infrastructure, including final landforms.

The existing Middlemount Coal Mine OPSIM water balance model was reviewed and updated to incorporate the Project to assess the performance of the proposed mine affected water management system. The updated OPSIM model was used to predict the performance of the following (WRM, 2020):

- overall water balance – the average inflows and outflows of the water management system for a number of representative realisations;
- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory;
- in-pit storage – the risk of accumulation of water in the mining pit, and the associated water volumes;
- external water demand – the risk and associated volumes of requiring imported external water (via the Anglo Coal pipeline) to supplement site mine water supplies;

- uncontrolled spillway discharges – the risk of uncontrolled discharge from the site storages to the receiving environment; and
- controlled releases – the risk and associated volumes of controlled release water to the receiving environment.

Key outcomes from the overall water balance are (WRM, 2020):

- The overall water management system alternates between generating a net gain or loss of water.
- Average annual external water supply requirements vary between 560 to 870 Megalitres (ML)/year over the life of the Project.
- The net CHPP demand (based upon forecast CHPP output numbers) are generally consistent, with a reduction towards the end of the Project life.
- There were no modelled spillway overflows from the mine water system over the life of the Project.

Furthermore, an URBS hydrological model and a TUFLOW two-dimensional hydraulic model was developed by WRM (2020) to simulate the flood behaviour of Roper Creek (including the proposed realignment and extension of Roper Creek Diversion 2) and Thirteen Mile Gully in the vicinity of the Project. The URBS and TUFLOW models were calibrated to recorded water levels and surveyed peak flood levels for the January 2013 ex-tropical Cyclone Oswald flood event. The existing calibrated TUFLOW model was reconfigured to represent:

- pre-mining conditions;
- approved (Stage 2) mine conditions;
- proposed mine conditions; and
- final landform conditions (post-mining).

Peak food levels, extents and depths were determined for the 50 %, 5 %, 2 %. 1 % and 0.1 % AEP events and the PMF event, for the approved and proposed mine conditions models to assess the flood impacts of the Middlemount Coal Mine Southern Extension Project. These events were also used to define the crest height of the flood protection levee during operations and final landform design surrounding the residual voids, post-mining. The flood modelling results for the operations scenario indicate that (WRM, 2020):

- For the 5 % AEP event, flood levels would be unchanged from approved conditions upstream of Roper Creek Diversion 1 and moderately reduce peak flood levels within Roper Creek Diversion 1. Roper Creek would overflow and drain across Middlemount Road for this event, which is not predicted to occur for pre-mining or approved conditions.
- For the 2 % and 1 % AEP events, peak flood levels are generally unchanged upstream of Roper Creek Diversion 2. The Project will increase flows on Middlemount Road and further downstream above approved and pre-mining conditions. Peak flood levels (and flows) would reduce within the Roper Creek channel.

The southern portion of the realigned flood protection levee would be decommissioned to widen the post-mining Roper Creek floodplain at the cessation of mining, with the rehabilitated final landform providing flood immunity to the southern void up to the PMF level from Roper Creek. The post-mining flood modelling results indicate that (WRM, 2020):

- For the 5 % AEP event, Middlemount Road would remain trafficable. The removal of the haul road crossing of Roper Creek and widening of the floodplain would reduce the flows overtopping the Roper Creek Diversion predicted for the operations scenario.

- For the 2 % and 1 % AEP events, peak flood levels along Roper Creek Diversions 1 and 2 would reduce from approved conditions due to the additional conveyance capacity of the widened floodplain.

3.5.3.3 Soil and Capping Material Assessment

Quantity of Available Resources

Soil surveys conducted for the Middlemount Coal Mine by Parsons Brinckerhoff (2010b) suggested the recommended topsoil stripping depths should be based on the quality of the topsoil. Preliminary material inventory to determine the quantity of topsoil available for rehabilitation at the Middlemount Coal Mine was undertaken by Parsons Brinckerhoff. MCPL will continue to assess the available and required soil resource quantities. Majority of topsoil from the proposed disturbance areas will be recovered, reused and available for use in rehabilitation of disturbed areas to meet the requirements of rehabilitation concepts.

Ameliorants and Fertilisers

Prior to commencement of topsoiling works, adequate sampling is to be undertaken to ensure the soil parameters are within the specified range. Dependent upon soil results, additional nutrients may need to be added to the fertilising process.

Existing data indicates that available topsoil materials generally have poor physical and chemical fertility, including low salinity, low organic matter, low nutrient content and a neutral to slightly acidic pH (MCPL, 2012). Therefore, whilst topsoil materials are suitable for use in rehabilitation, they are deficient in key plant nutrients particularly nitrogen and phosphorous. If nutrient deficiencies are not corrected, the rehabilitation would – over the long term – be constrained to a very low level of plant growth and productivity, and to greatly increased erosion risk.

For rehabilitation works to achieve a high level of surface cover, and for that cover to be sustainable, the topsoil needs to be amended to:

- alleviate sodicity;
- increase total nutrient contents;
- establish an organic pool of nutrients; and
- improve soil structure.

As the primary driver for productivity, nitrogen deficiency will likely result in slow growing conditions, likewise phosphorous deficiency commonly results in slow development and stunted plant growth.

Target level (concentration) for the topsoil for Nitrate is > 30 mg/kg with total Nitrogen target > 1,500 mg/kg (Verterra, 2022). There are no target ranges for Total phosphorous.

After laboratory analyses are complete and the existing nutrient levels are known, amelioration rates can be calculated. Target ranges for each parameter as stated above are considered to be levels at which plant nutrient deficiencies are relieved and plant growth will be promoted (Hazelton and Murphy, 2017; Lambert and Turner, 2000; Noble, 1996; Baker and Eldershaw, 1993). It is not possible to achieve these increases using a single application of soluble fertilisers without significant impacts on plant growth. Therefore, topsoil amelioration will be applied through the application of gypsum and organic matter at rates calculated from soil testing and targets.

Surface Preparation Process

Rehabilitation will be undertaken progressively as the Middlemount Coal Mine expands. The revegetation sequence of works is generally:

1. Rip waste rock material to a minimum of 300 mm using bulldozer or grader tynes spaced at 50 cm centres.
2. Spread topsoil to a minimum depth of 100 mm and maximum of 200 mm (based on topsoil availability).
3. Spread gypsum and organic matter at rates calculated from soil testing and targets.
4. Harrow with offset disc harrows or similar, and on the contour and void turning over the soil.
5. Apply seed and fertiliser together integrated into soil with scarifiers or harrows (maximum < 100 mm depth) or tracking chains to assist with seed incorporation.

General Soil Management Measures

Specific measures that would be implemented to manage soil resources include:

- Areas of disturbance would be stripped progressively, as required, to reduce potential erosion and sediment generation, and to minimise the extent of topsoil stockpiles and the period of soil storage.
- Areas of disturbance to be stripped would be clearly defined so the dozer operator clearly understands the boundaries of the area to be stripped.
- During the topsoil stripping:
  - visual inspections would be conducted to confirm that appropriate soil stripping depth is being recovered; and
  - small areas (e.g. 1 m by 1 m) can be left unstripped at approximately 100 m intervals to record stripping depths, soil profile observations and collect soil samples for analysis.
- Topsoil would be placed directly on completed sections of the final landform or placed in topsoil stockpiles.
- The perimeter of topsoil stockpiles would be marked and appropriately signed.
- The topsoil stockpile locations and volume would be surveyed for inclusion in the topsoil inventory.

Any long-term soil stockpiles would be managed to maintain long-term soil viability through the implementation of the following management practices as listed below:

- Topsoil stockpiles would be retained at a maximum height of 3 m and would not be double stacked to avoid compaction and deterioration of the soil itself.
- Topsoil stockpiles would be constructed to minimise erosion (e.g. roughened surface maintained), encourage drainage, and promote revegetation.
- Wherever practicable, soil stockpiles would not be trafficked, deep ripped or removed in wet conditions to avoid breakdown in soil structure.
- All topsoil stockpiles would be protected with a non-persistent cover crop to reduce erosion potential as soon as practicable after completion of stockpiling.
- Soil stockpiles would be located in positions to avoid surface water flows. Silt stop fencing would be placed immediately down-slope of stockpiles until stable vegetation cover is established.

- An inventory of soil resources (available and stripped) would be maintained and regularly reconciled with rehabilitation requirements.

3.5.3.4 Waste Characterisation

Detailed geochemical investigations (including static and kinetic net acid generation [NAG] testing) have been undertaken on drill-hole interval samples representing the different material types and lithologies present at the Middlemount Coal Mine in 2012, 2013, 2016 and 2019. Coal and mining waste materials at the Middlemount Coal Mine are generated from mining and processing of the Pisces, Tralee and Middlemount coal seams. Spoil is generated from overburden and interburden materials required to be removed in order to access the coal seams. As a result, coal rejects are produced as a by-product from the coal processing at the CHPP.

Geochemical testing was undertaken by RGS Environmental Pty Ltd (RGS) (2013) at the Middlemount Coal Mine and included 'contact' testing and static and kinetic geochemical testing of representative samples of inter/overburden, coal, and coal reject materials from the open cut and CHPP operations. Additional to these investigations, an extensive program of kinetic leach column testing was undertaken for selected sample materials at ALS Laboratory in Brisbane.

On-going characterisation of the mining waste materials (including overburden, interburden, floor, roof and partings) will be completed on a project basis if new areas of the site are planned to be mined that have not been previously characterised. Ongoing characterisation of coarse rejects and tailings will be undertaken periodically to ensure that the material treatment suits the categorisation (MCPL, 2020b).

Overburden and Interburden Characterisation

Testing undertaken by RGS (2013; 2019) collected 32 samples of overburden/interburden (spoil) materials from the open put to best represent the alluvium, weathered and unweathered Tertiary materials (generally sandy clays) and Permian materials (generally sandy siltstone and occasionally mudstone) encountered within the typically uniform stratigraphic profile.

These test results indicate that (RGS, 2013; 2019):

- The overburden and interburden samples ranges from pH neutral to alkaline (pH 7.7 to 10). The overburden samples represent alluvium and tertiary materials which are typically slightly alkaline (median pH 8.3). The interburden samples represent Permian materials which are typically more alkaline (median pH 9.7). the median $EC_{1:5}$ values of the overburden and interburden samples are regarded as representing 'Medium' (450-900 weight-volume [w/v] microSiemen per centimetre [µS/cm]) and 'Low' (140-450 w/v µS/cm) salinity materials.
- Overburden and interburden materials at the Middlemount Coal Mine suggests that spoil is essentially barren of sulfur, is classified as NAF, and has a high factor of safety with respect to any potential to generate Acid and Metalliferous Drainage (AMD).
- The ANC of the interburden (Permian) samples is significantly greater than the overburden (Alluvium and Tertiary) samples and the median ANC values are 4.5 and 57.2 kg H_2SO_4/t, respectively. Hence, the Permian interburden samples may represent a material that could provide a useful source of alkalinity at the Project.
- Results demonstrated that all of the inter/overburden samples have negative NAPP values ranging from -93.5 to -0.3 kg H_2SO_4/t (median -8.6 kg H_2SO_4/t). This data further confirms the AMD risk classification of NAF (Barren) for all of the inter/overburden samples tested, since the negligible amount of acidity that could theoretically be generated would be neutralised in-situ by the inherent amount of excess ANC.

The overburden and interburden excavated as waste rock, is either dozer pushed into the in-pit waste rock emplacements or loaded into trucks for hauling to dedicated out-of-pit waste rock emplacements. The weathered material is typically removed without blasting, but the more competent material requires drilling and blasting.

RGS (2013; 2019) provided the following recommendations for management of the overburden and interburden waste rock:

- Overburden is classified as NAF and is placed in any in-pit or ex-pit spoil dump. Dispersive material is preferentially placed away from the final landform surface.
- Interburden is preferentially placed in-pit to provide the acid neutralisation capacity for spot-dumping of Potentially Acid Forming (PAF) materials and creation of Permian caps and bunds on coal reject cells. Placement in ex-pit spoil can be used to neutralise any PAF material that is placed in the ex-pit spoil.
- If practical, PAF floor materials from the Middlemount seam should remain in the open pit and be covered with NAF spoil. If this is not practical, and any PAF floor materials from the Middlemount seam need to report to the out-of-pit spoil dump areas, it is then recommended that these materials be lime dosed (at a rate of 10 t/ha or as confirmed by field trials) and kept at least 10 m away from the outer surfaces of final landforms by covering with Permian spoil.
- Scale up of leaching tests for PAF materials and mixed PAF/Permian spoil materials is recommended as part of operational planning if co-disposal of these materials is to be implemented;
- Implementing practical site rehabilitation practices for potentially sodic spoil materials to limit the risk of dispersion and erosion of surface materials at emplacement areas (eg. utilise a topsoil cover as part of final rehabilitation).

MCPL will implement these recommended measures at the Middlemount Coal Mine.

Coarse Rejects Characterisation

RGS (2012; 2016) detailed the geochemical characterisation of coarse rejects data for the Middlemount Coal Mine.

Test results indicate that (RGS, 2012; 2016):

- Majority of coarse reject materials have a pH range from neutral (6.1) to alkaline (9.7). Three coarse reject samples that were tests had a pH of below 5, two of them have the lowest observed pH values of 2.6 and 2.8 (RGS, 2013). Additionally, coarse reject samples range from 252 to 687 µS/cm.
- The ANC for coarse reject samples has a median of 21.8 kg H_2SO_4/t. Lowest ANC value was 4.5 H_2SO_4/t., with a maximum of 100 H_2SO_4/t. No results are available regarding the potential availability of the ANC, however previous studies completed on coarse rejects at the Middlemount Coal Mine suggest that most of the ANC content is likely to be readily available to provide acid buffering at higher pH values (RGS, 2012).
- A Standard NAG test was applied to the coarse reject materials and concluded that majority of the samples were PAF, with some samples being from NAF due to the NAG pH identification.

RGS, (2012; 2013; 2016; 2019) provided the following additional recommendations for management of coarse rejects:

- Coarse rejects are discharged to the 240 t rejects bin via the rejects conveyor. Mine Haul trucks haul the rejects from the bin for disposal within the in-pit spoil dump.

- Where rejects production exceeds haulage to in-pit disposal or wet-weather constrains pit access, rejects may be temporarily stored on the rejects pads. Stockpiled rejects are then loaded into haul trucks using front-end loaders or excavator for haulage to the disposal location in-pit.
- To prevent hang-ups of material and minimise temporary stockpiling of rejects, the Coarse Rejects Bin is to be kept below 75 % full and drawn down regularly when operating with Coarse Rejects only while the CHPP is running. The Bin is to be emptied prior to any planned shut-downs.
- In the event that tailings are co-mingled with the coarse rejects on the rejects conveyor, the Coarse Rejects Bin is to be maintained below 50 % capacity and is to be emptied regularly.
- Drainage from coarse rejects storage areas (rejects bin and temporary rejects storage locations) is contained on site (as detailed in the Middlemount Coal Mine Water Management Plan (WRM, 2019). Water is returned to the Raw Water Dam for reuse as soon as practicable.
- Co-disposal of PAF coarse reject/tailings materials and Permian spoil within the boundaries of the open pit area (i.e. internally draining bounds of the open pit spoil). To provide an extra factor of safety, it is recommended that the maximum ratio of PAF coarse reject/tailings to Permian spoil at the open pit spoil emplacement area be 1 to 3 and ideally 1 to 5 as well as being located at least 10 m from the final landform surface.
- If co-disposal is intended to be used at the out-of-pit spoil emplacement area, it is recommended that lime dosing of co-disposed coarse reject/tailings be considered (at a rate of 10 t/ha or at a rate determine in field trials) to increase the lag time of these materials prior to covering with at least 10 m of Permian spoil. Lime dosing could involve a mobile lime dosing plant and/or broadcast application of agricultural lime, for example. To provide an extra factor of safety, it is recommended that the maximum ratio of PAF coarse reject/tailings to Permian spoil at the out-of-pit spoil emplacement area be 1 to 10.
- Ongoing geochemical characterisation (Acid Base Accounting) of representative samples of coal and potential coal rejects materials from the target coal seams below the weathered zone in the open pit.

These recommendations will be implemented by MCPL for the Middlemount Coal Mine.

Tailings Characterisation

RGS (2012; 2016) detailed the geochemical characterisation of coarse rejects and fine rejects (tailings) data for the Middlemount Coal Mine.

Test results indicate that (RGS, 2012; 2016):

- Majority of tailings materials have a pH range from neutral (7) to alkaline (8.6). Additionally, tailings contained an EC range from 488 µS/cm to 1,390 µS/cm.
- The ANC for tailings samples had a minimum of 3.8 kg H2SO4/t, and a maximum of 65.6 kg H_2SO_4/t. No results are available regarding the potential availability of the ANC, however previous studies completed on tailings materials at the Middlemount Coal Mine suggest that most of the ANC content is likely to be readily available to provide acid buffering at higher pH values (RGS, 2012).
- A Standard NAG test was applied to the coarse reject materials and concluded that majority of the samples were PAF, with some samples being from NAF due to the NAG pH identification.

Tailings storage facility design and management are described further in Section 3.5.4.

RGS (2012; 2013; 2016) provided the following additional recommendations for management of coarse rejects and tailings:

- Tailings materials are stored at the small TSF located adjacent to the south western boundary of ML70379, and near the CHPP.
- Co-disposal of PAF coarse reject/tailings materials and Permian spoil within the boundaries of the open pit area (i.e. internally draining bounds of the open pit spoil). To provide an extra factor of safety, it is recommended that the maximum ratio of PAF coarse reject/tailings to Permian spoil at the open pit spoil emplacement area be 1 to 3 and ideally 1 to 5 as well as being located at least 10 m from the final landform surface.
- If co-disposal is intended to be used at the out-of-pit spoil emplacement area, it is recommended that lime dosing of co-disposed coarse reject/tailings be considered (at a rate of 10 t/ha or at a rate determine in field trials) to increase the lag time of these materials prior to covering with at least 10 m of Permian spoil. Lime dosing could involve a mobile lime dosing plant and/or application of agricultural lime. To provide an extra factor of safety, it is recommended that the maximum ratio of PAF coarse reject/tailings to Permian spoil at the out-of-pit spoil emplacement area be 1 to 10.
- At the Middlemount Coal Mine, MCPL uses earth bunded structures as ILF cells designed to hold flocculated tailings temporarily whilst dewatering takes place and excavation/reclamation of dried tailings can occur. The ILF cells have a minimum capacity of one week of CHPP production with additional allowance (freeboard) for rainfall and water management. Cells are designed with no external catchment to minimise flooding potential, environmental risk and Design Storage Allowance (DSA) requirements and will include sufficient DSA capacity in addition to the operational volumes. All water produced is returned to the CHPP or the Raw Water Dam to supply plant make-up water.
- The tailings are dosed with flocculant to accelerate the dewatering process prior to placement in the ILF cells. The dewatered tailings are allowed to dry and are then excavated and trucked to the pit for placement within the in-pit spoil dump. The CHPP is responsible for the operation of the tailings discharge and return water. Mine operations are responsible for tailings reclamation.

3.5.3.5 Landform Design

The approved Middlemount Coal Mine final landform consists of the following:

- in-pit and out-of-pit waste rock emplacements (slopes and upper surface);
- two residual voids;
- water storage/water management dams;
- rehabilitated infrastructure areas (including mine infrastructure area [MIA], CHPP and roads);
- rehabilitated Roper Creek Diversions;
- rehabilitated Thirteen Mile Gully Diversion; and
- rehabilitated TSF and TFCs (FC1 and FC2).

The final landform is presented on Figure 15 which includes surface elevation contours and final project domains.

MCPL engaged Landloch Pty Ltd (2019) to assess landform designs and erosion modelling of the Middlemount Coal Mine. In consideration of the landform design, Landloch (2019) applied the following work scope to parameterise and run runoff/erosion modelling;

- Laboratory measurements of runoff and erosion on rock:soil mixes of materials;
- Use of the Water Erosion Prediction Program (WEPP) erosion model parameters from the laboratory data; and
- Generation of WEPP simulations to develop landform design rules.

The runoff/erosion simulations showed that establishment of a sufficient and sustainable vegetation cover is critical for landform stability.

A further description of each of the key landforms is provided below.

Out-of-pit Waste Rock Emplacements

During the excavation of the box cuts, waste rock is loaded into haul trucks for hauling to out-of-pit waste rock emplacements. Once sufficient space is available behind the active face, waste rock material is placed in-pit behind the active workings to minimise surface disturbance associated with the out-of-pit waste rock emplacements. When the out-of-pit waste rock emplacements are no longer required (i.e. once in-pit emplacement resumes), progressive rehabilitation will be commenced to minimise the amount of time there is active disturbance associated with the out-of-pit waste rock emplacements.

Waste rock will also be placed in out-of-pit waste rock emplacements in selected areas around the final voids so that the rehabilitated final landform provides flood immunity for the final voids up to the PMF. The final elevations of the out-of-pit waste rock emplacements will be at least 8.5 m above natural ground level and 150 m wide. The out-of-pit waste rock emplacements will be contoured to an angle of < 18.5%, utilising rock mulch where necessary to achieve greater stability (>16%).

The out-of-pit waste rock emplacements will be topsoiled and seeded with grass, tree and shrub species. Revegetation management is discussed further in Section 3.5.3.8.

The final landform design is shown on Figure 15.

In-pit Waste Rock Emplacements (Backfilled Voids)

Once sufficient space is available behind the active face, waste rock material is placed in-pit behind the active workings to minimise surface disturbance associated with out-of-pit waste rock emplacements and to also minimise the size of the final voids. Rehabilitation of the in-pit waste rock emplacements will progressively follow the active mining face, thereby minimising the area of active disturbance at any given time.

Coal rejects will also be disposed of in the in-pit waste rock emplacements. Coarse reject material from the CHPP is placed within in-pit waste emplacements.

In pit Coal Rejects Emplacements

All coarse coal rejects from the CHPP are placed within the in-pit co-disposal waste emplacements.

Final Voids

Two residual voids are approved at the Middlemount Coal Mine in the northern and southern areas of the open cut extent (Figure 15). The residual voids are to be designed to not cause any serious environmental harm to land, surface water or groundwaters outside of the void in accordance with Condition G21 of the EA. Further detail on the final voids is provided within Section 3.5.5.

The residual voids would partly fill with water (i.e. groundwater recovery and incident rainfall and runoff) and be subject to evapo-concentration effects which would result in the salinity gradually increasing over time.

A safety bund wall consisting of competent rock and/or fencing would be constructed to limit human and livestock/animal access to the residual voids. The bund wall would have a minimum height of 2 m, with a minimum base width of 4 m and be located at least 10 m beyond the area potentially affected by any instability of the open cut pit edge. In places, the safety bund will be incorporated as part of the out-of-pit waste rock emplacements which will serve the purpose of PMF flood protection (as described earlier in this Section 3.5.3.5).

Infrastructure

This mining domain is dominated by the infrastructure associated with the existing mine infrastructure area as well as site wide supporting infrastructure. The infrastructure domain includes, but is not limited to:

- CHPP;
- ROM coal and product stockpiles;
- train loadout and rail loop;
- workshops, stores, administration buildings, toilet complexes, vehicle wash bays, control room and coal testing laboratory, diesel fuel storage area;
- major access roads and haul roads;
- electrical supply infrastructure; and
- water management features including water storages, sediment control structures, diversions, drains and operational flood levees.

Due to the ongoing use of the infrastructure, progressive rehabilitation of significant areas is not practicable as the domain will remain actively utilised with majority of disturbance required for the life of the Middlemount Coal Mine. Notwithstanding, disturbance associated with infrastructure is minimised and will be progressively rehabilitated where possible.

Water Management Features

Water storage and water management dams will be either decommissioned and rehabilitated, or rehabilitated and retained for beneficial reuse, conducive to the surrounding land use if the post-mining land-owner agrees and the dam complies with the limits detained within Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000, or its revision) for a period of at least 5 years post mining. Water management features that are required for the life of the mine will not be able to be progressively rehabilitated until the mine lifetime has expired.

Two diversions of Roper Creek are approved at the Middlemount Coal Mine. Both diversions of Roper Creek will be retained as water management infrastructure and revegetated to the PMLU of native ecosystem and as per Treatment Zone 1 in Section 3.5.3.8.

The Thirteen Mile Gully Diversion was approved in July 2013, predominately outside the former boundary of ML 70379, diverts the upstream sub-catchments of Thirteen Mile Gully to Roper Creek. This diversion will be retained as water management infrastructure and revegetated to the PMLU of native ecosystem and as per Treatment Zone 1 in Section 3.5.3.8.

Quality Assurance/Quality Control Requirements

MCPL currently undertakes quality assurance/quality control of rehabilitated areas throughout the rehabilitation process. MCPL staff complete Environmental Quality Inspection Forms (EQIF) at designated Hold Points to ensure that rehabilitation works have been completed to the relevant specifications. At all stages of the rehabilitation sequence, EQIFs need to be completed and signed off by appropriate personnel prior to the continuation of the rehabilitation sequence.

The EQIF process outlines 'Hold Points' which represent key steps in the rehabilitation process where signoff must be obtained from the nominated entities, this may include:

- the contractor representative;
- MCPL Project Managers (e.g. HSEC Manager or similar); and/or
- Members of the Middlemount Coal Mine environmental team.

Methodology to Verify the Success of the Final Landform Design

Successful rehabilitation of the final landform will be assessed through the completion criteria and monitored following the program outlined in Section 3.7.

The certification process undertaken by DES will verify that the rehabilitation and final landform are successful prior to surrender of the EA.

Limitations and Assumptions of the Landform Design

The final landform design has the following limitations and assumptions:

- Simulations were run for a 500-year period.
- Simulations were developed using a 100-year climate sequence.
- Soil availability and quality are based on soil test sites located at an appropriate density.
- Waste characterisation is based on appropriately selected representative samples.
- Climate change projections (CSIRO, 2015) for the central slopes were adopted.

3.5.3.6 Cover Design

As described in Section 3.5.3.4, the waste characterisation test results indicate that appropriate cover design for each the waste outputs is as follows:

- Overburden and interburden:
  - Geochemical testwork has found that there is a low to negligible risk of acid mine drainage from overburden at the Middlemount Coal Mine. Notwithstanding, laboratory characterisation of overburden material during operations would be conducted to confirm acid generation potential, consistent with existing operations. Any material that is found to be potentially acid forming (PAF) will not be used as capping material and would continue to be buried within the overburden dump with material that has some acid neutralising capacity (MCPL, 2011).

  - Overburden at the Middlemount Coal Mine has been found to be susceptible to dispersion and is erosion prone. Consistent with existing operations, testing of overburden would be conducted to identify material with high susceptibility for dispersion and slaking. Less dispersive material will be utilised as capping material, where possible.

- Coarse rejects and tailings
  - It is recommended that PAF materials (coarse rejects and tailings) be mixed with Permian and /or covered with Permian spoil. PAF disposal locations should be placed at least 10 m from the final landform and drain to the pit (MCPL, 2020b).
  - Spot dumping of PAF coarse rejects and tailings co-disposal and Permian spoil will occur within the boundaries of the open pit area, with the objective of enabling the acid neutralising capacity of the spoil to neutralise the potential acid formation (MCPL, 2020b).
  - PAF material will be mixed with minimum of three parts Permian spoil by weight (target of five parts Permian to one part PAF material) (MCPL, 2020b).
  - Non-Acid Forming coarse rejects and tailings materials will be treated the same as PAF coarse and fine rejects (MCPL, 2020b).

3.5.3.7 Water Management

Site Water Management System

The Middlemount Coal Mine site water management system is operated in accordance with the *Middlemount Coal Mine Water Management Plan* (WMP) and EA EPML00716913. The objective of the water management system at the Middlemount Coal Mine is to manage all water on site to meet operational, social and environmental objectives encapsulated by the Middlemount Coal Mine EA (EPML00716913).

The objectives of the Middlemount Coal Mine water management system specifically seek to:

- have a strategy that ensures Middlemount Coal Mine does not cause environmental harm via mine affected water spills and has sufficient water available for operation in dry times; and
- to be a good custodian of the community's water resources.

To meet these objectives, specific objectives for each water type are utilised. The existing/approved Middlemount Coal Mine water management system includes:

- Tailings return water: Prevent all discharges of tailings return water to the downstream environment. as well as the reuse of tailing return water.
- Mine affected water: Minimise uncontrolled discharges and ensure adequate water supplies are maintained for site demand.
- On-site stormwater: Maintain water quality leaving the Erosion and Sediment Control (ESC) structures to a quality as close to background levels as reasonably possible.
- Catchment runoff water: Ensure that it is separated from the mine affected and on-site stormwater systems, and allowed to pass uninterrupted down the catchment.
- Contaminated water: Prevent all discharges of contaminated water to the downstream environment.
- External water: Ensure that external water allocation and associated infrastructure is sufficient to meet site demands under low rainfall conditions.

WRM (2020) concluded that the Middlemount Coal Mine surface water management system was detailed and had adequate storage capacity to manage surface water runoff contained on-site for a wide range of possible climatic conditions, including extended wet and dry periods. WRM (2020) also concluded that the potential for an uncontrolled release to receiving waters from the sites water management system was very low (i.e. <1 % AEP).

Water Demand and Supply

The Middlemount Coal Mine sources water subject to the following priority order:

- water runoff captured within the water management system (including any groundwater inflows);
- supplied water from the German Creek mine through a Water Supply Agreement with Anglo Coal Pty Ltd (Anglo Coal);
- portable water supplied via truck from Middlemount township to Middlemount Coal Mine; and
- through the usage of water allocations of the Bingegang Pipeline, which runs between the Bingegang weir to the town of Dysart.

Runoff water is preferentially utilised within the CHPP or used as haul road and stockpile dust suppression. Water recycled from the tailing flow cells is returned to a Raw Water Dam (RWD), and reused in the CHPP.

Contaminants That Pose a Risk to Environmental Values

The following potential contaminants have been identified as posing a potential risk to environmental values of the receiving environment:

- acid forming materials;
- dissolved metals;
- total dissolved solids; and
- hydrocarbons.

Source, Pathway and Fate of Contaminants

Key potential sources of contaminants (post-rehabilitation) are:

- in-pit waste rock emplacements;
- In-pit rejects emplacements;
- final voids; and
- the Tailings Storage Facilities.

Pathways for the potential contaminants to reach the receiving environment (e.g. water courses or the groundwater table) include overland flow (e.g. overtopping of the final voids) or infiltration/seepage (e.g. from out-of-pit rejects emplacements).

With regards to overland flow, once rehabilitation is completed, all runoff will be clean water as it will be from rehabilitated surfaces. Runoff within the final void catchments will be directed into the final voids via the safety bund, and will not flow into the receiving environment. Final void catchments will be minimised to allow for rehabilitation contribution to environmental flows.

Infiltration and Seepage Intervention and Collection Controls

With regards to infiltration/seepage (Appendix G):

- Studies undertaken by RGS (2016) determined that most coal samples are initially pH neutral to alkaline, but theoretically have a reduced factor of safety with respect to potential acid generation (albeit that most sulfur is likely to be present in a non-acid generating form (eg. organic sulfur).
- Coal materials are stockpiled for a limited time at site prior to transport off-site to export markets. Coal stockpile areas are sealed with clay compaction during construction and sheeted with competent material. Therefore, the current measures for managing coal stockpile surface water and seepage (collection and monitoring - with lime dosing, if required) employed by MCPL are expected to be appropriate to address the relatively low level of risk to surface water and groundwater resources posed by these materials.

The final landform has been designed to minimise contamination potential as the storages have been designed to prevent seepage. Notwithstanding, if seepage were to occur, it would be drawn to the final voids which act as groundwater sinks for the area, thereby preventing any potential exposure to the receiving environment.

Surface Water Diversions

Temporary and permanent up-catchment diversion structures would be constructed over the life of the Middlemount Coal Mine to divert runoff from undisturbed areas around the open cut pits and waste rock emplacements.

The diversion of Thirteen Mile Gully diverts the flow of water between Drainage line 1 (upstream of Thirteen Mile Gully) to Roper Creek. This diversion that resides within ML 70379 is authorised by the EA. The diversion of Thirteen Mile Gully outside of ML 70379 is authorised under a water licence (No. 608025) under the QLD *Water Act 2000*.

Two diversions of Roper Creek (Roper Creek Diversions 1 and 2) are currently approved under the EA. Roper Creek Diversion 1 has been constructed while Roper Creek Diversion 2 will be constructed in 2022-2023 to allow for the southern extension of the open cut mine within ML 70379.

Ongoing Water Management and Reduction Requirements

As mining approaches completion, MCPL will consult with landholders and/or relevant agencies regarding the potential for retaining water management structures. As native ecosystem is the target PMLU, it is assumed that most water management structures would be rehabilitated and retained post-mining.

If specific water structures are not suitable to be retained, they would be decommissioned or remediated in consultation with relevant stakeholders, future landholders and with the approval of DES. Relevant remediation measures would be determined on a case-by-case basis.

Once remediation is completed, no ongoing water management would be required for the site.

3.5.3.8 Revegetation

Verterra (2022; Appendix H) has reviewed the existing rehabilitation management methodologies implemented at the Middlemount Coal Mine and have prepared a detailed Revegetation Management Plan as part of this PRCP describing three distinct revegetation treatment zones (consistent with the PMLU of native ecosystem). These are:

- Treatment Zone 1 – Areas of the final landform which contain slopes of ≤ 16 %.
- Treatment Zone 2 – Areas of the final landform which contain slopes of > 16 %.
- Treatment Zone 3 – Riparian areas associated with creek diversions of the final landform.

A fourth Treatment Zone (Treatment Zone 4 – Non-use Management Area) has been implemented detailing the revegetation of low-walls and high-walls of the residual voids at the Middlemount Coal Mine.

Treatment Zone 1

Treatment Zone 1 consists of all revegetation areas with low slopes (i.e. slopes of less than 16%) (Verterra, 2022). This zone does not require rock mulch if the waste rock material is chemically treated for dispersive properties. Treatment Zone 1 includes portions of:

- in-pit and out-of-pit waste rock emplacements (both upper surface and slopes if ≤16%);
- rehabilitated infrastructure areas (including MIA, CHPP, water management infrastructure, creek diversions, dams, and roads); and
- rehabilitated Tailings Storage Facilities and Tailings Flocc Cell (i.e. Flocc Cell [FC]1and FC2).

Treatment Zone 2

Treatment Zone 2 consists of all revegetation areas with high slopes (i.e. slopes of greater than 16%), noting this zone does not include the high-walls and some portions of the low-walls for the residual voids (refer to Treatment Zone 4).

Treatment Zone 2 requires the addition of rock mulch to stabilise the steep slope and includes portions of in-pit and out-of-pit waste rock emplacements (where slope >16%).

Treatment Zone 3

Treatment Zone 3 consists of all revegetation areas associated with creek diversions (blue area adjacent to the blue creek line shown in Figure 2). This includes:

- Roper Creek Diversions 1 and 2; and
- Thirteen Mile Gully Diversion.

Treatment Zone 4

Treatment Zone 4 consists of the residual voids at end of mine life (i.e. approved NUMAs as described in Section 3.4). This includes residual void:

- equilibrated void waterbody;
- high-wall; and
- portions of the low-wall.

Revegetation of the low-walls and high-walls would be undertaken to stabilise the landform (consistent with the approach for Treatment Zone 2 [i.e. slopes >16%]).

The revegetation strategy for the Middlemount Coal Mine has been based on the re-construction approach to ecological restoration. This approach is most suitable for disturbed areas or construction areas that show modified or disturbed soils, depleted or absent soil seed bank and high potential for domination by weed species that prevent natural regeneration and succession of the pre-disturbance ecological community. This approach is employed when removal of ongoing threatening processes alone is insufficient to allow natural establishment of ecological processes and communities (Appendix H).

The revegetation strategy does not aim to recreate the conditions of the target regional ecosystems in their remnant or undisturbed state. Rather, the strategy is aimed at establishing a safe, stable and non-polluting landform, with a self-sustaining vegetation cover consistent with the proposed PMLU of native ecosystem (Appendix H).

Initial revegetation activities will focus on the implementation of a fast-establishing cover crop species, alongside a deep-rooted legume to bind the soil and contribute nitrogen to the topsoil within the short term. An improved pasture species comprising a mix of species with a stoloniferous habit is utilised to stabilise the landform, and species with a tussock habit to provide palatable grass for grazing and to increase the capacity to accumulation of soil organic matter (Appendix H).

Cover crop species selection will be based on time of year and may vary depending on the topsoil spreading program. Cover crops suitable for use in revegetation treatment zones 1, 2 and where appropriate treatment zone 3 are specified based on seasonality in Table 19. Cover crop species will be sown at an approximate depth of 50 mm below the soil surface to ensure adequate soil moisture is stored before germination is initiated, and that the seed is not too deep to penetrate the soil surface.

Table 19
Seasonal Preferences and Application Rates for Cover Crops

Cover Crop	Optimal Sowing Time	Application Rate (kg/ha)
Japanese Millet	Summer	5 – 15
White French Millet	Summer	5 – 15
Wintaroo Oats	Winter	5 – 15
Barley	Winter	5 – 15
Annual Ryegrass	Winter-Spring	5 – 15

Species recommended for the revegetation project are presented in Table 20. Not all species listed in Table 20 (especially grasses and forbs) are required to be used in the revegetation program. Rather, a combination of species will be chosen from the list based on the availability of seed prior to revegetation works. However, native groundcover species will be preferentially sourced for treatment zones 1, 2 and 3. In addition, if live topsoiling is used, there will likely be natural recruitment of groundcover species. Native tree species will be seeded within treatment zones 1, 2 and 3 whereby only selected trees are to be seeded on treatment zone 2 due to its steeper gradient. Note that species listed in Table 20 are recommendation only, and the species mix and seeding will be subject to availability at the time.

Seed Procurement and Collection

Seed should be sourced from reputable seed suppliers with documented quality control procedures. Germination and purity testing by a certified laboratory is desirable, however visual inspections by a person possessing suitable qualifications will otherwise be acceptable.

Native seed procurement has a long lead time and without adequate seed storage facilities the timing of supply, resupply and application of seed is important to minimise the storage time outside of controlled conditions. As the Middlemount Coal Mine currently lacks on-site seed storage conditions, procurement timing and storage capabilities should also be considered when scheduling the rehabilitation works.

Table 20
Revegetation Species

Scientific Name	Common Name[3]	Form	Revegetation Methodology	Treatment Zone 1	Treatment Zone 2
Bothriochloa insculpta	Creeping blue grass	Grass	Direct Seed	✔	✔
Chloris gayana	Rhodes grass	Grass	Direct Seed	✔	✔
Cynodon dactylon	Green couch	Grass	Direct Seed	✔	✔
Urochloa mosambicensis	Sabi grass	Grass	Direct Seed	✔	✔
Bothriochloa bladhii	Forest bluegrass	Grass	Direct Seed	✔	✔
Bothriochloa decipiens	Pitted bluegrass	Grass	Direct Seed	✔	✔
Bothriochloa ewartiana	Desert bluegrass	Grass	Direct Seed	✔	✔
Cymbopogon refractus	Barbwire grass	Grass	Direct Seed	✔	✔
Dichanthium sericeum	Queensland blue grass	Grass	Direct Seed	✔	✔
Enteropogon acicularis	Curly windmill grass	Grass	Direct Seed	✔	✔
Heteropogon contortus [1]	Black spear grass	Grass	Direct Seed	✔	✔
Panicum decompositum	Native millet	Grass	Direct Seed	✔	✔
Themeda triandra	Kangaroo grass	Grass	Direct Seed	✔	✔
Corymbia erythrophloia	Variable barked bloodwood[2]	Tree	Direct Seed	✔	✔
Eucaluptus exerta	Queensland peppermint[2]	Tree	Direct Seed	✔	✔
Eucalyptus microcarpa	Grey Box[2]	Tree	Direct Seed	✔	✔
Eucalyptus melanophloia	Silver leaved ironbark[2]	Tree	Direct Seed	✔	✔
Eucalyptus orgadophila	Mountain coolibah[2]	Tree	Direct Seed	✔	✔
Acacia harpophylla	Brigalow	Tree	Direct Seed	✔	✔
Casaurina cristata	Belah	Tree	Direct Seed	✔	✔
Corymbia citriodora	Lemon-scented gum	Tree	Direct Seed	✔	✔

Table 20 (continued)
Revegetation Species

Scientific Name	Common Name	Form	Revegetation Methodology	Treatment Zone 1	Treatment Zone 2
Corymia clarksoniana	Clarkson's bloodwood	Tree	Direct Seed	✔	✔
Corymbia dallachiana	Dallachy's gum	Tree	Direct Seed	✔	✔
Eucalyptus cambageana	Dawson River blackbutt	Tree	Direct Seed	✔	✔
Eucalyptus crebra	Narrow leaved ironbark	Tree	Direct Seed	✔	✔
Eucalyptus populnea	Poplar box	Tree	Direct Seed	✔	✔
Geijera parviflora	Wilga	Shrub	Direct Seed	✔	✔
Acacia salicina	Native Willow	Tree	Direct Seed	✔	✔
Lysiphyllum hookeri	Pegunny	Tree	Direct Seed	✔	✔
C. tessellaris	Carbeen	Tree	Direct Seed	✔	✔
E. brownii	Brown's Box	Tree	Direct Seed	✔	✔
Cassia brewsteri	Bean Tree	Tree	Direct Seed	✔	✔
Carissa ovata	Conkerberry	Shrub	Direct Seed	✔	✔

[1] Important to note that unless threshed and coated, *Heteropogon contortus* is very difficult to mix and can cause problems with spreading machinery.
[2] Priority species
[3] These species are the recommended revegetation species, and will be subject to availability at the time of revegetation.

NB: This seed list is a guide and not exclusive. Mixes will vary due to seed availability and will be subject to ongoing improvements.

Riparian Vegetation (Treatment Zone 3)

Creek diversions and drainage lines within the Middlemount Coal Mine final landform (i.e. Treatment Zone 3) would be rehabilitated to achieve the target PMLU of native ecosystem. However, as described above, riparian areas would require a quick to establish seed mix more suited to a riparian environment. Seed species required would vary from the toe of the bank to the overbank area and, while utilising some species noted in Table 20, seed mixes would require species such as:

- Native trees:
  - *Casuarina cunninghamiana* (River she-oak);
  - *Eucalyptus camaldulensis* (River red gum);
  - *Eucalyptus tereticornis* (Forest red gum);
  - *Melaleuca viminalis* (Dawson River bottlebrush); and
- Native sedge-rushes:
  - *Lomandra longifolia* (Spiny-head mat-rush);
  - *Cyperus exaltatus* (Tall flatsedge).

Establishment Methods

Direct seeding will be preferred to achieve a dense or continuous cover of green cover crops and grass species. Seeding may be undertaken using conventional broadacre seeding equipment (e.g. combine seeder, spreader with harrows or spinner).

Grass seeding rates for the improved pastures have a range from 1.0 kg/ha, to 6.0 kg/ha. However, application rates for native grasses utilised for grazing have a range from 0.5 kg/ha to 3.0 kg/ha. The application rate for cover crops has a range between 5.0 kg/ha to 15.0 kg/ha and the application rate for legumes has a range between 2.5 kg/ha to 10 kg/ha.

It is recommended that MCPL conduct trials of direct mechanical seeding of tree and shrub species. This can be done after the rehabilitation is stable around years 2-4. These can be completed as a patch mosaic for example. Starting with smaller patches to identify successful methodologies and increasing these areas when confidence of success increases.

Table 21 sets out the anticipated proportion of seed by plant species for vegetation treatment zones 1, 2, 3 and 4.

Note that not all species listed in Tables 21 and 22 will be used in the revegetation. Rather, a combination of species will be chosen from the list based on the availability of seed. A contingency amount of 20 % will typically be utilised to account for mortality. Table 22 sets out the anticipated seed quantities for grasses and cover crops per ha across vegetation treatment zones 1, 2, 3 and 4. Seed quantity includes cover crop species, although it should be noted that cover crops will be chosen in consideration of season of application.

Table 21
Seed Mix Proportions per Plant Species

Stratum	Treatment Zone 1 (Slope ≤16%)	Treatment Zone 2 (Slope >16%)	Treatment Zone 3 (Riparian)	Treatment Zone 4 (NUMA)
Target application rate	35kg/ha	55kg/ha	20 kg/ha	Nil [1]
Cover crop	28.5%	33.0%	25.0%	-
Non-native grass	43.0%	45.5%	25.0%	-
Native grass	25.5%	18.0%	25.0%	-
Native tree and shrub	3.0%	3.5%	15.0%	-
Native sedge	-	-	10.0%[2]	-

[1] Where portions of the low wall can be revegetated, but not grazed, revert to Treatment Zone 2 mix.
(Verterra, 2022)
[2] Sedge species are importance to riparian vegetation establishment but are sensitive to soil moisture content. There may be greater success if supplemented or replaced with tube stock planting.

Table 22
Seed Quantities Required for Grasses and Cover Crops

Scientific Name	Common Name	Form	Suitability	Rate (kg/ha)[1]	Target Rate from Verterra
Echinochloa esculenta	Japanese Millet	Cover Crop	Summer	5.0 – 15.0	1 – 2 species
Panicum miliaceum	White French Millett		Summer	5.0 – 15.0	
Avena sativa	Wintaroo Oats		Winter	5.0 – 15.0	
Hordeum vulgare	Barley		Winter	5.0 – 15.0	
Lolium rigidum	Annual ryegrass		Winter-Spring	5.0 – 15.0	
Bothriochloa insculpta	Creeping blue grass	Non-native Grasses	N/A	2.5 – 5.0	3 – 5 species
Chloris gayana	Rhodes grass		N/A	2.5 – 5.0	
Cynodon dactylon	Green couch		N/A	4.0 – 6.0	
Urochloa mosambicensis	Sabi grass		N/A	2.5 – 5.0	
Bothriochloa bladhii	Forest bluegrass	Native grasses (grazing)	N/A	1.0 – 3.0	3 – 5 species
Bothriochloa decipiens	Pitted bluegrass		N/A	0.5 – 2.0	
Bothriochloa ewartiana	Desert bluegrass		N/A	0.5 – 2.0	
Cymbopogon refractus	Barbwire grass		N/A	0.5 – 2.0	
Dichanthium sericeum	Queensland blue grass		N/A	1.0 – 3.0	
Enteropogon acicularis	Curly windmill grass		N/A	1.0 – 2.0	
Heteropogon contortus [3]	Black spear grass		N/A	0.5 – 1.0	
Panicum decompositum	Native millet		N/A	0.5 – 2.0	
Themeda triandra	Kangaroo grass		N/A	0.5 – 2.0	

[1]Important to note that unless threshed and coated, *H. contortus* is very difficult to mix and can cause problems with spreading machinery.

Further detail candidate tree, shrub and legume species suitable for inclusion in the revegetation seed mix as well as additional detail on the revegetation strategy is provided in the Revegetation Management Plan (Appendix H).

3.5.4 Tailings Storage Facilities

Coarse reject material from the CHPP is placed within in-pit waste emplacements. Fine reject material is stored in TSF cells TSF1 and TSF2 (Figure 2). TSF2 has been divided into four cells with a further two tailings flocc cells (TFC's) (FC1 and FC2) providing emergency capacity, which have not been required to date. All tailings facilities are constructed with earthen embankments on all sides and do not receive runoff from external catchments.

Fine rejects from the CHPP are comprised mostly of fine silt, clay, water and coal material. The fine rejects are pumped to the TSF cells and flocculant is added prior to deposition. Decant water is pumped to SD1 then returned to the CHPP and raw water dam for reuse.

3.5.5 Voids

3.5.5.1 Minimisation of Residual Voids

There are two residual voids approved at the Middlemount Coal Mine, located in the northern and southern area of the mine pit (Figure 16).

The north void will have a maximum area of 358 ha, and the south void area will have a maximum area of 163 ha. The design of the final landform (including the residual voids) has taken into consideration the disposal of waste rock in-pit to minimise the size of the residual voids where reasonable and practicable.

3.5.5.2 Residual Void Dimensions and Slope Angles

As described in Section 3.4, the residual voids must be consistent with the description provided in most recent Middlemount Coal Mine Geotechnical – Final Void Study (Appendix K), as per Plate 4 below.

Table 5 Recommended slope geometry for the final voids

Material	Overall Slope Angle (°)	Bench Height (m)	Berm Width (m)	Batter Angle (°)
Surficial Soils	20	NA	NA	NA
Weathered Permian	NA	30	25	55
Fresh Permian	NA	60	60	60

Table 6 Recommended slope geometry for lowwalls

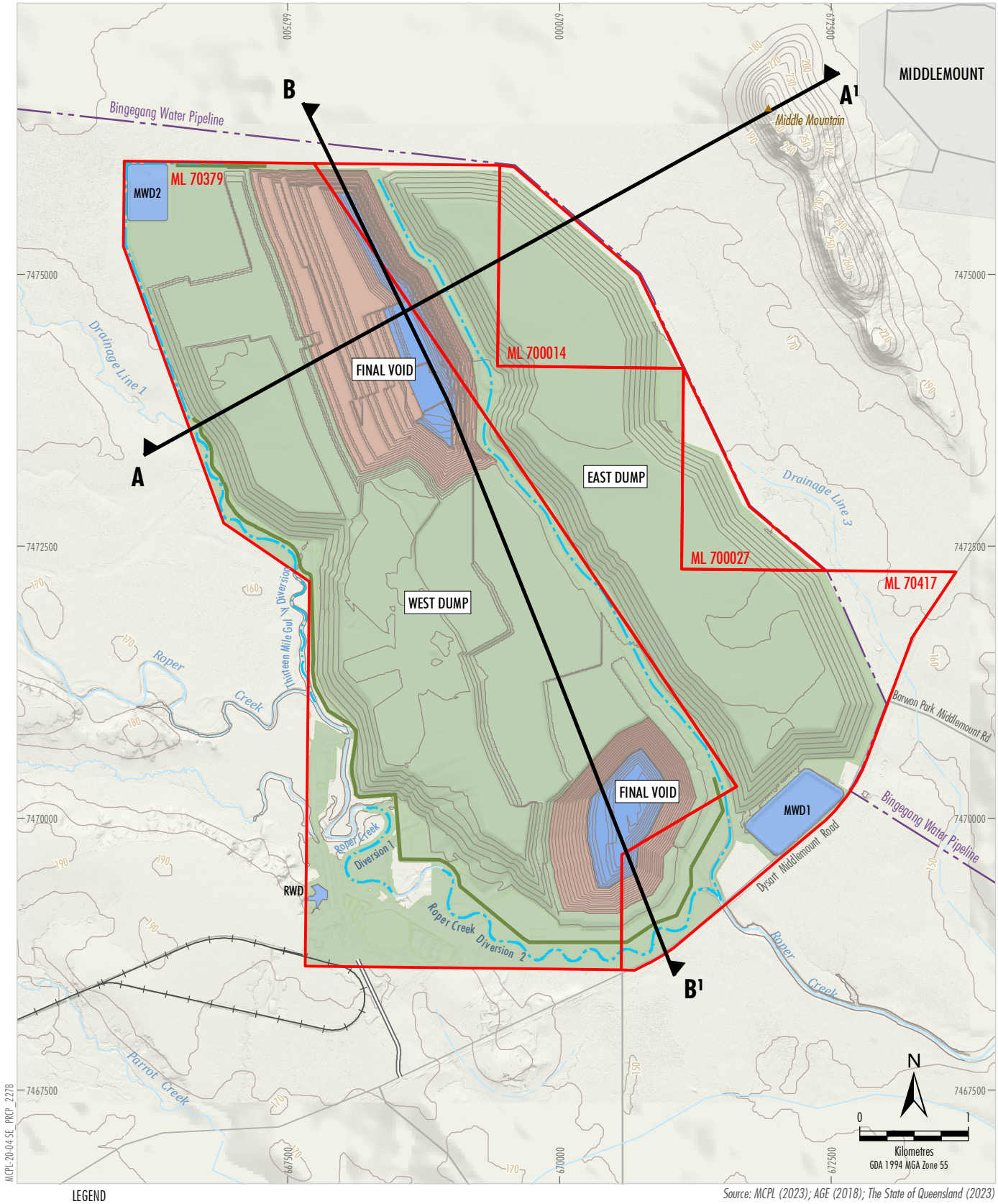
Material	Overall Slope Angle (°)~	Max. Bench Height (m)	Berm Width (m)*	Batter Angle (°)
Lowwall CAT3 Spoil	27	40	12 to 25	37

~This is the maximumOSA allowed for lowwall designs

*The bench geometries maybe changed to satisfy the OSA, this include bench height and berm width

Plate 4 – Table 5 and 6 from the Middlemount Coal Mine Geotechnical – Final Void Study

The residual void designs are shown on Figures 19, 20 and 21.



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee (Rehabilitated)
- Final Landform Contour (10 m)
- Established Rehabilitation
- Final Void
- Water Storage

Source: MCPL (2023); AGE (2018); The State of Queensland (2023)

Refer Figure 20 and 21 for Cross Sections.

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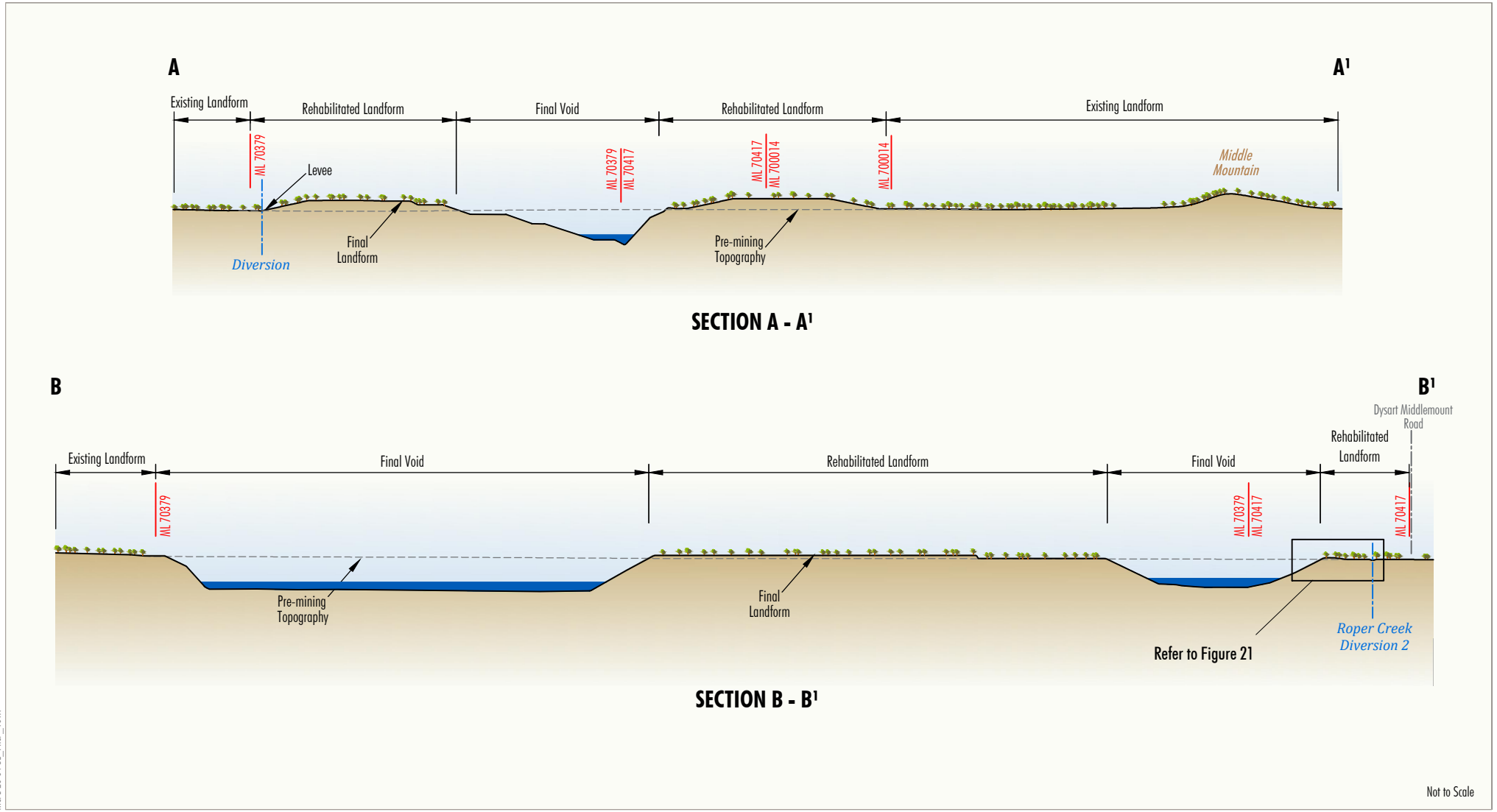
MIDDLEMOUNT COAL MINE

Conceptual General Arrangement Post-mining - Cross Section Locations

Figure 19



MCPL-20-04 SE_PRCP_101A

Source: MCPL (2022); AGE (2020)

Refer Figure 19 for Cross Section locations.

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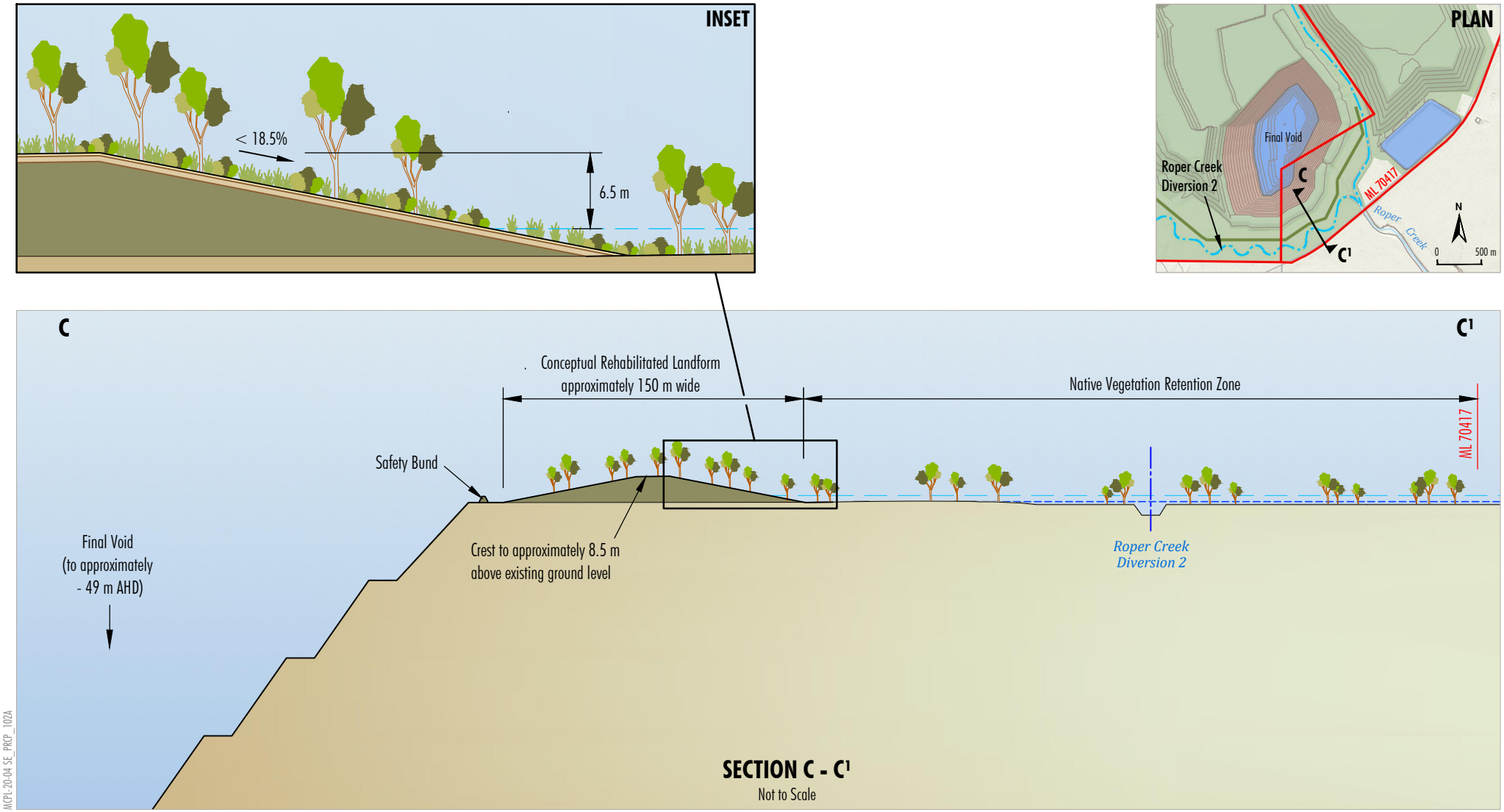
MIDDLEMOUNT COAL MINE

Conceptual Cross Sections
of the Rehabilitated Mine Landform

Figure 20



MCPL-20-04 SE_PRCP_102A

LEGEND

0.1% AEP Flood Level (approximately 155 m AHD) (WRM, 2020)

Probable Maximum Flood (PMF) Level (approximately 156.5 m AHD) (WRM, 2020)

Source: MCPL (2022); WRM (2020); AGE (2020)

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MIDDLEMOUNT COAL MINE

Conceptual Final Landform Design
Relative to the Roper Creek Floodplain

Figure 21

3.5.5.3 Final Void Stability

The Southern Extension Project EVA (MCPL, 2020a) included a Residual Void Slope Stability Study by Geotechnical Consulting Services (2014). The study included an investigation of geotechnical stability of highwall and low wall slopes, environmental stability and provides an indication of the remedial measures needed to achieve geotechnical stability.

The Residual Void Slope Stability Study (Geotechnical Consulting Services, 2014) concluded that the rock highwalls are inherently stable against mass failure in normal conditions but large scale instability is likely in proximity to the Jellinbah fault. The location and nature of the Jellinbah fault system has not been adequately defined, noting that at this stage closure is still a long way off and the final highwall location is likely to change as mining proceeds.

Final void highwalls will be treated (e.g. benched or blasted) so that they are geotechnically stable to an appropriate factor of safety. Once completed, a safety assessment and geotechnical investigation will be undertaken to confirm the safety and stability of the highwall for the long term. An as-built design report will be completed to confirm that the final voids are consistent with the requirements of EA EPML00716913.

A safety bund wall consisting of competent rock and/or fencing would be constructed to limit human and livestock/animal access. The bund wall would have a minimum height of 2 m, with a minimum base width of 4 m and be located at least 10 m beyond the area potentially affected by any instability of the open cut pit edge.

Appropriate signage alerting people to the presence of the voids will be placed around the bund.

3.5.5.4 Final Void Hydrology

Inflows

Once mining operations cease, groundwater inflows to the residual voids would no longer be collected and pumped out, and as a result, the residual voids would gradually begin to fill with groundwater.

Inflows into the residual voids would comprise incident rainfall, runoff within the residual void catchment area and groundwater (including spoil dump infiltration). The catchment area of the residual voids would be minimised and is defined by the surrounding landform including safety bunds and/or upslope diversion channels. The catchment area of the residual voids is shown in the Surface Water Assessment (Appendix A).

Water Level Recovery Analysis

Final void water recovery analyses have been conducted as part of the Surface Water Assessment (Appendix A) based on predicted groundwater inflows developed as part of the Groundwater Assessment (Appendix B).

The model analyses the long-term water level behaviour within both the northern and southern residual voids over a time period of 500 years. These modelling results are highlighted below (Appendix A):

- Final Void (Northern), the water level reaches equilibrium between 6.5 m AHD and 13 m AHD after 200 years, with variation present from this equilibrium value for the remaining 300 years of the simulation. The maximum water level modelled was measured to be around 150 m below the full supply level, and 127 mbgl (pre-mining).

- Final Void (Southern), the water level reaches equilibrium between 32 m AHD and 37 m AHD after 200 years of simulation, with little variation present from the equilibrium value for the remaining 300 years of the simulation. The maximum water level modelled was measured to be around 122 m below the full supply level, and 93 mbgl (pre-mining).

The final void waterbodies are not predicted to spill under any of the simulated climatic sequences, and the voids would remain as long-term groundwater sinks (Appendix A). The water balance modelling also indicates that there would be no interaction between the long-term surface water levels within the North Void and the South Void. Due to different floor elevations and predicted water levels within the voids, a groundwater flow gradient from the South Void into the North Void through the spoil backfill would occur (Appendix A).

3.5.5.5 Final Void Water Quality

Residual void water recovery analyses have been conducted as part of the Surface Water Assessment, which included simulations of the long-term salinity of the residual void waterbodies (Appendix A).

The salinity of the residual voids would gradually increase over time, however as described further below would be contained within the voids (i.e. the voids would remain as long-term groundwater sinks and would not spill [Appendix A]). The salinity levels within the residual void waterbodies were modelled for the first 500 years, with salinity levels expected to increase past the 500 year limit. Comparisons of the peak salinity concentrations and the accumulation of salt for the northern and southern void are given below (Appendix A):

- Final Void (Northern) maximum salinity concentration was modelled to be 74,700 milligrams (mg) per Litre (L) (mg/L), with an accumulation rate of 2,470 tonnes per year;
- Final Void (Southern) maximum salinity concentration was modelled to be 53,950 mg/L, with an accumulation rate of 2,450 tonnes per year.

3.5.6 Underground Mining

This section of the PRCP Guideline is not relevant to the Middlemount Coal Mine as it is an open cut mining operation (Section 3.1.1).

3.5.7 Built Infrastructure

3.5.7.1 Infrastructure Decommissioning and Removal

The vast majority of the Middlemount Coal Mine infrastructure domain is required to support mining operations up to closure, and will be accordingly rehabilitated at the cessation of mining operations. Following cessation of mining, MCPL will progressively decommission and remove all infrastructure from the Middlemount Coal Mine unless otherwise agreed with post-mining landholder(s) and the administering authority. Hydrocarbons (petrol, diesel, oils, greases, degreasers and kerosene), explosives, chemicals and liquid and non-liquid wastes left unused at the completion of mining will be returned to the supplier and/or disposed of in accordance with relevant safety and handling procedures.

If applicable, infrastructure areas which have been the subject of Notifiable Activities will be added to the EMR. The EMR is a public register which contains information about contaminated land in QLD. The EMR also contains information of land which is, or could potentially be, contaminated because it is being used for a Notifiable Activity (i.e. an activity that has the potential to cause land contamination).

3.5.7.2 Remediation of Contaminated Land

Operation of the Middlemount Coal Mine involves undertaking several Notifiable Activities that have the potential to cause land contamination and will potentially disturb areas where evidence of contamination or historical contaminating activities has occurred. Management of contaminated land during the operation of the Middlemount Coal Mine is described in Section 3.1.2.6.

Site investigations of potentially contaminated areas will be undertaken after an area becomes available for rehabilitation, but prior to rehabilitation occurring (Section 3.5.1), to identify and remediate any contaminated soil materials that may exist in accordance with the requirements under Part 8 of Chapter 7 of the EP Act or equivalent statutory provision in force at the time.

Where areas of potential land contamination are identified, MCPL will undertake:

- Preliminary and intrusive contaminated land investigations, as required.
- Removal or onsite-treatment of contaminated water (e.g. affected by hydrocarbons, brine, metals, etc.).
- Removal and appropriate disposal of contaminated materials (PCBs, Dioxins, Mercury, hydrocarbon contaminated soils).
- On-site remediation of hydrocarbon contaminated soils.
- Removal and disposal of asbestos.
- Removal and disposal of plastic (geofabric) liners from dams, leach pads, etc.
- Validation testing to confirm that contaminated soils have been removed/remediated.

3.5.7.3 Environmental Management Register

When land is listed on the EMR for a notifiable activity, it is an indication that the land is likely to be contaminated but it does not mean it needs to be cleaned up or is not suitable for its current land use. This will depend on the nature, extent and risks of any contamination on the land, which can be determined by engaging a suitably qualified person to carry out a site investigation.

Where land is listed on the EMR because it is contaminated, details about the hazardous contaminant affecting the land will be included on the EMR as well as information about what land uses the land is suitable for. Where there is a site management plan in place to manage the contamination so it is suitable for a particular land use, the plan will also be attached to the EMR.

Once the site management plan has been successfully executed and the contamination has been resolved, MCPL will apply for the land to be removed from the EMR.

3.5.7.4 Retained Infrastructure

On 15 May 2020, MCPL wrote to the Department of Environment and Science (*RE: Middlemount Coal Mine, EPML00716913 – Retention of Water Structures)* (Attachment 3) describing the desired retention of several water holding structures within the Middlemount Coal Mine ML. MCPL desires that water holding structures are retained for the purpose of supporting future land uses. All infrastructure proposed to be retained for water management purposes are on land solely held by MCPL.

MCPL as the future landholder consented to the retention of the following water structures and associated infrastructure, which therefore do not require decommissioning, but do require progressive rehabilitation to make non-polluting and safe for farming activities as part of this PRC Plan:

- Mine Water Dam.
- Raw Water Dam.
- Sediment Dam 1 and Sediment Dam 1 extension.
- Sediment Dam 2.
- Sediment Dam 3.
- Sediment Dam 6.
- Sediment Dam 7.
- Sediment Dam 9.
- Sediment Dam 10.
- Sediment Dam 12.
- Workshop sediment dam.
- Blast yard sediment dam.
- Bangers dam.
- Highwall dam 1.
- Highwall dam 2.
- Northern pitwater transfer dam.
- ROM2 sediment dam.
- ROM2 go line sediment dam.
- Polypipe network (to allow future transfer between the dams and pit).

3.6 RISK ASSESSMENT

3.6.1 Risk Identification

Risk Mentor Pty Ltd (Risk Mentor) has undertaken a risk assessment (Risk Mentor, 2021; Appendix I) to identify the risks of a stable condition for land described as a post mining land use not being achieved, and how the risks will be managed or minimised. Risk Mentor has identified the sources of risk, areas of impacts, events and their causes and potential consequences (Tables 23 and 24).

The risks identified by the assessment team generally fell into the following categories:

- Market or other conditions leading to a move to care and maintenance or premature closure of the operation, which could compromise the ability to rehabilitate the Middlemount Coal Mine in line with community expectations.
- Issues with achieving a stable final landform arising from poor physical performance of rehabilitated dumps, dams, or slopes.
- Impacts on the receiving environment (water) due to excursions of contaminated or sediment laden water flows.
- Decommissioning challenges leaving either contaminated or dangerous materials on the site after the completion of rehabilitation works.
- Impacts on ecology (flora or fauna) arising from failure to achieve the target landform and species mix on the site.
- Rehabilitation management issues related to insufficient resourcing or inadequate experience/execution of rehabilitation works.

Risks that were considered to be a result of controls failing could not be ranked (on the basis that a failed control has an indeterminant outcome) and are listed in Table 24.

3.6.2 Risk Evaluation and Treatment

The identified risks were ranked (considering the effect of the applied controls) using the Risk and Control Assessment Criteria (Table 25). The risks identified were considered to be able to be effectively controlled through the implementation of the controls, management and mitigation measures as outlined in Tables 26 and 27.

Further consideration of interactions between rehabilitation milestones and the identified risks is provided in Table 27. The timeframes proposed in this PRC Plan and PRCP Schedule have been developed in consideration of the risks that were attributed to each of the rehabilitation milestones.

A detailed analysis of all risks identified, the residual risk rankings and their associated controls is provided in Appendix I.

Table 23
Identified Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Ranking with Controls		
MCPL.01.A	General	Insufficient resourcing (including skills and experience of rehabilitation personnel; funding for, or prioritisation of, rehabilitation activities; ongoing maintenance of rehabilitation requirements).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact (R) Impact on Reputation	01DV.06 - Reduced area for final rehabilitation 01DY.03 - Offset arrangements 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.01.B	General	Lack of clearly defined responsibilities.	Rehabilitation inadequate, requiring further works.	(O) Asset Damage and Other (R) Impact on Reputation	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.01.C	General	Care and maintenance/premature closure.	Delayed rehabilitation.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.01.D	General	Poor monitoring records management, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.01.E	General	Inadequate consultation with key stakeholders.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.01.F	General	Change in Isaac Regional Council Planning Scheme.	Final land use no longer aligns with local planning scheme.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place	2	C	6
MCPL.02.A	Decommissioning	Generation of waste products from demolition process (e.g. conveyors, electrical substations, compressors, services [pipes/cables], stores, laydown areas, etc.).	Inappropriate disposal of waste products (e.g. at licensed disposal facility).	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols	2	D	4
MCPL.02.B	Decommissioning	Failure to remove all infrastructure that is not to be retained post-closure (e.g. services, infrastructure, roads, carparks, hardstand areas, concrete footings).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors	2	D	4
MCPL.02.C	Decommissioning	Failure to remove all hazardous materials (e.g. carbonaceous material on the surface, hazardous wastes, other wastes).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 02PY.02 - Specific guidelines for hazardous chemicals 03SY.05 - Contractor Management Plan and Protocols	2	D	4

Table 23 (Continued)
Identified Ranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Ranking with Controls		
MCPL.02.D	Decommissioning	Land contamination sites not successfully identified or remediated resulting in impacts to the environment.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols	2	D	4
MCPL.02.E	Decommissioning	Failure of borehole or gas well seals.	Resealing of boreholes or gas wells required.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols 04TV.01 - Guidance on gas borehole decommissioning	2	D	4
MCPL.02.F	Decommissioning	Lack of structural integrity of buildings and infrastructure to be retained in final land use.	Collapse/failure of infrastructure to be retained (e.g. dams).	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols	2	D	4
MCPL.02.G	Decommissioning	Impacts on European/ historic heritage items.	Damage to heritage items. Prosecution.	(E) Environmental Impact	02PV.01 - Processes to identify all heritage items 02PV.02 - Site land disturbance permits 02PV.03 - Work is occurring within already disturbed footprints 03SV.01 - Database which tracks all known heritage items	1	E	1
MCPL.02.H	Decommissioning	Impacts on Aboriginal heritage items.	Damage to heritage items. Prosecution.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SV.01 - Database which tracks all known heritage items	1	E	1
MCPL.03.A	Ecology - flora and fauna	Landform aspect not suitable for intended target plant species - not meeting required habitats for fauna. With causes including the establishment of overly steep slopes (18.5 degrees may be too steep for ongoing leading practice works on site)	Inability to meet post-mining land use criteria.	(E) Environmental Impact	01DV.10 - Selection of appropriate analogue and reference sites 01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances	1	C	3
MCPL.03.B	Ecology - flora and fauna	Tree species established are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances	1	C	3

Table 23 (Continued)
Identified Ranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Ranking with Controls		
MCPL.03.C	Ecology - flora and fauna	Tree species established along creek diversions are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances	1	C	3
MCPL.03.D	Ecology - flora and fauna	Inappropriate revegetation species mix for targeted final land use.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP) 01DV.10 - Selection of appropriate analogue and reference sites 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances	1	C	3
MCPL.03.E	Ecology - flora and fauna	Poor quality Topsoil available and spread in areas for revegetation (with contributing factors from relatively young site and limited understanding of requirements by operational teams)	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan	1	C	3
MCPL.04.A	Final Landform	Unknown characterisation of spoil material.	Tertiary spoil material is highly susceptible to erosion which could lead to landform instability, landform failure and insufficient revegetation to meet PMLUs.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.B	Final Landform	Insufficient permian rock material for rock mulching and capping of relevant surfaces.	Landform instability, landform failure and insufficient revegetation to meet PMLUs.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control 03SV.06 - Rehabilitation management plan	2	D	4
MCPL.04.C	Final Landform	Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use.	Landform failure (public safety risk).	(P) Harm to People	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4

Table 23 (Continued)
Identified Ranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Ranking with Controls		
MCPL.04.D	Final Landform	Final landform instability (e.g. NUMAs, final voids, etc.) affecting post-mining land use.	Landform failure (public safety risk) and NUMAs causing environmental harm.	(P) Harm to People (E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.E	Final Landform	Final landform instability (e.g. steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use (e.g. due to insufficient amelioration of dispersive tertiary spoil and soils).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.F	Final Landform	Final landform unsuitable for final land use (e.g. large rocks present affecting cultivation, settlement and surface subsidence leading to extended ponding etc.).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.G	Final Landform	Final landforms are not consistent with and do not complement the topography of the surrounding region.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.H	Final Landform	Erosion and failure of drainage and water management/storage structures.	Impacts on water quality and potential discharge.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.04.I	Final Landform	Failure of the tailings storage facility over time.	Impact on surrounding landform and movement of tailings off site (Pollution of land or surface water by tailings).	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.06 - Capping of TSF 03SV.03 - RQP involvement in TSF design	2	D	4
MCPL.04.J	Final Landform	Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is native ecosystem - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4

Table 23 (Continued)
Identified Ranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Ranking with Controls		
MCPL.04.K	Final Landform	Landform (excluding final void domains) not free draining.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	2	D	4
MCPL.05.P	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation techniques, timing and scheduling including allocation of the equipment fleet.	Rehabilitation inadequate, requiring further works and potentially compromising position with Regulators.	(E) Environmental Impact (R) Reputation	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PY.01 - Works conducted by suitable contractors 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan 03SY.05 - Contractor Management Plan and Protocols	2	C	6
MCPL.06.A	Water	Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan	2	D	4
MCPL.06.B	Water	Diversion of surface water runoff away from catchment areas.	Loss of water flow downstream due to capture of water in voids.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PV.06 - Erosion and sediment control 03SY.06 - Water Management Plan	2	D	4
MCPL.06.C	Water	Water accumulation in residual voids.	Overtopping/discharge to receiving environment.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 03SV.09 - Mine voids are ground water sinks	2	D	4
MCPL.06.D	Water	Failure of final landform embankments in proximity to the southern residual void.	Inundation of the southern residual void and potential discharge to receiving environment.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols	2	D	4
MCPL.06.E	Water	Groundwater seepage from residual voids.	Impact to receiving environment.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 03SV.09 - Mine voids are ground water sinks	2	D	4
MCPL.06.F	Water	Poor water quality/excessive discharges (e.g. acid-drainage, high salinity, etc.).	Impact to receiving environment.	(E) Environmental Impact	02PV.09 - Stripping and stockpiling procedures 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan	2	D	4

Table 24
Identified Unranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control
MCPL.05.A	Rehabilitation Management	Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation/habitat resources lost.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.B	Rehabilitation Management	Lack of availability and quality of seed resources.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.02 - External supplier of seeds 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
MCPL.05.C	Rehabilitation Management	Weed and pest control (or lack thereof), including damage from insects, plant disease, fauna and livestock.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.07 - Weed and Pest Control Management Plan
MCPL.05.D	Rehabilitation Management	Weather and climatic influences (e.g. drought, intense rainfall events/flooding, bushfire, etc.).	Damage or delays to rehabilitation, requiring further works.	(E) Environmental Impact	01DV.07 - Dump designs allow for rainfall events 02PE.08 - Drainage minimises water reporting to voids on site 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
MCPL.05.E	Rehabilitation Management	Insufficient establishment or cover of vegetation due to high plant mortality.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
MCPL.05.F	Rehabilitation Management	Overgrazing of pasture rehabilitation areas.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SY.04 - Third party agreements
MCPL.05.G	Rehabilitation Management	Vandalism to revegetation areas.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.H	Rehabilitation Management	Inadvertent or unauthorised access to rehabilitated areas by mining equipment and vehicles.	Damage or delays to rehabilitation (e.g. collapse of soil structure), requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan

Table 24 (Continued)
Identified Unranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control
MCPL.05.I	Rehabilitation Management	Adverse/less well understood geotechnical/geochemical issues associated with dumps and process waste storage facilities (e.g. tailings, reject emplacements, presence of sodic sub-soils) overburden and waste rock dumps etc.	Failing to meet completion criteria, significant erosion and poor quality runoff/infiltration from rehabilitated surfaces effecting surface water and groundwater quality.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring
MCPL.05.J	Rehabilitation Management	Inadequate capping or removal of carbonaceous material.	Spontaneous combustion event.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan
MCPL.05.K	Rehabilitation Management	Availability of suitable materials for capping of hazardous materials and tailings.	Unable to cap due to lack of suitable material on site.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 01DV.09 - Mine plan makes allowances for rehabilitation of the TSF 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.05 - Stockpiling rock material for use as an erosion control 02PE.06 - Capping of TSF 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan
MCPL.05.L	Rehabilitation Management	Insufficient spreading of topsoil (not to required thickness) and/or development of soil crusting.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.M	Rehabilitation Management	Availability of suitable topsoil for growth medium to support revegetation.	Rehabilitation inadequate, requiring further works/importing of topsoil.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.N	Rehabilitation Management	Topsoil or rock/soil mixture (in particular for dispersive tertiary spoil) unsuitable as growth medium.	Rehabilitation inadequate, requiring further works such as additional treatment/amelioration.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan

Table 24 (Continued)
Identified Unranked Rehabilitation Risks

PRCP ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control
MCPL.05.O	Rehabilitation Management	Substrate inadequate to support revegetation or agricultural land capability (e.g. lack of organic matter, nutrient deficiency, lack of soil biota, adverse soil chemical properties, exposed hostile geochemical materials, overly compacted, and any other factors impeding the effective rooting depth).	Soil quality insufficient to support revegetation.	(E) Environmental Impact	As for MCM.04.I 01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring
MCPL.05.Q	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation monitoring to inform maintenance program.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
MCPL.05.R	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation monitoring to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.S	Rehabilitation Management	Rehabilitation doesn't align with analogue/reference site, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.10 - Selection of appropriate analogue and reference sites 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
MCPL.05.T	Rehabilitation Management	Vegetation not self-sustaining, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SY.02 - Milestone and completion criteria 04TV.01 - Guidance on gas borehole decommissioning
MCPL.05.U	Rehabilitation Management	Public/livestock access to void.	Risk to public safety and livestock.	(P) Harm to People	02PE.03 - Site security, fencing, etc. 02PE.07 - Bunding and barricading of voids and steep slopes 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MCPL.05.V	Rehabilitation Management	Legacy exploration bore holes not rehabilitated at end of mine life.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	03SV.09 - Mine voids are ground water sinks 04TV.04 - Response to third party audits
MCPL.05.W	Rehabilitation Management	Discharge of particulates to the atmosphere during rehabilitation earthworks	Air pollution by discharge of particulates	(E) Environmental Impact	02PV.02 - Site land disturbance permits 03SV.06 - Rehabilitation Management Plan 03SY.05 - Contractor Management Plan and Protocols 04TV.02 - Internal reporting of any non-compliances

Table 25
Risk and Control Assessment Criteria

MCPL RISK MATRIX						
LIKELIHOOD		**RISK LEVEL**				
A **Very Likely** (5)	Likely to occur on site in most circumstances.	MODERATE (5)	MODERATE (10)	HIGH (15)	EXTREME (20)	EXTREME (25)
B **Likely** (4)	Probably will occur on site under certain circumstances.	LOW (4)	MODERATE (8)	HIGH (12)	HIGH (16)	EXTREME (20)
C **Possible** (3)	Could occur on site at some point in time.	LOW (3)	MODERATE (6)	MODERATE (9)	HIGH (12)	EXTREME (15)
D **Unlikely** (2)	May occur but not very likely on this site.	LOW (2)	LOW (4)	MODERATE (6)	MODERATE (8)	HIGH (10)
E **Rare** (1)	Highly unlikely to occur on this site.	LOW (1)	LOW (2)	LOW (3)	LOW (4)	MODERATE (5)

Area of Effect	**ESTIMATED LEVEL OF CONSEQUENCE**				
	Low (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
P Harm to People	Report only Near miss First aid injury (RO, FAI)	Medical treatment injury or restricted work injury (MTI, RWI)	Serious injury or disabling reversible impairment (LTI)	Fatality or disabling irreversible impairment	Multiple fatalities
E Environmental Impact	Environmental nuisance Limited damage to minimal area of low significance	Minor short term medium term material environmental harm to small area(s) of limited significance	Serious short to medium term environmental harm with widespread impacts	Major environmental harm Relatively wide spread medium to long term impacts	Extreme environmental harm Long term wide spread effects on environment
A Asset damage and other consequential business losses	Slight damage <$5,000 No disruption to operations	Minor damage <$50,000 Brief disruption < 12 hours	Localised damage <$500,000 Partial shutdown < 1 day	Major damage <$2,000,000 Major shutdown < 1 week	Extensive damage >$2,000,000 Extensive loss > 1 week
R Impact on Reputation	Slight impact Public aware but no public concern	Limited impact Some local public concern	Considerable impact with potential for wider public concern	National impact with potential for wider public concern	International impact. International public attention

Table 25 (Continued)
Risk and Control Assessment Criteria

RISK	ACCEPTABILITY / AUTHORITY TO PROCEED	ACTION TO TAKE
Extreme Risk	**UNACCEPTABLE RISK – STOP – DO NOT START** If an Formal Risk Assessment is being conducted, a Manager is to re-conduct / review risk assessment with a team and identify appropriate controls to reduce the risk to an acceptable level. If a JSEA is being conducted, then a formal Risk Assessment shall be conducted under the guidance of the Department Manger. Upon agreement with findings and the controls the SSE shall formally approve the risk assessment. The SSE may engage more people to review the risk assessment if an acceptable level of risk was not achieved. The SSE must be contacted if not present on the site at the time the hazard / risk are identified.	Cannot proceed until elimination, substitution or engineering controls or a combination of these are implemented to reduce the risk to Moderate or Low. The overall task approach must be under Supervision (minimum the Department Superintendent) when it is undertaken and the most senior personnel at MCPL are aware of the task's occurrence. Emergency Response considerations are documented within the risk assessment. Monitoring of the controls effectiveness (PTO) shall be undertaken and documented by the work's Supervisor throughout the activity.
High Risk	**UNACCEPTABLE RISK – STOP – DO NOT START** If an Formal Risk Assessment is being conducted, Departmental Superintendent is to reconvene the team (option to involve more experts) and review the Risk Assessment. Appropriate controls must be identified to reduce the risk to an acceptable level. If a JSEA is being conducted, then a formal Risk Assessment shall be conducted under the guidance of the Department Superintendent. Upon agreement with findings and the controls the Department Manager shall formally approve the JSEA or RA. The SSE shall review the RA and approve the commencement of the works if the Department Manager is not on site.	Cannot proceed until elimination, substitution or engineering controls or a combination of these are implemented to reduce the risk to Moderate or Low. The task must be Supervised (minimum Supervisor / OCE) while it is being performed and a senior MCPL Manager must be aware that the tsk is being performed. Monitoring of the controls effectiveness (PTO) shall be undertaken and documented by the work's Supervisor throughout the activity.
Moderate Risk	**ACCEPTABLE RISK – CAN START** Provided that identified controls are implemented immediately and the controls effectiveness is being monitored. Relevant OCE / Superintendent shall approve the Risk Assessment / JSEA.	Proceed with task: Requires supervision and monitoring of controls effectiveness.
Low Risk	**ACCEPTABLE RISK – CAN START PROVIDED:** Implement controls are identified. Continue to monitor for changes which may elevate risk score. Relevant OCE / Superintendent shall approve the Risk Assessment / JSEA.	Proceed with agreed controls in place.

Table 26
Controls, Management and Mitigation Measures

Control Name	Expectation	Selection Reason	Responsible
01DE.01 - Tailings and dam designs and management systems	Tailings and other dams appropriately designed - to contain material and any affected water.	Addressing potential for collapse or uncontrolled release of site fluids.	Maintenance & Project Manager
01DV.01 - Surveyed plans of all mine features	Surveyed plans (and all infrastructure included in the PRCP) (to confirm that all locations, structures and features of substance are identified).	Preventing key items or built features not being addressed during rehabilitation as their physical locations are known and mapped.	Technical Services Manager
01DV.02 - Geotechnical analysis and design	Geotechnical analyses and implementation of designs to achieve long term stable landforms. As new materials are identified this leads to review and updating (as required) of designs.	Protection against changes in geotechnical conditions leading to final landform instability.	Technical Services Manager
01DV.03 - Geomorphic design protocols	Current designs are aligned with relevant QLD design principles. Planned to implement geomorphic design principles being applied to the design of the final landform.	Protection against longer term instability of the final landform.	HSEC Manager
01DV.04 - Factor of safety applied to designs	Factor of safety of 2 applied to the void design - to address the weathering expected within 10's of years.	Protection against longer term instability of the final landform.	Technical Services Manager
01DV.05 - Longitudinal study of erosion performance	Prior studies of erosion potential of dumps and rehabilitation methodology has been developed.	Addressing potential for using incorrect inputs in final landform designs.	HSEC Manage r
01DV.06 - Reduced area for final rehabilitation	Progressive rehabilitation (in conformance with the PRCP) minimising the amount of land to rehabilitate.	Addressing potential for extensive works being required at the end of mine life.	Technical Services Manager
01DV.07 - Dump designs allow for rainfall events	Dump designs covering modelled rainfall events.	Addressing potential for excessive erosion in heavy rainfall.	HSEC Manager
01DV.08 - Mine design considers carbonaceous material in dumps	Mine design/mine planning identifies carbonaceous material and manages this appropriately.	Addressing potential for spontaneous combustion in dumps or stockpiles.	Technical Services Manager
01DV.09 - Mine plan makes allowances for rehabilitation of the TSF	Mine plan has significant time-frame for rehabilitating TSF whilst ongoing mining of the pit is occurring.	Addressing potential for incomplete capping of the tailings storage facility.	Technical Services Manager
01DV.10 - Selection of appropriate analogue and reference sites	Selection of appropriate analogue and reference sites - Verterra have reviewed the reference sites to confirm suitability and present a monitoring strategy based on which site suits which domain on site.	Addresses potential to not achieve desired rehabilitation performance due to a lack of understanding of species mix and micro-climate impacts.	HSEC Manager
01DY.01 - Planning for decommissioning works	Appropriate planning and decommissioning works.	Specifically identifies waste products to allow for their safe disposal on or off site.	HSEC Manager
01DY.02 - Revegetation plan (in line with PRCP).	Revegetation plan (in line with PRCP) to identify appropriate species, purchase in line with the plan and arrange for planting and relevant nurturing to meet requirements.	Achieve a species mix which will allow the completion criteria to be met	HSEC Manager
01DY.03 - Offset arrangements	Provisions in place to provide like for like habitat to replace any degraded habitats on the mine site.	Minimise environmental impacts.	HSEC Manager
02PE.01 - Flocculant use achieving a stiff tailings deposition	Operational strategy is the use of flocculant - leading to a very stiff material - which would constrain any release.	Addresses long term escape of stored tailings.	CHPP Manager
02PE.02 - External supplier of seeds	External supplier of seeds.	Addresses potential for poor germination rates and inappropriate seed mix.	HSEC Manager
02PE.03 - Site security, fencing, etc.	Site security, including rural fencing of lease, demarcation and signage, and exclusion of stock.	Addressing potential for overgrazing, access by unwanted third parties or feral animal access to the site.	HSEC Manager
02PE.04 - Gypsum remediation to improve run-off	Gypsum remediation assists in improving run-off quality.	Addressing poor quality run-off from the site.	HSEC Manager
02PE.05 - Stockpiling rock material for use as an erosion control	Rock material for hydraulic breaks over tailings.	Addressing hydraulic erosion of the TSF dam wall (and other dam walls, drains, etc.).	HSEC Manager
02PE.06 - Capping of TSF	Rehab management plan includes procedures for and description of capping requirements for the TSF.	Addressing potential for incomplete capping of the tailings storage facility.	HSEC Manager
02PE.07 - Bunding and barricading of voids and steep slopes	Bunding and barricading - Construct a safety bund wall of competent rock and/or fencing to limit human and livestock/animal access.	Addressing potential for injury to members of the public or livestock at the site.	HSEC Manager

Table 26 (Continued)
Controls, Management and Mitigation Measures

Control Name	Expectation	Selection Reason	Responsible
02PE.08 - Drainage minimises water reporting to voids on site	Executed designs minimise the catchment reporting to the void.	Addressing the unwanted build up of water stocks in site voids.	Technical Services Manager
02PE.09 - Over-topping buffer in site voids	Significant buffer before over-topping and final void water balance indicates a very low risk of spill (<1% annual exceedance probability).	Addressing potential for over-topping of site voids post mining.	Technical Services Manager
02PV.01 - Processes to identify all heritage items	Planning and survey process to identify all heritage items so that they can be avoided.	Prevent damage to a heritage site degrading environmental values in an area.	Health, Safety, Training, Environment & Community Manager
02PV.02 - Site land disturbance permits	Site land disturbance permits.	Preventing damage to heritage sites, natural features or other sensitive locations.	Health, Safety, Training, Environment & Community Manager
02PV.03 - Work is occurring within already disturbed footprints	Work is predominantly occurring within already disturbed footprints.	Preventing disturbance to less affected items of environmental value.	Executive General Manager/SSE
02PV.04 - Rehabilitation of appropriate species of vegetation	Rehabilitation protocols including identifying and planting appropriate species of vegetation.	Minimise the potential that planted species will not lead to meeting required environmental values at closure.	Health, Safety, Training, Environment & Community Manager
02PV.05 - Long mine life (>20 years)	The long mine life (>20 years) means there is sufficient time to confirm the appropriate vegetation strategy and implement accordingly (time to trial multiple options in order to get the processes right for long term rehabilitation success).	Having a long mine life addresses the potential for seasonal variations to misrepresent the effectiveness of rehabilitation efforts.	HSEC Manager
02PV.06 - Erosion and sediment control	Erosion and sediment control - informed by geochemistry assessments and site operating knowledge.	Protecting against releases to the wider environment during construction and for the longer term landform.	Health, Safety, Training, Environment & Community Manager
02PV.07 - Timing for access to rehabilitated areas	Subsequent land holders could not access the land until the ML's are relinquished and MCPL sells the land to a subsequent party.	Prevents damage to the rehabilitated areas by third parties.	HSEC Manager
02PV.08 - Cleared vegetation is mulched or burnt	Vegetation is mulched or burnt.	Addresses potential for unwanted species in the rehabilitated areas.	HSEC Manager
02PV.09 - Stripping and stockpiling procedures	Stripping processes lead to adequate burial (to prevent any spontaneous combustion threats).	Addressing potential for spontaneous combustion in dumps or stockpiles.	Technical Services Manager
02PY.01 - Works conducted by suitable contractors	Works conducted by suitably qualified contractors - including permits for disposing of any contaminated materials.	This business input/control is intended to minimise the potential for poor execution of required works. It is supported by appropriate supervision, inspection and test plans, and formal contractual arrangements to optimise the outcomes from any works.	HSEC Manager
02PY.02 - Specific guidelines for hazardous chemicals	Specific guidelines in place - beyond standard planning and execution that address any hazardous materials on site.	To minimise the outcome from any hazardous materials brought to, used or created by the operating site.	Senior Environment & Community Advisor
03SV.01 - Database which tracks all known heritage items	Database which tracks all known heritage items.	To identify, geo-locate and characterise all items within proximity of the site and workings.	HSEC Manager
03SV.02 - Biannual environmental audits	Two yearly internal (to the company) independent (to the site) environmental audits commissioned by the company and any recommendations are reviewed and actions tracked.	Challenge any slippage of standards and identify emerging conditions that may require additional resources to be allocated.	HSEC Manager
03SV.03 - RQP involvement in TSF design	RPQ involvement of the TSF as a regulated structure - nominated as a significant risk to ecosystems but with low risk to potential downstream features (harm to humans and environment is low) - and subject to annual inspection.	Addressing instability in the tailings storage facility (TSF).	HSEC Manager
03SV.04 - Change management for rehabilitation	Processes available for amending PRCP in the event of requirement to close the mine early (meeting requirements of a stable landform).	Reducing the potential for delivered rehabilitation not meeting community expectations.	HSEC Manager
03SV.05 - Topsoil management plan	Topsoil management plan (includes identifying the resource, addressing/treating any sodic soils, stockpiling to preserve soil quality, site wide topsoil study, monitoring of topsoil pre-rehab to confirm nutrient and soil chemistry levels/requirements) and topsoil balance reporting.	Addressing potential for topsoil to not meet rehabilitation growing requirements.	HSEC Manager
03SV.06 - Rehabilitation management plan	Quantity of required species is in rehab management plan and monitoring of germination rates. The plan also covers monitoring of general rehabilitation performance, offset status/performance, and programmed and as-required maintenance works.	Addressing failure to execute rehabilitation works in line with PRCP and license requirements.	HSEC Manager

Table 26 (Continued)
Controls, Management and Mitigation Measures

Control Name	Expectation	Selection Reason	Responsible
03SV.07 - Weed and Pest Control Management Plan	Weed and Pest Control Management Plan.	Addressing potential for rehabilitation failure due to weeds or invasive pests.	HSEC Manager
03SV.08 - Water quality monitoring	Water quality monitoring for site dams and the receiving environment.	Addressing potential for cumulative impacts from poor quality water presence or release.	HSEC Manager
03SV.09 - Mine voids are ground water sinks	Ground water modelling of long-term performance indicate that voids will continue to act as a ground water sink.	Addressing unintended releases to or draw from ground water/aquifers.	HSEC Manager
03SY.01 - Monitoring and adaptive management programs	Monitoring and adaptive management programs which determine relevant conditions and provide modification (within design parameters) of activities to achieve design goals.	To prevent changes in performance from becoming more significant by reducing the impact of an emerging condition/threat.	HSEC Manager
03SY.02 - Milestone and completion criteria	Milestone and completion criteria to confirm outcomes are being achieved.	Prevent any long-term slippage of progressive rehabilitation.	HSEC Manager
03SY.03 - Annual reporting of PRCP progress to the Regulator.	Annual reporting of PRCP progress to the Regulator.	Minimise the potential for executed rehabilitation drifting from community expectations.	HSEC Manager
03SY.04 - Third party agreements	Third party agreements - Any third party grazing would be in accordance with appropriate license terms (Rural licence).	Addressing unmanaged access to rehabilitated areas by third parties conducting rural businesses.	HSEC Manager
03SY.05 - Contractor Management Plan and Protocols	Contract management - confirming site requirements are met.	Achieved well executed works being performed by contractors.	Maintenance & Projects Manager
03SY.06 - Water Management Plan	Water Management Plan with clean and dirty water diversions around the pit.	Addressing potential for unwanted collection, storage or release of waters on the site during operations and post closure.	HSEC Manager
04TV.01 - Guidance on gas borehole decommissioning	Gas borehole guidance on decommissioning - that lead to a removal of any threats.	To minimise outcome from encountering any unexpected legacy drill holes and associated features during rehabilitation.	HSEC Manager
04TV.02 - Internal reporting of any non-compliances	Internal reporting of any non-compliances (weekly/monthly) in order to alert management to any emerging threats and required allocation of resources.	Minimise the extent to which rehabilitation works fail to meet requirements of the PRCP.	HSEC Manager
04TV.03 - Government rehabilitation bonds in place	Government holds bonds - which are sufficient to return the site to a stable, suitable landform in the event of the company failing.	Addresses failure of the company.	Executive General Manager/SSE
04TV.04 - Response to third party audits	Response to any third party audits - and activation of the exploration rehabilitation requirements.	Addressing leaving an ongoing threat when one has been identified.	HSEC Manager

Table 27
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
General	MCPL.01.A - Insufficient resourcing (including skills and experience of rehabilitation personnel; funding for, or prioritisation of, rehabilitation activities; ongoing maintenance of rehabilitation requirements).	Rehabilitation inadequate, requiring further works.	01DV.06 - Reduced area for final rehabilitation 01DY.03 - Offset arrangements 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.01.B - Lack of clearly defined responsibilities.		01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.01.C - Care and maintenance/premature closure.	Delayed rehabilitation.	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.01.D - Poor monitoring records management, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.01.E - Inadequate consultation with key stakeholders.		01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.01.F - Change in Isaac Regional Council Planning Scheme.	Final land use no longer aligns with local planning scheme.	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.05.D - Weather and climatic influences (e.g. drought, intense rainfall events/flooding, bushfire, etc.).	Rehabilitation inadequate, requiring further works.	01DV.07 - Dump designs allow for rainfall events 02PE.08 - Drainage minimises water reporting to voids on site 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
	MCPL.05.G - Vandalism to revegetation areas.		02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.H - Inadvertent or unauthorised access to rehabilitated areas by mining equipment and vehicles.	Damage or delays to rehabilitation (e.g. collapse of soil structure), requiring further works.	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
General (continued)	MCPL.05.P - Adoption of inappropriate or inadequate rehabilitation techniques, timing and scheduling including allocation of the equipment fleet.	Rehabilitation inadequate, requiring further works and potentially compromising position with Regulators.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PY.01 - Works conducted by suitable contractors 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan03SY.05 - Contractor Management Plan and Protocols
	MCPL.05.Q - Adoption of inappropriate or inadequate rehabilitation monitoring to inform maintenance program.	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
	MCPL.05.R - Adoption of inappropriate or inadequate rehabilitation monitoring to demonstrate compliance with completion criteria.		02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.S - Rehabilitation doesn't align with analogue/reference site, unable to demonstrate compliance with completion criteria.		01DV.10 - Selection of appropriate analogue and reference sites 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
RM1 Infrastructure Decommissioning and Removal	MCPL.02.A - Generation of waste products from demolition process (e.g. conveyors, electrical substations, compressors, services [pipes/cables], stores, laydown areas, etc.).	Inappropriate disposal of waste products (e.g. at licensed disposal facility).	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols
	MCPL.02.B - Failure to remove all infrastructure that is not to be retained post closure (e.g. services, infrastructure, roads, carparks, hardstand areas, concrete footings).	Rehabilitation inadequate, requiring further works.	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors
	MCPL.02.C - Failure to remove all hazardous materials (e.g. carbonaceous material on the surface, hazardous wastes, other wastes).		01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 02PY.02 - Specific guidelines for hazardous chemicals 03SY.05 - Contractor Management Plan and Protocols
	MCPL.02.E - Failure of borehole or gas well seals.	Resealing of boreholes or gas wells required.	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols 04TV.01 - Guidance on gas borehole decommissioning

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM1 Infrastructure Decommissioning and Removal (continued)	MCPL.02.F - Lack of structural integrity of buildings and infrastructure to be retained in final land use.	Collapse/failure of infrastructure to be retained (e.g. dams).	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols
	MCPL.02.G - Impacts on European/ historic heritage items.	Damage to heritage items. Prosecution.	02PV.01 - Processes to identify all heritage items 02PV.02 - Site land disturbance permits 02PV.03 - Work is occurring within already disturbed footprints 03SV.01 - Database which tracks all known heritage items
	MCPL.02.H - Impacts on Aboriginal heritage items.		01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SV.01 - Database which tracks all known heritage items
RM2 Remediation of Contaminated Land (Characterisation) RM3 Remediation of Contaminated Land (Waste Rock Material Treatment)	MCPL.02.C - Failure to remove all hazardous materials (e.g. carbonaceous material on the surface, hazardous wastes, other wastes).	Rehabilitation inadequate, requiring further works.	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 02PY.02 - Specific guidelines for hazardous chemicals 03SY.05 - Contractor Management Plan and Protocols
	MCPL.02.D - Land contamination sites not successfully identified or remediated resulting in impacts to the environment.		01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols
	MCPL.05.I - Adverse/less well understood geotechnical/geochemical issues associated with dumps and process waste storage facilities (e.g. tailings, reject emplacements, presence of sodic sub-soils) overburden and waste rock dumps etc.	Failing to meet completion criteria, significant erosion and poor quality runoff/infiltration from rehabilitated surfaces effecting surface water and groundwater quality.	01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring
	MCPL.05.V - Legacy exploration bore holes not rehabilitated at end of mine life.	Rehabilitation inadequate, requiring further works.	03SV.09 - Mine voids are ground water sinks 04TV.04 - Response to third party audits
	MCPL.06.A - Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM4 Landform Establishment (Capping, Development and Reshaping/Re-profiling)	MCPL.04.B - Insufficient permian rock material for rock mulching and capping of relevant surfaces.	Landform instability, landform failure and insufficient revegetation to meet PMLUs.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control 03SV.06 - Rehabilitation management plan
	MCPL.04.I - Failure of the tailings storage facility over time.	Impact on surrounding landform and movement of tailings off site (Pollution of land or surface water by tailings).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.06 - Capping of TSF 03SV.03 - RQP involvement in TSF design
	MCPL.05.I - Adverse/less well understood geotechnical/geochemical issues associated with dumps and process waste storage facilities (e.g. tailings, reject emplacements, presence of sodic sub-soils) overburden and waste rock dumps etc.	Failing to meet completion criteria, significant erosion and poor quality runoff/infiltration from rehabilitated surfaces effecting surface water and groundwater quality.	01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring
	MCPL.05.J - Inadequate capping or removal of carbonaceous material.	Spontaneous combustion event.	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan
	MCPL.05.K - Availability of suitable materials for capping of hazardous materials and tailings.	Unable to cap due to lack of suitable material on site.	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 01DV.09 - Mine plan makes allowances for rehabilitation of the TSF 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.05 - Stockpiling rock material for use as an erosion control 02PE.06 - Capping of TSF 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM4 Landform Establishment (Capping, Development and Reshaping/Re-profiling) (continued)	MCPL.06.A - Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan
	MCPL.04.A - Unknown characterisation of spoil material.	Tertiary spoil material is highly susceptible to erosion which could lead to landform instability, landform failure and insufficient revegetation to meet PMLUs.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.C - Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use.	Landform failure (public safety risk).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.E - Final landform instability (e.g. steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use (e.g. due to insufficient amelioration of dispersive tertiary spoil and soils).	Rehabilitation inadequate, requiring further works.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.F - Final landform unsuitable for final land use (e.g. large rocks present affecting cultivation, settlement and surface subsidence leading to extended ponding etc.).		01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.G - Final landforms are not consistent with and do not complement the topography of the surrounding region.		01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.K - Landform (excluding final void domains) not free draining.		01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM4 Landform Establishment (Capping, Development and Reshaping/Re-profiling) (continued)	MCPL.04.H - Erosion and failure of drainage and water management/storage structures.	Impacts on water quality and potential discharge.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.W - Discharge of particulates to the atmosphere during rehabilitation earthworks.	Air pollution by discharge of particulates.	02PV.02 - Site land disturbance permits 03SV.06 - Rehabilitation Management Plan 03SY.05 - Contractor Management Plan and Protocols 04TV.02 - Internal reporting of any non-compliances
RM5 Growth Medium Application (Surface preparation and application of ameliorants)	MCPL.03.E - Poor quality Topsoil available and spread in areas for revegetation (with contributing factors from relatively young site and limited understanding of requirements by operational teams).	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.04.F - Final landform unsuitable for final land use (e.g. large rocks present affecting cultivation, settlement and surface subsidence leading to extended ponding etc.).	Rehabilitation inadequate, requiring further works.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.A - Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation/habitat resources lost.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.L - Insufficient spreading of topsoil (not to required thickness) and/or development of soil crusting.	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.M - Availability of suitable topsoil for growth medium to support revegetation.		02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.N - Topsoil or rock/soil mixture (in particular for dispersive tertiary spoil) unsuitable as growth medium.	Rehabilitation inadequate, requiring further works such as additional treatment/amelioration.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM6 Revegetation (native ecosystem)	MCPL.03.A - Landform aspect not suitable for intended target plant species - not meeting required habitats for fauna. With causes including the establishment of overly steep slopes (18.5 degrees may be too steep for ongoing leading practice works on site).	Inability to meet post-mining land use criteria.	01DV.10 - Selection of appropriate analogue and reference sites 01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances
	MCPL.03.D - Inappropriate revegetation species mix for targeted final land use.	Rehabilitation inadequate, requiring further works.	
	MCPL.03.B - Tree species established are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions.	01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances
	MCPL.04.J - Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is native ecosystem - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.A - Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation/habitat resources lost.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.B - Lack of availability and quality of seed resources.	Rehabilitation inadequate, requiring further works.	02PE.02 - External supplier of seeds 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
	MCPL.05.C - Weed and pest control (or lack thereof), including damage from insects, plant disease, fauna and livestock.	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.07 - Weed and Pest Control Management Plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM6 Revegetation (native ecosystem) (continued)	MCPL.03.B - Tree species established are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions.	01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances
	MCPL.04.J - Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is native ecosystem - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.A - Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation/habitat resources lost.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.B - Lack of availability and quality of seed resources.	Rehabilitation inadequate, requiring further works.	02PE.02 - External supplier of seeds 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
	MCPL.05.C - Weed and pest control (or lack thereof), including damage from insects, plant disease, fauna and livestock.	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.07 - Weed and Pest Control Management Plan
	MCPL.05.E - Insufficient establishment or cover of vegetation due to high plant mortality.		02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan
	MCPL.05.T - Vegetation not self-sustaining, unable to demonstrate compliance with completion criteria.		02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SY.02 - Milestone and completion criteria 04TV.01 - Guidance on gas borehole decommissioning
RM7 Surface Conditions	MCPL.02.A - Generation of waste products from demolition process (e.g. conveyors, electrical substations, compressors, services [pipes/cables], stores, laydown areas, etc.).	Inappropriate disposal of waste products (e.g. at licensed disposal facility).	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM7 Surface Conditions (continued)	MCPL.04.C - Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting PMLU.	Landform failure (public safety risk).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.D - Final landform instability (e.g. NUMAs, final voids, etc.) affecting PMLU	Landform failure (public safety risk) and NUMAs causing environmental harm.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.H - Erosion and failure of drainage and water management/storage structures.	Impacts on water quality and potential discharge.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.K - Landform (excluding final void domains) not free draining.	Rehabilitation inadequate, requiring further works.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.O - Substrate inadequate to support revegetation or agricultural land capability (e.g. lack of organic matter, nutrient deficiency, lack of soil biota, adverse soil chemical properties, exposed hostile geochemical materials, overly compacted, and any other factors impeding the effective rooting depth).	Soil quality insufficient to support revegetation.	As for MCM.04.I 01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring
	MCPL.06.A - Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan
	MCPL.06.D - Failure of final landform embankments in proximity to the southern residual void.	Inundation of the southern residual void and potential discharge to receiving environment.	01DV.02 - Geotechnical analysis and design 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols
	MCPL.06.F - Poor water quality/excessive discharges (e.g. acid-drainage, high salinity, etc.).	Impact to receiving environment.	02PV.09 - Stripping and stockpiling procedures 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM8 Achievement of PMLU to Stable Condition (native ecosystem)	MCPL.01.F - Change in IRC Planning Scheme.	Final land use no longer aligns with local planning scheme.	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place
	MCPL.03.A - Landform aspect not suitable for intended target plant species - not meeting required habitats for fauna. With causes including the establishment of overly steep slopes (18.5 degrees may be too steep for ongoing leading practice works on site).	Inability to meet PMLU criteria.	01DV.10 - Selection of appropriate analogue and reference sites 01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances
	MCPL.03.C - Tree species established along creek diversions are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions.	01DY.02 - Revegetation plan (in line with PRCP) 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator 04TV.02 - Internal reporting of any non-compliances
	MCPL.04.C - Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting PMLU.	Landform failure (public safety risk).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.D - Final landform instability (e.g. NUMAs, final voids, etc.) affecting post-mining land use.	Landform failure (public safety risk) and NUMAs causing environmental harm.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM8 Achievement of PMLU to Stable Condition (native ecosystem) (continued)	MCPL.04.I - Failure of the tailings storage facility over time.	Impact on surrounding landform and movement of tailings off site (Pollution of land or surface water by tailings).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.06 - Capping of TSF 03SV.03 - RQP involvement in TSF design
	MCPL.04.J - Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is native ecosystem - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.05.A - Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation/habitat resources lost.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
	MCPL.05.C - Weed and pest control (or lack thereof), including damage from insects, plant disease, fauna and livestock.	Rehabilitation inadequate, requiring further works.	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.07 - Weed and Pest Control Management Plan
	MCPL.06.A - Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan
RM9 Retained Water Structures	MCPL.02.F - Lack of structural integrity of buildings and infrastructure to be retained in final land use.	Collapse/failure of infrastructure to be retained (e.g. dams).	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols
	MCPL.04.H - Erosion and failure of drainage and water management/storage structures.	Impacts on water quality and potential discharge.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.J - Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is native ecosystem - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
RM9 Retained Water Structures (continued)	MCPL.06.A - Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan
	MCPL.06.B - Diversion of surface water runoff away from catchment areas.	Loss of water flow downstream due to capture of water in voids.	02PE.08 - Drainage minimises water reporting to voids on site 02PV.06 - Erosion and sediment control 03SY.06 - Water Management Plan
	MCPL.06.C - Water accumulation in residual voids.	Overtopping/discharge to receiving environment.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 03SV.09 - Mine voids are ground water sinks
	MCPL.06.E - Groundwater seepage from residual voids.	Impact to receiving environment.	02PE.08 - Drainage minimises water reporting to voids on site 03SV.09 - Mine voids are ground water sinks
MM1 High- and Low Wall Treatment	MCPL.04.D - Final landform instability (e.g. NUMAs, final voids, etc.) affecting PMLU.	Landform failure (public safety risk) and NUMAs causing environmental harm.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
MM2 Surface Conditions	MCPL.05.U - Public/livestock access to void.	Risk to public safety and livestock.	02PE.03 - Site security, fencing, etc. 02PE.07 - Bunding and barricading of voids and steep slopes 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan
MM3 Achievement of Sufficient Improvement	MCPL.04.C - Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting PMLU.	Landform failure (public safety risk).	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.D - Final landform instability (e.g. NUMAs, final voids, etc.) affecting PMLU.	Landform failure (public safety risk) and NUMAs causing environmental harm.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control
	MCPL.04.E - Final landform instability (e.g. steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use (e.g. due to insufficient amelioration of dispersive tertiary spoil and soils).	Rehabilitation inadequate, requiring further works.	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control

Table 27 (Continued)
Interactions between Rehabilitation Milestones and Identified Rehabilitation Risks

Rehabilitation Milestone	Risk Sources	Associated Potential Events/Consequences	Relevant Controls
MM3 Achievement of Sufficient Improvement (continued)	MCPL.06.B - Diversion of surface water runoff away from catchment areas.	Loss of water flow downstream due to capture of water in voids.	02PE.08 - Drainage minimises water reporting to voids on site 02PV.06 - Erosion and sediment control 03SY.06 - Water Management Plan
	MCPL.06.C - Water accumulation in residual voids.	Overtopping/discharge to receiving environment.	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 03SV.09 - Mine voids are ground water sinks
	MCPL.06.E - Groundwater seepage from residual voids.	Impact to receiving environment.	02PE.08 - Drainage minimises water reporting to voids on site 03SV.09 - Mine voids are ground water sinks

3.6.3 Rehabilitation Trials and Studies

Rehabilitation trials are undertaken at the Middlemount Coal Mine to inform and improve rehabilitation methodologies for the nominated rehabilitation outcomes. Rehabilitation trials are intended to better manage and minimise the risk of a stable condition not being achieved.

Table 28 below provides a summary of rehabilitation trials undertaken to date at the Middlemount Coal mine, as well as future trials planned to inform ongoing improvements to rehabilitation. Table 28 outlines for each trial:

- the objective of the trial;
- the trial design including, but not limited to, the location, underlying land characteristics and potential issues;
- the details of how the trial will be carried out;
- when the trial will commence;
- the duration of the trial;
- how the trial will be assessed for success;
- how the results of the trial will be incorporated into rehabilitation strategies and the development of milestones; and
- where the trial has previously been carried out by the applicant.

Table 28
Onsite Rehabilitation Trial Details

Rehabilitation Trial and Objectives	Trial Design and Details	Trial Commencement, Location and Duration	Assessment of Success	Incorporation into Rehabilitation Strategies and Milestones
Rock Mulch Trial on the South Dump Outer Slope to determine rock mulch effectiveness at controlling erosion	Trial was established upon a 4H:1V slop using Permian overburden rock and topsoil, covering an area of 7.5 ha of the outer batter of the south dump (Bilyarra, 2020)	Rehabilitation of the rock mulch trial was undertaken in September 2017 within the trial area.	The application of rock mulch was not effective in controlling the development of a series of down cutting gullies across the slope (LRS Environmental, 2017).	This trial was not incorporated into the rehabilitation strategies and milestones.

Table 28 (continued)
On Site Rehabilitation Trial Details

Rehabilitation Trial and Objectives	Trial Design and Details	Trial Commencement, Location and Duration	Assessment of Success	Incorporation into Rehabilitation Strategies and Milestones
North Top of Dump Trial	Trial involved the leveling of spoil, establishing of drains, surface grading and the topsoil replaced. The trial area was then deep ripped, fertilised and seeded with a species mix (Bilyarra, 2019).	Rehabilitation of the North Dump trial was undertaken in 2017, with monitoring in both 2018 and 2019 being noted.	Within the 2018 monitoring, urochloa was noted as the dominant pasture grass, with other species being observed within the rehabilitation area. Within all quadrats, 74% were identified to have less than 50% projected cover (LRS Environmental, 2018). Within the 2019 monitoring of the rehabilitation area, it was observed that Rhodes was the dominant pasture species within 47& of all quadrants. The other dominant pasture species across the rehabilitation trial was both buffel and urochloa (Bilyarra, 2020).	The outcome of the trial was utilised to inform which grassy species would perform as an pasture grass for the rehabilitated land within the PMLU. The trial was also used as an indication of the effectiveness of just topsoil as an rehabilitation method.

Additional studies were compiled both on and off site for the effectiveness of differing methods to control erosion effects on site. The details of these studies are provided below.

Within 2019, a comparison of utilising two different types of rock within the rock mulch was undertaken by Landloch. The two rocks that are studied pit sandstone (Permian rock) and Quarry rock (from Parrot Quarry), with size restrictions for the mulch of 300 mm to 450 mm and a rock:topsoil ratio of 4:1 (Landloch, 2019). This trial was commenced within 2019, with bulk samples being sent to Landloch's Toowoomba Laboratory to be mixed into proportions of rehabilitation interest. The material was testing utilising simulated rain and overland flow, with a control group consisting of just topsoil.

Quarry rock was investigated and found to be considered impractical (Landloch, 2019). Topsoil, along with sufficient vegetation cover level (> 40 %), can be utilised to achieve erosion targets within slopes ≤ 17 %. Rock mulch (utilising 4:1 Permian rock to topsoil) will be required for higher gradients to achieve stability (Landloch, 2019).

Composite soil sampling was undertaken by MCPL personnel within 2021, with laboratory results and recommendations provided by Verterra (2021b). The objective of this study is to determine the recommended rates for both the amelioration (gypsum) and fertilizing requirements.

Additional requirements are the determination of the recommended application and incorporation of ameliorants into rehabilitation zones, and the recommended revegetation species and rates based upon soil analysis. Samples were taken from across the Middlemount Coal Mine, for each rehabilitation area (Verterra, 2021b) (Figure 17).

Post-vegetation modelling indicates a trend of decreased risk of high/very high surface erosion than the pre-vegetation establishment across all sample areas, highlighting the importance of early vegetation cover establishment within rehabilitation works. Additionally, the primary cause of tunnel erosion formation is the inclusion of ripping into the model. Whilst ripping can provide benefits, ripping on the contour or within rocky, dispersive profiles may lead to ponding, seepage and preferential flow paths.

Although less pronounced, a similar trend is recognised where high/very high tunnel erosion risk is reduced post-vegetation establishment (Verterra, 2021b). Amelioration was identified to have a significant effect on the reduction of both surface and tunnel erosion, and should be applied to topsoil if rock mulch is < 500 mm thick.

Soil and waste analysis was undertaken by Landloch within 2019, testing three samples of topsoil and three samples of waste for differing chemical and physical properties. The particle size analysis showed that two of the topsoil samples being similar, with the third topsoil sample possessing more clay and an increased sandy loam texture. Particle distributions of all three waste samples were alike, possessing relatively similar clay, fine and coarse sand proportions between the samples.

Across both the topsoil and the waste samples, the levels of nitrogen were measured to be low, indicating that the organic content within the samples was low. The topsoil samples possessed low phosphorous levels, with plant available phosphorous levels were measured to be moderate in two of the samples, and low in the other sample. The waste samples possessed high phosphorous levels, with plant available phosphorus being measured as moderate across all samples (Landloch, 2019).

Compost analysis was undertaken at Landloch within 2019, testing three samples of compost that were collected by Middlemount Coal Mine personnel for differing chemical properties. Plant available nitrogen was very high, ranging from 27,936 mg/kg to 31,027 mg/kg. Plant available phosphorus was also very high, ranging form 4,300 mg/kg to 4,410 mg/kg within the compost samples. All three samples were also extremely saline, with electrical conductivity ranging from 11.7 dS/cm to 13.4 dS/cm. This high salinity is likely caused by the high levels of chloride within the samples. These high levels of salinity, nitrogen and chloride will cause issues if too much compost is incorporated within the revegetation soils. It is recommended that the rate of compost applied and incorporated into the soil be reduced from 25 m^3/ha to approximately 13 m^3/ha, diluting the chloride and nitrogen levels within the soil into tolerable levels for most plants (Landloch, 2019).

Further soil analysis was undertaken within the Thirteen Mile Creek diversion in 2020, with samples being undertaken from six soil stockpiles, four of which consisting of a clay texture and two consisting of a sandy texture. Chemical properties of the samples were tested, with all samples recording low plant available nitrogen. Plant available phosphorus levels were low to moderate for most of the soil samples undertaken, with one sample recording a high phosphorus level.

The electrical conductivity within the samples all ranged from very low to high, however, chloride levels were recorded as low across the samples, meaning that soluble salts present have a lower likelihood of impairing plant growth. Fertiliser recommendations provided are utilised to improve the levels of nitrogen within the soil, with soluble urea recommended to be applied to aid in the rapid establishment of grasses and shrubs. Application of a polymer coated urea should be applied, to ensure a slow release of nitrogen into the soil, maintaining nitrogen levels for plant growth. For long term nitrogen sources, appropriate legume species are recommended to be incorporated within any seed mixes proposed for revegetation.

3.7 MONITORING AND MAINTENANCE

3.7.1 Milestone Monitoring

Successful revegetation outcomes rely on an integrated and adaptive approach to risk identification and control. Monitoring plays an integral part within the overall management strategy, as it will enable early detection of any risks to revegetation areas as well as the effectiveness of risk management actions undertaken. Effective monitoring will enable significant processes or trends to be detected and, where required, appropriate management actions to be implemented.

Table 30 and 31 provides an overview of the monitoring and/or maintenance program for each of the rehabilitation and improvement milestones, including timing of the activities, quality assurance and/or data management procedures, as well as reporting and review procedures.

3.7.1.1 Revegetation Monitoring

Revegetation monitoring is split into two phases, an establishment phase and a maintenance phase (Table 29). Areas of endemic floral vegetation (i.e. Treatment Zones 1, 2 and 3) have longer establishment and maintenance phases because tree and shrub species as well as grasses and forbs will be directly seeded.

Table 29
Revegetation Phases

Phase	Definition	Anticipated Timeframe (Years)	
		Treatment Zone 1	Treatment Zone 2 and 3
Establishment	The period required for revegetated areas to become self-reliant without watering in normal seasonal conditions.	2	5
Maintenance	The period of growth post-establishment until the time that the revegetated plants become dominant and self-sustaining on the site.	3-5	6-20

A summary of the proposed monitoring methods for each Treatment Zone is provided in Table 32 and discussed in further detail in the Revegetation Plan (Appendix H).

Rehabilitation monitoring sites will be established consistent with the Middlemount Coal Mine Rehabilitation Monitoring Program 2021 (MCPL, 2021) (Attachment 4) and the Revegetation Management Plan (Verterra, 2022) following the completion of each rehabilitation area. Monitoring at these sites will include:

- one fixed 50 m transect;
- one 50 m x 10 m plot (centred on the 50 m transect); and
- five 1 m x 1 m quadrats (at 10 m intervals along the transect, alternating sides).

Sites will be placed at random within newly established rehabilitation polygons, at a density of approximately one site per 10 ha. The data to be collected in each plot/subplot is summarised in Table 32 and discussed further below. Photographic records and GPS locations for all monitoring sites and observed issues will be kept up to date in an appropriate database. To monitor revegetation progress, the data for each vegetation scenario will be averaged across monitoring sites established in similar timeframes and compared to the corresponding reference sites.

Table 30
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM1 Infrastructure Decommissioning and Removal	3 months	• All services decommissioned.	Confirm all services decommissioned.	Immediately after decommissioning and removal works are completed.	Decommissioning and removal works will be conducted and certified by suitably qualified person(s).	A report will be provided by the relevant person(s) detailing the activities completed.
		• Contaminated land and water (e.g. affected by hydrocarbons, metals, brine, etc) is treated to ensure consistency with upstream water quality characteristics, or removed off site. Upstream water quality parameters and monitoring sites would be consistent with those listed in Table 3.2 of Appendix A	Confirm all contaminated water treated, transferred to final voids or removed, as necessary.			
		• All wastes removed from site and lawfully disposed.	Confirm all relevant materials, buildings and water storages demolished and removed (unless otherwise agreed in writing with landholders and relevant agencies).			
		• All infrastructure water storages demolished and removed, unless retained, and agreed in writing by the landholders and relevant agencies.				
		• All haul roads and access tracks ripped and removed to reduce compaction, unless agreed in writing by landholders and relevant agencies.	Confirm all roads and access tracks have been removed and ripped (unless agreed in writing with landholders and relevant agencies).			
		• Risk assessment undertaken to ensure that all infrastructure has been appropriately disconnected and decommissioned.	Review safety of any remaining infrastructure and confirm zero significant difference.		Safety assessment will be conducted by suitably qualified person(s) in consideration of ISO 31000:2018 Risk Management.	A report will be provided by the relevant person(s) detailing the outcomes of the safety assessment.
		• Certification that all exploration drill holes not agreed to in writing with the post-mining landholder to be converted to either a water bore or groundwater monitoring bore have been rehabilitated safe and stable, and will remain safe and stable.	Visual Monitoring to confirm that all exploration drill holes are either converted to a water bore, or will commence rehabilitation appropriately.		Certification that all exploration drill holes not converted to water bores or monitoring bores have been rehabilitated by a suitably qualified person.	A report will be provided by the relevant person(s) detailing the activities completed.
RM2 Remediation of Contaminated Land (Characterisation)	3 months	• Detailed site investigation report, as required under the *Environmental Protection Act 1994*, completed.	Prepare report detailing outcomes/recommendations as a result of the preliminary and intrusive contaminated land investigations.	Within two weeks of undertaking investigations.	Preliminary and intrusive contaminated land investigations will be conducted by suitably qualified person(s).	The Annual Return will include a summary of all remediation works.
		• Contaminated and hazardous materials (e.g. PCBs, Mercury, hydrocarbon contaminated soils, Dioxins etc.) have been removed and appropriately disposed of or remediated. • Hydrocarbon, heavy metal, or other contaminants are within allowable departmental limits (established in accordance with DES' *Queensland Auditor Handbook for Contaminated Land*) and has been certified by an appropriately qualified person.	Monitor levels of hydrocarbons, heavy metals, salinity and cation exchange capacity.	Immediately following removal/remediation of contaminated materials/land.	Removal/remediation works will be conducted by suitably qualified person(s).	
		• A site suitability statement confirms the uses or activities for which the land is suitable and aligns to the approved PMLUs for the site. • Validation testing confirms that contaminated soils have been removed or remediated.	Site suitability statement prepared confirming suitability of land with PMLU. Validation testing completed detailing outcomes and confirming removal of contaminated soils.	Immediately following completion of site suitability statement and commencement validation testing.	Validation testing will be conducted by suitably qualified person(s).	The Annual Return will include a summary of outcomes from validation testing.

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM3 Remediation of Contaminated Land (Waste Rock Material Treatment)	3 months	• Site added to the Environmental Management Register, if required.	Notification that site has been successfully added to the Environmental Management Register received.	Immediately following addition of site to the Environmental Management Register.	N/A	The Annual Return will include a summary of any sites added to the Environmental Management Register.
		• Remediation of contaminated soil materials such as hydrocarbon has been undertaken as required.	Monitor levels of hydrocarbons, heavy metals, salinity and cation exchange capacity.	Immediately following removal/remediation of contaminated materials/land.	Removal/remediation works will be conducted by suitably qualified person(s).	The Annual Return will include a summary of all remediation works.
		• Validation testing confirms that contaminated soils have been removed or remediated.	Validation testing completed detailing outcomes and confirming removal of contaminated soils.	Immediately following commencement of validation testing.	Testing will be conducted by a suitably qualified and experienced person(s).	Outcomes of validation testing will be reported to the Environment & Community Superintendent and will inform the Annual Return.
		• No acid rock drainage is occurring or has the potential to occur. Acid rock drainage would be measured against the thresholds detailed in the Global Acid Rock Drainage Guide (INAP, 2009)	Confirm absence of acid rock drainage via testing conducted by an appropriately qualified person (s).	Immediately after completion. .	Testing will be conducted by a suitably qualified and experienced person(s).	Outcomes of acid rock drainage testing will be reported to the Environment & Community Superintendent.

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM4 Landform Establishment (Capping, Development and Reshaping/ Reprofiling	6 months	• Engineering and design plans for TSF and emplacement areas finalised. • Engineering report on completed cover finalised, certifying that the capping system has been built/installed as per engineering design plan.	N/A	N/A	The engineering and design plans will be completed and certified by a suitably qualified person(s).	The engineering and design plans will be provided to the Environment & Community Superintendent.
		• Tailings have settled before capping.	Test ongoing settlement.	Monthly following cessation of deposition.	Testing will be conducted by a suitably qualified person(s).	Outcomes of settlement testing will be reported to the Environment & Community Superintendent.
		• All major earthworks completed. • Landform recontoured to conform with adjacent landforms. • Out-of-pit coal emplacement slopes no greater than 10%, or up to 18.5% where rock mulch or other stabilisation controls are used. Backfilled emplacement areas would follow the same landform design criteria to be considered geotechnically stable. • Infrastructure area slope angles do not exceed 5%. For slopes over 2%, continuous slope length does not exceed 70 m • Overburden is classified as NAF and is placed in any in-put or ex-pit spoil dump • NAF waste rock or other identified capping materials such as clay will be compacted with suitable oxygen diffusion control properties to reduce the minimum encapsulation thickness. • Interburden is preferentially placed in-pit to provide the acid neutralisation capacity for spot-dumping of PAF materials and creation of Permian caps and bunds on coal reject cells. • PAF floor materials from the Middlemount seam should remain in the open pit and be covered with NAF spoil. • Burial of PAF be lime dosed (at a rate of 10 t/ha or as confirmed by field trials) and kept at least 10 m away from the outer surfaces of final landforms by covering with Permian spoil. • Consideration of leaching potential via leaching tests for PAF materials • The maximum ratio of PAF coarse reject/tailings to Permian spoil at the out-of-pit spoil emplacement area be 1 to 10. • Slopes of >16% have been treated with rock mulch to assist with maintaining slope stability. • Installation of contour or graded drains as per construction design which has been certified by an appropriately qualified person. • Final voids certified by a suitably qualified and experienced person as geotechnically stable. • Final landform is stable and has been certified by an appropriately qualified person.	Review and confirm the landform is consistent with requirements.	Immediately following completion.	"As built" drawings will be prepared by a suitably qualified and experienced person(s). Engineering report will certify the cover/capping system has been constructed and installed as per the design.	The Annual Return will include a summary of the development and reshaping of the land, and will include a summary of the capping undertaken

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM5 Growth Medium Application (Surface Preparation and application of ameliorants).	3 months	• An assessment of soil health and suitability has been completed by an appropriately qualified person to confirm soil is suitable for target vegetation growth. • Waste rock material ripped to a minimum of 300 mm depth via grader tyres or equivalent. • Topsoil/growth medium placed to a minimum depth of 200 mm, to achieve 300 mm of amended subsoil. • Topsoil amelioration and fertilisation process completed to minimise chemical and physical limitations of establishment and growth of vigorous vegetation cover. Approach involves the application of gypsum and organic matter prior to spreading of topsoil and chemical fertiliser (as required) (target total N: >1,500 milligram [mg] per kg [mg/kg], Phosphate: >20 mg/kg). • Topsoil to be ripped with a bulldozer or with tynes spaced at 50 centimetre (cm) centres. • Use of offset disc harrows to harrow gypsum and organic matter into full depth (200 mm) and on the contour. Use of scarifies or harrows (maximum less than 50 mm depth) to apply fertiliser and seed incorporation. • Installation of fencing (if required) completed. • Evidence, certified by an appropriately qualified person, that topsoil/growth medium has been spread to a suitable depth in rehabilitated areas to sustain the post mining land use. • Amelioration of topsoil undertaken to minimise chemical and physical properties limiting establishment and growth of vegetation cover. • For areas < 16 % slope, vertical rills and troughs removed, and topsoil applied to a minimum depth of 0.2 m. • Seed and harrow applied to average depth of approximately 50 mm. • For areas > 16 %, seed over rock mulch applied. • Soil surface crusting occurs in less than 2% of the rehabilitated domain area	Assessment of soil health and surface preparation activities undertaken and confirmed to meet requirements.	Immediately following completion.	Surface preparation will be conducted and certified by a suitably qualified person(s).	The Annual Return will include a summary of surface preparation activities.

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM6 Revegetation (native ecosystem)	12 months	• Direct seeding of cover crop, pasture species completed and native vegetation (seed mix proportions relevant to grazing and native ecosystem representative of relevant RE's, native shrubs and grasses are specified in Revegetation Management Plan [Table 9]).	Early survivorship assessment.	Zero, three, six and 12 months after completion of seeding.	Suitably qualified person(s) to undertake revegetation monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of revegetation activities and associated monitoring data.
		• Seed incorporated to a depth of approximately 5 cm to ensure adequate soil moisture is stored before germination is initiated and so that the seed is not penetrated too deep in the soil surface.	Confirm seed placement has occurred to depth of approximately 5 cm (i.e. machinery has been set accordingly).	Zero, three, six and 12 months after completion of seeding.		
		• Use of tractor drawn, and dozer mounted seeding equipment to sow seed integrated with scarifies, harrows or tracking chains.		N/A		
		• Seed sourced from reputable seed suppliers with documented quality control procedures.		N/A		
		• Stock fencing to protect early stages of revegetation instalment.	Review whether fencing is still required.	Quarterly.	N/A	
		• Topsoil to be ripped no more than three months after initial placement. • Till along the contour with a tyned implement with tyne spacing no greater than 0.5m.	Confirm ripping and tillage has been undertaken as required.	Immediately following completion.	Activities to be undertaken by a suitably qualified person(s).	
		• Non-vegetation cover (stones, rock cover, litter, logs, grasses etc) does not cover greater than 30% of the total area. • Pasture grass and native species are comparable in cover to designated vegetation reference sites. • Germination and purity visual inspections by a certified professional undertaken (e.g. agronomist or reputable seed supplier). • A minimum of 65% vegetation cover is present, and evidence of generational succession of trees and shrubs is evident. • Bare surface areas are not to exceed 100 m^2 in area, and exceed a length of 10 m along slope, based on a five-year average period. • Reseed/plant tube stocks with native shrub, tree and grass species, where required.	Confirm establishment of non-native cover and evidence of generational succession.	Annually.	Activities to be undertaken by a suitably qualified person(s).	
RM7 Surface Conditions	5 years	• No evidence of slumping and erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining.	Photo monitoring. Line intercept monitoring.	Annually, for a period of five years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of surface conditions and associated monitoring data.
		• Hydraulic and geomorphic characteristics of Roper Creek Diversion 1 and 2, and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of the existing Roper Creek Diversion 1, 2 and Thirteen Mile Creek Diversion channels..				
		• Target ranges for chemical and physico-chemical nutrients are considered to be at levels in which plant nutrient deficiencies are relieved and plant growth is encouraged (refer to Revegetation Management Plan).	Soil monitoring.	Annually, for a period of five years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	
		• Hydrocarbon, heavy metals or other contamination levels are within appropriate DES limits				

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM8 Achievement of PMLU to Stable Condition (native ecosystem)	Up to 20 years	**Safe:** • Certification that slopes are safe, and predicted to remain safe. • Certification that specified cover thickness has been obtained.	Final landform review.	At commencement of milestone.	Certification provided by suitably qualified and experienced person(s).	The Annual Return will include a summary of rehabilitation progress.
		• Evidence that any site contamination has been resolved and relevant measures implemented, resulting in removal of the site from the Environmental Management Register (if required).	Obtain record of site removal from the Environmental Management Register.	Once contamination has been resolved.	Removal/remediation works will be conducted by suitably qualified person(s). Validation testing will be conducted by suitably qualified person(s).	The Annual Return will include a summary of all remediation works.
		• Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for an ongoing period of time.	Water quality testing and review.	Six-monthly.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of water quality monitoring data.
		• A Bushfire Management Plan developed in accordance with relevant Queensland Fire and Emergency Services is in place.	Review bushfire risk. Implement recommendations, as necessary.	Every two years.	Bushfire risk review to be undertaken by suitably qualified person(s).	The Annual Return will include a summary of all bushfire risk related works.
		Stable: • Rehabilitation area has remained stable when comparing photographs from successive monitoring events, for a period of at least five years post-mining. • Active erosion (t/ha/year) is less than 110% of the levels present in designated vegetation reference sites. • Erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. • No evidence of severe erosion[4] • Nutrient cycling processes are comparable to designated reference sites which are representative of the PMLU. • Pest species abundance comparable to designated reference sites. • Weed diversity and density less than 110% of the levels present in the designated reference sites, for a period of at least two years. • Vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass. • Persistent groundcover greater than or equal to 65% established as assessed against comparable reference sites. • Assessed hypothetical stocking rates in rehabilitated pasture areas are comparable to designated vegetation reference sites. • Hydraulic and geomorphic characteristics of rehabilitated portions of Roper Creek (Diversion 1 and 2), and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of undisturbed sections of Roper Creek and Thirteen Mile Gully channels.	Photo monitoring. Line intercept monitoring.	Annually, for a period of five years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of surface conditions and associated monitoring data.

[4] Severe erosion has any of the following characteristics – Loss of surface horizons, root exposure, etc. (sheet erosion), >30 rills and/or any >0.3 m deep (rill / gully erosion); presence of tunnel erosion; or evidence of mass soil movement.

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM8 (continued)	Up to 20 years	**Self-sustaining land use:** • Assessed hypothetical stocking rates in rehabilitated areas are comparable to designated vegetation reference sites. • Litter density comparable to vegetation designated vegetation reference sites. • Declared weed species cover is comparable to designated vegetation reference sites. • Tree and shrub species are comparable to designated vegetation reference sites. • Tree and shrub species show evidence of flowering, viable seed setting, germination and emergence. • Persistent groundcover greater than or equal to 65 % as assessed against comparable reference sites.	Groundcover and organic litter assessment. Plant species list and richness review. Carrying capacity review. Brigalow Belt Pasture Photo Standards. Soil assessment.	Annually for five years.	Photo monitoring and transect data will be collected and certified by suitably qualified specialists.	The Annual Return will include evaluations of the effectiveness of achieving the PMLU.
		• Salinity levels of less than 0.6 dS/m in soil root zone or less than 110% of designated vegetation reference sites. • Cation exchange capacity levels are greater than 8 to 10 in soil root zone or less than 110% of designated vegetation reference sites.	Soil monitoring.	Annually, for a period of five years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of surface conditions and associated monitoring data.
		Non-polluting: • Hydrocarbon, heavy metal or other contamination levels are within relevant DES limits.	Review of soil contamination levels relevant to DES limits.	Annually, for a period of five years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of surface conditions and associated monitoring data.
		• Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for a period of at least two years. • Groundwater quality monitoring results comply with Table D2: Groundwater Quality Investigation Trigger levels in EA EPML00716913, and are reviewed every two years.	Water quality testing and review.	Six monthly, for two years.	Suitably qualified person(s) to undertake monitoring and record progressive development allowing for tracking of trends against milestone criteria and reference sites.	The Annual Return will include a summary of water quality monitoring data.

Table 30 (continued)
Management Milestones for Rehabilitation Areas

Rehabilitation Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
RM9 Retained Water Structures	2 years	• Certification of structural integrity.	Review structural integrity.	Within two years of milestone commencement.	Engineering report will certify structural integrity.	The Annual Return will include a description of the water storages and relevant outcomes.
		• Water quality within the retained water structures is comparable with upstream values. Upstream water quality parameters and monitoring sites would be consistent with those listed in Table 3.2 of Appendix A.	Review of water quality against comparable reference sites.	Annually	Testing to be undertaken by suitably qualified person (s	The Annual Return to include a summary of water quality for any retained water structures.
		• Water quality monitoring results comply with EA EMPL00716913 for an ongoing period of time. • All retained structures and landforms to be assessed and approved as safe and stable for post-mining use by an appropriate qualified person.	Water quality testing and review against relevant guidelines.	Six monthly	Testing to be undertaken by suitably qualified person(s).	

Table 31
Management Milestones for Improvement Areas

Management Milestone	Timeframe	Milestone Criteria	Monitoring and Maintenance	Timing of Monitoring and Maintenance	Quality Assurance and Data Management Processes and Systems	Reporting and Review
MM1	2 years	• Certification from an appropriately qualified and experienced person that the final voids are safe. • Factor of Safety to determine geotechnical stability as highwall competent rock slopes are no greater than 59°, and incompetent slopes no greater than 36°. • Low wall slopes no greater than 30°. • Low and high walls certified by a suitably qualified and experienced person as geotechnically stable. • Slope geometry for the final voids is as follows: i. Surficial Soils – Overall slope angle does not exceed 20 degrees ii. Weathered Permian – Bench height does not exceed 30 m. – Berm width does not exceed 25 m – Batter Angle does not exceed 55 degrees. iii. Fresh Permian – Bench height does not exceed 60 m – Berm width does not exceed 60 m – Batter angle does not exceed 60 degrees. • Northern Void does not exceed 358 ha in surface area and 285,870,000 m3 in volume. • Southern void does not exceed 163 ha in surface area and 157,960,000 m3 in volume.	Review and confirm the final void high- and low walls are consistent with requirements.	Immediately following completion.	"As built" drawings will be prepared by a suitably qualified and experienced person(s).	The Annual Return will include a summary of the development and reshaping of the land.
MM2	12 months	• Access is prohibited to final voids by a bund wall with a minimum height of 2 m, a minimum base width of 4 m and be located at least 10 m beyond the area potentially affected by any instability of the pit edge or a fence. • Appropriate signage placed to clearly identify and convey the purpose (e.g. *EP Act 1994 Non- Use Management Area No Entry*).	Visual inspection of bund wall and signage.	Following installation.	Record of visual inspection.	Record of visual inspection to be provided to Environment and Community Superintendent.
MM3	2 years	• Bund wall remains in place. • Appropriate signage remains in place.	Visual inspection of bund wall and signage.	One and two years after commencement of milestone.	Record of visual inspection.	Record of visual inspection to be provided to the Environment & Community Superintendent.
		• Final voids remain structurally stable, with no maintenance requirements and are predicted to remain stable. • High walls and low walls certified by a suitably qualified and experienced person as geotechnically stable. • Groundwater quality monitoring results comply with EA EPML00716913, for an ongoing period of time. • Final void walls confirmed to drain internally to the final void. • Review of final void water recovery confirms the void is predicted to act as a long-term groundwater sink.	Review and confirm the landform is consistent with requirements.	Immediately following completion.	Engineering report will certify the final voids remain stable.	The engineering report will be provided to the Environment & Community Superintendent.

Table 32
Monitoring Methods for Rehabilitation Milestones

Performance Indicator	Completion Criteria	Monitoring Method	Monitoring Measurement/ Analysis	Treatment Zone 1	Treatment Zone 2	Treatment Zone 3	Establishment	Maintenance
Landform Stability and Erosion	No evidence of severe erosion[5]	Vegetation Monitoring	Line intercept (50 m transect)	✔	✔	✔	✔	✔
	Erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post- mining.	Documentation review	N/A	✔	✔	✔	✔	✔
Topsoil Characterisation	Hydrocarbon, heavy metal, or other contaminants are within allowable departmental limits has been certified by an appropriately qualified person.	Soil sampling	Heavy metals scan, Hydrocarbons	✔	✔	✔	✔	
	Salinity levels of less than 0.6 dS/m in soil root zone or less than 110% of designated vegetation reference sites.		Salinity (dS/m)	✔	✔	✔	✔	
	Cation exchange capacity levels are greater than 8 to 10 in soil root zone or greater than 110% of designated vegetation reference sites.		Cation Exchange Capacity (CEC)	✔	✔	✔	✔	

[5] Severe erosion has any of the following characteristics – Loss of surface horizons, root exposure, etc. (sheet erosion), >30 rills and/or any >0.3 m deep (rill / gully erosion); presence of tunnel erosion; or evidence of mass soil movement.

Table 32 (Continued)
Monitoring Methods for Rehabilitation Milestones

Performance Indicator	Completion Criteria	Monitoring Method	Monitoring Measurement/ Analysis	Treatment Zone 1	Treatment Zone 2	Treatment Zone 3	Establishment	Maintenance
Ecosystem Functionality and Sustainability	Litter density comparable to designated vegetation reference sites.	Vegetation monitoring	Groundcover quadrats (5 x 1 m^2 quadrats)	✔	✔	✔		✔
	Pasture grass and native species are comparable in cover to designated vegetation reference sites.		Tree and shrub diversity (1 m^2 x 1 m^2 quadrats along 50 m transect at 10 m intervals).	✔	✔	✔		✔
	Evidence of generational succession of trees and shrubs is apparent in rehabilitation areas.		Tree and shrub diversity (1 m^2 x 1 m^2 quadrats along 50 m transect at 10 m intervals).	✔	✔	✔		✔
Native Ecosystem	minimum of 65% vegetation cover is present, and evidence of generational succession of trees and shrubs is apparent in rehabilitated areas.	Vegetation monitoring	Groundcover quadrats (5 x 1 m^2 quadrats)	✔	✔			✔
	Direct seeding of cover crop, pasture species and native vegetation completed (seed mix proportions relevant to grazing and native vegetation specified in Revegetation Management Plan).		Tree and shrub diversity (1 m^2 x 1 m^2 quadrats along 50 m transect at 10 m intervals).	✔	✔		✔	✔

Table 32 (Continued)
Monitoring Methods for Rehabilitation Milestones

Performance Indicator	Completion Criteria	Monitoring Method	Monitoring Measurement/ Analysis	Treatment Zone 1	Treatment Zone 2	Treatment Zone 3	Establishment	Maintenance
Pest Flora and Fauna	Evidence of weed management being successful by weed diversity and density being less than 110% of baseline survey results and abundance being comparable to designated vegetation reference sites.	Vegetation monitoring	Weed cover (1 m^2 x 1 m^2 quadrats along 50 m transect at 10 m intervals)	✔	✔	✔	✔	✔
	Evidence of effective pest management with pest species abundance being comparable to designated vegetation reference sites.		Observations and analysis of vegetation monitoring (5 x 1 m^2 plot)	✔	✔	✔	✔	✔

3.7.1.2 Reference Sites

11 reference sites have been established at the Middlemount Coal Mine in accordance with Condition G11 of EA EPML00716913 and the Middlemount Coal Mine Rehabilitation Monitoring Program (Figure 22) to provide a benchmark for rehabilitation monitoring sites to develop rehabilitation success criteria. Table 33 below lists the reference sites relative to certain revegetation scenarios.

Table 33
Rehabilitation Reference Sites

Site	Easting	Northing	Domain Reference	Ecosystem Description
Existing Reference Sites as per Table G11 of EA EPML00716913 and Middlemount Rehabilitation Monitoring Program (MCPL, 2021)				
1	662226	7475606	• In-pit and out-of-pit spoil dumps	RE 11.5.3
2	665445	7469732	• MIA and CHPP Area • Roads including haul roads • Tailing Storage Facility	RE 11.5.9
3	665832	7470708	• Roads including Haul Roads	RE 11.7.2
4	666054	7469733	• MIA and CHPP Area • Roads including haul roads • Tailing Storage Facility	RE 11.5.9/11.5.18
5	666693	7469888		RE 11.7.2/11.7.1
6	667513	7469830		RE 11.3.2/11.3.7
7	667020	7469836		RE 11.7.2/11.7.1
8	667397	7471016	• Creek Diversions and Levee Banks	RE 11.3.25
9	667724	7471051		RE 11.3.25
10	666702	7473050		RE 11.3.1/11.3.2
11	671581	7472907	• In-pit and out-of-pit spoil dumps	RE 11.5.3
Proposed Reference Sites as per the Revegetation Management Plan				
AS1	662883	7475606	Area not currently in use.	Pre clear RE 11.5.3
AS2	664591	7468202	Area not currently in use.	Pre clear RE 11.12.2
AS3	663833	7471263	Area not currently in use.	Pre clear RE 11.3.25

3.7.1.3 Survivorship Assessment

Monitoring the survivorship of seeded stock will commence immediately after the wet season to obtain baseline data and then at three, six and twelve-month intervals thereafter.

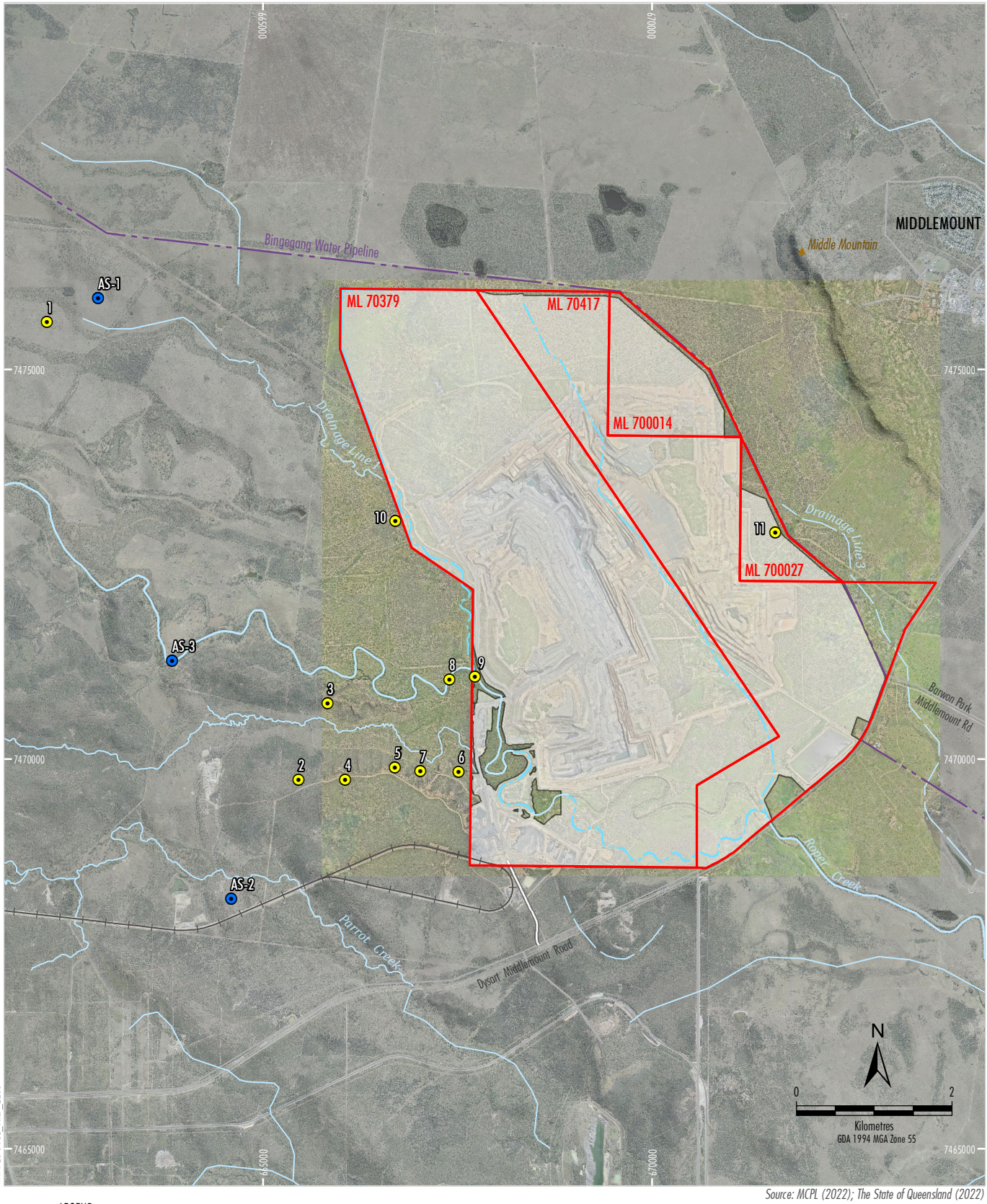
All germinated seeds along the transect will be counted. If survivorship is less than 65 %, supplementary seeding will be undertaken.

Note that monitoring the survivorship does not need to be undertaken by an Ecologist.

3.7.1.4 Landform Stability and Erosion

At the centre point of the transect (25 m), four (4) landscape photos (north, south, east and west) will be taken to record and assess site stability.

An estimation of the prevalence of erosion features, including sheets, rills and gullies along the 50 m transect will be made using the line intercept method. The start and end points of erosion features as they intersect the 50 m transect will be recorded, allowing total length of erosion features to be compared with reference site values.



MCPL-20-04 SE_RKD_222C

Source: MCPL (2022); The State of Queensland (2022)
Orthophoto Mosaic: 2021, 2015

LEGEND

- Mining Lease Boundary (ML)
- Approved Disturbance Footprint
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure

Rehabilitation Reference Sites

- Existing
- Proposed

middlemount coal PTY LTD

MIDDLEMOUNT COAL MINE

Existing and Proposed
Rehabilitation Reference Sites

Figure 22

3.7.1.5 Topsoil Characterisation

Soil sampling will be undertaken at all monitoring sites during the establishment phase and subsequently if further investigation is required based on other monitoring data (e.g. persistent poor performance in relation to ground cover, erosion etc.).

Soil sampling will generally be undertaken according to the following methodology:

- At the 20 m mark and 40 m mark of each transect, a small area (25 cm by 25 cm) will be cleared of loose surface vegetation, litter and debris to avoid inclusion in the soil sample. Where grass and/or other growing vegetation is present, the vegetation will be cut off at ground level and discarded.
- A clean spade will be used to collect two 0.25 L soil samples to a depth of 10 cm below the surface of the soil.
- The two samples will be combined in a clean plastic clip seal bag (total soil sample approximately 0.5 L) and labelled with site name, monitoring point identifier, collection date and collector's name using a permanent marker.
- Labelled soil samples will be sent for analysis as soon as possible following collection.

3.7.1.6 Ecosystem Functionality and Sustainability

Groundcover and Organic Litter

For the 1 x 1 m quadrats, groundcover will be split into the following components: native perennial grass cover, native forb cover, pasture grass cover, non-native grass cover (that are not pasture species), non-native forb cover and leaf litter, rock and bare ground. Groundcover will be measured by a vertical projection downwards of the living and attached plant material.

Plant Species List / Richness

All pasture and native flora species within the 50 m by 10 m plot (i.e. 5 m either side of the central transect) will be recorded. The presence or absence of reproductive structures (flowers and/or fruit) per species will be noted.

Evidence of Generational Succession

The recruitment attribute assesses the presence of regeneration of the dominant tree and shrub species in the 50 m x 10 m plot. Recruitment is assessed as the proportion of dominant species present at a site that are regenerating.

Tree Canopy Height

Tree canopy height (measured to the top of the highest leaves) refers to the median canopy height in metres, estimated for the trees in the ecologically dominant layer (EDL) or canopy layer within the 50 m x 10 m plot. The median canopy height is the height that has 50 % of canopy trees higher and lower than it.

Tree and Shrub Cover

An estimation of the percentage canopy cover of the living, native tree layer along the 50 m transect will be made using the line intercept method (Greig Smith, 1964). Canopy cover equates to crown cover as defined by Walker and Hopkins (1990). The vertical projection of the tree canopy over the 50 m transect will be recorded. The total length of the project canopy cover of each layer is then divided by the total length of the tape to give an estimate of percentage canopy cover on the site, which then can be compared with the reference site value.

Shrub canopy cover refers to the estimate of the percentage cover of native shrubs recorded along the 50 m transect (similar to the estimation of tree canopy cover using a vertical projection of shrub crowns downwards over the centre line transect).

3.7.1.7 Native Ecosystem Suitability

Groundcover and Organic Litter

For the 1 m x 1 m quadrats, groundcover will be split into the following components: native perennial grass cover, native forb cover, pasture grass cover, non-native grass cover (that are not pasture species), non-native forb cover and leaf litter, rock and bare ground. Groundcover will be measured by a vertical projection downwards of the living and attached plant material.

Plant Species List/Richness

All pasture and native flora species within the 50 m x 10 m plot (i.e. 5 m either side of the central transect) will be recorded.

Carrying Capacity

Carrying capacity is measured as the number of head of cattle per 100 ha. This is calculated by dividing the dry biomass required per head of cattle by the measured mean pasture biomass (kg/ha) of each monitoring plot and converting to head per 100 ha.

To estimate pasture biomass, a 1 m height pole will be placed at the 26 m mark along the 50 m transect. A photo will then be taken at the 23 m mark facing the pole. The field of view for each photo will be aligned by tilting the camera down until the top of frame meets the horizon. The photos will then be compared to the Brigalow Belt Pasture Photo Standards to estimate biomass in tonnes per ha (Future Beef, 2012).

3.7.1.8 Pest Flora and Fauna

Weed Density

The number of stems or estimate foliage projective cover within the 50 m x 10 m plot of each non-pasture weed species will be recorded. The data will then be extrapolated to obtain the number of stems per ha.

For the 1 m x 1 m quadrats, groundcover will be split into the following components: native perennial grass cover, native forb cover, pasture grass cover, non-native grass cover (that are not pasture species), non-native forb cover and leaf litter, rock and bare ground. Groundcover will be measured by a vertical projection downwards of the living and attached plant material.

Pest Animal Browsing Damage

Pest animal browsing damage is defined as any evidence of damage to planted grasses, shrubs and trees by wallabies, hares, rabbits etc. Where possible, the number of plants within the 50 m x 10 m plot will be counted. A score of 0 to 3 will then be assigned to the plot, with 0 being no damage, 1 being light damage, 2 being moderate damage and 3 being severe damage.

3.7.2 Rehabilitation Maintenance/Contingency

Consistent with the requirements of Condition G14 of the Middlemount Coal Mine EA EPML00716913, MCPL undertakes regular monitoring of rehabilitation areas at the Middlemount Coal Mine in the form of the annual Middlemount Coal Mine Rehabilitation Monitoring Program.

The *Middlemount Coal Mine Rehabilitation Monitoring Program* collects site-specific data on a regular basis to assess and compare against the Middlemount Coal Mine rehabilitation objectives, indicators and completion criteria. The outcomes of monitoring are used to determine the performance of the rehabilitation, and to identify any areas that are at risk of failing to reach rehabilitation objectives. The findings of the Rehabilitation Monitoring Program are compiled annually into a report and submitted to the administering authority.

Whilst the Rehabilitation Monitoring Program would be superseded by this PRCP, all monitoring methods would continue to be implemented as part of the PRCP and regular monitoring and subsequent maintenance and contingencies for rehabilitated areas would continue to take place at the Middlemount Coal Mine.

3.7.2.1 Weed Control

Weed invasion is common throughout the Middlemount Coal Mine area, especially in disturbed areas. As part of Terrestrial Ecology Studies undertaken for the Middlemount *Coal Mine Stage 2 Environmental Impact Statement* four declared plants listed under the *Land Protection (Pest and Stock Route Management) Act, 2002* were recorded (Prickly Acacia [*Acacia nilotica*], Tiger Pear [*Opuntia aurantiaca*], Prickly Pear [Opuntia stricta], and Parthenium Weed [*Parthenium hysterophorus*]). Studies undertaken for the Western Extension and Southern Extension Projects further identified Velvety Tree Pear (*Opuntia tomentosa*) and Harrisia Cactus (*Harrisia martini*) within the Middlemount Coal Mine area.

A weed management strategy is implemented at the Middlemount Coal Mine to reduce the presence of environmental weeds/restricted invasive plants which have potential to impact on the desired conservation outcomes.

The procedure for controlling and monitoring environmental weeds/restricted invasive plants will be as follows:

1. Monitor the location and density of environmental weeds/restricted invasive plants through inspections, including annual monitoring events.
2. Identification of suitable control methods for target environmental weeds/restricted invasive plants.
3. Implementation of the selected control methods on the target environmental weeds/restricted invasive plants.
4. Follow-up site inspections to evaluate the effectiveness of the weed control (within 2 weeks of control).
5. Follow-up control where previous control has been sub-optimal (within 2 weeks of point 4).

Additional weed management activities at the Middlemount Coal Mine to reduce the presence of environmental weeds/restricted invasive plants include:

- Vehicle and machinery wash down before entering the rehabilitation works;
- Treatment of any significant infestations; and
- Recording and mapping infestations/treatments.

The implementation of measures that favour the restoration of healthy native vegetation is also an effective method of weed management. The introduction, establishment and spread of environmental weeds/restricted invasive plants will be minimised through regular monitoring and treatment activities.

In regard to weed management measures, physical removal and chemical application are the main weed control methods available. Appropriately qualified persons will be engaged to undertake weed control.

Active weed control measures will be necessary during establishment of revegetated areas. Management techniques will be species specific, however the preferential management hierarchy is:

- Handpull.
- Spot spray.
- Cut stump (for established woody weeds).

Minor infestations of weeds would be hand removed from rehabilitation areas, larger infestations however would be spot spayed with “frog friendly” glyphosate or approved equivalent (eg. ROUNDUP Bioactive®, Weedmaster DUO®). Broad scale herbicide application will generally be avoided due to the likelihood of damaging or killing grass cover and reducing site stability.

The following controls will be implemented to reduce the risks to safety and environment where appropriate:

- Herbicide applications will be primarily carried out by professional commercial operators, licenced under the *Agricultural Chemicals Distribution Control Act 1966*.
- Weed hygiene declarations for all equipment and vehicles brought onto the site will be up to date prior to arrival. An onsite inspection protocol for equipment and vehicles including personnel and contractor training will be developed and implemented.
- Work orders issued to contractors will stipulate constraints on spray operations, including weather constraints relating to wind, rainfall and temperatures.
- Work orders issued to contractors will include clear operations maps showing delineated work areas, boundaries of different treatment zones and locations of sensitive areas and weed hygiene boundaries.

3.7.2.2 Irrigation/Watering

For the majority of the Middlemount Coal Mine revegetation process, dryland seeding is proposed, with no manual watering activities or irrigation planned to promote soil moisture and sustain vegetation growth.

In some circumstances revegetation of riparian vegetation (blanket cover crop, stoloniferous grasses and legumes) may require irrigation for at least six to eight weeks before the start of the wet season. Hand watering or spraying from a water truck will be utilised where establishment of irrigation is not feasible or practicable.

3.7.2.3 Erosion and Sediment Control

Erosion control strategies are implemented on a catchment basis at the Middlemount Coal Mine. Erosion control structures that have been installed at the Middlemount Coal Mine include, but are not limited to, the following:

- Non-natural erosion control techniques such as chemical surface stabilisers, erosion control matting, soil cement treatment, and/or surface roughening to be used when natural control techniques are unavailable.
- Long sections of run-off in the workings and haul road areas may have bunds installed to minimise the velocity of water. Regular diversions installed off the works via stabilised discharge points.
- Limit the access of clean water in active pit areas by diverting it away or into sediment controls.

Site vehicles and plant generally confined to the defined roadways to prevent unnecessary destabilisation of surfaces.

Sediment control strategies are also implemented on a catchment basis at the Middlemount Coal Mine. Sediment control strategies that have been installed at the Middlemount Coal Mine include, but are not limited to, the following:

- Discharging of sediment basins as required by portable primer pumps with flexible hosing when possible.
- Inspection of sediment ponds and control devices following events such as significant rainfall.
- Boundaries of the permitted disturbance area clearly marked and reinforced through both formal training and toolbox meetings.
- No mining traffic allowed outside the marked disturbance area except at designated entry and exit points.
- Machinery operators given instructions regarding the extent of the site operations, and the meaning of site markings prior to the commencement of works.
- Buffer zones as sediment control devices used where possible.
- Sediment controls, such as silt fences and diversion rains, may be used where sediment run-off occurs as reasonably uniform sheet flow on a slope. The preferable maximum catchment for sediment fences is 0.6 ha per 100 m of fence. Where larger catchments give rise to higher flows, which are concentrated in a narrow channel, more substantial devices than sediment fences may be required.
- Permanent settlement structures constructed and modified as required, and utilised during the site set up phase as a component of the temporary drainage.

3.7.2.4 Management of Pest Fauna

To maintain and preserve the quality of the revegetated pasture (once established), a pest fauna management strategy is implemented at the Middlemount Coal Mine to monitor and, where necessary, control pest fauna. A number of pests have been recorded at the Middlemount Coal Mine including the Red Fox (*Vulpes vulpes*), Feral Pig (*Sus scrofa*), Feral Cat (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*), Cane Toad (*Rhinella marina*) and Wild Dog (*Canis lupis*) (MCPL, 2014; 2020).

Mine staff and/or appropriately qualified persons will be engaged to undertake pest fauna control as required using the most current best-practice methods. The procedure for controlling pest fauna is as follows:

1. Identification of suitable control methods for target vertebrate pest animals (e.g. trapping, systematic 1080 baiting and/or shooting).
2. Implementation of the selected control methods on the target vertebrate pest animals (focusing on high activity areas).
3. Follow-up control where previous control has been sub-optimal.

Where regular monitoring indicates that damage to rehabilitation areas is significant (i.e. browsing from wallabies, hares, rabbits etc) fencing and tree guards will be installed to protect affected areas. Some level of reseeding may be required in these areas following the result of monitoring.

The following actions implemented as part of the pest fauna management strategy:

- Protect feed and water sources.
- Regularly check and mend broken fences.
- Ensure any buildings are in good repair.
- Dispose of any carcasses properly and promptly.
- Work with neighbours and other producers in the area to implement a coordinated approach to feral animal control.
- Keep records as part of the control program.
- Refer to any regional, State or National action plans

Removing available feed and maintaining a clean, rubbish-free environment in order to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna (e.g. introduced rodents, predators and birds) is undertaken at the Middlemount Coal Mine.

3.7.2.5 Management of Livestock

Livestock should be excluded from areas undergoing active revegetation. If native trees are included within the pasture seed mix, these may require several years before they can tolerate cattle presence and browsing stress on the trees should be considered before allowing cattle access to the area. Livestock should be excluded from these areas through the use of fencing.

Once revegetation has been successfully established, low density beef cattle grazing may occur. Benefits of introducing livestock to revegetation areas may include nutrient recycling, stimulation of active growing phases and fire risk reduction.

- Total grazing pressure.
- Appropriate utilisation/stocking rates.
- Strategic grazing (e.g. spelling and herd management).
- Pasture composition.
- Use of hay, supplements, fodder trees and shrubs in a strategic manner.
- Foraging budget strategies.
- Climate and seasonal forecasting of resources.
- Fire management practices.

- Fencing according to land type.
- Access to water.

3.7.3 Reporting Requirements

3.7.3.1 Annual Return

In accordance with section 316J of the EP Act, MCPLs Annual Return must include an evaluation of the effectiveness of:

- the actions taken in relation to each rehabilitation milestone or management milestone under the PRCP Schedule; and
- the environmental management carried out under the PRCP Schedule.

The evaluation must state whether any rehabilitation milestones or management milestones to be completed under the PRCP Schedule during the year have been met and whether MCPL has complied with the conditions imposed on the PRCP Schedule.

3.7.3.2 Progressive Certification

Under section 318Z of the EP Act, the administering authority may certify that a particular area within a relevant tenure for a resource project has been rehabilitated under all relevant requirements of the EP Act, EA EPML00716913, a PRCP Schedule and any relevant guidelines or documents made under the EP Act.

As required by section 318ZF of the EP Act, the progressive certification report must:

- contain the following information:
  - information showing how the rehabilitation milestones and management milestones under the PRCP Schedule have been achieved; and
  - information about the extent to which the relevant conditions stated in the PRCP Schedule have been complied with;
- include:
  - a map of an appropriate scale that shows the proposed certified area; and
  - relevant information to locate the proposed certified area, including, for example, GPS information or a survey; and
- if progressive certification has previously been given for a relevant tenure for the environmental authority:
  - state when the certification was given; and
  - identify the certified area.

3.7.3.3 Surrender Application

Under section 257 of the EP Act, MCPL may apply to the administering authority to surrender the EA (EPML00716913) if, under the *Mineral Resources Act 1989*, MCPL has sought a conditional surrender for all, or part of, a relevant mining tenure.

The surrender application must be accompanied by a compliance statement for the EA, the PRCP Schedule and the conditions imposed on the PRCP Schedule. The compliance statement must state:

- the extent to which relevant activities carried out under the environmental authority have complied with the conditions of the authority;
- whether the rehabilitation milestones and management milestones under the PRCP Schedule have been met; and
- the extent to which conditions imposed on the PRCP Schedule have been complied with.

3.7.4 Auditing

In accordance with section 285 of the EP Act, MCPL must commission an audit of the PRCP Schedule by a rehabilitation auditor for the following periods:

- the three-year period starting on the day the PRCP Schedule takes effect; and
- each three-year period starting on the day after the previous audit period ended.

MCPL must, within four months after the end of each audit period, give the administering authority the rehabilitation auditor's report and a declaration for the audit report stating that MCPL has not knowingly given false or misleading information to the rehabilitation auditor and has given all relevant information to the rehabilitation auditor.

In accordance with section 286 of the EP Act, an audit report for a PRCP Schedule must be in the approved form, and include the following:

- a statement about whether the holder has complied with the PRCP Schedule during the audit period, including:
  - details of actions MCPL has taken, or failed to take, in relation to the rehabilitation milestones and management milestones under the PRCP Schedule; and
  - whether MCPL has complied, or failed to comply, with conditions imposed on the PRCP Schedule; and
  - whether information given to the administering authority about rehabilitation carried out under the PRCP Schedule is accurate;
- an assessment of whether the PMLU for land the subject of the PRCP Schedule is likely to be achieved, having regard to the rehabilitation that has been and is to be carried out under the PRCP Schedule; and
- recommendations about actions MCPL should take to ensure rehabilitation milestones and management milestones are achieved or conditions of the PRCP Schedule are complied with.
- any other information the administering authority reasonably considers necessary to decide whether to take action to amend the schedule under part 6 of the EP Act.

In addition to the mandatory three-yearly audits, the administering authority has the power (under section 322 of the EP Act) to issue an audit notice, which requires the holder of a PRCP Schedule to commission an audit.

3.8 REFERENCES

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ATTACHMENT 1

PROGRESSIVE REHABILITATION AND CLOSURE PLAN SCHEDULE

Refer to separate excel spreadsheet

ATTACHMENT 2

ENVIRONMENTAL AUTHORITY EMPL00716913 (MAY 2021)

Environmental Protection Act 1994

Environmental authority EPML00716913

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00716913

Environmental authority takes effect on 26 May 2021

Environmental authority holder(s)

Name(s)	Registered address
RIBFIELD PTY. LTD.	Level 17 444 Queen St BRISBANE CITY QLD 4000 Australia
MIDDLEMOUNT COAL PTY LTD	Level 17 444 Queen St BRISBANE CITY QLD 4000 Australia

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 13: Mining black coal	ML70379
	ML70417
	ML700014
	ML700027
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-i) 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML70379
	ML70417
	ML700014
	ML700027
Ancillary 31 - Mineral processing 2: Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000t	ML70379
	ML70417
	ML700014
	ML700027

Environmentally relevant activity/activities	Location(s)
Ancillary 15 - Fuel burning Using fuel burning equipment that is capable of burning at least 500kg of fuel in an hour	ML70379
	ML70417
	ML700014
	ML700027
Ancillary 08 - Chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	ML70379
	ML70417
	ML700014
	ML700027

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days)

that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term ‘duty to notify’.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority-on the nominated day; or

b) if the authority states a day or an event for it to take effect-on the stated day or when the stated event happens; or

c) otherwise- one the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Planning Act 2016* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.

Dr Alison Cummings
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Date Issued*: 26 May 2021*

Enquiries:
Business Centre (Coal)
Department of Environment and Science
PO Box 3028
EMERALD QLD 4720
Phone: (07) 4987 9320
Email: CRMining@des.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Other permits required

This permit only provides an approval under the *Environmental Protection Act 1994*. In order to lawfully operate you may also require permits / approvals from your local government authority, other business units within the department and other State Government agencies prior to commencing any activity at the site. For example, this may include permits / approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access state controlled roads), the Department of Natural Resources, Mines and Energy (to clear vegetation), and the Department of Agriculture and Fisheries (to clear marine plants or to obtain a quarry material allocation).

Obligations under the *Mining and Quarrying Safety and Health Act 1999*

If you are operating a quarry, other than a sand and gravel quarry where there is no crushing capability, you will be required to comply with the *Mining and Quarrying Safety and Health Act 1999*. For more information on your obligations under this legislation contact Mine Safety and Health at www.dnrme.qld.gov.au, or phone 13 QGOV (13 74 68) or your local Mines Inspectorate Office.

Development Approval

This permit is not a development approval under the *Planning Act 2016*. The conditions of this environmental authority are separate, and in addition to, any conditions that may be on the development approval. If a copy of this environmental authority is attached to a development approval, it is for information only, and may not be current. Please contact the Department of Environment and Science to ensure that you have the most current version of the environmental authority relating to this site.

Conditions of environmental authority

Schedule A: General	
Condition number	**Condition**
A1	**Scope of activity** This environmental authority authorises the mining of 5.7 million tonnes of run of mine (ROM) coal per annum.
A2	**Prevent and /or minimise likelihood of environmental harm** In carrying out the environmentally relevant activities, you must take all reasonable and practicable measures to prevent and/or to minimise the likelihood of environmental harm being caused. Any environmentally relevant activity, that, if carried out incompetently, or negligently, may cause environmental harm, in a manner that could have been prevented, shall be carried out in a proper manner in accordance with the conditions of this authority.
A3	**Maintenance of measures, plant and equipment** The environmental authority holder must ensure: a) that all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority are installed; b) that such measures, plant and equipment are maintained in a proper condition; c) that such measures, plant and equipment are operated in a proper manner; and d) ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.
A4	**Monitoring and records** Record, compile and keep for a minimum of **five (5) years** all monitoring results required by this environmental authority and provide all or any of these records upon request by the administering authority.
A5	Where monitoring is a requirement of this environmental authority, ensure that an appropriately qualified person(s) conducts all monitoring.
A6	**Notification of emergencies, incidents and exceptions** The holder of this environmental authority must notify the administering authority by written notification within **twenty-four (24) hours**, after becoming aware of any emergency or incident which results in the release of contaminants, or information about circumstances which results or may result in environmental harm, not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority.
A7	Not more than **ten (10) business days** following the initial notification of an emergency, incident or information about circumstances which result or may result in environmental harm or the release of contaminants, or within **twenty-four (24) hours** after receiving the results from analysed samples, written advice must be provided to the administering authority in relation to: a) results and interpretation of any samples taken and analysed; and b) proposed actions to prevent a recurrence of the emergency or incident.

A8	The notification in **Conditions A9 and A10** must include, but not be limited to, the following: a) the environmental authority number and name of the holder; b) the name and telephone number of the designated contact person; c) the location of the emergency or incident; d) the date and time of the emergency or incident; e) the time the holder of the environmental authority became aware of the emergency or incident; f) where known: i. the estimated quantity and type of substances involved in the emergency or incident; ii. the actual or potential cause of the emergency or incident; iii. a description of the nature and effects of the emergency or incident including environmental risks, and any risks to public health or livestock; g) any sampling conducted or proposed, relevant to the emergency or incident; h) immediate actions taken to prevent or mitigate any further environmental harm caused by the emergency or incident; and i) what notification of stakeholders who may be affected by the emergency or incident has occurred or is being undertaken.
A9	**Risk Management** The environmental authority holder must maintain and implement a risk management system for mining activities which conforms to the "Risk Management - Principles and Guidelines (AS/NZS ISO 31000:2009)".
A10	The environmental authority holder must not implement a risk management system that contravenes or prevents the implementation of any condition of this environmental authority.
A11	**Emergency Response and Contingency Planning** An emergency response/contingency plan must be developed and implemented to manage unacceptable environmental risks identified in the risk management system or the associated monitoring.

A12	The emergency response/contingency plan must address the following matters: a) response procedures to be implemented to reduce the likelihood of environmental harm arising from incidents of unacceptable risk; b) response procedures to minimise the extent and duration of environmental harm by an incident; c) the practices and procedures to be employed to restore the environment or mitigate any environmental impact caused; d) a description of the resources to be used in response to an incident; e) the training of staff that will be called upon to respond to incidents; f) procedures to investigate the cause of any incidents, including releases, and where necessary, implement remedial actions to reduce the likelihood of recurrence of similar events; g) the provision and availability of documented procedures to staff attending any incident to enable them to effectively respond; and h) timely and accurate reporting of the circumstance and nature of incidents to the administering authority.
A13	**Third Party Audit** The holder of the environmental authority must nominate an appropriate third party auditor to audit compliance with the conditions of this environmental authority. The third party audit must be completed by 3 December 2017, and then at regular intervals not exceeding **three (3) years**.
A14	The holder must, at its cost, arrange for independent certification by a third party auditor of findings of the audit report required under **Condition A13**.
A15	Within **ninety (90) days** of completing the audit, provide a written report to the administering authority detailing any non-compliance issues that were found (if no non-compliance issues were found this should be stated in the report). If non-compliance issues were found the report must also address: a) actions taken by the holder of this environmental authority to ensure compliance with this environmental authority; and b) actions taken to prevent a recurrence of non-compliance.
A16	Where a condition of this environmental authority requires compliance with a standard published externally to this environmental authority and the standard is amended or changed subsequent to the issue of this environmental authority the holder of this environmental authority must: a) comply with the amended or changed standard within **two (2) years** of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation; and b) until compliance with the amended or changed standard is achieved, continue to remain in compliance with the standard that was current immediately prior to the relevant amendment or change.

A17	**Activity** All land subject to mining activities must be rehabilitated to a safe, stable and non-polluting landform, with a self-sustaining vegetation cover (except for the residual voids), in accordance with **Condition G9**.
A18	Contaminants must not be released to the receiving environment unless they are in accordance with the contaminant limits authorised by this environmental authority.
A19	This environmental authority does not authorise environmental harm unless a condition contained within the authority explicitly authorises that harm. Where there is no condition or the authority is silent on a matter, the lack of a condition or silence shall not be construed as authorising harm.
A20	The only mining activities to be carried out under this environmental authority are the mining activities defined within the parameters in Attachment A of this environmental authority.
A21	**Definitions** Words and phrases used throughout this environmental authority are defined in the Definitions section of this authority. Where a definition for a term used in this environmental authority is sought and the term is not defined within this environmental authority, the definitions in the *Environmental Protection Act 1994*, its regulations and policies must be used.

Schedule B: Air	
Condition number	**Condition**
B1	**Dust nuisance** Subject to **Conditions B2 and B3** the release of dust or particulate matter or both resulting from the mining activity must not cause an environmental nuisance at any sensitive or commercial place.
B2	When requested by the administering authority, dust and particulate monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.

B3	The environmental authority holder must ensure that all reasonable and feasible avoidance and mitigation measures are employed so that the dust and particulate matter emissions generated by the mining activities do not cause an exceedance of the following levels when measured at any sensitive or commercial place: a) dust deposition of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with the most recent version of Australian Standard AS3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulates – Deposited matter – Gravimetric method. b) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (µm) (PM_{10}) suspended in the atmosphere of 50 micrograms per cubic metre over a **twenty four (24) hour** averaging time, for no more than five exceedances recorded each year (excluding natural events such as bushfires and dust storms), when monitored in accordance with the most recent version of either: i. Particulate matter – determination of suspended particulate PM10 high-volume sampler with size-selective inlet – Gravimetric method, when monitored in accordance with Australian Standard AS 3580.9.6 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 high volume sampler with size-selective inlet – Gravimetric method; or ii. Australian Standard AS3580.9.9 Methods for sampling and analysis of ambient air—Determination of suspended particulate matter—PM_{10} low volume sampler—Gravimetric method. c) The use of alternative methods of monitoring dust and particulate matter, in accordance with the administering authority's 'Air Quality Sampling Manual' must be approved in writing by the administering authority prior to implementation.
B4	If monitoring indicates exceedance of the relevant limits in **Conditions B3**, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; b) immediately implement dust abatement measures so that emissions of dust from the activity do not result in further environmental nuisance; and c) notify the administering authority within **five (5) business days**.
B5	**Odour nuisance** The release of noxious or offensive odour(s) or any other noxious or offensive airborne contaminant(s) resulting from the mining activity must not cause an environmental nuisance at any nuisance sensitive or commercial place.
B6	When requested by the administering authority odour monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.

B7	If the administering authority determines the odour released to constitute an environmental nuisance the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement odour abatement measures so that emissions of odour from the activity do not result in further environmental nuisance.
B8	**Meteorological monitoring** The environmental authority holder must establish a permanent, continuous, real time meteorological and dust monitoring network to measure and record wind speed, wind direction, temperature, rainfall, relative humidity and PM10. The station must comply with the following Standards (or their successors): a) "AS 2923-1987: Ambient air – Guide for measurement of horizontal wind for air quality applications" or its successor. b) "AS/NZS 3580.1.1:2016: Methods for sampling and analysis of ambient air. Guide to siting air monitoring equipment" or its successor.

Schedule C: Surface Water	
Condition number	**Condition**
C1	**Contaminant release** Contaminants that will, or have the potential to cause environmental harm must not be released directly or indirectly to any waters as a result of the authorised mining activities, except as permitted under the conditions of this environmental authority.
C2	The release of mine affected water to waters must only occur from the release points specified in **Table C1: Mine Affected Water Release Points, Sources and Receiving Waters** and depicted in Attachment B, attached to this environmental authority.

Table C1: Mine Affected Water Release Points, Sources and Receiving Waters

Release point (RP)	Easting (GDA94, MGA 55)	Northing (GDA94, MGA 55)	Mine affected water source and location	Monitoring point	Receiving waters description
RP 1	667,725	7,469,370	Raw Water Dam	Spillway/pipe	Roper Creek
RP 2	671,743	7,469,842	Mine Water Dam	Spillway/pipe	Roper Creek
SD 1	668,008	7,469,218	Sediment Dam 1	Spillway/pipe	Roper Creek
SD 2	668,093	7,470,858	Sediment Dam 2	Spillway/pipe	Roper Creek
SD 3	668,457	7,470,213	Sediment Dam 3	Spillway/pipe	Roper Creek
SD 7	671,125	7,474,067	Sediment Dam 7	Spillway/pipe	An unnamed drainage feature
NROM	667,858	7,470,294	North ROM Dam	Spillway/pipe	Roper Creek

C3	The release of mine affected water to internal water management infrastructure that is installed and operated in accordance with a water management plan that complies with **Conditions C28 to C29** inclusive is permitted.
C4	The release of mine affected water to waters in accordance with **Condition C2** must not exceed the release limits stated in **Table C2: Mine Affected Water Release Limits** when measured at the monitoring points specified in **Table C1: Mine Affected Water Release Points**, **Source and Receiving Waters** for each quality characteristic.

Table C2: Mine Affected Water Release Limits

Quality Characteristic	Release Limits	Monitoring Frequency	Comments
Electrical Conductivity (µS/cm)	Release limits specified in Table C4 for variable flow criteria	Daily during release (the first sample must be taken within 2 hours of commencement of release)	
pH (pH units)	6.5 (minimum) 9.0 (maximum)	Daily during release (the first sample must be taken within 2 hours of commencement of release)	
Turbidity (NTU)	No limit	Daily during release (first sample within 2 hours of commencement of release)	Turbidity is required to assess ecosystems impacts and can provide instantaneous results.
Suspended Solids (mg/L) (80th percentile of reference sites detailed in Table C6)	Flow <2m^3/s 562 mg/L Flow >2m^3/s 1062 mg/L	Daily during release (first sample within 2 hours of commencement of release)	Suspended solids are required to measure the performance of sediment and erosion control measures.
Sulfate (SO_4^{2-}) (mg/L)	Release limits specified in **Table C4** for variable flow criteria	Daily during release (first sample within 2 hours of commencement of release)	Drinking water environmental values from National Health and Medical Research Council 2006 guidelines or ANZECC 2000

C5	The release of mine affected water to waters from the release points must be monitored at the locations specified in **Table C1: Mine Affected Water Release Points, Sources and Receiving Waters** for each quality characteristic and at the frequency specified in **Table C2: Mine Affected Water Release Limits** and **Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants**.

Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants

Quality characteristic	Trigger levels (µg/L)	Comment on trigger level	Monitoring frequency
Aluminium	55	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Arsenic	13	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Cadmium	0.2	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Chromium	1	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Copper	2	For aquatic ecosystem protection, based on LOR for ICPMS	Commencement of release and thereafter weekly during release
Iron	300	For aquatic ecosystem protection, based on low reliability guideline.	Commencement of release and thereafter weekly during release
Lead	4	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Mercury	0.2	For aquatic ecosystem protection, based on LOR for CV FIMS	Commencement of release and thereafter weekly during release
Nickel	11	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Zinc	8	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Boron	370	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Cobalt	90	For aquatic ecosystem protection, based on low reliability guideline	Commencement of release and thereafter weekly during release
Manganese	1,900	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Molybdenum	34	For aquatic ecosystem protection, based on low reliability guideline	Commencement of release and thereafter weekly during release
Selenium	10	For aquatic ecosystem protection, based on LOR for ICPMS	Commencement of release and thereafter weekly during release
Silver	1	For aquatic ecosystem protection, based on LOR for ICPMS	Commencement of release and thereafter weekly during release
Uranium	1	For aquatic ecosystem protection, based on LOR for ICPMS	Commencement of release and thereafter weekly during release

Vanadium	10	For aquatic ecosystem protection, based on LOR for ICPMS	Commencement of release and thereafter weekly during release
Ammonia	900	For aquatic ecosystem protection, based on SMD guideline	Commencement of release and thereafter weekly during release
Nitrate	1,100	For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN	Commencement of release and thereafter weekly during release
Petroleum hydrocarbons (C6-C9)	20	For aquatic ecosystem protection, based on LOR for GC-FID	Commencement of release and thereafter weekly during release
Petroleum hydrocarbons (C10-C36)	100	For aquatic ecosystem protection, based on LOR for GC-FID	Commencement of release and thereafter weekly during release
Fluoride (total)	2,000	Protection of livestock and short term irrigation guideline	Commencement of release and thereafter weekly during release
Sodium (mg/L)	180	Based on the Australian Drinking Water Guidelines (NHMRC,NRMCC, 2011)	Commencement of release and thereafter weekly during release

Note:
1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered).Trigger levels for metals/metalloids apply if dissolved results exceed trigger.
2. SMD – slightly moderately disturbed level of protection, guideline refers ANZECC & ARMCANZ (2000).
3. LOR – typical reporting for method stated. ICPMS/CV FIMS/GC-FID – analytical methods required to achieve LOR.

C6

If quality characteristics of the release exceed any of the trigger levels specified in **Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants** during a release event, the environmental authority holder must cease the release and compare the downstream results in the receiving waters to the trigger values specified in **Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants** and:

a) where the trigger values are not exceeded then no action is to be taken; or
b) where the downstream results exceed the trigger values specified in **Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants**, for any quality characteristic, compare the results of the downstream site to the data from background monitoring sites and;
    i. if the result is less than the background monitoring site data, then no action is to be taken; or
    ii. if the result is greater than the background monitoring site data, complete an investigation into the potential for environmental harm and provide a written report to the administering authority within 28 days of receiving the result, outlining:
        1. details of the investigations carried out; and
        2. actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with **C6(b)(ii)** of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.

C7	If an exceedance in accordance with **Condition C6(b)(ii)** is identified, the holder of the environmental authority must notify the administering authority in writing within **twenty four** (**24) hours** of receiving the result.
C8	**Mine affected release events** The holder must ensure an automatic stream flow gauging station/s is installed, operated and maintained to determine and record stream flows at the locations and flow recording frequency specified in **Table C4: Mine Affected Water Release During Flow Events**.
C9	The release of mine affected water to waters in accordance with **Condition C2** must only take place during periods of natural flow events in accordance with the receiving water flow criteria for discharge specified in **Table C4: Mine Affected Water Release During Flow Events** for the release point(s) specified in **Table C1: Mine Affected Water Release Points, Sources and Receiving Waters.**
C10	The release of mine affected water to waters in accordance with **Condition C2** must not exceed the Electrical Conductivity and Sulfate release limits or the Maximum Release Rate (for all combined release point flows) for each receiving water flow criteria for discharge specified in **Table C4: Mine Affected Water Release During Flow Events** when measured at the monitoring points specified in **Table C1: Mine Affected Water Release Points, Sources and Receiving Waters**.
C11	The daily quantity of mine affected water released from each release point must be measured, recorded and provided to the administering authority on request.
C12	Releases to waters must be undertaken so as not to cause erosion of the bed and banks of the receiving waters, or cause a material build-up of sediment in such waters.
C13	The environmental authority holder must notify the administering authority via WaTERS within **twenty four (24) hours** after commencing to release mine affected water to the receiving environment. Notification must include the submission of written advice to the administering authority of the following information: a) Release commencement date and time; b) Details regarding the compliance of the release with the conditions of Department interest: Water of this environmental authority (that is, contaminant limits, natural flow, discharge volume); c) Release point/s; d) Release rate; e) Release salinity; and f) Receiving water/s including the natural flow rate.

Table C4: Mine Affected Water Release During Flow Events

Release point (RP)	Gauging station	Gauging station Easting, (GDA94, MGA 55)	Gauging station Northing, (GDA94, MGA 55)	Receiving water flow recording frequency	Receiving water flow criteria for discharge	Maximum release rate (for all combined RP flows)	Electrical conductivity and Sulfate release limits
RP1 RP2 SD1 SD2 SD3 SD7 NROM	Ref 1	667,484	7,471,112	Continuous (minimum daily)	Low Flow For a period of 28 days after natural flow events that exceed 2m^3/s	0.4 m^3/s	Electrical conductivity (µS/cm) 700. Sulfate (SO_4^{2-}): 250 mg/L
					Medium flow > 2 m^3/s	1.12 m^3/s	Electrical conductivity (µS/cm) 1500. Sulfate (SO_4^{2-}): 250 mg/L
					High flow > 10 m^3/s	5.6 m^3/s	Electrical conductivity (µS/cm) 1500. Sulfate (SO_4^{2-}): 250 mg/L
					>10 m^3/s	>1.6 m^3/s	Electrical conductivity (µS/cm) 3500. Sulfate (SO_4^{2-}): 300 mg/L
					Very High Flow >25 m^3/s	2.1 m^3/s	Electrical conductivity (µS/cm) <6000. Sulfate (SO_4^{2-}): 500 mg/L

C14	The holder of this environmental authority must notify the administering authority, via WaTERS, as soon as practicable (and within twenty four hours) after cessation of a release notified under **Condition C13**. The cessation notification must include the following information: a. release cessation date/time; b. release points; c. release rates; d. water quality of release; e. total volume of water released; f. natural flow rate in the receiving water; and g. details regarding the compliance of the release with the conditions of Schedule F Water of this environmental authority. Note: Successive or intermittent releases occurring within twenty four hours of the cessation of any individual release can be considered part of a single release event and do not require individual notification for the purpose of compliance with **Conditions C13**, **C14** and **C15**, provided the relevant details are submitted in the final cessation and 28 day report in accordance with **Conditions C14** and **C15**.
C15	The holder of this environmental authority must within twenty eight days after cessation of a release event notified under **Condition C13** provide a report and supporting raw data to the administering authority via WaTERS, which must include the following information: a. all continuous and in-situ water quality monitoring results (including laboratory analyses); and b) any further matters pertinent to the water release event.
C16	**Notification of release event exceedance** If the release limits defined in **Table C2: Mine Affected Water Release Limits** are exceeded, the holder of the environmental authority must notify the administering authority via WaTERS within **twenty-four (24) hours** of receiving the results.

C17	The environmental authority holder must, within **twenty-eight (28) days** of a release that is not compliant with the conditions of this environmental authority, provide a report to the administering authority via WaTERS detailing: a) the reason for the release; b) the location of the release; c) the total volume of the release and the daily quantity of mine affected water released from each release point, and which (if any) part of these releases was non-compliant; d) the total duration of the release and which (if any) part of this period was non-compliant; e) all in situ and any water quality monitoring results (including all laboratory analyses); f) identification of any environmental harm as a result of the non-compliance; and g) any other matters pertinent to the water release event.
C18	**Receiving environment monitoring and contaminant trigger levels** The quality of the receiving waters must be monitored at the locations specified in **Table C6: Receiving Water Upstream Background Sites and Downstream Monitoring Points** for each quality characteristic and at the monitoring frequency stated in **Table C5: Receiving Waters Contaminant Trigger Levels**.
C19	If quality characteristics of the receiving water at the downstream monitoring points exceed any of the trigger levels specified in **Table C5: Receiving Waters Contaminant Trigger Levels** during a release event, the environmental authority holder must compare the downstream results to the upstream results in the receiving waters and: a) where the downstream result is the same or a lower value than the upstream value for the quality characteristic, then no action is to be taken; or b) where the downstream results exceed the upstream results, complete an investigation into the potential for environmental harm and provide a written report to the administering authority within **three (3) months**, outlining: i. details of the investigations carried out; and ii. actions taken to prevent environmental harm.

Table C5: Receiving Waters Contaminant Trigger Levels

Quality characteristic	Trigger level	Monitoring frequency
pH	6.5 – 8.5	Daily during the release
Electrical Conductivity (µS/cm)	700	
Suspended Solids (mg/L) (80th percentile* of reference**)	562 at Flow <2m^3/s	
	1062 at Flow >2m^3/s	
Sulfate (SO_4^{2-}) (mg/L)	250	
Sodium (mg/L)	180	

Note:
* 80th percentiles are calculated using ANZECC (2000) methodology (section 7.4.4.1)
** Reference sites are defined in Table C6.

Table C6: Receiving Water Upstream Background Sites and Downstream Monitoring Points

Monitoring points	Receiving waters location description	Easting (GDA94, MGA 55)	Northing (GDA94, MGA 55)
Upstream background monitoring points			
Ref 1	Roper Creek at western ML70379 boundary (Upstream of Thirteen Mile Gully diversion)	667,484	7,471,112
Downstream monitoring points			
IMPAC1	Roper Creek at Middlemount Road	671,505	7,469,167
IMPAC2	Roper Creek Tributary at Middlemount Road	673,094	7,471,230

Note:
a) The upstream monitoring point should be within six (6) km of the release point.
b) The downstream point should not be greater than six (6) km from the release point.
c) The data from background monitoring points should not be used where they are affected by releases from other mines.

C20	**Receiving environment monitoring program (REMP)** The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site. For the purposes of the REMP, the receiving environment is the waters of Roper Creek and connected waterways within ten (10) km downstream of the release. The REMP should encompass any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be directly affected by an authorised release of mine affected water.
C21	The REMP must: a) assess the condition or state of receiving waters, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g. seasonality); and b) be designed to facilitate assessment against water quality objectives for the relevant environmental values that need to be protected; and c) include monitoring from background reference sites (e.g. upstream or background) and downstream sites from the release (as a minimum, the locations specified in **Table C6: Receiving Water Upstream Background Sites and Down Stream Monitoring Points**); and d) specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site specific background reference values in accordance with the Queensland Water Quality Guidelines 2006. This should include monitoring during periods of natural flow irrespective of mine or other discharges; and e) include monitoring and assessment of dissolved oxygen saturation, temperature and all water quality parameters listed in **Table C2: Mine Affected Water Release Limits** and **Table C3: Release Contaminant Trigger Investigation Levels Potential Contaminants**); and f) include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZECC & ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.1 Guidance on Sampling of Bottom Sediments); and g) include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivas methodology, and h) apply procedures and/or guidelines from ANZECC & ARMCANZ 2000 and other relevant guideline documents; and i) describe sampling and analysis methods and quality assurance and control; and j) incorporate stream flow and hydrological information in the interpretations of water quality and biological data.

C22	A REMP Design Document that addresses the requirements of the REMP must be prepared and made available to the administrating authority upon request.
C23	A report outlining the findings of the REMP, including all monitoring results and interpretations must be prepared annually and made available on request to the administrating authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.
C24	**Water reuse** Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as farm dams or tanks, or used directly at properties owned by the environmental authority holder or a third party (with the written consent of the third party) for the purpose of: a) stock watering; b) irrigation; or c) dust suppression; with water quality limits appropriate for the intended purpose.
C25	If the responsibility for mine affected water is given or transferred to another person in accordance with **Condition C24:** a) the responsibility for the mine affected water must only be given or transferred in accordance with a written agreement (the third party agreement); and b) the third party agreement must include a commitment from the person utilising the mine affected water to use it in such a way as to prevent environmental harm or public health incidents and generally make the persons aware of the General Environmental Duty (GED) under section 319 of the *Environmental Protection Act 1994*, environmental sustainability of the water disposal and protection of environmental values of waters; and **c)** the third party agreement must be signed by both parties to the agreement.
C26	**Water general** All determinations of water quality and biological monitoring must be performed by an appropriately qualified person.
C27	The release of any contaminants as permitted by this environmental authority, directly or indirectly to waters, other than internal water management infrastructure that is installed and operated in accordance with a water management plan that complies with **Conditions C29 to C30** inclusive: a) must not produce any visible discolouration of receiving waters; and b) must not produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.

C28	**Annual water monitoring reporting** The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format with each annual return: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; d) the measured or estimated daily quantity of the mine affected waters released from all release points; e) the release flow rate at the time of sampling for each release point; f) the results of all monitoring and details of any exceedance with the conditions of this environmental authority; and g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.
C29	**Water Management Plan** A Water Management Plan must be developed by an appropriately qualified person and implemented for all stages of the mining activities. The Water Management Plan must: a) provide for effective management of actual and potential environmental impacts resulting from water management associated with the mining activity carried out under this environmental authority; and b) be developed in accordance with Department of Environment and Science guideline Preparation of water management plans for mining activities and include: i. a study of the source of contaminants; ii. a water balance model for the site; iii. a water management system for the site; iv. measures to manage and prevent saline drainage; v. measures to manage and prevent acid rock drainage; vi. contingency procedures for emergencies; and vii. program for monitoring and review of the effectiveness of the water management plan.
C30	A copy of the Water Management Plan must be provided to the administering authority on request.
C31	**Saline drainage** The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of saline drainage
C32	**Acid rock drainage** The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage

C33	**Stormwater and water sediment controls** An Erosion and Sediment Control Plan must be developed by an appropriately qualified person and implemented for all stages of the mining activities on the site to minimise erosion and the release of sediment to receiving waters and contamination of stormwater. The Erosion and Sediment Control Plan must be reviewed, updated and submitted to the administering authority at an interval no greater than **3 years** from the previous submission of an Erosion and Sediment Control Plan.
C34	Stormwater, other than mine affected water, is permitted to be released to waters from: a) erosion and sediment control structures that are installed and operated in accordance with the Erosion and Sediment Control Plan required by **Condition C33**; and b) water management infrastructure that is installed and operated, in accordance with a Water Management Plan that complies with **Conditions C29 to C30** inclusive, for the purpose of ensuring water does not become mine affected water.
C35	**Sewage Treatment** The daily operation of the sewage treatment plant and pollution control equipment must be carried out by a person(s) with appropriate experience and/or qualifications to ensure the effective operation of that treatment system and control equipment.
C36	Treated effluent from the sewage treatment plant must only be discharged from the authorised discharge points, as specified in Table C7: Effluent Discharge Locations.

Table C7: Effluent Discharge Locations

Authorised discharge points	Location
STP Discharge Point 1	Tailings Storage Facility

C37	Treated effluent must not be released to land, or used for irrigation or dust suppression.
C38	Treated effluent must not be released from the site to any waters or the bed and banks of any waters.
C39	Water or stormwater contaminated by sewage treatment activities must not be released to any waters or the bed and banks of any waters.
C40	**Biosolids** Biosolids produced by the activity for re-use must be: a) sampled, analysed, graded and classified according to the procedures specified in the administering authority's systems and standard; and b) re-used under a relevant approval issued by the administering authority

Schedule D: Groundwater	
Condition number	**Condition**
D1	**Groundwater monitoring and management program** The holder of this environmental authority must implement a groundwater monitoring and management program. The program must be able to detect a significant change to groundwater quality values due to the mining activities conducted under this environmental authority.
D2	The groundwater monitoring and management program required by **Condition D1** must: a) identify potential sources of contamination to groundwater from the mining activity; b) identify and minimise the potential for environmental harm on relevant groundwater environmental values; c) document sampling and monitoring methodology; d) ensure that the parameters being monitored are appropriate for use; e) ensure that monitoring bores are chemically representative of the target aquifer ; f) ensure sufficient information to allow the holder to determine predicted seasonal fluctuations of groundwater levels; g) ensure that adequate groundwater monitoring and data analysis is undertaken to achieve the following objectives: i. detect any impacts to groundwater levels due to the activity; detect any impacts to groundwater quality due to the activity; ii. determine compliance with **Condition C1**; iii. determine trends in groundwater quality; iv. include an appropriate quality assurance and quality control program; and v. include a conceptual groundwater model that includes groundwater flow parameters.

D3	The groundwater monitoring and management program required by **Condition D1**, must be reviewed on an annual basis by an appropriately qualified person. The review must include: a) an assessment of groundwater levels and groundwater quality value data collected in relation to **Schedule C – Water** of this environmental authority; b) an assessment of the suitability of the monitoring network to detect a significant change to groundwater quality values; c) an assessment of the program against the requirements under **Condition D2**; d) recommended actions and reasonable timeframes for these actions to ensure that actual and potential environmental impacts are effectively identified and managed; e) identification of any amendments to the groundwater monitoring and management program following the review; f) identification of any changes in water quality in the monitoring bores; g) maps showing the actual water level drawdown contours caused by the take of associated water for each aquifer; h) details of any review undertaken of the numerical groundwater model since the previous Annual Monitoring Report; i) an assessment of any differences between the actual water level impact and the impact predicted for the same period in the most current numerical groundwater model; and j) details of any bores which are predicted by the most current numerical groundwater model to be located in the affected area.
D4	A report outlining the findings and outcomes of the review required by **Condition D3** must be prepared by the appropriately qualified person and provided to the administering authority within 6 months of the end of the annual period to which the review relates. The report must include: a) an outline of the findings and outcomes of the assessments required by **Condition D3**; and b) any groundwater monitoring data obtained by the environmental authority holder under **Condition D1** and an outline of the findings and outcomes of any analysis undertaken in relation to that data under **Condition D2**; and c) an outline of any actions and their associated timeframes recommended by the appropriately qualified person under **Condition D3 (d)**; and d) all groundwater data to be submitted to the administering authority via WaTERS.
D5	The holder of this environmental authority must attach to the review report required by **Condition D4**, a written response detailing the actions taken or to be taken by the holder of this environmental authority: a) to ensure compliance with this environmental authority; and b) to minimise impacts or potential impacts on groundwater resources by the mining activities carried out under this environmental authority.

D6	The recommended actions detailed under **Condition D3 (d)** must be completed within the associated timeframes detailed under **Condition D3 (d)**, unless the administering authority has approved otherwise in writing.
D7	**Groundwater Monitoring** Groundwater quality must be monitored at the locations and frequencies specified in **Table D1: Groundwater Quality Monitoring Locations and Frequency** for the parameters identified in **Table D2: Groundwater Quality Investigation Trigger Levels**.
D8	The groundwater investigation trigger levels limit type ‘Median” referred to in **Table D2: Groundwater Quality Investigation Trigger Levels** must be determined on the most recent three (3) consecutive routine monitoring samples.

Table D1: Groundwater Quality Monitoring Locations and Frequency

Monitoring points	Easting (GDA 94, MGA 55)	Northing (GDA 94, MGA 55)	Target Aquifer	Monitoring frequency
MW2	667,603	7,471,239	Tertiary	Quarterly
MW3 [a]	670,647	7,469,955	Tertiary	
MW4	667,683	7,468,659	Intrusives and Girrah coal seam	
MW5M [b]	667,790	7,475,131	Middlemount coal seam	
MW5P [b]	667,796	7,745,130	Pisces coal seam	
MW6	669,452	7,468,670	Tertiary	
MW7P [b]	669,777	7,472,247	Pisces coal seam	
MW8FR [b]	669,941	7,472,277	Fort Cooper Coal Measures	
MW9A	670,246	7,469,610	Tertiary	
MW9M	670,243	7,469,619	Middlemount coal seam	
MW9P	670,251	7,469,592	Pisces coal seam	
MW10A	669,783	7,475981	Tertiary	
MW11A	672,355	7,472,275	Tertiary	
MW12A	671,640	7,469,853	Tertiary	
MW16A	666,878	7,472,826	Tertiary and weathered Fort Cooper Coal Measures	
MW17A	669,790	7,475,985	Weathered and fresh Fort Cooper Coal Measures	
MW18A	666,452	7,478,605	Tertiary and weathered Fort Cooper Coal Measures	

Note:
[a]MW3 will continue to be monitored until pit progression prevents monitoring. MW9A installed as a replacement well for MW3.
[b]To be monitored until pit progression prevents monitoring.

D9	Subject to requirements of **Condition D7**, if the groundwater investigation trigger levels defined in **Table D2: Groundwater Quality Investigation Trigger Levels** are exceeded then the environmental authority holder must: a) complete an investigation into the potential for environmental harm; and b) notify the administering authority via WaTERS within **twenty-eight (28) days** of receiving the analysis results.

D10	The exceedance investigation under **Condition D9** must be completed and submitted to the administering authority via WaTERS within **three (3) months** of the exceedance.
D11	Where it is identified that there is potential for environmental harm, an action plan to mitigate potential harm must be developed by an appropriately qualified person and implemented within **three (3) months** of the completion of the investigation under **Condition D9**.
D12	Groundwater levels affected by the mining activities must be monitored at the locations and frequencies defined in **Table D3: Groundwater Level Monitoring Locations.**
D13	In the event that groundwater fluctuations exceed the groundwater level trigger values defined in **Table D4: Groundwater Level Trigger Values** at the groundwater monitoring locations nominated in **Table D3: Groundwater Level Monitoring Locations**, 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 licensed bores; or c) seasonal variation.
D14	If the results of the investigation undertaken in accordance with **Condition D13** identify that the groundwater fluctuations are a result of mining activities, the holder of the environmental authority must notify the administering authority via WaTERS and provide a copy of a report detailing the findings and outcomes of the investigation within **seven (7) days** of completing the investigation.

Table D2: Groundwater Quality Investigation Trigger Levels

Parameter	**Unit**	**Trigger Levels**	**Limit Type**
pH	pH Units	6.5 – 8.5	Minimum/ Maximum
Electrical Conductivity	μS/cm	35,000	Maximum
Total Dissolved Solids	mg/L	23,550	Maximum
Calcium Magnesium Sodium Potassium CO^3 HCO^3	mg/L	No triggers or limit set for these parameters. Analysis is conducted for groundwater quality interpretation only.	
Chloride	mg/L	12,700	Median
SO_4^{2-}	mg/L	2,000	Median
Iron	mg/L	14	Maximum
Mercury	mg/L	0.002	Maximum
Selenium	mg/L	0.05	Maximum
Total Petroleum Hydrocarbons (C10-14)	μg/L	50	Maximum
Total Petroleum Hydrocarbons (C15-28)	μg/L	185	Maximum
Total Petroleum Hydrocarbons (C29-36)	μg/L	90	Maximum

.

Table D3: Groundwater Level Monitoring Locations

Monitoring points	Easting (GDA94, MGA 55)	Northing (GDA94, MGA 55)	Surface RL (mAHD)	Target Aquifer	Frequency
MW2	667,603	7,471,239	163.12	Tertiary	Quarterly
MW3 [a]	670,647	7,469,955	155.44	Tertiary	Quarterly
MW4	667,683	7,468,659	183.11	Intrusives and Girrah coal seam	Quarterly
MW5M [b]	667,790	7,475,131	174.52	Middlemount coal seam	Quarterly
MW5P [b]	667,796	7,475,130	174.66	Pisces coal seam	Quarterly
MW6	669,452	7,468,670	158.26	Tertiary	Quarterly
MW7P [b]	669,777	7,472,247	163.87	Pisces coal seam	Quarterly
MW8FR [b]	669,941	7,472,277	164.33	Fort Cooper Coal Measures	Quarterly
MW9A	670,246	7,469,610	156.32	Tertiary	Quarterly
MW9M	670,243	7,469,619	156.36	Middlemount coal seam	Quarterly
MW9P	670,251	7,469,592	156.26	Pisces coal seam	Quarterly
MW10A	669,783	7,475981	175.75	Tertiary	Quarterly
MW11A	672,355	7,472,275	156.21	Tertiary	Quarterly
MW12A	671,640	7,469,853	158.28	Tertiary	Quarterly
MW16A	666,878	7,472,826	162.48	Tertiary and weathered Fort Cooper Coal Measures	Quarterly
MW17A	669,790	7,475,985	175.77	Weathered and fresh Fort Cooper Coal Measures	Quarterly
MW18A	666,452	7,478,605	181.70	Tertiary and weathered Fort Cooper Coal Measures	Quarterly
MW19VWP	671,659	7,469,856	158.38	Weathered Fort Cooper Coal Measures and Fort Cooper Coal Measures [c]	Quarterly
MW20VWP	672,816	7,471,543	155.90	Fort Cooper Coal Measures[d]	Quarterly

Notes:
[a] MW3 will continue to be monitored until pit progression prevents monitoring. MW9A installed as a replacement well for MW3;
[b] To be monitored until pit progression prevents monitoring.
[c] MW19VWP sensors installed at 50 mbgl (VW3) (for the base of weathered Fort Cooper Coal Measures), and 109 mbgl (VW2) and 150 mbgl (VW1) (for the Fort Cooper Coal Measures).
[d] MW20VWP sensor installed at 88 mbgl (VW2) (for the Fort Cooper Coal Measures).

Table D4: Groundwater Level Trigger Values

Monitoring points	Groundwater Fluctuation Trigger Level Threshold
MW2	>2 metres per year
MW3 [a]	total groundwater level of <115.39 m AHD
MW4	>2 metres per year
MW6	total groundwater level of <122.15 m AHD
MW9A	total groundwater level of <113.17 m AHD
MW10A	>2 metres per year
MW11A	>2 metres per year
MW12A	>2 metres per year
MW16A	total groundwater level of <129.2 m AHD
MW17A	total groundwater level of <135.6 m AHD
MW18A	>2 metres per year
MW19VWP-VW3	total groundwater level of <130.8 m AHD
MW19VWP-VW2	>2 metres per year
MW19VWP-VW1	>2 metres per year
MW20VWP-VW2	>3 metres per year

Notes:
[a]MW3 will continue to be monitored until pit progression prevents monitoring. MW9A installed as a replacement well for MW3.

D15	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.
D16	The groundwater quality trigger values in **Table D2 Groundwater Quality Investigation Trigger Levels** and monitoring points must be reviewed every two years. Total Groundwater contaminant limits are to be determined in accordance with the Guideline 'Using monitoring data to assess groundwater quality and potential environmental impacts' and provided in an amendment application to the administering authority by 16 April 2022.
D17	The groundwater level trigger values in **Table D4 Groundwater Trigger Level Values** and monitoring points must be reviewed every two years. Total Groundwater levels are to be determined in accordance with the guideline 'Using monitoring data to assess groundwater quality and potential environmental impacts' and provided in an amendment application to the administering authority by 16 April 2022.
D18	**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.

D19	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 Monitoring and Sampling Manual.
D20	**Bore construction and maintenance and decommissioning** All groundwater bores (including groundwater monitoring bores) must be constructed in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (2012)(or its latest version).
D21	The construction, maintenance and management, and decommissioning of groundwater bores (including groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring.

Schedule E: Acoustic	
Condition number	**Condition**
E1	**Noise nuisance** Subject to **Conditions E2 and E3**, noise from the mining activity must not cause an environmental nuisance at any noise sensitive or commercial place.
E2	**Noise monitoring** When requested by the administering authority, noise monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring. Monitoring must include: a) $L_{Aeq, adj, 15 mins}$ (external); b) $L_{A1, adj, 15 mins}$ (internal – or a measured external noise level and calculation of corresponding internal noise level); c) the level and frequency of occurrence of impulsive or tonal noise; d) atmospheric conditions including wind speed and direction; e) effects due to extraneous factors such as traffic noise; and f) location, data and time of recording.

E3

If the environmental authority holder can provide evidence through monitoring that the limits defined in **Table E1: Noise Limits**, are not being exceeded then the holder is not in breach of **Condition E1**.

E4

If monitoring indicates the noise component from the Project exceeds the limits in **Table E1: Noise Limits**, then the environmental authority holder must:

a) address the complaint including the use of appropriate dispute resolution if required; and

b) immediately implement noise abatement measures so that emissions of noise from the activity do not result in further environmental nuisance.

Table E1: Noise Limits

Noise level dB(A)	**Monday to Sunday (including public holidays)**		
	7am – 6pm	**6pm – 10pm**	**10pm – 7am**
Noise measured at a 'sensitive place' expressed as:			
$L_{Aeq, adj, 15 mins}$*	**RBL + 5**	**RBL + 5**	**RBL + 5**
$L_{A1, adj, 15 mins}$**	40	40	40
Noise measured at a 'commercial place' expressed as:			
$L_{Aeq, adj, 15 mins}$*	**RBL + 10**	**RBL + 10**	**RBL + 10**
$L_{A1, adj, 15 mins}$**	45	45	45

NOTE:
* External noise limit
** Internal noise limit
RBL means Rated Background Level as defined in the administering authority's Guideline, Planning for Noise Control.

E5

The method of measurement and reporting of noise monitoring must comply with the current edition of the administering authority's Noise Measurement Manual.

E6

Vibration nuisance

Vibration from the licensed activities must not cause an environmental nuisance at any sensitive or commercial place.

E7

When requested by the administering authority, vibration monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.

E8

Vibration monitoring must include the following descriptors, characteristics and conditions:

a) location of the blast(s) within the mining area (including which bench level);
b) atmospheric conditions including temperature, relative humidity and wind speed and direction; and
c) location, date and time of recording.

E9	If monitoring indicates exceedance of the relevant limits in **Table E2: Vibration Limits**, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement vibration abatement measures so that vibration from the activity does not result in further environmental nuisance.
E10	The airblast overpressure level from blasting operations on the premises must not exceed the limits defined in **Table E3: Airblast Overpressure Level** at any nuisance sensitive or commercial place.

Table E3: Airblast Overpressure Level

Location	**Airblast Overpressure Measured**
Sensitive or commercial place	Air blast overpressure level of 115 dB (Linear peak) for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear peak) at any time.

E11	When requested by the administering authority, airblast overpressure monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.
E12	Airblast overpressure monitoring must include the following descriptors, characteristics and conditions: a) location of the blast(s) within the mining area (including which bench level); b) atmospheric conditions including temperature, relative humidity and wind speed and direction; and c) location, date and time of recording.
E13	If monitoring indicates exceedance of the relevant limits in **Table D3: Airblast Overpressure Level**, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement airblast overpressure abatement measures so that airblast overpressure from the activity does not result in further environmental nuisance.
E14	The method of measurement and reporting of airblast overpressure levels must comply with the current edition of the administering authority's Noise Measurement Manual.

Schedule F: Waste	
Condition number	**Condition**
F1	Unless otherwise permitted by the conditions of this environmental authority or with prior approval from the administering authority and in accordance with a relevant standard operating procedure, waste must not be burnt.
F2	The holder of this environmental authority may burn vegetation cleared in the course of carrying out extraction activities provided the activity does not cause environmental harm at any sensitive place or commercial place.

F3	**Mine waste** A Mining Waste Management Plan must be developed and implemented by an appropriately qualified person for every stage of the mining activities. The Mining Waste Management Plan must at a minimum include: a) characterisation programs to ensure that all mining waste is progressively characterised during disposal for net acid producing potential, salinity and the following contaminants: pH, Electrical Conductivity (EC), Acid Neutralising Capacity (ANC), Net Acid Generation (NAG) (reporting NAG capacity and NAG pH after oxidation), Total Sulphur (S), Chromium Reducible Sulphur (Scr), Boron (B) Cadmium (Cd), Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na), Zinc (Zn) and Sulfate (SO_4); b) characterisation programs to ensure that the physical properties of the mining waste is progressively characterised during disposal; c) the availability or leachability of metals from the mining waste; d) quantification of PAF from mining waste present; e) review impacts of the PAF mining waste on the rehabilitation; f) management actions for mining waste that has been identified as having a high availability or leachability of metals; g) management actions for mining waste that has been defined as PAF; h) identification of environmental impacts and potential environmental impacts; i) control measures for routine operations to minimise likelihood of environmental harm; j) contingency plans and emergency procedures for non-routine situations; k) periodic review of environmental performance and continual improvement. l) containment of tailings; m) records to indicate locations and characteristics of tailings stored within the tailings storage facility; n) the management of seepage and leachates from tailings storages both during operation and the foreseeable future; o) the control of fugitive emissions to air; and p) a program for progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings.
F4	Within **twenty (20) business days** of receiving comments from the administering authority as per **Condition F3**, the Mining Waste Management Plan must be updated to address the comments and submitted to the administering authority.
F5	**Acid Sulfate soils** Treat and manage acid Sulfate soils in accordance with the latest edition of the Queensland Acid Sulfate Soil Technical Manual.

Schedule G: Land	
Condition number	**Condition**
G1	**Topsoil** Topsoil must be strategically stripped ahead of mining in accordance with a Topsoil Management Plan.
G2	**Preventing contaminant release to land** Contaminants must not be released to land in a manner which constitutes nuisance, material or serious environmental harm, unless otherwise authorised by a condition of this environmental authority.
G3	**Chemicals Storage** Chemicals and fuels must be effectively contained and controlled in a manner that prevents environmental harm and where relevant, meet Australian Standards, where such a standard is applicable.
G4	Spillage of all chemicals and fuels must be controlled in a manner that prevents environmental harm.
G5	All explosives, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in accordance with the relevant Australian Standard, where such a standard is applicable.
G6	**Spill Kit** An appropriate spill kit, personal protective equipment and relevant operator instructions/emergency procedure guides for the management of wastes, chemicals and flammable and combustible liquids associated with the activity must be kept at the site.
G7	Anyone operating with wastes, chemicals or flammable and combustible liquids under this approval must be trained in the use of the spill kit
G8	**Infrastructure** All infrastructure, constructed by or for the environmental authority holder during the licensed activities including water storage structures, must be removed from the site prior to surrender, except where agreed in writing by the post-mining landowner/holder and where there is a demonstrated benefit to the post-mining landowner/holder
G9	All areas significantly disturbed by mining activities must be rehabilitated to a safe, stable and non-polluting landform, with a self-sustaining vegetation cover (except for the residual voids), in accordance with: a) Table G1: Landform Design Criteria; b) Table G2: Final Land Use and Rehabilitation Approval Schedule; c) Table G3: Residual Void Design; d) Table G4: Rehabilitation Schedule; e) Attachment C: Final Landform f) Attachment F: Rehabilitation Requirements; and g) As otherwise detailed in **Condition G21**.

Table G1: Landform Design Criteria

Disturbance Type	Maximum Projective Surface Area (ha)	Maximum Slope	Vertical Height Range (m)
Elevated Landforms	853	< 18.5%	0-64
Infrastructure Areas	112	< 5%	0-15

Table G2: Final Land Use and Rehabilitation Approval Schedule

Disturbance type	Maximum surface area (ha)	Pre-mine land use	Post-mine land suitability classification for cattle grazing*	Proposed post-mine land use
MIA and CHPP area	111	Stage 1 MIA and CHPP area	3 to 5 (as per pre-mining)	Low density beef cattle grazing or recreated Regional Ecosystem 11.5.9 (*Eucalyptus crebra* and other *Eucalyptus spp*. And *Corymbia spp*. Woodland on Cainozoic sand plains/remnant surfaces.)
Roads including haul roads	46	Stage 1 roads and sparse cattle grazing on native vegetation	3 to 5 (as per pre-mining)	Retained for beneficial reuse where appropriate, or a land use conducive to the surrounding land use including recreation of: Regional Ecosystem 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains) Regional Ecosystem 11.7.2 (*Acacia spp*. Woodland on Cainozoic lateritic duricrust. Scarp retreat zone) Regional Ecosystem 11.5.9 (*Eucalyptus crebra* and other *Eucalyptus spp*. And *Corymbia spp*. Woodland on Cainozoic sand plains/remnant surfaces)
Creek diversion and levee banks	371	Low density cattle grazing on native vegetation	5	Retained, with recreated RE 11.3.25 (*Eucalyptus terticornis* or *E. camaldulensis* woodland fringing drainage lines) Thirteen Mile Gully Diversion would be revegetated with species characteristic of RE 11.3.1b (Open forest dominated by *Acacia harpophylla* and/or *Casuarina cristata*), RE 11.3.2c (*Eucalyptus populnea* woodlands on floodplains) and RE 11.3.25 (*Eucalyptus tereticornis* or *Eucalyptus camaldulensis* woodland fringing drainage lines)

In-pit and out-of-pit overburden spoil dumps (Slopes)	691	Low density cattle grazing on native vegetation and Stage 1 bulk sample pit	5	Rock mulched surface with native grass, with exception of the slope of the southern overburden spoil dump relative to the Roper Creek Floodplain which would be native ecosystem with recreated RE 11.5.3 (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces)
In-pit and out-of-pit overburden spoil dumps (upper surface)	1458	Low density cattle grazing on native vegetation and Stage 1 bulk sample pit	5	Native ecosystem** with recreated RE 11.5.3 (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces)
Low wall spoil (above natural ground level)	60	Low density cattle grazing on native vegetation and Stage 1 bulk sample pit	5	Native ecosystem** with recreated RE 11.5.3 on benches (*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* on Cainozoic sand plains/remnant surfaces)
North residual void	358	Low density cattle grazing on native vegetation	N/A	Residual void
South residual void	163	Low density cattle grazing on native vegetation	N/A	Residual void
Water storage/water management dams	68	Low density cattle grazing on native vegetation	3-4 (where rehabilitated) 5 (where retained)	Retained for beneficial reuse where appropriate, or a land use conducive to the surrounding land use, including wetlands, recreated RE 11.3.27 (Freshwater wetlands)
TSF and TFC	24	Stage 1 TSF and TFC	5	RE 11.7.2 (*Acacia spp*. Woodland on Cainozoic lateritic duricrust. Scarp retreat zone)

Notes:** Where native ecosystem is defined as recreating land to a natural ecosystem as similar as possible to the original ecosystem.
* Low density cattle grazing is assumed to be up to 0.07 head/hectare. Stocking rates will be revised based on field trials and establishment of reference sites during mine operation.

Table G3: Residual Void Design

Void identification	Void high wall – competent rock slope (degrees)	Void high wall incompetent rock slope (degrees)	Void low wall – competent rock slope (degrees)	Void low wall – incompetent rock slope (degrees)	Void maximum surface area (ha)	Void maximum depth (m)	Void volume* (m^3)
North Void	59	36	30	30	358	235	285,870,000
South Void	59	36	30	30	163	199	157,960,000

Note: * based on the full supply volume at full supply levels of 160 m AHD and 150 m AHD for the North Void and South Void, respectively.

Table G4: Rehabilitation Schedule

End of Calendar year	Maximum total area of disturbance (ha)	Minimum area of rehabilitation (ha)
2023	2,265	348
2028	2,700	821
2032	2,850	1,398

G10	Self-sustaining vegetation, as per **Attachment F**, must be consistent with the reference sites identified in **Table G5: Reference Sites.**

Table G5: Reference Sites

Reference Site	Domain Reference	Easting (GDA94, MGA 55)	Northing (GDA94, MGA 55)	Description
1	• In-pit and out-of-pit spoil dumps	662,226	7,475,606	RE 11.5.3
2	• MIA and CHPP area • Roads including haul roads • Tailings Storage Facility	665,455	7,469,732	RE 11.5.9
3	▪ Roads including haul roads	665,832	7,470,708	RE 11.7.2

G11	Rehabilitation must commence and be undertaken progressively in accordance with: a) the Rehabilitation Management Plan; and **b) Table G4: Rehabilitation Schedule.**

G12	Complete a Rehabilitation Management Plan for all areas disturbed by authorised mining activities. The Rehabilitation Management Plan must be developed and implemented by an appropriately qualified person that includes, at a minimum: a) a map of existing areas of rehabilitation; b) a strategy and schedule for the progressive rehabilitation of all disturbance during the life of the mine; c) a strategy for successfully achieving the rehabilitation requirements of this environmental authority; d) details of rehabilitation methods to be applied to each domain; e) description of rehabilitation indicators and how these will be monitored; f) description of management actions to address unsuccessful rehabilitation or redesign; g) explanation of planned native vegetation rehabilitation areas and corridors; h) details of the objectives and success criteria for rehabilitation of each mining domain to achieve rehabilitation outcomes listed in Attachment F: Rehabilitation Requirements and **Table G3: Residual Void Design**; i) an assessment of the geotechnical issues and erosivity of the proposed final landforms, including final voids, to demonstrate long-term landform stability. Reference is to be made to the Queensland Mining Guidelines (or subsequent reprints) in making this assessment. Reference is also to be made to the Natural Hazard Management Areas (Landslide) within the SPP 1/03 Guideline. Emergency service agencies will be consulted in relation to any required hazard and risk management advice; j) details of landform design to achieve rehabilitation outcomes listed in Attachment F: Rehabilitation Requirements and **Table G1: Landform Design Criteria**, including end of mine design and schematic representation of final landform inclusive of: i. drainage design and features; ii. slope designs; iii. cover design; iv. erosion controls proposed on reformed land; k) details of how landform design will be consistent with the surrounding topography; l) specify the spoil characteristics, soil analysis and soil separation for use on rehabilitation; m) specify the topsoil requirements for the site and how topsoil will be managed for use in rehabilitation; n) details of any topsoil deficit and how any deficit will be managed for successful rehabilitation; o) identifies 3 reference and 3 rehabilitation sites to be used to develop rehabilitation success criteria; p) description of monitoring of reference sites and rehabilitated areas inclusive of statistical design; q) description of rehabilitation monitoring and maintenance requirements to be applied to all areas of disturbance; r) include a cost benefit analysis/triple bottom line assessment (or an alternative assessment method) of the proposed final landform design criteria and alternatives; and s) identification of potential problems and how they will be addressed.

G13	Where there is any inconsistency between the Rehabilitation Management Plan and this environmental authority, the conditions of this environmental authority prevail.
G14	**Rehabilitation Monitoring Program** A Rehabilitation Monitoring Program must be developed and implemented by a person possessing appropriate qualifications and experience in the field of rehabilitation management, nominated by the environmental authority holder.
G15	The environmental authority holder must review the Rehabilitation Monitoring Program required by **Condition G14** at intervals no greater than **three (3) years** from **29 June 2019**. If the environmental authority holder needs to make changes to the Rehabilitation Monitoring Program, they must: a) submit the Rehabilitation Monitoring Program to the administering authority for review and comment; and b) within **twenty (20) business days** of receiving comments from the administering authority, the Rehabilitation Monitoring Plan must be updated to address the comments and resubmitted to the administering authority.
G16	A report of the findings of the Rehabilitation Monitoring Program must be updated and submitted to the administering authority, on 29 June of each calendar year , containing at a minimum: a) how the rehabilitation objectives as per Attachment F of this environmental authority will be achieved; b) how the rehabilitation objectives in the Rehabilitation Management Plan required by **Condition G12** are being met; c) if rehabilitation objectives are not being met, the corrective actions to be taken; d) specify the minimum sampling intensity for the monitoring of progressive rehabilitation; e) a statistical analysis of how areas of rehabilitation compared to analogue sites listed in **Table G5: Reference Sites**; f) a statistical analysis of how areas of rehabilitation are meeting the requirements of **Condition G9**; g) the sampling and monitoring intensity used in the Rehabilitation Monitoring Program required by **Condition G14**; h) justification of the suitability of the minimum sampling intensity; and i) justification of the sampling and monitoring intensity used in the Rehabilitation Monitoring Program required by **Condition G14**.
G17	**Residual void outcome** Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.
G18	At the completion of decommissioning and rehabilitation, residual voids must be protected from Probable Maximum Floods (PMFs) from nearby watercourses such that the protection is sustainable for the foreseeable future.

G19	Complete an investigation into residual voids and submit a report to the administering authority proposing acceptance criteria to meet the outcomes in **Conditions G17 and G18** and landform design criteria by **31 October 2021**. The investigation must at a minimum include the following: a) a study of options available for minimising final void area and volume; b) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term; and c) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit walls and the effects of significant hydrological events. Note: These studies will be undertaken during the life of the mine, and must include detailed research and modelling.
G20	All reasonable and practical measures must be taken to minimise the size of the void remaining after mining activities cease.
G21	**Post Closure Management Plan** A Post Closure Management Plan for the site must be developed and submitted, for review and comment, to the administering authority at least **eighteen (18) months** prior to the final coal processing on site and implemented for a nominal period of: a) at least thirty (30) years following final coal processing on site; or b) a shorter period if the site is proven to be geotechnically and geochemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm.

G22	The Post Closure Management Plan must include the following elements: a) operation and maintenance of: i. wastewater collection and reticulation systems; ii. wastewater treatment systems; iii. the groundwater monitoring network; iv. the flood protection levee and final landform relative to Roper Creek; v. final cover systems of spoil dumps; and vi. vegetative cover; and b) monitoring of: i. surface water quality; ii. groundwater quality; iii. seepage rates; iv. erosion rates; v. the integrity of the flood protection levee and final landform relative to Roper Creek; vi. the integrity and stability all slopes, ramps and voids; and vii. the health and resilience of native vegetation cover. c) investigation of: i. soil contamination; and ii. landform failure.
G23	Within **twenty (20) business days** of receiving comments from the administering authority on the Post Closure Management Plan submitted in accordance with **Condition G21**, the Post Closure Management must be updated to address the comments and resubmitted to the administering authority.
G24	**Impacts to Prescribed Environmental Matters** Significant residual impacts to prescribed environmental matters as per the *Environmental Offsets Act 2014*, are only authorised to occur: a) for the prescribed environmental matter specified in **Table G6: Significant residual impacts to prescribed environmental matters**, and as indicated in **Attachment D: Location of Authorised impacts to prescribed environmental matters**; and b) for the prescribed environmental matter specified in **Table G6: Significant residual impacts to prescribed environmental matters**, the impacts do not exceed the maximum extent of impact specified for that prescribed environmental matter.
G25	A notice of election for the environmental offset, must be provided to the administering authority no less than **three (3) months** before the proposed commencement of the significant residual impacts to the prescribed environmental matters.

Table G6: Significant residual impacts to prescribed environmental matters.

Prescribed environmental matter	Maximum extent of impact (ha)	Environmental offset required
Regulated Vegetation		
Regional ecosystems (not within an urban area) that intersect a watercourse on the vegetation management watercourse map – RE 11.3.25e	1	Yes
Endangered Regional Ecosystem - RE 11.4.9*	0.5*	No*
Endangered Regional Ecosystem - RE 11.3.1*	15*	No*
Of Concern Regional Ecosystem (not within an urban area) - RE 11.3.2	63	Yes
Of Concern Regional Ecosystem (not within an urban area) RE 11.3.2b	1	Yes
Of Concern Regional Ecosystem (not within an urban area) - RE 11.3.2/RE 11.3.4	1.5	Yes
Regional ecosystems (not within an urban area) that intersect a wetland on the vegetation management wetlands map - RE 11.3.27d	1.9	No
Regional ecosystems within the defined distance of a vegetation management watercourse (RE 11.3.2, 11.3.7 and RE 11.3.25)	3.7	Yes
Connectivity areas		
Connectivity area that is a regional ecosystem (not in urban area)	439.5	Yes
Wetlands and watercourses		
A wetland of high ecological significance shown on the Map of referable wetlands	0.75	Yes
Protected wildlife habitat		
Habitat for an animal that is vulnerable wildlife – *Denisonia maculata* (ornamental snake)*	15.5*	No*
	12.81	No
Habitat for an animal that is vulnerable wildlife – *Geophaps scripta scripta* (squatter pigeon)*	569.5*	No*
	233	No
Habitat for an animal that is vulnerable wildlife – *Petauroides volans* (greater glider)*	175*	No*
	63.3	Yes
Habitat for an animal that is vulnerable wildlife – *Phascolarctos cinereus* (koala)*	175*	No*
	63.3	Yes
Habitat for an animal that is special least concern wildlife – *Tachyglossus aculeatus* (short-beaked echidna)	351.5	No
Legally Secured Offset Area		
Legally secured offset area - Stage 2 Offset Area*	32*	No*
Legally secured offset area - Rail Loop and Spur Offset Area	22	Yes

*This matter will be offset under EPBC Act approval conditions.

G26	**Exploration Activities on Mining Lease 70379** The environmental authority holder is authorised to conduct exploration activities, including rehabilitation activities, on Mining Lease (ML) 70379.
G27	**Conditions G28 to G40** only apply to parts of ML70379 where surface rights are held for exploration drilling only.
G28	When conducting exploration activities, the holder of the environmental authority must ensure that the area and duration of disturbance to land and vegetation is minimised. The operational areas of individual drill sites must not exceed 1000 metres squared. Sump size must not exceed 100 metres squared and 2 metres deep.

G29	All clearing of mature trees must be prevented or minimised
G30	The holder of the environmental authority must not carry out exploration activities in a Category A or B environmentally sensitive area or riverine areas. Activities involving machinery must not be carried out within 1km of a Category A environmentally sensitive area. The holder of the environmental authority is authorised to undertake no more than 119 drill sites, within the 500 m buffer of Category B environmentally sensitive areas, in accordance with **Attachment E: Drill Hole Locations ML70379**.
G31	The holder of the environmental authority must not carry out activities within 100m of a Historical, Archaeological or Ethnographic site.
G32	The holder of the environmental authority must not drill, excavate or clear vegetation: a) in standing waters, wetlands or lakes; or b) on the sloped banks or within 3m of the top of the bank or 5m of the toe of the bank; or c) within, or on the levee banks of the normal flow channel.
G33	The holder of this environmental authority must consult with the landowner prior to establishing any new roads and tracks.
G34	When constructing new roads and tracks, the holder of the environmental authority must ensure that the area and duration of disturbance to land, vegetation and watercourses is minimised. Track construction involving blade clearing of established vegetation and or the clearing of mature trees is to be minimised.
G35	Tracks are not to be constructed greater than 5m in width.
G36	The holder of the environmental authority must decommission all non-artesian drill holes, apart from those still required for monitoring purposes as soon as practical, but no later than 6 months after the hole was drilled by undertaking the following actions: a) where practical dispose of all unused drill chips to the hole or to a sump pit and; b) cap the hole at a depth that is appropriate for the previous land use of the area (unless the land owner stipulates a future use which requires the cap to be placed deeper); and c) backfill the hole above the cap with soil or material similar to the surrounding soil or material. For drill holes that will be mined through within 2 years, the hole must be capped and the sump backfilled as soon as practical, but no later than 6 months after the hole was drilled.
G37	The holder of the environmental authority must isolate non-artesian aquifers where a drill hole intersects more than one water bearing strata by casing or plugging the hole as soon as practical after the hole is no longer required, but no later than **two (2) months** after the hole was drilled, apart from those holes that are still required for monitoring purposes if: a) the flow difference between aquifers exceeds 500 L/hour; and b) the difference in electrical conductivity of water is greater than 10 percent of the lower value.

G38	**Conditions G39** and **G40** do not apply to a non-artesian exploration drill hole if: a) the land owner and the explorer have agreed that it should be left for conversion to a water bore; and b) the landowner gives a written undertaking to accept responsibility for the hole; and c) the details of the agreement and the drill hole (such as its GPS location and the drill logs showing the water bearing strata and flow rates) are provided to the Department of Natural Resources, Mines and Energy within **30 days** of the land owner giving the undertaking; and d) the hole is temporarily capped so as to prevent possible ingress of surface waters and associated sediments and pollutants.
G39	The holder of the environmental authority must ensure that exploration drill holes do not strike artesian flows of water.
G40	The holder of the environmental authority must ensure that exploration drill holes that are to be retained for future mineral resource evaluation purposes are cased and capped. Holes to be retained for more than three years must be capped with steel casing and appropriately identified.
G41	**Rehabilitation of exploration activities on ML70379** For all exploration drill holes on ML70379, the holder of the environmental authority must complete the rehabilitation processes as soon as practical and within **six (6) months** of the completion of exploration activities at those areas. For drill holes that will be mined through within 2 years, the hole must be capped and the sump backfilled as soon as practical, but no later than 6 months after the hole was drilled.
G42	**Condition G43** does not apply to any excavations, drill holes or sampling sites that are to remain after the completion of exploration activities, by agreement with the land owner.
G43	The holder of the environmental authority must rehabilitate areas disturbed by exploration drilling to a stable landform similar to that of surrounding undisturbed areas and in accordance with **Attachment F: Rehabilitation Requirements**.
G44	The holder of the environmental authority must spread seeds or plant species that will promote vegetation of a similar species and density of cover to that of the surrounding undisturbed areas or vegetation that is appropriate for providing erosion control and stabilisation of the areas disturbed by exploration drilling.

Schedule H: Regulated Structures	
Condition number	**Condition**
H1	**Assessment of consequence category** The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933) at the following times: a) prior to the design and construction of the structure, if it is not an existing structure; or b) prior to any change in its purpose or the nature of its stored contents.
H2	A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.
H3	Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933).
H4	**Design and construction[1] of a regulated structure** **Conditions H5 to H9** inclusive do not apply to existing structures. [1] Construction of a dam includes modification of an existing dam — refer to the definitions.
H5	All regulated structures must be designed by, and constructed under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933).
H6	Construction of a regulated structure is prohibited unless the holder has submitted a consequence category assessment report and certification to the administering authority has been certified by a suitably qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant condition of this authority.
H7	Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933), and must be recorded in the Regulated Dams-Levees register.

H8	Regulated structures must: a) be designed and constructed in accordance with and conform to the requirements of the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933); b) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of: i. floodwaters from entering the regulated dam from any watercourse or drainage line; and ii. wall failure due to erosion by floodwaters arising from any watercourse or drainage line.
H9	Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that: a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure; and b) construction of the regulated structure is in accordance with the design plan.
H10	**Operation of a regulated structure** Operation of a regulated structure, except for an existing structure, is prohibited unless the holder has submitted to the administering authority: a) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with **Condition H6**; b) a set of 'as constructed' drawings and specifications; c) certification of those 'as constructed drawings and specifications' in accordance with **Condition H9**; d) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, a copy of the certified system design plan; e) the requirements of this authority relating to the construction of the regulated structure have been met; f) the holder has entered the details required under this authority, into a Register of Regulated Dams; and g) there is a current operational plan for the regulated structures.

H11	For existing structures that are regulated structures: a) where the existing structure that is a regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the holder must submit to the administering authority within **twelve (12) months** of the commencement of this condition a copy of the certified system design plan including that structure; and b) there must be a current operational plan for the existing structures
H12	Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in a manner that is consistent with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings
H13	**Mandatory reporting level** **Conditions H14 to H17** inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.
H14	The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.
H15	The holder must, as soon as practical and within **forty-eight (48) hours** of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.
H16	The holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.
H17	The holder must record any changes to the MRL in the Register of Regulated Structures
H18	**Design storage allowance** The holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to **1 July** of each year.
H19	By **1 November** of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the dam (or network of linked containment systems).
H20	The holder must, as soon as possible and within **forty-eight (48) hours** of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on **1 November** of any year, notify the administering authority.
H21	The holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on **1 November** of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.

H22	**Annual inspection report** Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.
H23	At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include recommended actions to ensure the integrity of the regulated structure.
H24	The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933).
H25	The holder must: a) within **20 business days** of receipt of the annual inspection report, provide to the administering authority: i. the recommendations section of the annual inspection report; and ii. if applicable, any actions being taken in response to those recommendations; and b) if, following receipt of the recommendations and (if applicable) actions, the administering authority requests a full copy of the annual inspection report from the holder, provide this to the administering authority within **ten (10) business** days of receipt of the request.
H26	**Transfer arrangements** The holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority
H27	**Decommissioning and rehabilitation** Dams must not be abandoned but be either: a) decommissioned and rehabilitated to achieve compliance with Conditions **G21** to **G31** of this environmental authority; or b) be left in-situ for a beneficial use(s) provided that: i. it no longer contains contaminants that will migrate into the environment; and ii. it contains water of a quality that is demonstrated to be suitable for its intended beneficial use(s); and iii. the administering authority, the holder of the environmental authority and the landholder agree in writing that the dam will be used by the landholder following the cessation of the environmentally relevant activity(ies).

H28	**Register of Regulated Dams** A Register of Regulated Dams must be established and maintained by the holder for each regulated dam
H29	The holder must provisionally enter the required information in the Register of Regulated Dams when a design plan for a regulated dam is submitted to the administering authority
H30	The holder must make a final entry of the required information in the Register of Regulated Dams once compliance with **Condition H10 and H11** has been achieved.
H31	The holder must ensure that the information contained in the Register of Regulated Dams is current and complete on any given day.
H32	All entries in the Register of Regulated Dams must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.
H33	The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Dams, in the electronic format required by the administering authority.
H34	**Transitional arrangements** All existing structures that have not been assessed in accordance with either the Manual or the former Manual for Assessing Hazard Categories and Hydraulic Performance of Dams must be assessed and certified in accordance with the Manual within **six (6) months** of amendment of the authority adopting this schedule.
H35	All existing structures must subsequently comply with the timetable for any further assessments in accordance with the Manual specified in **Table H1: Transitional hydraulic performance requirements for existing structures**, depending on the consequence category for each existing structure assessed in the most recent previous certification for that structure
H36	**Table H1: Transitional hydraulic performance requirements for existing structures** ceases to apply for a structure once any of the following events has occurred: a) it has been brought into compliance with the hydraulic performance criteria applicable to the structure under the Manual; or b) it has been decommissioned; or c) it has been certified as no longer being assessed as a regulated structure.
H37	Certification of the transitional assessment required by **Conditions H34 and H35** (as applicable) must be provided to the administering by **22 February 2015**.

Table H1: Transitional hydraulic performance requirements for existing structures

Transition period required for existing structures to achieve the requirements of the Manual for Assessment Consequence Categories and Hydraulic Performance of Dams (ESR/2016/1933)			
Compliance with criteria	**High**	**Significant**	**Low**
>90% and a history of good compliance performance in the last 5 years	No transition required	No transition required	No transitional conditions apply. Review consequence assessment every 7 years.
> 70% to less than or equal to 90%	Within 7 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 10 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	No transitional conditions apply. Review consequence assessment every 7 years.
>50% less than or equal to 70%	Within 5 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 7 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	No transitional conditions apply. Review consequence assessment every 7 years.
less than or equal 50%	Within 5 years or as per compliance requirements (e.g. Transitional Environmental Program).	Within 5 years or as per compliance requirements (e.g. Transitional Environmental Program).	No transitional conditions apply. Review consequence assessment every 7 years.

Schedule I: Watercourse Diversion	
Condition number	**Condition**
I1	**Permanent watercourse diversion – Thirteen Mile Gully and Roper Creek** The Thirteen Mile Gully Diversion depicted at **Attachment G** and the Roper Creek Diversions depicted at **Attachment H** of this environmental authority are authorised as permanent watercourse diversions.

I2	Permanent watercourse diversions must be designed and constructed to: a) incorporate natural features (including geomorphic and vegetation) present at the location of the diversion; b) maintain the pre-existing hydrologic characteristics of surface water and groundwater systems for the area in which the watercourse diversion is located; c) maintain the hydraulic characteristics of the permanent watercourse diversion that are equivalent to other local watercourses and are suitable for the area in which the diversion is located without using artificial structures that require ongoing maintenance; d) maintain sediment transport and water quality regimes that allow the diversion to be self-sustaining, while minimising any impacts to upstream and downstream water quality, geomorphology or vegetation; and e) maintain equilibrium and functionality in all substrate conditions at the location of the diversion.
I3	**Design plan – All diversions** A certified Design Plan that achieves **Condition I2** must be submitted to the administering authority at least **ten (10) business days** before commencing construction of the diversion.
I4	The certified design plan for any temporary or permanent watercourse diversion must be consistent with the functional design/s that formed a part of the application documents for this authority
I5	**Construction and operation – All diversions** A certified set of 'as constructed' drawings and specifications must be submitted to the administering authority within **sixty (60) business days** from the completion of construction of the permanent watercourse diversion. These drawings and specifications must state: a) that the 'as constructed' drawings and specifications meet the original intent of the design plan for the watercourse diversion. b) construction of the watercourse diversion is in accordance with the design plan.
I6	**Register – All diversions** The details of watercourse diversions planned and constructed under an environmental authority must be accurately recorded on the Register of Watercourse Diversions kept by the holder of the authority. An electronic copy must be provided to the administering authority on request.

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Definitions

Key terms and/or phrases used in the environmental authority EPML00716913 document are defined in this section. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

"acceptance criteria" means the measures by which the actions implemented to rehabilitate the land are deemed to be complete. The acceptance criteria indicate the success of the rehabilitation outcome or remediation of areas which have been significantly disturbed by the mining activities. Acceptance criteria may include information regarding:

a) vegetation establishment, survival and succession;

b) vegetation productivity, sustained growth and structure development;

c) fauna colonisation and habitat development;

d) ecosystem processes such as soil development and nutrient cycling, and the recolonisation of specific fauna groups such as collembola, mites and termites which are involved in these processes;

e) microbiological studies including recolonisation by mycorrhizal fungi, microbial biomass and respiration;

f) effects of various establishment treatments such as deep ripping, topsoil handling, seeding and fertiliser application on vegetation growth and development;

g) resilience of vegetation to disease, insect attack, drought and fire; and

h) vegetation water use and effects on groundwater levels and catchment yields.

"acid rock drainage" means any contaminated discharge emanating from a mining activity formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of mining activity.

"airblast overpressure" means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dB).

"affected person" means an affected person under section 38 of the *Environmental Protection Act 1994.*

"annual inspection report" means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan);

a) against recommendations contained in previous annual inspections reports;

b) against recognised dam safety deficiency indicators;

c) for changes in circumstances potentially leading to a change in consequence category;

d) for conformance with the conditions of this authority;

e) for conformance with the 'as constructed' drawings;

f) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year, of

accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems);

g) for evidence of conformance with the current operational plan.

"Annual exceedance probability" or "**AEP**" the probability that at least one event in excess of a particular magnitude will occur in any given year

"appropriately qualified person" means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods or literature.

"assessed" and **"assessment"** by a suitably qualified and experienced person in relation to a hazard assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit at any time:

a) exactly what has been assessed and the precise nature of that assessment;

b) the relevant legislative, regulatory and technical criteria on which the assessment has been based;

c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and

d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.

"associated works" in relation to a dam, means:

a) operations of any kind and all things constructed, erected or installed for that dam; and

b) any land used for those operations.

"authorised place" means the place authorised under this environmental authority/development approval for the carrying out of the specified environmentally relevant activities.

"authority" means this environmental authority (EPML001716913) under the *Environmental Protection Act 1994*.

"certification" means assessment and approval must be undertaken by a suitably qualified and experienced person in relation to any assessment or documentation required by this Manual, including design plans, 'as constructed' drawings and specifications, construction, operation or an annual report regarding regulated structures, undertaken in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQs (ID: 1.4 (2A)).

"certifying", "certify" or "certified" have a corresponding meaning as 'certification'.

"chemical" means

a) an agricultural chemical product or veterinary chemical product under the *Agricultural and Veterinary Chemicals Code Act 1994* (Cwlth); or

b) a dangerous good under the dangerous goods code; or

c) a drug or poison mentioned on the current Poisons Standard under the Therapeutic Goods Act 1989 (Cwlth); or

d) a substance intended for use as

i) a fertiliser for agricultural, horticultural or garden use, other than mushroom growing substrate or compost; or

ii) a paint or paint solvent, pigment, dye printing ink, industrial polish, degreasing agent, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, biocide or firefighting foam; or

iii) a pesticide, insecticide, fungicide, herbicide, rodenticide, nematicide, miticide, fumigant or related product; or

iv) a surface active agent, including, for example, soap and detergent; or

e) class 1 and 2 combustible liquids under AS1940; or

f) a chemical toxicant for which guidelines are prescribed under the Australian water quality management guidelines.

"commercial place" means any of the following types of premises

a) a hotel, motel, caravan park, café, food store or canteen;

b) an assembly building, institution building, kindergarten, child minding centre, school or other building used for education;

c) premises where a sport or game is ordinarily played in public

d) an exhibition round, show ground or racecourse

e) an office, shop or other premises where business or work, other than a manufacturing process, is carried out.

"competent person" means a person with the demonstrated skill and knowledge required to carry out the task to a standard necessary for the reliance upon collected data or protection of the environment.

"construction" or **"constructed"** in relation to a dam includes building a new dam and modifying or lifting an existing dam, but does not include investigations and testing necessary for the purpose of preparing a design plan.

"control measures" means actions that can be taken in order to minimise environmental impacts or environmental harm. Control measures can be, but are not limited to, planning, procedural or engineering controls.

"consequence" in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.

"consequence category" means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933).

"cover material" means any soil or rock suitable as a germination medium or landform armouring.

"dam" means a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works.

"dam crest volume" means the volume of material (liquids and/or solids) that could be within the walls of a dam at any time when the upper level of that material is at the crest level of the dam. That is, the instantaneous maximum volume within the walls, without regard to flows entering or leaving (e.g. via spillway)

"design plan" is a document setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.

"design storage allowance" or **"DSA"** means an available volume, estimated in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933) published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.

"designer" for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

"environmental authority" means the same as "authority".

"environmental authority holder" or **"holder"** means the holder of this environmental authority.

"emergency action plan" means documentation forming part of the operational plan held by the holder or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam owners to annually update contact.

"environmental harm" has the meaning given in the *Environmental Protection Act 1994*.

"environmental impacts" means changes that occur in the environment as a result of the mining activities. Impacts could be positive, negative or neutral.

"environmental offset" has the meaning in section 7 of the *Environmental Offsets Act 2014.*

"environmental value" has the meaning given in the *Environmental Protection Act 1994*;

"environmentally sensitive areas" refer to Schedule 12 of the Environmental Protection Regulation 2008.

"existing structure" means a structure that prior to 22 August 2014 meets any or both of the following:

a) a structure with a design that is in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933) and that is considerably in progress; or

b) a structure that is under considerable construction or that is constructed.

"flowable substance" means matter or a mixture of materials which can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids, fluids or solids or a mixture that includes water and any other liquids, fluids or solids either in solution or suspension.

"**hydraulic performance**" means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933).

"infrastructure" means water storage dams, roads and tracks, buildings and other structures built for the purpose of mining activities but does not include facilities required for the long term management of mining impacts or the protection of potential resources. Such facilities include dams containing hazardous waste, waste rock dumps, voids, or ore stockpiles and buildings or other structures whose ownership can be transferred and which have a residual beneficial use for the next owner of the operational land or the background land owner.

"$L_{A\ 10,\ adj,\ 10\ mins}$" means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 10% of any 10-minute measurement period, using Fast response.

"$L_{A\ 1,\ adj,\ 10\ mins}$" means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 1% of any 10-minute measurement period, using Fast response.

"$L_{A,\ max\ adj,\ T}$" means the average maximum A-weighted sound pressure level, adjusted for noise character and measured over any 10-minute period, using Fast response.

"land" in the "land schedule" of this document means land excluding waters and the atmosphere.

"land capability" as defined in the DME 1995 Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.

"land suitability" as defined in the DSITI 2015 "Guideline for Agricultural Land Evaluation in Queensland".

"levee" means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times

"low consequence dam" means any dam that is not a high or significant consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933).

"mandatory reporting level" or **"MRL"** means a warning and reporting level determined in accordance with the criteria in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933) published by the administering authority.

"manual" means the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933) published by the administering authority.

"mature tree" means any tree that is 70% or greater of the predominant canopy height.

"maximum extent of impact" means the total, cumulative, residual extent and duration of impact to a prescribed environmental matter that will occur over a project's life after all reasonable avoidance and reasonable on-site mitigation measures have been, or will be, undertaken.

"mg/L" means milligrams per litre.

"mine affected water"

a) means the following types of water:

   (i) pit water, tailings dam water, processing plant water;

(ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity;

(iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;

(iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;

(v) groundwater from the mine's dewatering activities;

(vi) a mix of mine affected water (under any of paragraphs i)-v) and other water.

b) does not include surface water runoff which, to the extent that it has been in contact with areas disturbed by mining activities that have not yet been completely rehabilitated, has only been in contact with:

(i) land that has been rehabilitated to a stable landform and either capped or revegetated in accordance with the acceptance criteria set out in the environmental authority but only still awaiting maintenance and monitoring of the rehabilitation over a specified period of time to demonstrate rehabilitation success; or

(ii) land that has partially been rehabilitated and monitoring demonstrates the relevant part of the landform with which the water has been in contact does not cause environmental harm to waters or groundwater, for example:

a. areas that are been capped and have monitoring data demonstrating hazardous material adequately contained with the site;

b. evidence provided through monitoring that the relevant surface water would have met the water quality parameters for mine affected water release limits in this environmental authority, if those parameters had been applicable to the surface water runoff; or

(iii) both.

"modification" or "**modifying"** (see definition of 'construction').

"non polluting" means having no adverse impacts upon the receiving environment.

"notice of election" has the meaning in section 18(2) *Environmental Offsets Act 2014*.

"noxious" means harmful or injurious to health or physical well-being, other than trivial harm.

"natural flow" means the flow of water through waters caused by nature.

"NTU" means nephelometric turbidity units.

"offensive" means causing reasonable offence or displeasure; is disagreeable to the sense; disgusting, nauseous or repulsive, other than trivial harm.

"operational land" means the land on which the mining activities are authorised to be carried out.

"operational plan" includes:

a) normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA allowance); and

b) contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

"peak particle velocity (ppv)" means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mms^{-1}).

"**prescribed environmental matters**" has the meaning in section 10 of the *Environmental Offsets Act 2014*, limited to the matters of State environmental significance listed in schedule 2 of the Environmental Offsets Regulation 2014.

"protected area" means a protected area under the *Nature Conservation Act 1992*; or

a) a marine park under the *Marine Parks Act 2004*; or

b) a World Heritage Area.

"receiving environment" in relation to an activity that causes or may cause environmental harm, means the part of the environment to which the harm is, or may be, caused. The receiving environment includes (but is not limited to):

a) a watercourse;

b) groundwater; and

c) an area of land that is not specified in Schedule # – Table # (Authorised Activities) of this environmental authority.

The term does not include land that is specified in Schedule # – Table # (Authorised Activities) of this environmental authority.

"receiving waters" means the waters into which this environmental authority authorises releases of mine affected water.

"reference site" (or analogue site) may reflect the original location, adjacent area or another area where rehabilitation success has been completed for a similar biodiversity. Details of the reference site may be as photographs, computer generated images and vegetation models etc.

"Register of Regulated Dams" includes:

a) date of entry in the register;

b) name of the dam, its purpose and intended/actual contents;

c) the consequence category of the dam as assessed using the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933);

d) dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;

e) name and qualifications of the suitably qualified and experienced person who certified the design plan

f) for the regulated dam, other than in relation to any levees –

   (i) the dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;

(ii) coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area

(iii) dam crest volume (megalitres);

(iv) spillway crest level (metres AHD).

(v) maximum operating level (metres AHD);

(vi) storage rating table of stored volume versus level (metres AHD);

(vii) design storage allowance (megalitres) and associated level of the dam (metres AHD);

(viii) mandatory reporting level (metres AHD);

g) the design plan title and reference relevant to the dam;

h) the date construction was certified as compliant with the design plan;

i) the name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;

j) details of the composition and construction of any liner;

k) the system for the detection of any leakage through the floor and sides of the dam;

l) dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;

m) dates when recommendations and actions arising from the annual inspection were provided to the administering authority; and

n) dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.

"regulated dam" means any dam in the significant or high consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933) published by the administering authority.

"regulated structure" includes land-based containment structures, levees, bunds and voids, but not a tank or container designed and constructed to an Australian Standard that deals with strength and structural integrity.

"rehabilitation" the process of reshaping and revegetating land to restore it to a stable landform.

"release event" means a surface water discharge from mine affected water storages or contaminated areas on the licensed place.

"representative" means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activities.

"riverine" the land adjoining and associated with watercourses, including the bed, banks adjoining terraced land and riparian vegetation.

"RL" means reduced level, relative to mean sea level as distinct from depths to water.

"saline drainage" means the movement of waters, contaminated with salt(s), as a result of the mining activity.

"self-sustaining" means an area of land which has been rehabilitated and has maintained the required acceptance criteria without human intervention for a period nominated by the administering authority.

"sensitive place" means:

a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or

b) a motel, hotel or hostel; or

c) an educational institution; or

d) a medical centre or hospital; or

e) a protected area under the Nature Conservation Act 1992, the Marine Parks Act 2004 or a World Heritage Area; or

f) a public park or gardens.

"significant residual impact" has the meaning in section 8 *Environmental Offsets Act 2014.*

"site" means the same as "operational land"

"stable" in relation to land, means land form dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.

"stakeholder" means an individual or group concerned with or affected by the environmental performance of the holder of the environmental authority.

"structure" means dam or levee.

"spillway" means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges form the dam, normally under flood conditions or in anticipation of flood conditions.

"suitably qualified and experienced person" in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the Professional Engineers Act 2002, and has demonstrated competency and relevant experience:

a) for regulated dams, an RPEQ who is a civil engineer with the required qualifications in dam safety and dam design.

b) for regulated levees, an RPEQ who is a civil engineer with the required qualifications in the design of flood protection embankments.

Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology

"system design plan" means a plan that manages an integrated containment system that shares the required.

"TFC" means Tailings Flocc Cell.

'the Act' means the *Environmental Protection Act 1994*.

"tolerable limits" means a range of parameters regarded as being sufficient to meet the objective of protecting relevant environmental values. For example, a range of settlement for a tailings capping, rather than a single value, could still meet the objective of draining the cap quickly, preventing pondage and limiting infiltration and percolation.

"**total groundwater level**" means the total groundwater level drawdown observed within each monitoring bore measured since the commencement of mining.

"µS/cm" means micro siemens per centimetre.

"void" means any constructed, open excavation in the ground.

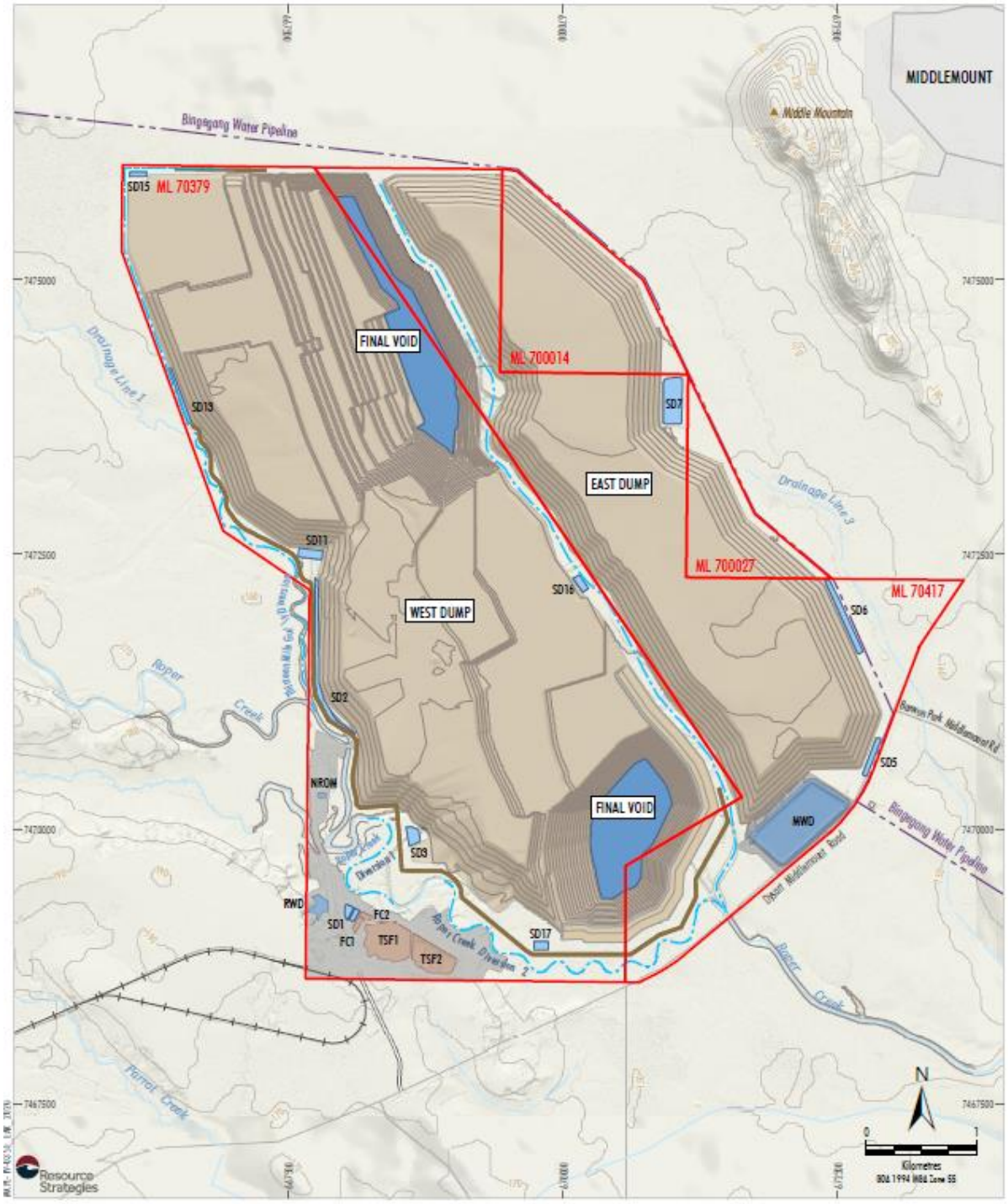
"watercourse" has the same meaning given in the *Water Act 2000*.

"water quality" means the chemical, physical and biological condition of water.

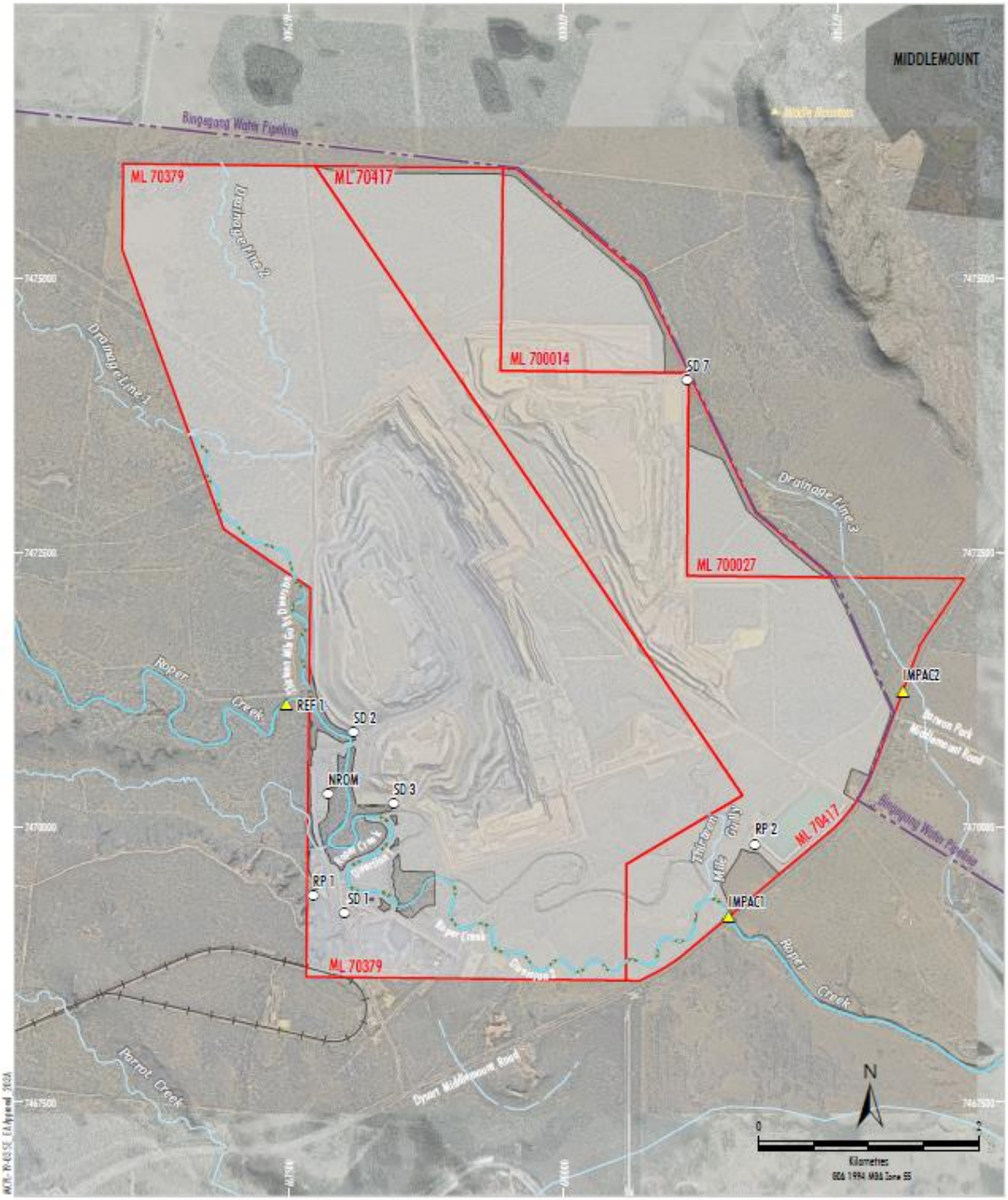
"waters" includes all or any part of a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and banks of a watercourse, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater.

End of definitions

Attachment A: Mining Activities



Attachment B: Mine affected water release points

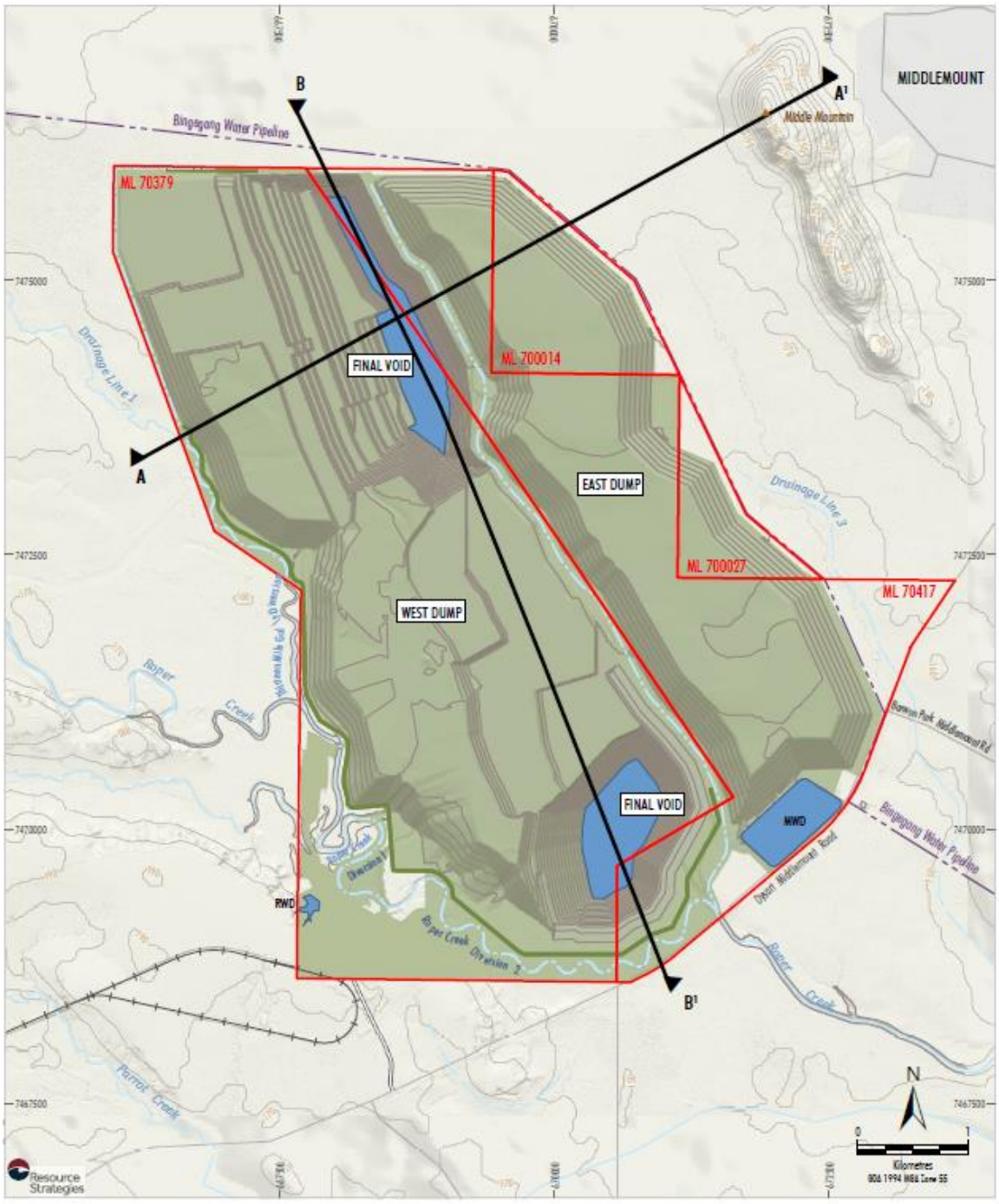


LEGEND
- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Approved Disturbance Footprint
- Diversion Structure
- Surface Water Reference Site
- Surface Water Release Point

Source: MCPL (2021); The State of Queensland (2020)
Orthophoto: MCPL (Sept 2019)

MIDDLEMOUNT COAL MINE

Attachment C: Final Landform

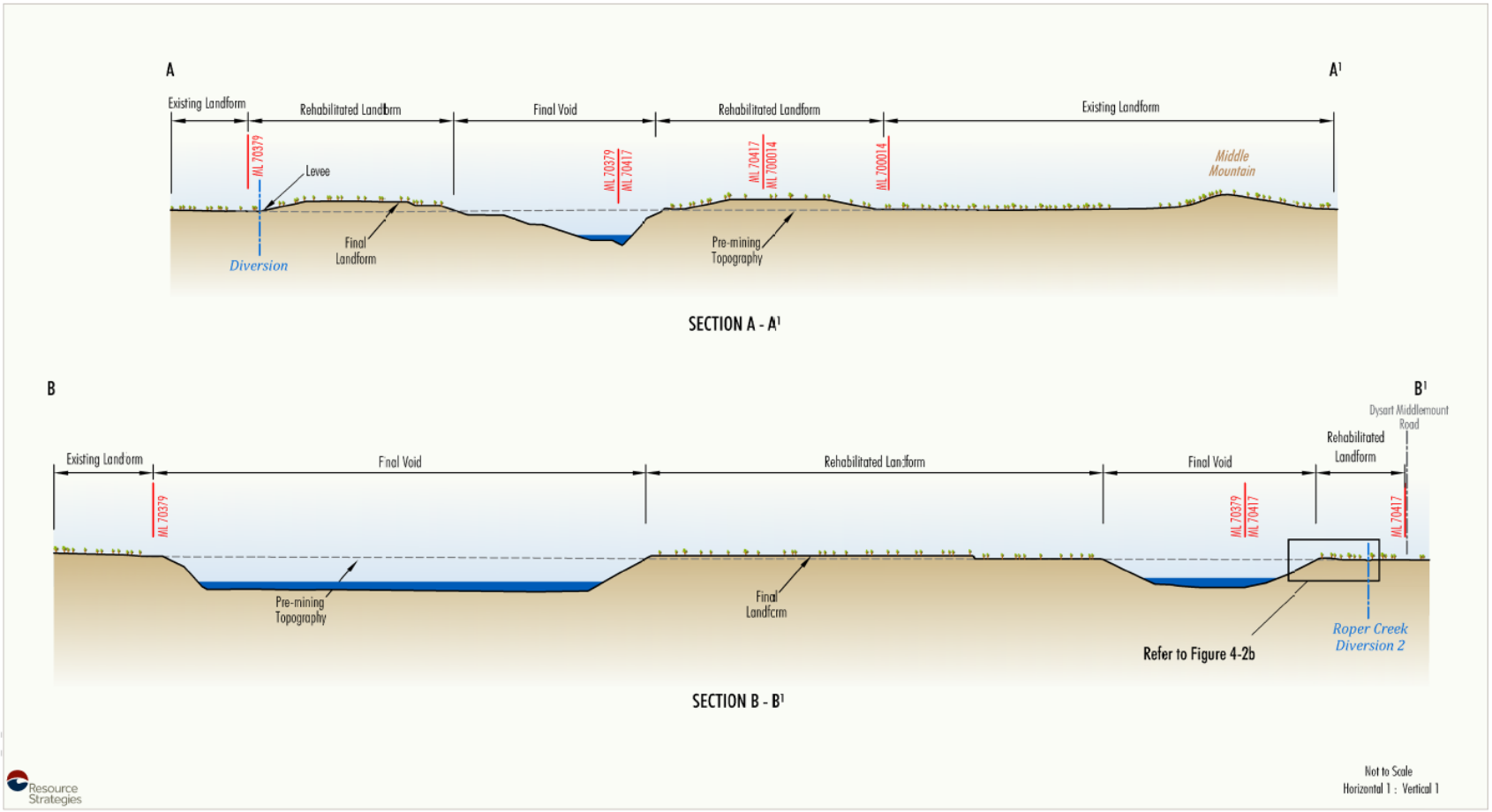


LEGEND
Mining Lease Boundary (ML)
Established Rehabilitation
Water Storage
Diversion Structure
Removed Levee (Rehabilitated)
Mine Access Road (Retained or Rehabilitated)
Middlemount Rail Spur and Loop (Retained or Rehabilitated)
Cross Section Location

Source: MCPL (2020); AGE (2020); The State of Queensland (2020)

middlemount coal

Conceptual General Arrangement
Post-mining
- Cross Section Locations

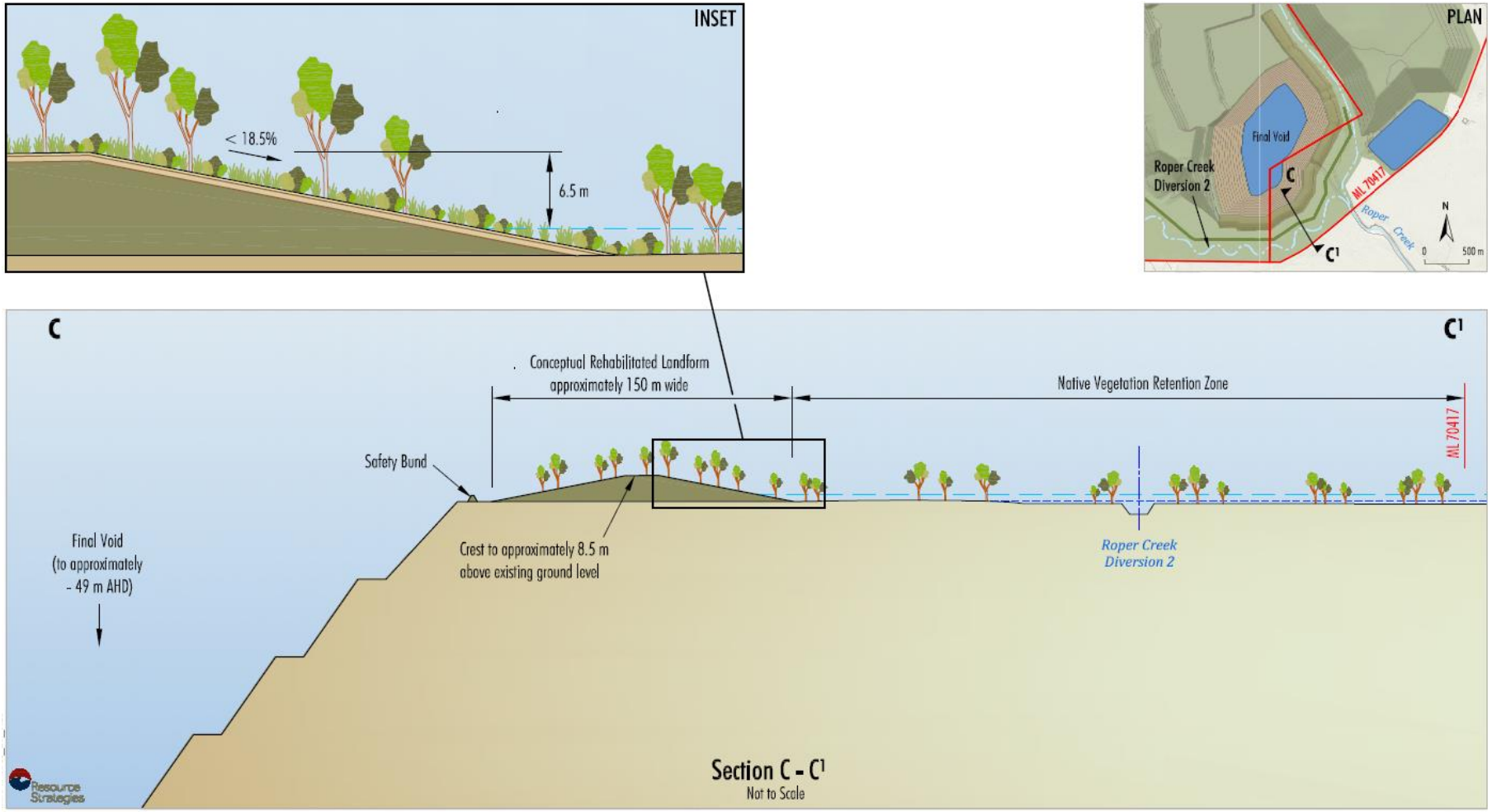


Source: MCPL (2020); AGE (2020)

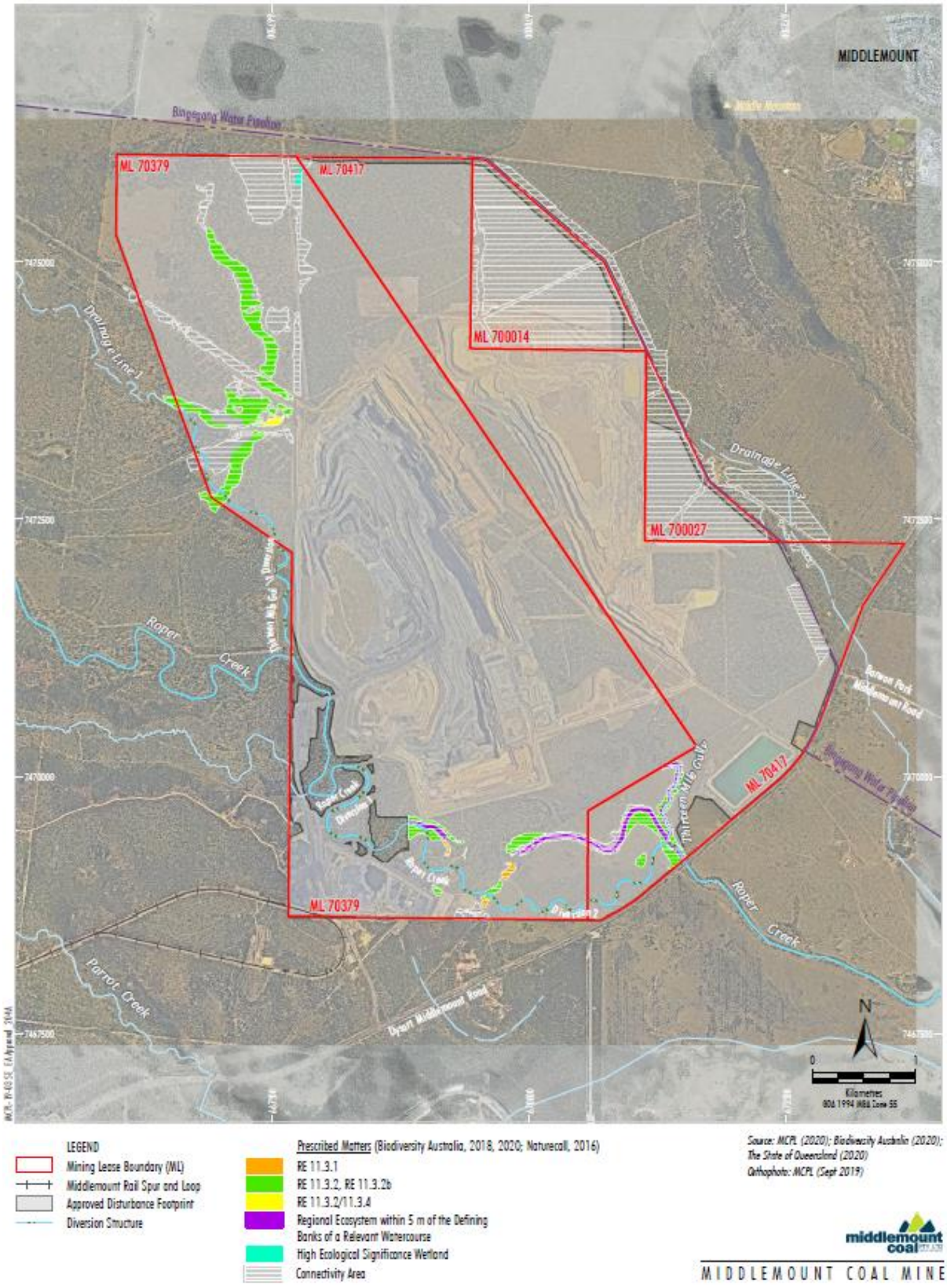
Refer Figure 4-1 for Cross Section locations.

middlemount coal PTY LTD

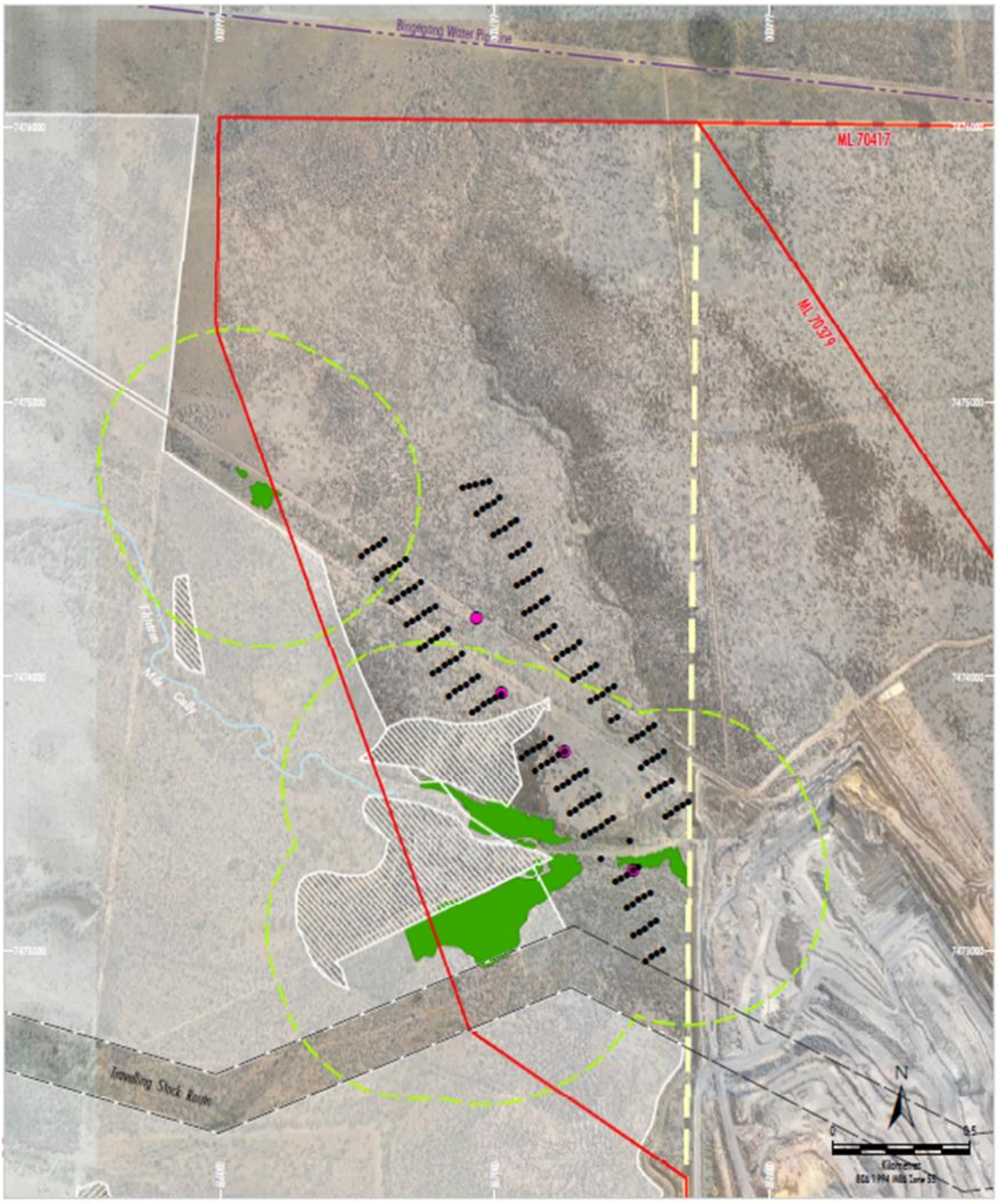
Conceptual Cross Sections of the Rehabilitated Mine Landform


INSET
< 18.5%
6.5 m
PLAN
Final Void
Roper Creek
Diversion 2
C
C1
ML 70417
Roper Creek
N
0
500 m
C
C1
Conceptual Rehabilitated Landform
approximately 150 m wide
Native Vegetation Retention Zone
ML 70417
Safety Bund
Final Void
(to approximately
- 49 m AHD)
Crest to approximately 8.5 m
above existing ground level
Roper Creek
Diversion 2
Resource Strategies
Section C - C1
Not to Scale
LEGEND
0.1% AEP Flood Level
(approximately 155 m AHD) (WRM, 2020)
Probable Maximum Flood (PMF) Level
(approximately 156.5 m AHD) (WRM, 2020)
Source: MCPL (2020); WRM (2020); AGE (2020)
middlemount coal
Conceptual Final Landform Design
Relative to the Roper Creek Floodplain

Attachment D: Location of authorised impacts to prescribed environmental matters



Attachment E: Drill Hole Locations ML70379



LEGEND
Mining Lease Boundary (ML)
Existing Offset Area - Stage 2 Project (EPBC 2010/5394) (Declared Area Map 2013/003919)
Existing Offset Area - Thirteen Mile Gully Project (Declared Area Map 2013/003919)
Existing Offset Area - Rail (Declared Area Map 2013/003919)
Surface Rights Area Boundary
Category B Environmentally Sensitive Areas
Ground-truthed Endangered Regional Ecosystems (Brigalow RE11.3.1 and RE11.4.9) (Nature Call, May 2017)
Ground-truthed Endangered Regional Ecosystems 500m Buffer
Drill Hole Type
Proposed LOX Hole
Proposed Core Hole

Source: MCPL (2018); Department of Natural Resources and Mines (2017)
Orthophoto: MCPL (June 2017)

middlemount coal

MIDDLEMOUNT COAL MINE

Proposed Drill Hole Locations

Figure 1

Attachment F: Rehabilitation Requirements

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
MIA, CHPP and roads (including haul roads)	Safe to humans and wildlife	Hazardous materials adequately managed or removed.	Contaminated land assessment undertaken by an appropriately qualified person.	Evidence which has been certified by an appropriately qualified person that: - Residual soil contamination on the mining leases has been removed, neutralized or isolated. - Hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits - Site added to the Environmental Management Register if required.
			Remediation of contaminated land.	
		Very low probability of subsidence or rock fails with serious consequences.	Safety assessment of landform stability.	Certification by an appropriately qualified person that the land is safe for the post-mining land use.
			Appropriate decommissioning of infrastructure.	A risk assessment undertaken by an appropriately qualified person prior to the surrender of the environmental authority to ensure the site is safe and all infrastructure has been decommissioned appropriately and in accordance with the conditions of the environmental authority and any applicable Australian Standard or guideline.
	Non-polluting	Polluted water contained on site or treated	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc.) meet EA conditions.	▪ Evidence certified by an appropriately qualified person that receiving waters affected by surface water run-off have contaminant limits consistent with those specified in **Table C5** of the EA, for the period of the Post Closure Management Plan required by Condition F31.
		Ensure any residual water bodies have a low risk of environmental harm		
		No contamination of surface water and groundwater resources.		

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ Evidence certified by an appropriately qualified person that groundwater quality characteristics are within those prescribed in **Table C8** of the EA, for the period of the Post Closure Management Plan required by Condition F31.
	Stable	Very low probability of subsidence or rock fails with serious consequences	Slope angle, length and profile	Evidence certified by an appropriately qualified person that: - Landform recontoured to be conducive to the adjacent landforms. - All slopes are less than 5%. - For slopes over 2%, continuous slope length does not exceed 70 m (i.e. engineered structures such as contour banks, cut-off drains etc. are implemented on all slopes such that continuous slope length does not exceed 70 m.
		Very low probability of slope slippage with serious consequences		
		Adequate vegetation cover established to minimise erosion	Vegetation type, density and cover.	Evidence certified by an appropriately qualified person that: - a minimum of 70% vegetative cover is present and maintained; - non-vegetation cover (stones, rock cover, litter, logs etc) does not cover greater than 30% of the total area; - bare surface areas are not to exceed 20 m^2 in area, based on a five year average period; and - bare surface areas are not to exceed a length of 10 m along slope, based on a five year average period

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Landform design achieves appropriate erosion rates	Erosion rates and gully formation.	▪ Evidence certified by an appropriately qualified person that erosion rates comparable to designated reference sites, for the period of the Post Closure Management Plan required by Condition F31.
	Able to sustain an agreed post mining land use	Soil properties that support and will continue to support the desired final land use	Landscape function, such as rate of soil loss, erosion features, soil physical parameters, organic matter and nutrient content and cycling	▪ Evidence, certified by an appropriately qualified person, that: - Vegetation established in accordance with post-mining land use given in Table F2 of the EA; and - Water infiltration, aggregate stability and bulk density rates of rehabilitated areas are comparable to rates at designated reference sites that are representative of the post mining land use.
			Topsoil and subsoil support the proposed land use.	
		Establish specified self-sustaining natural vegetation or habitat.	Ecosystem functionality, such as vegetation dynamics, habitat complexity and habitat quality	▪ Evidence certified by an appropriately qualified person that: - Nutrient cycling processes are comparable to designated references sites which are representative of the post mining land use; - Species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence; - Evidence of generational succession of trees and shrubs is apparent in rehabilitated areas;

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				- Weeds do not dominate native species after disturbance or after rain; - Pests do not occur in substantial numbers or visibly affect the development of native plant species; - Vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass.
		Establish land use with comparable management requirements to similarly used non-mining land	Achievement of agreed final land use	Evidence certified by an appropriately qualified person that for areas established to cattle grazing: - Cattle stocking rate is comparable to designated reference sites; and
			Rehabilitation progress and success rate	

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
			Ongoing sustainability of agreed final land use.	- land maintenance requirements are comparable to designated reference sites ▪ Evidence certified by an appropriately qualified person that for areas established to regional ecosystems: - densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; - community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; - non-native cover crop grass species constitute no more than 20% of the area of total vegetative cover; and - native tree, shrub and grass species which are representative of surrounding ecosystems and which will support the post-mine land use are to constitute 80% of the area of established vegetative cover
Final voids below natural ground level (including ramps)	Safe to humans and wildlife	Structurally safe with very low probability of subsidence or rock fails with serious consequences	Safety assessment of landform stability.	Certification by an appropriately qualified person, that final voids are stable, including: - Certification that slopes are as per Table F3:Residual Void Design and are geotechnically stable for the foreseeable future; - Certification that drainage structures are sufficiently designed and implemented for operation into the

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				foreseeable future, and direct surface water flow away from residual voids; - Certification that erosion and sediment controls are sufficiently designed and implemented for operation into the foreseeable future. - Safety assessment conducted and included in Post Closure Management Plan; and - Geotechnical stability of the high wall, low wall and end walls has been achieved and geotechnical investigations demonstrating this have been undertaken and reported.
		Hazardous materials adequately managed	Contaminated land assessment.	Evidence which has been certified by an appropriately qualified person that: ▪ Hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits;
			Risk to humans and animals	- No acid rock drainage is occurring or has the potential to occur; and ▪ Fencing and/or safety bunding and prominent signage is installed around the perimeter of the final voids to restrict access.
	Non-polluting	Polluted water contained on site or treated	Residual void water quality	Evidence which is certified by an appropriately qualified person that: - The low, high and end walls drain internally to the final void; and - Final void waters comply with specifications detailed in the Residual Void Water Quality Management Plan.
		Ensure any residual water bodies have a low risk of environmental harm		

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		No contamination of surface water and groundwater resources	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc) meet EA conditions	Evidence which is certified by an appropriately qualified person that: ▪ Groundwater and monitoring bores have parameters consistent with those specified in **Table C8** of the EA, for the period of the Post Closure Management Plan; ▪ Based on up to date groundwater modelling, that any residual void water will not overflow nor potentially contaminate any other surface water bodies; and ▪ Voids do not discharge to any receiving waters, including surface water and groundwater.
	Stable	Very low probability of subsidence or rock fails with serious consequences	Safety assessment of landform stability including slope angle, length and profile.	Certification from an appropriately qualified person that the final voids are stable into the foreseeable future and have been constructed in accordance with RPEQ designs and the criteria defined in Table F3: Residual Void Design of the EA.
		Very low probability of slope slippage with serious consequences		

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Landform design achieves appropriate erosion rates	Erosion rates and gully formation	
In-pit and out-of-pit overburden spoil dumps (slopes)	Safe to humans and wildlife	Hazardous materials adequately managed	Contaminated land assessment.	Evidence which has been certified by an appropriately qualified person that: - Hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits; and - No acid rock drainage is occurring or has the potential to occur.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Very low probability of subsidence or rock fails with serious consequences	Safety assessment of landform stability including slope angle, length and profile.	Evidence certified by an appropriately qualified person that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported; ▪ The land is safe for the proposed post mining land use detailed in Table F2 of the EA; ▪ The landform is designed in accordance with the parameters defined in Table F1; and ▪ Slope angle does not exceed 18.5 percent.
	Non-polluting	Polluted water contained on site or treated.	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc) meet EA conditions.	Evidence certified by an appropriately qualified person that: ▪ Groundwater monitoring bores have parameters consistent with those specified in **Table C8** of the EA, for the period of the Post Closure Management Plan; and ▪ Receiving waters affected by surface water run-off have contaminant limits consistent with those specified in **Table C5** of the EA, for the period of the Post Closure Management Plan;
			Performance of capping.	
		Ensure any residual dams have a low risk of environmental harm.	Residual dam water quality.	Evidence certified by an appropriately qualified person that: - Water quality in water storage and management dams which are retained for beneficial reuse comply with the limits detailed within ANZECC or ARMCANZ for that beneficial use, for a period of at least five years.
	Stable	Very low probability of subsidence or rock fails with serious consequences.	Safety assessment of landform stability including	Evidence certified by an appropriate person that:

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Very low probability of slope slippage with serious consequences.	slope angle, length and profile.	▪ rock mulch has 100% coverage of the overburden spoil dumps surface area (i.e. no bare areas exist) ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported; ▪ The land is safe for the proposed post mining land use detailed in Table F2 of the EA; ▪ The landform is designed in accordance with the parameters defined in Table F1; and ▪ Slope angle does not exceed 18.5 percent.
		Landform design achieves appropriate erosion rates.	Erosion rates and gully formation	Evidence, which has been certified by an appropriately qualified person, that erosion rates of rehabilitated areas are suitable for the post mining land use defined in Table F2 of the EA.
		Adequate vegetation cover established to minimise erosion.	Vegetation type and density	Evidence, which has been certified by an appropriately qualified person, that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining land use defined in Table F2 of the EA.
	Able to sustain an agreed post mining land use	Soil properties that support and will continue to support the desired final land use.	Landscape function, such as rate of soil loss, erosion features, soil physical parameters, organic matter and nutrient content and cycling.	Evidence, certified by an appropriately qualified person, that: - Vegetation established in accordance with post-mining land use given in Table F2 of the EA; and - Water infiltration, aggregate stability and bulk density rates of rehabilitated areas are comparable to rates at designated reference sites that are representative of the post mining land use; and - vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass.
			Topsoil and subsoil support the proposed land use.	

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Establish specified self-sustaining natural vegetation or habitat.	Ecosystem functionality, such as vegetation dynamics, habitat complexity and habitat quality.	Evidence, certified by an appropriately qualified person, that: ▪ Species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence; ▪ Evidence of generational succession of trees and shrubs is apparent is rehabilitated areas; ▪ weeds do not dominate native species after disturbance or after rain; and ▪ pests do not occur in substantial numbers or visibly affect the development of native plant species.
		Establish land use with comparable management requirements to similarly used non-mining land	Rehabilitation progress and success rate. Achievement of agreed final land use. Ongoing sustainability of agreed final land use.	▪ Evidence certified by an appropriately qualified person that for areas established to cattle grazing: - Cattle stocking rate is comparable to designated reference sites; and - land maintenance requirements are comparable to designated reference sites ▪ Evidence certified by an appropriately qualified person that for areas established to regional ecosystems: - densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; - community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; - non-native cover crop grass species constitute no more than 20% of the area of total vegetative cover; and

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				- native tree, shrub and grass species which are representative of surrounding ecosystems and which will support the post-mine land use are to constitute 80% of the area of established vegetative cover.
In-pit and out-of-pit overburden spoil dumps (upper surface)	Safe to humans and wildlife	Hazardous materials adequately managed.	Contaminated land assessment.	Evidence which has been certified by an appropriately qualified person that: - Hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits; and - No acid rock drainage is occurring or has the potential to occur.
		Very low probability of subsidence or rock fails with serious consequences.	Safety assessment of landform stability including slope angle, length and profile.	Evidence certified by an appropriately qualified person that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported; ▪ The land is safe for the proposed post mining land use detailed in Table F2 of the EA; and ▪ Slope angle does not exceed 2%
	Non-polluting	Polluted water contained on site or treated	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc) meet EA conditions. Performance of capping.	Evidence certified by an appropriately qualified person that: ▪ Groundwater monitoring bores have parameters consistent with those specified in **Table C8** of the EA, for the period of the Post Closure Management Plan; ▪ receiving waters affected by surface water run-off have contaminant limits consistent with those specified in **Table C5** of the EA, for the period of the Post Closure Management Plan; and ▪ no long-term (>2 months) ponding of water on soil surface.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Ensure any residual water bodies have a low risk of environmental harm	Residual dam water quality.	Evidence certified by an appropriately qualified person that: ▪ Water quality in water storage and management dams which are retained for beneficial reuse comply with the limits detailed within ANZECC or ARMCANZ for that beneficial use, for a period of at least five years.
	Stable	Very low probability of subsidence or rock fails with serious consequences. Very low probability of slope slippage with serious consequences.	Safety assessment of landform stability including slope angle, length and profile.	Evidence certified by an appropriate person that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported; ▪ the land is safe for the proposed post mining land use detailed in Table F2 of the EA; ▪ slope angle does not exceed 2%; ▪ a minimum of 70% vegetative cover is present and maintained; ▪ non-vegetation cover (stones, rock cover, litter, logs etc.) comprise not greater than 30% of the total area ▪ bare surface areas do not exceed 5m^2 in area, over a five year average period; and ▪ bare surface areas are not to exceed a length of 5 m along slope, over a five year average period.
		Landform design achieves appropriate erosion rates.	Erosion rates and gully formation.	Evidence, which has been certified by an appropriately qualified person, that erosion rates of rehabilitated areas are suitable for the post mining land use specified in Table F2 of the EA.
		Adequate vegetation cover established to minimise erosion.	Vegetation type, density and cover.	Evidence, which has been certified by an appropriately qualified person, that the vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining land use defined in Table F2 of the EA.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
	Able to sustain an agreed post mining land use	Soil properties that support and will continue to support the desired final land use	Topsoil and subsoil support the proposed land use.	Evidence, certified by an appropriately qualified person, that topsoil has been respread to a suitable depth in rehabilitated areas to sustain the post mining land use specified in Table F2 of the EA.
			Landscape function, such as rate of soil loss, erosion features, soil physical parameters, organic matter and nutrient content and cycling.	Evidence, certified by an appropriately qualified person, that: ▪ soil surface crusting occurs in less than 2% of the rehabilitated domain area; ▪ water infiltration, aggregate stability and bulk density rates of rehabilitated areas are comparable to rates at designated reference sites which are representative of the post-mining land use; ▪ nutrient cycling processes are comparable to designated references sites which are representative of the post mining land use; and ▪ vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass.
		Establish specified self-sustaining natural vegetation or habitat	Ecosystem functionality, such as vegetation dynamics, habitat complexity and habitat quality	Evidence, certified by an appropriately qualified person, that: ▪ vegetation established in accordance with post-mining land use given in Table F2 of the EA; ▪ species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence; ▪ evidence of generational succession of trees and shrubs is apparent is rehabilitated areas; ▪ weeds do not dominate native species after disturbance or after rain; ▪ pests do not occur in substantial numbers or visibly affect the development of native plant species;

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; ▪ community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; ▪ non-native cover crop grass species constitute no more than 20% of the area of total vegetative cover; and ▪ native tree, shrub and grass species which are representative of surrounding ecosystems and which will support the post-mine land use are to constitute 80% of the area of established vegetative cover.
		Establish land use with comparable management requirements to similarly used non-mining land.	Ongoing sustainability of agreed final land use.	▪ Evidence certified by an appropriately qualified person that for areas established to cattle grazing: - Cattle stocking rate is comparable to designated reference sites; and - land maintenance requirements are comparable to designated reference sites.
			Rehabilitation progress and success rate.	
			Achievement of agreed final land use	

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ Evidence certified by an appropriately qualified person that for areas established to regional ecosystems: - densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; and - community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites.
Low wall spoil (above natural ground level)	Safe to humans and wildlife	Hazardous materials adequately managed.	• Safety assessment of dumps, voids and other slopes. • landform stability including slope angle, length and profile.	Evidence, certified by an appropriately qualified person, that: - Hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits; and - no acid rock drainage is occurring or has the potential to occur.
		Very low probability of subsidence or rock fails with serious consequences.		Evidence, certified by an appropriately qualified person, that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ slope angle will be retained at angle specified in Table F2 of the EA.
	Non-polluting	Polluted water contained on site or treated	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc) meet EA conditions	Evidence, certified by an appropriately qualified person, that: ▪ Groundwater monitoring bores have parameters consistent with those specified in Table C8 of the EA, for the period of the Post Closure Management Plan. ▪ receiving waters affected by surface water run-off have contaminant limits consistent with those specified in Table C5 of the EA, for the period of the Post Closure Management Plan.
			Performance of capping	
		Ensure any residual water bodies have a low risk of environmental harm	Residual dam water quality.	Evidence certified by an appropriately qualified person that: ▪ Water quality in water storage and management dams which are retained for beneficial reuse comply with the limits detailed within ANZECC or ARMCANZ for that beneficial use, for a period of at least five years.
	Stable	Very low probability of subsidence or rock fails with serious consequences	Safety assessment of landform stability including slope angle, length and profile.	Evidence, certified by an appropriately qualified person, that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported. ▪ slope angle retained at angle specified in Table F2 of the EA.
		Very low probability of slope slippage with serious consequences		
		Landform design achieves appropriate erosion rates	erosion rates and gully formation	Evidence, which has been certified by an appropriately qualified person, that erosion rates of rehabilitated areas are suitable for the post mining land use defined in Table F2 of the EA.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
	Able to sustain an agreed post mining land use (benches within low wall spoil only)	Soil properties that support and will continue to support the desired final land use	Topsoil and subsoil support the proposed land use.	Evidence, certified by an appropriately qualified person, that topsoil has been respread to a suitable depth in rehabilitated areas to sustain the post mining land use specified in Table F2 of the EA.
			Landscape function, such as rate of soil loss, erosion features, soil physical parameters, organic matter and nutrient content and cycling.	Evidence, certified by an appropriately qualified person, that: ▪ vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass.
		Establish specified self-sustaining natural vegetation or habitat	Ecosystem functionality, such as vegetation dynamics, habitat complexity and habitat quality.	Evidence, certified by an appropriately qualified person, that: ▪ evidence of generational succession of trees and shrubs is apparent in rehabilitated areas; ▪ vegetation established in accordance with post-mining land use given in Table F2 of the EA on benches within low wall spoil; ▪ species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence; ▪ weeds do not dominate native species after disturbance or after rain; and ▪ pests do not occur in substantial numbers or visibly affect the development of native plant species.
		Establish land use with comparable management requirements to similarly used non-mining land	Rehabilitation progress and success rate.	Evidence certified by an appropriately qualified person that for areas established to regional ecosystems: - densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as
			Achievement of agreed final land use	

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
			Ongoing sustainability of agreed final land use.	determined through comparison with designated reference sites; and ▪ community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites.
Water storage/ water management dams	Safe to humans and wildlife	Hazardous materials adequately managed	Contaminated land assessment	Evidence, certified by an appropriately qualified person, that: ▪ hydrocarbon, heavy metal or other contamination levels are within allowable departmental limits; ▪ site added to the Environmental Management Register if required.
		Very low probability of subsidence or rock fails with serious consequences	Safety assessment of landform stability.	Evidence, certified by an appropriately qualified person, that: ▪ Geotechnical stability has been achieved and geotechnical investigations demonstrating this have been undertaken and reported; and ▪ the land is safe for the proposed post mining land use detailed in Table F2 of the EA.
	Non-polluting	Polluted water contained on site or treated	Contaminated land assessment	Evidence, certified by an appropriately qualified person, that:

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
		Ensure any residual water bodies have a low risk of environmental harm	Upstream and downstream surface and ground water quality (e.g. sediment load, pH, heavy metal content, etc) meet EA conditions.	▪ Receiving waters affected by surface water run-off have contaminant limits consistent with those specified in **Table C5** of the EA, for the period of the Post Closure Management Plan. ▪ water quality in water storage and management dams which are retained for beneficial reuse comply with the limits detailed within ANZECC or ARMCANZ for that beneficial use, for a period of at least five years.
	Stable	Very low probability of subsidence or rock fails with serious consequences Very low probability of slope slippage with serious consequences	Safety assessment of landform stability including slope angle, length and profile.	Evidence, certified by an appropriately qualified person, that: ▪ non-vegetation cover (stones, rock cover, litter, logs etc.) comprise not greater than 30% of the total area; ▪ bare surface areas do not exceed 20 m^2 in area, over a five year average period; and ▪ bare surface areas are not to exceed a length of 10 m along slope, over a five year average period.
		Landform design achieves appropriate erosion rates	Erosion rates and gully formation	Evidence, which has been certified by an appropriately qualified person, that erosion rates of rehabilitated areas are suitable for the post mining land use defined in Table F2 of the EA.
		Adequate vegetation cover established to minimise erosion	Vegetation type, density and cover	Evidence, certified by an appropriately qualified person, that: ▪ minimum of 70% vegetative cover is present and maintained on banks and external dam walls.
	Able to sustain an agreed post mining land use	Soil properties that support and will continue to support the desired final land use.	Landscape function, such as rate of soil loss, erosion features, soil physical parameters, organic matter and nutrient content and cycling.	Evidence, certified by an appropriately qualified person, that: ▪ Soil surface crusting occurs in less than 5% of the rehabilitated domain area; ▪ water infiltration, aggregate stability and bulk density rates of rehabilitated areas are comparable to rates at designated reference sites which are representative of the post mining land use;

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass; and ▪ nutrient cycling processes are comparable to designated references sites which are representative of the post mining land use.
		Establish specified self-sustaining natural vegetation or habitat.	Ecosystem functionality, such as vegetation dynamics, habitat complexity and habitat quality.	Evidence, certified by an appropriately qualified person, that: ▪ Species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence; ▪ evidence of generational succession of trees and shrubs is apparent in rehabilitated areas; ▪ weeds do not dominate native species after disturbance or after rain; and ▪ pests do not occur in substantial numbers or visibly affect the development of native plant species.
		Establish land use with comparable management requirements to similarly used non-mining land	Rehabilitation progress and success rate. Achievement of agreed final land use. Ongoing sustainability of agreed final land use.	Evidence certified by an appropriately qualified person that for areas established to regional ecosystems: - densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites; and

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
				▪ community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites.
Exploration	Safe to humans and wildlife Non-polluting Stable	Site is safe for humans and animals now and in the foreseeable future	All exploration drill holes undertaken have been rehabilitated	▪ Certification that all exploration dill holes not agreed to in writing with the post-mining landholder to be converted to either a water bore or groundwater monitoring bore have been made safe and stable, and will remain safe and stable.

Mine Domain	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
	Able to sustain an agreed post mining land use			▪ Certification that all aquifers have been isolated where exploration drill holes have intersected more than one water bearing strata, in accordance with the 'Minimum Construction Requirements for Water Bore in Australia' (Australian Government, February 2012) or latest edition. ▪ Evidence of written landholder agreement for the retention of any exploration drill holes to be converted to a water bore. ▪ Certification that all exploration drill holes agreed to in writing with the post-mining landholder to be converted to a water bore, have been converted in accordance with the 'Minimum Construction Requirements for Water Bore in Australia' (Australian Government, February 2012) or latest edition. ▪ Certification that all exploration drill holes converted to water bores as per the written landholder agreement, are compliant with the Water Act 2000.

Attachment G: Diversion footprint - Thirteen Mile Gully

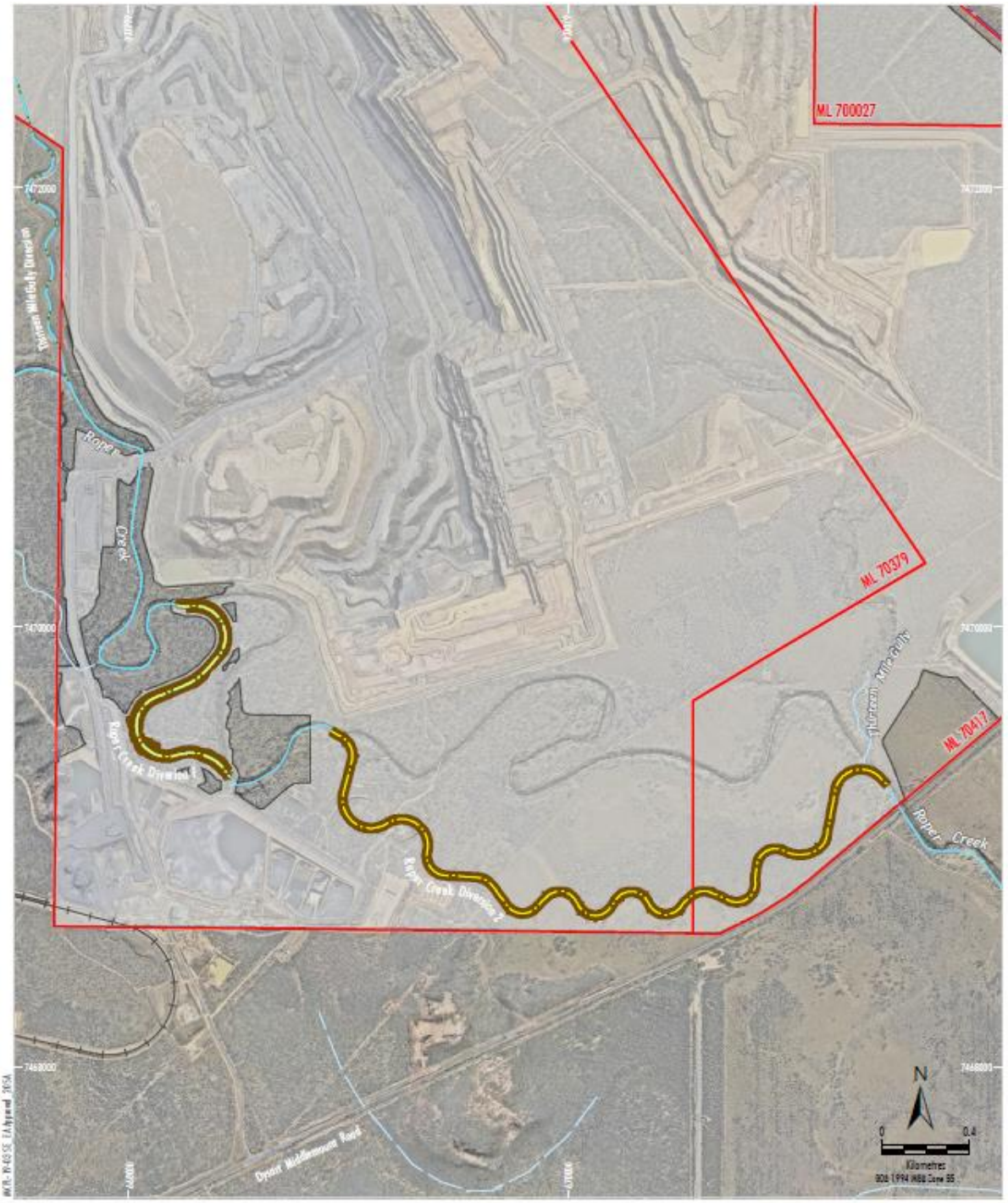
LEGEND
Mining Lease Boundary (ML)
Watercourse
Drainage
Existing Thirteen Mile Gully Diversion Footprint
Western Extension Project Diversion (Functional Design)

Source: MCPL (2018); Department of Natural Resources and Mines (2019); WRM (2019)
Orthophoto: MCPL (Dec 2018)

middlemount coal

MIDDLEMOUNT COAL MINE
Diversion Footprint

Attachment H: Diversion Footprints - Roper Creek



END OF ENVIRONMENTAL AUTHORITY

ATTACHMENT 3

LETTER FROM MIDDLEMOUNT COAL MINE TO THE DEPARTMENT OF ENVIRONMENT AND SCIENCE (RE: MIDDLEMOUNT COAL MINE, EMPL00716913 – RETENTION OF WATER STRUCTURES). DATED 15 MAY 2020

Level 17,444 Queen Street,
Brisbane City, QLD 4000

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middlemount coal PTY LTD
ABN 49 122 348 412

15 May 2020

Jeremy Wheeler
Senior Environmental Officer (Assessment)
Department of Environment and Science
GPO Box 3028
Emerald QLD 4720

Dear Jeremy,

RE: Middlemount Coal Mine, EMPL00716913 – Retention of Water Structures

Background

Middlemount Coal Pty Ltd owns the following cadastral lots under the Middlemount Coal MLs.

- Lot 5 on SP210524
- Lot 3 on SP282156
- Lot 2 on SP248577
- Lot 1 on SP282156
- Lot 4 on SP242660

A plan showing the ML and cadastral boundaries is presented below in Figure 1.

Retention of Water Structures

For the purposes of the Estimated rehabilitation Calculator, as the owner of the cadastral lots mentioned above, Middlemount Coal Pty Ltd agrees to allow the retention of a number of water holding structures across the ML.

The structures would serve a useful purpose for future land uses in the event of the project going into administration and closure of the mine.

These water retention structures include the following:

- Mine Water Dam
- Raw Water Dam
- Sediment Dam 1 and Sediment Dam 1 extension
- Sediment Dam 2
- Sediment Dam 3
- TSF2 (drying cells)
- Sediment Dam 6

- Sediment Dam 7
- Sediment Dam 9
- Sediment Dam 10
- Sediment Dam 12
- Workshop sediment dam
- Blast yard sediment dam
- Bangers dam
- Highwall dam 1
- Highwall dam 2
- Northern pitwater transfer dam
- ROM2 sediment dam
- ROM2 go line sediment dam
- Polypipe network (to allow future transfer between the dams and pit

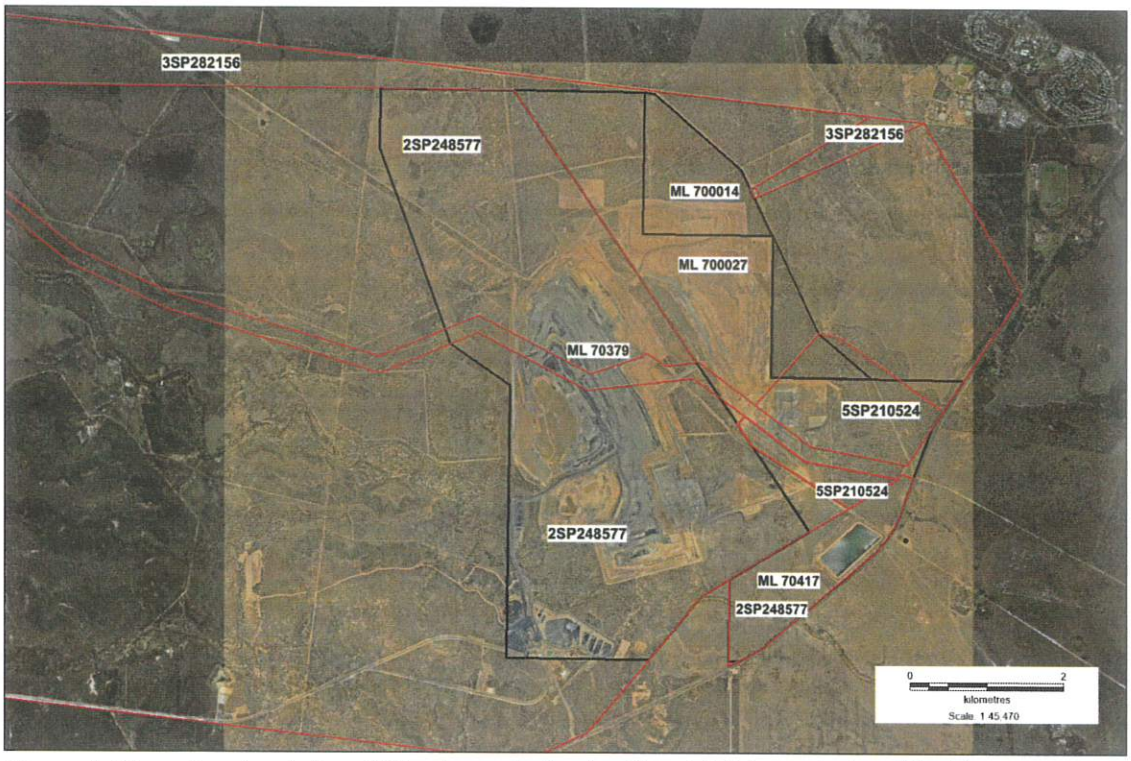

Figure 1: Map showing Lot and Plan boundaries (red) and ML boundaries (black)

If you wish to discuss this matter, please don't hesitate to contact the undersigned on (07) 4985 0059.

Yours faithfully

Albert Schneepers
Executive General Manager/SSE
Middlemount Coal

ATTACHMENT 4

MIDDLEMOUNT COAL MINE REHABILITATION MONITORING PROGRAM 2021

middlemount coal PTY LTD

Rehabilitation Monitoring Program and Schedule

2021

8 October 2021

Project No.: 0606252

The business of sustainability

ERM

Document details	
Document title	Rehabilitation Monitoring Program and Schedule
Document subtitle	2021
Project No.	0606252
Date	8 October 2021
Version	1.0
Author	Martine Goldner; Amanda Maier
Client Name	Middlemount Coal Pty Ltd

Document history

				ERM approval to issue		
Version	Revision	Author	Reviewed by	Name	Date	Comments
Draft	1.0	Martine Goldner / Amanda Maier	Dr Toivo Zoete	Chris Gimber	30/07/21	

Signature Page

8 October 2021

Rehabilitation Monitoring Program and Schedule

2021

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1. INTRODUCTION

Middlemount Coal Pty Ltd is an incorporated joint venture between Peabody Energy Australia Pty Ltd and Yancoal Australia Ltd, and operate Middlemount Coal Mine (MCM), an open cut coal operation located approximately 90 kilometres north-east of Emerald, Queensland.

MCM is required under their current Environmental Authority (EA) EPML00716913 (issued 26 May 2021) to develop and implement a Rehabilitation Monitoring Program (RhMP) as per the EA excerpt below (Condition G14), and to comply with the following conditions in the EA relating to rehabilitation monitoring:

G15	The environmental authority holder must review the Rehabilitation Monitoring Program required by **Condition G14** at intervals no greater than **three (3) years** from **29 June 2019**. If the environmental authority holder needs to make changes to the Rehabilitation Monitoring Program, they must: a) submit the Rehabilitation Monitoring Program to the administering authority for review and comment; and b) within **twenty (20) business days** of receiving comments from the administering authority, the Rehabilitation Monitoring Plan must be updated to address the comments and resubmitted to the administering authority.
G16	A report of the findings of the Rehabilitation Monitoring Program must be updated and submitted to the administering authority, on 29 June of each calendar year , containing at a minimum: a) how the rehabilitation objectives as per Attachment F of this environmental authority will be achieved; b) how the rehabilitation objectives in the Rehabilitation Management Plan required by **Condition G12** are being met; c) if rehabilitation objectives are not being met, the corrective actions to be taken; d) specify the minimum sampling intensity for the monitoring of progressive rehabilitation; e) a statistical analysis of how areas of rehabilitation compared to analogue sites listed in **Table G5: Reference Sites**; f) a statistical analysis of how areas of rehabilitation are meeting the requirements of **Condition G9**; g) the sampling and monitoring intensity used in the Rehabilitation Monitoring Program required by **Condition G14**; h) justification of the suitability of the minimum sampling intensity; and i) justification of the sampling and monitoring intensity used in the Rehabilitation Monitoring Program required by **Condition G14**.

Table G5: Reference Sites

Reference Site	Domain Reference	Easting (GDA94, MGA 55)	Northing (GDA94, MGA 55)	Description
1	• In-pit and out-of-pit spoil dumps	662,226	7,475,606	RE 11.5.3
2	• MIA and CHPP area • Roads including haul roads • Tailings Storage Facility	665,455	7,469,732	RE 11.5.9
3	▪ Roads including haul roads	665,832	7,470,708	RE 11.7.2

The intent of rehabilitation monitoring is to collect site-specific data on a regular basis to assess and compare against the site's rehabilitation objectives, indicators and completion criteria. The outcomes of monitoring are used to determine the performance of the rehabilitation, and to identify any areas that are at risk of failing the stability, safety, and sustainability criteria.

This rehabilitation monitoring program is designed to be an evolving document that is reviewed and updated as areas of rehabilitation are completed and established. The results of each monitoring period should be utilised to guide corrective actions for any areas or aspects of rehabilitation that were found to be inadequate during monitoring, such as rework in areas of significant erosion. The results may also be used to adjust the monitoring program, including changes to the monitoring sites, frequency of monitoring, and variables monitored.

A long term review of monitoring results may be required in the future to assess the appropriateness of rehabilitation targets, as rehabilitation areas continue to be monitored against these targets.

2. REVIEW OF THE EXISTING MONITORING PROGRAM

Under Condition G15 of the EA, a review of the existing RhMP (previously developed by GT Environmental (2018), was completed and is provided in *Table 1*.

The basis of the assessment was to determine if the RhMP is meeting its key objective of collecting the required information to support an understanding of how rehabilitated areas are progressing towards achieving the rehabilitation objectives and completion criteria stipulated for the site. The assessment considered accepted standard practices in the region, practical experience of rehabilitation monitoring in the region, and the site's EA requirements.

Upon consultation with site, reviewing the existing monitoring program (GT Environmental, 2018) and considering the latest monitoring reporting provided (Bilyarra Consulting, 2019), which were completed in accordance with the previous RhMP specification, a preliminary re-design of the RhMP was completed.

ERM's rehabilitation and closure expert, Matt Lord, developed an updated draft monitoring framework, drawing from an understanding of the site and the historical monitoring, leading industry practice for rehabilitation monitoring and an appreciation of the science of demonstrating progression towards relinquishment criteria and associated timelines. The re-designed monitoring program was aimed at addressing any gaps found, was supplied to site personnel for discussion, and tentatively agreed to be adopted as a preliminary revised RhMP to be 'tested' through application.

Field surveys were then conducted using the new monitoring techniques (and the methodology outlined in the revised RhMP), to determine if the revised program was deemed to be adequate to address the requirements in the EA. The RhMP was subsequently finalised with the benefit of this additional understanding of site context and conditions.

Table 1: Assessment of existing rehabilitation monitoring techniques

Overview of existing monitoring program	Updates to monitoring program
■ On ground monitoring for three (3) years, then use remote sensing techniques every 5 years. Formal audit of progress towards EA requirements every 3 years ■ Survey timing between May and August ■ Sampling density 1 transect per hectare up to 100 hectare, then reducing in resolution ■ Aerial photo interpretation ■ Photo monitoring points (geotagged for context & start/end of transects) ■ Resurvey of previous transects ■ Reference site sampling at 3x locations (as per EA) ■ Primary assessment: transect sampling (Nelder et al, 2005) - 25x10m - Trees and shrubs within 100m of transect start - Flora spp list, recording stratum, abundance and height/density of strata - Proportion of groundcover veg, litter and bare earth within 10x1m^2 quadrats, as well as dominant spp contributions - Measurements of individual trees in every 10th transect, plus data collection for Landscape Function Analysis (LFA) in these locations ■ Not clear if soil sampling and assessment, and groundwater and surface water monitoring and assessment, is within monitoring scope ■ Secondary assessment: revegetation monitoring (with varied frequency) considering weeds, health of plants, signs of disturbance & regeneration, habitat values, and diversity and structure. Timing from monthly to 3 yearly. ■ Tertiary assessment also proposed: 'passive surveillance by site personnel' ■ Annual summary rehabilitation report (primary assessment), and rehabilitation monitoring report (secondary assessment) (to be completed at six monthly intervals up to 2 years, then annually for 7 years, then every 3 years) to be provided.	■ On ground monitoring agreed every 1, 2, 3, 5 and 10 years ■ Field survey completed in June due to supplier contract negotiations, however moving forward this should aim to be completed by May at the latest. ■ Sampling density reduced to 1 transect per 10 hectares as per Queensland Herbarium best practice (Neldner et al. 2020). ■ Reference site sampling at 9x locations (to increase representativeness of the underlying RE communities). ■ Pre-monitoring work: - Identification of rehabilitation areas with uniform rehabilitation (e.g. age) and site characteristics (e.g. slopes), as can be represented in mapping polygons, to be included in the annual monitoring and identification of the locations for transects to be established, ensuring the stipulated sampling intensity (of 1 transect per 10ha) is met. - Assessment of slope angles and lengths for compliance with site-specific criteria using LiDAR survey data. - Assessment of sediment deposition, using LiDAR survey data to show areas and extent of erosion and deposition. Note that this was not completed during the pre-work this year due to time constraints for field surveys, but should be incorporated moving forward; - Identification of any areas of persistent bare ground in rehabilitation five years old or greater. - Assessment of any factors that may have adversely affected rehabilitation areas including drought, fire, predation by insects, excessive grazing, unauthorised vehicle traffic, vegetation die-back, or soil disturbance/ burrowing caused by pest animals (e.g. pigs or rabbits). - Review of climate data (preferably from the site weather station, or alternatively from the nearest weather observation station), including records of recent rainfall events, intensity, duration and relationship to the time of seeding. ■ Primary assessment: transect sampling: - 50m x 10m belt transects were established, and appeared to adequately capture all species present. Photo monitoring points recorded (geotagged start/ end). - Flora spp. list, was recorded noting species name, location on transect where they are first encountered, native/ introduced/ declared, and height of each woody plant species recorded that occurs over 2m in height and density.

Overview of existing monitoring program	Updates to monitoring program
	- Proportion of groundcover (basal/ live cover, litter, bare ground, rocks and cryptograms) within 5x1m2 quadrats. Biomass estimated using photostandards (grasses) and point frame method (basal cover). - Habitat complexity estimated at start, middle and end points of transect, noting percentage of canopy (tree and shrub) cover, ground cover, logs, rocks and woody debris cover, free standing water and soil moisture, and tree hollows. - Soil sampling to a depth of 10cm at 5 points across the transect, to create a composite soil sample to be analysed for the transect. - Visual assessment of erosion, with rills/ gullies start and end points recorded along the transect to assess through time. - LFA was removed, as it had not been completed during the 2019 monitoring due to time constraints (Bilyarra Consulting, 2019). The revised RhMP was considered to provide a suitable snapshot of the rehabilitation condition without this technique being employed. ■ Annual summary rehabilitation monitoring report provided.

Relevant Rehabilitation Objective (From EA)	Relevant Completion Criteria (from EA)	Assessment of Existing Monitoring Techniques	Initial Assessment & Suggestions	Updates after completing surveys
Very low probability of subsidence or rock fails with serious consequences	■ *Slope angle does not exceed 18.5 degrees (dump slopes)* ■ *Slope angle does not exceed 2% (dump tops)*	No assessment of slope completed.	Consider including: ■ Field slope assessment (clinometer) ■ GIS slope compliance review	Both field slope assessments were completed as well as an overall slope review using LiDAR. Recommended to continue to use LiDAR as primary method as yield more valuable information as to compliance with slope requirements, with better spatial coverage..
Polluted water contained on site or treated.	■ *Groundwater monitoring bores have parameters consistent with those specified in Table C8 of the EA, for the period of the Post Closure Management Plan* ■ *Receiving waters affected by surface water run-off have contaminant limits consistent with those specified in Table C5 of the EA, for the period of the Post Closure Management Plan* ■ *No long-term (>2 months) ponding of water on soil surface (dump tops)*	No consideration of groundwater or receiving waters monitoring results, or long term ponding on dump tops.	Consider including: ■ High-level review of groundwater & receiving water monitoring results ■ Standing/ponded water in habitat assessment	High level review of groundwater and receiving water monitoring results was not completed, due to discrepancies in reporting periods, however it is recommended to include these in future monitoring. Standing water assessments completed as part of habitat complexity assessment.
Very low probability of subsidence or rock fails/ slope slippage with serious consequences.	■ *Rock mulch has 100% coverage of the overburden spoil dumps surface area (i.e. no bare areas exist)*	Proportion of groundcover veg, litter and bare earth monitored within 10x1m^2 quadrats.	Continue to record proportion of bare earth as existing. Consider including:	Completed.

Relevant Rehabilitation Objective (From EA)	Relevant Completion Criteria (from EA)	Assessment of Existing Monitoring Techniques	Initial Assessment & Suggestions	Updates after completing surveys
Very low probability of slope slippage with serious consequences.	■ *The land is safe for the proposed post mining land use detailed in Table F2 of the EA* ■ *Slope angle does not exceed 18.5 degrees* *For dump tops* ■ *slope angle does not exceed 2%* ■ *a minimum of 70% vegetative cover is present and maintained* ■ *non-vegetation cover (stones, rock cover, litter, logs etc.) comprise not greater than 30% of the total area* ■ *bare surface areas do not exceed 5m^2 in area, over a five year average period* ■ *bare surface areas are not to exceed a length of 5 m along slope, over a five year average period*	No link between areas monitored and PMLUs. No assessment of slope completed.	■ Field slope assessment (clinometer) and/or GIS slope compliance review ■ Another measure of stability (an erosion ranking?) to decouple from rock mulching ■ Expand habitat assessment to consider percent stones, rock cover and woody debris. ■ Bolster reference site monitoring to present the 'natural' state for PMLUs. Expand replicates transects, and across REs to show natural diversity.	Have utilised a standard erosion ranking as discussed in next sections. Completed. Completed.
Landform design achieves appropriate erosion rates.	*… erosion rates of rehabilitated areas are suitable for the post mining land use defined in Table F2 of the EA.*	No consideration of erosion completed.	Consider including: ■ Field assessment and ranking of erosion (in line with standard practices)	Have utilised a standard erosion ranking as discussed in next sections.
Adequate vegetation cover established to minimise erosion.	*… vegetation type and density of species in rehabilitated areas are suited to the soil composition, slope, aspect, climate and post mining land use defined in Table F2 of the EA.*	Linkages between vegetation type and density between rehabilitated areas and	Consider including: ■ Bolster monitoring at reference sites/ REs and	Completed.

Relevant Rehabilitation Objective (From EA)	Relevant Completion Criteria (from EA)	Assessment of Existing Monitoring Techniques	Initial Assessment & Suggestions	Updates after completing surveys
		reference sites/ REs/ PMLUs not apparent.	conduct analysis to link rehab areas to these areas ■ Use monitoring to establish a 'reference' range for soil composition, slope, aspect climate and PMLUs	Require further monitoring at now established locations (including previous reference site monitoring data) to start to build a reference 'range' across soil composition, slope, climate and PMLUs, to compare with rehabilitated areas.
Soil properties that support and will continue to support the desired final land use.	■ *Vegetation established in accordance with post-mining land use given in Table F2 of the EA* ■ *Water infiltration, aggregate stability and bulk density rates of rehabilitated areas are comparable to rates at designated reference sites that are representative of the post mining land use* ■ *vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass* *… topsoil has been respread to a suitable depth in rehabilitated areas to sustain the post mining land use specified in Table F2 of the EA (dump tops)* ■ *soil surface crusting occurs in less than 2% of the rehabilitated domain area*	Primary transect sampling likely to cover some of requirements to address the completion criteria, with some exceptions. Proportion of groundcover veg, litter and bare earth monitored within 10x1m2 quadrats.	Continue with primary transect based sampling. Consider including: ■ Basic soil analysis to inform water infiltration, aggregate stability, nutrient cycling etc. ■ Widen habitat assessment to consider recording crusting	Completed.
Establish specified self-sustaining	*Species in rehabilitated areas show evidence of flowering, viable seed setting, germination and emergence;*	Primary transect sampling likely to cover some of requirements to	Continue with primary transect based sampling.	Tree heights and density are recorded as part of the

Relevant Rehabilitation Objective (From EA)	Relevant Completion Criteria (from EA)	Assessment of Existing Monitoring Techniques	Initial Assessment & Suggestions	Updates after completing surveys
natural vegetation or habitat	■ *Evidence of generational succession of trees and shrubs is apparent is rehabilitated areas;* ■ *weeds do not dominate native species after disturbance or after rain; and* ■ *pests do not occur in substantial numbers or visibly affect the development of native plant species.* *vegetation established in accordance with post-mining land use given in Table F2 of the EA (dump tops)* *densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites* ■ *community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites;* ■ *non-native cover crop grass species constitute no more than 20% of the area of total vegetative cover; and* ■ *native tree, shrub and grass species which are representative of surrounding ecosystems and which will support the post-*	address the completion criteria, with some exceptions. Weeds and pest species likely to be recorded. Densities of tree, shrub and grass species are recorded, as is community structure and native/non-native species, and can be compared to reference sites.	Consider including: ■ Indication of successional processes ■ Ensure full flora list is collated for each stratum, down to species level	monitoring, however the presence of reproductive features, and number of seedlings was not recorded. Recommend to include these in future monitoring. A full flora list is provided (down to species level where able).

Relevant Rehabilitation Objective (From EA)	Relevant Completion Criteria (from EA)	Assessment of Existing Monitoring Techniques	Initial Assessment & Suggestions	Updates after completing surveys
	mine land use are to constitute 80% of the area of established vegetative cover.			
Establish land use with comparable management requirements to similarly used non-mining land	*for areas established to cattle grazing:* ■ *Cattle stocking rate is comparable to designated reference sites;* *and for areas established to regional ecosystems:* ■ *densities of native tree, shrub and grass species are representative of the target Regional Ecosystems as determined through comparison with designated reference sites;* ■ *community structure (groundcover, shrub and tree layers) are representative of the target Regional Ecosystems as determined through comparison with designated reference sites;* ■ *non-native cover crop grass species constitute no more than 20% of the area of total vegetative cover; and* ■ *native tree, shrub and grass species which are representative of surrounding ecosystems and which will support the post-mine land use are to constitute 80% of the area of established vegetative cover.*	Primary transect sampling likely to cover some of requirements to address the completion criteria, particularly for regional ecosystems. Densities of tree, shrub and grass species are recorded, as is community structure and native/non-native species, and can be compared to reference sites.	Continue with primary transect based sampling. Consider including: ■ An indicator of pasture yield to establish cattle stocking rates comparisons (either using photo standards or direct pasture yields) ■ Ensure full flora list is collated for each stratum, down to species level.	Photo-standards were utilised (from the Queensland Government) and a full flora list is provided (down to species level where able).

3. DEVELOPMENT OF REVISED MONITORING PROGRAM

The revised monitoring framework developed on the basis of reviewing the existing program, monitoring reports, the EA, best practice and site consultation, is outlined in the following sections. The revised framework is intended to address a number of key concerns highlighted in the review, nominally around sampling density and linkage between monitoring techniques (and information collected) and the EA completion criteria. Ongoing annual review of the revised framework is recommended.

Given revised methodology was proposed for the 2021 monitoring event, it was agreed with site to complete monitoring for all the rehabilitation areas this year.

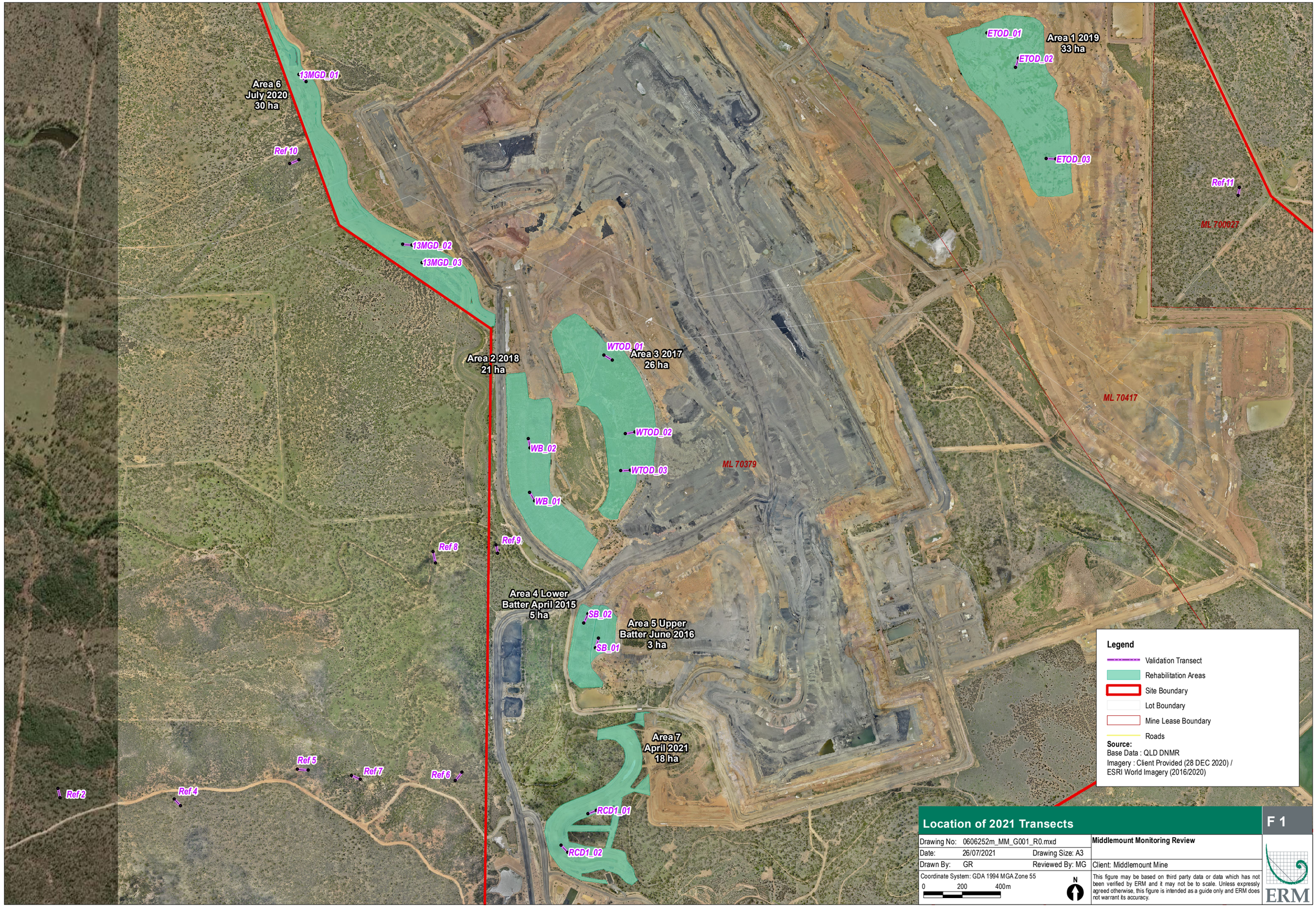
3.1 Establishment of monitoring locations

Transect based sampling is widely used in industry to monitor rehabilitation. For MCM, a sampling intensity of one transect per ten hectares has been adopted. This is consistent with the sampling density of one sample per 4ha-16ha for mapping scales of 1:10,000-1:20,000, respectively, as recommended by Neldner et al. (2020), for sampling of remnant vegetation in Queensland.

It is recommended that the transect start points be randomly selected, and that the transect runs diagonally across the slope. This will prevent coinciding with rehabilitation patterns that typically align with the contour of the slope itself, such as topsoil spreading or seeding equipment passes, as well as erosion features that typically run downslope. To avoid edge effects, randomly selected sites that fall within 20m of the edge of a rehabilitation area or disturbance features will be relocated. Photo points will be established at the start and end of each transect, aimed down the centreline. Three reference sites within particular Regional Ecosystem (RE) vegetation communities are stipulated within the existing EA for certain mining domains (as per Table G5: Reference Sites in the EA). These sites were chosen prior to the development of the mine and assume that edaphic and other conditions within the rehabilitated sites will approximate those in the reference sites. However, there were no replicate transects specified within a single RE community, and so the establishment of further reference site locations, within the same REs, was completed, so as to ensure the reference data is representative and is more capable of showing or capturing variability within a single RE community. As rehabilitation progresses and long term monitoring information continues to be collected, it may be necessary to re-assess the suitability of the reference sites given physical and vegetative constraints of rehabilitation.

The transect monitoring locations (for both rehabilitation and reference sites) for the 2021 monitoring event are provided in Figure 1. The location of the reference sites within the required REs is provided in Figure 2.

This program should be checked annually (noting a formal review is required every three years under the EA), to ensure the area to be monitored (in hectares) is aligned with the latest site plan or schedule for the completion of new rehabilitation areas.



Location of 2021 Transects

F 1

Drawing No:	0606252m_MM_G001_R0.mxd		**Middlemount Monitoring Review**
Date:	26/07/2021	Drawing Size: A3	
Drawn By:	GR	Reviewed By: MG	Client: Middlemount Mine

Coordinate System: GDA 1994 MGA Zone 55

0 200 400m

N

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

ERM

Area 6
Area 1
Area 3
Area 2
Area 4
Area 5
Area 7
ML 700014
ML 700027
ML 70379
ML 70417
13MGD_01
13MGD_02
13MGD_03
ETOD_01
ETOD_02
ETOD_03
WTOD_01
WTOD_02
WTOD_03
WB_01
WB_02
SB_01
SB_02
RCD1_01
RCD1_02
Ref 2
Ref 4
Ref 5
Ref 6
Ref 7
Ref 8
Ref 9
Ref 10
Ref 11

Legend

- Validation Transect
- Rehabilitation Areas
- Site Boundary
- Mine Lease Boundary

Regional Ecosystem

- 11.12.1
- 11.12.2
- 11.3.1
- 11.3.1/11.3.2
- 11.3.2
- 11.3.2/11.3.21
- 11.3.2/11.3.7
- 11.3.25
- 11.3.27
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- 11.4.9
- 11.4.9/11.4.8
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- 11.5.3
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- 11.5.9/11.5.18
- 11.7.2/11.5.18
- 11.7.2/11.7.1
- 11.7.2/11.7.4
- 11.7.4/11.5.18

<bol>Source:</bol>
Base Data & RE Mapping : QLD DNMR
Imagery : Client Provided (28 DEC 2020) / ESRI World Imagery (2016/2020)

Regional Ecosystem Mapping

F 2

Drawing No: 0606252m_MM_G003_R0.mxd		Middlemount Rehabilitation Monitoring
Date: 30/07/2021	Drawing Size: A3	
Drawn By: GR	Reviewed By: MG	Client: Middlemount Mine

Coordinate System: GDA 1994 MGA Zone 55
0 200 400 600m
N

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

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3.2 Monitoring Timing and Frequency

Monitoring should occur at the end of the 'wet season', nominally between March and May, when the presence of diagnostic parts (flowers, above ground parts) for many grasses, annuals, and other species is at its optimum. It will also enable an accurate assessment of erosion features, and understanding of the impact of surface water movement across the rehabilitated landscapes following the previous wet summer season.

Monitoring of rehabilitation is recommended at years 1, 2, 3, 5, 10 and 15, reflecting that the most rapid vegetation development, and options for early intervention, occurs in the early stages of establishment. While vegetation on rehabilitated sites is expected to develop relatively quickly, requiring frequent monitoring, vegetation in reference sites is mature, and is not expected to show significant changes from year to year. The frequency of monitoring in reference sites can therefore be completed once every 5 years. Note that where major rework is required, the year of the rework should be considered as Year 1 for the purpose of the rehabilitation monitoring scheduling. A recommended schedule for the completion of monitoring activities is provided in Section *5*.

The frequency of specific components of the monitoring are outlined below:

- Slope assessments – to be completed every monitoring event to ensure compliance with specific slope criteria prescribed in the EA (Table G1: Landform Design Criteria). This should be done using the latest available LiDAR for the site, assessed against the Landform Design Criteria.

Table G1: Landform Design Criteria

Disturbance Type	Maximum Projective Surface Area (ha)	Maximum Slope	Vertical Height Range (m)
Elevated Landforms	853	< 18.5%	0-64
Infrastructure Areas	112	< 5%	0-15

Soil sampling – to be completed during Year 1 to provide baseline information, then the need for additional sampling should be considered every five years, as soil chemistry is unlikely to show rapid changes. Although not considered essential, follow up soil sampling will determine if the growth media is maturing with time, so as to support establishment and growth of desirable species. Monitoring results may also indicate amelioration / maintenance requirements. Periodic ongoing monitoring may also ascertain effectiveness of amelioration, nitrogen fixation, emergence or leaching of salts in the soil profile, among other soil characteristics and processes. It is considered valid to initially review the condition and status of rehabilitation overall, and then progress soil sampling primarily (or only) for areas where concern is held as to the progression towards acceptable completion criteria.

- Persistent areas of bare ground – surface areas in which vegetation establishment has failed over five years, or where distinct dieback is apparent over three consecutive years, should be sampled to identify possible issues with growth media.

These requirements should be assessed prior to each annual monitoring event and be built into the program as appropriate.

4. MONITORING PROGRAM METHODOLOGY

4.1 Field Data Collection

4.1.1 Site Establishment

Monitoring transect start locations are to be randomly established within rehabilitation areas, for example, using a GIS tool prior to field work, then verified and confirmed by field technicians. Transects of 50m length should be laid out diagonally across the slope. Vegetation is to be assessed on and within 5m of each side of each transect, resulting in a 500m^2 assessment area. Metal star pickets are to be driven into the start and end points of each transect. The assessment area is divided into five blocks of 10m length each as sub-units for recording a range of vegetation variables (see below). Quadrats (1m x 1m) will be established at 10m intervals along each transect for cover monitoring.

Photo points are established at the start and end of each transect, aimed down the centre line. All field data will be captured using tablets with GIS capabilities, to ensure accurate recording of the GPS locations of the transects, and of any significant issues to be recorded. This data is recommended to be maintained in a GIS database onsite for ease of management. Relevant data is also entered into spreadsheets to allow data handling, analyses, display, and management post-monitoring.

4.2 Rehabilitation Objectives

The following steps of the updated methodology (outlined in Table 1) have been grouped according to which rehabilitation objective they help meet. There is some minor duplication, but this serves to highlight how interrelated the variables are, and how critical they are to achieving rehabilitation objectives.

Very low probability of subsidence or rock fails, or slope slippage, with serious consequences and landform design achieves appropriate erosion rates.

- Assessment of slope angles and lengths for compliance with site-specific criteria using LiDAR survey data.
- Assessment of sediment deposition, so as to comply with EA Condition G2 (preventing contaminant release to land) and assess erosional stability of slopes, using LiDAR survey data to show areas and extent of erosion and deposition. Note that this was not completed during the pre-work this year due to time constraints for field surveys, but should be incorporated moving forward.
- Identification of any areas of persistent bare ground in rehabilitation five years old or greater.
- Assessment of any factors that may have adversely affected rehabilitation areas including drought, fire, predation by insects, excessive grazing, unauthorised vehicle traffic, vegetation die-back, or soil disturbance/ burrowing caused by pest animals (e.g. pigs or rabbits).
- Habitat complexity is to be measured at each transect at the start of the transect (0m), the centre of the transect (25m) and at the end of the transect (50m) to obtain representative data of the habitat complexity for the area. The assessment should be conducted visually and identify:
    - Canopy (tree and shrub) cover percentage;
    - Ground cover percentage;
    - Logs, rocks and woody debris cover percentage;
    - Free standing water and available soil moisture; and

- Tree hollows (as visible from each monitoring assessment point along the transect).

- Visual signs of erosion within, or in close proximity to the transect, are recorded as per the *Australian Soil and Land Survey – Field Handbook 3rd edition (2009)*, including, for example, whether erosion is active or stable, the depth of erosion, erosion type, among other erosion characteristics. Where rills and/or gullies are recorded, the start and end points along the transect (position) and the depth (in cm) for each feature are recorded.
- Cover composition is to be recorded in 1m x 1m quadrats placed at 10m intervals along the transect. Variables recorded in each quadrat include percentage overall of basal/ live material, litter, bare ground, cryptograms, and competent rock (greater than 50mm diameter), for a total of 100 percent. Biomass for grasses should be estimated using relevant photo standards, whilst basal cover should be estimated using the point frame method.

Polluted water contained on site or treated.

- Groundwater and surface water monitoring records were unable to be incorporated due to time constraints but should be in future monitoring events.

Adequate vegetation cover established to minimise erosion.

- Review of climate data (preferably from the site weather station, or alternatively from the nearest weather observation station), including records of recent rainfall events, intensity, duration and relationship to the time of seeding. Seed germination and vegetation establishment success in the Bowen Basin is strongly reliant on rainfall. Rainfall following cultivation and prior to seeding can result in surface crusting and subsequent poor germination strike. Rainfall initiated germination followed by a period of hot, dry weather can result in desiccation and death of emerging seedlings. Regular light rainfall events following seeding will likely result in successful germination and vegetation establishment.
- Cover composition is to be recorded in 1m x 1m quadrats placed at 10m intervals along the transect. Variables recorded in each quadrat include percentage overall of basal/ live material, litter, bare ground, cryptograms, and competent rock (greater than 50mm diameter), for a total of 100 percent. Biomass for grasses should be estimated using relevant photo standards, whilst basal cover should be estimated using the point frame method.
- Habitat complexity is to be measured at each transect at the start of the transect (0m), the centre of the transect (25m) and at the end of the transect (50m) to obtain representative data of the habitat complexity for the area. The assessment should be conducted visually and identify:
  - Canopy (tree and shrub) cover percentage;
  - Ground cover percentage;
  - Logs, rocks and woody debris cover percentage;
  - Free standing water and available soil moisture; and
  - Tree hollows (as visible from each monitoring assessment point along the transect).

Visual signs of erosion within, or in close proximity to the transect, are recorded as per the *Australian Soil and Land Survey – Field Handbook 3rd edition (2009)*, including, for example, whether erosion is active or stable, the depth of erosion, erosion type, among other erosion characteristics. Where rills and/or gullies are recorded, the start and end points along the transect (position) and the depth (in cm) for each feature are recorded.

Soil properties that support and will continue to support the desired final land use.

- Top soil samples are collected for subsequent soil analysis as described below:

1. At 10m intervals along the transect, a hole is dug using a stainless steel hand trowel to a depth of 100mm;
2. A sample of the hole wall is taken from 0 to 100mm (as a representation of the topsoil profile), collected in a container, and mixed once all five samples had been collected, creating one bulk soil sample per transect;
3. Approximately 200g of the bulk soil sample is bagged in a plastic ziplock bag, and sent for chemical analysis at a NATA-accredited laboratory, with the following analytes tested:
    a. pH;
    b. Electrical Conductivity at 25°C (EC, expressed in µS/cm);
    c. Sulphate as SO_4 (expressed in mg/kg);
    d. Chloride (expressed in mg/kg);
    e. Organic Matter (expressed in mg/kg);
    f. Total Nitrogen as N (expressed in mg/kg);
    g. Nitrate as N (in solution, expressed in mg/kg);
    h. Total Phosphorus as P (expressed in mg/kg);
    i. Cation Exchange Capacity and levels of exchangeable cations (Ca, Mg, K, Na) (expressed in m_{eq}/100g);
    j. Exchangeable Sodium Percent (ESP, expressed as a percentage);
    k. Emerson class, texture and colour and
    l. Extractable metals (Cu, Fe, Mn, Zn).

It is recommended to incorporate the full Agricultural suite moving forward, which provides further data on the fertility of the soil such as extractable potassium and phosphorus, ammonia as N, and exchangeable cations, in a discounted suite.

The amount (or presence), type and quality of the growth medium used in rehabilitation activities are factors that influence vegetation establishment, and therefore rehabilitation success. In relation to soil chemical properties in rehabilitation areas, general ideal criteria to be achieved are listed in Error! Reference source not found..

Table 2 Ideal Criteria for Key Soil Chemical Properties

Parameter	Land use – Pasture	Land use – Woodland
pH	5.5 – 7.5	5.0 – 8.5
EC (µS/cm)	< 700	< 700
Sulphates (mg/kg)	5 – 10	5 – 10
Nitrates (mg/kg)	> 12.5	> 12.5
Total Nitrogen (mg/kg)	200-1000	200-1000

Parameter	Land use – Pasture	Land use – Woodland
Phosphorus (mg/kg)	≥ 50	≥ 50
Chloride (mg/kg)	< 350	< 350
Cation Exchange Capacity (CEC) and Exchangeable cations (m_{eq}/100g)	>5	>5
Exchangeable Sodium Percentage (ESP) (%)	< 5	< 5
Organic Matter (mg/kg)	2-3	2-3

A brief interpretation of key chemical attributes of soils tested during this monitoring program (and how they underpin rehabilitation performance and plant establishment success) is provided below:

- Soil pH largely regulates the availability of nutrients to plants. A soil pH range of 5 – 8 is generally considered conducive to adequate plant growth for most species (Lake, 2000; Burns, 2005);
- Soil salinity inhibits plants growth for two reasons: by reducing the ability of the plants to take up water and by entering the transpiration stream of plants, thereby injuring plant cells in the transpiring leaves (Munns, 2002). Therefore, soil salinity can prevent seed germination, retard plant growth, reducing ecosystem diversity (DITR, 2006). Soils having an EC over 4000 µS/cm are considered saline (Munns, 2002);
- CEC is the capacity of the soil to hold and exchange cations, and is an important driver of stability of soil structure, nutrient availability for plant growth, soil pH, and the soil's reaction to fertilisers and other ameliorants. A CEC over 5 meq/100g is considered adequate and indicates a moderate/good capacity of the soil to retain nutrients (Hazelton and Murphy, 2007);
- Sodicity (measured as ESP) refers to a condition where a high proportion of readily soluble sodium is present in soil, affecting its structural stability, reducing infiltration rates and soil moisture holding capacity and increasing soil strength to the point where plant growth is affected (Rangasamy et al, 2010). Soil sodicity affects plant establishment by restricting root development and access to nutrients. Additionally, higher soil sodicity leads to an increasing potential for the development of erosion (DITR, 2006). Soils with ESP less than 6% are considered non-sodic, those where ESP is ranges between 6 – 15% are slightly to moderately sodic, and those with ESP over 15% are highly sodic;
- Soil fertility can be quantified through the levels of key nutrients and organic matter (or organic carbon) present in the soil. Of the available nutrients, N, P and K are important as they usually are the limiting nutrients for the growth of most plants. Sulphur is also a key nutrient in pasture communities. A critical range for extractable Sulphur is 5 – 10 mg/kg (Lewis 1999)
- The levels of chloride and sulphates in soils are usually tested to detect potential toxicities that would impede healthy plant growth. Chloride levels over 350 mg/kg are considered toxic and can cause severe problems to plants (e.g. severely limited growth, leaf necrosis), while sulphate levels over 3000 mg/kg can lead to soil acidification and plant death.
- Organic matter assists not only by providing habitat for organisms in the soil improving soil structure, but also by increasing organic nitrogen supply. The CEC of the soil is also likely to increase with time (Baker et al, 1993; Hazelton & Murphy, 2007).

- Cover composition is to be recorded in 1m x 1m quadrats placed at 10m intervals along the transect. Variables recorded in each quadrat include percentage overall of basal/ live material, litter, bare ground, cryptograms, and competent rock (greater than 50mm diameter), for a total of 100 percent. Biomass for grasses should be estimated using relevant photo standards, whilst basal cover should be estimated using the point frame method.

Establish specified self-sustaining natural vegetation or habitat

- Ground cover, shrub and tree species are identified and recorded by the first block in which they are encountered, to allow for species area curves to be calculated. For each species, the following information should be recorded:
  - Species name (scientific to at least genus, but ideally to species level where possible);
  - Location on transect of first encounter (block);
  - Native / Introduced / Declared weed; and
- The height and number of each woody plant species (shrubs and trees) recorded in the block over 2m in height (for example, using a clinometer).Descriptive statistics and accompanying graphs should be completed for vegetation biodiversity and cover condition for each rehabilitation area, covering the following:
  - Species Richness: The total number of species, accumulating across the length of the transect;
  - Native / Introduced Species: The proportion of native to introduced species. This information is particularly important where native ecosystem is the designated post-mining land use; and
  - Ground Cover Distribution: The percentage of each cover type (live material/ basal, litter, bare ground, cryptograms, and competent rock) as an average across the length of the transect.
- Increased sampling intensity of reference sites to ensure representativeness and establish a range of reference values to apply to rehabilitation.

5. MONITORING PROGRAM SCHEDULE

Table 3 shows which rehabilitation areas should be included in the ongoing rehabilitation monitoring program for all current and future anticipated rehabilitation areas at MCM, and is current for the 2021 year. The schedule is aligned to both the sampling density and also frequency for monitoring to be completed over time. This should be updated annually as rehabilitation is completed (and therefore new rehabilitation areas confirmed), as well as ensuring any changes to the schedule is captured.

Middlemount Coal - Rehabilitation Monitoring Program Schedule

	Transect identifier	RE (reference sites)	Rehabilitation Completion Year	Area (ha)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Middlemount Coal Rehabilitation																								
Reference sites	*Ref 1*									NC					√					√				
	Ref 2	11.5.9b/ 11.5.18								√					√					√				
	Ref 3									NC					√					√				
	Ref 4	11.5.9b/ 11.5.18								√					√					√				
	Ref 5	11.7.2/ 11.7.1								√					√					√				
	Ref 6	11.3.2/ 11.3.7								√					√					√				
	Ref 7	11.7.2/ 11.7.1								√					√					√				
	Ref 8	11.3.25								√					√					√				
	Ref 9	11.3.25								√					√					√				
	Ref 10	11.3.1/ 11.3.2								√					√					√				
	Ref 11	11.5.3								√					√					√				
Diversions (Roper Ck and 13 Mile Gully)	RCD1_01		2021	17						√	Y1	Y2	Y3		Y5					Y10				
	RCD1_02									√	Y1	Y2	Y3		Y5					Y10				
	13MGD_01		2020	30						√	Y2	Y3		Y5					Y10					
	13MGD_02									√	Y2	Y3		Y5					Y10					
	13MGD_03									√	Y2	Y3		Y5					Y10					
Western Batter	WB_01		2018	21				Y1	Y2	√		Y5					Y10							
	WB_02							Y1	Y2	√		Y5					Y10							
Southern Batter	SB_01		2015/ 2016	7		Y1	Y2	Y3		√					Y10									
	SB_02					Y1	Y2	Y3		√					Y10									
Western Top of Dump	WTOD_01		2017	26			Y1	Y2	Y3	√	Y5					Y10								
	WTOD_02						Y1	Y2	Y3	√	Y5					Y10								
	WTOD_03						Y1	Y2	Y3	√	Y5					Y10								
Eastern Top of Dump	ETOD_01		2019	33					Y1	√	Y3		Y5					Y10						
	ETOD_02								Y1	√	Y3		Y5					Y10						
	ETOD_03								Y1	√	Y3		Y5					Y10						
add forecasted areas																								

Table Legend: Y1 – Year 1; Y2 – Year 2; Y5 – Year 5; Y10+ – Year 10+; U – Unknown (age of rehabilitation); NC - Not Completed

*** Note the monitoring frequency/ survey year has been reset for all rehabilitated areas at Middlemount.*

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MIDDLEMOUNT COAL MINE

SOUTHERN EXTENSION PROJECT
Environmental Values Assessment

APPENDIX A
Surface Water Assessment

September 2020

middlemount coal PTY LTD
ABN 49 122 348 412

Middlemount Coal Mine

Southern Extension Project
Surface Water Impact Assessment

Middlemount Coal Pty Ltd

0469-29-J4, 3 September 2020

Report Title	Middlemount Coal Mine Southern Extension Project Surface Water Impact Assessment
Client	Middlemount Coal Pty Ltd
Report Number	0469-29-J4

Revision Number	Report Date	Report Author	Reviewer
4	3 September 2020	MGB	GR

For and on behalf of WRM Water & Environment Pty Ltd
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1 Introduction

1.1 BACKGROUND

Middlemount Coal Pty Ltd (MCPL) owns and operates the Middlemount Coal Mine, an existing open cut coal mine, located approximately 7 kilometres (km) to the south-west of the Middlemount township within the Isaac Regional Local Government Area, Queensland. The location of the mine is shown in Figure 1.1.

The Middlemount Coal Mine Environmental Authority (EA) was amended on 29 June 2012 to approve the expansion of open cut mining operations within Mining Leases (ML) 70379 and 70417 (referred to as "Stage 2" of the Middlemount Coal Mine). Stage 2 allows for open cut mining of run-of-mine (ROM) coal up to 24 hours per day, seven days per week, using a conventional truck and shovel fleet at a rate of up to 5.4 million tonnes per annum (Mtpa).

Minor amendments to the EA were made on 22 August 2017 and 21 May 2018 for various minor changes, including conditions to enable exploration activities in the extended northwest portion of ML 70739. An amendment to the Middlemount Coal Mine EA was granted on 21 March 2019 to extend the open cut pit within ML 70379 to the north-west, increase ROM coal throughput to 5.7 Mtpa and expand the East Dump in ML 700014 and ML 700027 (the Western Extension Project).

ROM coal is mined in a general west to east direction within ML 70379, with overburden and interburden material emplaced in-pit behind the advancing open cut operations, and within the East Dump, located within ML 70417 and ML 700014. Up to 5.7 Mtpa of ROM coal is processed through a coal handling and preparation plant (CHPP) to produce Pulverised Coal Injection (PCI) and coking coal (and small amounts of thermal coal) for the export market. Product coal is transported by rail to the Dalrymple Bay Coal Terminal and Abbot Point Coal Terminal.

1.2 PROJECT DESCRIPTION

MCPL is seeking Queensland Government and Commonwealth Government approval for changes to the approved Middlemount Coal Mine, herein referred to as the Southern Extension Project (the Project). The Project involves extension within ML 70379 and ML 70417 to the south and extension of waste rock emplacement areas within ML 70014, ML700027 and ML 70417. The main activities associated with the development of the Project would include:

- extension of the open cut pit to the south within MLs 70379 and 70417;
- continued extraction of ROM coal at up to 5.7 Mtpa using conventional open cut mining equipment;
- placement of waste rock in existing emplacements, expanded emplacements (West Dump and East Dump) and within the mined-out void;
- minor extensions to waste rock emplacements footprint;
- progressive development of sediment dams, pipelines and other water management equipment and structures;
- re-positioning of the approved southern flood levee and water management infrastructure;
- re-alignment and extension of the approved (but not yet constructed) eastern diversion of Roper Creek (Roper Creek Diversion 2) inside the MLs;
- 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;
- extension of the approved mine life by approximately seven years (to 2044); and
- a change to the residual landform for the end of the mine life.

The approximate footprint of the Project is shown in Figure 1.2.

The proposed general layout of the Middlemount Coal Mine in 2023, 2028, 2037, 2043 and for the post-mining landform are shown in Figure 1.3 to Figure 1.7.

1.3 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development gas information guidelines (IESC, 2018) advice on coal seam gas and large coal mining development proposals and outlines where in the document they have been addressed;
- Section 3 describes the drainage characteristics and environmental values of the regional and local drainage receiving waters;
- Section 4 presents the surface water characteristics of the approved (existing) mine site;
- Section 5 describes the surface water management system including the management objectives and principles;
- Section 6 provides a summary of the water balance model results for the mine water management system;
- Section 7 describes the outcomes from the residual void water assessment;
- Section 8 describes the development and calibration of the flood models developed for the assessment;
- Section 9 describes the proposed Roper Creek Diversion 2 realignment and extension and presents the findings of the flood modelling assessment;
- Section 10 describes the outcomes from the impact assessment for surface water and presents the mitigation and management measures;
- Section 11 summarises the outcomes from the surface water assessment;
- Section 12 gives a list of references;
- Appendix A summarises select recent water quality monitoring data as time-series graphs;
- Appendix B describes the mine water balance model configuration;
- Appendix C presents the flood mapping for pre-mining, approved, proposed and post mining conditions;
- Appendix D presents the flood impact mapping between proposed and post mining conditions compared to approved conditions.

Figure 1.1 – Regional location of Middlemount Coal Mine

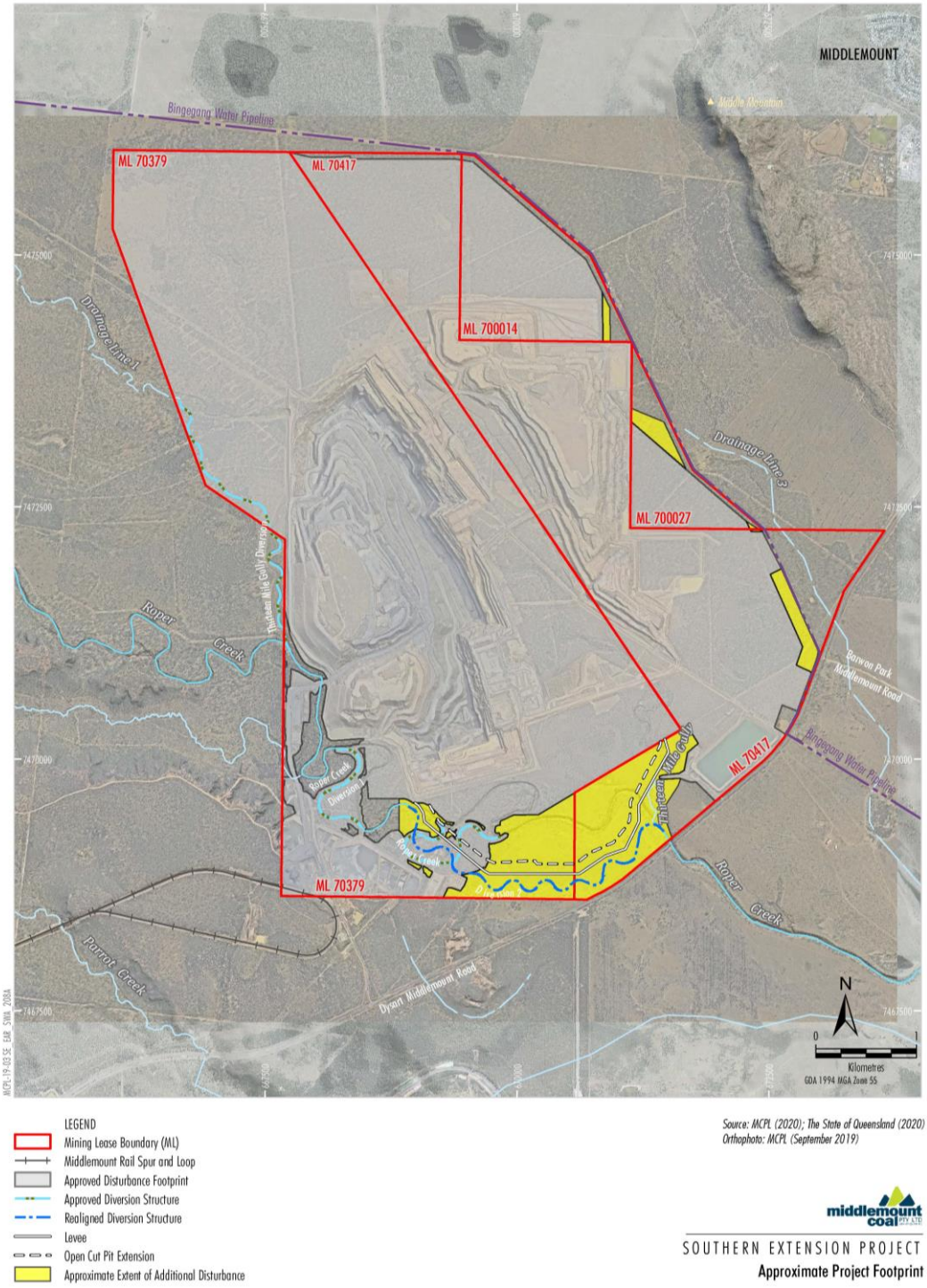

Figure 1.2 – Approximate Project Footprint

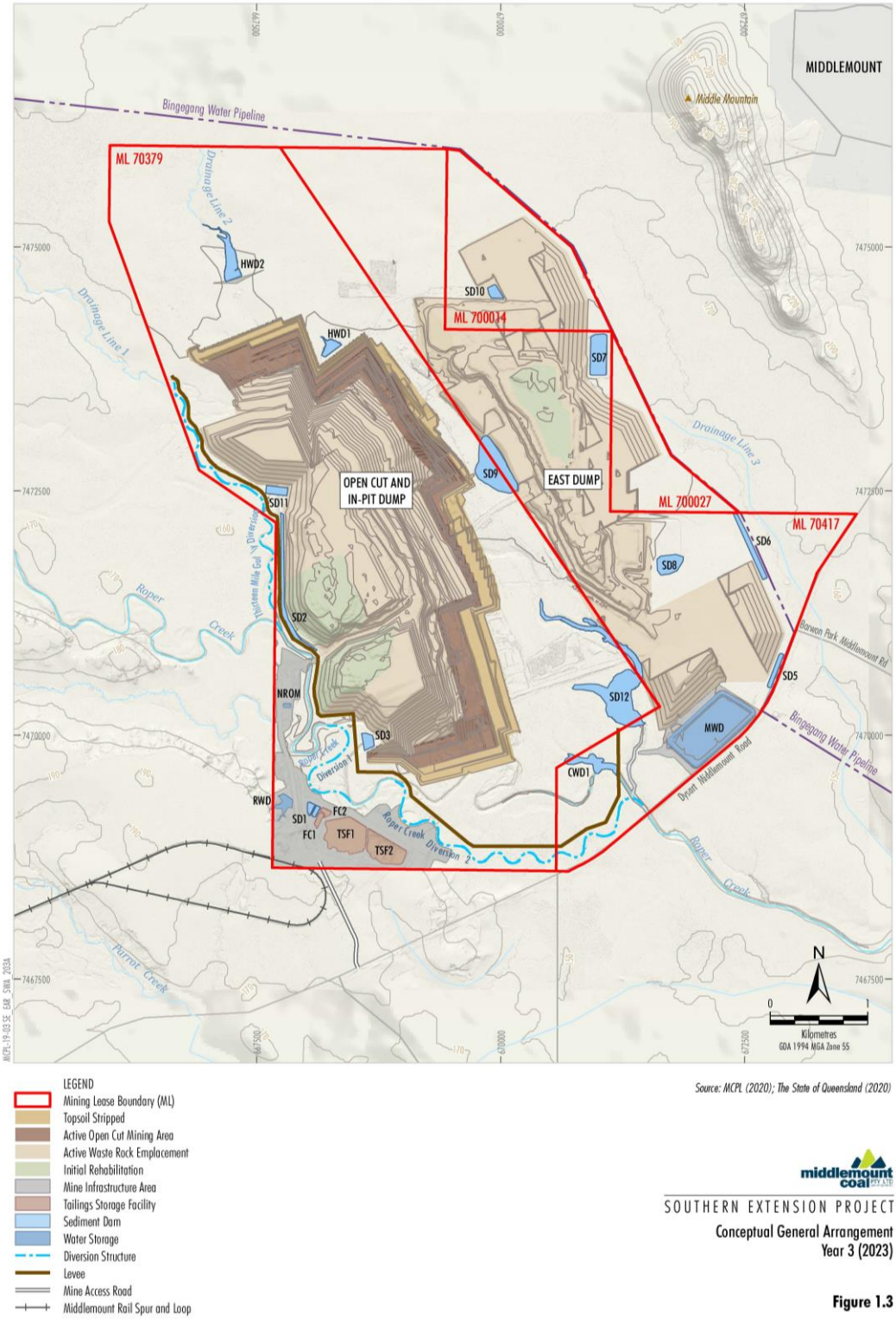

Figure 1.3 – Proposed general layout, Year 3 (2023)

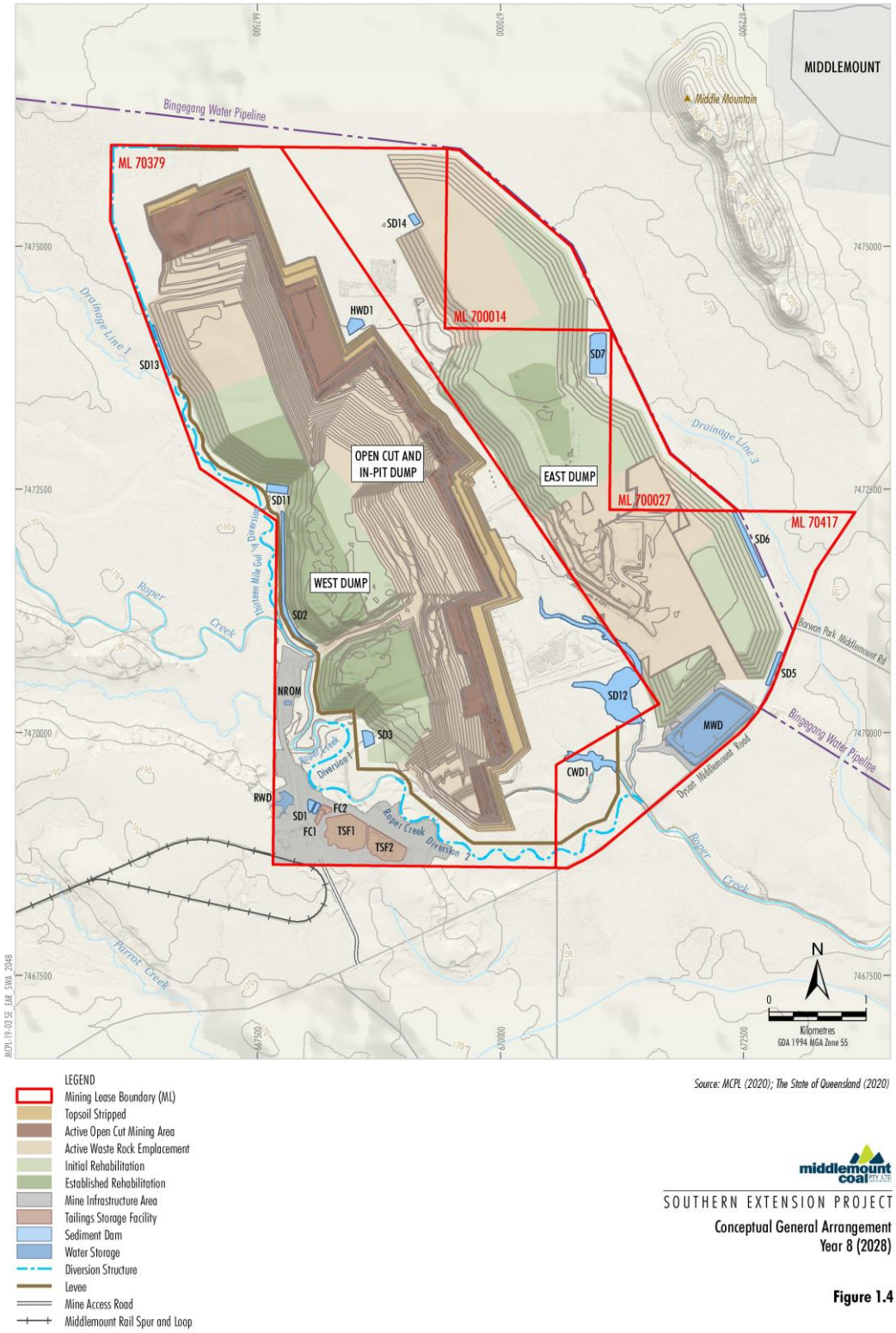

Figure 1.4 – Proposed general layout, Year 8 (2028)

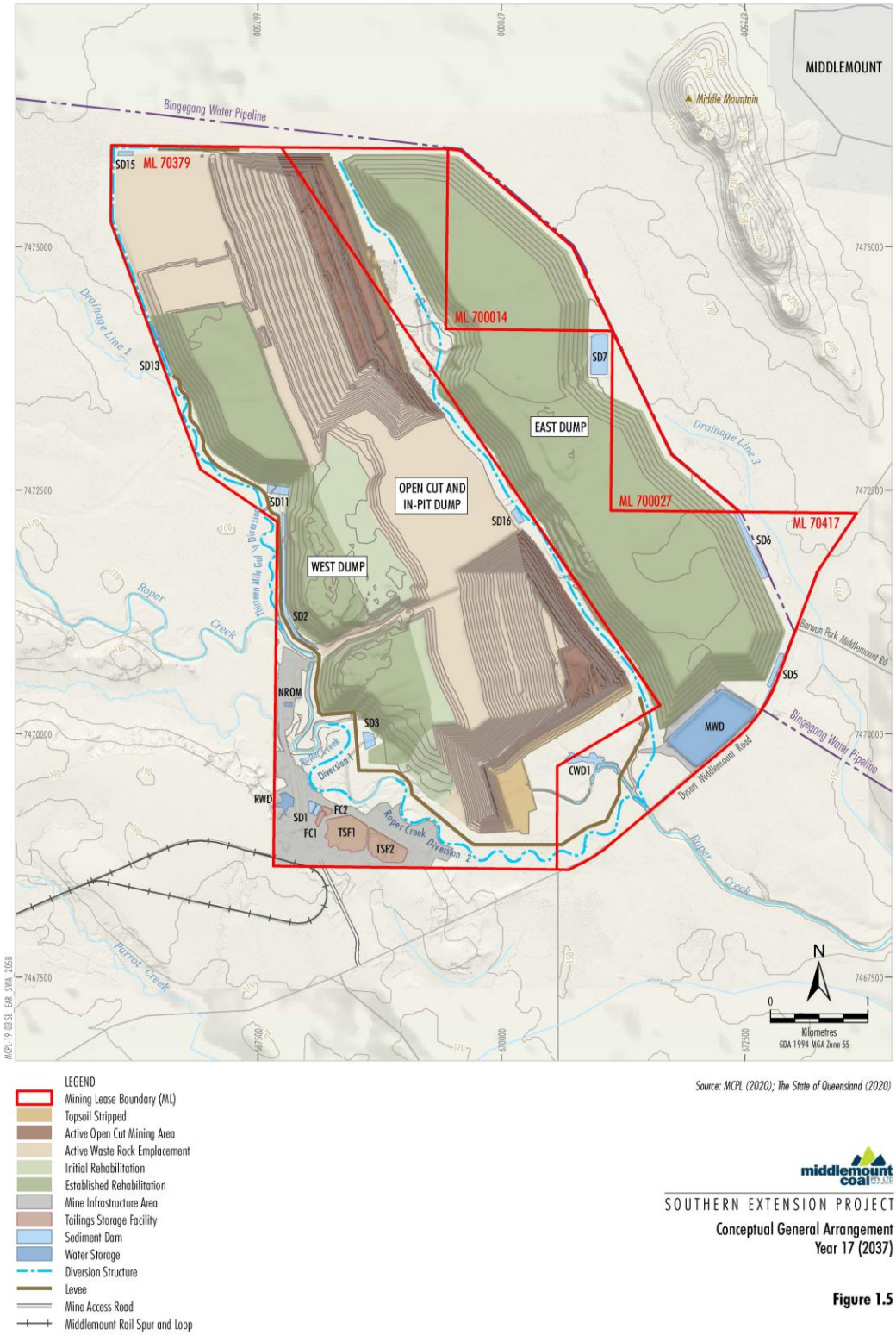

Figure 1.5 – Proposed general layout, Year 17 (2037)

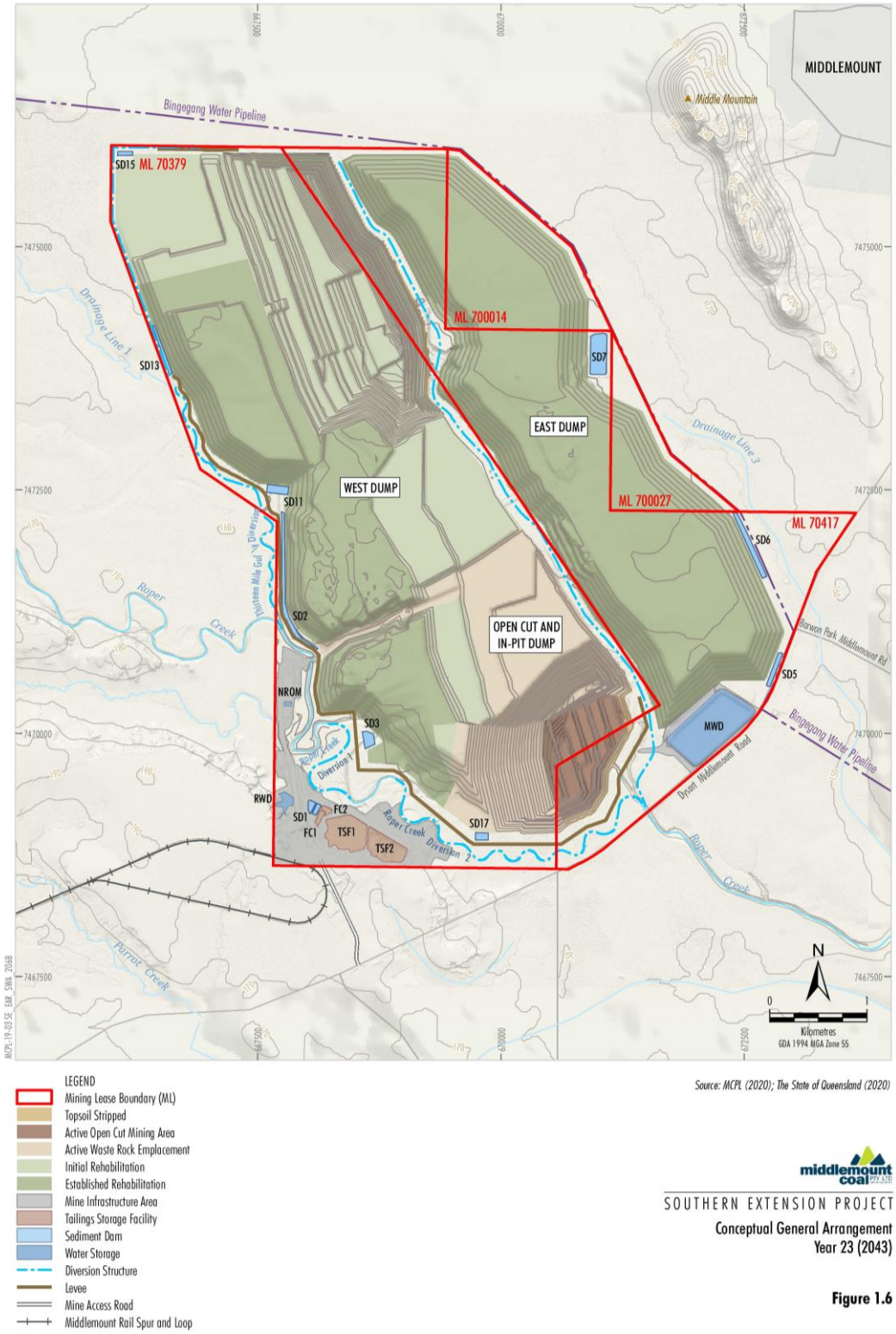

Figure 1.6 – Proposed general layout, Year 23 (2043)

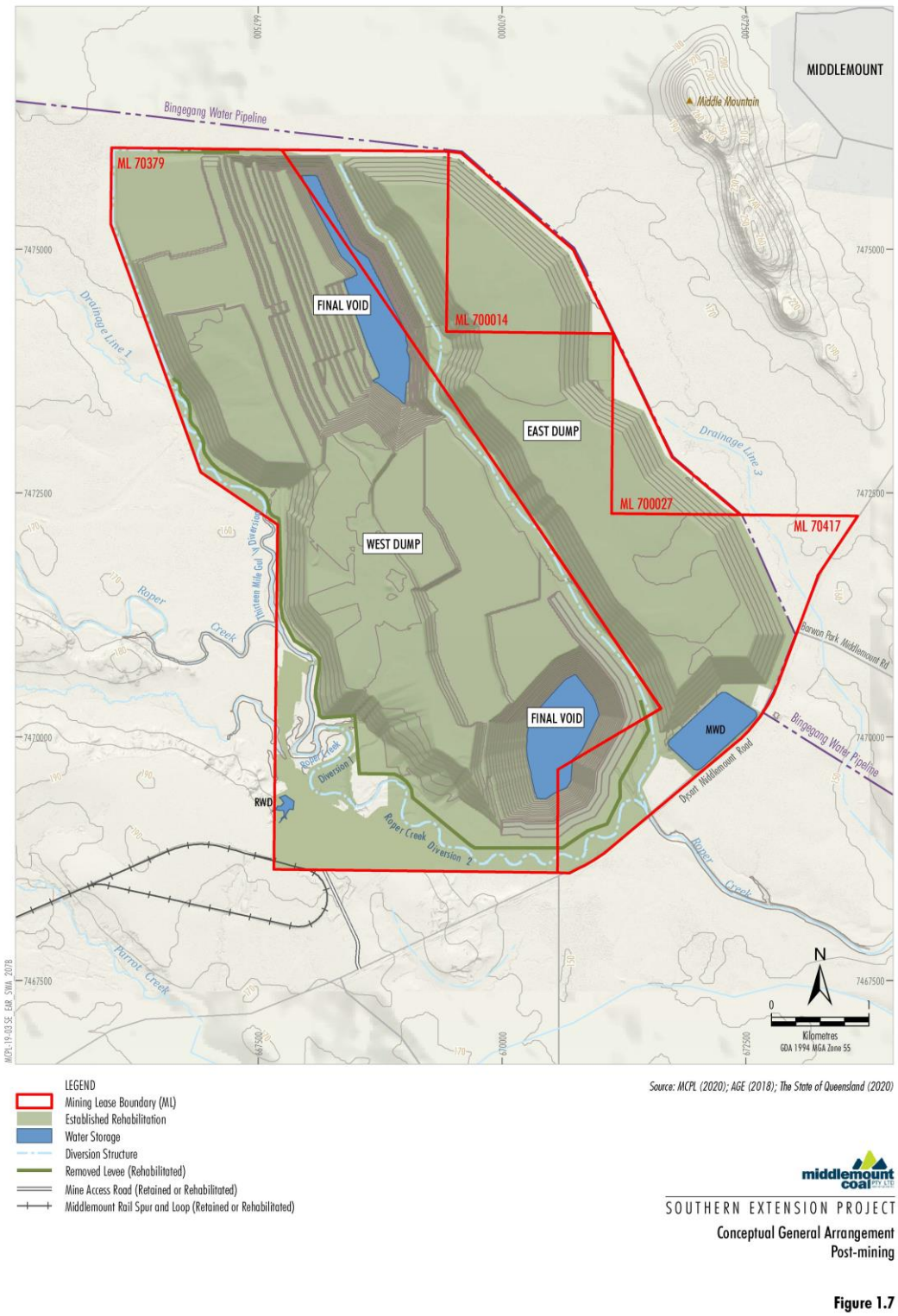

Figure 1.7 – Proposed general layout, Post-mining

2 Independent Expert Scientific Committee guidelines

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development gas information guidelines (IESC, 2018) provides assessment consideration advice on coal seam gas and large coal mining development proposals. The report sections where the IESC information requirements for individual proposals have been addressed are outlined in Table 2.1.

Table 2.1- IESC information requirements

Project information	Report section
Description of the proposal	
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, current and reasonably foreseeable coal mining and CSG developments.	Sections 1, 3, 4 & 5
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, 5 & 6
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Refer to Main Report
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 & 3.8
Surface water - context and conceptualisation	
Describe the hydrological regime of all watercourses, standing waters and springs across the site including:	
• geomorphology, including drainage patterns, sediment regime, and floodplain features;	Section 3.2, 3.3 & 3.4
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 3.3
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 3.6
• current stressors on watercourses, including impacts from any currently approved projects.	Section 3.6 & 3.7
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Section 8 & Appendix C
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater Report

Project information	Report section
Surface water – analytical and numerical modelling	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Appendix B, Appendix C Sections 6 & 8
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Section 8
Develop and describe a program for review and update of the models as more data and information becomes available.	Appendix B1
Describe and justify model assumptions and limitations, and calibrate with appropriate surface water monitoring data.	Section 8.2, 8.4 & Appendix B8
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 6.3
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Models verified against historical data Section 8.2, 8.4, Appendix B8
Surface water – impacts to water resources and water-dependent assets	
Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider:	
• impacts on streamflow under the full range of flow conditions.	Section 9 & 10.4
• impacts associated with surface water diversions.	Section 9
• impacts to water quality, including consideration of mixing zones.	Section 6.3 & 0
• the quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets.	Section 6.3 & 0
• landscape modifications such as subsidence, voids, post rehabilitation landform collapses, onsite earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 7
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 3.7 & 0
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 5.5.2
Propose mitigation actions for each identified significant impact.	Section 5, 8 and 10

Project information	Report section
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 6 & 9
Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 10.6
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Section 9
Surface water – data and monitoring	
Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	Section 4.4
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 4.4
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a describe of data methods, including whether missing data has been patched.	Section 3.3 & Appendix B2
Develop and describe a surface water monitoring programme that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions, and assess the effectiveness of mitigation and management measures. The program will: • include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals). • comparison of physico-chemical data to national/regional guidelines or to site-specific guidelines derived from reference condition monitoring if available. • identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 4.4
Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	Section 3.3
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 4.4
Water-dependent assets – context and conceptualisation	
Identify water-dependent assets, including: • water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). • public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Section 3.8 Refer to Ecology report
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox15 (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
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).	Refer to Groundwater Report

Project information	Report section
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Refer to Groundwater Report
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	Refer to Groundwater Report
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 3.8
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).	Section 5.5.2
Water-dependent assets – impacts, risk assessment and management of risks	
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Refer to Ecology Report & Groundwater Report
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Report
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.	Section 3 & 4
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 7
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.	Section 6.3.5, 6.3.6 & 0
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 10
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 5.5.2
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 10

Project information	Report section
Water-dependent assets – data and monitoring	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	Section 4.4, 5.5.2 and Section 10
Describe the process for regular reporting, review and revisions to the monitoring program.	
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	
Water and salt balance, and water management quality	
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.	Section 6 & Appendix B
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 6 & Appendix B
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.	Section 6
Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	Section 6
Cumulative impacts – context and conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 10.6
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 10.6

Project information	Report section
Cumulative impacts - impacts	
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 10
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.	Section 10.6
Cumulative Impacts - Mitigation, monitoring and management	
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.	
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 10.6
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	

Project information	Report section
Final landform and voids – coal mines	
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.	
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	
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 considers: • 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.	Section 7
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	Section 7 & Section 10
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	Section 3.4 & 4.4
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, encapsulation).	Refer to Geological Report
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.	
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	

3 Catchment hydrology and environmental values

3.1 GENERAL

This section describes the regional drainage characteristics in the vicinity of the Middlemount Coal Mine. The environmental values as defined by the Queensland *Environmental Protection Act 1994* (EP Act), Environmental Protection Policies (EPPs), Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Australian and New Zealand Environment and Conservation Council [ANZECC] & Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) (ANZECC 2000 Guidelines) and regulations of these waterways are also described.

New and revised Default Guideline Values (DGVs) for aquatic ecosystems were published by ANZECC in late 2018. These have been compared against the previous 'trigger values' and updated where appropriate.

3.2 CATCHMENT HYDROLOGY

Middlemount Coal Mine tenement areas are drained by:

- Roper Creek;
- Thirteen Mile Gully Diversion which diverts the upstream sub-catchments of Thirteen Mile Gully (north and west of the ML 70379 boundary – called Drainage line 1 and 2) to Roper Creek;
- Thirteen Mile Gully downstream of the operations; and
- An unnamed tributary of Roper Creek (called Drainage Line 3), which intersects the eastern extent of ML 70417, beyond the extent of the East Dump and joins Roper Creek about 4.2 km downstream of Dysart Middlemount Road.

Figure 3.1 shows the wider locality of the Roper Creek catchment and Figure 3.2 shows the drainage characteristics in the vicinity of the Project. Roper Creek is an ephemeral watercourse flowing for short periods following rainfall. The catchment commences about 35 km to the west of the Project area. The creek traverses in an easterly direction across ML 70379 and ML 70417 before turning south-east to cross Dysart-Middlemount Road, and eventually into the Mackenzie River some 40 km to the south-east of the Project. The Mackenzie River is a major tributary of the Fitzroy River.

The total catchment area of Roper Creek to the downstream boundary of the Middlemount Coal Mine tenements, including the Thirteen Mile Gully catchment, is approximately 389 square kilometres (km^2). The catchment area of Thirteen Mile Gully to its confluence with Roper Creek is approximately 55 km^2. ML 70379, ML 70417 and ML700014 cover an area of approximately 33.8 km^2, or 9% of the Roper Creek catchment to the downstream boundary of ML 70417 and 1.3% of the Roper Creek catchment to its confluence with the Mackenzie River. No water resource development, such as dams or major irrigation infrastructure, is located within the Roper Creek catchment.

The Roper Creek catchment upstream of Dysart-Middlemount Road, to the west of ML 70379, generally consists of moderately disturbed native forests with some cleared grazing land along the waterway corridor. The catchment downstream of Dysart Middlemount Road has been mostly cleared for grazing. Several other coal mines also exist in the catchment, including the southern extent of Norwich Park Mine, Capcoal Complex, Oaky Creek Coal Mine and Foxleigh Coal Mine (see Figure 1.1).

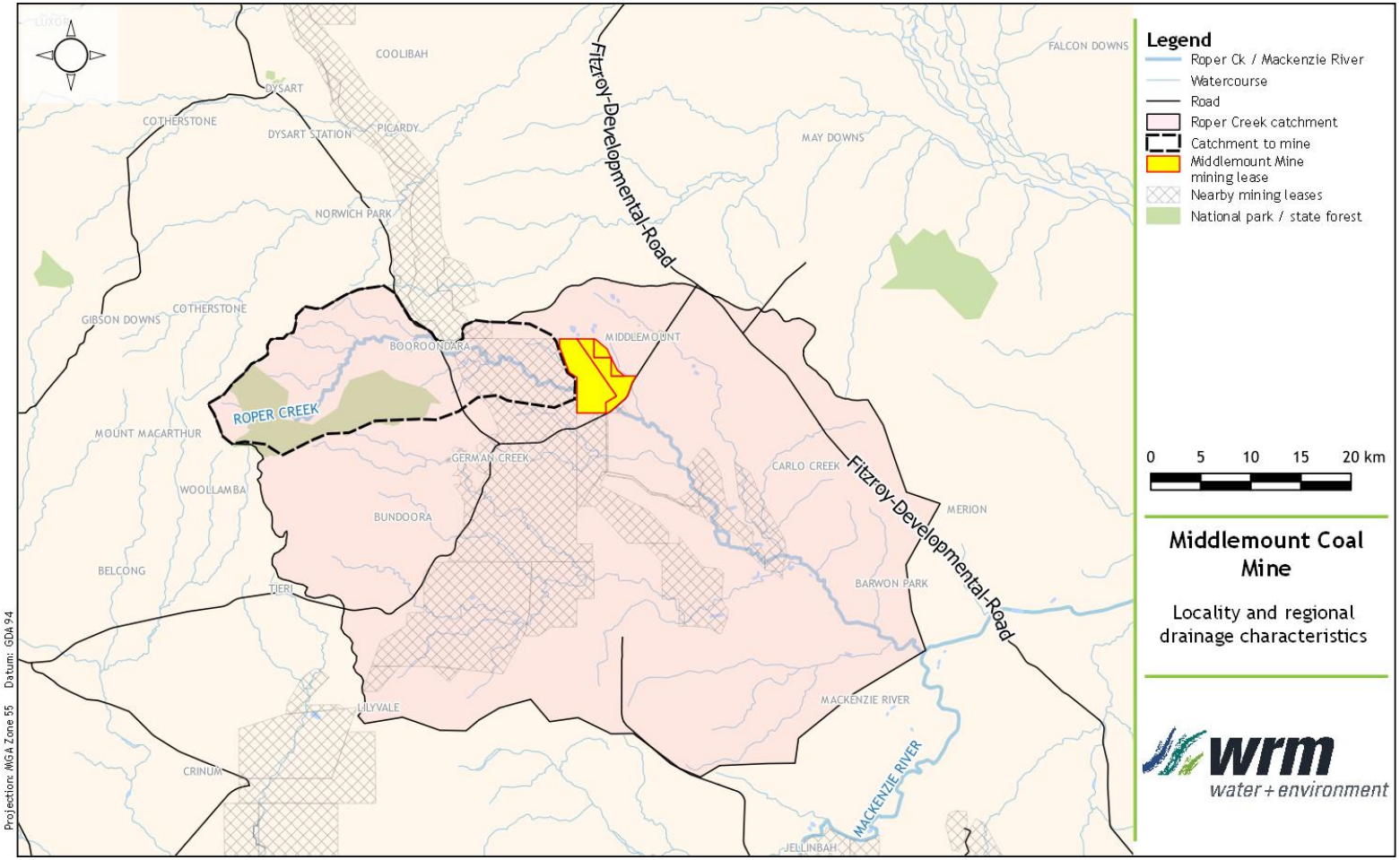

Figure 3.1 – Regional drainage characteristics

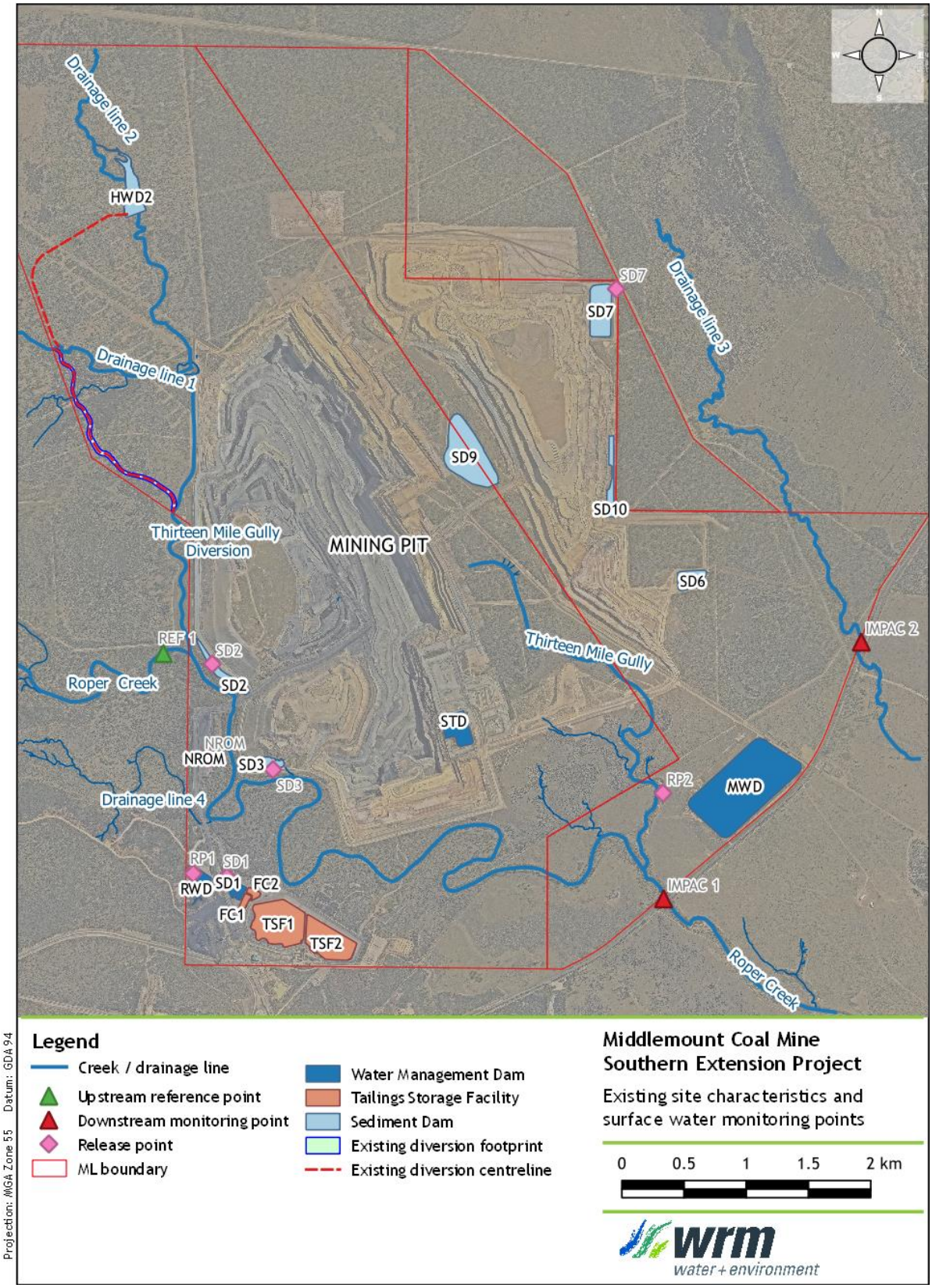

Figure 3.2 – Middlemount Coal Mine existing site characteristics and surface water monitoring locations

Figure 3.2 shows the drainage characteristics of Thirteen Mile Gully in the vicinity of the Project. 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 metres (m) upstream of Dysart Middlemount Road. The upstream sub-catchments of Thirteen Mile Gully were diverted along the western boundary of ML 70379 in late 2014. The realignment of the Thirteen Mile Gully Diversion was approved as part of the Western Extension Project and was completed in July 2020.

Upstream of the diversion, the sub-catchments of Thirteen Mile Gully drain via two drainage features; Drainage Line 1 (to the west) and Drainage Line 2 (to the north). The Department of Natural Resources and Mines (DNRM) confirmed that these drainage lines are not watercourses, rather they are drainage features defined under the *Water Act 2000* that facilitates overland flow (DNRM, 2017). Both of these drainage lines have been redirected around the mine into the Thirteen Mile Gully Diversion.

An unnamed ephemeral tributary of Roper Creek, shown on Figure 3.2 as Drainage Line 3, is located approximately 1 km east and south east of Middlemount Coal Mine. It is poorly defined in some areas upstream of Dysart Middlemount Road, with a channel depth of less than 0.5 m in some locations. The drainage line reappears at Dysart Middlemount Road where it discharges under the road via several box culverts.

Another unnamed ephemeral tributary of Roper Creek, shown on Figure 3.2 as Drainage Line 4, drains into Roper Creek along the western boundary of the mining lease to the north of the mine infrastructure area. It has a catchment area of about 8.7 km^2 and it drains along a relatively well-defined channel. The haul road crosses drainage line 4.

As part of the Southern Extension Project, it is proposed to realign and extend the approved (but not yet constructed) Roper Creek Diversion 2 inside the existing MLs.

3.3 STREAMFLOW

From 1971 to 1988, the Queensland Government operated a streamflow gauge on Roper Creek at Barwon Park (Station No. 130107A), located approximately 28 km downstream of the Project. The total catchment area draining to the Barwon Park streamflow gauge is 2,126 km^2. The maximum recorded flow rate at this station was 922 m^3/s in December 1973.

Table 3.1 shows the annual recorded runoff volume at the Barwon Park streamflow gauge for the period of record, as well as total annual rainfall taken from the SILO rainfall data. The annual volumetric runoff coefficient is low, ranging from 0.3% to 14.6% with an average of 3.7%.

Figure 3.3 shows a plot of monthly runoff versus rainfall for Roper Creek at the Barwon Park stream gauge. Very little runoff is generated by the catchment for monthly rainfall below about 100 mm. Once monthly rainfall exceeds about 200 mm, the volume of surface runoff increases substantially.

Figure 3.4 shows a ranked plot of daily flows at the Barwon Park gauging station over the period of record and with all zero flows omitted. Stream flows are ephemeral with flows recorded on approximately 34% of all days. Of the days when flows were recorded, the median flow is 10 ML/day and the 20th percentile flow is 200 ML/day.

The magnitude of stream flows along Roper Creek near the Project would be much less than that recorded at Barwon Park as the catchment area draining to the Barwon Park streamflow gauge downstream is more than 50% larger. However, the stream flows recorded at Barwon Park provide a good indication of the behaviour of streamflow in Roper Creek following rainfall events.

3.4 GEOLOGY AND GEOCHEMISTRY

Middlemount Coal Mine is located on the northern extension of the Rangal Coal Measures on the western flank 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.

Table 3.1 – Annual rainfall and runoff volumes for Roper Creek at Barwon Park gauging station

Year commencing	Annual rainfall[a] (mm)	Annual runoff volume at Barwon Park gauging station		Volumetric runoff coefficient
		(ML)	(mm)	
Oct 1971	553	12,513	5.9	0.011
Oct 1972	628	3399	1.6	0.003
Oct 1973	976	202,462	95.2	0.098
Oct 1974	840	58,052	27.3	0.033
Oct 1975	989	248,180	116.7	0.118
Oct 1976	584	18,313	8.6	0.015
Oct 1977	834	157,530	74.1	0.089
Oct 1978	584	17,894	8.4	0.014
Oct 1979	524	10,520	4.9	0.009
Oct 1980	641	34,080	16.0	0.025
Oct 1981	567	22,229	10.5	0.018
Oct 1982	805	249,154	117.2	0.146
Oct 1983	527	20,029	9.4	0.018
Oct 1984	510	3,833	1.8	0.004
Oct 1985	697	15,766	7.4	0.011
Oct 1986	519	11,152	5.2	0.010
Oct 1987	683	11,942	5.6	0.008
Mean	**674**	**64,532**	**30.4**	**0.037**

a/ Based on SILO rainfall at Middlemount Coal Mine
mm = millimetres

The target coal 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. The main target seams are the Pisces Seam and the overlying Middlemount Seam. The depth of cover for the Pisces Seam ranges from about 30 m near the limit of oxidation (lox) line to 200 m at the eastern boundary of ML 70379. Geochemical assessment (RGS, 2013) of overburden material identified that the majority of coal and mining waste rock materials are classified as Non-Acid Forming, have excess acid buffering capacity, and a high factor of safety with respect to potential for acid generation.

A recent study (RGS, 2016) did however conclude that based on the results of a number of the coal reject samples, there is some risk of acid generation over time, if left unmanaged. MCPL currently implements the management practices outlined in the *Mine By-Products Management Plan* and *Mining By-Product In-Pit Disposal Site Practice* for the Middlemount Coal Mine. Therefore, it is expected that the current management measures for coal rejects materials are sufficiently robust to avoid significant potential impacts to surface water and groundwater resources.

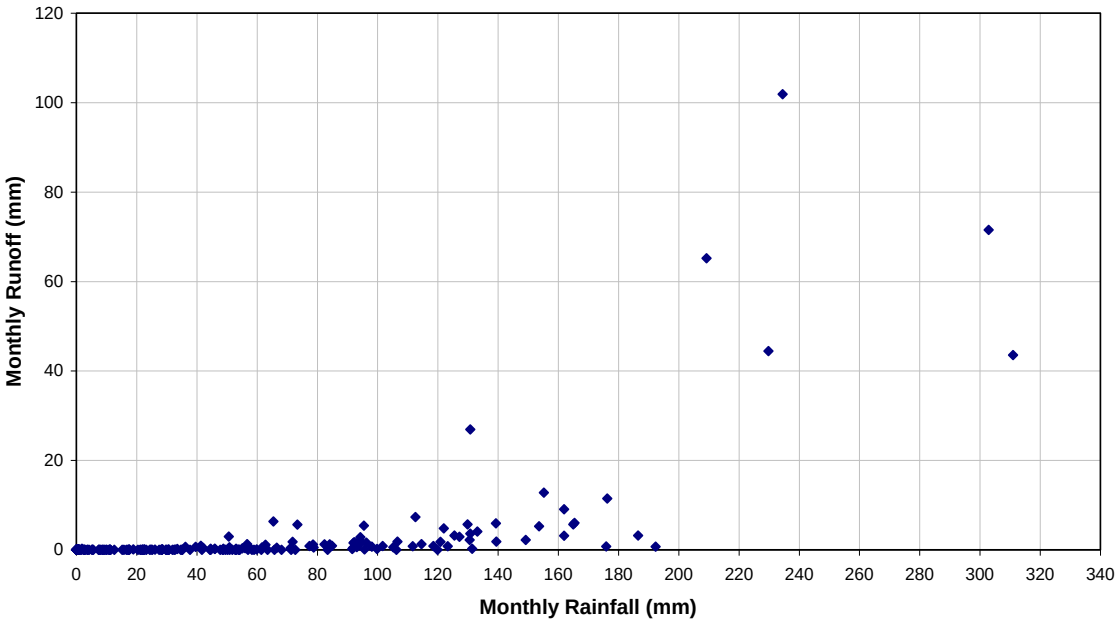

Figure 3.3 - Monthly runoff versus rainfall for Roper Creek at Barwon Park gauging station

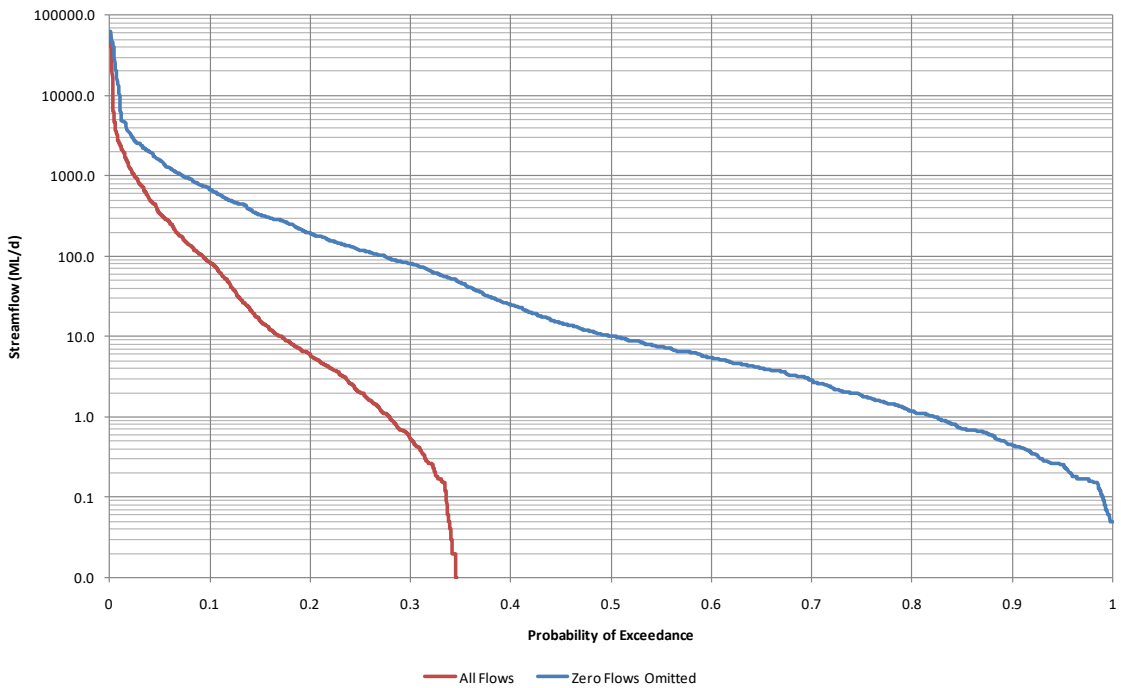

Figure 3.4 - Roper Creek at Barwon Park flow frequency curve, all flows and zero flows omitted

Water quality monitoring in mine affected water storages shows that runoff and seepage from the coal stockpiles, mining pits and tailings storage facilities (TSFs) is brackish with moderate sulphate concentrations and pH levels have historically fluctuated from acidic to alkaline. However, all recent samples taken since late 2012 have been generally neutral to moderately alkaline, and not shown any evidence of acid generation.

Surface water runoff from overburden dumps is fresh to brackish with lower sulphate levels than those recorded in mine affected water dams and pH levels are moderately alkaline. Again, there has not been any evidence of acid generation, which supports the above geochemical assessment conclusions.

Salinity levels in the mine water management system may increase over time due to evapo-concentration (e.g. due to the large evaporative surface of the MWD) of on-going salt loads from coal and mining waste rock materials.

3.5 GROUNDWATER

Three hydro-stratigraphic units have been identified by AGE (2020) based on their hydraulic properties and lithology at the Middlemount Coal Mine and surrounds. 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 drainage lines within the mining leases. Neither Roper Creek or Thirteen Mile Gully are targeted for water supply within the near vicinity of the Middlemount Coal Mine. Two other creeks containing alluvial deposits also occur further afield, Rolf Creek to the north and Oaky Creek to the far south of 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.
    - 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 (AGE, 2020).

Quaternary Alluvium

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.

Tertiary Aquifers

MCPL has implemented an extensive groundwater monitoring bore network, located both within and outside of the Middlemount Coal Mine tenements. A number of groundwater monitoring bores focus on the Tertiary aquifers (MW2, MW3, MW6, MW9A, MW10A, MW11A, MW12A, MW13A, MW14A and MW15A). Depth to water in the monitoring bores ranges from 7.7 metres below ground level (mbgl) (MW15A) to 28.9 mbgl (MW9A), with an average depth of 17.3 mbgl.

Groundwater quality in the Tertiary aquifers is generally poor and either unsuitable or marginal for beneficial uses. This is supported by no records (within approximately 10 km of the Middlemount Coal Mine) in the DNRM registered bore database of any bores screened within the Tertiary aquifer. The average EC is approximately 19,000 microSiemens per centimetre (µS/cm) and contains elevated chloride, sodium and total dissolved solids (TDS).

Permian Aquifers

The groundwater monitoring bore network also includes monitoring of the Permian aquifers (MW1P[1], MW4, MW5, MW5M/P, MW7M/P, MW8FR and MW9M/P). The average depth to groundwater in the Permian aquifer is greater than 30 mbgl.

Similar to the tertiary aquifers, groundwater quality is generally poor and either unsuitable or marginal for beneficial uses. The average EC is approximately 19,000 µS/cm and contains elevated chloride, sodium and TDS.

3.6 WATER QUALITY

The background water and sediment quality data for Roper Creek and the downstream catchment is described in the Middlemount Coal Mine Receiving Environment Monitoring Plan (REMP) (GHD, 2019). Water quality in Roper Creek is characterised by high and variable turbidity, moderate and variable EC and low dissolved oxygen concentrations at times.

The concentrations of most metals were very low within Roper Creek and did not exceed the EA trigger values, with the exception of aluminium and copper (which was recorded at elevated concentrations at upstream and downstream sites), as well as chromium, iron and vanadium (which was recorded at elevated concentrations at the downstream site). As there have been no discharges to Roper Creek since 2014, the elevated metal concentrations at the reference and impact sites are unlikely to be attributable to Middlemount Coal Mine operations.

GHD (2019) (cited in DPM Envirosciences, 2020) found that the macroinvertebrate community of Roper Creek exhibited signs of stress. Given the ephemeral nature of Roper Creek, changes in metrics over time associated with macroinvertebrate communities are to be expected. Given the lack of discharges from Middlemount Coal Mine, there had been no indication of impacts from Middlemount Coal Mine operations on the macroinvertebrate community of Roper Creek.

Table 3.2 shows the water quality at the upstream and downstream surface water monitoring sites. Time series graphs of the historical water quality sampling data of the receiving water contaminant trigger parameters at the upstream and downstream surface water monitoring sites are provided in Appendix A. Given the ephemeral nature of the upstream sub-catchments of Thirteen Mile Gully, no water quality data is available for the minor drainage lines.

3.7 EXISTING WATER USE ENTITLEMENTS

The Queensland Government water entitlement viewer indicates that there are no licensed surface water users along Roper Creek. That is, there are no users with an extraction volume issued under the provisions of the *Water Act 2000*.

There are two registered Self-Assessed Riparian Access Works located on Roper Creek which authorise stock and domestic supplies only. Section 20 of the *Water Act 2000* provides that an owner of land adjoining a watercourse may take water for domestic and stock purposes without the need for a permit or licence.

[1] Excavated within the advancing open cut.

Table 3.2 - Water quality summary, upstream and downstream surface water monitoring sites

Parameter	Units	Middlemount EA conditions		REF1				IMPAC1				IMPAC2			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	48	7.7	8.1	8.2	45	7.8	7.9	8.1	5	7.0	8.0	8.9
EC	µs/cm	700 - 6,000	700	48	207	674	840	45	290	426	619	5	246	374	455
Suspended solids	mg/L	562 - 1,062	562 - 1,062	53	5	23	494.2	50	33.2	563.5	1168	7	28	39	274
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	8	20	47	66	6	22	34	51	4	10	16	25
Turbidity	NTU			50	7	19	507	47	110	845	1718	6	56	220	856
Aluminium (dissolved)	mg/L	0.055	-	15	0.010	0.010	0.140	14	0.010	0.025	0.074	6	0.025	0.055	1.635
Arsenic (dissolved)	mg/L	0.013	-	16	0.001	0.001	0.002	15	0.001	0.001	0.001	7	0.001	0.001	0.004
Cadmium (dissolved)	mg/L	0.0002	-	16	0.0001	0.0001	0.0001	15	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		16	0.001	0.001	0.001	15	0.001	0.001	0.001	7	0.001	0.001	0.0074
Copper (dissolved)	mg/L	0.002	-	16	0.001	0.001	0.004	15	0.001	0.002	0.002	7	0.001	0.002	0.005
Iron (dissolved)	mg/L	0.3		15	0.06	0.08	0.30	14	0.05	0.12	0.25	6	0.05	0.06	1.04
Lead (dissolved)	mg/L	0.004	-	16	0.001	0.001	0.001	15	0.001	0.001	0.001	7	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		15	0.0001	0.0001	0.0001	14	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	16	0.002	0.003	0.003	15	0.002	0.002	0.004	7	0.002	0.002	0.005
Zinc (dissolved)	mg/L	0.008	-	16	0.005	0.005	0.020	13	0.005	0.005	0.006	7	0.005	0.005	0.005
Boron (dissolved)	mg/L	0.37	-	15	0.05	0.07	0.09	14	0.05	0.06	0.08	6	0.05	0.06	0.105
Cobalt (dissolved)	mg/L	0.090	-	15	0.001	0.001	0.001	14	0.001	0.001	0.001	6	0.001	0.001	0.001
Manganese (dissolved)	mg/L	1.9		15	0.001	0.025	0.152	14	0.001	0.001	0.0503	6	0.001	0.0015	0.054
Molybdenum (dissolved)	mg/L	0.034		14	0.001	0.001	0.001	13	0.001	0.002	0.003	5	0.001	0.001	0.011
Selenium (dissolved)	mg/L	0.01		15	0.01	0.01	0.01	14	0.01	0.01	0.01	6	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		14	0.001	0.001	0.001	13	0.001	0.001	0.001	5	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		14	0.001	0.001	0.001	11	0.001	0.001	0.001	5	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		15	0.010	0.010	0.010	12	0.010	0.010	0.010	6	0.010	0.010	0.015
Ammonia (dissolved)	mg/L	0.9		16	0.02	0.06	0.24	15	0.024	0.06	0.112	7	0.046	0.07	0.216
Nitrate	mg/L	1.1		16	0.010	0.010	0.485	15	0.010	0.300	0.448	7	0.006	0.010	0.316
Petroleum hydrocarbons (C6-C9)	µg/L	20		15	20	20	20	15	20	20	20	7	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		15	50	50	80	15	50	50	50	7	50	50	94
Fluoride	mg/L	2		16	0.1	0.2	0.2	15	0.1	0.2	0.3	7	0.1	0.3	0.4
Sodium (dissolved)	mg/L	TBA		30	10	40	104	23	16	65	91	7	24	36	55

** Shaded values represent an exceedance of the relevant trigger level/DGV*

A permit to take water from Roper Creek, Connors River, Murray Creek, Lotus Creek, Clive Creek and an unnamed tributary of Isaac River (Eungy Waterhole) has been issued under the provisions of the *Water Act 2000*. Such permits are typically granted to a corporate entity, such as local government, for temporary supply of water to construction or similar projects. A total entitlement of 8.5 ML per water year is attached to this permit. The above information indicates that there is currently minimal use of surface water from Roper Creek.

3.8 ENVIRONMENTAL VALUES

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water)), which is subordinate legislation to the *Environment Protection Act 1994* (EP Act), provides a framework for identifying environmental values (EVs) for a waterway and deciding water quality objectives (WQOs) to protect or enhance those EVs. EVs for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These environmental values are to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flow to ensure healthy aquatic ecosystems and waterways that are safe for community use.

Roper Creek is located within the Mackenzie River north-western tributaries region and is classified as a 'fresh' water source (*Department of Environment and Heritage Protection* [DEHP], 2011).

Roper Creek is part of the Mackenzie River catchment in the Fitzroy Basin. The Mackenzie River catchment received a 'C' grade (Fair) for aquatic ecosystem health in the *Fitzroy Basin Report Card 2018-19* (Fitzroy Partnership for River Health, 2020).

The environmental values selected for protection include:

- aquatic ecosystem protection (Level 2 – disturbed ecosystems [QWQG - DEHP 2009]);
- stock watering;
- human consumption;
- primary, secondary and visual recreation;
- drinking water;
- industrial use; and
- cultural and spiritual values.

In summary, the key environmental values for water that are to be protected are:

- physical, chemical and biological integrity of the watercourses within the catchment and their amenity as potential water sources for human use and to support aquatic ecosystems;
- the qualitative and quantitative integrity of local groundwater as a potential water source for agricultural or other suitable uses; and
- the integrity of raw water supplies and associated infrastructure in the region.

4 Site characteristics

4.1 OVERVIEW

This section describes the activities at the existing and proposed Middlemount Coal Mine that could potentially generate contaminants that may impact on the environmental values of the receiving waters, if not managed. The source of the contaminants has been identified and evaluated based on water quality data that has been collected on site since 2010. The proposed changes to the water management system due to the Project are also provided.

4.2 EXISTING SITE OPERATING ACTIVITIES

The major components of the existing Middlemount Coal Mine are shown in Figure 3.2 and include:

- an open cut mining pit;
- out-of-pit spoil dumps;
- access and haul roads;
- mine infrastructure areas including:
    - office buildings and workshops;
    - ROM coal stockpiles; and
    - a CHPP including crushing facility, a product coal stockpile pad, a rail loop and rail loading facilities;
- TSF and In-line Flocculation Cells;
- sewerage treatment;
- flood protection levees;
- stream diversion; and
- mine water management structures.

4.3 SURFACE WATER TYPES

The surface water generated on the mine site has been categorised into types, based on water quality:

- '*Tailings return water*' – water that has been used to wash coal in the CHPP. Tailings water potentially has a lower pH and higher concentrations of TDS and metals than 'Mine affected' water.
- '*Mine affected water*' – surface water that has generally come in contact with coal such as in the pit, or from the ROM coal stockpile. This water may contain high TDS and metals above relevant guideline trigger values.
- '*On-site stormwater*' – surface runoff water from areas that are disturbed by mining operations (including out-of-pit overburden dumps and haul roads). This runoff may contain high sediment loads but is generally of neutral pH and does not contain high salt concentrations or metals.
- '*Catchment runoff water*' – surface runoff from catchment areas where water quality is unaffected by mining operations. Catchment runoff water includes runoff from undisturbed areas and any fully rehabilitated areas.

- '*Contaminated water*' – surface water from areas potentially containing chemicals of various types used in the mining operations (e.g. hydrocarbons). Contaminated water areas include sumps, service bays and fuel storage areas. Rainfall and resulting runoff from these areas is also potentially contaminated.
- '*External water*' – External water is water sourced external to the mining operation.

4.4 SITE WATER QUALITY

Water quality data has been collected from the on-site water storages since May 2010. The parameters tested have been defined by the Queensland Government to cover the range of constituents that could impact on the environmental values of the receiving waters.

Table 4.1 shows the time periods that water quality samples have been collected in each of the water storages at Middlemount Coal Mine. The locations of the dams are shown in Figure 3.2. Table 4.2 and Table 4.3 summarise the water quality of the tailings and mine affected dams.

Table 4.4 and Table 4.5 show the water quality in the sediment dams that have not been affected by mine water. Sediment dams that are not mine affected collect runoff from the East Dump, as well as SD2. Descriptions of the water quality draining the various areas on the mine site are given in the following sections.

According to Table C3 of the Middlemount Coal Mine EA, trigger values for metals and metalloids only apply when the dissolved concentrations exceed the trigger values. The majority of the water quality sampling for metals has been reported as total concentrations, and regular reporting of dissolved concentrations has only occurred since 2015.

Time series graphs of the historical water quality sampling data for the mine affected water release parameters are provided in Appendix A.

Table 4.1 – Water quality sampling periods

Water storage	ID	Start date	End date (latest sample)
Raw Water Dam	RWD	May 2010	May 2020
Tailings Storage Facility 1	TSF1	October 2010	May 2020
Tailings Storage Facility 2	TSF2	January 2011	March 2020
Mine Water Dam	MWD	January 2015	May 2020
North ROM Dam	NROM	January 2015	April 2020
Mining Pit		July 2015	March 2020*[1]
Sediment Dam 1	SD1	October 2010	May 2020
Sediment Dam 2	SD2	November 2010	May 2020
Sediment Dam 3	SD3	May 2010	May 2020
Sediment Dam 6	SD6	March 2019	January 2020
Sediment Dam 7	SD7	April 2015	June 2019
Sediment Dam 9	SD9	April 2013	June 2019
Sediment Dam 10	SD10	January 2014	January 2020

*[1] Water quality from South Transfer Dam (STD) is assumed to represent mining pit water quality

Table 4.2 - Water quality summary, mine affected water storages (1 of 2)

Parameter	Units	Middlemount EA conditions		RWD				TSF 1				TSF 2				Combined TSF 1/2			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	53	6.5	8.5	8.8	43	4.6	8.2	8.7	30	7.6	8.0	8.6	73	7.0	8.1	8.7
EC	µs/cm	700 - 6,000	700	53	1,748	7,400	13,957	43	1,356	8,980	16,228	30	1,687	4,440	15,061	73	1,476	6,570	15,700
Suspended solids	mg/L	562 - 1,062	562 - 1,062	18	5	6	16	11	6	13	61	8	7	65	388	19	6	14	336
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	16	254	288	379	15	203	538	822	13	11	235	287	26	211	401	793
Turbidity	NTU			18	3.6	7.8	14.1	11	3.7	12.1	29.0	9	3.2	10.1	225	20	3	12	219
Aluminium (dissolved)	mg/L	0.055	-	12	0.01	0.01	0.01	9	0.010	0.010	0.078	7	0.010	0.010	0.014	16	0.010	0.010	0.050
Arsenic (dissolved)	mg/L	0.013	-	12	0.001	0.001	0.001	9	0.001	0.002	0.002	7	0.001	0.001	0.003	16	0.001	0.002	0.003
Cadmium (dissolved)	mg/L	0.0002	-	11	0.0001	0.0001	0.0001	8	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0002	14	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		10	0.001	0.001	0.001	7	0.001	0.001	0.001	5	0.001	0.001	0.001	12	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	11	0.001	0.001	0.002	8	0.001	0.001	0.002	6	0.001	0.002	0.002	14	0.001	0.001	0.002
Iron (dissolved)	mg/L	0.3		14	0.05	0.05	0.06	7	0.05	0.05	0.11	5	0.05	0.05	0.05	12	0.050	0.050	0.104
Lead (dissolved)	mg/L	0.004	-	12	0.001	0.001	0.001	8	0.001	0.001	0.001	6	0.001	0.001	0.001	14	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		14	0.0001	0.0001	0.0001	8	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	14	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	11	0.007	0.010	0.014	8	0.012	0.013	0.032	6	0.005	0.014	0.018	14	0.009	0.013	0.020
Zinc (dissolved)	mg/L	0.008	-	11	0.005	0.006	0.025	8	0.005	0.006	0.012	6	0.005	0.005	0.018	14	0.005	0.005	0.013
Boron (dissolved)	mg/L	0.37	-	10	0.25	0.35	0.40	6	0.37	0.45	1.97	4	0.181	0.395	0.609	10	0.334	0.405	0.957
Cobalt (dissolved)	mg/L	0.090	-	11	0.001	0.001	0.001	8	0.001	0.004	0.019	6	0.001	0.001	0.006	14	0.001	0.002	0.008
Manganese (dissolved)	mg/L	1.9		8	0.0017	0.003	0.0096	6	0.02	0.03	0.18	4	0.001	0.018	0.103	10	0.001	0.031	0.150
Molybdenum (dissolved)	mg/L	0.034		10	0.0124	0.017	0.024	7	0.019	0.022	0.039	5	0.008	0.012	0.032	12	0.010	0.022	0.034
Selenium (dissolved)	mg/L	0.01		13	0.01	0.01	0.01	6	0.01	0.01	0.01	4	0.01	0.01	0.01	10	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		9	0.001	0.001	0.001	7	0.001	0.001	0.001	4	0.001	0.001	0.001	11	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		6	0.004	0.005	0.008	7	0.005	0.009	0.015	5	0.001	0.010	1.204	12	0.001	0.009	0.015
Vanadium (dissolved)	mg/L	0.01		6	0.010	0.010	0.010	7	0.010	0.010	0.010	5	0.010	0.010	0.010	12	0.010	0.010	0.010
Ammonia (dissolved)	mg/L	0.9		10	0.029	0.160	0.324	5	0.10	0.76	2.16	3	0.06	0.14	1.23	8	0.040	0.475	1.974
Nitrate	mg/L	1.1		11	0.01	0.40	0.77	6	0.01	0.39	1.05	4	0.019	0.055	0.42	10	0.010	0.055	0.986
Petroleum hydrocarbons (C6-C9)	µg/L	20		17	20	20	20	9	20	20	60	7	20	20	20	16	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		17	50	50	54	9	50	50	112	7	50	50	54	16	50	50	95
Fluoride	mg/L	2		36	0.4	0.8	1.0	28	0.3	0.9	1.2	22	0.6	0.8	1.1	50	0.4	0.8	1.2
Sodium (dissolved)	mg/L	TBA		23	883	1,690	2,968	13	974	2,000	3,326	12	556	1,485	3,125	25	614	1,890	3,210

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.3 - Water quality summary, mine affected water storages (2 of 2)

Parameter	Units	Middlemount EA conditions		MWD				NROM				SD1				Mining Pit				Combined NROM/SD1			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	26	8.7	9.1	9.5	14	8.1	8.6	9.3	38	5.7	8.5	9.1	9	8.3	8.8	9.3	52	6.2	8.6	9.1
EC	µs/cm	700 - 6,000	700	24	7,332	15,370	17,725	13	1,057	2,760	11,066	38	856	6,160	12,606	9	8,084	11,290	13,111	51	934	5,380	12,010
Suspended solids	mg/L	562 - 1,062	562 - 1,062	14	5	8	23	9	5	5	38	14	7	21	56	5	14	22	27	23	5	20	56
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	-	-	-	-	-	-	-	-	14	120	302	471	1	-	1,240	-	14	120	302	471
Turbidity	NTU			10	3.7	6.2	11.5	8	2.9	14.7	46.6	15	4.2	17.4	45.3	2	5.5	10.7	15.8	23	3	17	46
Aluminium (dissolved)	mg/L	0.055	-	10	0.010	0.010	0.038	6	0.010	0.010	0.015	8	0.010	0.010	0.010	6	0.010	0.010	0.010	14	0.010	0.010	0.010
Arsenic (dissolved)	mg/L	0.013	-	10	0.002	0.004	0.005	6	0.001	0.001	0.002	8	0.001	0.0015	0.002	6	0.001	0.002	0.003	14	0.001	0.001	0.002
Cadmium (dissolved)	mg/L	0.0002	-	10	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	5	0.0001	0.0001	0.0001	13	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		10	0.0010	0.0010	0.0019	6	0.001	0.001	0.001	6	0.001	0.001	0.001	5	0.001	0.001	0.001	12	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	10	0.001	0.001	0.002	6	0.001	0.001	0.002	7	0.001	0.001	0.002	5	0.0010	0.0010	0.0016	13	0.001	0.001	0.002
Iron (dissolved)	mg/L	0.3		12	0.05	0.05	0.05	6	0.05	0.05	0.05	6	0.05	0.05	0.09	6	0.050	0.050	0.165	12	0.05	0.05	0.05
Lead (dissolved)	mg/L	0.004	-	10	0.001	0.001	0.001	6	0.001	0.001	0.001	7	0.001	0.001	0.001	5	0.001	0.001	0.001	13	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		12	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	13	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	10	0.006	0.007	0.009	6	0.001	0.002	0.007	7	0.003	0.006	0.026	5	0.003	0.008	0.011	13	0.001	0.004	0.010
Zinc (dissolved)	mg/L	0.008	-	10	0.005	0.005	0.005	5	0.005	0.005	0.007	7	0.005	0.006	0.031	5	0.005	0.005	0.005	12	0.005	0.005	0.018
Boron (dissolved)	mg/L	0.37	-	10	0.330	0.425	0.452	6	0.05	0.05	0.38	6	0.12	0.24	0.47	5	0.256	0.340	0.382	12	0.05	0.16	0.58
Cobalt (dissolved)	mg/L	0.090	-	10	0.001	0.001	0.001	6	0.0010	0.0010	0.0025	7	0.001	0.001	0.011	5	0.001	0.001	0.001	13	0.001	0.001	0.003
Manganese (dissolved)	mg/L	1.9		8	0.0010	0.0015	0.0204	4	0.001	0.002	0.002	5	0.0014	0.0050	0.0326	4	0.001	0.001	0.021	9	0.001	0.002	0.016
Molybdenum (dissolved)	mg/L	0.034		10	0.0157	0.0185	0.0204	6	0.005	0.009	0.017	6	0.003	0.011	0.017	6	0.009	0.017	0.022	12	0.004	0.010	0.020
Selenium (dissolved)	mg/L	0.01		12	0.01	0.01	0.01	6	0.01	0.01	0.01	6	0.01	0.01	0.01	6	0.01	0.01	0.01	12	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		7	0.001	0.001	0.001	6	0.001	0.001	0.001	6	0.001	0.001	0.001	2	0.001	0.001	0.001	12	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		5	0.003	0.004	0.004	4	0.0010	0.0015	0.0055	6	0.001	0.001	0.006	1	-	0.003	-	10	0.001	0.001	0.007
Vanadium (dissolved)	mg/L	0.01		5	0.010	0.010	0.010	4	0.010	0.010	0.010	6	0.010	0.010	0.010	1	-	0.01	-	10	0.010	0.010	0.010
Ammonia (dissolved)	mg/L	0.9		10	0.019	0.055	0.297	6	0.01	0.03	0.42	6	0.02	0.115	0.76	5	0.02	0.03	0.04	12	0.01	0.05	0.71
Nitrate	mg/L	1.1		9	0.01	0.52	2.12	6	0.01	0.04	2.20	7	0.01	0.01	0.124	5	0.01	0.43	3.87	13	0.01	0.01	0.15
Petroleum hydrocarbons (C6-C9)	µg/L	20		11	20	20	20	6	20	20	20	8	20	20	20	5	20	20	20	14	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		12	50	50	50	6	50	50	55	8	50	50	50	6	50	50	50	14	50	50	50
Fluoride	mg/L	2		14	0.8	0.9	1.2	9	0.4	0.9	2.8	29	0.3	0.7	1.2	5	0.6	1.0	1.1	38	0.3	0.75	1.5
Sodium (dissolved)	mg/L	TBA		13	1,000	1,920	3,560	8	147	462	1,595	14	524	1,060	2,154	5	1,448	2,240	3,866	22	203	1,015	2,158

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.4 - Water quality summary, on-site stormwater storages (1 of 2)

Parameter	Units	Middlemount EA conditions		SD2				SD3 (from Jan-16 onwards)				SD6			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	44	4.2	8.2	9.5	13	7.4	8.7	9.2	5	8.1	8.5	9.4
EC	µs/cm	700 - 6,000	700	42	593	979	2,199	13	1020	1400	6,104	5	271	328	862
Suspended solids	mg/L	562 - 1,062	562 - 1,062	11	8	31	54	5	12	24	63	2	74	138	202
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	13	100	158	320	6	83	116	279	-	-	-	-
Turbidity	NTU			19	25	58	343	5	15	57	168	2	2,454	3,150	3,846
Aluminium (dissolved)	mg/L	0.055	-	6	0.01	0.01	0.01	5	0.010	0.010	0.042	2	0.961	1.565	2.169
Arsenic (dissolved)	mg/L	0.013	-	6	0.0010	0.0010	0.0035	5	0.0010	0.0010	0.0016	2	0.001	0.001	0.001
Cadmium (dissolved)	mg/L	0.0002	-	5	0.0001	0.0001	0.0001	5	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.0011	0.0015	0.0019
Copper (dissolved)	mg/L	0.002	-	5	0.0010	0.0020	0.0036	5	0.001	0.002	0.002	2	0.002	0.002	0.002
Iron (dissolved)	mg/L	0.3		4	0.05	0.05	0.05	6	0.050	0.050	0.050	2	0.351	0.635	0.919
Lead (dissolved)	mg/L	0.004	-	5	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		5	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	5	0.0010	0.0010	0.0034	5	0.001	0.001	0.001	2	0.002	0.003	0.003
Zinc (dissolved)	mg/L	0.008	-	5	0.005	0.005	0.006	5	0.005	0.005	0.006	2	0.007	0.016	0.024
Boron (dissolved)	mg/L	0.37	-	4	0.050	0.085	0.176	5	0.074	0.11	0.17	2	0.085	0.145	0.205
Cobalt (dissolved)	mg/L	0.090	-	5	0.0010	0.0010	0.0016	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Manganese (dissolved)	mg/L	1.9		3	0.001	0.001	0.001	4	0.0010	0.0015	0.0041	2	0.003	0.003	0.003
Molybdenum (dissolved)	mg/L	0.034		4	0.004	0.008	0.009	5	0.003	0.006	0.006	2	0.001	0.001	0.001
Selenium (dissolved)	mg/L	0.01		4	0.01	0.01	0.01	6	0.01	0.01	0.01	2	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	4	0.001	0.001	0.001	2	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		4	0.01	0.01	0.01	4	0.01	0.01	0.01	2	0.01	0.01	0.01
Ammonia (dissolved)	mg/L	0.9		4	0.013	0.080	0.175	5	0.010	0.080	0.886	2	0.071	0.075	0.079
Nitrate	mg/L	1.1		5	0.01	0.01	0.57	5	0.01	0.01	0.114	2	0.107	0.215	0.323
Petroleum hydrocarbons (C6-C9)	µg/L	20		7	20	20	20	6	20	20	20	2	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		7	50	50	90	6	50	50	50	2	50	50	50
Fluoride	mg/L	2		25	0.2	0.8	1.6	5	1.1	1.2	1.3	2	0.4	0.4	0.4
Sodium (dissolved)	mg/L	TBA		13	121	260	515	6	164	212	824	1	63	63	63

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.5 - Water quality summary, on-site stormwater storages (2 of 2)

Parameter	Units	Middlemount EA conditions		SD7				SD9				SD10				Combined SD2/SD6/SD9/SD10/SD3			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	8	9.0	9.7	9.8	11	8.1	8.4	9.1	15	8.2	8.9	9.9	91	5.6	8.6	9.7
EC	µs/cm	700 - 6,000	700	8	586	918	4,063	11	368	526	2,080	16	380	664	1,328	90	469	961	2,385
Suspended solids	mg/L	562 - 1,062	562 - 1,062	6	15	26	114	2	13	27	41	5	26	37	83	29	10	30	89
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	-	-	-	-	-	-	-	-	-	-	-	-	13	100	158	320
Turbidity	NTU			6	17	37	147	3	57	229	275	7	215	409	2,358	40	18	85	556
Aluminium (dissolved)	mg/L	0.055	-	3	0.014	0.030	0.038	3	0.24	1.18	4.22	2	0.221	0.265	0.309	19	0.010	0.010	0.492
Arsenic (dissolved)	mg/L	0.013	-	2	0.001	0.002	0.003	3	0.001	0.001	0.001	2	0.001	0.001	0.001	18	0.001	0.001	0.003
Cadmium (dissolved)	mg/L	0.0002	-	2	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.0011	0.0015	0.0019	14	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	3	0.001	0.002	0.003	2	0.0023	0.0035	0.005	2	0.001	0.001	0.001	17	0.001	0.002	0.003
Iron (dissolved)	mg/L	0.3		2	0.05	0.05	0.05	1	0.05	0.05	0.05	2	0.121	0.125	0.129	15	0.05	0.05	0.092
Lead (dissolved)	mg/L	0.004	-	2	0.001	0.001	0.001	2	0.001	0.003	0.005	2	0.001	0.001	0.001	16	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		2	0.0001	0.0001	0.0001	1	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	3	0.001	0.001	0.002	2	0.003	0.004	0.004	2	0.001	0.002	0.002	17	0.001	0.001	0.003
Zinc (dissolved)	mg/L	0.008	-	2	0.005	0.006	0.007	2	0.010	0.012	0.013	2	0.006	0.012	0.018	16	0.005	0.005	0.012
Boron (dissolved)	mg/L	0.37	-	3	0.204	0.220	0.412	1	0.15	0.15	0.15	2	0.18	0.18	0.18	15	0.05	0.15	0.22
Cobalt (dissolved)	mg/L	0.090	-	2	0.001	0.001	0.001	2	0.001	0.003	0.005	2	0.001	0.001	0.001	16	0.001	0.001	0.002
Manganese (dissolved)	mg/L	1.9		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.0011	0.0015	0.0019	12	0.001	0.001	0.002
Molybdenum (dissolved)	mg/L	0.034		3	0.002	0.003	0.004	1	0.004	0.004	0.004	2	0.0031	0.0035	0.0039	15	0.003	0.004	0.008
Selenium (dissolved)	mg/L	0.01		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	15	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.001	0.001	0.001	14	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.001	0.001	0.001	13	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	13	0.01	0.01	0.01
Ammonia (dissolved)	mg/L	0.9		2	0.101	0.145	0.189	1	0.01	0.01	0.01	2	0.014	0.030	0.046	14	0.01	0.065	0.197
Nitrate	mg/L	1.1		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	15	0.01	0.01	0.114
Petroleum hydrocarbons (C6-C9)	µg/L	20		2	20	20	20	4	20	20	20	2	20	20	20	21	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		2	64	120	176	4	50	50	120	2	50	50	50	21	50	50	150
Fluoride	mg/L	2		6	1.1	1.4	2.7	4	0.2	0.4	0.9	6	0.8	1.2	1.8	46	0.2	1.0	1.7
Sodium (dissolved)	mg/L	TBA		6	104	194	832	4	32	47	291	6	64	122	213	35	62	202	503

** Shaded values represent an exceedance of the relevant trigger level/DGV*

4.4.1 Tailings return water

Tailings (i.e. fine rejects) from the CHPP comprise mostly of fine silt, clay, water and coal material. Water quality monitoring of the TSF cells (TSF1 and TSF2) since October 2010 (see Table 4.2) indicates that the stored water exceeds the *EPP Water WQOs* and has the following characteristics:

- Brackish with a median EC of 6,570 µS/cm and 10% exceeding 15,700 µS/cm;
- Moderate sulphate with a median of 400 mg/l and 10% exceeding 795 mg/l;
- Generally slightly alkaline, with a median pH of 8.1, 10% exceeding 8.7 and 10% less than 7.0; and
- Metals (dissolved) less than the default trigger values with the exception of median values of nickel, boron and uranium and 90th percentile values of aluminium, zinc and molybdenum.

The tailings return water management system will remain unchanged for the Project.

4.4.2 Mine affected water

Mine affected water includes runoff collected within the open cut pit (includes groundwater), which is pumped to the MWD and runoff from the ROM and product coal stockpiles, which drains to SD1, NROM and the RWD. It also includes external water pumped in from German Creek Mine. Water quality monitoring of all mine affected water storages exceeds the *EPP Water WQOs* for pH, salinity, sulphate, aluminium and zinc.

For surface runoff draining coal stockpile areas only including SD1 and the NROM, the data in Table 4.2 and Table 4.3 indicates that the stored water has the following characteristics:

- Brackish with a median EC of 5,380 µS/cm and 10% exceeding 12,010 µS/cm;
- Moderate sulphate with a median of 300 mg/l and 10% exceeding 470 mg/l;
- Generally slightly alkaline, with a median pH of 8.6, 10% exceeding 9.1 and 10% less than 6.2; and
- Metals (dissolved) generally below the default trigger values with the exception of 90th percentile values of boron, uranium and zinc.

The mine affected water management system will remain generally unchanged (i.e. continued collection of water, including groundwater, in the open cut pit as it advances) for the Project with augmentations as necessary. Further details are provided in Section 5.

Refer to Section 4.4.5 for a summary of the water quality of the external water supply from German Creek Mine.

4.4.3 On-site stormwater

On-site stormwater includes runoff from the overburden dumps and haul roads. On-site stormwater is managed under the site's Erosion and Sediment Control Plan (ESCP) (WRM, 2019a). Water quality monitoring of sediment dams (that have not been historically affected by mine water (SD2, SD3, SD6, SD7, SD9 and SD10)) since April 2013 indicates that the collected runoff has the following characteristics (Table 4.4 and Table 4.5):

- Fresh to brackish with a median EC of 960 µS/cm and 10% exceeding 2,385 µS/cm;
- Moderate sulphate with a median of 158 mg/l and 10% exceeding 320 mg/l;
- Moderate suspended solids with a median of 30 mg/l and 10% exceeding 89 mg/l; and
- Moderately alkaline, with a median pH of 8.6, 10% exceeding 9.7 and 10% less than 5.6.

Review of Table 4.4 and Table 4.5 shows that the metals (dissolved) are generally below the release contaminant trigger levels, with the exception of:

- Aluminium and zinc readings in SD6, SD9 and SD10;
- Chromium readings in SD6 and SD10;
- Copper readings in SD2, SD7 and SD9;
- Iron readings in SD6;
- Lead in SD9;
- Zinc in SD6, SD9 and SD10; and
- Boron readings in SD7.

A further review of the on-site stormwater storage's data showed that salinity values vary between seasons with elevated levels recorded during the dry season when dam levels are low and evapo-concentration has occurred. Salinity concentrations are generally lower during the wet season when surface runoff is highest.

The recorded total suspended solids concentrations are also lower than what would be otherwise expected for surface runoff from overburden waste material. Almost all suspended solid concentration readings were taken during the dry season, which suggest that the total suspended solids data represents water quality after long periods of settlement. It is therefore possible that the suspended solids concentrations of surface runoff to the on-site stormwater storages could be greater than recorded values to date.

Mine affected water has historically been pumped to SD3. SD3 also temporarily received de-sludged pit material after the January 2013 storm event. It is no longer used for mine affected water and the recent water quality samples indicate that the residual salts and contaminants are largely removed.

Water quality monitoring of three release events from on-site stormwater storages has occurred in the months:

- January 2013 – SD1;
- January 2013 – SD3; and
- February 2014 – SD2.

Investigations into all three release events were completed by MCPL to ensure compliance with the EA conditions. The water quality results showed that all parameters were within the release limits and trigger investigation limits, with the exception of copper and zinc during the February 2014 release from SD2. The investigation found that copper and zinc concentrations were also elevated at the upstream reference site and could be attributed to naturally higher background levels from the upstream catchment area (MCPL, 2014b).

The monitoring results show that although total aluminium exceeded the trigger value in all three release events, the dissolved aluminium concentration was significantly lower than both the trigger value and the reference sites in Roper Creek. The highest dissolved aluminium concentration recorded in the three events was 0.02 mg/L.

Suspended solids concentrations were also low across all three release events with the highest concentration of 23 mg/L recorded at SD3 during the January 2013 event.

The additional disturbance footprint associated with the Project (233 hectares [ha]) will increase the volume of stormwater requiring to be contained and managed on the mine site. Notwithstanding the on-site stormwater management system will remain generally unchanged (i.e. continued collection of runoff from the overburden dumps) for the Project with augmentations as necessary. Further details, including additional sediment dams, are provided in Section 5.7.

4.4.4 Contaminated water

Water collected in sumps, service bays and fuel storage areas is not currently monitored given the small volumes. The water is contained and managed accordingly as it is expected to come into contact with petroleum hydrocarbons. Details of the contaminated water management system is provided in Section 5.6.

4.4.5 External water

MCPL have an arrangement with Anglo American plc to supply water from the German Creek Mine for use on the mine site. Water is pumped from German Creek on an 'as needed' basis and placed in the RWD, STD and MWD, up to a limit of 250 ML per month and 1,800 ML per year. Water is supplied in accordance with the Water Supply Agreement between MCPL and Anglo Coal (Capcoal Management) Pty Ltd dated 22nd December 2010. Water captured on-site is used in preference to the German Creek water.

Water quality monitoring of the external water supply from German Creek indicates that the water exceeds the EPP Water WQOs and has the following characteristics:

- Brackish with a median EC of 7,870 µS/cm and 10% exceeding 9,515 µS/cm;
- Moderate to high sulphate with a median of 1,845 mg/l;
- Moderately alkaline with pH ranging from 8.2 to 8.7; and
- Metals (total) generally below the default trigger values with the exception of nickel.

External water will continue to be pumped to site on an 'as needed' basis for the Project.

5 Existing surface water management system

5.1 OVERVIEW

Middlemount Coal Mine is operated under the MCPL Environmental Management System. The documents related to the mine water management system include:

- Middlemount Coal Mine Environmental Management Plan (MCPL, 2018);
- Water Management Plan (WRM, 2019b);
- Water Management Site Practice (MCPL, 2014a);
- Site Water Balance (WRM, 2019c);
- Regulated Structures Operational Plan (MCPL, 2019);
- Receiving Environment Monitoring Program – Design Document (DPM Enviros ciences, 2019);
- Erosion and Sediment Control Plan (WRM, 2019a); and
- Severe Weather Site Practice (MCPL, 2013a).

The locations of the existing mine water management infrastructure are shown Figure 3.2, and shown schematically in Figure 5.1. Descriptions of the tailings return water management system, mine affected water, on-site stormwater, contaminated and catchment runoff water management systems for the Project are provided below. The mine water management system framework will generally not change as a result of the Project. However, a number of additional sediment dams are proposed as part of the Project.

5.2 SURFACE WATER MANAGEMENT OBJECTIVES

The objective of the mine water management system is to manage all types of water on site to meet operational, social and environmental objectives encapsulated by the sites EA (EPML00716913).

Specific objectives for each water type are as follows:

- External water: Ensure that external water allocation and associated infrastructure is sufficient to meet site demands under low rainfall conditions.
- Mine affected water: Minimise uncontrolled discharges in wet periods and to ensure adequate water supplies are maintained for site demand during dry periods.
- Groundwater: Understand, manage and minimise the potential impact of the water management system on the regional groundwater system.
- On-site stormwater: Maintain water quality leaving the Erosion and Sediment Control (ESC) structures to a quality as close to background levels as reasonably possible.
- Catchment runoff water: Ensure that it is separated from the mine affected and on-site stormwater systems and allowed to pass uninterrupted down the catchment.

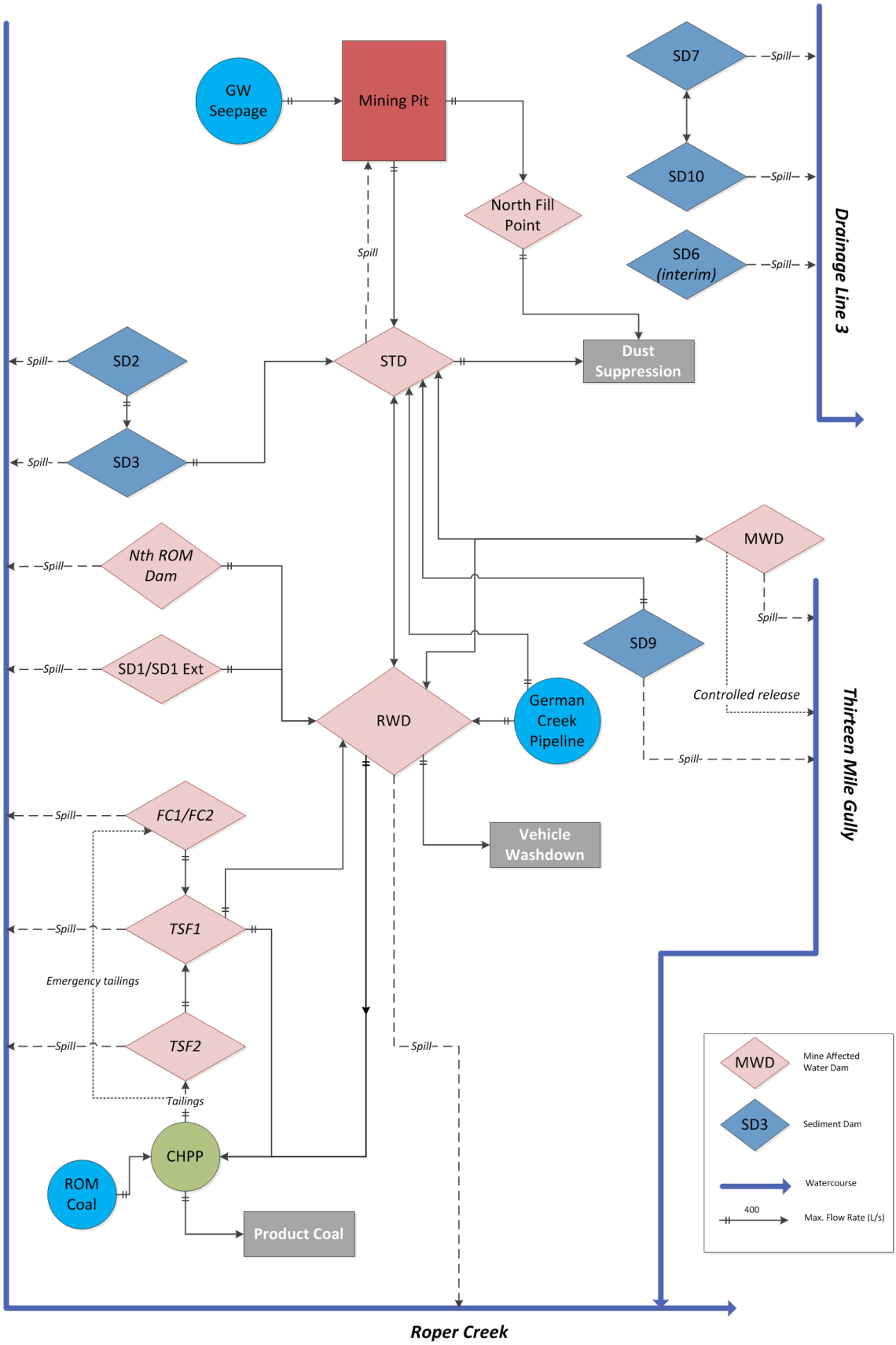

Figure 5.1 - Existing water management system schematic

5.3 SURFACE WATER MANAGEMENT PRINCIPLES

The general principles to manage surface water for the site are as follows:

- The separation of catchment runoff, on-site stormwater, mine affected water, tailings return water and contaminated water.
- Minimise the area of surface disturbance, thus minimising the volume of on-site stormwater capture or contaminated water runoff.
- Collect and contain on site all potential mine affected water pumped from the open cut pits in dedicated mine water storages. The mine water storages will be used as the primary water source for the CHPP and for dust suppression.
- Retain and reuse on site any on-site stormwater runoff that has high sediment concentrations whenever possible. If not, release it in a controlled manner (i.e. following settlement) in compliance with the ESCP.
- Minimise the potential for generation of contaminated water by installing a roof over the bunded areas. Where this is not possible, use oil and water separators or collect and contain the potentially contaminated water within the bunds and pump it to the mine affected water storages.
- Maximise the use of on-site water and thus minimise the need for importing external water.
- Prioritise the use of poorer quality water over better quality water.
- Complete flood mitigation works to provide a minimum of 0.1% annual exceedance probability (AEP) immunity from Thirteen Mile Gully and Roper Creek floods.

5.4 TAILINGS AND REJECTS CIRCUIT

The TSFs at the Middlemount Coal Mine comprise a series of 4 in-line flocculation cells (ILF cells) (within TSF2), emergency ILF cells (at FC1/FC2) and the inactive TSF (TSF1). All tailings facilities are constructed with earth embankments on all sides and do not receive runoff from external catchments. The tailings circuit is managed as follows:

- Fine rejects are pumped to the ILF cells at TSF2 (or emergency cells FC1/FC2).
- Flocculant is added prior to removal of water from the TSFs.
- Decant water is pumped to TSF1 then returned to the CHPP and RWD for reuse.
- Fine tailings are dried and reclaimed for in-pit disposal.

The inactive TSF (TSF1) is only used for the temporary storage of decant water. FC1 and FC2 have not been utilised for tailings since the construction of the ILF cells within TSF2.

Coarse rejects are managed separately to the fine rejects and disposed of within overburden emplacements. Refer to Figure 3.2 and Figure 5.1 for the locality and configuration of the tailings circuit.

5.5 MINE AFFECTED WATER MANAGEMENT

The mine affected water management system is managed in accordance with the Regulated Structures Operational Plan (MCPL, 2019).

The layout of the mine water management system is shown in Figure 3.2, and shown schematically in Figure 5.1. Mine affected water is managed as follows:

- There are two main mine water management storages: RWD and MWD. Mine affected water in excess of the RWD capacity is stored in the MWD.

- STD is operated as a transfer dam adjacent the mining pit to transfer mine affected water to RWD or MWD and as a source of water for dust suppression. STD has no external catchment area.
- Water captured in the mining pit may also be pumped directly to RWD or MWD (via STD).
- Runoff from a section of the haul road immediately north of the CHPP and portions of the ROM and coal stockpile area drains to SD1. SD1 is dewatered to RWD for reuse in the CHPP. Any overflow from SD1 drains to the SD1 Extension dam.
- A dedicated pump is permanently situated at SD1 to minimise the risk of uncontrolled releases during rain events.
- Runoff from the northern ROM stockpile and hardstand area is captured in NROM and transferred to RWD for reuse in the CHPP.
- Controlled releases can be made from RWD, MWD and SD1 subject to the relevant EA conditions.

5.5.1 Mine affected water management storages

Figure 3.2 shows the location of the mine water management storages. A summary of the mine affected water storages, their capacities and surface areas are provided in Table 5.1.

Table 5.1 – Existing mine affected water management storages

Dam Name	Full supply volume (ML)	Surface area at FSL (ha)	Maximum water depth (m)	Catchment area (ha)	Overflows to
Raw Water Dam (RWD)	191	2.7	6.2	25.5	Roper Creek
Mine Water Dam (MWD)	1,928	28.6	8.1	36	Thirteen Mile Gully
Sediment Dam 1 (SD1)	60	0.7	3.8	16.2	Roper Creek
South Transfer Dam (STD)	26	1.5	1.6	28.7	Mining Pit
North ROM Dam (NROM)	4	0.2	1.2	5.5	Roper Creek
Tailings Storage Facility 1 (TSF1)	187[#]	14.3	12.8	15.5	Roper Creek*
Tailings Storage Facility 2/In-line Flocc cells (TSF2)	535[#]	9.1	8.9	9.7	Roper Creek*
Emergency Flocc cells (FC1/FC2)	52	1.4	7.1	9.7	Roper Creek*
Mining Pit	24,500	104.5	68.0	463.5	-

[#] Excludes volume of tailings placed within storage.
* No releases are expected to occur from either of the TSFs or FC1/FC2.
FSL = full supply level.

5.5.2 Environmental Authority (EA) - release conditions

The current Middlemount Coal Mine EA (EPML00716913) took effect on 26 February 2020. The EA conditions require that mine affected water may only be released from designated release points when water quality is within defined end-of-pipe limits. A description of these compliance conditions is given below.

Table 5.2 lists all the mine affected water release points and associated receiving water for the current water management system (Table C1 in the EA). The locations of the release points are shown in Figure 3.2.

Table 5.3 shows the mine affected water release limits given in the Middlemount Coal Mine EA. Condition C4 requires that water is only released when the water quality is within these limits.

Condition C9 of the EA requires that the release of mine affected waters must only take place during periods of natural flow at a flow gauging station at Ref 1 as specified in Table 5.4. Further, Condition C10 requires that the release of mine affected water must not exceed the EC and sulphate release limits specified in Table 5.4.

Table 5.2 - Mine affected water release points (EA Table C1)

Release point	Easting	Northing	Mine affected water source and location	Monitoring point	Receiving waters
RP 1	667,725	7,469,370	RWD	Spillway/pipe	Roper Creek
RP 2	671,743	7,469,842	MWD	Spillway/pipe	Roper Creek
SD 1	668,008	7,469,218	SD1	Spillway/pipe	Roper Creek
SD 2	668,093	7,470,858	SD2	Spillway/pipe	Roper Creek
SD 3	668,457	7,470,213	SD3	Spillway/pipe	Roper Creek
SD 7	671,125	7,474,067	SD7	Spillway/pipe	Roper Creek
NROM	667,858	7,470,294	NROM	Spillway/pipe	Roper Creek

Table 5.3 - Mine affected water release limits (EA Table C2)

Quality characteristic	Units	Minimum	Maximum
EC	µs/cm		See Table 5.4
pH	pH units	6.5	9.0
Turbidity	NTU	N/A	No limit
Suspended solids	mg/L	N/A	Flow < 2m³/s - 562 mg/L Flow > 2m³/s - 1,062 mg/L
Sulphate	mg/L		See Table 5.4

Table 5.4 - Mine affected water release during flow events (EA Table C4)

Gauging station	Recording frequency	Flow criteria for release	Maximum release rate (for all combined RP flows)	Release limit	
				EC (µs/cm)	Sulphate (mg/L)
Ref 1	Continuous (minimum daily)	**Low flow** For a period of 28 days following natural flow events that exceed 2 m³/s	0.4 m³/s	700	250
		Medium flow >2 m³/s	1.12 m³/s	1,500	250
		High flow >10 m³/s	5.6 m³/s	1,500	250
		High flow >10 m³/s	1.6 m³/s	3,500	300
		Very high flow >25 m³/s	2.1 m³/s	6,000	500

5.6 CONTAMINATED WATER MANAGEMENT SYSTEM

5.6.1 Chemical storage

Primary chemical storage areas at Middlemount Coal Mine are located on the mine infrastructure area at the workshop and the CHPP workshop area. These storage facilities have been constructed and bunded generally in accordance with the relevant specifications of *AS1940 – Storage and Handling of Flammable and Combustible Liquids* (AS1940). Hazardous substances operating procedures are in place at these operations. A register is also maintained onsite for all chemicals. Where appropriate, safety data sheets will be kept in storage areas or accessed online, as required.

5.6.2 Fuel storage

Fuel storage areas are a potential source of hydrocarbons. Primary fuel storage areas at the mine infrastructure area have been constructed and bunded in accordance with the relevant specifications of *AS1940 – Storage and Handling of Flammable and Combustible Liquids* (AS1940). Fuel storage areas have also been constructed at service and operational points across the mining lease.

Fuel storage areas associated with Middlemount Coal Mine operations are inspected regularly, with repair and maintenance work completed on an as-needs basis. Bunds filled with stormwater are drained (i.e. diesel/oil storage bunding at warehouse drains to oil sump and onto oil separator system) or pumped out by a licensed contractor as soon as practicable to maintain the bund volume.

5.6.3 Sewage

Middlemount Coal Mine has installed a sewerage treatment plant that collects effluent from the main administration building, workshop, project offices and CHPP. Treated effluent from the sewage treatment plant is discharged to TSF1 for re-use in the CHPP. All other sewerage generated on site is trucked off site by registered waste transport contractors.

5.7 ON-SITE STORMWATER MANAGEMENT SYSTEM

5.7.1 Overview

On-site stormwater runoff from the overburden dumps and haul roads is managed in accordance with the ESCP (WRM, 2019a).

The ESCP would be reviewed and updated to incorporate the Project.

5.7.2 Sediment dam sizing

Sediment dams capture runoff from overburden dumps in accordance with the ESCP (WRM, 2019a). The proposed sediment dams have been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). Runoff collected in the dams will be released to the downstream environment in accordance with the Middlemount Coal Mine EA conditions or pumped back into the mine water system to maintain capacity.

The proposed sediment dams have been based on the following design standards and methodology:

- "Type D/F" sediment basins;
- total sediment basin volume = settling zone + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;
- sediment basin settling volume based on 85th percentile 5-day duration rainfall of 33.6 mm, with an adopted volumetric event runoff coefficient for disturbed catchments of 0.59 (Group D soils – clay); and
- solids storage volume = 50% of settling zone volume.

Table 5.5 shows the maximum contributing catchment areas and design volumes for each of the proposed sediment dams. The locations of the proposed sediment dams are shown in Figure 1.3 to Figure 1.6.

Table 5.5 – Proposed sediment dam sizes

Sediment Dam	Maximum catchment area (ha)	Sediment Basin Requirements			Overflows to
		Settling Volume (ML)	Sediment Storage Volume (ML)	Total Volume (ML)	
SD3	70.9	13.9	7.0	20.9	Roper Creek (pumped)
SD5	110.0	21.6	10.8	32.4	Drainage Line 3
SD6	256.0	50.3	25.2	75.5	Drainage Line 3
SD10	64.4	12.7	6.3	19.0	SD7 (pumped)
SD11	109.9	21.6	10.8	32.4	Thirteen Mile Gully Diversion (pumped)
SD12	666.5	131.0	65.5	196.5	Thirteen Mile Gully
SD13	92.9	18.3	9.1	27.4	Unnamed Diversion
SD14	38.7	7.6	3.8	11.4	SD7 (pumped)
SD15	39.1	7.7	3.8	11.5	Unnamed Diversion
SD16	50.9	10.0	5.0	15.0	Thirteen Mile Gully
SD17	60.8	11.9	6.0	17.9	Roper Creek (pumped)

Six new sediment dams (SD3, SD5, SD6, SD10[2], SD11 and SD12[3]) would be constructed by 2023 to capture runoff from the expanding overburden dump. Note that SD3 is an existing dam but would be moved and redesigned by 2023 to the location shown on Figure 1.3. By 2028, the existing sediment dams SD8 and SD9, as well as the proposed dam SD10 would be removed due to the expanding open cut and waste dump footprints. In addition, proposed dams SD13 and SD14 would be required by 2028. By 2037, proposed dams SD12 and SD14 would be removed and proposed dams SD15 and SD16 would be introduced. By 2043, proposed sediment dam SD17 would be introduced.

5.8 CATCHMENT RUNOFF WATER MANAGEMENT SYSTEM

5.8.1 Flood protection levees

Flood levees are used across Middlemount Coal Mine to prevent up-catchment floodwater from Roper Creek and the drainage lines from entering the water management system. The location of the existing levee is shown in Figure 5.2. These levees have been progressively constructed since 2008 and are regulated structures under the EP Act.

The approved Western Extension Project allowed mining of the western extension area, which required a realignment of the Thirteen Mile Gully levee and diversion (see Figure 5.2). The realigned diversion and levee were completed in July 2020.

The levees are regulated structures under the EP Act and are therefore required to have a crest above the 0.1% AEP event. The levees at Middlemount Coal Mine are operated and maintained in accordance with *Regulated Structures Operational Plan* (MCPL, 2019).

The Project proposes to realign the levee approved under the Western Extension Project to allow mining of the southern extension area. The location of the proposed levee change is shown in Figure 1.2. The modified levee will be a regulated structure under the EP Act and will therefore be required to have a crest above the 0.1% AEP event. An assessment of the levee against the requirements of the EP Act is given in Section 9.6.

5.8.2 Waterway diversions

Three waterway diversions have been approved at Middlemount Coal Mine; two diversions of Roper Creek (Roper Creek Diversions 1 [western diversion] and 2 [eastern diversion]) and a diversion of Thirteen Mile Gully into Roper Creek along the eastern boundary of ML 70730.

The Thirteen Mile Gully diversion has been constructed and its location is shown in Figure 5.2. Approval to realign Thirteen Mile Gully diversion was granted as part of the Western Extension Project. The diversion will commence about 1 km upstream of the commencement of the existing levee along Drainage Line 1 and drain into the existing diversion about 1 km downstream of the commencement of the existing diversion as shown in Figure 5.2. The diversion was completed in July 2020.

The approved locations of the Roper Creek diversions are shown in Figure 5.2. The conditions of approval for the two diversions are given in the current EA.

Detailed design of the Roper Creek Diversion 1 has been completed (Engeny, 2020) and is planned for construction in 2020.

As part of the Project, it is proposed to realign the approved (but not yet constructed) Roper Creek Diversion 2 inside the existing MLs.

[2] Would adopt the name 'SD10' following the decommissioning of existing dam SD10.
[3] SD12 is associated with a natural depression from the diverted alignment of Thirteen Mile Gully.

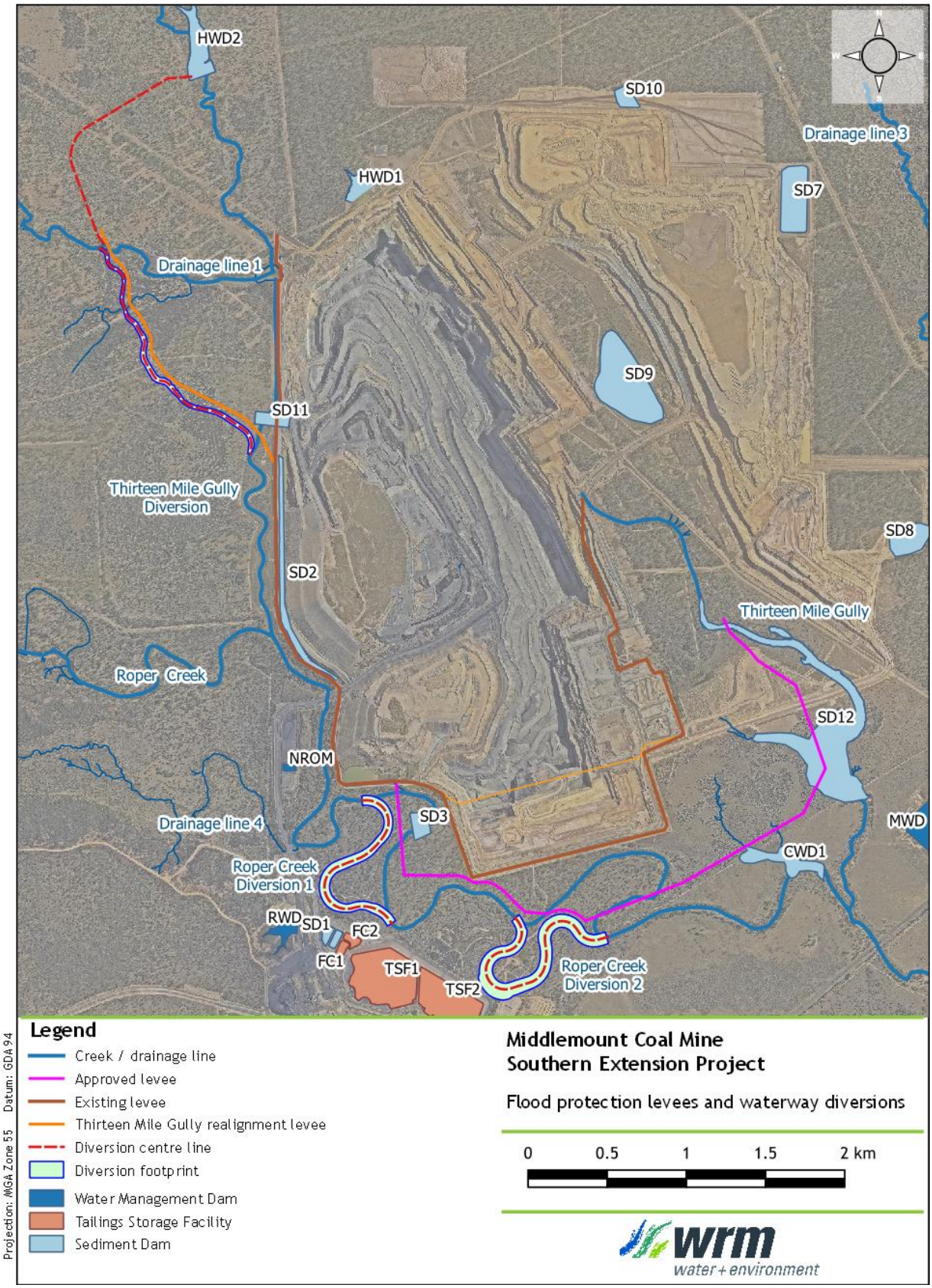

Figure 5.2 - Existing and approved flood protection levees and waterway diversions

5.8.3 Up-catchment runoff water diversions

A series of up-catchment water drains and temporary water storages have been or are proposed to be constructed to capture and divert catchment runoff water around the mining areas. The locations of the temporary water storages are shown in Figure 5.2. Descriptions of the temporary water storages are as follows:

- High Wall Dam 2 (HWD2) has been constructed to the north of the mining areas to capture overland flows from drainage line 2. The captured overland flows are drained to the Thirteen Mile Gully diversion.
- High Wall Dam 1 (HWD1) will be constructed towards the end of 2020 to the north of the mining areas to capture overland flows. The captured overland flows will be pumped to HWD2. This structure is currently in the detailed design phase.

5.9 EXTERNAL WATER SUPPLY

MCPL have an arrangement with Anglo American plc to supply water from the German Creek Mine. Water is pumped from German Creek on an 'as needed' basis and placed in the RWD up to a limit of 250 ML per month and 1,800 ML per year.

Water is supplied in accordance with the Water Supply Contract between MCPL and Anglo Coal (Capcoal Management) Pty Ltd dated 22 December 2010.

External water will continue to be pumped to site on an 'as needed' basis for the Project. The modelling results presented in Section 6.3.4 show that the current agreement with Anglo American is sufficient to meet the mines external water supply requirements under all but the driest climatic conditions.

Water captured on-site will however continue to be used in preference to the German Creek Mine water supply.

6 Water management system assessment

6.1 OVERVIEW

The performance of the mine affected water management system was assessed using the OPSIM water balance model. OPSIM is a computer-based operational simulation model that has been developed to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the Project. The model has been in operation since the conception of the mine and has been continually updated as data becomes available or mining operations have changed. The model will be continually updated throughout the life of the Project.

The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step. Full details of the configuration and calibration of the Middlemount Coal Mine OPSIM model, including input assumptions, are provided in Appendix B.

The model represents five different representative stages of the mine life. The adopted model stages are summarised in Table B.3.

The Middlemount Coal Mine OPSIM model was used to predict the performance of the following:

- overall water balance – the average inflows and outflows of the water management system for a number of representative rainfall sequences (Section 6.3.1);
- mine water inventory and salinity – the risk of accumulation (or reduction) of the overall mine water inventory and associated water quality (Section 6.3.2);
- in-pit storage – the risk of accumulation of water in the mining pit, and the associated water volumes (Section 6.3.3);
- external water demand – the risk and associated volumes of requiring imported external water (via the Anglo pipeline) to supplement site mine water supplies (Section 6.3.4);
- uncontrolled spillway discharges – the risk of uncontrolled discharge from the mine affected water storages to the receiving environment (Section 6.3.5); and
- controlled releases – the risk and associated volumes of controlled release of mine affected water to the receiving environment (Section 6.3.6).

6.2 INTERPRETATION OF RESULTS

In order to undertake forecasting simulations of the behaviour of the water management system over the future 24 years of mine operations, for a range of climatic conditions, the calibrated water balance model was configured to run 107 simulations of a 24 year (mine life) period, using the 131 years of available SILO Data Drill historic climate data. The 24 year forecast simulation period commences on 1 January 2021 and ends on 31 December 2044.

The model results are presented as a probability of exceedance. For example, the 10th percentile represents 10% probability of exceedance and the 90th percentile results represent 90% probability of exceedance. There is an 80% chance that the result will lie between the 10th and 90th percentile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is that available storage capacity will be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1 percentile storage volume will be exceeded, which would generally correspond to wet conditions.

For external site water supply volumes (for example), where the risk is that insufficient water will be available, there is only a small chance that more than the 1 percentile water supply volume would be required. This would generally correspond to dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50th percentile trace does not represent the model time series for median climatic conditions.

6.3 WATER BALANCE MODEL RESULTS

6.3.1 Overall water balance

Water balance results for all of the 107 modelled realisations are presented in Table 6.1, over each model Stage. The results presented in Table 6.1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield and evaporation for each Stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 6.1 – Annual water balance – all realisations

Component	Process	Average annual volume (ML/year) per model Stage			
		Stage 1	Stage 2	Stage 3	Stage 4
Inflows	Catchment runoff & direct rainfall	1,962	1,871	1,678	1,580
	Groundwater inflows	827	801	903	463
	External supply	870	707	561	660
	Total inflows	**3,659**	**3,379**	**3,142**	**2,704**
Outflows	Evaporation	1,189	1,034	878	873
	Dust suppression	1,187	1,187	1,187	1,187
	Net CHPP demand	929	928	841	471
	Controlled releases	0	0	0	0
	Spillway overflows – mine water dams	0	0	0	0
	Spillway overflows – sediment dams	250	214	178	209
	Spillway overflows - catchment runoff dams	33	21	19	0
	Total outflows	**3,588**	**3,385**	**3,102**	**2,739**
	Change in volume	**71**	**-6**	**40**	**-36**

Table 6.1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- During each Stage the overall mine system alternates between generating a net gain or loss of water;
- The groundwater inflows (which are based on the calibrated model predictions by AGE [2020]) are generally consistent between Stage 1 and Stage 3, with a reduction towards the end of the Project in Stage 4;

- Average annual external water supply requirements vary between 560 to 870 ML/year over the life of the Project;
- The net CHPP demand (based upon forecast CHPP output numbers) is generally consistent between Stage 1 and Stage 3, with a reduction towards the end of the Project in Stage 4;
- On average, there are no spills to the environment from mine water dams; and
- External supply requirements are greatest in Stage 1, decreasing to Stage 3 and slightly increasing in Stage 4.

6.3.2 Mine site storage inventory and salinity

Figure 6.1 shows the modelled behaviour of the MWD over the 24-year simulation period. The MWD is the primary mine affected water storage on the site and is therefore indicative of the overall mine water storage behaviour. Although the capacity of the MWD is 1,928 ML, the maximum operating storage level of the MWD is set at 1,815 ML to prevent uncontrolled spills.

If the MWD is anticipated to exceed 1,815 ML, water will be managed within the individual dams rather than pumped to the MWD. Releases from the MWD are restricted when the stored volume falls below 1,200 ML to maintain water for mine site use. The following is of note:

- The MWD does not empty over the simulation period due to the supply of water via the Anglo pipeline from German Creek Mine; and
- The MWD does not spill under any of the realisations, with its maximum operating volume staying below 1,910 ML under all realisations.

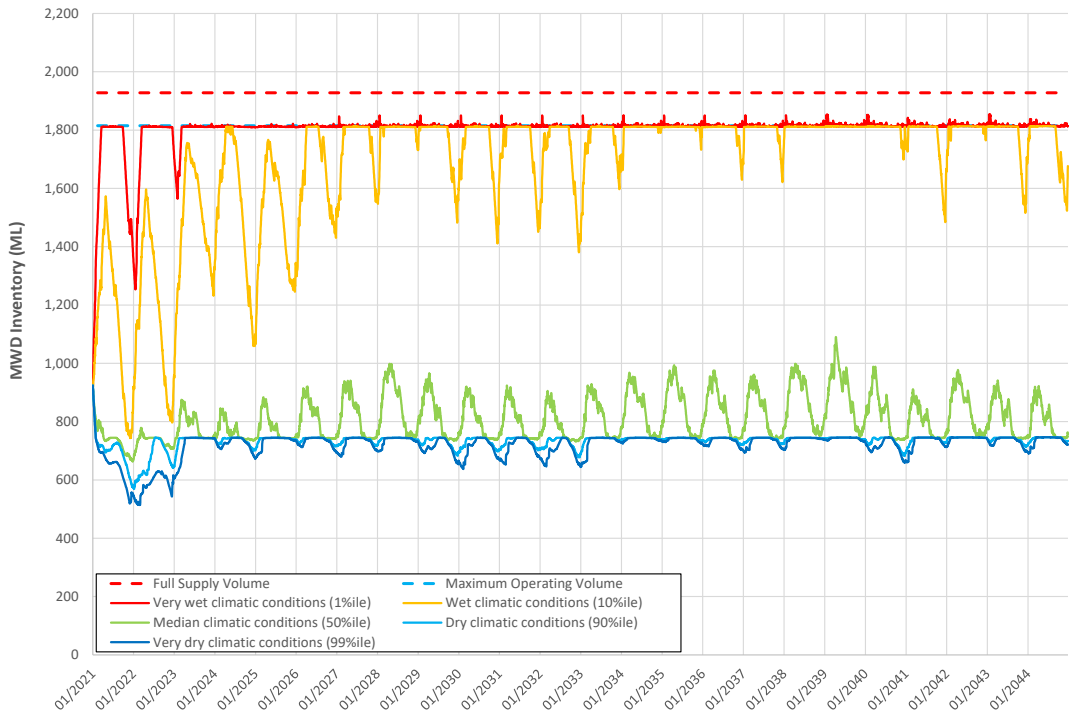

Figure 6.1 – Forecast MWD inventory

Figure 6.2 shows the modelled salinity of the MWD over the 24-year simulation period. The following is of note:

- The initial modelled salinity of 17,270 µS/cm reduces rapidly over the first two years of the simulation.

- During dryer climatic conditions, the salinity of MWD is expected to be around 13,000 to 16,000 µS/cm. This is due to the greater reliance on the water supply from the Anglo pipeline, which has a modelled salinity of 8,000 µS/cm, as well as the lower overall inventory in the MWD.
- During median climatic conditions, the salinity of MWD is expected to be around 11,000 to 14,000 µS/cm.
- During wetter climatic sequences, the salinity of MWD is expected to reduce to around 6,000 to 9,000 µs/cm. This is due to the reduced reliance on the water supply from the Anglo pipeline and the higher overall inventory in MWD.

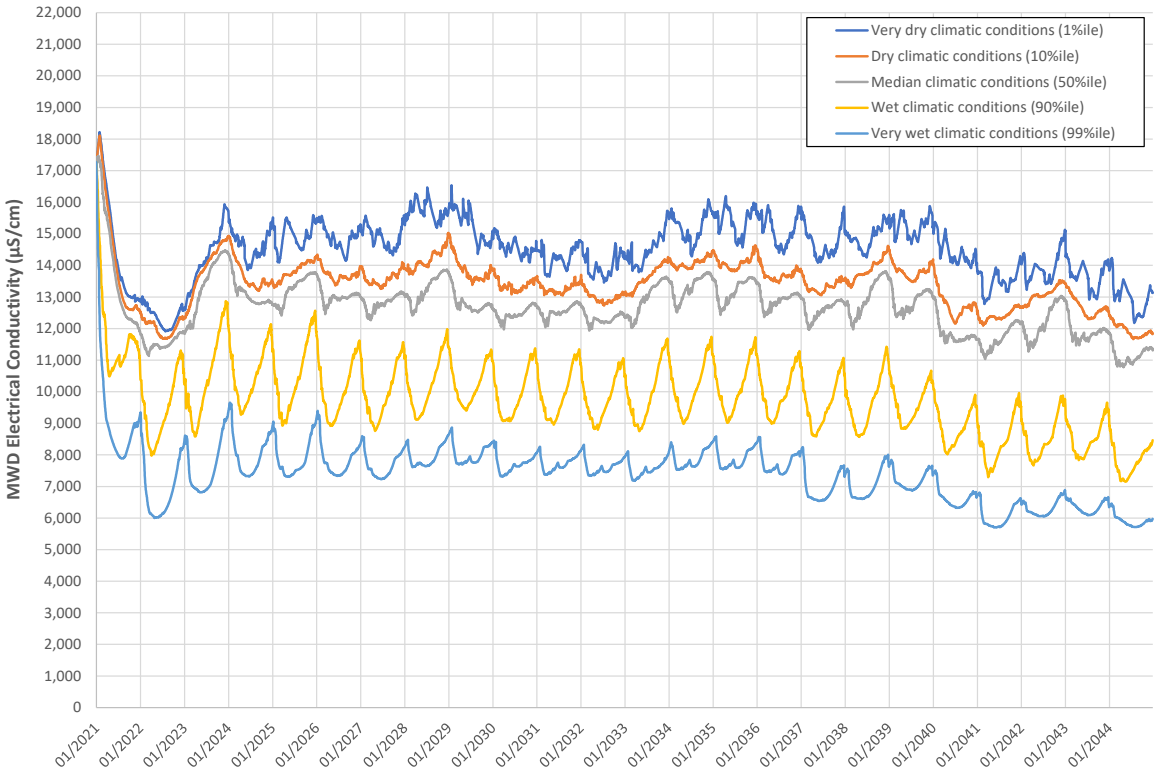

Figure 6.2 – Forecast MWD salinity

6.3.3 Pit inundation characteristics

Figure 6.3 shows the modelled behaviour of the mining pit over the 24-year simulation period.

The pit inundation characteristics provides an indication as to whether there is sufficient in-pit pumping infrastructure and out-of-pit storage volume to prevent operational problems. The following is of note:

- There is a relatively low risk of accumulating significant volumes of water in the pit over the Project life, with the 1%ile (very wet conditions) peaking at approximately 2,850 ML.
- Under 10%ile (wet) conditions the pit inventory will not increase over 1,000 ML over the Project life.
- The pit inventory does not increase above 30 ML over the Project life under 50%ile conditions.

These modelling results indicate that the risk of excessive pit inundation is relatively low due to the storage capacity available in the MWD and the existing pit pump capacity.

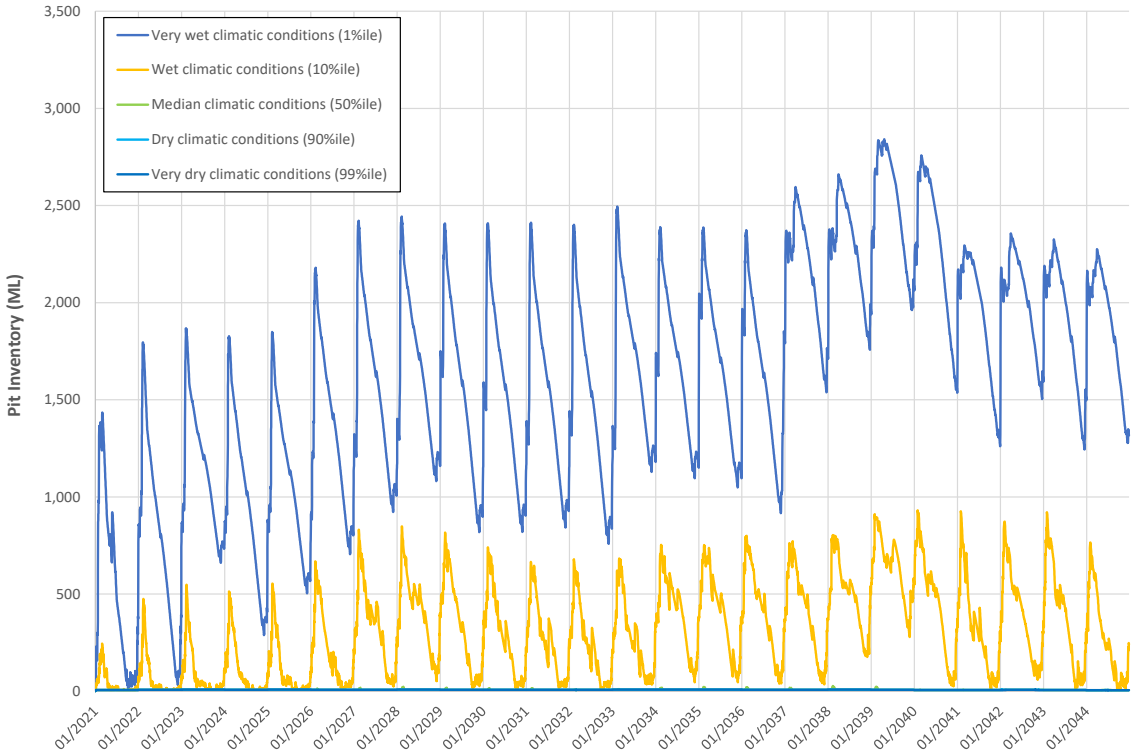

Figure 6.3 – Forecast mining pit inventory

6.3.4 Water supply reliability

The model results show that the mine water management system including the external water supply via the Anglo pipeline from German Creek Mine can meet all mine site demands over the 24-year Project life. Further to this, the modelling indicates that:

- an external water supply source is required in almost all years to satisfy demand;
- under 50th %ile conditions there is a requirement for between 460 ML/yr to 1,330 ML/yr over the Project life; and
- there is <1% chance that the Project would require more than 1,800 ML/yr of external water (i.e. greater than the maximum cap of the external Water Supply Contract with Anglo).

That is, the existing external water supply arrangements with Anglo (via the pipeline from German Creek Mine) would be sufficient for the vast majority of climatic cases.

6.3.5 Uncontrolled discharges

The water balance model shows that there is less than a 1% chance of uncontrolled spills to the environment from the Project mine water dams. Therefore, the operational procedures given in the Regulated Dams Operational Management Plan (MP214-001) achieve the assessment criteria objective of a less than 10% chance of uncontrolled discharges from the mine affected water dams.

The model results indicate that the Project will continue to achieve the assessment criteria objective of a less than 10% chance of uncontrolled discharges from the mine affected water dams.

6.3.6 Controlled releases

The water balance model simulates that no controlled releases from the MWD to Roper Creek would occur based on the conditions of the EA. This is due to the high initial salinity of the MWD and the high salinity of the groundwater, runoff parameters and from the external water supply pipeline.

Although controlled releases can be made from other storages, it is only made from the MWD under the current mine affected water management system.

7 Residual void behaviour

7.1 OVERVIEW

Water levels in the residual voids will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater. A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term water level behaviour of the residual voids. The historical rainfall and evaporation sequences (131 years) were repeated 5 times to create an indicative long-term climate record.

The volume of water in the voids is calculated at each time step as the sum of direct rainfall to the water surface, catchment runoff and groundwater inflows, less evaporation losses.

7.2 RESIDUAL VOID CONFIGURATION

The residual void configuration and contributing catchment areas are shown in Figure 7.1 and Table 7.1. The final catchment draining to the voids will be minimised using upslope diversion drains, as shown in Figure 7.1. The total catchment draining to the two residual voids is less than the total catchment of the approved residual voids. A depth varying storage evaporation factor has been applied to each void to simulate the expected change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void – 0.5
- 10 m from top of void – 0.9
- Top of void – 1.0

Table 7.1 – Contributing catchment to residual void

Residual void	Contributing catchment (ha)
North Void	440.4
South Void	240.8

7.3 STAGE-STORAGE CHARACTERISTICS

The stage-storage curve for North Void and South Void have been estimated from the final landform terrain model provided by MCPL. The geometries of the residual voids are summarised in Table 7.2.

The depths of each void at the end of mining vary from north to south across both mine pits, with the 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 metres Australian height datum (mAHD).

Table 7.2 – Modelled residual void geometry

Residual void	Depth (m)	Top surface area (ha)	Full supply volume (ML)
North Void	235	358	285,870
South Void	199	163	157,960

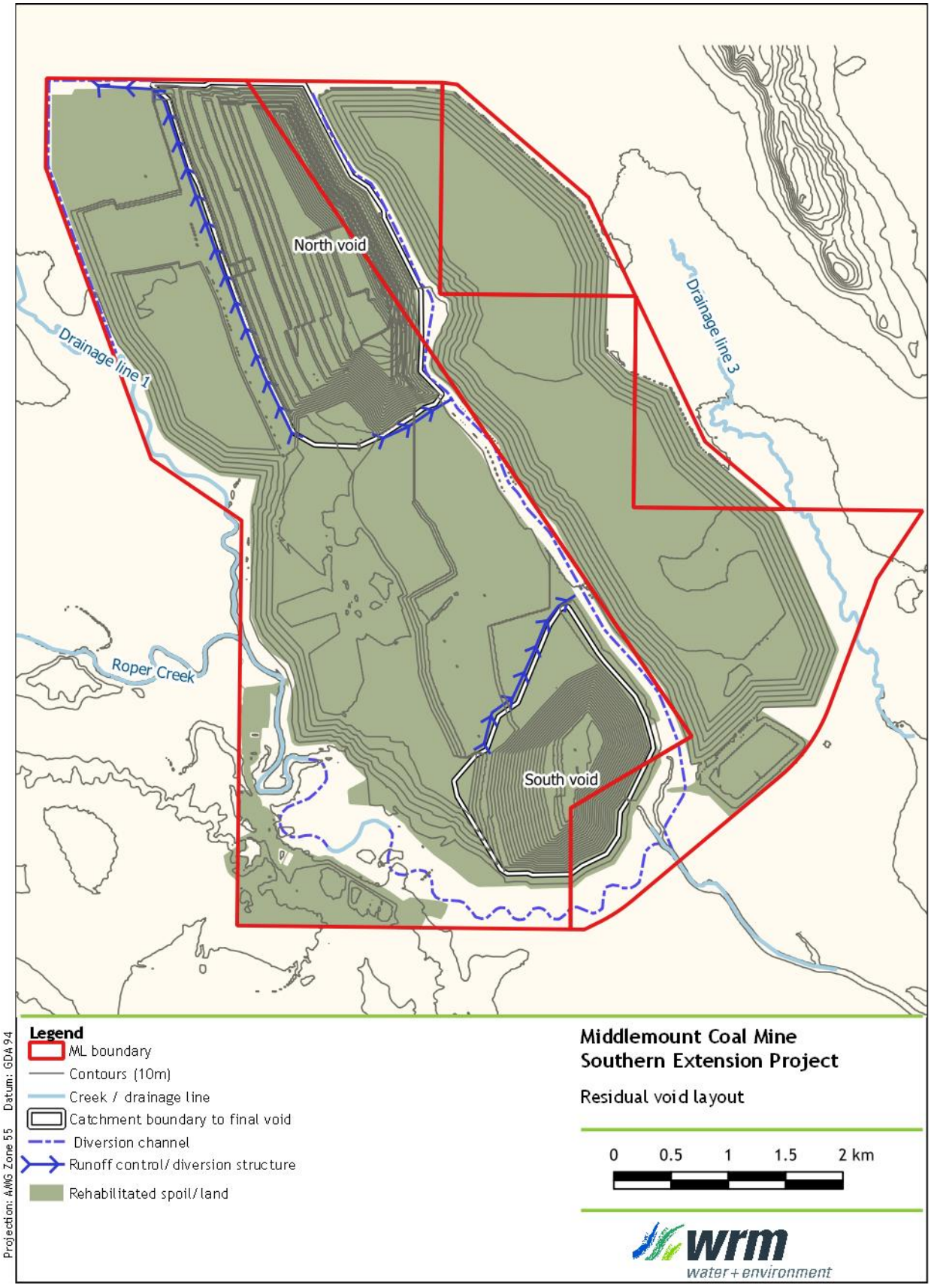

Figure 7.1 – Residual void catchment plan

7.4 GROUNDWATER INFLOWS

Groundwater inflows to the north and south void have been predicted by AGE (2020). These inflow rates take into account the movement of water between the North Void and South Void through the in-pit spoil which separates the voids. Groundwater inflows at water levels above the provided inflow curves have been assumed to be zero. This assumption is not expected to have a significant impact to the residual void water level behaviour given that the predicted groundwater inflows to the residual void are relatively small (Age, 2020).

7.5 WATER QUALITY

Weathering processes on the mine spoil will result in the dissolution of soluble minerals, partial dissolution of lower solubility minerals (mineral weathering), cation exchange, and reaction. Mining activities increase the hydraulic conductivity and surface area of naturally occurring materials resulting in a body of spoil more prone to leaching. The salts released are mainly chlorides of Na, Ca and Mg, and to a lesser extent, sulphates and carbonates.

As a result, the GOLDSIM site water balance model has been developed using Total Dissolved Solids (TDS) as an indicator of water quality in the residual voids. There is insufficient quality data available to develop a site-specific relationship between EC and TDS at Middlemount Coal Mine. Therefore, the following relationship has been adopted for Middlemount Coal Mine: TDS (mg/L) = 0.6 x EC (µS/cm)

Salts will enter the residual void via:

- Surface runoff from the rehabilitated spoil;
- Groundwater inflows.

Based on a combination of past experience on similar sites, and water quality data collected at Middlemount Coal Mine operation, the TDS values shown in Table 7.3 have been adopted for this study. The adopted groundwater salinity is consistent with the outcomes presented in the AGE groundwater assessment for the Southern Extension Project (AGE, 2020) which indicated that the average TDS for inflows from the Permian aquifers was around 10,000 mg/L.

Table 7.3 – Indicative contaminant concentrations of runoff

Contaminant source	Adopted TDS (mg/L)	EC (µs/cm)
Rehabilitated spoil	300	500
Groundwater	10,000	16,666

The adopted runoff salinity for the residual void assessment is applied at a fixed concentration and does not include any allowance for decay in runoff salinity over time (and hence is likely to overstate the rate of salinity level increase).

Prior to mine closure, the spoil surface will be regraded, topsoiled and revegetated. These changes should result in improved surface runoff quality. In the long-term, leaching of salts, should result in runoff salinities reducing to background levels.

7.6 MODEL RESULTS

7.6.1 Long-term water level behaviour

Figure 7.2 to Figure 7.5 show the simulated long-term water levels and volumes in the North and South voids. Table 7.4 shows a summary of the storage details of the residual voids and the results of the water balance modelling.

Table 7.4 – Residual void modelling results summary

Void	Elevation (mAHD)			
	Floor level	Pre-mining groundwater level	Overflow level	Modelled average long-term water level
North Void	-72	140	163	10.5
South Void	-40	130	159	35.1

The model results show the following:

- North Void (Figure 7.2 and Figure 7.3)
    - The water level reaches equilibrium between 6.5 mAHD and 13 mAHD after around 200 years, and generally varies between these levels throughout the remaining 300 years of the simulation.
    - The maximum modelled water level is around 150 m below the North Void full supply level and around 127 m below the pre-mining groundwater level.
- South Void (Figure 7.4 and Figure 7.5)
    - The water level reaches equilibrium between 32 mAHD and 37 mAHD after around 200 years, and generally varies between these levels throughout the remaining 300 years of the simulation.
    - The maximum modelled water level is around 122 m below the South Void full supply level and around 93 m below the pre-mining groundwater level.

The residual void modelling indicates that the expected water levels are well below the full supply levels for each void, and the voids will remain as long-term groundwater sinks in perpetuity with no escape of contained water into the Rangal Coal Measures or Fort Cooper Coal Measures (AGE, 2020).

The water balance modelling indicates that there would be no interaction between the long-term surface water levels within North Void and South Void. Due to the different floor elevations and predicted water levels in the voids, a groundwater flow gradient from the South Void into the North Void through the spoil backfill would occur (AGE, 2020).

7.6.2 Long-term salinity

The predicted long-term void water levels do not exceed the current regional groundwater level. Therefore, there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline (around 33,000 mg/L) within the first 200-300 years of the simulation.

Figure 7.2 and Figure 7.3 shows the North Void salt accumulation and salt concentration over the first 500 years of simulation. Figure 7.4 and Figure 7.5 shows the South Void salt accumulation and salt concentration of the first 500 years of simulation.

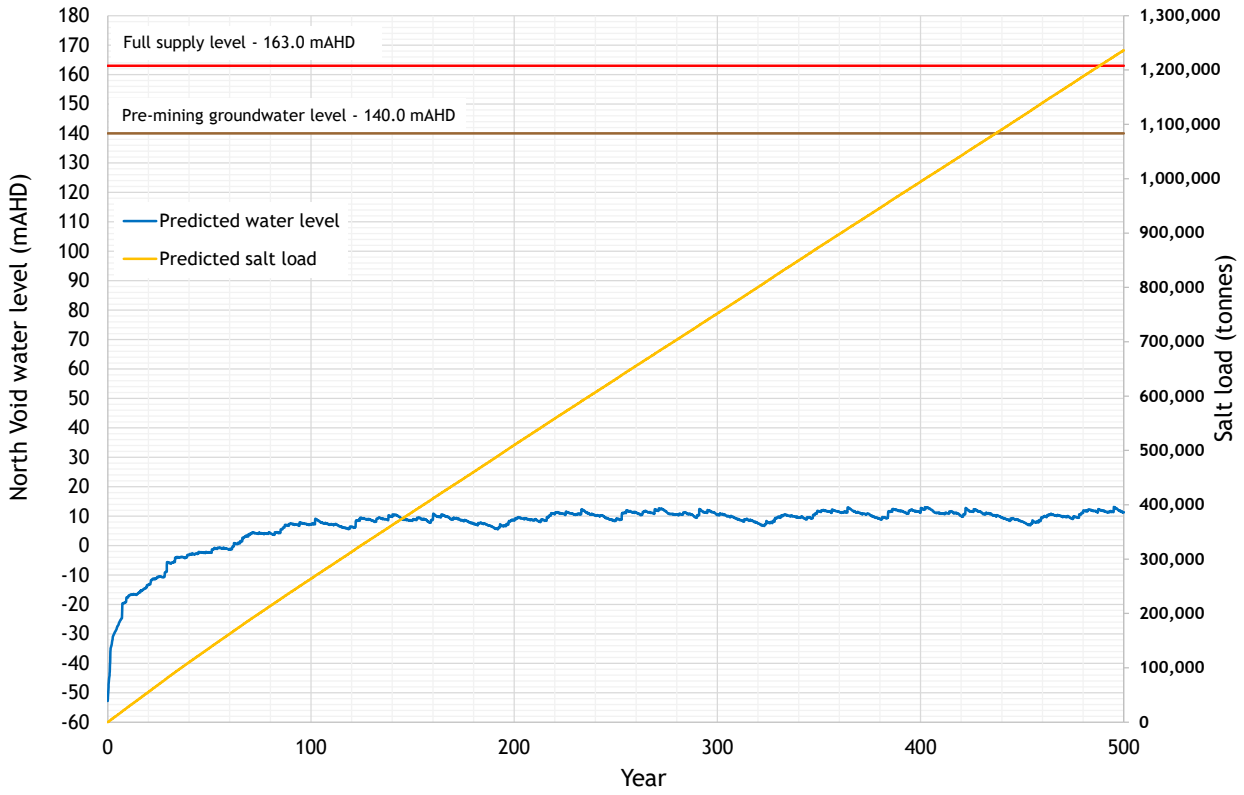

Figure 7.2 - Residual void water levels and salt load - North Void

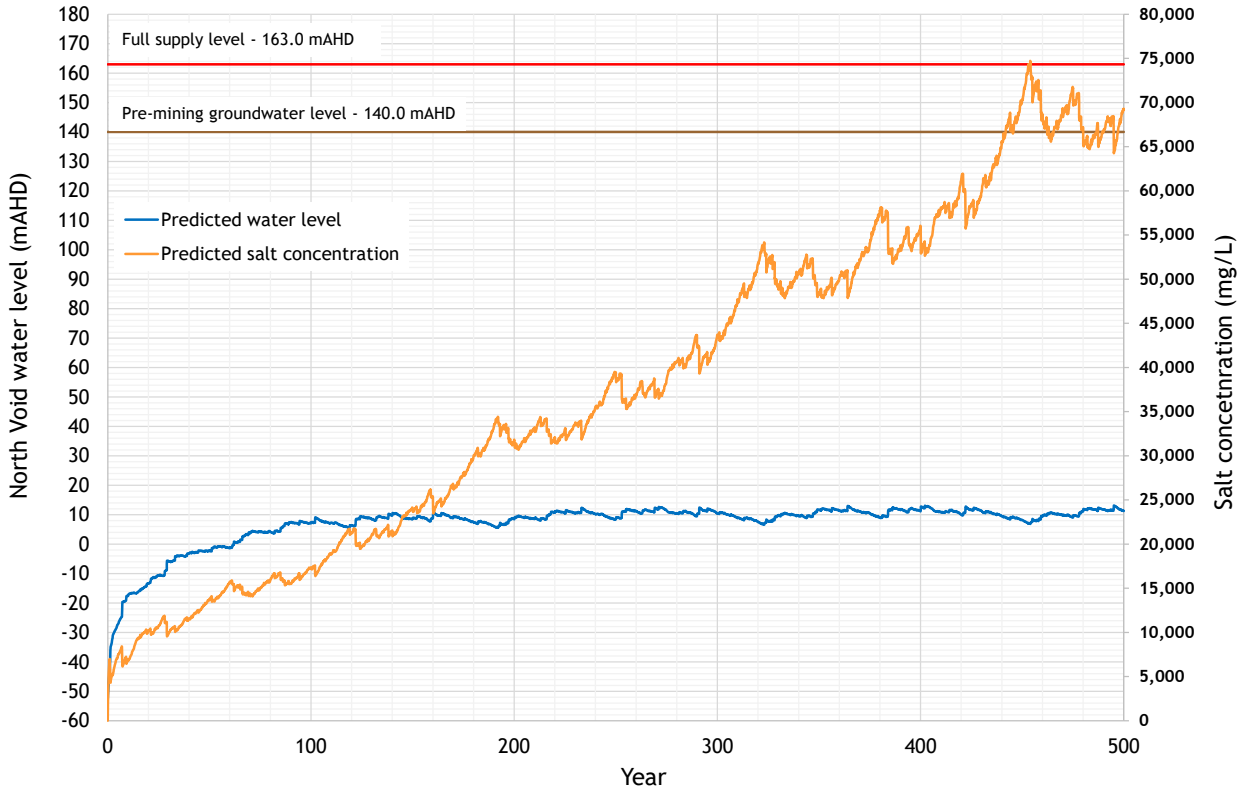

Figure 7.3 - Residual void water levels and salt concentration - North Void

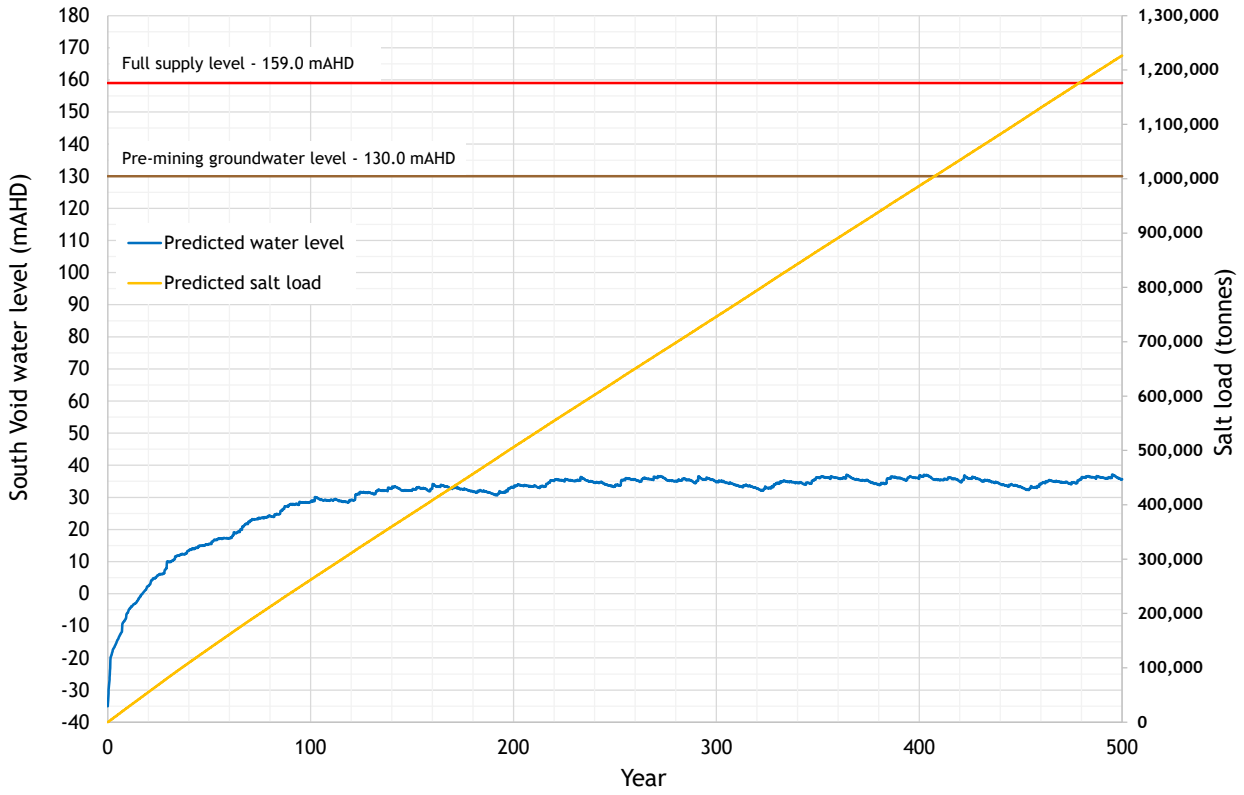

Figure 7.4 - Residual void water level and salt load - South Void

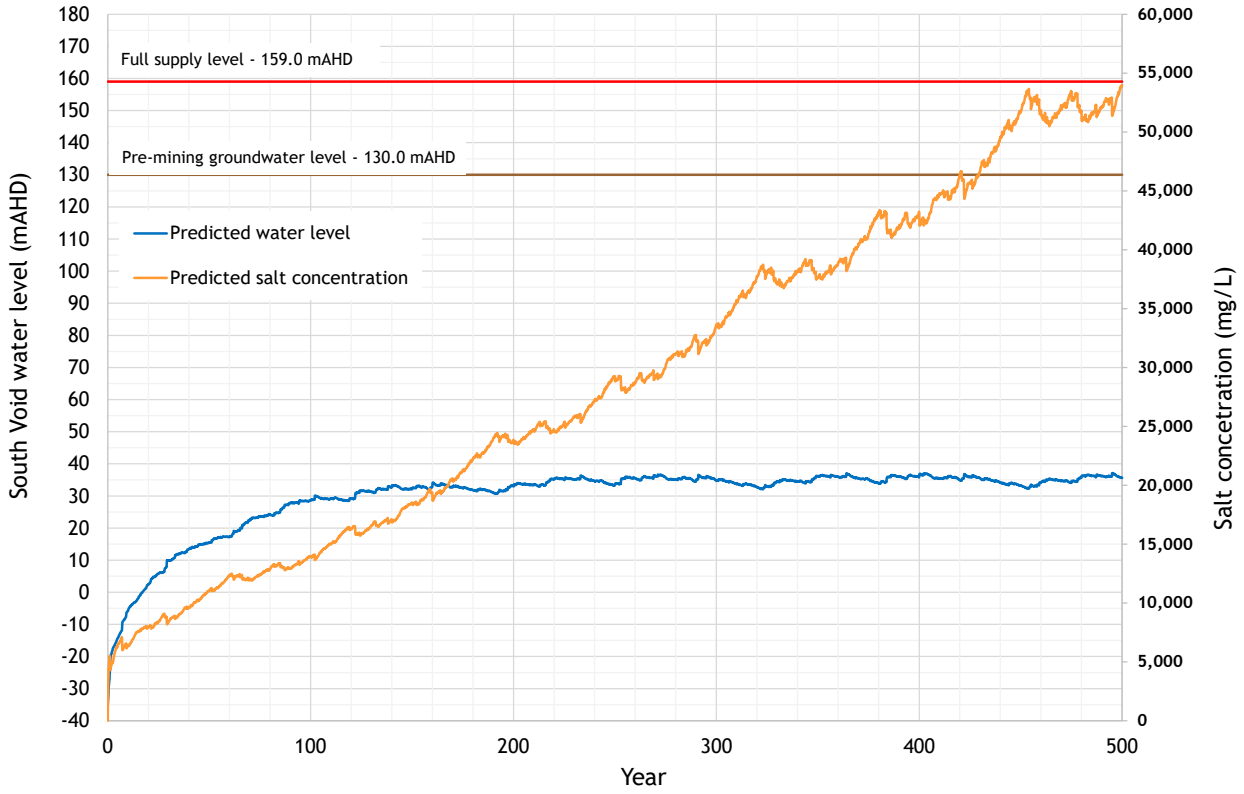

Figure 7.5 - Residual void water level and salt concentration - South Void

The model results show the following:

- North Void (Figure 7.2 and Figure 7.3)
    - In the first 500 years, the modelled salinity reaches a peak concentration of 74,700 mg/L;
    - Salt accumulates within the North void at an average rate of around 2,470 tonnes per year; and
- South Void (Figure 7.4 and Figure 7.5)
    - In the first 500 years, the modelled salinity reaches a peak concentration of 53,950 mg/L;
    - Salt accumulates within the South void at an average rate of around 2,450 tonnes per year; and

It is noted that the driving head of groundwater inflow from the surrounding groundwater table towards the void (i.e. sink effect) would be expected to overcome any density-driven groundwater flow within the void lake itself. Therefore, the residual voids would not result in an increase in groundwater salinity concentrations beyond the extent of the residual voids.

7.7 STORM EVENT BEHAVIOUR

7.7.1 Overview

An assessment of the impact of storm events on the water level in the residual voids has been undertaken. The potential for discharge of void water has been assessed for the following design rainfall events using 72-hour (3 day) rainfall depths:

- 1 in 100 AEP;
- 1in 1,000 AEP.

7.7.2 Initial conditions

The maximum water level simulated in the base case water balance modelling were adopted as the initial conditions for the storm event analysis. The following values were adopted for each void:

- North Void – Initial volume of 19,100 ML (13.2 mAHD).
- South Void - Initial volume of 23,650 ML (37.2 mAHD).

7.7.3 Design rainfall depths

Design rainfall depths for the 1 in 100 AEP, 1 in 1,000 AEP rainfall events were estimated using standard procedures in Australian Rainfall and Runoff (ARR) (Ball et al., 2016).

7.7.4 Assessment outcomes

Runoff volumes were calculated assuming no losses from the total catchment areas adopted in the water balance model. Table 7.5 show the results of the storm event analysis for the North and South voids respectively.

The results show that even during storm events with rainfall depths equivalent to the 1 in 1,000 AEP design event, there would be minimal impact on the level of water in the voids. The 1 in 1,000 AEP design event final water level is approximately 146 m and 120 m below spillway level for the North and South voids, respectively.

Table 7.5 – Storm event behaviour – North Void and South Void

Storm event (AE)	Rainfall depth (mm)	Runoff volume (ML)	Final volume (ML)	Change in water level (m)	Final water level (mAHD)
North Void					
1 in 100	335	1,475	20,541	2.2	15.4
1 in 1000	519	2,286	21,351	3.4	16.6
South Void					
1 in 100	335	807	24,458	1.3	38.5
1 in 1000	519	1,250	24,902	2.1	39.2

7.8 POST-MINING POTENTIAL CHANGED CLIMATE ASSESSMENT

7.8.1 Methodology and sensitivity parameters

The potential changes to climate post-mining were assessed using the projections and methodologies given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled "Climate Change in Australia Technical Report" (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the Australian East Coast based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, wind speed and potential evapotranspiration. CSIRO (2015) presents a number of possible approaches to quantify risks associated with climate change impacts.

For this assessment, the Representative Concentration Pathway 4.5 (RCP4.5) emissions scenario has been adopted. The year 2090 was selected as the representative year, being approximately 50 years post-mine closure. Potential changes in climate have been obtained using the projection builder tool provided in the Climate Change Australia website. Climate variable inputs for the 'best case', 'maximum consensus' case 'and 'worst case' RCP4.5 climate change scenarios are provided in Table 7.6.

Rainfall is expected to change by between plus 4.4% and minus 19.8% and evapotranspiration is expected to increase by between 5.5% and 7.8%. The climate variable inputs (rainfall and evaporation) to the water balance model were adjusted to undertake the climate change impact assessment. All three scenarios have been assessed for the proposed residual voids.

Table 7.6 – Projections of changes to climate – Year 2090

Scenario	Climate model	Annual change (%)	
		Rainfall	Evapotranspiration
Best case	GFDL-ESM2M	-19.8%	6.9%
Maximum consensus	NorESM1-M	-10.1%	5.5%
Worst case	ACCESS1-0	4.4%	7.8%

7.8.2 Potential climate change impacts

7.8.2.1 Overview

Potential climate change impacts to the residual void water balance were assessed by simulating the 'best' case, 'maximum consensus case' and 'worst' case climate scenarios for the Year 2090 climate changes projection. The water balance model climate inputs (rainfall and evaporation) were factored by the values given in Table 7.6.

7.8.2.2 Potential impacts on residual void water levels

The impact of the potential changes in rainfall and evapotranspiration for the proposed residual voids are presented in Figure 7.6 and Figure 7.7. The results show the following (with the baseline results shown for reference):

- For the 'best' case climate scenario:
  - *North Void*: The equilibrium and peak water level are around 12 to 13 m lower than under baseline climate conditions.
  - *South Void*: The equilibrium and peak water level are around 14 to 15 m lower than under baseline climate conditions.
- For the 'maximum consensus' case climate scenario:
  - *North Void*: The equilibrium and peak water level are around 7 to 9 m lower than under baseline climate conditions.
  - *South Void*: The equilibrium and peak water level are around 9 to 10 m lower than under baseline climate conditions.
- For the 'worst' case climate scenario:
  - *North Void*: The equilibrium and peak water level are around 3 to 4 m lower than under baseline climate conditions.
  - *South Void*: The equilibrium and peak water level are around 3 to 4 m lower than under baseline climate conditions.

Under all three modelled climate changes scenarios, the water balance modelling results show that the residual voids will remain a groundwater sink in perpetuity, with no leakage of stored void water.

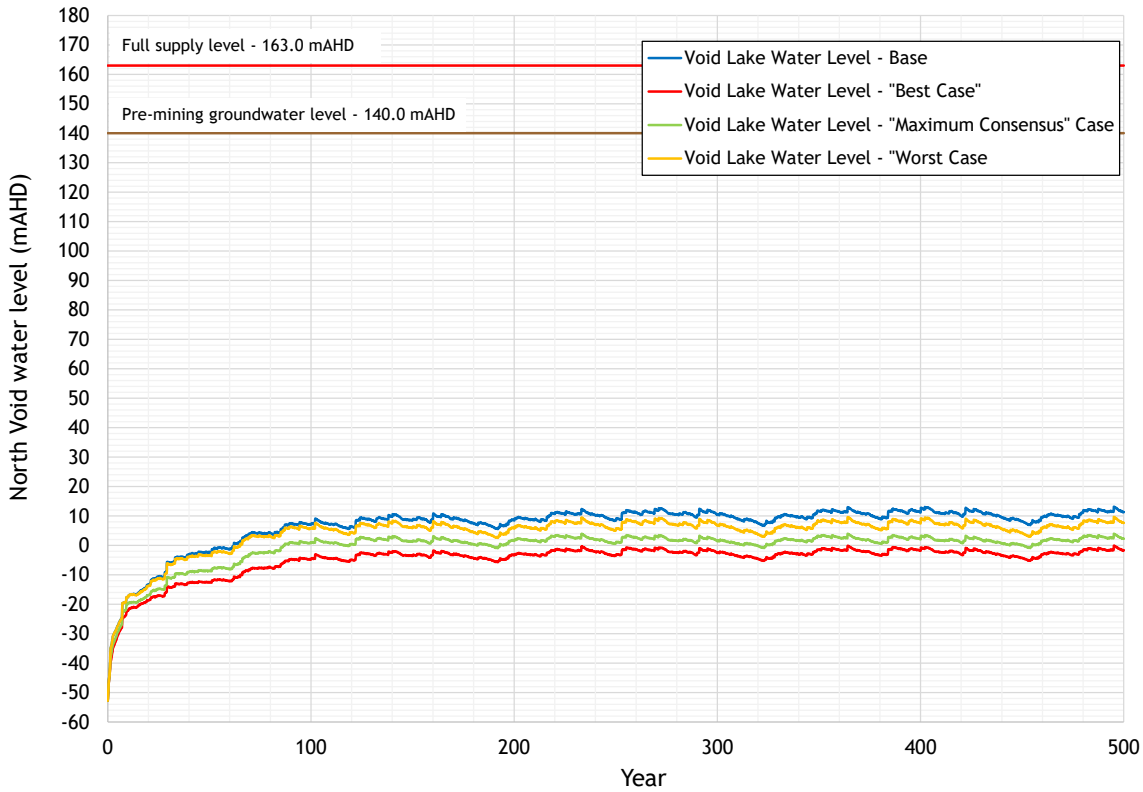

Figure 7.6 - North Void water level - climate change assessment

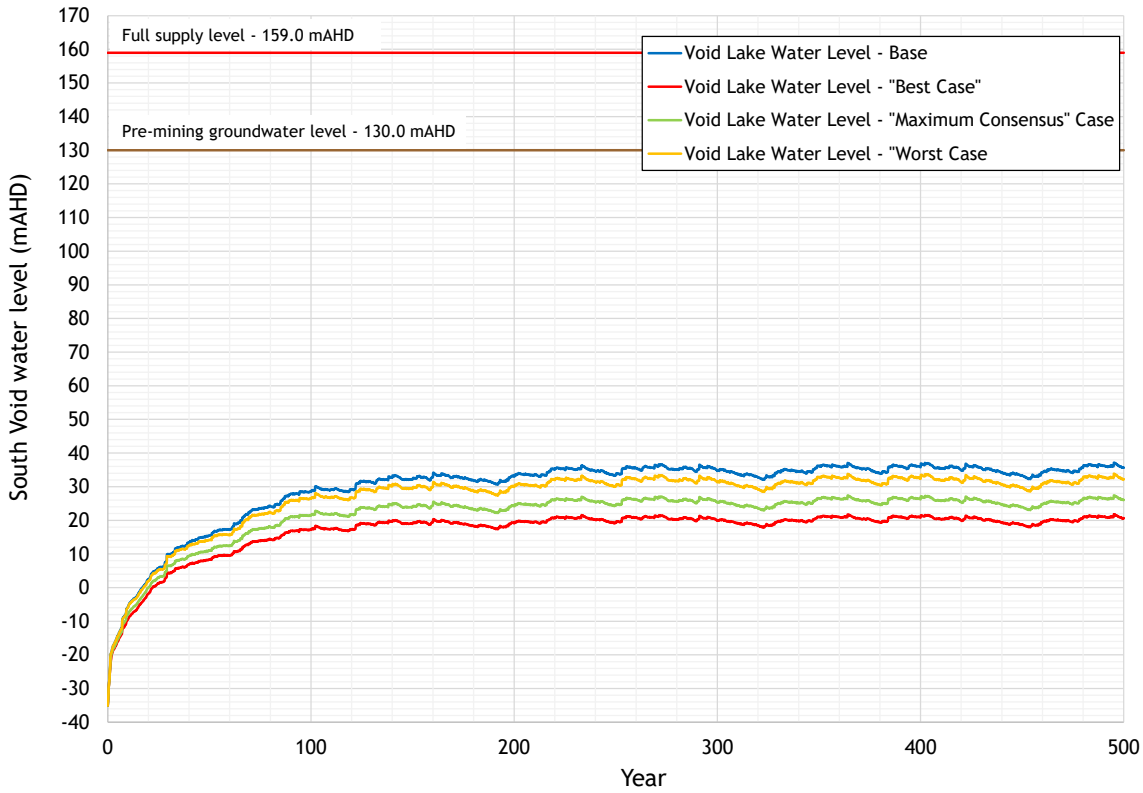

Figure 7.7 - South Void water level - climate change assessment

8 Flood model development and calibration

8.1 OVERVIEW

Flood models were developed to derive peak flood levels, extents and depths for a range of design flood events to assess the flood impacts of the Project, to define the proposed modified levee crest heights for the operational and final landform phase, and assess the proposed re-alignment to the approved Roper Creek Diversion 2.

The Unified River Basin Simulator (URBS) hydrological model (Carroll, 2004) was used to estimate stream flows (discharges) and the TUFLOW two-dimensional hydraulic model (BMT, 2018) was used to define flood levels and assess the impact of the project. The URBS and TUFLOW models were calibrated to recorded water levels and surveyed peak flood levels for the January 2013 ex tropical Cyclone Oswald flood event. The calibrated models were then modified to represent the following development scenarios:

- Pre-mining conditions;
- Approved conditions (in accordance with the existing Environmental Approval);
- proposed year 23 end-of-mine conditions (proposed); and
- final landform conditions (post-mine).

This section outlines the development and calibration of the Pre-mining and approved conditions models. The subsequent sections present the assessment of the proposed and final landform conditions.

8.2 HYDROLOGICAL MODELLING

8.2.1 Methodology

The URBS runoff-routing model (Carroll, 2004) was used to estimate flood discharges in the Roper Creek catchment. URBS is a runoff-routing computer model that uses a network of conceptual storages to represent the routing of rainfall excess through a catchment. URBS is used extensively throughout Australia by the Bureau of Meteorology (BoM) for flood forecasting on major river systems.

For this study, the URBS model was used in “split mode”, which enables the simulation of separate catchment and channel routing. Adopted rainfall losses are subtracted from the total rainfall hyetograph to obtain rainfall excess. Rainfall excess is routed through a conceptual storage representing each sub-catchment of the model before being added to the creek or river channel. Routing through the creek or river system uses the Muskingum method.

8.2.2 URBS model configuration

Figure 8.1 shows the configuration of the URBS model. The model extends approximately 11.5 km upstream (west) of the Middlemount Coal Mine lease and consists of 20 sub-catchments. Summary details of sub-catchment areas are given in Table 8.1.

8.2.3 URBS model calibration

The URBS model was calibrated to the recorded data available for the January 2013 ex-tropical cyclone Oswald event. Data was available for one stream gauge at the site; IMPAC1, located downstream of the Middlemount Coal Mine (see Figure 8.1) as well as at a number of water level marks that were surveyed after the event. The hydraulic model, described in Section 8.4 was used to derive a relationship between recorded water level and discharge at the IMPAC1 gauge.

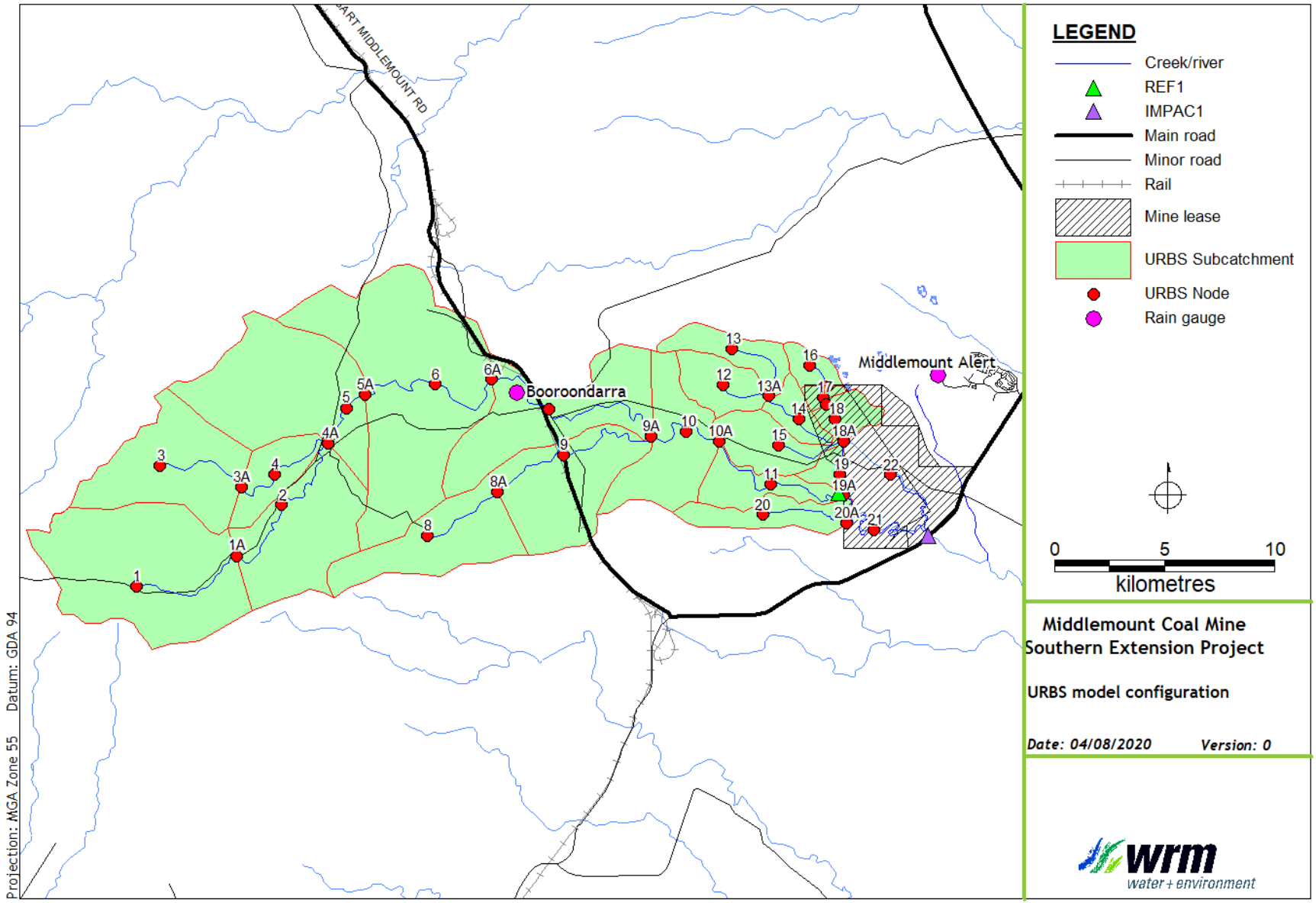

Figure 8.1 – URBS model configuration

Table 8.1 - Adopted URBS model sub-catchment areas

Sub-catchment number	Area (km^2)	Sub-catchment number	Area (km^2)
1	46.1	11	8.8
2	26.4	12	8.4
3	26.7	13	7.9
4	8.9	14	4.7
5	36.9	15	9.8
6	59.3	16	3.4
7	29.0	17	1.4
8	20.2	18	4.5
9	24.7	19	2.6
10	18.7	20	8.9

The calibration attempted to match the predicted and recorded flood peaks and volumes, and also the shape of the recorded and predicted hydrographs with a single (global) set of model parameters for the entire catchment. Each sub-catchment of the model was assigned the rainfall from the nearest rainfall station. A constant loss model (initial loss / continuing loss) was adopted uniformly for all sub-catchments.

8.2.4 Calibration event rainfall data

Rainfall data for the event was obtained from BoM rainfall stations in the vicinity of the Roper Creek catchment at the locations shown in Figure 8.1 and listed in Table 8.2.

Table 8.2 – Rainfall data available for calibration events

Station no.	Station name	Observation interval	Recorded rainfall 3 days to 0900 hours 27 Jan 2013
035109	Booroondarra	Daily	258.6
534022	Middlemount Alert	Hourly	333.0

The Booroondarra daily rainfall was distributed using the hourly rainfall temporal pattern recorded at the Middlemount Alert station. The Booroondarra rainfall was adopted for the URBS subcatchments 1 to 9 and the Middlemount Alert rainfalls were adopted for the downstream subcatchments 10 to 20.

8.2.5 URBS model parameters

The calibration of the URBS model was achieved by adjusting global parameters (**α, ß** and **m**) and adjusting initial and continuing rainfall losses to obtain the best fit between recorded and predicted discharge hydrographs. The adopted global URBS parameters and the initial and continuing losses for the January 2013 calibration event are shown in Table 8.3. The initial loss rate reflects the very dry antecedent conditions in the catchment prior the flood event.

Table 8.3 – Adopted URBS model parameters

Parameter	Value
α (channel lag parameter)	0.4
ß (catchment lag parameter)	2
m (catchment non-linearity parameter)	0.7
Initial loss (mm)	105
Continuing loss (mm/hr)	1.7

8.2.6 January 2013 calibration results

Figure 8.2 shows a comparison of predicted and recorded flood discharge at the Middlemount Road (IMPAC1) station for the January 2013 calibration event. The magnitude of the peak discharge has been overestimated by the URBS model due to the volume of water that was lost entering the pit, however the timing and shape of the hydrograph are a relatively good fit.

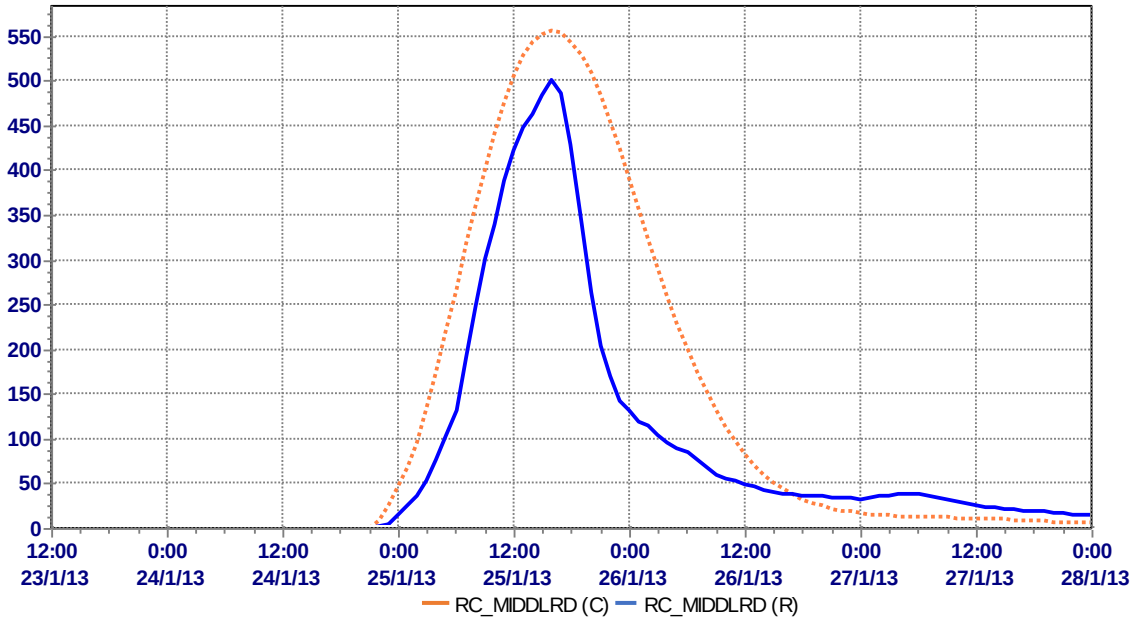

Figure 8.2 – Comparison of calculated (C) and recorded (R) discharge hydrographs, Middlemount Road (IMPAC1 gauge), January 2013

8.3 DESIGN DISCHARGES

The calibrated URBS model was used to estimate design flood discharges in Roper Creek in the vicinity of Middlemount Coal Mine for the 50%, 5%, 2%, 1%, 0.1% AEP events and for the probable maximum flood (PMF). The ensemble approach described in Australian Rainfall and Runoff (ARR) (Ball et al, 2019) was used to estimate design discharges. This method uses an 'ensemble' of 10 temporal patterns for each storm duration to derive a range of estimated flood peaks for each AEP. The magnitude of the design flood is then estimated from the weighted average of the flood peaks, where the weighting applied to each result reflects the relative likelihood of the selected input occurring. The 10 temporal patterns were obtained from the ARR data hub (Geoscience Australia, 2019) for events up to the 1% AEP event. Middlemount is located in the East Coast North Temporal Pattern region under the ARR. For design events rarer than 1% AEP up to PMF, design rainfalls and temporal patterns from Revised Generalised Tropical Storm Method (GTSMR) (BoM, 2005) were adopted, in accordance with ARR.

8.3.1 Design rainfalls

Table 8.4 shows the design rainfalls for a range of storm durations for the Roper Creek catchment to Middlemount Coal Mine. Design rainfalls for events up to the 0.1% AEP event were obtained from the BoM (2016). Rainfalls to estimate the PMF were determined using the GTSMR (BoM, 2005). Areal reduction factors and rainfall losses (IL=49 mm CL=1.7 mm/hr), which were adjusted according to the median pre-burst depths and ratios, were obtained from the ARR data hub (Geoscience Australia, 2019).

Table 8.4 – Design rainfalls depths – Roper Creek catchment

Duration (hours)	Design rainfall (mm)					
	50% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	Probable Maximum Precipitation
6	57.2	110.4	133.2	150.6		
12	68.6	134.4	163.2	186.0	294.4	780.0
18	77.0	152.1	185.4	212.4	337.8	890.0
24	83.8	166.6	203.8	234.2	364.8	1000.0
36	94.7	189.4	233.3	269.3	416.8	1200.0
48	102.7	207.4	256.3	296.6	457.9	1390.0
72	115.2	234.0	290.2	336.2	514.8	1730.0
96	122.9	252.5	313.0	362.9	550.1	1940.0
120	128.4	265.2	328.8	379.2	571.2	2050.0

8.3.2 Results

Figure 8.3 to Figure 8.7 shows the distribution of peak discharges at Middlemount Coal Mine estimated from the ensemble of 10 temporal patterns for each storm duration and for each AEP. The distribution is represented as a box and whisker plot for each duration, which is a standardised way of presenting the distribution of data. For each duration, the rectangle box represents the 25%ile and 75%ile (1st and 3rd quartile, the interquartile range or IQR) bound of the estimate. The black horizontal line (whiskers) represents the upper and lower estimates for 1.5 times of the IQR. The red horizontal line within the box is the median value and the red dot represents the mean value. The peak discharges adopted from the analyses together with the critical duration and the adopted temporal pattern is shown in Table 8.5. Based on these results, the January 2013 event had an AEP of between 5% and 2% AEP.

Table 8.5 – Roper Creek design discharge at Middlemount Coal Mine

Event	Critical duration	Temporal pattern	Discharge (m^3/s)
50% AEP	72	8	65
5% AEP	24	3	374
2% AEP	24	10	550
1% AEP	24	3	689
0.1% AEP	18	7	1,283
PMF	24	3	4,250

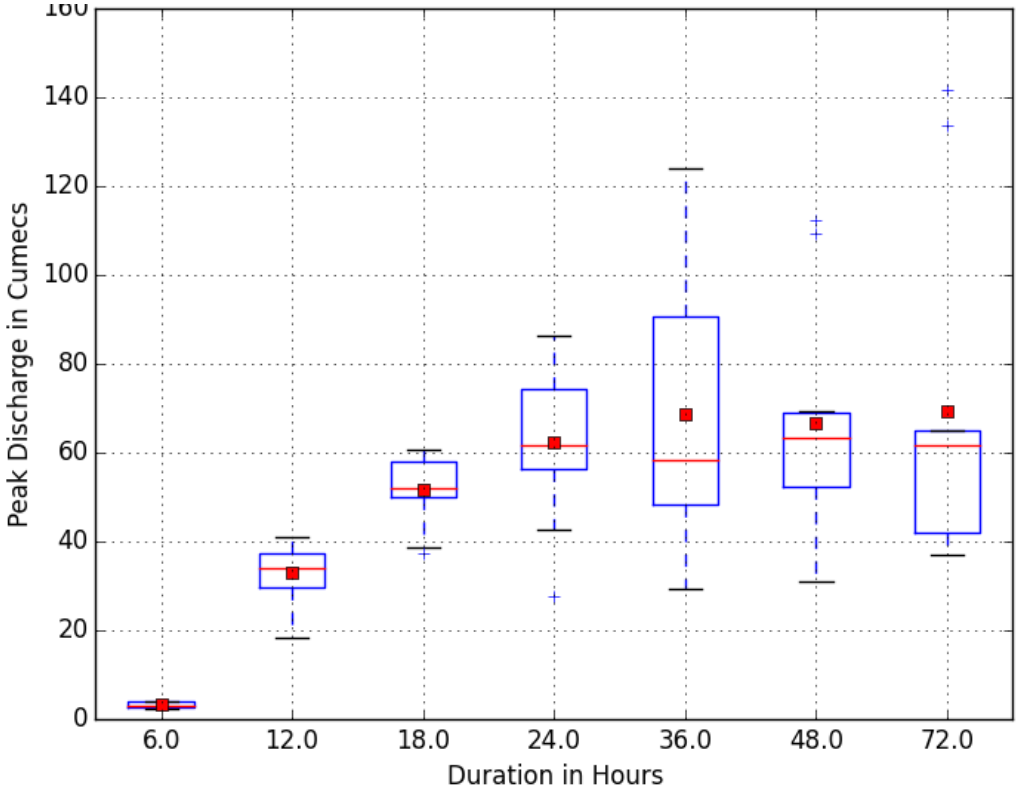

Figure 8.3 - Roper Creek discharge box plots at Middlemount Coal Mine, 50% AEP event

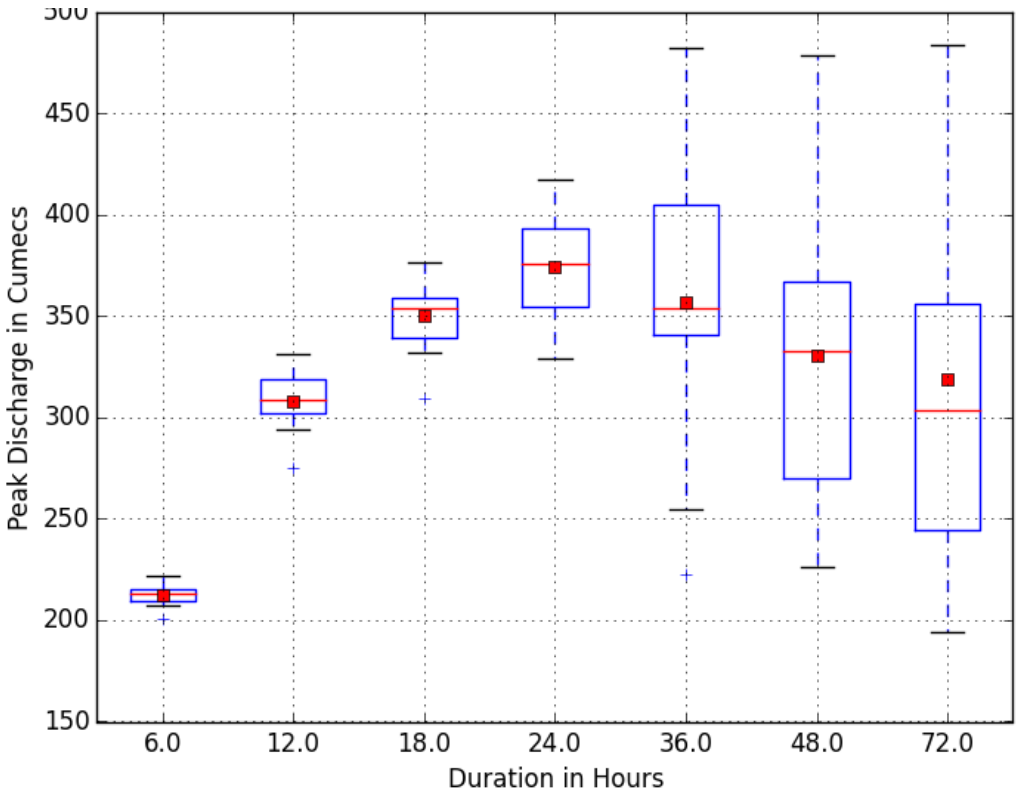

Figure 8.4 - Roper Creek discharge box plots at Middlemount Coal Mine, 5% AEP event

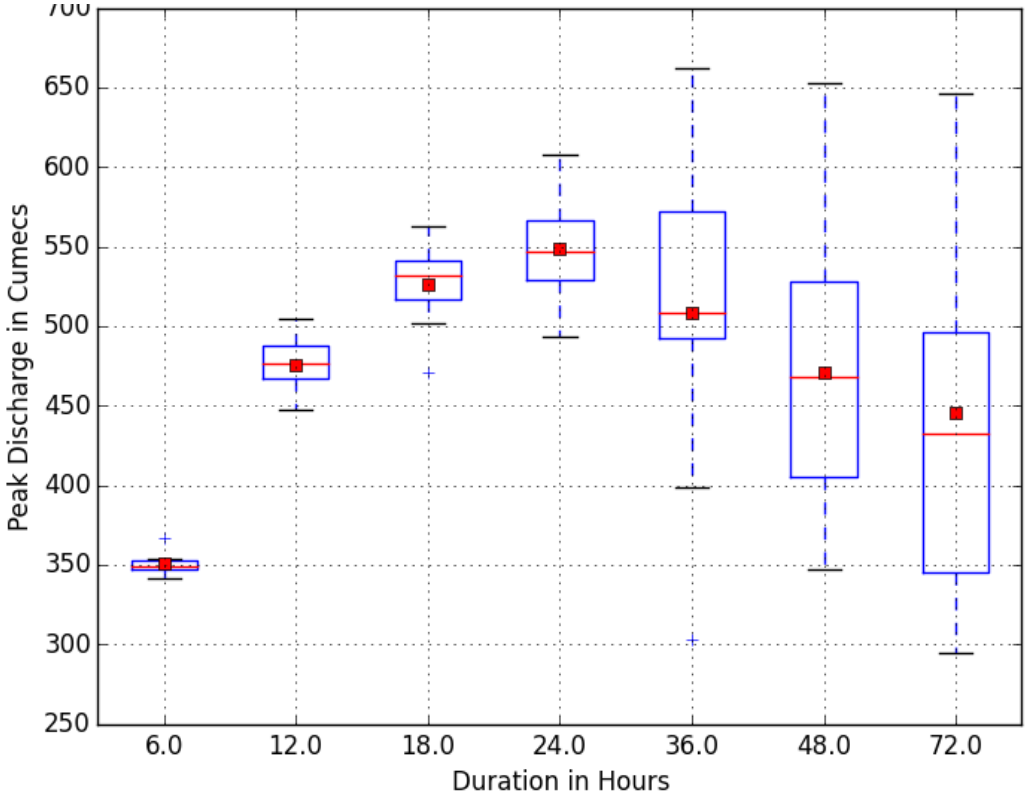

Figure 8.5 – Roper Creek discharge box plots at Middlemount Coal Mine, 2% AEP event

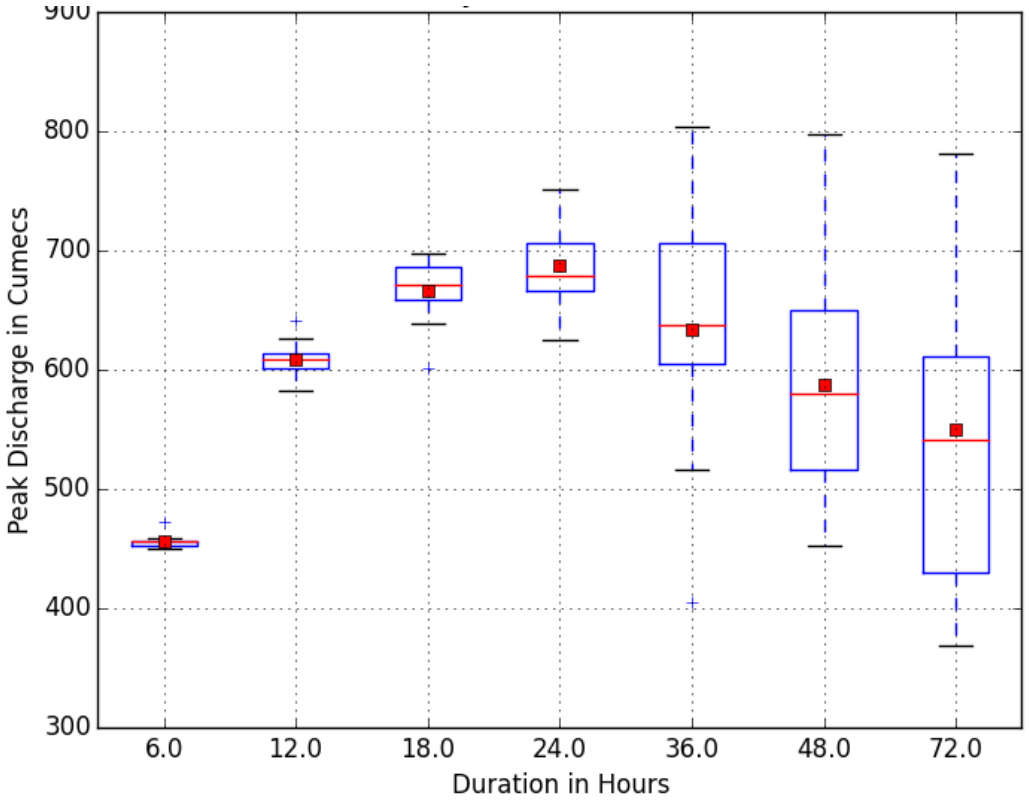

Figure 8.6 – Roper Creek discharge box plots at Middlemount Coal Mine, 1% AEP event

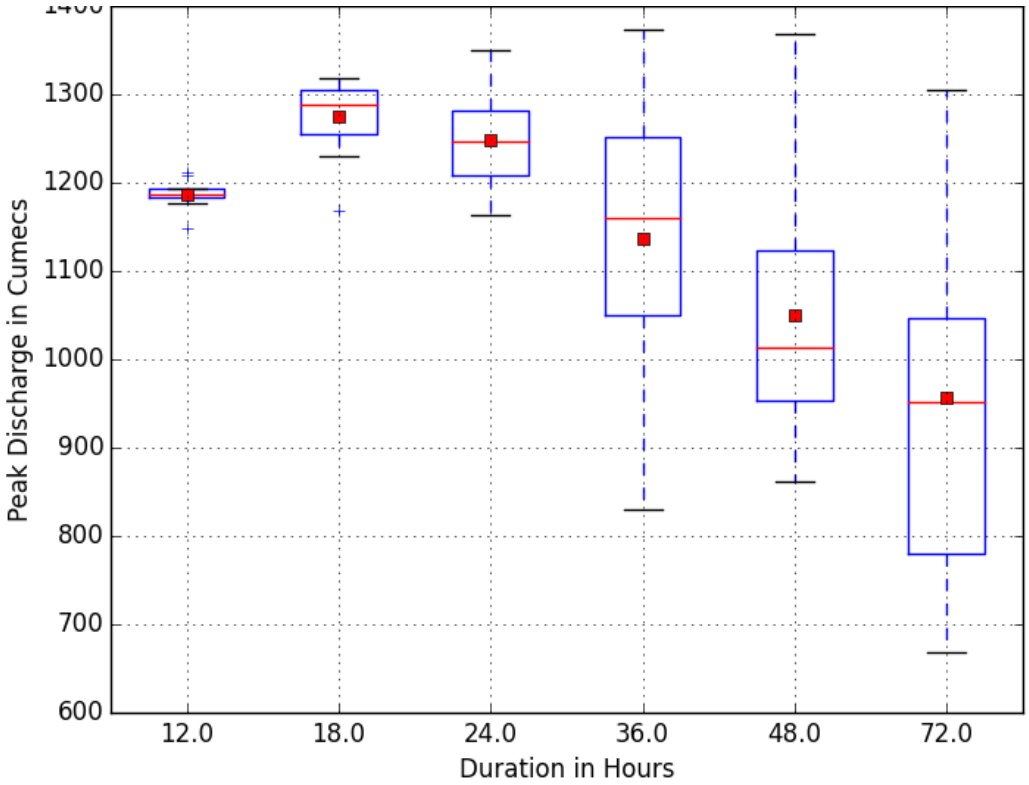

Figure 8.7 – Roper Creek discharge box plots at Middlemount Coal Mine, 0.1% AEP event

8.4 HYDRAULIC MODELLING

8.4.1 General

The two-dimensional unsteady flow (TUFLOW) hydrodynamic model (Version 2020-01-AB-iSP-w64) (BMT, 2018) was used to simulate the flow behaviour of Roper Creek and its tributaries at Middlemount Coal Mine. TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically identifies breakout points and flow directions within the study area.

8.4.2 Calibration model configuration

Figure 8.8 shows the extent of the January 2013 (calibration conditions) TUFLOW model. The locations of the inflow and outflow boundaries are also shown.

The modelled study area covers approximately 44.5 km^2, commencing approximately 11.5 km upstream of the mine lease area and extends to the east of the mine lease area to Middlemount Road. A 5 m grid size was adopted for the two-dimensional model area.

8.4.3 Available topographic data

Topographic aerial survey data for the study area was provided by MCPL. The underlying survey in the model area was performed in May/June 2008 and covers an area of some 90 km^2. Updated survey of the mine lease area obtained in December 2012 was used as the primary ground level information for the January 2013 event.

MCPL provided additional ground survey of the area to the south of Middlemount Road in 2019.

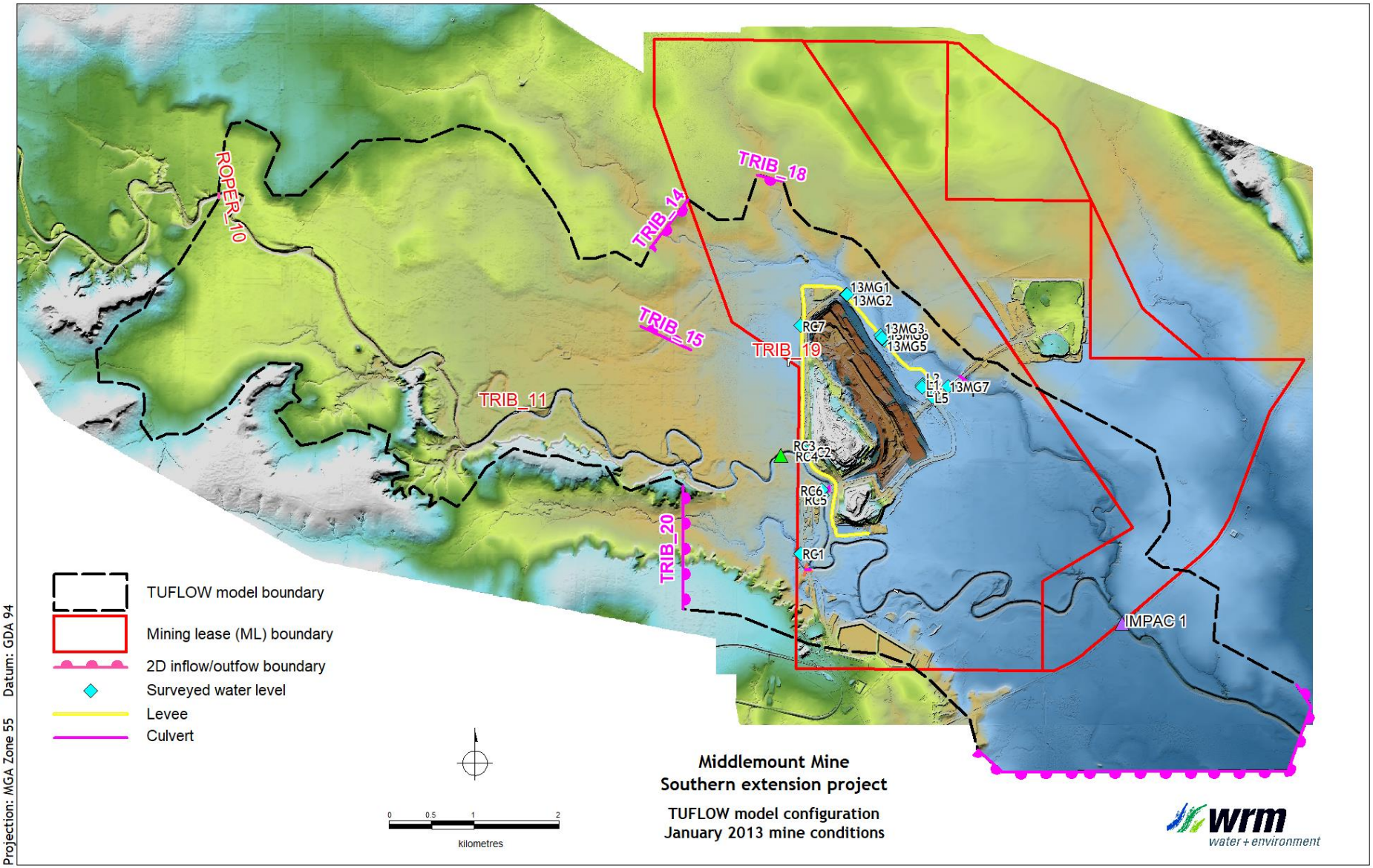

Figure 8.8 – January 2013 Roper Creek TUFLOW model configuration

8.4.4 Adopted Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). Manning's 'n' values were initially selected based on typical published values (for example, those of Chow (1959)) and calibrated using recorded water level data in Roper Creek for the January 2013 event. The adopted Manning's n values for the TUFLOW model are:

- Roper creek channel: 'n' = 0.045
- Overbank areas: 'n' = 0.06

8.4.5 Road crossings

The Middlemount Road crossing of Roper Creek downstream of the mine is a bridge which spans the main channel. The bridge was represented in the TUFLOW model as a layered flow constriction with a 1.2 m thick superstructure and a road deck level of 152.5 mAHD. The bridge piers below the superstructure were represented by applying a 10% blockage below the superstructure.

Table 8.6 shows details of the haul road crossings of the various waterways. The locations of the haul road crossings are shown in Figure 8.8.

Table 8.6 – Haul Road crossing details

Location ID (see Figure 8.8)	Location	Details
1	Roper Creek	2 x 2.4 m diameter CMP* 2 x 2.6 m diameter CMP
2	Unnamed Roper Creek tributary	2 x 2.1 m diameter CMP
3	Thirteen Mile Gully	2 x 0.9 m diameter CMP

CMP – Corrugated metal pipe

8.4.6 Model calibration

The TUFLOW model was calibrated to the recorded water level at the IMPAC1 stream gauge located at Middlemount Road and surveyed flood marks obtained for the January 2013 event. The locations of the gauge and the surveyed flood marks are shown in Figure 8.8.

Figure 8.9 compares the recorded and predicted water level hydrographs at the IMPAC1 gauge and Table 8.7 compares the surveyed and predicted peak water levels across the mine. Overall, a good calibration was achieved for the event and is therefore suitable to estimated design flood levels for the various mine phases.

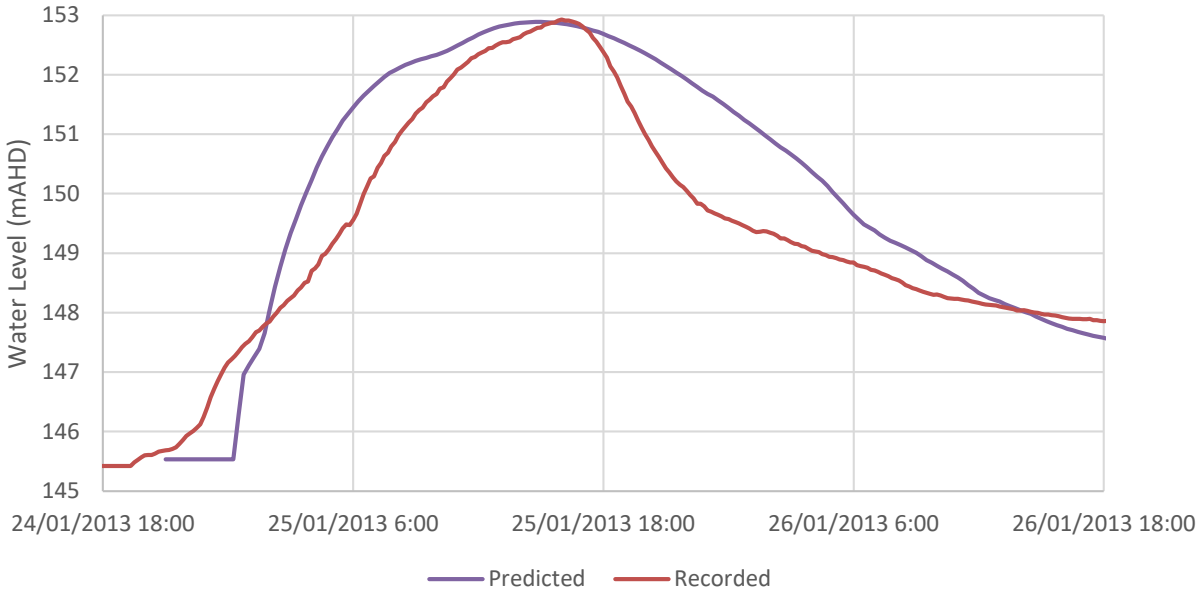

Figure 8.9- Recorded and predicted water level at the IMPAC1 gauge at Middlemount Road, January 2013 event.

Table 8.7 - Comparison of surveyed and predicted flood levels, January 2013 event

Location	Surveyed (mAHD)	Predicted (mAHD)	Difference (m)
RC1	162.01	163.04	1.03
RC2	162.66	163.09	0.43
RC3	162.66	162.92	0.26
RC4	162.99	163.15	0.16
RC5	162.25	161.98	-0.27
RC6	162.26	162.47	0.21
RC7	161.79	162.36	0.57
13MG1	161.01	161.13	0.12
13MG2	161.01	161.13	0.12
13MG3	160.33	161.05	0.72
13MG4	160.82	161.04	0.22
13MG5	160.83	161.01	0.17
13MG6	160.83	161.01	0.18
L1	160.70	161.04	0.34
L2	160.69	161.04	0.35
L3	160.75	161.04	0.29
L4	160.71	161.04	0.33
L5	160.76	161.04	0.28
13MG7	160.78	161.04	0.26

8.5 PRE-MINING CONDITIONS FLOODING

8.5.1 Model changes

Figure 8.10 shows the configuration and topography of pre-mining conditions. Pre mining conditions uses the underlying survey from May/June 2008 (prior to mining). Ground levels along the Roper Creek channel were updated using Lidar data flown in July 2018. Hydrology model inflows remained unchanged from the model calibration conditions. Note that mining catchments were not included in the hydrology model for consistency across all scenarios.

8.5.2 Flood depths and velocities

Figure 8.11 show the pre-mining conditions flood levels, depth and extent within the vicinity of the Project and Figure 8.12 show the pre-mining conditions flood velocities for the 1% AEP event. Peak flood depths and velocities for the 50%, 5%, 2% and 0.1% AEP events are given in Appendix C. The results show the following:

- The 50% AEP flood would not exceed the capacities of the Roper Creek or Thirteen Mile Gully channels. The overbank flooding shown on the figure is due to local catchment runoff that drains the floodplain. Roper Creek channel velocities average 1.1 m/s.
- The 5% AEP flood would be confined to the main Roper Creek channel upstream of the mine but would break out of the main channel near the mine lease boundary. The overflowing floodwater would drain in an easterly direction to Thirteen Mile Gully or back to Roper Creek near the Thirteen Mile Gully confluence. Floodwater would also overflow to the south before draining back into Roper Creek immediately downstream of the Mine lease boundary. Roper Creek channel velocities average 1.6 m/s and overbank velocities would be generally less than 0.3 m/s.
- The 2% and 1% AEP flood events would overflow the Roper Creek channel both upstream of the mine and near the mine lease boundary. The Roper Creek channel is 'perched' above the floodplain both upstream and within the mine with overbank floodwater draining along independent flow paths. Two of these independent flow paths drain to Thirteen Mile Gully to the east (eastern flow paths). A third independent flow path drains to the south of Roper Creek (southern flow path) along a remnant flood channel and across Middlemount Road. Roper Creek channel velocities average 1.7 to 1.8 m/s and overbank velocities are generally less than 0.5 m/s.
- The 0.1% AEP event would inundate much of the floodplain between Roper Creek and Thirteen Mile Gully.

8.6 APPROVED FINAL LANDFORM CONDITIONS FLOODING

8.6.1 Model changes

The following changes have occurred or are approved to be constructed from pre-mining conditions:

- The approved flood protection levees that extend around the western and southern areas of the mine.
- Existing mine infrastructure within the Roper Creek floodplain as defined by the 2018 LiDAR information including:
    - the haul road and culvert crossings;
    - North ROM; and
    - topsoil stockpiles.
- The two approved (not constructed) Roper Creek diversions (WRM, 2020).

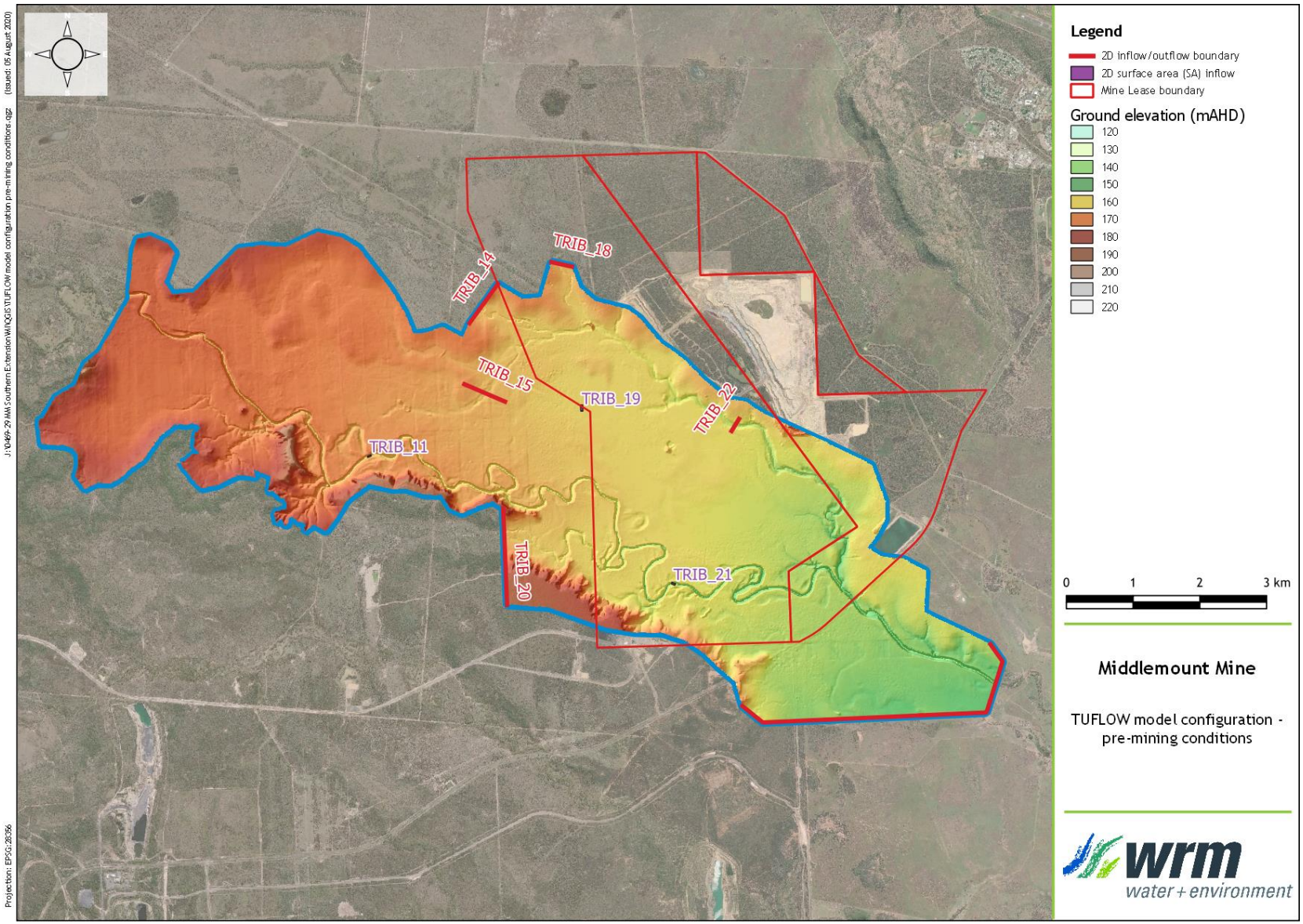

Figure 8.10 – Pre-mining Roper Creek TUFLOW model configuration

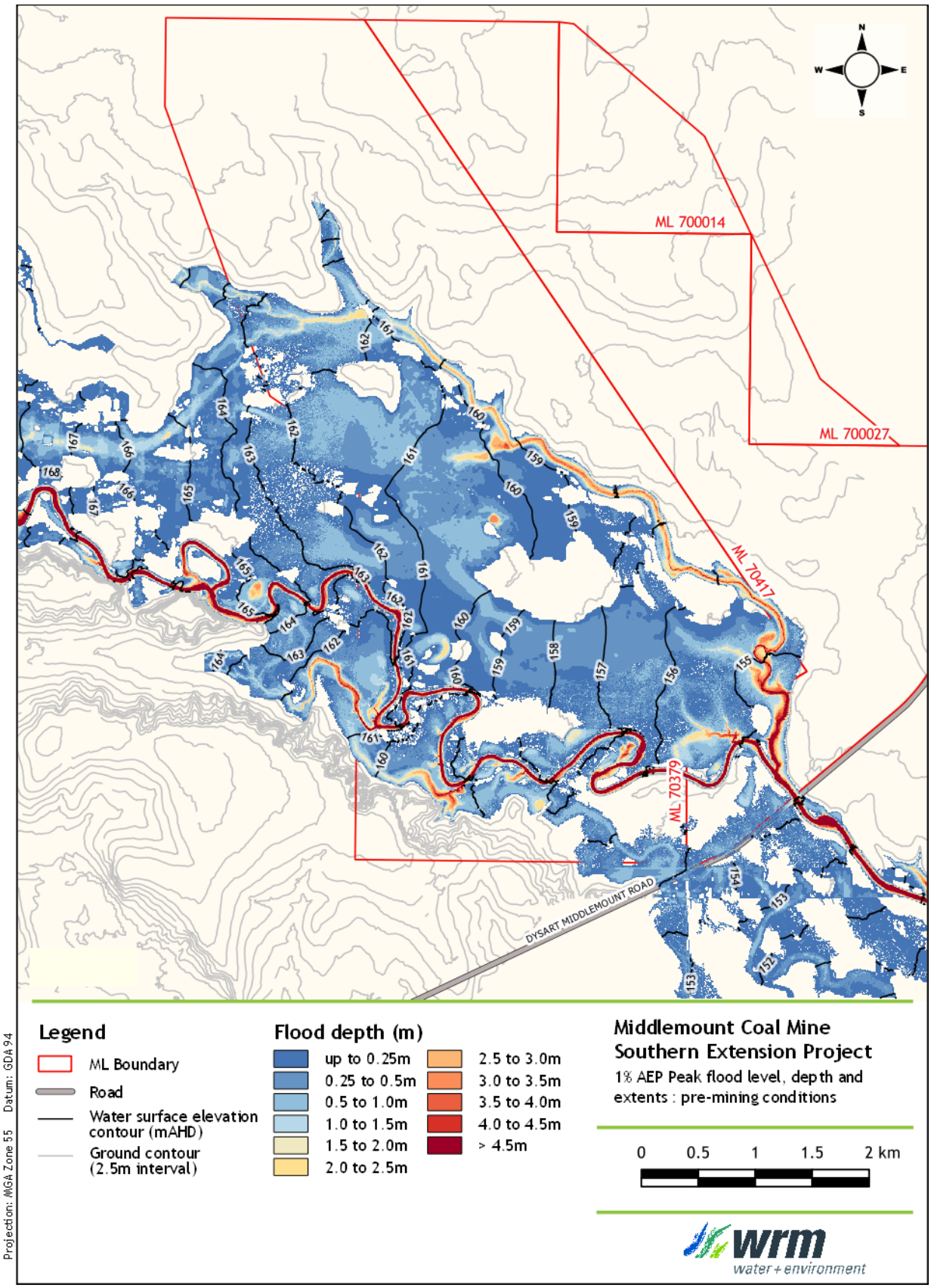

Figure 8.11 – Pre-mining conditions flood levels, depths and extent, 1% AEP event.

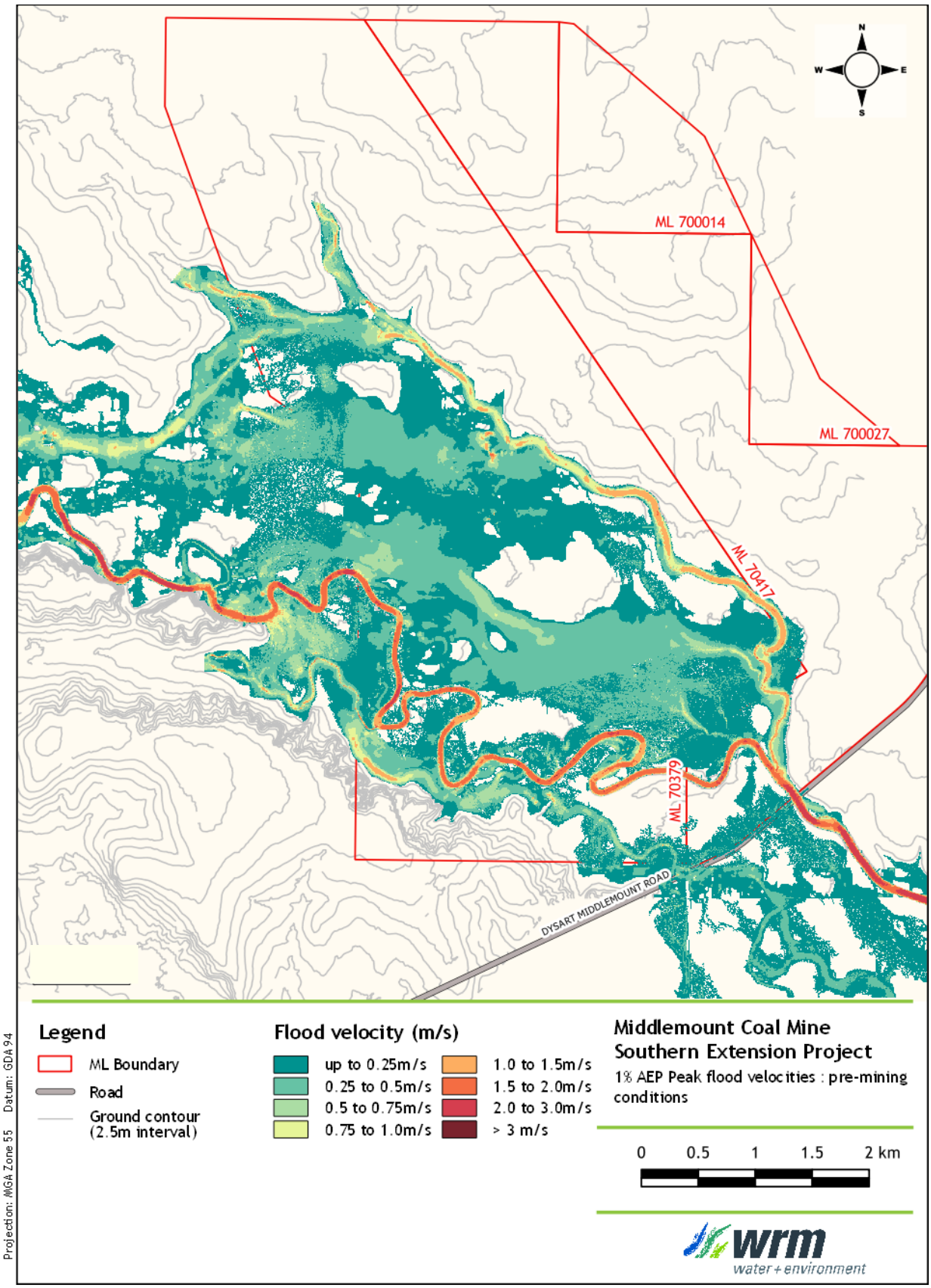

Figure 8.12 - Pre-mining conditions flood velocities, 1% AEP event.

Descriptions of the approved diversions and the levee are given in Section 5.8. The Roper Creek diversions were designed within the 12D software using the cross sections shown in Section 4.8 as a template. The 12D tins were then converted to digital elevation model (DEM) files to override the pre-mining conditions ground levels. The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW.

The flood levee was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made to the pre-mining TUFLOW model.

8.6.2 Flood depths and velocities

Figure 8.13 show the flood levels, depths and extent within the vicinity of the Project and Figure 8.14 show the peak flood velocities for the 1% AEP event. Flood maps for the 50%, 5% AEP, 2% and 0.1% AEP events for the approved conditions are provided in Appendix C. The results show the following:

- The 50% AEP flood would not exceed the capacities of the Roper Creek or Thirteen Mile Gully diversion channels in a similar manning to pre-mining conditions. Roper Creek channel velocities would remain at around 1.1 m/s.
- For the 5% AEP event, floodwater would break out of the Roper Creek channel near the upstream boundary of the mine (in a similar location to the pre-mining conditions) to pond along the Thirteen Mile Gully diversion and upstream of the haul road from the mine infrastructure area. Overbank ponding depths exceed 2.5 m. The flood protection levees and Thirteen Mile Gully Diversion divert the eastern flow paths and Thirteen Mile Gully flows to Roper Creek. The haul road and mine infrastructure would obstruct the southern overland flow path back to Roper Creek. Flows are generally confined to the Roper Creek channel and the two diversion channels across the mining area. Roper Creek channel velocities average 1.6 m/s.
- The 2% and 1% AEP flood events pond upstream of the Thirteen Mile Gully Levees and upstream of the haul road to the south of Roper Creek to depths exceeding 3 m. Floodwater also overflows to the south of the mine and drains across Middlemount Road in a similar manner to pre-mining conditions.
- The 0.1% AEP event inundates much of the floodplain behind the flood protection levees.

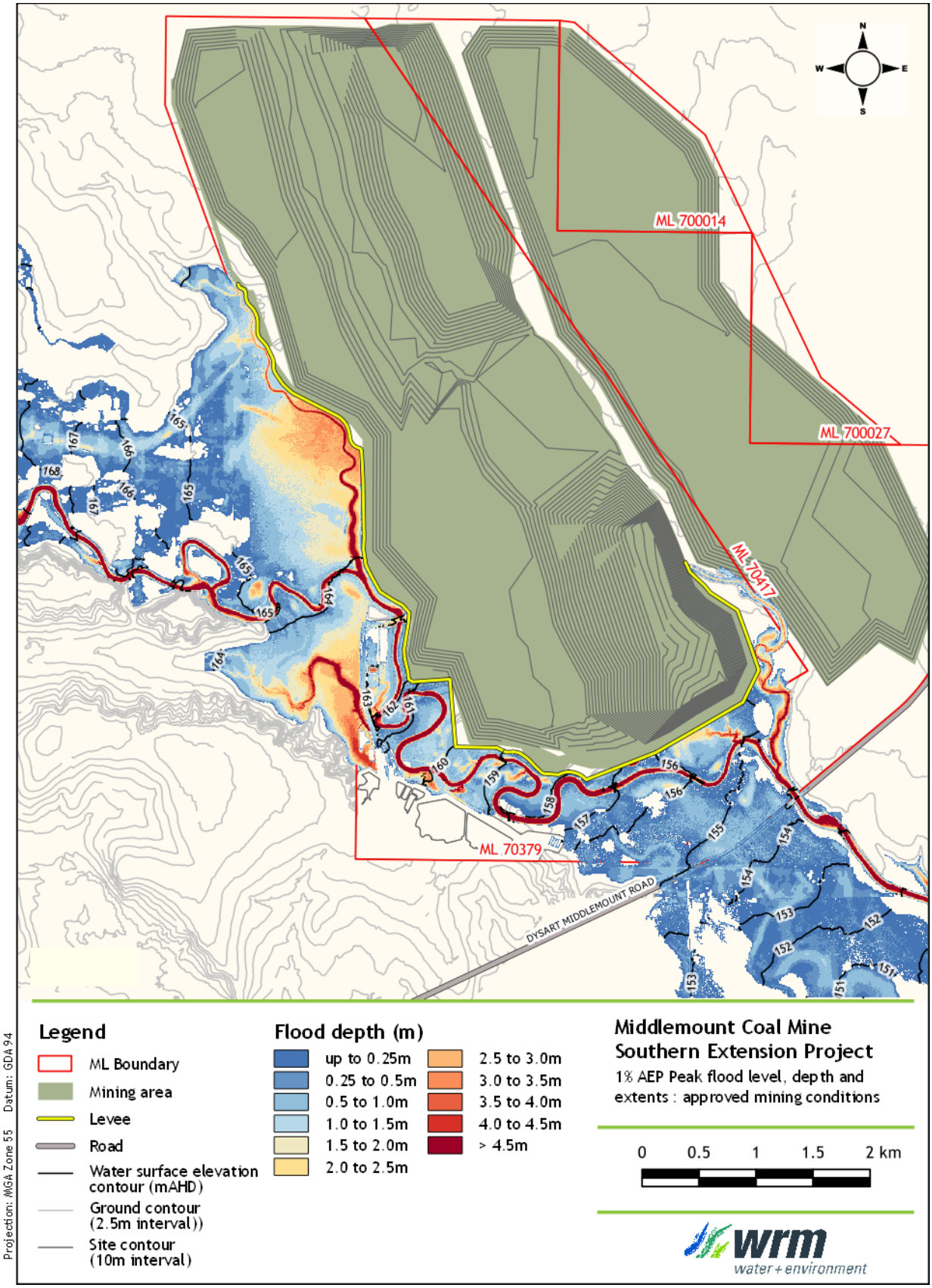

Figure 8.13 - Approved conditions flood levels, depths and extent, 1% AEP event.

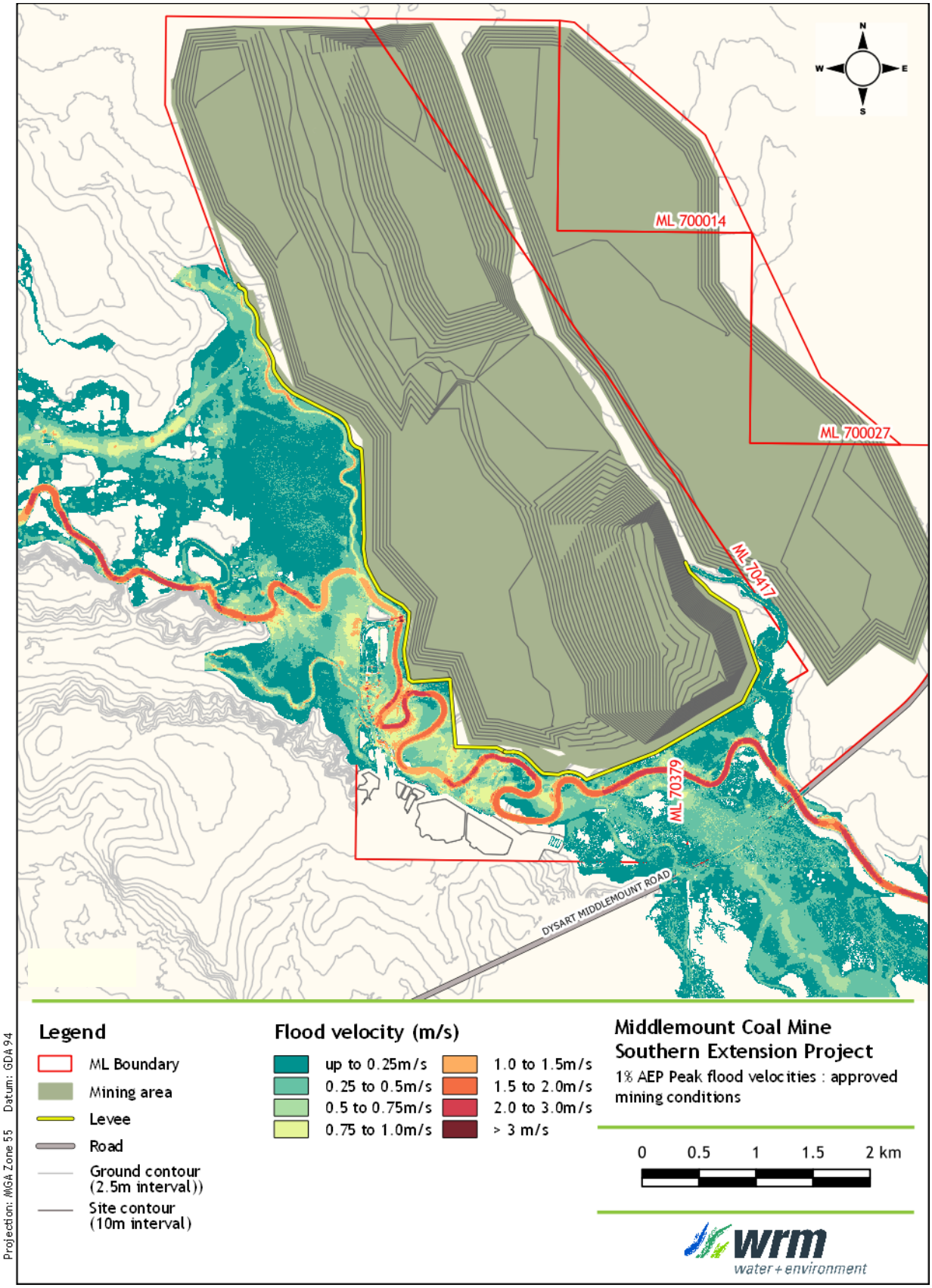

Figure 8.14 - Approved conditions flood velocities, 1% AEP event.

9 Flood modelling assessment

9.1 OVERVIEW

The flood models were updated to derive peak food levels, extents and depths for a range of design flood events to assess flood impacts of the Project. The models were also used to assess the performance of:

- the proposed Roper Creek diversion against the Guideline: *Works that interfere with water in a watercourse — watercourse diversions* (DNRM, September 2014);
- define the proposed modified levee crest heights to satisfy the flood immunity requirements for regulated levees in accordance with the 'Manual for Assessment Consequence Categories and Hydraulic Performance of Structures' (Structures Manual) (DES, 2016); and
- the post mining conditions landform to confirm that the open void will not be inundated for a probable maximum flood (PMF).

The assessment was undertaken for the:

- proposed year 23 end-of-mine conditions (proposed); and
- final landform conditions (post-mine).

9.2 ROPER CREEK DIVERSION

The Proponent has approval to divert Roper Creek in two locations (see Figure 5.2). The upstream diversion (Diversion 1) is in the process of being constructed. The downstream diversion (Diversion 2) is proposed to be modified as part of the project. The new alignment is shown in Figure 9.1 and will be constructed prior to 2023. The diversion will drain along a confined floodplain during the operational phase of the project. At the completion of mining, the floodplain will be widened to improve flood conveyance (refer revised location shown on Figure 9.2). No changes are proposed to the diversion channel post mining.

The Guideline: *Works that interfere with water in a watercourse — watercourse diversions* (DNRM, September 2014) provides guidance to proponents seeking approval to divert a watercourse as part of a new or amended environmental application. It includes guidance on watercourse diversion design and operation including maintenance, monitoring and revegetation. The guideline sets out key design principles and requirements for the functional designs of permanent diversions.

A contemporary version of this guideline has been prepared for stream diversions authorised under the Water Act (DNRME, 2019) (guideline). Updated guidelines for EP Act authorisations have not yet been prepared and therefore this assessment has been developed in consideration of the guideline for watercourse diversions authorised under the Water Act.

Design of the proposed Roper Creek Diversion 2 is generally in accordance with both guideline requirements. Details of how they have been addressed are provided below.

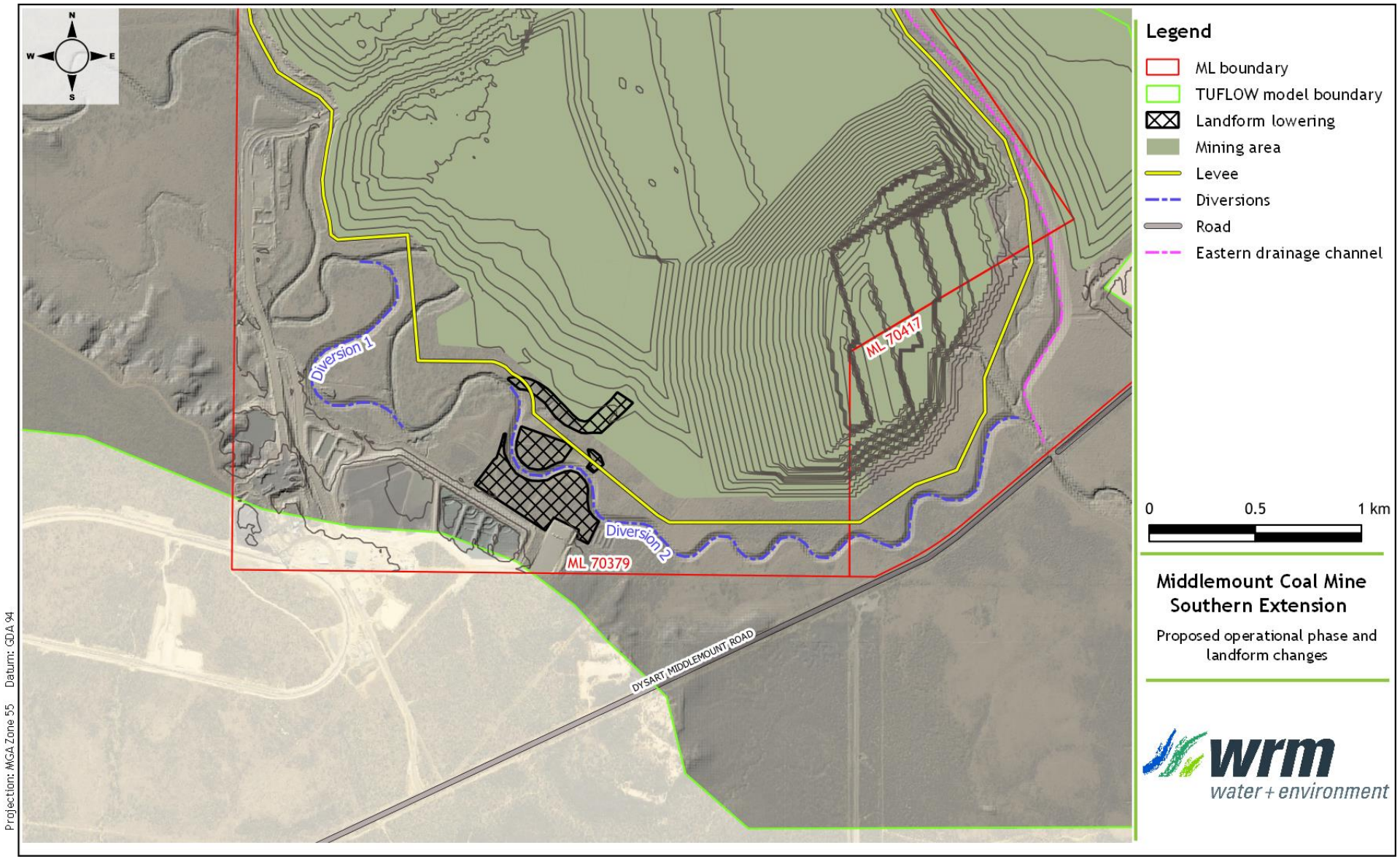

Figure 9.1 – Middlemount Mine Operational Phase (Year 2043 conditions)

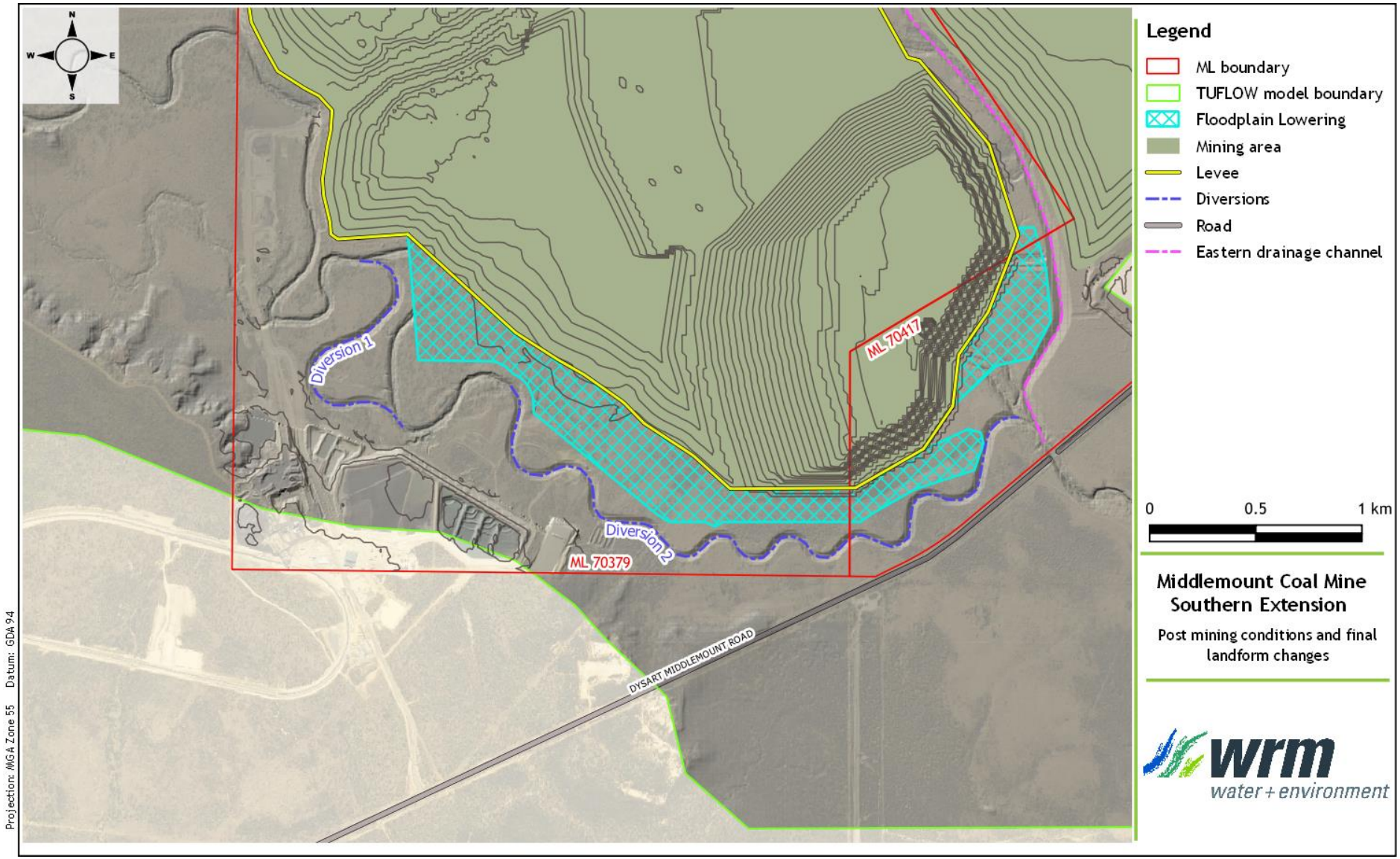

Figure 9.2 – Middlemount Mine Final Landform configuration

9.2.1 Roper Creek Diversion Design objectives

The proposed Roper Creek Diversion 2 aims to achieve the following key objectives:

- be self-sustaining and include geomorphic and vegetation features of regional watercourses and the surrounding landscape;
- where possible, positively contribute to river health values for the system; and
- not impose liability on the State, the proponent or the community to maintain the watercourse diversion and its associated components.

9.2.2 Adopted design approach

9.2.2.1 Guideline outcomes

The proposed diversions will need to satisfy the following outcomes:

Outcome 1: The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.

Outcome 2: The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.

Outcome 3: The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and are suitable for the region in which the watercourse diversion is located.

Outcome 4: The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts to upstream and downstream reaches.

Outcome 5: The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

9.2.2.2 Design hydraulic criteria

The Guideline has been developed using the results of the Australian Coal Association Research Program (ACARP) stream diversion project (Fisher Stewart, 2002). The Fisher Stewart study investigated the hydraulic characteristics of a number of natural streams in the area of the Project. The performance and design faults of existing stream diversions within the Bowen Basin were also assessed as part of the Fisher Stewart study.

Table 9.1 shows the design criteria given in the Guideline. Stream power, stream velocity and shear stress are the main hydraulic characteristics of interest:

- Stream power is a function of discharge, hydraulic gradient and flow width. It represents the energy that is available to do work in and on the channel. High stream powers are indicative of elevated erosion potential.
- The velocity criteria have been selected to minimise the potential for damage to the channel through erosion associated with high flow velocities. Where calculated velocities exceed the adopted velocity criteria, additional bank protection (increased vegetation density or rock protection) will be required. Note there is no direct relationship between velocity and the force exerted on soil particles at the boundary and thus stream power and shear stress are used as more reliable indicators of erosion potential.
- The shear stress provides a measure of the tractive force acting on sediment particles at the boundary of the stream, and is used to determine the threshold of motion for bed material. It provides an indication of the potential for erosion of cohesive sediments or movement of non-cohesive sediments at the channel boundary.

Table 9.1 – Guideline design criteria for Bowen Basin stream diversions

Scenario	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
50% AEP event without vegetation	<35	<1.0	<40
50% AEP event with vegetation	<60	<1.5	<40
2% AEP event with vegetation	<150	<2.5	<50

The Guideline design criteria are based on an incised channel with confinement of flows up to and including the 5% AEP design event. The Guideline hydraulic parameters were derived in the Fisher Stewart (2002) study from depth averaged channel cross sections using the HEC-RAS one dimensional hydraulic model. The Fisher Stewart study also derived the small event values for the 2 year average recurrence interval (ARI) event and not the 50% AEP event, which is slightly larger. The difference is expected to be minor.

The 50% AEP event (an approximation of the 2 Year ARI event) represents the behaviour of the main channel of the creek and proposed diversion at bank full flow conditions. In geomorphologic assessments, the bank full flow is often considered to be the stream forming flow because it often exerts the greatest influence on channel geometry. The channel shape, peak flood velocities, shear stresses and stream power for this event were used to define the characteristics of the diversion.

An assessment of the 2% AEP (50 Year ARI) design flood represents the behaviour of Roper Creek and the diversion during a representative large flood. It can be used to identify whether the changed out of bank flood behaviour could inadvertently cause an avulsion of the channel.

9.2.2.3 Current research design guidelines

ACARP engaged consultants to review the success or otherwise of diversions constructed using the ACARP design criteria and to update the design criteria based on the outcomes of this research and other recent research (project C20017) (Alluvium, 2014).

The study found that constructed diversions in Central Queensland comprise elements of both alluvial and threshold channel design. A description of these design processes is given below.

Alluvial channel design

For alluvial channel design, the study found that sediment supply and bed load transport were a critical factor in the performance of the diversions assessed, particularly new diversions that had applied the above Guideline criteria. The volume of bed load sediment transported by a watercourse system is controlled by both the amount of sediment delivered to the watercourse and the capacity of the watercourse to transport sediment. Bed load transport in a watercourse can be broadly described as being either supply limited (can transport more sediment than is available) or transport limited (sediment supply exceeds transport capacity). Given the sediment loads currently within the bed of Roper Creek, it would be a transport limited stream.

The outcome of the study was the development of a modified approach to diversion design based on the systems with high and low sediment supply to the constructed watercourse using stream power as a surrogate for sediment transport. The revised alluvial channel design parameters are given in Table 9.2.

In addition, the guidelines suggest the following for stream power:

- Cross sections within a constructed waterway are not to vary by greater than 50% of the mean reach stream power; and
- The 25th and 75th percentile range of stream power is to be within the range shown in Table 9.2. No stream power value shall be more than 30% greater than the maximum value shown in Table 9.2.

Table 9.2 – Revised ACARP design criteria for Bowen Basin stream diversions

Stream Type	Sediment Transport group	Stream Power (W/m^2)	
		2 year ARI	50 year ARI
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

Threshold channel design

Threshold channel design focusses on maintaining stability up to a design flow event. It uses shear stress to define the threshold to:

- achieve an acceptable level of success over the vegetation establishment phase; and
- protect the stream and mine infrastructure against stream flow events.

The adopted shear stress thresholds for typical vegetation types in the Bowen Basin is given Table 9.3.

Table 9.3 – Shear stress thresholds for vegetation

Vegetation Types	Design shear stresses (N/m^2) for constructed waterways in the Bowen Basin
Buffel Grass	40
Structurally diverse suite of established native vegetation	120

The recommended design events for long term stability against extreme floods is given in Table 9.4.

Table 9.4 – Design flood events for long term performance

Consequence of channel scour	Proposed design event	
	During mine life	Post mining
Scour that threatens mine infrastructure	To be determined by mine operator	n/a
Scour that threatens public infrastructure	To be determined in consultation with relevant stakeholder (asset owner)	To be determined in consultation with relevant stakeholder (asset owner)
Scour that threatens capture of watercourse into the open cut pit.	1 in 1000 AEP	Probable Maximum flood

9.2.3 Diversion 2 characteristics

9.2.3.1 Channel characteristics

The proposed Roper Creek diversion has been designed to replicate as close as possible the Roper Creek sections that they replace and be constructible. Figure 9.3 shows a typical cross-section of the proposed Diversion 2 superimposed on thirty cross sections of the existing Roper Creek in the vicinity of the proposed diversion.

The following is of note with respect to the concept design of the channel diversion:

- The channel will have a base width of 4 m with batter slopes of 1V:3H.
- The confluence of the proposed diversions and Roper Creek will be designed with consideration to:
    - minimising the disruption to existing bank vegetation;
    - ensuring the diversion outflows are not directed onto the banks of Roper Creek; and
    - ensuring that the bed elevation at the downstream end of the diversion is the same as the Roper Creek bed elevation so drop structures would not be required.
- Depending upon the substrate material encountered, the base of the channel will be layered with sand (the depth to be determined during detailed design).

Further work will be undertaken on the channel design during detailed design to enhance the in-stream channel form. Note that the existing channel has bank batter slopes of often less than 1V:2H. During the design of Diversion 1, it was advised that a constructed channel would not be stable at these slopes. The adopted bank batter slopes of 1V:3H are expected to behave in a similar manner.

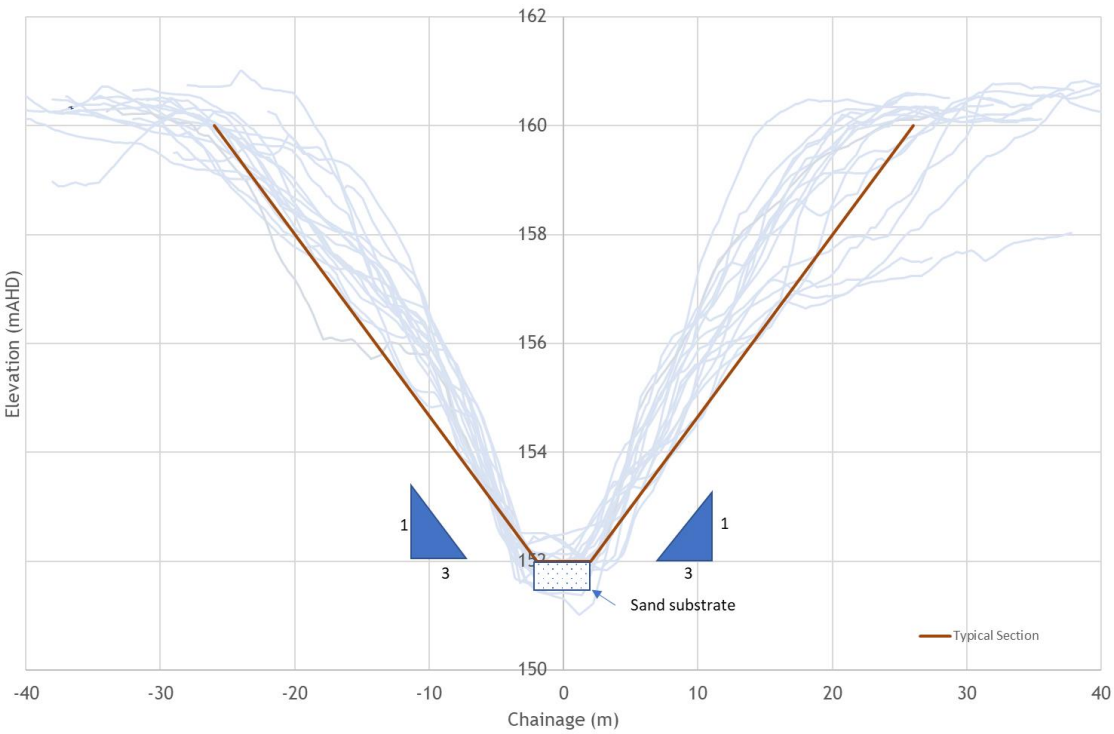

Figure 9.3 - Proposed Roper Creek Diversion cross-sections for the straight and meander sections

9.2.3.2 Floodplain modifications

Ground levels between the TSF and Diversion 2 will be modified to increase the conveyance of the floodplain at this location. There is currently a topographical ridge that is about 5 m above the adjacent floodplain, which will be lowered to match the surrounding ground levels of 158.2 m AHD on the upstream side and 155.25 mAHD on the downstream side. The location of the land to be lowered is shown in Figure 9.1.

At the completion of mining, the northern floodplain of Roper Creek will be rehabilitated back to an active floodplain. The operational phase levee will be relocated some 150 m to 300 m further to the north and the floodplain shaped to drain local catchment runoff from the floodplain back to the Roper Creek channel (see Figure 9.2).

Figure 9.4 shows a typical cross section of the Roper Creek diversion and the final landform floodplain. The location of the cross section is shown in Figure 9.2. The conceptual design of the reinstated floodplain consists of side slopes varying from 1 in 200 at the upstream end to 1 in 12 as it drains back into Roper Creek. The floodplain will fall at a gradient varying from 0.45% to 0.26%. In effect, the rehabilitated floodplain will mimic adjacent inflow channels that drain the pre-mine Roper Creek floodplain.

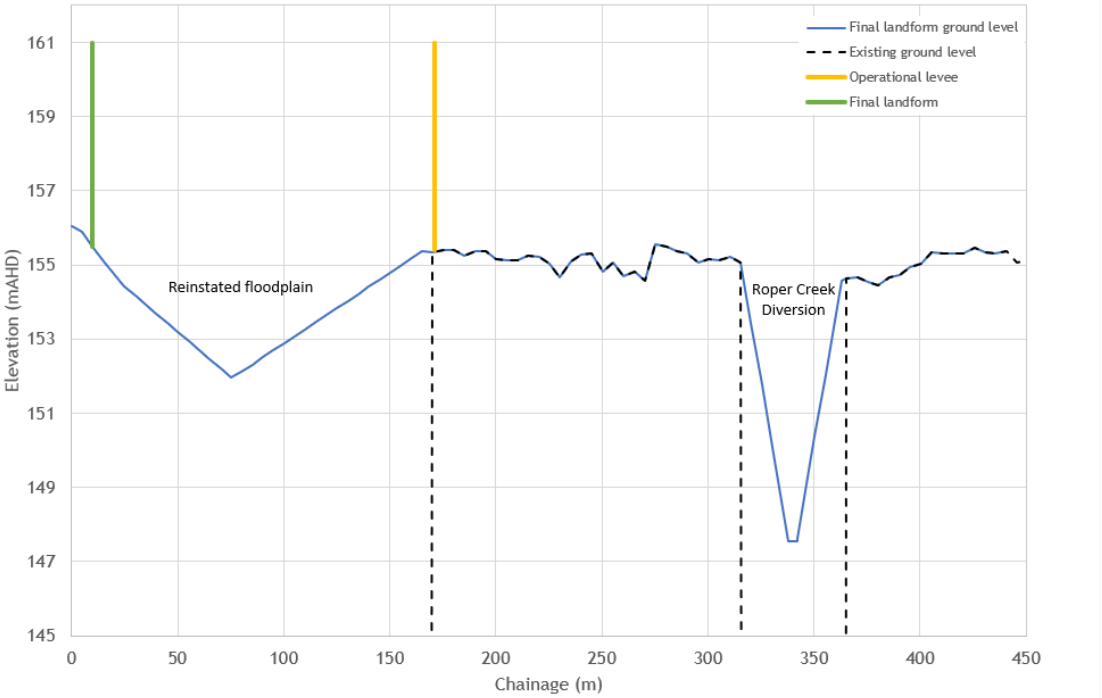

Figure 9.4 – Typical cross section of the Roper Creek diversion and final landform floodplain

9.2.3.3 Revegetation

The establishment and maintenance of riparian vegetation is essential for bank stability. Root systems from trees and shrubs provide much of the erosion resistance for channel widening from the shear stresses of flowing water and grasses protect the soil surface from raindrop splash erosion and overland flows.

Tree and shrub root systems take time to establish and grass root systems cannot provide sufficient depth and strength to provide the necessary erosion protection. The revegetation design must therefore provide for the rapid establishment of high strength, deep root systems to protect the soil surface from raindrop splash and overland flows and provide for long term erosion protection and ecological function. Revegetation will be undertaken in accordance with the Middlemount Mine Rehabilitation Management Plan required by EA EPML00716913.

9.2.4 Geomorphic channel parameter comparison

Table 9.5 shows comparisons of the geomorphic characteristics between the pre-mining/existing Roper Creek channel and the proposed Diversion 2. Diversion 2 replicates the geometric properties of the channel and bed grade of the existing Roper Creek channel. However, due to restrictions within the floodplain, Diversion 2 is about 13% shorter than the existing channel and the meander geometry cannot be fully replicated.

Table 9.5 – Roper Creek and Drainage Line 2 hydraulic and geomorphic characteristics

Parameter	Existing Roper Creek	Proposed Diversion 2
Length (km)	4,400	3,840
Bed grade (%)	0.111	0.114
Bed width (m)	7 to 9	4
Mean Top Width (m)	49	50
Depth to Floodplain (m)	7 – 8	7 - 8
Meander Radius (m)	80 to 550	85 to 150
Meander Sinuosity Index	1.77	1.54
Meander Wavelength (m)	400 to 1,000	300 to 500
Meander Amplitude (m)	250 to 600	150

9.3 PROPOSED CONDITIONS FLOODING AND FLOOD IMPACTS

9.3.1 Model changes

The following changes from approved mining conditions have been undertaken to the model to represent the proposed conditions:

- The revised Roper Creek Diversion 2, as described in Section 9.2.
- The proposed floodplain changes to remove the high ground around the upstream end of Diversion 2.
- The proposed final landform; and
- The proposed drainage channel between the active mining area and the eastern dump.

The Roper Creek Diversion 2 was designed within the 12D software using the cross sections shown in Figure 9.3 as a template. The 12D tin was then converted to digital elevation model (DEM) files to override the 2018 lidar ground levels. The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW. Further work will be undertaken to refine the ground level changes as part of the final design of Diversion 2.

The flood levee was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made from the approved conditions TUFLOW model.

9.3.2 Flood depths and velocities

Figure 9.5 show the flood levels, depths and extents and Figure 9.6 show the flood velocities across the Project area for the 1% AEP events under proposed conditions. The 50%, 2% and 0.1% AEP flood depths and velocities are given in Appendix C. The change in flood level and velocity between proposed and approved conditions are given in Figure 9.7 and Figure 9.8 respectively for the 1% AEP event and in Appendix D for the other events.

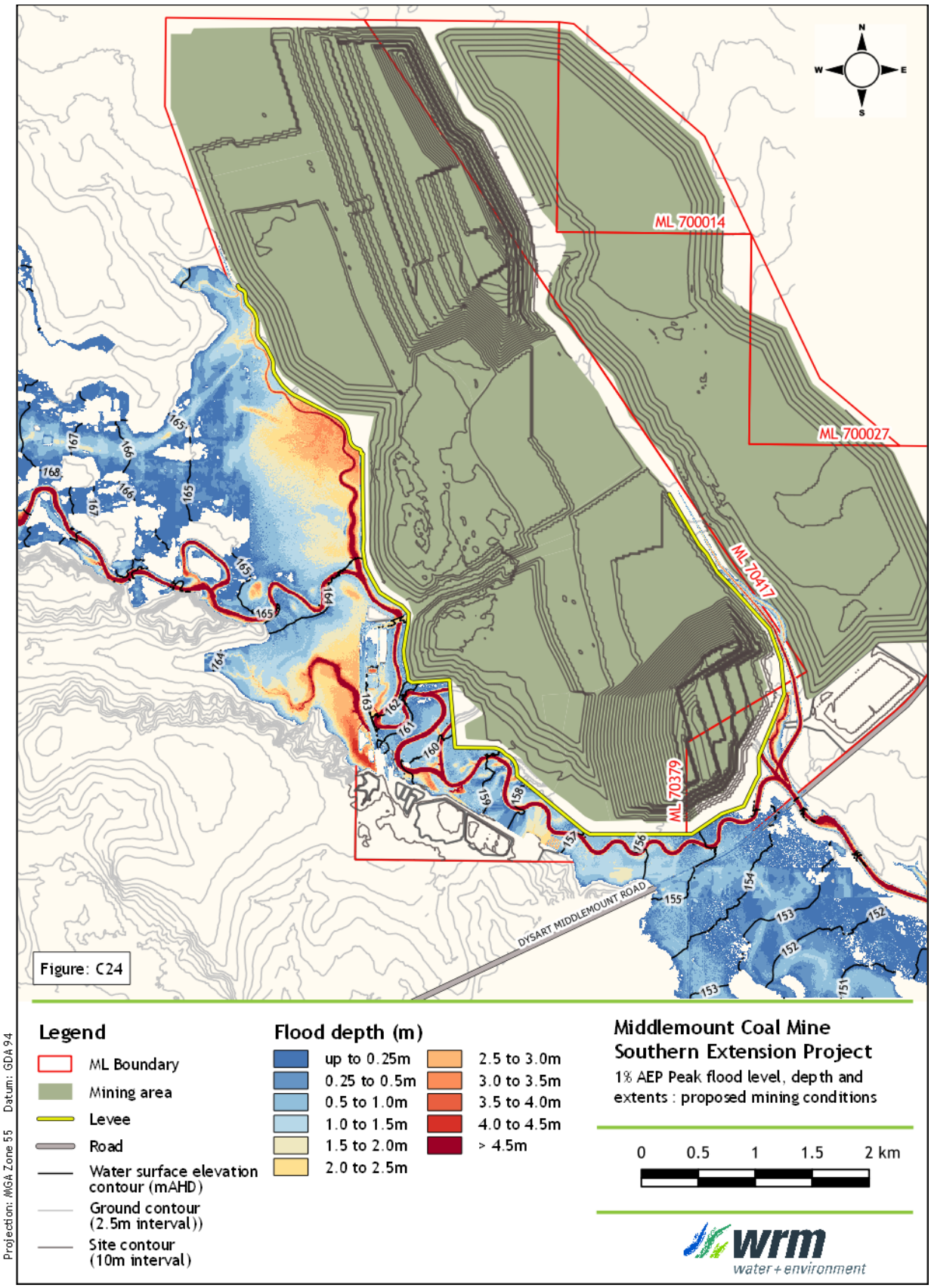

Figure 9.5 - Flood depths and extent, proposed conditions, 1% AEP

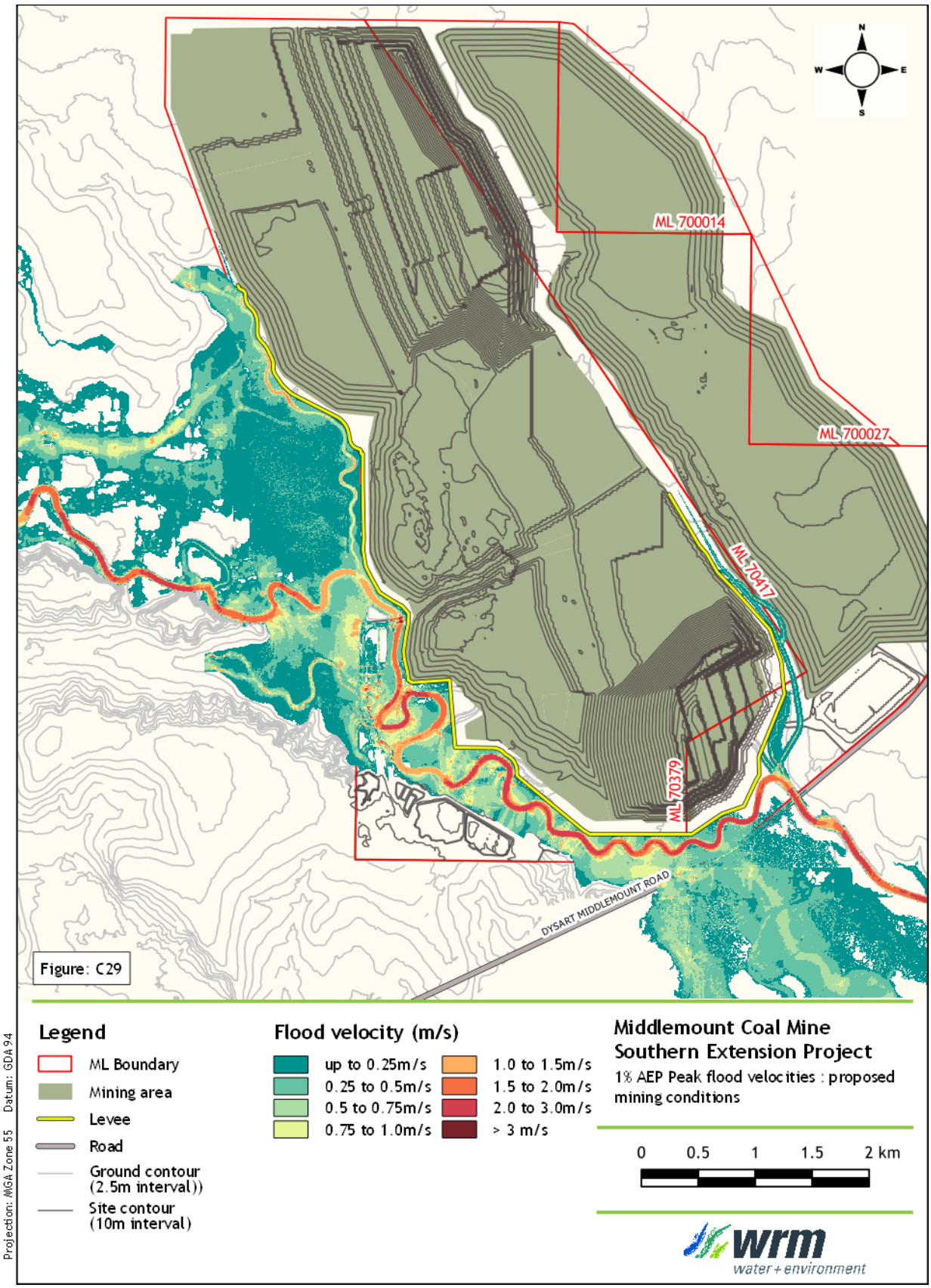

Figure 9.6 - Flood velocities, proposed conditions, 1% AEP

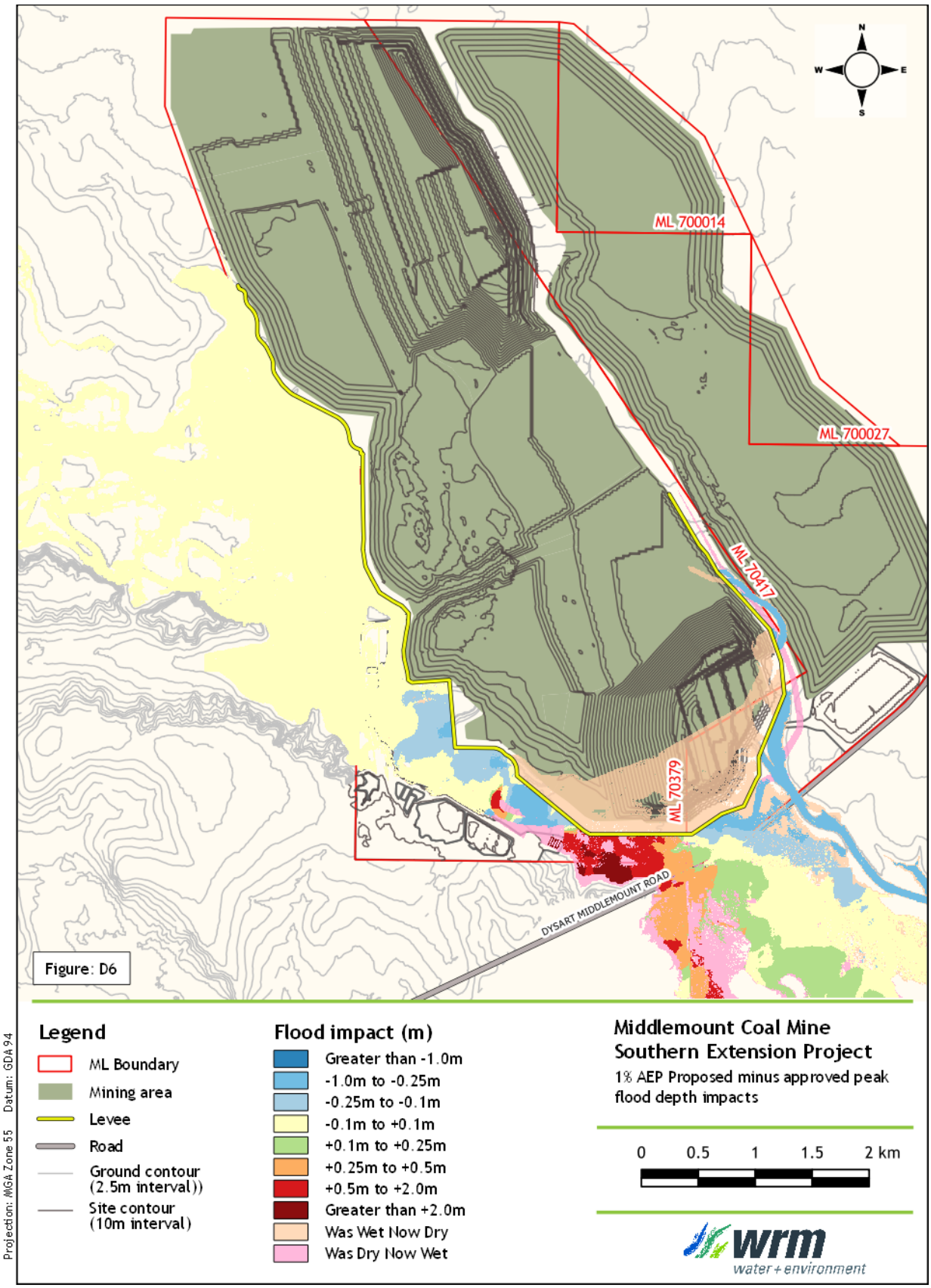

Figure 9.7 – Proposed minus approved conditions flood level impacts, 1% AEP

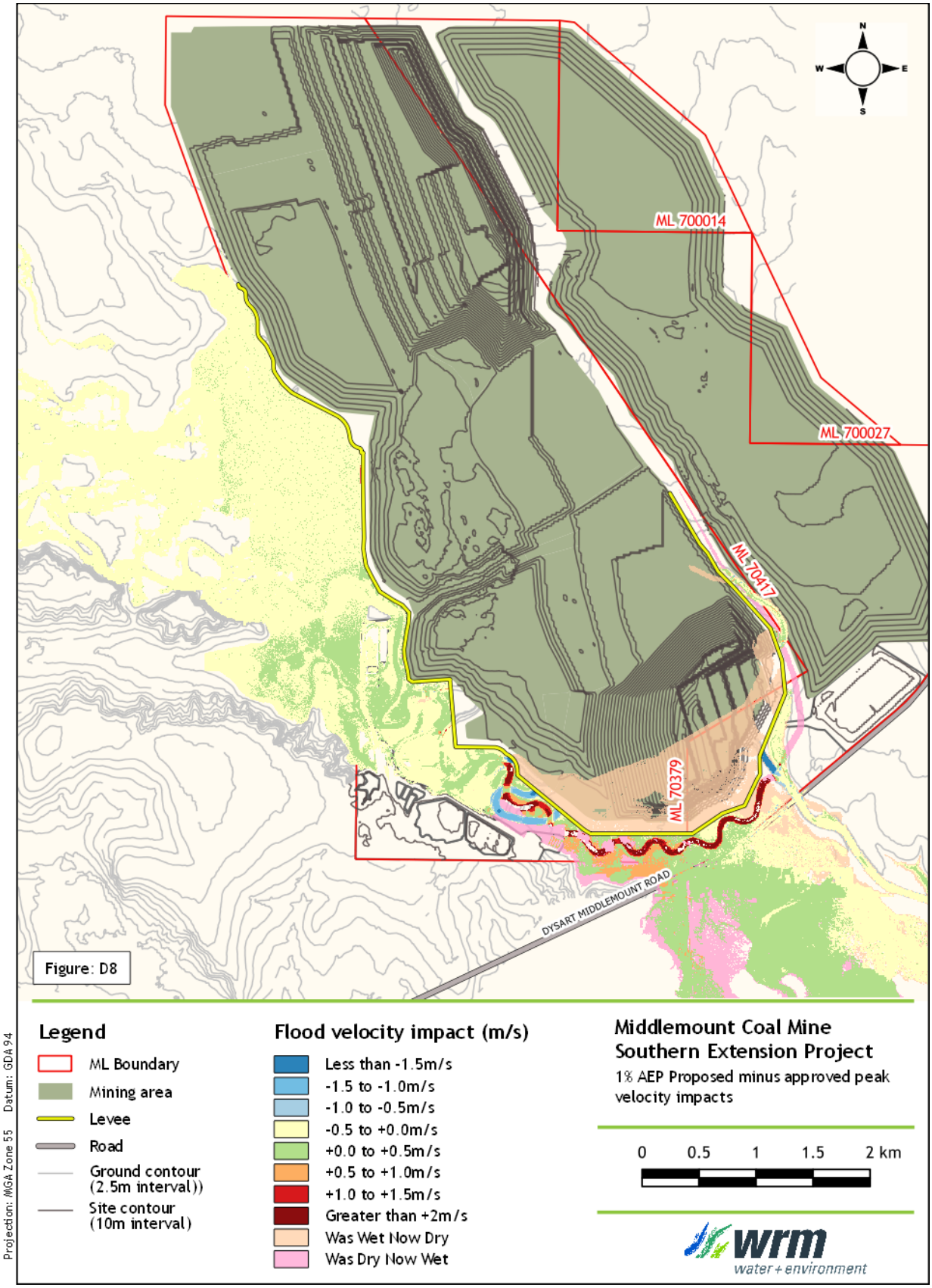

Figure 9.8 - Proposed minus approved conditions flood velocity impacts, 1% AEP

The results show the following:

- There are no significant changes to flood levels and velocities from approved conditions for the 50% AEP event with the exception of the change due to Diversion 2 relocation.
- The 5% AEP event flood levels would be unchanged from approved conditions upstream of Diversion 1 and moderately reduce peak flood levels within Diversion 1. Diversion 2 would overflow and drain across Middlemount Road for this event, which is not predicted to occur for pre-mining or approved conditions. The depth of flooding on Middlemount Road for this event is predicted to be 0.4 m and therefore likely impassable. The floodwater is confined to the old flood channel downstream of Middlemount Road.
- The 2% and 1% AEP peak flood levels are generally unchanged upstream of Diversion 2. The Project will increase flows on Middlemount Road and further downstream above approved and pre mining conditions. Peak flood levels (and flows) would reduce within the Roper Creek channel. The impact extent goes beyond the available topographic data. However, a review of the aerial imagery shows the flood channel that conveys this floodwater drains back into Roper Creek about 4.6 km downstream of Middlemount Road. The impact is not expected to extend further downstream of this location.

9.4 POST MINING CONDITIONS FLOODING AND FLOOD IMPACTS

9.4.1 Model changes

The following changes are proposed as part of the final post mining conditions from proposed mining conditions:

- The ground levels between the proposed conditions levee and the toe of the final landform around the southern void were lowered and reshaped back to an active floodplain.
- The proposed conditions levee was removed such that the toe of the proposed final landform around the southern void formed the edge of the floodplain.
- The haul road, North ROM and associated infrastructure between the mine infrastructure area and the mining areas were removed back to pre-mining ground levels.
- Minimal works are proposed along the Operational phase floodplain and Diversion 1 and Diversion 2 channels. Minor break out channels will be incorporated (at existing break out locations) to encourage more overbank flow into the newly created floodplain to mitigate the flooding on Middlemount Road.

The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW. Further work will be undertaken to refine the ground level changes as part of the final design of the floodplain modifications.

The toe of the final landform was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made from the proposed conditions TUFLOW model.

9.4.2 Flood depths and velocities

Figure 9.9 show the flood levels, depths and extents and Figure 9.10 show the flood velocities across the Project area for the 1% AEP events under the post mining final landform conditions. The 50%, 2% and 0.1% AEP flood depths and velocities are given in Appendix C. The flood level and velocity impacts between proposed and approved conditions are given in Figure 9.11 and Figure 9.12 respectively for the 1% AEP event and in Appendix D for the other events.

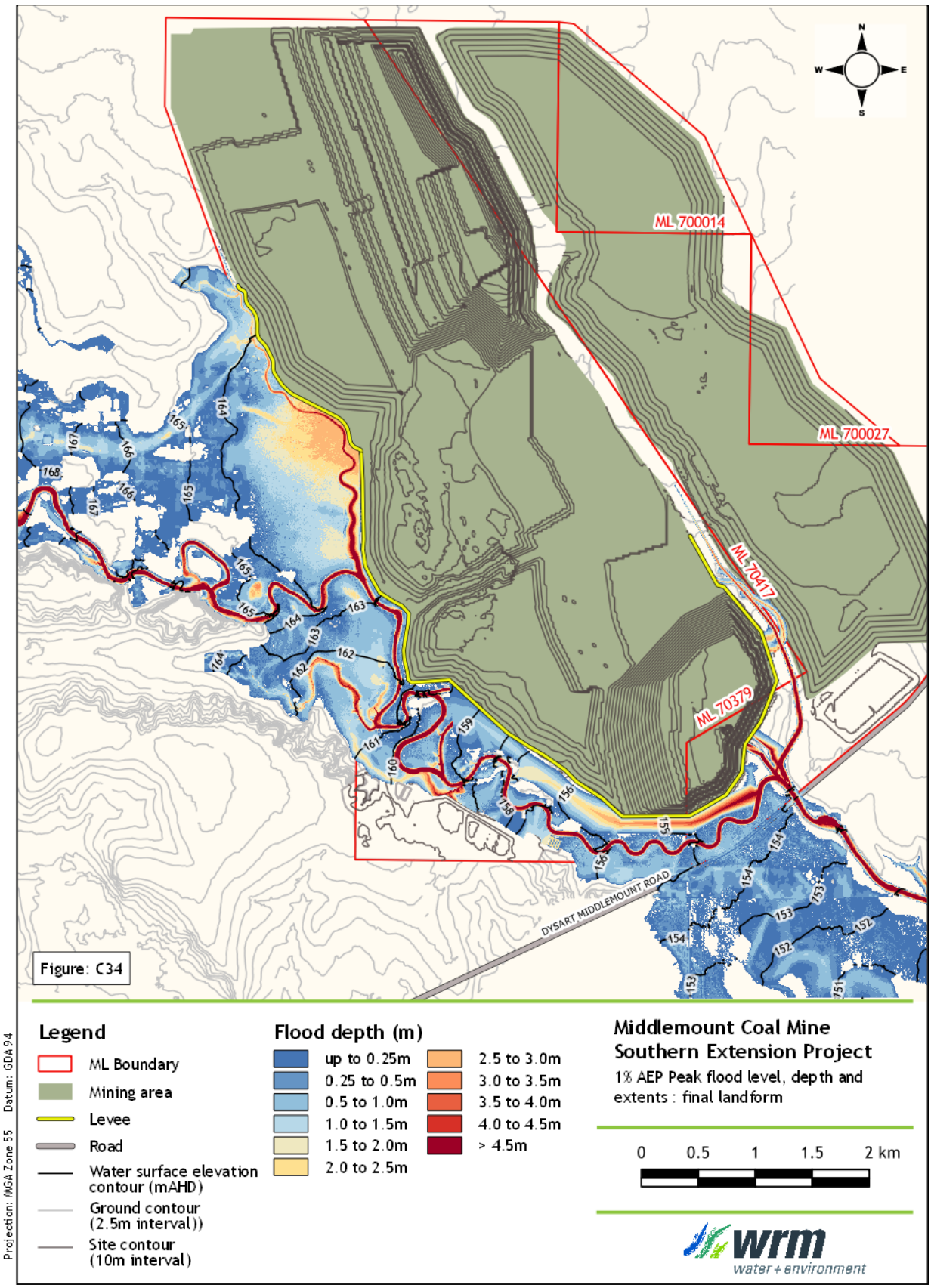

Figure 9.9 - Flood depths and extent, Post mining conditions, 1% AEP

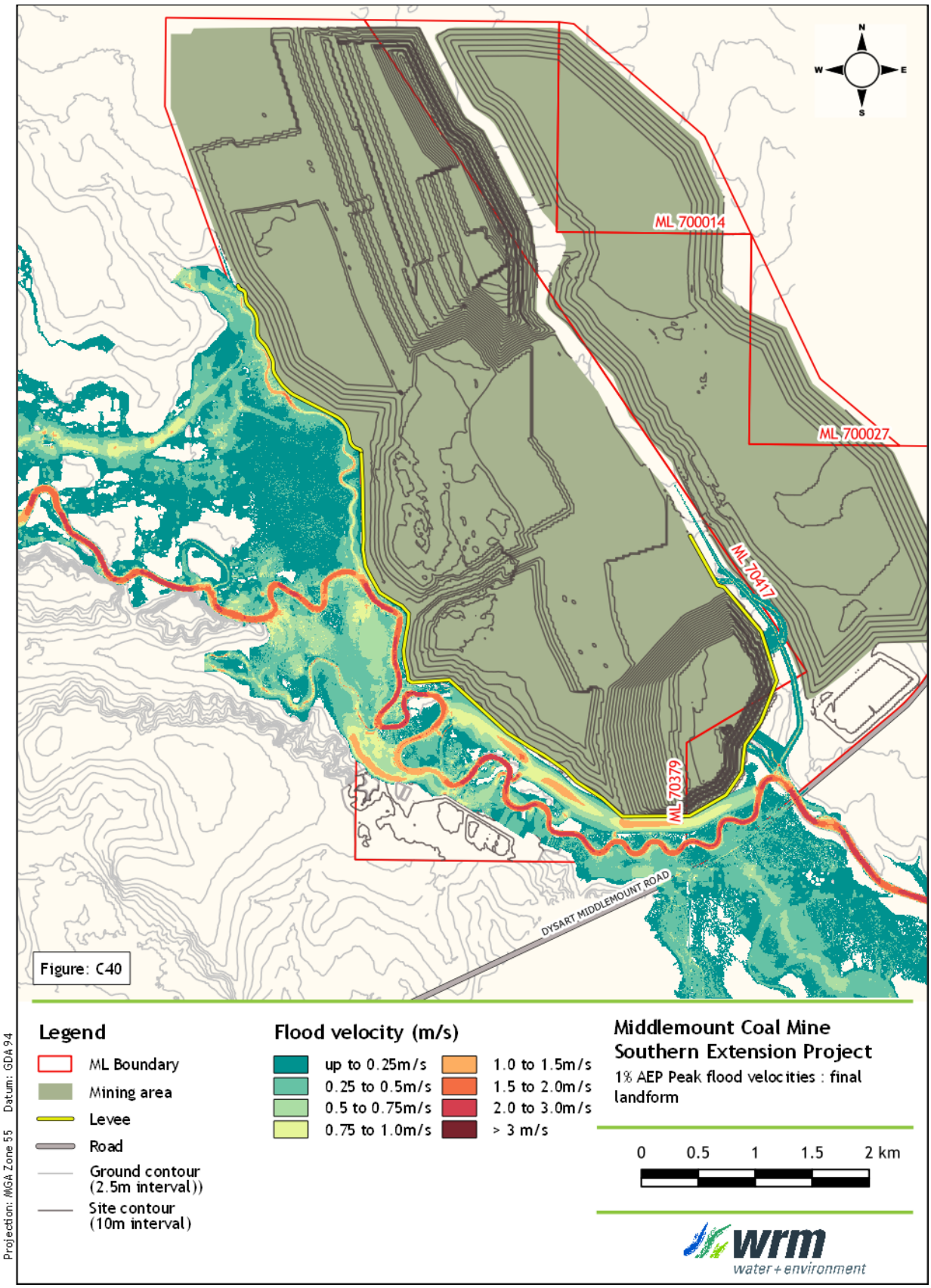

Figure 9.10 - Flood velocities, Post mining conditions, 1% AEP

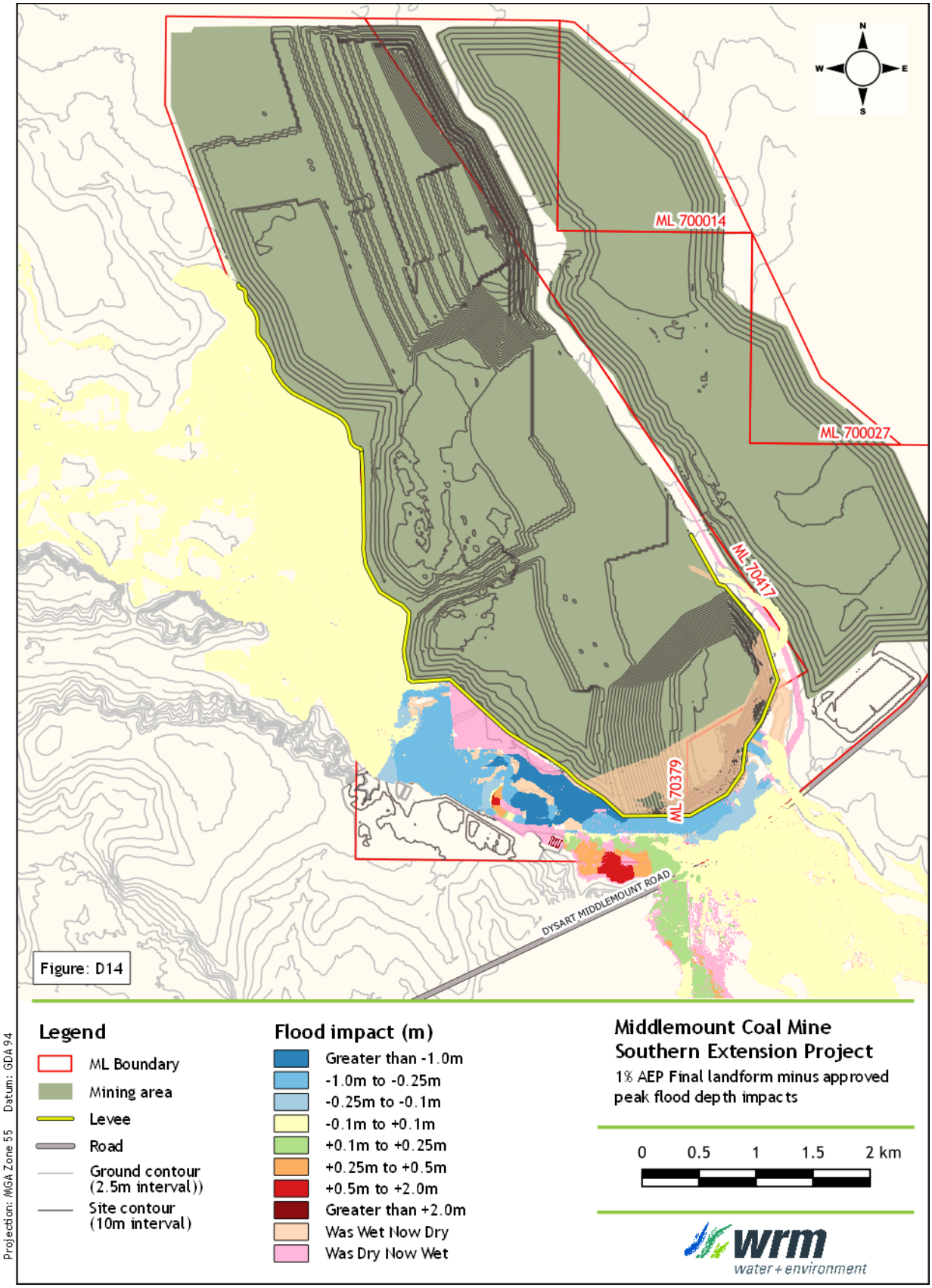

Figure 9.11 - Post mining minus approved conditions flood level impacts, 1% AEP

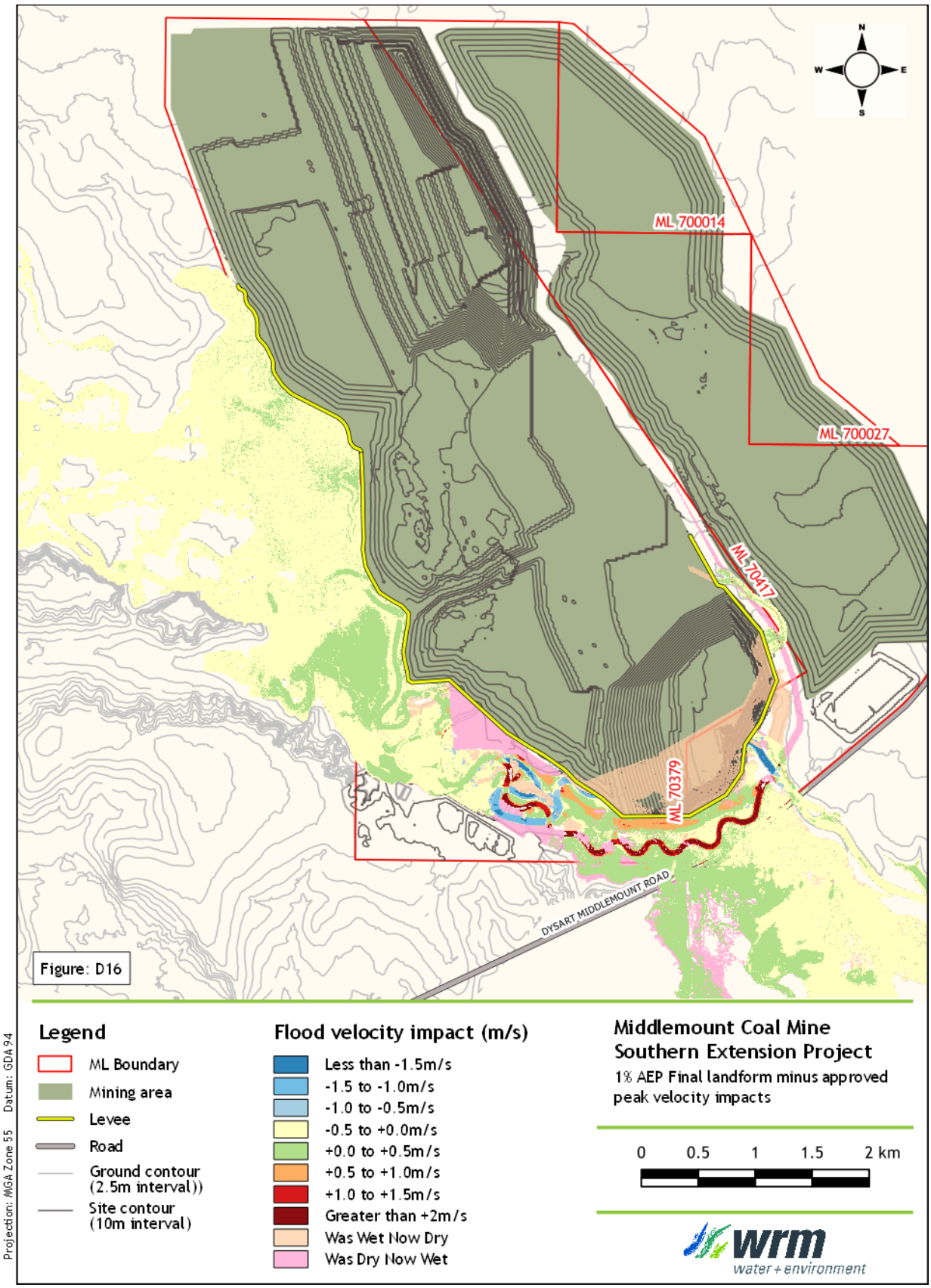

Figure 9.12 - Post mining minus approved conditions flood velocity impacts, 1% AEP

The results show the following:

- There would be a minor increase in flood levels and velocities from proposed conditions for the 50% AEP event due to the removal of the detention effects of the haul road.
- For the 5% AEP event, the removal of the haul road would re-activate flows along the southern flood channel adjacent to the mine infrastructure area. The rehabilitated floodplain adjacent to the South Void would also convey flood flows, which in turn would reduce the flows overtopping Diversion 2 that were predicted to flow across Middlemount Road for approved conditions. Middlemount Road would be trafficable for this event under final landform conditions. Peak velocities on the rehabilitated floodplain would not exceed 0.8 m/s.
- For the 2% and 1% AEP events, peak flood levels along Diversion 1 and 2 would reduce from approved conditions due to the additional conveyance capacity of the rehabilitated floodplain. This in turn would minimise the change in flooding behaviour downstream of Middlemount Road from approved conditions.

9.5 ROPER CREEK DIVERSION ASSESSMENT

9.5.1 Alluvial channel design criteria

Table 9.6 shows the hydraulic parameters (stream power, bed shear and velocity) of the Roper Creek channel for pre-mining conditions and compares them to the hydraulic parameters along Diversion 2 for the proposed operational and post mining conditions. Results are provided for the 50% and 2% AEP floods to compare the results to the Guideline values in Table 9.1 and the revised ACARP criteria given in Table 9.2.

Results have been provided for stream power, bed shear and channel velocity ranging from 25%ile (low) to 95%ile (high). To replicate the Guideline and ACARP criteria, which was derived using the HEC-RAS model, the following process was used:

- Standard 50 m wide cross sections (the approximate top width of the channel) were generated at 50 m increments along the channel;
- At 1 m increments along each cross section, the flow depth and velocity were extracted from the TUFLOW depth and velocity grids generated for each scenario; and
- The data at each cross section was used to generate a depth averaged channel velocity, hydraulic radius, flow and slope, which was then used to calculate bed shear stress and stream power.

Shear stress was calculated as follows:

$$\text{Shear stress} = \rho g R S$$

where ρ = water density, g = gravitational acceleration, R = hydraulic radius, S = hydraulic gradient

Stream power was calculated by multiplying shear stress with the depth averaged channel velocity.

Along the proposed Diversion 2, the results show the following:

- For the 50% AEP event, the 75%ile values for stream power, shear stress and velocity are below the guideline values and revised ACARP criteria for both proposed operational and post mining conditions. The values are moderately above the pre mining conditions values due to the approved diversion of Thirteen Mile Gully into Roper Creek. The 95%ile stream power is less than 50% of the mean stream power within the reach.

Table 9.6 – Roper Creek hydraulic and geomorphic characteristics, pre-mine (full reach and Diversion 2 reach) and proposed operational conditions along Diversion 2

Parameter	Stream Power (N/m s)	Bed Shear Stress (N/m^2)	Velocity (m/s)	Stream Power (N/m s)	Bed Shear Stress (N/m^2)	Velocity (m/s)
	50% AEP			2% AEP		
Guideline and ACARP criteria	35-60	<40	<1.5	80-150	<50	<2.5
Pre-mining (full reach)						
25%	14.6	15.0	1.0	48.0	29.8	1.6
Mean	20.8	18.8	1.1	65.7	36.2	1.7
75%	24.3	21.4	1.2	80.5	42.3	1.9
95%	37.7	28.6	1.3	113.1	53.0	2.1
Pre-mining (Diversion 2 reach)						
25%	14.2	14.7	1.0	49.2	30.1	1.6
Mean	20.2	18.4	1.1	63.8	35.5	1.8
75%	23.3	20.6	1.1	80.0	41.8	1.9
95%	35.8	27.9	1.3	90.0	45.8	2.0
Proposed Operational Phase (Diversion 2 reach)						
25%	23.6	21.1	1.1	81.2	42.5	1.9
Mean	26.7	22.9	1.2	98.0	47.5	2.0
75%	28.7	24.3	1.2	111.8	51.8	2.1
95%	36.3	28.3	1.3	127.5	57.4	2.2
Post mining (Diversion 2 reach)						
25%	24.7	21.7	1.1	74.5	40.2	1.9
Mean	28.0	23.6	1.2	84.0	43.1	1.9
75%	30.0	24.9	1.2	85.1	44.0	1.9
95%	38.0	29.1	1.3	130.7	58.6	2.2

- For the 2% AEP event under proposed operational conditions;
    - The mean and 75%ile stream power are below the guideline value and revised ACARP criteria but exceeds the pre-mining conditions value by 40% to 50%;
    - The 95%ile stream power within the reach does not exceed the mean stream power by more than 50%.
    - The mean bed shear stress is below the vegetated channel guideline value but above the unvegetated channel guideline value. Both values exceed the pre-mining conditions by 20% to 30%.
    - Velocities are generally consistent with the guideline values and pre-mining conditions.
- For the 2% AEP event under proposed post mining conditions;

- The 75%ile stream power remains below the guideline value and revised ACARP criteria and has reduced to be only be 6% above the pre-mining conditions;
- The 75%ile bed shear stress remains below the guideline values (assuming it has been vegetated) and within 5% of the pre-mining conditions bed shear.
- Velocities are generally consistent with the guideline values and pre-mining conditions.

The results suggest that the proposed operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria. The results are higher than pre-mining conditions, which are potentially more relevant for the assessment of long-term sustainability. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.

9.5.2 Threshold channel design criteria

Figure 9.13 shows the 0.01% AEP (1 in 1,000) bed shear stress calculated by TUFLOW along the Roper Creek Diversion 2 for the proposed and post mining conditions. The key threshold criteria for the various vegetation characteristics is given in Table 9.3.

For the proposed conditions, the results suggest the channel bed shear would vary from 40 to 120 Pa. The majority of the floodplain bed shear is below 40 Pa. There would be minor areas of bed shear greater than 120 Pa. However, any scour at these locations would not threaten to capture the watercourse into the open cut pit. The channel is proposed to be vegetated with a structurally diverse suite of established native vegetation and therefore should withstand the elevated bed shear values.

For the post mining conditions, channel and floodplain bed shear would significantly reduce, with most of the channel with bed shear below 60 Pa and the undisturbed sections of the floodplain below 20 Pa. Higher bed shear within the rehabilitated floodplain would range from 20 Pa to 65 Pa. It is expected that further refinement of the floodplain during detailed design (to remove the sharp changes in shape that are present in the conceptual design) would further reduce the bed shear in the over bank areas. Notwithstanding, the rehabilitated floodplain will be vegetated with a structurally diverse suite of established native vegetation and therefore should withstand the elevated bed shear values without threatening to capture the watercourse in the open cut pit (residual void).

9.5.3 Outcome assessment

An assessment of the proposed diversion against the outcomes in the Queensland watercourse diversion guidelines (see Section 9.2.2.1) is as follows:

9.5.3.1 Outcome 1

The watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the regional landscape and associated local watercourses.

Table 9.5 shows that the proposed Diversion 2 channel would replicate the geomorphic features of the existing Roper Creek channel. Due to restrictions within the floodplain, Diversion 2 is about 13% shorter than the existing channel and the meander geometry cannot be fully replicated. The channel depths to the adjacent floodplain and channels shape would be similar to the pre-mining conditions channel. The widening of the floodplain post mining would provide independent overbank flood channels in a similar manner to pre-mining conditions.

A revegetation plan will be developed as part of the detailed design that will use vegetation characteristics seen in the Existing Roper Creek channel.

On this basis, the proposed diversion would satisfy Outcome 1.

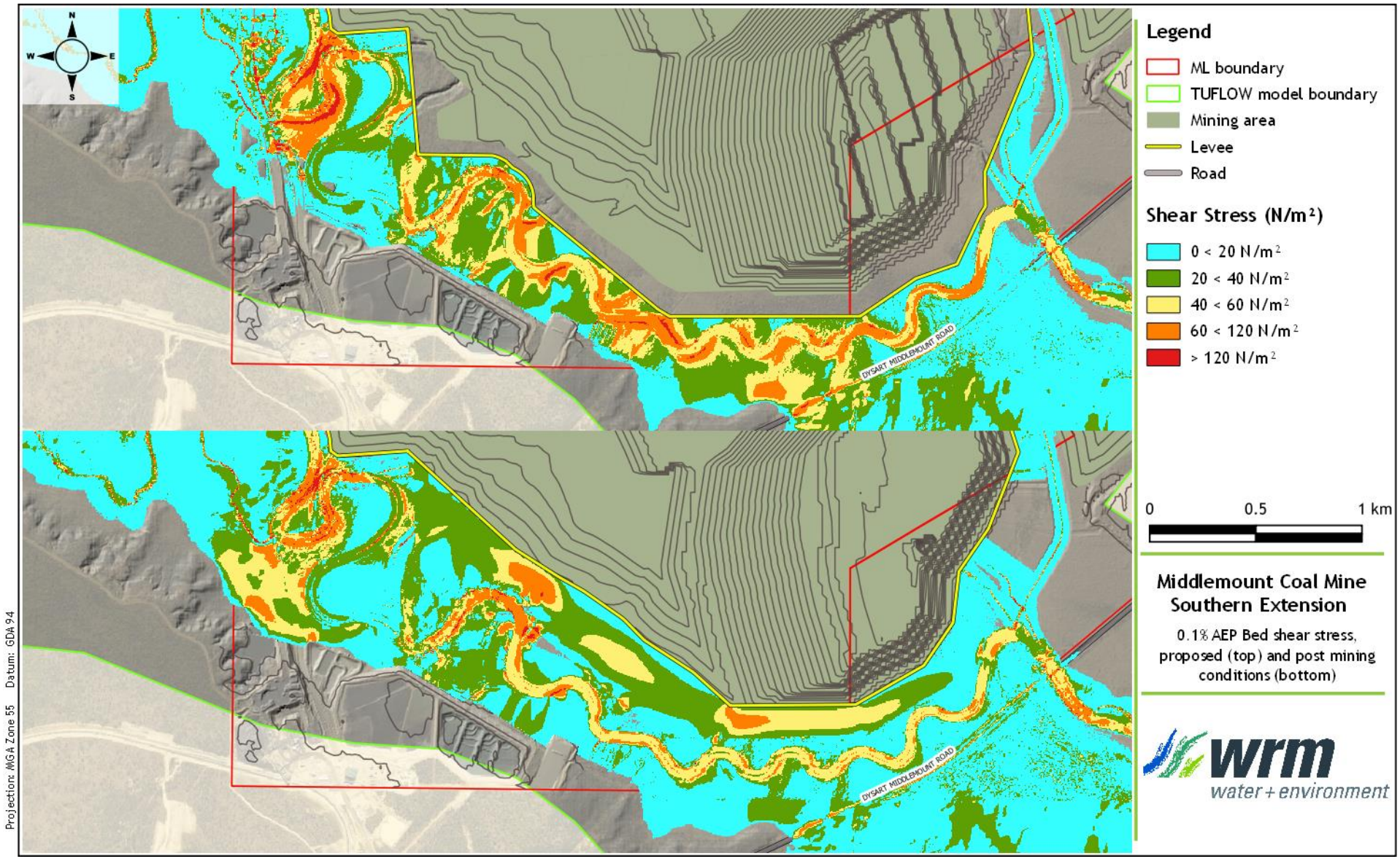

Figure 9.13 – 1 in 1000 AEP bed shear stress, proposed and post mining conditions

9.5.3.2 Outcome 2

The watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.

The proposed diversion will convey the same upstream catchment as the approved diversion because the catchment area has not changed. Peak discharges for the range of events assessed has not changed from approved conditions.

The diversions will also maintain the same groundwater characteristics as it will intercept the same sandy alluvial substrate material experienced across the floodplain. Further groundwater investigations will be undertaken during detailed design as part of the geotechnical investigations to confirm this.

On this basis, the proposed diversion would satisfy Outcome 2.

9.5.3.3 Outcome 3

The hydraulic characteristics of the watercourse diversion are comparable with other local watercourses and suitable for the region in which the diversion is located.

The proposed diversions will replicate the hydraulic characteristics of the existing Roper Creek channel in which they replace (see Section 9.5.1) and would therefore satisfy Outcome 3.

9.5.3.4 Outcome 4

A sediment transport regime that allows the watercourse diversion to be self-sustaining and not result in material or serious environmental harm on upstream and downstream reaches.

The hydraulic analysis shows that channel stream powers, which can be used as a surrogate for sediment transport, within the proposed diversion would mimic the Roper Creek channel stream power for the 50% AEP (in channel) event. The post mining stream power is within 6% of pre-mining conditions stream power. On this basis, the sediment transport regime of the diversion should be self-sustaining and would satisfy Outcome 4.

9.5.3.5 Outcome 5

The watercourse diversion and associated structures maintain stability and functionality and are appropriate for all substrate conditions they encounter.

Parsons Brinckerhoff and Landloch have undertaken preliminary sampling of agronomic and erosion parameters of surface soils for the approved diversion. The soil analysis demonstrates a considerable variation in the erosion risk and revegetation risk across the site. The erosion risk comes from the presence or dispersive and/or sodic soils that erode chemically in the presence of water.

The soils also have high magnesium levels (magnesic). The very weak ionic bonding within the soil particles creates a similar effect to dispersion. The sandy texture of some of the soils also allows erosion at low flow velocities. The soil chemical and physical constraints provide an extreme erosion risk in many circumstances. The high electrical conductivity, sodium and magnesium levels, poor calcium to magnesium ratio, moderate to strong alkalinity and low organic carbon levels provide significant constraints to vegetation establishment and growth. It will be necessary to ameliorate and modify the soils to allow the vegetation growth necessary to control creek bed and channel erosion (Landloch, 2012).

Geotechnical investigations were undertaken for the approved diversions to determine the engineering design parameters relevant for the proposed works (Parsons Brinkerhoff, 2013). These investigations were based on detailed bore logs along the proposed alignment. A sensitivity analysis was also undertaken should less favourable subsurface conditions be encountered.

No free groundwater was observed within the substrate materials encountered. However, sand lenses were evident within the profile, which are likely to convey shallow groundwater when soils are saturated. It is expected that the proposed diversion would intercept the same sand lenses as the existing channel.

Given that the proposed diversion will be located along the same floodplain with likely similar substrate conditions as the approved diversion, it is expected the same geotechnical design parameters will be acceptable.

9.6 OPERATIONAL PHASE FLOOD LEVEE ASSESSMENT

The proposed realigned flood protection levee along the southern extension area will be a regulated structure designed such that the crest level is above the 0.1% AEP design event. The extent and depth of inundation for the 0.1% AEP flood with the proposed levee in place is shown in Appendix C Figure C25.

The results show that the proposed levee alignment and extent will sufficiently prevent the inundation of the open cut pit throughout the life of the Project. Detailed design plans of the proposed levee together with a consequence assessment and certification by a suitably qualified and experienced person(s) will be prepared prior to commencement of construction of the levee for assessment and approval by the administering authority.

9.7 FINAL LANDFORM ASSESSMENT

Figure C36 in Appendix C shows the final landform and the extent of the PMF from Roper Creek. The proposed final landform for the Project will include two residual voids. The southern void is located on the pre-mine Roper Creek floodplain. The final landform around the southern void will be constructed to prevent floodwater from entering. This landform feature will be constructed to be up to 100 m wide at the crest, have a crest height above the PMF level from Roper Creek and be incorporated into the rehabilitated landform to form a self-sustaining final landform. The PMF is defined as the largest flood that could conceivably occur at a particular location and is estimated from probable maximum precipitation (PMP).

It is also proposed to remove the flood protection levees on the western side of the mine such that the rehabilitated out-of-pit overburden areas will prevent floodwater from entering the pit. There is at least 150 m of out-of-pit overburden area and 1 km of in-pit overburden between the floodplain and the residual void, which is more than adequate to prevent floodwater from entering the residual voids.

Figure 9.14 shows a longitudinal profile of bed shear for the 0.1% AEP measured approximately 10 m from the toe of the proposed southern extension final landform. The section commences near the Roper Creek Diversion 1 and extends to the existing Roper Creek channel. The vegetation thresholds that would protect against scour, as described in Section 9.5.2 are also shown for comparison. The results show that bed shear against the toe of the landform remains below the native vegetation threshold at all locations for the 0.1% AEP event.

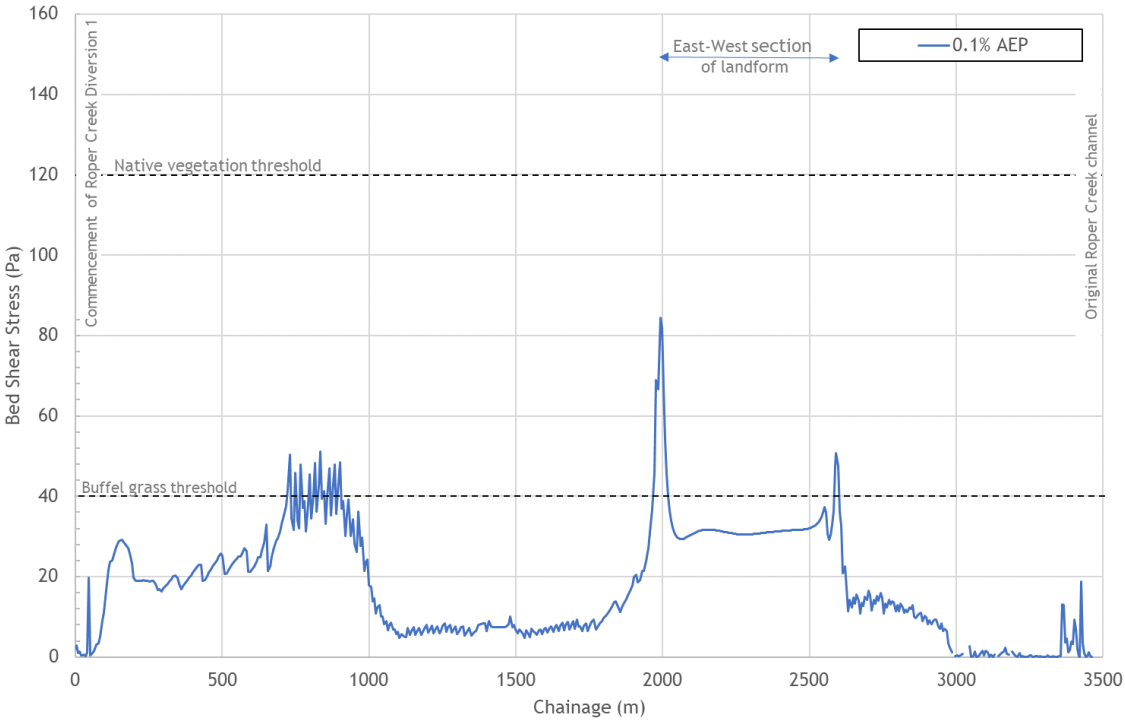

Figure 9.14 - Flood depths and extent, Final landform conditions, PMF

10 Mitigation and management measures

10.1 POTENTIAL IMPACTS

The potential impacts of the Project on surface water resources include:

- impacts on the geomorphology and the flooding regime of Roper Creek;
- impacts on regional water availability due to the potential need to obtain water from external sources to meet operational water requirements of mining operations;
- impacts on stream flows due to loss of catchment area draining to local drainage paths due to capture of runoff within onsite storages and the open cut pit;
- adverse impacts on the quality of on-site stormwater runoff draining from the disturbance areas to the various receiving waters surrounding the Project, during both construction and operation of the Project;
- adverse impacts on environmental values in Roper Creek associated with controlled releases from the mine water management system; and
- cumulative impacts of all projects in the region on the environmental values of the receiving waters.

An assessment of each of these potential impacts of the Project is provided in the following sections.

The assessment of surface water impacts has been undertaken based on commonly applied methodologies for the simulation of hydrologic and hydraulic processes using currently available data. The adopted approach is considered suitable for quantifying impacts to a level of accuracy consistent with current industry practice. Certain aspects of the project, such as changes to landforms due to construction of overburden emplacements, will create impacts that are irreversible, although this does not mean that any such impacts are necessarily detrimental to the environmental values of receiving waters.

10.2 FLOODING AND GEOMORPHIC IMPACTS

Potential impacts of the Project on flood levels and flood velocities in Roper Creek are addressed in Section 9 of this report. In summary, the proposed conditions levees would increase the depth and frequency of flooding downstream of the mine for events up to and including the 5% AEP event. There would be no change for the more frequent events or impact upstream of the mine from approved conditions.

It is proposed to increase the width of the floodplain post mining to improve the flood conveyance, which in turn would mitigate the increased flooding downstream of the mine.

The proposed Roper Creek Diversion 2 realignment has been designed to replicate the channel that it replaces as much as practicable. The operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria but the results are higher than for pre-mining conditions. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.

An operation and monitoring plan will be developed for the proposed diversion as part of detailed design that will be consistent with the monitoring programme developed for the existing Roper Creek diversion. Collection of monitoring data will help identify any issues with the construction of the diversion and assist with relinquishment at mine closure. The monitoring plan will be prepared using the process documented in Queensland watercourse diversion guidelines (DNRM, 2014).

10.3 REGIONAL WATER AVAILABILITY IMPACTS

The water balance modelling results indicates that between 460 ML/year and 1,330 ML/year will be required from the external supply (Anglo pipeline), under median climatic conditions (refer Section 6.3.4). This is slightly higher than previous modelling results undertaken as part of the Western Extension Surface Water Assessment (WRM, 2018), which predicted that between 420 ML/year and 990 ML/year would be required under median climatic conditions.

This change is primarily due to the increase in predicted net CHPP usage (113 to 170 L/ROM t), which is based on recent observed usage. As the external water supply is sourced from surplus mine affected water reserves of a neighbouring mine, the external supply requirements will have no impact on regional water availability.

10.4 STREAM FLOW IMPACTS

10.4.1 During active mining operations

10.4.1.1 Whole of mine

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to the receiving waters of Roper Creek and Thirteen Mile Gully. The captured catchment area will change as the mine develops. A breakdown of the catchment areas reporting to the whole of mine water management system is provided in Table 10.1. Note that areas managed under the ESCP have been included in the total captured catchment area.

The total catchment area of Roper Creek to the downstream boundary of the Middlemount Coal Mine tenements, including the Thirteen Mile Gully catchment, is approximately 389 km^2. The maximum captured catchment areas represent:

- Between 6.3% and 7.8% of the Roper Creek catchment to the downstream boundary of the mine, depending on the Stage. This is generally consistent with the catchment that would be excised as part of the approved mine.
- Of the total Stage 5 captured catchment area, a maximum of 13.5 km^2 is captured in pits and mine affected dam catchments. This represents only 3.5% of the Roper Creek to the downstream boundary of the mine.
- The remaining catchment drains off site through the on-site stormwater management system.

Table 10.1 – Catchment area captured within the whole mine water management system

Catchment	Total catchment area (km^2)	Captured catchment area (km^2)			
		Stage 1	Stage 2	Stage 3	Stage 4
Roper Creek (to d/s of site)	389	25.9	30.3	26.0	24.5

Given that areas managed under the ESCP will drain from the site following treatment, and the sediment dam catchments typically have higher runoff coefficients than under natural conditions, the loss of stream flows will likely be less than the total loss of catchment area (proportionally).

On this basis, the loss of catchment flows in Roper Creek would be indiscernible. The potential impact on water quantity in Roper Creek due to the whole of mine is considered negligible, particularly given that no water resource development, such as dams or major irrigation infrastructure or water licences for the take of water are located on Roper Creek downstream of the mine.

10.4.1.2 Project only

The Project will result in changes to flows in local creeks due to the progressive extension of open cut mining operations to the south and subsequent capture and re-use of drainage from operational catchment areas.

The additional surface disturbance area associated with the Project would excise an additional 110 ha (maximum during operations) from the catchment area of the former Thirteen Mile Gully and other associated drainage features. This represents approximately 2% of the total catchment area of the former Thirteen Mile Gully (approximately 5,600 ha) (of which the majority has already been diverted to Roper Creek by the existing/approved Thirteen Mile Gully Diversion.

The loss also represents less than 0.3% of the Roper Creek catchment to the downstream boundary of the mine. The loss of catchment flows in Roper Creek would be indiscernible, and as such the potential impact on water quantity in Roper Creek due to the Project Only is considered negligible.

10.4.2 Post-mining landform

At the completion of mining, permanent drainage of waste rock emplacement areas will be installed to minimise capture of surface runoff into the residual voids in general accordance with the configuration shown in Figure 7.1. The majority of the disturbed area at the site will be rehabilitated and allowed to drain back to Roper Creek. A residual area of approximately 6.8 km^2 will continue to drain to the residual voids.

The net change in catchment area draining from the site is summarised in Table 10.2. The changed topography as a result of the final landform will have the following impacts on catchment area:

- The catchment draining to Roper Creek (to the downstream of site) will reduce by around 6.8 km^2 (compared to pre-mining conditions), a decrease of less than 2%. This is a reduction compared to the approved final landform, which would excise 7.4 km^2 of catchment that would otherwise drain to Roper Creek.
- The loss of catchment flows in Roper Creek would be indiscernible, and as such the potential impact on water quantity in Roper Creek due to the final landform is considered negligible.

Table 10.2 – Post-mining landform – captured catchment areas

Catchment	Pre-mining catchment area (km^2)	Post-mining catchment area (km^2)	Captured catchment area (km^2)
Roper Creek (to d/s of site)	389	382.2	6.8

10.5 REGIONAL WATER QUALITY AND ENVIRONMENTAL VALUES

10.5.1 Overview

Section 5 describes the objectives and principals of the water management system, which have been developed to protect water quality and the environmental values of the waterways potentially affected by the Project. No changes are proposed to these objectives and principals as part of the project and the water management system and infrastructure remains mostly unchanged.

The general principles of the water management system, are as follows:

- A **catchment runoff water management system** that separates clean water from mine affected, on-site stormwater wherever possible. Details of the catchment runoff water management system are provided in Section 5.8. Further details of the proposed waterway diversions and associated levee infrastructure are provided in Sections 8 and 9.
- An **on-site stormwater management system** that contains runoff that potentially has high sediment concentrations in sediment dams. Water collected in the sediment dams will be managed in accordance with the ESCP and used for dust suppression or will overflow to receiving watercourses after a period of settling. Details of the on-site stormwater management system are provided in Section 5.7.
- A **mine affected water management system** that contains potentially saline runoff from the pit and Mine Infrastructure Area (including ROM coal stockpile) in mine affected water dams. Mine affected water will be used as a priority in meeting makeup demand in the CHPP (after supplies are used from the tailings water management system) and for road watering. Water from the mine affected water management system may only be released to the downstream environment in compliance with the EA conditions. Details of the existing and proposed mine affected water management system and its expected performance are provided in Section 5.5 and Section 6.
- A **tailings water management system** that contains and dewaters the tailings and allows for maximum recycle of water to the CHPP. Details of the tailings and rejects circuit are provided in Section 5.4.
- A **contaminated water management system** that collects and contains all potentially contaminated water on site. This water will be recycled for use on the mine site without releasing it to the natural watercourses. Details of the existing and proposed contaminated water management system and its expected performance are provided in Section 5.6.

10.5.2 Performance of the water management system

An assessment of the water management system is given in Section 6. The results of the water balance modelling indicate that, under the current model assumptions and configuration, there is less than a 1% chance of uncontrolled spills of mine affected water from the site to the receiving environment.

Some overflow of water from sediment dams may occur during wet periods that exceed the design standard of the sediment control system (Section 5.7). As described in Section 4.4.3, water quality monitoring of three release events from sediment dams over 2013/14 indicated that the releases complied with the EA conditions with the exception of zinc and copper. However, it should be noted zinc and copper concentrations were also elevated at the upstream reference site, which indicates that the elevated levels are due to naturally higher background concentrations.

The additional disturbance footprint associated with the Project (233 ha) will increase the volume of stormwater requiring to be contained and managed on the mine site. Notwithstanding, the on-site stormwater management system will remain generally unchanged (i.e. continued collection of runoff from the overburden dumps) for the Project with augmentations as necessary.

On this basis, it is unlikely that overflows from sediment dams will have a measurable impact on receiving water quality.

10.5.3 Controlled releases

There are no proposed changes to the current release conditions as prescribed in Condition C5 of the site's EA (EPML00716913, dated 26 February 2020).

Due to the salinity of water currently stored in MWD, and the high salinity of the groundwater inflows and external water supply, the water balance modelling indicates that no controlled releases from site would occur over the life of the Project. As such, there would be no impacts on downstream water quality or environmental values of the downstream waterway associated with controlled releases of mine affected water.

Discharges may continue to be undertaken in accordance with Condition C5 of EPML00716913 if the salinity of water held on site decreases (e.g. if the salinity of the external water supply decreases).

10.5.4 Monitoring and maintenance

It will be necessary to manage each of these systems so that they are operating as designed.

- Continual monitoring of water quality and storage volumes in the mine affected storages will be undertaken to ensure that uncontrolled spills do not occur and cause a downstream impact.
- The pit and MWD pumps will be inspected and operated regularly to ensure they will operate when required.
- Sediment dams will be cleaned out on a regular basis to maintain the available sediment storage volume.
- Sediment dam monitoring will be used to validate the anticipated quality of water runoff reporting to sediment dams. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam monitoring would be reviewed and updated accordingly (e.g. to be sampled only when releases occur).
- Diversion drains will be monitored regularly to ensure they are operating as designed and do not allow mixing of clean and dirty water.
- Contaminated water sumps and interceptors are to be inspected and cleaned out regularly.
- Continual monitoring of potable water quality to ensure it meets potable water standards.

10.6 CUMULATIVE IMPACTS – SURFACE WATER

10.6.1 Overview

The objective of this assessment is to identify the potential for impacts from the Project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the Project.

There are three levels at which cumulative impacts may be relevant:

- Localised cumulative impacts – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the Project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause additive effect on the receiving environment. For the purposes of this assessment, all existing and proposed projects located within the Roper Creek catchment have been included.

- Regional cumulative impacts – These include the Project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operations in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.
- Global cumulative impacts – These include impacts that the Project might contribute to at a global scale. The only potential global scale impact for the Project is greenhouse gas emissions, and as such has not been addressed in this assessment.

10.6.2 Existing projects

Projects which are currently operating within the Roper Creek catchment and have been included in the cumulative impacts assessment for the Project, and are listed in Table 10.3.

Note that all of the projects listed below are located on waterways which discharge into Roper Creek downstream of the Project, as follows:

- Parrot Creek discharges into Roper Creek approximately 14 km downstream of the Project.
- Oaky Creek discharges into Roper Creek approximately 32 km downstream of the Project.

There are no active projects located within the Roper Creek catchment upstream of the Project. The southern extent of Norwich Park Mine (which is currently closed) is located within the Roper Creek catchment upstream of the Project.

10.6.3 New or developing projects

Relevant projects that have been considered include:

- Projects within the predicted sphere of influence of the Project, as listed on the Department of State Development, Infrastructure and Planning website that are undergoing assessment under the Queensland *State Development and Public Works Organisation Act 1971* for which an Initial Advice Statement (IAS) or an Environmental Impact Statement (EIS) are available; and
- Projects within the predicted sphere of influence of the project, which are listed on the website of the DEHP that are undergoing assessment under the EP Act for which an IAS or an EIS are available.

There have been no projects identified as currently undergoing assessment or having recently completed assessment under these processes.

10.6.4 Cumulative impacts – surface water quality

The Project is located in the Mackenzie River catchment boundary, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government undertook an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (Environmental Protection Agency [EPA, 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through environmental authorities.
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream environmental values.

Table 10.3 - Existing projects considered in the cumulative impact assessment

Project Proponent	Description	Operational status	Relationship to the Project Mining Lease	
			Timing	Location
Capcoal Complex - Anglo Coal	Open cut and underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project	• German Creek - located 10 km southwest of the Project on Parrot Creek • German Creek East - located 6 km south of the Project on Parrot Creek • Oak Park - located 14 km south of the Project on Parrot Creek • Lake Lindsay - located 24 km southeast of the Project on Oaky Creek
Foxleigh Mine - Middlemount South	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project	Located 15 km southeast of the Project on Roper Creek
Oaky Creek Mine - Glencore	Underground coal mine (with inactive open cut pits)	Operating	May have overlapping operational phases with the construction and operations of the Project	Located 25 km southwest of the Project on Oaky Creek
Norwich Park Mine- BMA	Open cut coal mine	Ceased production indefinitely	Unlikely to have overlapping operational phases with the construction and operations of the Project	Located 24 km northwest of the Project on Roper Creek

These conclusions led to a number of inter-related actions by the Queensland Government and other stakeholders:

- WQOs were developed for the Fitzroy Basin and added to Schedule 1 of the EPP (Water) in October 2011.
- Model water conditions were developed for coal mines in the Fitzroy basin (DES, 2018). These model water conditions are designed to manage water discharges to meet the WQOs set out in the EPP (Water) and to provide consistency between mining operations in the Fitzroy basin.
- EAs for a number of mining operations were amended to introduce conditions consistent with the model water conditions.
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new EA conditions and upgrade operating conditions.

With these measures in place, a strong strategic and policy framework is in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching WQOs can be achieved.

Mine affected water from the proposed Project will be managed through the existing Middlemount Coal Mine mining complex water management system as this allows water to be reused in coal handling and preparation. The EA EPML00716913 is in line with the model water conditions, with discharge conditions and in-stream trigger levels aligned with WQOs in the EPP (Water). Using a water balance model, an analysis has been undertaken of the effect of water from the Project on the ability of Middlemount Coal Mine to maintain compliance with environmental authority conditions. This analysis indicates that the addition of mine affected water from the Project makes no difference to the compliance profile for Middlemount Coal Mine and is negligible in terms of salt load to the Mackenzie River.

While the EPA cumulative impact assessment of mining in the Fitzroy Basin focussed on salinity as the key water quality issue related to mining activities, surface disturbance associated with mining activities can result in erosion and increased sediment levels in surface waters. The Great Barrier Reef outlook report also identified that the Fitzroy Basin contributed one of the highest sediment loads to the reef, largely attributing sediment loads to use of land for agricultural activities (Great Barrier Reef Marine Park Authority [GBRMPA], 2009).

The Queensland Government commissioned an assessment of mine affected water releases in the Fitzroy River basin during the 2012–2013 wet season (known as the Pilot Scheme).

The report (Gilbert and Sutherland and Marsden Jacob Associates, 2013) concluded that the Fitzroy River as a whole is not currently 'at capacity' in terms of salt load at a catchment or sub-catchment scale (Gilbert and Sutherland and Marsden Jacob Associates, 2013).

The operational policy of the Pilot Scheme aims to manage the cumulative impact of mine affected water releases across the Fitzroy Basin. To achieve this, trigger values have been derived for six monitoring locations across the basin. If in-stream EC triggers are exceeded during times when mine affected water releases are being undertaken upstream, the regulator has the ability to issue a "cease release" notification to all coal mines in the Fitzroy Basin with conditions that authorise the release of mine affected water.

The water quality assessment undertaken for the Project has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. On this basis, the proposed Project is not expected to make any significant contribution to cumulative sediment loads in the Fitzroy River Basin.

Given that the Middlemount Coal Mine affected water releases are being managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine affected water from the Project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

10.6.5 Cumulative impacts – surface water flows

In Queensland, the water resource planning process focussed on balancing water extraction and use with protection of ecosystems and takes into account cumulative impacts from major water storages and extraction. The Project does not require any additional raw water allocations and therefore does not contribute to cumulative impacts in relation to extraction of surface water resources from the catchment. The Project will locally impact flows in Roper Creek and its minor tributaries due to water being captured within the site water management system. The impacts of these changes in conjunction are outlined in Section 10.4. No other projects have been identified which would further increase these impacts.

10.7 PROPOSED EA AMENDMENTS

10.7.1 Authorised releases

There are no additional mine affected water dams proposed as part of the Project. As such, there are no new authorised release points as listed in Table C1 of the EA.

The additional sediment dams will be managed under the ESCP and therefore require no changes to the EA.

10.7.2 Mine affected water release limits and trigger levels

There are no proposed changes to the mine affected water release limits, release contaminant trigger investigations levels or mine affected water release conditions in Table C2, Table C3 and Table C4 of the Middlemount EA.

10.7.3 Mine affected water release events

There are no additional stream gauges proposed as part of the Project. The existing stream gauge is adequate to define the trigger release conditions from the existing mine water release points.

10.7.4 Receiving environment monitoring

There are no proposed changes to the receiving water monitoring locations given in Table C6 of the EA. In addition, the monitoring locations and regime given in the Middlemount REMP (GHD, 2019) does not change.

10.7.5 Location and basic specification of regulated dams

There are no new regulated dams proposed as part of the Project.

11 Conclusion

The key findings of this surface water impact assessment of the Project are as follows:

- During operations, the Project would result in increases to the depth and frequency of flooding downstream of the mine for events up to and including the 5% AEP event. There would be no change for the more frequent events or impact upstream of the mine from approved conditions.
- The proposed removal of the operational flood levee at the end of mining would improve flood conveyance, which in turn would mitigate the increased flooding downstream of the mine that is predicted to occur during operations.
- The proposed Roper Creek Diversion 2 realignment has been designed to replicate the channel that it replaces as much as practicable. The operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria but the results are higher than for pre-mining conditions. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.
- Modelling 0.1% AEP flood event indicates that bed shear against the toe of the landform would be below acceptable thresholds for native vegetation.
- The water balance modelling results indicates that between 460 ML/year and 1,330 ML/year will be required from the external supply (Anglo pipeline), under median climatic conditions. This is slightly higher than previous modelling results undertaken as part of the Western Extension Surface Water Assessment (WRM, 2018), which predicted that between 420 ML/year and 990 ML/year would be required under median climatic conditions.
- A maximum of between 6.3% and 7.8% of the Roper Creek catchment would be excised during the Project (depending on the mining stage). This is generally consistent with the catchment that would be excised as part of the approved mine.
- Post-mining, the catchment draining to Roper Creek (to the downstream of site) will reduce by around 6.8 km^2 (compared to pre-mining conditions) due to the Project. This is a reduction compared to the approved final landform, which would excise 7.4 km^2 of catchment that would otherwise drain to Roper Creek.
- It is unlikely that overflows from sediment dams will have a measurable impact on receiving water quality.
- No impacts on downstream water quality or environmental values of the downstream waterway are predicted to occur due to controlled releases of mine affected water.

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Appendix A – Water quality sampling plots

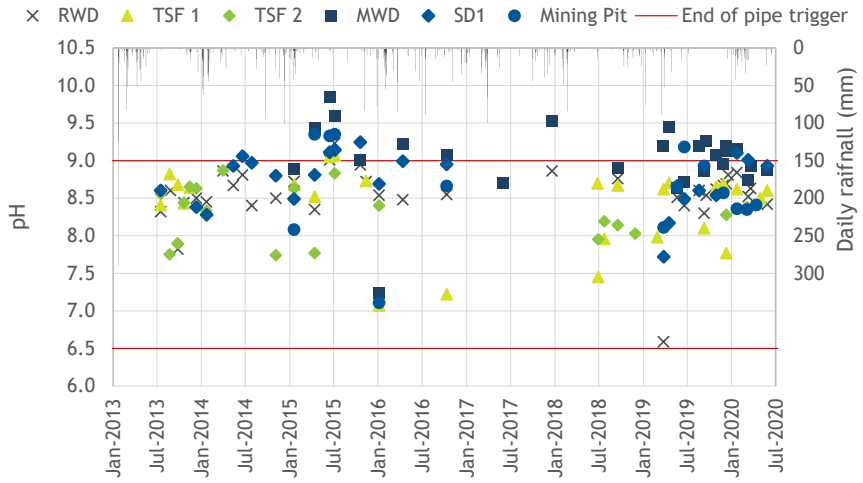


Figure A.1 - pH - Mine affected water dams

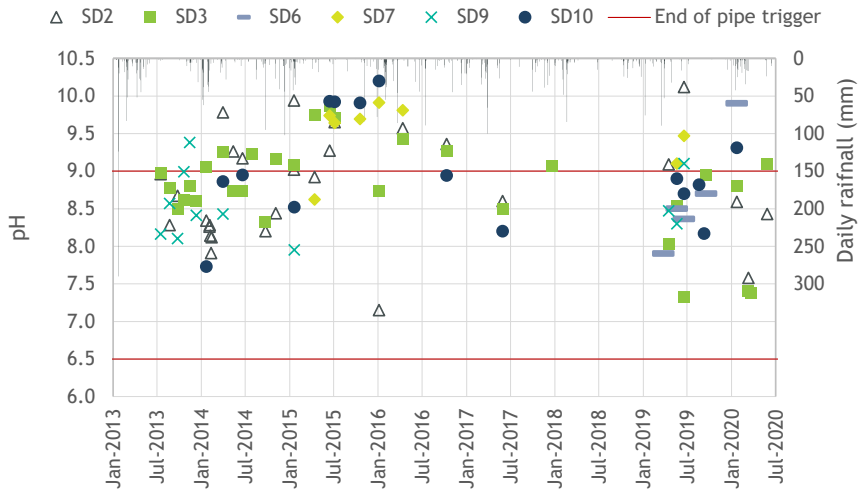
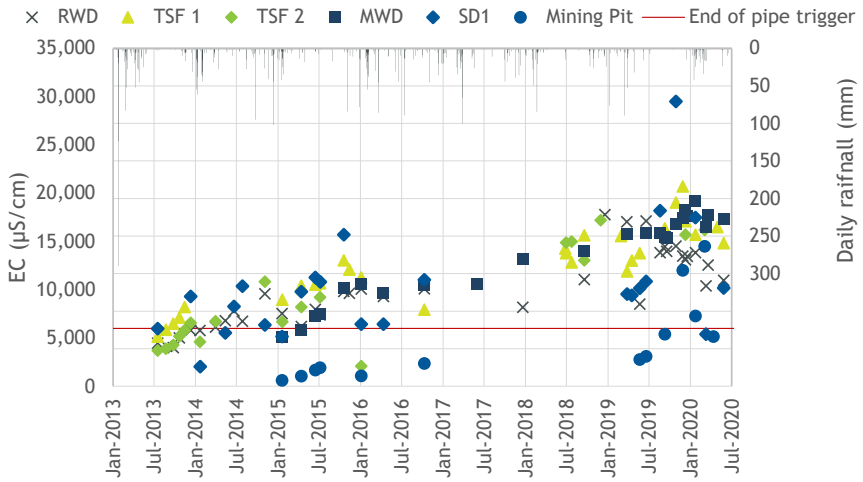
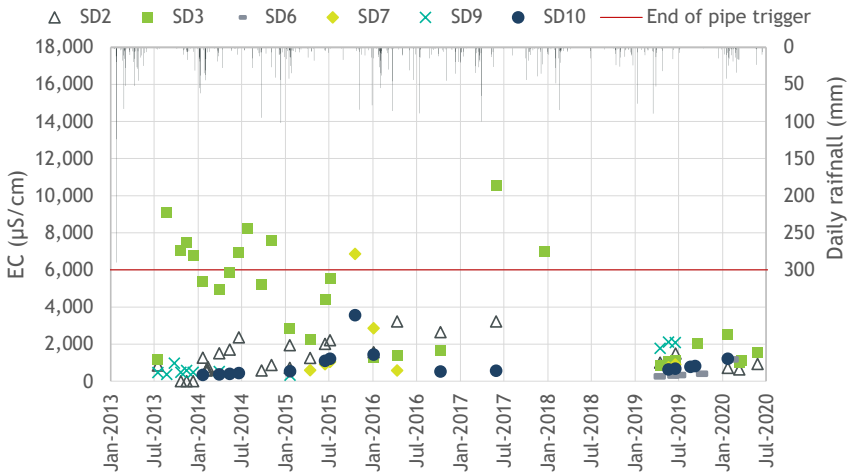


Figure A.2 - pH - On-site stormwater sediment dams



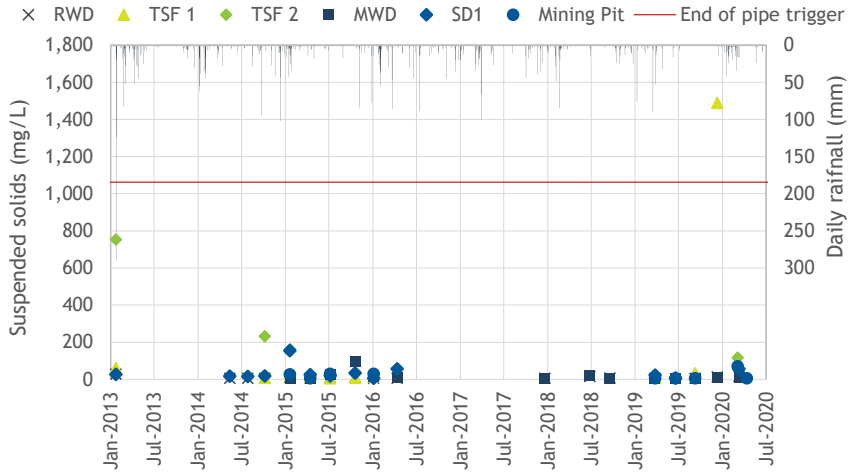
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.3 - EC - Mine affected water dams



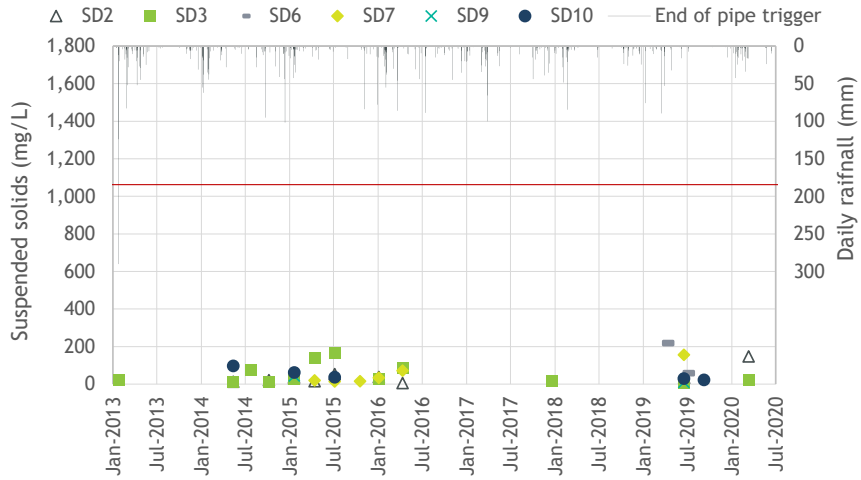
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.4 - EC - On-site stormwater sediment dams



End of pipe trigger based on high flow (see Table 4.3)

Figure A.5 - Suspended solids - Mine affected water dams



End of pipe trigger based on high flow (see Table 4.3)

Figure A.6 - Suspended solids - On-site stormwater sediment dams

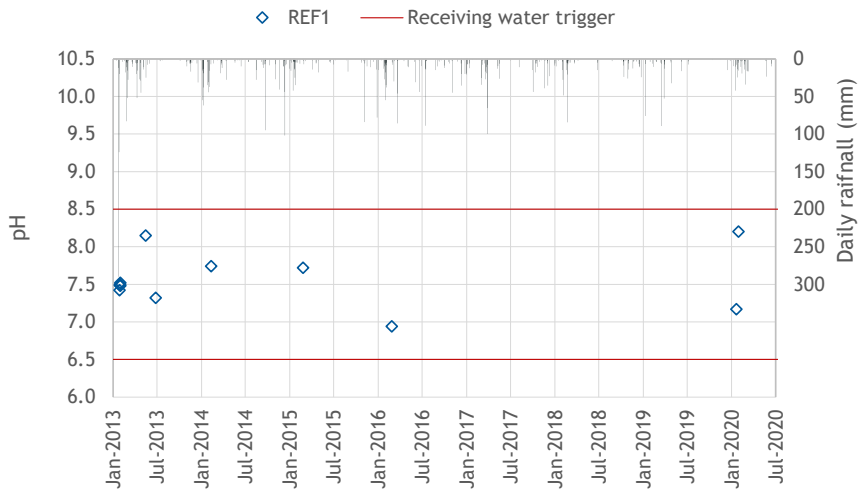


Figure A.7 - pH - Upstream surface water monitoring locations

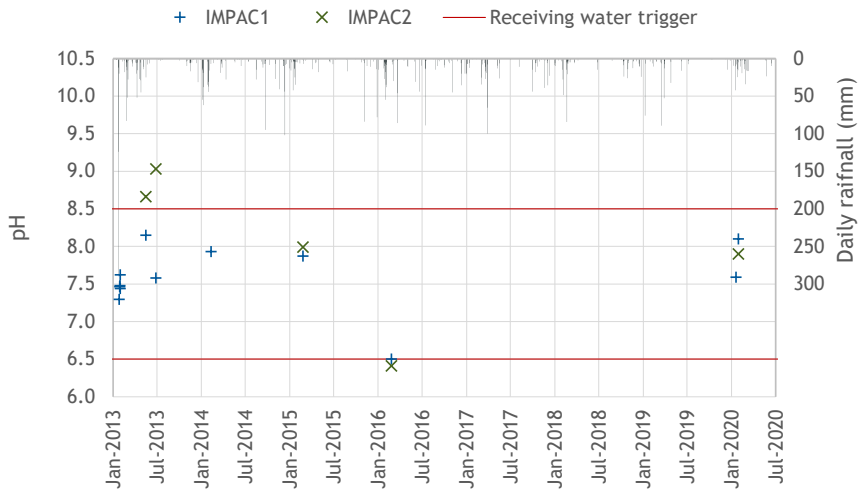
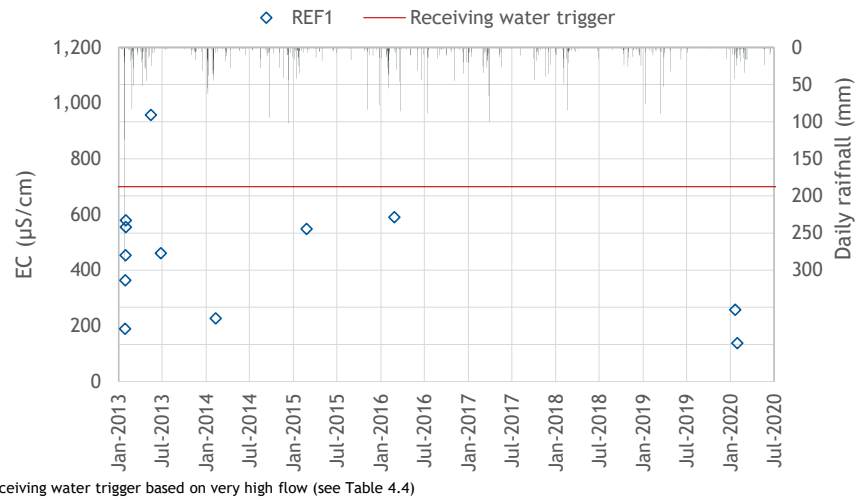
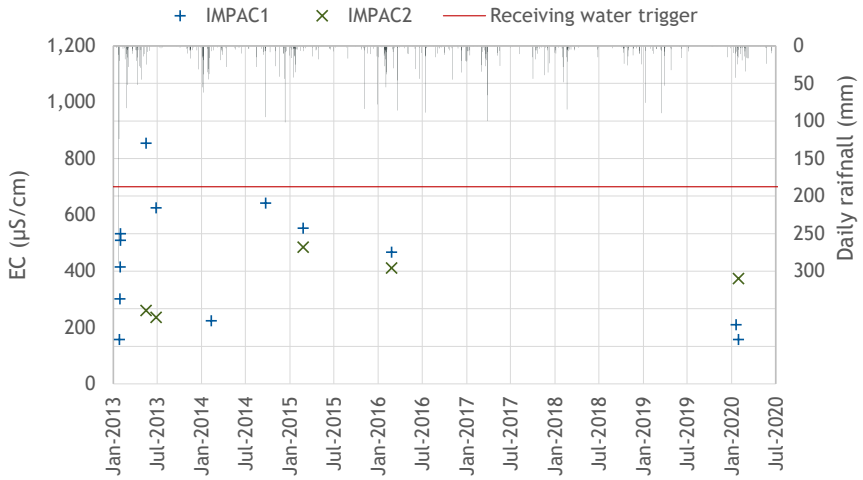


Figure A.8 - pH - Downstream surface water monitoring locations



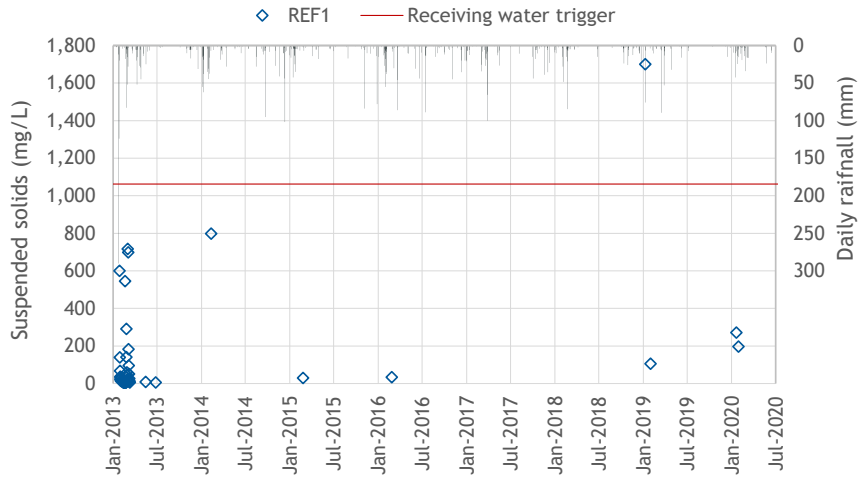
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.9 - EC - Upstream surface water monitoring locations



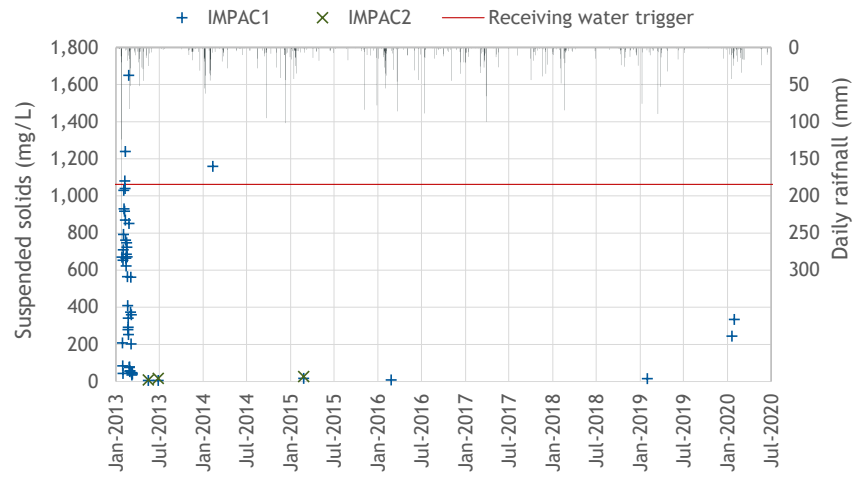
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.10 - EC - Downstream surface water monitoring locations



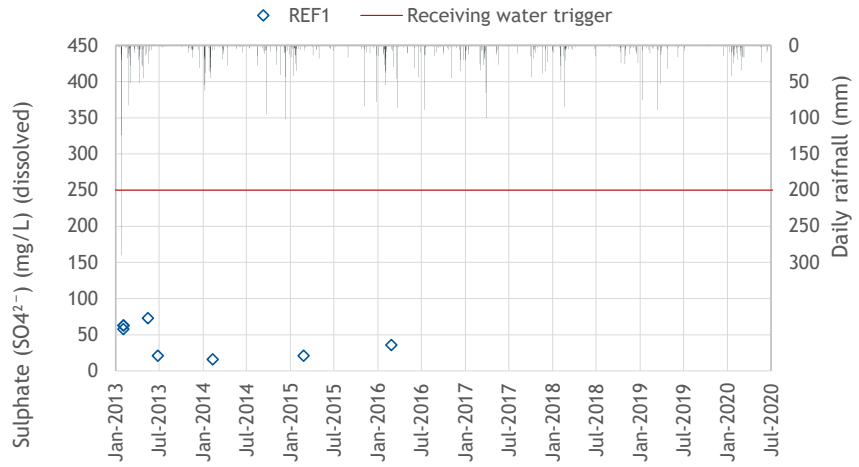
Receiving water trigger based on high flow (see Table 4.3)

Figure A.11 - Suspended solids - Upstream surface water monitoring locations



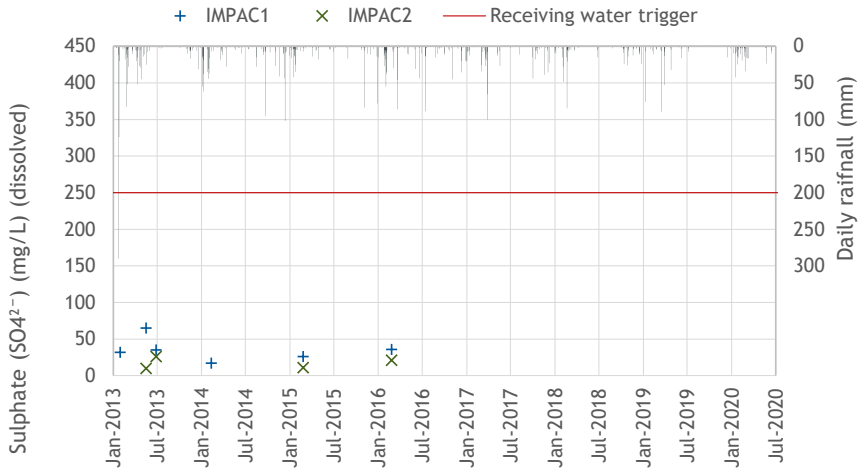
Receiving water trigger based on high flow (see Table 4.3)

Figure A.12 - Suspended solids - Downstream surface water monitoring locations



Receiving water trigger based on very high flow (see Table 4.4)

Figure A.13 – Sulphate - Upstream surface water monitoring locations



Receiving water trigger based on very high flow (see Table 4.4)

Figure A.14 – Sulphate - Downstream surface water monitoring locations

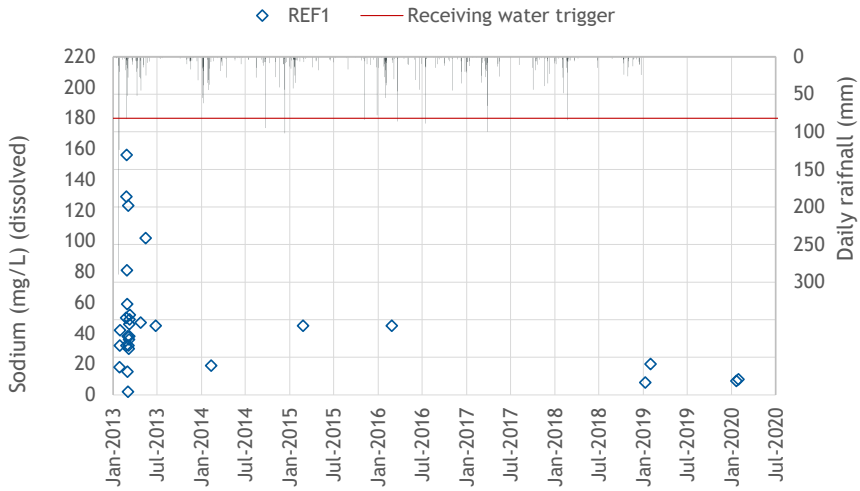


Figure A.15 – Sodium (dissolved) - Upstream surface water monitoring locations

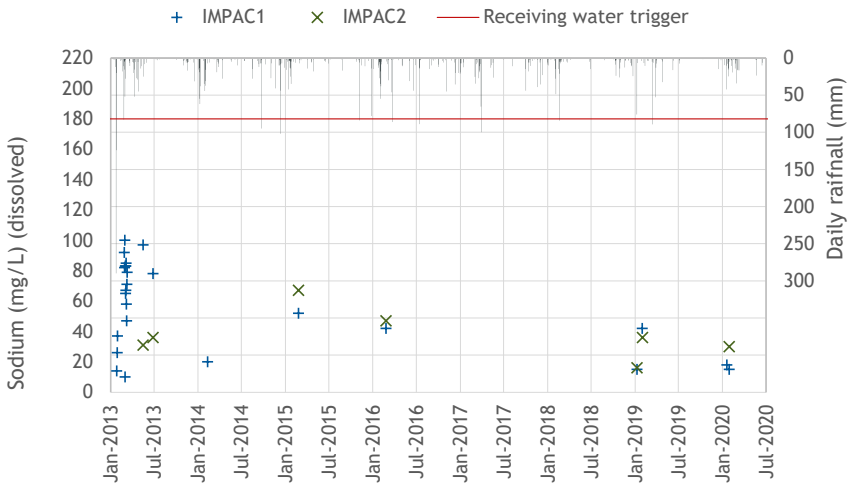


Figure A.16 – Sodium (dissolved) - Downstream surface water monitoring locations

Appendix B - Mine water balance model configuration

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B1 Overview

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the Project. This model has been in operation since the conception of the mine and has been continually updated as data becomes available or mining operations have changed. The model will be continually updated throughout the life of the Project.

The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operation of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table B.1.

Table B.1 - Simulated inflows and outflows to the mine affected water management system

Inflows	Outflows
Direct rainfall on water storage surfaces	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows	Dust suppression demand
External water supply (Anglo)	Offsite spills from storages
	Controlled Releases

B2 Climate data

Rainfall is recorded on a daily basis at Middlemount Coal Mine and is available from January 2008 to June 2020. This dataset is too short for water balance model forecasting. In addition, previous investigations of the site rainfall data undertaken by WRM have indicated that during certain periods it is inconsistent with data from surrounding rainfall stations (WRM, 2014). Therefore, regional data has been used to provide a long-term rainfall dataset.

A representative long-term rainfall dataset was obtained from the Queensland Government Department of Science (DES) SILO climate data service for the period January 1889 to January 2020 (131 years) (DES, 2020). Morton's Lake evaporation has been used to estimate evaporation losses from storages.

Table B.2 shows the long-term monthly averages for Morton's Lake evaporation and monthly SILO rainfall data.

Figure B.1 shows the annual distribution of average monthly rainfall and evaporation from the SILO dataset. The evaporation pattern indicates higher evaporation in the warmer months and less evaporation in the colder months. The rainfall pattern shows most rainfall occurring during the summer months. Mean monthly evaporation is significantly higher than mean monthly rainfall throughout the year.

Table B.2 – Long-term average rainfall and evaporation (1889 – 2020)

Month	Monthly Rainfall (mm)	Monthly Evaporation (mm)
Jan	116.0	202.1
Feb	97.5	170.3
Mar	66.9	169.8
Apr	32.3	133.8
May	29.4	101.9
Jun	30.8	80.7
Jul	23.6	90.7
Aug	18.9	118.0
Sep	18.2	150.9
Oct	35.5	187.9
Nov	54.9	199.8
Dec	96.2	211.6
TOTAL	620.3	1,817.5

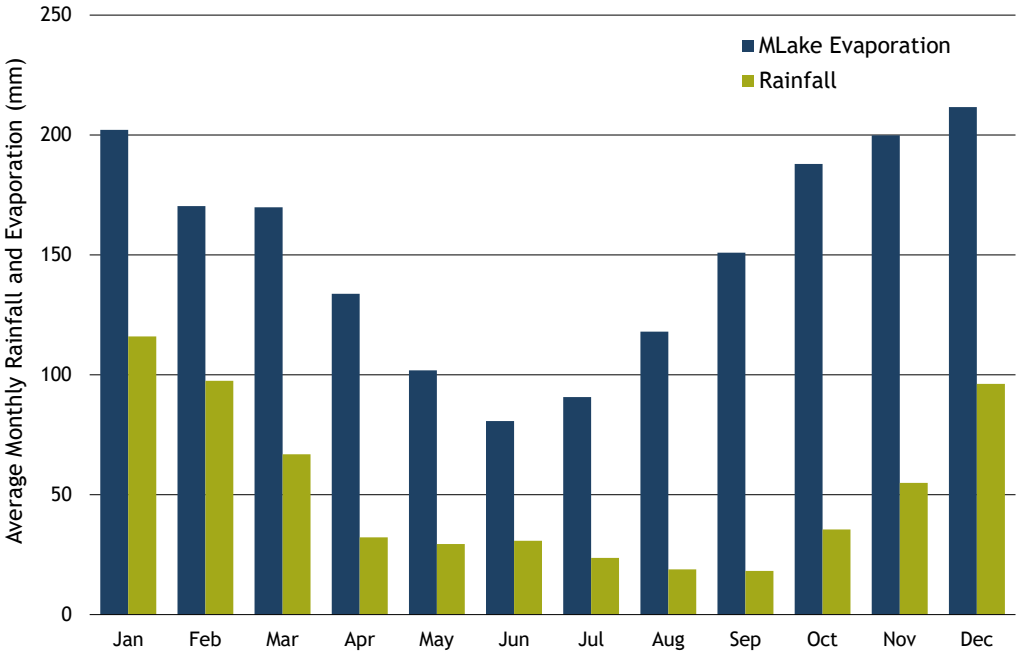


Figure B.1 – Distribution of monthly rainfall and evaporation (Data source: DES, 2020)

B3 Simulation methodology

The simulation used the 'forecast' simulation method in OPSIM. The model was run on a daily timestep for 24 years, to match the operational phase of the mine life, and incorporated five different representative stages of the mine life. The adopted model stages are summarised in Table B.3.

Table B.3 – Adopted model stages

Representative mine stage	Applied range of mine life	Stage duration
Stage 1 (2023)	Year 2021 – 2025	5 years
Stage 2 (2028)	Year 2026 – 2032	7 years
Stage 3 (2037)	Year 2033 – 2039	7 years
Stage 4 (2043)	Year 2040 – 2044	5 years

The forecast simulation type allows the model configuration to change over the modelled 24 years by linking the representative stages, reflecting variations in the water management system over time such as catchment area, production and groundwater inflows. Although the catchment areas will continuously change as the mine progresses, the adopted approach of modelling discrete stages will provide a reasonable representation of site conditions over the 24 year period.

The changes in the physical layout and site catchment areas are provided in Section B4. The adopted operating rules for the water balance model assessment are summarised in Table B.4.

To assess the effects of varying climatic conditions, the forecast model was run for 107 realisations (with each realisation corresponding to the 24-year mine life), using 131 years of climatic data available from January 1889 to December 2019. A different rainfall input sequence is applied to each realisation. The first realisation adopts climatic

data from 1889 to 1912, the second from 1890 to 1913 etc. through the 131 years of simulated climatic data. A percentile analysis of the resultant realisations can then be undertaken at user-defined confidence intervals to assess the behaviour of the various storages over extended dry and wet periods, reflecting the full range of climatic conditions experienced in the last 131 years.

B4 Catchment area and land use classifications

To adequately simulate the site water balance, the mine site catchments were classified as either:

- Undisturbed, representing natural areas;
- Roads / hardstand, representing coal stockpile areas and mine infrastructure such as haul roads and plant area;
- Mining pit, representing the pit floor;
- Spoil dump, representing uncompacted dumped overburden material;
- Rehabilitated spoil, representing both initial and established rehabilitation areas;
- Tailings, representing the surface area of the TSF's / flocculation cells; and
- Cleared, representing pre-strip areas ahead of mining.

Catchment areas and associated land use classifications within the mine have been determined from topographic mapping (dated February 2020), aerial photography (dated September 2019) and plans of operations disturbance areas for each mine stage.

Figure B.2 to Figure B.5 shows the locations of catchment areas and land use classifications for the water balance model, which have been summarised in Table B.4 to Table B.8.

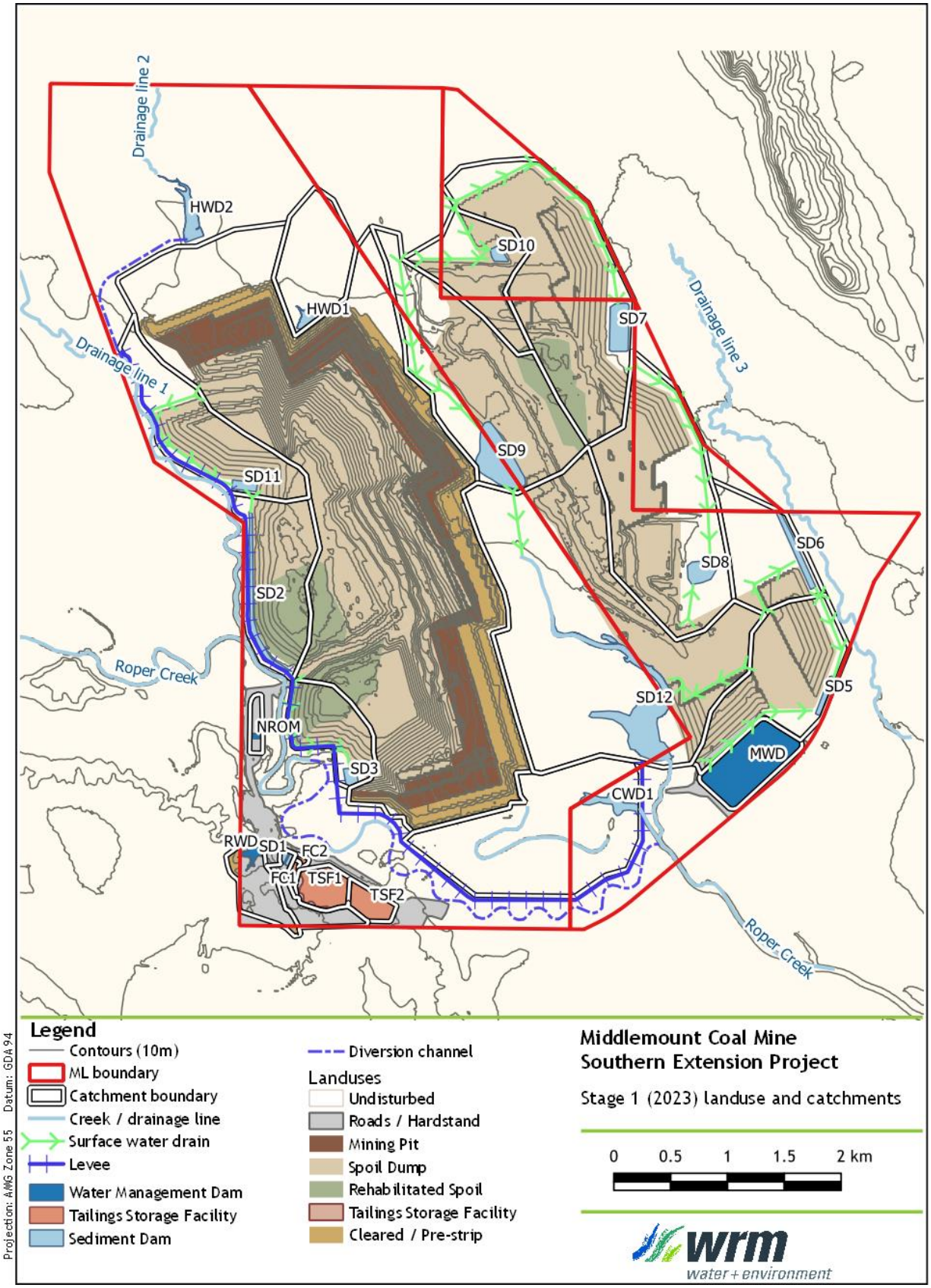


Figure B.2 – Catchment and land use breakdown – Stage 1 (2023)

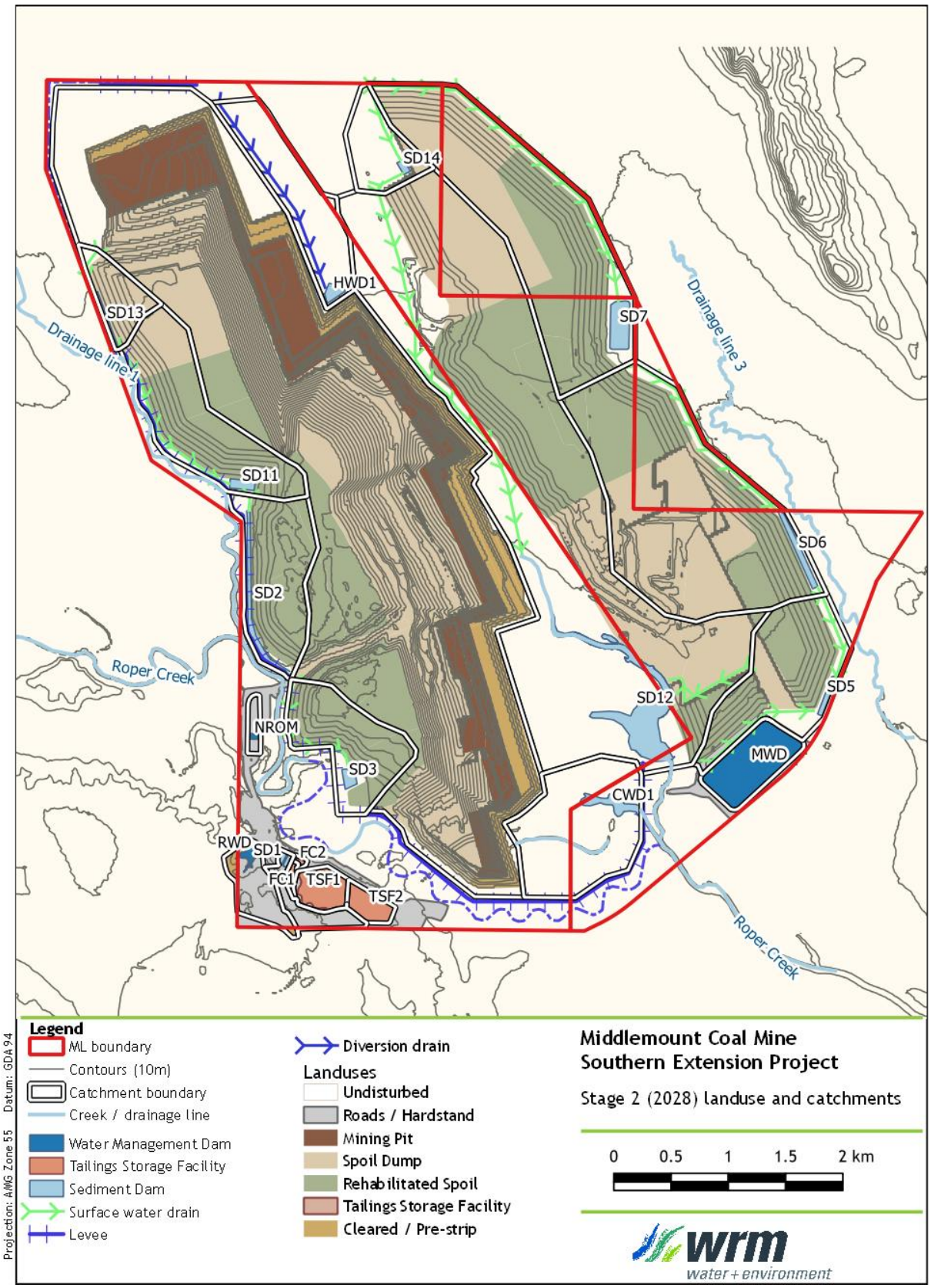


Figure B.3 – Catchment and land use breakdown – Stage 2 (2028)

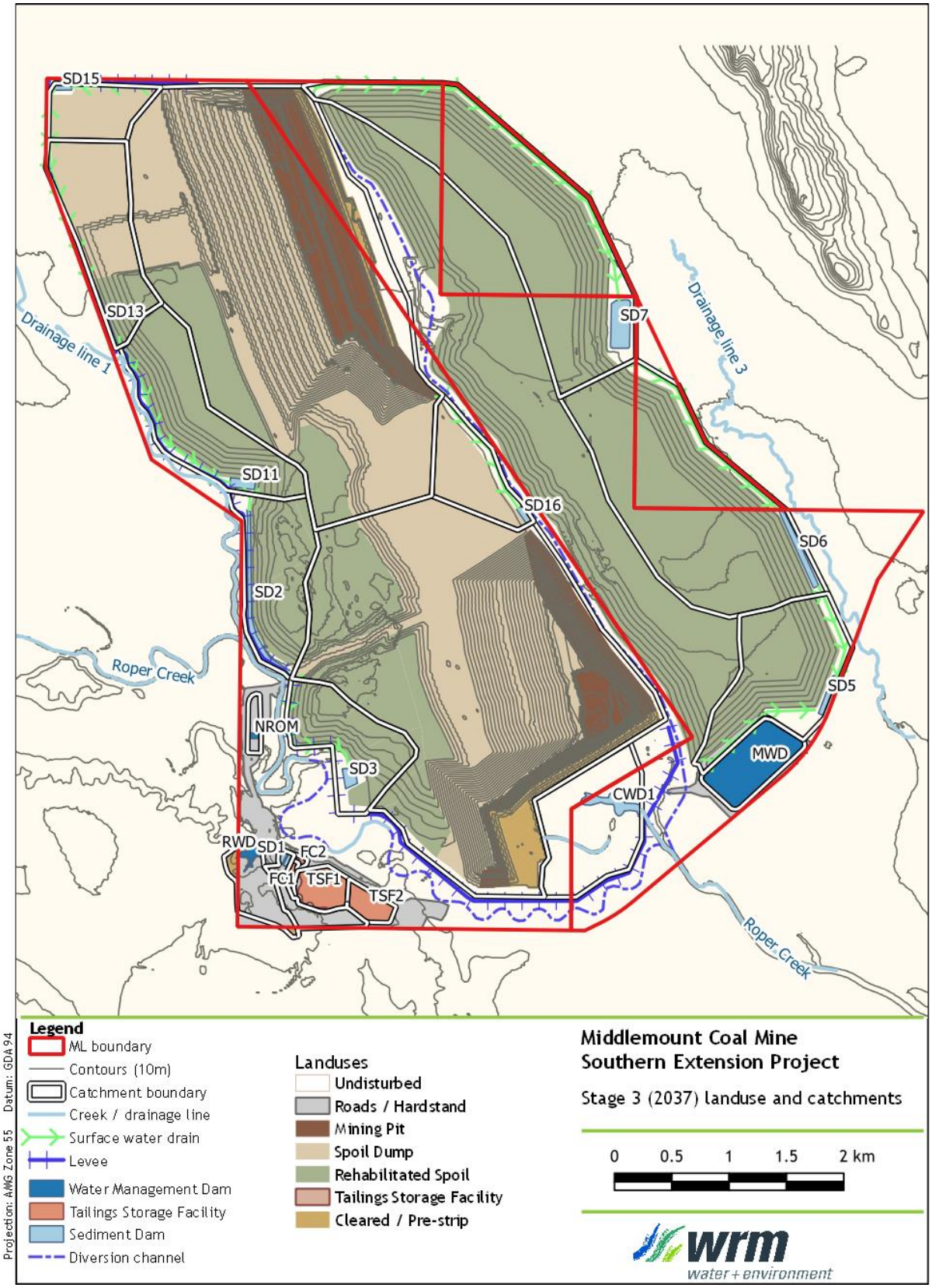


Figure B.4 - Catchment and land use breakdown - Stage 3 (2037)

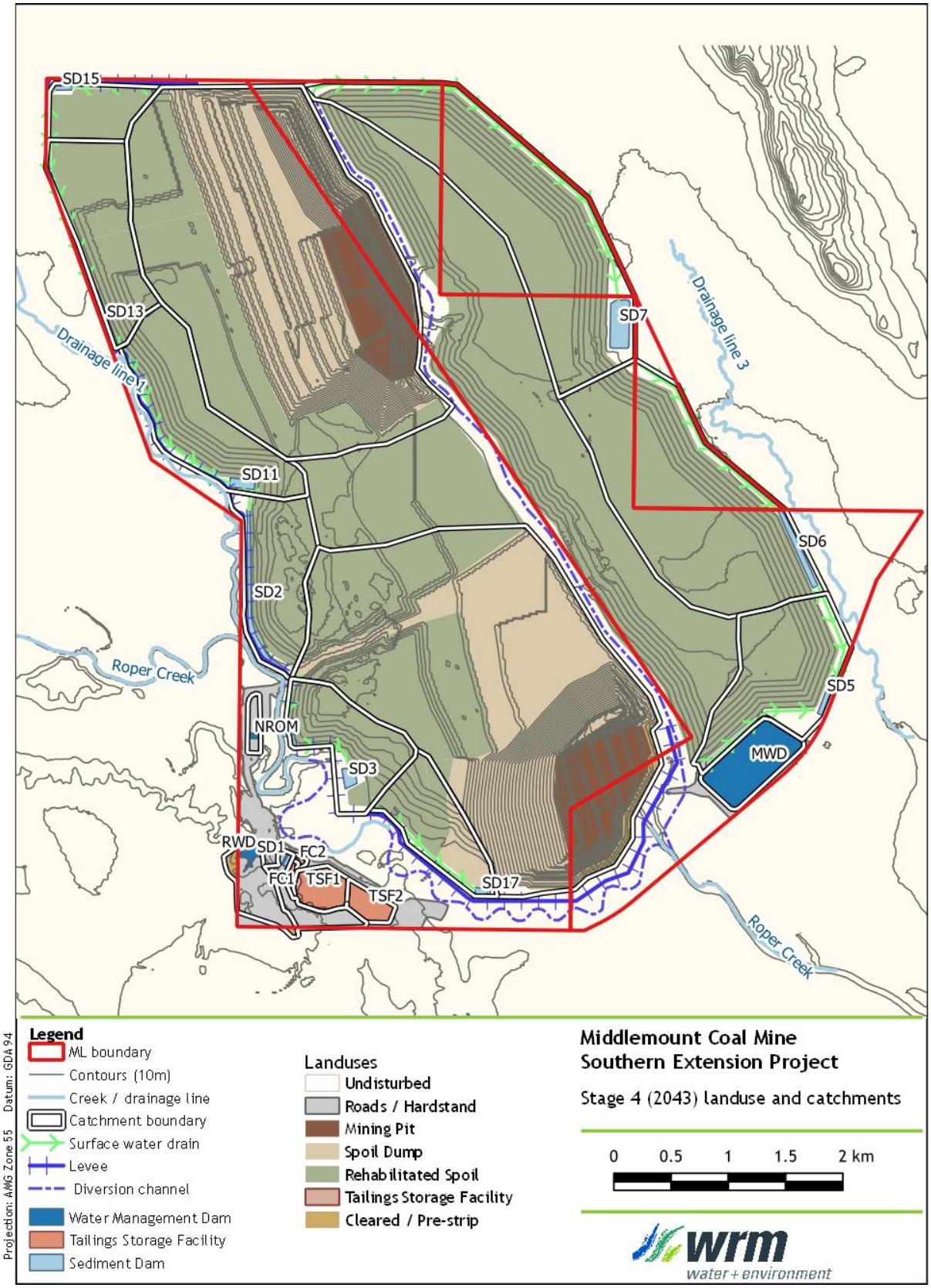


Figure B.5 – Catchment and land use breakdown – Stage 4 (2043)

Table B.4 - Middlemount Coal Mine catchment area and land use breakdown - Stage 1 (2023)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	120.9	0.0	165.1	375.3	40.7	0.0	138.2	840.2
RWD	5.8	19.7	0.0	0.0	0.0	0.0	0.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.4	14.7	0.0	0.0	0.0	0.1	0.0	16.2
Sediment dams								
SD2	15.1	0.0	0.0	37.1	33.3	0.0	0.0	85.5
SD3	6.8	0.0	0.0	19.2	19.3	0.0	0.0	45.2
SD5	19.1	6.3	0.0	76.6	0.0	0.0	0.0	102.0
SD6	49.3	0.0	0.0	13.6	0.0	0.0	0.0	62.9
SD7	41.0	0.0	0.0	146.9	19.7	0.0	0.0	207.6
SD8	71.7	0.0	0.0	118.5	0.0	0.0	0.0	190.2
SD9	66.9	0.0	0.0	98.2	15.0	0.0	0.3	180.4
SD10	14.0	0.0	0.0	49.6	0.8	0.0	0.0	64.4
SD11	33.8	0.0	0.0	56.6	0.0	0.0	0.0	90.3
SD12	241.9	0.0	0.0	142.5	0.1	0.0	0.0	384.5

Table B.5 – Middlemount Coal Mine catchment area and land use breakdown – Stage 2 (2028)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	121.6	0.0	232.9	481.1	144.0	0.0	140.0	1119.6
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.1
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	14.0	62.6	0.0	0.0	102.0
SD6	22.7	0.0	0.0	140.0	117.9	0.0	0.0	280.6
SD7	36.9	0.0	0.0	88.4	111.9	0.0	0.0	237.2
SD11	12.5	0.0	0.0	25.8	71.7	0.0	0.0	109.9
SD12	305.6	0.0	0.0	199.1	161.7	0.0	0.0	666.5
SD13	3.7	0.0	0.0	24.9	0.0	0.0	0.0	28.7
SD14	32.0	0.0	0.0	6.8	0.0	0.0	0.0	38.8

Table B.6 – Middlemount Coal Mine catchment area and land use breakdown – Stage 3 (2037)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	54.0	0.0	206.6	751.8	254.2	0.0	63.1	1329.7
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.1
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	0.0	84.7	0.0	0.0	110.1
SD6	22.3	0.0	0.0	0.0	234.2	0.0	0.0	256.4
SD7	40.8	0.0	0.0	0.0	214.8	0.0	0.0	255.6
SD11	12.5	0.0	0.0	0.1	97.4	0.0	0.0	109.9
SD13	3.4	0.0	0.0	67.2	22.4	0.0	0.0	92.9
SD15	5.1	0.0	0.0	34.0	0.0	0.0	0.0	39.1
SD16	10.4	0.0	0.0	40.6	0.0	0.0	0.0	51.0

Table B.7 – Middlemount Coal Mine catchment area and land use breakdown – Stage 4 (2043)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	8.8	0.0	151.1	635.6	439.9	0.0	19.8	1255.2
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.4
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.2
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	0.0	84.7	0.0	0.0	110.1
SD6	22.3	0.0	0.0	0.0	234.2	0.0	0.0	256.4
SD7	40.8	0.0	0.0	0.0	214.8	0.0	0.0	255.6
SD11	12.5	0.0	0.0	0.0	97.4	0.0	0.0	109.9
SD13	3.4	0.0	0.0	0.0	89.5	0.0	0.0	92.9
SD15	5.1	0.0	0.0	0.0	34.0	0.0	0.0	39.1
SD17	7.8	0.0	0.0	19.7	33.3	0.0	0.0	60.8

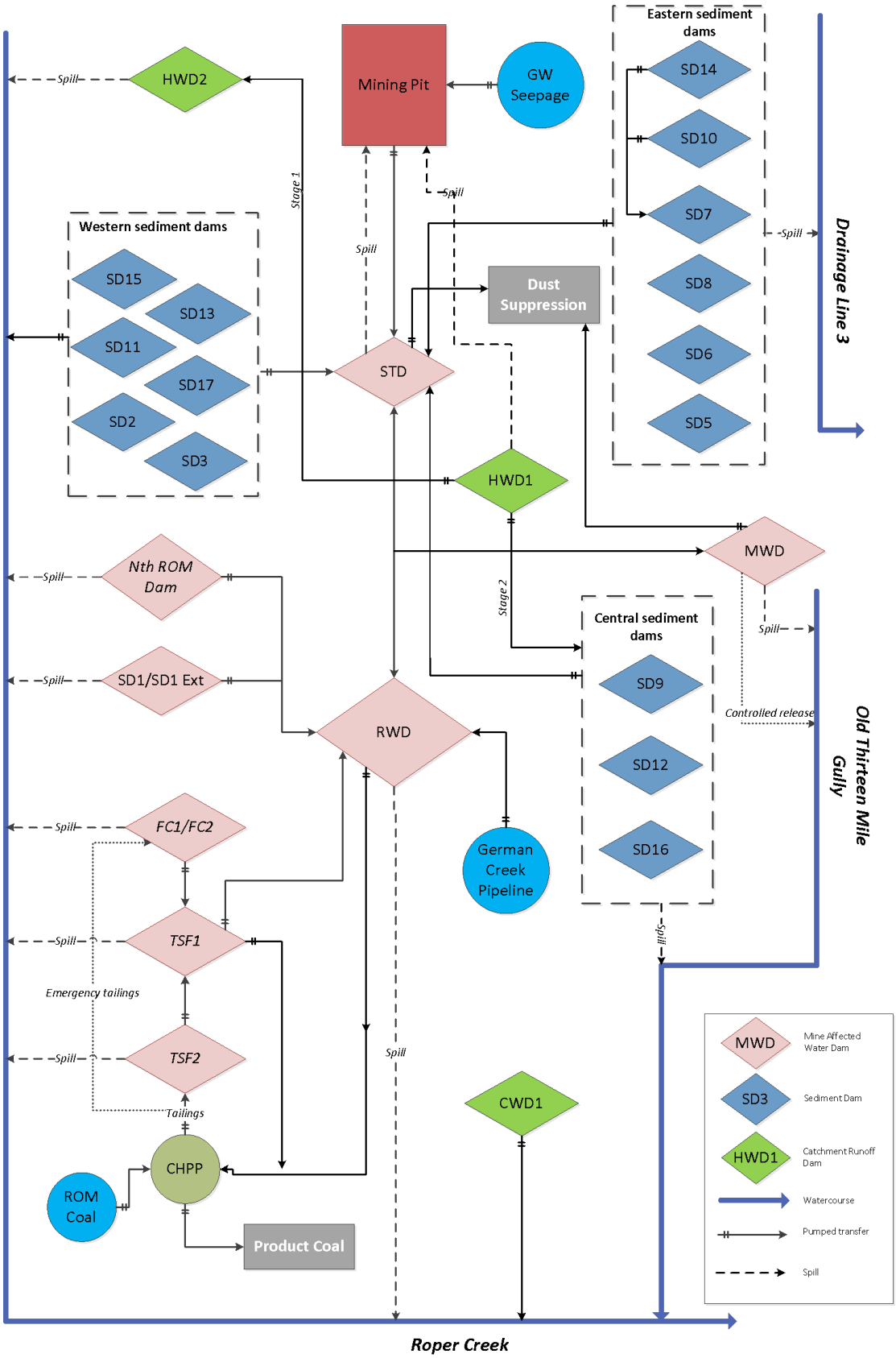


Figure B.6 - Water management system schematic - Stage 1 to Stage 4

Table B.8 – Water management system operating rules

Item	Node Name	Operating Rules
1.0	***External water supply***	
1.1	German Creek water supply	• Supplies water to RWD as required, in accordance with the arrangement detailed in Section 5.8.3. • Water is imported if the inventory of MWD reduces below 750 ML.
2.0	***Water demands***	
2.1	CHPP	• Supplied from RWD and TSF1
2.2	Haul road dust suppression	• Supplied from STD and MWD • 100% loss assumed
3.0	***Open-cut operations***	
3.1	Mining pit	• Receives groundwater inflows. • Continuous dewatering to STD at a maximum rate of 100 L/s, or 180 L/s if the pit water inventory exceeds 50 ML.
4.0	***Water storages***	
4.1	RWD	• Existing mine affected water storage • Receives pumped transfers from NROM, TSF1, TSF2 and SD1 at up to 100 L/s if its inventory drops below 30 ML • Pumps to STD when it reaches an inventory of 120 ML at a maximum rate of 100 L/s • Can receive inflows from German Creek water supply • Overflows to Roper Creek
4.2	MWD	• Existing mine affected water storage • Receives pumped transfers from STD and the Mining Pit • Pumps to STD as required • Pumps to RWD (bypassing STD) • Supplies water to dust suppression demand • Can make controlled releases to Old Thirteen Mile Gully • Overflows to Thirteen Mile Gully
4.3	STD	• Existing mine affected water storage • Can receive pumped inflows from the Mining pit, RWD, MWD, and from the eastern, western and central sediment dams • Pumps to RWD and MWD at a maximum rate of 100 L/s as required • Supplies water to dust suppression demand • Overflows to the Mining Pit
4.4	NROM	• Existing mine affected water storage • Pumps to RWD at a maximum rate of 100 L/s • Overflows to Roper Creek
4.5	SD1/SD1 Extension	• Existing mine affected water storage • Pumps to RWD at a maximum rate of 50 L/s • Overflows to Roper Creek (via SD1 Extension)
4.6	Western sediment dams (SD2, SD3, SD11, SD13, SD15, SD17)	• On-site stormwater storages • SD2 is an existing storage. SD11, SD13, SD15 and SD17 are proposed storages for the Project. SD3 is existing but is proposed to be relocated and resized for the Project • Transfers to STD at up to a maximum rate of 100 L/s • Overflows to Roper Creek (SD2, SD3, SD11 and SD17 overflow via pumping, SD13 and SD15 overflow via spill)
4.7	Central sediment dams (SD9, SD12, SD16)	• On-site stormwater storages • SD9 is an existing storage. SD12 is a proposed storage which will sit within the Old Thirteen Mile Gully. SD16 is a proposed storage • Pumps to STD at up to a maximum rate of 100 L/s

Item	Node Name	Operating Rules
		• Overflows to the Old Thirteen Mile Gully
4.8	Eastern sediment dams (SD5, SD6, SD7, SD8, SD10, SD14)	• On-site stormwater storages • SD7 and SD8 are existing storages. SD5, SD6, SD10 and SD14 are proposed storages • SD10 and SD14 pump to SD7 when required to avoid spilling • SD5, SD6 and SD7 overflow to Drainage line 3
4.9	HWD1	• Proposed highwall catchment runoff water storage bordering the mining pit • Pumped to HWD2 during Stage 1 when it exceeds 2 ML inventory at up to 50 L/s • Pumped out to a location which is TBC from Middlemount during Stage 2 when it exceeds 2 ML inventory at up to 50 L/s • Overflows to the mining pit
4.10	HWD2	• Existing highwall catchment runoff water storage bordering the mining pit • Will receive pumped inflows from HWD1 once constructed • Overflows through a constructed diversion channel to Roper Creek
4.11	TSF1	• Receives decant water from TSF2 (active flocc cells) • Supplies water to RWD and the CHPP as required • Overflows to Roper Creek
4.12	TSF2	• A series of 4 flocc cells • Receives the tailings waste stream, where flocculant is added to remove water • Decant water is pumped to TSF1 temporarily, before being pumped to RWD and the CHPP as required • Supplies water to RWD • Overflows to Roper Creek
4.13	FC1/FC2	• Emergency flocc cells • Pumps to TSF1 at a maximum rate of 100 L/s • Overflows to Roper Creek
5.0	***Receiving waters***	
5.1	Roper Creek	• Receives storage overflows from RWD, NROM, TSF1, TSF2, SD1, SD2, SD3, SD11, SD15, SD17 and HWD2
5.2	Thirteen Mile Gully	• Receives storage overflows from MWD, SD9, SD12 and SD16
5.3	Drainage Line 3	• Receives storage overflows from SD5, SD6, SD7 and SD8
6.0	***All storages***	• All storages and pits receive local catchment runoff and lose water through evaporation

B5 Catchment yield (AWBM) parameters

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2004) to estimate daily runoff from daily rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evapotranspiration. Simulated surface runoff occurs when the storages fill and overflow. Figure B.7 shows a conceptual configuration of the AWBM model.

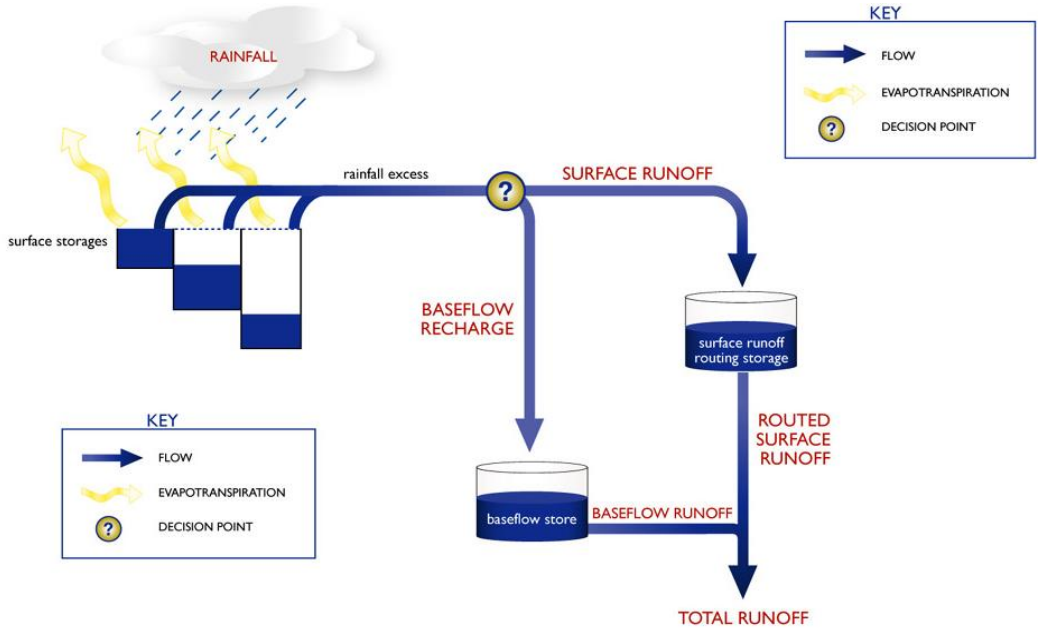


Figure B.7 – AWBM model configuration

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area. The model parameters define the storage depths, the proportion of the catchment draining to each of the storages, and the rate of flux between them (Boughton & Chiew, 2003).

The adopted AWBM parameters for the various catchment types (given in Tables B.4 to B.7) on the mine site are shown in Table B.9.

The AWBM model parameters were based on the latest Middlemount Coal Mine water balance model used as part of the Middlemount water management documentation update (WRM, 2019). The adopted parameters were verified by confirming that the modelled inventories represented recorded MWD and mining pit inventory over 2014 – 2020 (see Section B8).

The AWBM model was originally calibrated to recorded streamflow in Roper Creek as part of the EIS studies for the Stage 1 Middlemount Coal Mine. Details of this calibration can be found in WRM (2010).

To represent undisturbed areas on the mine site, the same parameters as Roper Creek were used, with the baseflow component removed, since baseflow is related to hydrological processes at a large scale. The simulated runoff coefficient for undisturbed areas expressed as a percentage was 6.5%, which is similar to the value for the Roper Creek catchment.

Disturbed catchments, which include hardstand, mining pit and tailings areas, are characterised by hard surfaces which inhibit water infiltration, resulting in much higher rates of surface runoff. To represent disturbed catchments, the depth of the model surface stores was substantially reduced and baseflow eliminated. The simulated volumetric runoff percentage for disturbed catchments was 36.6%, about 6 times higher than undisturbed catchments. This value is similar to typical values for urban catchments, which have similar characteristics.

The adopted model parameters for spoil dump areas have been based on the calibration outcomes. The simulated volumetric runoff percentage of 3.4% is slightly lower than undisturbed catchments.

Rehabilitated catchments have been assumed to have similar rainfall runoff characteristics as undisturbed catchments. We have therefore adopted the undisturbed parameter set for rehabilitated catchments. The adopted model parameters for cleared catchments have been selected based on experience with other coal mines in the area.

Table B.9 – AWBM parameters

AWBM Parameter		Roper Creek	Undisturbed catchments	Hardstand	Mining Pit/Tailings	Spoil Dump	Rehab	Cleared
Surface Store Depth (mm)	C1	24	24	4	3	40	24	20
	C2	118	118	20	15	200	118	100
	C3	268	268	40	30	400	268	200
Partial Areas	A1	0.062	0.062	0.33	0.33	0.1	0.062	0.1
	A2	0.439	0.439	0.33	0.33	0.4	0.439	0.4
Base flow index	BFI	0.936	0	0	0	0.9	0	0
Base flow recession constant	Kb	0.53	0	0	0	0.8	0	0
Surface flow recession constant	Ks	0.73	0	0	0	0	0	0
Long-term runoff coefficient (%)	C_v	5.6%	5.6%	36.6%	40.6%	3.4%	5.6%	8.3%

B6 Water demands

B6.1 COAL HANDLING AND PREPARATION PLANT (CHPP)

The projected annual coal production schedule at Middlemount Coal Mine over the Project life is summarised in Table B.11.

MCPL records CHPP water use as well as the volumes of water decant from the tailings disposal system and returned to the CHPP. The makeup water, supplied from the RWD, is the difference between the CHPP water use and the volume of water returned to the CHPP from TSF1. The tailings disposal system has been treated as a closed loop water circuit with the reuse of decant water taken into account with the provided CHPP water use data.

The adopted CHPP demand has been based on a net consumption rate of 170 L/ROM tonne (including return water from the TSF1). This rate is based on the historical net CHPP usage over 2017 and 2018 and has been confirmed as accurate from site personnel. The forecast net CHPP consumption over the Project life is provided in Table B.10.

Table B.10 - Forecast annual production data and water usage

Stage	Year	CHPP production and water usage		
		Feed tonnage (Mt)	Net CHPP Usage (ML)	Net CHPP Usage (ML/day)
1	2021	5.4	928	2.54
	2022	5.4	928	2.54
	2023	5.4	928	2.54
	2024	5.4	931	2.54
	2025	5.4	928	2.54
2	2026	5.4	928	2.54
	2027	5.4	928	2.54
	2028	5.4	931	2.54
	2029	5.4	928	2.54
	2030	5.4	928	2.54
	2031	5.4	928	2.54
	2032	5.4	925	2.53
3	2033	5.4	928	2.54
	2034	5.1	870	2.38
	2035	5.4	928	2.54
	2036	5.4	931	2.54
	2037	4.8	826	2.26
	2038	4.7	801	2.19
	2039	3.5	598	1.64
4	2040	3.8	651	1.78
	2041	3.5	596	1.63
	2042	1.9	332	0.91
	2043	3.2	549	1.51
	2044	1.3	225	0.61

B6.2 HAUL ROAD DUST SUPPRESSION

Mine site haul road dust suppression water and vehicle washdown is sourced from water cart fill points located at the MWD and STD. Dust suppression is preferentially sourced from the lowest quality water available onsite. This is controlled on a daily basis by site personnel.

MCPL has supplied historical monthly dust suppression demand volumes based on truck fill counts and truck capacity over the period January 2016 to September 2018. MCPL have previously advised that there is an approximate 25 ML/month of additional unmetered usage. The estimated average daily dust suppression demand over the period January 2016 to September 2018 was 3.25 ML/day, however the seasonal distribution of this demand varies.

The average monthly dust suppression rates are shown in Figure B.8.

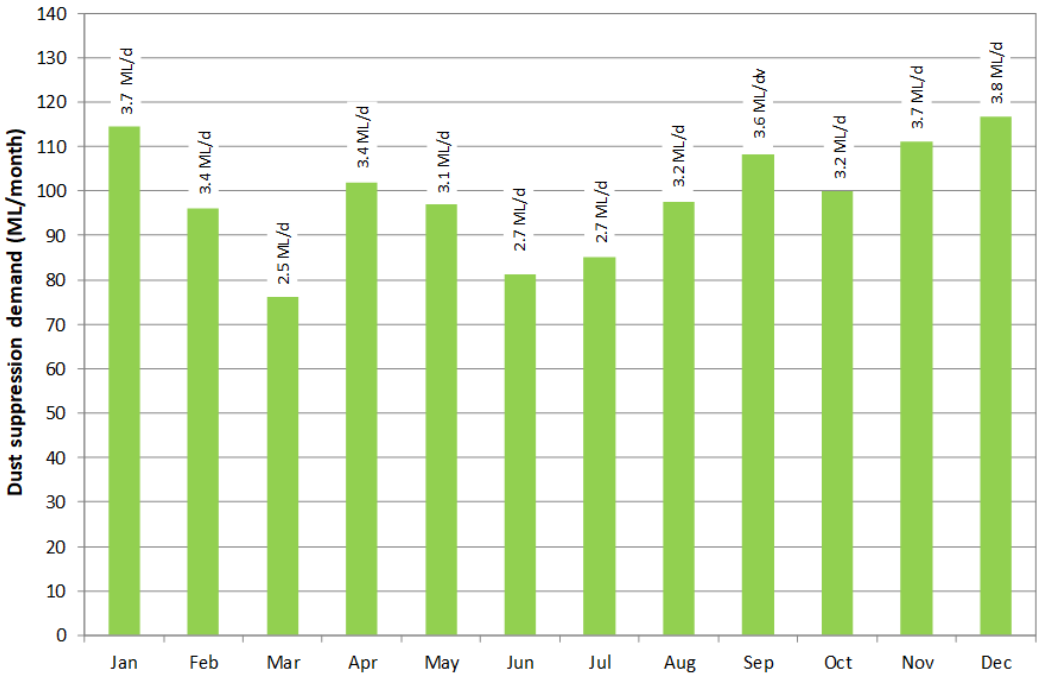


Figure B.8 – Adopted average monthly dust suppression demands

B7 Groundwater inflows

The adopted groundwater inflows to the open cut and underground mining areas are based on estimates provided by AGE (2020) and are summarised in Table B.11.

Table B.11 – Forecast groundwater inflows

Stage	Year	GW Inflow	
		ML/year	ML/day
1	2021	429	1.2
	2022	605	1.7
	2023	1270	3.5
	2024	770	2.1
	2025	1063	2.9
2	2026	833	2.3
	2027	846	2.3
	2028	1029	2.8
	2029	698	1.9
	2030	752	2.1
	2031	772	2.1
	2032	676	1.8
3	2033	1023	2.8
	2034	992	2.7
	2035	987	2.7
	2036	861	2.4
	2037	772	2.1
	2038	986	2.7
	2039	699	1.9
4	2040	429	1.2
	2041	587	1.6
	2042	603	1.7
	2043	452	1.2
	2044	243	0.7

B8 Model calibration

B8.1 MODEL OVERVIEW

Calibration of the Middlemount Coal Mine water balance model has been undertaken against recorded site data (including water storage volumes) over the period from January 2014 to May 2020. The model was configured to reflect the site operations during this period, with appropriate transfer rates, system configuration and water inflows and outflows.

Calibration of the water balance model was undertaken against the recorded combined inventory for the MWD and the mining pit. To achieve a satisfactory calibration outcome, changes to a number of the Project parameters was undertaken.

B8.2 CALIBRATION RESULTS

The model had been previously calibrated to site data between January 2016 – August 2017. Extending the calibration backwards to 2014 and forwards to 2020 created inaccurate calibration results during the 2018 – 2020 period. The calibration overestimated results. It was noted that the calibrated AWBM parameters produced accurate results for the 2014 – 2018 period. It was also noted that there were numerous inaccuracies of site data from 2018 – 2020, including estimated values for site demands.

This suggests that the AWBM parameters were suitable but that some inaccuracies relating to the site data were causing errors in the calibration.

The following changes were made to the site data to refine the calibration:

- The CHPP usage data from 2018 shows negligible return water recycle and therefore appears to overestimate CHPP usage. A flat CHPP usage rate of 170 L/ROM tonne which was observed from 2016 – 2018 was applied from 2018 – 2020.
- The haul road dust suppression numbers from late 2018 onward show a flat rate with no seasonal variance. This is inconsistent with data from previous years. The average monthly values from 2017 have therefore been applied from 2018 – present.
- The onsite rainfall collected since 2014 has been collected at a number of different weather stations. Previous WRM investigations have indicated that the site station may have been poorly calibrated and overrepresents actual rainfall for numerous years. QLD Government SILO data for the site had therefore been used for the calibration to provide consistent results across the period.
- Groundwater inflow rates are not measured onsite but rather are estimated. Groundwater inflow rates of 1 ML/d from 2014 – 2016 and 1.7 ML/d from 2016 – present have therefore been assumed.

The observed and modelled inventory for the combined MWD and mining pit inventory is presented in Figure B.9, along with the site rainfall for the calibration period. Review of Figure B.9 indicates the following:

- The simulated combined inventory generally reproduces the observed inventory fluctuations over the calibration period between January 2014 and May 2020.
- The modelled increase in inventory at the end of March 2017 (due to Cyclone Debbie) of around 350 ML is not as evident in the recorded inventories. During this period, only 50 ML of pit water was recorded.
- Given the magnitude of the rainfall at this time (around 165 mm over two days), the volume of water collected in-pit would likely have been significantly higher. It is possible that water was stored in-pit but was not recorded. This would potentially account for the differences in modelled and observed inventory.

- The calibration results are considered to be within reasonable bounds given the potential variability in mine affected water movements about the site and water losses, and the constraints imposed on the water balance model by the operational guidelines.

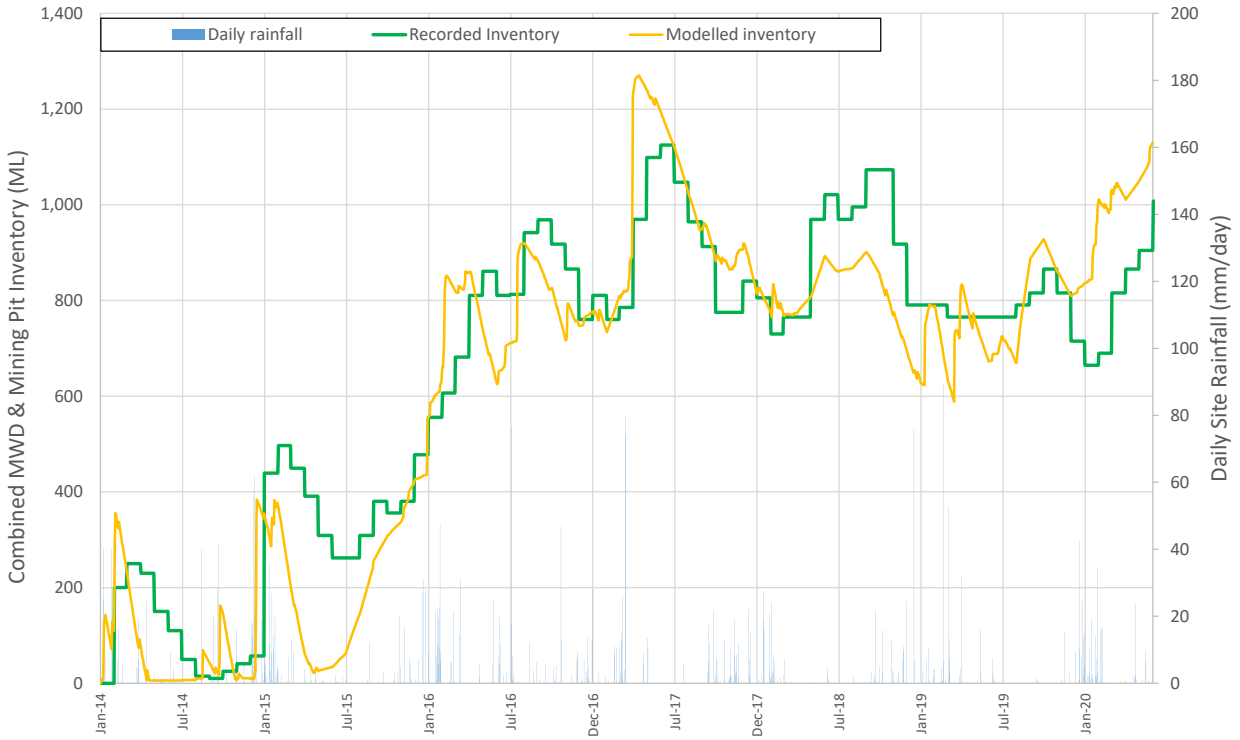


Figure B.9 - Model calibration - combined MWD and mining pit inventory

Appendix C – Flood depth and velocity maps

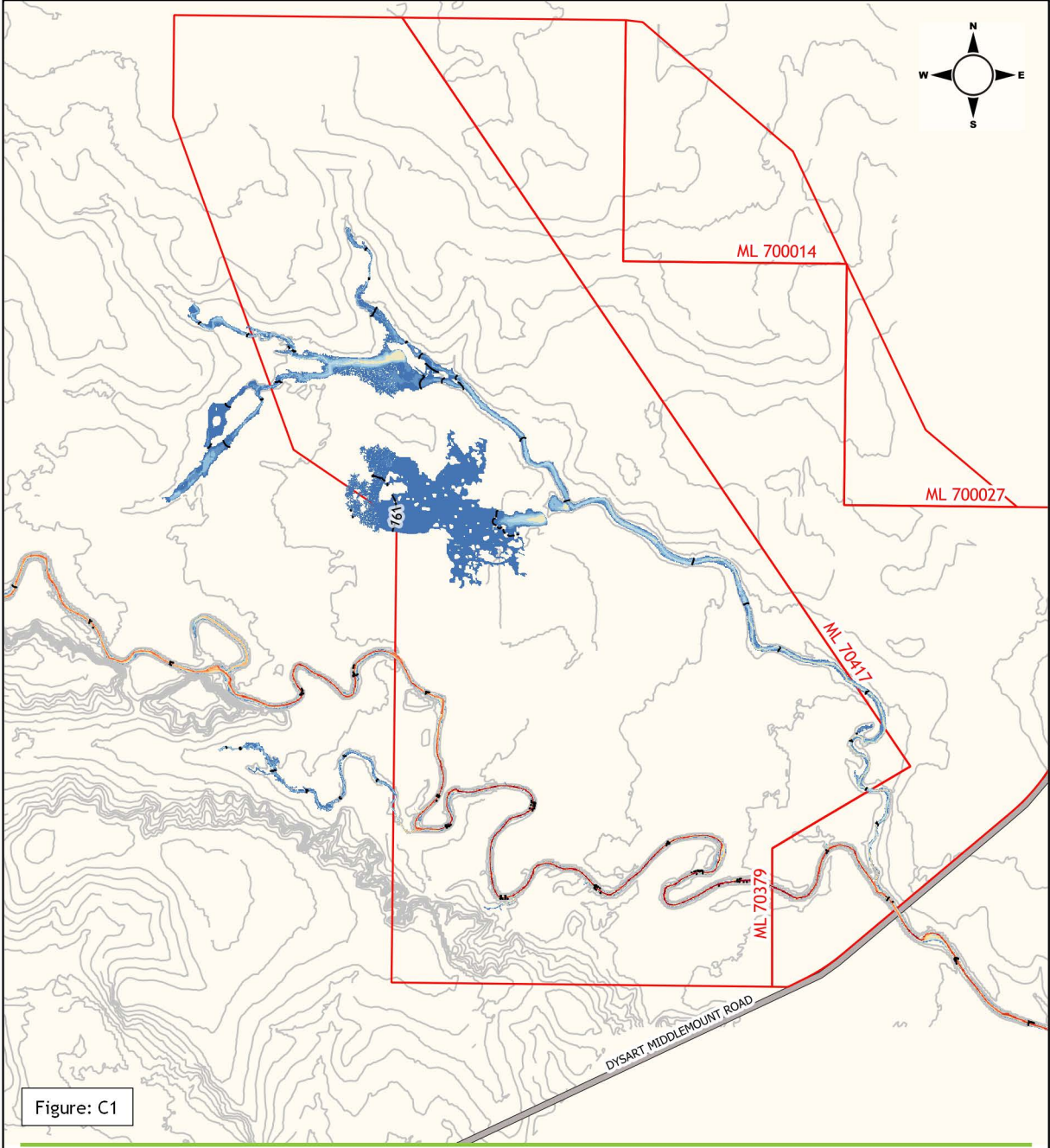


Figure: C1

Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

50% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

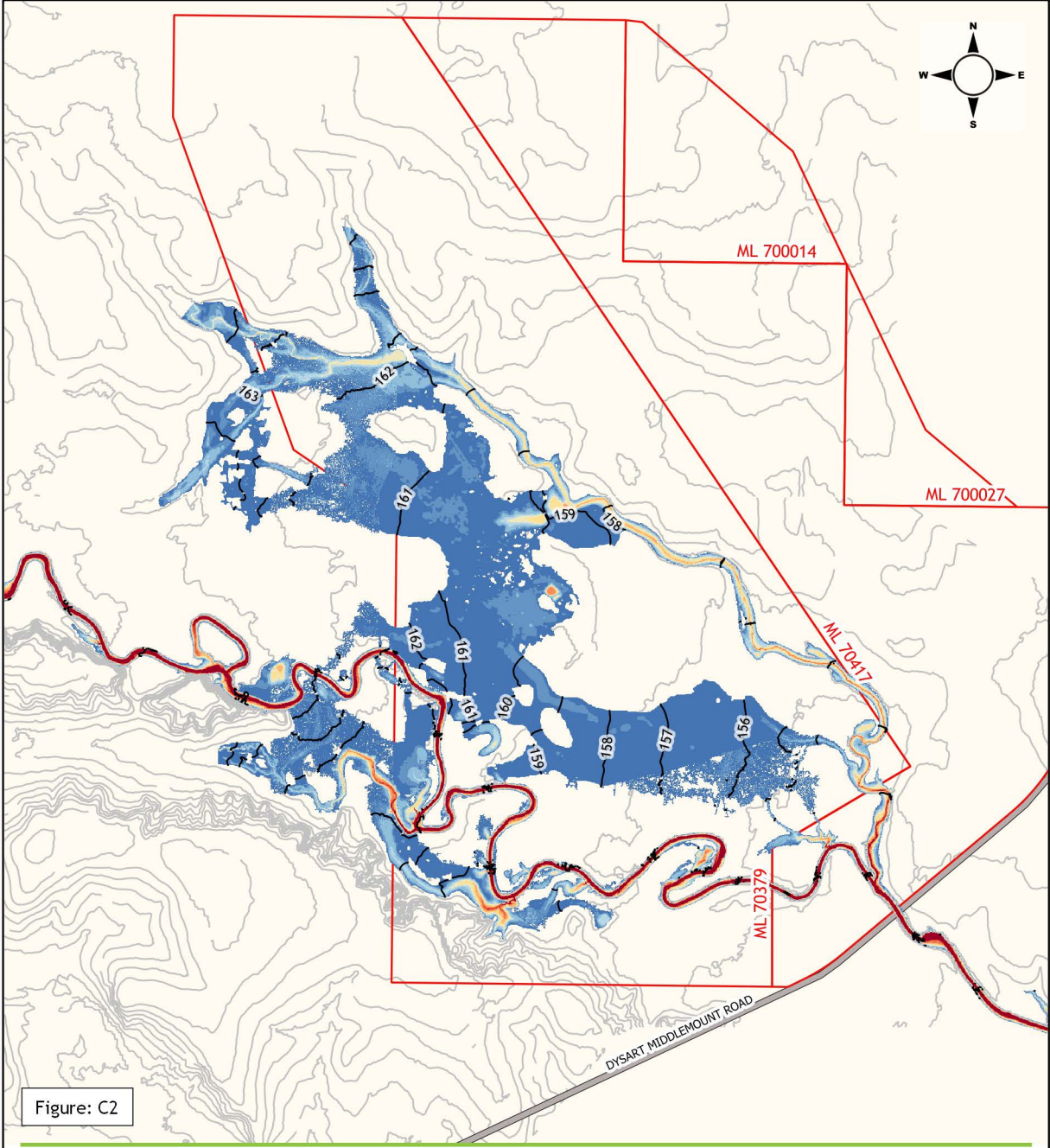


Figure: C2

Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

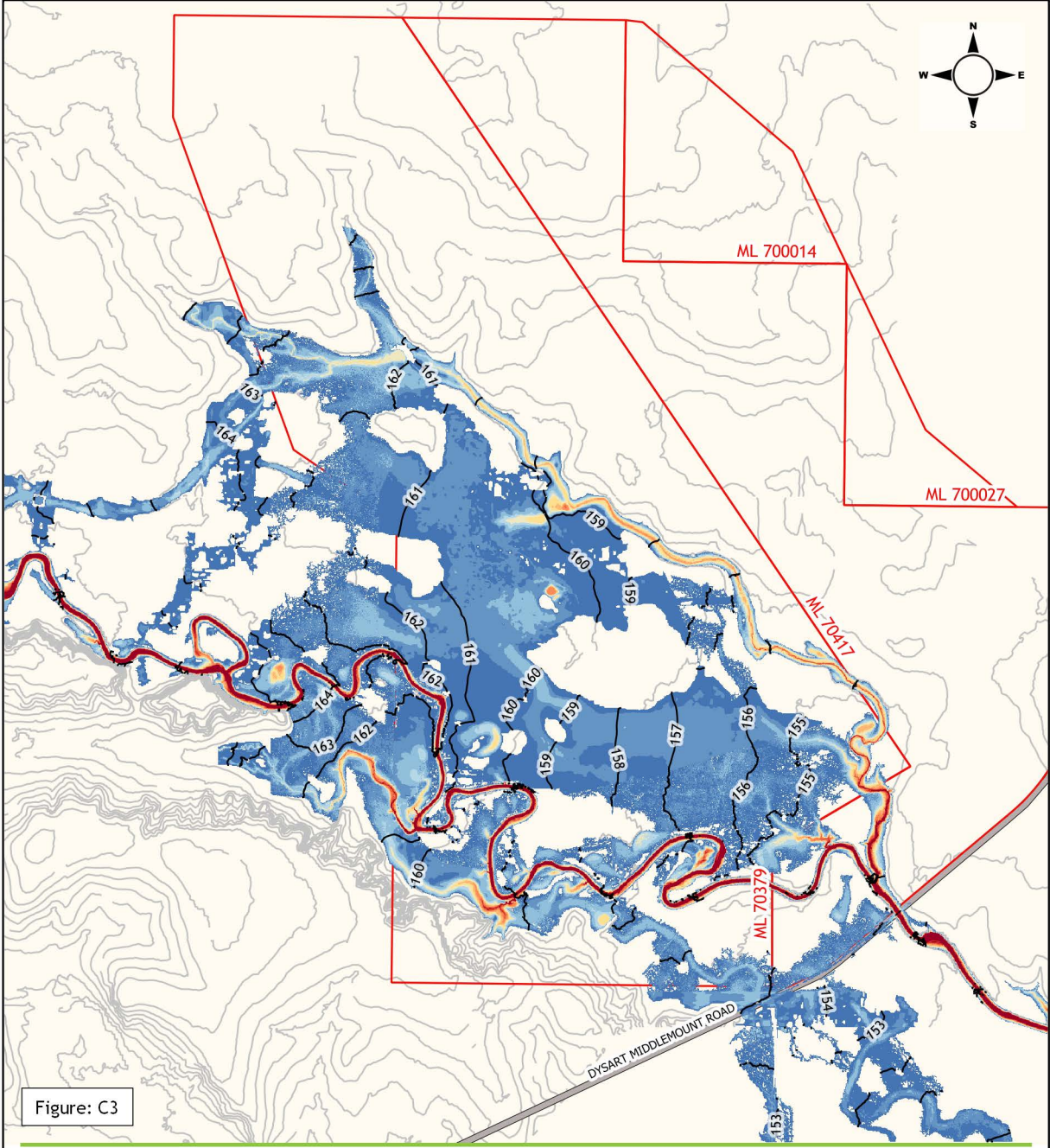


Figure: C3

Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

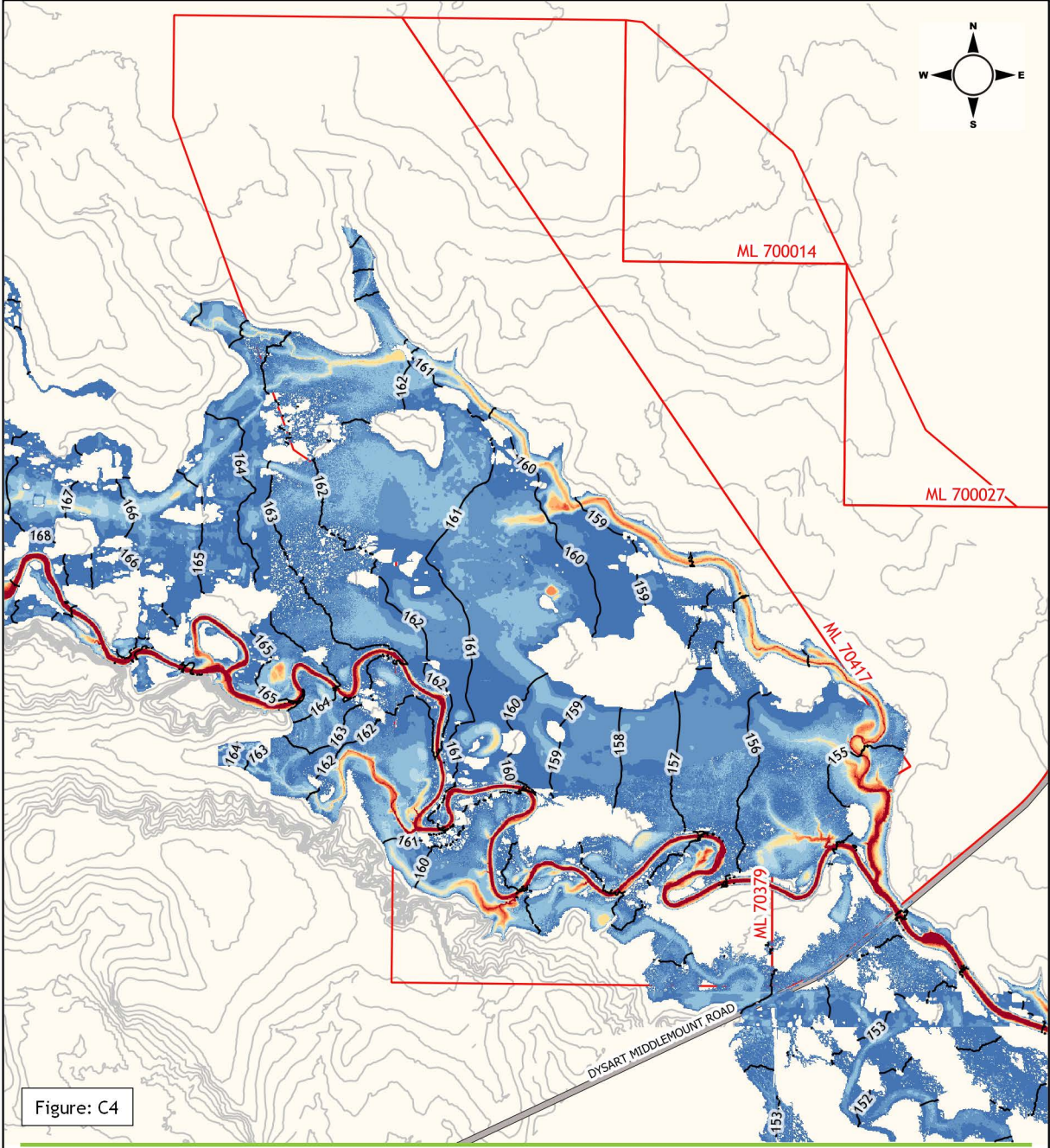
Middlemount Coal Mine
Southern Extension Project

2% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

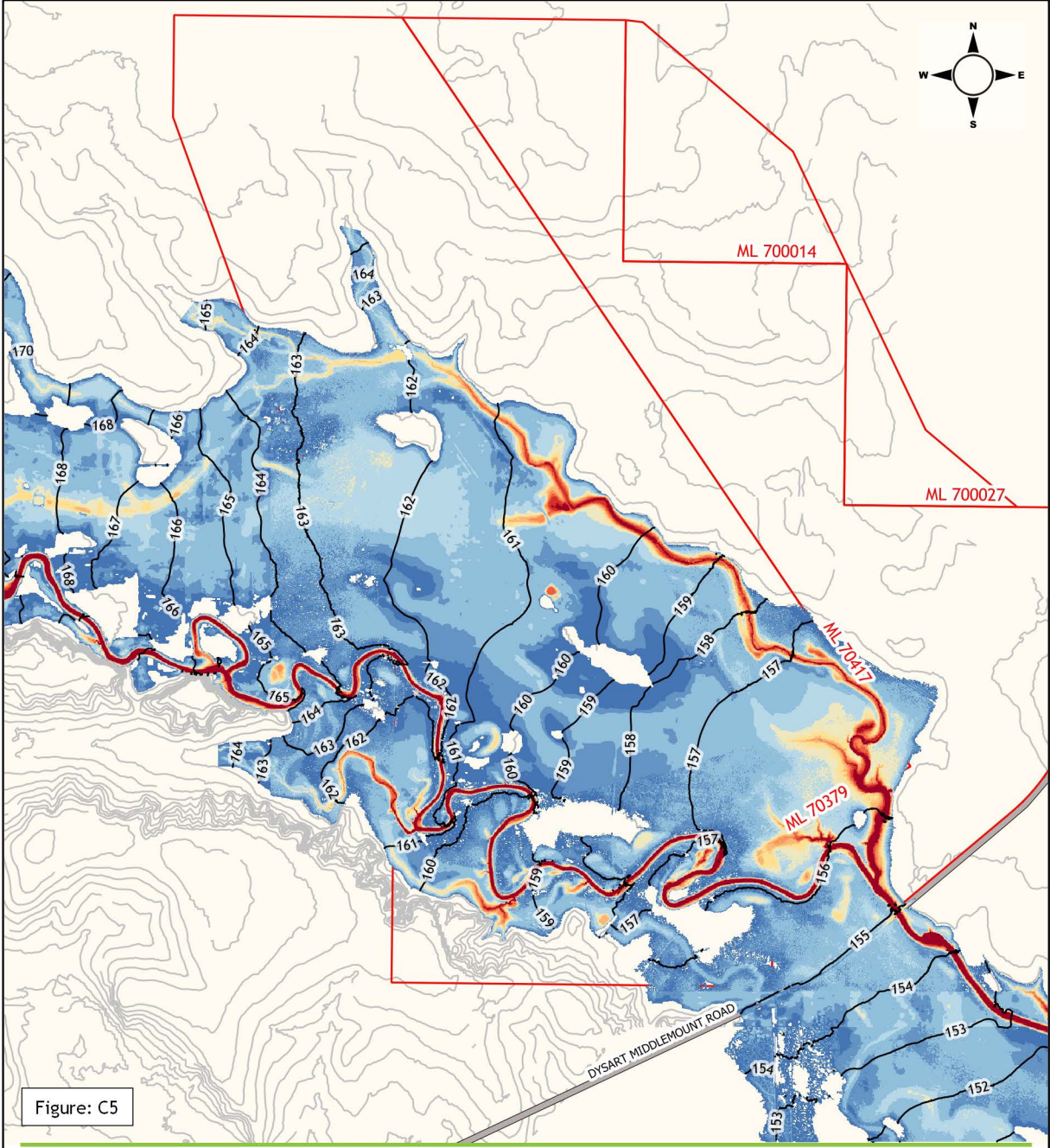
Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

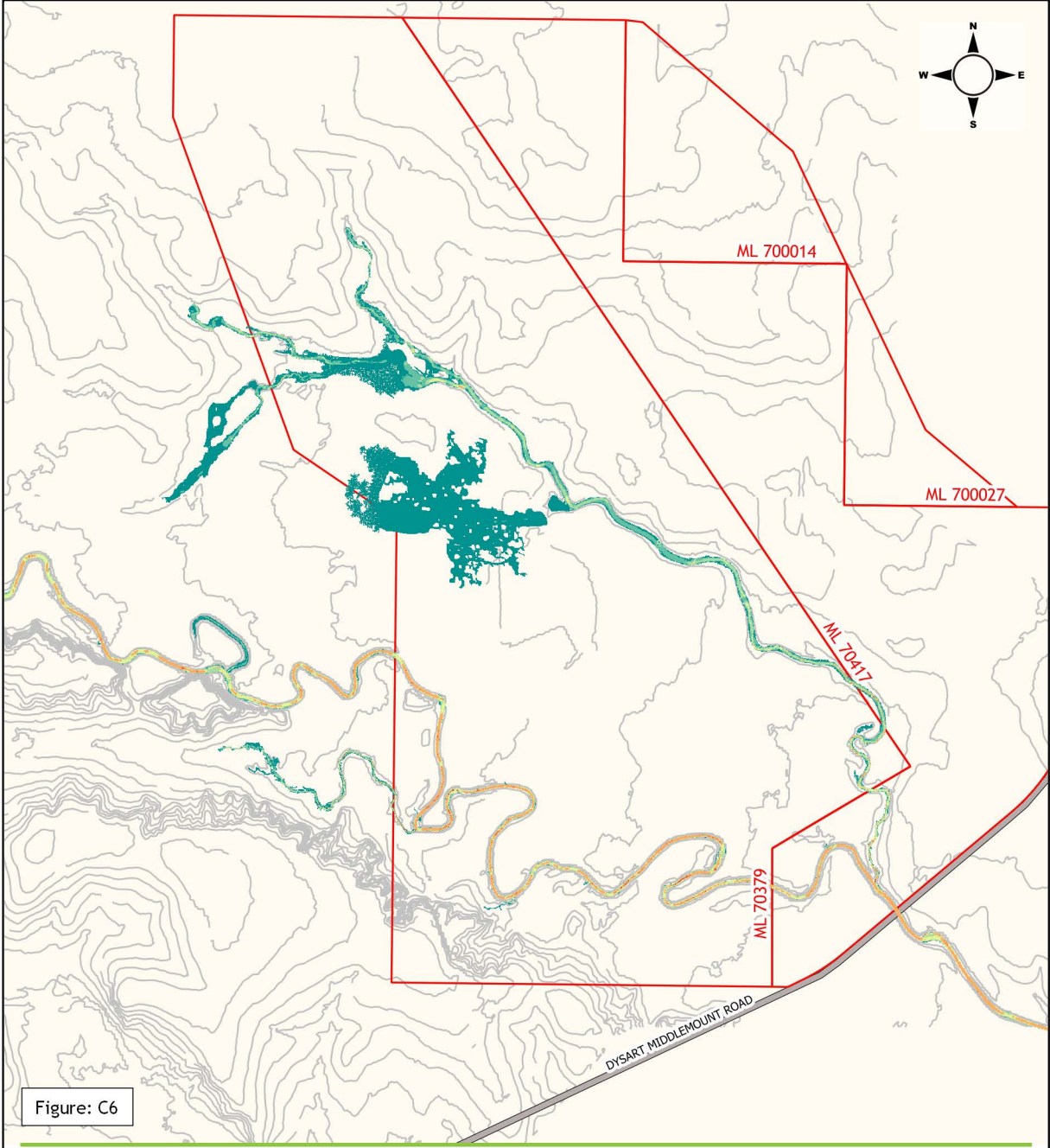


Figure: C6

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

50% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

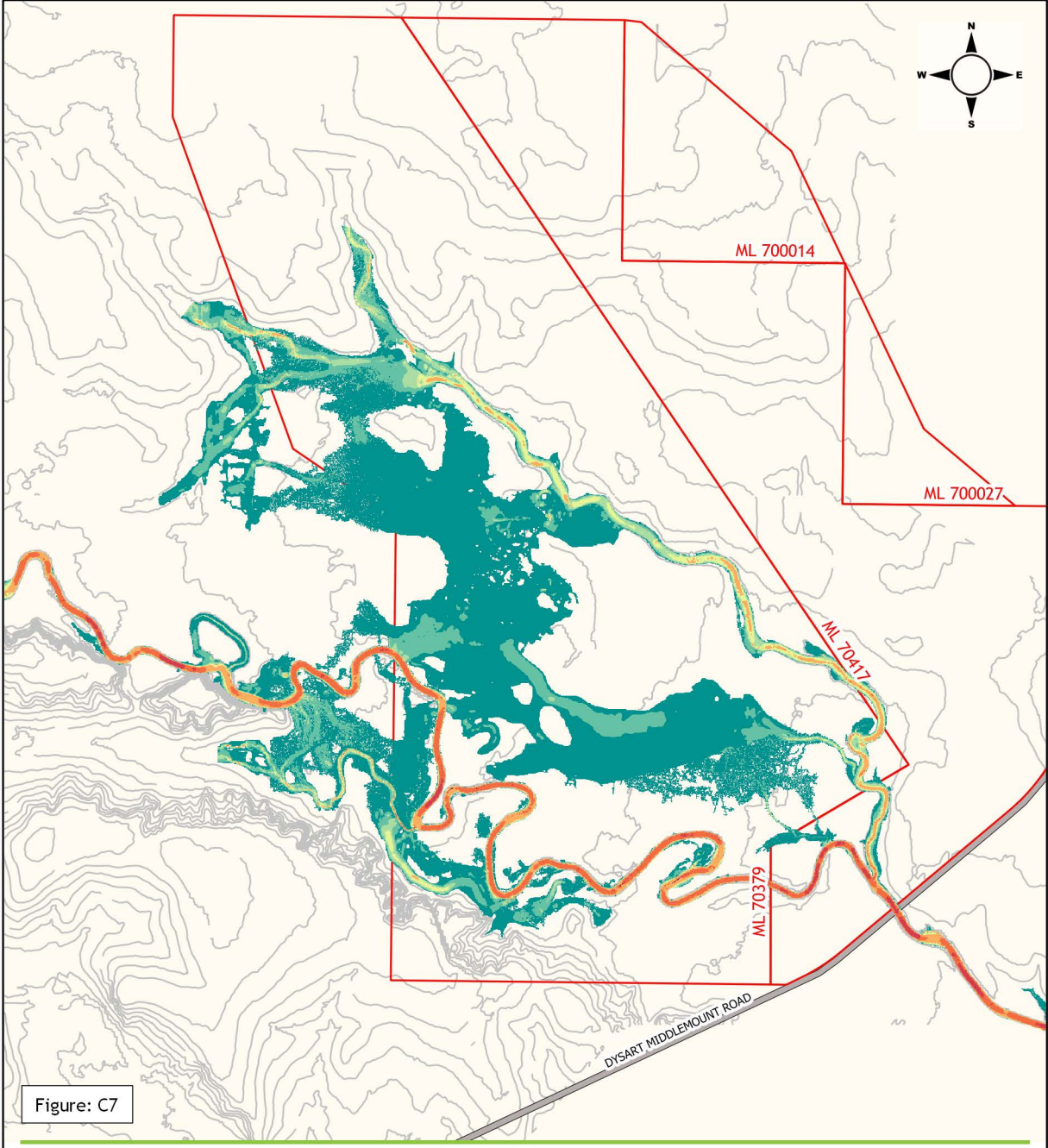


Figure: C7

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

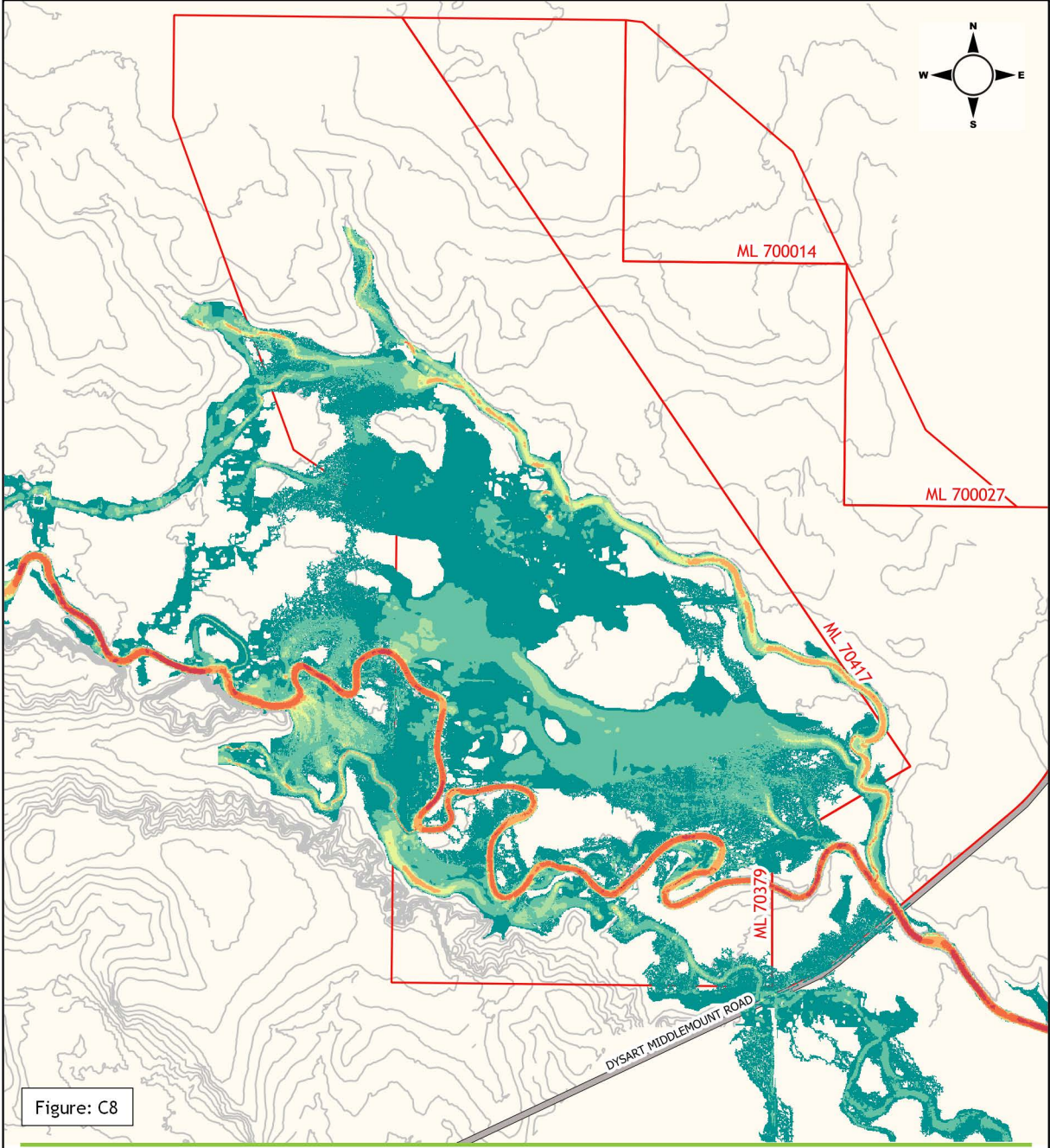


Figure: C8

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

2% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

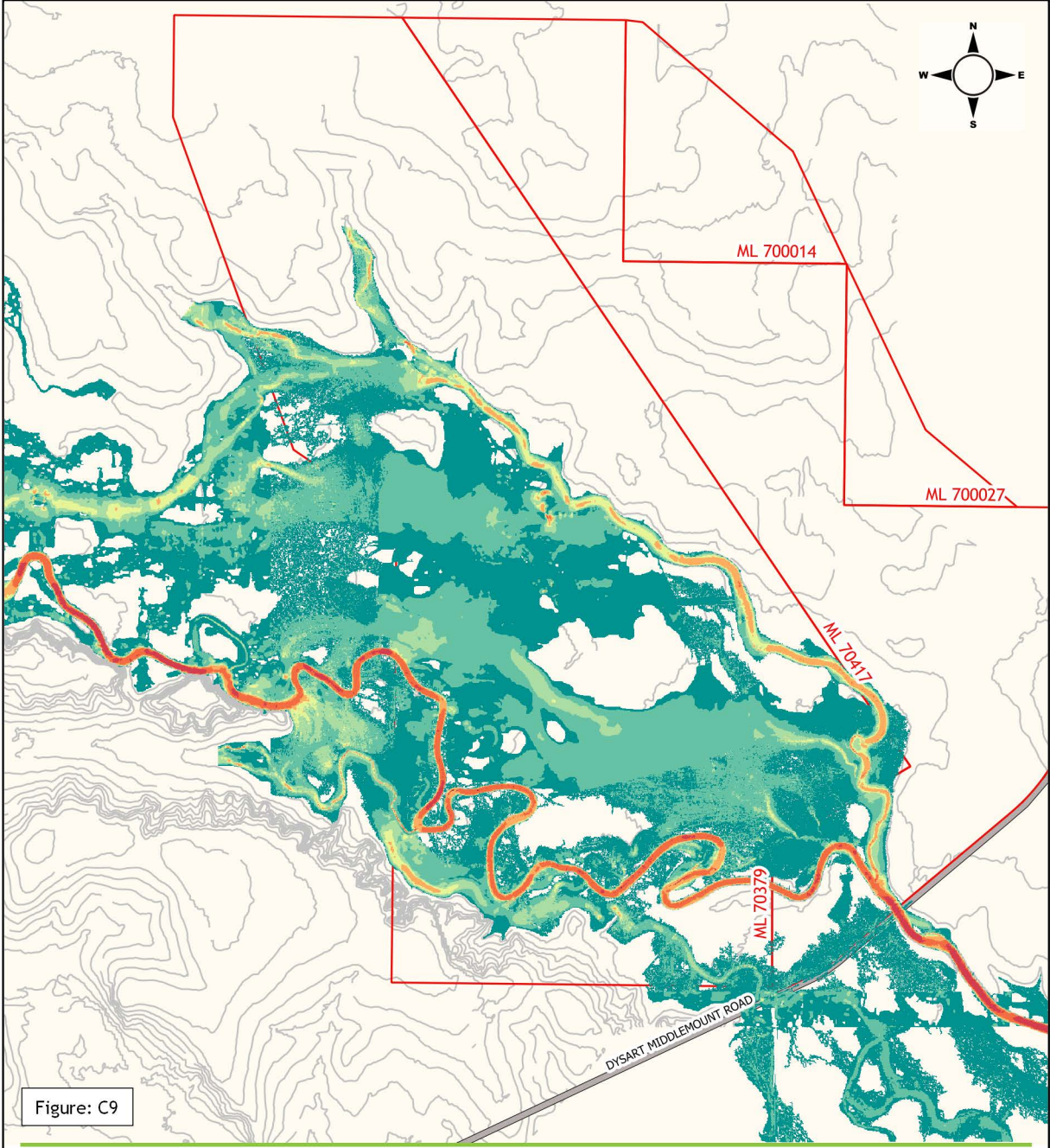


Figure: C9

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

1% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

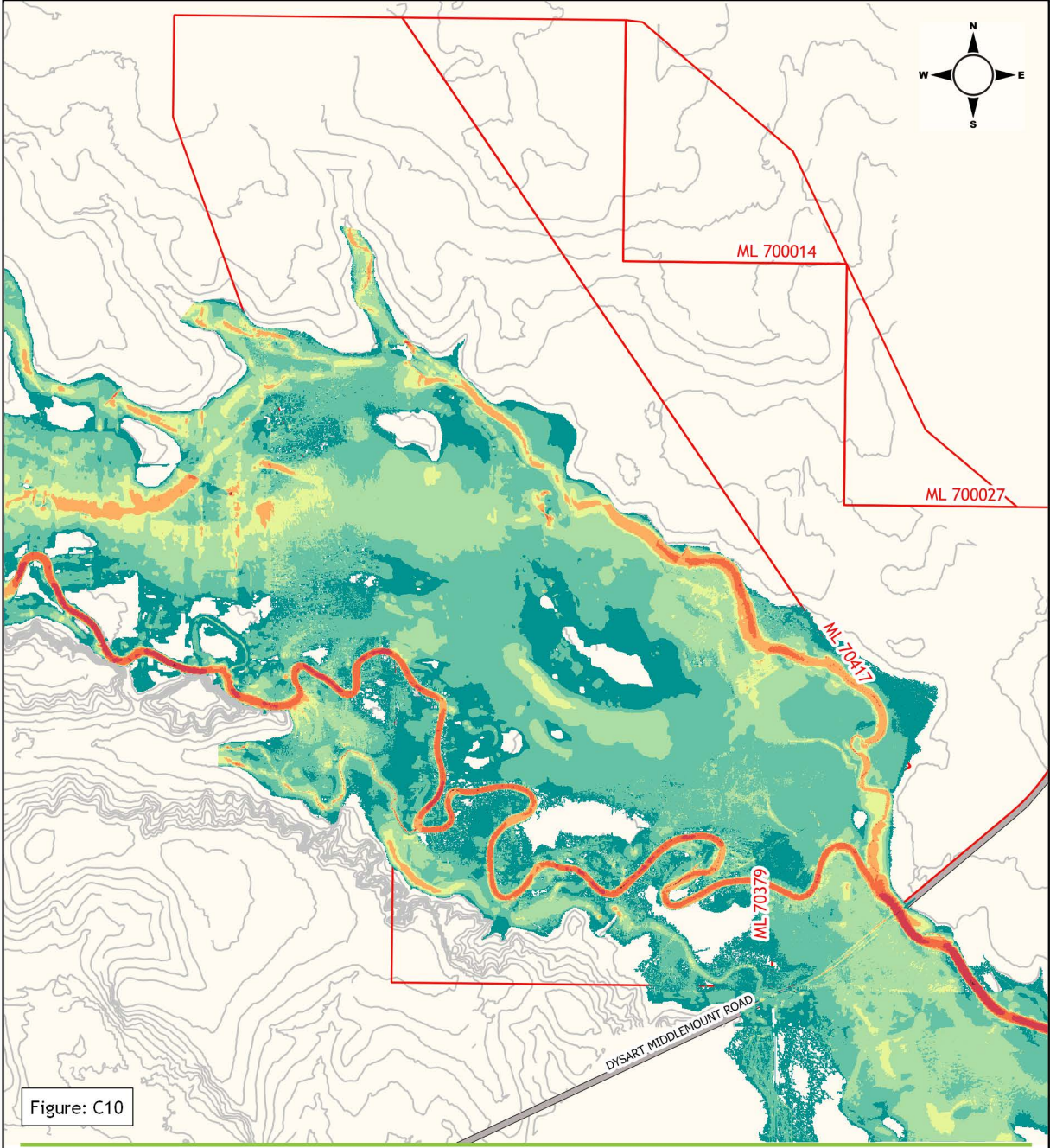


Figure: C10

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

0.1% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

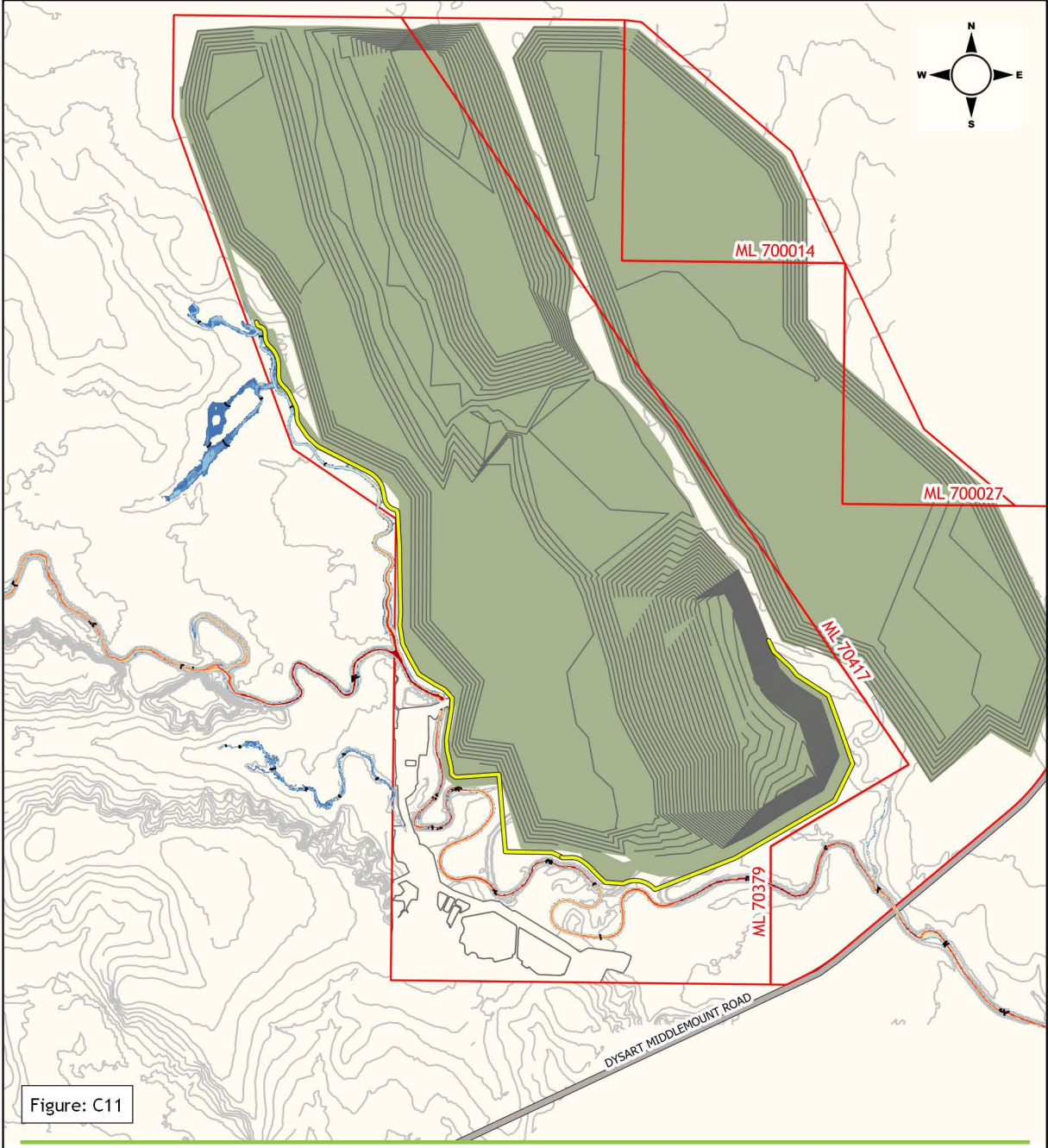


Figure: C11

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

50% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

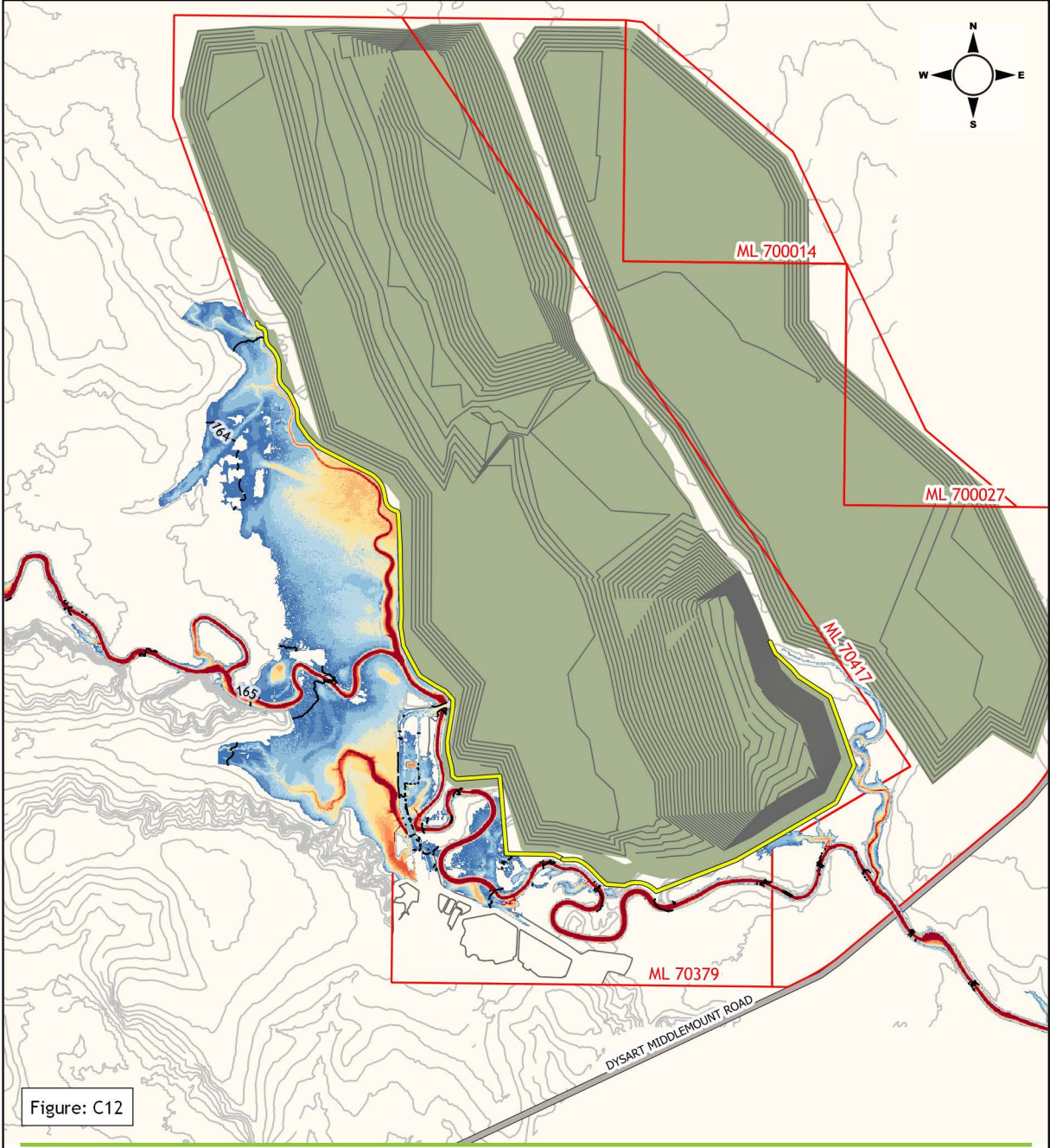


Figure: C12

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

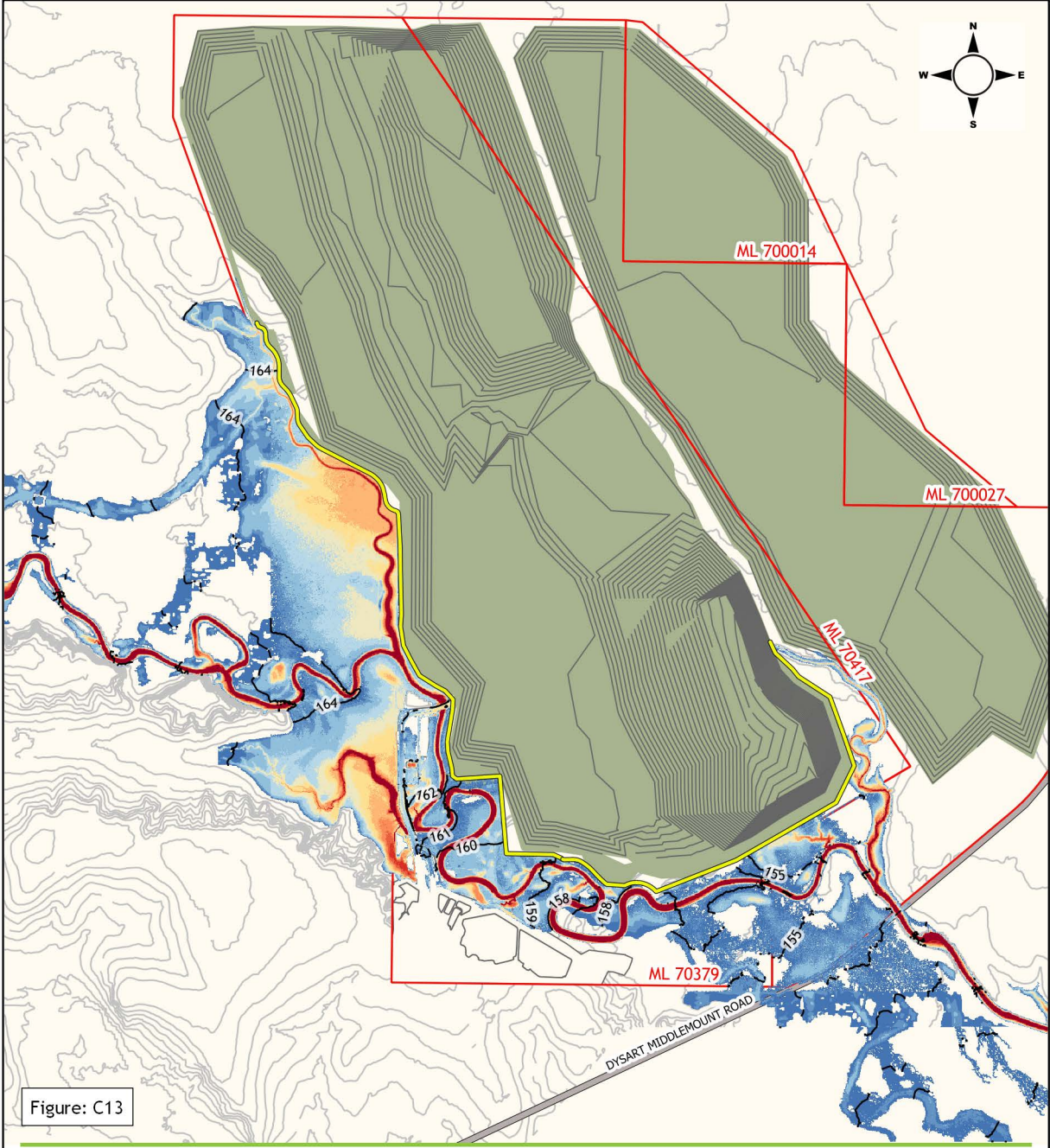


Figure: C13

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

2% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

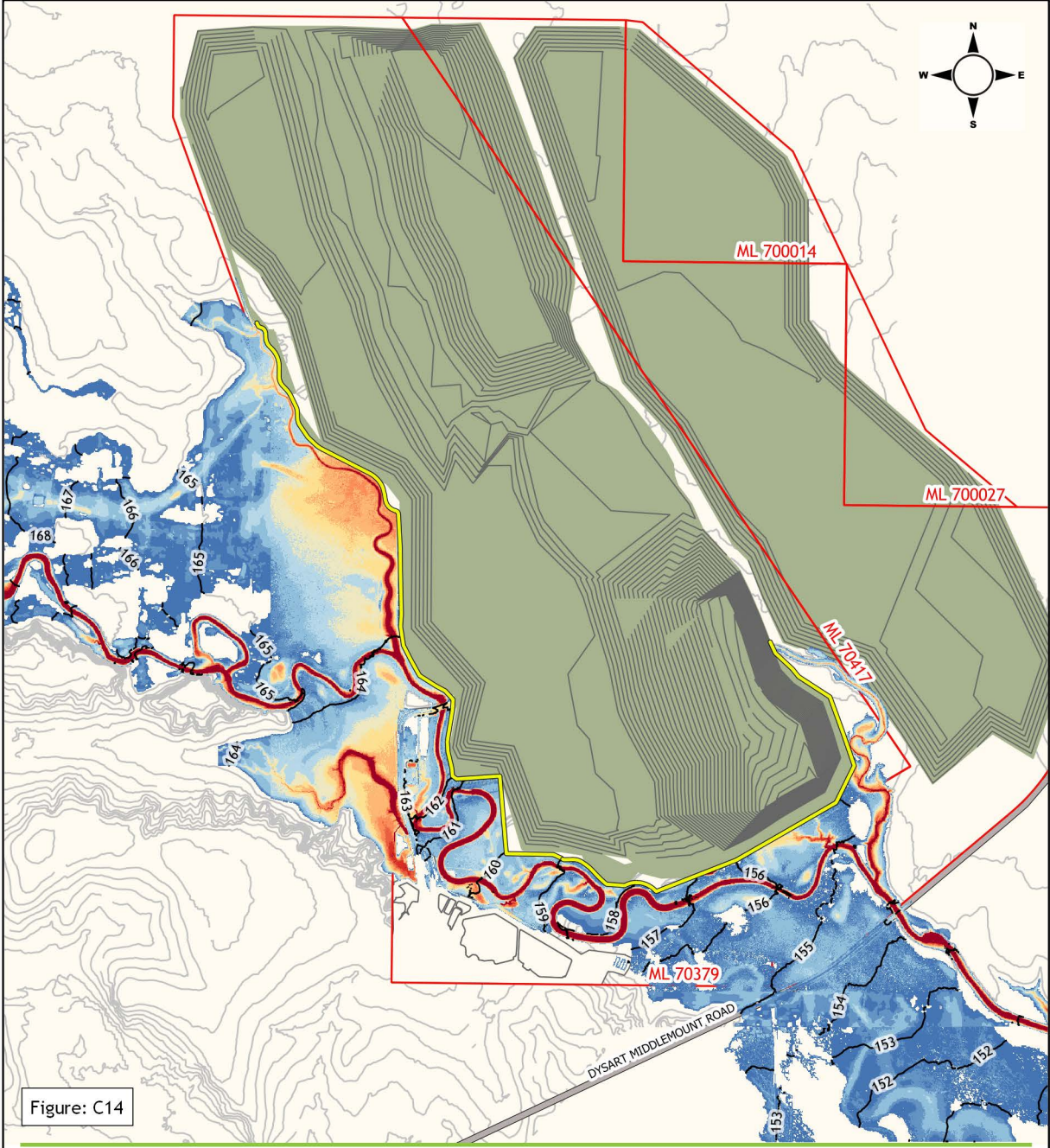


Figure: C14

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

1% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

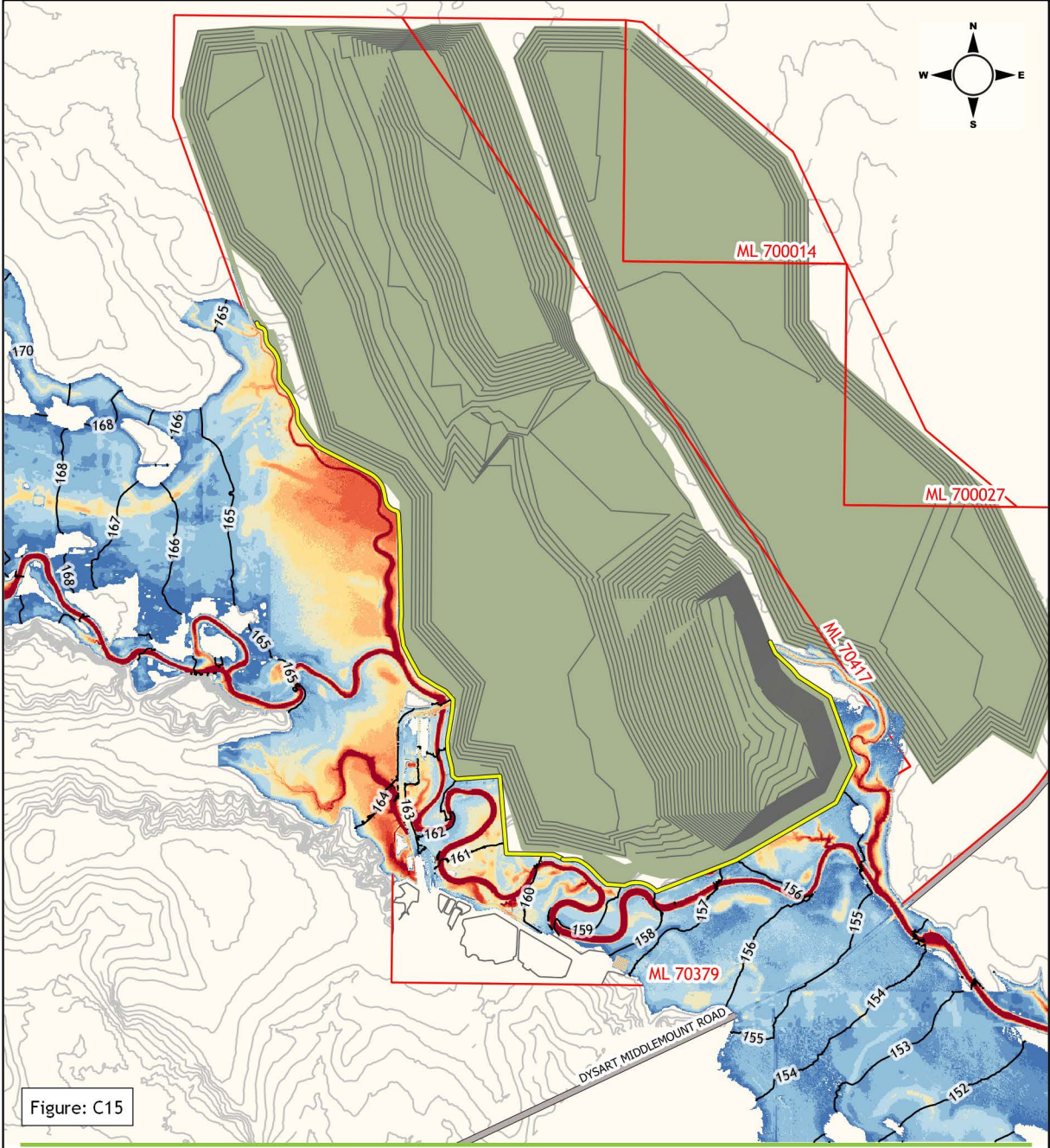


Figure: C15

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

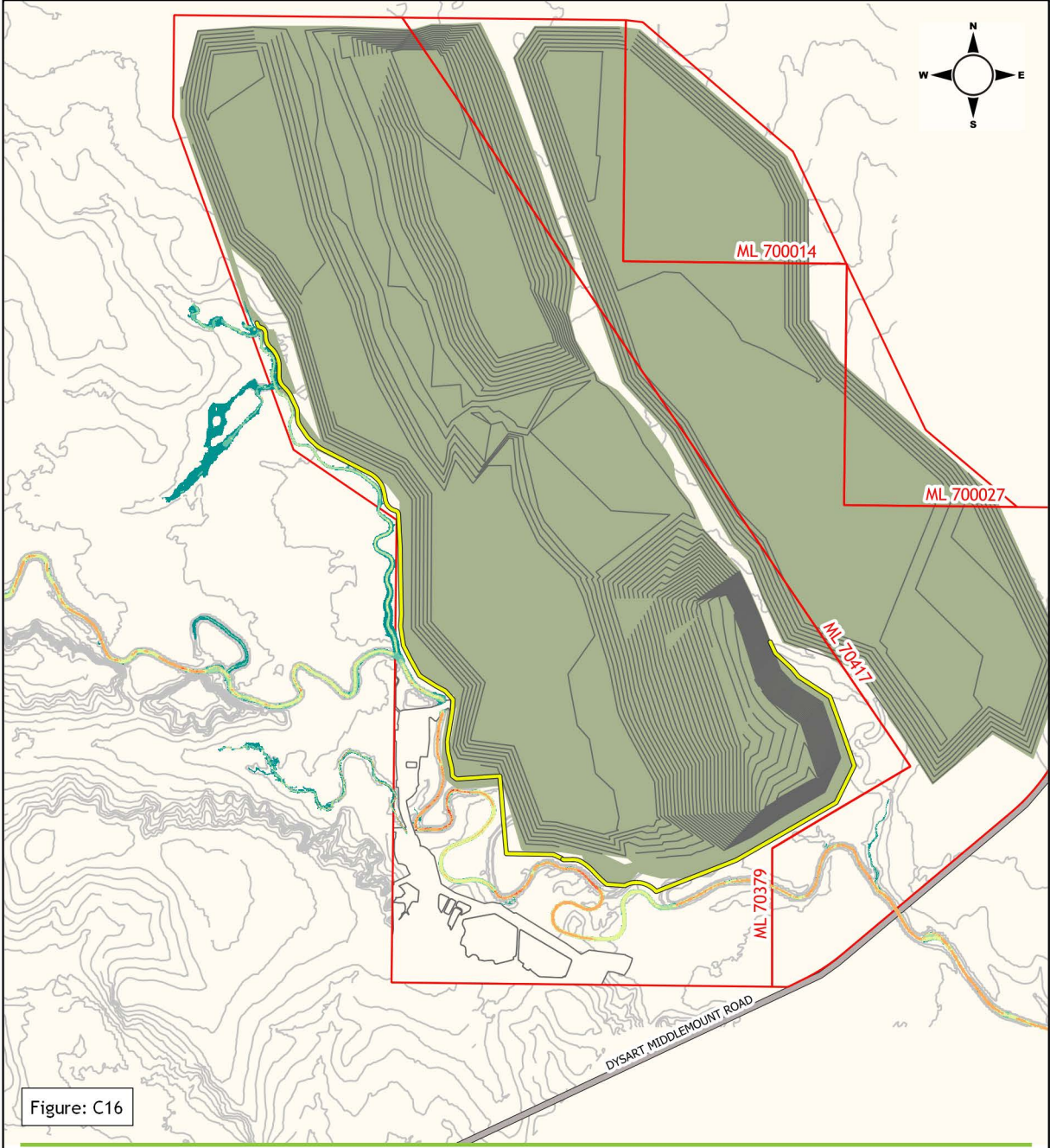


Figure: C16

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

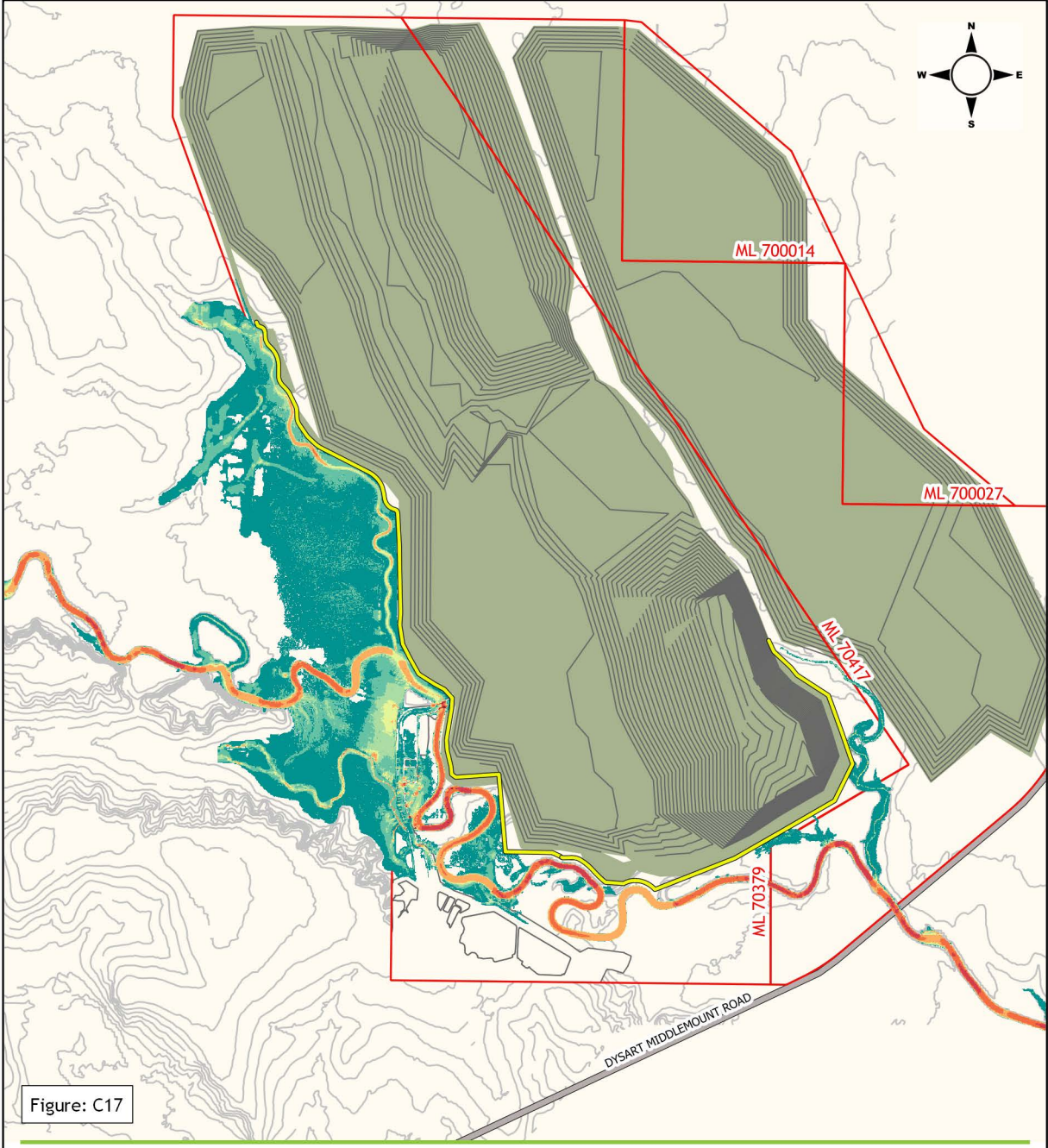


Figure: C17

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

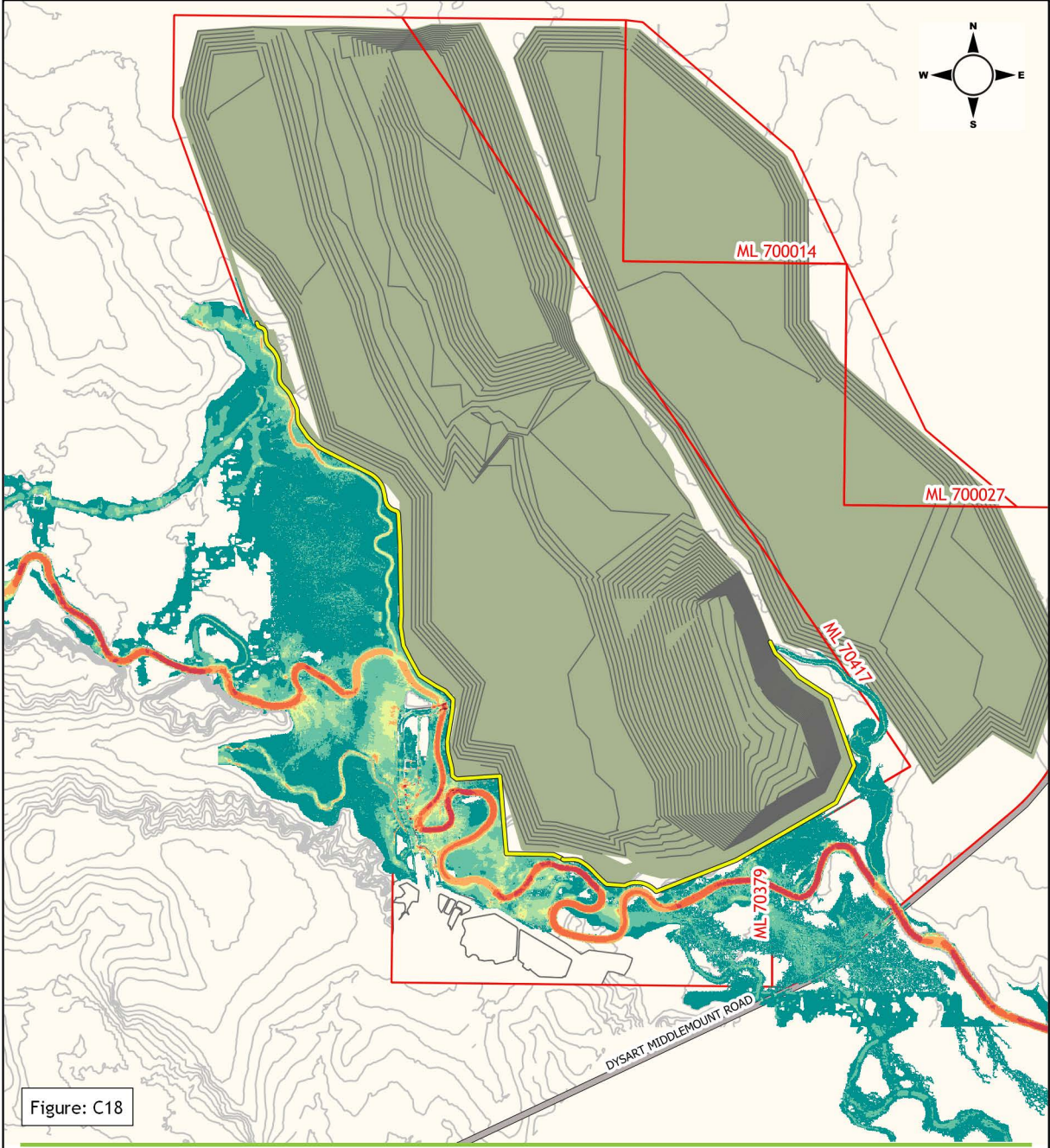


Figure: C18

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

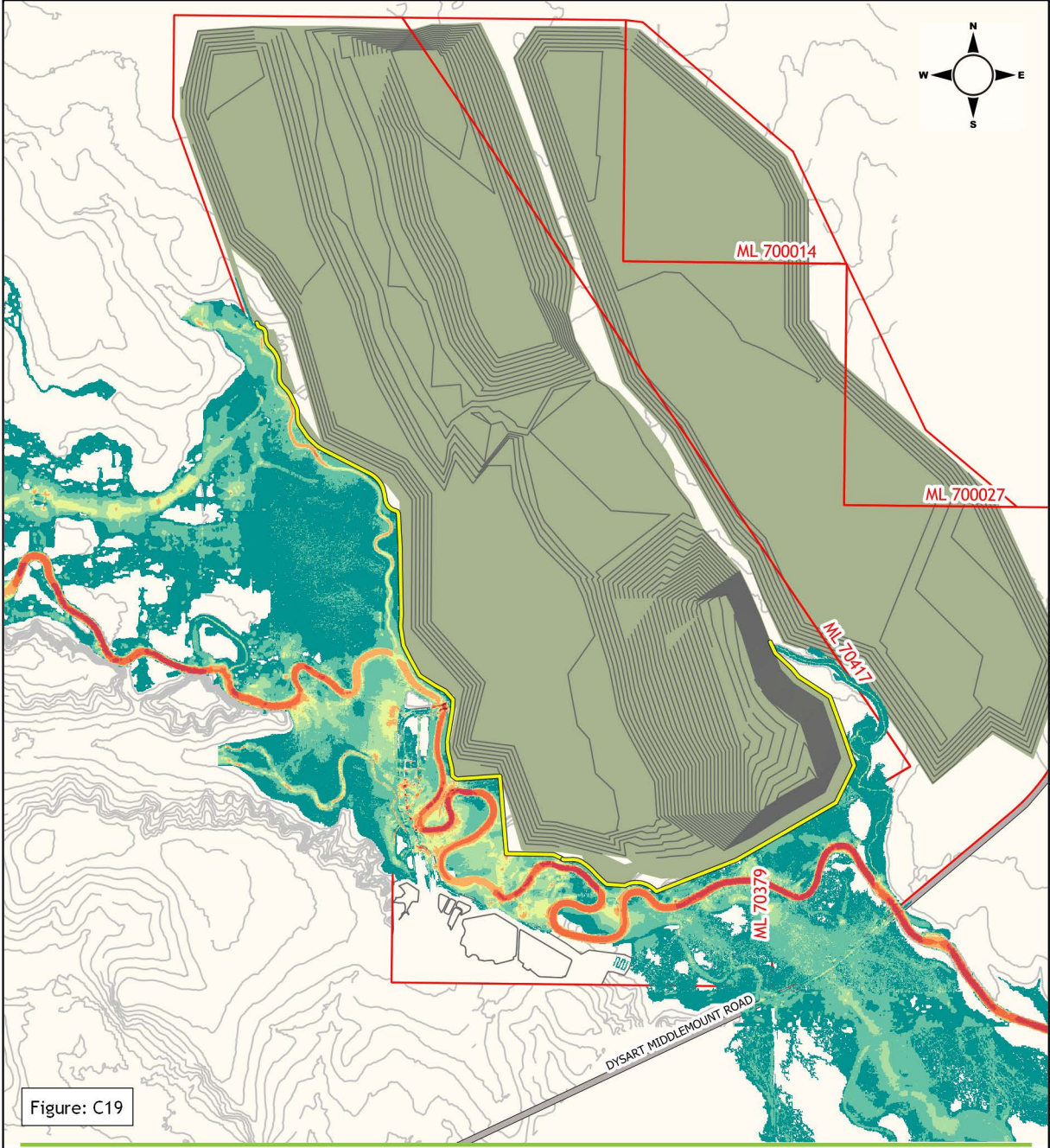


Figure: C19

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

1% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

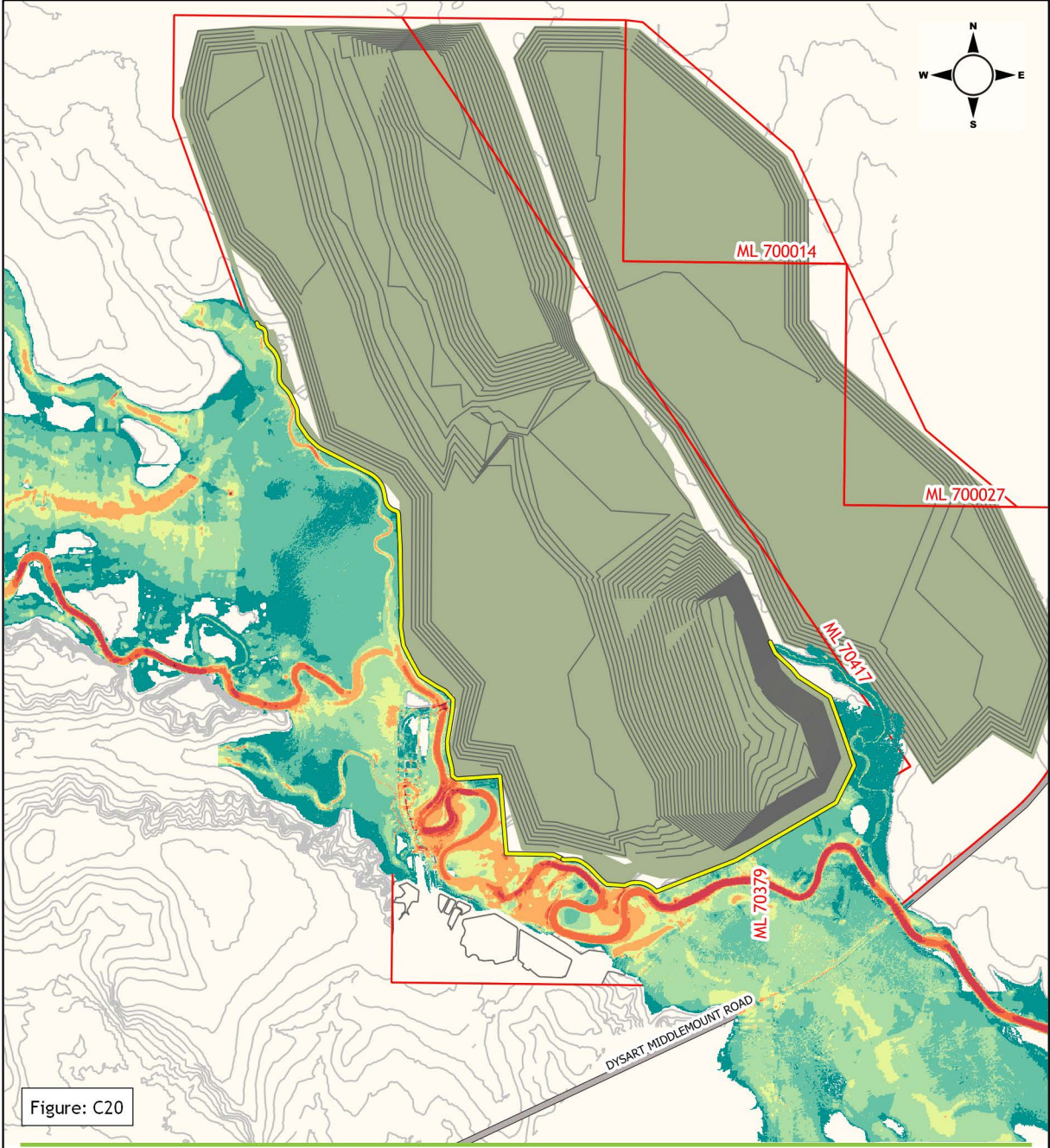


Figure: C20

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

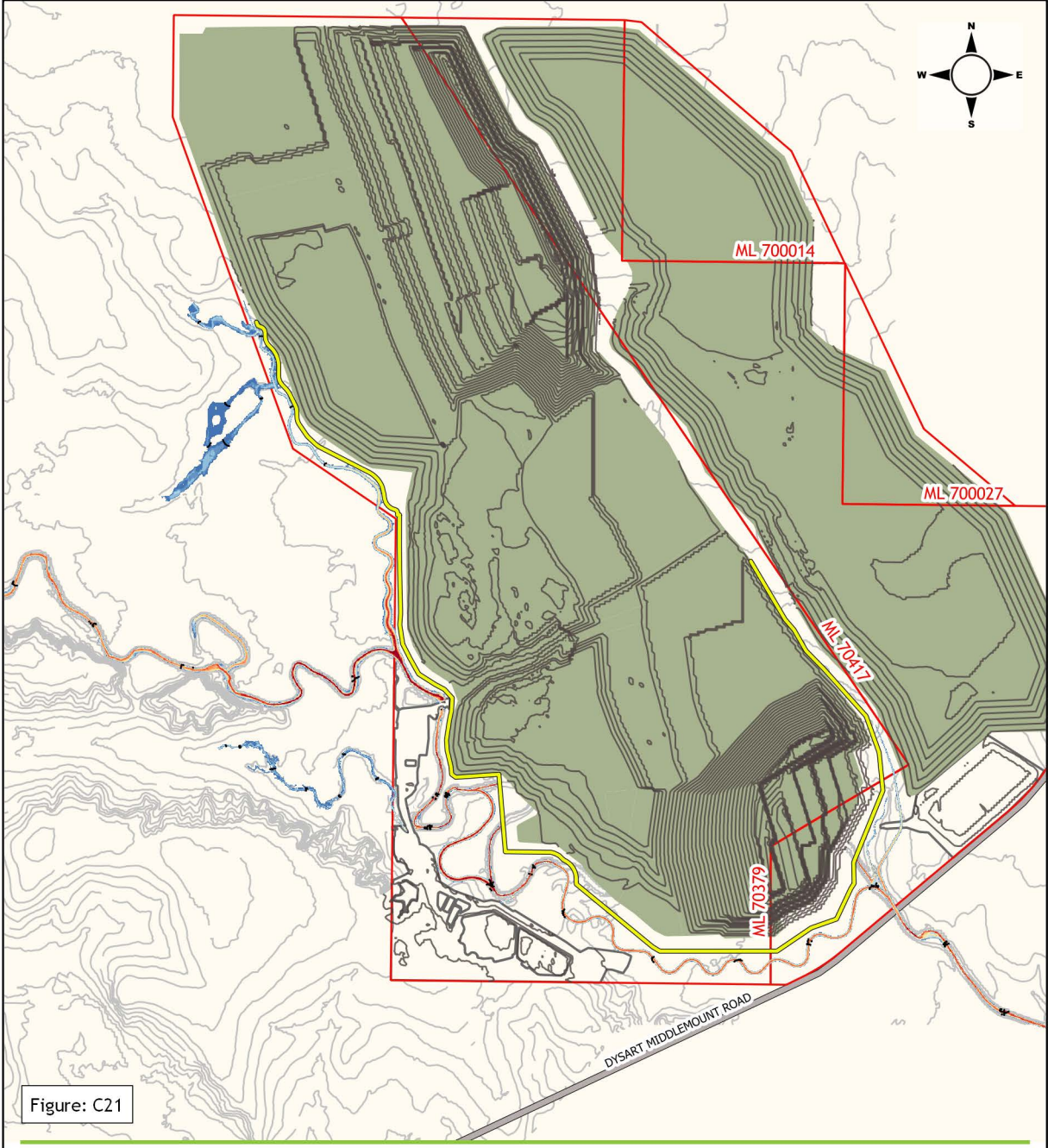


Figure: C21

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

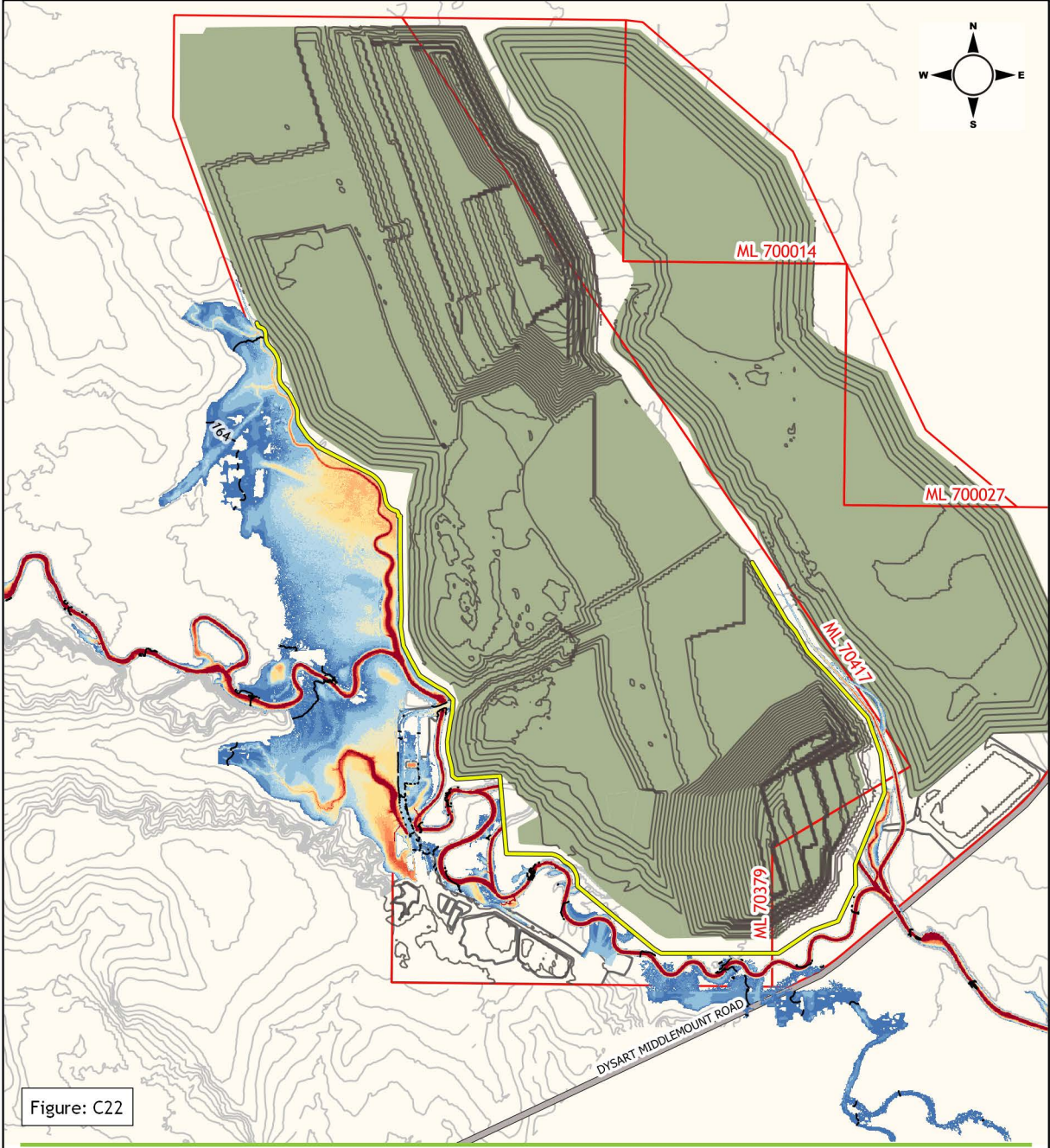


Figure: C22

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

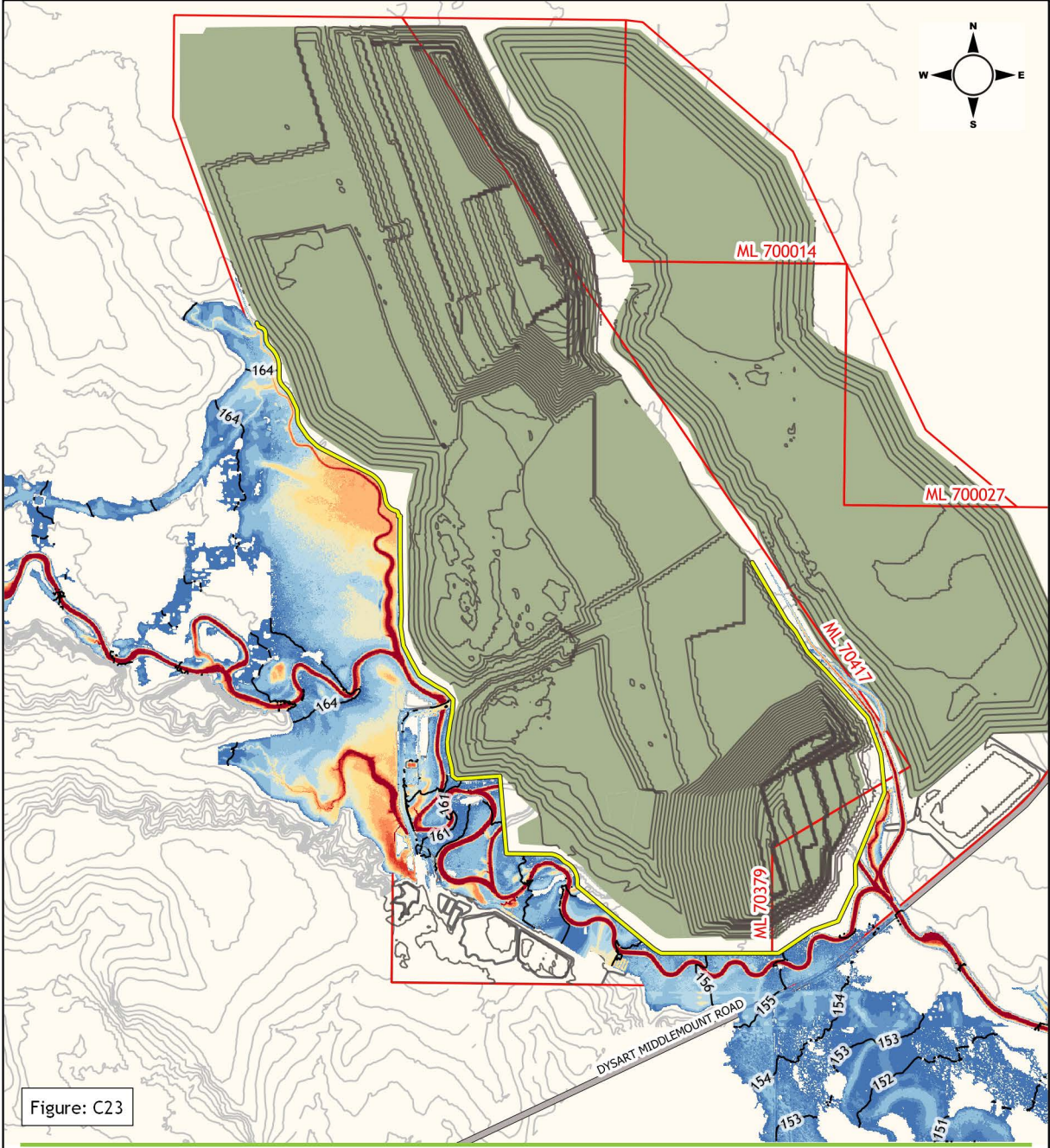


Figure: C23

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

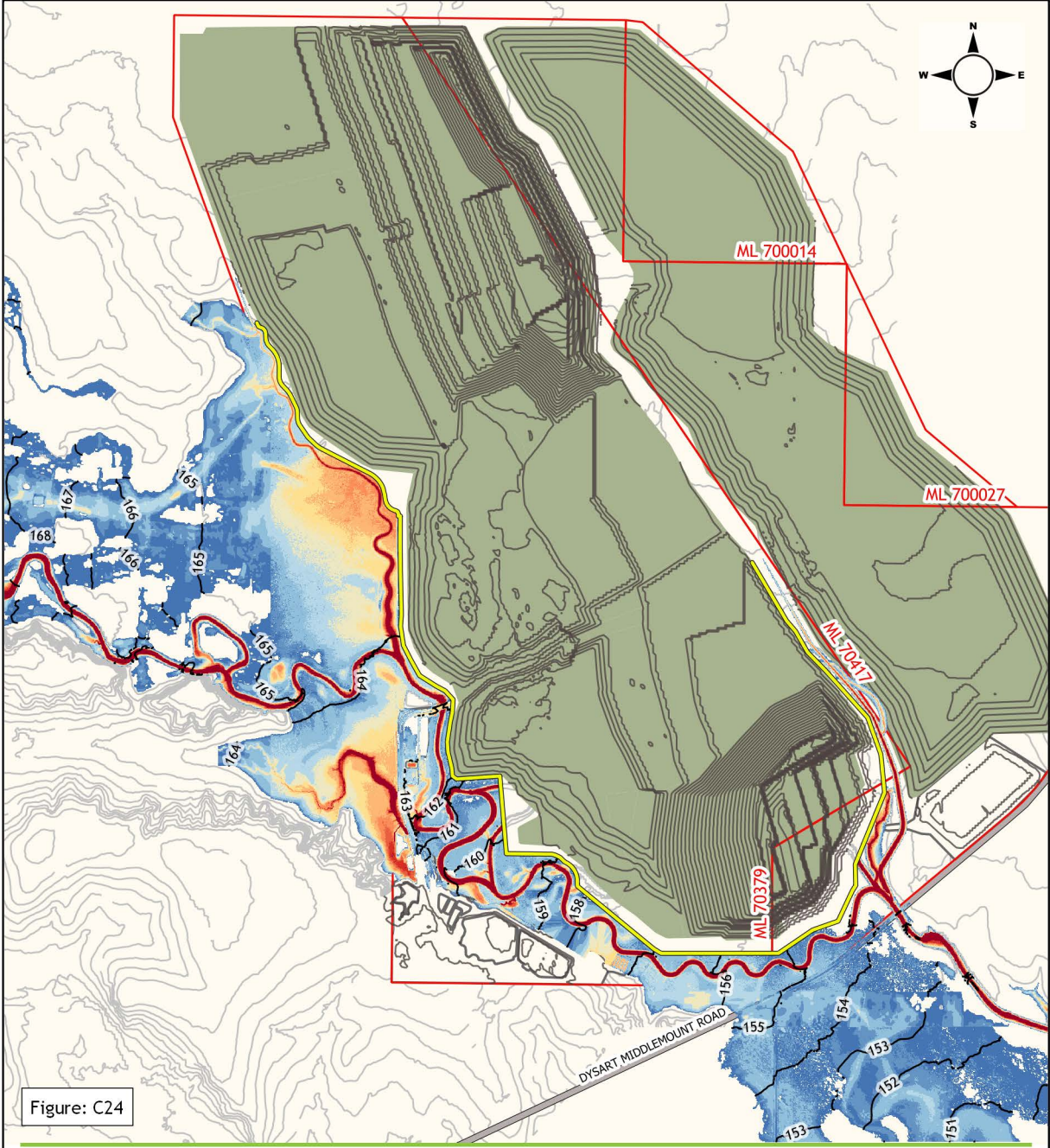


Figure: C24

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

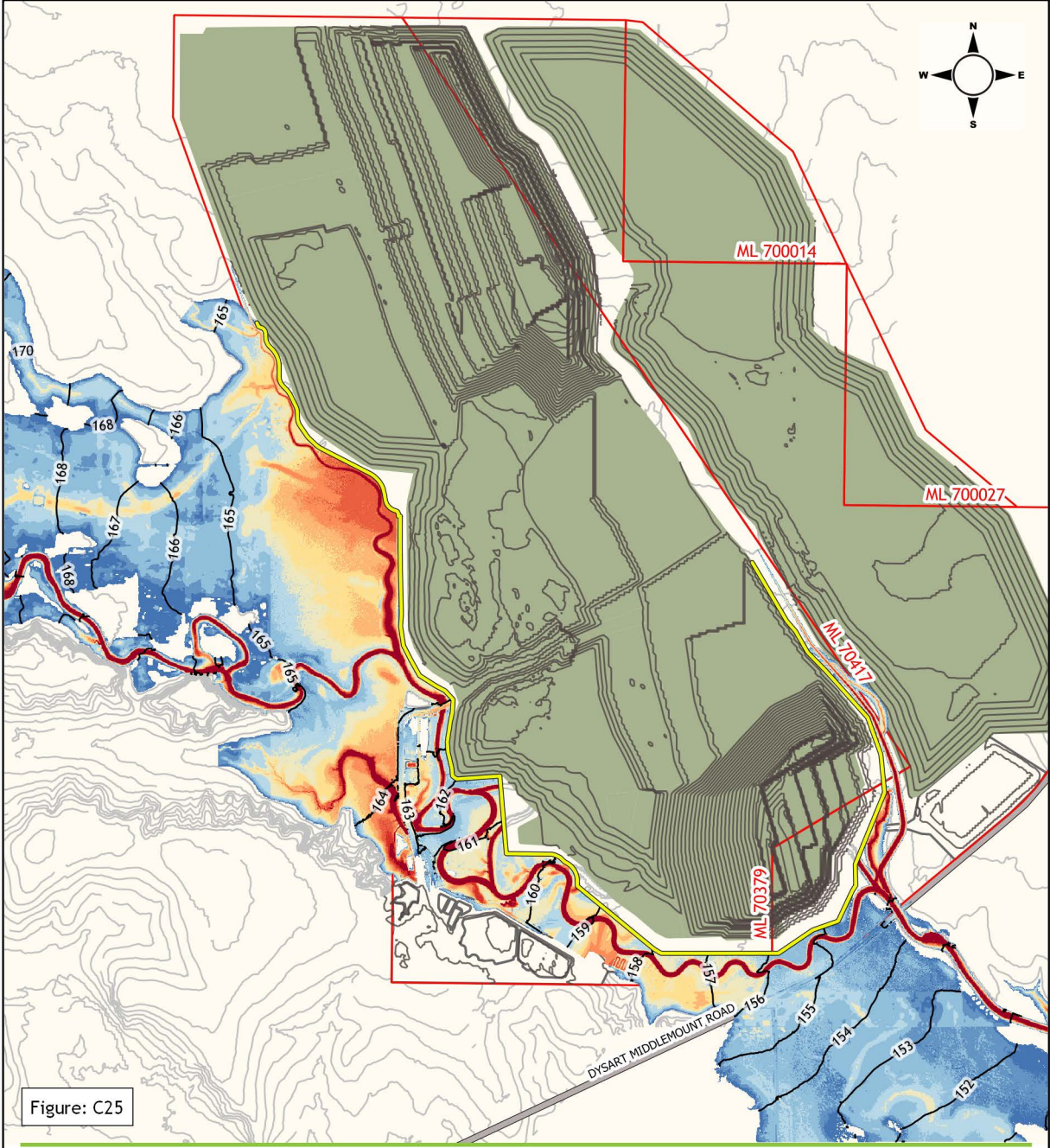


Figure: C25

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

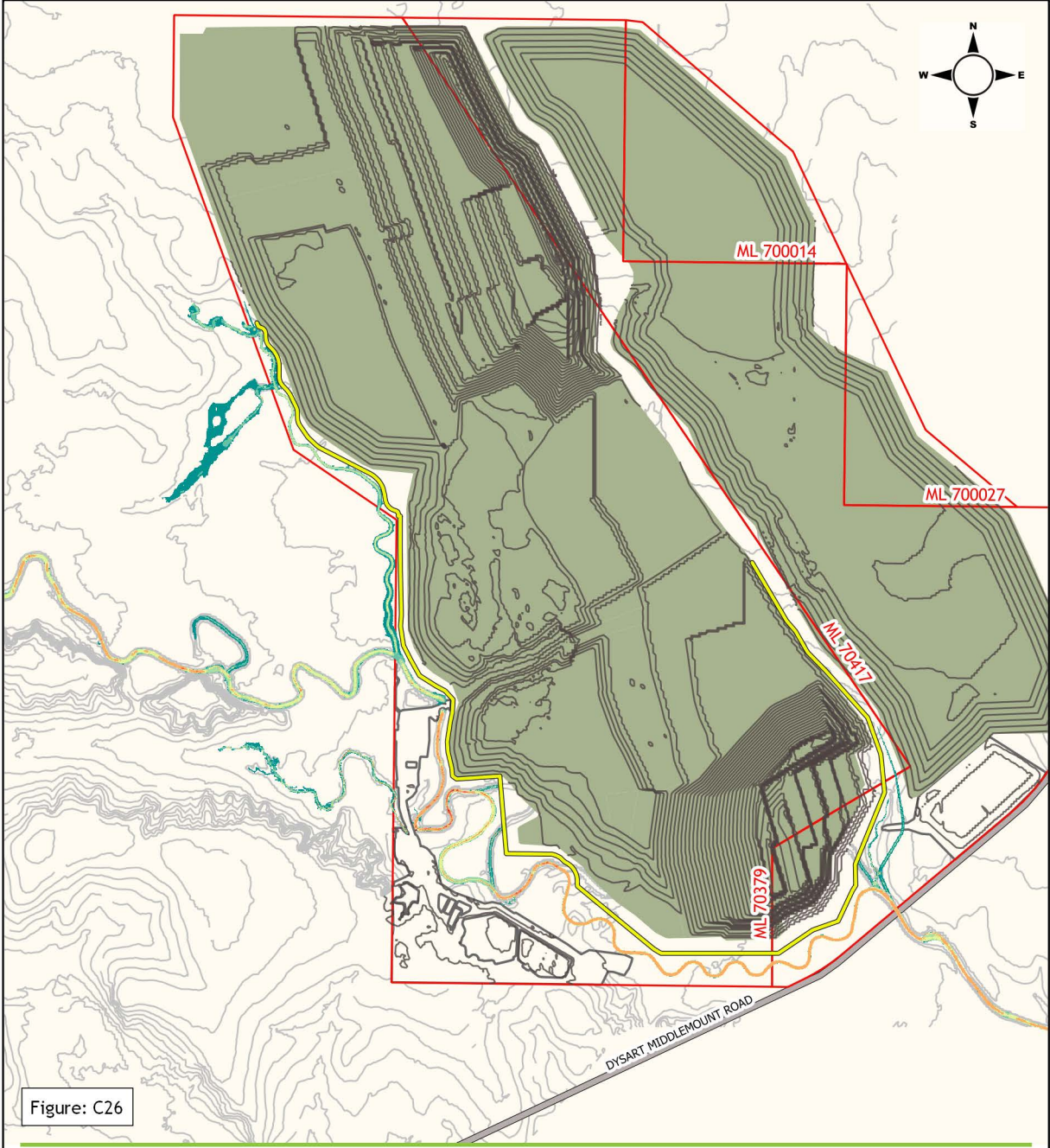


Figure: C26

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

50% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

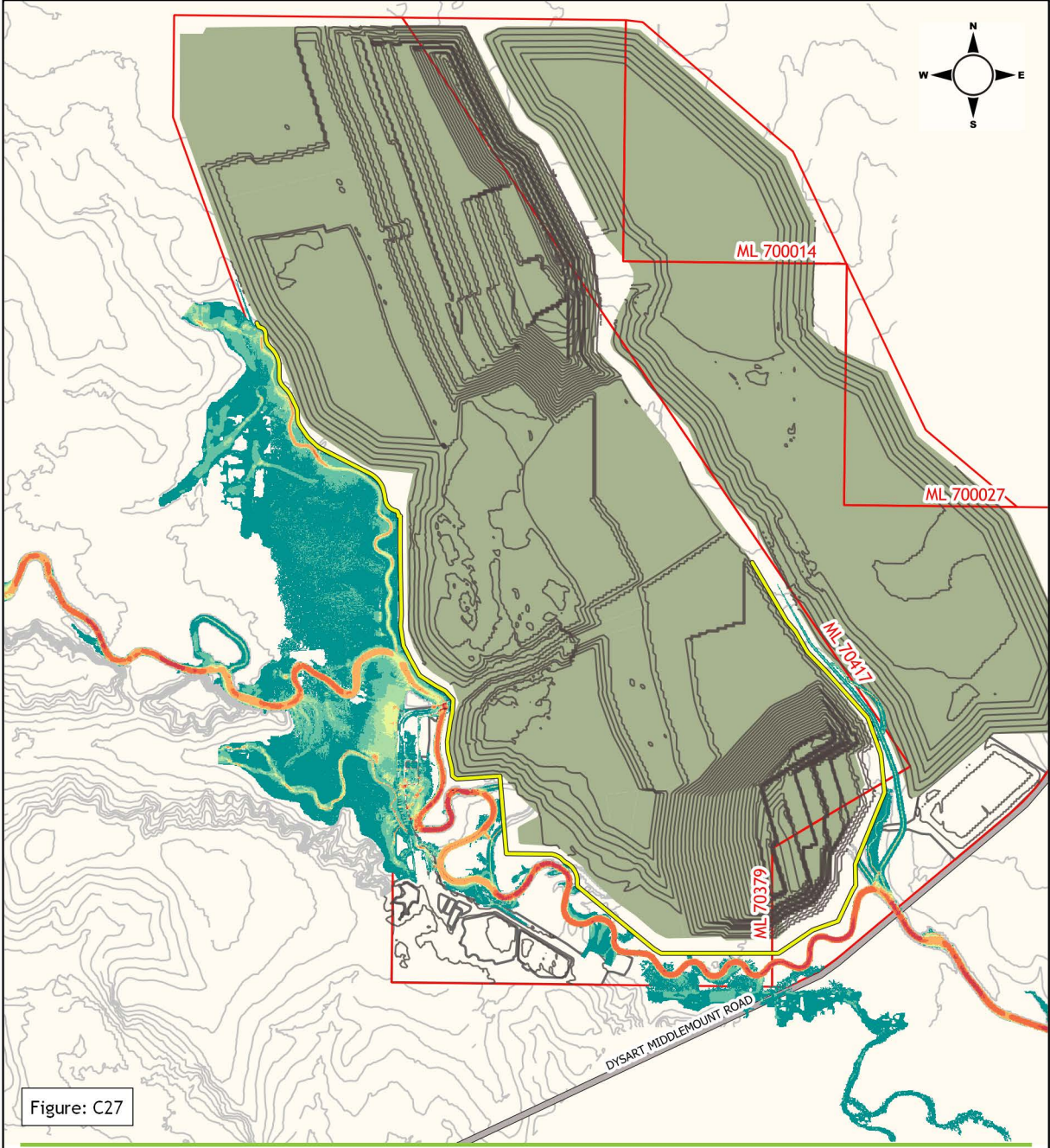


Figure: C27

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

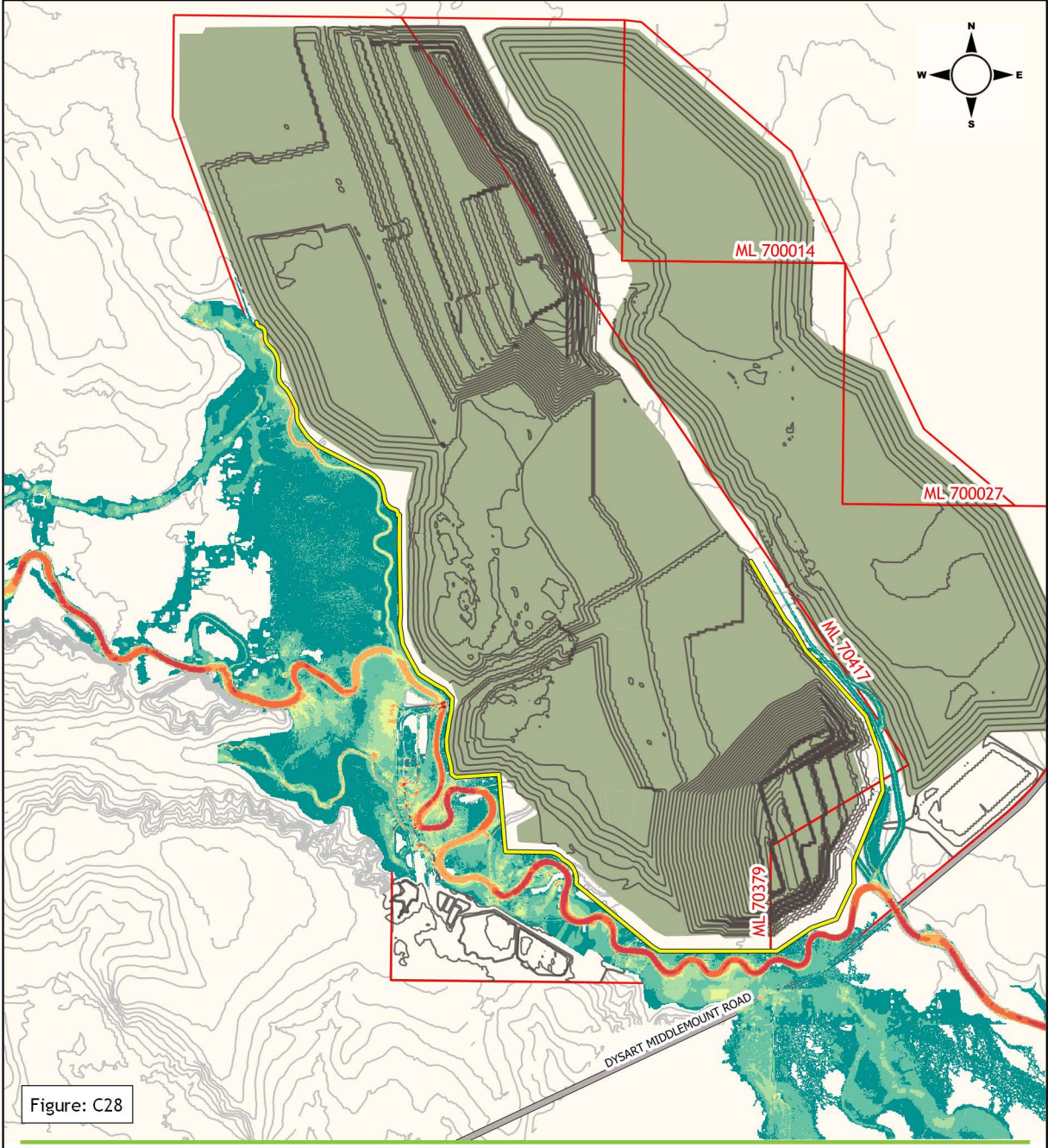


Figure: C28

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

2% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

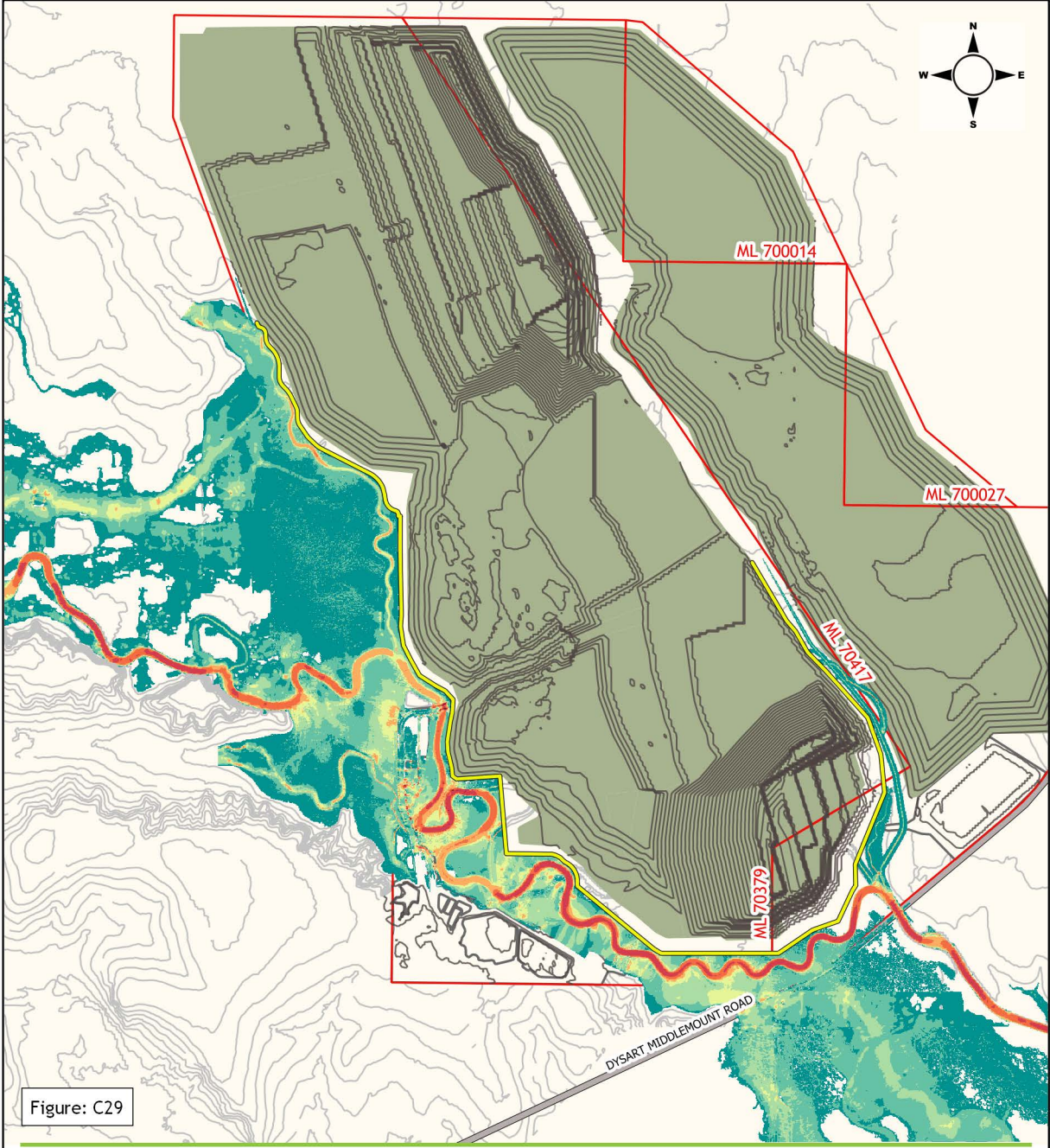


Figure: C29

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

1% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

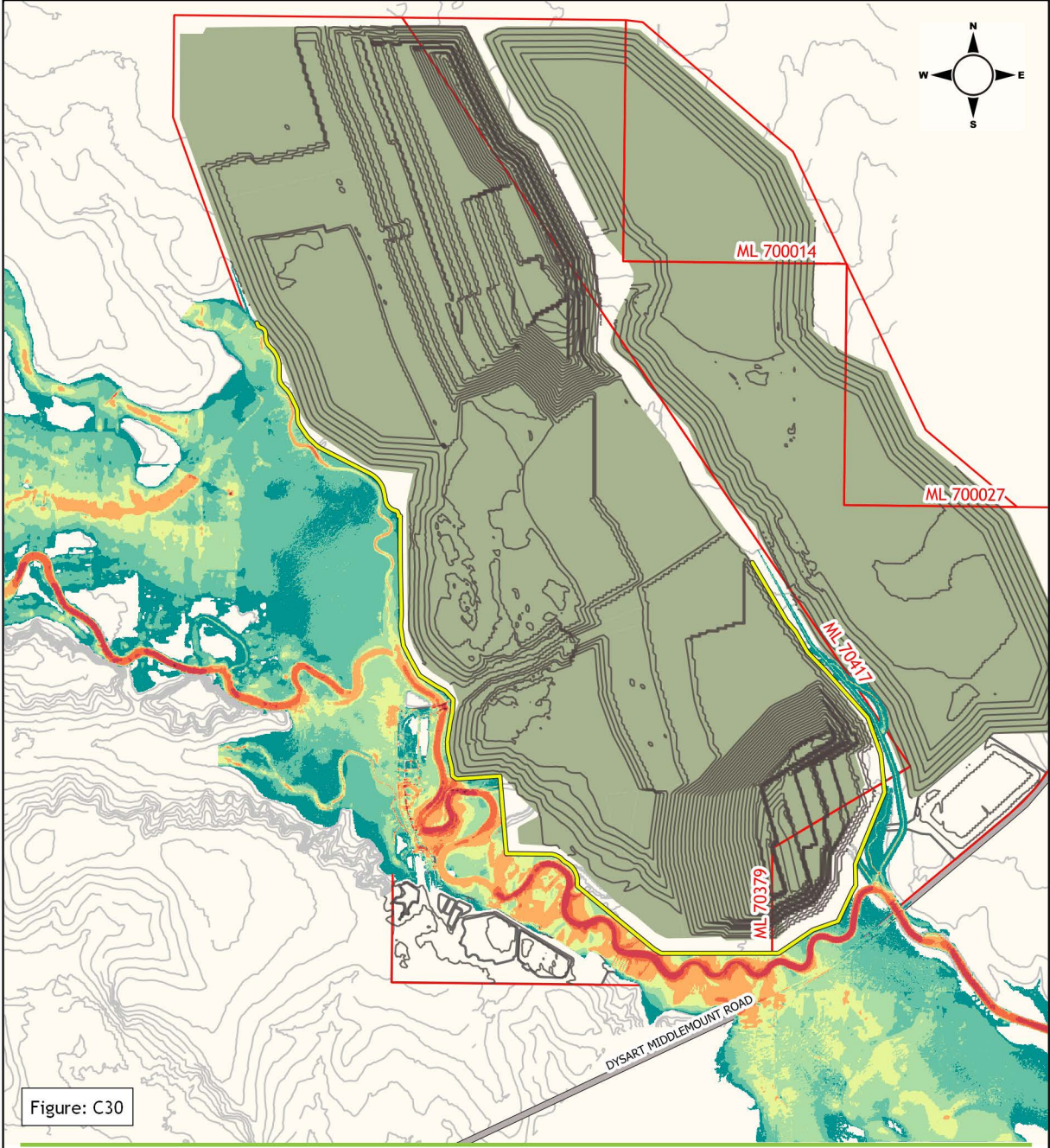


Figure: C30

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

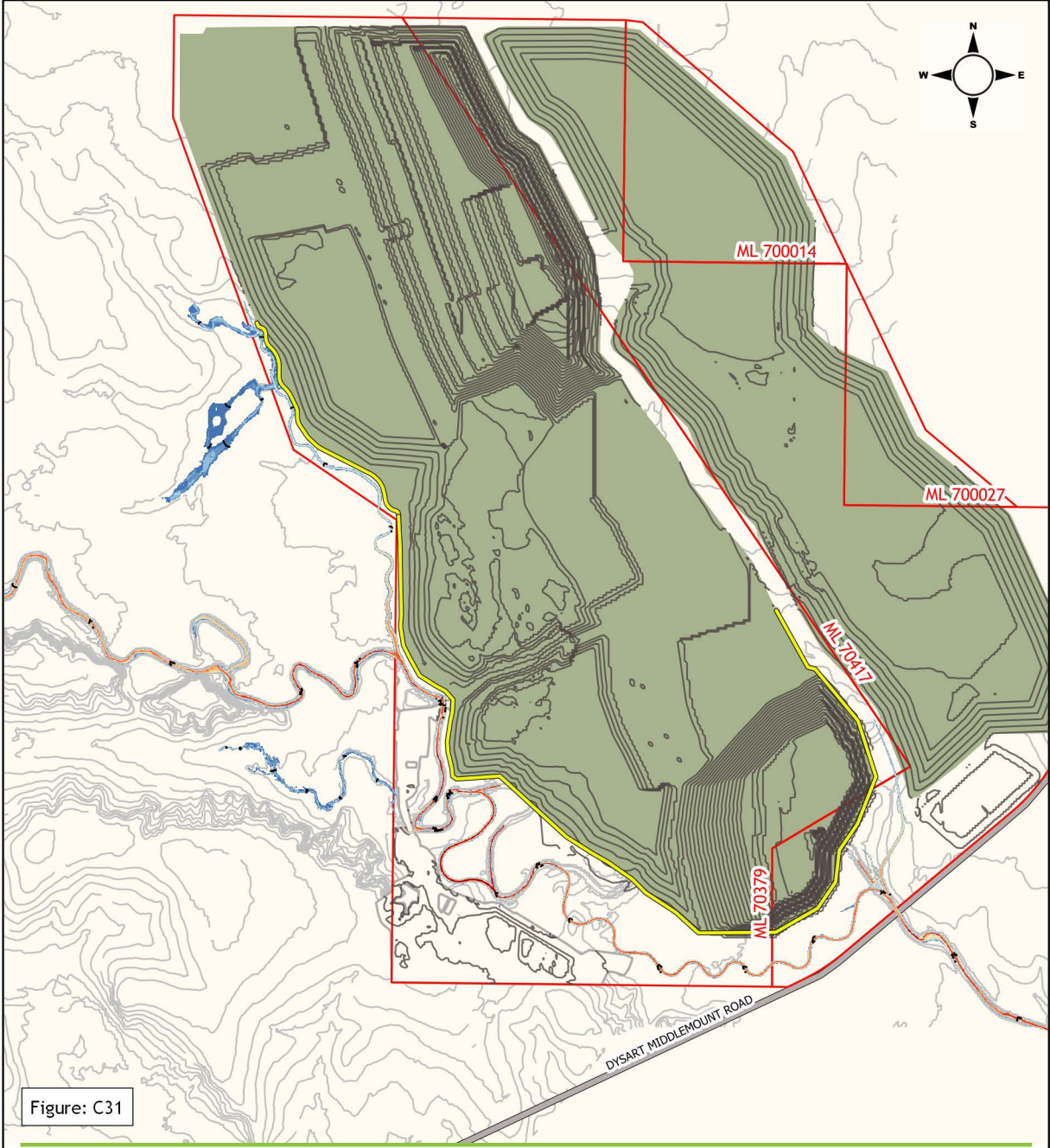


Figure: C31

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

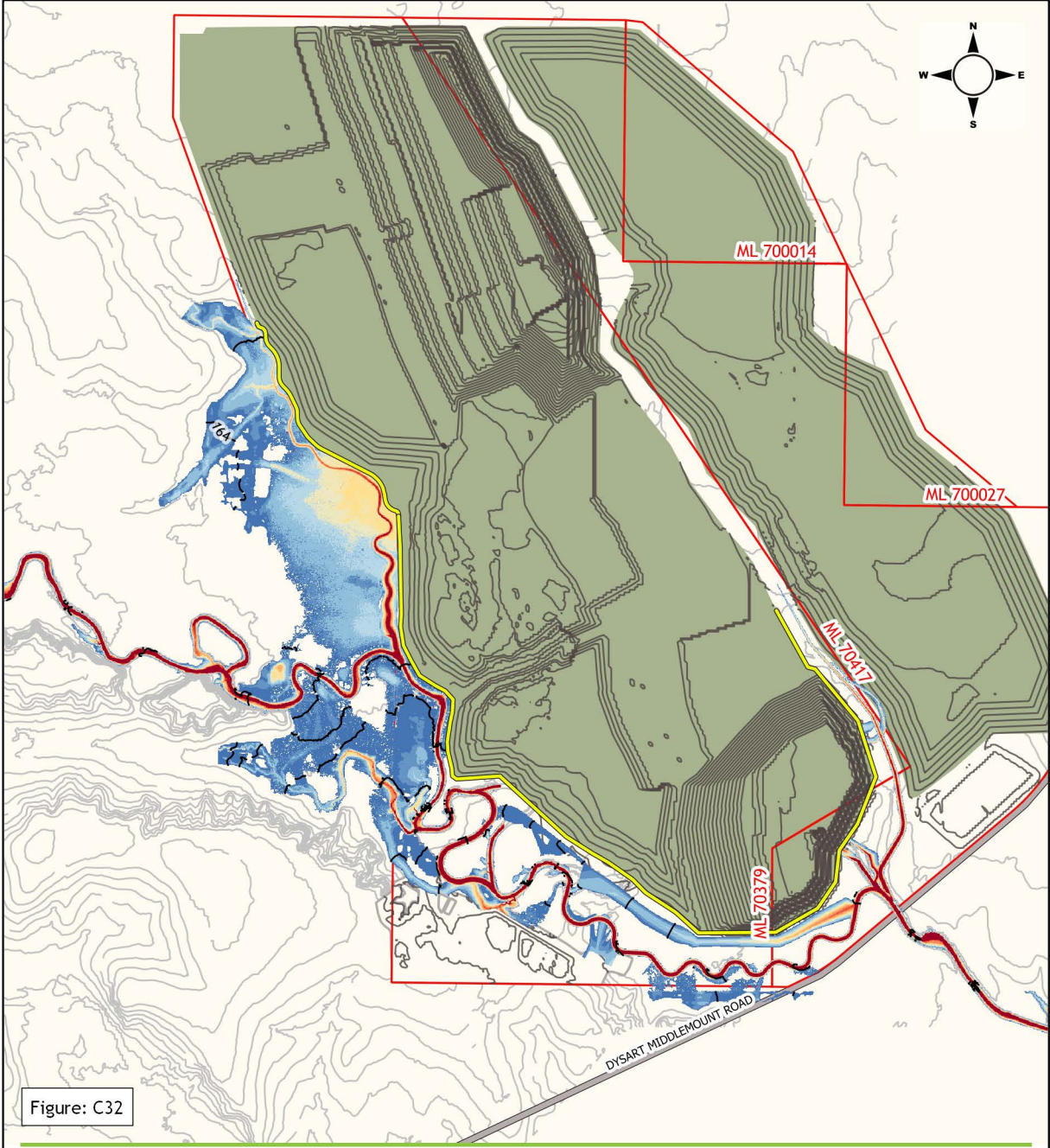


Figure: C32

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

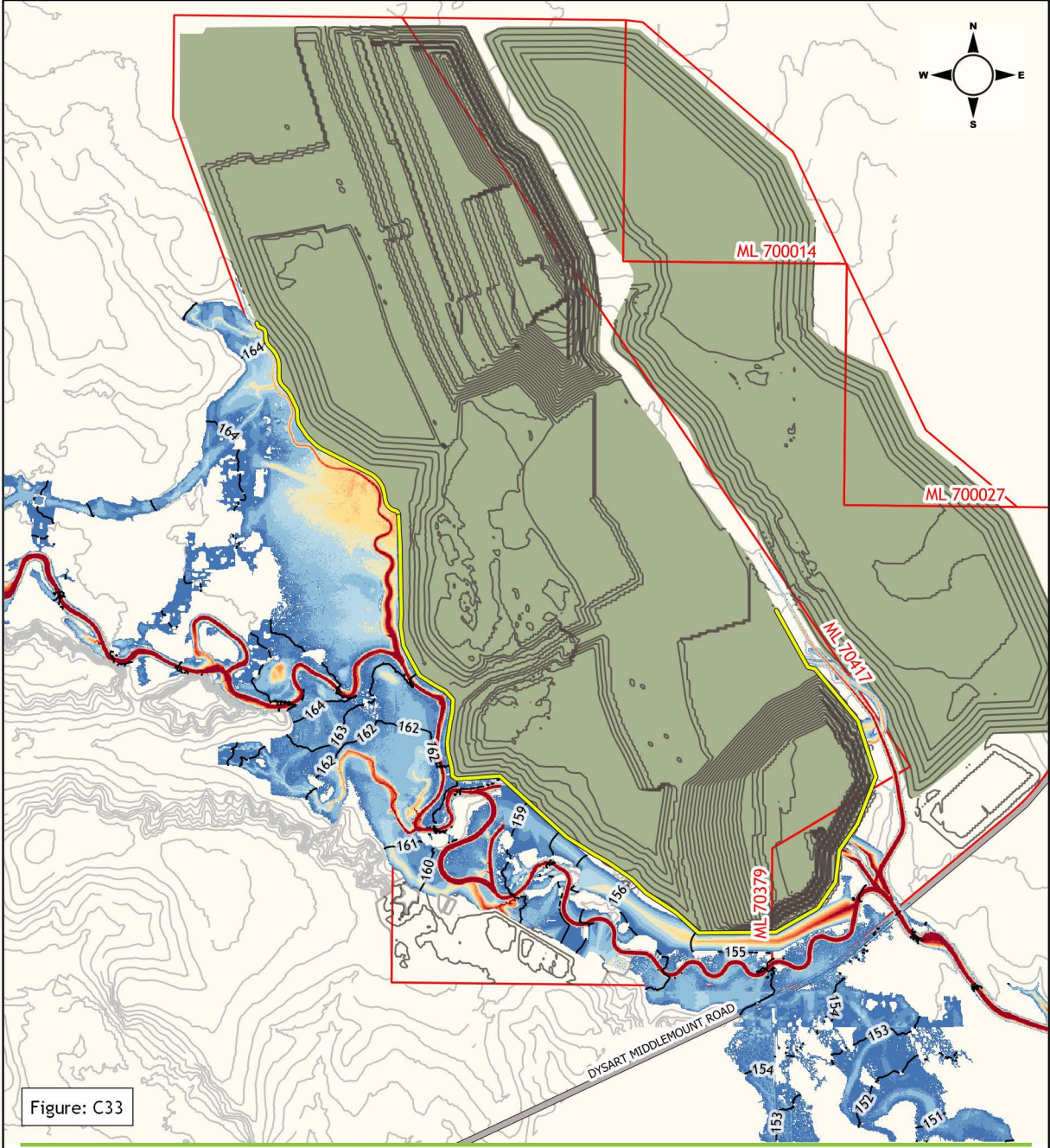


Figure: C33

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

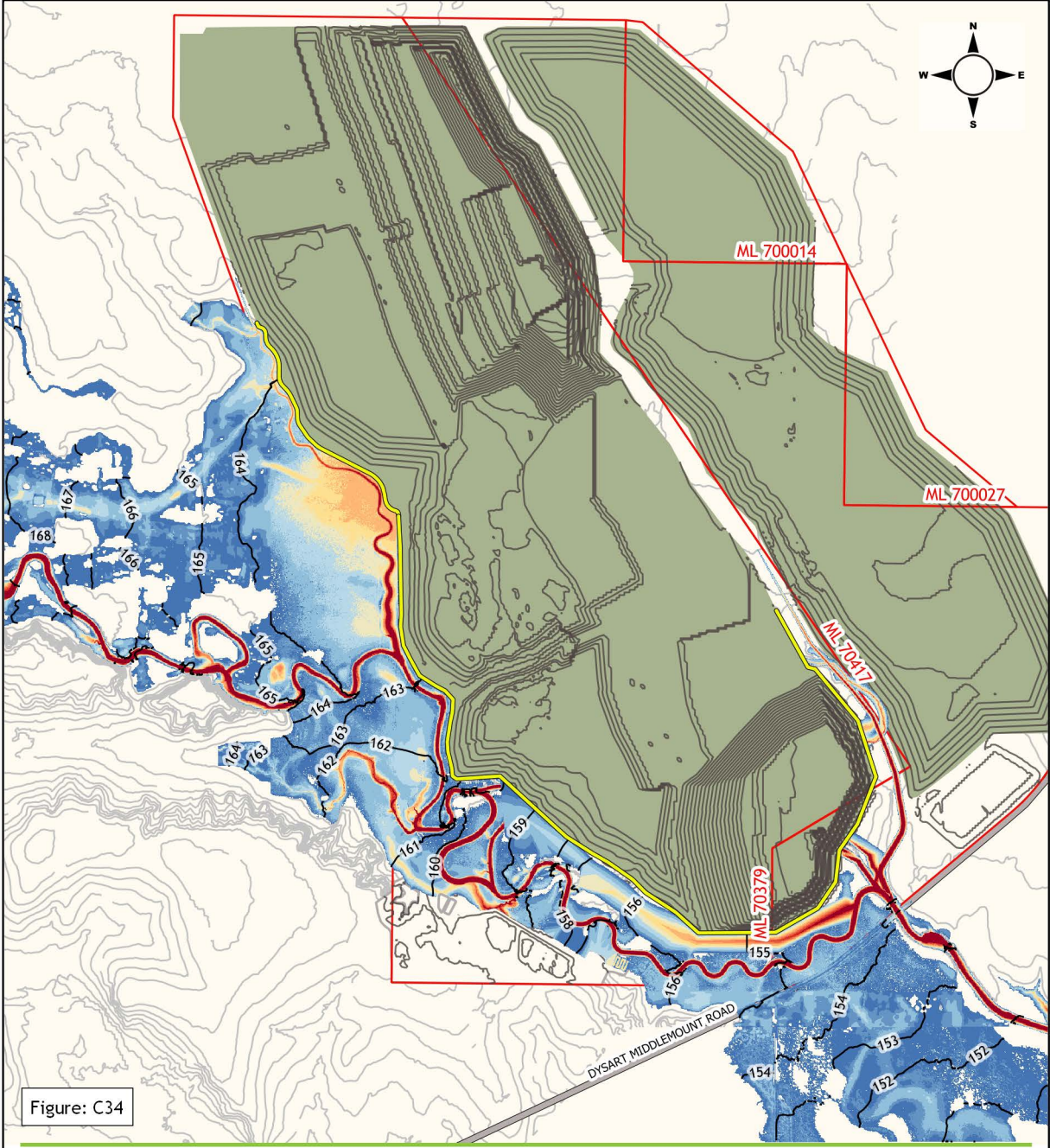
Middlemount Coal Mine
Southern Extension Project

2% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

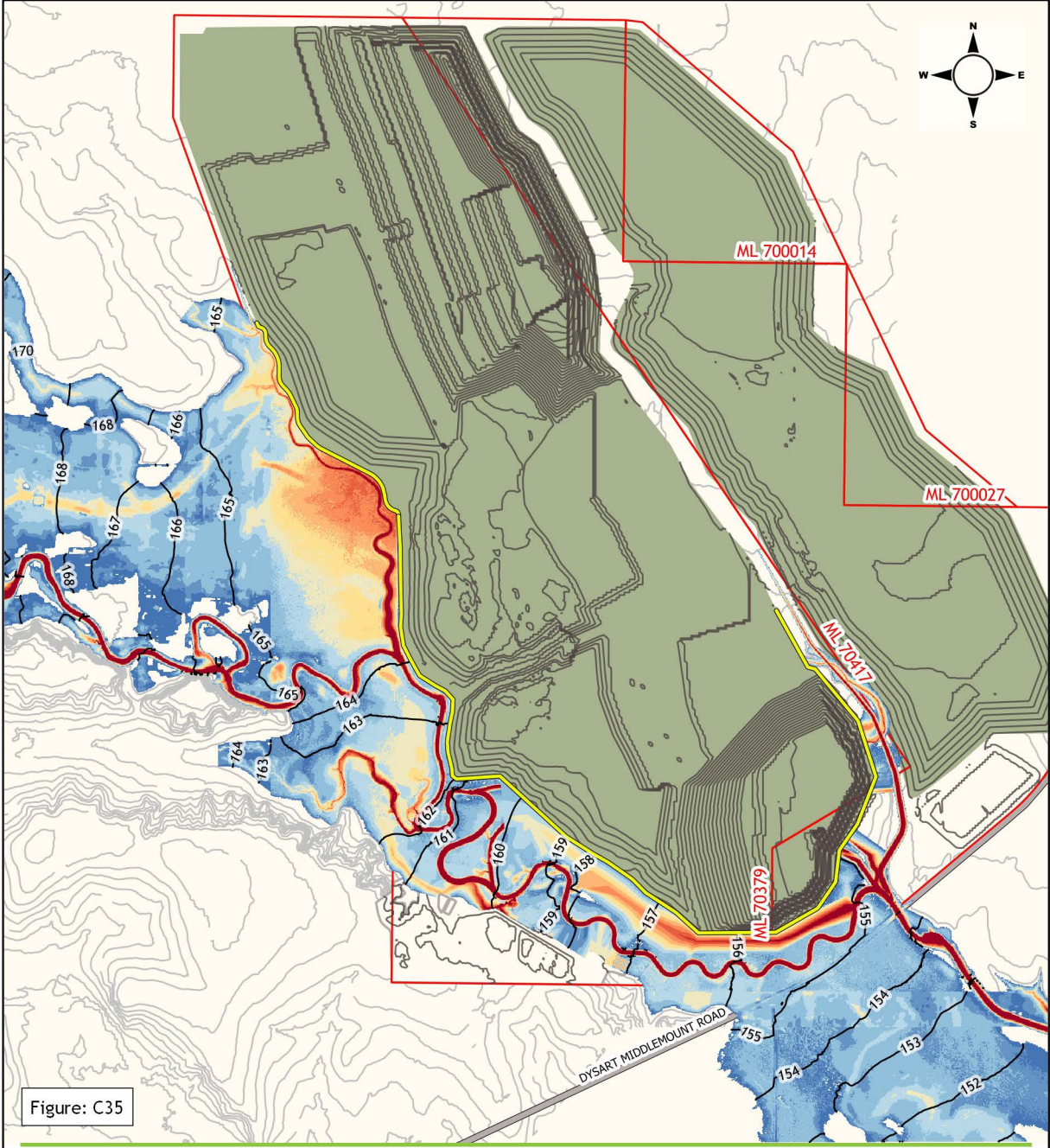


Figure: C35

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

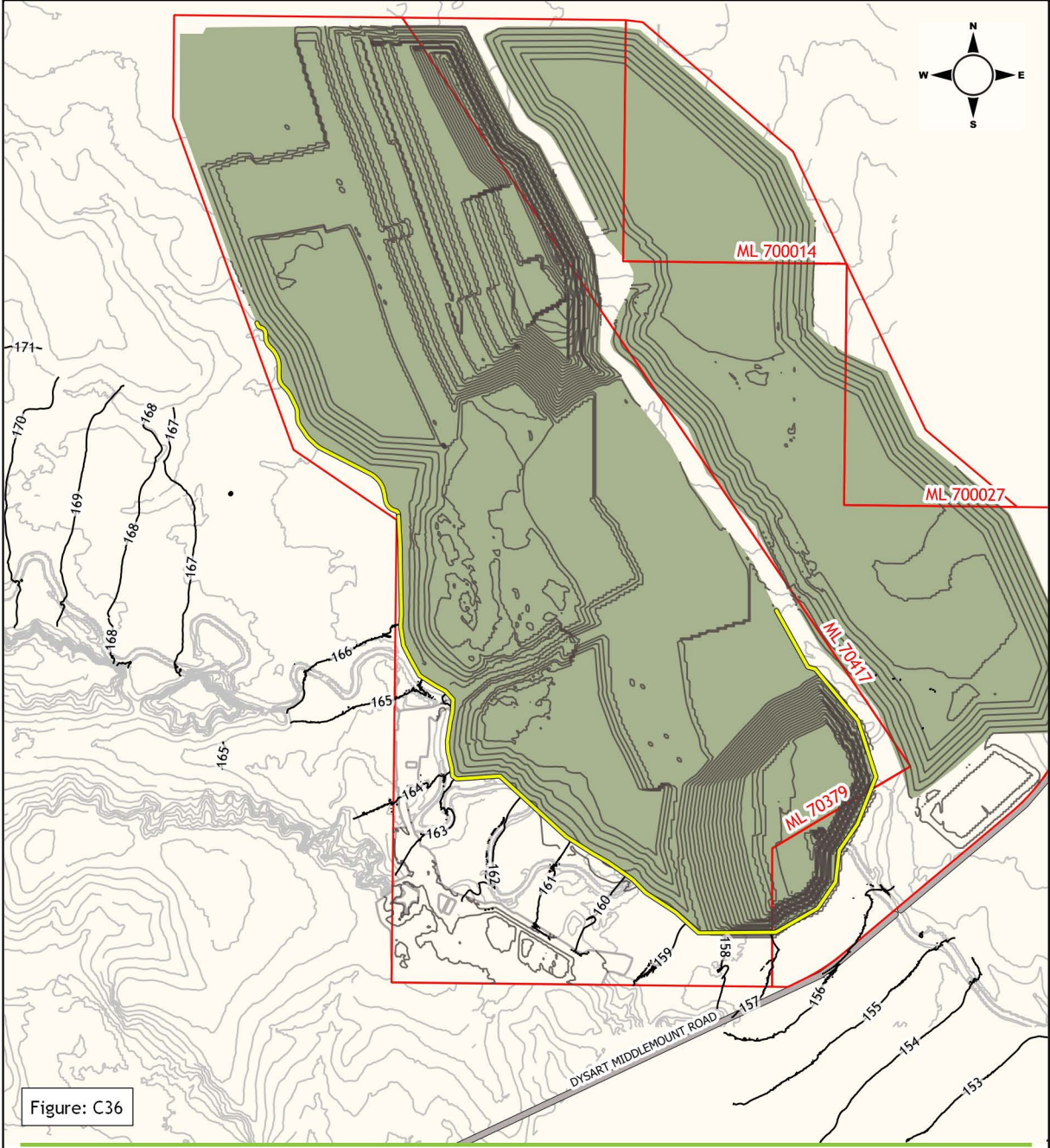


Figure: C36

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

PMF Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

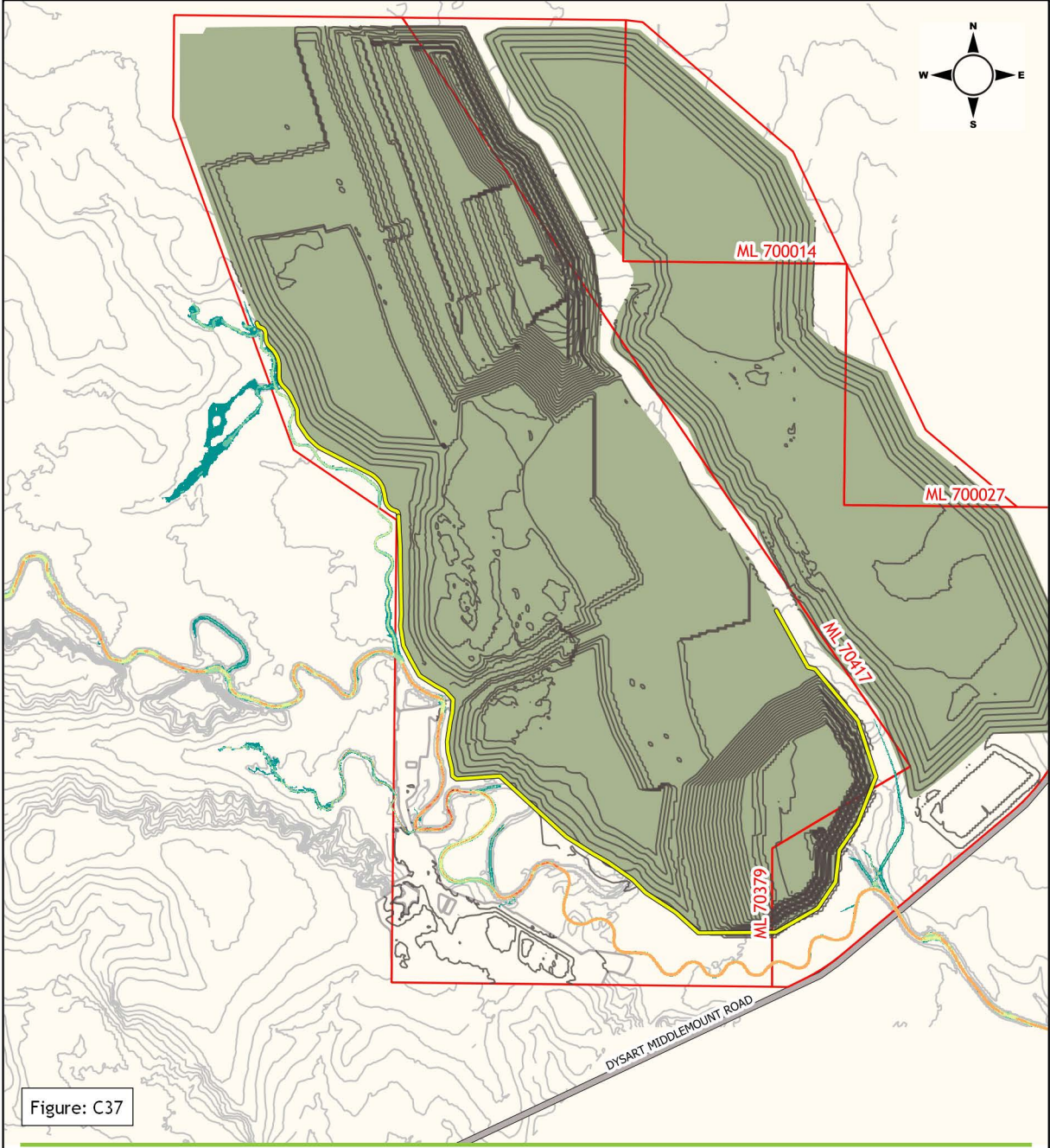


Figure: C37

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

50% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

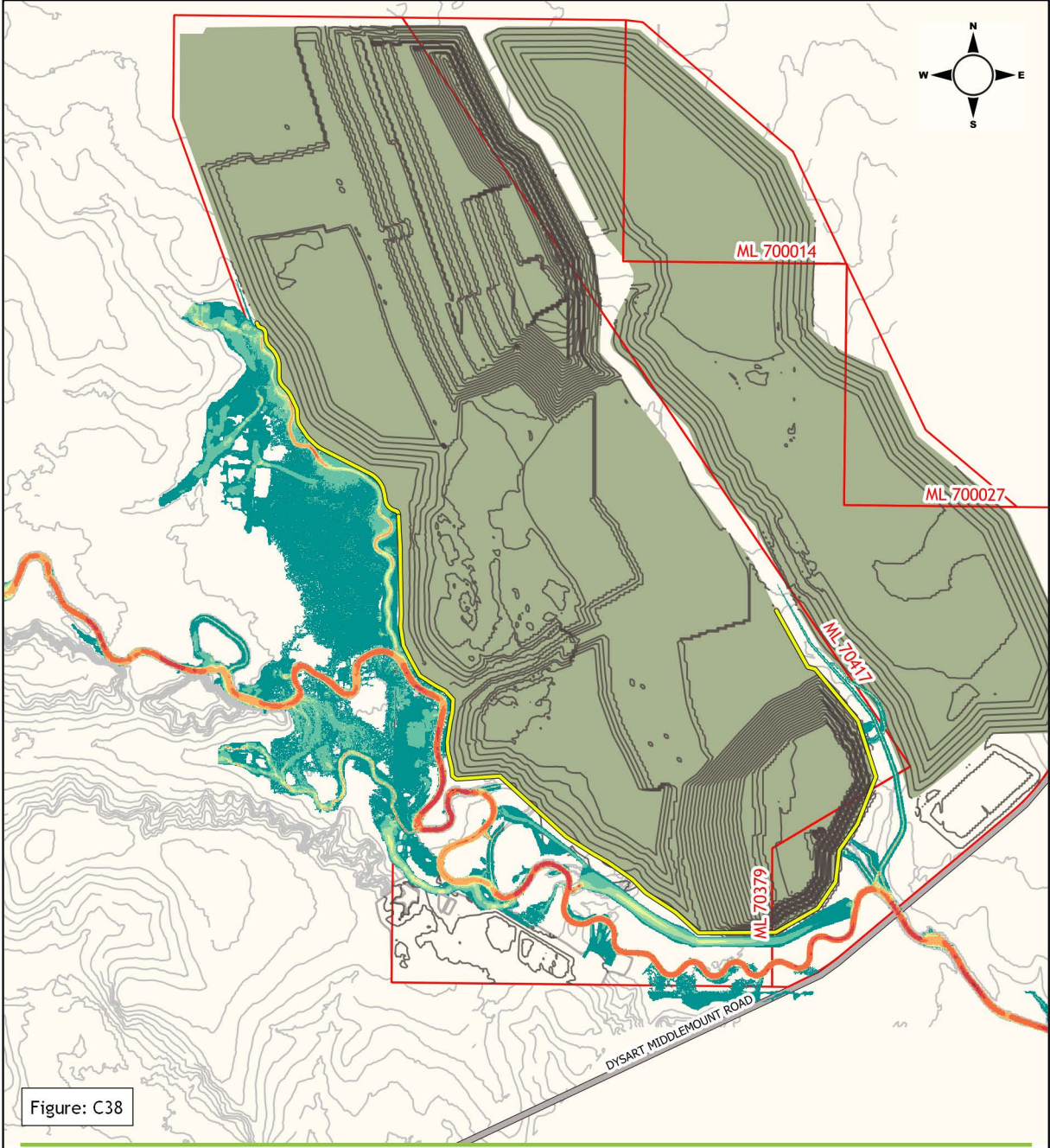


Figure: C38

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine
Southern Extension Project

5% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

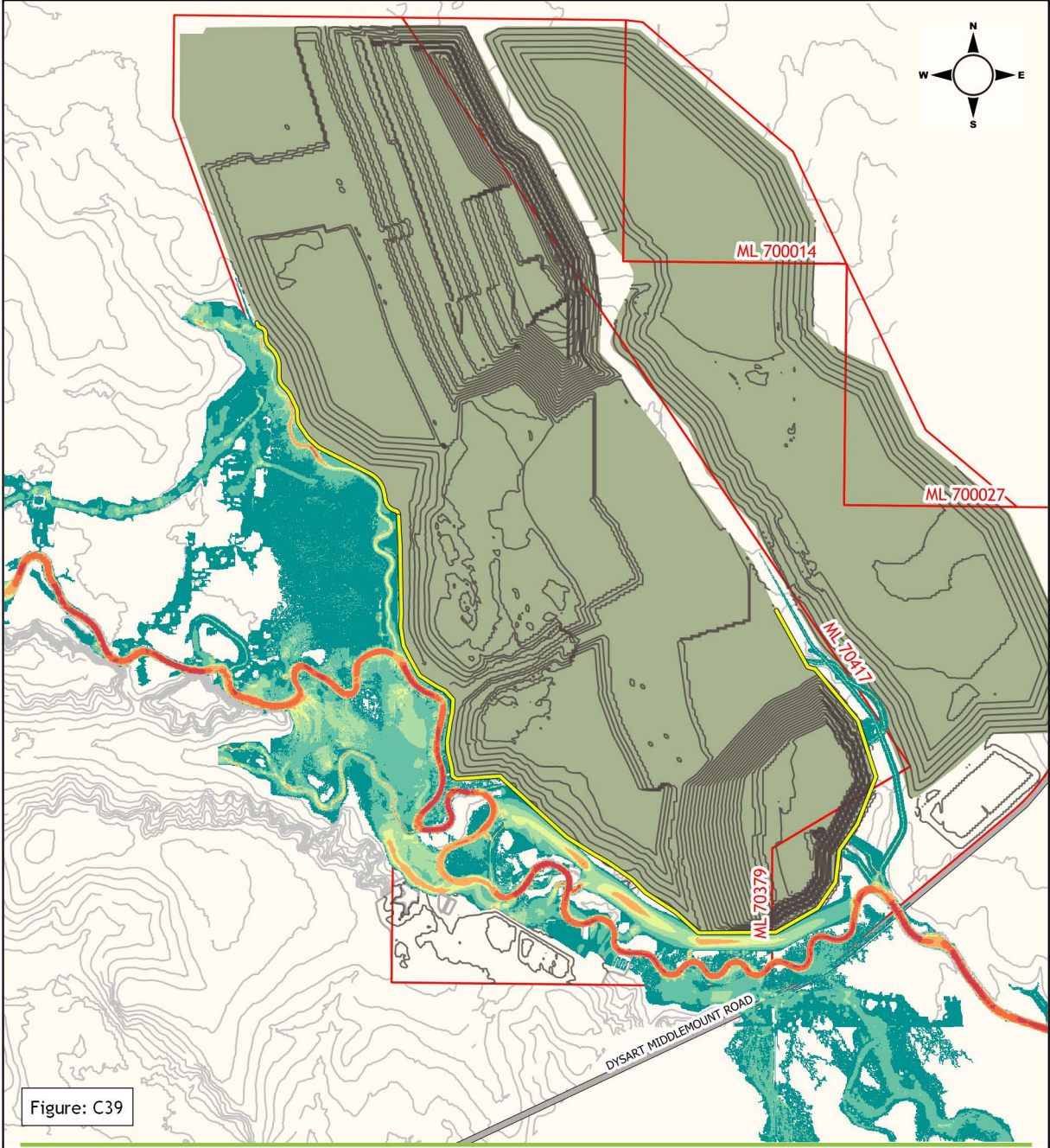


Figure: C39

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

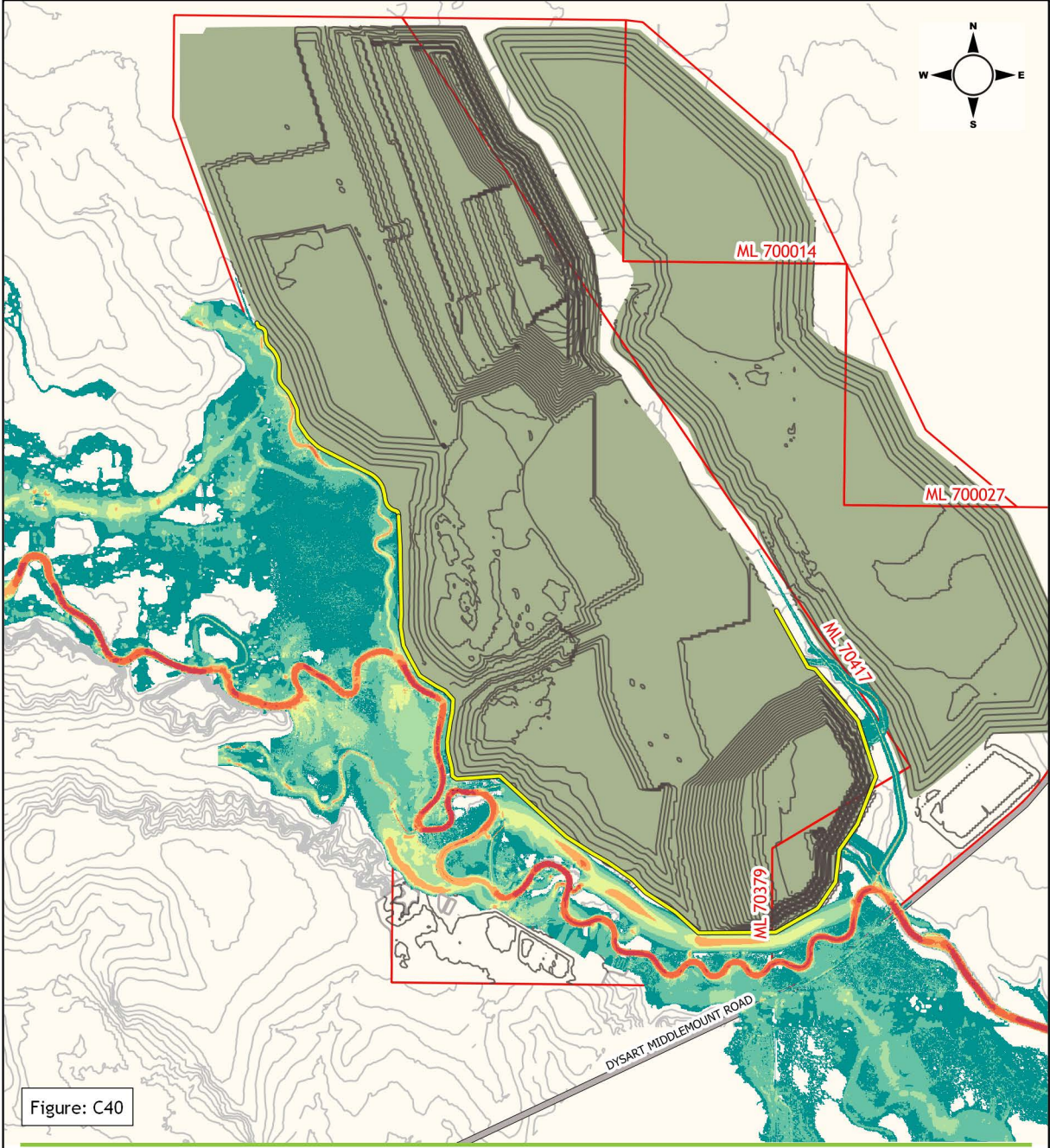


Figure: C40

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

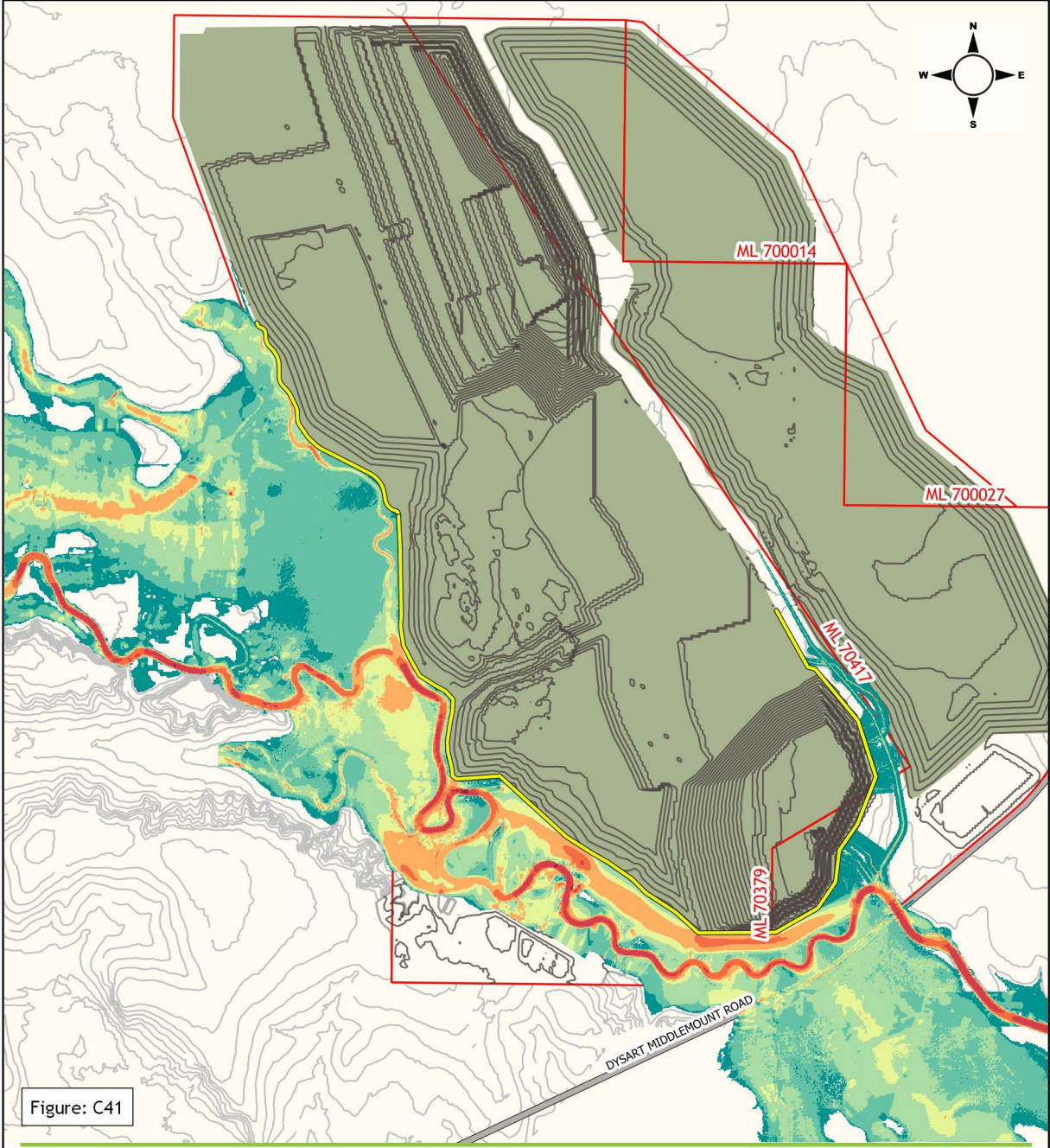


Figure: C41

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

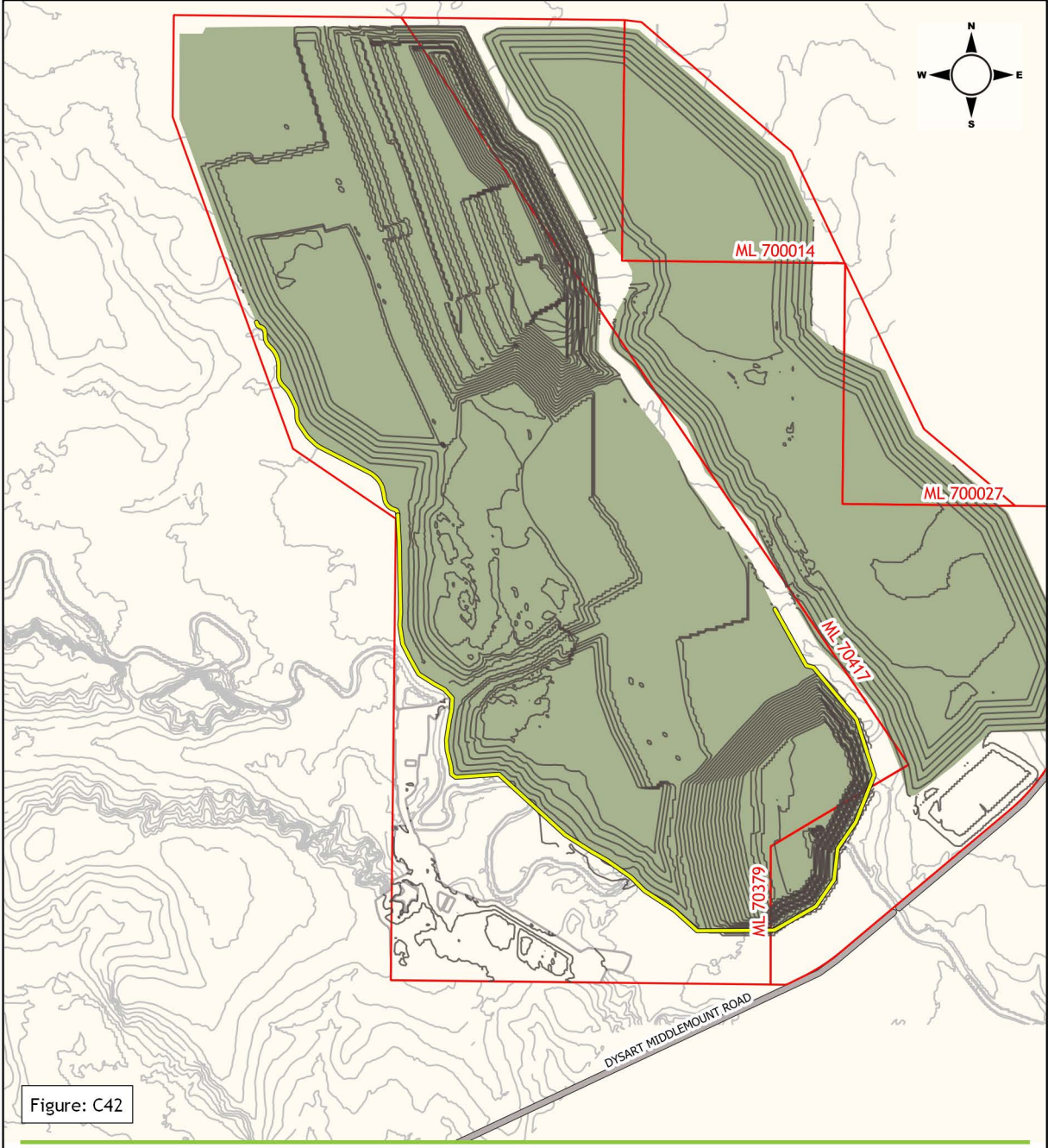


Figure: C42

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

PMF Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Appendix D – Flood Impact maps

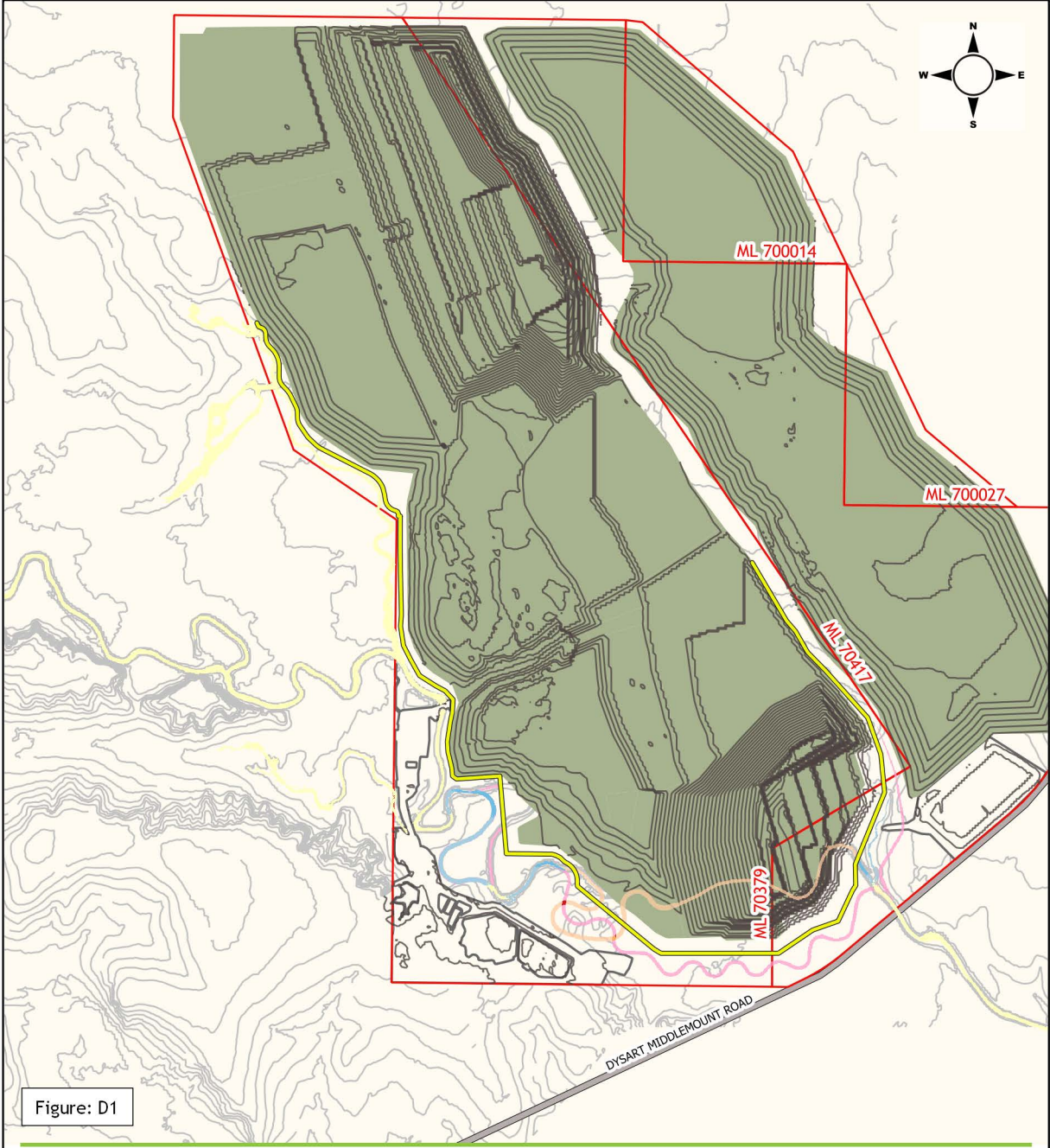


Figure: D1

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

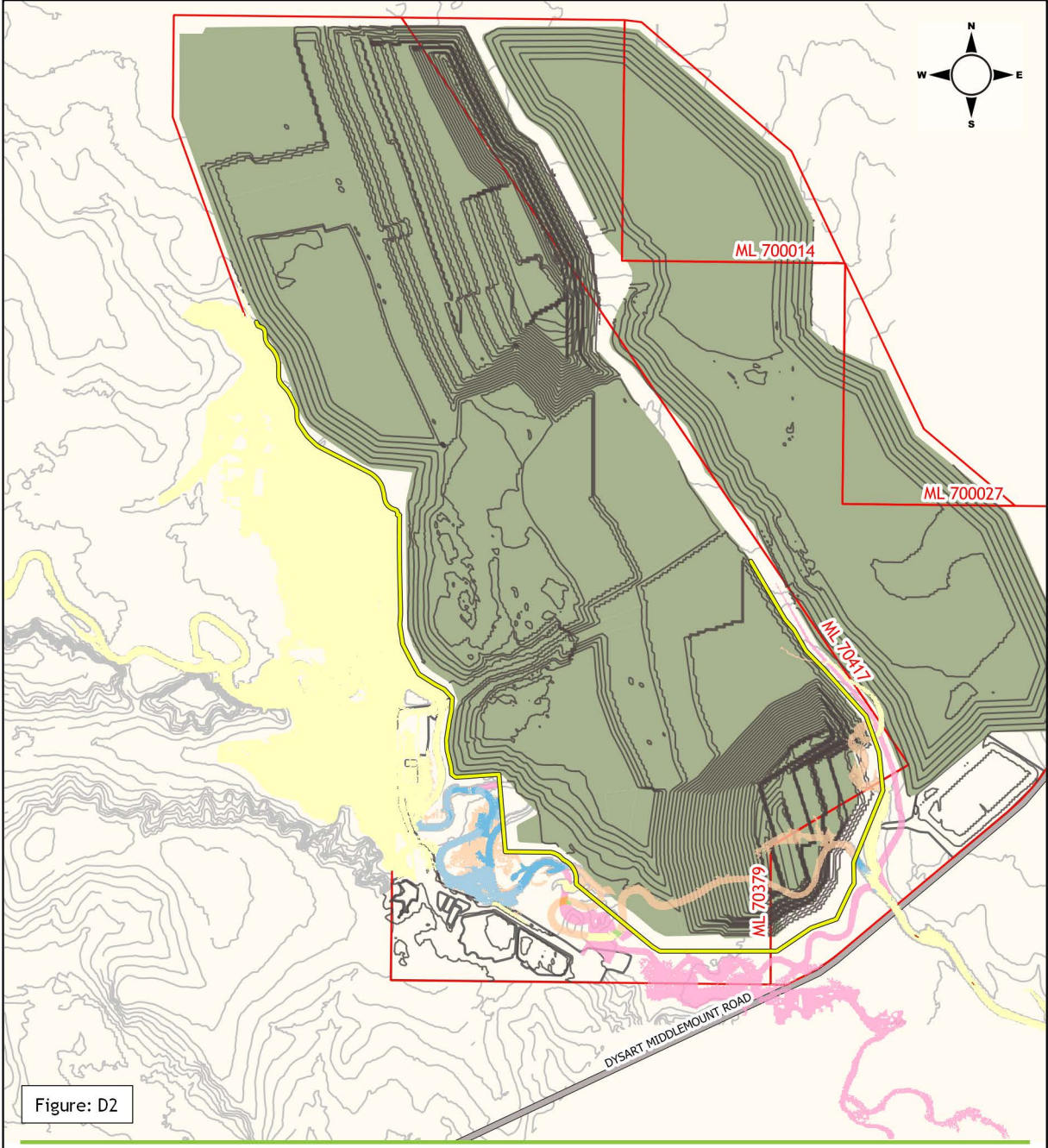


Figure: D2

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

5% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

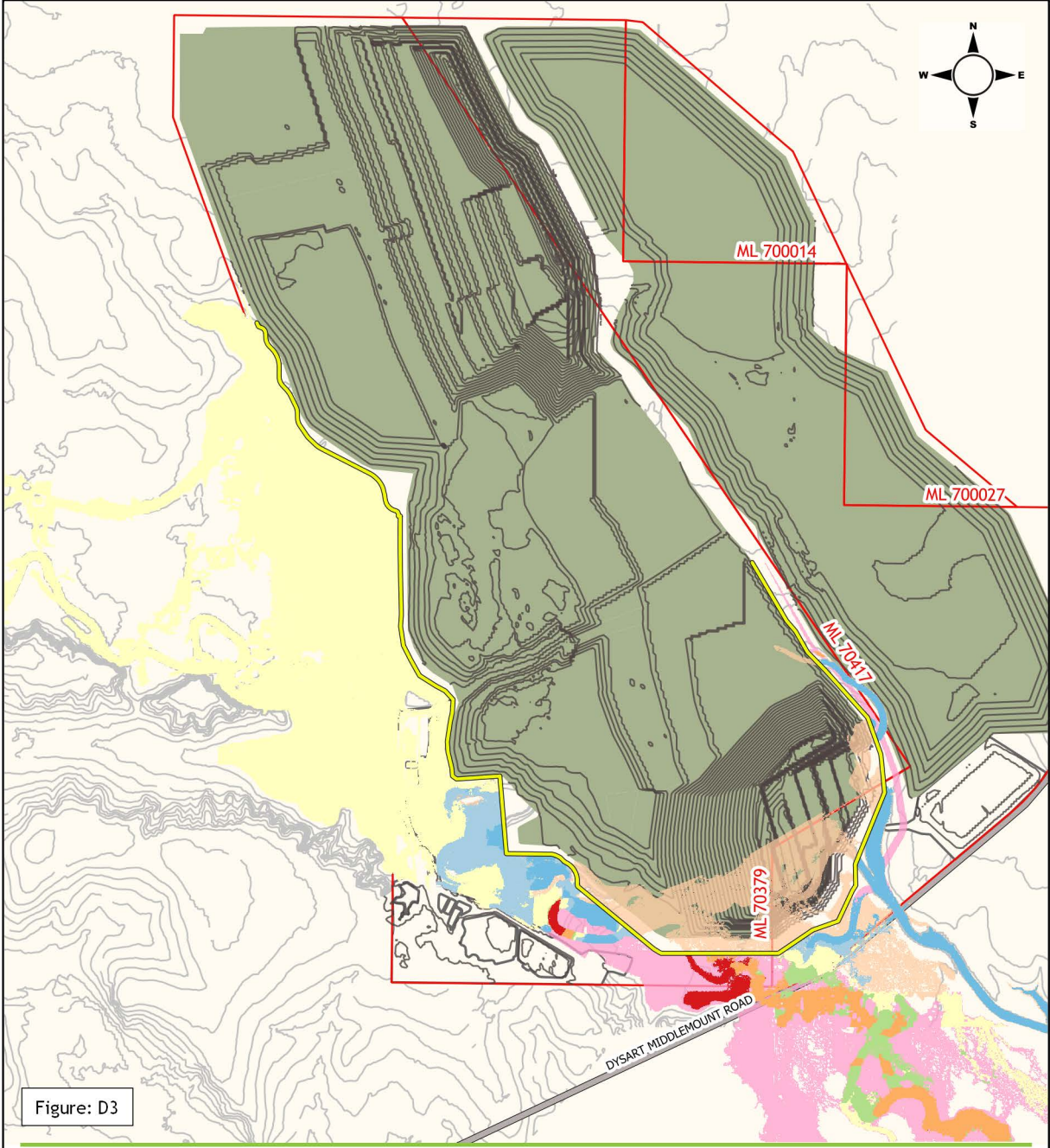


Figure: D3

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

2% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

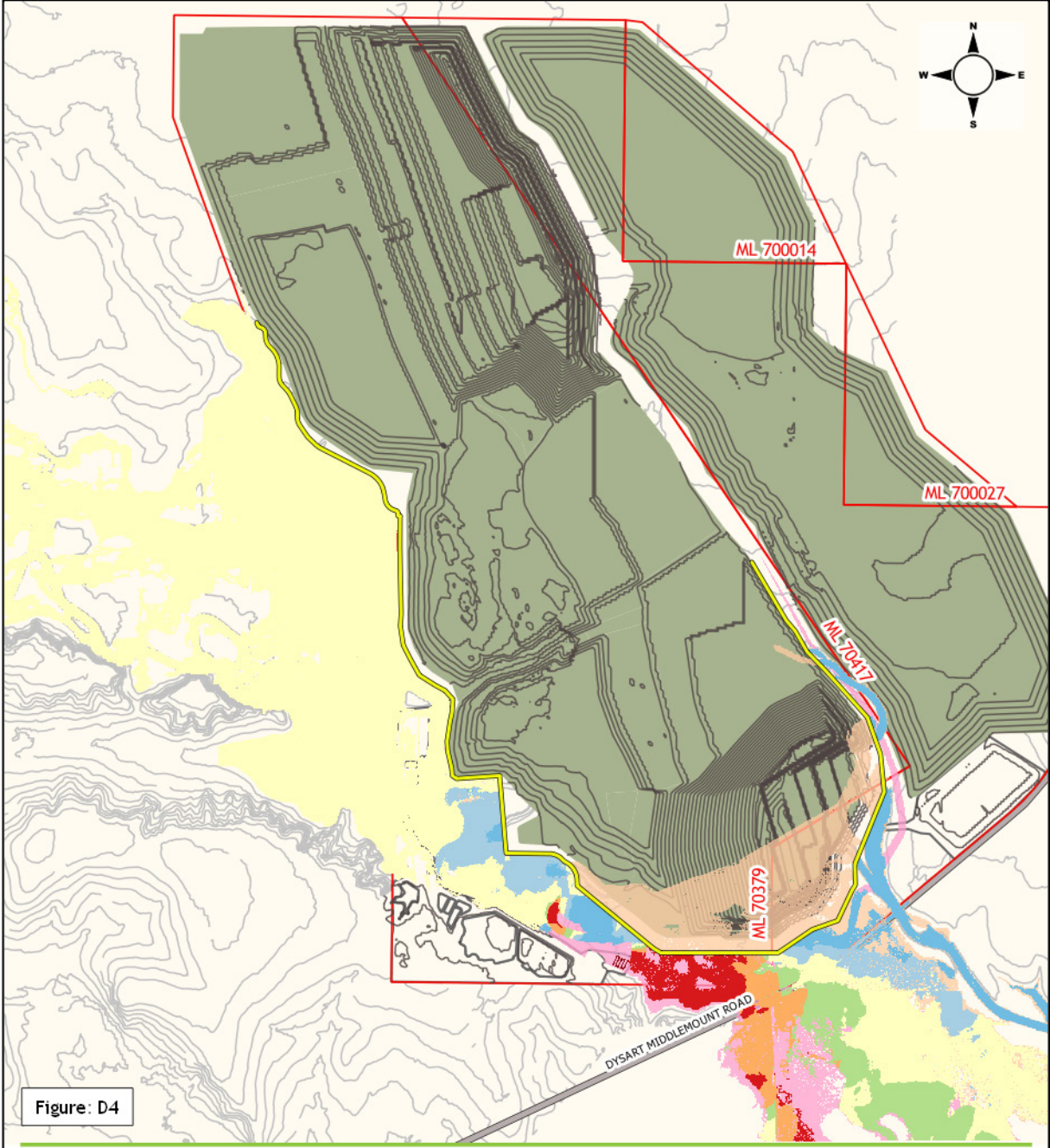


Figure: D4

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

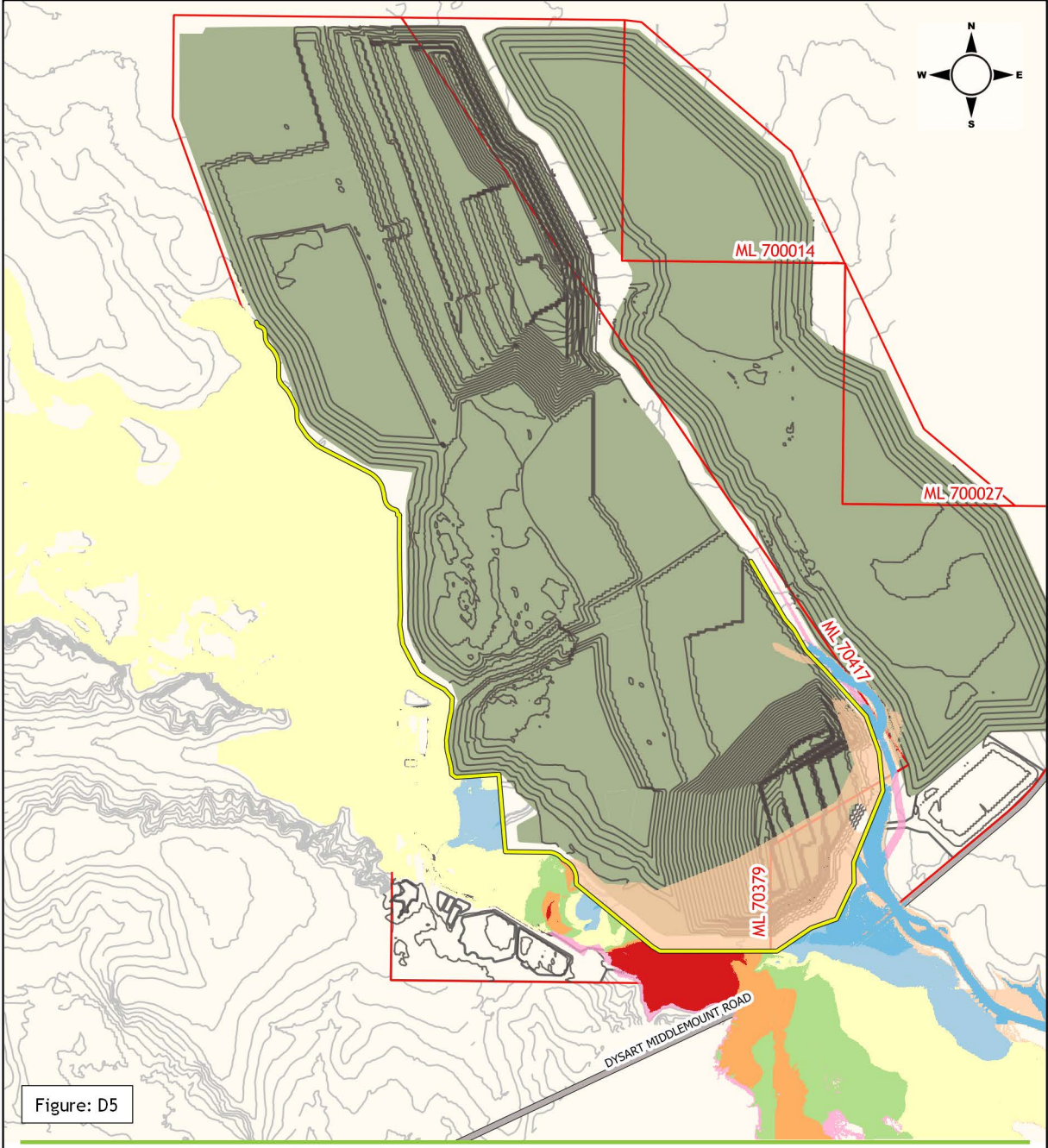
Middlemount Coal Mine Southern Extension Project

1% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

0.1% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

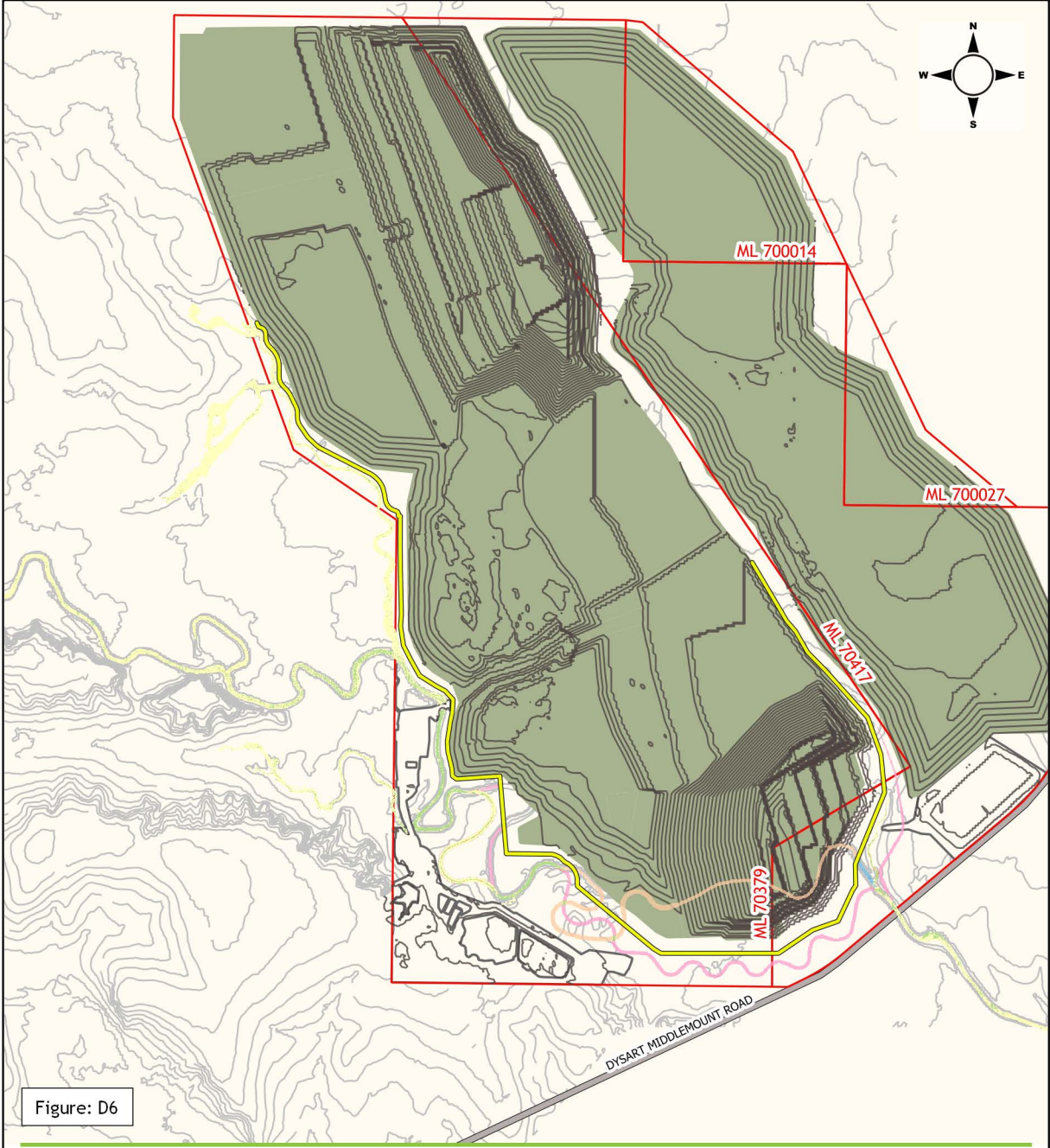


Figure: D6

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

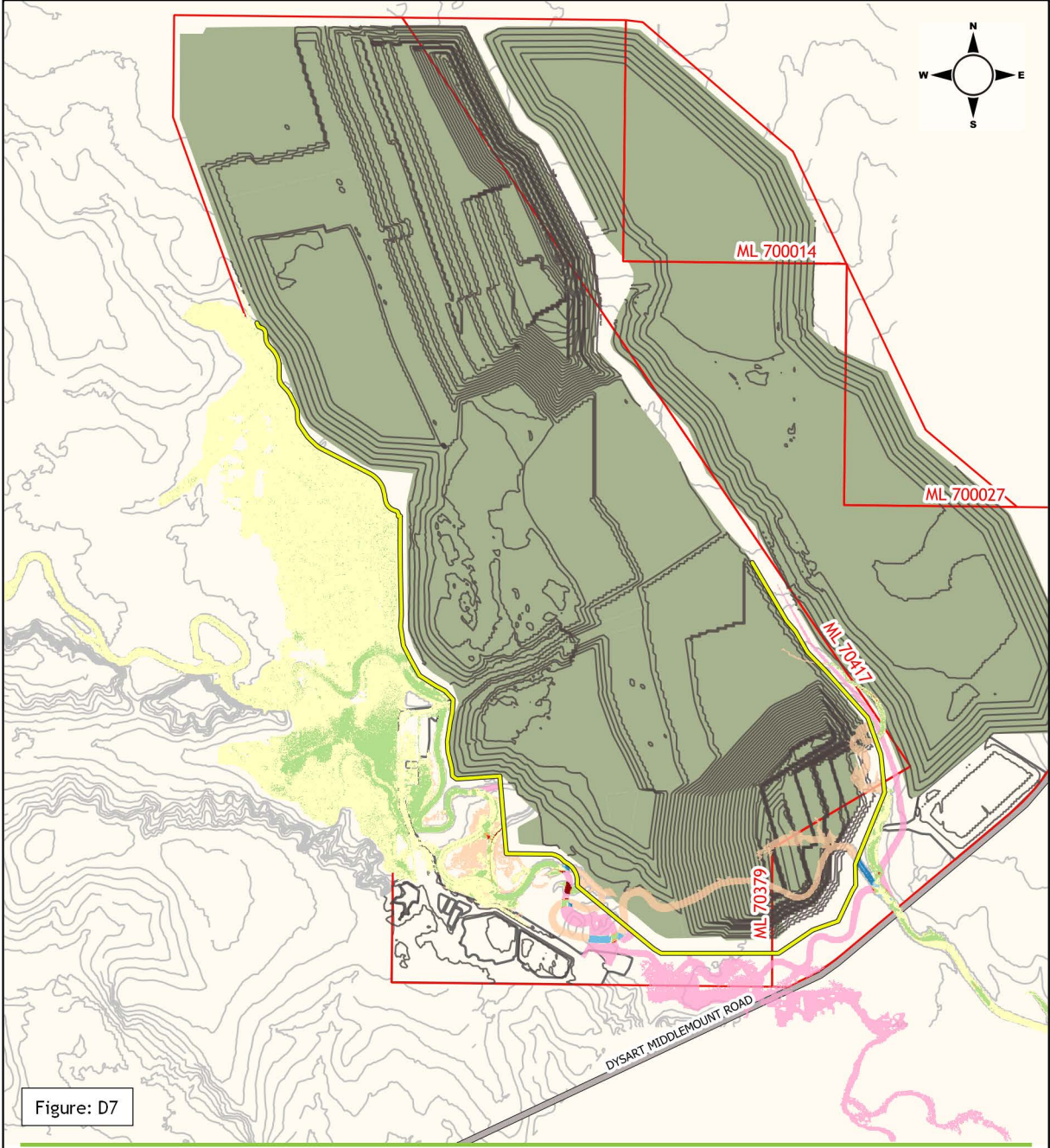


Figure: D7

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

5% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

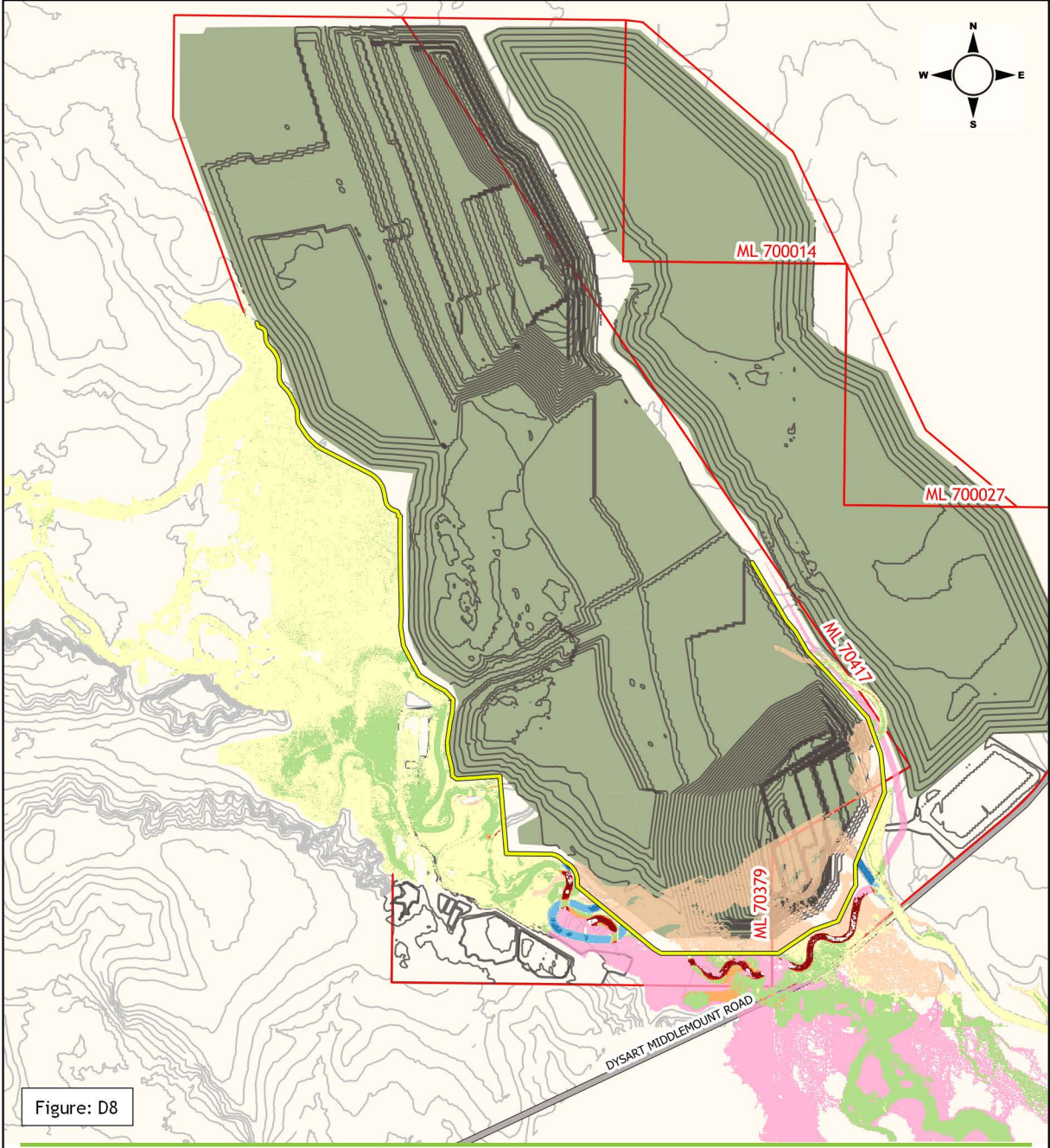


Figure: D8

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

2% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

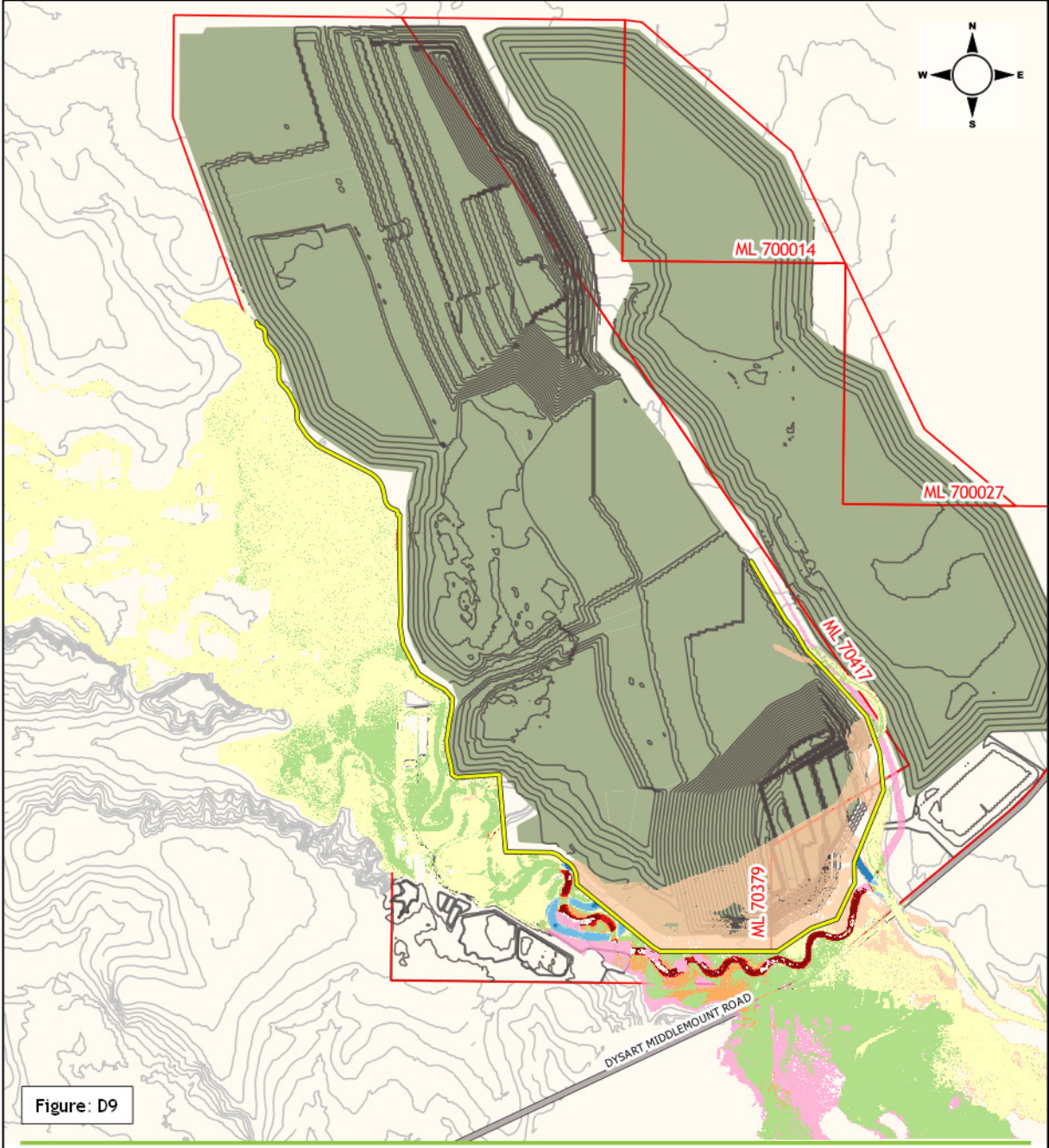


Figure: D9

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

1% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

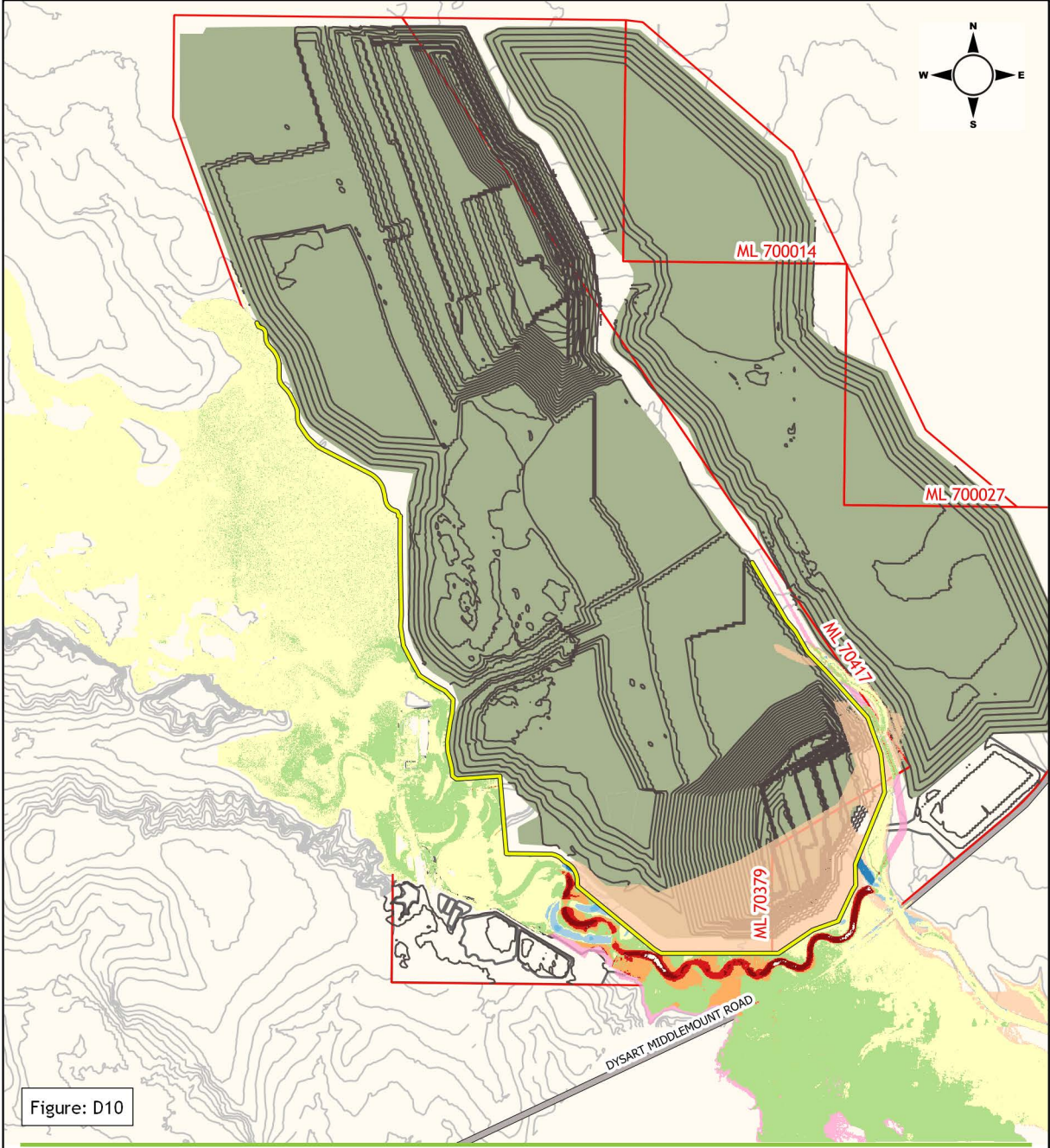


Figure: D10

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

0.1% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

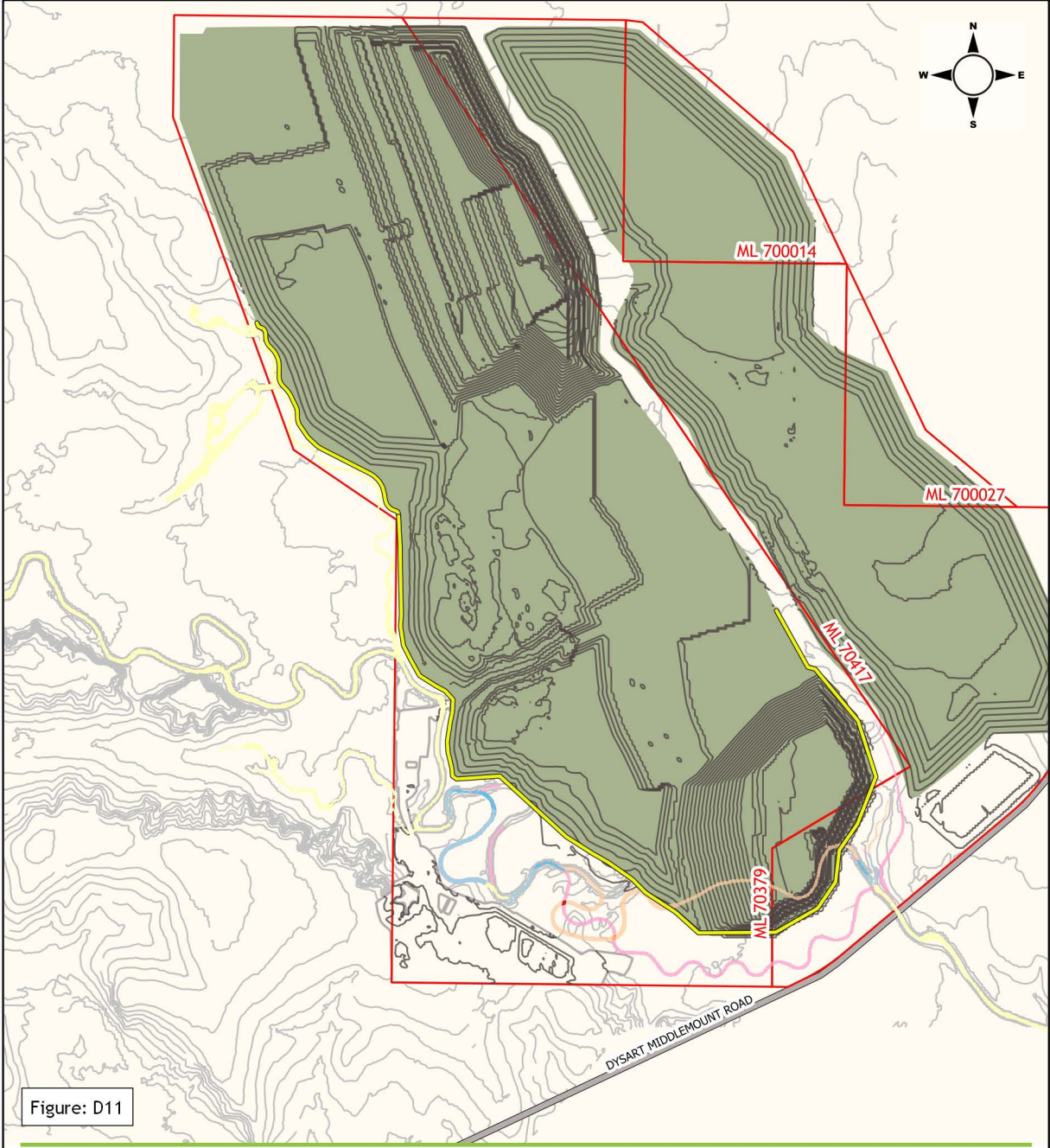


Figure: D11

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

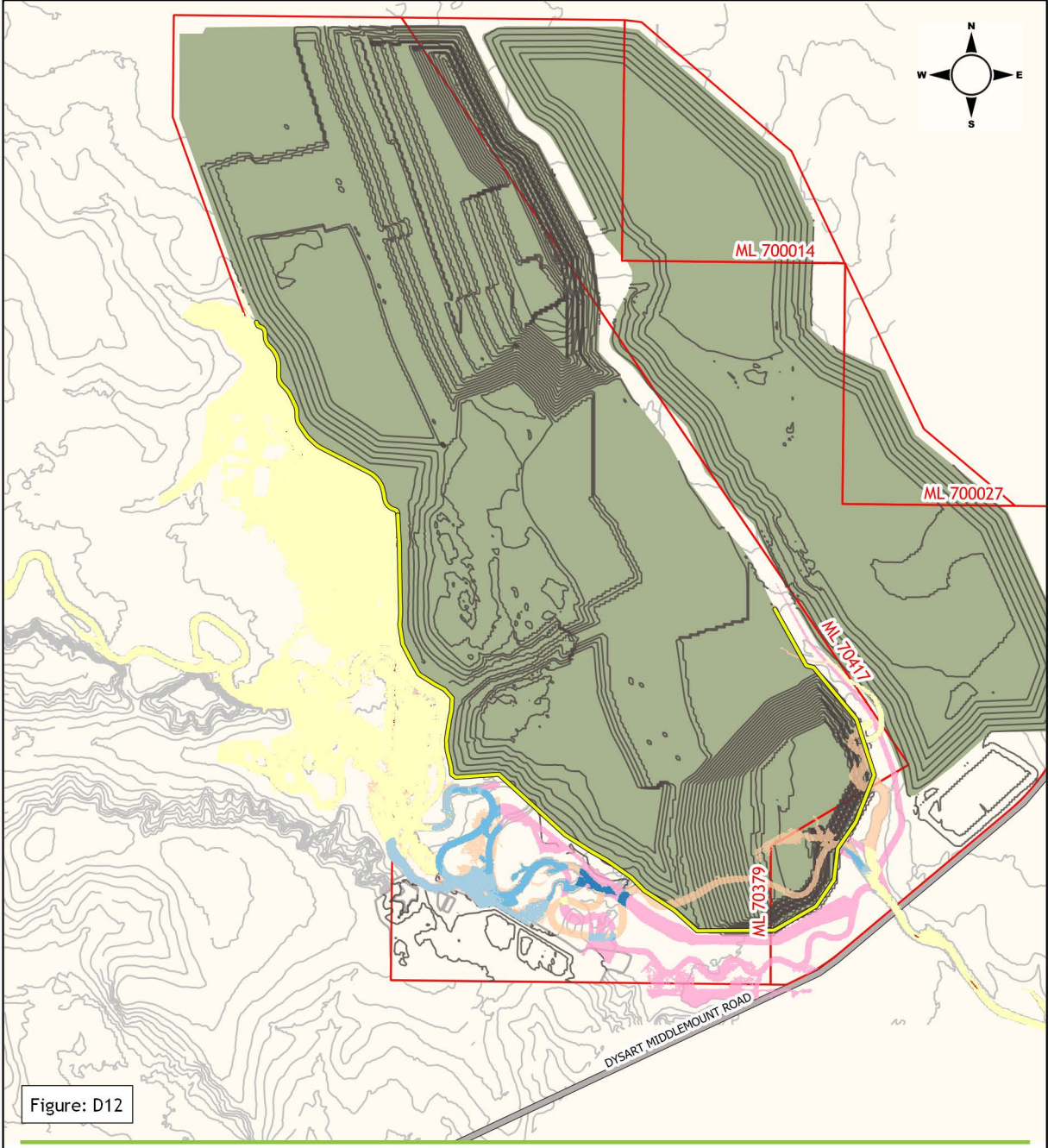


Figure: D12

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

5% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

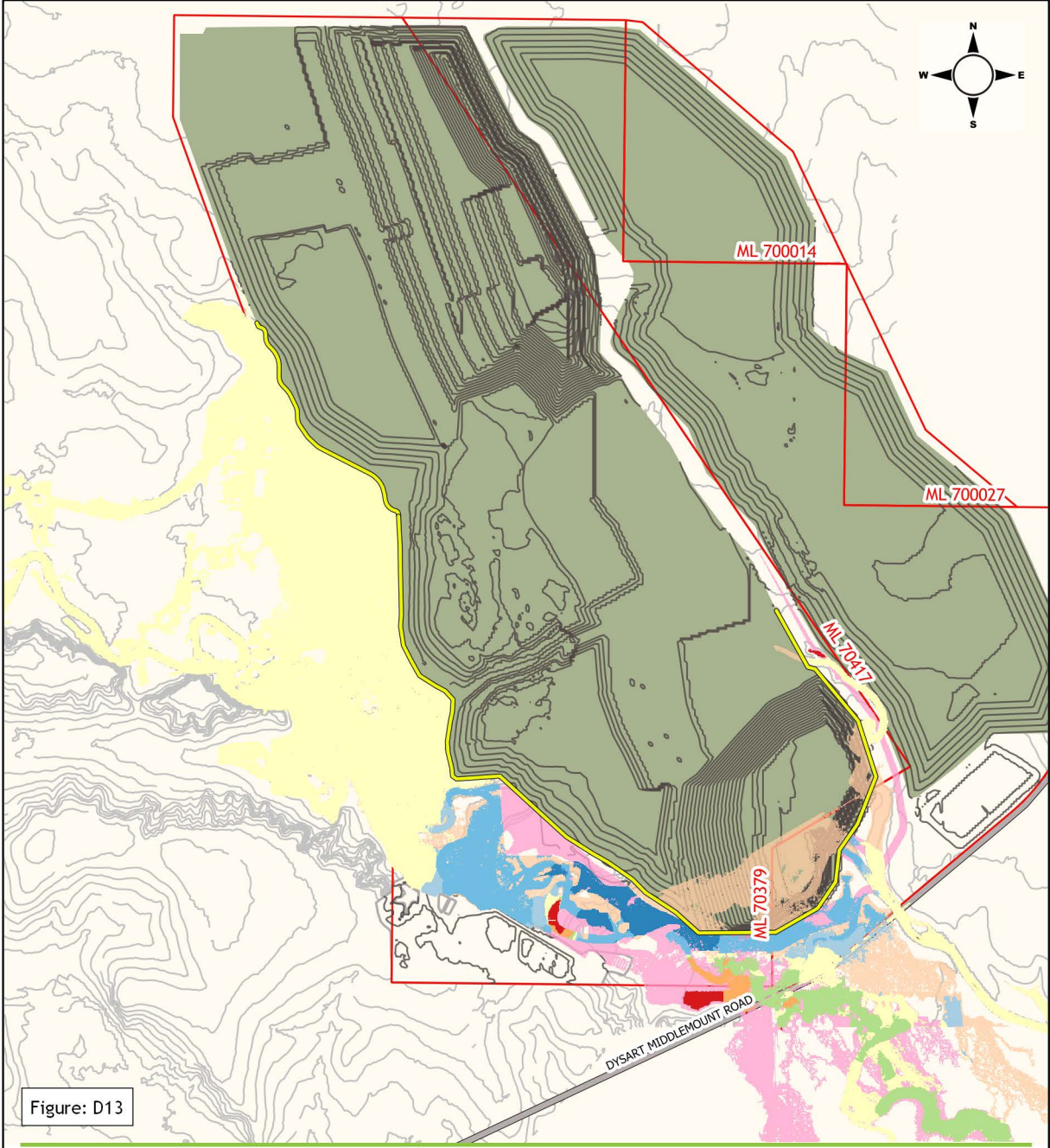


Figure: D13

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

2% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

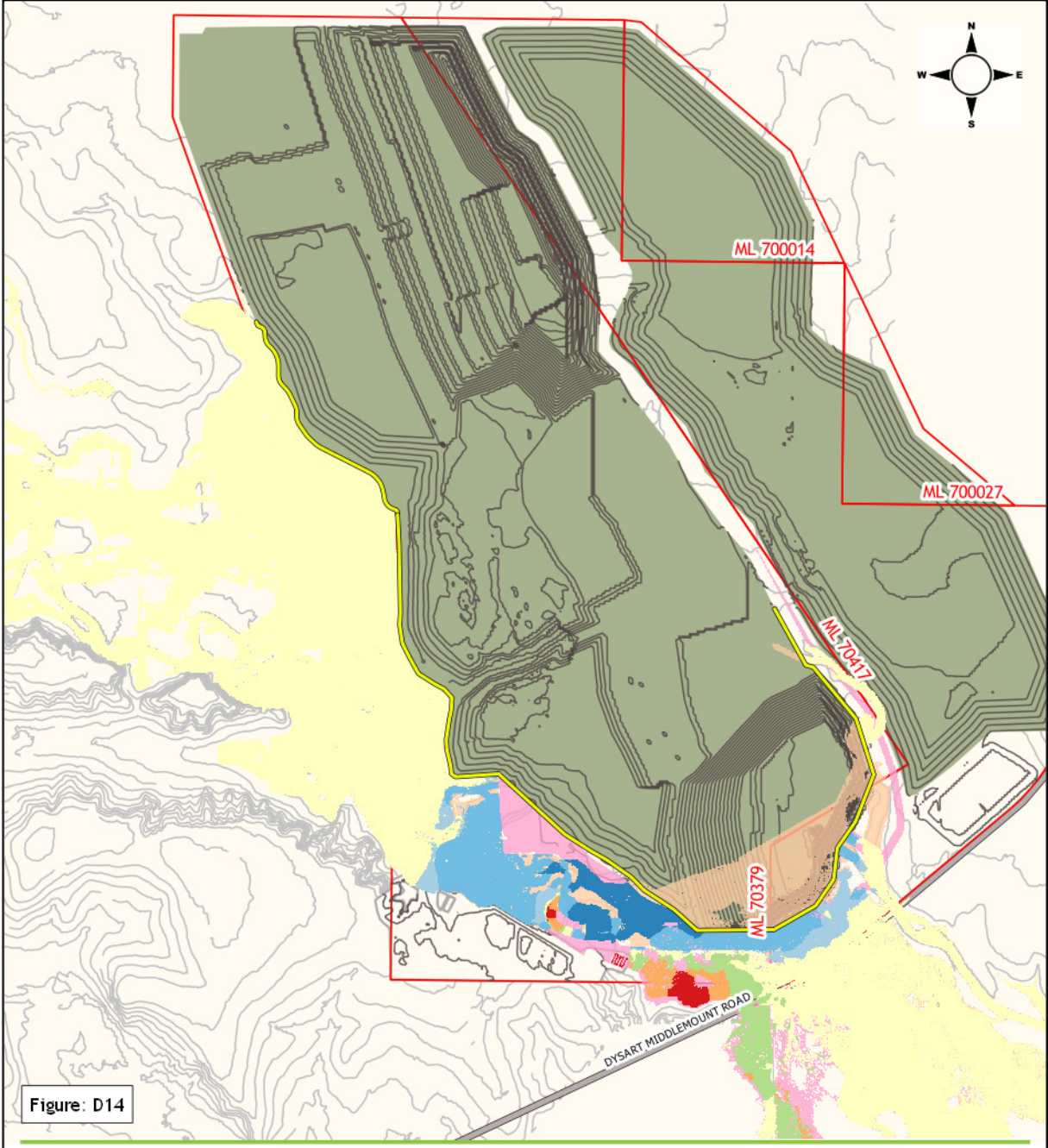


Figure: D14

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

1% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

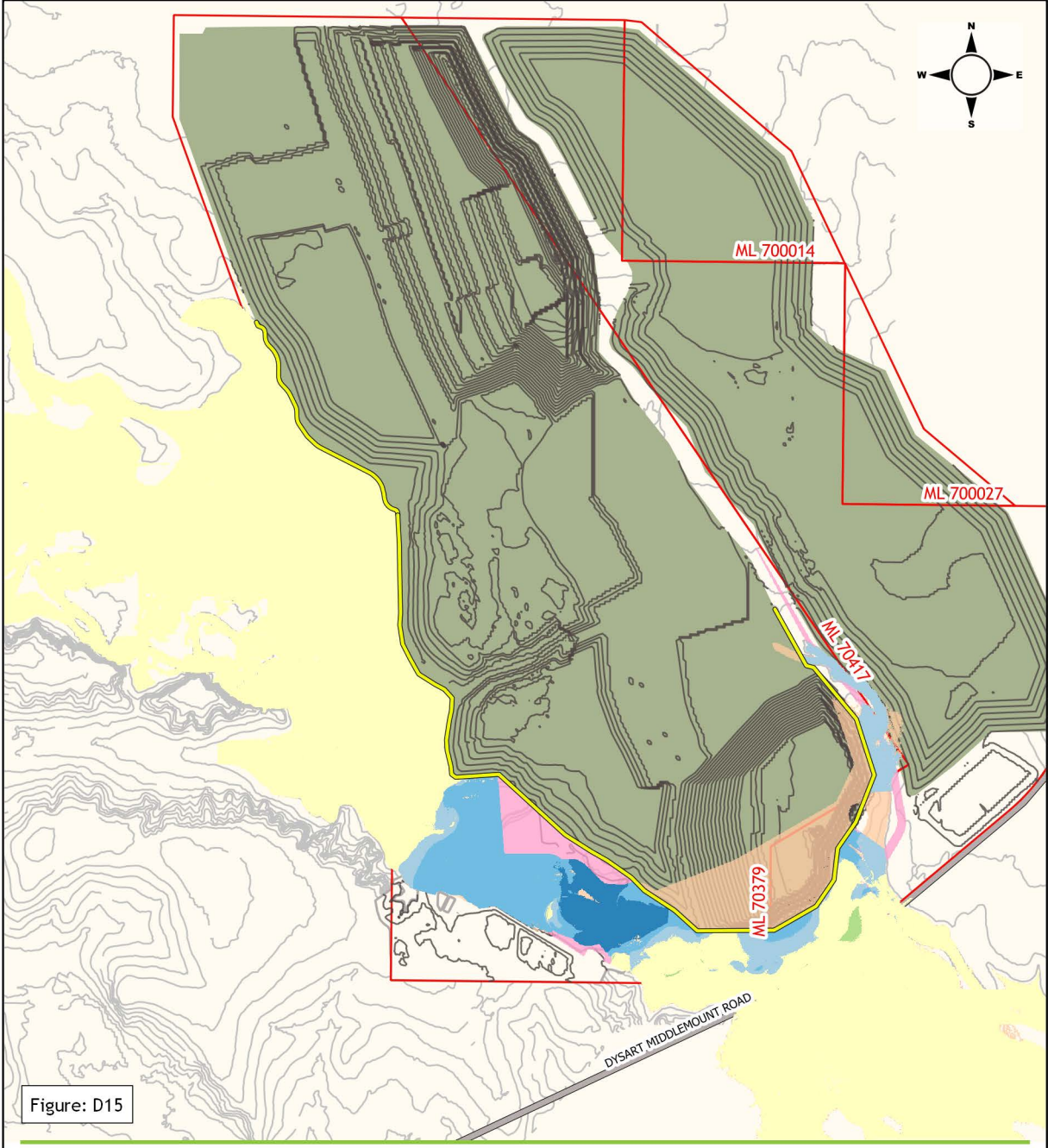


Figure: D15

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

0.1% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

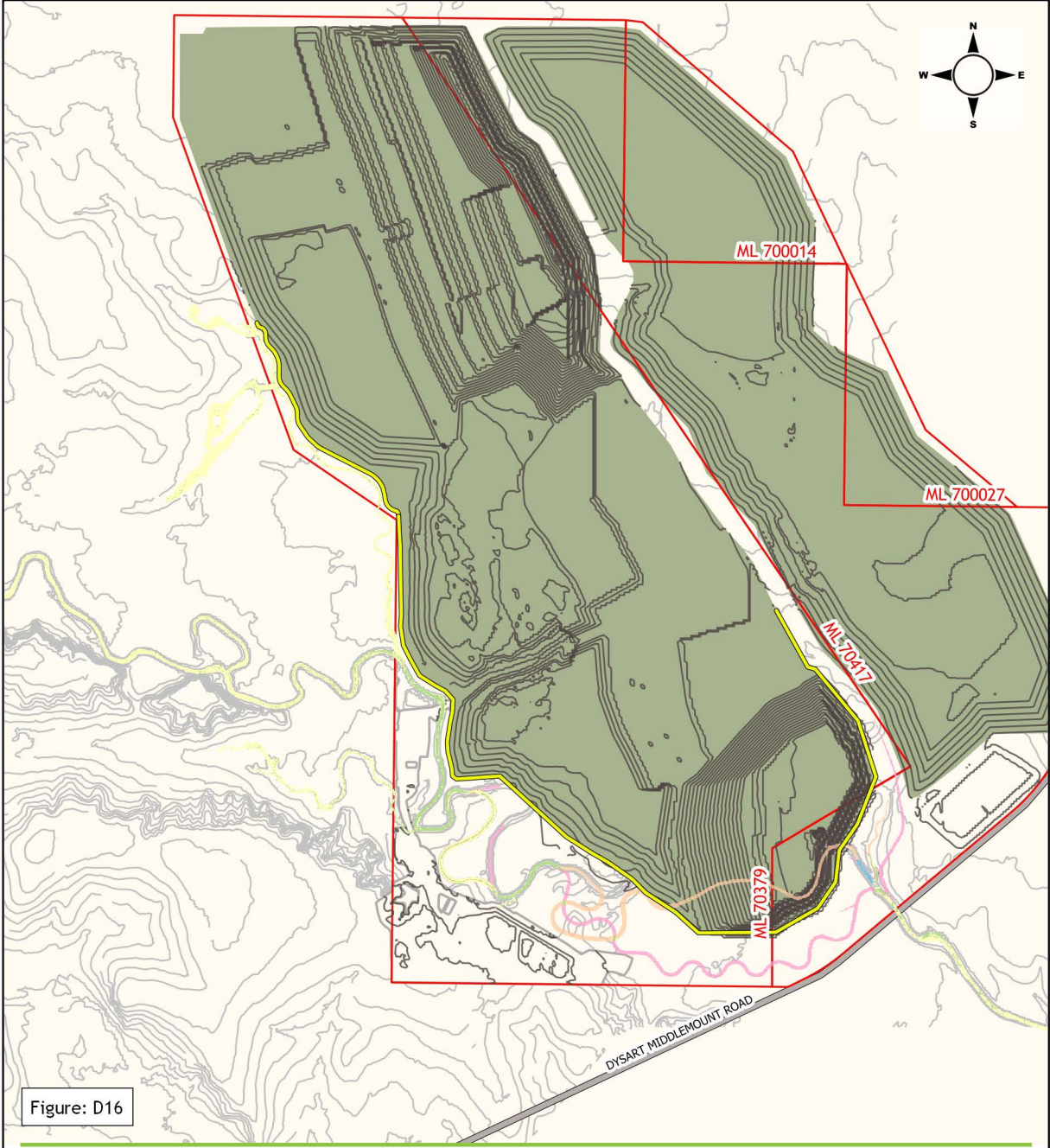


Figure: D16

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

50% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

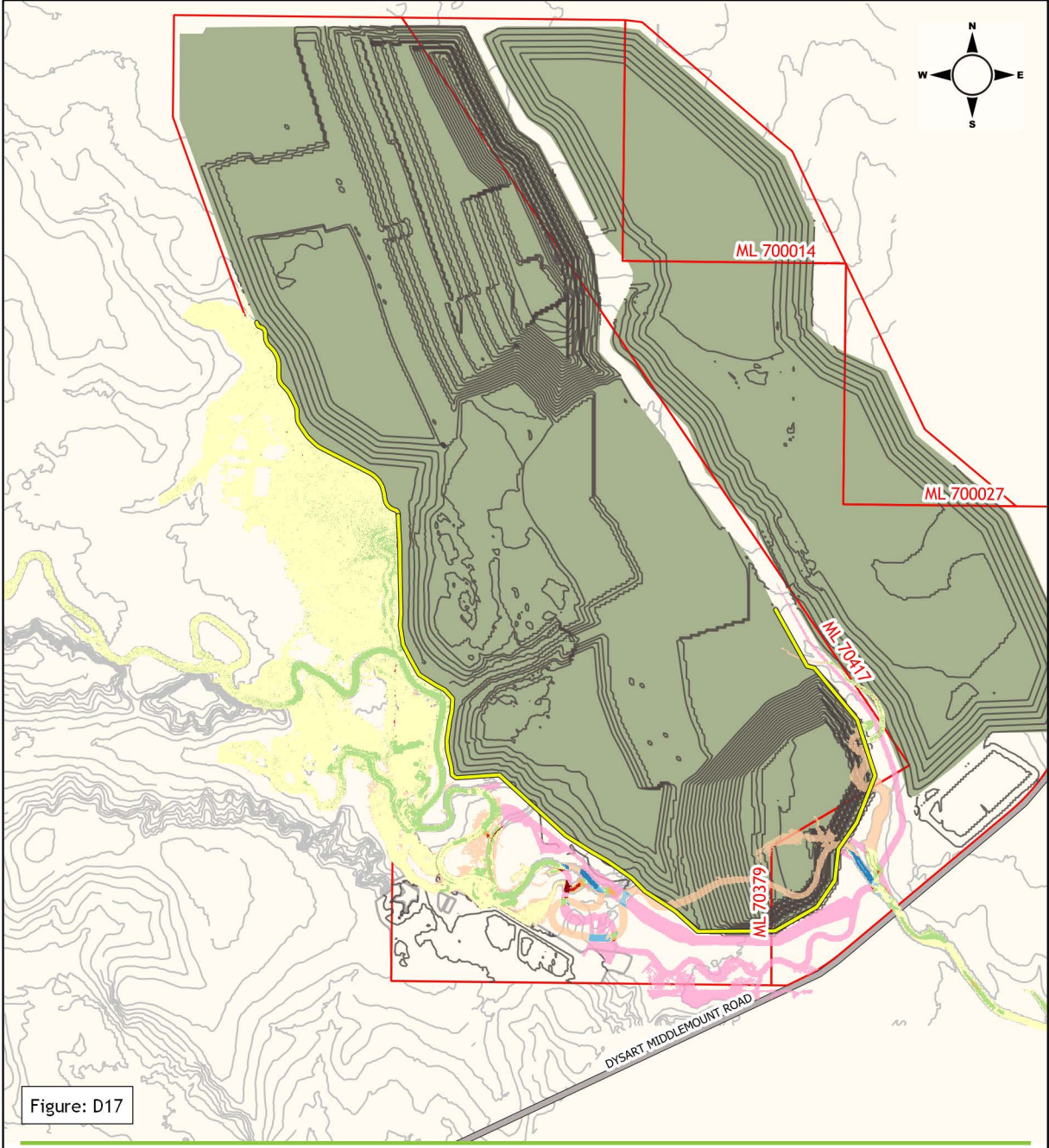


Figure: D17

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

5% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

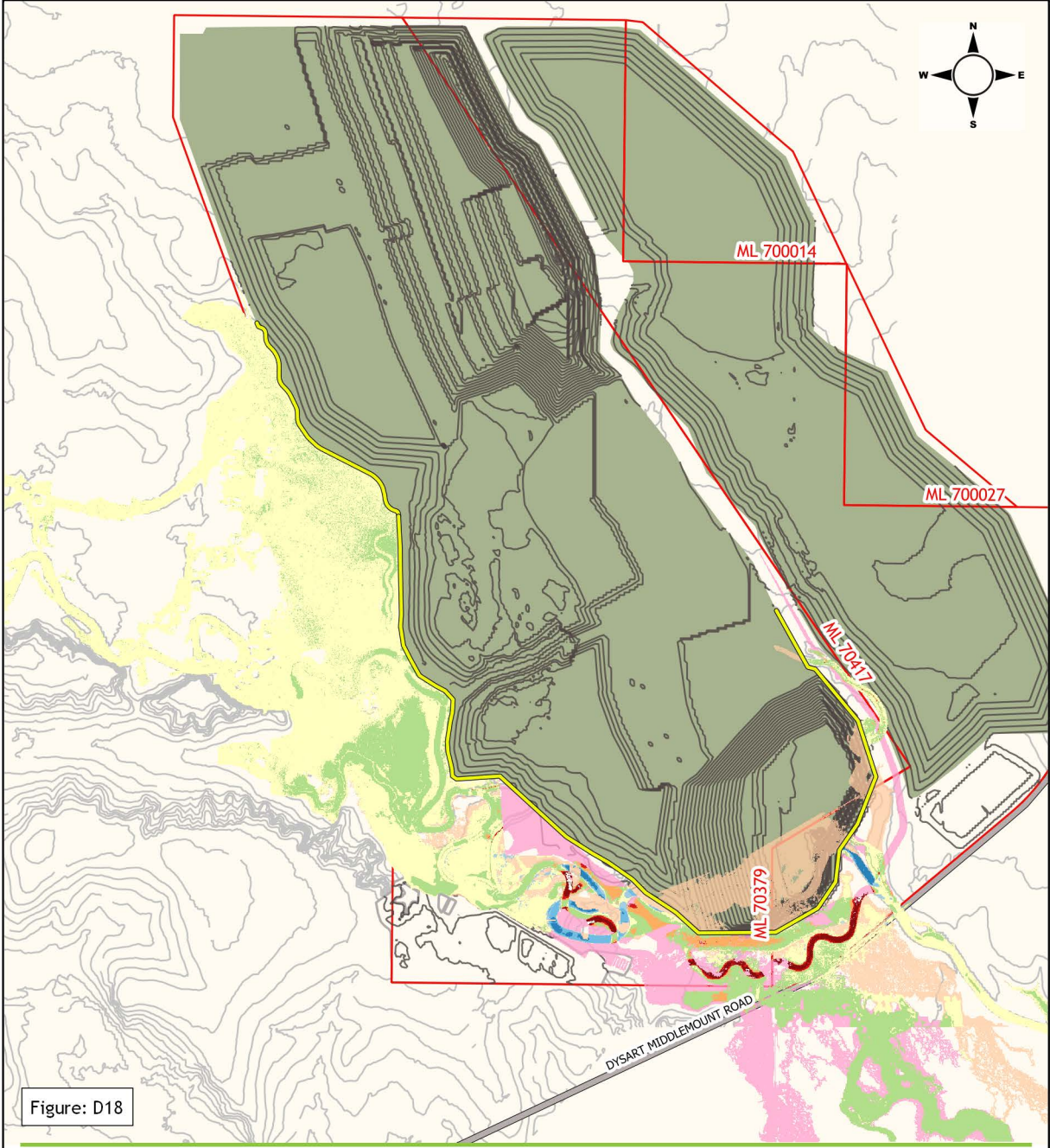


Figure: D18

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

2% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

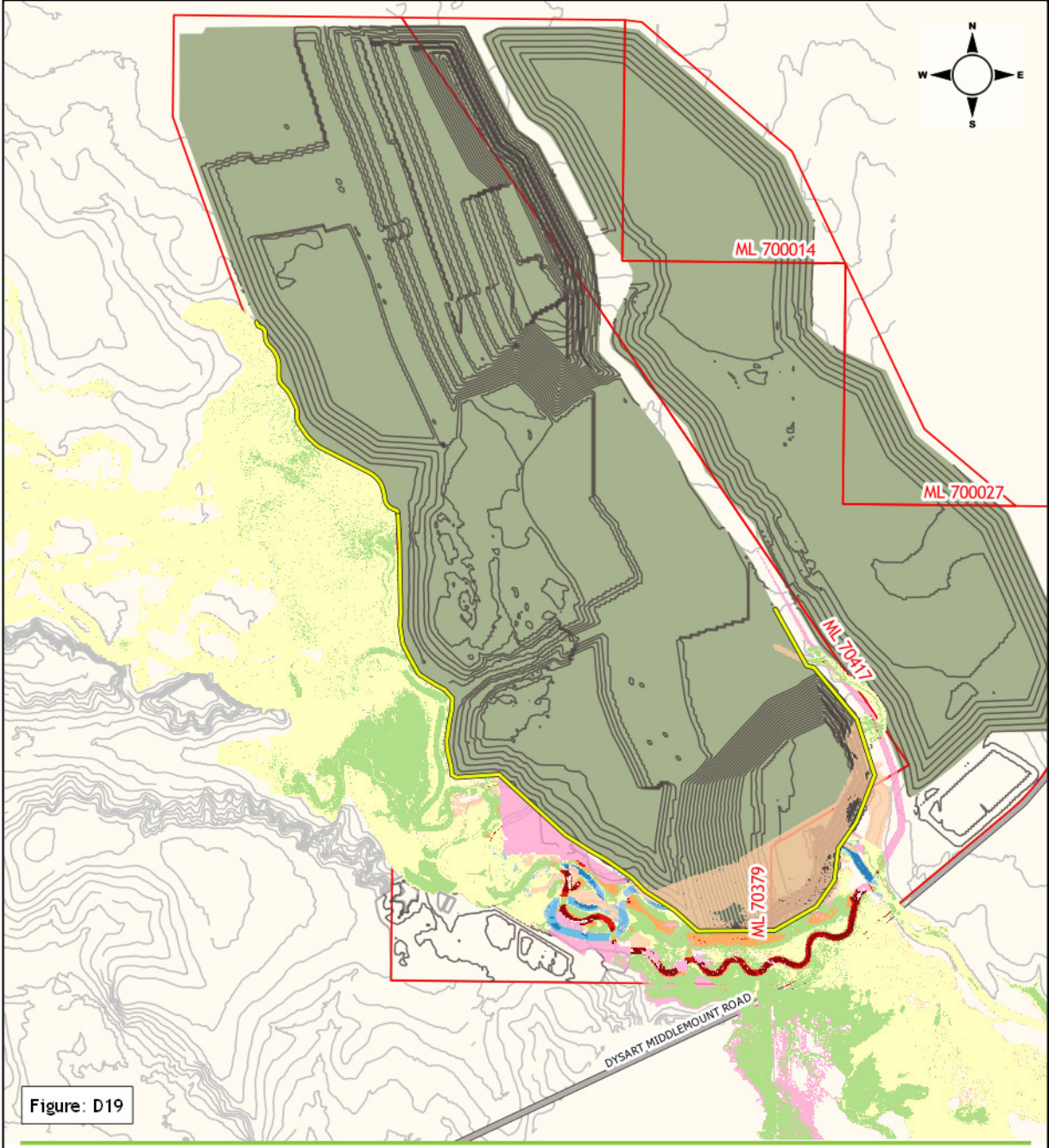


Figure: D19

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

1% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

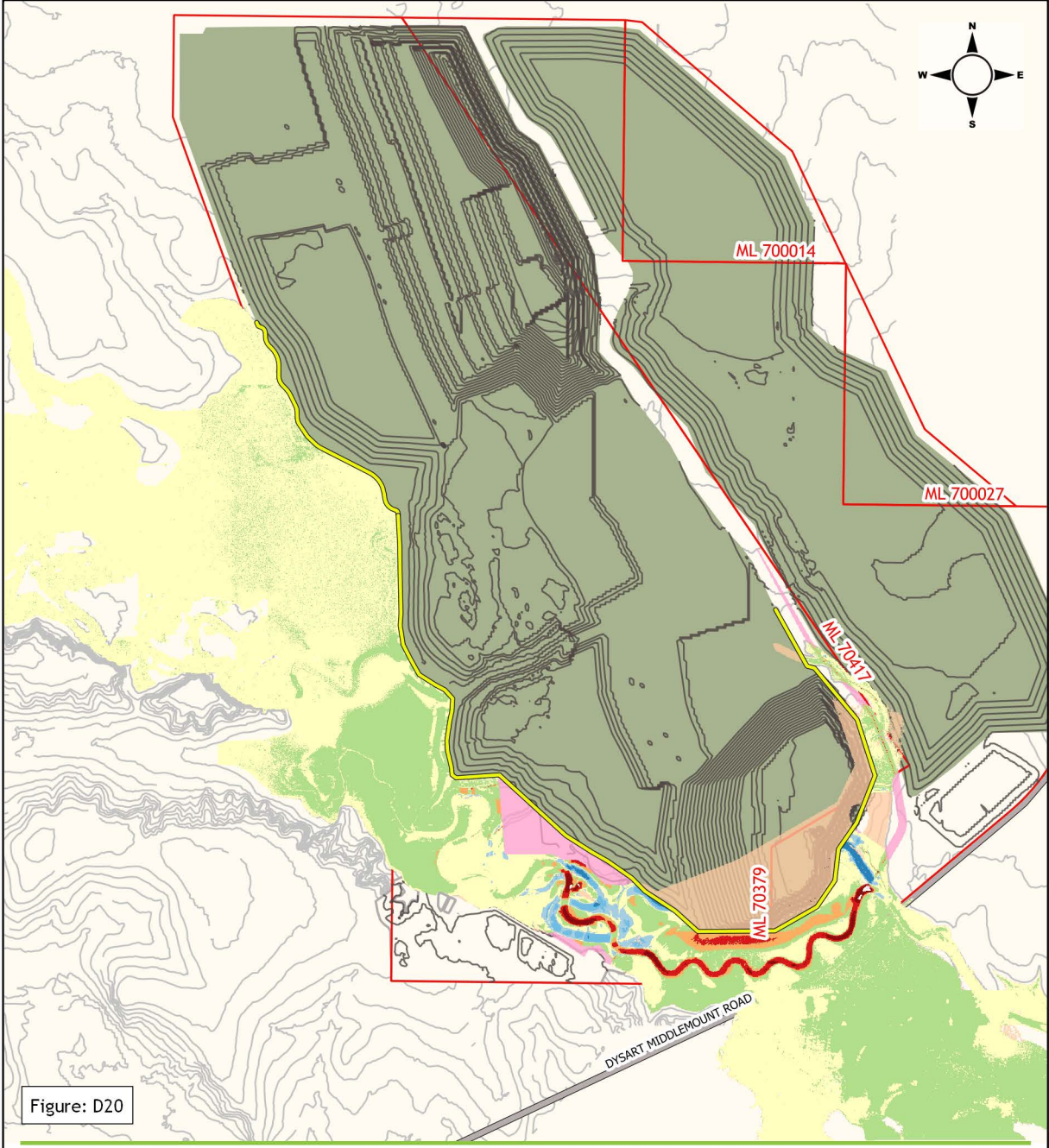


Figure: D20

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine
Southern Extension Project

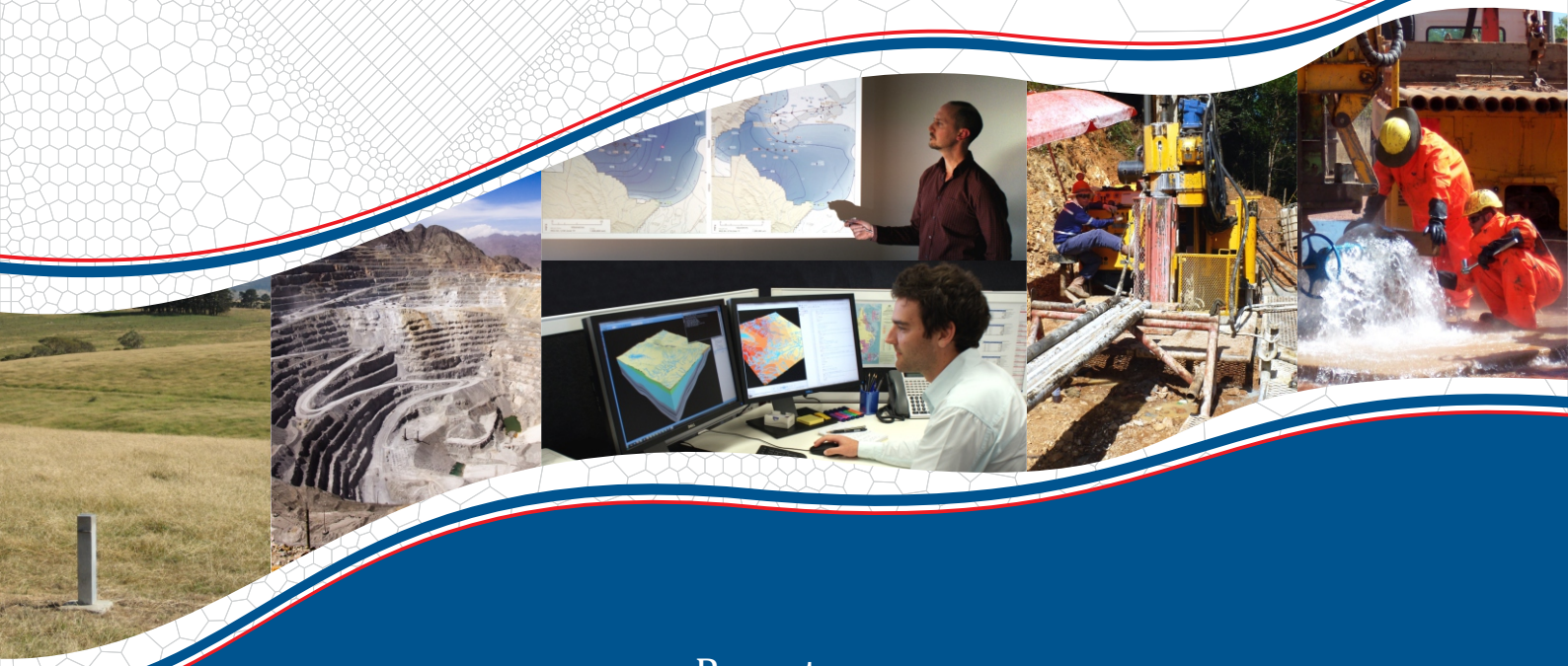
0.1% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Australasian Groundwater and
Environmental Consultants Pty Ltd



Report on

Middlemount Coal Mine
Southern Extension Project
Groundwater Impact Assessment

Prepared for
Middlemount Coal Pty Ltd

Project No. G1840P November 2020
www.ageconsultants.com.au ABN 64 080 238 642

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Report on

Middlemount Coal Mine Southern Extension Project
Groundwater Impact Assessment

1 Introduction

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

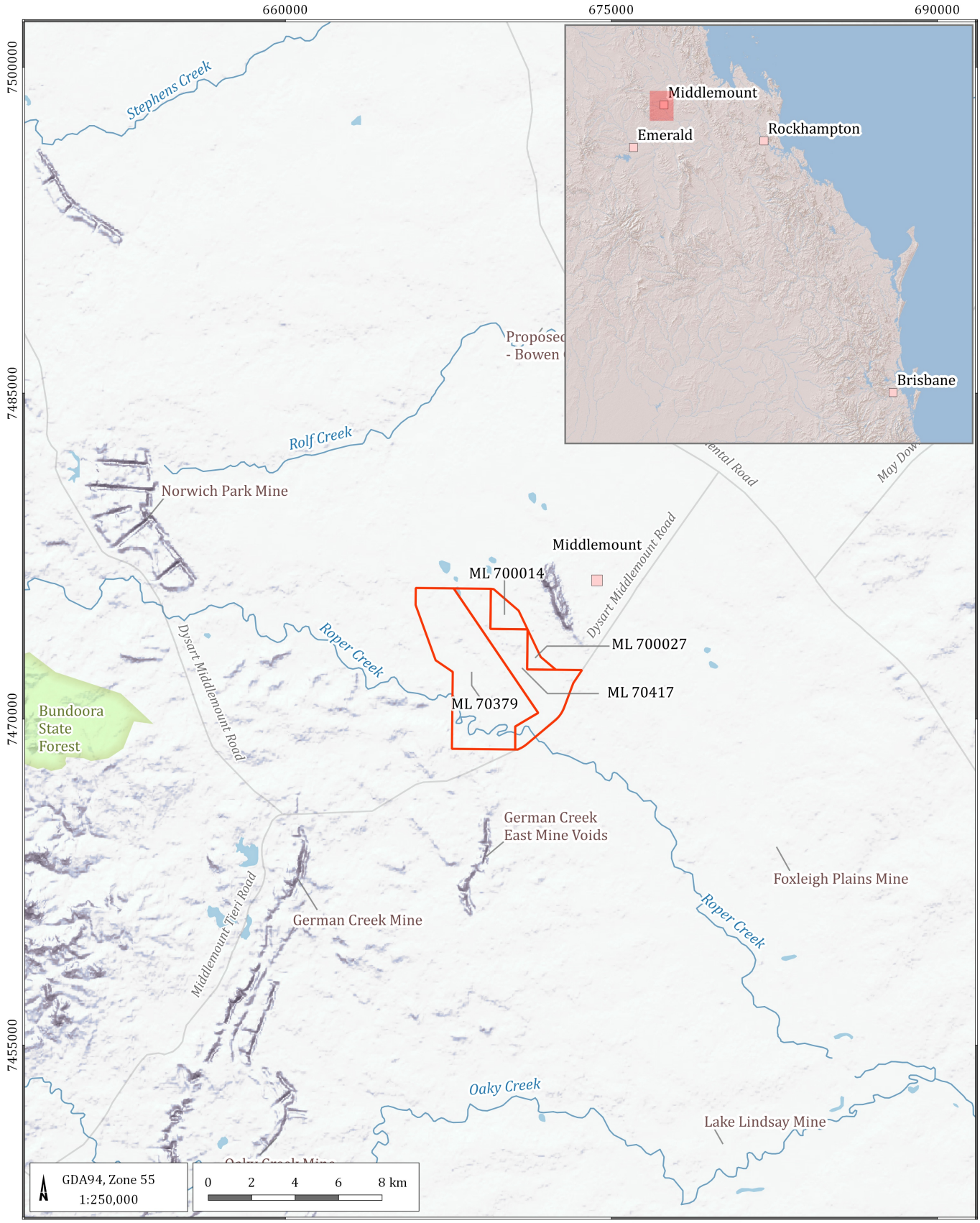
The Middlemount Coal Mine currently operates under Environmental Authority (EA) EPML00716913, dated 26 February 2020, which permits those activities associated with mining to be undertaken within Mining Lease (ML) 70379, ML 70417, ML 700014 and ML700027. The main activities associated with the development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

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

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

1.1 Scope of work and objective of report

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



LEGEND

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

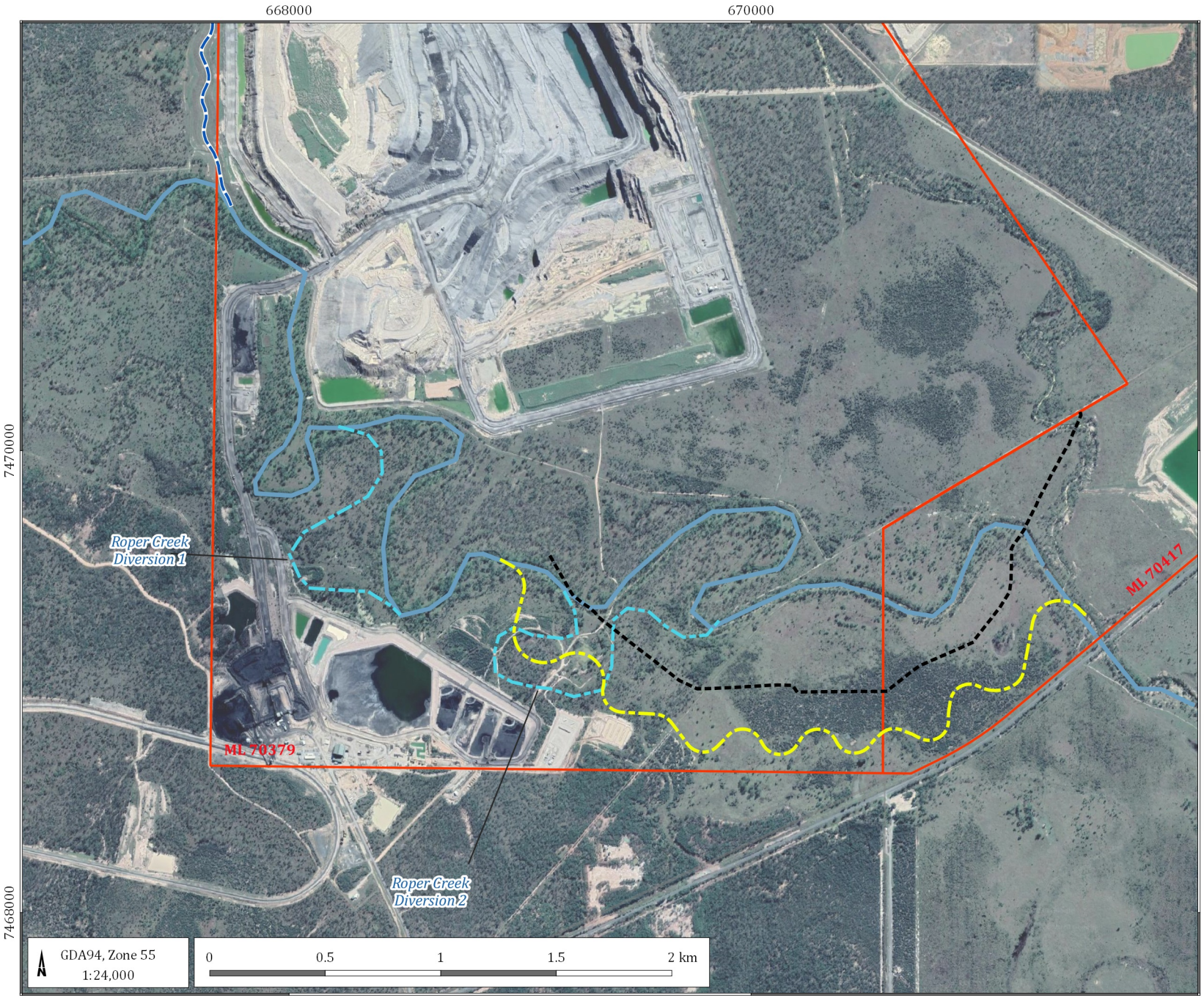
Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount Coal Mine location

DATE 21/08/2020

FIGURE No: **1.1**

©2020 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\01.01_G1840P_Middlemount Coal Mine Location_v01.qgs



LEGEND

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Conceptual Southern Extension Project Layout

DATE
31/08/2020

FIGURE No:
1.2

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

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

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

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

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

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

1.2 Background

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

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

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

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

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

1.3 Report structure

This report is structured as follows:

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

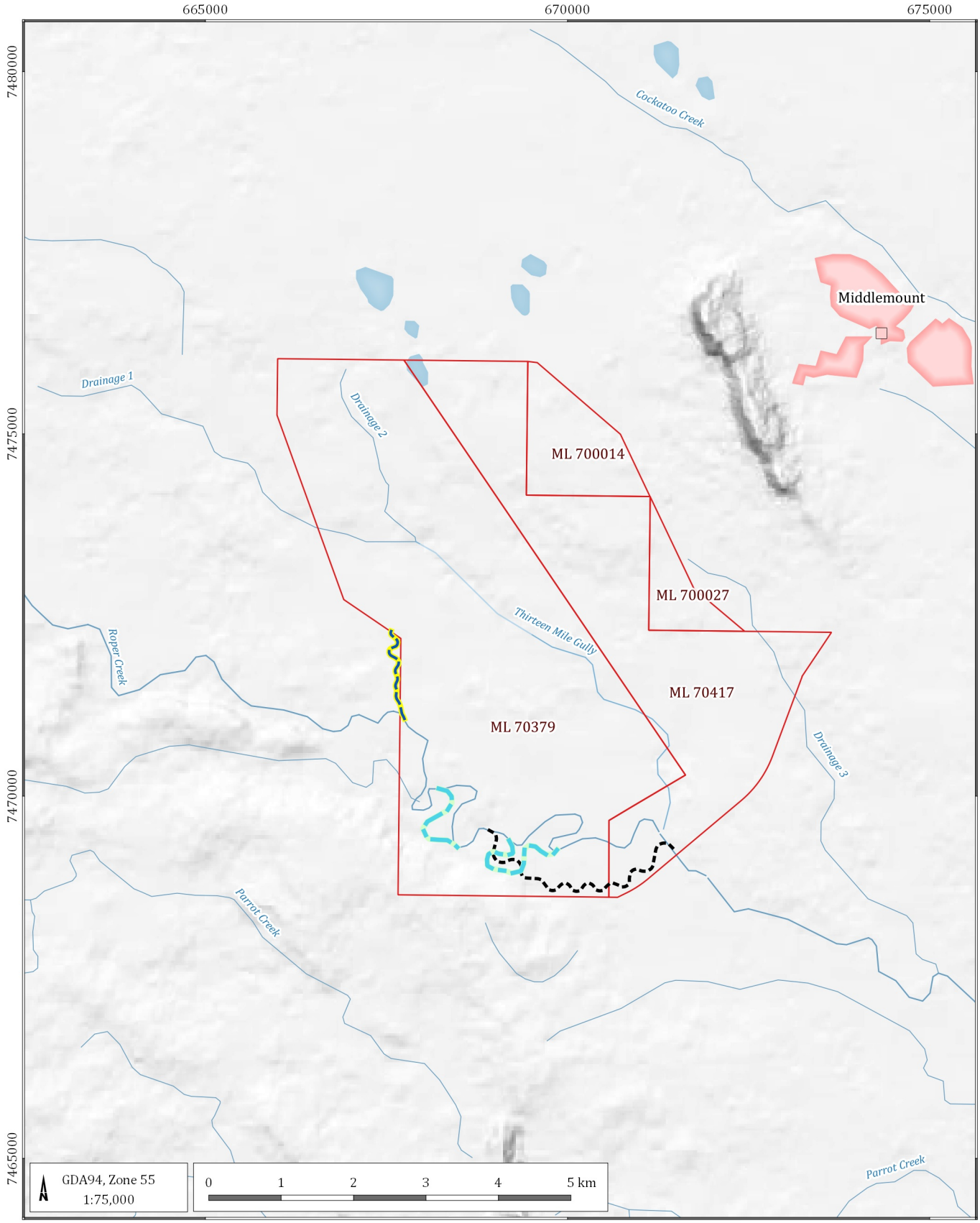
- **Section 9 – Groundwater monitoring strategy/program:** describes the proposed groundwater monitoring for the Project and provides recommendations for trigger levels.
- **Section 10 – Conclusions:** summarises the main aspects of the Project.
- **Section 11 – References:** lists the documents cited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

2 Mining history

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

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

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



LEGEND

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Middlemount Coal Mine - mining leases

DATE 26/08/2020

FIGURE No: **2.1**

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3 Queensland regulatory framework for groundwater

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

3.1 Acts, regulations, and plans

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

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

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

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

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

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

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

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

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

3.2 Fitzroy Basin water resource and operation plans

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

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

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

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

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

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

3.3 Queensland Environmental Protection Act 1994

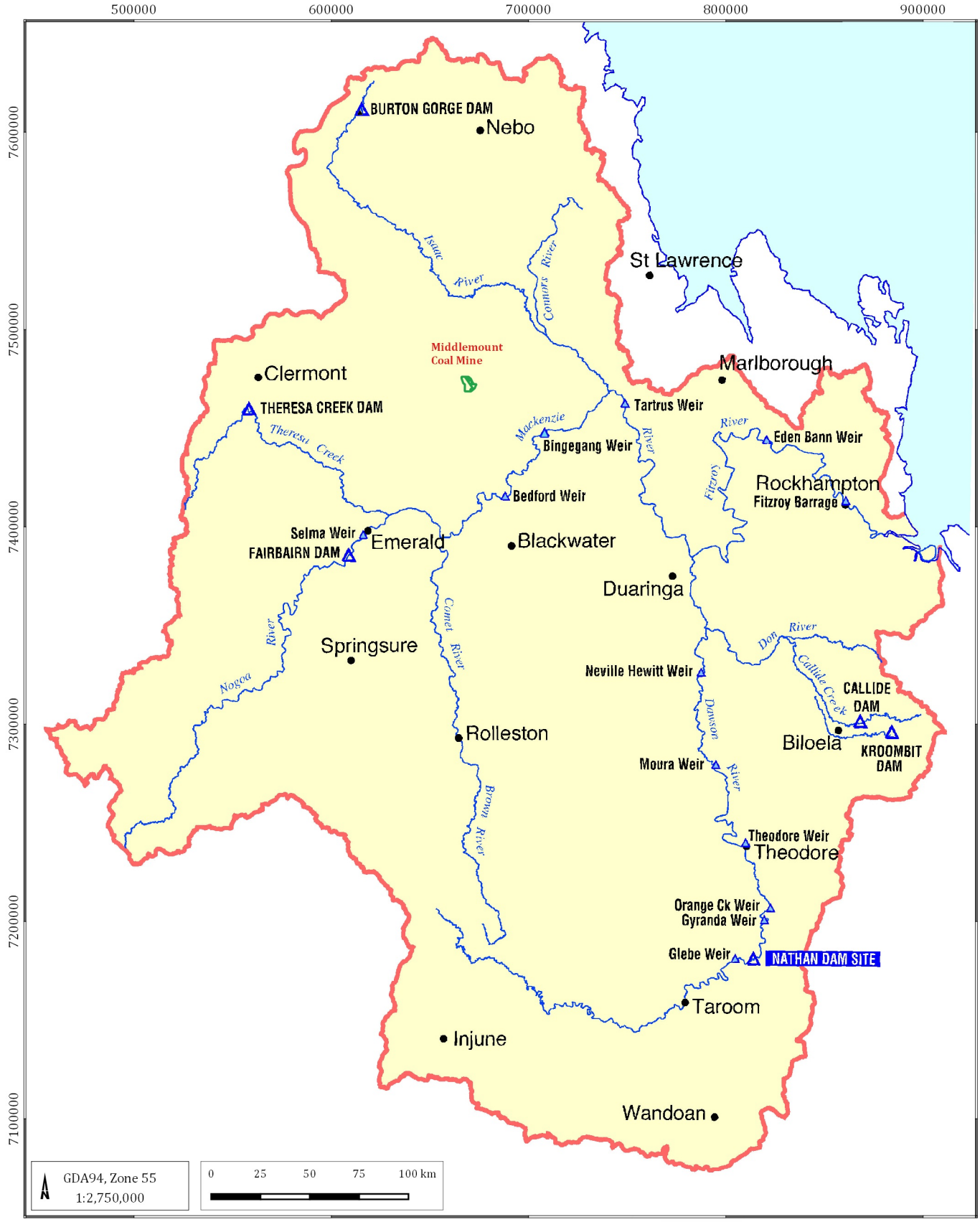
The EP Act provides a regulatory framework for the protection and management of the Queensland Environment. The objective of the EP Act is to protect Queensland's environment while allowing for sustainable development.

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

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

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

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



LEGEND

location

- Weir
- Dam
- Mining Lease boundary (ML)

Middlemount Coal Mine Souther Extension Project - GIA (G1840P)

Water Plan (Fitzroy Basin) 2011

DATE 23/07/2020

FIGURE No: **3.1**

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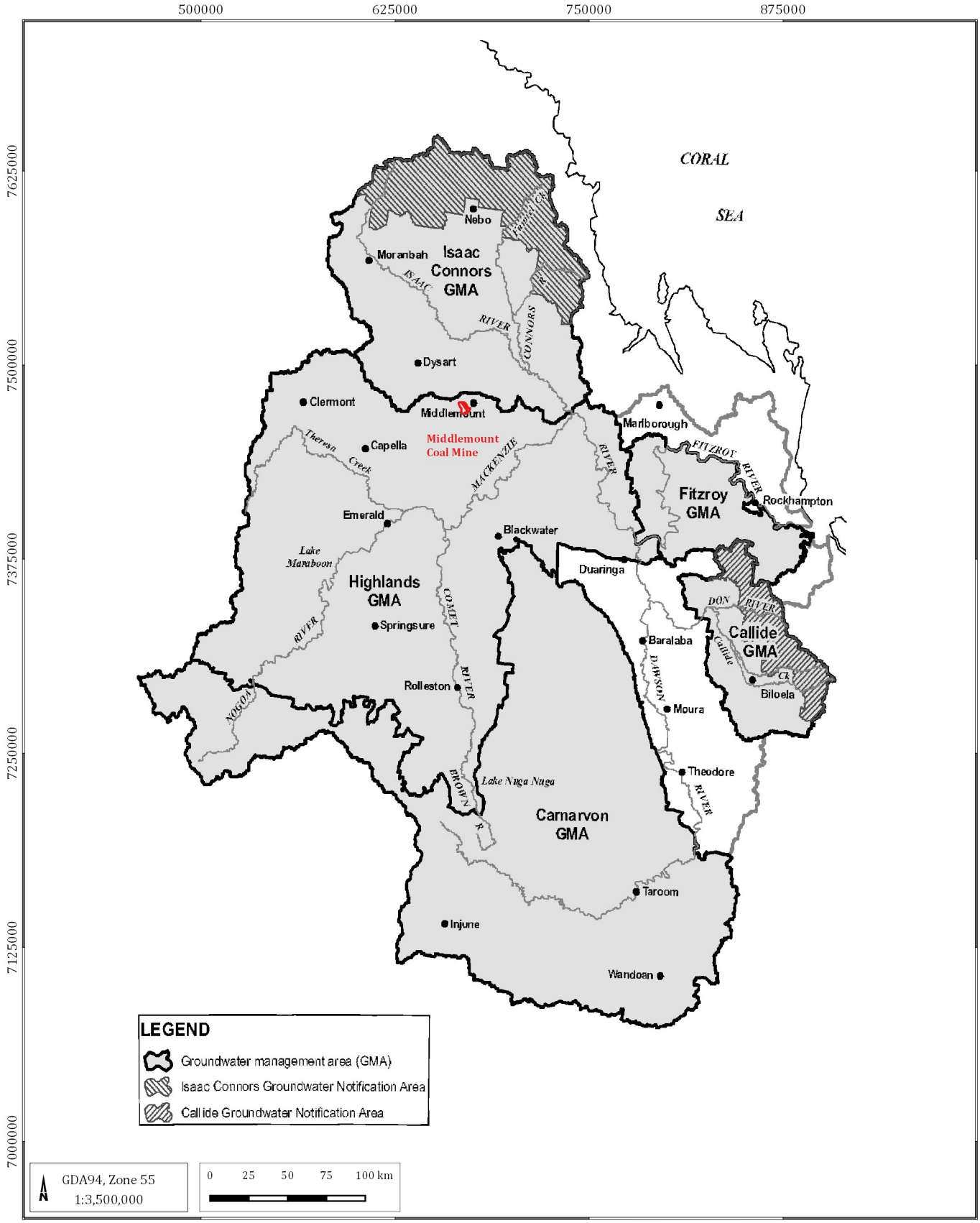

LEGEND

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Highlands groundwater management area

DATE 23/07/2020

FIGURE No: **3.2**

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

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

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

µS/cm = microsiemens per centimetre

$CaCO_3$ = Calcium Carbonate

meq/L = milliequivalents per litre

mV = millivolts

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

3.4 Environmental authority – groundwater conditions

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

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

Table 3.2 Summary of the Middlemount Coal Mine EA groundwater conditions

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

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

3.5 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

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

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

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

4 Environmental setting

4.1 Climate and weather

4.1.1 Climate and weather data availability

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

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

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

4.1.2 Rainfall and evaporation

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

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

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

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

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

4.2 Terrain and drainage

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

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

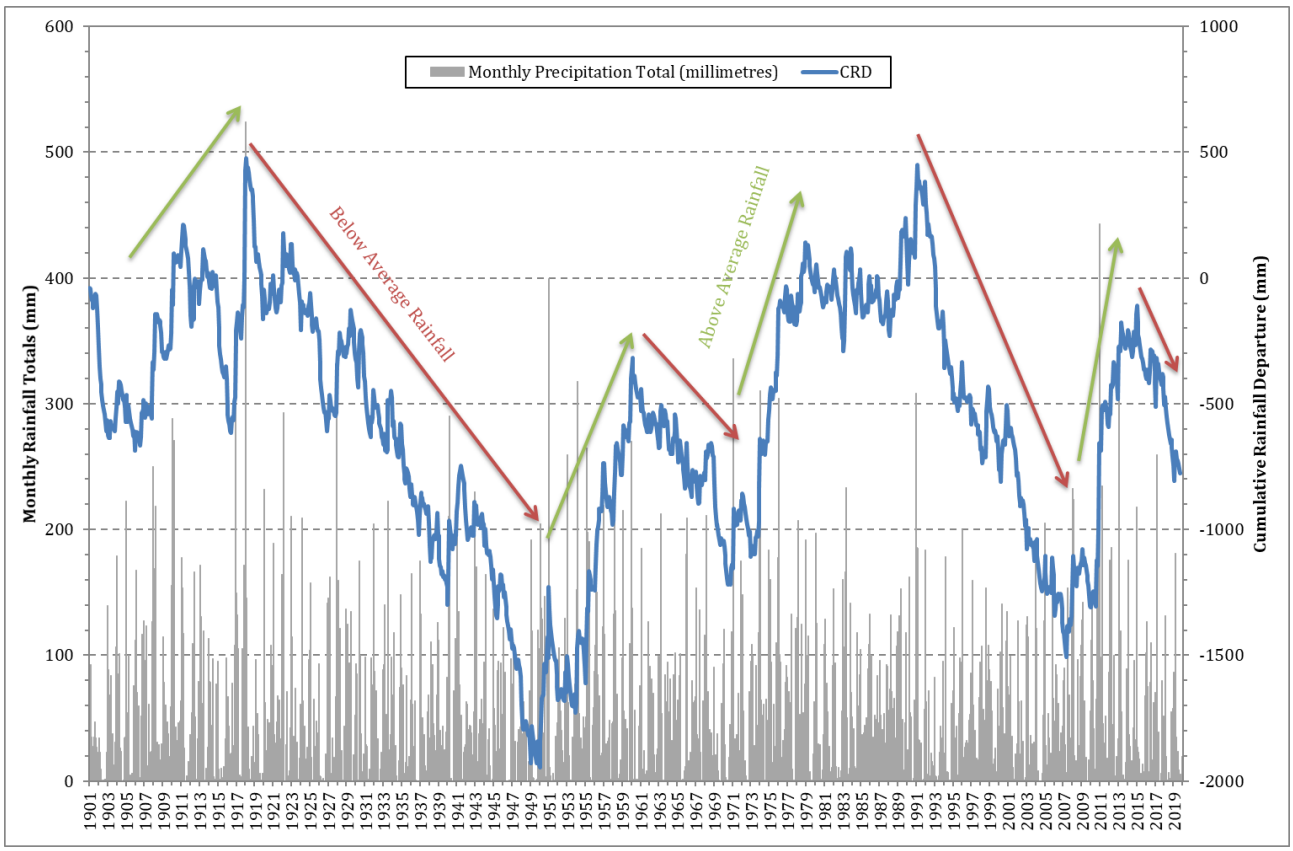
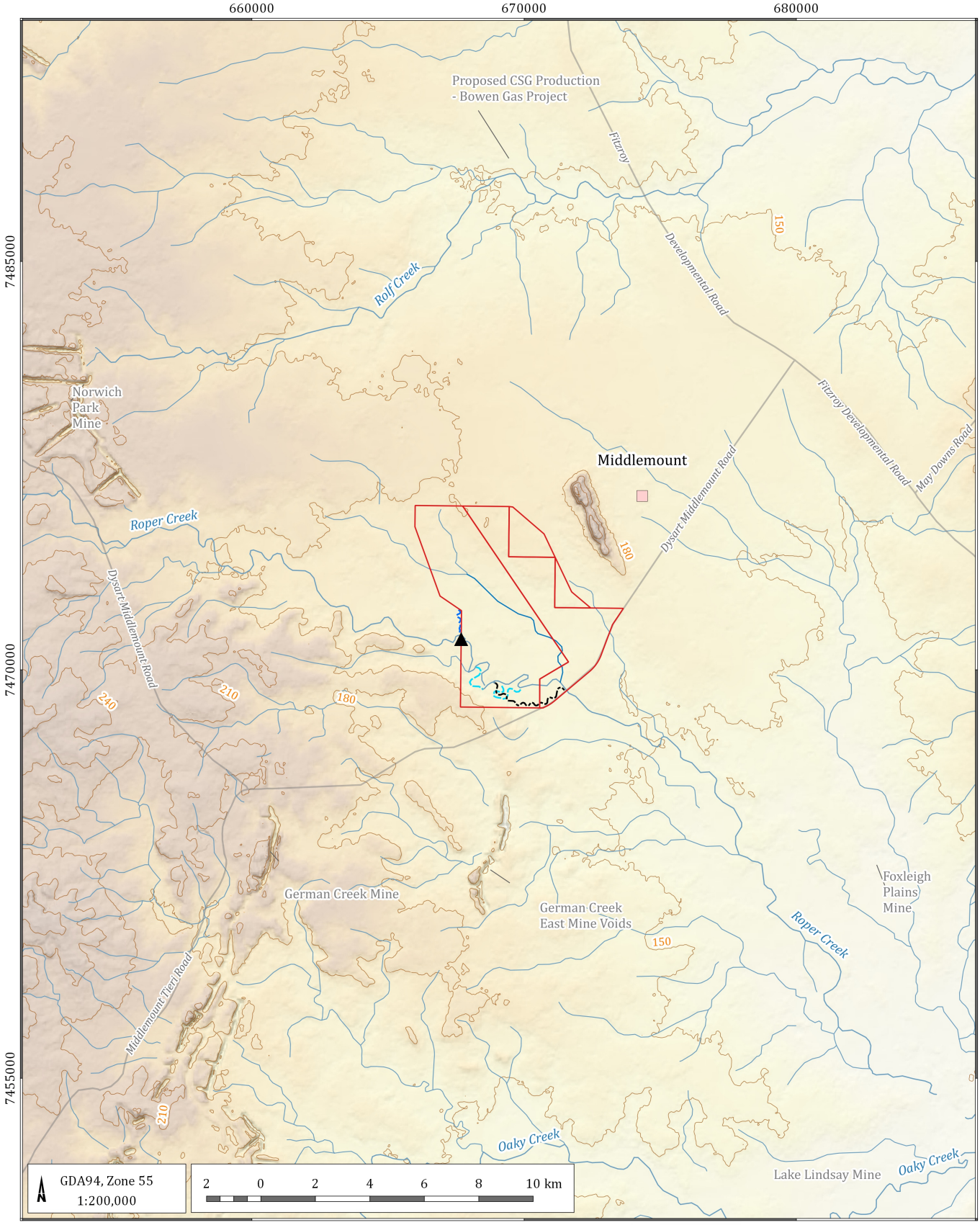


Figure 4.1 Monthly rainfall and cumulative rainfall departure – SILO Data for Middlemount Coal Mine 1901 to 2019



LEGEND

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

Terrain elevation (mAHD)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Terrain, drainage and stream gauge location within study area

DATE 26/08/2020

FIGURE No: **4.2**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\04.02_G1840P_Terrain, drainage, and stream gauge location within study area.qgs

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

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

4.2.1 Surface water data availability

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

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

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

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

4.3 Regional land use

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

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

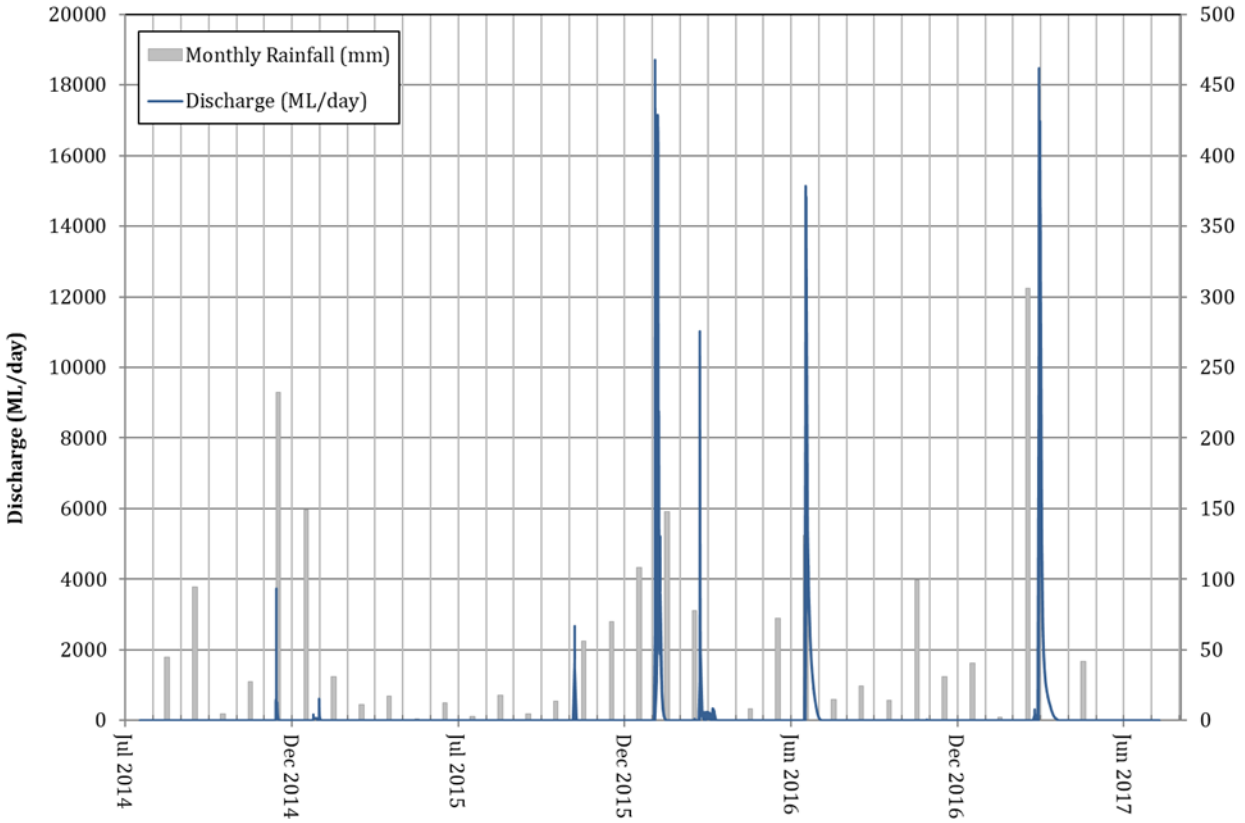


Figure 4.3 MCPL Roper Creek gauging station (Ref1)

5 Geology within the study area

5.1 Geology data availability

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

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

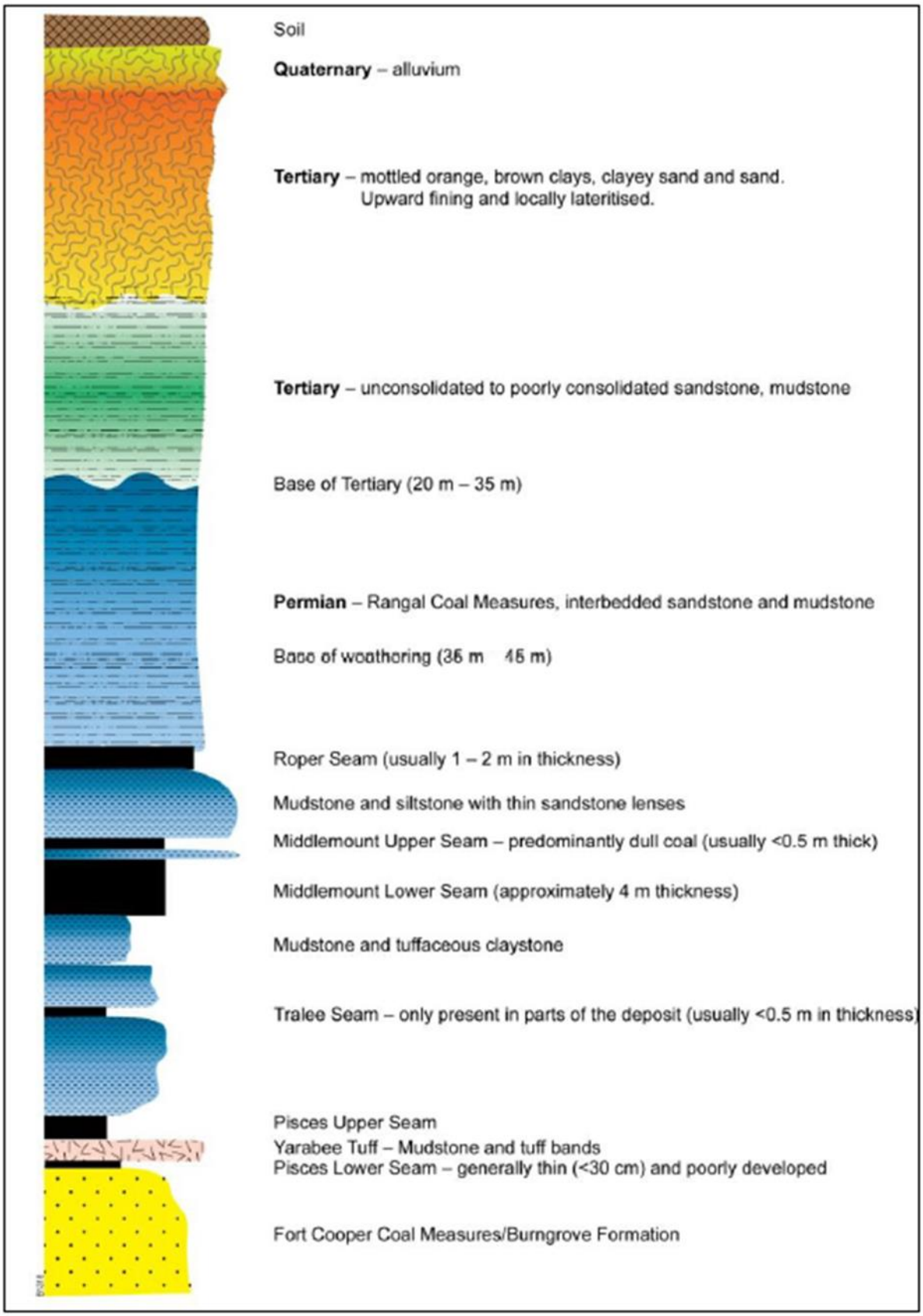
MCPL has undertaken exploration drilling across the Middlemount Coal Mine tenements. However, targeted exploration continues to define product coal structure and quality within the Project area. Exploration drilling has confirmed the geological units present in the ML areas and in the surrounds. MCPL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

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

5.2 Bowen Basin geology

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

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



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

Figure 5.1 Stratigraphic sequence Middlemount Coal Mine

5.3 Mapped geology

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

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

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

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

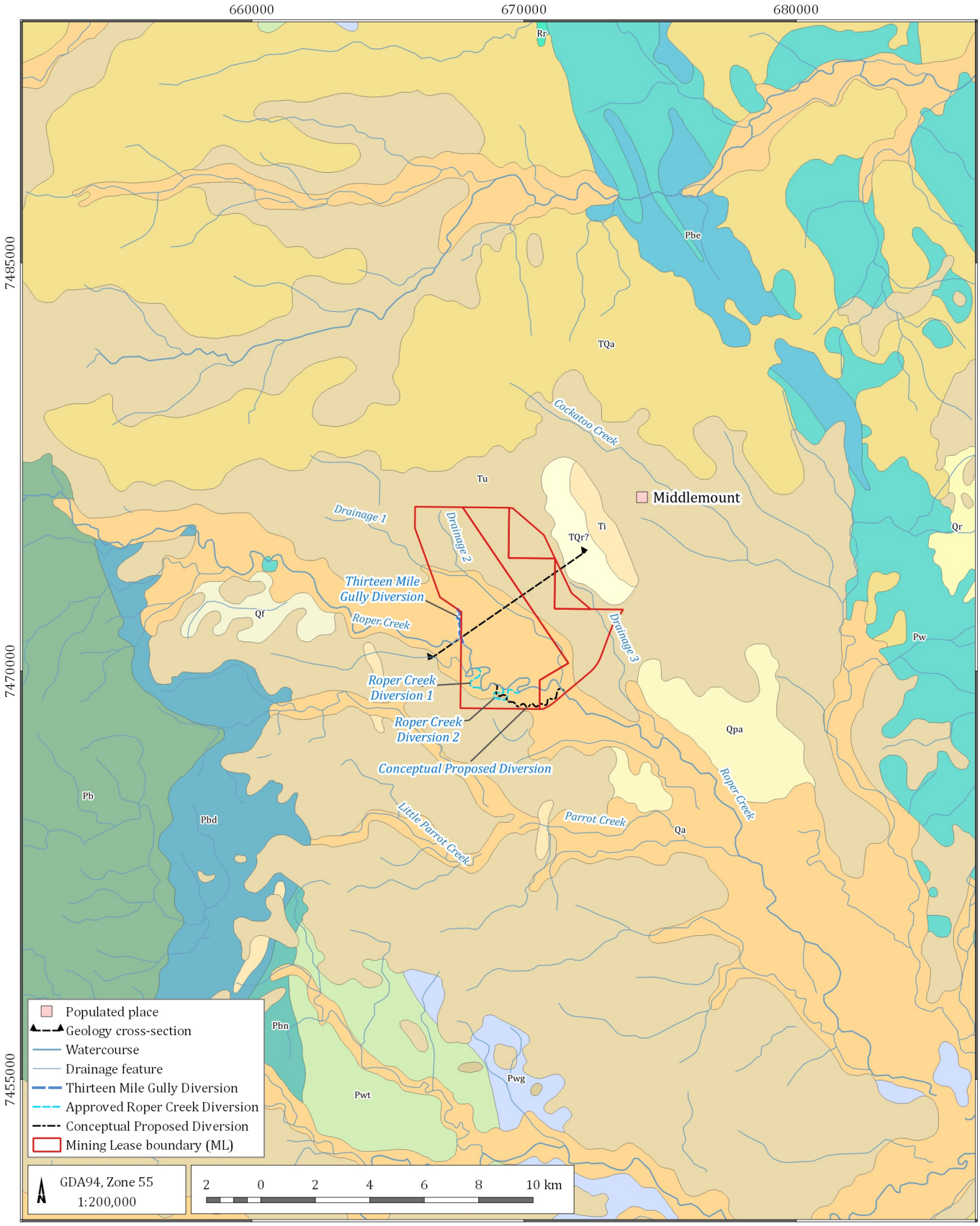
The Triassic Rewan Formation (Rr) does not outcrop within the study area, but does sub-crop within the study area beneath the Tertiary cover east of Middlemount township and southeast of the current mine footprint.

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

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

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

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



LEGEND

Bowen Basin surface geology

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840D)

Surface geology within study area

DATE 26/08/2020

FIGURE No: **5.2**

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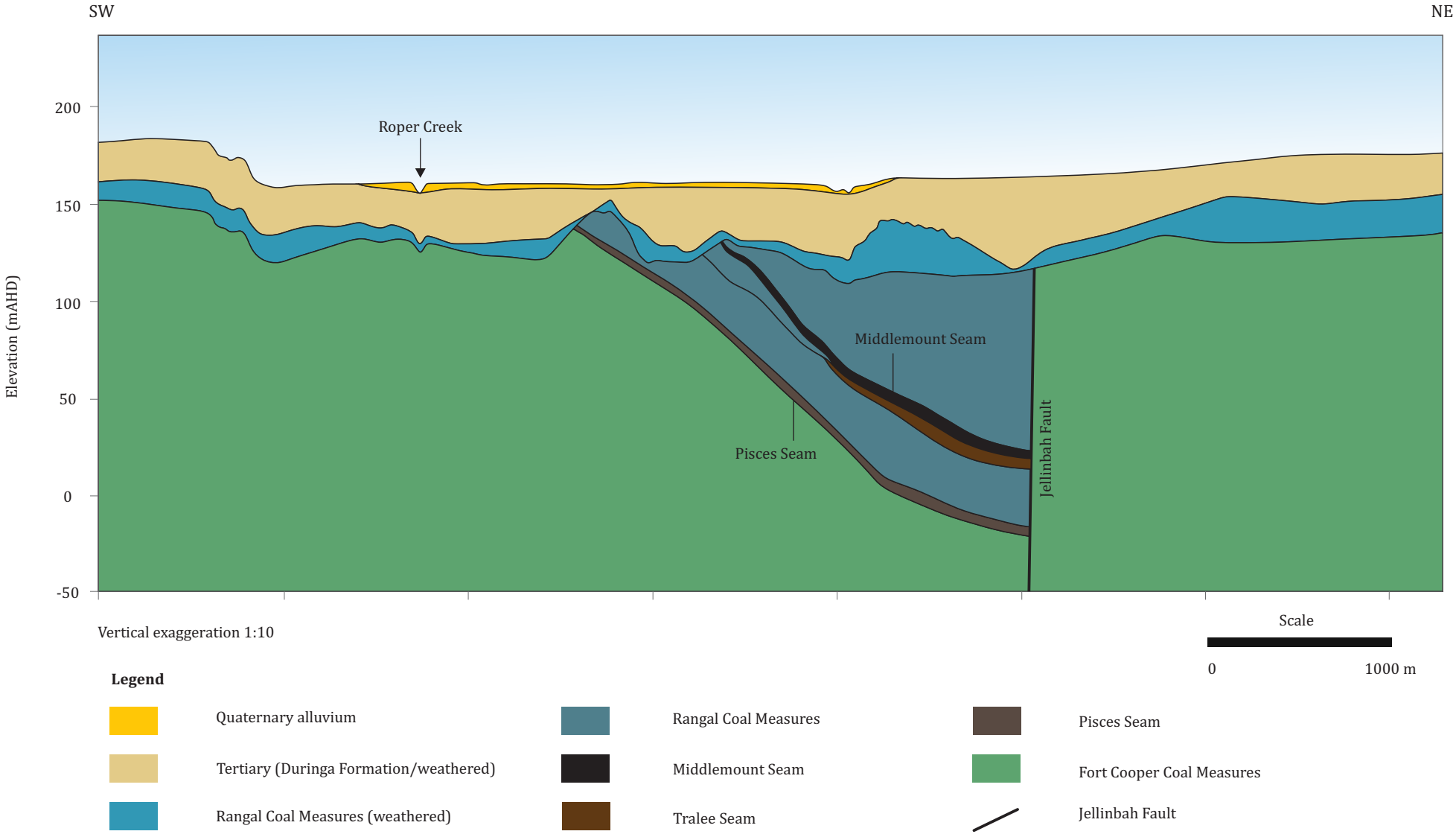

South-west to north-east geological cross section

Figure - 5.3

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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Table 5.1 Regional stratigraphy units

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

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

5.4 Quaternary aged geological units

5.4.1 Alluvial deposits

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

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

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

5.5 Tertiary aged geological units

5.5.1 Duaringa Formation

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

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

5.6 Triassic aged geology

5.6.1 Rewan Formation

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

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

5.7 Permian aged geology

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

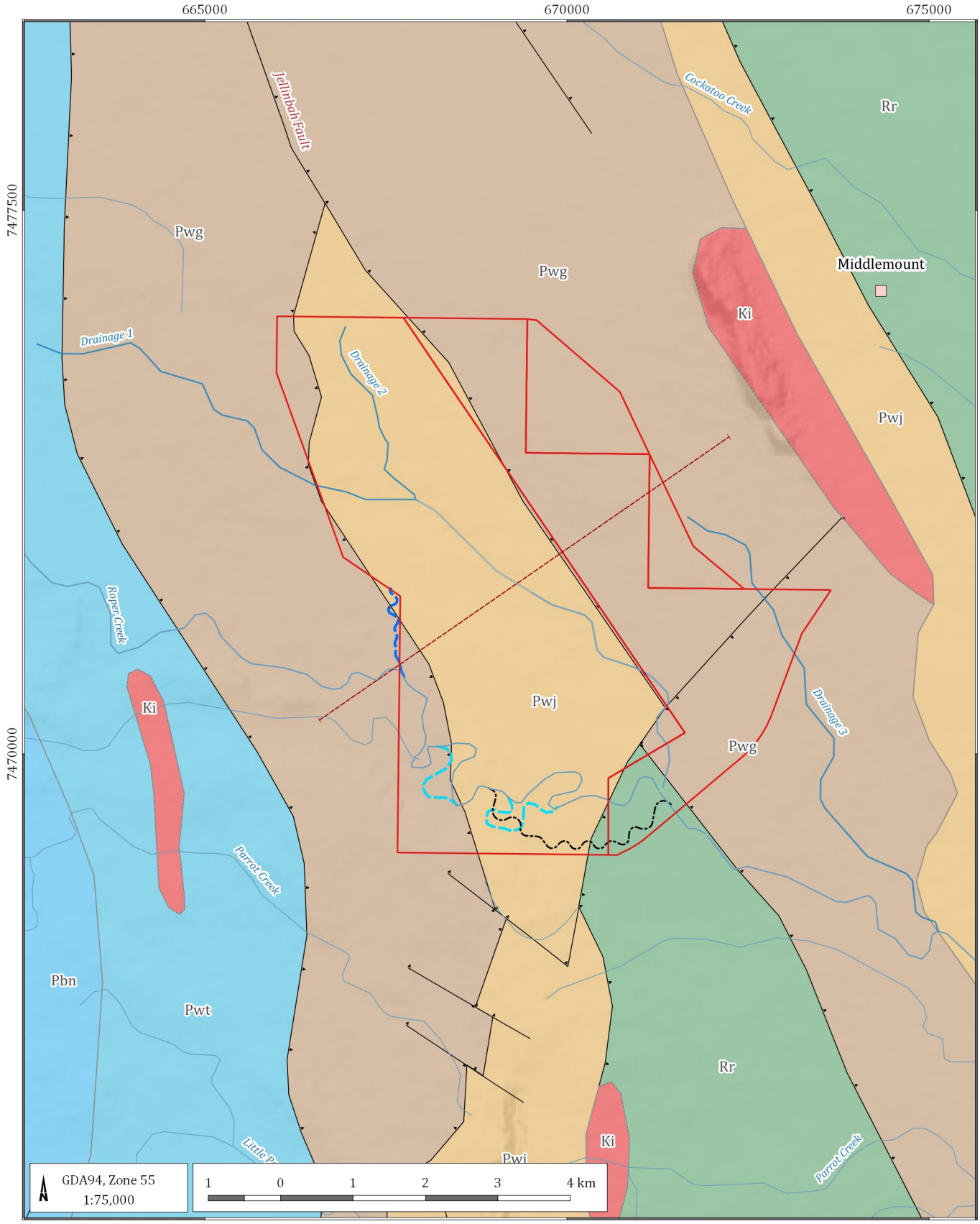
5.7.1 Rangal Coal Measures

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

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

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

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



LEGEND

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

Bowen Basin solid geology

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Bowen Basin solid geology with publicly available fault interpretation

DATE 26/08/2020

FIGURE No: **5.4**

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Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\05.04_G1840P_Bowen Basin solid geology with publicly avialable fault interpretation.qgs

5.7.2 Fort Cooper Coal Measures

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

5.8 Geological structure

5.8.1 Publicly available fault data

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

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

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

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

5.8.2 Jellinbah Fault interpretation

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

6 Conceptual groundwater model

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

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

6.1 Hydro-stratigraphic units

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

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

6.2 Groundwater resources and concepts of groundwater flow

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6.3 General aspects of groundwater and mining

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

6.3.1 Mine dewatering impacts

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

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

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

6.3.2 Post-mining groundwater recovery

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

6.4 Groundwater data availability

6.4.1 DNRME groundwater database bores

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

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

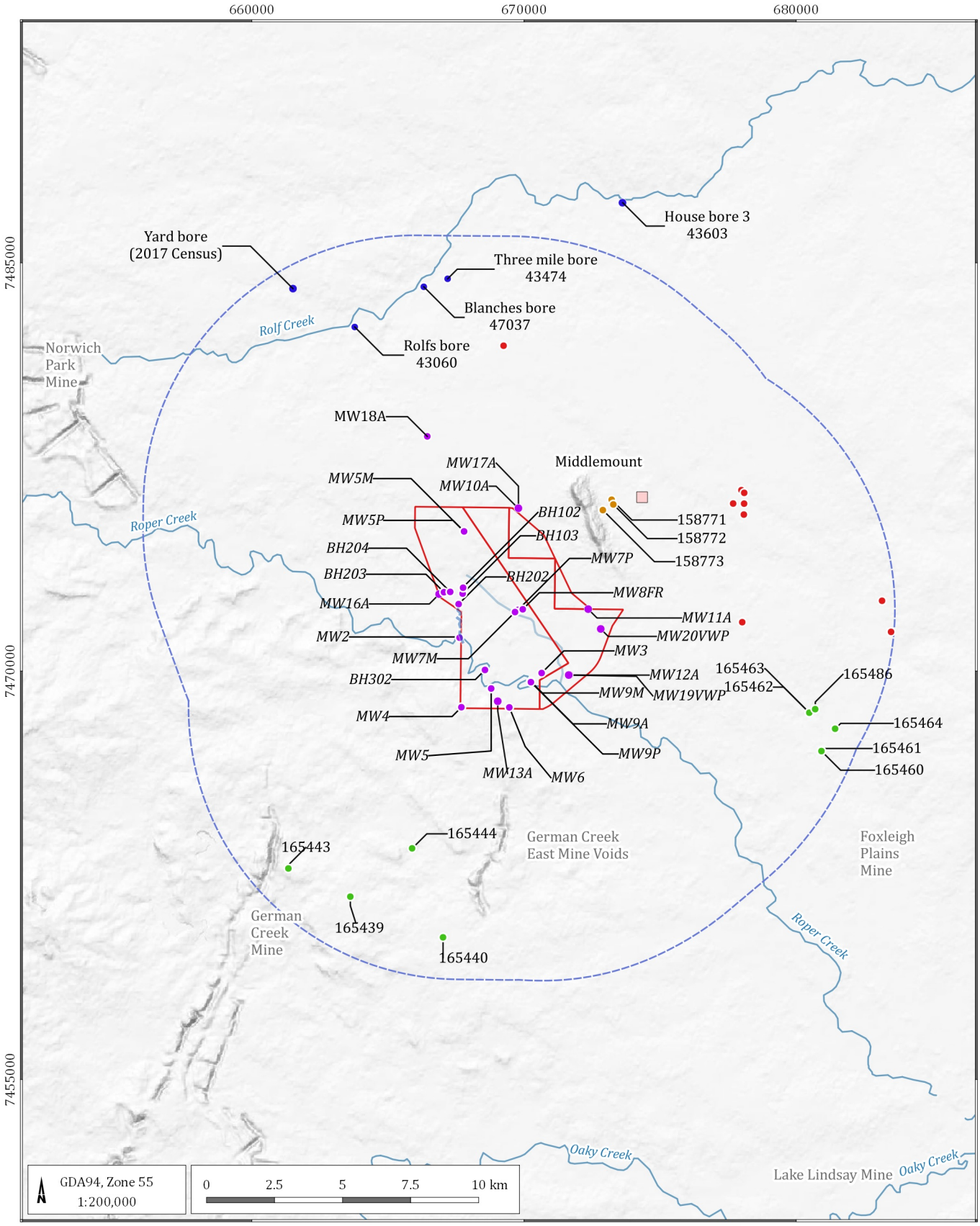
Roles of DNRME GWDB bores (2020)	Number of GWDB bores within the 10 km radius of MLs
Landholder water supply	
No specified role, but likely to be used for landholder water supply	6
Total number of bores used for landholder water supply	**6**
Monitoring bores	
Middlemount Landfill groundwater monitoring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

Source: *DNRME, 2020*

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

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

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



LEGEND

- Populated place
- Watercourse
- Mining Lease boundary (ML)
- 10 km buffer zone
- CSG well bores
- Landholder bores
- Mine monitoring bores
- Landfill Monitoring bores
- Other mine Monitoring bores

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

DNRM GWDB and census bores identified within study area

DATE 21/08/2020

FIGURE No: **6.1**

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

6.4.2 *Landholder bores – bore census data*

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

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

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

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

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

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

Table 6.2 Bore census landholder water supply bores

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

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

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

NA – Not available.

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

6.4.3 *Mine groundwater monitoring bore networks*

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

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

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

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

Table 6.3 Mine monitoring bore network

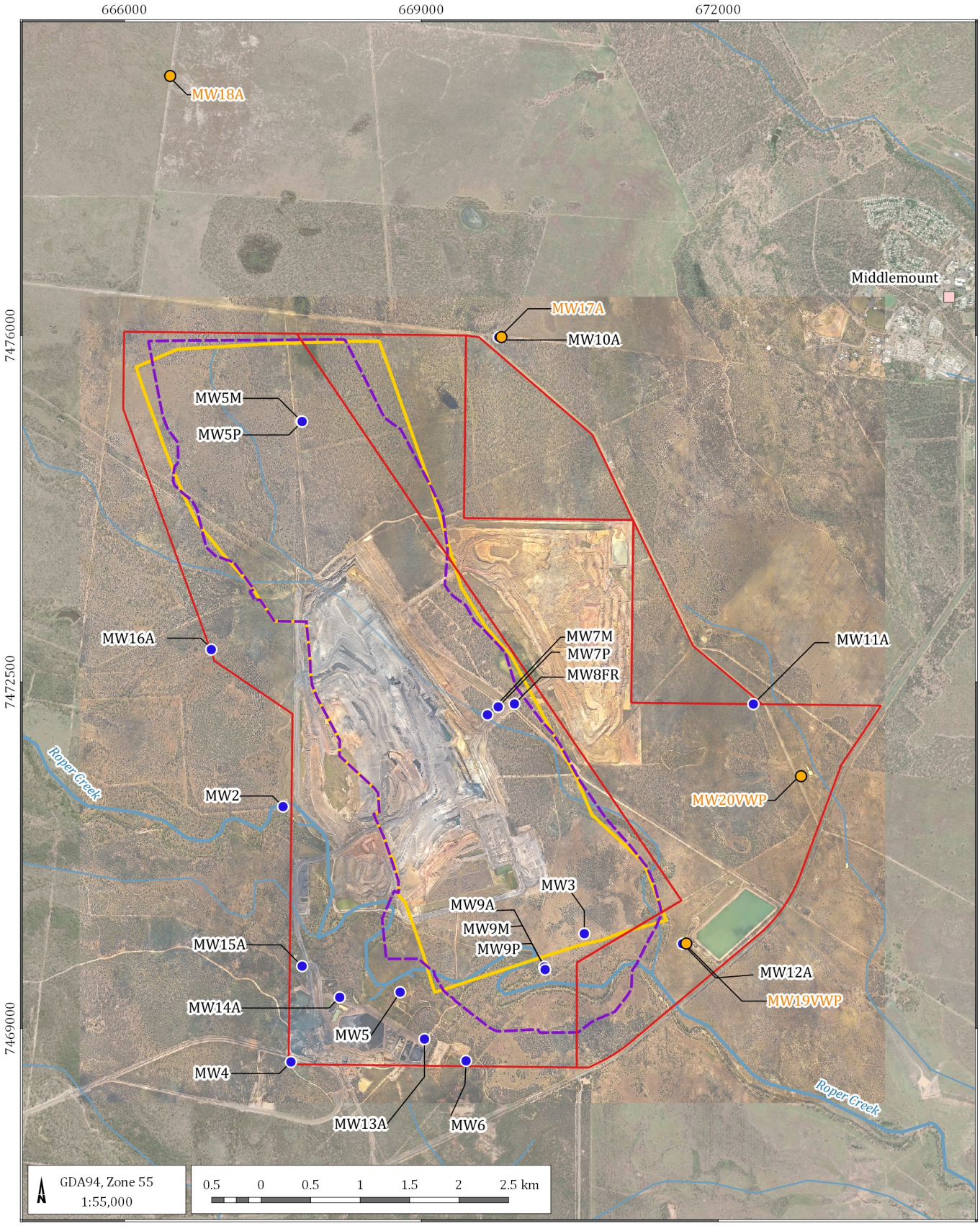
RN	Monitoring bore	Easting [1] (m)	Northing [1] (m)	Ground elevation (mAHD)	Bore depth (m)	Screen depth (m)	Screen lithology	Screen geology
151334	MW1 (Mined out)	667851	7473155	161.5	30.0	21.0-29.0	Clay/sandy clay	Tertiary
161059	MW1P (Mined out)	667818	7473149	161.1	77.2	72.0-75.0	Coal	Pisces coal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

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

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

2 – Sensor believed to be faulty.

3 – No details available on Queensland Globe.



LEGEND

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

Middlemount Coal Mine Southern Extension Project - GIA(G1840P)

Middlemount Coal Mine monitoring bore locations

DATE 26/08/2020

FIGURE No: 6.2

©2020 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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6.5 Quaternary alluvial aquifer

6.5.1 Groundwater yield

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

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

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

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

6.5.2 Hydraulic parameters

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

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

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

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

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

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

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

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

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

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

6.5.3 Groundwater recharge, levels, and flow

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

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

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

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

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

6.5.4 Groundwater quality

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

6.6 Tertiary Duaringa Formation aquifer/aquitard

6.6.1 Groundwater yield

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

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

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

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

6.6.2 Hydraulic parameters

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

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

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

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

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

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

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

6.6.3 Groundwater levels, recharge, and flow

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

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

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

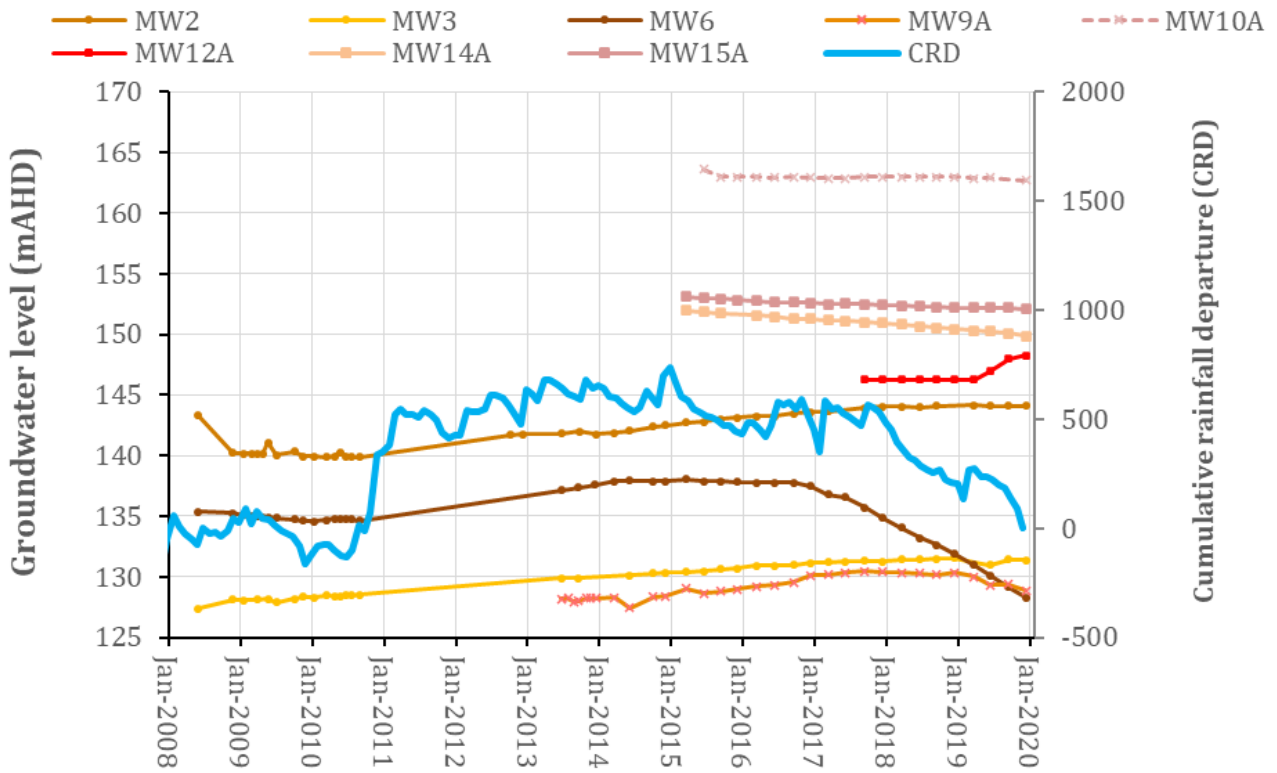


Figure 6.3 Measured groundwater levels in Tertiary aquifer monitoring bores

6.6.4 Groundwater quality

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

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

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

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

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

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

Table 6.4 Summary of groundwater quality analyses – Tertiary aquifers

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

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

Notes: *- Not determined.*

µg/L = micrograms per litre

**included samples at the limit of reporting*

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

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

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

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

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

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

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

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

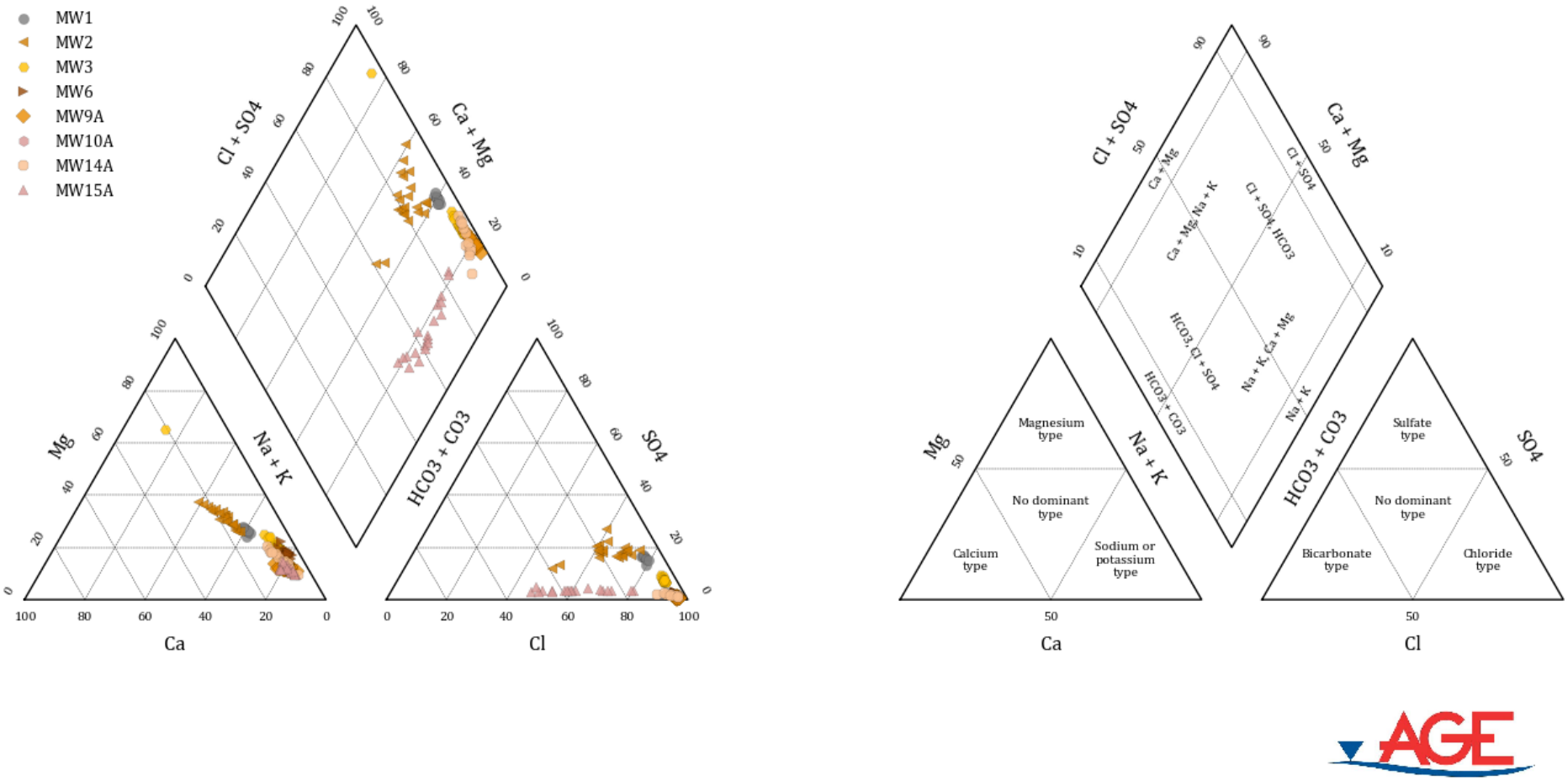


Figure 6.4 Piper diagram – Tertiary aquifer

6.7 Permian coal measures aquifer

6.7.1 Groundwater yield

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

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

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

6.7.2 Hydraulic parameters

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

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

Table 6.5 Summary of hydraulic parameters of Permian coal measures

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

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

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

6.7.3 *Groundwater recharge, levels, and flow*

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

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

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

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

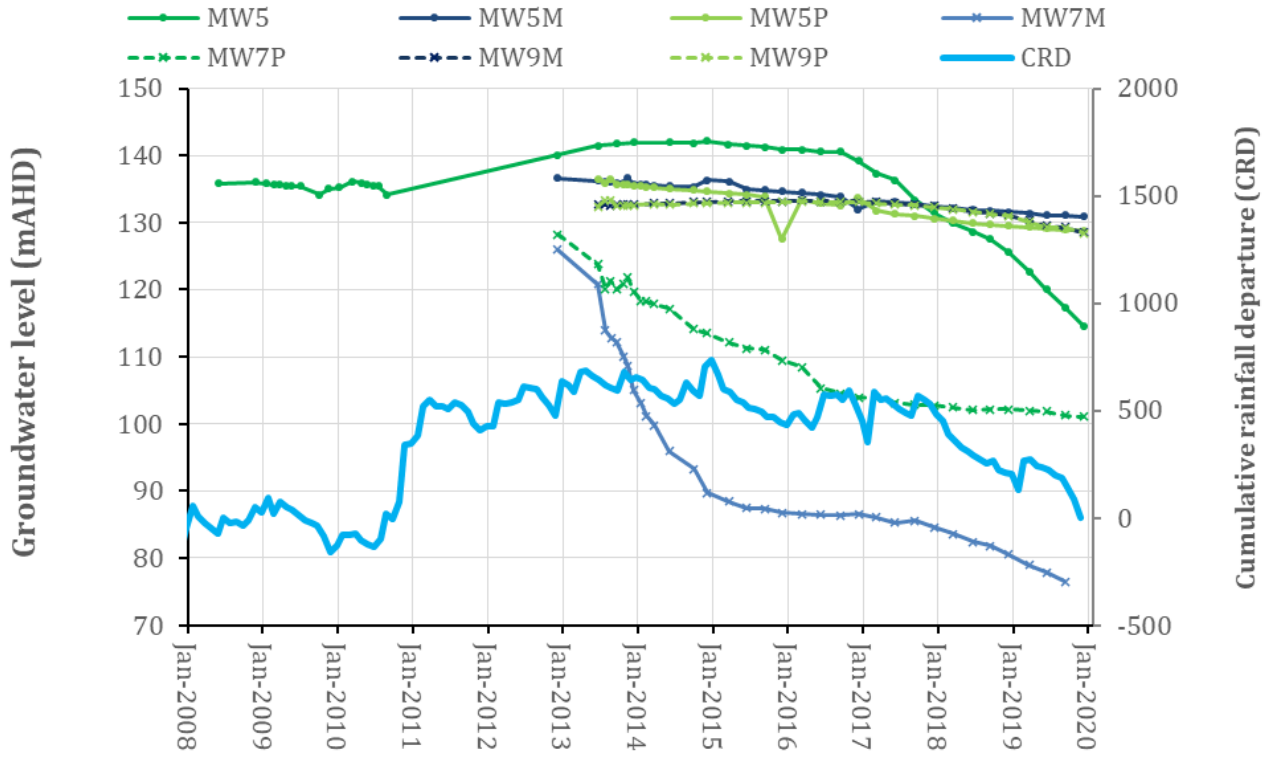


Figure 6.5 Measured groundwater levels in Rangal coal measures monitoring bores

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

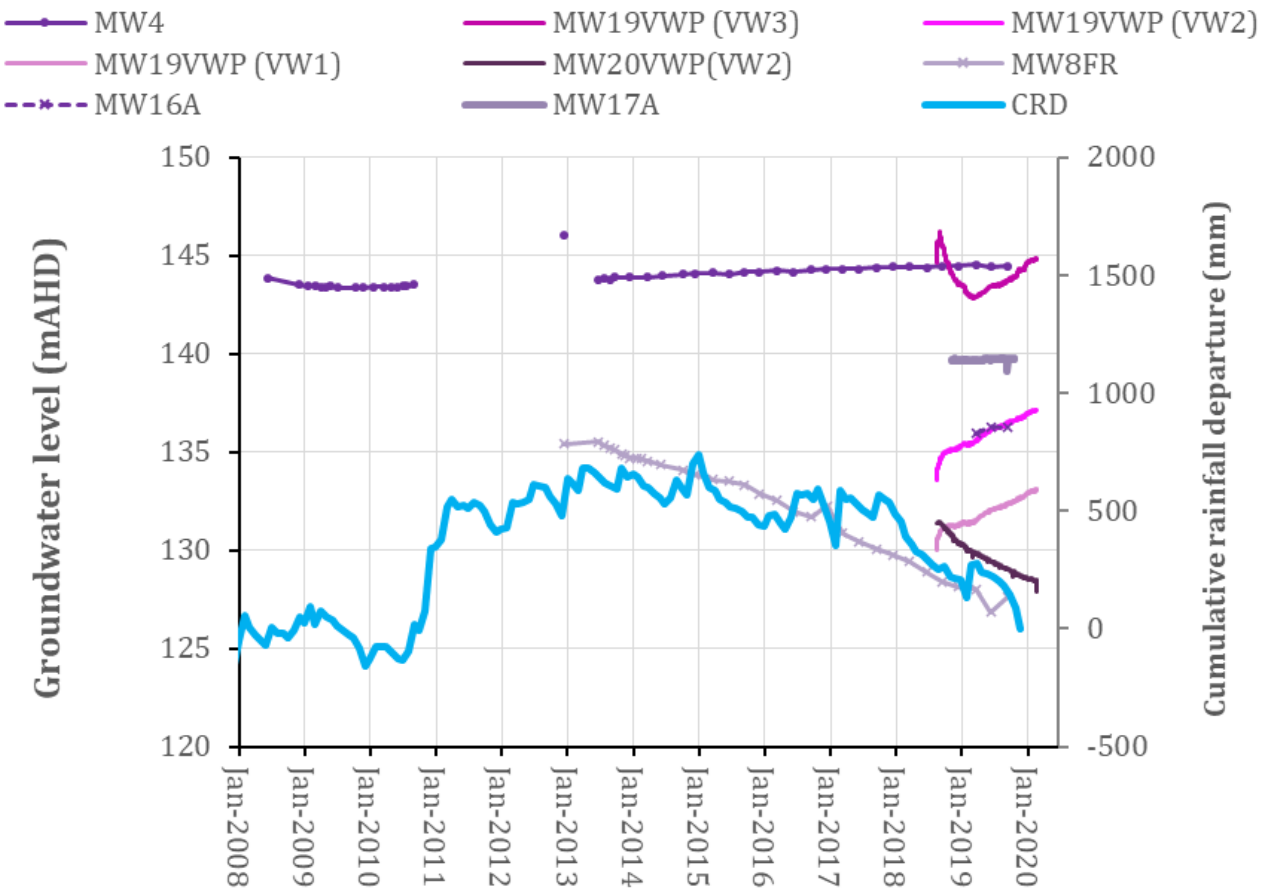


Figure 6.6 Measured groundwater levels in Fort Cooper coal measures monitoring bores

6.7.4 Groundwater quality

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

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

Table 6.6 Summary of water quality analyses – Permian aquifers

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

Notes: *# EC – Electrical conductivity.*

- Not determined.

** Included samples at the limit of reporting.*

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

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

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

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

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

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

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

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

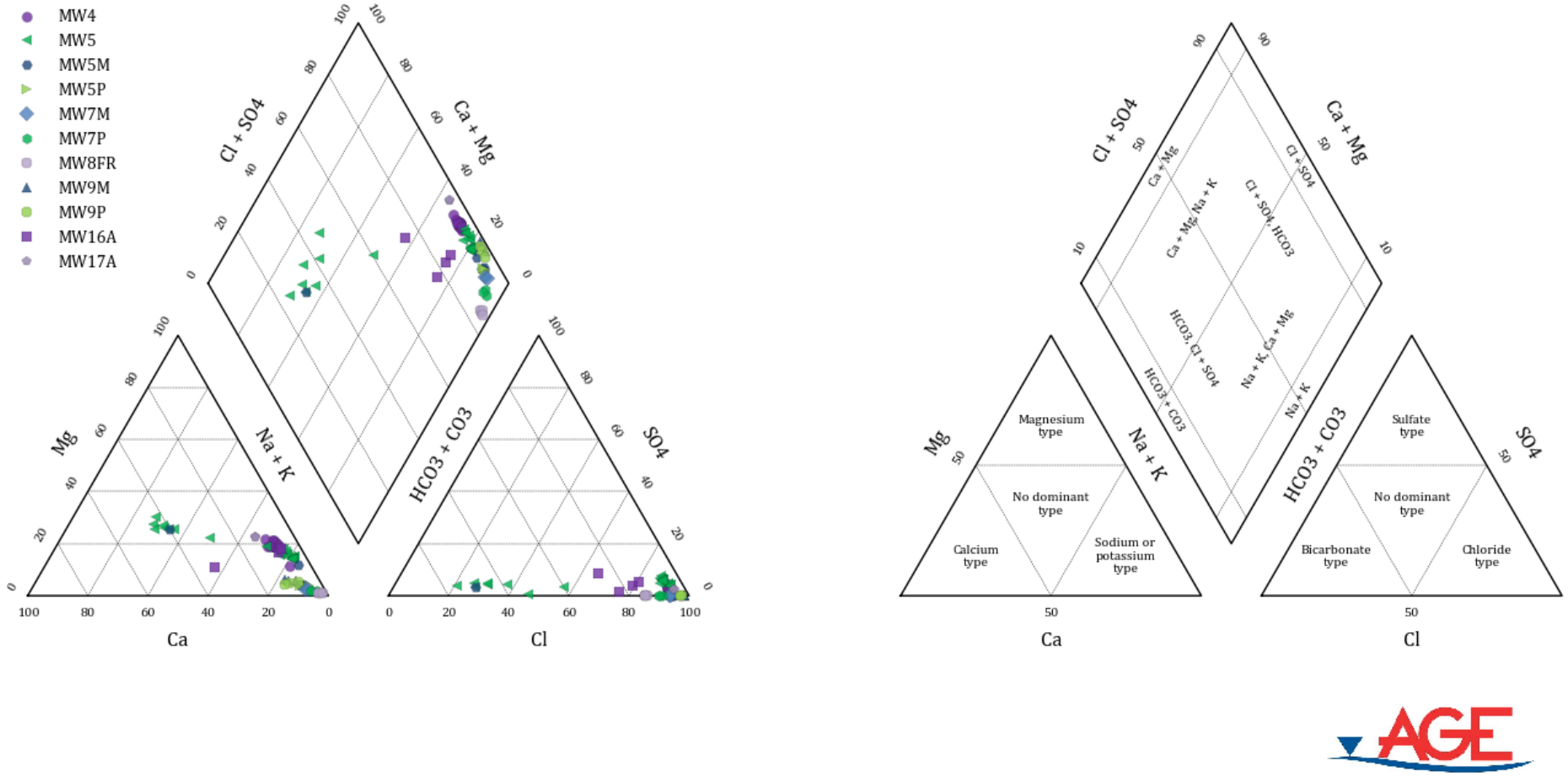


Figure 6.7 Piper diagram – Permian coal measures aquifer

6.8 Groundwater dependent ecosystems

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

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

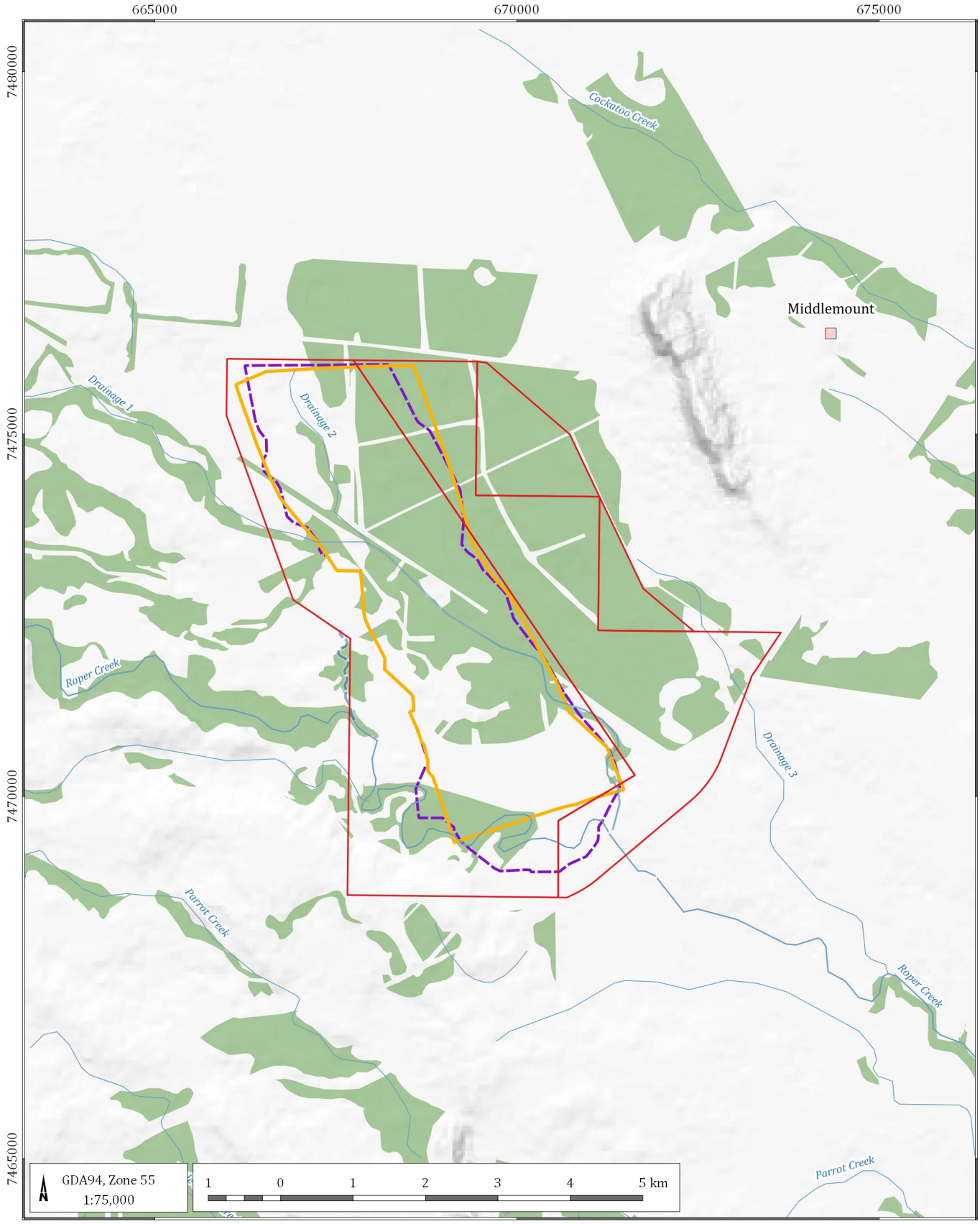
Figure 6.8 shows the potential GDE's identified by the BoM GDE mapping within and around Middlemount Coal Mine.

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

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

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

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



LEGEND

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

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

- Low potential GDE - from regional studies

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Groundwater Dependent Ecosystems - GDE Atlas

DATE 26/08/2020

FIGURE No: 6.8

©2020 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.08_G1840P_Groundwater dependent ecosystems.qgs

In summary, this desktop assessment of the GDE mapping (BoM, 2020) is consistent with the findings provided for the Western Extension GIA (AGE, 2018) which concluded:

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

6.9 Stygofauna

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

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

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

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

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

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

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

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

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

Table 6.7 Potential stygofauna habitat at Middlemount Coal Mine

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

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

6.10 Hydraulic influence of faults

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

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

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

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

6.11 Groundwater use and extraction

6.11.1 Landholder groundwater use

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

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

6.11.2 Mine groundwater extraction

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

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

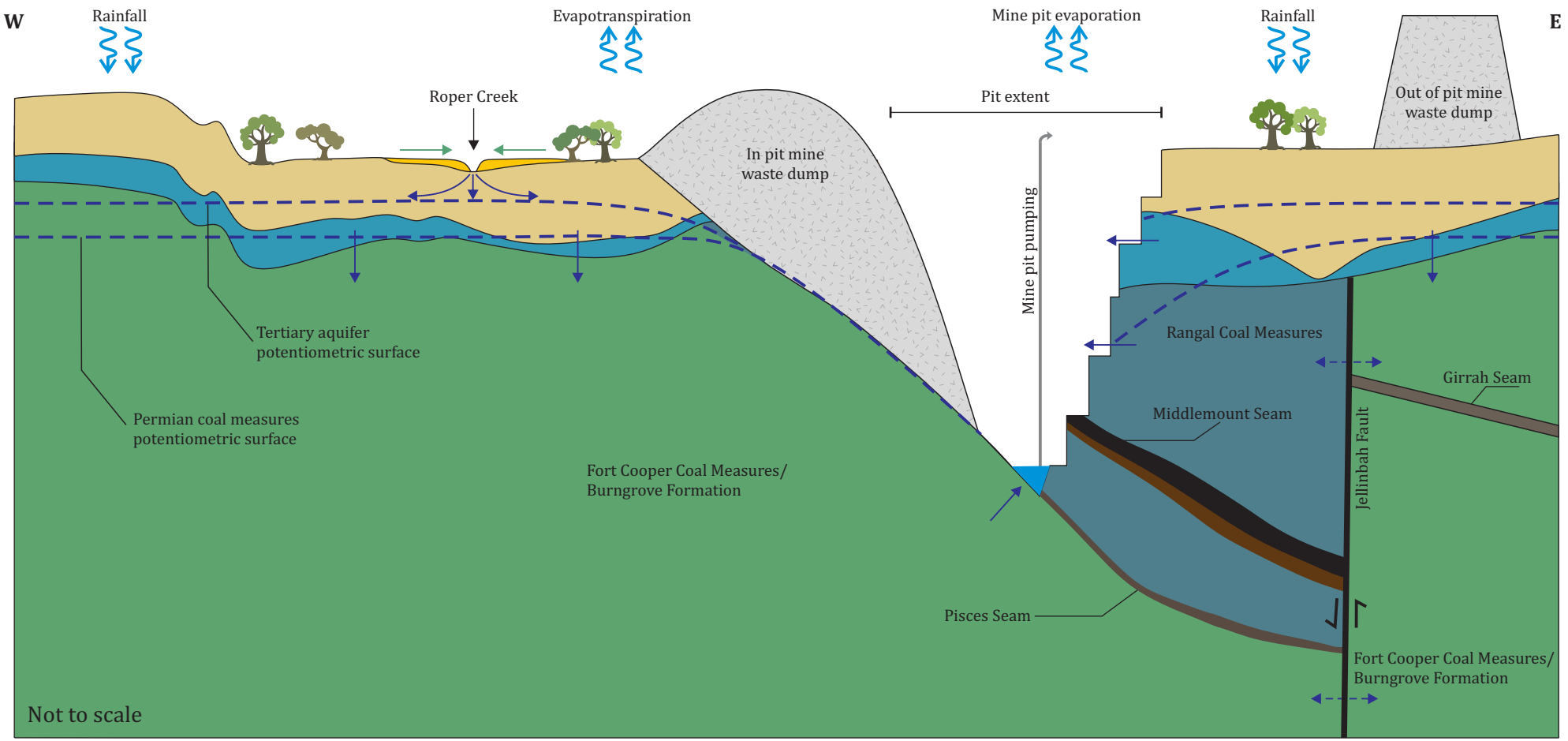
6.12 Groundwater geochemistry from coal, overburden, and interburden

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

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

6.13 Summary of conceptual groundwater model

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



Legend

- Quaternary alluvium
- Tertiary (weathered)
- Rangal Coal Measures (weathered)
- Rangal Coal Measures
- Middlemount Seam
- Tralee Seam
- Pisces Seam
- Fort Cooper Coal Measures
- Girrah Seam
- Fault
- Surface runoff direction
- Groundwater flow direction
- Assumed groundwater flow across fault zone
- Potentiometric surface

Vertical exaggeration is approximately 1:10

South-west to north-east hydrogeological conceptualisation

Figure - 6.9

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

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

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

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

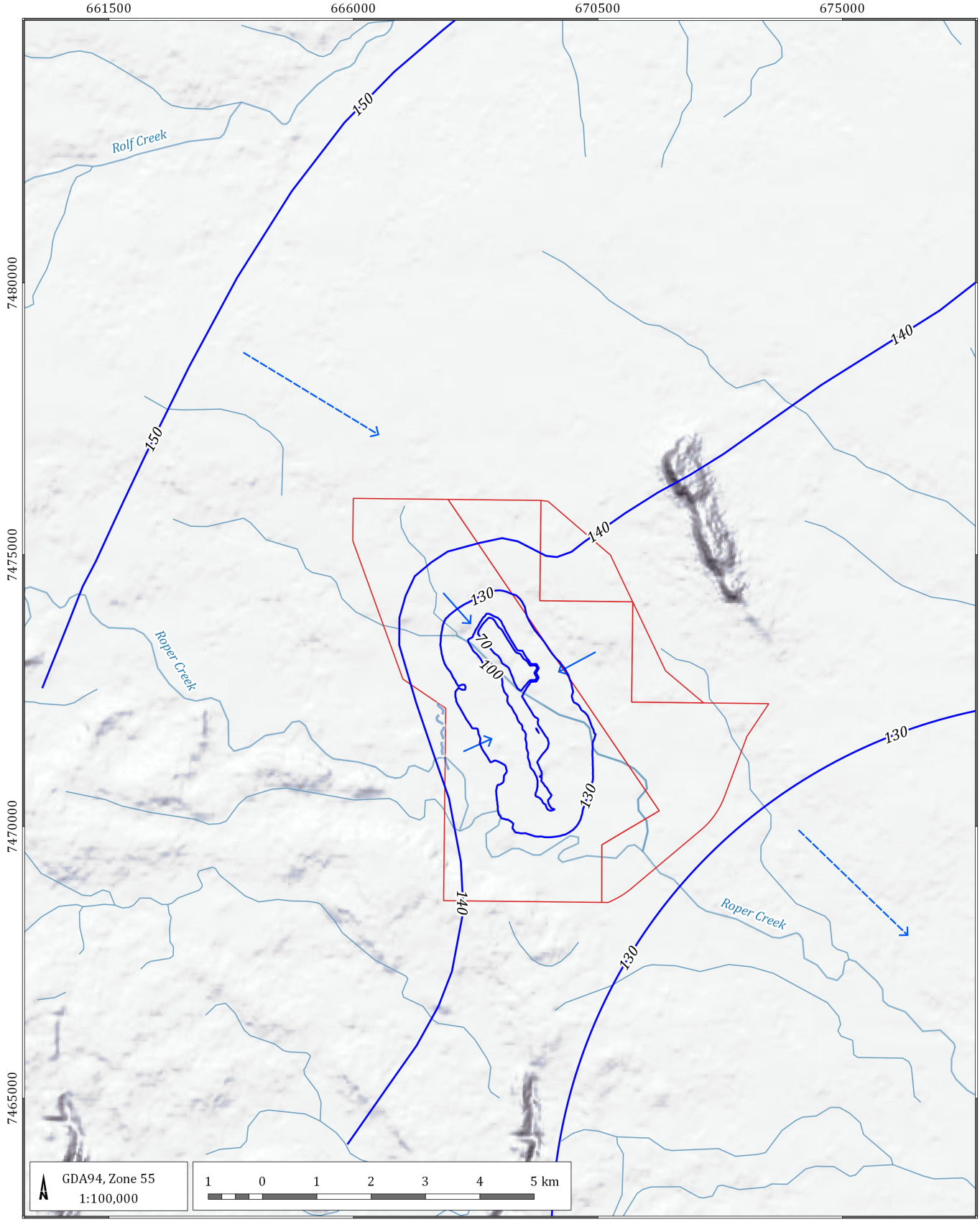
The regional water table within the Tertiary aquifer is a subdued reflection of topography with a general flow towards the south-east. The exception to this is immediately around the mine where groundwater levels would have declined due to localised depressurisation resulting from mining. Figure 6.10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

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

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

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

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



LEGEND

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

Flow directions

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Inferred 2020 Tertiary aquifer groundwater levels

DATE 21/08/2020

FIGURE No: **6.10**

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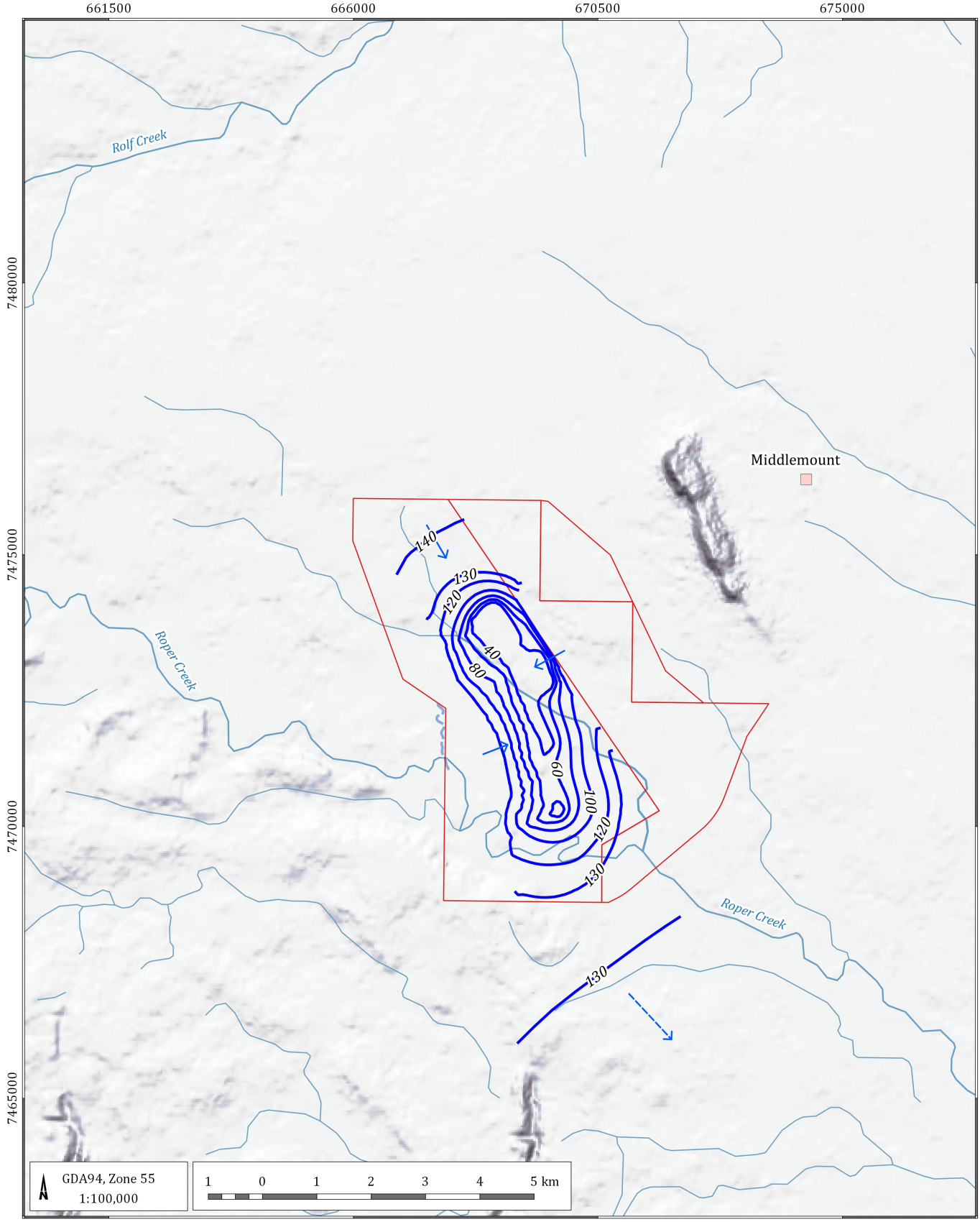

LEGEND

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

Flow directions

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Inferred 2020 Permian Coal Measures groundwater levels

DATE 31/07/2020

FIGURE No: **6.11**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\06.11_G1840P_Inferred 2017 Permian Rangal Coal Measures groundwater levels.qgs

7 Environmental value of groundwater

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

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

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

7.1 Aquatic ecosystem

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

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

7.2 Irrigation and farm supply/use

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

7.3 Stock water

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

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

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

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

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

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

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

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

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

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

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

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

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

Metal values relate to the total concentration of the constituent.

7.4 Drinking water

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

7.5 Industrial purposes

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

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

7.6 Cultural and spiritual values

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

8 Numerical modelling

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

The predictive model scenarios have been designed to estimate:

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

8.1 Previous modelling

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

8.2 Overview of groundwater modelling

8.2.1 Model software and code selection

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

8.2.2 Proposed mine plan

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

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

8.2.3 Model design and calibration

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

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

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

The following sections describe the predictions of the groundwater model.

8.3 Groundwater modelling predictions

8.3.1 Groundwater inflow to mining areas

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

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

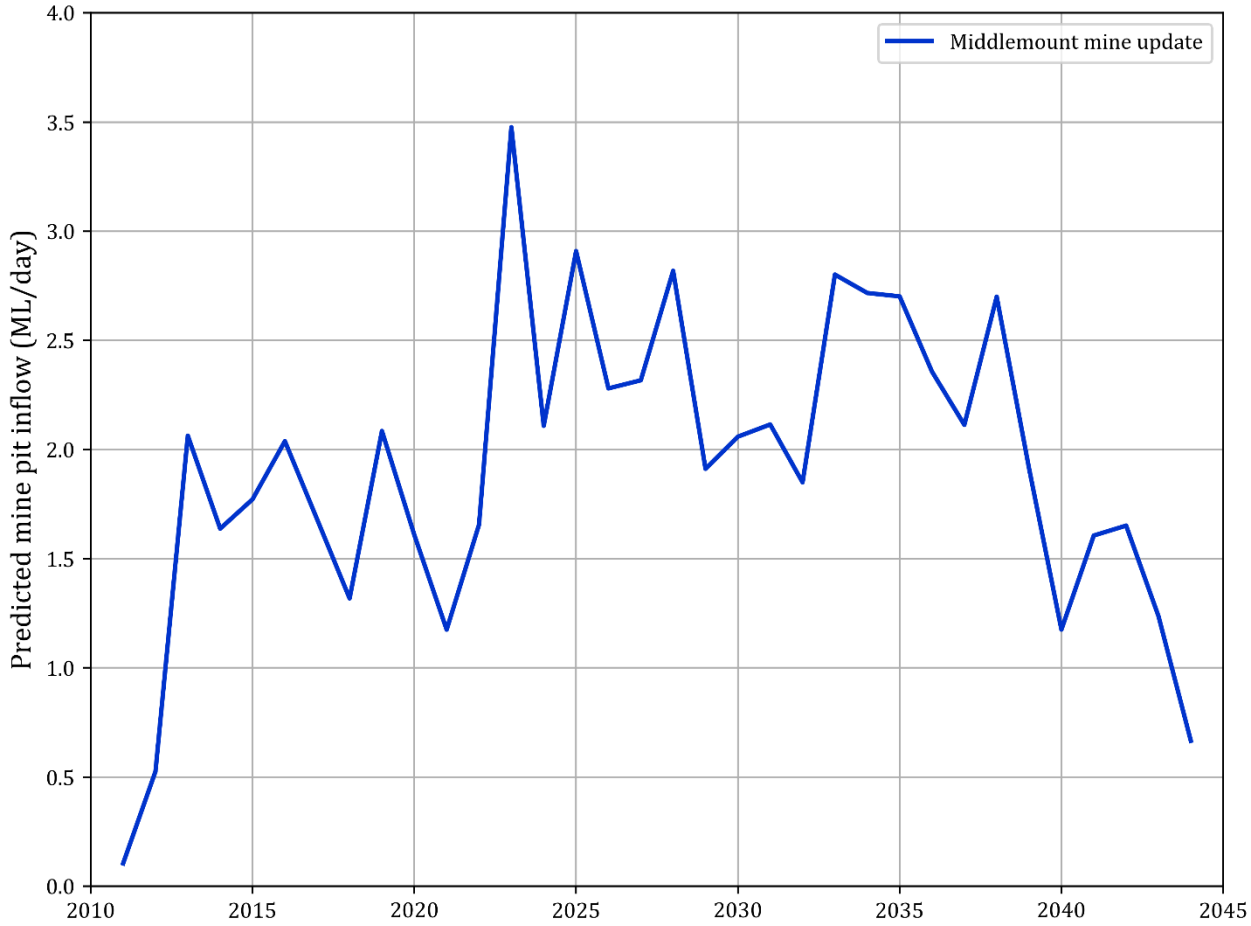


Figure 8.1 Predicted average annual pit inflows

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

Table 8.1 Predicted groundwater inflow – 2011 to 2044

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

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

Notes: *ML/year = megalitres per year*

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

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

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

8.3.2 Drawdown and depressurisation during mining operations

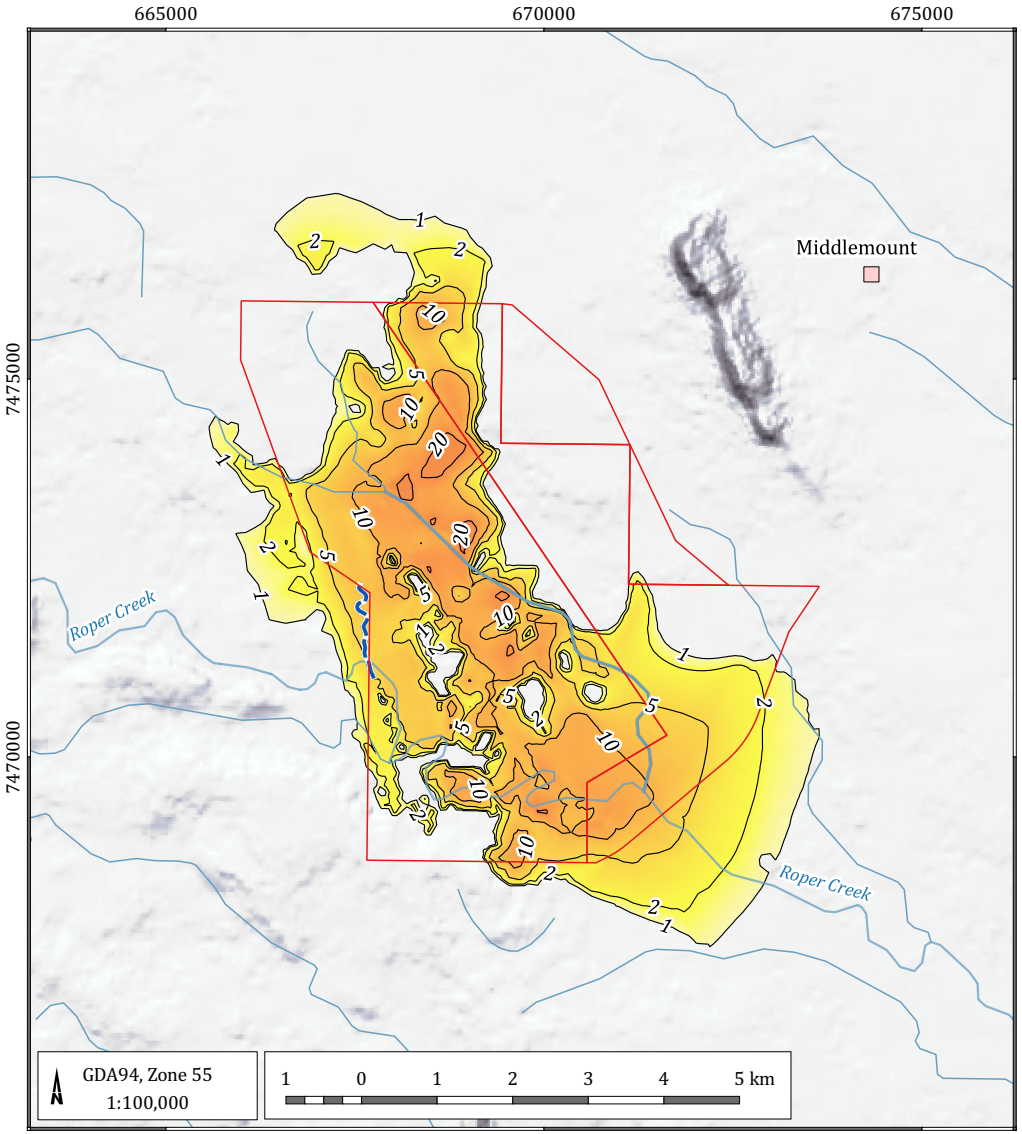
The zone of depressurisation due to the Middlemount Coal Mine (incorporating the Project) within the Tertiary and Weathered Permian (Layers 2 and 3), Middlemount Seam (layer 5), Pisces Seam (layer 7) and Fort Cooper Coal Measures (Layers 16 and 17), are shown in Figure 8.2, Figure 8.3, and Figure 8.4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

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

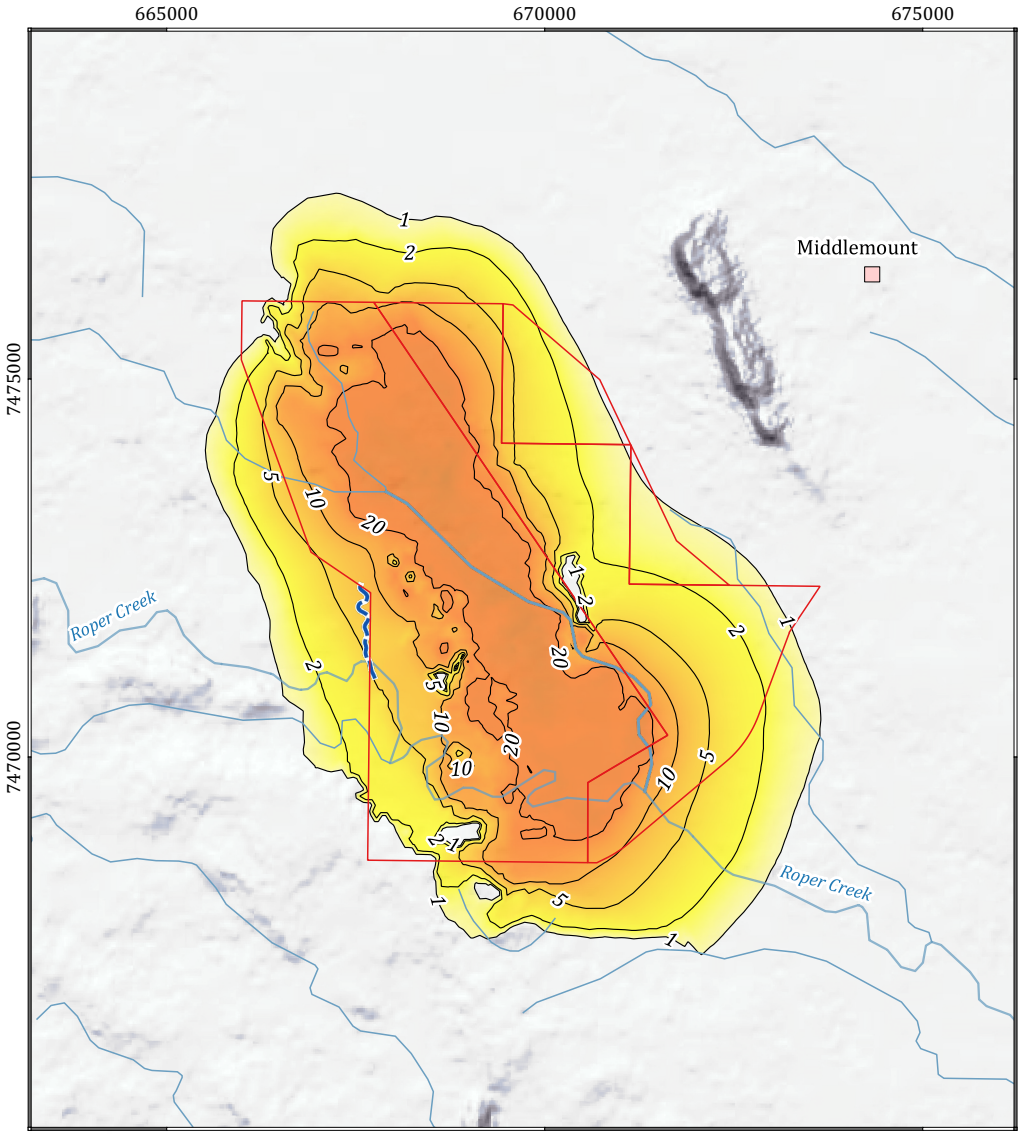
The predicted extent of drawdown and depressurisation to the north, east and west of the Middlemount Coal Mine (incorporating the Project) is largely consistent with the extent of drawdown predicted for the Western Extension Project. The extent of depressurisation in the Fort Cooper Coal Measures is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

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

Maximum zone of drawdown (Layer-2)



Maximum zone of drawdown (Layer-3)



LEGEND

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

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE
31/07/2020

FIGURE No:
8.2

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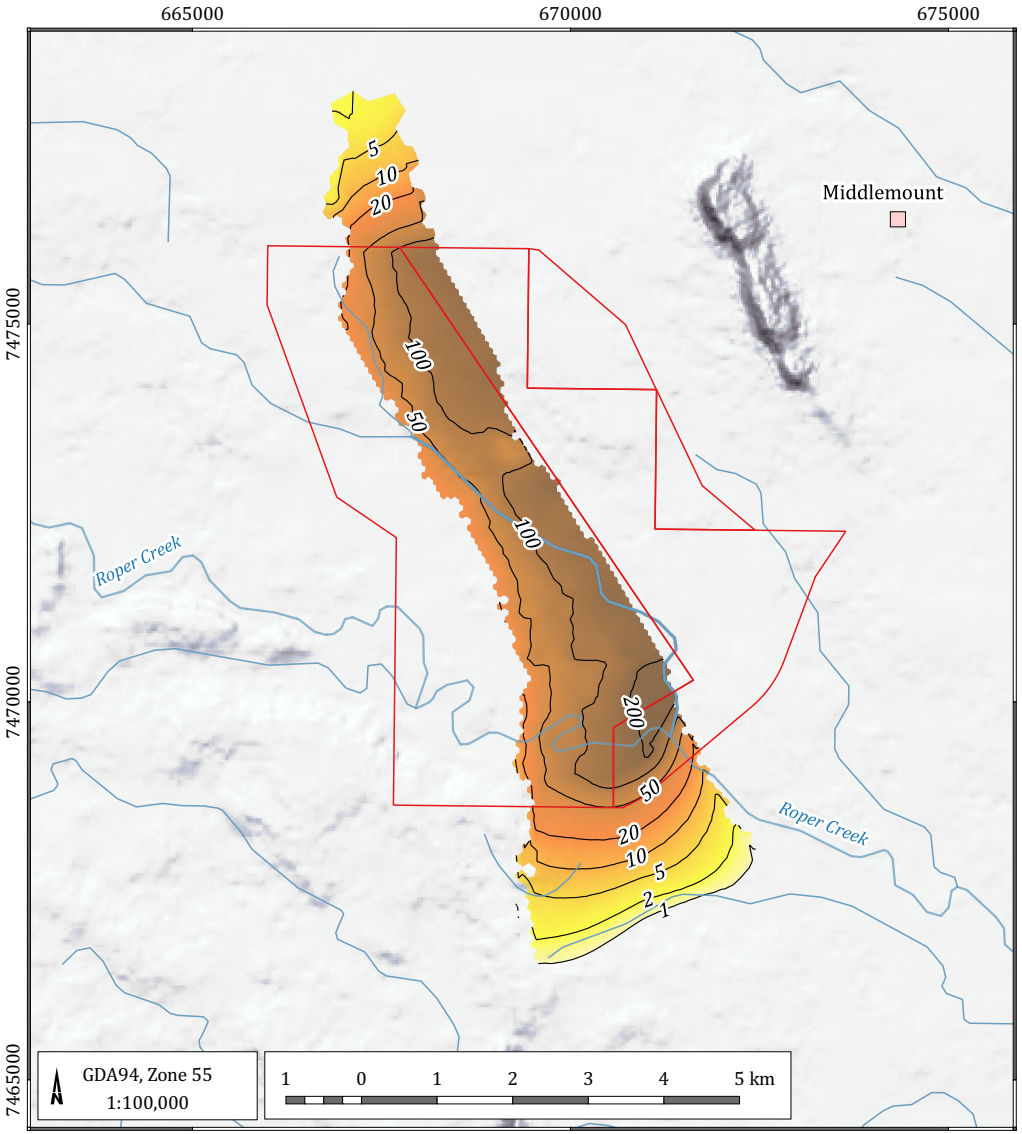
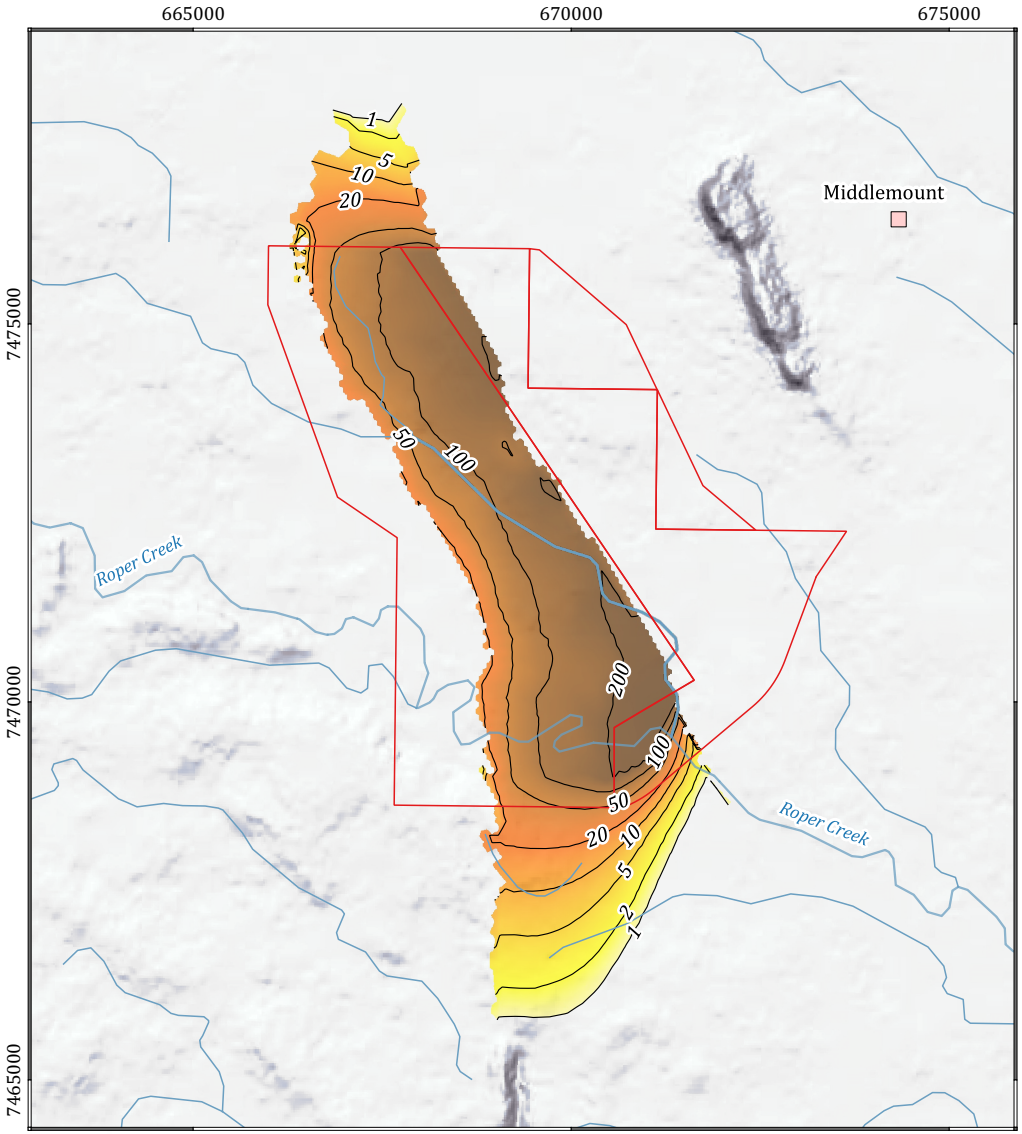
Maximum zone of drawdown - (Layer 5)



Maximum zone of drawdown - (Layer 7)



LEGEND

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

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE
21/08/2020

FIGURE No:
8.3

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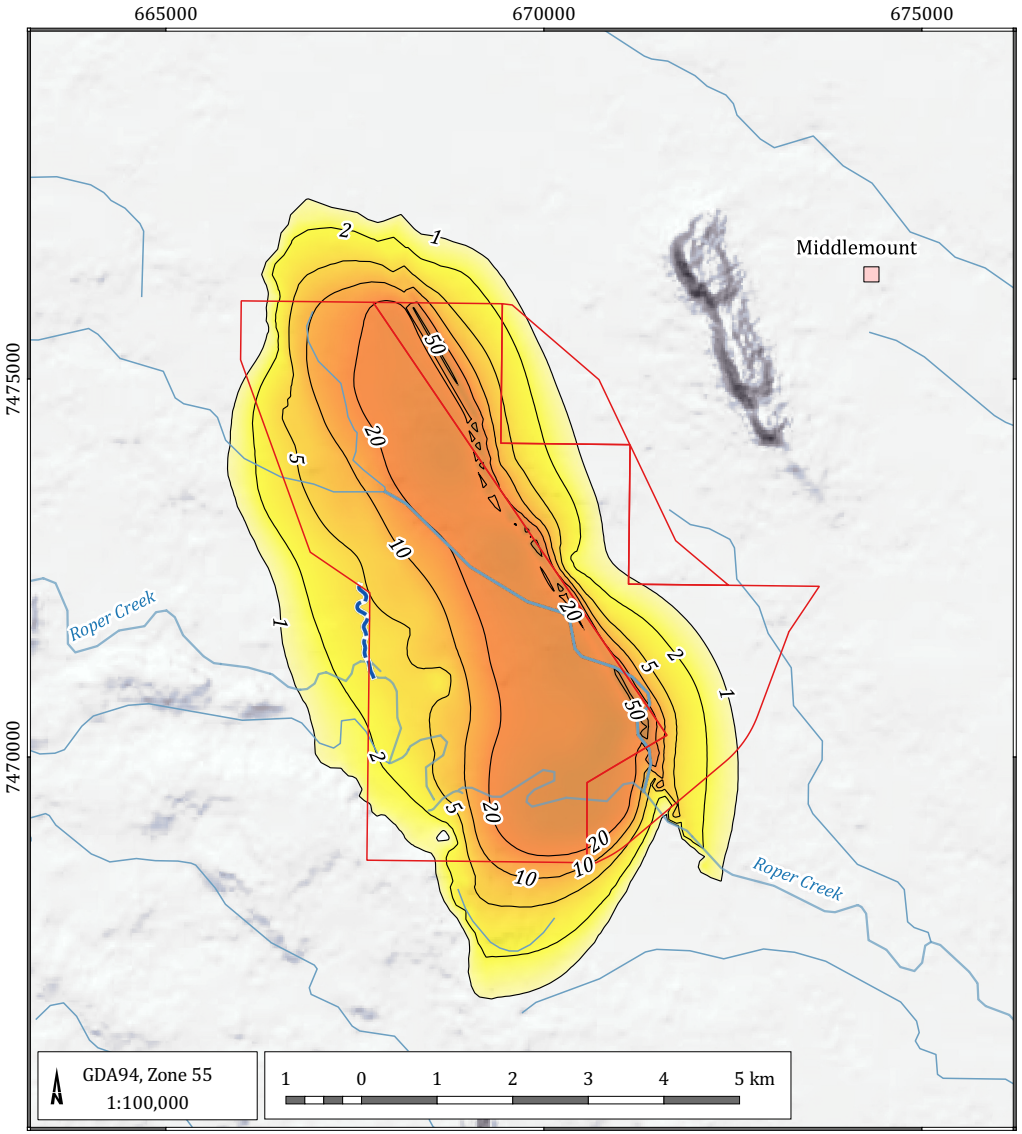
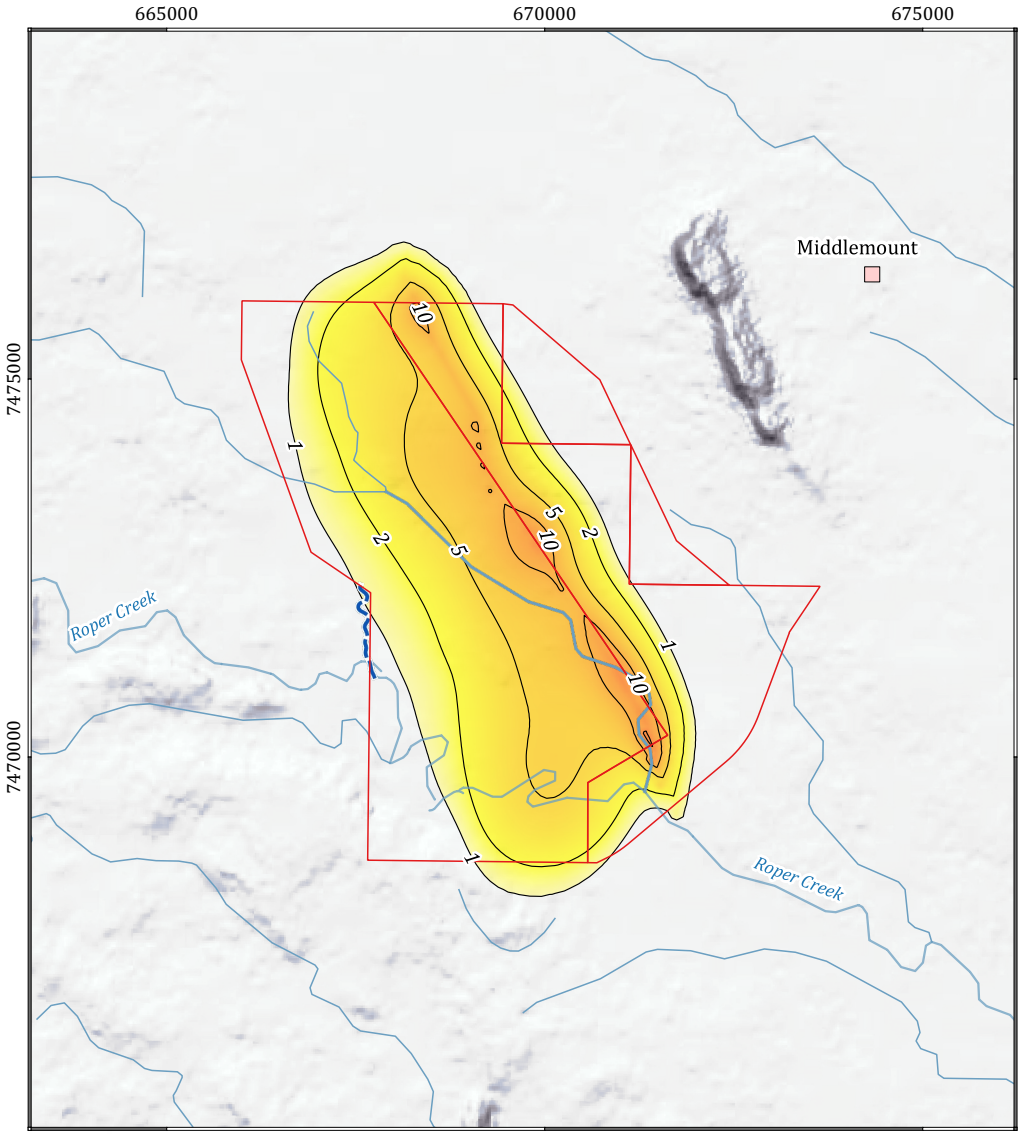
Maximum zone of drawdown (Layer-9 & 16)



Maximum zone of drawdown (Layer-10 & 17)



LEGEND

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

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE
24/08/2020

FIGURE No:
8.4

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8.3.3 Cumulative impacts

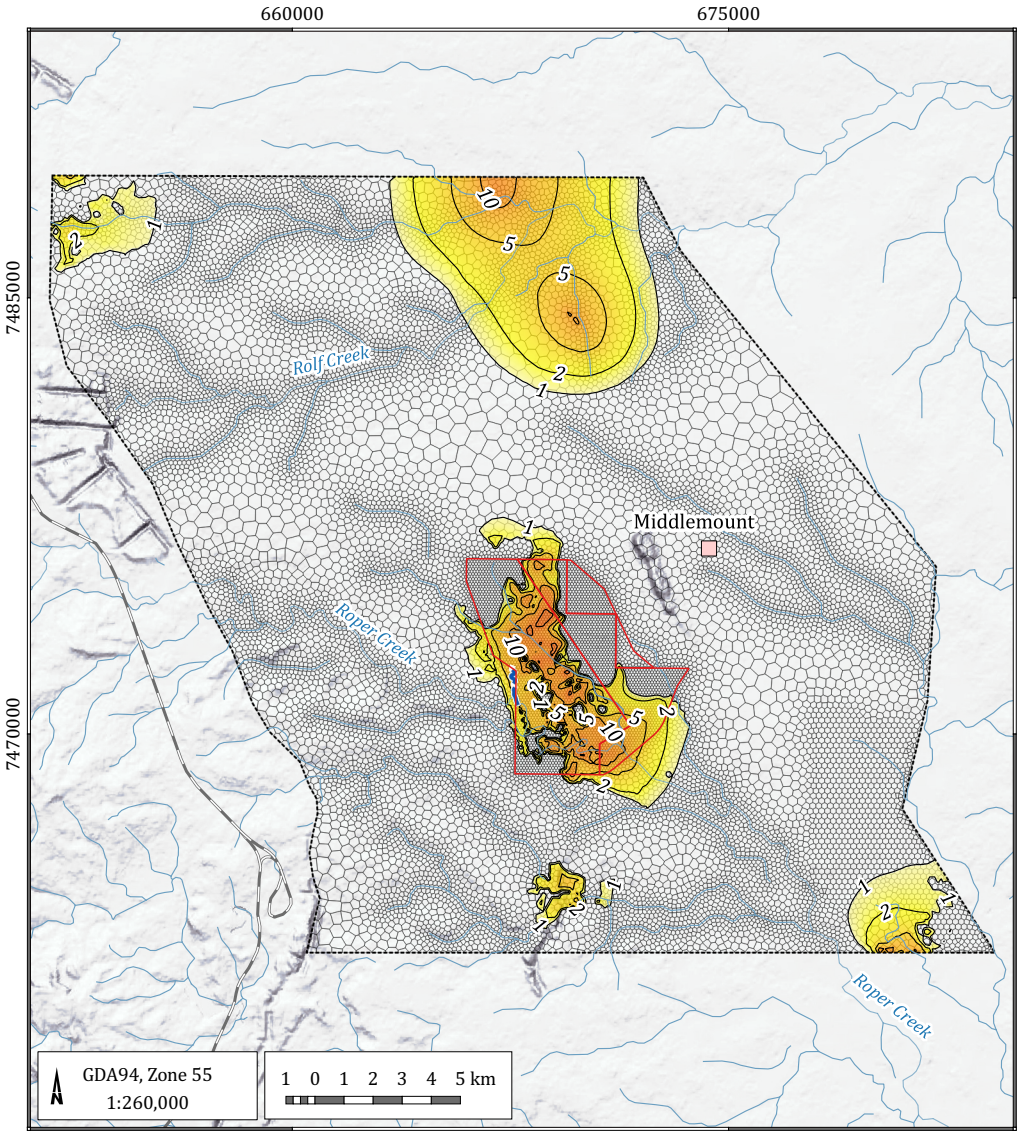
The numerical groundwater model was used to assess the cumulative impact between the Middlemount Coal Mine (incorporating the Project) and nearby operational and closed mines which include German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park. CSG production as part of the Bowen Gas Project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

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

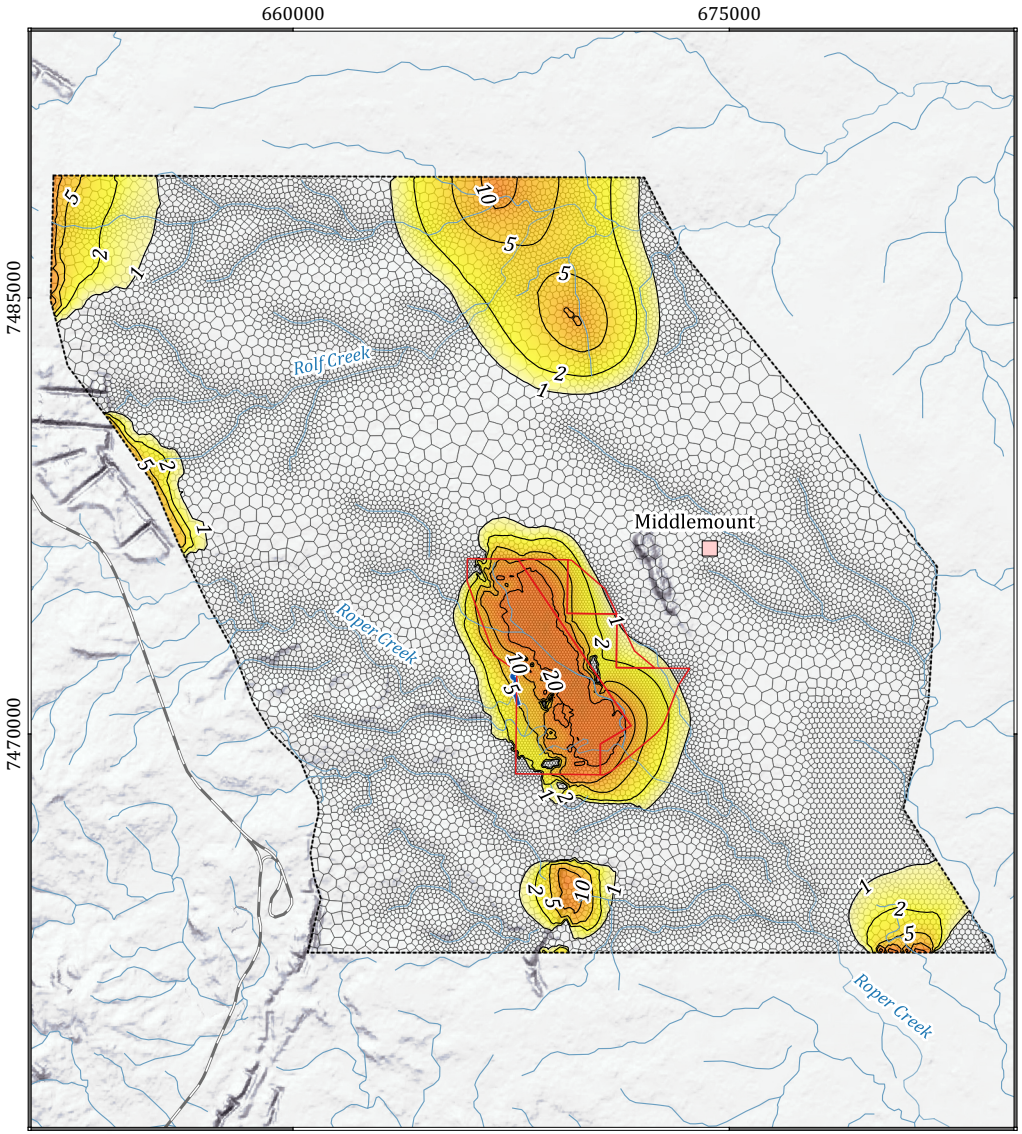
- Within the Tertiary and Weathered Permian (Figure 8.5) do not show overlap between Middlemount and Foxleigh mines resulting in no cumulative drawdown between model layers 2 and 3.
- For the Middlemount Seam (layer 5) 1 m contour, just intersects roughly midway between the Middlemount Coal Mine and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

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

Maximum cumulative drawdown (Layer-2)



Maximum cumulative drawdown (Layer-3)



LEGEND

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

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

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FIGURE No:
8.5

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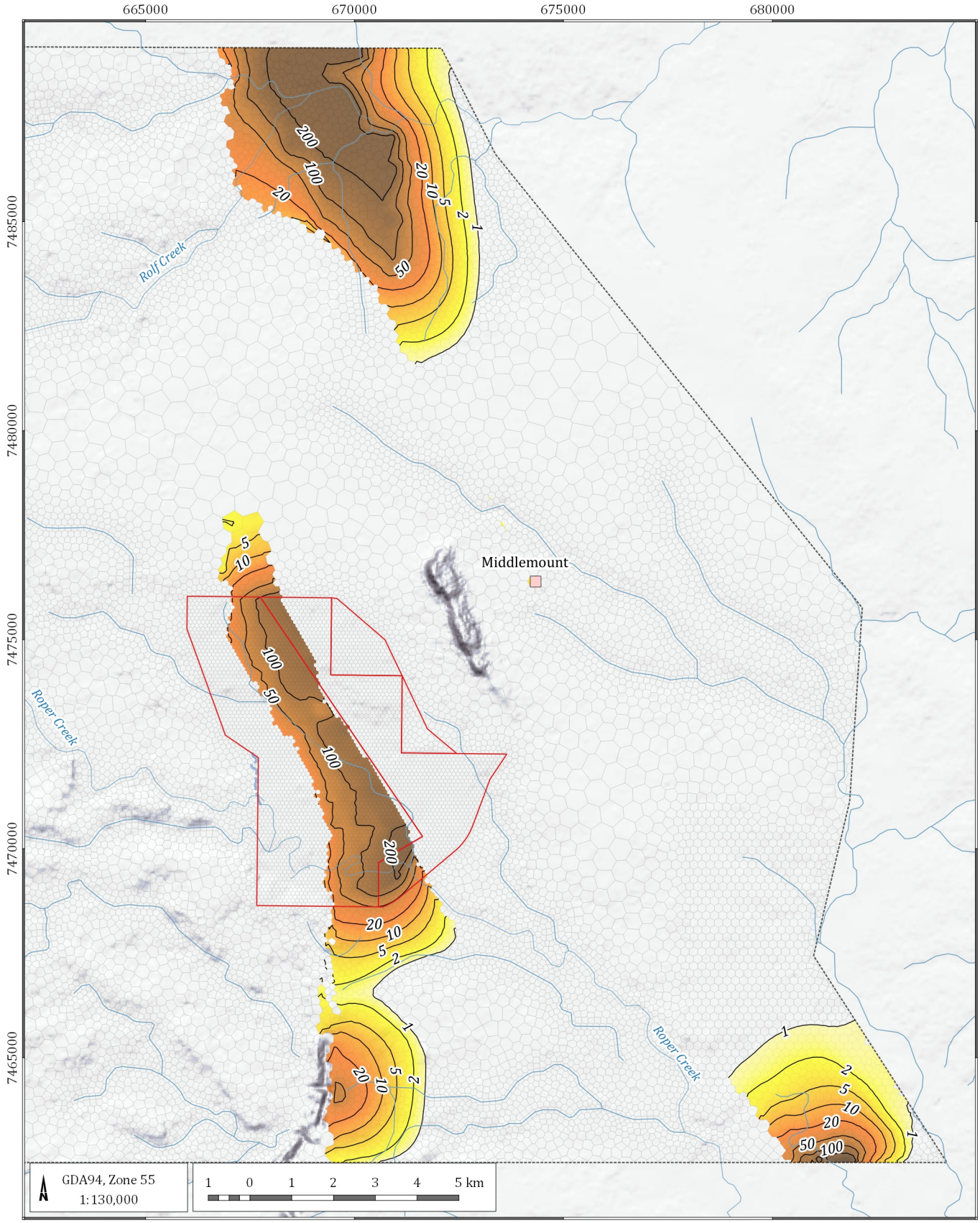
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.05_G1840P_Maximum cumulative drawdown Tertiary and Weathered Permian – Layers 2 & 3 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 31/08/2020

FIGURE No: **8.6**

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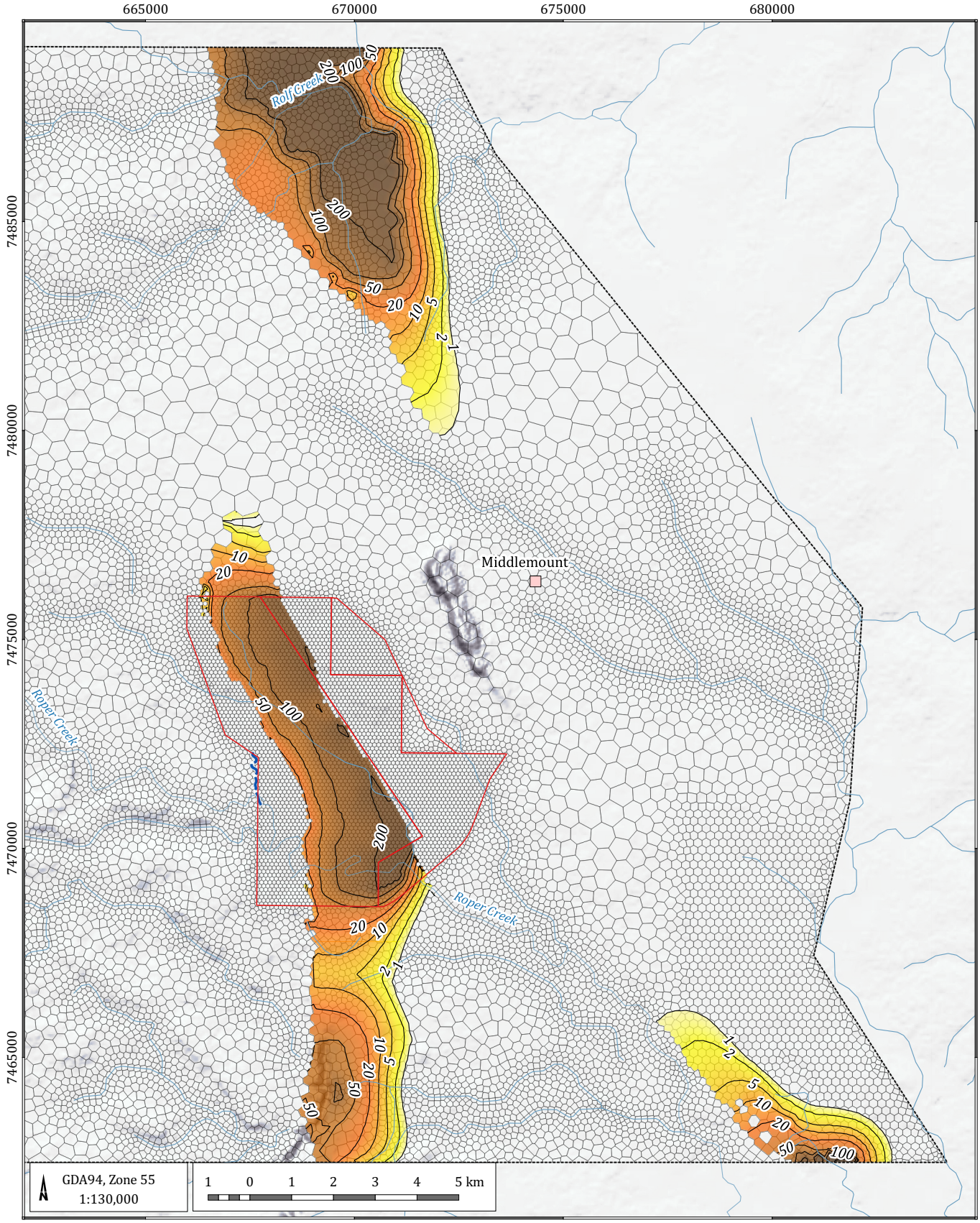
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.06_G1840P_Maximum cumulative drawdown Middlemount Seams and Leichhardt – Layer 5 & Layer 12 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 24/08/2020

FIGURE No: **8.7**

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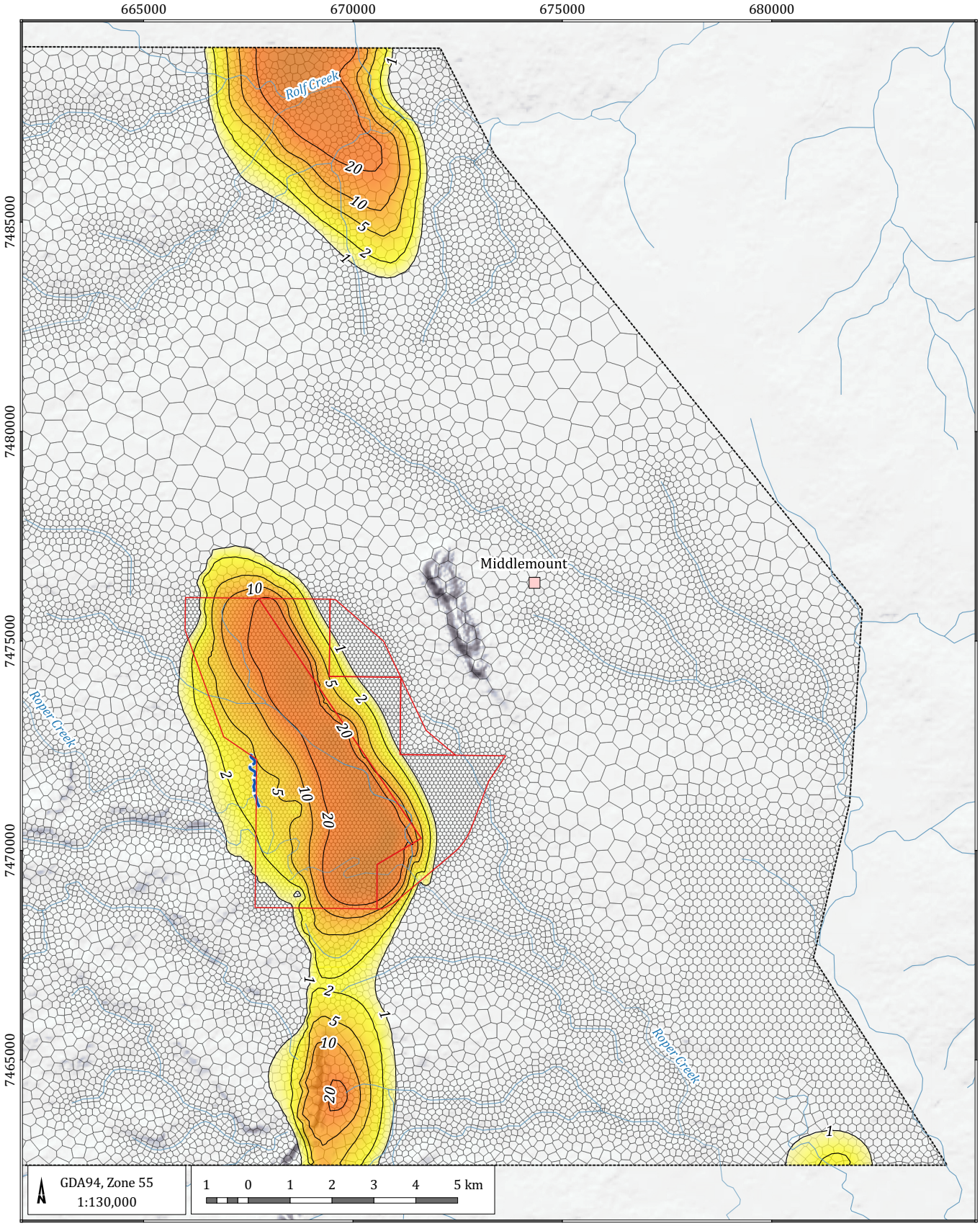
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.07_G1840P_Maximum cumulative drawdown Pisces and Vermount Seam – Layer 7 & Layer 14 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 24/08/2020

FIGURE No: **8.8**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.08_G1840P_Maximum cumulative drawdown Fort Cooper Coal Measures – Layers 9,10,16 & 17 (CSG extraction, Foxleigh Mine, German Creek East Mine).qgs

8.3.4 Impacts on groundwater users

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

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

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

8.3.5 Impacts on groundwater dependent ecosystems

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

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

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

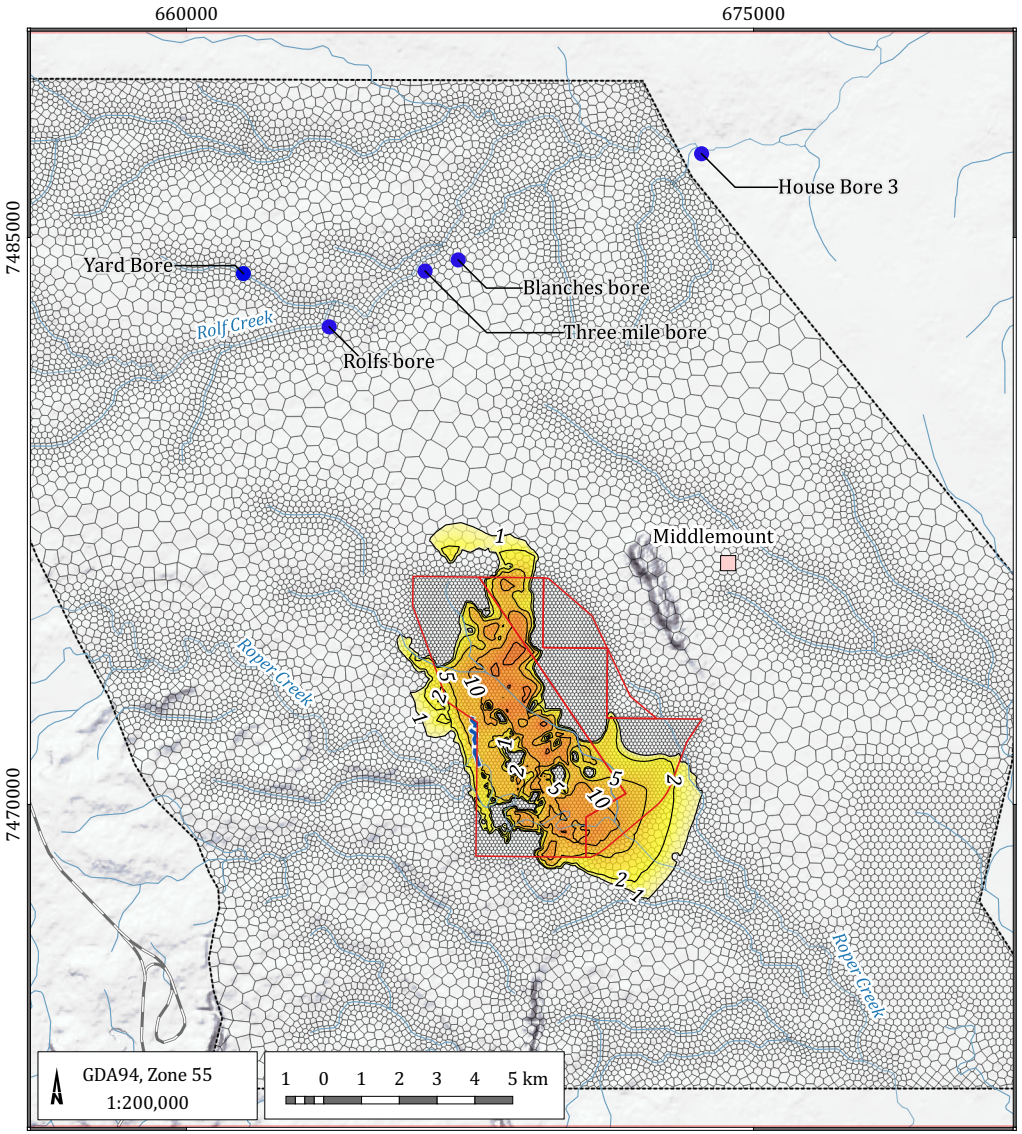
As discussed in Section 6.9, sampling in 2011 found a naturally low diversity of stygofauna (taxa from two Families). Stygofauna from the same two Families were found in bores that were located both in and outside the maximum zone of drawdown associated with the Middlemount Coal Mine (incorporating the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

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

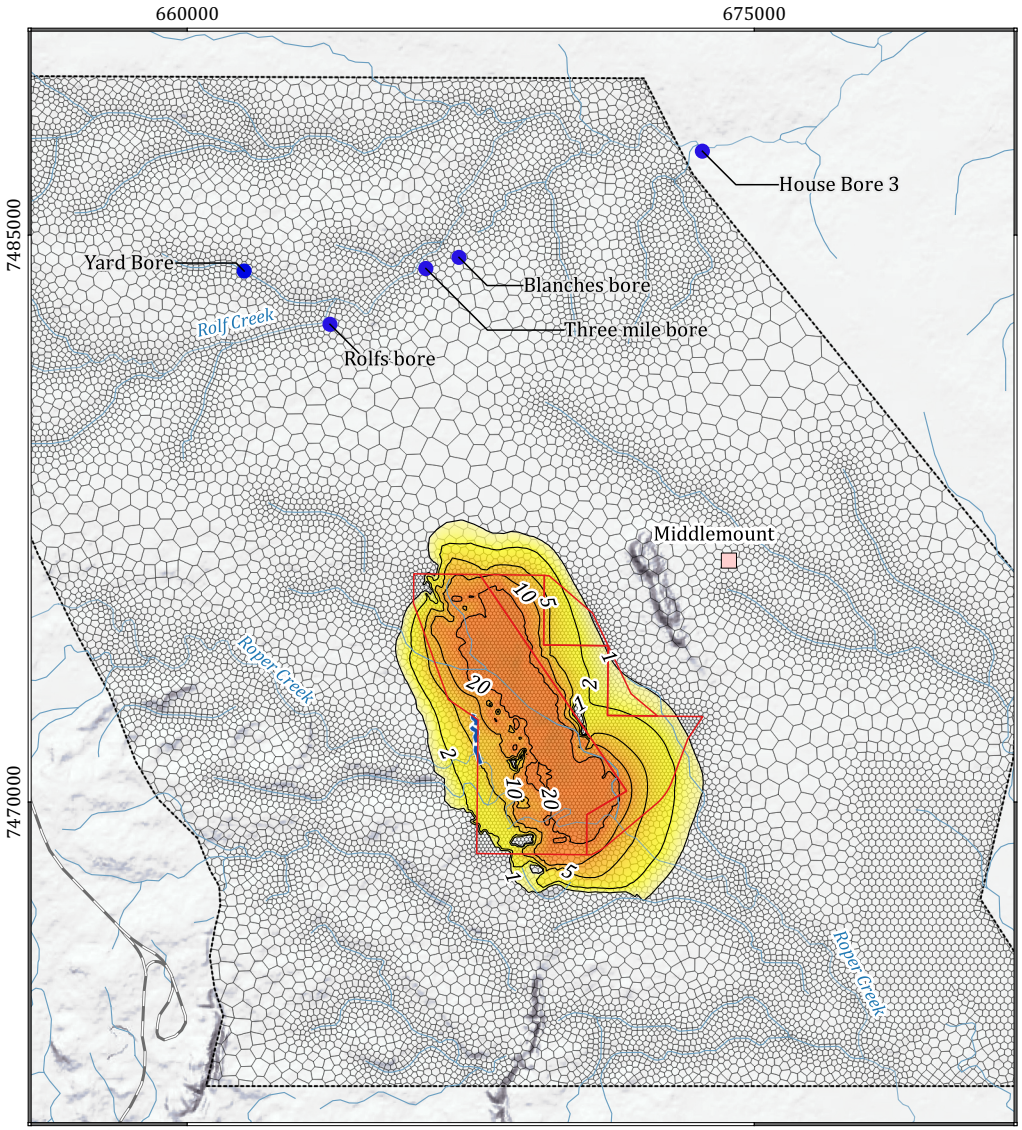
8.3.6 Roper Creek Diversion

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

Maximum zone of drawdown (Layer-2)



Maximum zone of drawdown (Layer-3)



LEGEND

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

Drawdown (m)

0	20
1	50
2	100
5	200
10	500

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Landholder bores within predicted maximum zone of drawdown during mining

DATE
24/08/2020

FIGURE No:
8.9

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.09_G1840P_Landholder bores within predicted maximum zone of drawdown during mining.qgs

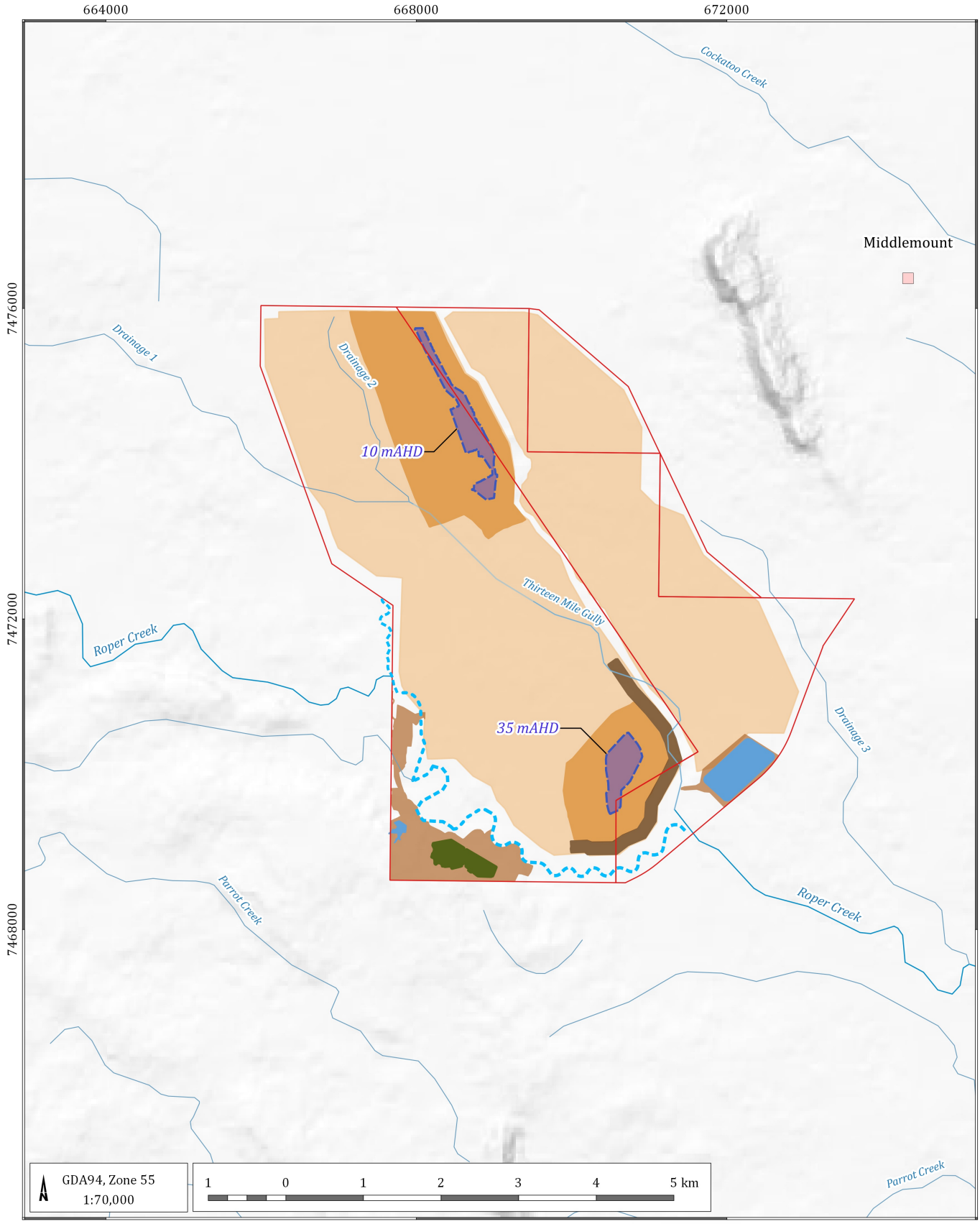
8.4 Post mining recovery conditions

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

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

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

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



LEGEND

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

Mine infrastructures

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Southern Extension Project residual voids

DATE 27/08/2020

FIGURE No: **8.10**

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

8.4.1 Post closure groundwater recovery

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

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

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

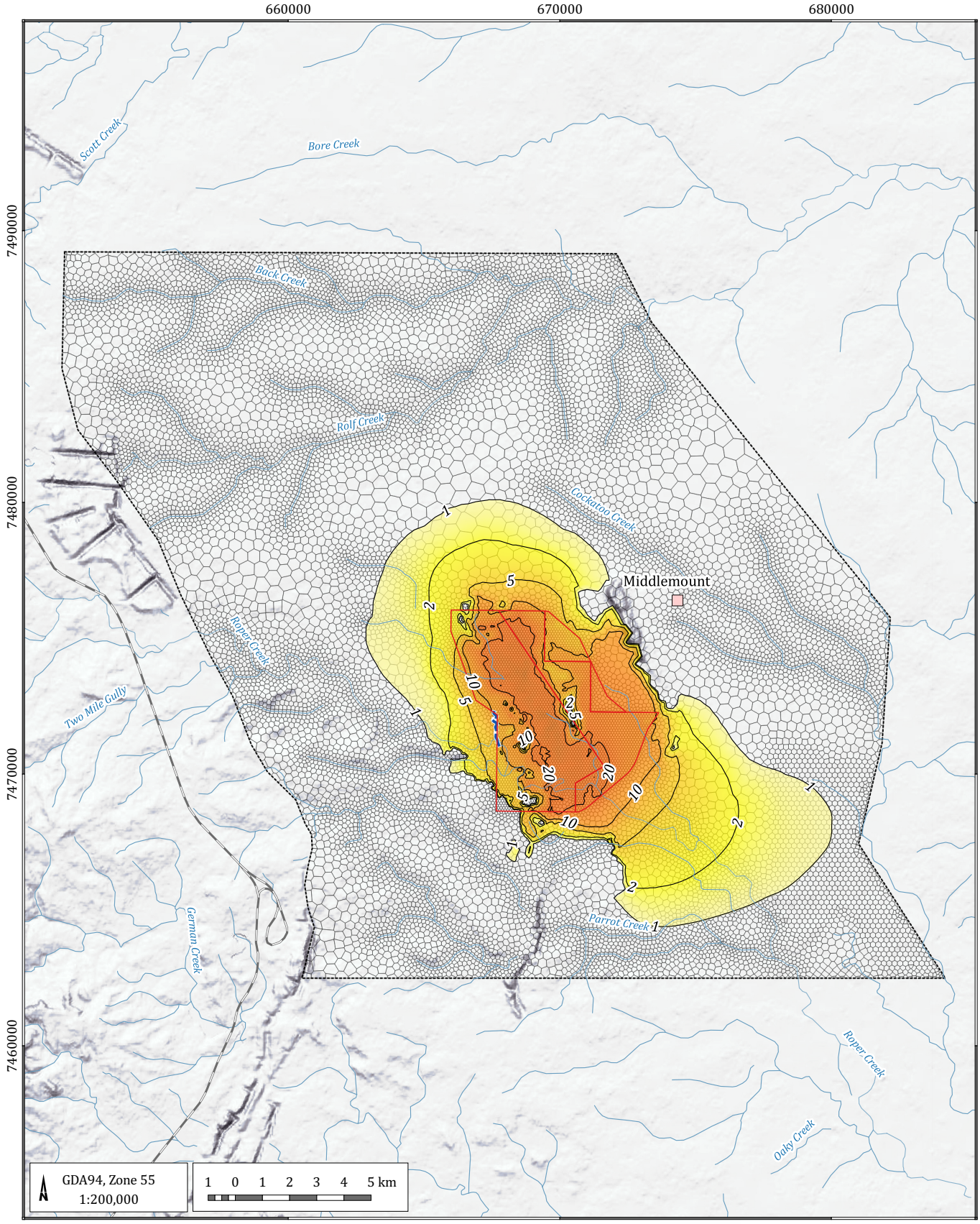
Figure 8.11 to Figure 8.14 show the predicted extent and magnitude of post mining drawdown in the Tertiary and Weathered Permian (layer 3), Middlemount Seam (layer 5), Pisces Seam (layer 7) and the Fort Cooper Coal Measures (layer 16), respectively. As a result of the residual voids remaining as groundwater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

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

8.4.2 Groundwater intercepted post mining

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

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



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 24/08/2020

FIGURE No: **8.11**

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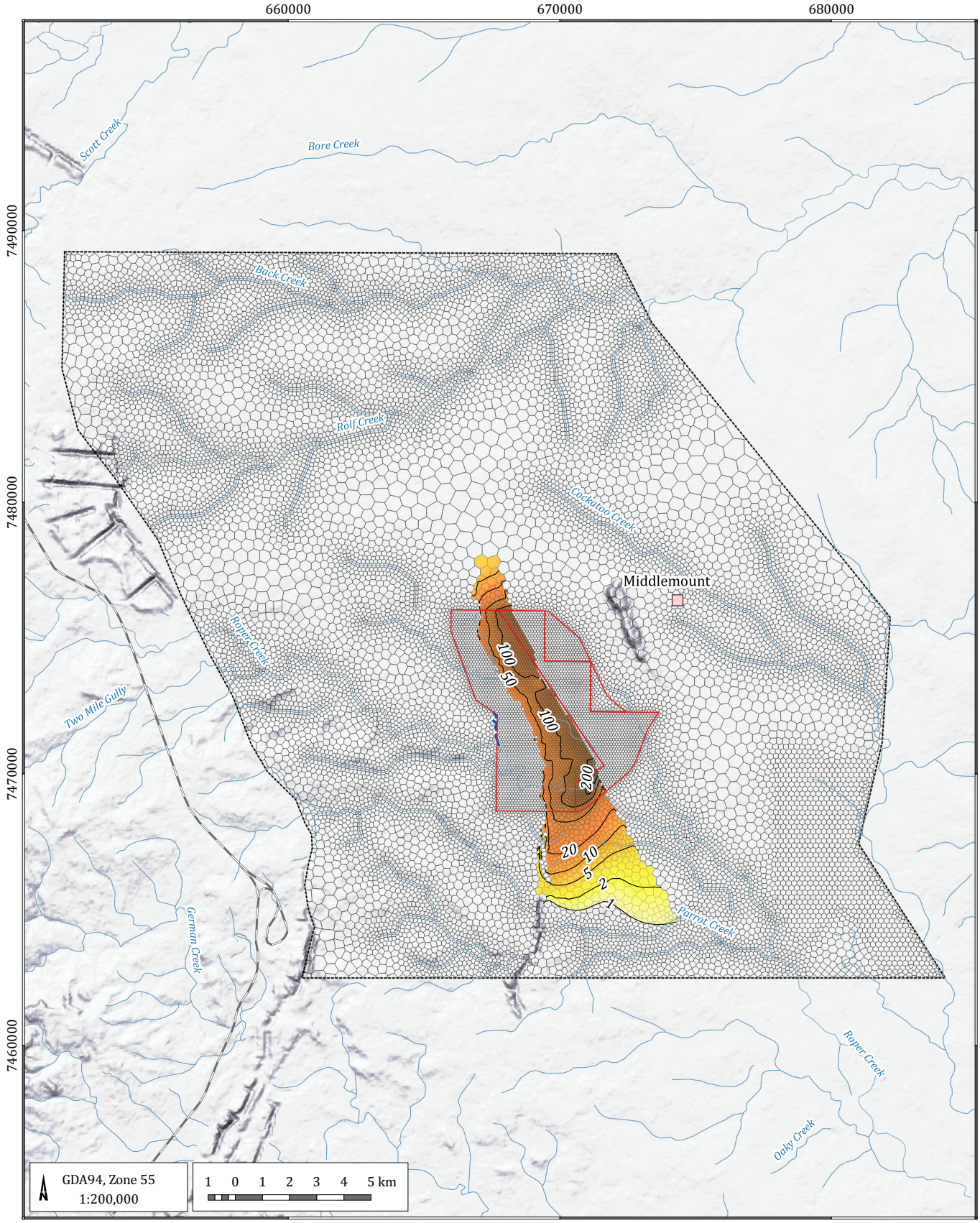
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.11_G1840P_Post mining equilibrium drawdown – Tertiary and Weathered Permian (Layer 3).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Post mining equilibrium drawdown – Middlemount Seam (layer 5)

DATE 24/08/2020

FIGURE No: **8.12**

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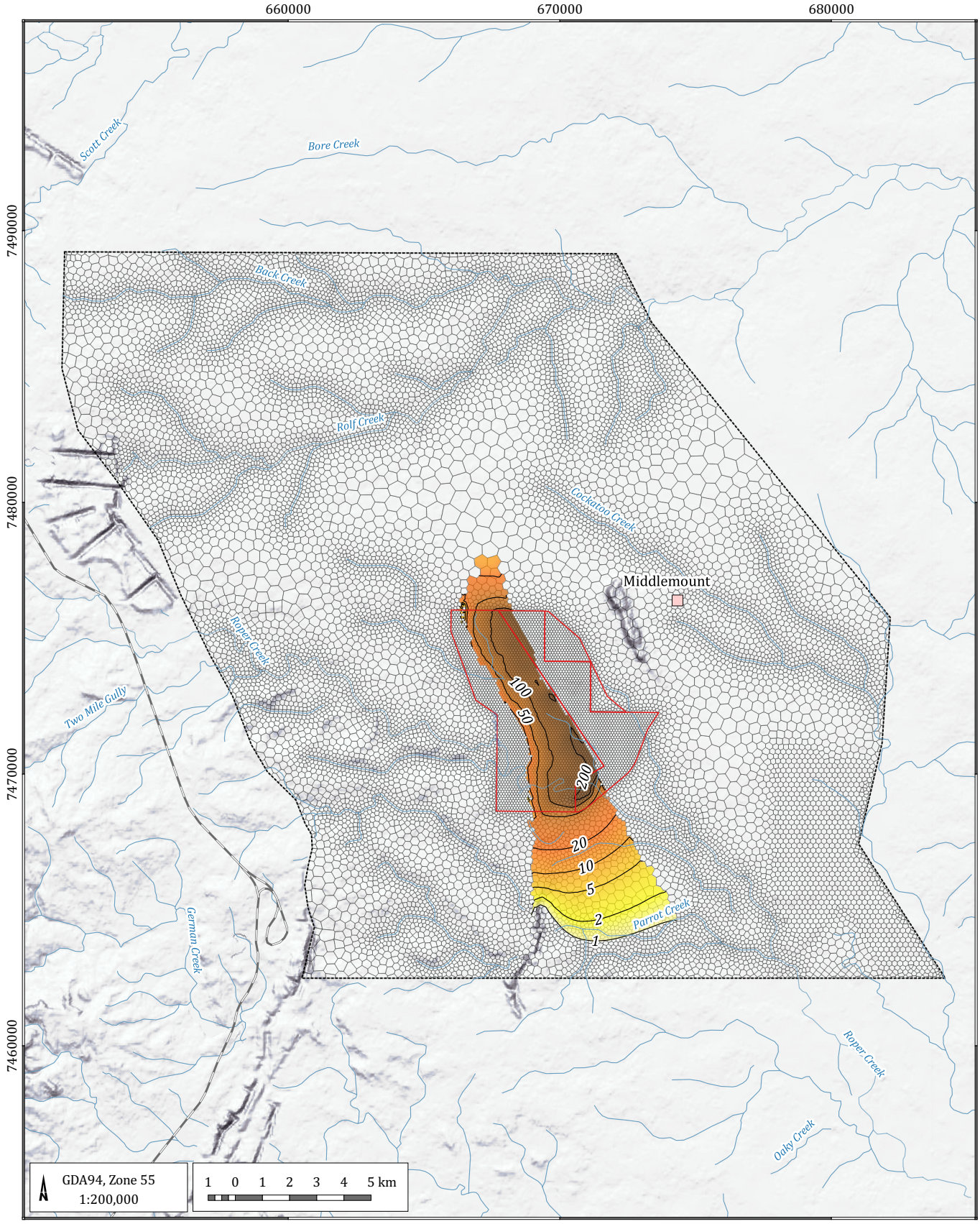
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.12_G1840P_Post mining equilibrium drawdown – Middlemount Seam (layer 5).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Post mining equilibrium drawdown – Pisces Seam (Layer 7)

DATE 24/08/2020

FIGURE No: **8.13**

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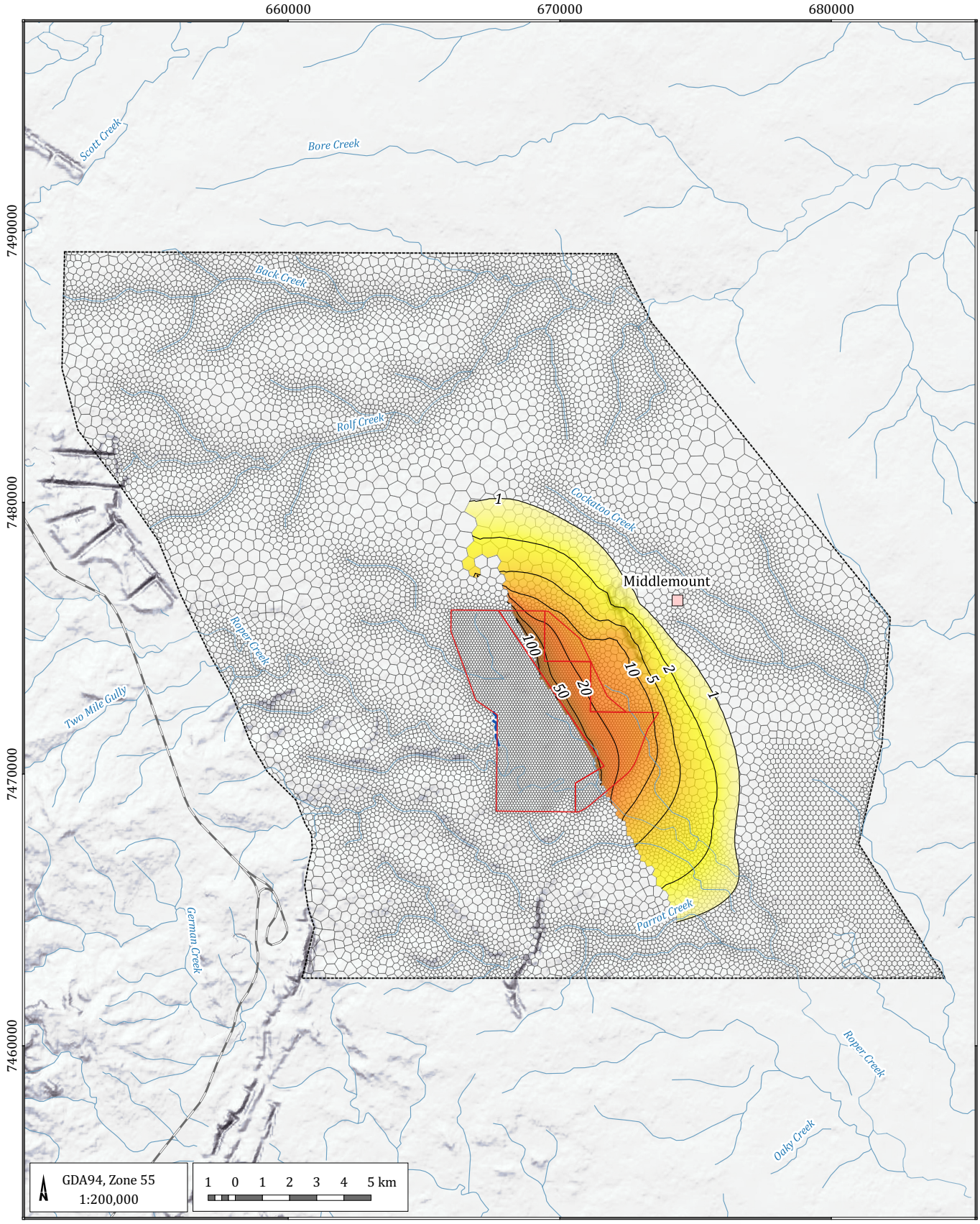
G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.13_G1840P_Post mining equilibrium drawdown – Pisces Seam (Layer 7).qgs



LEGEND

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

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 24/08/2020

FIGURE No: **8.14**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\08.14_G1840P_Post mining equilibrium drawdown – Fort Cooper Coal Measures (Layer 16).qgs

8.5 Impacts on groundwater quality

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

8.5.1 Overburden emplacement areas and residual void lakes

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

8.5.2 Hydrocarbons

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

8.5.3 Coal rejects storage

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

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

8.5.4 Impacts on environmental values

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

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

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

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

9 Groundwater monitoring strategy/program

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

9.1 Monitoring bore network

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

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

Table 9.1 Proposed Middlemount Coal Mine groundwater monitoring network

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

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

Notes: *Coordinates in GDA94Z55*

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

 # Sensor believed to be faulty.

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

9.2 Water level monitoring plan

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

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

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

9.3 Water quality monitoring plan

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

The full groundwater quality suite should continue to include:

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

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

9.4 Groundwater triggers

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

9.4.1 Groundwater quality trigger values

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

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

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

Table 9.2 Groundwater investigation trigger levels

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

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

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

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

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

These reports indicated the exceedances in relation to:

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

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

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

9.4.2 Groundwater level trigger thresholds

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

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

Table 9.3 Groundwater level trigger thresholds

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

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

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

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

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

9.5 Mine groundwater inflow monitoring

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

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

9.6 Data management and reporting

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

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

10 Conclusions

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

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

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

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Appendix A IESC Guidelines

A1 Independent Expert Scientific Committee guidelines

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

A1.1 Description of the proposal

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

A1.2 Risk Assessment

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

A1.3 Groundwater – Context and conceptualisation

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

A1.4 Groundwater – Numerical modelling

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

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

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

A1.6 Groundwater – Data and monitoring

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

A1.7 Water dependent assets – Context and conceptualisation

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

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

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

A1.9 Water dependent assets – Data and monitoring

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

A1.10 Water and salt balance and water management strategy

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

A1.11 Cumulative Impacts – Context and conceptualisation

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

A1.12 Cumulative Impacts – Impacts

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

A1.13 Cumulative Impacts – Mitigation, monitoring and management

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

A1.14 Final landform and voids – coal mines

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

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

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

Appendix B DNRME groundwater data base bores

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

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

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

Notes: *Table A.1 excludes CSG bores*

mbGL metres below ground level

\- *no information provided*

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

Appendix C **Bore census**

Middlemount Coal Mine Western Extension Project

Groundwater Bore Census

September 2017

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

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

3.2.2 Field Validation and Bore Census

Conduct site visit with landholders in order to confirm:

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

4 Bore Census Methodology

4.1 Identification of bore locations for assessment

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

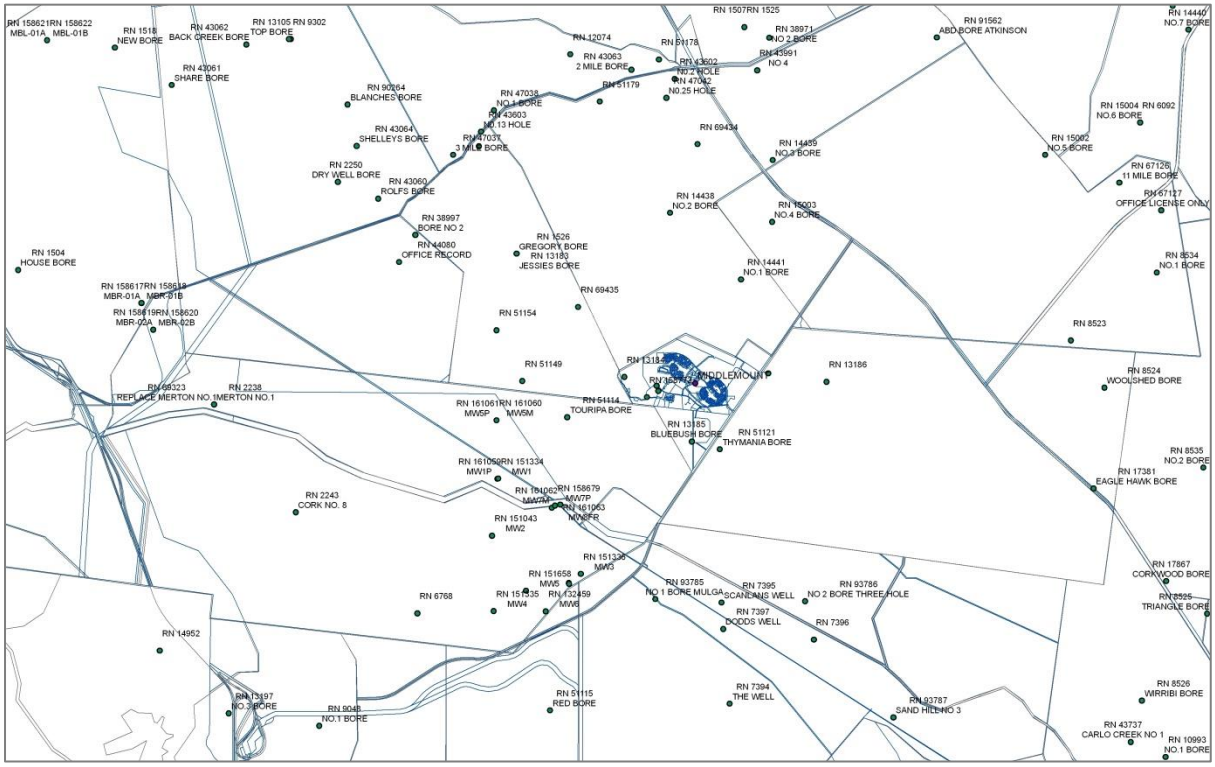

Figure 1: Draft map based on the 2012 DNRM database of registered groundwater bores.

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

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

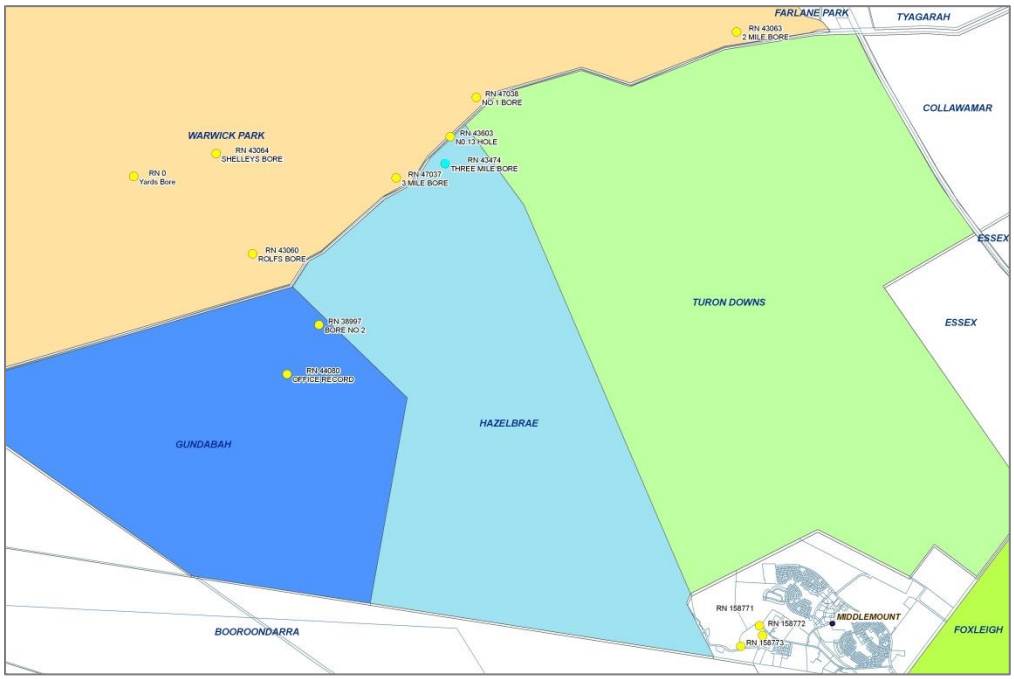

Figure 2: Bores that were assessed in the census.

4.2 Prior notice to landholders

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

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

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

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

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

4.3 Location of bores

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

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

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

4.4 Bore census records

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

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

4.5 Sampling and analysis

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

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

5 Bore census information

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

5.1 Summary of field surveys

Table 2: Bores that were recorded during the census

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

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

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

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

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

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

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

5.2 Bore census – 'Warwick Park'

The following bores were located and recorded:

- Yards Bore RN not available – not registered.
- Rolfs Bore RN43060
- Blanches Bore RN47037
  This bore is incorrectly named as 3 Mile Bore in the DNRM database. This may have been due to confusion with the Three Mile Bore across the road in Hazelbrae. Mr. Jim Curran advised that this bore has always been called Blanches Bore.
- House Bore 1 RN43063
  This bore is incorrectly named as 2 Mile Bore in the DNRM database.

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

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

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

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

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

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

Mr Curran also advised 4T that:

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

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

5.3 Gundabah

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

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

5.4 Hazelbrae

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

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

5.5 Tuon Downs

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

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

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

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

5.6 Foxleigh

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

5.7 Tralee

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

5.8 Middlemount Jockey Club and Racecourse

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

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

5.9 Isaac Regional Council – Middlemount Landfill

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

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

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

6 Census Information and Bore Logs

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

7 Laboratory analysis data

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

8 Additional test reports

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

9 Health, Safety and Environment (HSE) summary.

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

APPENDIX 1

Bore Assessment Information and Bore Logs [2]

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

WARWICK PARK

1. Property and bore owner

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

Residential address:	500 Warwick Park Road
	Middlemount 4746
	Queensland
	Australia
Postal address:	As above
Additional information:	Next to the back cattle yards at Warwick Park. Currently used by Warwick Park as emergency water supply during dry conditions. Could not sample on 13/9/17 as generator set required. Warwick Park generator set deployed elsewhere.

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

3. Bore equipment / use

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

Equipment and maintenance notes:

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

Headworks include Grundfos bore cover plate, pressure switch, one-way valve, blue oine poly 300mm delivery line. Pump has s/s safety wire.

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

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

6. Photographs

1. Property and bore owner

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

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

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

3. Bore equipment / use

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

Equipment and maintenance notes:

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

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 43060

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

FIELD MEASUREMENTS

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

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

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 47037

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

BORE REPORT

REG NUMBER 47037

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

BORE REPORT

REG NUMBER 47037

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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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 current;y in use.

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

BORE REPORT

REG NUMBER 43063

REGISTRATION DETAILS

		BASIN	1304	**LATITUDE**	22-42-55	**MAP-SCALE**	104
OFFICE	Rockhampton	**SUB-AREA**		**LONGITUDE**	148-40-42	**MAP-SERIES**	M
DATE LOG RECD		**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	672366	**MAP-NO**	8652
D/O FILE NO.	50-1371	**LOT**		**NORTHING**	7487004	**MAP NAME**	WINDEYERS HILL
R/O FILE NO.	C598/E272	**PLAN**		**ZONE**	55	**PROG SECTION**	
H/O FILE NO.	L40772B	**ORIGINAL DESCRIPTION**	L4 CNS38	**ACCURACY**		**PRES EQUIPMENT**	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	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	01/02/1973			**DATA OWNER**	
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	DEPTH (m)	RMK	SRC	COND (uS/cm)	pH	Si (mg/L)	TOTAL IONS (mg/L)	TOTAL SOLIDS (mg/L)	HARD	ALK	FIG. OF MERIT	SAR	RAH
A	18/11/1972	1 GCL	054774	26.00	PU	GB	890	7.6		765.05	499.72	340	428	2.0	1.8	1.77

BORE REPORT

REG NUMBER 43063

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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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 (mBTOC):	-		
SWL at assessment (mBTOC):	12.10		
Pressure at assessment (psi)*:	-	Bore log:	NA
Yield at drilling (l/sec):	-	Geological formation:	-
Historical level records:	-	Construction details:	-
		Casing material:	Steel **
Installed equipment:	None	Casing diameter(mm):	150
		Casing length (m):	-
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

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

** 125mm inner PVC casing.

3. Bore equipment / use

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

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

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

1. Property and bore owner

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

Residential address:	500 Warwick Park Road Middlemount 4746 Queensland Australia
Postal address:	As above
Additional information:	Confirmed with Jim Curran that this is current House Bore. Nominated in this survey as House Bore 3 to distinguish it from the other two (abandoned) bores. All in same aquifer. Arrow Energy photos.

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

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

3. Bore equipment / use

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

Equipment and maintenance notes:
Mains powered submersible pump.

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

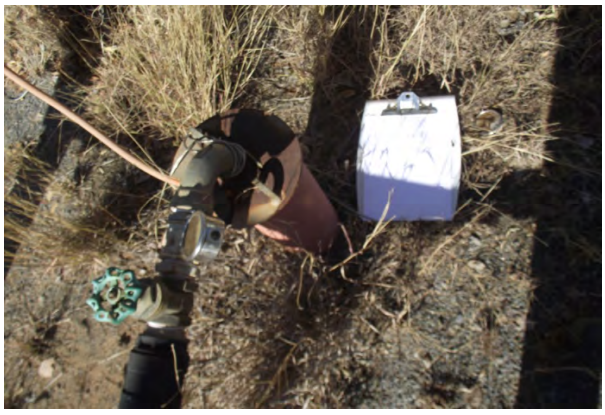
Date of assessment:	13/09/2017		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs



GUNDABAH

1. Property and bore owner

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

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

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

Refer to field survey method for search procedure.

3. Bore equipment / use

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

Equipment and maintenance notes:
NA

4. Water quality

In-situ tests

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

Additional notes:

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 38997

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

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 DNRM database. Search conducted by 4T in AGD66 and GDA94 datum but no evidence of bore found.

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

Refer to field survey method for search procedure.

.

3. Bore equipment / use

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

Equipment and maintenance notes:
NA

4. Water quality

In-situ tests

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

Additional notes:

4. Assessment date and details:

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

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

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

Additional information:

6. Photographs

BORE REPORT

REG NUMBER 44080

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

BORE REPORT

REG NUMBER 44080

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

BORE REPORT

REG NUMBER 44080

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

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

HAZELBRAE

1. Property and bore owner

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

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

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

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

3. Bore equipment / use

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

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

4. Water quality

In-situ tests

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

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

5. Assessment date and details:

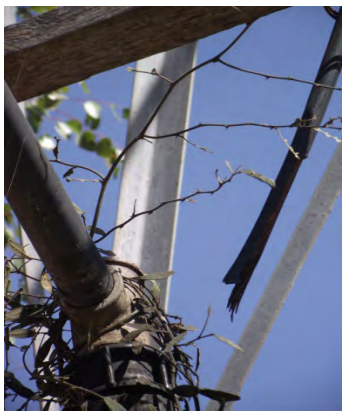
Date of assessment:	14/09/2001		
Assessment Officer 1:	Ian Rankine	Company:	4T Consultants Pty Ltd
Address:	PO Box 1946	Telephone No.:	07 49824100
Sub urb:	Emerald 4720	eMail:	i.rankine@4t.com.au
State:	Queensland		
Country:	Australia		
Assessment Officer 2:		Company:	
Address:		Telephone No.:	
		eMail:	

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs



GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 47037

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

BORE REPORT

REG NUMBER 47037

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

BORE REPORT

REG NUMBER 47037

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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

middlemount coal

ISAAC REGIONAL COUNCIL

1. Property and bore owner

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

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

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

Total depth from bore log.

3. Bore equipment / use

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

Equipment and maintenance notes:

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

4. Water quality

In-situ tests

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

Additional inotes:

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

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 158773

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

BORE REPORT

REG NUMBER 158773

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

BORE REPORT

REG NUMBER 158773

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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

1. Property and bore owner

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

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

2. Bore - Base information

Geographic location

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

Bore information:

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

Additional notes: * *Artesian*

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

3. Bore equipment / use

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

Equipment and maintenance notes:

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

4. Water quality

In-situ tests

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

Additional inotes:
No sample taken. Bore dry.

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 158772

REGISTRATION DETAILS

		BASIN	1301	**LATITUDE**	22-48-49	**MAP-SCALE**	
OFFICE	Emerald	**SUB-AREA**		**LONGITUDE**	148-41-18	**MAP-SERIES**	
DATE LOG RECD	22-APR-14	**SHIRE**	3980-ISAAC REGIONAL	**EASTING**	673279	**MAP-NO**	
D/O FILE NO.	LON/515/000(1733	**LOT**	49	**NORTHING**	7476120	**MAP NAME**	
R/O FILE NO.		**PLAN**	CNS281	**ZONE**	55	**PROG SECTION**	
H/O FILE NO.		**ORIGINAL DESCRIPTION**		**ACCURACY**		**PRES EQUIPMENT**	
				GPS ACC			
GIS LAT	-22.81363908	**PARISH NAME**	5200-WYNDHAM			**ORIGINAL BORE NO**	
GIS LNG	148.6883504	**COUNTY**	CAIRNS			**BORE LINE**	-
CHECKED	Y						
						POLYGON	
						RN OF BORE REPLACED	
FACILITY TYPE	Sub-Artesian Facility	**DATE DRILLED**	18/04/2014			**DATA OWNER**	
STATUS	Existing	**DRILLERS NAME**	MALCOLM, SCOTT				
ROLES	SM	**DRILL COMPANY**	M & J DRILLING				
		METHOD OF CONST.	ROTARY AIR				

CASING DETAILS

PIPE	DATE	RECORD NUMBER	MATERIAL DESCRIPTION	MAT SIZE (mm)	SIZE DESC	OUTSIDE DIAM (mm)	TOP (m)	BOTTOM (m)
A	18/04/2014	1	Polyvinyl Chloride	10.000	WT	60	0.00	12.70
A	18/04/2014	2	Perforated or Slotted Casing			60	9.20	12.20
A	18/04/2014	3	Gravel Pack			60	8.00	12.70
X	18/04/2014	4	Grout			150	0.00	7.00
X	18/04/2014	5	Bentonite Seal			150	7.00	8.00
X	18/04/2014	6	Centraliser			150	5.00	9.20

STRATA LOG DETAILS

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
1	0.00	1.00	CLAY, DARK BROWN
2	1.00	3.50	CLAY, GREY SANDY
3	3.50	6.00	CLAY, ORANGE

BORE REPORT

REG NUMBER 158772

RECORD NUMBER	STRATA TOP (m)	STRATA BOT (m)	STRATA DESCRIPTION
4	6.00	12.50	SAND
5	12.50	12.70	SNADSTONE WITH QUARTZ GRAINS

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

BORE REPORT

REG NUMBER 158772

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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**** End of Report. Produced:** 10/09/2017 01:18:42 PM ******

1. Property and bore owner

Bore name:	MB03	Property name:	Middlemount Landfill
Registered No.:	158771	Owner/Contact:	Isaac Regional Council
Lot/Plan:	L49 CNS281	Telephone:	1300472227
Parish:	Wyndham	Mobile:	
County:	Cairns	eMail:	

Residential address:	c/o Isaac Regional Council
	Middlemount Shopping Centre
	Middlemount 4746
	Queensland
Postal address:	PO Box 97
	Moranbah 4744
	Queensland
Additional information:	Dry. Depth tape stopped at 26.57m

2. Bore - Base information

Geographic location

Datum:	GDA94	GPS:	Garmin GPS76 handheld
East:	0673109	EPE (m):	4
North:	7476116		
Zone:	55K	Photographs:	Yes
Elevation (m):	177		

Bore information:

Total depth (m):	27	Date drilled:	18/04/2017
TOC to GL (m):	0.65	Driller name:	Malcolm Scott
Screened interval (m):	23.5 - 26.5	Drilling company:	M & J Drilling
SWL when drilled (mBTOC):	NA		
SWL at assessment (mBTOC):	Dry		
Pressure at assessment (psi)*:	-	Bore log:	Y
Yield at drilling (l/sec):	NA	Geological formation:	NA
Historical level records:	No	Construction details:	Landfill monitoring bore
		Casing material:	PVC
Installed equipment:	Nil	Casing diameter(mm):	60
		Casing length (m):	12.2
Artesian/Sub-artesian:	Sub-artesian		

Additional notes: * *Artesian*

Total depth from bore log. Depth sensor stopped at 26.57m.

3. Bore equipment / use

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

Equipment and maintenance notes:

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

4. Water quality

In-situ tests

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

Additional inotes:
No sample taken. Bore dry.

5. Assessment date and details:

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

Contact details for corporation conducting baseline assessment (if applicable)

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

Additional information:

6. Photographs

GROUNDWATER DATABASE

BORE REPORT

REG NUMBER 158773

REGISTRATION DETAILS

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

CASING DETAILS

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

STRATA LOG DETAILS

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

BORE REPORT

REG NUMBER 158773

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

STRATIGRAPHY DETAILS

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

AQUIFER DETAILS

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

PUMP TEST DETAILS PART 1

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

PUMP TEST DETAILS PART 2

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

BORE CONDITION

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

ELEVATION DETAILS

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

WATER ANALYSIS PART1

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

WATER ANALYSIS PART 2

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

WATER LEVEL DETAILS

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

WIRE LINE LOG DETAILS

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

BORE REPORT

REG NUMBER 158773

FIELD MEASUREMENTS

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

SPECIAL WATER ANALYSIS

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

BORE REPORT

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APPENDIX 2

Bore Assessment – Water Quality Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1719214**	Page	: 1 of 5
Client	: **4T CONSULTANTS PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR IAN RANKINE	Contact	: Jenny Bevan
Address	: PO BOX 1946 EMERALD QLD, AUSTRALIA 4720	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 7 49824100	Telephone	: +61-7-3243 7222
Project	: 745 GWQ	Date Samples Received	: 19-Sep-2017 09:20
Order number	: ----	Date Analysis Commenced	: 19-Sep-2017
C-O-C number	: ----	Issue Date	: 25-Sep-2017 15:54
Sampler	: ----		
Site	: ----		
Quote number	: BNBQ/001/16		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Sydney Organics, Smithfield, NSW
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG020-T (Total Metals by ICP-MS) is less than EG020-F (Dissolved Metals by ICP-MS) for some samples. However, the difference is within experimental variation of the methods.
- **Methane analysis will be conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rolf's Bore	House Bore	Blanches Bore	----	----
				Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	CAS Number	LOR	Unit		EB1719214-001	EB1719214-002	EB1719214-003	--------	--------
					Result	Result	Result	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.23**	**7.25**	**7.37**	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**13600**	**4330**	**2270**	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		**9280**	**2510**	**1370**	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**764**	**719**	**614**	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**764**	**719**	**614**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**21**	**168**	**196**	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**5200**	**1090**	**342**	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**311**	**196**	**93**	----	----
Magnesium	7439-95-4	1	mg/L		**496**	**135**	**86**	----	----
Sodium	7440-23-5	1	mg/L		**2070**	**582**	**286**	----	----
Potassium	7440-09-7	1	mg/L		**3**	**5**	**3**	----	----
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		**2820**	**1040**	**586**	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L		**0.213**	**0.192**	**0.115**	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	**0.012**	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L		**0.006**	**0.007**	**0.019**	----	----
Manganese	7439-96-5	0.001	mg/L		**1.80**	**0.019**	**0.003**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rolf's Bore	House Bore	Blanches Bore	----	----
				Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	CAS Number	LOR	Unit		EB1719214-001	EB1719214-002	EB1719214-003	--------	--------
					Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	**0.006**	**0.002**	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Boron	7440-42-8	0.05	mg/L		**0.30**	**0.40**	**0.19**	----	----
Iron	7439-89-6	0.05	mg/L		**19.7**	<0.05	<0.05	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.03**	<0.01	<0.01	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.002**	<0.001	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L		**0.240**	**0.210**	**0.122**	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	**0.0001**	----	----
Chromium	7440-47-3	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	**0.015**	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L		**0.007**	<0.005	**0.017**	----	----
Manganese	7439-96-5	0.001	mg/L		**1.80**	**0.022**	**0.004**	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	**0.005**	**0.002**	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Boron	7440-42-8	0.05	mg/L		**0.32**	**0.44**	**0.22**	----	----
Iron	7439-89-6	0.05	mg/L		**19.8**	<0.05	<0.05	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.5**	**0.2**	----	----
EK084: Un-ionized Hydrogen Sulfide									
Unionized Hydrogen Sulfide	----	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EN055: Ionic Balance									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rolf's Bore	House Bore	Blanches Bore	----	----
				Client sampling date / time	13-Sep-2017 11:15	13-Sep-2017 15:45	13-Sep-2017 13:30	----	----
Compound	CAS Number	LOR	Unit		EB1719214-001	EB1719214-002	EB1719214-003	--------	--------
					Result	Result	Result	----	----
EN055: Ionic Balance - Continued									
Total Anions	----	0.01	meq/L		**162**	**48.6**	**26.0**	**----**	**----**
Total Cations	----	0.01	meq/L		**146**	**46.3**	**24.2**	**----**	**----**
Ionic Balance	----	0.01	%		**5.16**	**2.40**	**3.50**	**----**	**----**
EP033: C1 - C4 Hydrocarbon Gases									
Methane	74-82-8	10	µg/L		**6790**	<10	<10	**----**	**----**

ALS Environmental

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		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Sydney Organics, Smithfield, NSW
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA005P: pH by PC Titrator (QC Lot: 1122177)									
EB1719153-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	6.87	6.83	0.584	0% - 20%
EB1719214-001	Rolf's Bore	EA005-P: pH Value	----	0.01	pH Unit	7.23	7.24	0.138	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 1122175)									
EB1719153-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	4140	4090	1.22	0% - 20%
EB1719214-001	Rolf's Bore	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	13600	13600	0.00	0% - 20%
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 1123893)									
EB1719208-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	662	672	1.55	0% - 20%
EB1719234-004	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	3360	3380	0.505	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 1122176)									
EB1719153-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	465	468	0.738	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	465	468	0.738	0% - 20%
EB1719214-001	Rolf's Bore	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	764	765	0.00	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	764	765	0.00	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1128258)									
EB1719100-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	13	13	0.00	0% - 50%
EB1719214-002	House Bore	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	168	168	0.00	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 1128259)									
EB1719100-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	4	5	0.00	No Limit
EB1719214-002	House Bore	ED045G: Chloride	16887-00-6	1	mg/L	1090	1090	0.346	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1123833)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED093F: Dissolved Major Cations (QC Lot: 1123833) - continued									
EB1719140-012	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	<1	<1	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EB1718574-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	5	5	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	1	1	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	10	10	0.00	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123830)									
EB1719140-012	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1718574-001	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.028	0.027	0.00	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.009	0.009	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.032	0.022	36.9	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.55	0.55	0.00	0% - 20%
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123830) - continued									
EB1718574-001	Anonymous	EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.27	0.28	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1123831)									
EB1718574-001	Anonymous	EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1123839)									
EB1719202-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.010	0.010	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.010	0.011	0.00	0% - 50%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.04	0.02	83.8	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1719204-009	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.013	0.013	0.00	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.043	0.044	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.011	0.011	0.00	0% - 50%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.007	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	3.13	3.13	0.147	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.007	0.008	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.029	0.029	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2.62	2.59	1.26	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.07	2.10	1.75	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	7.77	7.86	1.06	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 1123840)									
EB1719202-001	Anonymous	EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EB1719204-009	Anonymous	EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.007	0.007	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1123841)									
EB1719214-003	Blanches Bore	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.122	0.125	2.16	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.015	0.016	0.00	0% - 50%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.017	0.018	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.22	0.23	5.37	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1719263-004	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.022	0.022	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.185	0.186	0.00	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.007	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.030	0.030	0.00	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.899	0.905	0.650	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.19	0.20	0.00	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 1123834)									
EB1719140-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1719278-013	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory 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**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 1122177)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98	102
				----	7 pH Unit	101	98	102
EA010P: Conductivity by PC Titrator (QCLot: 1122175)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	220 µS/cm	98.2	91	107
				<1	12890 µS/cm	95.2	91	107
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 1123893)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	293 mg/L	99.8	88	112
				<10	2000 mg/L	94.6	88	112
ED037P: Alkalinity by PC Titrator (QCLot: 1122176)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	102	80	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1128258)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	103	85	118
				<1	100 mg/L	99.0	85	118
ED045G: Chloride by Discrete Analyser (QCLot: 1128259)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	104	90	115
				<1	1000 mg/L	110	90	115
ED093F: Dissolved Major Cations (QCLot: 1123833)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	97.5	79	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	88	116
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	98.6	81	117
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	110	70	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	99.8	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	101	87	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.4	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	96.0	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	89.3	89	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	95.5	89	120
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	97.3	89	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	101	89	113

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830) - continued								
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	99.8	83	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	104	88	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	96.6	87	113
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	105	81	125
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	95.6	82	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123831)								
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1123839)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	103	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	101	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	111	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	96.9	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	100	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.3	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	105	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	103	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	98.6	88	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	102	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	97.1	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	101	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	106	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	91.6	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	111	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.8	82	118
EG020T: Total Metals by ICP-MS (QCLot: 1123840)								
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1123841)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	108	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.9	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	107	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	114	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	98.9	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	100	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	96.0	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	102	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	102	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	102	88	114

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EG020T: Total Metals by ICP-MS (QCLot: 1123841) - continued								
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	99.7	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	94.7	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.2	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	111	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	90.8	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	121	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	82	118
EG035F: Dissolved Mercury by FIMS (QCLot: 1123834)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	94.1	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1123844)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	100	84	118
EK040P: Fluoride by PC Titrator (QCLot: 1122174)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.5 mg/L	100	80	117
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 1127457)								
EP033: Methane	74-82-8	10	µg/L	<10	28.48 µg/L	91.4	86	114

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1128258)							
EB1719100-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 1128259)							
EB1719100-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	110	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830)							
EB1718574-002	Anonymous	EG020A-F: Aluminium	7429-90-5	0.5 mg/L	# Not Determined	70	130
		EG020A-F: Arsenic	7440-38-2	1 mg/L	97.5	70	130
		EG020A-F: Beryllium	7440-41-7	1 mg/L	97.4	70	130
		EG020A-F: Barium	7440-39-3	5 mg/L	108	70	130
		EG020A-F: Cadmium	7440-43-9	1 mg/L	97.7	70	130
		EG020A-F: Chromium	7440-47-3	1 mg/L	92.4	70	130
		EG020A-F: Cobalt	7440-48-4	1 mg/L	97.6	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1123830) - continued							
EB1718574-002	Anonymous	EG020A-F: Copper	7440-50-8	2 mg/L	96.4	70	130
		EG020A-F: Lead	7439-92-1	1 mg/L	81.7	70	130
		EG020A-F: Manganese	7439-96-5	0.1 mg/L	# Not Determined	70	130
		EG020A-F: Molybdenum	7439-98-7	1 mg/L	85.8	70	130
		EG020A-F: Nickel	7440-02-0	1 mg/L	99.7	70	130
		EG020A-F: Selenium	7782-49-2	1 mg/L	96.3	70	130
		EG020A-F: Vanadium	7440-62-2	1 mg/L	99.6	70	130
		EG020A-F: Zinc	7440-66-6	2 mg/L	95.2	70	130
		EG020A-F: Boron	7440-42-8	5 mg/L	101	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1123839)							
EB1719186-067	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	97.4	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	102	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	107	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	93.1	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	97.2	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	102	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	103	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	113	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	97.4	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	93.9	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	96.4	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	93.3	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1123841)							
EB1719218-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	100.0	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	108	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	119	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	98.2	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	93.8	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	95.6	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	94.9	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	110	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	92.8	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	87.8	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	95.8	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	90.1	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 1123834)							
EB1719140-004	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	82.0	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1123844)							
EB1719186-067	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	88.4	70	130
EK040P: Fluoride by PC Titrator (QCLot: 1122174)							
EB1719174-001	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	99.8	70	130
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 1127457)							
EM1712836-001	Anonymous	EP033: Methane	74-82-8	28.48 µg/L	126	70	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1719214**	Page	: 1 of 8
Client	: **4T CONSULTANTS PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR IAN RANKINE	Telephone	: +61-7-3243 7222
Project	: 745 GWQ	Date Samples Received	: 19-Sep-2017
Site	: ----	Issue Date	: 25-Sep-2017
Sampler	: ----	No. of samples received	: 3
Order number	: ----	No. of samples analysed	: 3

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EB1719100--002	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EB1718574--002	Anonymous	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	EB1718574--002	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural						
Rolf's Bore, House Bore, Blanches Bore	----	----	----	19-Sep-2017	13-Sep-2017	**6**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type / Method	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Control Samples (LCS)					
Dissolved Metals by ICP-MS - Suite B	0	3	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	0	10	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
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	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F)							
Rolf's Bore, House Bore, Blanches 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, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**20-Sep-2017**	11-Oct-2017	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P)							
Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**19-Sep-2017**	11-Oct-2017	✓
EP033: C1 - C4 Hydrocarbon Gases							
Amber VOC Vial - Sulfuric Acid (EP033)							
Rolf's Bore, House Bore, Blanches Bore	**13-Sep-2017**	**----**	----	----	**21-Sep-2017**	27-Sep-2017	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	16	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	0	3	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	0	10	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
C1 - C4 Gases	EP033	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Total Dissolved Solids (High Level)	EA015H	WATER	In house: Referenced to APHA 2540C. A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Un-ionized Hydrogen Sulfide	EK084	WATER	In house: Referenced to APHA 4500-S2- H. Sulfide in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
C1 - C4 Gases	EP033	WATER	Technical Guidance for the Natural Attenuation Indicators: Methane, Ethane, and Ethene, US EPA - Region 1, EPA New England, July 2001. Automated static headspace, dual column GC/FID. A 12 mL sample is pipetted into a 20 mL headspace vial containing 3g of sodium chloride and sealed. Each sample is equilibrated with shaking at 40 degrees C for 10 minutes prior to analysis by GC/FID using a pair of PLOT columns of different polarity.

Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

Appendix D **Monitoring bores**

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Drilling Log

Monitoring Well **MW1**

Project MEMS | Owner Middlemount Coal Pty Ltd

Location Middlemount Mine | Proj. No. ENVINEWS08629AA

Surface Elev. NA | Total Hole Depth 30.0 m. | North | East

Top of Casing NA | Water Level Initial ▽ 26.0 m. | Static ▼ 24.0 m. | Diameter 125 mm.

Screen: Dia NA | Length NA | Type/Size Class 18 UPVC

Casing: Dia NA | Length NA | Type Class 18 UPVC

Fill Material | Rig/Core

Drill Co. QLD Drilling | Method Air Rotary

Driller Corey Evetts | Log By M Weir | Date 5/6/08 | Permit # NA

Checked By | License No.

COMMENTS
Backfill used above bentonite plug.

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW1P

SHEET 1 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 12.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 19.06.2010
Borehole Location:	MW1P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 161 m AHD
Borehole Diameter:	171mm to 121mm	Driller Lic No: 3046	Co-ords: E 667818 N 7473149 MGA94 Zone 55
		TOC (RL): 162 m AHD	Local Co-ords:

Borehole Information

Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			TOC 1 m Monument cover with PVC cap. Cement 0 to 5m bgl (below ground level) 50mm ID, Class 18 uPVC casing. 0 to 72m bgl Backfill, 5 to 67m bgl	160 158 3.00 156 5.00 154 8.00 152 10.00 150 11.00 148 146 144 17.00 142 140 21.00 138 23.00 24.00 136 134 132 130 32.00 128 126 35.00 124 38.00 122 39.00 40.00 120 41.00 42.00 118 44.00 116 114 48.00 112	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48			SC	**Clayey SAND:** fine to medium grained, orange brown, dry.	D	VS S F ST VST H FB VL L MD D VD	171mm Diameter, 0 to 44m bgl
									CL	**Sandy CLAY:** grey, medium grained, sand component, soft, bands of iron staining.			
									CL	**CLAY:** grey, stiff, bands of iron staining.			
									SP	**SAND:** fine to medium grained, yellow, dry.			
										medium grained, yellow and red, with clay, dry.			
									CL	**CLAY:** grey and brown, stiff, banded.			
									CL/SP	grey, pink and orange, stiff and **SAND:** fine to medium grained, pink.			
									CL	**CLAY:** grey, pink and orange, stiff.			
									SC	**Clayey SAND:** fine to medium grained, orange red, soft, dry.			
									CL	**CLAY:** grey, pink and orange, soft to firm.			
									CL	**Sandy CLAY:** grey, fine grained sand component, soft.			
										COAL: black, distinctly weathered, (Middlemount Seam).			
										SANDSTONE: fine to medium grained, dark grey, carbonaceous, distinctly weathered.			
										SILTSTONE: dark grey, slightly weathered.			
									CL	**Sandy CLAY:** pale grey, fine to medium grained sand component, soft.			
									CL/SP	**CLAY:** grey, soft and **SAND:** fine to medium grained, yellow.			
										SANDSTONE: fine to medium grained, yellow, distinctly weathered.			
										fine to medium grained, grey, distinctly weathered, dry.			121mm Diameter, 44 to 77.2m bgl
										very fine to fine grained, grey, distinctly weathered, dry.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW1P

SHEET 2 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 12.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 19.06.2010
Borehole Location:	MW1P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	161 m AHD
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046	Co-ords:	E 667818 N 7473149 MGA94 Zone 55
		TOC (RL):	162 m AHD	Local Co-ords:	

Borehole Information

Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F ST H / FB VL L MD D VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 67 to 69.5m bgl 5mm Filter gravel, 69.5 to 72m bgl 50mm ID, Class 18 uPVC, 0.5mm Slotted screen from 72 to 75m bgl, 1m uPVC sump Bentonite, 76 to 77m bgl	110 52 108 (53.00) 54 106 (55.00) 56 104 58 102 60 100 (62.00) 62 98 (63.00) 64 96 66 94 68 92 (70.00) 70 90 72 88 74 86 (75.00) 76 84 78 82 80 80 82 78 84 76 86 74 88 72 90 70 92 68 94 66 96 64 98 62				very fine to fine grained, grey, distinctly weathered, dry. *(continued)* medium grained, grey, distinctly weathered, dry. medium grained, grey, fresh, dry. very fine grained, grey brown, fresh. **SHALE:** dark grey. **SANDSTONE:** fine grained, grey, fresh. **COAL:** black, moist, soft, (Pisces Seam) **CLAY:** black, carbonaceous, firm. **SILTSTONE:** grey, carbonaceous, fresh. END OF BOREHOLE AT 77.20 m	D M		

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

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Drilling Log

Monitoring Well **MW2**

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

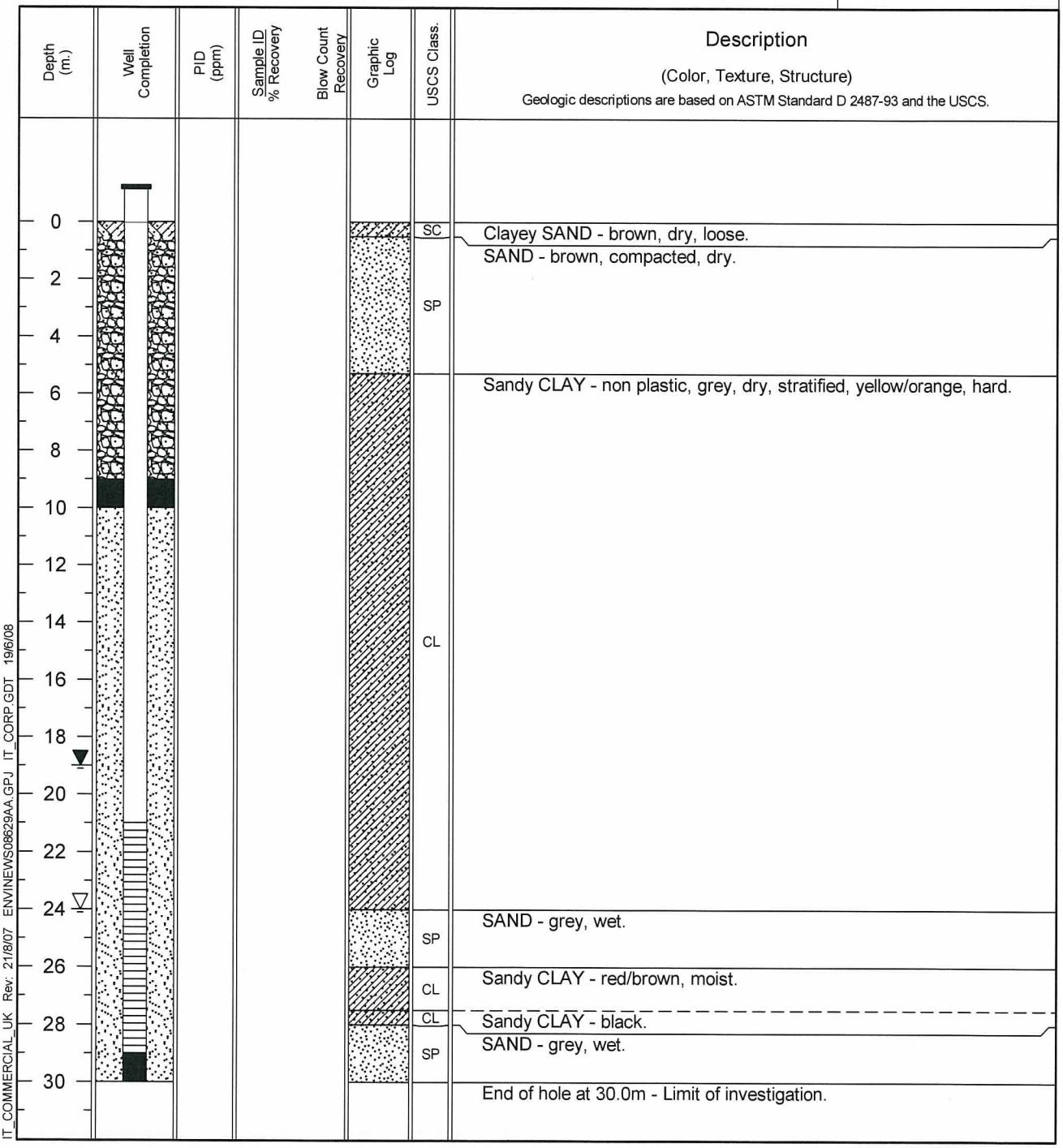
Drill Co. QLD Drilling — Method Air Rotary

Driller Corey Evetts — Log By M Weir — Date 5/6/08 — Permit # NA

Checked By — License No.

COMMENTS

Backfill used above bentonite plug.



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Drilling Log

Monitoring Well **MW3**

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

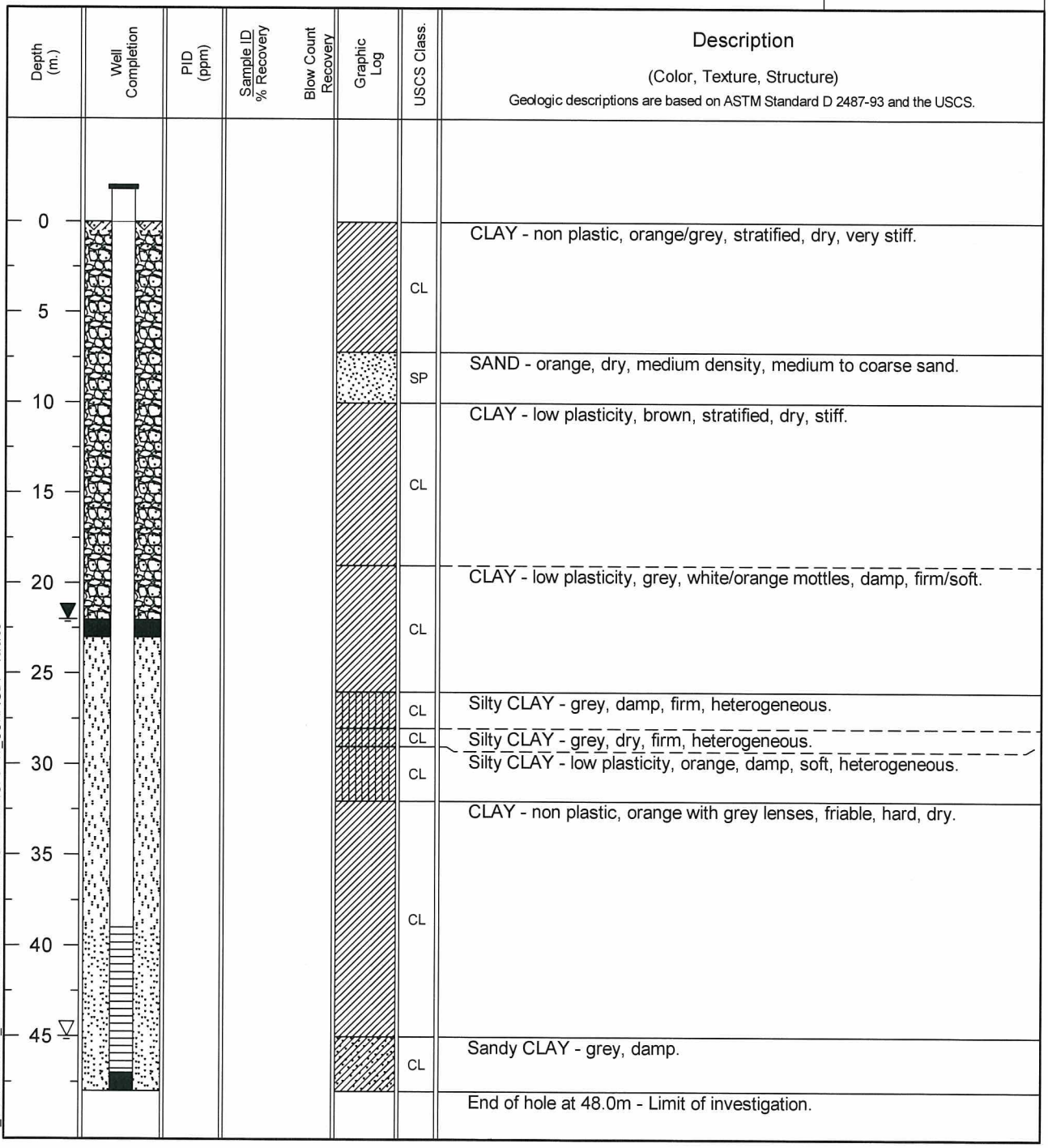
Fill Material | Rig/Core

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.



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coffey environments

Drilling Log

Monitoring Well **MW4**

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.
						CLAY - non plastic, orange/white/grey/black, stratified, dry, damp.
20					CL	
						Weathered GRANITE/CLAYSTONE.
25						
30						Weathered BASALT - blue/grey, dry.
35						
					CL	CLAY - non plastic, brown, damp, stiff.
40	▼					Weathered BASALT - dry.
45						
	▽					COAL - hard, dry.
50					SP	Sandy COAL - wet.
						End of hole at 50.0m - Limit of investigation.

coffey environments

Drilling Log

Monitoring Well **MW5**

Project *MEMS* Owner *Middlemount Coal Pty Ltd*

Location *Middlemount Mine* Proj. No. *ENVINEWS08629AA*

Surface Elev. *NA* Total Hole Depth *46.0 m.* North _____ East _____

Top of Casing *NA* Water Level Initial ▽ *40.0 m.* Static *NA* Diameter *125 mm.*

Screen: Dia *NA* Length *NA* Type/Size *Class 18 UPVC*

Casing: Dia *NA* Length *NA* Type *Class 18 UPVC*

Fill Material _____ Rig/Core _____

Drill Co. *QLD Drilling* Method *Air Rotary*

Driller *Corey Evetts* Log By *M Weir* Date *3/6/08* Permit # *NA*

Checked By _____ License No. _____

COMMENTS
Backfill used above bentonite plug.

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.
						CL	CLAY - non plastic, brown, hard, dry.
5							
							CLAY - non plastic, dark grey, hard, dry.
10						CL	
							CLAY - non plastic, red/brown, hard, dry.
15						CL	
20							CLAY - non plastic, brown, hard, dry.
25						CL	
30							
35							CLAY - non plastic, grey, dry, friable.
						CL	
40 ▽							COAL - black, moist.
							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	PB Borehole No.:	Date Commenced: 10.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667790 N 7475131 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RB			TOC 1 m; Monument cover with PVC cap, Cement: 0 to 6.5m bgl (below ground level); 80mm ID, Class 18 uPVC casing, 0 to 127m bgl; Backfill, 6.5 to 121.5m bgl	172 / 170 / 168 / 166 / 164 / 162 / 160 / 158 / 156 / 154 / 152 / 150 / 148 / 146 / 144 / 142 / 140 / 138 / 136 / 134 / 132 / 130 / 128 / 126	1.00 / 2 / 4 / 6.00 / 6 / 8 / 10.00 / 10 / 12 / 14.00 / 14 / 16 / 17.00 / 18 / 19.00 / 20.00 / 20 / 22 / 24.00 / 24 / 25.00 / 26 / 27.00 / 28.00 / 28 / 29.00 / 30 / 32 / 33.00 / 34 / 36 / 38 / 39.00 / 40.00 / 40 / 42 / 42.00 / 44.00 / 44 / 45.00 / 46.00 / 46 / 48 / 49.00		
RAB							

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F ST, MD VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, firm, moist.	M		200mm Diameter, 0 to 46m bgl
	CL/SP	**CLAY:** grey, pink and brown, firm, moist and **SAND:** fine grained, brown, moist.			
		Clayey SANDSTONE: fine grained, brown, extremely weathered, moist.			
		SANDSTONE: fine to medium grained, brown, distinctly weathered, moist.			
		SILTSTONE: yellow, distinctly weathered, moist.			
		SANDSTONE: fine grained, brown, distinctly weathered, moist.			
		CLAYSTONE: brown, distinctly weathered, moist, calcite alteration.			
		grey and pink, extremely weathered, moist.			
		Sandy CLAYSTONE: black, grey and red, distinctly weathered, moist.			
		SANDSTONE: very fine grained, yellow, distinctly weathered, moist.			
		Sandy CLAYSTONE: grey, brown and pink, distinctly weathered, moist.			
		SANDSTONE: very fine grained, brown, distinctly weathered, moist.			
		Silty CLAYSTONE: grey and orange, distinctly weathered, moist.			
		SANDSTONE: very fine grained, red brown, distinctly weathered, moist.			
		SILTSTONE: red brown, distinctly weathered, moist.			
		SANDSTONE: very fine grained, red brown, distinctly weathered, moist.			
		grey and orange.			
		SILTSTONE: red, distinctly weathered, moist.			
		CLAYSTONE: grey and red, slightly weathered, moist.			
		SILTSTONE: grey and brown, distinctly weathered, moist.			140mm Diameter, 46 to 131m bgl
		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.
MW5M
SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 10.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667790 N 7475131 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			TOC 1 m	122	52		
				120	54		
				118.60	56		
				117.00			
				116	58		
				114	60		
				113.00			
				112	62		
				111.00			
				110	64		
				108	66		
				106.00	68		
				104.00	70		
				103.00			
				102.00	72		
				100.00	74		
				99.00			
				98	76		
				96	78		
				94	80		
				92	82		
				91.00			
				90.00	84		
				88.00	86		
				86.00	88		
				85.00			
				84.00	90		
				82	92		
				80	94		
				78.00	96		
				76.00	98		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		grey, slightly weathered. *(continued)*	M		
		fresh.			
		SANDSTONE: very fine grained, grey, fresh, moist.			
		SILTSTONE: grey, fresh, moist.			
		SANDSTONE: very fine grained, grey, fresh, moist.			
		SILTSTONE: grey, fresh, moist.			
		SANDSTONE: very fine grained, grey, fresh, moist.			
		SILTSTONE: grey, fresh, moist.			
		SANDSTONE: very fine grained, grey, fresh, moist.			
		SILTSTONE: grey, fresh, moist.			
		SANDSTONE: very fine grained, grey, fresh, moist.			
		distinctly weathered, wet.	W		
		fine grained.			
		very fine grained, dark grey.			
		fine grained.			
		very fine grained.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 10.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667790 N 7475131 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST VST H / VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 121.5 to 126m bgl; 3mm Filter gravel, 126 to 131m bgl; 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 127 to 130m bgl, 1m uPVC sump	101.00 72 102; 70 104; 105.00 68 106; 66 108; 109.00 64 110; 62 112; 113.00 60 114; 58 116; 117.00 56 118; 54 120; 121.00 52 122; 123.00 50 124; 125.00 48 126; 127.00 46 128; 44 130; 42 132; 40 134; 38 136; 36 138; 34 140; 32 142; 30 144; 28 146; 26 148					SILTSTONE: dark grey, fresh, wet. *(continued)*	W		
									SILTSTONE: dark grey, fresh, wet.			
									CLAYSTONE: black, fresh, carbonaceous, wet.			
									SANDSTONE: fine grained, dark, grey, fresh, wet.			
									medium grained.			
									SILTSTONE: dark grey, fresh, wet.			
									SANDSTONE: medium grained, dark, grey, fresh, wet.			
									very fine grained.			
									fine grained.			
									very fine grained.			
									fine grained.			
									SILTSTONE: dark grey, fresh, wet.			
									COAL: black, fresh, wet, (Middlemount Seam).			
									silty.			Airlift yield: 0.21 L/S
									non-silty.			
									SILTSTONE: black, fresh, carbonaceous, wet.			Airlift yield: 0.76 L/S
									END OF BOREHOLE AT 131.00 m			

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	PB Borehole No.:	
Project:	MIDDLEMOUNT COAL PROJECT	Date Commenced:	06.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE	Date Completed:	24.07.2010
Project Number:	2117076B	Recorded By:	Malcolm Graham
		Log Checked By:	

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RB			TOC 1 m; Monument cover with PVC cap. Cement 0 to 6.5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 165m bgl; Backfill, 6.5 to 160.5m bgl	172	2.00		
					3.00		
				170	4		
				168	6.00		
				166	8		
				164	10.00		
				162	12		
				160	14		
					15.00		
				158	16		
					17.00		
				156	18		
					19.00		
				154	20		
				152	22		
					23.00		
				150	24.00		
				148	26.00		
					27.00		
				146	28.00		
					29.00		
				144	30		
				142	32		
				140	34.00		
				138	36		
				136	38		
				134	40.00		
					41.00		
				132	42		
					43.00		
				130	44.00		
					45.00		
				128	46.00		
				126	48.00		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB VL L S F ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, moist, firm.	M		200mm Diameter, 0 to 52m bgl
	CL	**CLAY:** grey and red, moist, firm.			
	CL/SP	**CLAY:** grey and red, moist, firm and **SAND:** fine grained, brown.			
		SANDSTONE very fine grained, brown, extremely weathered, moist.			
		distinctly weathered			
		SILTSTONE: yellow-brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, brown, distinctly weathered, moist.			
		CLAYSTONE: grey and red, distinctly weathered, moist.			
		Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.			
		SANDSTONE: fine grained, brown, distinctly weathered.			
		Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.			
		SANDSTONE: fine grained, yellow, extremely weathered, moist.			
		Clayey SANDSTONE: fine grained, yellow, extremely weathered, moist.			
		Silty CLAYSTONE: grey and brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, red-brown, distinctly weathered, moist.			
		SILTSTONE: red-brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, red-brown, distinctly weathered, moist.			
		grey			
		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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 2 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS, S, F, ST, VST, H; L, MD, D, VD; FB, VL)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB				122.00 52					**SILTSTONE:** grey, slightly weathered, dry. *(continued)*	D		
RAB				53.00					**SANDSTONE:** fine grained, grey, slightly weathered, dry.			140mm Diameter, 52 to 174m bgl
				120 54					**SILTSTONE:** grey, slightly weathered, dry.			
				55.00								
				118 56					**SANDSTONE:** fine grained, grey, fresh, dry.			
				57.00								
				116.00 58					**SILTSTONE:** grey, fresh, dry.			
				58.00					**SANDSTONE:** fine grained, grey, fresh, dry.			
				114 60								
				112.00 62					**SILTSTONE:** grey, fresh, dry.			
				62.00					**SANDSTONE:** very fine grained, grey, fresh, dry.			
				110 64								
				108 66								
				106 68								
				69.00					**SILTSTONE:** grey, fresh, dry.			
				104 70								
				102 72								
				73.00					**SANDSTONE:** fine grained, grey, dry.			
				100.00 74					**SILTSTONE:** grey, fresh, dry.			
				98 76								
				96.00 78					**SANDSTONE:** fine grained, grey, fresh, dry.			
				94.00 80					slightly weathered, wet.	W		
				92 82								
				90.00 84					fresh, wet.			
				88 86								
				87.00					**SILTSTONE:** grey, fresh, wet.			
				86.00 88					**SANDSTONE:** fine grained, fresh, wet.			
				84.00 90					**SILTSTONE:** dark grey, fresh, wet.			
				82 92								
				80 94								
				78.00 96					**SANDSTONE:** fine grained, grey, fresh, wet.			
				76.00 98					**SILTSTONE:** dark grey, fresh, wet.			
				99.00					**SANDSTONE:** fine grained, grey, fresh, wet.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 3 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			TOC 1 m	101.00	72 102		
					70 104		
				105.00	68 106		
					66 108		
					64 110		
					62 112		
				113.00	60 114		
					58 116		
					56 118		
					54 120		
					52 122		
					50 124		
				125.00	48 126		
				127.00	46 128		
					44 130		
				131.00	42 132		
				133.00	40 134		
					38 136		
					36 138		
					34 140		
					32 142		
					30 144		
					28 146		
					26 148		
				149.00			

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: fine grained, grey, fresh, wet. *(continued)*	W		
		SILTSTONE: dark grey, fresh, wet.			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		fine grained.			
		SILTSTONE: dark grey, fresh, wet.			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		SILTY COAL: black, fresh, wet, (Middlemount Seam).			Airlift yield: 0.12 L/S
		COAL: black, fresh, wet.			
		SILTSTONE: dark grey, fresh.			Airlift yield: 0.14 L/S
		SANDSTONE: fine grained, grey, fresh, wet.			Airlift yield: 0.14 L/S
		SILTSTONE: black, fresh, wet.			

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 4 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S FB; VL L ST; MD VST; D H VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 160.5 to 164m bgl 3mm Filter gravel, 164 to 169m bgl 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 165 to 168m bgl, 1m uPVC sump Bentonite, 169 to 171m bgl Backfill, 171 to 174m bgl	22 152 20 154 18 156 16 158 14 160 12 162 10 164 165.00 8 166 6 168 169.00 4 170 2 172 0 174 -2 176 -4 178 -6 180 -8 182 -10 184 -12 186 -14 188 -16 190 -18 192 -20 194 -22 196 -24 198				**SILTSTONE:** black, fresh, wet. *(continued)* **SANDSTONE:** fine grained, dark grey, fresh, wet. **CLAYSTONE:** black, fresh, carbonaceous, wet. **COAL:** black, fresh, wet, (Pisces Seam). **SILTSTONE:** dark grey, fresh, carbonaceous, wet. **SANDSTONE:** very fine grained, grey, fresh, wet. fine grained. END OF BOREHOLE AT 174.00 m	W		Airlift yield: 0.29 L/S Airlift yield: 0.31 L/S Airlift yield: 0.34 L/S

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

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coffey environments

Drilling Log

Monitoring Well **MW6**

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.
					CL	CLAY - non plastic, brown, hard, dry, homogeneous.
5					CL	CLAY - non plastic, brown/grey, hard, dry.
10					CL	CLAY - low plasticity, red, dry, homogeneous.
15					CL	
20					CL	CLAY - low plasticity, white, damp, firm, stiff.
					CL	CLAY - low plasticity, white/brown, firm, dry, homogeneous.
25					CL	CLAY - non plastic, black/grey, dry, friable.
30					CL	CLAY - non plastic, brown/white, dry, friable.
35					CL	CLAY - grey, hard, damp.
					CL	CLAY - non plastic, grey, wet, hard.
40						End of hole at 42.0m - Limit of investigation.

GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7M

SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 15.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 19.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	160 mAHD*
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046	Co-ords:	E 669668 N 7472167 MGA94 Zone 55
		TOC (RL):	161 mAHD*	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			TOC 1 m Monument cover with PVC cap. Cement: 0 to 5m bgl (below ground level) 50mm ID uPVC, Class 12 casing, 0 to 132m bgl Backfill: 9 to 129m bgl	2.00 2 3.00 4.00 4 5.00 6.00 6 7.00 8 10 12.00 12 13.00 14.00 14 16 17.00 18 20 22.00 22 24 25.00 26.00 26 27.00 28.00 28 29.00 30 32.00 32 34 35.00 36.00 36 38.00 38 40 42 44 45.00 46.00 46 48		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST / FB VL L MD D VD H)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Sandy CLAY:** brown, fine grained, sand component, firm, dry.	D		* Elevations inferred from DTM 171mm Diameter, 0 to 55.5m bgl
	SP	**Clayey SAND:** fine to medium grained, orange, moist.	M		
	SP	**SAND:** fine to medium grained, orange, with clay.			
		medium grained, yellow, moist, loose.			
		medium grained, yellow, moist, trace coarse sand and gravel, loose.			
		brown clay bands.			
	SP	**Clayey SAND:** fine to medium grained, orange and grey, bands of firm, grey clay, moist.			
	SP	**SAND:** medium grained, orange, with clay, moist.			
		bands of firm, brown clay.			
		medium to coarse grained, bands of firm, grey clay, moist.			
	CL/ SP	**CLAY:** grey and brown, firm and **SAND:** fine grained, yellow.			
	SP/ CL	**SAND:** medium grained, orange and **CLAY:** grey, firm.			
	SP	**SAND:** medium grained, yellow.			
	CL	**CLAY:** brown and grey, soft, trace fine grained sand.			
	CL	**Silty CLAY:** grey and brown, firm.			
	CL	**Sandy CLAY:** grey and orange, fine to medium grained sand component, firm.			
	CL	**CLAY:** grey and brown, firm.			
	SP	**SAND:** medium grained, yellow, bands of firm, grey clay.			
	CL	**CLAY:** brown and grey, firm.			
	CL/ SP	**CLAY:** brown and grey, firm and **SAND:** fine to medium grained, yellow.			
	SP	**SAND:** medium grained, pale grey.			
	SP/ CL	**SAND:** medium grained, pale grey and **Sandy CLAY:** grey and brown, soft.			
	SP	**SAND:** medium grained, pale grey.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7M

SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 15.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 19.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	160 mAHD*
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046	Co-ords:	E 669668 N 7472167 MGA94 Zone 55
		TOC (RL):	161 mAHD*	Local Co-ords:	

Borehole Information / Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				50.00					medium to coarse grained, pale grey, trace gravel.	M		
				52								
				54.00 54				SC	SAND: medium to coarse grained, pale grey, trace gravel and Sandy CLAY: grey, soft.			
				56.00 56					SANDSTONE: very fine grained, dark grey, distinctly weathered, soft, moist.			121mm Diameter, 55.5 to 143m bgl
				57.00 58					fine grained, pale grey, slightly weathered, moist.			
				59.00 60.00 60					very fine grained, dark grey, distinctly weathered, bands of dark grey clay, moist. very fine grained, grey, slightly weathered, moist.			
				62								
				64								
				65.00 66					distinctly weathered.			
				68.00 68					slightly weathered, dry.	D		
				69.00 70					fine grained, dark grey, slightly weathered, dry.			
				71.00					moist.	M		
				72.00 72					dry, fresh.	D		
				74								
				75.00 76					SILTSTONE: dark grey, fresh, dry.			
				78								
				80								
				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 96					SANDSTONE: very fine grained, grey, fresh, wet.			
				98								
				99.00					SILTSTONE: dark grey, fresh, wet.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 15.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 19.06.2010
Borehole Location:	MW7M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	160 mAHD*
Borehole Diameter:	171mm to 121mm	Driller Lic No:	3046	Co-ords:	E 669668 N 7472167 MGA94 Zone 55
		TOC (RL):	161 mAHD*	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			TOC 1 m Bentonite, 129 to 131m bgl 5mm Filter gravel, 131 to 136m bgl 50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 132 to 134.5m bgl, 1m uPVC sump Bentonite, 135.5 to 137.5m bgl Backfill, 137.5 to 143m bgl	100.00 101.00 102 103.00 104 105.00 106 108 110 112 114 115.00 116 118 119.00 120 121.00 122 124 125.00 126 128 129.00 130 131.00 132 134 135.00 136 138 140 142 144 146 148		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F FB VL L ST MD VST D VD H)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: very fine grained, grey, fresh, wet.	W		
		SILTSTONE: dark grey, fresh, wet.			
		SNADSTONE: very fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		carbonaceous.			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		COAL: black, fresh, wet, (Middlemount Seam)			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		COAL: black, fresh, wet, (Middlemount Seam).			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			
		fine grained.			
		END OF BOREHOLE AT 143.00 m			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 1 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information

Field Material Description

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			TOC 1 m Monument cover with PVC cap. Cement 0 to 5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 189.5m bgl Backfill, 5 to 186.5m bgl	162	2				CL	**Silty CLAY:** brown, firm, moist.	M		254mm Diamter, 0 to 45m bgl
				160	4				SP	**SAND:** medium, grained, orange, moist.			
				158	6				SC	**Clayey SAND:** very fine grained, pale brown, moist.			
				156	8				SP	**SAND:** medium grained, orange, moist.			
				154	10					fine grained, pale grey.			
				152	12					medium grained, orange.			
				150	14				CL	**CLAY:** grey and brown, firm, moist.			
				148	16				CL/SP	**CLAY:** grey, black and orange, firm, moist and **SAND:** medium grained, orange, moist.			
				146	18								
				144	20				SP	**SAND:** medium grained, orange, moist.			
				142	22				CL/SP	**Sandy CLAY:** grey and brown, firm, moist and **SAND:** medium grained, grey and brown, moist.			
				140	24								
				138	26				CL	**CLAY:** grey and brown, firm, moist.			
				136	28					wet.	W		
				134	30					with fine grained brown sand.			
				132	32				CL/SP	**Sandy CLAY:** grey and brown, firm, wet and **SAND:** fine grained, brown, wet.			
				130	34					medium grained, yellow sand component.			
				128	36				SC	**SAND:** coarse grained, yellow, with firm grey clay, wet.			
				126	38					medium grained, pale yellow, trace gravel.			
				124	40								
				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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 2 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB				112 52; 110 54; 108 56; 106 58; 104 60; 102 62; 100 64; 98 66; 96 68; 94 70; 92 72; 90 74; 88 76; 86 78; 84 80; 82 82; 80 84; 78 86; 76 88; 74 90; 72 92; 70 94; 68 96; 66 98		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY / CONSISTENCY (VS FB, SF VL, L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		fresh, with very fine grained, pale yellow, sandstone.	W		
		distinctly weathered, iron staining.			
		SANDSTONE: very fine grained, grey and brown, slightly weathered, minor black carbonaceous siltstone, iron staining and quartz veins, wet.			
		SILTSTONE: dark grey, fresh, iron staining and calcite veins, wet.			140mm Diameter, 66 to 203m bgl
		SANDSTONE: very fine grained, grey, slightly weathered, pyrite alteration, wet.			
		fresh, no pyrite.			
		fresh, calcite veins, no pyrite.			
		fine grained, fresh, calcite veins.			
		very fine grained, fresh, calcite veins.			
		fine grained, fresh.			
		very fine grained, black, fresh, carbonaceous.			
		SHALE: dark brown, fresh, carbonaceous, calcite alteration.			
		SANDSTONE: very fine grained, pale brown, fresh, slightly metamorphosed, minor soft sandstone - fault gouge material.			
		grey, fresh, no evidence of metamorphosis or fault gouge material.			
		COAL: black, fresh, (Roper Seam).			
		SILTSTONE: grey, fresh.			
		pale, grey.			
		COAL: black, fresh, (Middlemount Seam fault repeated)			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 3 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				101.00					**SILTSTONE:** grey, fresh.	W		
				62 102					**COAL:** black, fresh, (Middlemount Seam fault repeated).			
				60 104								
				58 106								
				56 108								
				54 110								
				52 112								
				50 114					**SILTSTONE:** grey, fresh, carbonaceous.			
				115.00					non-carbonaceous.			
				48 116					**SANDSTONE:** very fine grained, grey, fresh, slightly carbonaceous.			
				46 118								
				44 120								
				42 122					**SILTSTONE:** grey, fresh.			
				40 124								
				125.00					**SANDSTONE:** very fine grained, grey, fresh.			
				38 126								
				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.			
				149.00					grey, non-carbonaceous.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 4 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

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

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS

RAB

12 152
10 154
8 156
6 158
4 160
2 162
0 164
-2 166.00
167.00
-4 168.00
-6 170
171.00
-8 172
-10 174
-12 176
-14 178.00
179.00
-16 180
-18 182
-20 184
-22 186
-24 188
189.00
-26 190
-28 192
-30 194
195.00
-32 196
-34 198

grey, non-carbonaceous. *(continued)* — W

very fine grained, black, carbonaceous.

grey, high strength, non-carbonaceous.

fine grained.

very fine grained.

fine grained.

fine to medium grained.

COAL: black, fresh, some very fine grained, white tuff, (Pisces Seam).

SANDSTONE: fine grained, grey.

Bentonite, 166.5 to 189m bgl

3mm Filter gravel, 189 to 198m bgl

80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 189.5 to 193.5m bgl, 1m uPVC sump

Bentonite, 194.5 to 197m bgl

Backfill, 197 to 203m bgl

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW7P

SHEET 5 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 21.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW7P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	164 m AHD
Borehole Diameter:	254mm to 140mm	Driller Lic No:	3127	Co-ords:	E 669777 N 7472247 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H / FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				-38 202					**SANDSTONE:** fine grained, grey. *(continued)*	W		
				-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.

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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: [signature]

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information | **Field Material Description**

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB S VL F L ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			Monument cover with PVC cap, Cement 0 to 7m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 94m bgl						SC	**CLAYEY SAND:** fine grained, yellow brown, dry	D		200mm Diameter, 0 to 40m bgl
				1.00					CL	**SANDY CLAY:** orange brown, firm, fine grained sand component, dry.			
				162	2								
				160 4.00	4				SC	**CLAYEY SAND:** fine to medium grained, brown, dry.			
				158	6								
			Backfill, 7 to 91m bgl	7.00					SP	**SAND:** fine grained, orange brown, with clay, dry.			
				156	8								
				154 10.00	10					medium to coarse grained grained, trace of clay fines, pale yellow to orange, moist.	M		
				152	12								
				13.00						fine to medium grained, yellow, moist.			
				150	14								
				15.00					SC	**CLAYEY SAND:** fine grained, grey, moist.			
				148 16.00	16				CL	**CLAY:** grey, firm, moist.			
				146	18								
				19.00					OL	**Silty CLAY:** brown, with organics, firm, moist.			
				144	20								
				21.00					SC	**CLAYEY SAND:** fine grained, pale grey, moist.			
				142 22.00	22					**SANDSTONE:** fine to medium grained, yellow grey, extremely weathered, moist.			
				23.00						clayey, fine grained, grey, extremely weathered, moist.			
				140 24.00	24					very fine to fine grained, orange, extremely weathered.			
				25.00						very fine grained, yellow-grey, distinctly weathered.			
				138	26								
				136	28								
				29.00						fine grained			
				134 30.00	30					**SILTSTONE:** brown ,slightly weathered, moist.			
				132 32.00	32					yellow and grey, moist.			
				130	34								
				128	36								
RAB				37.00						grey, fresh			
				126	38								
				124	40								143mm Diameter, 40 to 153m bgl
				122	42								
				120 44.00	44					calcite veins.			
				45.00						**SANDSTONE:** fine grained, pale grey, calcite veins, dry.	D		
				118 46.00	46					very fine grained.			
				116	48								

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW8FR

SHEET 2 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 10.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 25.07.2010
Borehole Location:	MW8MR MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				112 52					fine grained.	D		
				110 54								
				108 56								
				106 58								
				104 60								
				102 62								
				100 64								
				98 66								
				96 68								
				94 70								
				71.00								
				92/23.00 72					moist.	M		
									dry	D		
				90 74								
				88 76								
				77.00								
				86/18.00 78					moist.	M		
				79.00					SILTSTONE: grey, fresh, calcite alteration, dry.	D		
				84/20.00 80					SANDSTONE: fine grained, grey, fresh, calcite alteration.			
									very fine grained.			
				82/2.00 82					fine grained.			
				83.00					moist.	M		
				80/4.00 84					very fine grained, dry.	D		
				85.00					fine grained.			
				78 86								
				76 88								
				89.00					SHALE: dark grey to black, fresh, moist.	M		
				74/0.00 90					SANDSTONE: fine grained, dark grey ,fresh, carbonaceous and calcite alteration, moist.			
			3mm Filter gravel, 91 to 151m bgl	72 92								
				70/4.00 94					SHALE: dark grey to black, fresh, carbonaceous and calcite alteration, wet.	W		
			80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 94 to 100m bgl	68 96								
				66 98								
				97.00					SILTSTONE: dark grey, fresh, carbonaceous, calcite alteration, dry.	D		

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

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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:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			TOC 1 m 80mm ID, Class 18 uPVC casing from 100 to 123.5m bgl 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 123.5 to 129.5m bgl 80mm ID, Class 18 uPVC casing from 129.5 to 147m bgl 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 147 to 150.1m bgl, 0.9m uPVC sump	102.00 62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32.32 30.34 28 26 24 22 20 18 16	102 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146 148		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S FB VL L ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: very fine grained, dark grey, fresh, calcite alteration, carbonaceous, wet.	W		
		SILTSTONE: dark grey, fresh, calcite alteration, wet.			
		SANDSTONE : very fine grained, dark grey, fresh, calcite alteration, wet.			Airlift yield: 0.004 L/S

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW8FR

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:	[signature]

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	164 m AHD
Borehole Diameter:	200mm to 114mm	Driller Lic No:	3046	Co-ords:	E 669941 N 7472277 MGA94 Zone 55
		TOC (RL):	165 m AHD	Local Co-ords:	

Borehole Information | **Field Material Description**

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 151 to 153m bgl							SANDSTONE : very fine grained, dark grey, fresh, calcite alteration, wet. *(continued)*	W		
				12	152					SILTSTONE: grey, fresh, with calcite alteration, wet.			
			Backfill, 153 to 189m bgl		153.00					SANDSTONE: very fine grained, dark grey, fresh, wet.			114mm Diameter, 153 to 189m bgl
				10	154								
				8	156								
				6	158								
				4	160								
				2	162								
				0	164								
				-2	166								
				-4	168								
					169.00					fine grained.			
				-6	170					very fine grained.			
				-8	172					fine grained.			
					173.00					very fine grained.			
				-10	174					COAL: black, fresh, wet.			
					175.00					TUFF: pale grey, fresh, wet.			
				-12	176								
					177.00					COAL: black, fresh, wet.			
				-14	178								
				-16	180								
					181.00					TUFF: white, fresh, wet.			
				-18	182								
				-20	184					COAL: black, fresh, wet and TUFF: white, fresh, wet.			Airlift yield: 0.07 L/S
					185.00					COAL: black, fresh, wet.			
				-22	186								
				-24	188								
										END OF BOREHOLE AT 189.00 m			
				-26	190								
				-28	192								
				-30	194								
				-32	196								
				-34	198								

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

SHEET 1 OF 2

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 05.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9A -MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 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 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY / CONSISTENCY	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			TOC 1 m Monument cover with PVC cap. Cement 0 to 6.5m bgl (below ground level) 50mm ID, Class 12 uPVC casing, 0 to 40m bgl Backfill, 6.5 to 31m bgl Bentonite, 31 to 34m bgl 3mm Filter gravel, 34 to 52m bgl 50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 40 to 52m bgl	154 2.00 3.00 152 5.00 150 6.00 7.00 148 8.00 9.00 146 11.00 144 13.00 142 140 16.00 138 136 134 132 130 128 126 124 32.00 33.00 122 34.00 120 36.00 118 116 114 112 44.00 110 108 48.00	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 35 38 40 42 44 46 49			CL	**Silty CLAY:** brown, dry, firm.	D		143mm Diameter, 0 to 52m bgl
										moist	M		
									CL	**CLAY:** brown	D		
									SC	**Clayey SAND:** fine grained, pale brown, moist	M		
									SP	**SAND:** fine grained, pale brown, dry.	D		
									SC	with clay, moist.	M		
									CL	**CLAY:** pale grey, moist, firm			
									SC	and **Sandy CLAY:** brown, fine grained sand, moist.			
										Clayey SAND: fine to medium grained, grey and orange, moist.			
									CL/ ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
									CL	**CLAY:** grey, orange and pink, firm, trace very fine grained pink sand, moist.			
									CL/ ML	**Clay:** pale grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist.			
									ML/ CL	**SAND:** very fine grained, yellow, moist and **CLAY:** yellow brown, moist, firm.			
									CL	**CLAY:** brown, with pale brown silt, moist, firm.			
									ML	**SILT:** yellow, with firm grey clay, moist.			
										SANDSTONE: very fine grained, yellow brown, extremely weathered, moist.			
										grey, distinctly weathered, moist.			
										SILTSTONE: dark grey, slighly weathered, moist.			

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

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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:	IRTH 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 TOC 1 m	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST H / VL L MD VST D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB				104 52					**SILTSTONE:** dark grey, slightly weathered, moist, *(continued)*	M		Airlift yield: 0.01 L/S
									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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW9M
SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RB			TOC 1 m Monument cover with PVC cap, Cement 0 to 6m bgl (below ground level) 86mm ID, Class 12 uPVC casing, 0 to 135m bgl Backfill, 6 to 129m bgl	154 152 150 148 146 144 142 140 138 136 134 132 130 128 126 124 122 120 118 116 114 112 110 108	2 3.00 4 5.00 6 8 9.00 10 11.00 12 13.00 14 16 18 20 22 24 26 28 30 32 33.00 34 36 38 40 42 43.00 44 46 48		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, dry, firm.	D		200mm Diameter, 0 to 51m bgl
	SL	**CLAY:** brown, dry, firm.			
	SC	**Clayey SAND:** medium grained, brown, moist.	M		
	CL/SC	**CLAY:** grey, moist, firm and **Sandy CLAY:** brown, fine grained sand, moist.			
	SC	**Clayey SAND:** fine to medium grained, grey and orange, moist.			
	CL/ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
	CL	**CLAY:** pale grey, orange and pink, moist, firm, trace very fine grained pink sand.			
	CL/ML	**CLAY:** grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist			
	CL	**CLAY:** brown, moist, firm.			
	ML	**SILT:** yellow-brown, with firm grey clay, moist.			
		SANDSTONE: very fine grained, yellow-brown, extremely weathered, moist.			
		red, distinctly weathered.			
		CLAYSTONE: brown and orange, distinctly weathered, moist.			
		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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 2 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information							Field Material Description					
1	2	3	4	5	6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST H / FB VL L MD VST D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB / RAB				104 52					**CLAYSTONE:** grey, distinctly weathered, moist.	M		140mm Diameter, 51 to 144m bgl
				53.00								
				102 54					**SANDSTONE:** very fine grained, grey, fresh, dry.	D		
				100 56								
				57.00					**CLAYSTONE:** dark grey, fresh, dry.			
				98 58.00 58					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				96 60								
				94 62								
				92 64.00 64					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				90 66.00 66					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				88 68								
				86 70.00 70					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				71.00					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				84 72								
				73.00					**CLAYSTONE:** dark grey, distinctly weathered, carbonaceous, dry.			
				82 74.00 74					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				80 76								
				77.00					extremely weathered, clayey, wet.	W		
				78 78.00 78					slightly weathered, clayey, wet.			
				76 80								
				74 82								
				72 84								
				70 86								
				87.00								
				68 88.00 88					**SANDSTONE:** very fine grained, dark grey, fresh, wet. fine grained.			
				66 90								
				64 92								
				62 94								
				60 96.00 96					very fine grained.			
				97.00					**SILTSTONE:** dark grey, fresh, wet.			
				58 98.00 98					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RAB				54	102		
				52	104		
				105.00			
				50	106		
				107.00			
				48	108		
				109.00			
				46	110		
				44	112		
				42	114		
				40	116		
				38	118		
				119.00			
				36	120		
				121.00			
				34	122		
				32	124		
				30	126		
				28	128		
			Bentonite, 129 to 134m bgl	26	130		
				24	132		
				133.00			
			3mm Filter gravel, 134 to 139.5m bgl	22	134		
			80mm ID, Class 12 uPVC, 0.5mm Slotted screen from 135 to 138m bgl, 1.5m uPVC sump	20	136		
				18	138		
			Bentonite, 139.5 to 142m bgl	16	140		
				14	142		
			Backfill, 142 to 144m bgl	12	144		
				10	146		
				8	148		

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: very fine grained, dark grey, fresh, wet. *(continued)*	W		
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SHALE: black, fresh, carbonaceous, wet.			
		STONY COAL: fresh, carbonaceous, wet, (Roper Seam).			
		SANDSTONE: fine to medium grained, pale grey, fresh, bands of carbonaceous, claystone and quartz veins, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet and **SILTSTONE:** dark grey, fresh, carbonaceous, wet.			Airlift yield: 0.014 L/S
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		COAL: black, fresh, wet, (Middlemount Seam)			
		SILTSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			Airlift yield: 0.017 L/S
		END OF BOREHOLE AT 144.00 m			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 1 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
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 (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			Monument cover with PVC cap. Cement 0 to 5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 200m bgl	1.00				ML	Clayey SILT: brown, dry.	D		200mm Diameter, 0 to 46m bgl
				154 2				CL	Silty CLAY: brown and orange, moist, firm.	M		
				152 4								
			Backfill, 5 to 194m bgl	5.00				SC	SAND: fine grained, orange, with clay, moist.			
				150 6.00 6					fine to medium grained, brown.			
				7.00					medium grained, orange.			
				148 8.00 8				CL	CLAY: grey and orange, moist, firm, with medium grained, orange sand.			
				146 10								
				144 12								
				142 14.00 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 26.00 26				CL	CLAY: pink and grey, moist, firm.			
				128 28.00 28					orange and grey.			
				126 30.00 30				CL	Silty CLAY: grey, orange and dark brown, moist, firm.			
				124 32								
				33.00					SANDSTONE: very fine grained, yellow, extremely weathered, moist.			
				122 34								
				35.00					SILTSTONE: yellow, distinctly weathered, moist.			
				120 36.00 36					SANDSTONE: very fine grained, yellow and brown, extremely weathered, moist.			
				118 38								
				39.00					SILTSTONE: yellow, distinctly weathered, moist.			
				116 40.00 40					SANDSTONE: fine grained, grey, distinctly weathered, moist.			
				41.00					very fine grained.			
				114 42.00 42					brown, clayey in places.			
				112 44.00 44					SILTSTONE: grey and brown, slightly weathered, moist.			
RAB				110 46.00 46					SANDSTONE: fine grained, grey, slightly weathered, moist.			140mm Diameter, 46 to 203m bgl
				108 48.00 48					CLAYSTONE: grey, slightly weathered, minor silt, moist.			
				49.00					SILTSTONE: grey, slightly weathered, moist.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 2 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
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 (TOC 1m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F / VL L / ST MD / VST D / H VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				104 52					**SILTSTONE:** grey, slightly weathered, moist. *(continued)*	M		
				102 54								
				55.00					**SANDSTONE:** very fine grained, grey, slightly weathered, moist.			
				100 56								
				98 58								
				96 60								
				94 62								
				63.00					**SILTSTONE:** grey, fresh, moist.			
				92 64								
				65.00					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				90 66.00 66					**SILTSTONE:** grey, fresh, moist.			
				88 68								
				69.00					**SANDSTONE:** grey, fresh, moist.			
				86 70								
				71.00					**SILTSTONE:** grey, fresh, moist.			
				84 72								
				82 74								
				80 76								
				77.00					**SANDSTONE:** very fine grained, grey, fresh, moist.			
				78 78								
				79.00					fine grained.			
				76 80								
				74 82								
				72 84								
				70 86								
				68 88								
				69.00					very fine grained.			
				66 90.00 90					**SILTSTONE:** dark grey, fresh, moist.			
				91.00					**SANDSTONE:** fine grained, grey, fresh, wet.	W		
				64 92								
				93.00					**SILTSTONE:** dark grey, wet.			
				62 94								
				95.00					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			
				60 96								
				58 98								

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 3 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
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 (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST H / FB VL L MD VST D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				54 102					**SANDSTONE:** very fine grained, dark grey, fresh, wet. *(continued)*	W		
				52.04 104					calcite veins.			
				105.00					no calcite veins			
				50 106								
				48 108								
				46 110								
				111.00					**SILTSTONE:** grey, fresh, wet.			
				44.12 112					**SANDSTONE:** very fine grained, grey, fresh, wet.			
				113.00					**SILTSTONE:** grey, fresh, wet.			
				42.14 114					**SANDSTONE:** very fine grained, grey, fresh, wet.			
				40.16 116					**SILTSTONE:** dark grey, fresh, wet.			
				117.00					**SANDSTONE:** very fine grained, grey, fresh, wet.			
				38 118								
				36.20 120					fine grained.			
				34.22 122					very fine grained.			
				32 124								
				30 126								
				28 128								
				26 130								
				131.00					fine grained.			
				24.32 132					very fine grained.			Airlift yield: 0.03 L/S
				22 134								
				20.36 136					**SILTSTONE:** dark grey, fresh, carbonaceous, wet.			
				137.00					**Silty COAL:** dark brown, fresh, wet, (Middlemount Seam).			
				18.38 138					**COAL:** black, fresh, wet, (Middlemount Seam).			
				16 140								
				141.00					**SANDSTONE:** very fine grained, brown, fresh, wet.			
				14.42 142					fine grained, grey.			
				12 144								Airlift yield: 0.03 L/S
				10 146								
				147.00					very fine grained, brown, carbonaceous.			
				8 148								

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.
MW9P
SHEET 4 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
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 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB S VL F L ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB				152.00						fine grained, grey.	W		
				152.00	152					very fine grained, bands of carbonaceous siltstone.			
				153.00	154					fine grained.			
				156.00	156					brown			
				158.00	158					grey			
				160.00	160					brown.			
				162.00	162					grey.			
				163.00						very fine grained.			
				164.00	164					fine grained.			
				166.00	166					very fine grained.			
				169.00	168					fine grained.			
				170.00	170					brown			
				171.00	172					grey			
				173.00	174					brown.			
				174.00	174					grey.			
				175.00	176					brown.			
				177.00	178					calcite veins.			
				182.00	182					very fine grained, dark grey, no calcite veins.			
				185.00	184					fine grained.			
				186.00	186					SILTSTONE: dark grey, fresh, wet.			
				187.00	188					SANDSTONE: very fine grained, grey, fresh, calcite veins, wet.			
				189.00	190					SILTSTONE: dark grey, fresh, wet.			
			Bentonite, 194 to 199m bgl		194								
					196								
				198.00	198					Silty COAL: dark brown, fresh, wet, (Pisces Seam)			
			3mm Filter gravel, 199 to 204m bgl	199.00									

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9P

SHEET 5 OF 5

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 25.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 28.07.2010
Borehole Location:	MW9P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	HYDROPOWER SCOUT	Driller:	E Schumacher	Surface RL:	156 m AHD
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 (TOC 1 m)	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST VST H; FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 200 to 203m bgl, 1m uPVC sump	-46 202					**COAL:** black, fresh, wet, minor very fine grained, white tuff (Pisces Seam). *(continued)*	W		
			Bentonite, 204 to 207m bgl	-48 204					**SILTSTONE:** dark brown, fresh, carbonaceous, wet.			Airlift yield: 0.15 L/S
				205.00					with very fine grained, white tuff.			
			Backfill, 207 to 210m bgl	-50 206								
				207.00					no tuff present.			
				-52 208								
				209.00					tuff presents.			Airlfit yield: 0.15 L/S
				-54 210					END OF BOREHOLE AT 210.00 m			
				-56 212								
				-58 214								
				-60 216								
				-62 218								
				-64 220								
				-66 222								
				-68 224								
				-70 226								
				-72 228								
				-74 230								
				-76 232								
				-78 234								
				-80 236								
				-82 238								
				-84 240								
				-86 242								
				-88 244								
				-90 246								
				-92 248								

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

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APPENDIX C
2014 / 2015 EXPLORATORY HOLE RECORDS

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW10A
Client	MCPL	Start Date	22/12/2014
Project No.	PGC1214004	Completion Date	22/12/2014
		Driller	L. Dahler
		Supervisor	P. Rogers
		Licence No.	Class 2 / 2517
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	669782.88
		Northing	7475981.12
		Ground Level	175.75mAHD
		Checked By	S. Flux

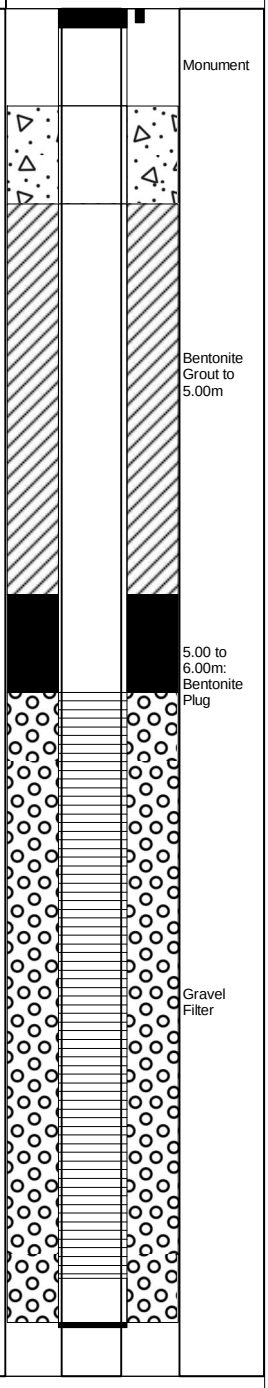
Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description
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

SPT (blows/300mm) 0 10 20 30 40 50

Sampling and Testing

Installation Details / Groundwater Levels



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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

middlemount coal

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW11A
Client	MCPL	Start Date	25/03/2015
Project No.	PGC1214004	Completion Date	25/03/2015
		Driller	L. Dahler
		Supervisor	R. Goldsworthy
		Licence No.	Class 2 / 2894
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	672355.00
		Northing	7472275.10
		Ground Level	156.20mAHD
		Checked By	S.Flux

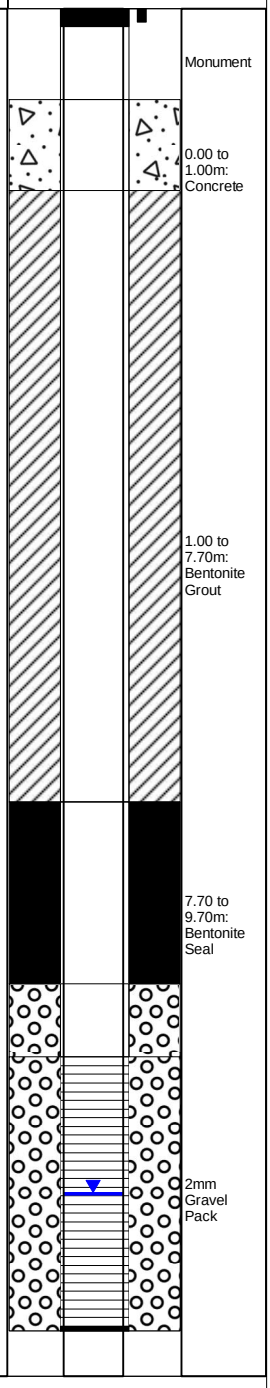
Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description
Continuous Flight Auger	156.2	0.00	SM: silty SAND, trace rootlets, dry. (TOPSOIL)
	155.9	0.30	CI: CLAY, intermediate plasticity, stiff, brown and reddish brown slightly sandy, trace gravel,dry
	154.2	2.00	CI:sandy CLAY, intermediate plasticity, brown and reddish brown, trace gravel,dry
	151.7	4.50	CH: CLAY, high plasticity, brown and reddish brown slightly sandy, trace gravel,dry
	149.2	7.00	CI: CLAY, intermediate plasticity, brown and reddish brown slightly sandy, trace gravel,dry
	146.2	10.00	CI: CLAY, intermediate plasticity, brown and reddish brown mottled white, slightly sandy, trace gravel,dry
	143.73	12.50	MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil

SPT (blows/300mm) 0 10 20 30 40 50

Sampling and Testing

Installation Details / Groundwater Levels



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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW12A
Client	MCPL	Start Date	15/12/2014
Project No.	PGC1214004	Completion Date	15/12/2014
		Driller	L. Dahler
		Supervisor	P. Rogers
		Licence No.	Class 2 / 2517
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	671639.97
		Northing	7469852.68
		Ground Level	158.28mAHD
		Checked By	S. Flux

Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description	SPT (blows/300mm)	Sampling and Testing	Installation Details / Groundwater Levels
						Monument
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

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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW13A
Client	MCPL	Start Date	12/12/2014
Project No.	PGC1214004	Completion Date	12/12/2014
		Driller	L. Dahler
		Supervisor	P. Rogers
		Licence No.	Class 2 / 2517
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	669032.15
		Northing	7468889.81
		Ground Level	162.79mAHD
		Checked By	S. Flux

Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description	SPT (blows/300mm)	Sampling and Testing	Installation Details / Groundwater Levels
						Monument
Open Hole / Air Flush	162.79	0.00	SM: silty SAND, trace rootlets, dry. (TOPSOIL)			0.00 to 1.00m: Concrete
	161.79	1.00	CI: CLAY intermediate plasticity, trace sand, dark brown, dry.			
	161.29	1.50	MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil			1.00 to 7.00m: Bentonite Grout
	154.79	8.00	SANDSTONE, grey banded yellowish brown, very low strength, extremely to distinctly weathered			7.00 to 8.00m: Seal 2mm Gravel Pack

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Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW14A
Client	MCPL	Start Date	14/12/2014
Project No.	PGC1214004	Completion Date	14/12/2014
		Driller	L. Dahler
		Supervisor	P. Rogers
		Licence No.	Class 2 / 2517
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	668175.46
		Northing	7469311.96
		Ground Level	159.65mAHD
		Checked By	S. Flux

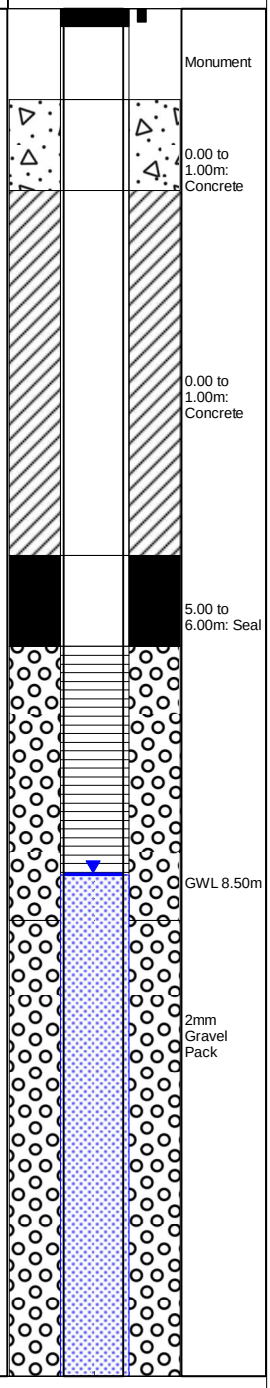
Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description
Open Hole / Air Flush	159.65	0.00	SM: silty SAND, fine and medium, reddish brown, dry
	158.65	1.00	SM: silty SAND, fine and medium, light brown, dry.
	158.15	1.50	CI: Sandy CLAY,intermediate plasticity, brown, dry.
	154.65	5.00	SP: fine to coarse SAND, yellowish brown, dry.
	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.
	149.9	9.75	MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil

SPT (blows/300mm)

Sampling and Testing

Installation Details / Groundwater Levels



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.

middlemount coal

Exploratory Hole Details

Project	Middlemount Coal - Monitoring Wells	Hole No.	MW15A
Client	MCPL	Start Date	15/12/2014
Project No.	PGC1214004	Completion Date	15/12/2014
		Driller	L. Dahler
		Supervisor	P. Rogers
		Licence No.	Class 2 / 2517
		Logged By	A. Horspool
		Co-ordinate System	GDA94 Zone 55
		Easting	667795.96
		Northing	7469627.08
		Ground Level	161.57mAHD
		Checked By	S. Flux

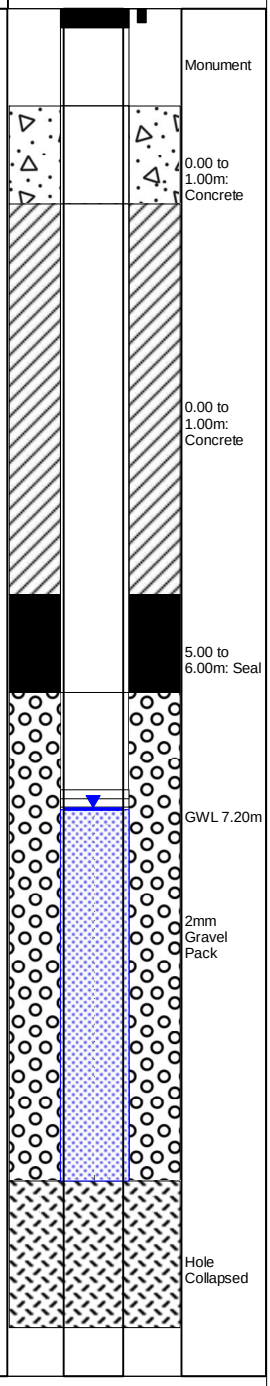
Phi GI

Drilling Method	R.L. (mAHD)	Depth (m)	Material Description
Open Hole / Air Flush	161.57	0.00	CH: CLAY with boulders, high plasticity, stiff, dry. FILL
	160.57	1.00	SM: Silty SAND, fine and medium, with trace organic matter (TOPSOIL)
	160.27	1.30	SM: Silty SAND, dark brown , dry.
	159.77	1.80	CI: CLAY with trace cobbles, dark brown, very stiff, iontermediate plastcity, dry
	158.87	2.70	CI: CLAY, dark brown, intermediate plasticity, very stiff, dry.
	157.77	3.80	SW: SAND, fine to coarse, dry
	153.57	8.00	CI: Very sandy CLAY, intermediate plasticity, grey, moist.
	150.57	11.00	MUDSTONE, mottled reddish brown and grey, extremely low strength, residual soil

SPT (blows/300mm) 0 10 20 30 40 50

Sampling and Testing

Installation Details / Groundwater Levels



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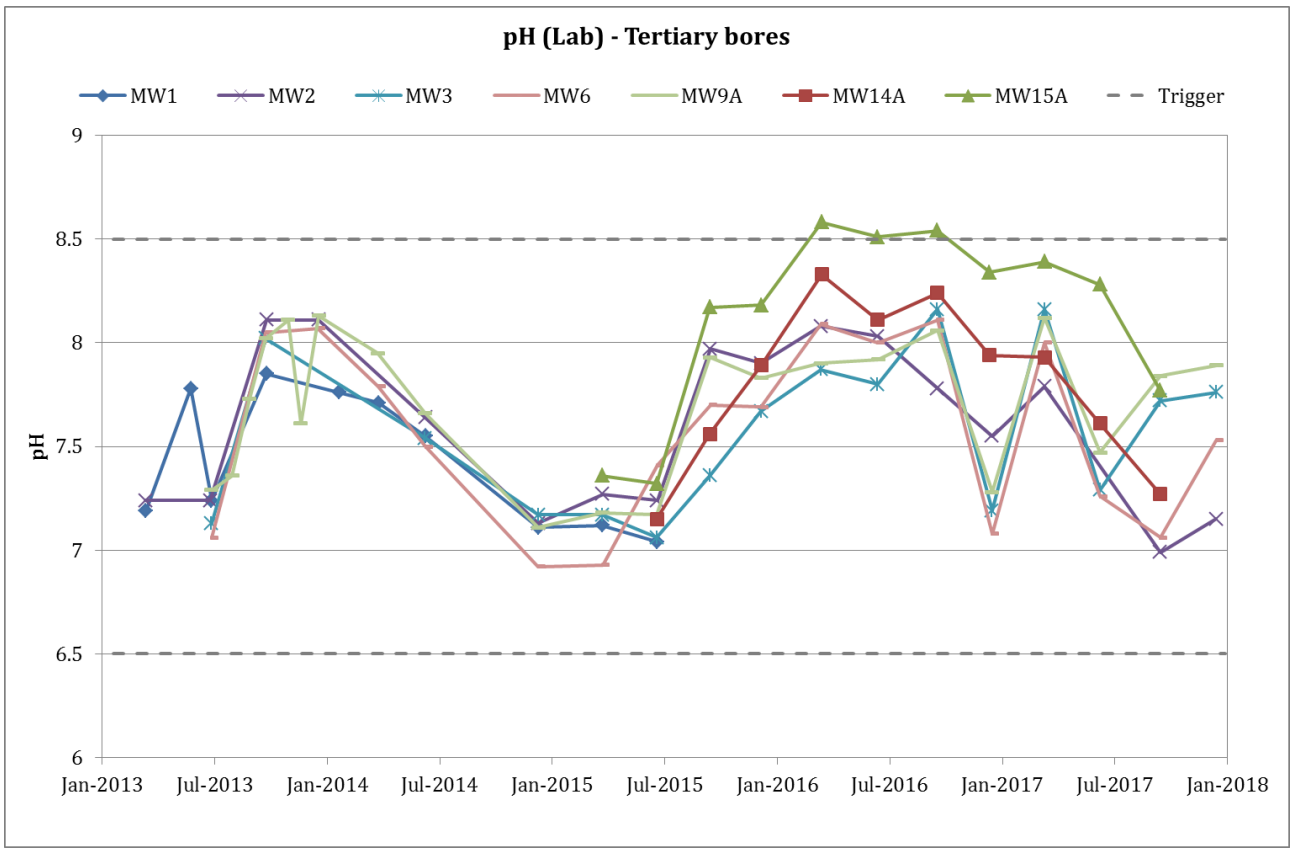
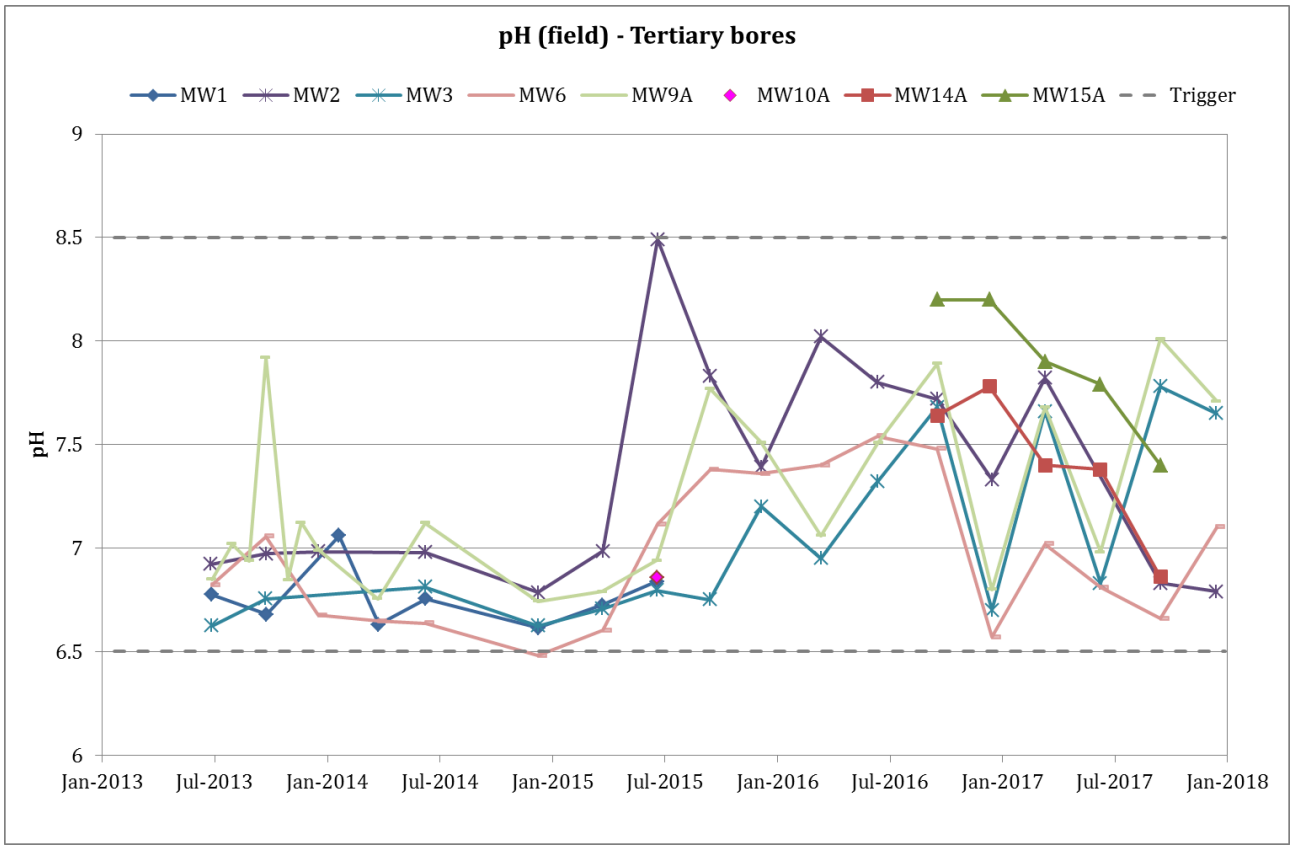
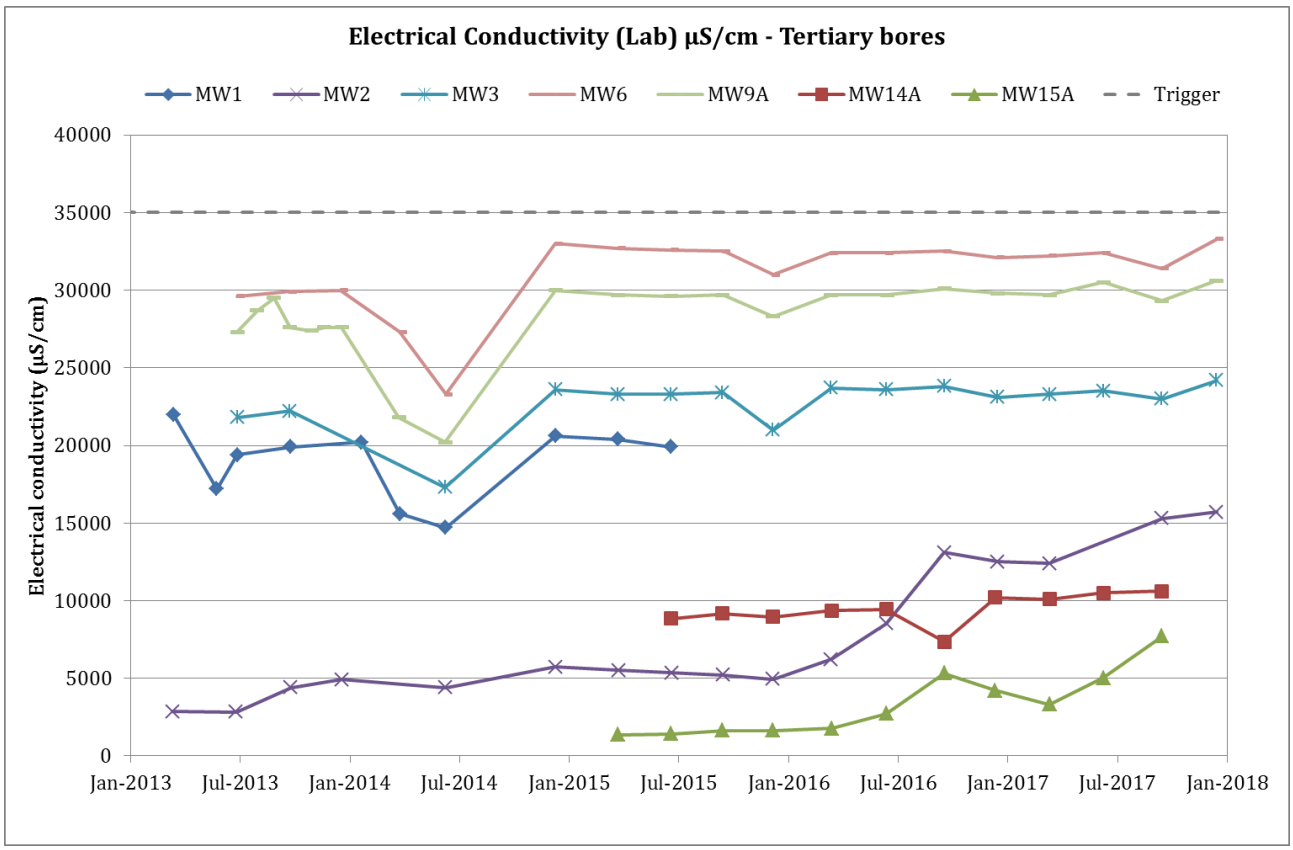
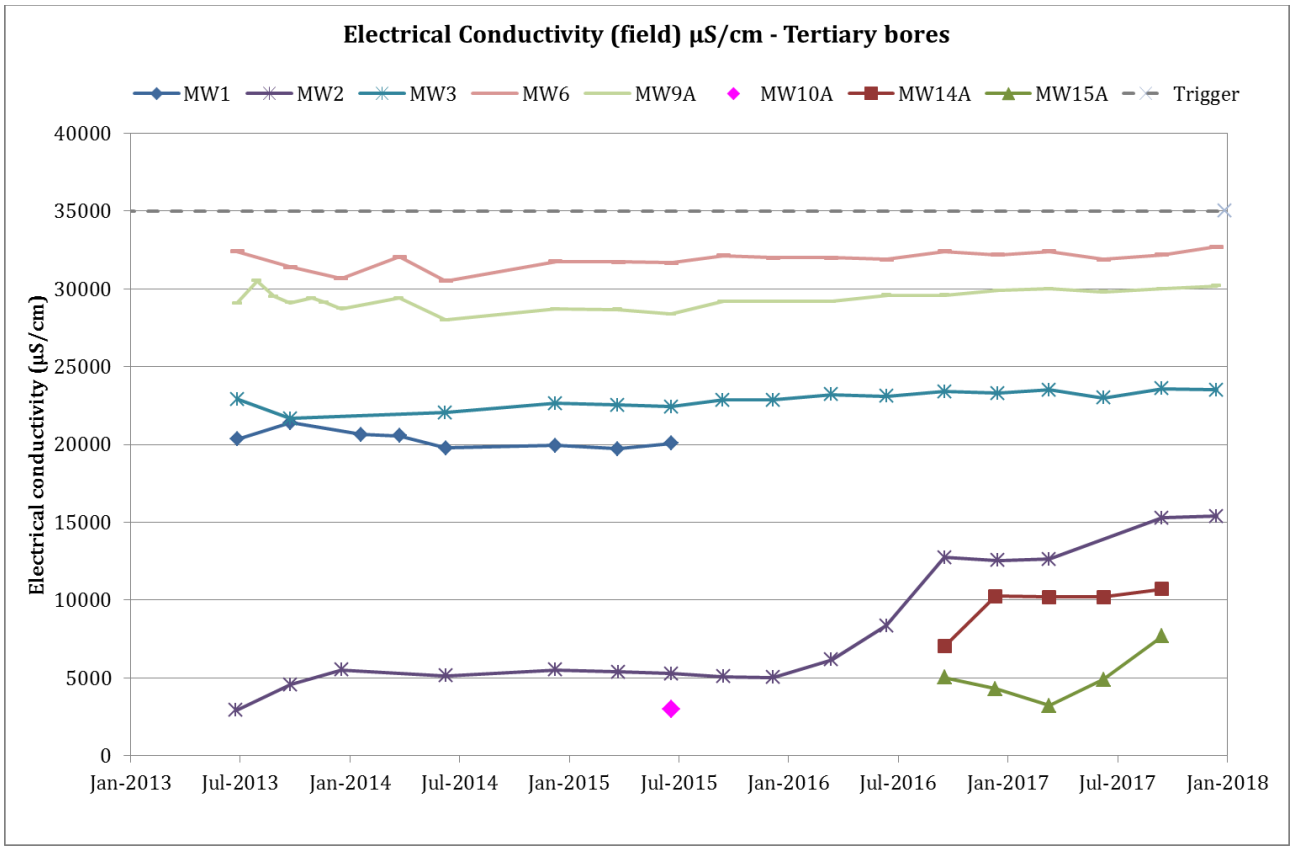
Remarks
50mm Inner Diameter Class 18 PVC Screen and Casing. 1.20m Lockable Monument at ground level.

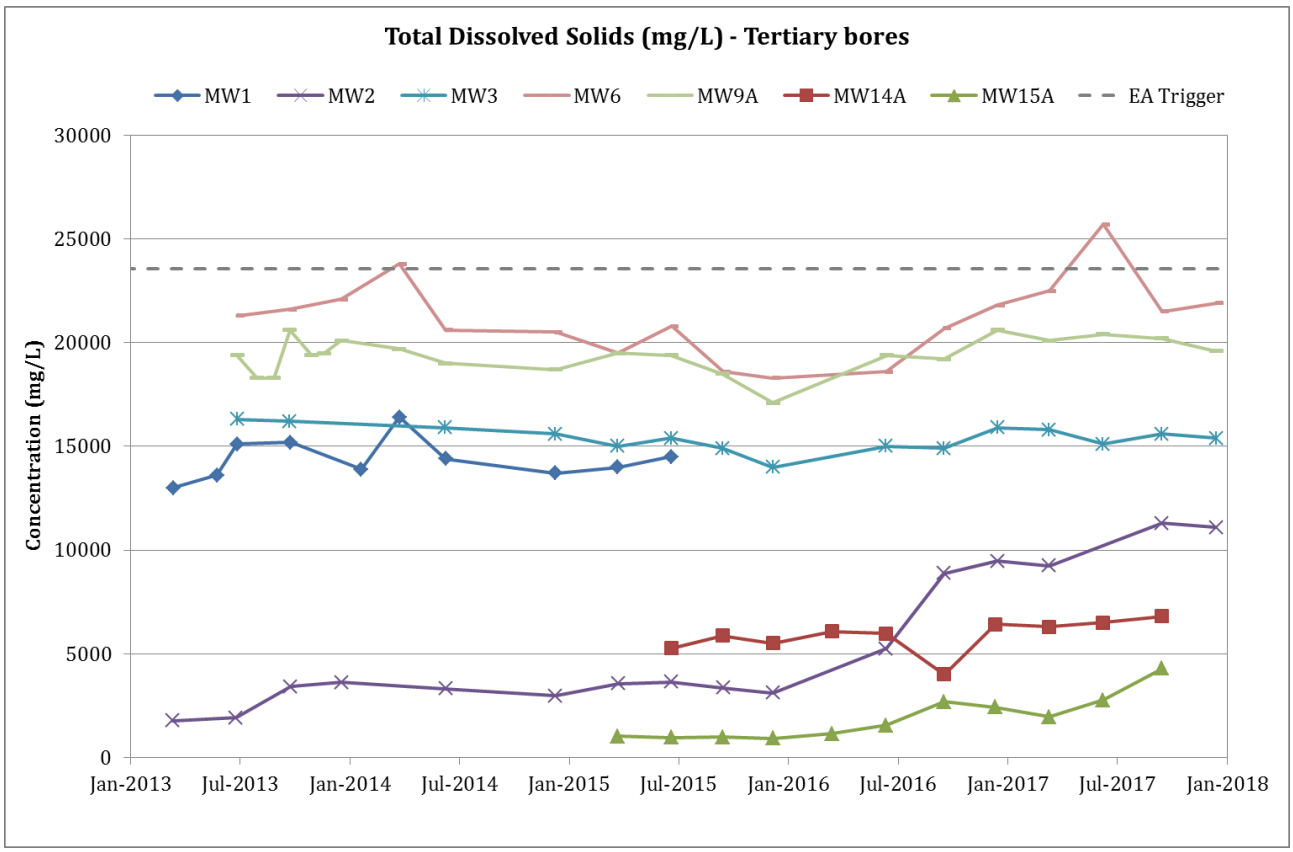
Appendix E Tertiary and Permian water quality data

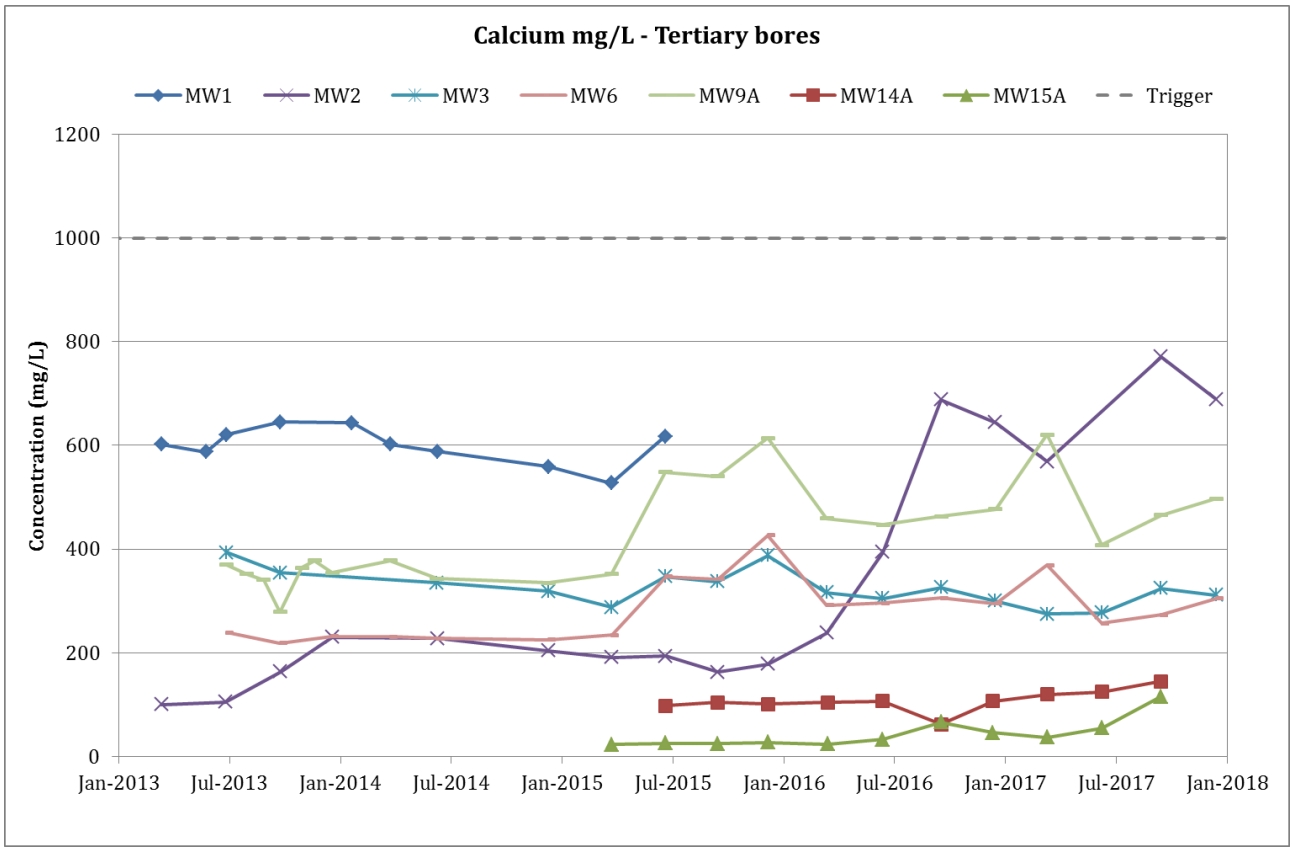

pH (Lab) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
pH
9
8.5
8
7.5
7
6.5
6
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

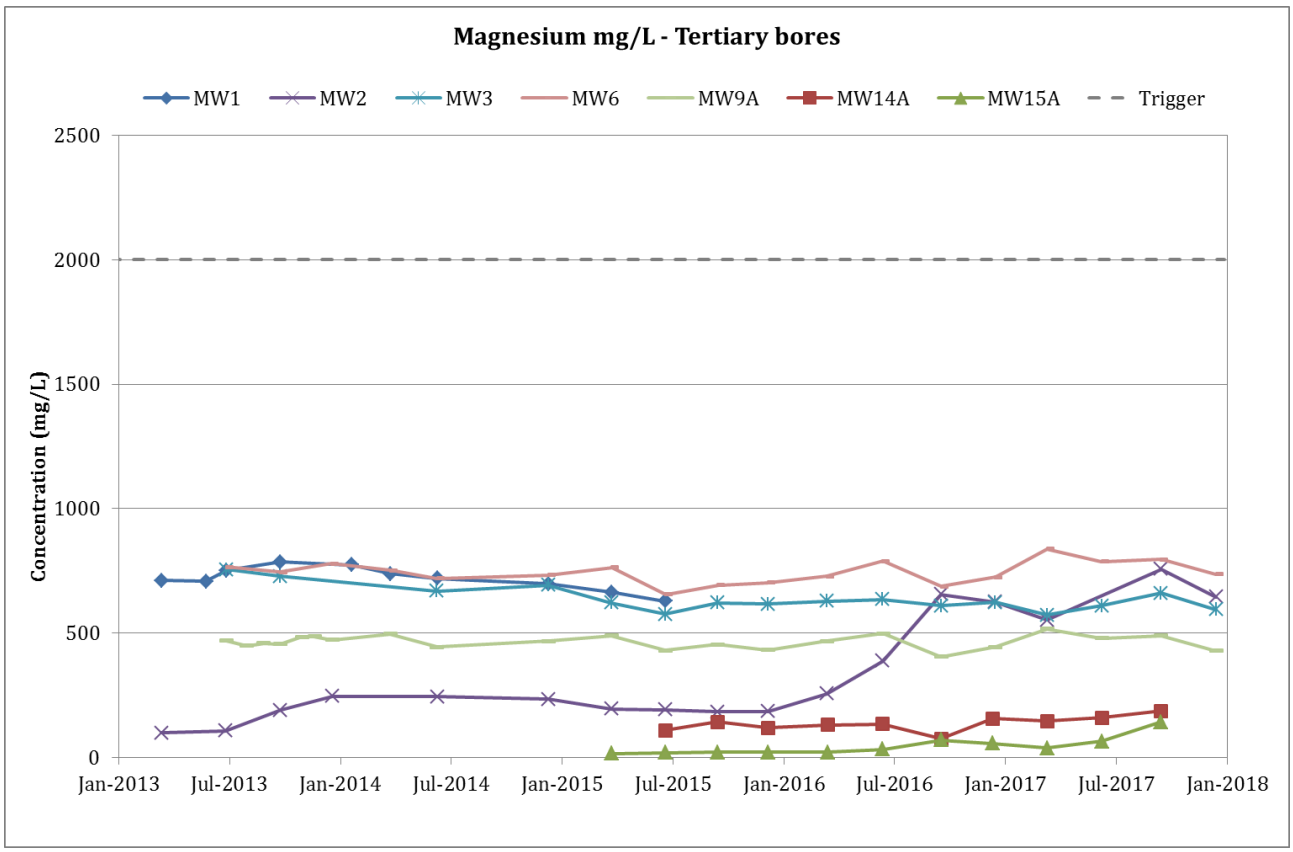

pH (field) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW10A
MW14A
MW15A
Trigger
pH
9
8.5
8
7.5
7
6.5
6
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

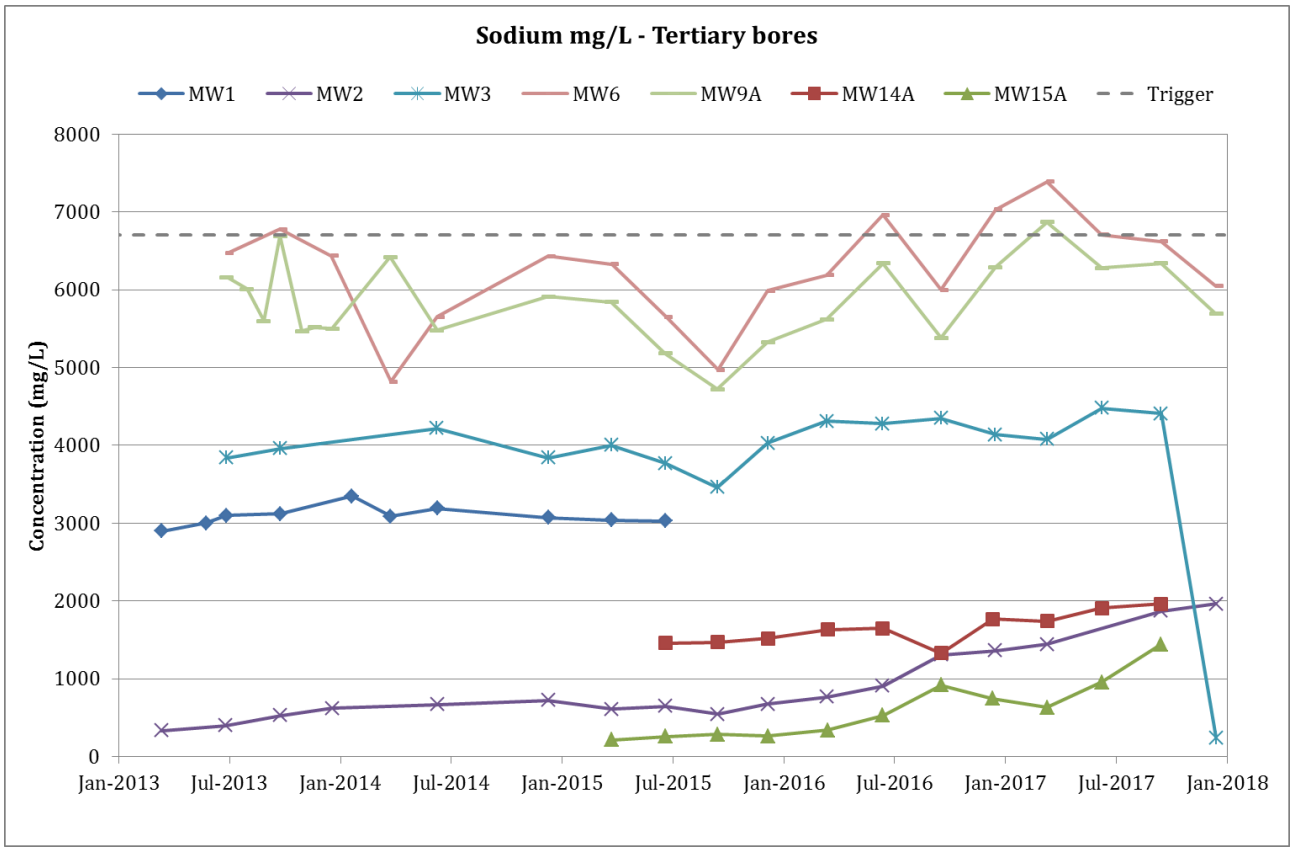

Electrical Conductivity (Lab) µS/cm - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

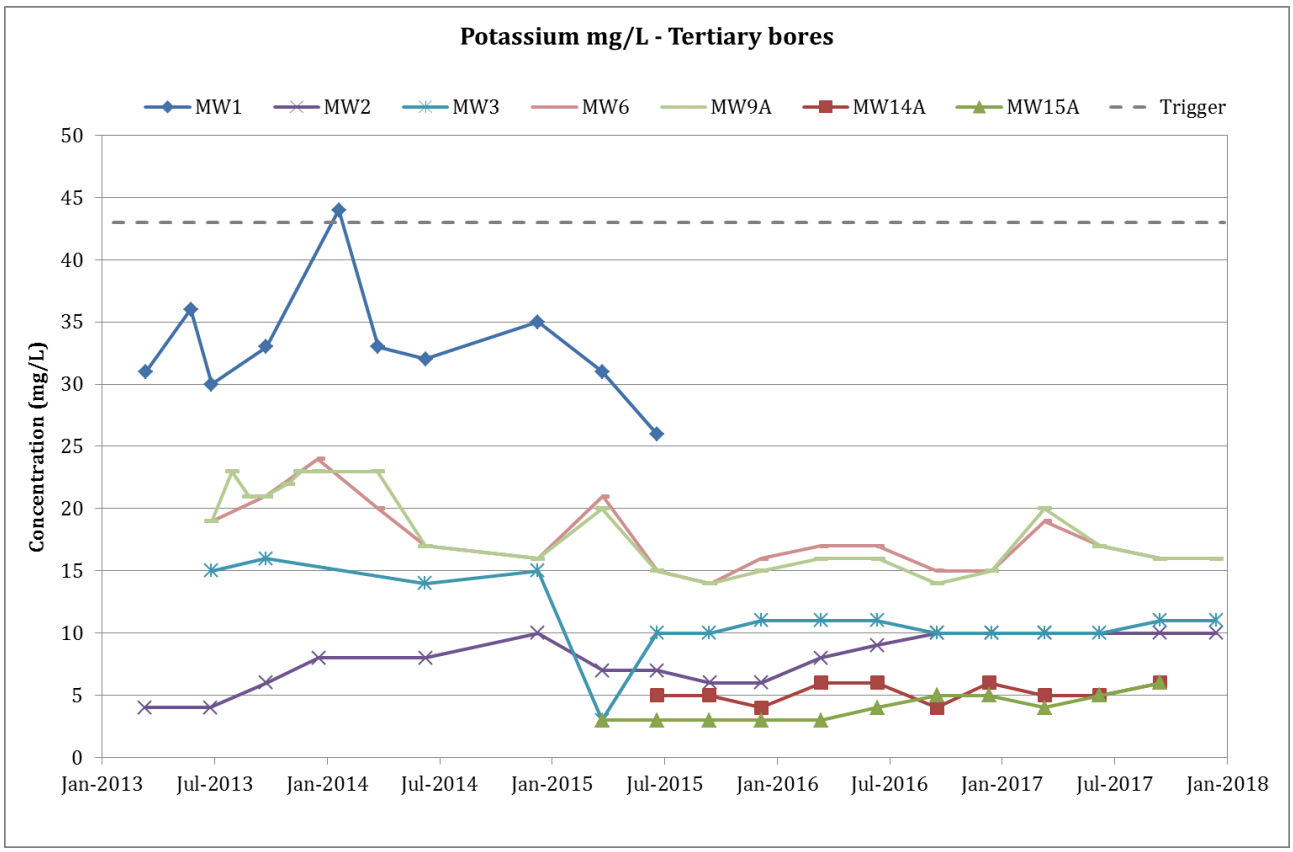

Electrical Conductivity (field) µS/cm - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW10A
MW14A
MW15A
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

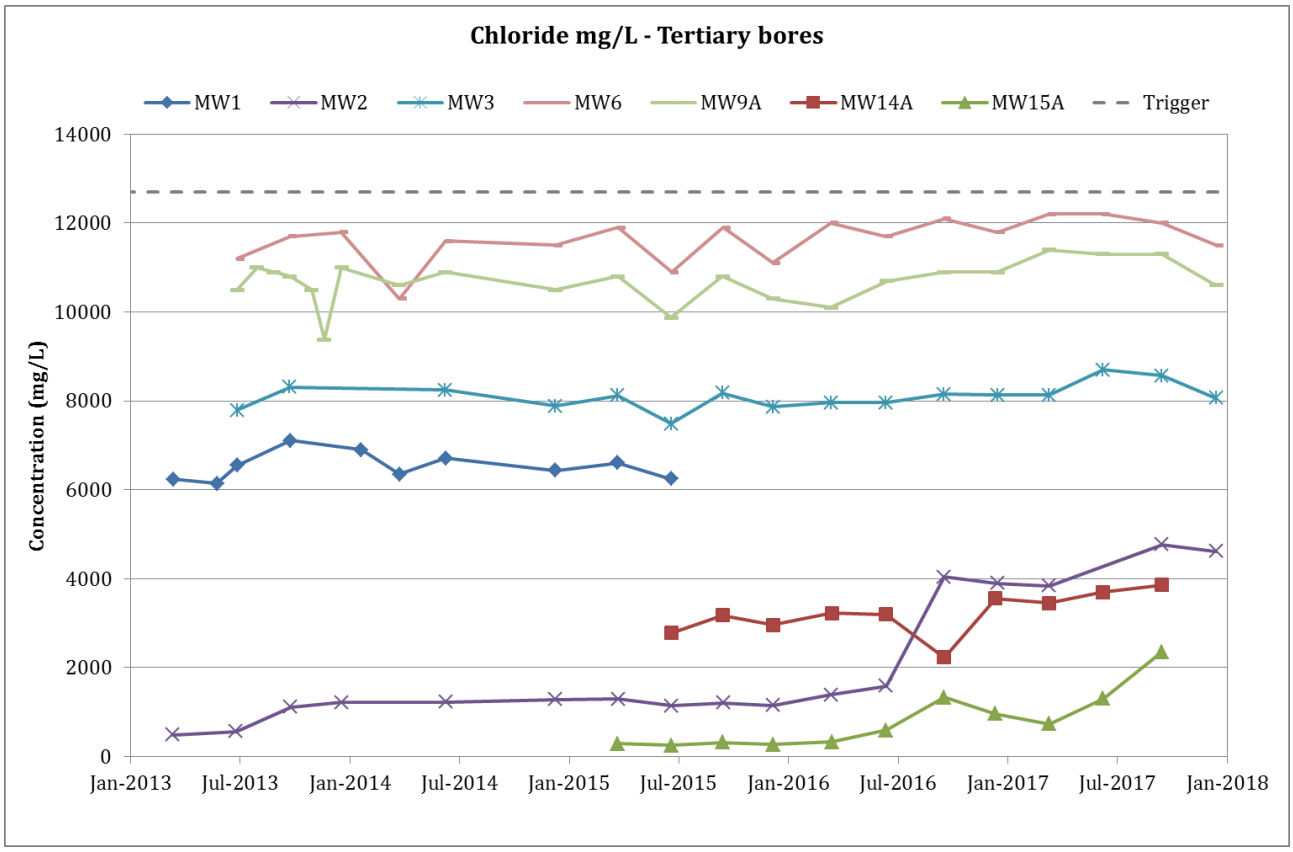

Total Dissolved Solids (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
EA Trigger
Concentration (mg/L)
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

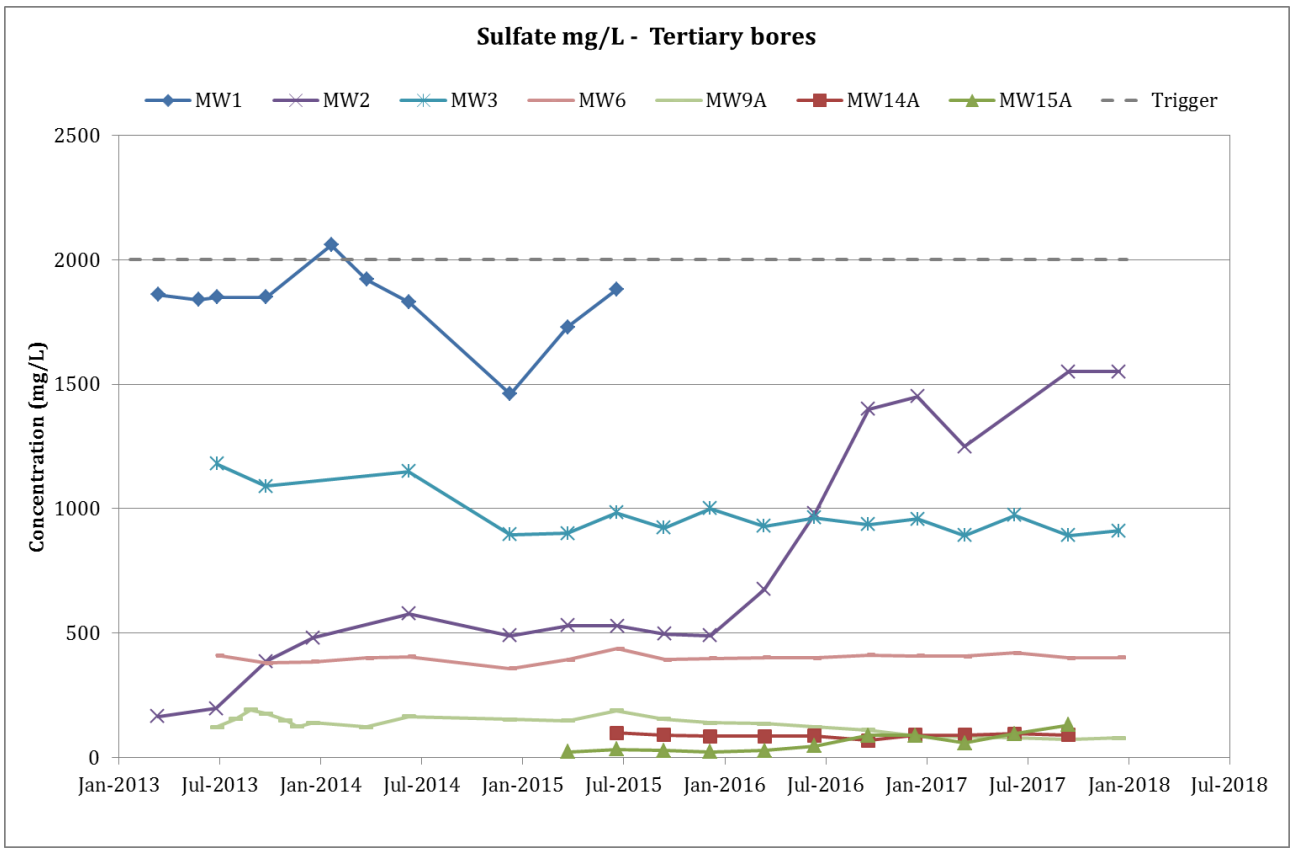

Calcium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

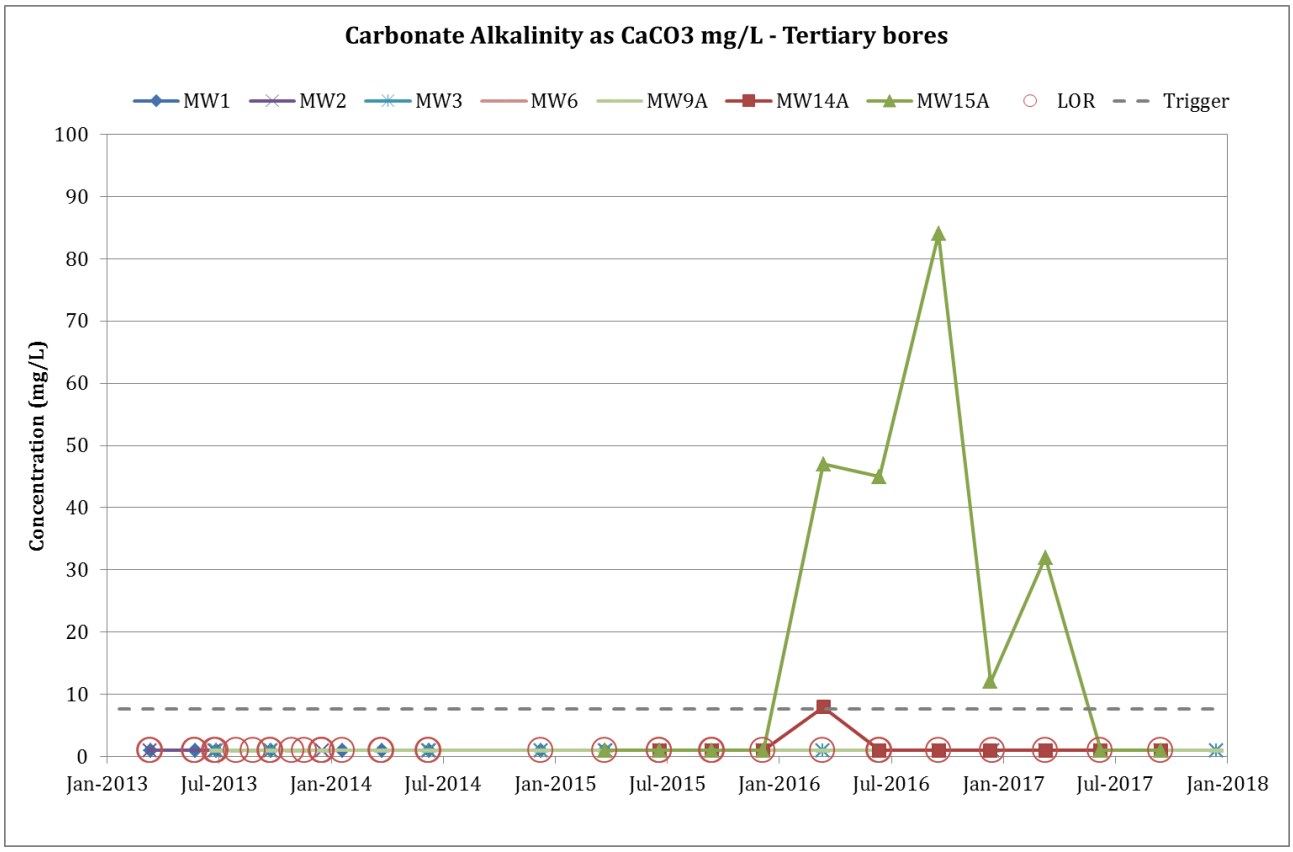

Magnesium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

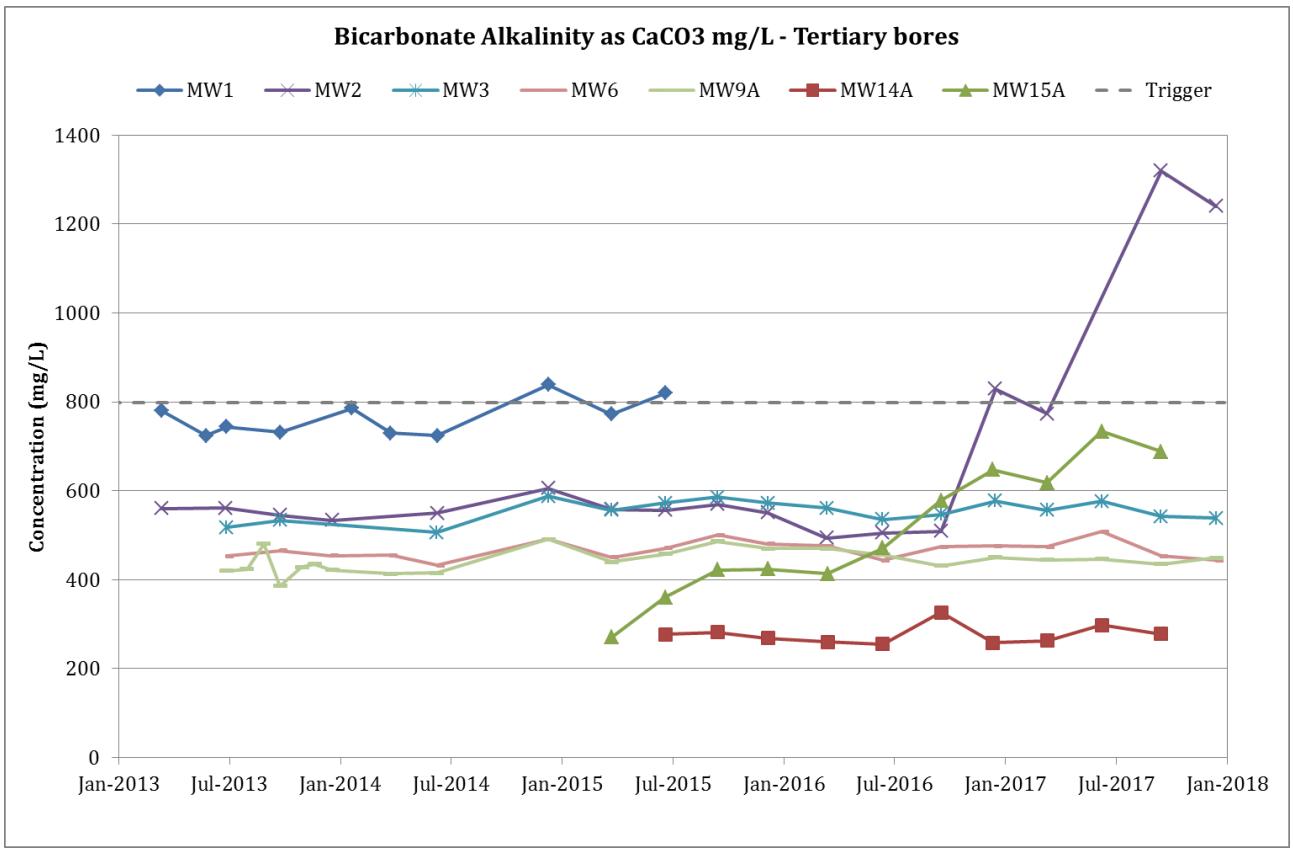

Sodium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

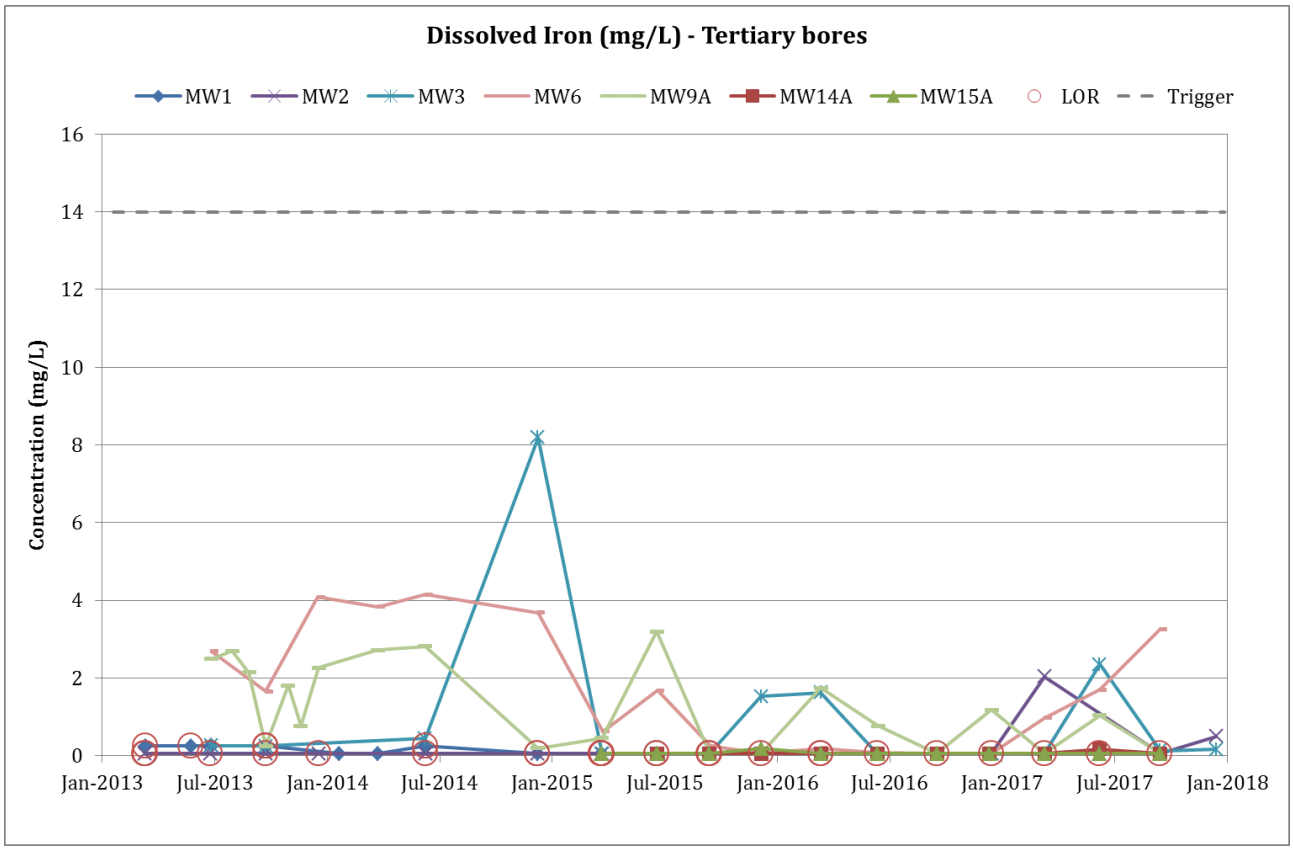

Potassium mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

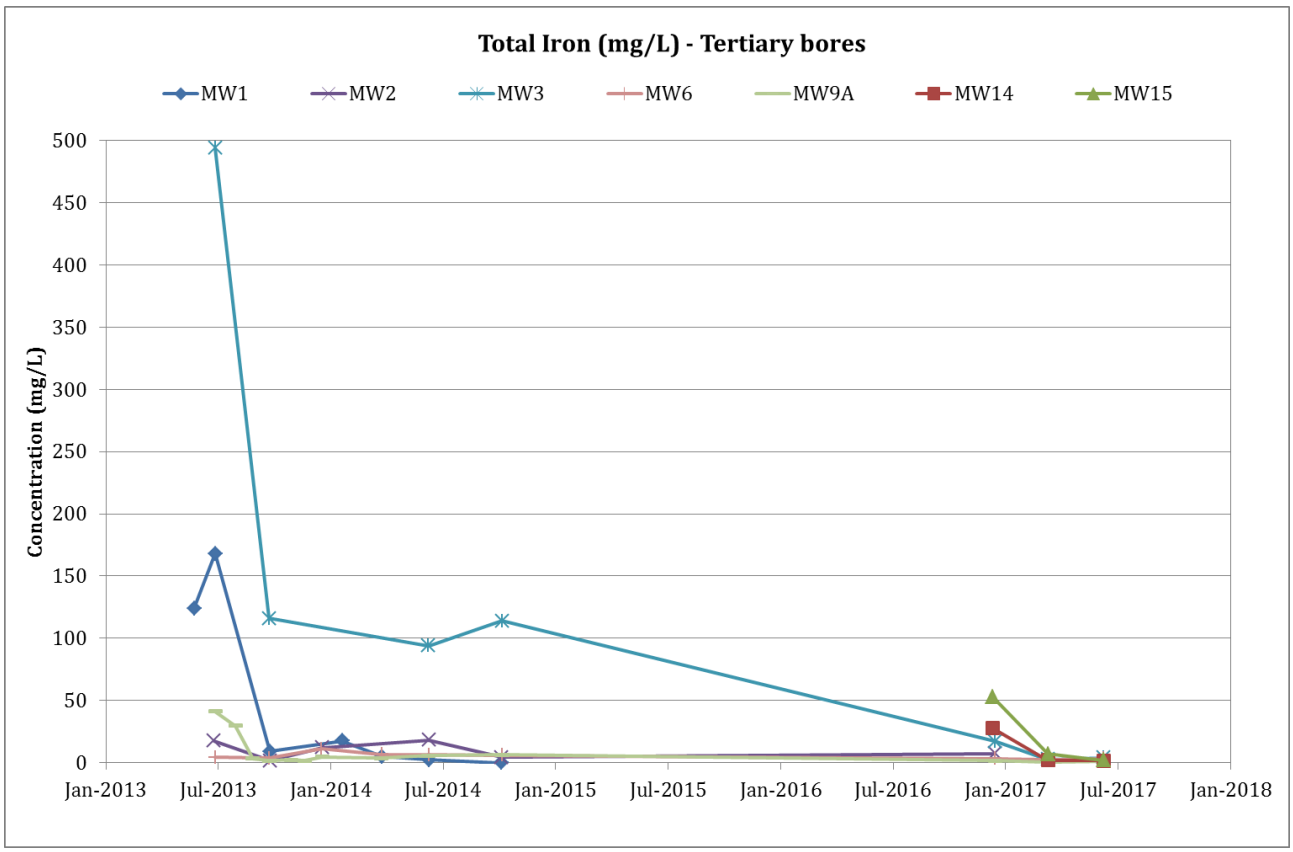

Chloride mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
14000
12000
10000
8000
6000
4000
2000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

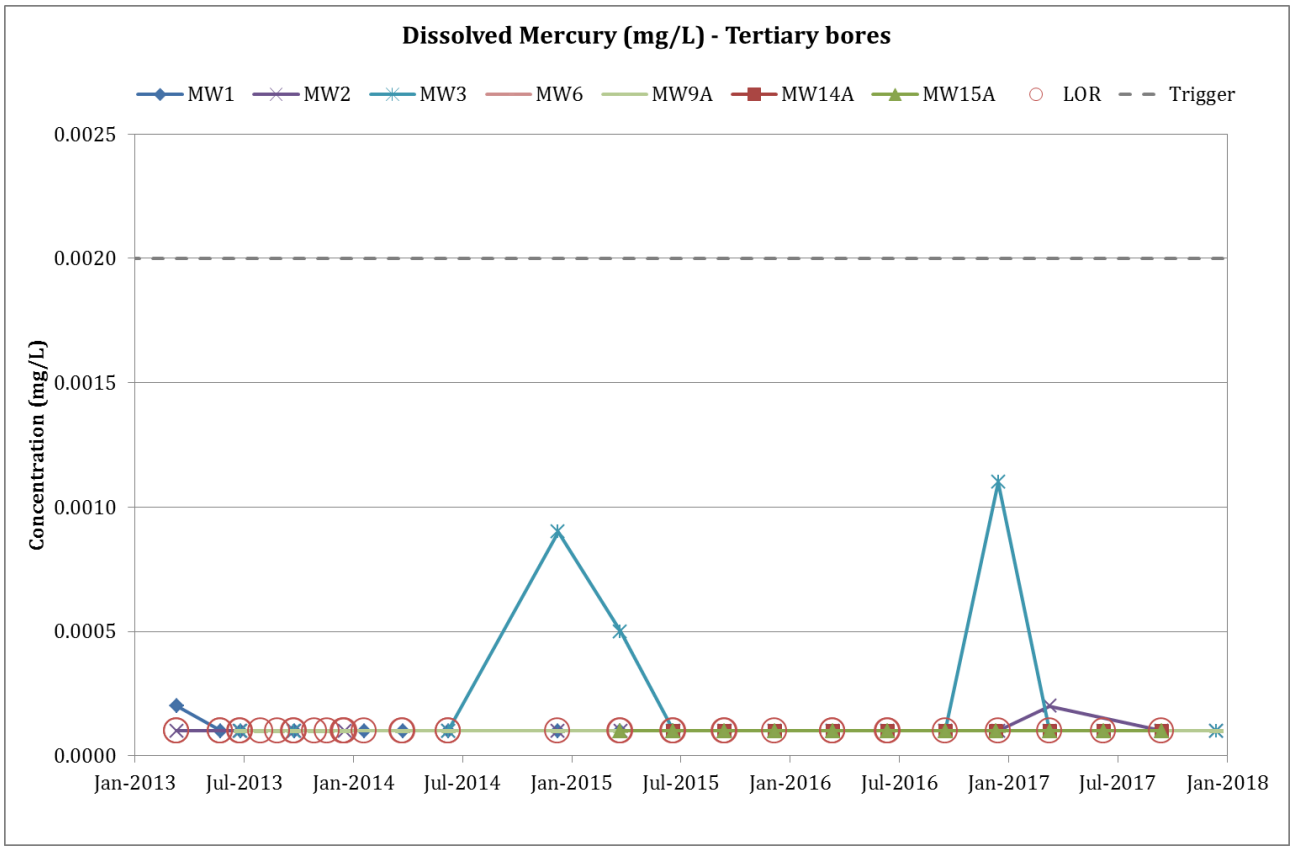

Sulfate mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018
Jul-2018

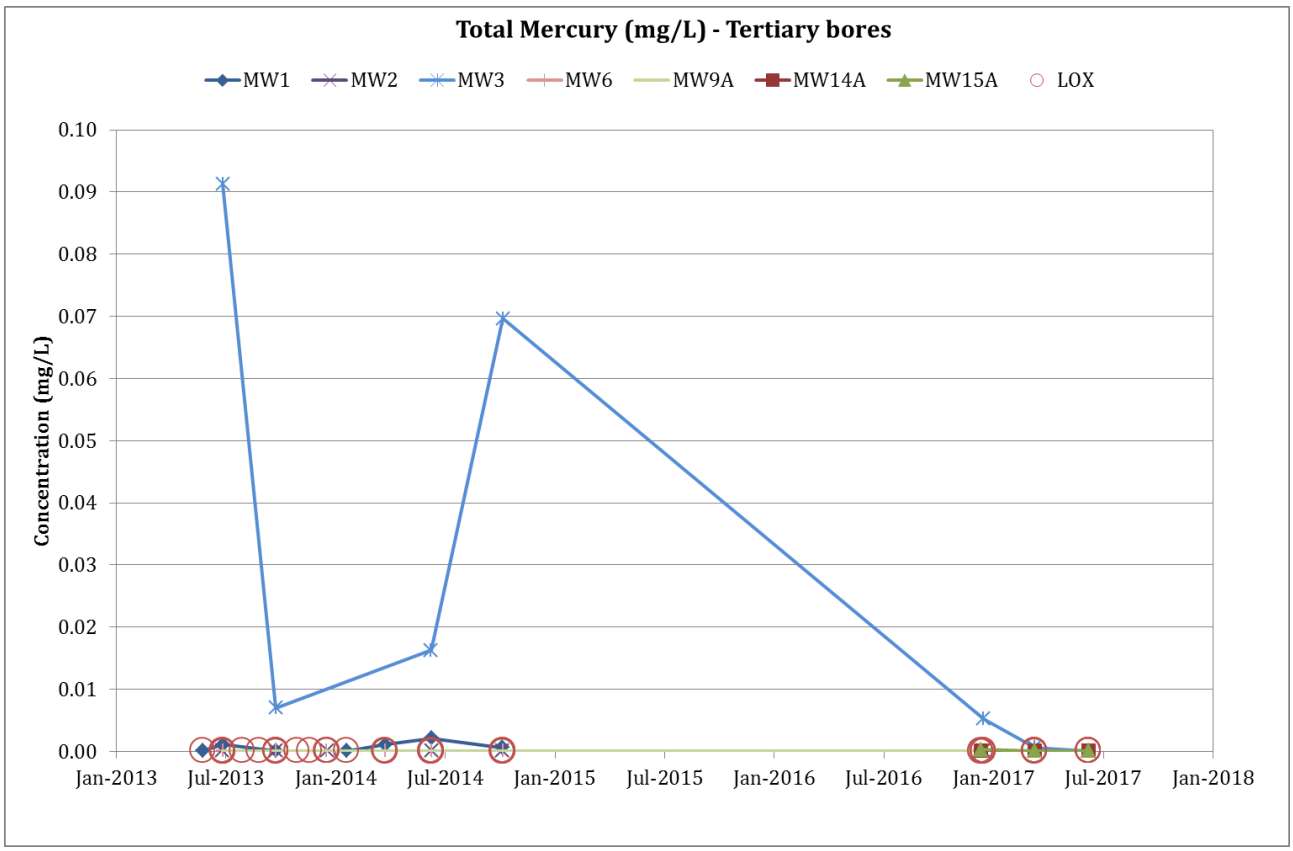

Carbonate Alkalinity as CaCO3 mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Bicarbonate Alkalinity as CaCO3 mg/L - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
Trigger
Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Dissolved Iron (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Total Iron (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14
MW15
Concentration (mg/L)
500
450
400
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Dissolved Mercury (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Total Mercury (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOX
Concentration (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
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Jul-2015
Jan-2016
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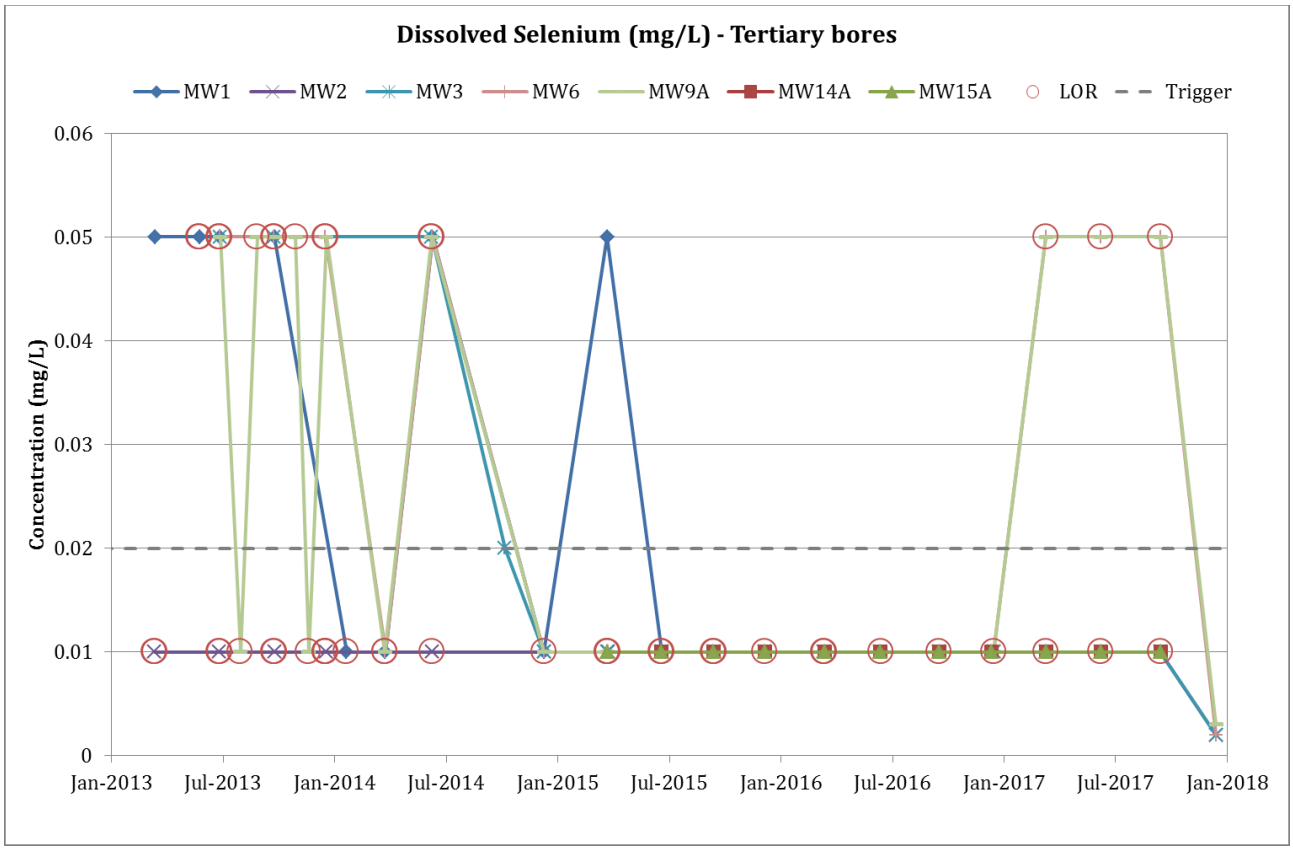
Jan-2018


Dissolved Selenium (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
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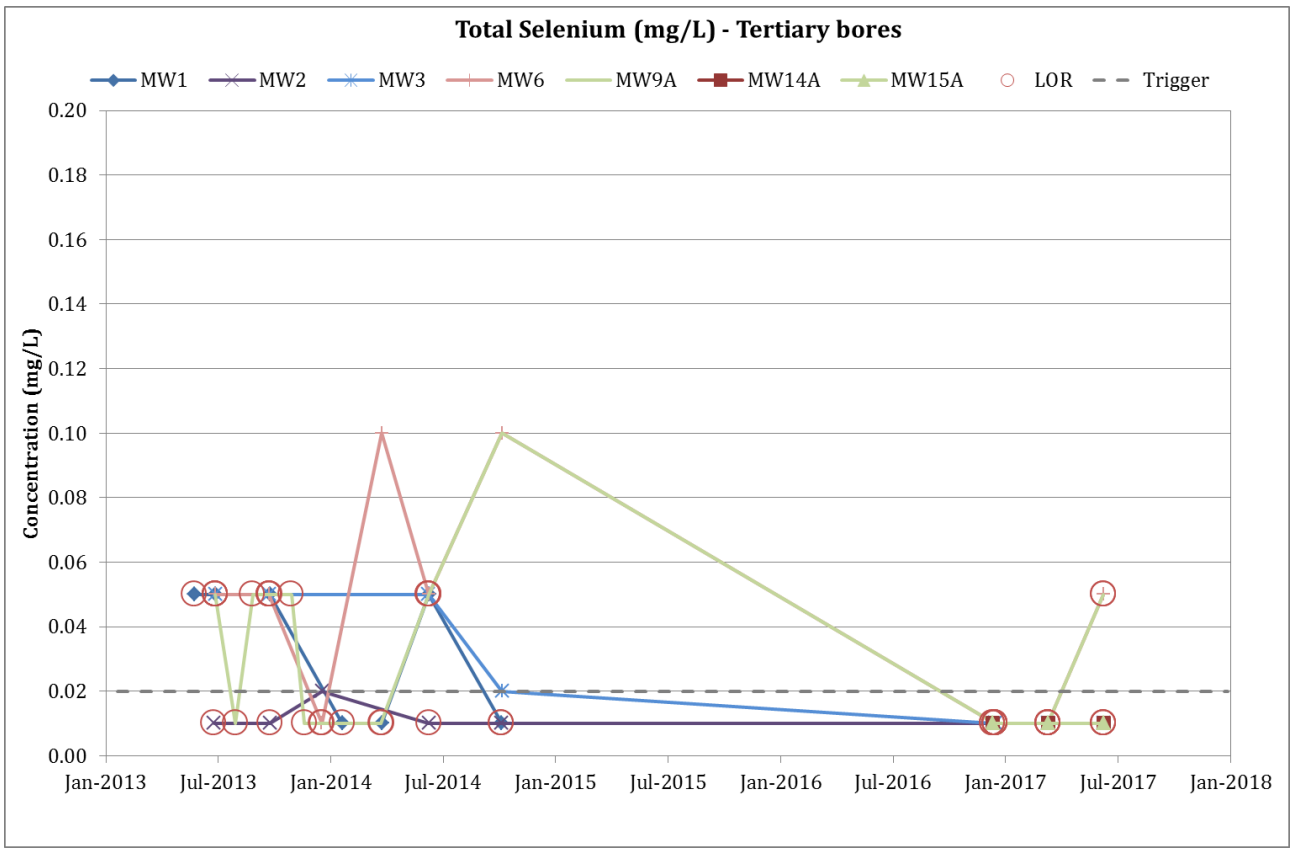
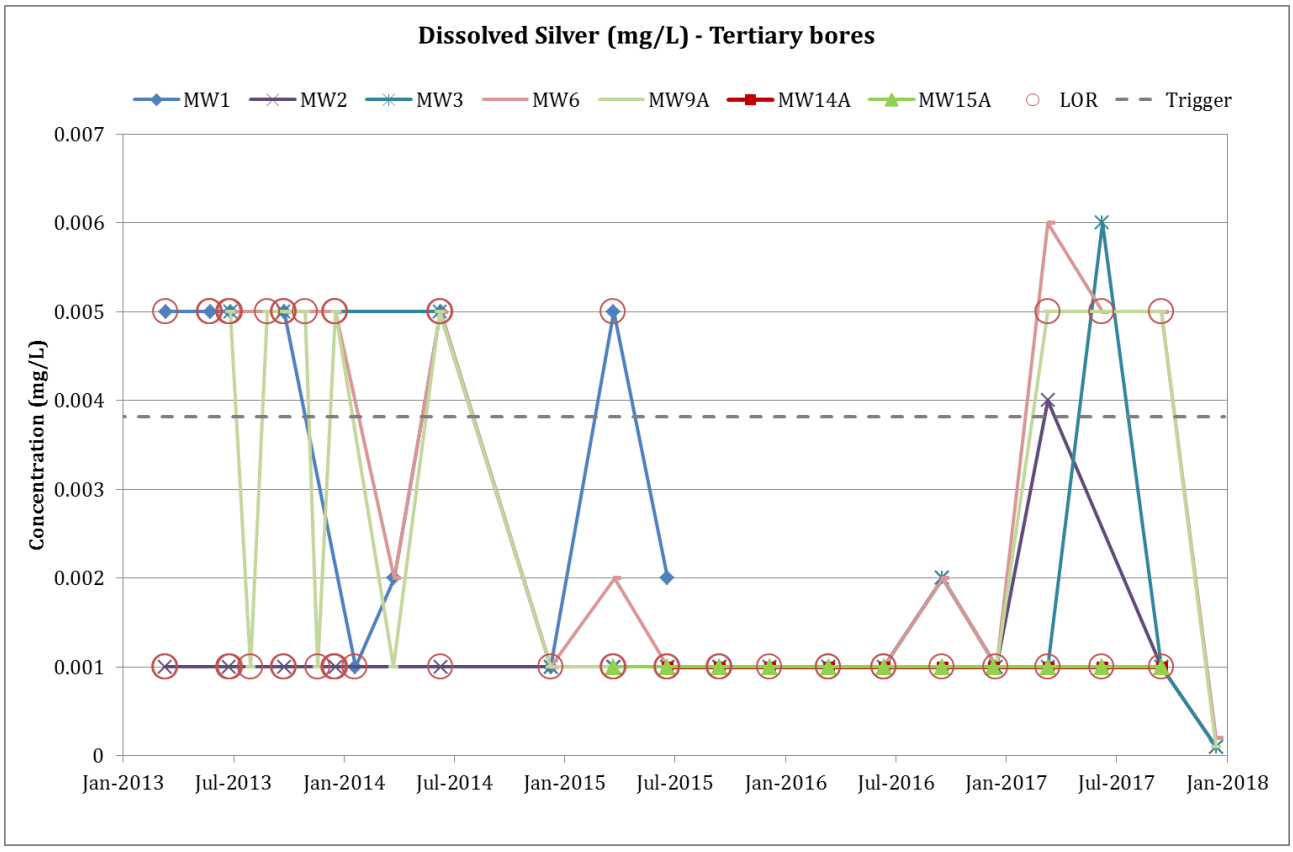
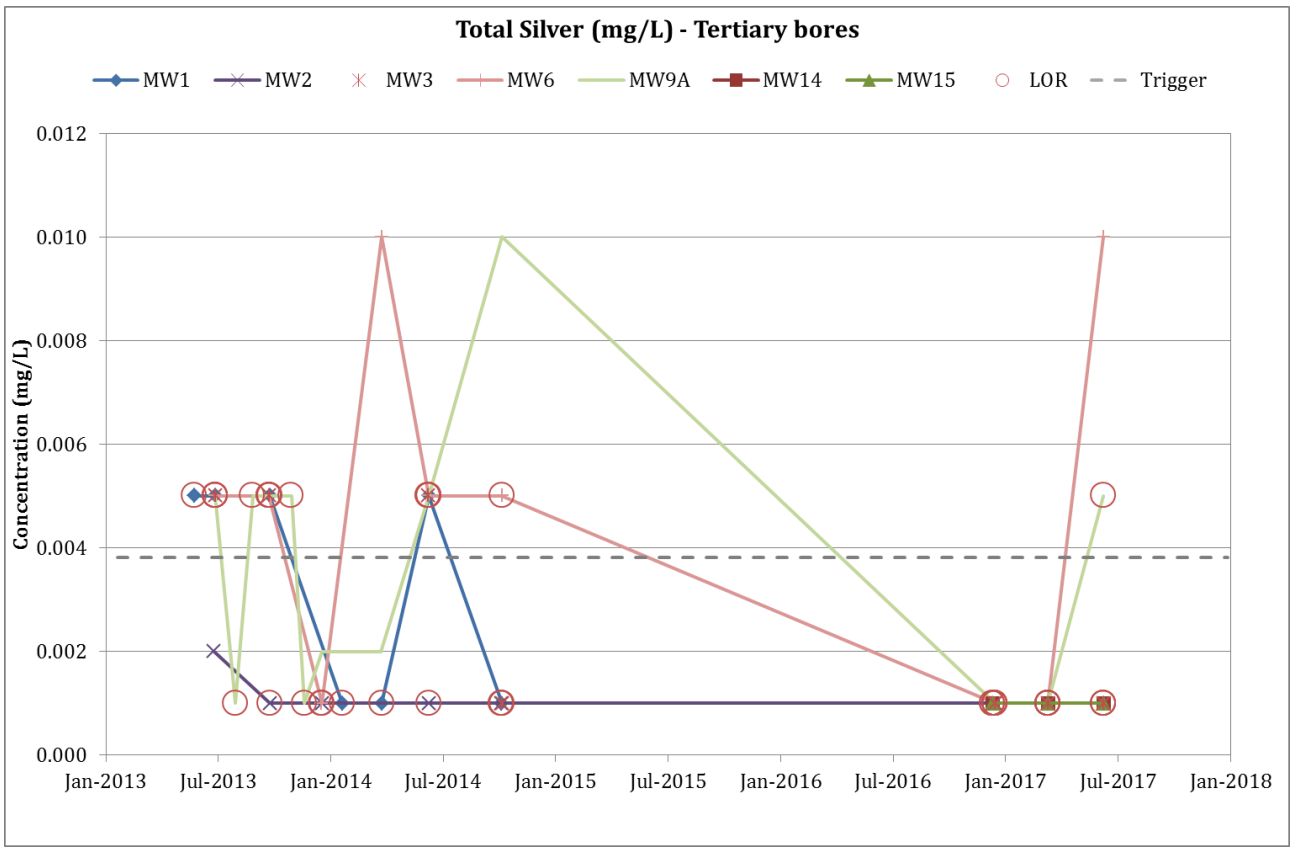
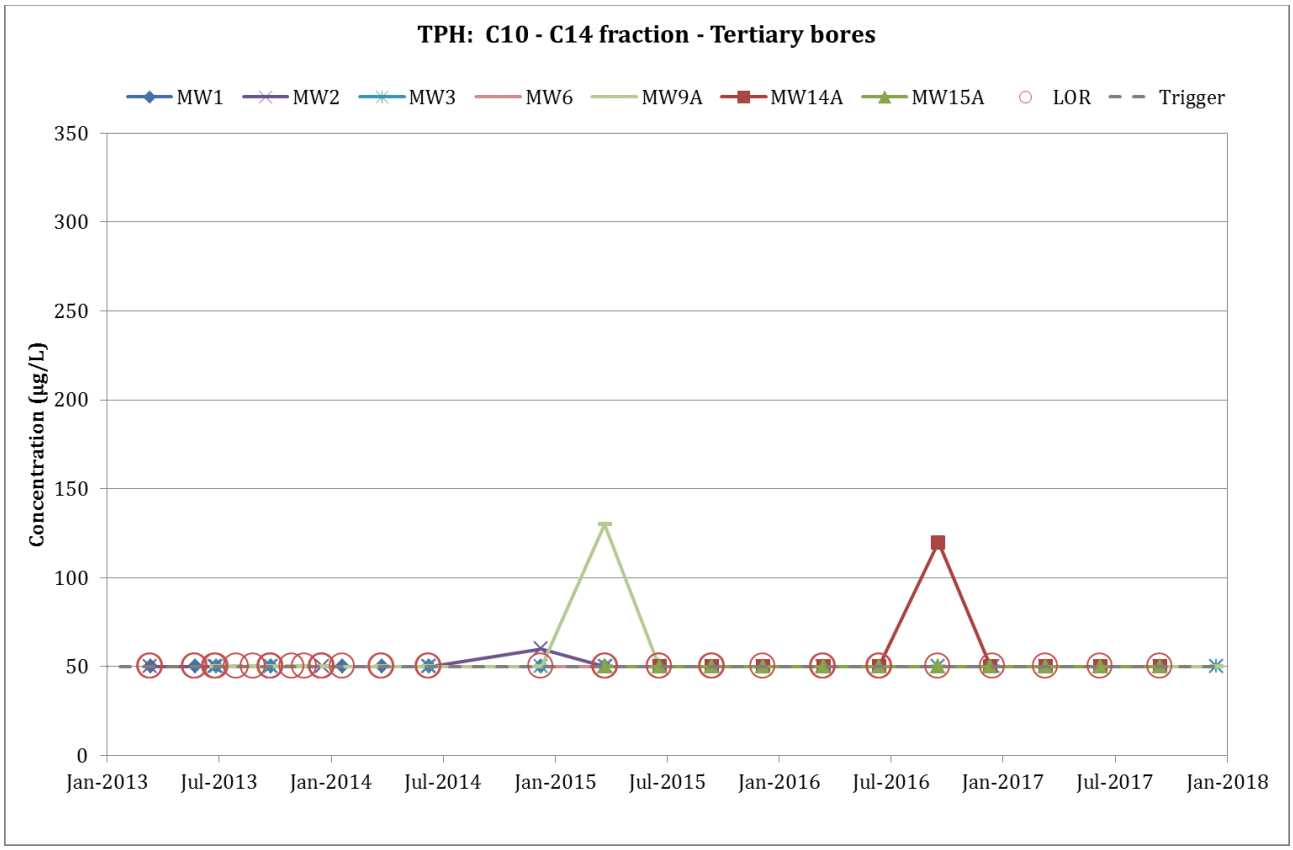
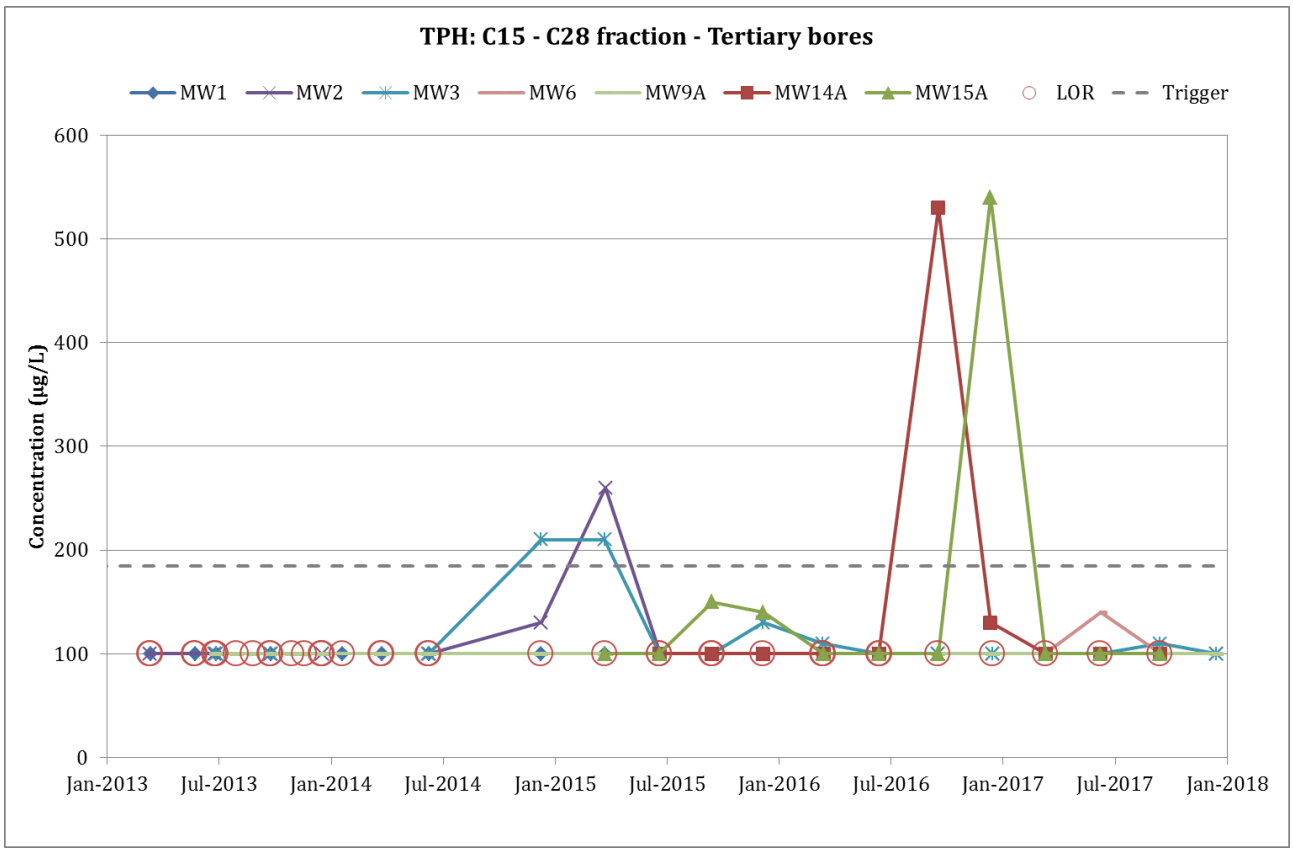
Jul-2017
Jan-2018

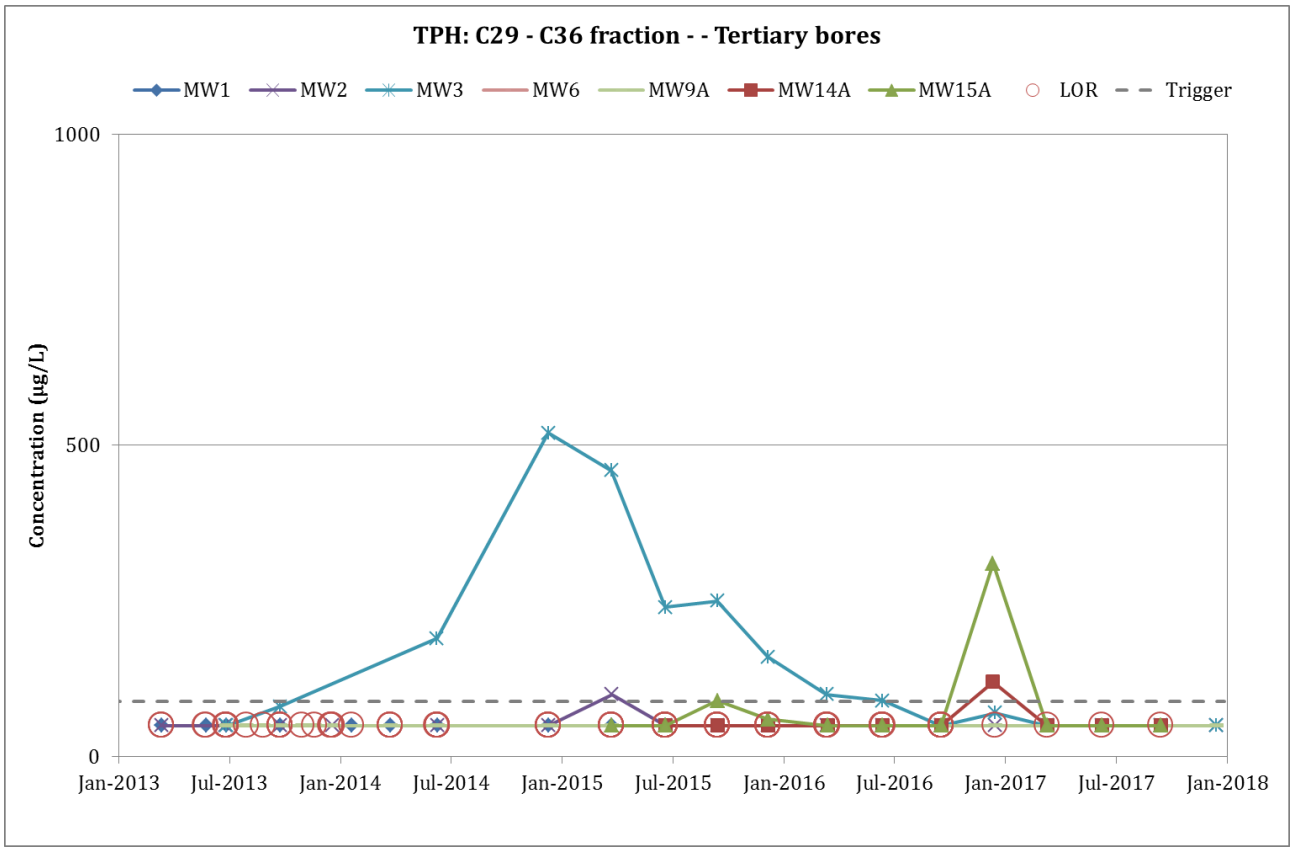

Total Selenium (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

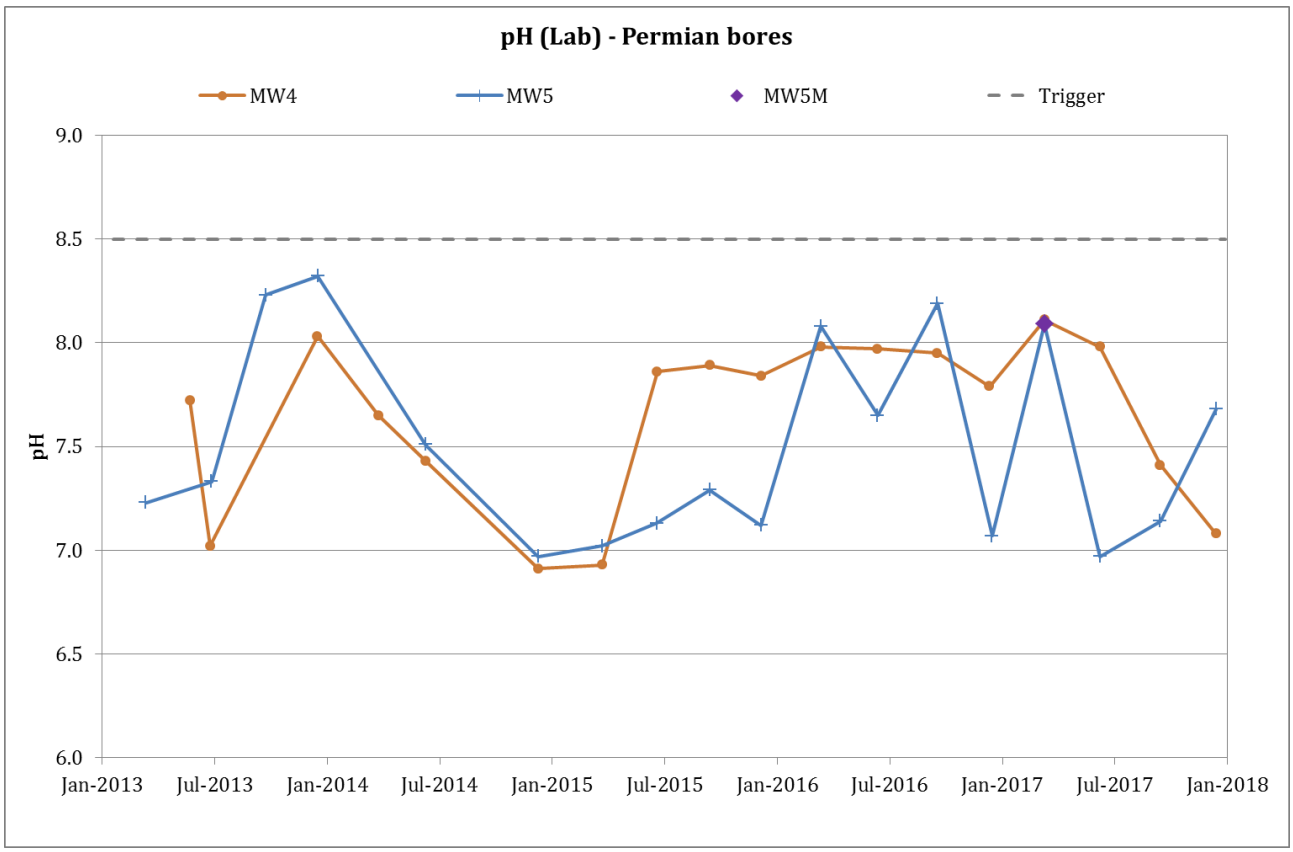

Dissolved Silver (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

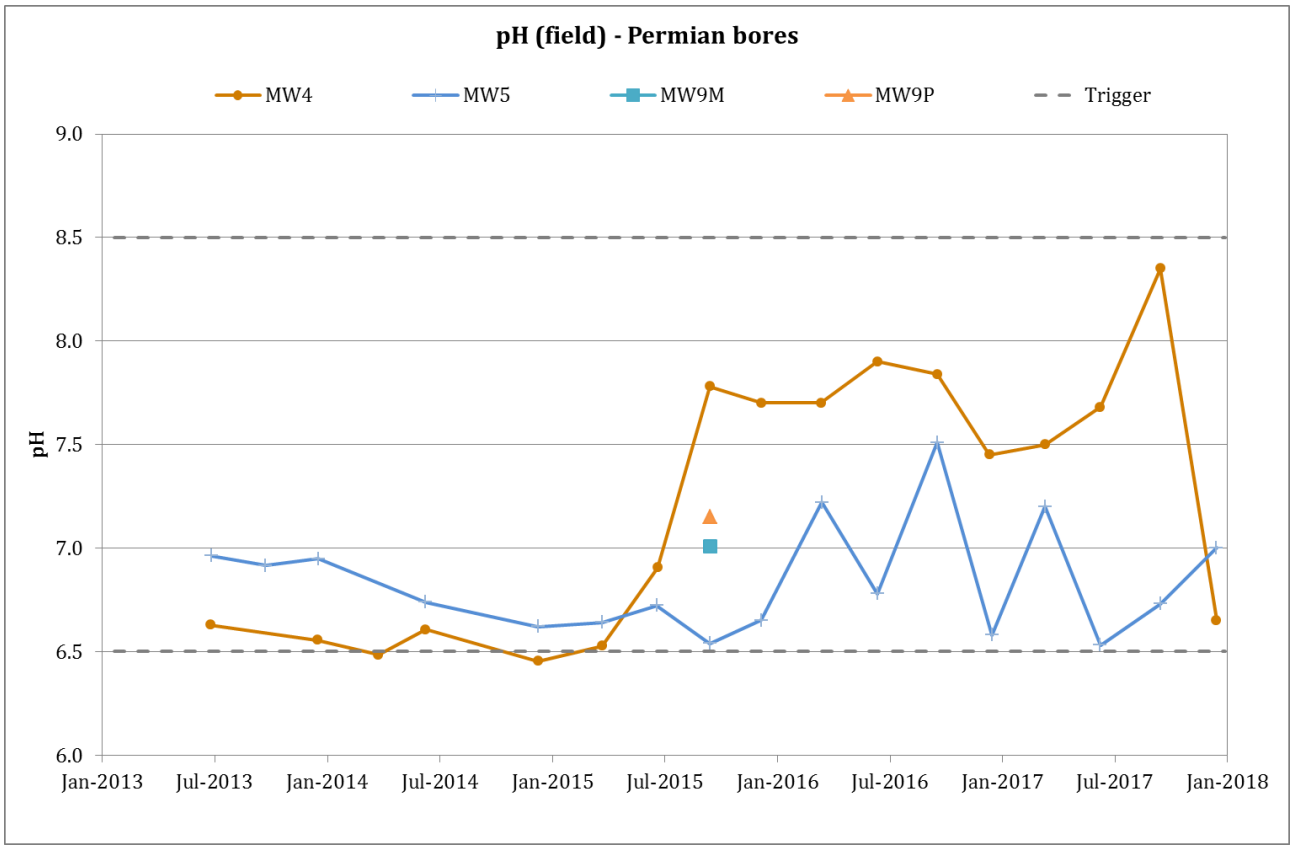

Total Silver (mg/L) - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14
MW15
LOR
Trigger
Concentration (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

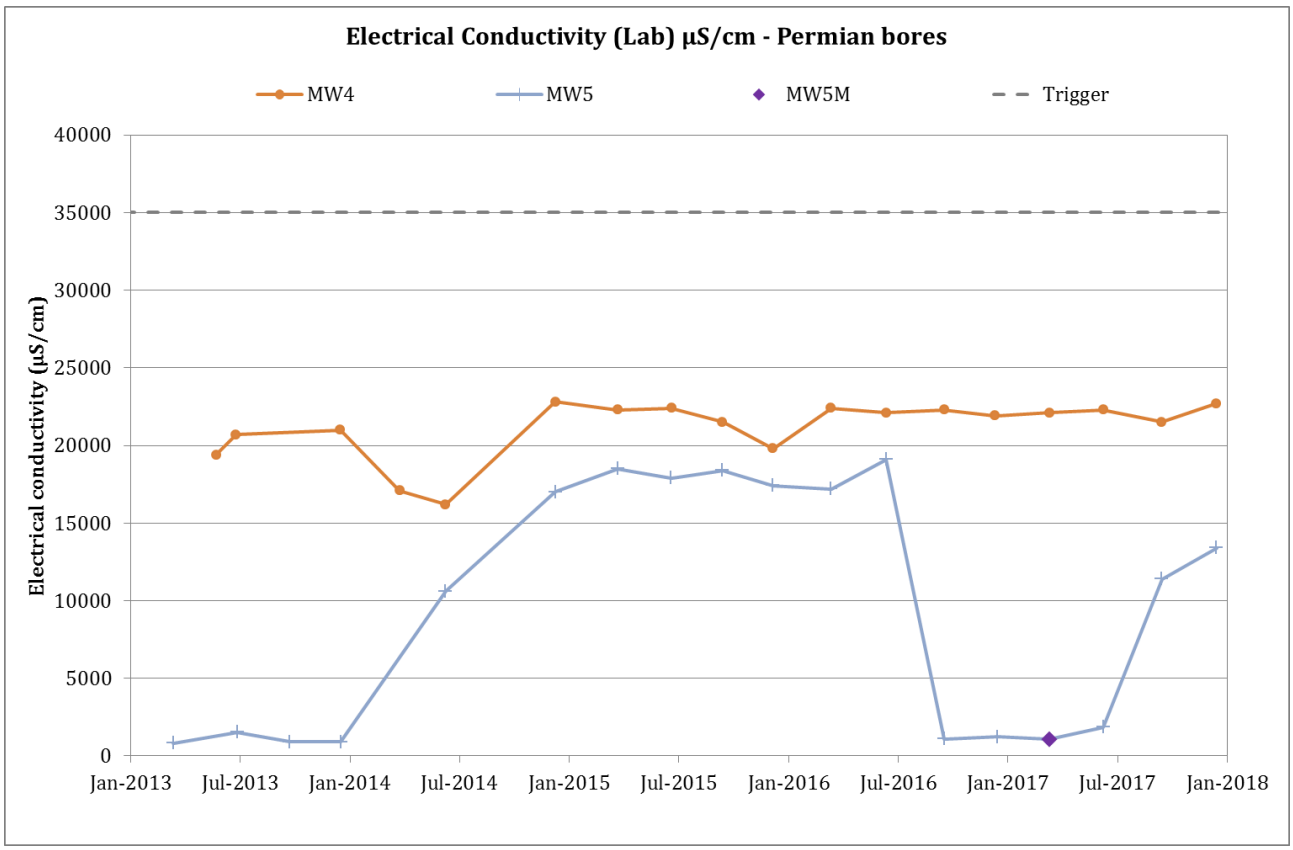

TPH: C10 - C14 fraction - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

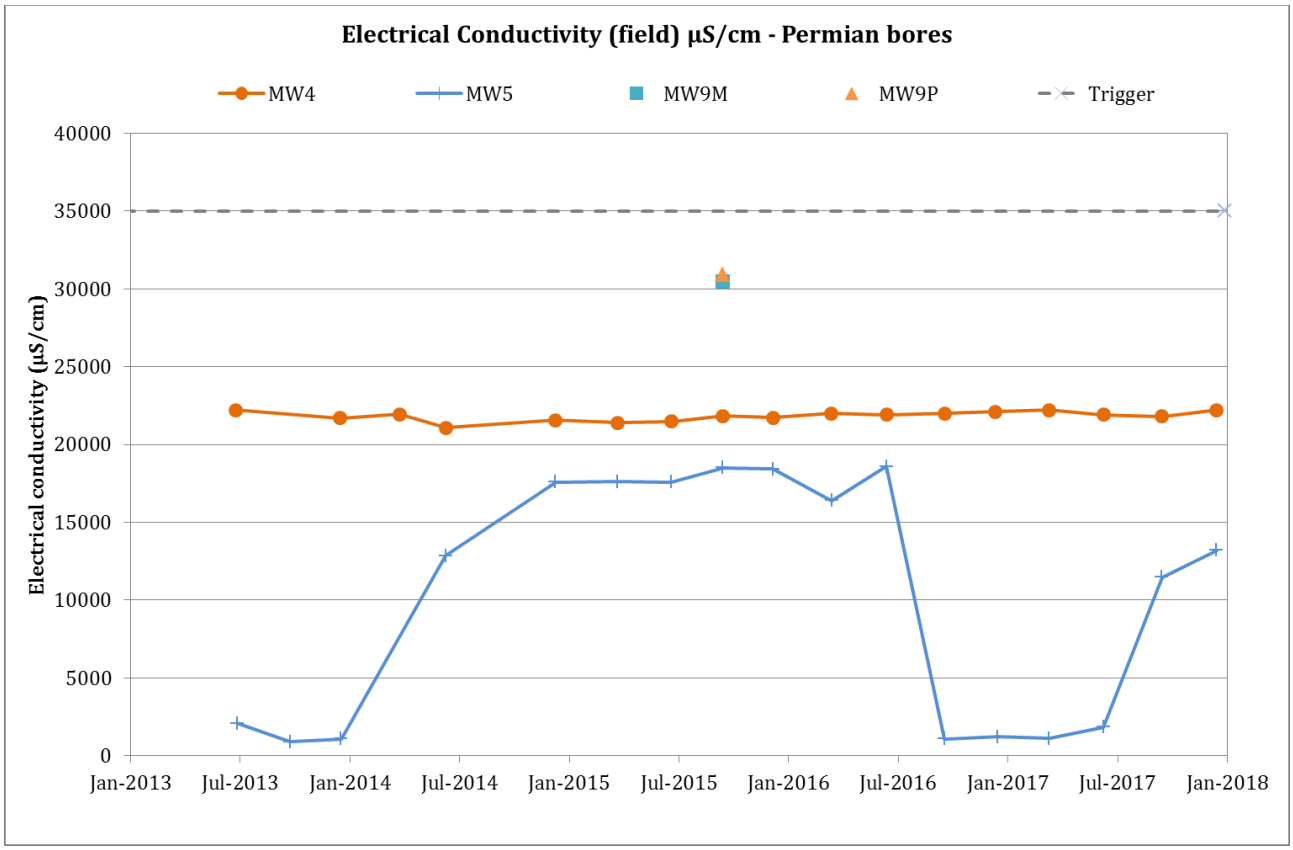

TPH: C15 - C28 fraction - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
600
500
400
300
200
100
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

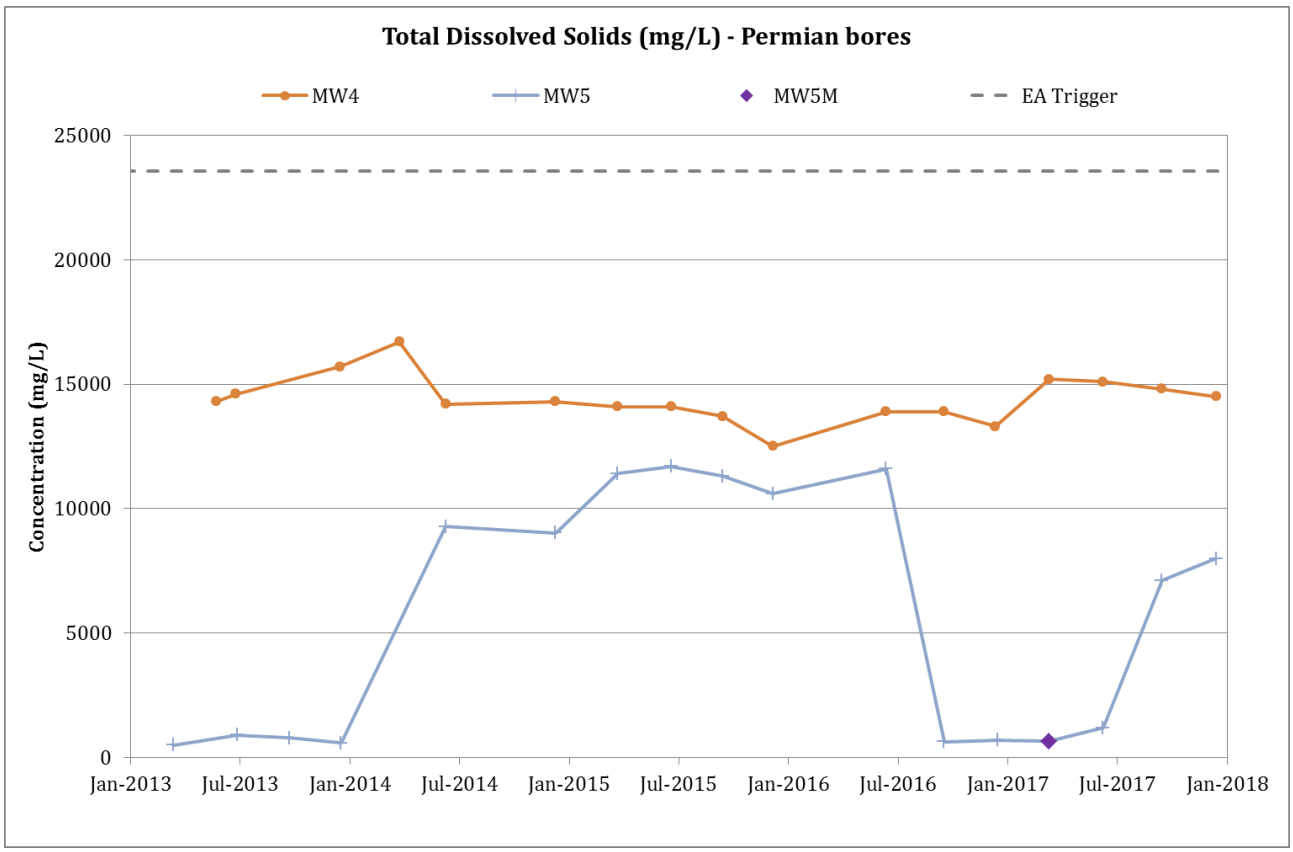

TPH: C29 - C36 fraction - - Tertiary bores
MW1
MW2
MW3
MW6
MW9A
MW14A
MW15A
LOR
Trigger
Concentration (µg/L)
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

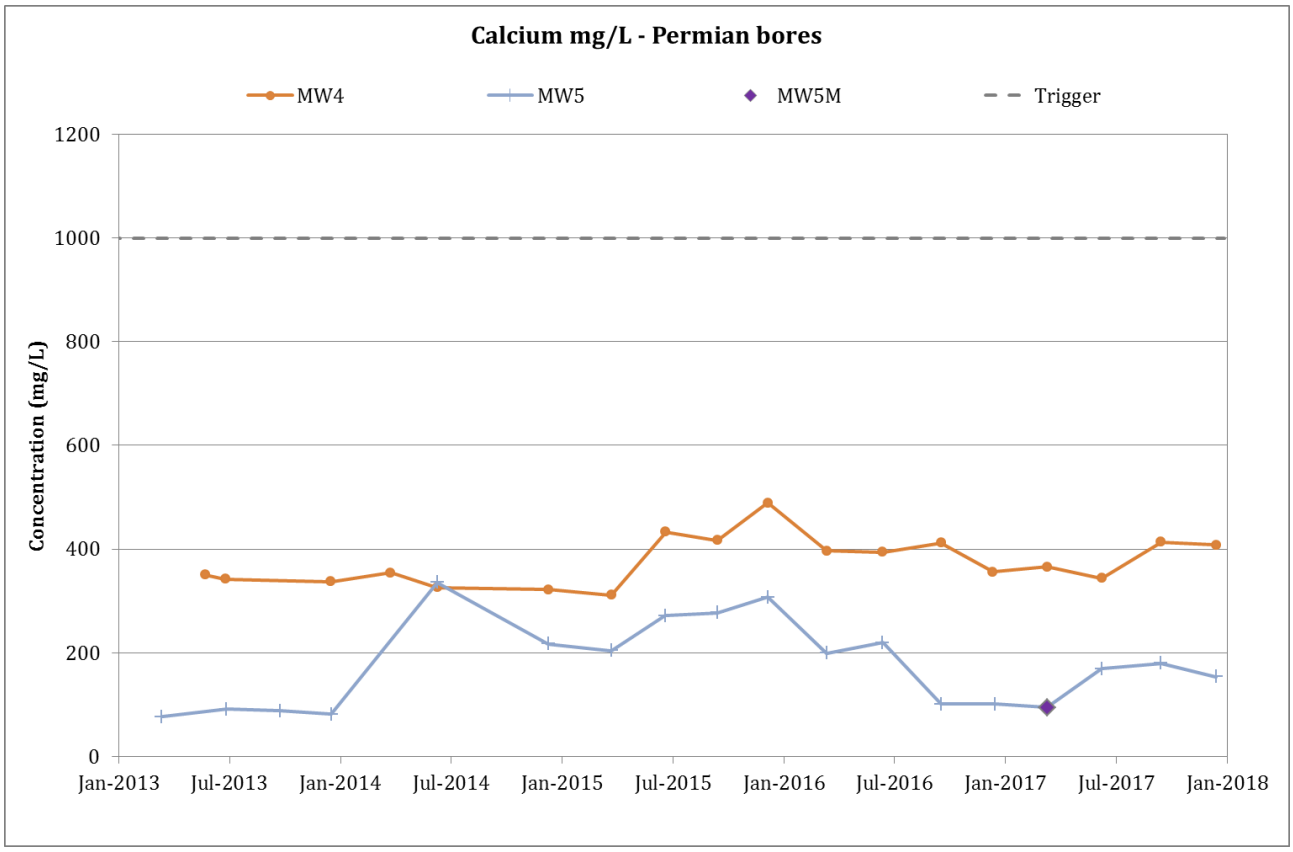

pH (Lab) - Permian bores
MW4
MW5
MW5M
Trigger
9.0
8.5
8.0
7.5
7.0
6.5
6.0
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

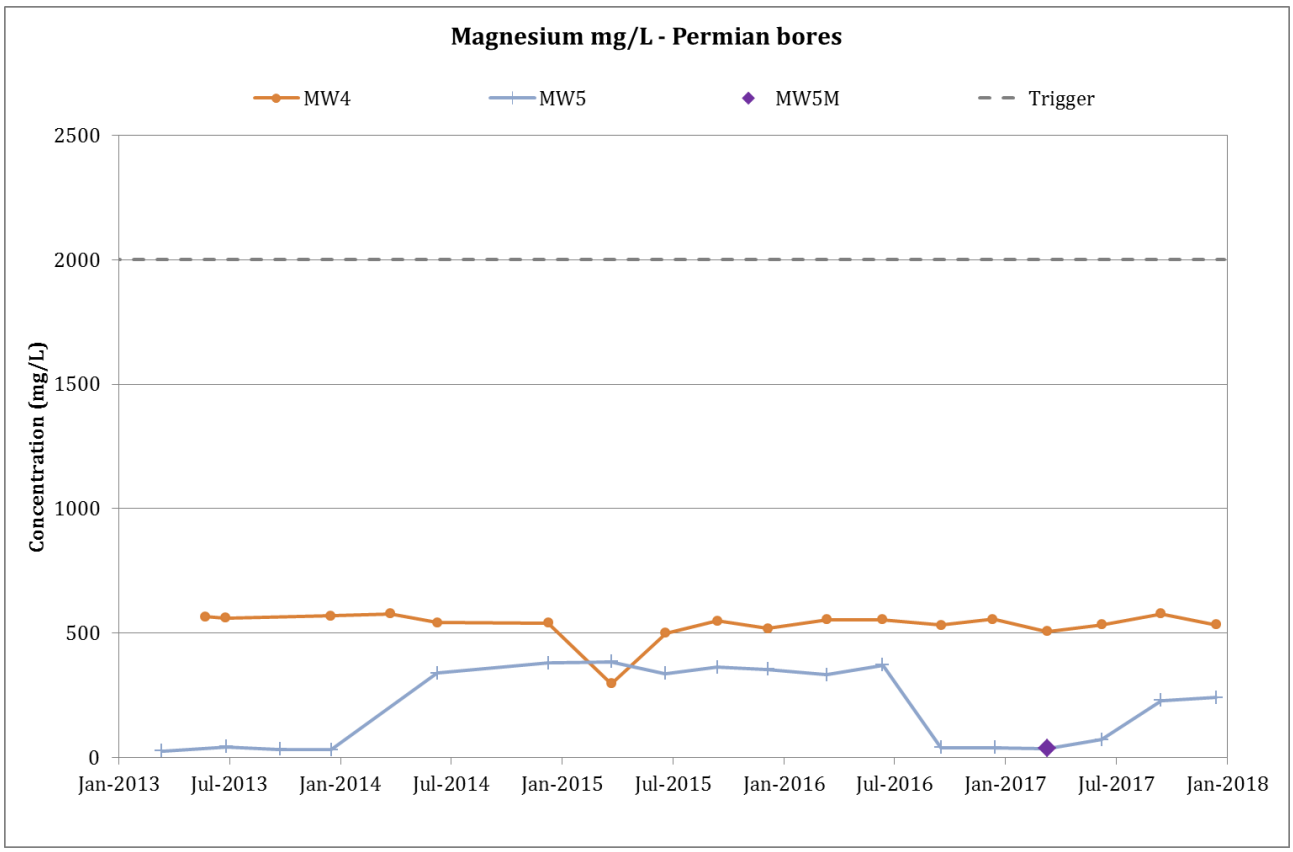

pH (field) - Permian bores
MW4
MW5
MW9M
MW9P
Trigger
9.0
8.5
8.0
7.5
7.0
6.5
6.0
pH
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

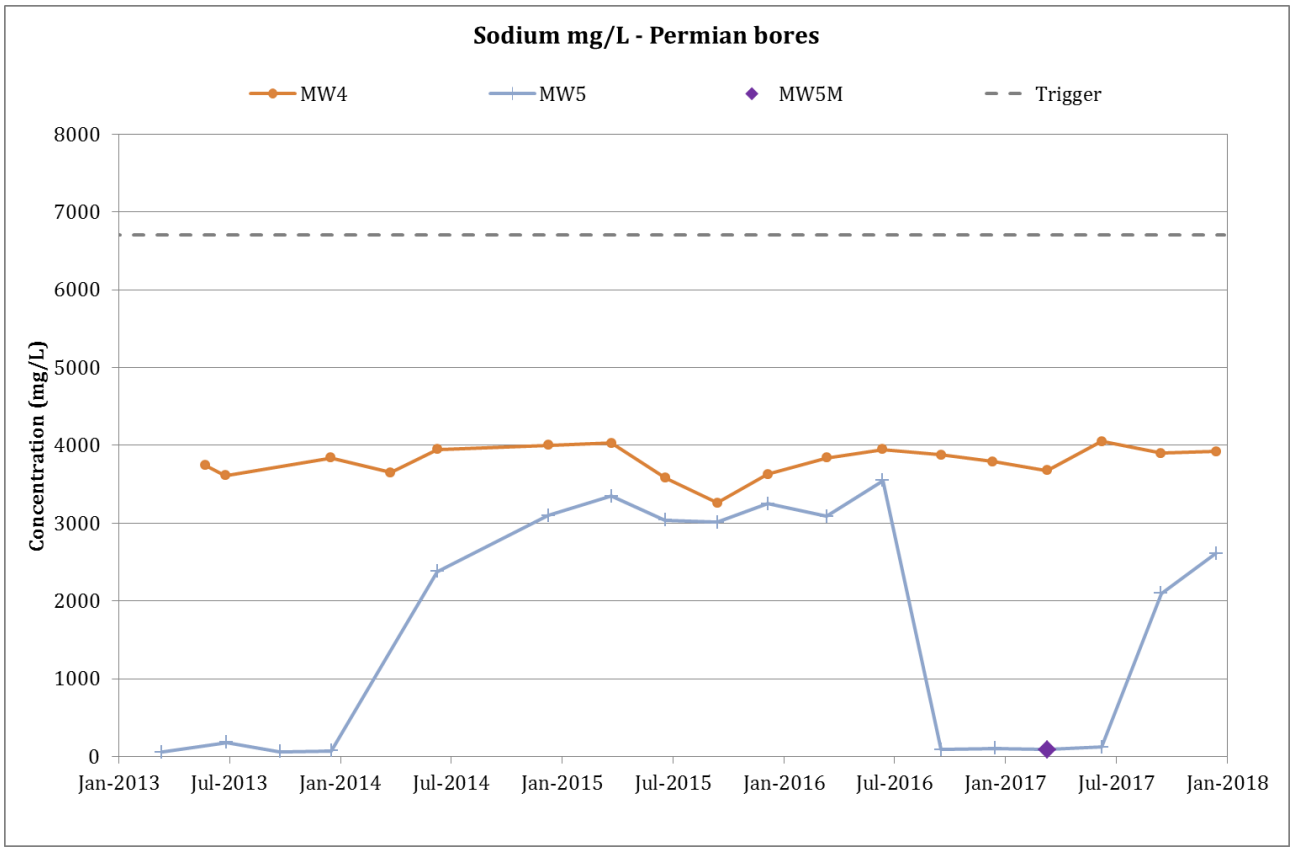

Electrical Conductivity (Lab) µS/cm - Permian bores
MW4
MW5
MW5M
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

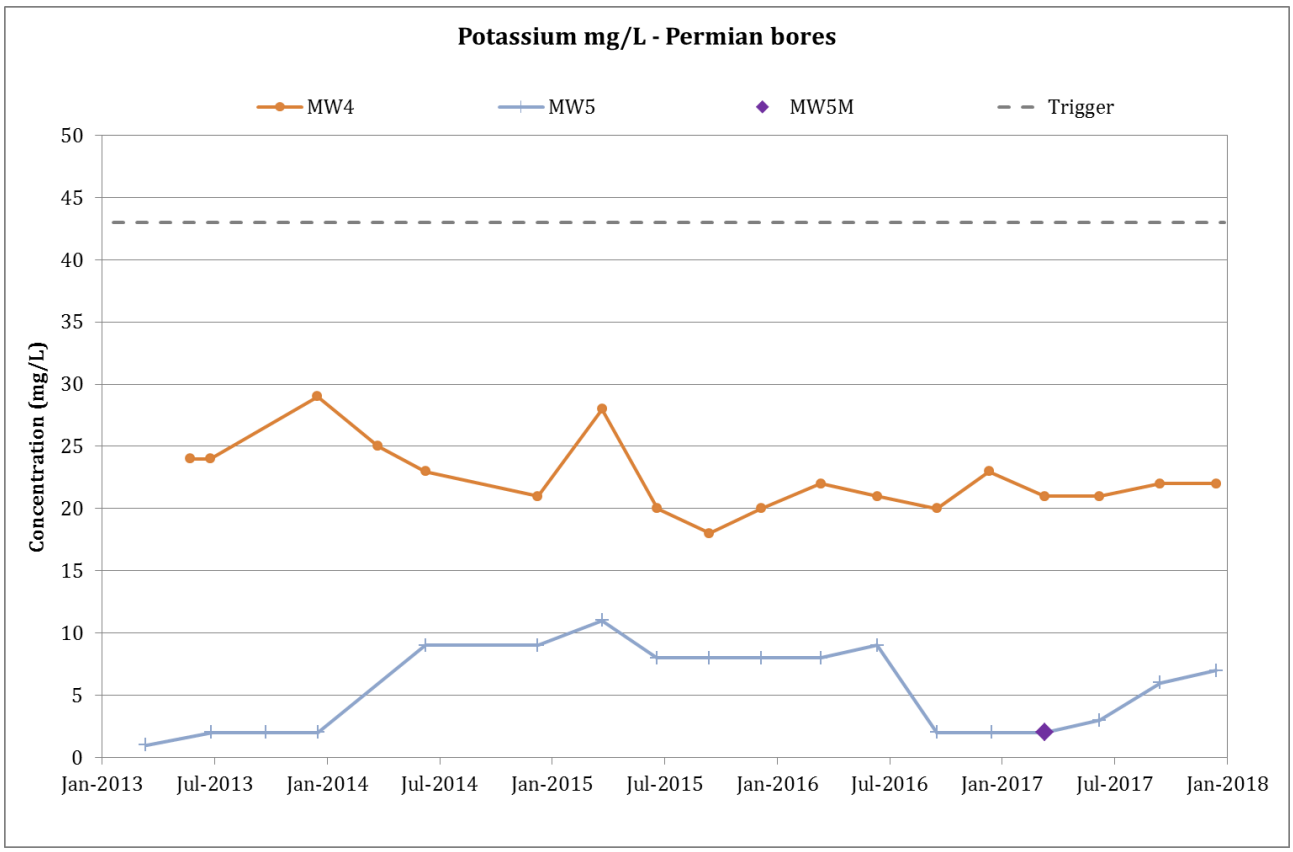

Electrical Conductivity (field) µS/cm - Permian bores
MW4
MW5
MW9M
MW9P
Trigger
Electrical conductivity (µS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

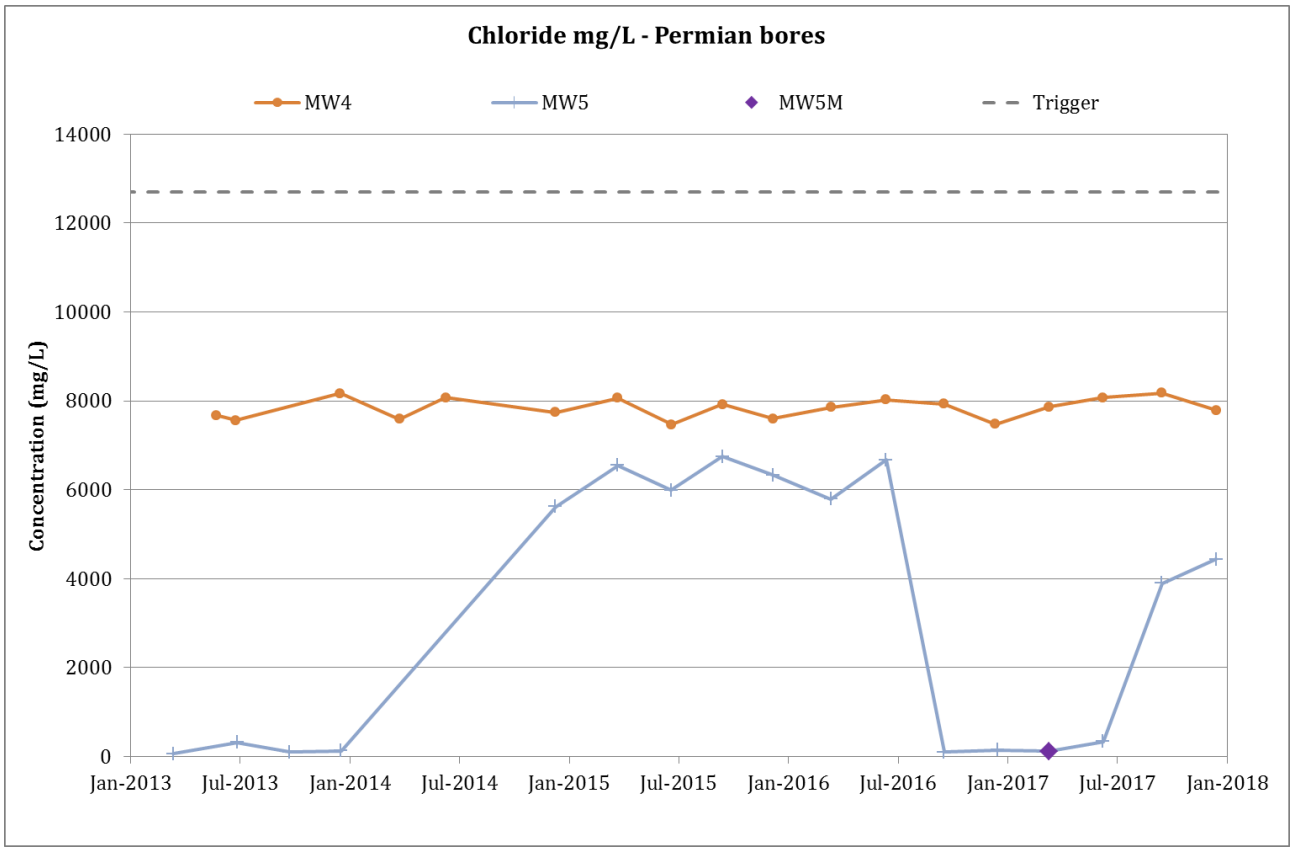

Total Dissolved Solids (mg/L) - Permian bores
MW4
MW5
MW5M
EA Trigger
Concentration (mg/L)
25000
20000
15000
10000
5000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

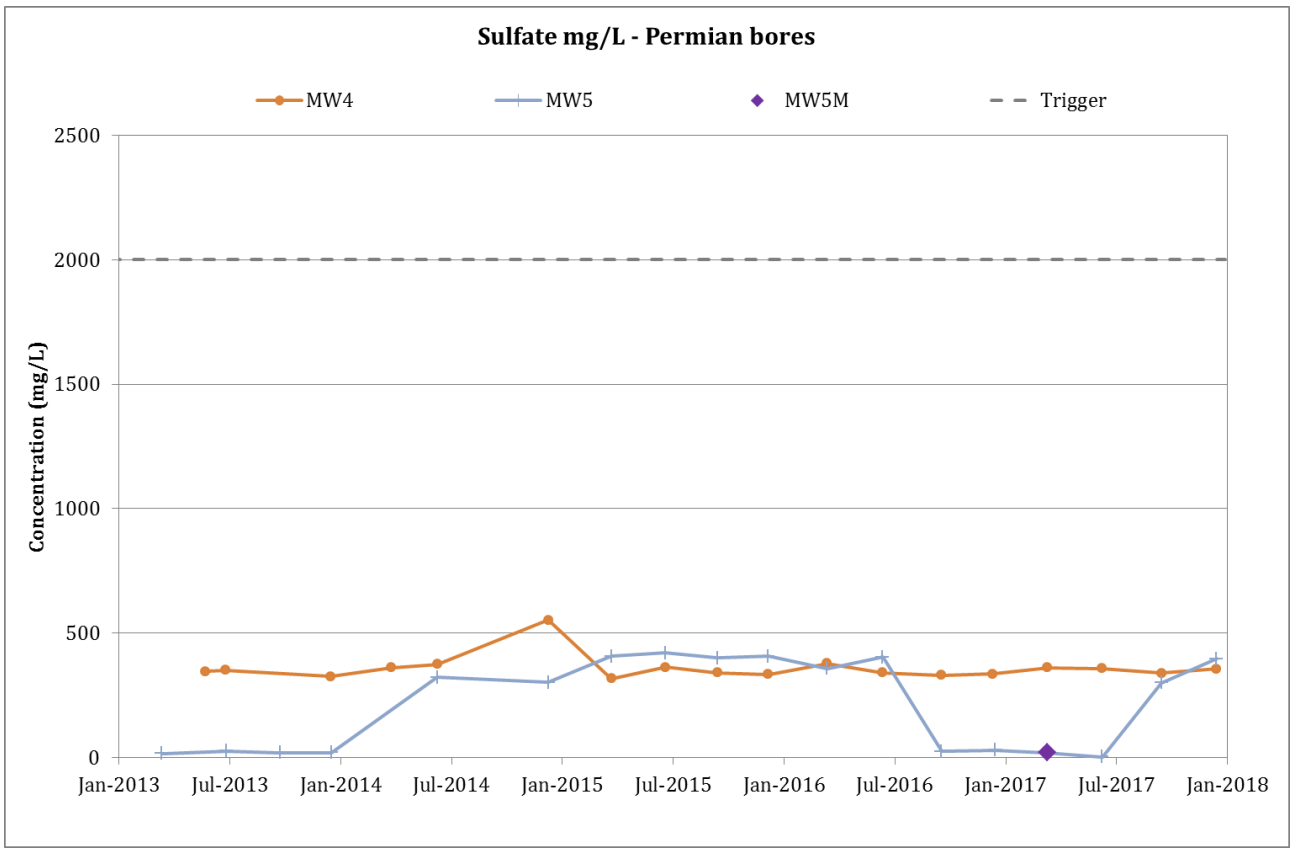

Calcium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

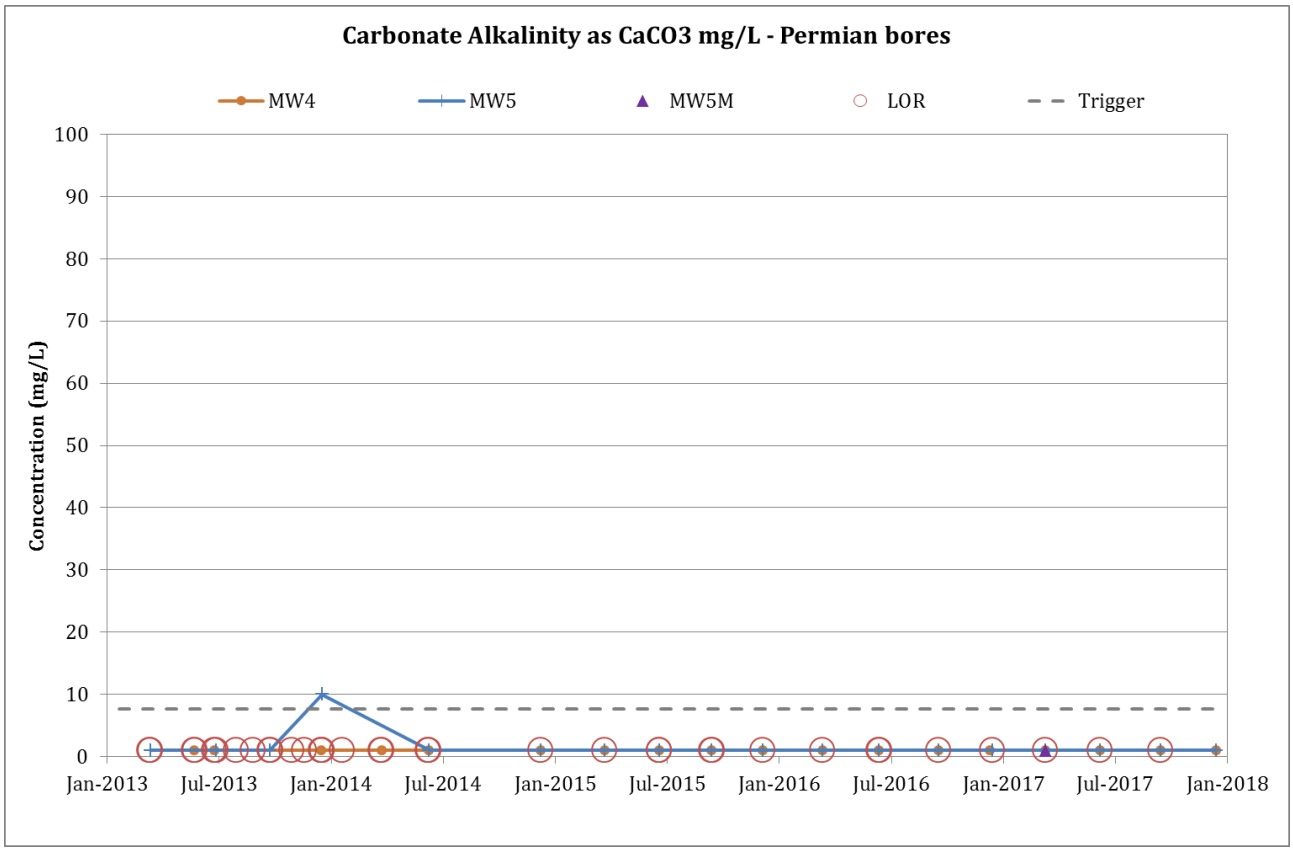

Magnesium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

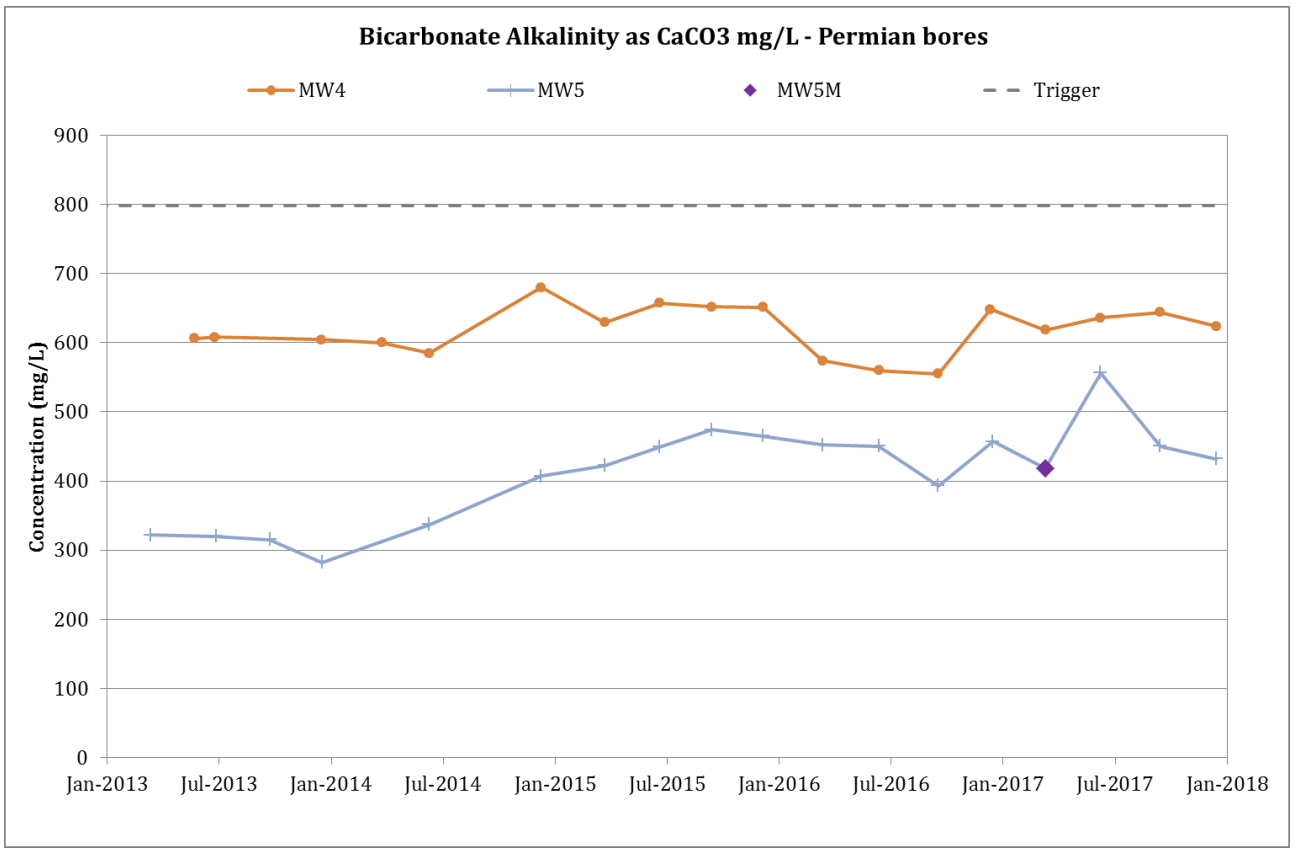

Sodium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

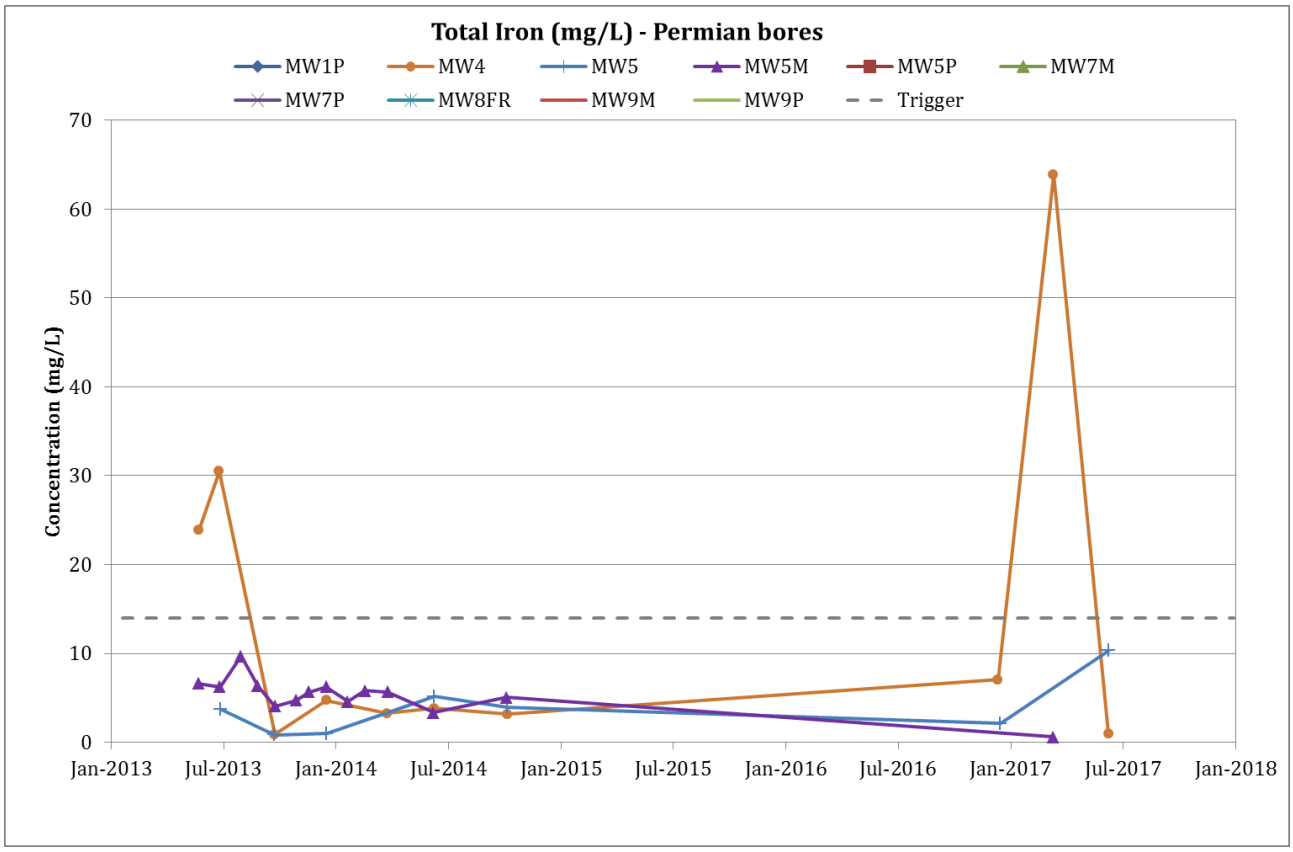

Potassium mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

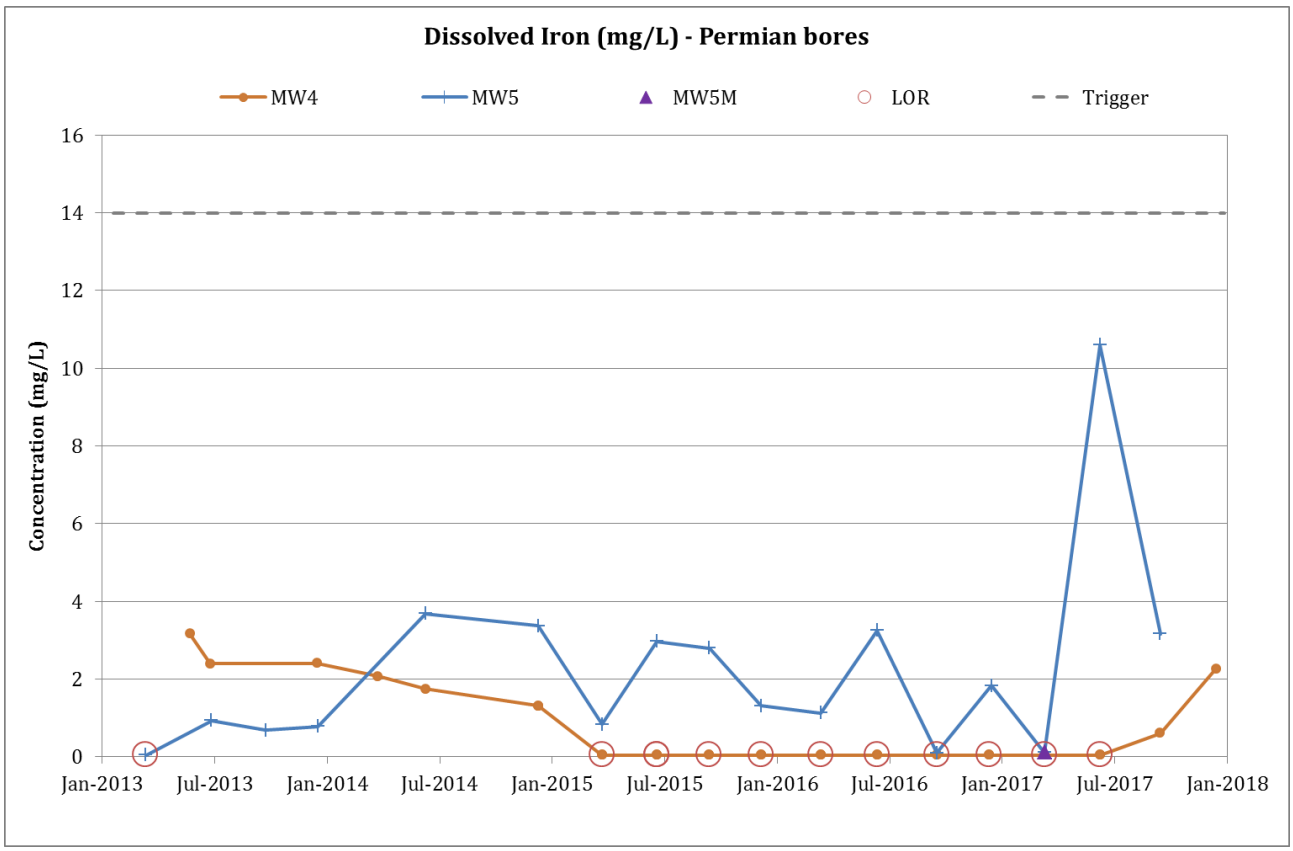

Chloride mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
14000
12000
10000
8000
6000
4000
2000
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

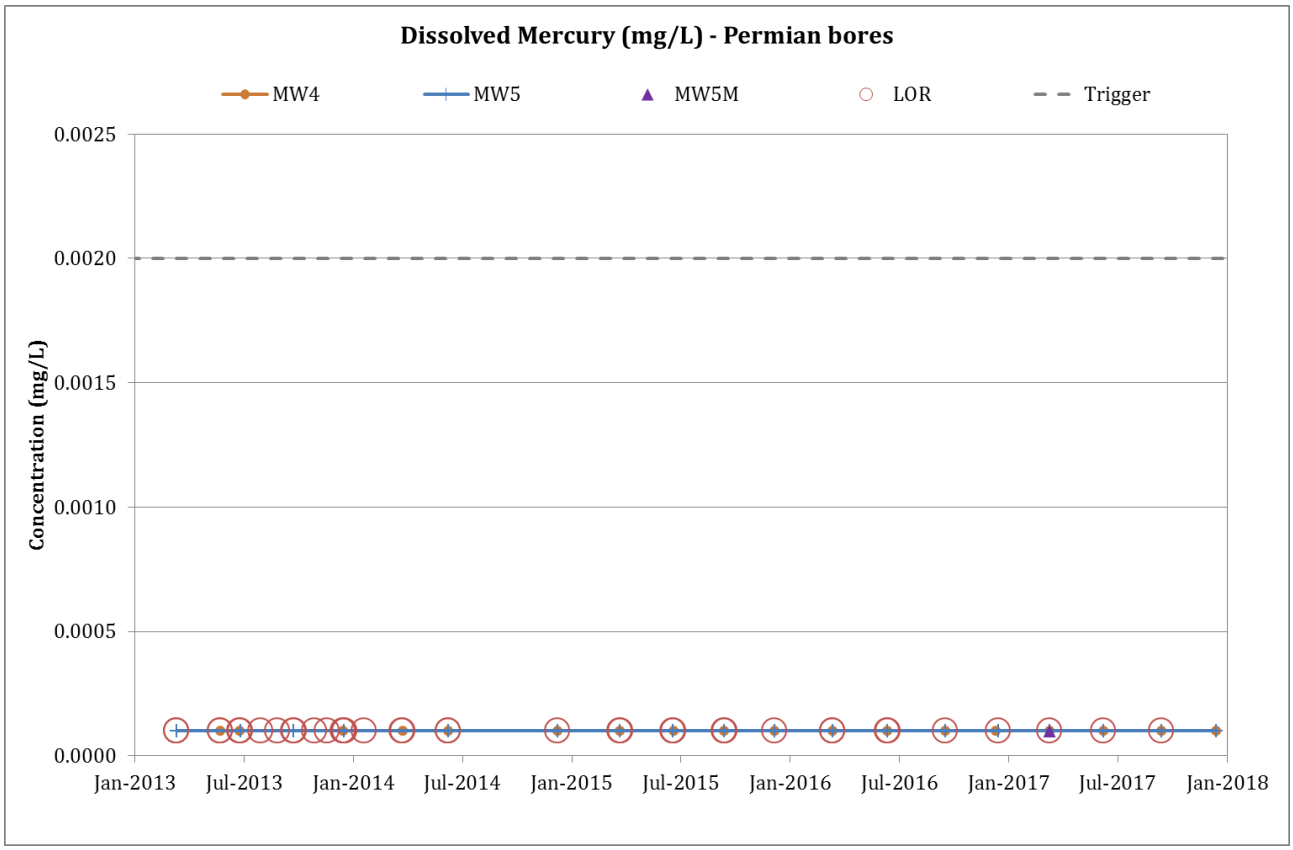

Sulfate mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

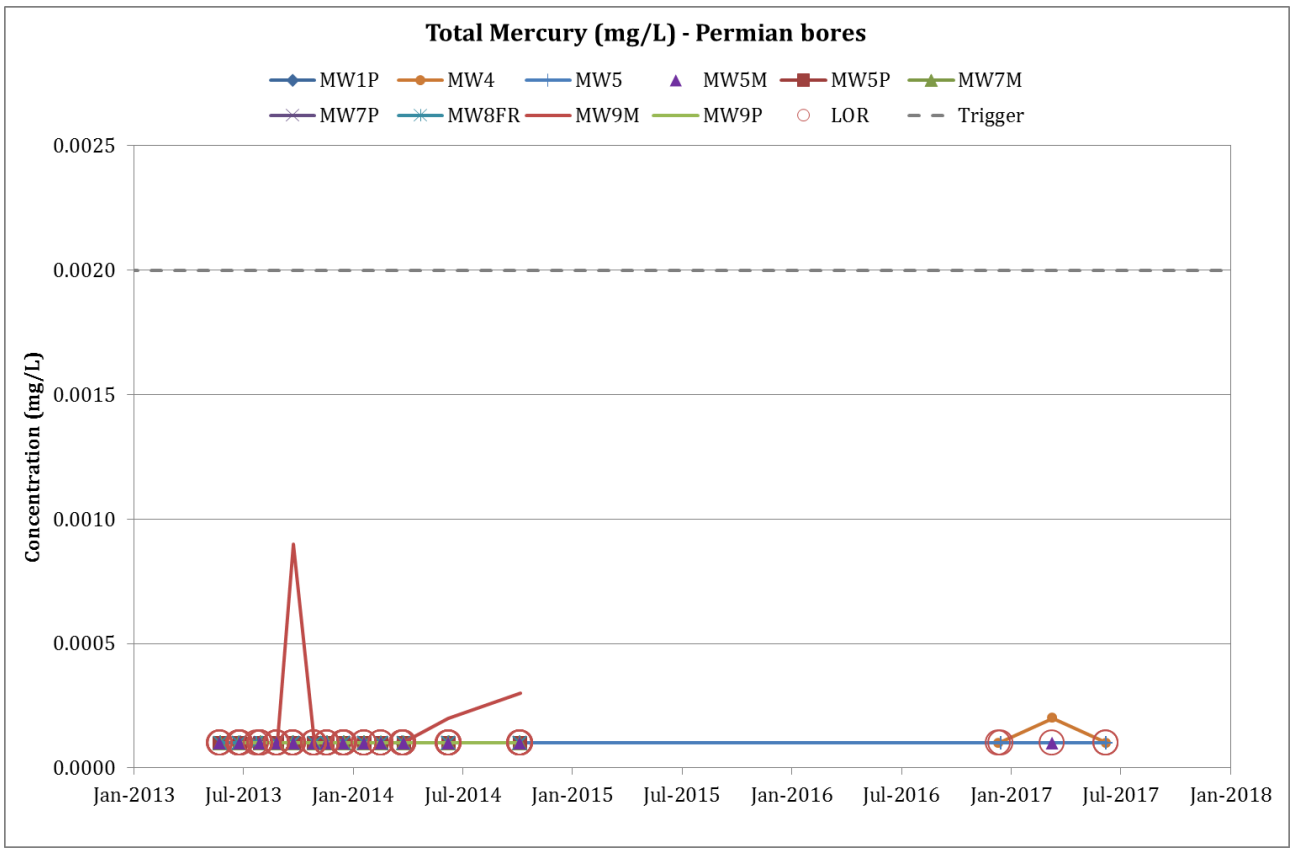

Carbonate Alkalinity as CaCO3 mg/L - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

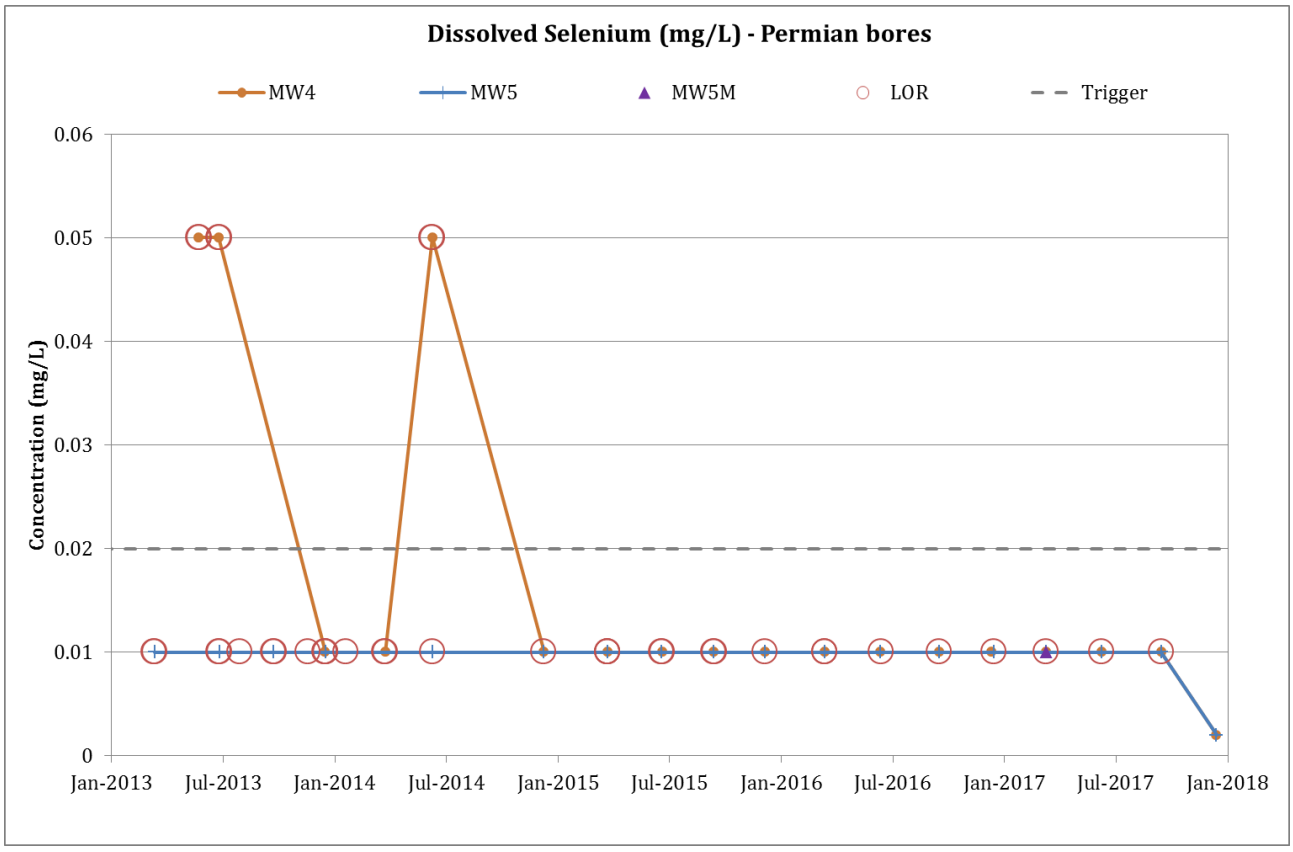

Bicarbonate Alkalinity as CaCO3 mg/L - Permian bores
MW4
MW5
MW5M
Trigger
Concentration (mg/L)
900
800
700
600
500
400
300
200
100
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

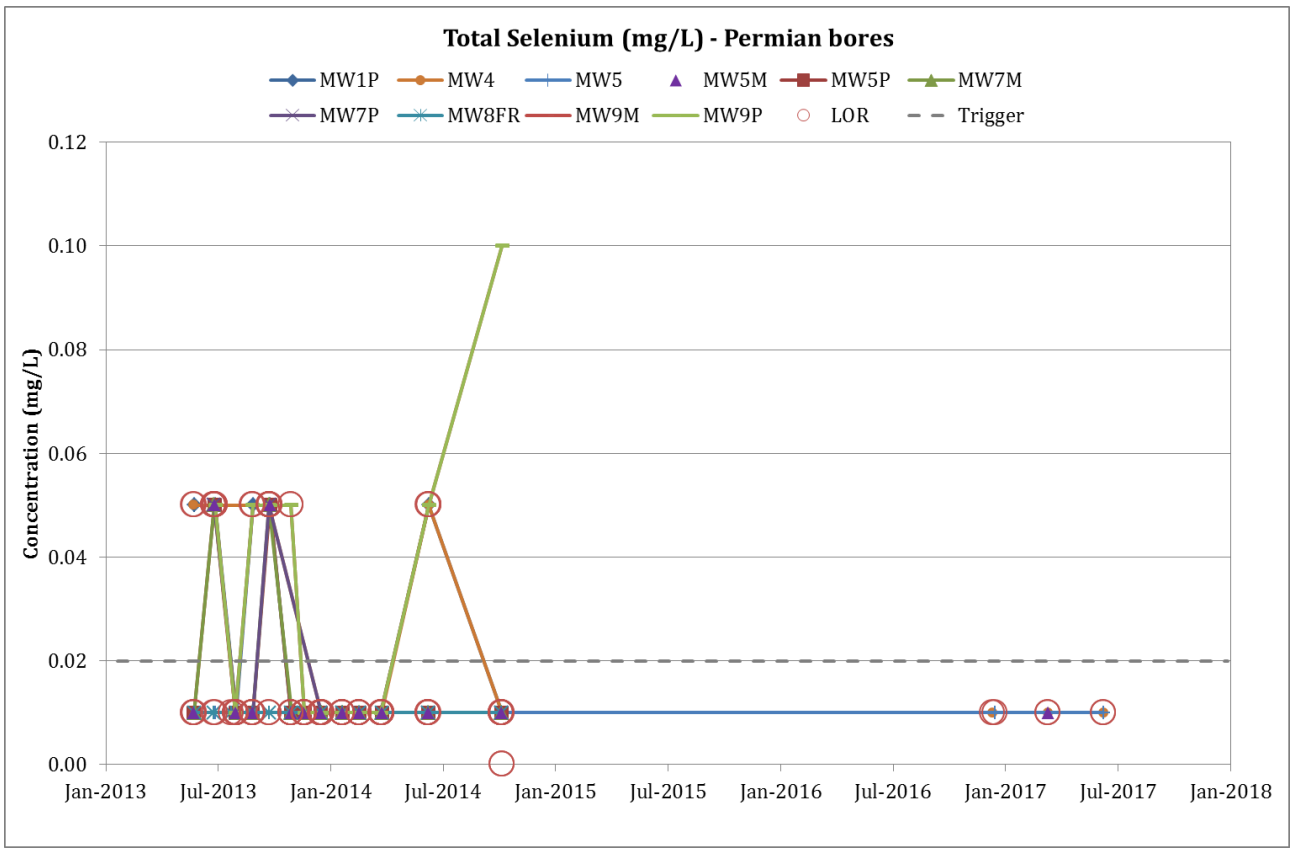

Total Iron (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
Trigger
Concentration (mg/L)
70
60
50
40
30
20
10
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

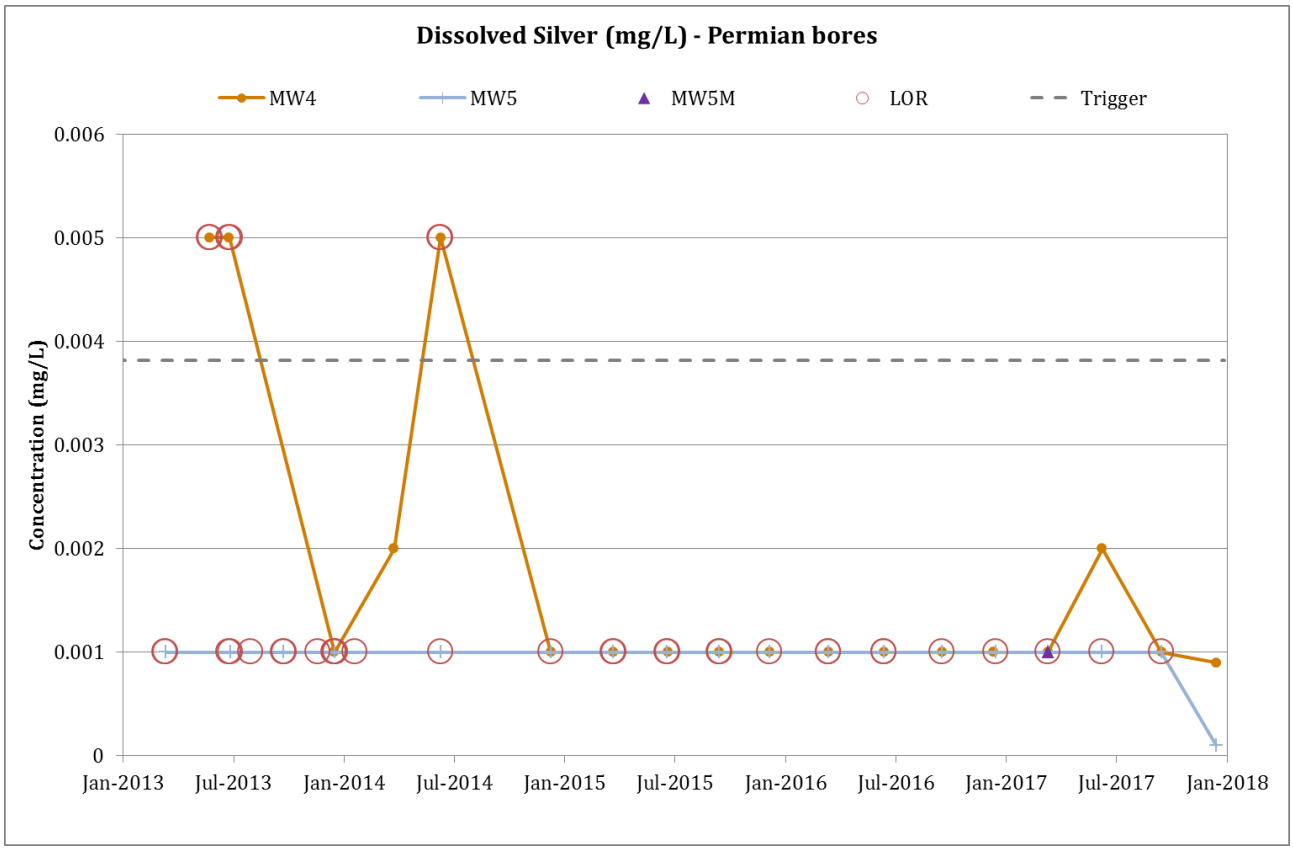

Dissolved Iron (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

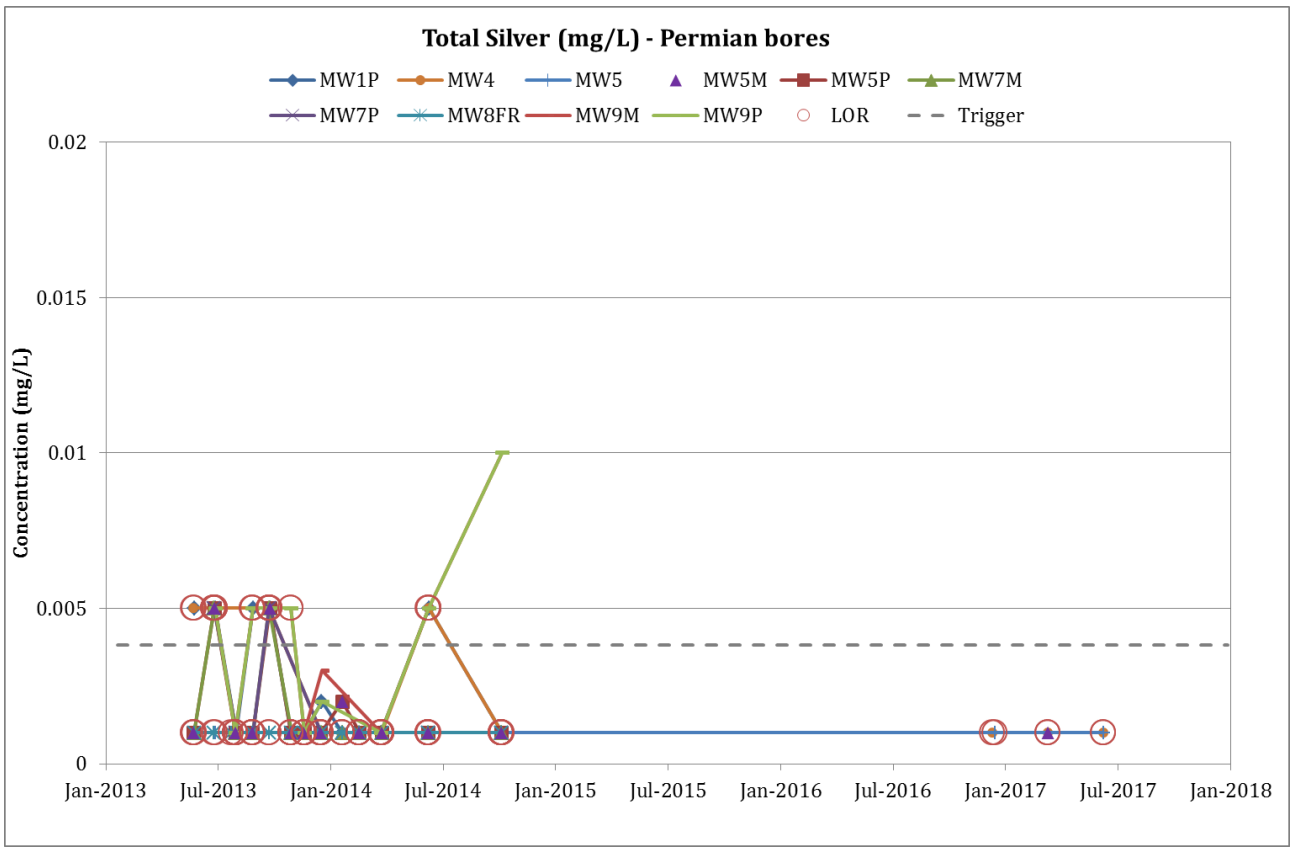

Dissolved Mercury (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

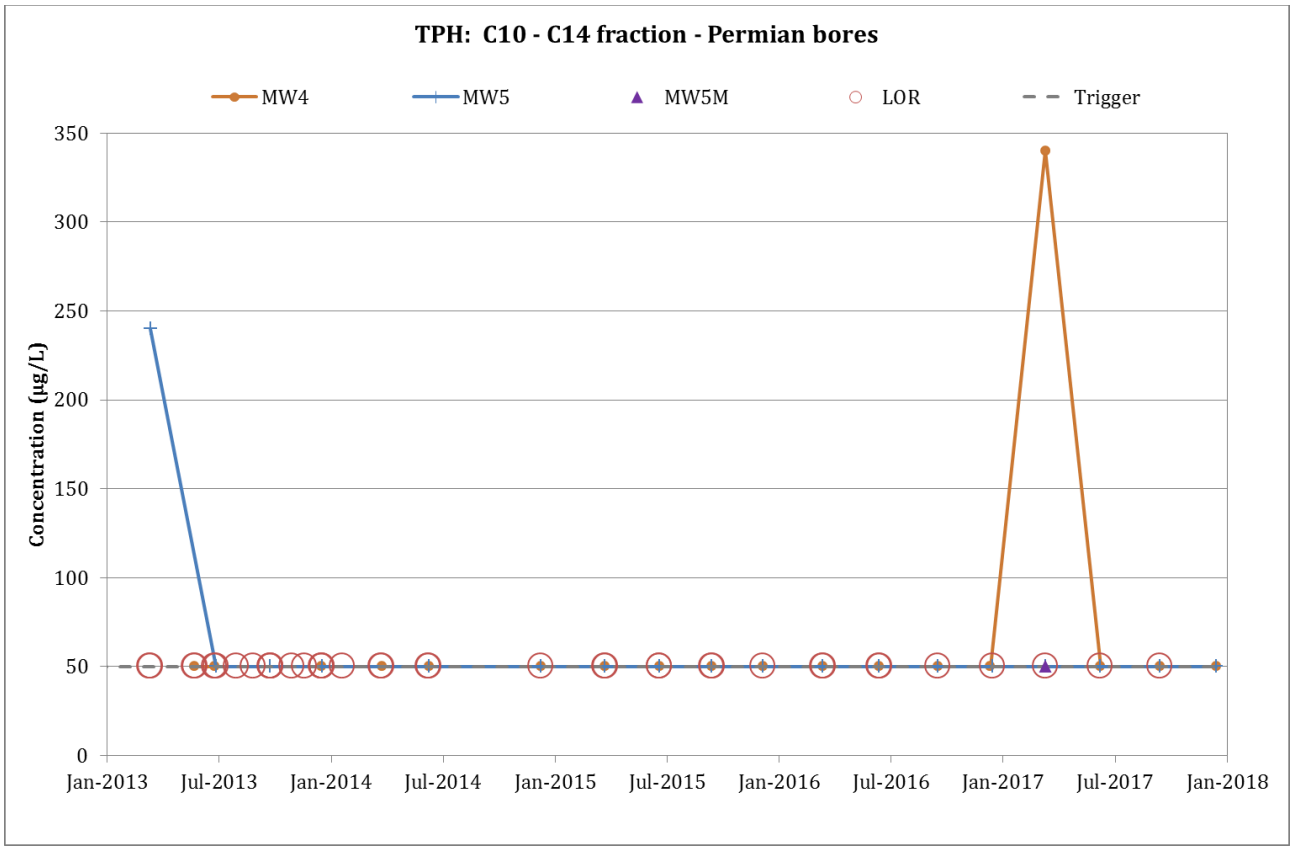

Total Mercury (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

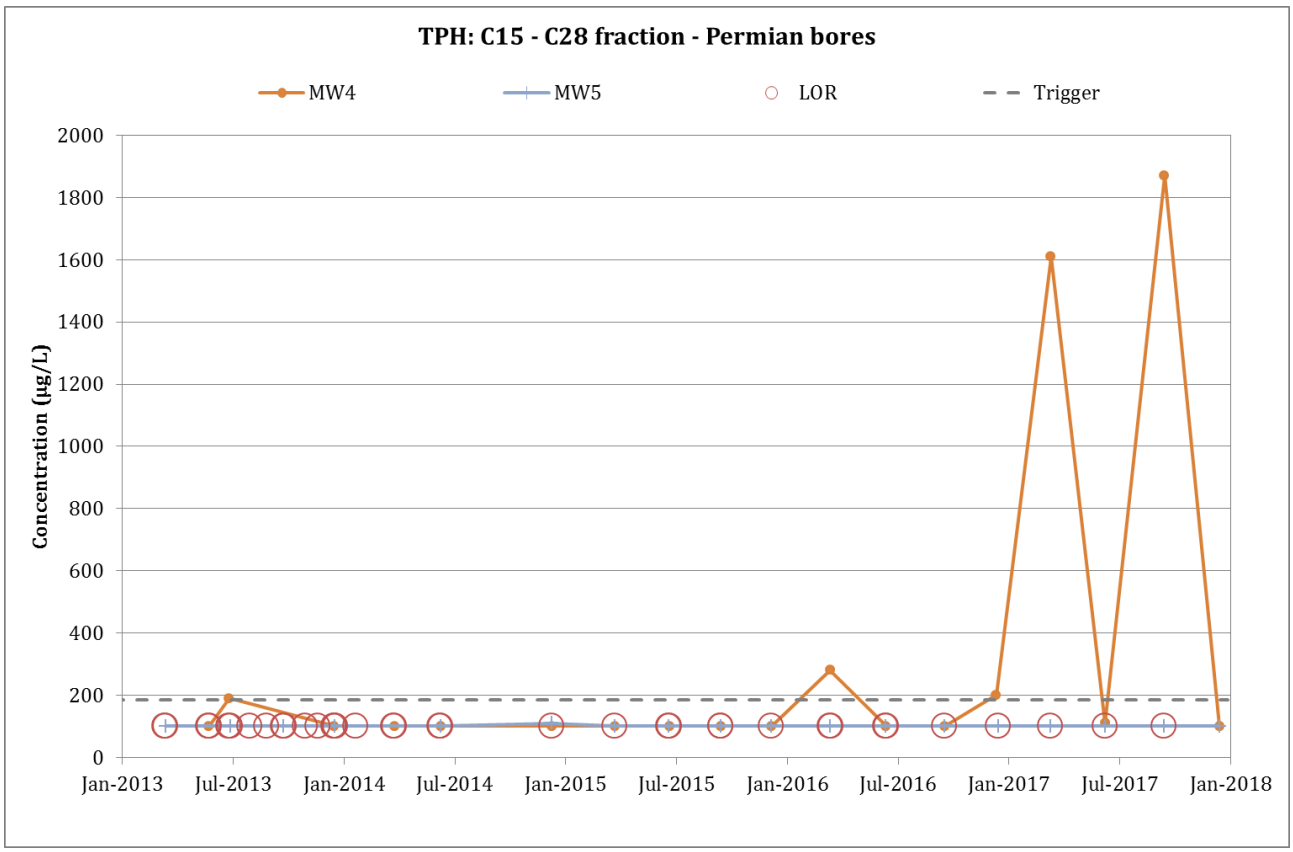

Dissolved Selenium (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

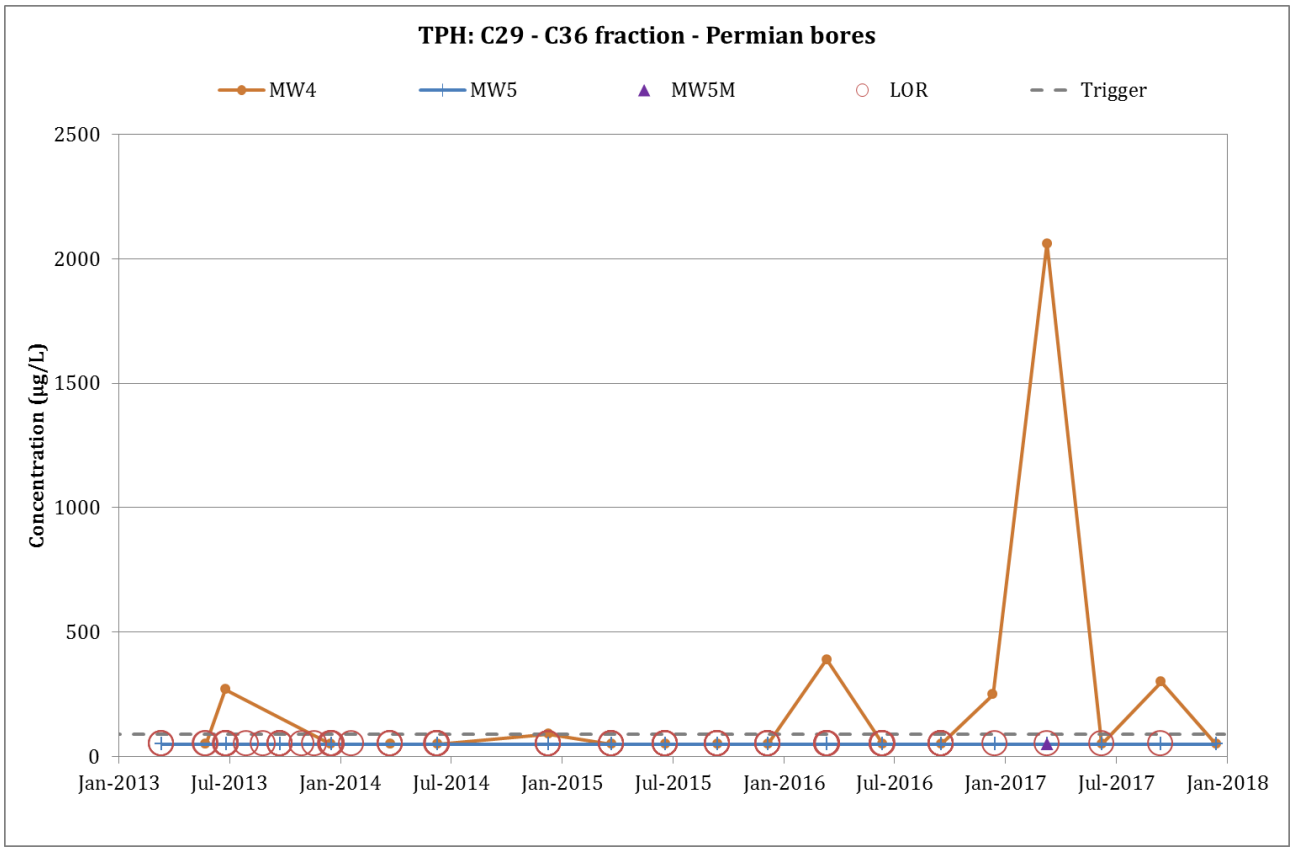

Total Selenium (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Dissolved Silver (mg/L) - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


Total Silver (mg/L) - Permian bores
MW1P
MW4
MW5
MW5M
MW5P
MW7M
MW7P
MW8FR
MW9M
MW9P
LOR
Trigger
Concentration (mg/L)
0.02
0.015
0.01
0.005
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C10 - C14 fraction - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (µg/L)
350
300
250
200
150
100
50
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C15 - C28 fraction - Permian bores
MW4
MW5
LOR
Trigger
Concentration (µg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018


TPH: C29 - C36 fraction - Permian bores
MW4
MW5
MW5M
LOR
Trigger
Concentration (µg/L)
2500
2000
1500
1000
500
0
Jan-2013
Jul-2013
Jan-2014
Jul-2014
Jan-2015
Jul-2015
Jan-2016
Jul-2016
Jan-2017
Jul-2017
Jan-2018

Appendix F **Numerical model report**

Middlemount Southern Extension Project
Numerical Modelling Report

F1 Introduction and objectives

Numerical modelling was undertaken to assess the impact of the proposed Middlemount Southern Extension Project (the Project) on the groundwater regime. The objectives of the modelling were to estimate with a high level of confidence:

1. potential mine inflows for water licencing; and
2. potential drawdown impacts on the surrounding environment due to mining.

This has been achieved by:

- simulating groundwater flow within the Quaternary, Tertiary, and Permian strata;
- calibrating the model under steady state and transient conditions;
- predicting future mine inflows and surrounding drawdown under the current hydrogeological conditions;
- predicting the volumetric take of groundwater, changes in regional groundwater levels and impacts on private bore water levels due to the Project and cumulatively;
- undertaking uncertainty analysis to capture range of predictions within the uncertainty in model parameters; and
- assessing the rate of groundwater recovery and long term impacts occurring on cessation of mining.

F1.1 Model confidence level classification

A high level of confidence in model predictions is required for the Project. Barnett *et al*., (2012) developed a system to classify the confidence-level for groundwater models. Models are classified as either Class 1, Class 2 or Class 3 in order of increasing confidence. Several factors are considered in determining the model confidence-level:

- available data;
- calibration procedures;
- consistency between calibration and predictive analysis; and
- level of stresses.

A Class 3 model is often referred to as an aquifer simulator, in that it encapsulates a very detailed and well understood conceptualisation. Despite the use of all available data for the model inputs, it is difficult to obtain all of the Class 3 descriptors, and an appropriate and achievable level is somewhere between an aquifer simulator and an impact model. Barnett *et al*., (2012) consistently suggest "*it is not expected that any individual model will have all the defining characteristics of Class 1, 2 or 3 models*".

Comparison against the performance indicators for individual model classes are presented in Table F 1.1.

Table F 1.1 Model classification – model performance indicators

Class	Data	Calibration	Prediction	Quantitative Indicators
1 (Simple)	× Not much	× Not possible	✓ Timeframe >> Calibration	× Timeframe > 10x
	✓ Sparse coverage	× Large error statistic	× Long stress periods	✓ Stresses < 5x
	✓ No metered usage	× Inadequate data spread	× Poor/no validation	× Mass balance > 1% (or one-off 5%)
	× Low resolution	× Targets incompatible with model purpose.	× Transient prediction but steady-state calibration	~ Properties < > field values
	× Poor aquifer geometry			× No review by Hydro/Modeller
2 (Impact Assessment)	✓ Some	× Partial performance	✓ Timeframe > Calibration	× Time frame = 3-10x
	✓ Ok coverage	× Some long term trends wrong.	× Long stress periods	✓ Stresses = 2-5x
	~ Some usage data/ low volumes	✓ Short term record.	✓ Ok validation	✓ Mass balance <1%
	~ Baseflow estimates. Some K & S measurements	✓ Weak seasonal match.	✓ Transient calibration and prediction	✓ Some properties < > field values. Review by Hydrogeologist
	✓ Some high resolution topographic DEM &/or some aquifer geometry	× No use of targets compatible with model purpose (heads & fluxes)	✓ New stresses not in calibration	× Some coarse discretisation in key areas of grid or at key times
3 (Complex Simulator)	✓ Lots, with good coverage.	✓ Good performance stats	× Timeframe ~ calibration	✓ Timeframe < 3x
	× Good metered usage info.	✓ Most long term trends matched	~ Similar stress periods	× Stresses < 2x
	~ Local climate data	× Most seasonal matches ok.	✓ Good validation	✓ Mass balance < 0.5%
	~ Kh, Kv & Sy measurements from range of tests	✓ Present day data targets	✓ Calibration & prediction consistent (transient or steady state).	~ Properties ~field measurements
	~ High resolution DEM all areas.	✓ Head & Flux targets used to constrain calibration	~ Similar stresses to those in calibration.	✓ No coarse discretisation in key areas (grid or time)
	✓ Good aquifer geometry.			✓ Review by experienced Modeller

This shows the Southern Extension Project groundwater model is classified between a Class 2 and Class 3 model. That is, the model classification identifies:

- 12 out 22 (55%) performance indicators align with a Class 2 model; and
- 12+ out 21 (57%) performance indicators align with a Class 3 model.

The above indicates the groundwater model has been developed to be suitable for predicting groundwater responses to changes in applied stress or hydrological conditions, and the evaluation and management of potential impacts.

F2 Model background

F2.1 Previous modelling for Middlemount Coal Mine

The most recent numerical groundwater model developed for the Middlemount Coal Mine was for the Middlemount Western Extension Project which was approved in 2018 (AGE, 2018). The groundwater model comprised 17 layers representing the geological units at the Middlemount Coal Mine. The numerical groundwater flow model was used to predict the rate of groundwater inflow to the open cut pit and the resultant drawdown in the surrounding geological units. This 2018 modelling for the Western Expansion Project has been utilised as the starting point for the Southern Expansion Project.

F2.2 Other nearby sites

There are a number of other mine sites in the vicinity of the Middlemount Coal Mine. The nearest mines include Lake Lindsay (approximately 20 km south), Oak Park (approximately 9 km south), German Creek (in care and maintenance) (approximately 8 km south-west), German Creek East (in care and maintenance) (approximately 2.5 km south), Foxleigh and Foxleigh Plains (approximately 12 km south-east), and Norwich Park (in care and maintenance) (approximately 11 km north-west). Of these, German Creek East, Lake Lindsay and Oak Park are the only mines that target coal from the same Rangal Coal Measures sub-basin as Middlemount Coal Mine. Mining at German Creek East mine ceased in 2007 and the voids are now used as mine water storage facilities, which will effectively mask the northwards propagation of any impacts from Lake Lindsay and Oak Park mines. On this basis, the only nearby mine operations considered likely to have a cumulative interaction with the Project will include German Creek East and Foxleigh mines.

The Bowen Gas Project (Arrow Energy, 2012b) identifies coal seam gas (CSG) production commencing in the Rangal Coal Measures approximately 7 km to the north of the Project in 2034 and within the Project area in the Moranbah Coal Measures in 2039. Groundwater drawdown from CSG production is predicted to extend within the Rangal Coal Measures into the northern portion of the model domain approximately 4.5 km from the Project.

However, detail of this drawdown is only provided for the end of CSG production in 2072 (Arrow Energy, 2012). Groundwater drawdown from the CSG production in the Moranbah Coal Measures is not predicted to extend vertically upwards into the overlying Rangal Coal Measures. Therefore, the only CSG production considered likely to have any cumulative interaction with the Project would be that within the Rangal Coal Measures north of the Project.

F2.3 Conceptual model

The conceptual model of the groundwater systems at Middlemount Coal Mine and Western Extension Project assumes the following key processes for water movement.

Inflow:

- recharge from rainfall infiltration (deep drainage);
- recharge from streamflow; and
- up-gradient inflow from surrounding strata.

Outflow:

- groundwater extraction from the existing mine operations;
- evapotranspiration;
- baseflow to surface drainages; and
- down-gradient outflow to surrounding strata.

The conceptual groundwater model for the Middlemount Coal Mine and Southern Extension Project is presented in Section 6 of the main report. This graphically presents and illustrates the main hydrogeological processes and mechanisms thought to be operating in the area, including recharge, flow directions, discharge, and anthropogenic activities (i.e. mine dewatering).

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

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

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

The regional water table within the Tertiary aquifer is a subdued reflection of topography with a general flow towards the southeast. The exception to this is immediately around the mine where groundwater levels will have declined due to localised depressurisation resulting from mining.

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

The coal measures form confined groundwater systems and they sub-crop beneath the Tertiary aquifers. The direction of groundwater flow for the Permian coal measures is influenced by the local geomorphology and structural geology (i.e. faults), and around the mine where groundwater levels have declined as a result of depressurisation from mining.

The presence of the Jellinbah Fault has been considered in the conceptual model. It is assumed that vertical displacement along the fault alignment has resulted in the Rangal Coal Measures coal seams being truncated against lower permeability Fort Cooper Coal Measures/Burngrove Formation interburden. That is groundwater flow/movement to the east across the Jellinbah Fault is not halted, rather it is slowed as a result of the lower permeability Fort Cooper Coal Measures/Burngrove Formation interburden sediments.

F3 Model software

F3.1 Code selection

The industry standard in groundwater modelling is MODFLOW. This software is freely available from the United States Geological Survey (USGS). The base MODFLOW code is a finite difference model that relies on an orthogonal model grid of rows and columns (and layers) of model cells.

The USGS have released their new version called MODFLOW-USG (USG) that allows for the model to have an unstructured grid. This allows for model cell refinement within specific areas of the model without requiring extended refinement to the edge of the model. This creates the opportunity to reduce the number of model cells in each model layer. Another key advantage of USG is the fact that model layers can be truncated where they cease to exist (such as sub-cropping and fault terminated geological units), and maintain the hydraulic connections with layers above and below where the model layer has ceased to exist. USG can also simulate unsaturated flow. The USG code is particularly effective when the model grid is made up of Voronoi (polygon) cells, which has been implemented for the Middlemount numerical model.

F3.1.1 Pre and post processing

In-house FORTRAN and Python codes have also been used to process the raw data into the model input file formats, as well as extracting the model results from the binary model output files. QGIS and Surfer software were also used to implement the layer interpolation and visualise the modelling outcomes.

F4 Model design

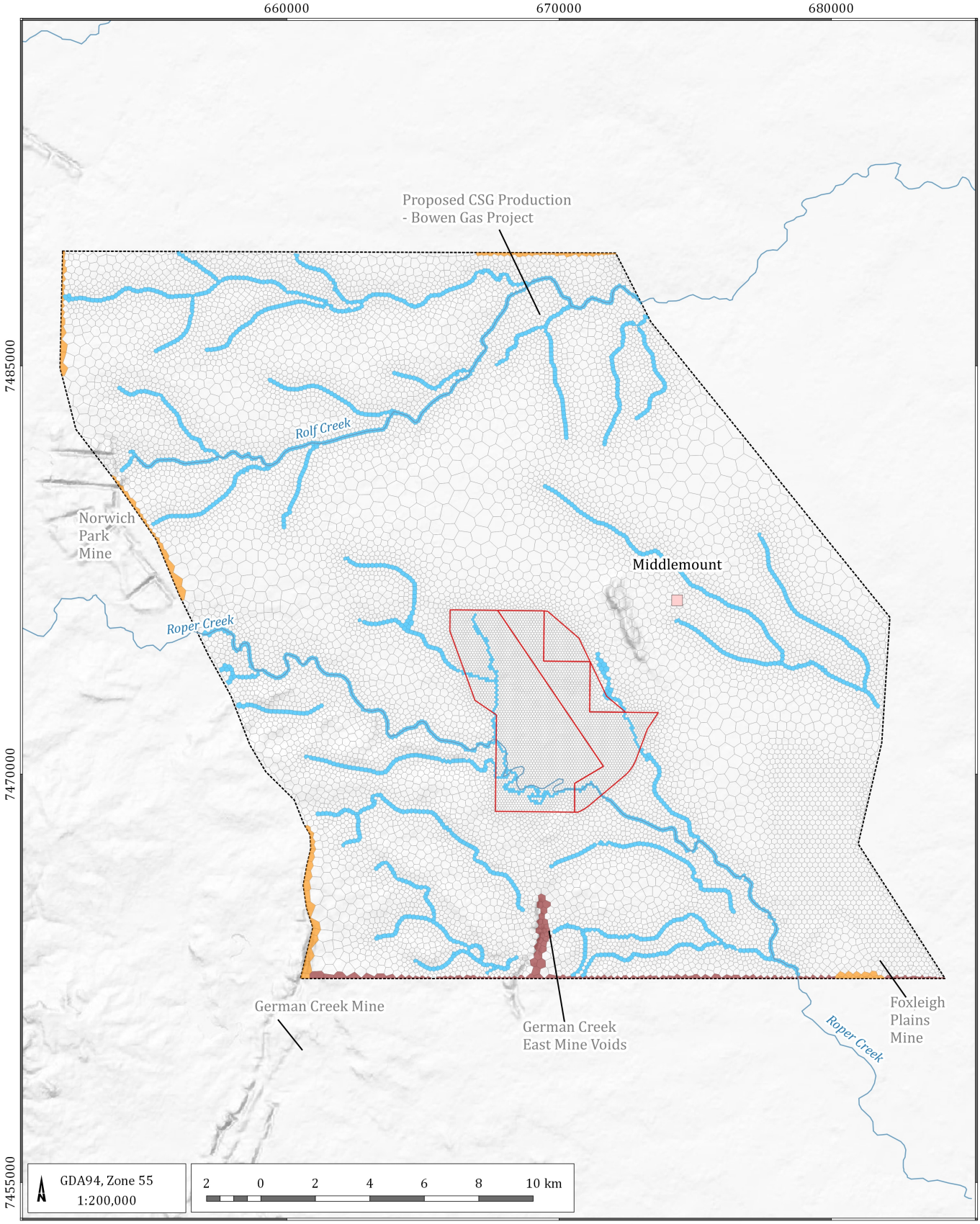
The model grid domain was designed to account for the current and future likely drawdown attributable to the Project. The model boundaries are sufficiently distant to the area of interest, such that there is no undue influence on the model predictions from the boundary assumptions. Where necessary, natural hydrogeological boundaries such as geological units and regional catchment boundaries, have been adopted in the model.

The model cell dimensions have been optimised to replicate the historical and future mining progressions and associated groundwater level responses. Grid spacing across the model domain is variable, with refinement around the mine site and locations of groundwater level observations. The model cell size becomes larger away from these key areas. The model domain was discretised into 19,412 cells per layer, and a total of 109,147 cells for the whole model. Layers 4 to 17 pinch out where these layers sub-crop beneath the weathered zone, or are truncated by the Jellinbah Fault. Cell sizes range from 100 m by 100 m within the mining area and up to 700 m by 700 m outside the Project area (Figure F 4.1).

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

- the drawdown observed from the current approved coal operations;
- cumulative impacts given the proximity of the Project to the nearest operational mines which include Lake Lindsay, Oak Park, German Creek, German Creek East, Foxleigh, Foxleigh Plains, and Norwich Park;
- inclusion of the areas targeted for the bore census for the Project; and
- adequacy to capture the predicted drawdown attributable to the Project.

The current model extent is shown by the dashed line in Figure F 4.1.



LEGEND

- Populated place
- Watercourse
- Thirteen Mile Gully Diversion
- Mining Lease boundary (ML)
- Model boundary
- General Head Boundary
- River package
- Drain package

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Extent of the modelling domain - model grid

DATE 21/08/2020

FIGURE No: **F 4.1**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-4.1_G1840P_Extent of the modelling domain - model grid.qgs

The vertical discretisation of the model is described by the geological layers. Geological surfaces have been developed for the Middlemount Coal mining area from the mine geology model, and have been extrapolated across the entire proposed numerical model extent from interpretation of the regional geological mapping and layering for the Bowen Gas Project (Arrow Energy, 2012). The model layering is similar to the 2010 numerical model, and includes the Quaternary alluvium as a separate layer to represent recharge from ephemeral surface water flows and rainfall in these areas.

The hydraulic properties of the model are based on the initial parameters established for the 2010 groundwater model (Parsons Brinkerhoff, 2010). These initial parameters were based on available field data, which includes site permeability tests conducted at bores on site. The parameters have been calibrated for a better fit to the available data. In addition, the range of parameters used for the Bowen Gas Project (Arrow Energy, 2012), were used as a reference to set the valid ranges of the model calibration.

F4.1 Time discretisation – stress periods

The time discretisation adopted for the calibration and prediction periods incorporated a variable stress period ranging between 90 days and 365 days.

F4.2 Boundary conditions

Areal recharge from rainfall infiltration has been estimated as a percentage of rainfall (namely, 0.01%) and applied across the model domain. Evapotranspiration has not been applied in the model due to the depth of water below the ground surface.

The surface drainages are represented by the RIV package. The focus of representing Roper Creek in the model is to capture its potential interaction with the underlying groundwater regime. Due to the creek predominantly being a losing stream, the key feature requiring simulation is recharge from the creek to the water table during flow events. The water table is generally located well below the creek bed, and as such, baseflow is assessed to not occur, meaning there is no need to route the baseflow downstream.

The western model boundary has been established coincident with the generally north-south extents of the German Creek and Norwich Park open cut mine voids. Review of aerial imagery provided through Queensland Globe (DNRME, 2017) shows these mine voids are no longer operational mines and are used for either water storage or tailings disposal. Similarly, the model southern boundary intersects the German Creek East Mine voids. Mining is understood to have commenced operations in 1991 and ceased mining around 2007, with the mine voids subsequently used as mine water storage facilities, which includes provision of process water to Middlemount Coal Mine. For the purposes of assessment, it has been assumed (based on advice from Middlemount Coal Mine) that the void water level in the German Creek East Mine voids is maintained coincident with the base of Tertiary in these pits. This being the case, the German Creek and Norwich Park open cut mine voids are represented as drains using the Drain package. Similarly, the German Creek East Mine voids are initially represented as drains between 1991 and 2005 (during mining), and then by the General Head Boundary (GHB) between 2005 to 2044 (when used for mine water storage). In both instances, a reference level was set to the base of the Tertiary layer for the southern and western model extents.

The south-eastern corner of the model boundary is located at the northern extents of the Foxleigh Mine. The Drain package has been applied to model cells along this boundary where the mine exists, and remain active up to 2034. The levels for the Drain cells were set at the base of the Rangal Coal Measures to represent depressurisation from this mine operation, beyond which groundwater drawdown from the Project would not be able to propagate.

The northern boundary is situated sufficient distant from drawdown predicted from the Project and is simulated as a no flow boundary for model calibration.

However, inclusion of CSG production commencing in the Rangal Coal Measures approximately 7 km to the north of the Project in 2034 is represented as drains along the eastern end of the northern model boundary from 2034 to 2044 prediction simulation. The levels for the Drain cells were set 30 m above the base of the Leichhardt and Vermont Seams within the Rangal Coal Measures to represent depressurisation from this activity. The drain conductance was set to 100 m^2/day.

The model's eastern boundary is approximately 10 km east of the Project, and extends northwest from the south-eastern model corner boundary until it intersects the model's northern boundary. The model's eastern extents are assumed to be a no-flow boundary. The no-flow status of the model extent is considered appropriate as this part of the model is sufficiently distant to the area of interest for the Project, that being the Middlemount Extension area and the existing Middlemount mining area.

Mine progression is extrapolated from the mine plan data provided by Middlemount Coal Mine and implemented into the model using DRN cells.

Pumping from private bores is limited in both location and volume. Groundwater data has been sourced from the NRM groundwater database and bore census for the Project. The NRM database does not include pumping data and the bore census identified that usage of groundwater is limited to an as-required basis if an emergency water supply during dry conditions is needed. As no actual pumping details were determined from the bore census or the NRM database, abstraction from the active bores identified within the model domain is not represented within the groundwater model.

F4.3 Initial conditions

A steady state model was created to represent pre-mining groundwater levels at Middlemount Mine. This has formed the starting heads for a simulation representing mine development in surrounding mines from 1974 to the end of 2010. The final predicted water levels from that model run become the starting heads for the historical transient simulation covering the period from 2011 to present.

F4.4 Hydraulic parameters

The fieldwork completed for the monitoring bores at the site has provided measurements of hydraulic parameters within the different hydrogeological units. Where available, these values were compared to published values for the same strata both regionally and for nearby areas.

Storage properties have not been determined on site as these are typically obtained from a pumping test with observation bores, which has not been performed for this site. As such, storage parameters have been adapted from the previous study undertaken for the Stage 2 EIS model and the CSG production for the Bowen Gas Project (Arrow Energy, 2012). Where required, estimates for hydraulic parameters have also been sourced from text book references and nearby projects to guide the parameter range for the calibration of different hydrogeological units. Table F 4.1 shows the layer details as well as the hydraulic property values assigned to each layer.

Layers 1 to 3 occur stratigraphically above the geology displaced by the Jellinbah Fault and as such are not assessed to be impacted by this fault, and are therefore consistent across the model domain. However, layers 4 to 17 includes replicated layers to represent strata (i.e Rangal Coal Measures and Fort Cooper Coal Measures) displaced east and west of the Jellinbah Fault northwest–southeast strike alignment.

Table F 4.1 Summary of groundwater model parameters

Layer	Layer name	Hydraulic conductivity (K m/day)			Specific storage (m^{-1})	Specific yield
		Horizontal (Kh)	Vertical (Kv)	Depth dependency		
Model Domain						
1	Alluvium	0.75	6.37E-02	No	1.30E-05	2.00E-02
2	Tertiary	0.75	5.47E-02	No	1.30E-05	2.00E-02
3	Weathered Zone (Rangal Coal Measures)	0.1	1.30E-02	No	1.30E-05	1.00E-02
Permian Geology West of Jellinbah Fault						
4	Rangal Coal Measures – overburden	1.00E-04	2.10E-05	No	1.00E-06	1.00E-02
5	Rangal Coal Measures – Middlemount coal seam	0.22 to 1.00E-05#	1.48E-01	Yes	1.00E-06	1.00E-02
6	Rangal Coal Measures – interburden	6.03E-06	3.24E-08	No	1.00E-06	1.00E-02
7	Rangal Coal Measures – Permian Pisces coal seam	0.09 to 1.00E-05#	1.29E-01	Yes	1.00E-06	1.00E-02
8	Rangal Coal Measures – strata underlying Pisces coal seam	5.43E-05	4.18E-06	No	1.00E-06	1.00E-02
9	Fort Cooper Coal Measures – Burngrove Formation	7.20E-05	6.48E-05	No	1.30E-05	1.00E-02
10	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	1.30E-05	1.00E-02
Permian Geology East of Jellinbah Fault						
11	Rewan Formation	1.00E-04	2.10E-05	No	1.00E-06	1.00E-02
12	Rangal Coal Measures – Leichhardt coal seam	0.18 to 1.00E-05#	1.48E-01	Yes	1.00E-06	1.00E-02
13	Rangal Coal Measures – interburden	6.03E-06	3.24E-08	No	1.00E-06	1.00E-02
14	Rangal Coal Measures – Vermont coal seam	0.06 to 1.00E-05#	1.29E-01	Yes	1.00E-06	1.00E-02
15	Rangal Coal Measures – strata underlying the Vermont coal seam	5.43E-05	4.18E-06	No	1.00E-06	1.00E-02
16	Fort Cooper Coal Measures – Burngrove Formation	7.20E-05	6.48E-05	No	1.30E-05	1.00E-02
17	Fort Cooper Coal Measures – Fair Hill Formation	3.59E-04	2.06E-05	No	1.30E-05	1.00E-02

Note: *# Range of horizontal hydraulic conductivity (Kh) values based on the depth dependence equations used for each coal seam (refer Section F4.4.1).*

The previous modelling utilised some specific storage values that were outside of what is now considered to be plausible ranges (Rau et. al., 2018) for the unconsolidated alluvium and Tertiary units and for the Fort Cooper Coal Measures. The specific storage for these units has been adjusted to be more consistent with the findings of Rau (2018) than was calibrated in the previous modelling (AGE, 2018).

It is acknowledged that whilst heterogeneity exists within the geological units, there is not enough data to support fully defining this in the model layers. The Jellinbah Fault is the main structural feature within the model domain, and is represented by offsetting the Rangal Coal Measures against the underlying Fort Cooper Coal Measures where this geology strata has been vertically displaced east of the Middlemount Mine area. Whilst there is likely to be other minor faults within the model domain, the nature of these faults is unknown and therefore have not been incorporated into the groundwater model to slow or halt groundwater flow / movement. This approach in conjunction with the available model inputs, has necessitated simplifications to the numerical model that are considered to create conservative predictions of the impacts from groundwater depressurisation. This simplified conceptualisation and representation of the groundwater model is presented in the cross section in Figure F 4.2.

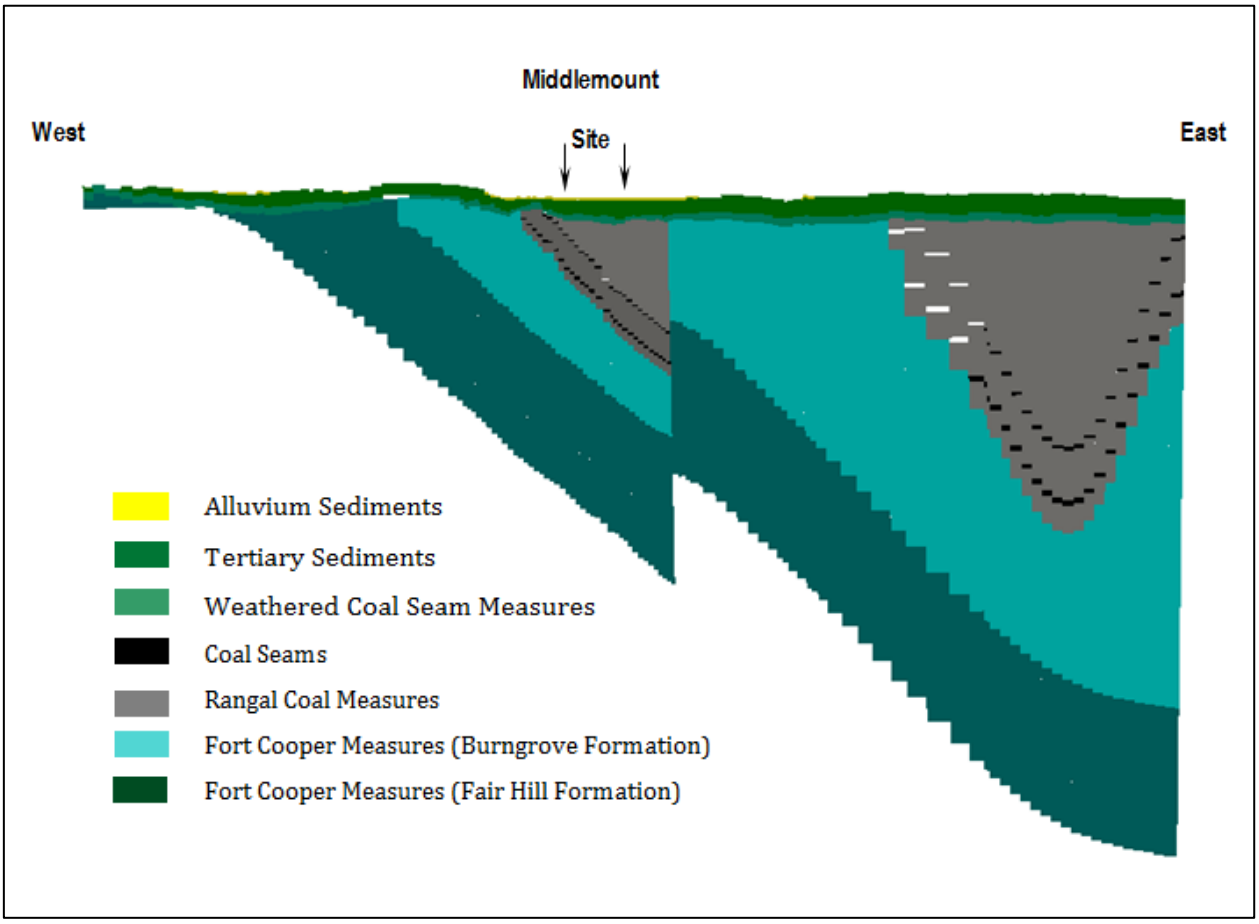


Figure F 4.2 Section through groundwater model showing layer design

Hence, the numerical model provides for a lateral, horizontal hydraulic connection across the Jellinbah Fault where different layers are juxtaposed on the eastern and western sides of the fault plane as represented in Figure F 4.2 and summarised in (Table F 4.2) below. This was achieved using the Algomesh software to provide non-neighbour connections which hydraulically connect model cells (nodes) within the different model layers positioned on either side of the Jellinbah Fault.

Table F 4.2 Model layer horizontal hydraulic connection as shown east and west of the Jellinbah Fault in Figure F 4.2

Model Layer (Geology) West of Jellinbah Fault	Model Layer (Geology) East of Jellinbah Fault
Rangal Coal Measures – overburden – layer 4	Fort Cooper Coal Measures – Burngrove Formation – layer 16
Rangal Coal Measures – Middlemount coal seam – layer 5	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – interburden – layer 6	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – Permian Pisces coal seam – layer 7	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Rangal Coal Measures – strata underlying Pisces coal seam – layer 8	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Fort Cooper Coal Measures – Burngrove Formation – layer 9	Fort Cooper Coal Measures – Fair Hill Formation – layer 16 or 17
Fort Cooper Coal Measures – Fair Hill Formation – layer 10	Fort Cooper Coal Measures – Fair Hill Formation – layer 17

F4.4.1 Depth dependence of hydraulic conductivity in coal seam

It is known that seam permeability typically reduces with depth within the Bowen Basin (Arrow Energy, 2012). The decrease occurs as increased pressure from the overlying strata closes up cleats in the coal and mineral precipitates seal fractures.

The model simulates a reduced (horizontal) hydraulic conductivity (Kh) of each coal seam with depth according to the following relationship:

- $Middlemount\ and\ Leichhardt\ seam\ Kh = 0.3731\ x\ e^{(-0.021\ x\ depth)}$
- $Pisces\ and\ Vermont\ seam\ Kh = 0.1504\ x\ e^{(-0.021\ x\ depth)}$

The above relationship was obtained using the available coal permeability measurements from the Middlemount Mine. This results in an order of magnitude reduction in the hydraulic conductivity over 110 m depth. The lower bound of coal seam horizontal conductivity was capped to two orders of magnitude lower than the upper bound value.

F4.5 Timing – proposed mining run

The model was run in three stages: the pre-mining starts from January 1974 to December 2010, followed by a transient lead-in period from January 2011 to December 2017, and then the prediction simulation of the proposed extension from January 2018 up to December 2044. The lead-in period was used to compare the model performance with observed field data (i.e. model calibration).

F4.6 Timing – post-mining

The post-mining conditions were simulated using a steady state model. The stabilised water levels for each void, obtained from the WRM void water level recovery (hydrological) modelling, were used to define the head in the voids, from which the steady state model defines the long term residual impacts from the Project. The Drain cells representing the Foxleigh Mine and CSG production were turned off, and the Drain cells along the model's western boundary representing German Creek Mine and Norwich Park open cut mines were changed to General Head Boundary cells coincident with the base of the Tertiary cover.

F4.7 Mine drainage

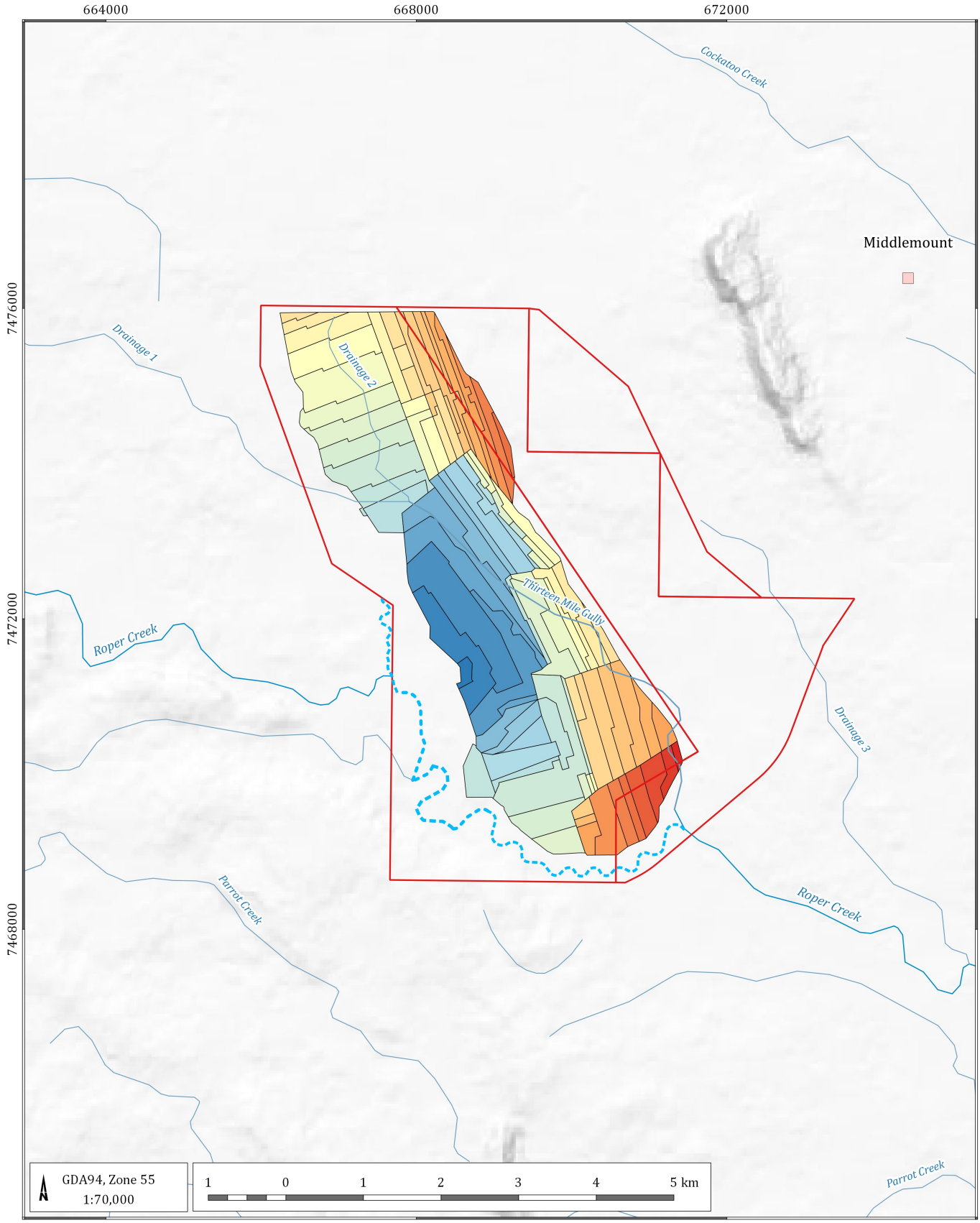
During the predictive run, a drain boundary condition (DRN) was used to simulate the effect of mine operations. A nominally high drain conductance of 100 m^2/day was applied to the drain cells and the elevation of the base of the modelled layer was used as the drain level. The drain cells were moved within the mine footprint in line with the proposed mine plan progression, simulating water removal from the active block for that particular stress period. The drain cell progression for both approved and proposed mining plans is presented in Figure F 4.3

At the completion of mining, drain cells were removed representing mining at Middlemount Coal Mine and the model simulated post-mining conditions.

F4.8 Recharge

Recharge to the groundwater system occurs through diffuse rainfall recharge across the land surface, leakage from surface water flows (i.e. perennial streams) and overland flow, as there are no specific bedrock outcrop areas that would form recharge zones within the model domain (PB, 2010). This is assumed to be via the Quaternary alluvium, Tertiary sediments, or weathered profile. These recharge mechanisms were condensed in a single package for the model using the recharge package (RCH) for MODFLOW-USG, and were applied to the uppermost layer.

For the steady-state modelling, a value of 0.06 mm/year has been adopted for recharge. This represents the proportion of rainfall that seeps through the predominantly clayey Tertiary and regolith surficial layers and becomes deep drainage to the water table.



LEGEND

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

Mine progression (Year)

2011	2023	2035
2012	2024	2036
2013	2025	2037
2014	2026	2038
2015	2027	2039
2016	2028	2040
2017	2029	2041
2018	2030	2042
2019	2031	2043
2020	2032	2044
2021	2033	
2022	2034	

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Mining progression – proposed operations

DATE 27/08/2020

FIGURE No: **F 4.3**

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F4.9 Water budget

Table F 4.3 shows the average rates of water transfer (flow into and out of the model) over the transient lead-in period (2011 to 2017). Table F 4.4 shows the average flow rates across model boundaries for the prediction period of 2018 to 2044.

Table F 4.3 Model budgets – transient lead-in period

Parameter	Average water transfer - 2011 – 2017 (ML/day)	
	Input	Output
Rainfall recharge	0.10	--
Drains	--	1.40
River	0.04	0.03
General head boundary	0.08	--

Table F 4.4 Model budgets – Prediction

Parameter	Average water transfer - 2018– 2044 (ML/day)	
	Input	Output
Rainfall recharge	0.10	--
Drains	--	2.05
River	--	0.04
General head boundary	0.04	--

Groundwater recharge during the transient and prediction periods is on average 0.1 ML/day. Mining is simulated via the DRN package with an average extraction rate of 1.40 ML/day for the calibration period. As mining progress to the deeper coal seams, the average rate of dewatering increases slightly to 2.05 ML/day (see Table F 4.4).

The mass balance error is a parameter used to quantify the quality of the internal numerical solution of the simulation, defined as the difference between the model inflows and outflows at the completion of calibration model run. The mass balance of the simulation was generally less than 0.41% indicating that the model was numerically stable and achieved an accurate numerical solution.

F5 Model calibration and verification

The groundwater model calibration was verified for the transient run (2011 to 2017) using available groundwater level data, including results of the 2017 bore census. The model was calibrated by adjusting aquifer hydraulic properties and recharge parameters to achieve the best match between the observed and simulated water levels. The modelled hydrographs were then compared to the observed water levels as well as modelled heads in previous report (PB, 2010).

F5.1 Calibration heads

The transient model simulated water levels at 26 site monitoring bores (MW1-18). The majority of monitoring bores are located within the footprint of the proposed mine and will be eventually destroyed as the mining progresses. Additional groundwater level data sourced from the Department of Natural Resources and Mines (DNRM) groundwater database identified that most DNRM registered bores were dry and only three bores (i.e. RN158617, RN158619 and RN158621) included water level data located further from the Project that was able to be used.

Figure F 5.1 presents the observed and simulated groundwater levels graphically as a scattergram. The calibration hydrographs for the site monitoring bores and regional registered bores are shown in Appendix F1, which present the calibration data in context with the overall predicted drawdown for each bore.

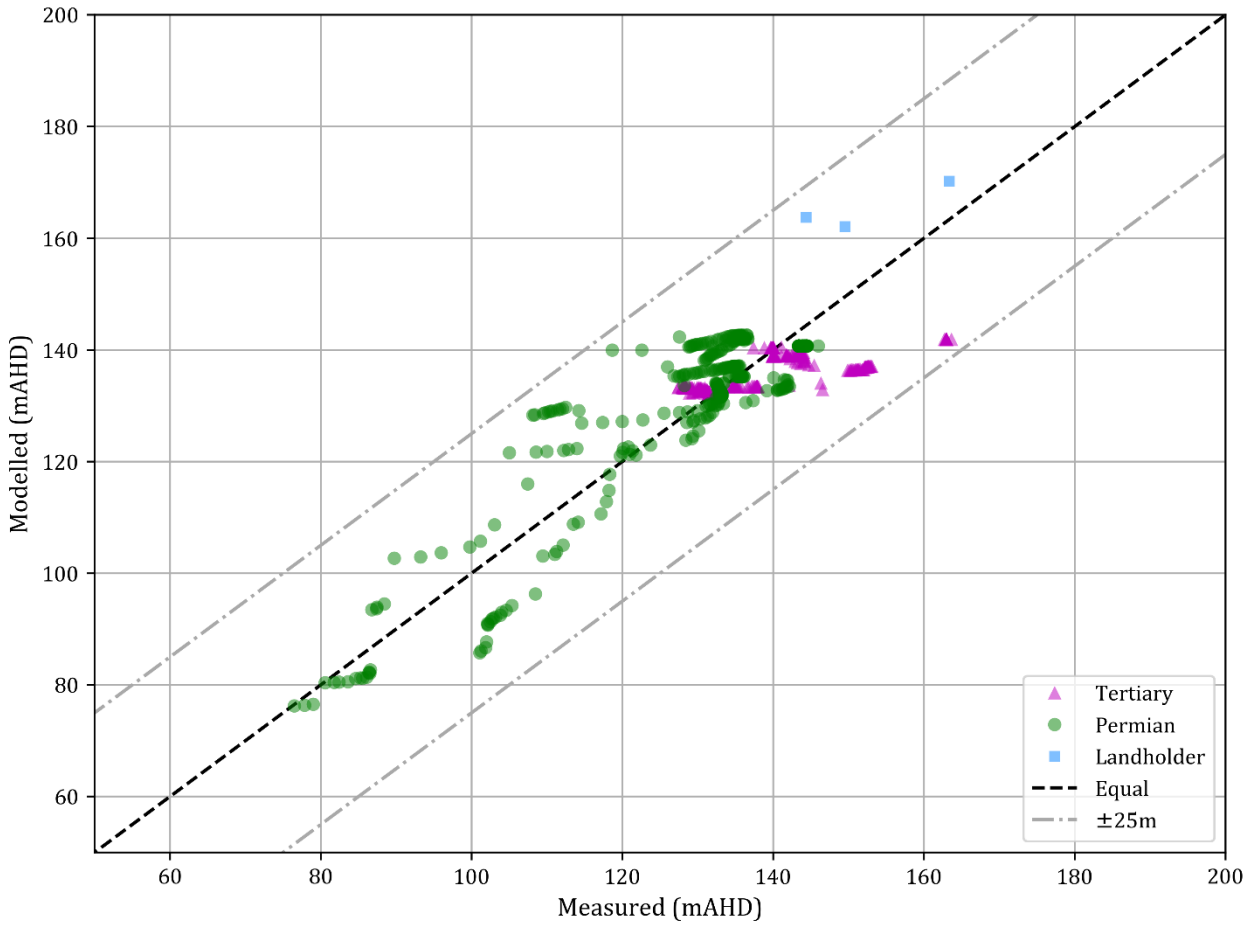


Figure F 5.1 Transient calibration – modelled vs observed groundwater levels

The root mean square (RMS) error calculated for the calibrated model was 7.9 m. The total measured head change across the model domain was 87.18 m, resulting in a scaled RMS (SRMS) of 9.1%. A lower SRMS would most likely be achieved through inclusion of heterogeneity to the aquifer parameters. However, the number and distribution of currently available observations would not support acalibrated parameter set that would also limit parameter non-uniqueness. That is, whilst it may be possible to find a set of parameter values that were able to match the observations almost perfectly, the required heterogeneity this creates would remove the model's predictive potential due to parameter non-uniqueness. The other critical aspect of the calibration is that all of the observation data is close to the mine and appears to have responded to historical mining. Incorporation of the historical mine progression has required it to be simplified to allow it to fit in with the model discretisation and transient progression, which in turn has impacted on the ability of the model to perfectly match the water level responses.

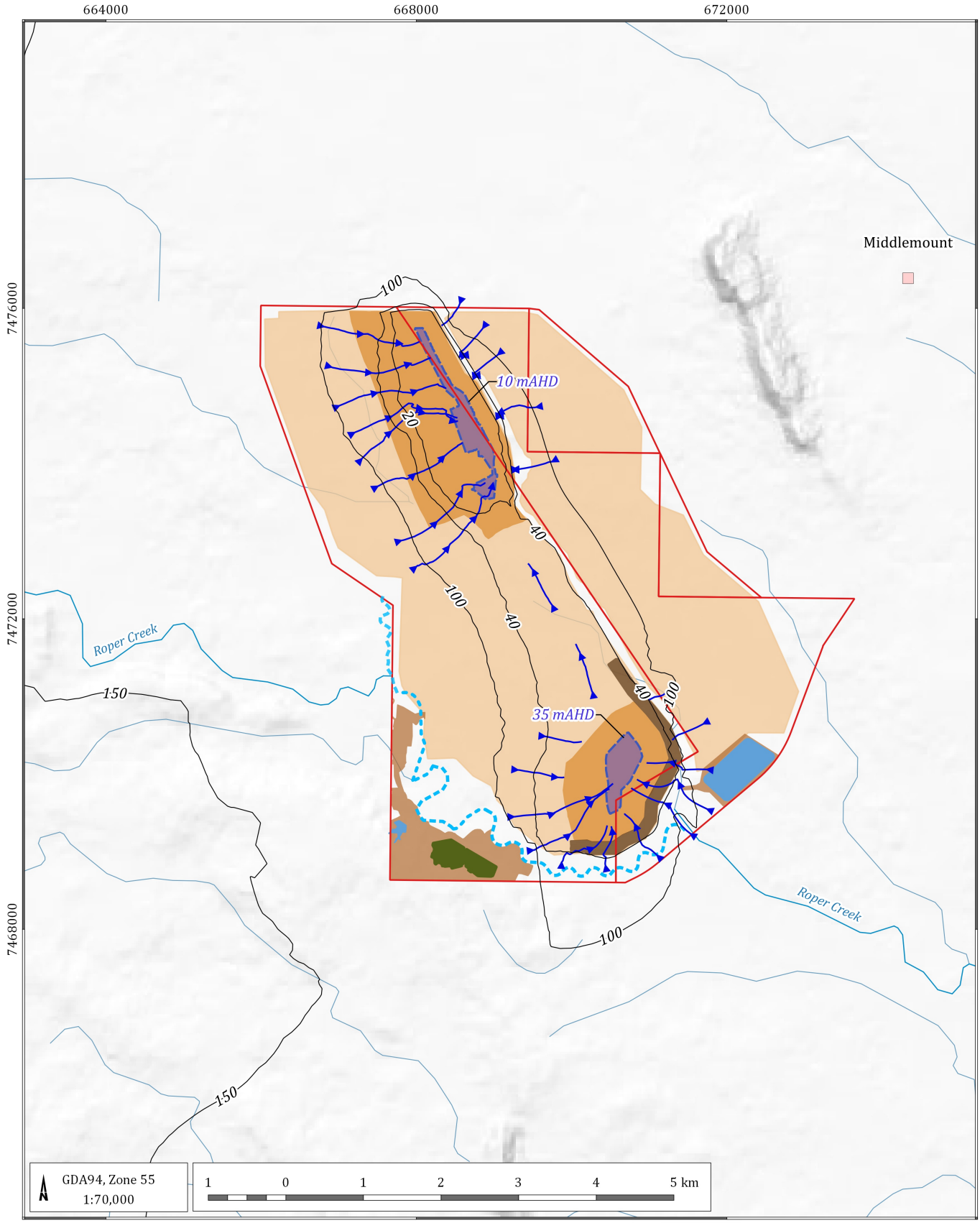
The calibration hydrographs for the site monitoring bores are shown in Appendix F1, which presents the calibration data in context with the overall predicted drawdown for each monitoring bore. These show a reasonably good match between the predicted and observed groundwater levels and trends with exception to bore MW01, where the predicted drawdown response did not replicate the observed rise in groundwater levels between 2013 and 2015 (when this bore was mined out and destroyed). This monitoring bore was located near the confluence of Drainage lines 1 and 2, in an area where surface water periodically ponds along the western side of the open cut pit. This interaction between surface water and groundwater (at a local scale) is not represented in the groundwater model as the creeks are ephemeral and the groundwater table is located generally below the creek bed (refer Section F4.2).

The Australian Modelling Guidelines (Barnett *et al*, 2012) suggest a SRMS of 10% or lower constitute a reasonably well calibrated model. This model meets this criterion. Additionally, the generally good match between the predicted and observed groundwater levels and trends suggests an acceptable model calibration. More widespread observation data around the model domain which could support the simulation of non-homogeneous hydraulic parameters would be necessary for a better match of the observed data while still retaining the prediction capacity.

F6 Groundwater fate modelling

Particle tracking was used to identify the likely travel paths of water particles surrounding the North and South Voids post closure for the Project. Points were placed around the two void lake footprints and simulated over a 10,000 year period (post mining) to simulate the path line a water particle would travel based on the gradients surrounding the final voids.

This analysis shows the particles positioned surrounding each void essentially track forwards radially towards each void (see Figure F 6.1), regardless of the length of the particle tracking timeframe. That is, the mine voids remain groundwater sinks in perpetuity post mining, with seepage draining from with the surrounding aquifers towards the two mine voids. No particles of water within the mine voids migrate away from the Project area.



LEGEND

- Populated place
- Drainage feature
- Contour line
- Particle trace
- Watercourse Diversion
- Mining Lease boundary (ML)

Mine infrastructures

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

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Particle tracking – Steady state

DATE 27/08/2020

FIGURE No: **F 6.1**

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G:\Projects\G1840P.Middlemount Southern Extension\3_GIS\Workspaces\001_Deliverable1\F-6.1_G1840P_Particle tracking – Steady state.qgs

F7 Uncertainty analysis

Uncertainty analysis was undertaken for the Middlemount Southern Extension Project. As the modelling for the Southern Extension merely involves a minor change to the mine footprint and utilises the same model parameters (except for the specific storage adjustments) and assumptions as the previous modelling, the uncertainty analysis that was previously undertaken is still considered a valid assessment. The previous analysis provides a reasonable assessment of the likely variability in model predictions, and so is reproduced below with the updated predicted basecase outputs superimposed.

Groundwater models represent complex environmental systems and processes in a simplified manner. This means that predictions from groundwater models, like so many other environmental models are inherently uncertain. The preceding sections highlight uncertainties in model inputs and the necessary simplifications within models to represent natural systems. National modelling guidelines encourage the acknowledgement of uncertainty and suggest methods to formulate predictions in which uncertainties are minimised. Barnett *et al* (2012) recommend uncertainty in model predictions can be quantified using linear or non-linear methods. The sections below describe the methodology and results of the uncertainty analysis.

F7.1 Methodology

A pseudo Null-space Monte Carlo uncertainty analysis was undertaken to quantify the magnitude of uncertainty in the future impacts predicted by the model. This type of analysis produces probability distributions for predictive impacts by assessing a composite likelihood of an impact occurring by assessing and ranking the predictions from hundreds of model 'realizations'. Each model realisation is informed by the observation dataset by using the relationship between the observations statistics to perturbations of each parameter in the groundwater model. The approach is described as a 'pseudo' Null-space Monte Carlo simply because this model did not utilise a 'highly parameterised inversion' approach, whereby pilot points are used extensively across the model as to not introduce artificial sensitivity (and consequently 'certainty') to small changes to homogenous aquifer units. To compensate, 'posterior' or post-calibration parameter ranges were informed by the Jacobian matrix, but were manually inspected and adjusted where posterior ranges appeared artificially constrained.

F7.2 Parameter generation

To undertake this type of analysis it is necessary to firstly quantify the parameter variability based on our prior knowledge about parameters. This requires specifying a distribution and range for each parameter, which is referred to as the "prior uncertainty range". Table F 7.1 to Table F 7.5 shows the 'prior' range explored for the Project. Each parameter is assumed to be log-normally distributed around the optimum value derived from calibration, and spreads gradually over the upper and lower bounds. The next step is to constrain the prior uncertainty range using information from the calibration matrix. This is achieved using Predunc7 utility from calibration and uncertainty software PEST (Doherty, 2010). In summary, PEST (Predunc7 utility) uses the prior parameter distribution and parameter sensitivities and provides a constrained parameter range which is known as "posterior uncertainty range". Appendix F2 presents the prior and posterior parameter distributions and ranges.

Table F 7.1 Prior uncertainty range - Horizontal hydraulic conductivity

Model layer	Lithology	Horizontal hydraulic K m/day (lower)	Horizontal hydraulic K m/day (optimum)	Horizontal hydraulic K m/day (upper)
1	Alluvium	0.01	0.75	10
2	Tertiary	0.001	0.75	5
3	Weathered Zone (Rangal Coal Measures)	0.001	0.1	1
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-6	1.00E-04	1.00E-03
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-2	0.37	5
6, 13	Rangal Coal Measures – interburden	1.00E-07	6.03E-06	1.00E-04
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-02	0.15	5
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-07	5.43E-05	1.00E-04
9, 16	Fort Cooper Coal Measures – Burngrove Formation	1.00E-06	7.20E-05	1.00E-03
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	1.00E-06	3.59E-04	1.00E-03

Table F 7.2 Prior uncertainty range - Vertical hydraulic conductivity

Model layer	Lithology	Vertical hydraulic conductivity (Kv) multiplier (lower)	Vertical hydraulic conductivity (Kv) multiplier (optimum)	Vertical hydraulic conductivity (Kv) multiplier (upper)
1	Alluvium	0.001	8.49E-02	1
2	Tertiary	0.001	7.29E-02	1
3	Weathered Zone (Rangal Coal Measures)	0.001	0.139	1
4, 11	Rangal Coal Measures – overburden Rewan Formation	0.001	0.217	1
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	0.001	0.405	1

Model layer	Lithology	Vertical hydraulic conductivity (Kv) multiplier (lower)	Vertical hydraulic conductivity (Kv) multiplier (optimum)	Vertical hydraulic conductivity (Kv) multiplier (upper)
6, 13	Rangal Coal Measures – interburden	0.001	5.38E-03	1
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	0.001	0.862	1
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	0.001	7.70E-02	1
9, 16	Fort Cooper Coal Measures – Burngrove Formation	0.001	0.901	1
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	0.001	5.74E-02	1

Table F 7.3 Prior uncertainty range - Specific yield

Model layer	Lithology	Specific yield - Sy (lower)	Specific yield - Sy (optimum)	Specific yield - Sy (upper)
1	Alluvium	0.001	2.00E-02	0.1
2	Tertiary	0.001	2.00E-02	0.1
3	Weathered Zone (Rangal Coal Measures)	0.001	1.00E-02	0.1
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-03	1.00E-02	5.00E-02
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-03	1.00E-02	5.00E-02
6, 13	Rangal Coal Measures – interburden	1.00E-03	1.00E-02	5.00E-02
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-03	1.00E-02	5.00E-02
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-03	1.00E-02	5.00E-02
9, 16	Fort Cooper Coal Measures – Burngrove Formation	1.00E-03	1.00E-02	5.00E-02
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	1.00E-03	1.00E-02	5.00E-02

Table F 7.4 Prior uncertainty range - Specific storage

Model layer	Lithology	Specific Storage m^{-1} (lower)	Specific Storage m^{-1} (optimum)	Specific Storage m^{-1} (upper)
1	Alluvium	5.00E-06	6.40E-05	5.00E-04
2	Tertiary	5.00E-06	1.76E-05	5.00E-04
3	Weathered Zone (Rangal Coal Measures)	5.00E-06	5.00E-05	5.00E-04
4, 11	Rangal Coal Measures – overburden Rewan Formation	1.00E-07	1.00E-06	1.00E-05
5, 12	Rangal Coal Measures – Middlemount coal seam Leichhardt coal seam	1.00E-07	1.00E-06	1.00E-05
6, 13	Rangal Coal Measures – interburden	1.00E-07	1.00E-06	1.00E-05
7, 14	Rangal Coal Measures – Pisces coal seam Vermont coal seam	1.00E-07	1.00E-06	1.00E-05
8, 15	Rangal Coal Measures – strata underlying Pisces and Vermont coal seams	1.00E-07	1.00E-06	1.00E-05
9, 16	Fort Cooper Coal Measures – Burngrove Formation	5.00E-06	8.42E-05	5.00E-04
10, 17	Fort Cooper Coal Measures – Fair Hill Formation	5.00E-06	8.21E-05	5.00E-04

Table F 7.5 Prior uncertainty range - Recharge

Model layer	Lithology	Recharge factor (lower)	Recharge factor (optimum)	Recharge factor (upper)
1, 2,	Alluvium and Tertiary	0.01	1	10

The posterior range and optimum values were used to generate random realisations. In summary, a total of 500 realisations were generated using a random parameter generator for which the model was run for each realisation. The 500 model runs were tested against the objective function to derive a threshold for model 'de-calibration'. Versions of the model that exceeded this threshold were assumed to be sufficiently un-calibrated, and hence were omitted from the uncertainty analysis. A threshold objective function of 1,200 m^2 was applied, which represented an increase of around 20% over the optimal solution. Of these 500 model runs, 304 versions had an objective function less than the threshold, which were included in the analysis. The remaining 196 simulations were removed from the analysis because they did not meet the criteria.

F7.3 Results

As discussed above, a total of 304 models achieved model convergence and produced acceptable calibration statistics. A summary of the calibration performance and predictive uncertainty is provided in Appendix F3. The hydrographs show the composite distribution of the heads across all 304 realisations and indicate that the majority of the models are acceptably calibrated.

F7.3.1 Predicted groundwater inflow

Figure F 7.1 presents the uncertainty of Permian groundwater inflow into the approved mining and the Project from 2011 to 2037. Added to this figure is the current predicted inflow for the Southern Extension Project. This demonstrates that while the uncertainty has not been simulated for this model update, the inflow has not varied significantly away from the Western Extension Project inflows (AGE, 2018) and the potential range arising from the updated inflows are likely to be very similar to the previous analysis.

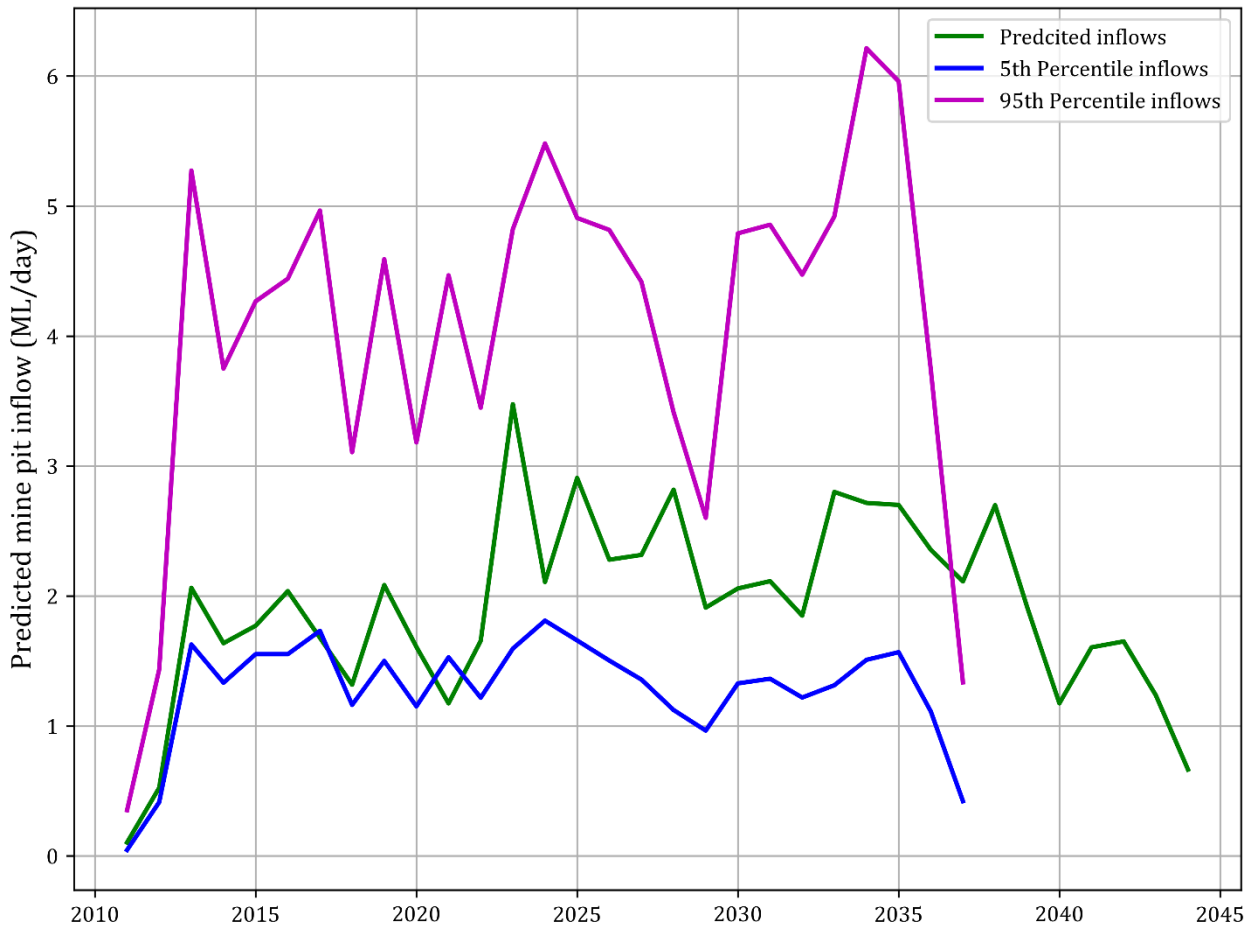


Figure F 7.1 Predicted Project groundwater inflow uncertainty

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

Table F 7.6 Predicted groundwater inflow – 2011 to 2037

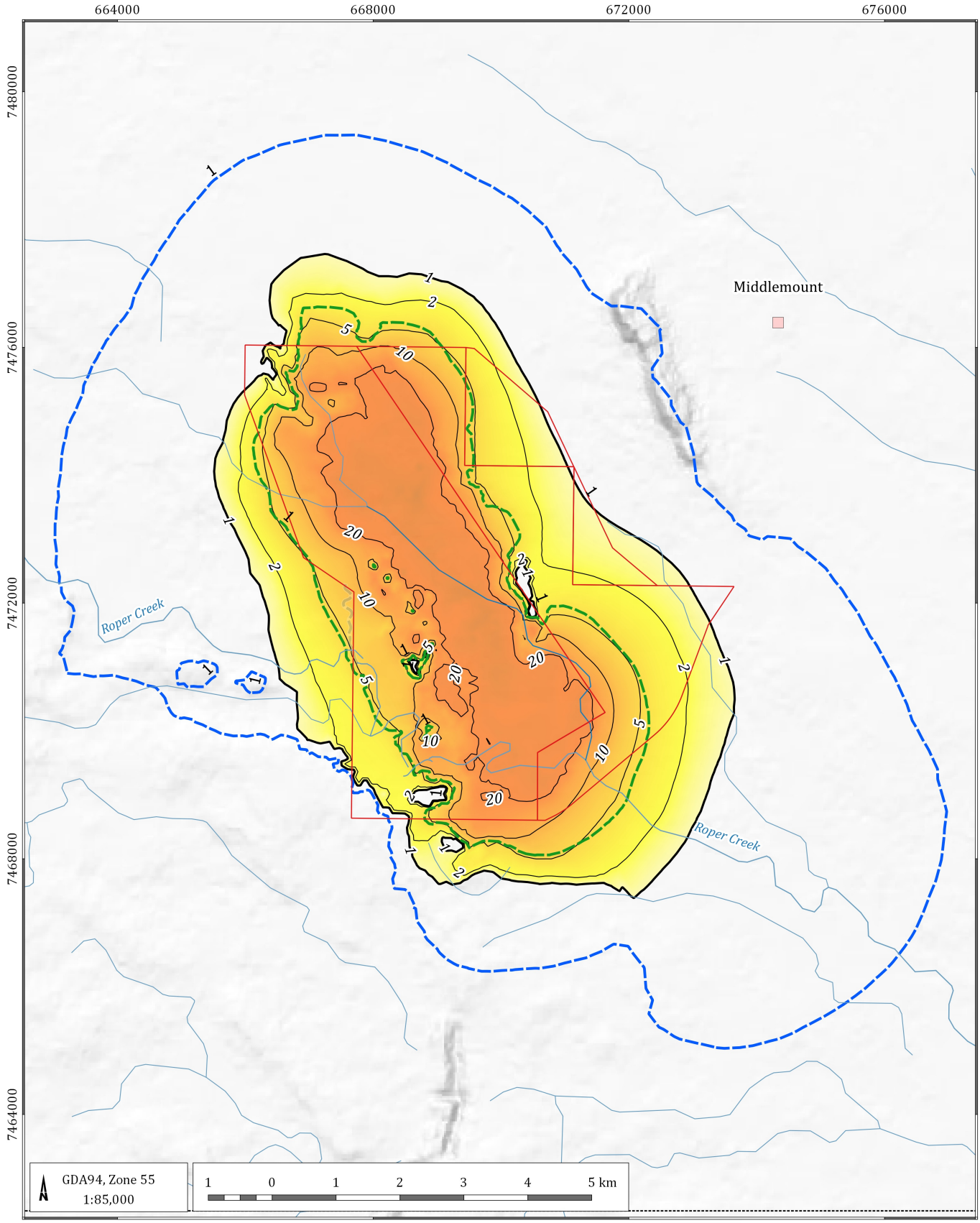
Year	Groundwater inflow (P05)	Groundwater inflow (Calibration)	Groundwater inflow (P95)
2011	0.05	0.1	0.35
2012	0.41	0.5	1.44
2013	1.63	2.1	5.27
2014	1.33	1.6	3.75
2015	1.55	1.8	4.27
2016	1.55	2.0	4.44
2017	1.73	1.7	4.97
2018	1.16	1.3	3.11
2019	1.50	2.1	4.59
2020	1.15	1.6	3.18
2021	1.53	1.2	4.47
2022	1.22	1.7	3.45
2023	1.60	3.5	4.82
2024	1.81	2.1	5.48
2025	1.66	2.9	4.91
2026	1.50	2.3	4.82
2027	1.36	2.3	4.42
2028	1.12	2.8	3.41
2029	0.97	1.9	2.60
2030	1.33	2.1	4.79
2031	1.36	2.1	4.86
2032	1.22	1.8	4.47
2033	1.31	2.8	4.92
2034	1.51	2.7	6.22
2035	1.57	2.7	5.96
2036	1.11	2.4	3.74
2037	0.42	2.1	1.34
2038	--	2.7	--
2039	--	1.9	--
2040	--	1.2	--
2041	--	1.6	--
2042	--	1.7	--
2043	--	1.2	--
2044	--	0.7	--
Max	**1.81**	**3.5**	**6.22**

F7.3.2 Groundwater drawdown

To assess the level of uncertainty in the extent of predicted drawdown, the calibrated drawdown extent was compared to the 1m drawdown extent for the 5th and 95th drawdown percentiles. Figure F 7.2 to Figure F 7.4 present the uncertainty in maximum groundwater drawdown at any time during mining within the Tertiary and Weathered Zone (layers 2 and 3), Middlemount and Pisces Seams (layers 5 and 7). These figures also show the predicted drawdown for the Southern Extension Project.

Figure F 7.2 shows that the 95th drawdown percentile has a larger drawdown extent within the weathered layer compared to the calibrated case. In particular, the 1 m drawdown extent was mainly contained around the mine area in the calibrated case and with the 95th drawdown; the drawdown extends approximately 3 km east of the mine extent and approximately 4 km west and south of the open cut. Figure F 7.3 and Figure F 7.4 show that 95th percentile drawdown in the Middlemount and Pisces Seams occurs up to 1 km further south of calibrated case.

Comparison of the updated 1m drawdown results with the previous 5th and 95th drawdown percentiles shows that except for Pisces coal seam, in all the other layers the calibrated model predictions are largely bound by the previous uncertainty predictions. The further expansion of the 1 m drawdown in the Pisces seam is due to extended mine plan to the South of the Middlemount mine and longer dewatering of the coal seam up to 2044.



LEGEND

- Populated place
- Drainage feature
- Mining Lease boundary (ML)
- Model boundary

Drawdown (m)

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

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

Tertiary and weathered Permian (Layers 2 and 3) – Uncertainty of maximum zone of drawdown during mining

DATE 27/08/2020

FIGURE No: **F 7.2**

©2020 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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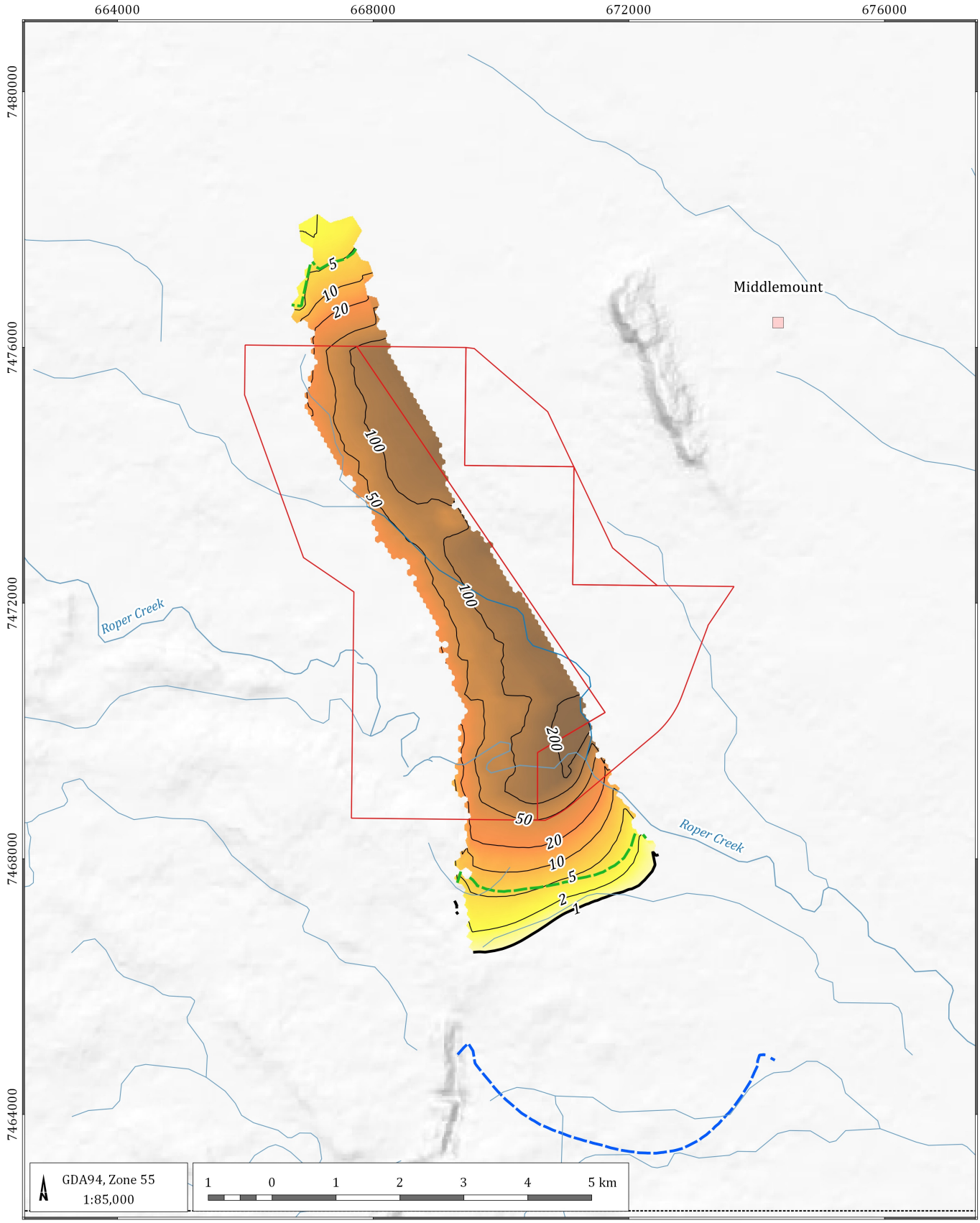

LEGEND

- Populated place
- Drainage feature
- Mining Lease boundary (ML)
- Model boundary

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- Drawdown contour (1 m)
- P05 drawdown contour (1 m)
- P95 drawdown contour (1 m)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 27/08/2020

FIGURE No: **F 7.3**

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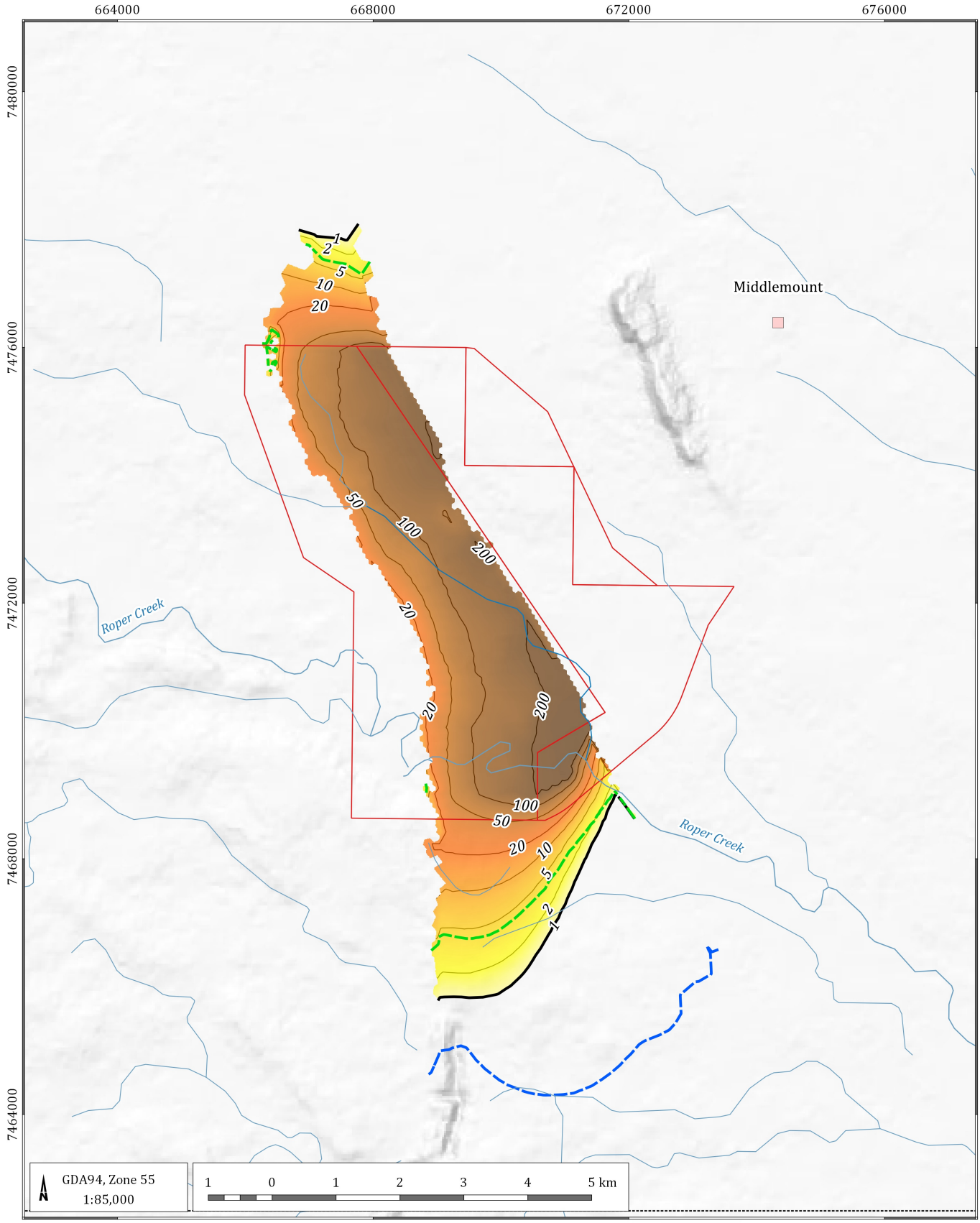

LEGEND

- Populated place
- Drainage feature
- Mining Lease boundary (ML)
- Model boundary

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- Drawdown contour (1 m)
- P05 drawdown contour (1 m)
- P95 drawdown contour (1 m)

Middlemount Coal Mine Southern Extension Project - GIA (G1840P)

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

DATE 27/08/2020

FIGURE No: **F 7.4**

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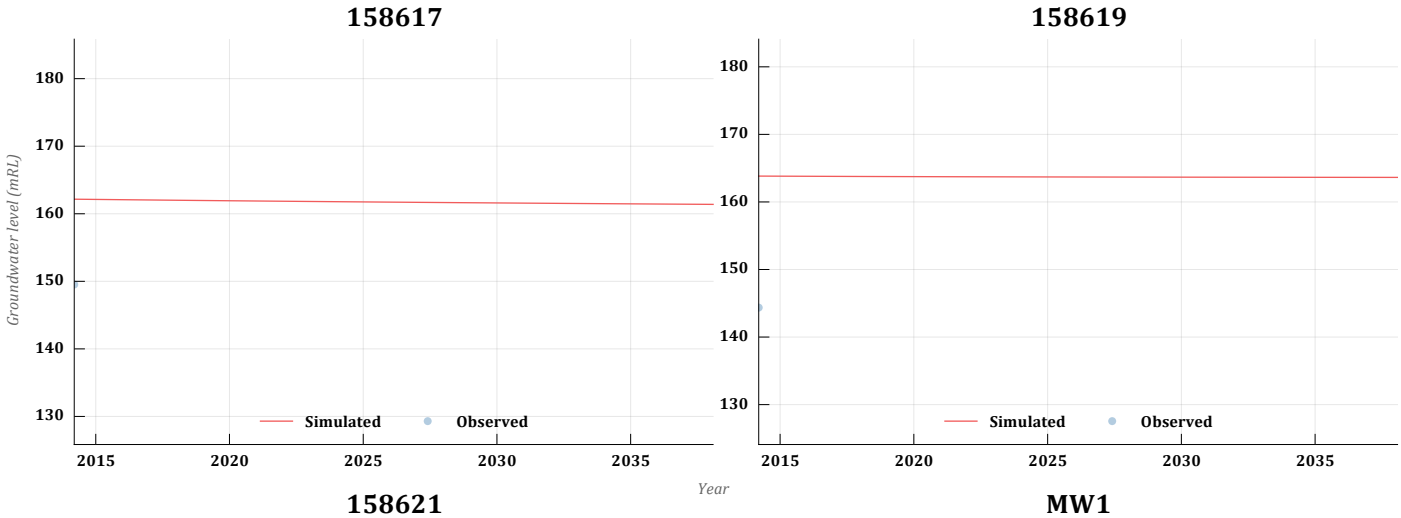
Appendix F1 Simulated and observed hydrographs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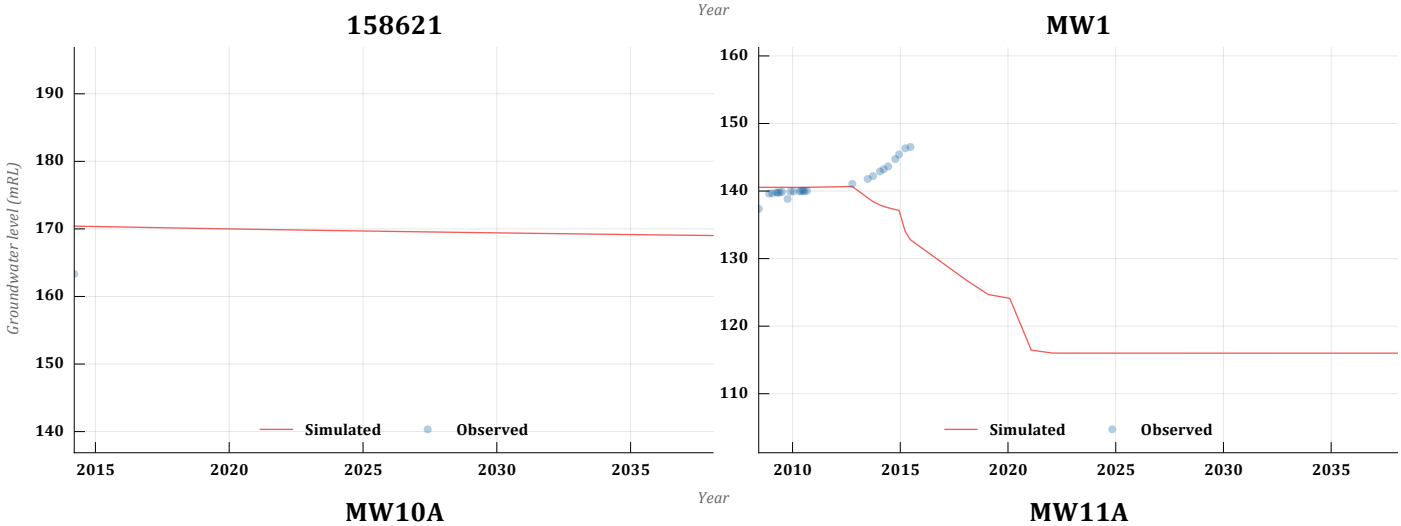
Groundwater level (mRL)
Simulated
Observed
Year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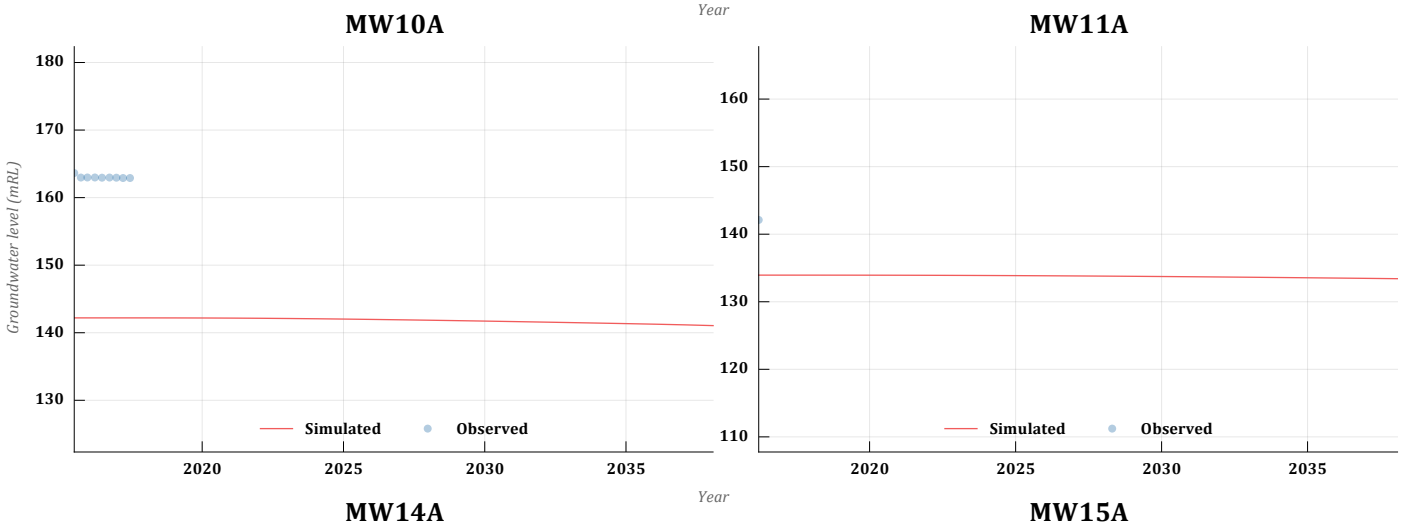
Simulated
Observed
Year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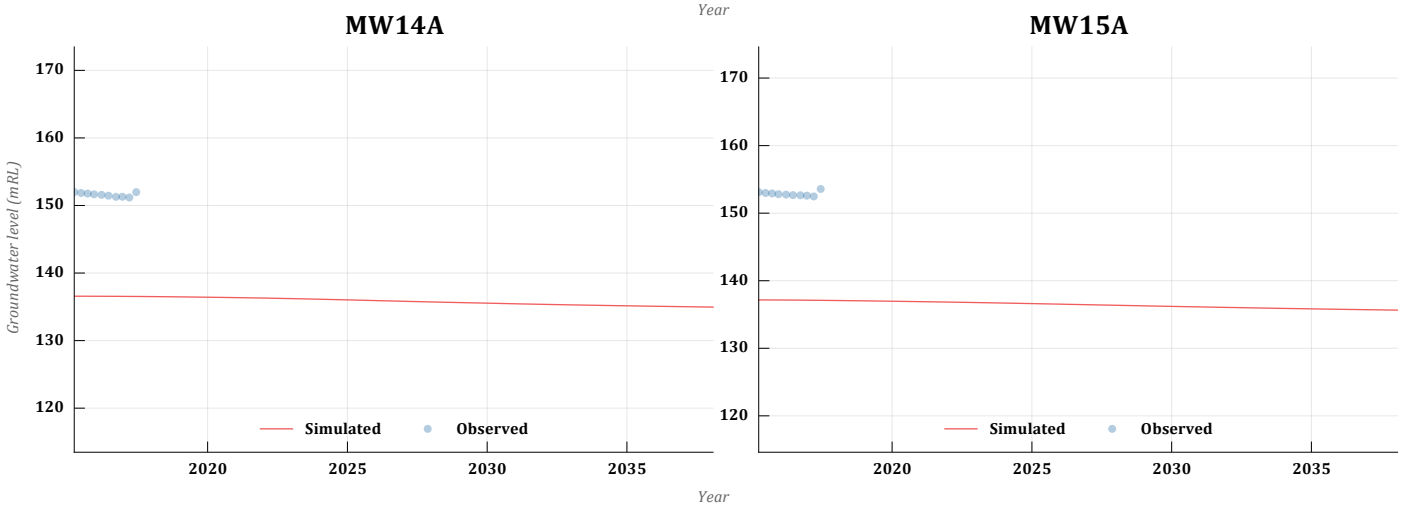
Simulated
Observed
Year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MW15A
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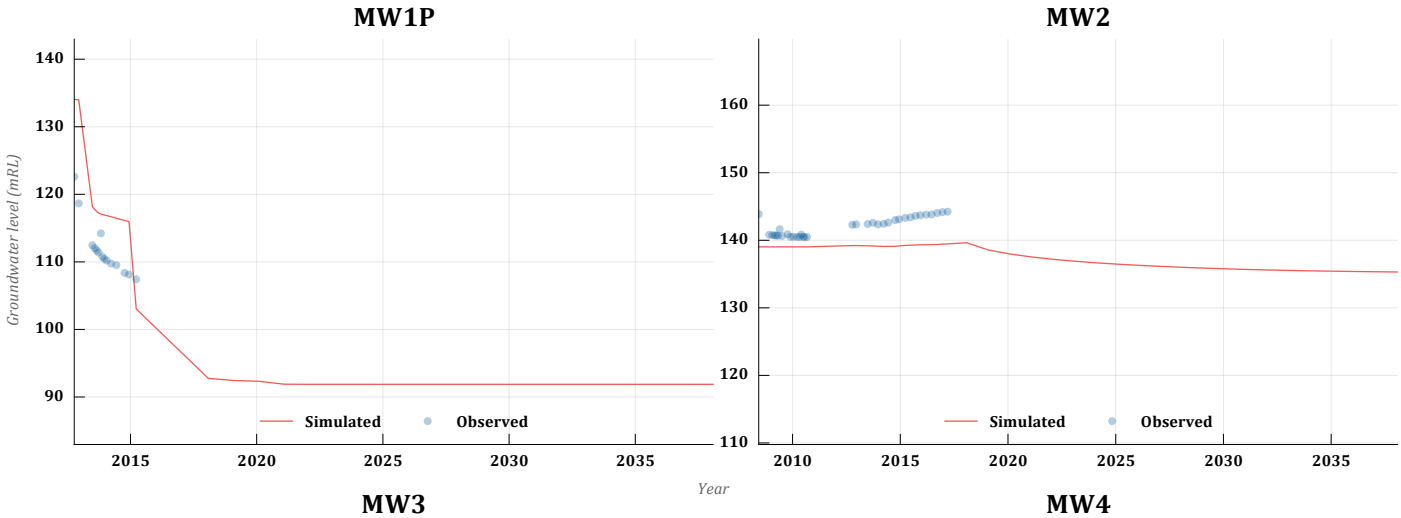
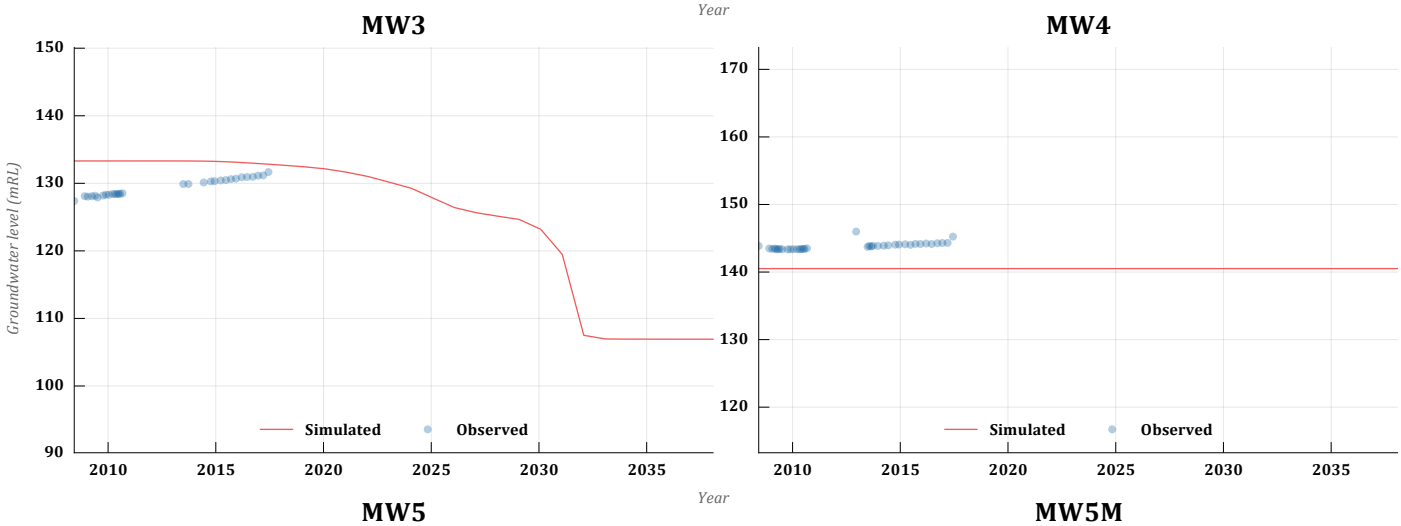
Simulated
Observed
Year



Year



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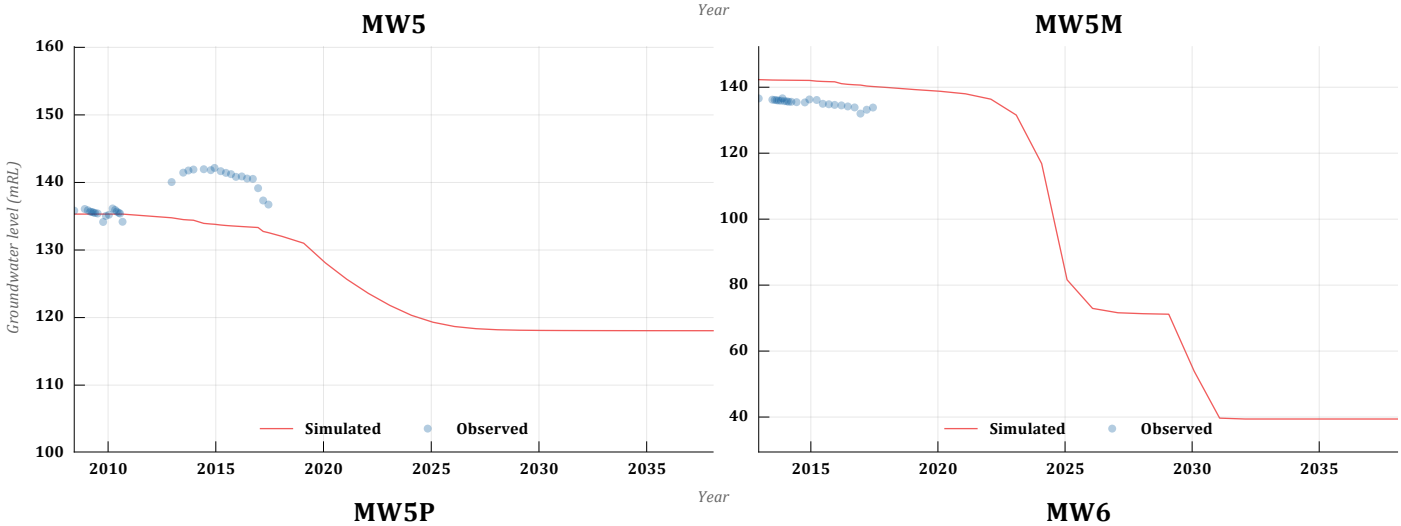

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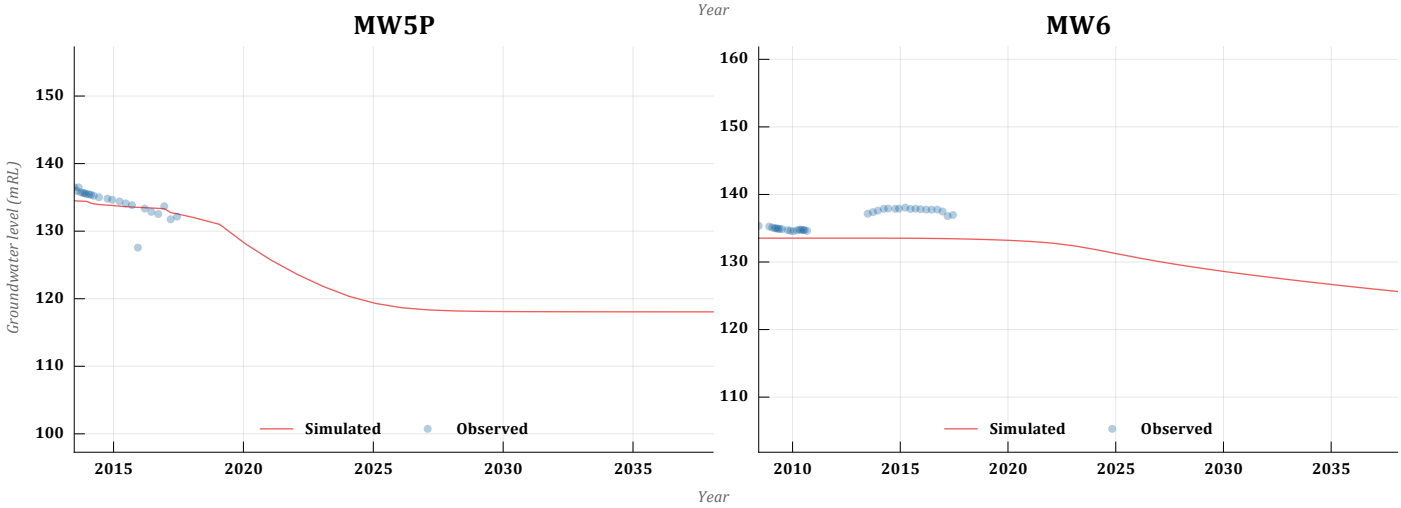

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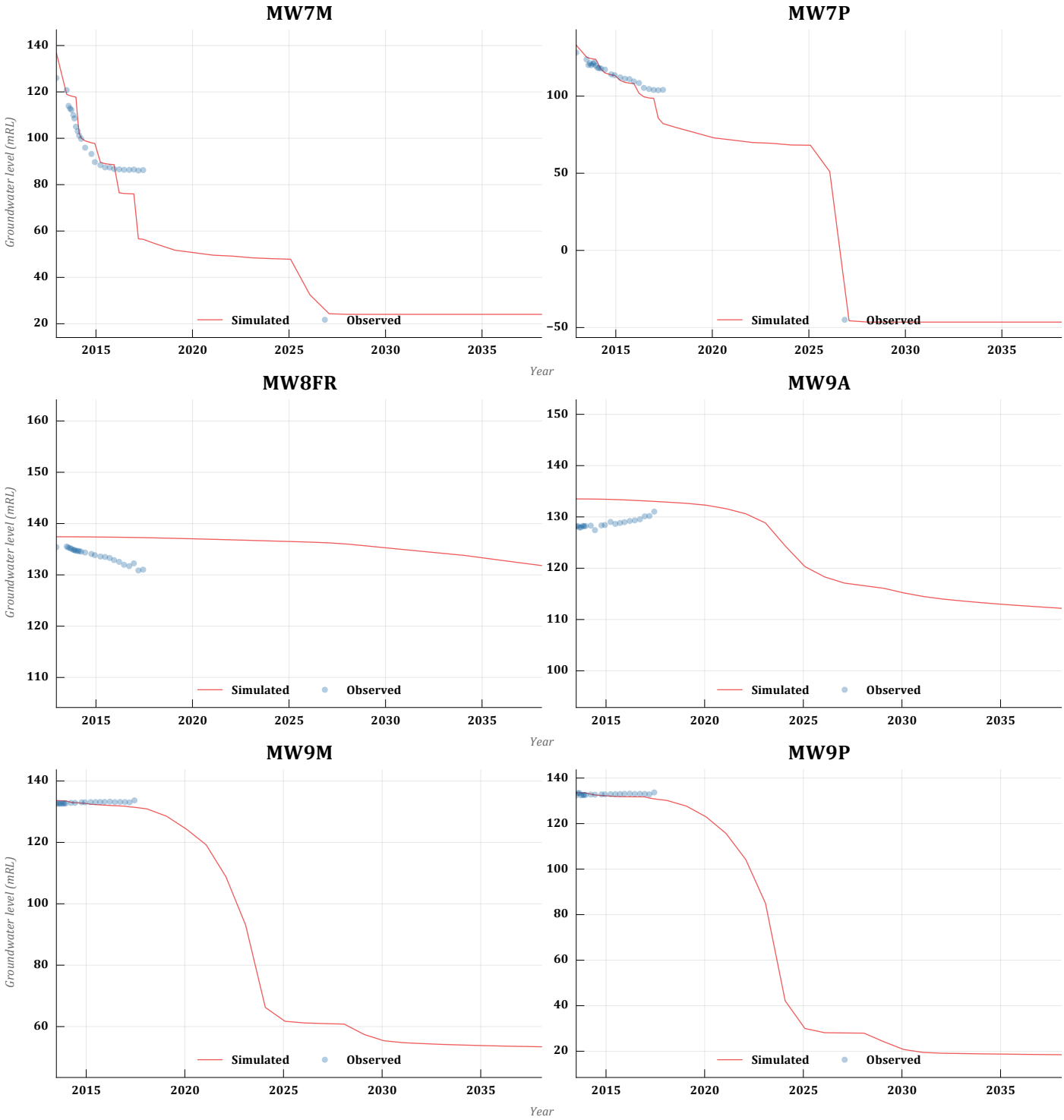
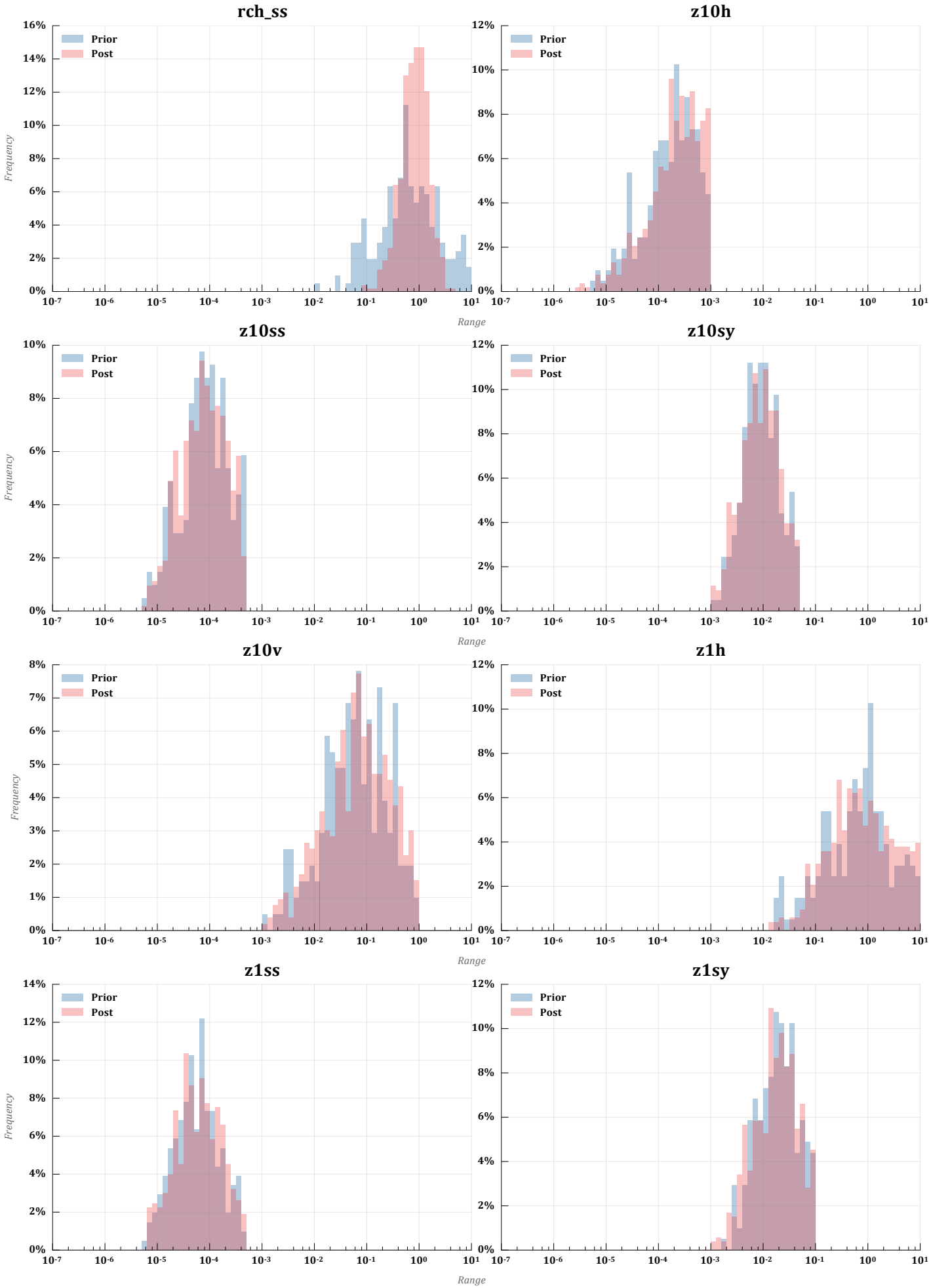

MW7M
MW7P
MW8FR
MW9A
MW9M
MW9P
Groundwater level (mRL)
Year
Simulated
Observed
2015
2020
2025
2030
2035

Appendix F2 Prior and posterior parameter distributions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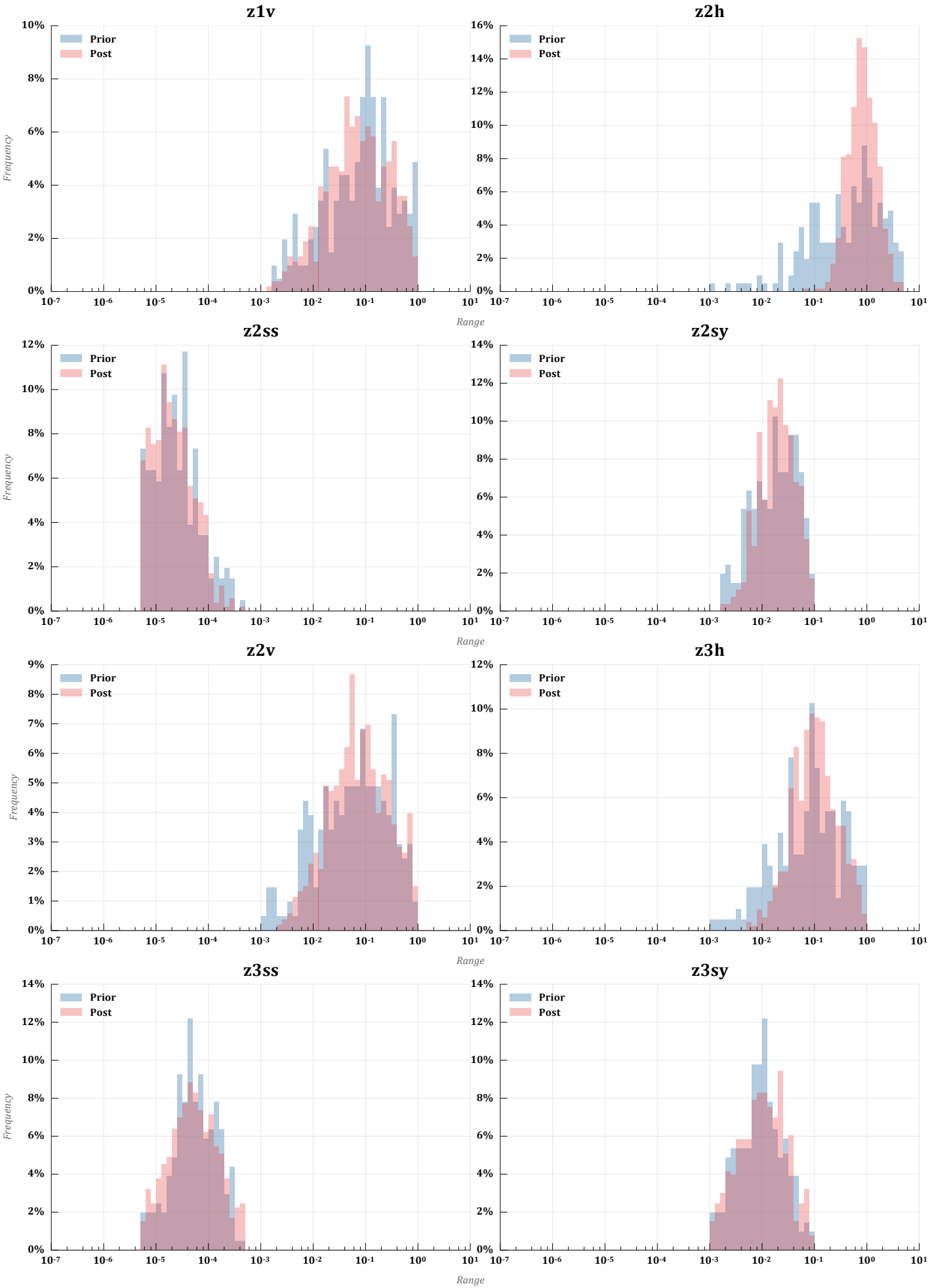
Prior
Post
Frequency
Range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Frequency
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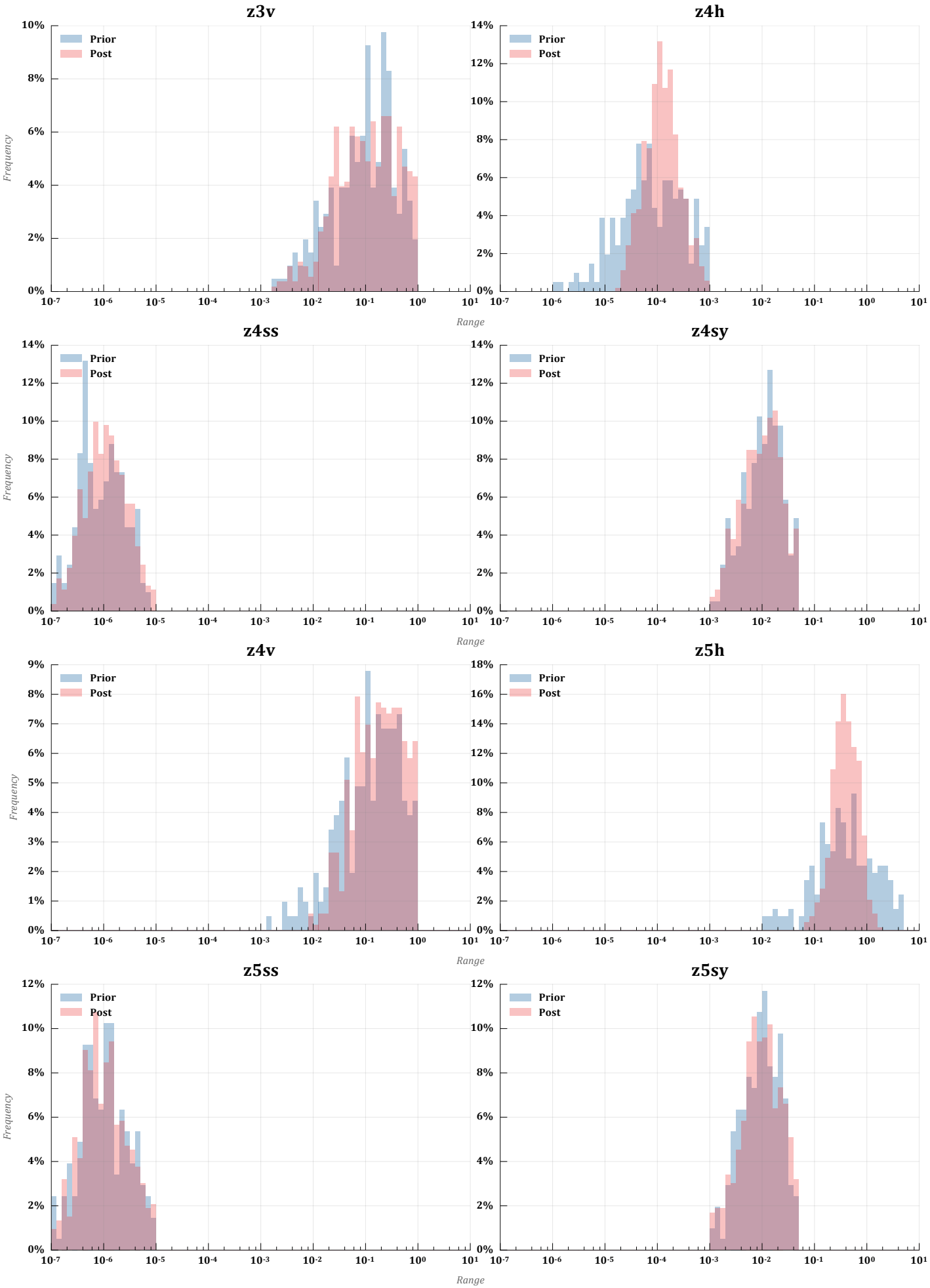
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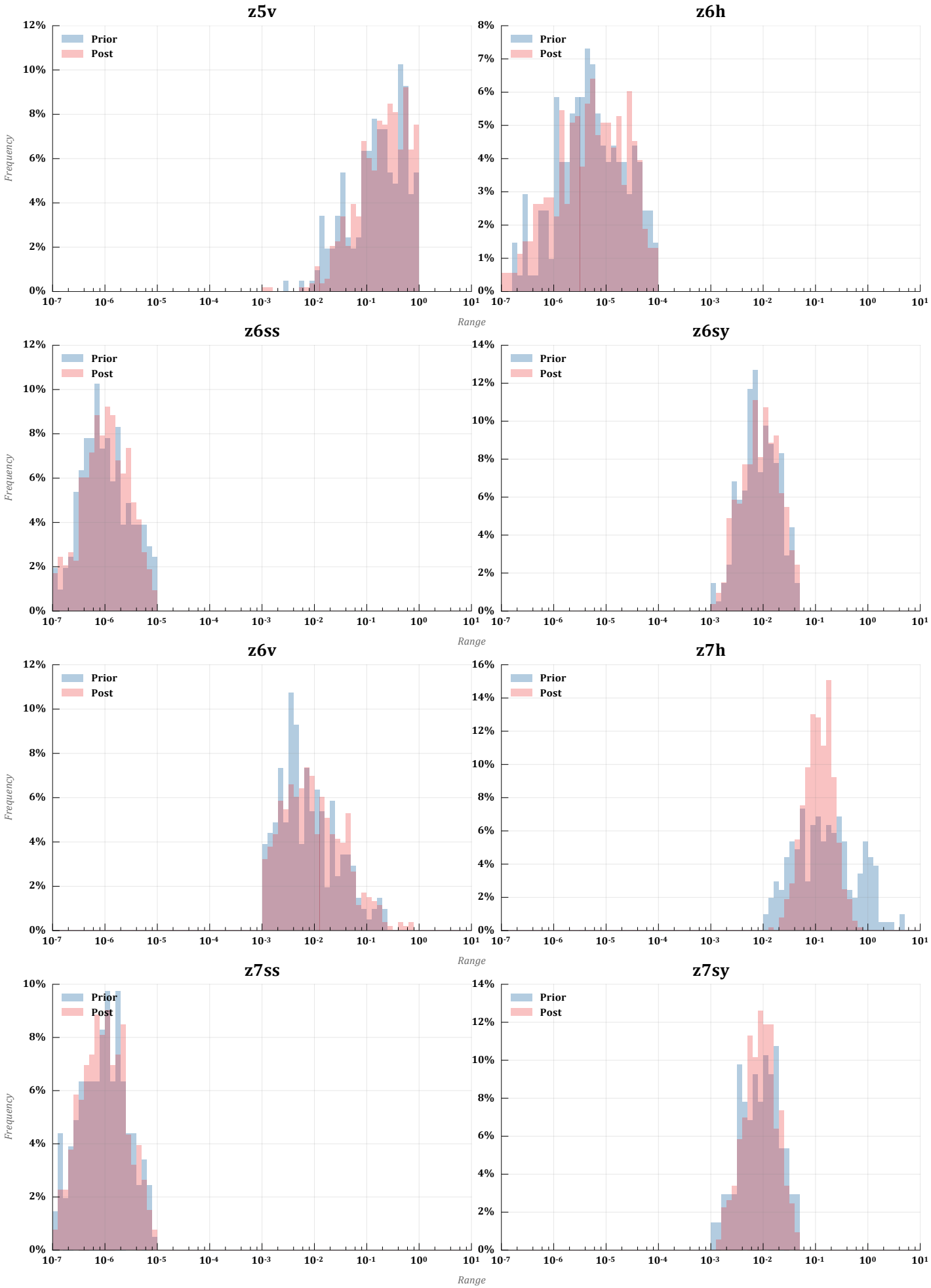
Frequency
Range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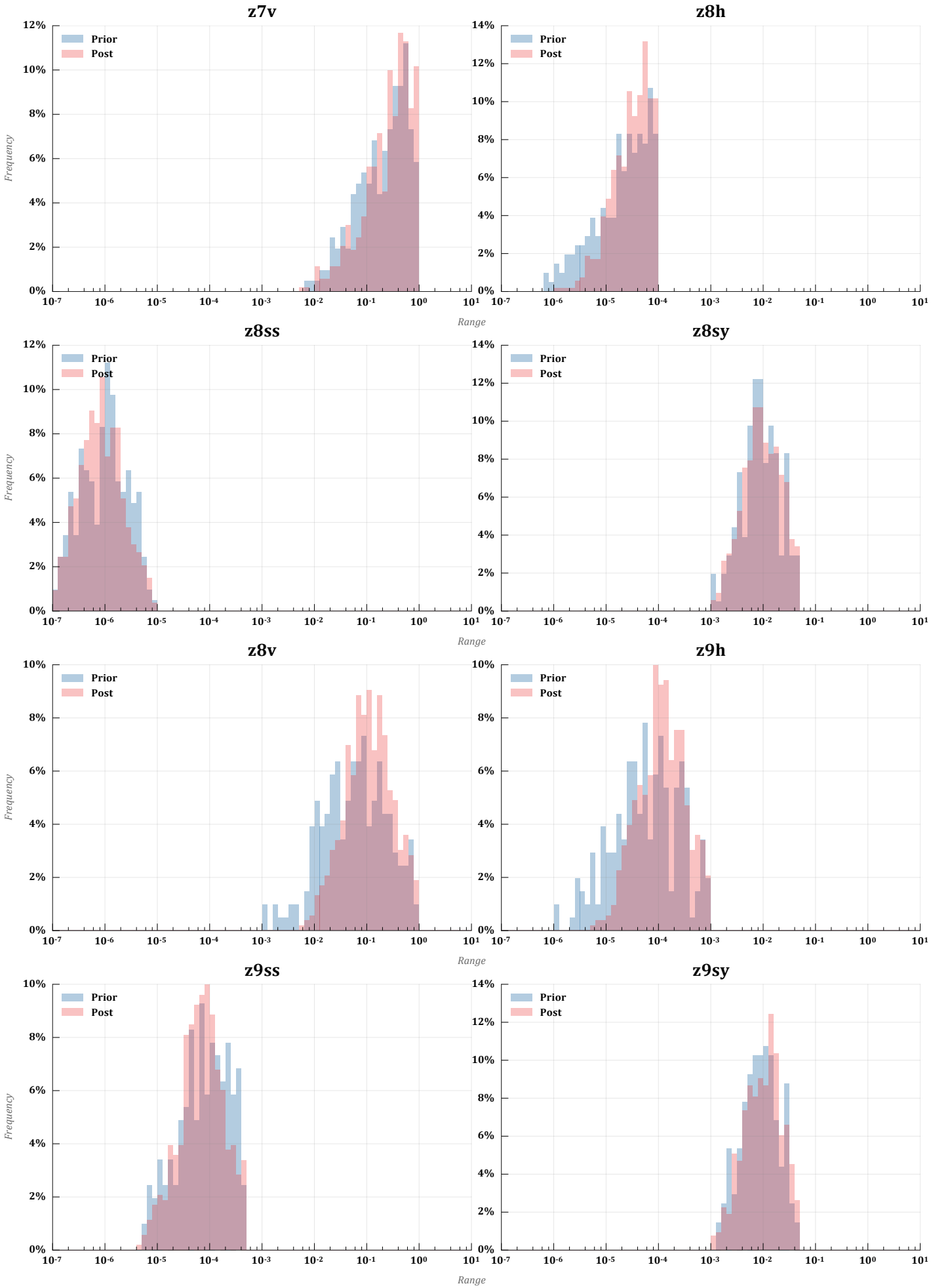
z6sy
z6v
z7h
z7ss
z7sy
Prior
Post
Frequency
Range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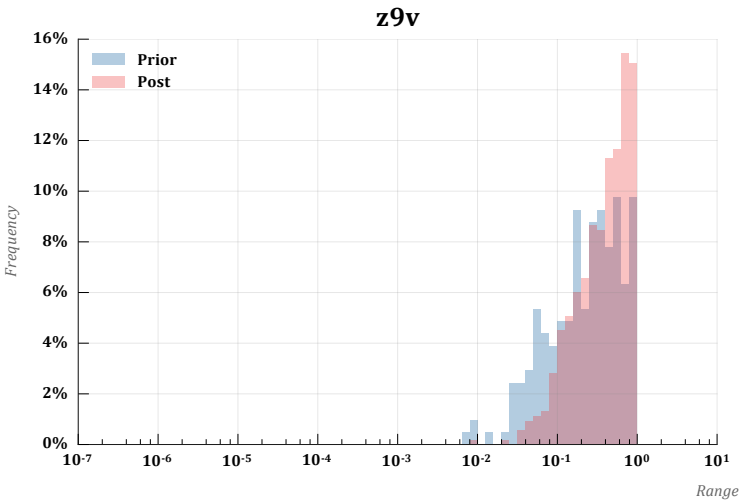
z8sy
z8v
z9h
z9ss
z9sy
Prior
Post
Frequency
Range


z9v
Prior
Post
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14%
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10%
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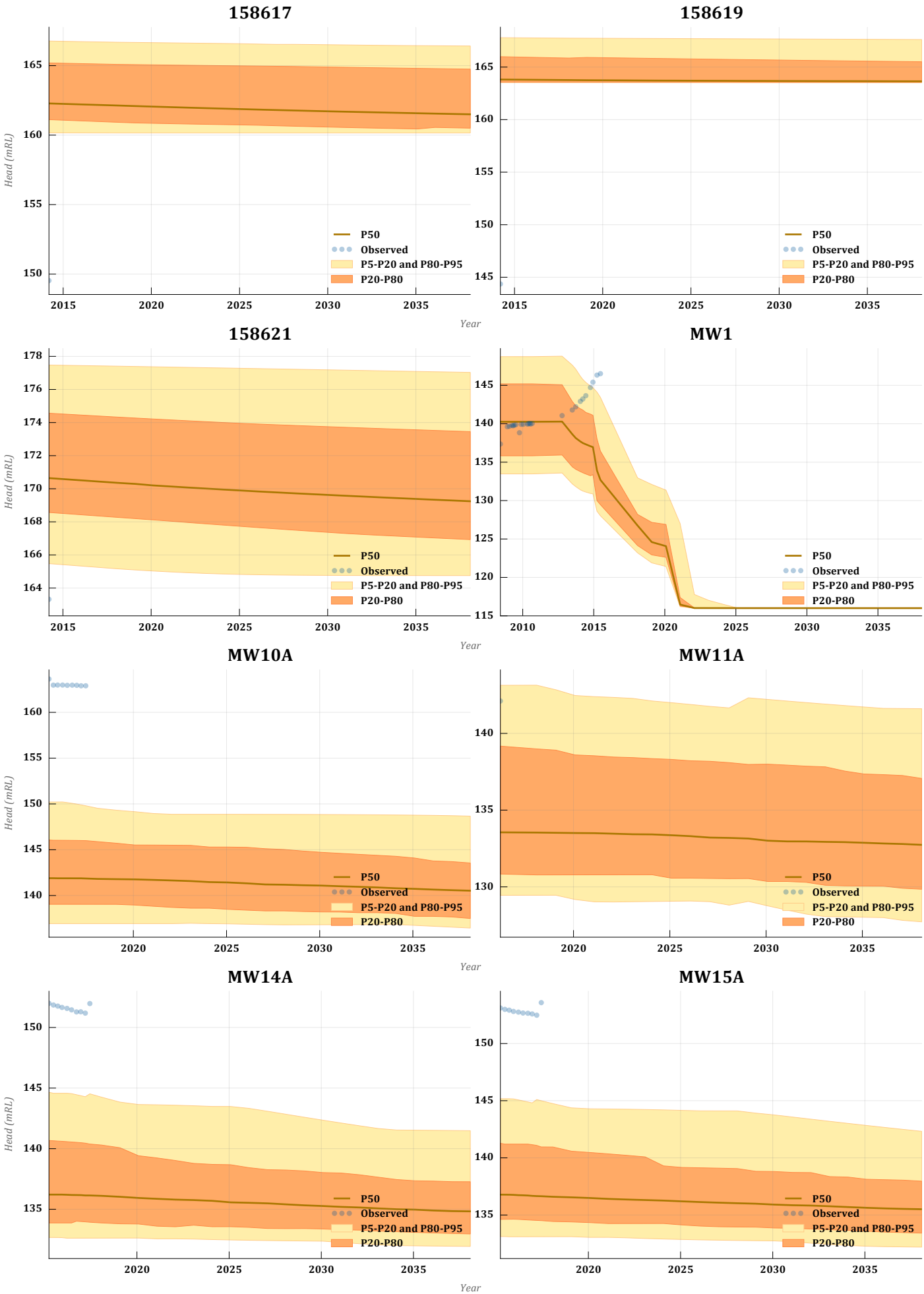
101
Range

Appendix F3 Predictive uncertainty hydrographs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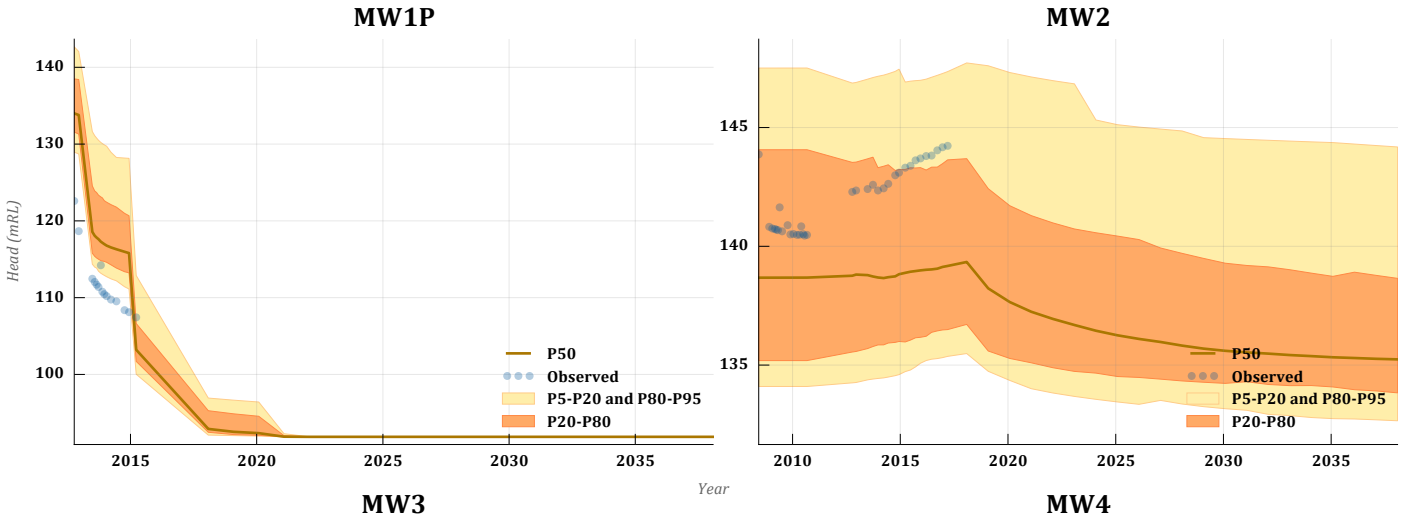
P20-P80



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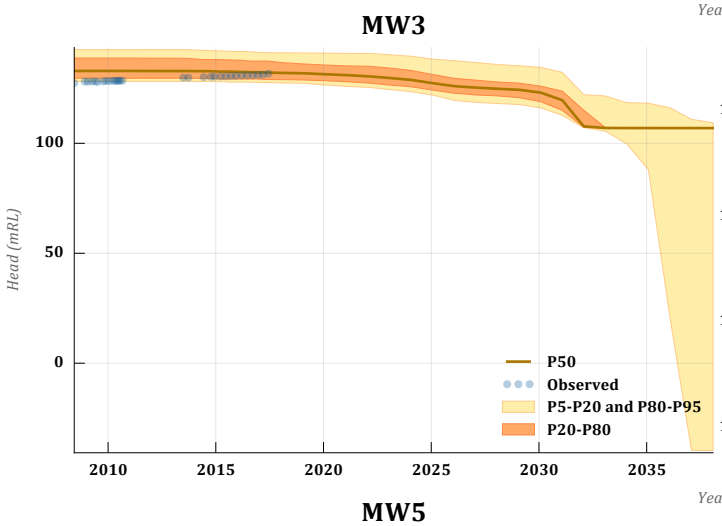

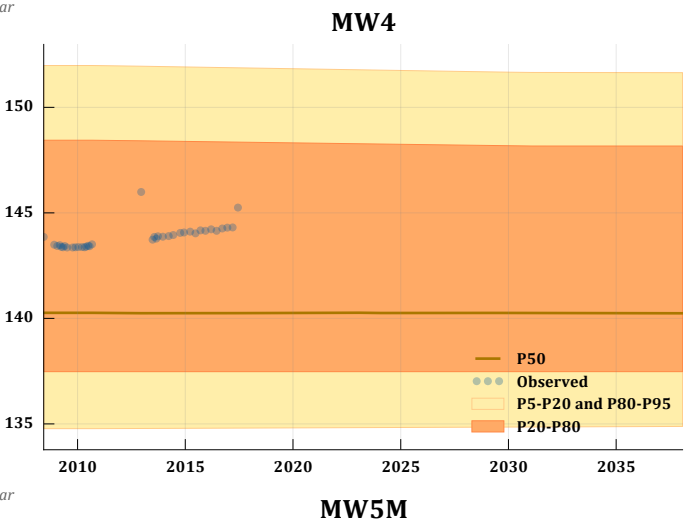

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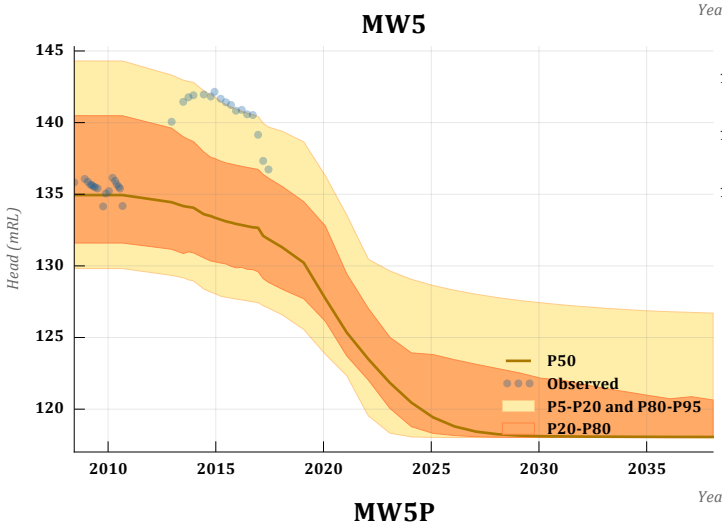

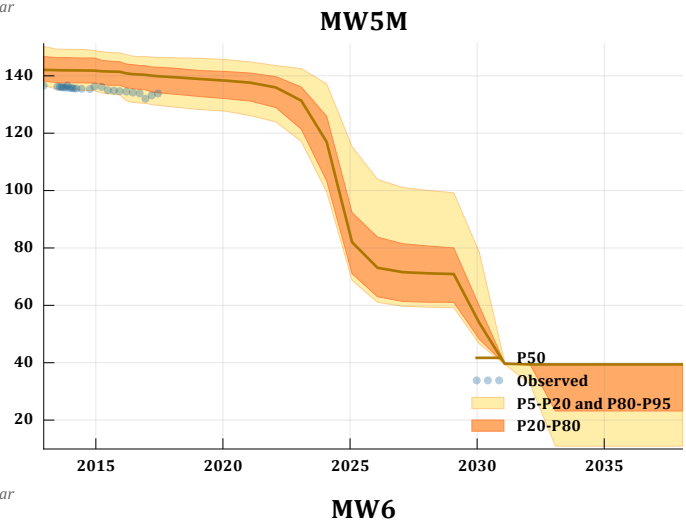

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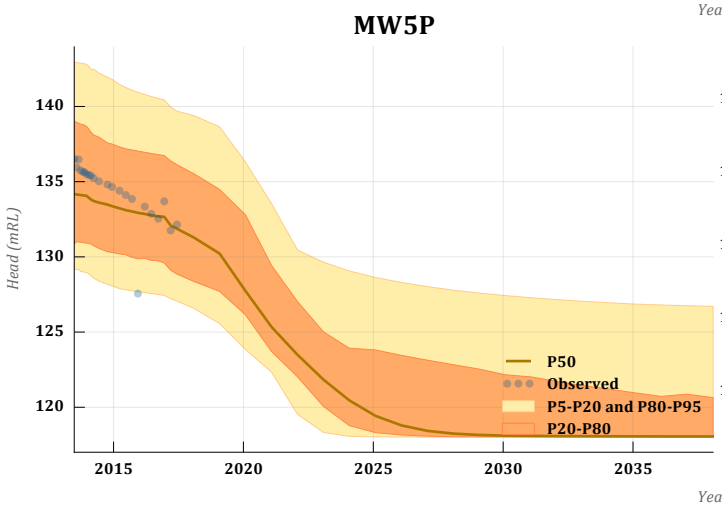

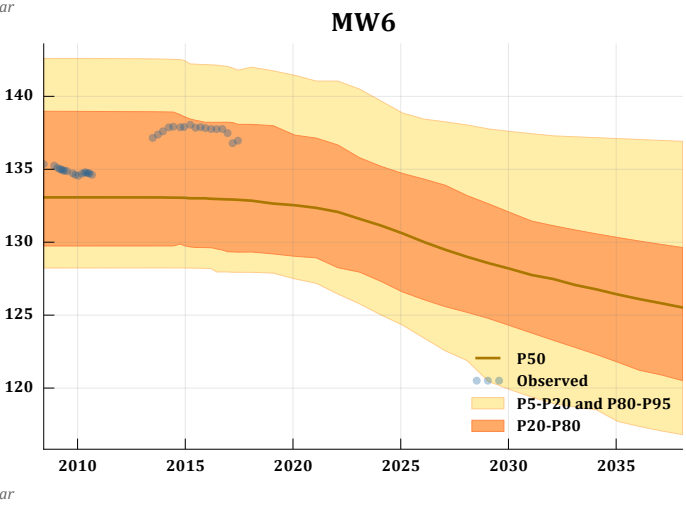

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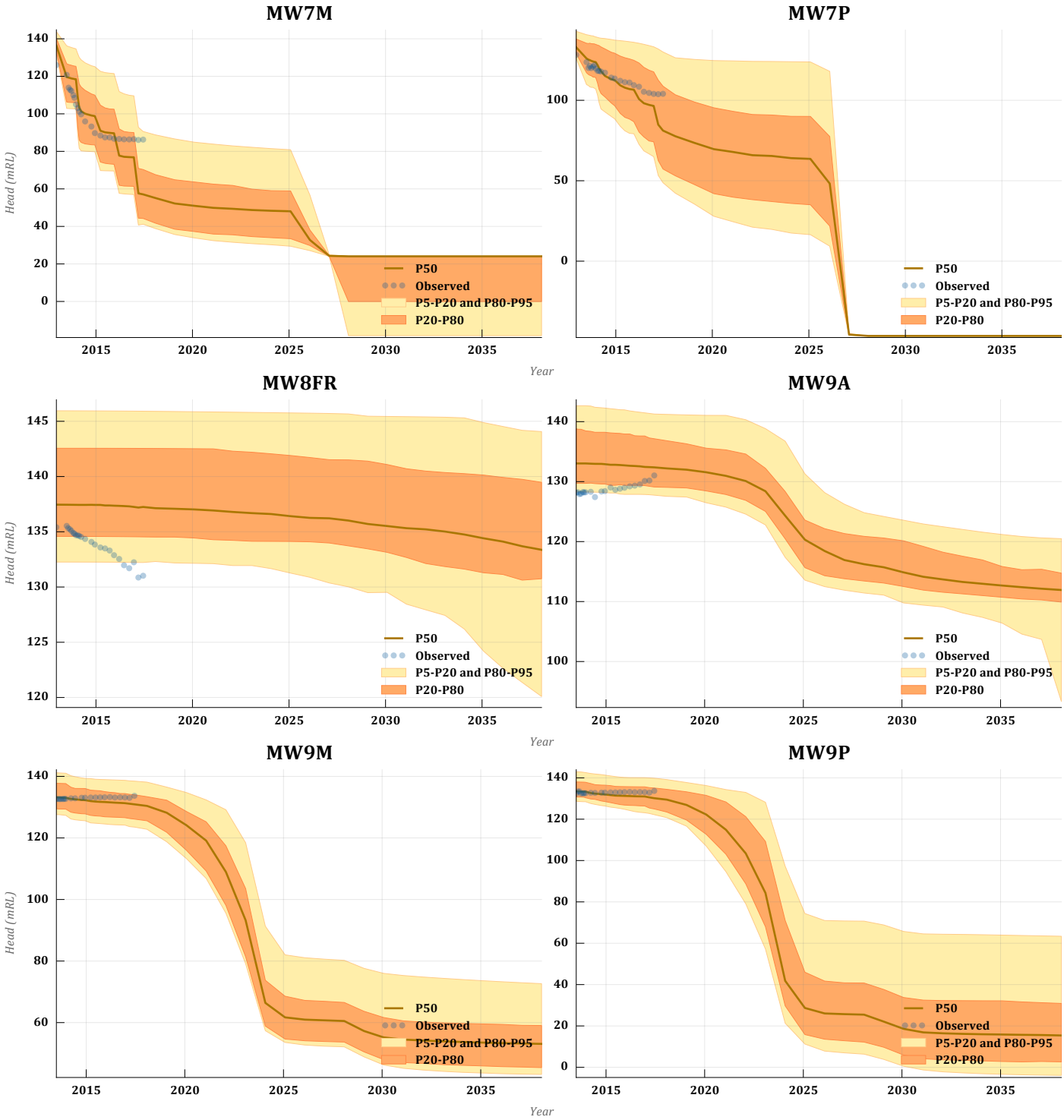
MW7M
MW7P
MW8FR
MW9A
MW9M
MW9P
Head (mRL)
Year
P50
Observed
P5-P20 and P80-P95
P20-P80
2015
2020
2025
2030
2035

Biodiversity AUSTRALIA

SUSTAINABLE PARTNERSHIPS
DEDICATED TO ACHIEVING
ECOLOGICAL AND ECONOMICAL BALANCE

LEADING THE WAY
IN ENVIRONMENTAL
MANAGEMENT

MIDDLEMOUNT COAL MINE
SOUTHERN EXTENSION PROJECT
TERRESTRIAL ECOLOGY

November 2020

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Executive Summary

Biodiversity Australia Pty Ltd was engaged by Middlemount Coal Pty Ltd (MCPL) to undertake terrestrial ecological surveys and to prepare an impact assessment for the proposed Middlemount Coal Mine Southern Extension Project (herein referred to as the Project). The main elements of the Project would include extension of the open cut pit to the south, re-positioning of the approved southern flood levee and water management infrastructure, realignment and extension of the eastern diversion of Roper Creek, minor extensions to waste rock emplacement footprint and changes to the final landform.

The primary outcomes of this terrestrial ecological assessment were to verify Regional Ecosystem (RE) mapping; identify any threatened species under the *Nature Conservation Act 1992* (NC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); identify and describe any Matters of State and National Environmental Significance; and identify proposed avoidance and mitigation measures to protect the natural values including consideration of biodiversity offset requirements.

Vegetation within the study area is characterised by a mix of remnant and non-remnant (regrowth and cleared areas) communities. The existing landform is generally flat with no significant geological features such as outcrops, cliff lines or escarpments. The main topographic feature of the study area is Roper Creek which is an ephemeral creek line. A second creek line, named Thirteen Mile Gully, feeds into Roper Creek in the study area.

Past agricultural land use has resulted in extensive clearing in the area and has introduced a number of threats to biodiversity such as weed invasion, feral species, edge effects and fragmentation. This is likely to have excluded many sensitive species from the area and reduced the ecological value for flora and fauna, especially rare and threatened species. Pastoral properties and a number of open cut and underground coal mines now dominate the local surrounding land use.

No threatened flora species listed under the NC Act or EPBC Act were detected during the survey. One RE within the study area (RE 11.3.1) consists of Brigalow forest which is listed as Endangered under the Queensland *Vegetation Management Act 1999* (VM Act). Two REs comprising Poplar Box woodland (RE 11.3.2 and RE 113.2b) are listed as Of Concern under the VM Act. These REs were found to meet the criteria for the Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (TEC) (RE 11.3.1) and Poplar Box Grassy Woodland on Alluvial Plains TEC (RE 11.3.2), which are both listed as Endangered under the EPBC Act.

Three threatened fauna species were recorded during the field surveys, the Greater Glider (*Petauroides volans*), Koala (*Phascolarctos cinereus*) (scat only) and Squatter Pigeon (Southern) (*Geophaps scripta scripta*). These species are listed as Vulnerable under the NC Act and EPBC Act. Two additional threatened fauna species, the Ornamental Snake (*Denisonia maculata*) and White-throated Needletail (*Hirundapus caudacutus*), were considered potential occurrences in the study area based on local records identified in the literature and database searches and the presence of suitable habitat. Both species are also listed as Vulnerable under the NC Act and EPBC Act.

The assessment identified several Matters of State Environmental Significance in the study area. These were regulated vegetation (the Of Concern and Endangered REs referred to above), connectivity areas and protected wildlife habitat for threatened fauna species.

The Project area is predominantly non-remnant vegetation (approximately 165 ha) with patches of remnant vegetation (totalling approximately 68 ha) (overall footprint is approximately 233 ha). The magnitude of impacts on biodiversity from the Project would be less than the Western Extension Project, which was more than double the footprint (571 ha) comprising clearance of approximately 380.5 ha of non-remnant vegetation and 190.5 ha of remnant vegetation. The approved Middlemount Coal Mine surface disturbance area totals approximately 3,071 ha.

The Project would result in the loss of 68 ha of remnant vegetation in the extended footprint areas (until it is revegetated) but is not likely to result in a new or materially increased adverse indirect impact on biodiversity compared to the existing approved mine.

The Project has potential to result in significant impacts on Matters of State Environmental Significance. Specifically, the Project would result in the clearance of 'endangered' or 'of concern' RE's 11.3.1 (approximately 2.2 ha), 11.3.2 (approximately 19.3 ha) and 11.3.2b (approximately 1 ha), as well as clearance of approximately 3.7 ha of Res 11.3.2 and 11.3.25, located within the defined distance of a vegetation management watercourse. The Project would result in the clearance of approximately 68 ha of connectivity areas.

The Project would also result in the clearance of protected wildlife habitat, in particular, approximately 63.3 ha of habitat for the Koala and Greater Glider.

Two diversions to Roper Creek are already approved at the Middlemount Mine which would fragment the riparian vegetation along Roper Creek. As an offset for this impact, the Stage 2 Offset Area was established by MCPL in 2013 and it includes enhancement and conservation of an 11 km stretch of the Roper Creek immediately to the west of the mine. This offset has been secured under a Voluntary Declaration and is managed for conservation purposes. The Project would increase disturbance to the riparian vegetation along Roper Creek for the realignment and extension of the eastern diversion of Roper Creek, however, it would not involve a new barrier to fauna movement (that impact would occur as a result of the approved mine), and the diversion would be revegetated with similar flora species as part of its construction.

Mitigation measures for the Project are expected to be consistent with existing Environmental Authority (EA) conditions and MCPL plans (e.g. Erosion and Sediment Control Plan and Rehabilitation Management Plan). Specific measures to reduce impacts on biodiversity include marking clearing limits, pre-clearing surveys and clearing supervision, and reducing light spillage into adjacent retained habitat. Offsets for the Project are expected to be consistent with existing EA conditions. Impacts on Matters of State Environmental Significance would be offset (including REs 11.3.1, 11.3.2 and 11.3.2b, as well as impacts on the Koala and Greater Glider).

Abbreviations

Table 1: List of abbreviations used within the report

BoM	Bureau of Meteorology
CE	Critically Endangered
DAWE	Department of Agriculture, Water and the Environment
DEE	Department of the Environment and Energy
DEHP	Department of Environment and Heritage Protection
DES	Department of Environment and Science
DPIE	Department of Planning, Industry and Environment
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
DEWHA	Department of Environment, Water, Heritage and the Arts
DNRM	Department of Natural Resources and Mines
DotE	Department of the Environment
E	Endangered
EA	Environmental Authority
EHP	Ecology & Heritage Partners
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GDE	Groundwater Dependant Ecosystems
GIS	Geographic Information System
ha	Hectares
IBRA	Interim biogeographic regionalisation of Australia
M	Migratory
MCPL	Middlemount Coal Pty Ltd
ML	Mining Lease
MNES	Matters of National Significance
MSES	Matters of State Significance
NC Act	*Nature Conservation Act 1992*
NT	Near Threatened
OMP	Offset Management Plan
PB	Parsons Brinckerhoff Pty Ltd
PIR	Passive Infrared
Qld	Queensland
RE	Regional Ecosystem
REDD	Regional Ecosystem Description Database
TEC	Threatened Ecological Community
TSSC	Threatened Species Scientific Committee
V	Vulnerable
VM Act	*Vegetation Management Act 1999*

1. Introduction

Biodiversity Australia Pty Ltd was engaged by Middlemount Coal Pty Ltd (MCPL) to undertake terrestrial ecological surveys and to prepare an impact assessment for the proposed Middlemount Coal Mine Southern Extension Project (herein referred to as the Project).

1.1 Project Description

MCPL owns and operates the Middlemount Coal Mine, an existing open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and approximately 3 km to the south-west of the Middlemount Township, Queensland (Qld).

MCPL propose to seek approval for changes to the approved Middlemount Coal Mine, herein referred to as the Southern Extension Project (the Project). The main activities associated with the development of the Project would include:

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

The study area comprises multiple areas of land immediately surrounding the existing mine boundary, and includes land immediately adjacent to the Project area (defined below). The majority of these are situated directly south of the existing open cut mine, with an additional area located to the east. The collective of these areas constitute the study area. This area totals approximately 274 hectares (ha). The locality is defined as land within 10 km of the Project.

The Project area is comprised of the additional surface disturbance area associated with the Project (Figure 2), and totals approximately 233 ha.

1.2 Objectives

The following lists the objectives of the Ecological Impact Assessment:

- Desktop literature review of relevant government databases and previous ecological assessments.
- Flora survey and field validation of Regional Ecosystems (RE) and habitat types within the study area as per the *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner *et al.* 2020).
- Survey as per the requirements of the *Guide to Determining Terrestrial Habitat Quality Version 1.3* (Department of Environment and Heritage Protection [DEHP] 2020a) to determine land-based offset requirements.
- Targeted surveys for threatened flora and fauna species listed under the Qld *Nature Conservation Act 1994* (NC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Identification of any Matters of State Environmental Significance (MSES) and Matters of National Environmental Significance (MNES).
- Assessment of impacts on terrestrial ecology, including MSES.
- Identification of avoidance and mitigation measures to protect the natural values, particularly threatened or near-threatened species, including consideration of biodiversity offset requirements in accordance with the *Queensland Environmental Offsets Policy* (DEHP 2017).

Figure 1: Location of the study area

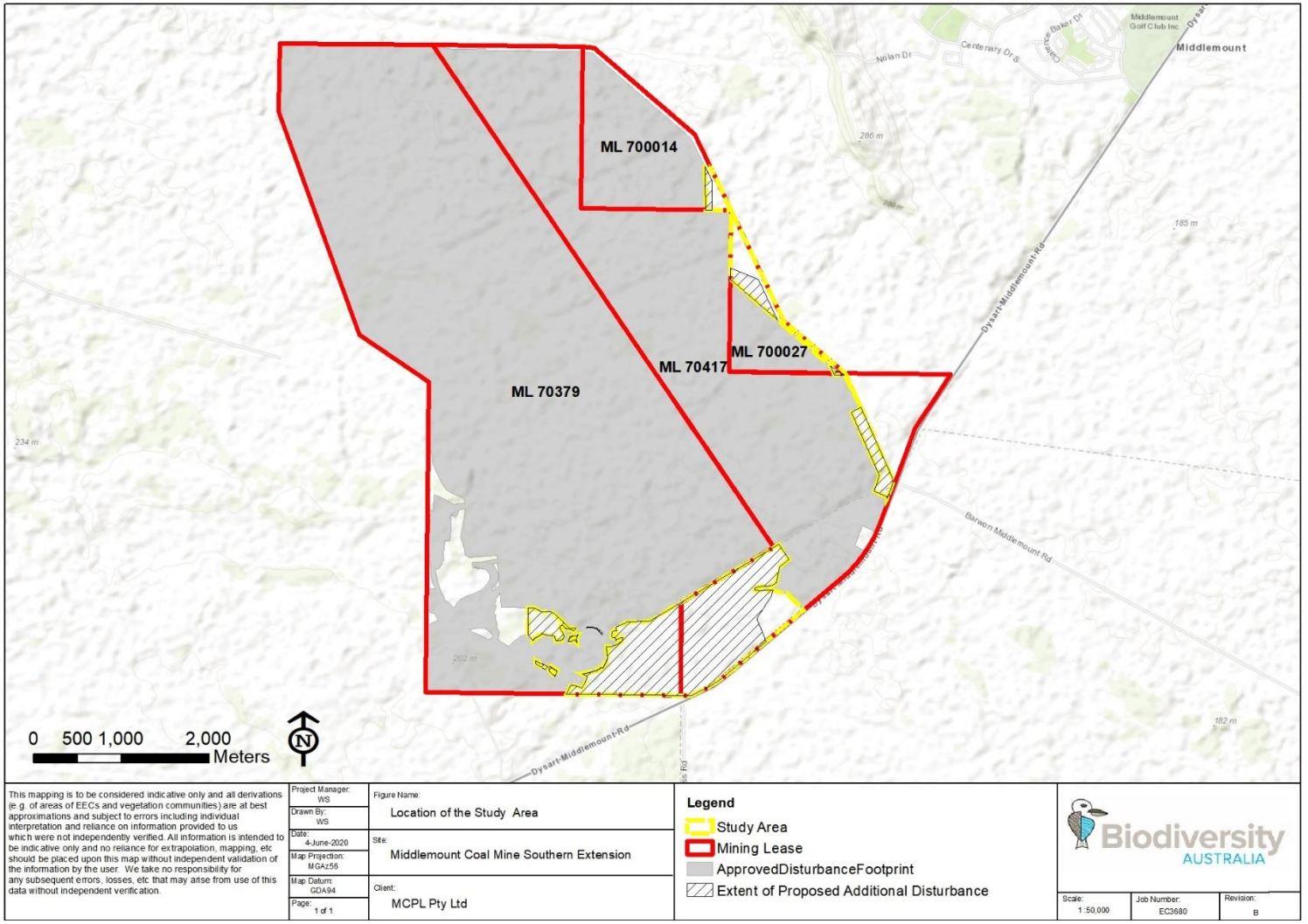
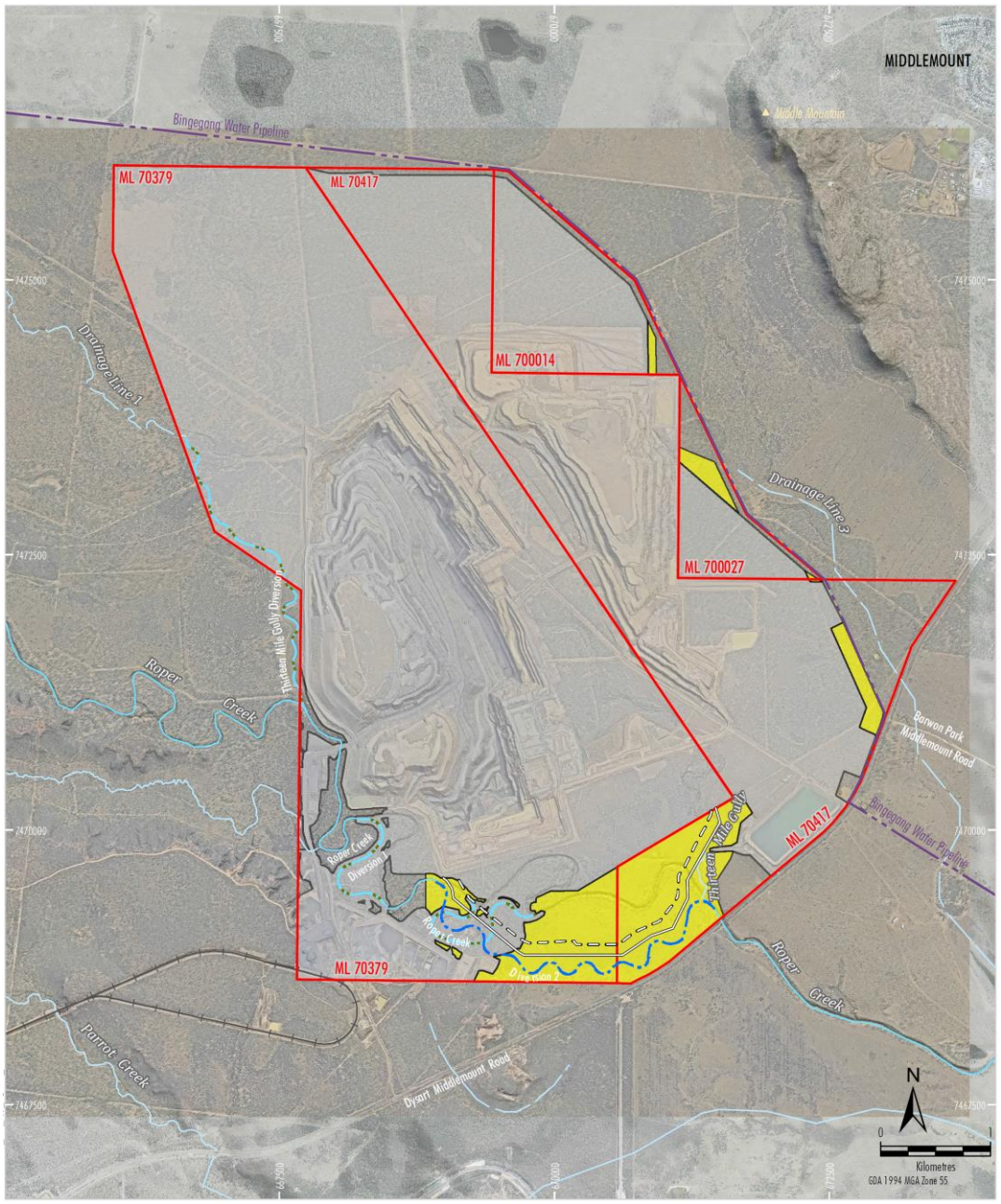


Figure 2: Approximate Project Footprint



2. Background Information

The Middlemount Coal Mine is an existing open cut coal mine located approximately 3 km to the south west of the Middlemount township within the Isaac Regional Local Government Area. The Project occurs within the Isaac-Comet Downs subregion of the Brigalow Belt North Bioregion.

2.1 Regional and Local Setting

The study area occurs within the Isaac-Comet Downs subregion of the Brigalow Belt North Bioregion, which falls within the Isaac Regional Council. Surrounding land uses largely comprise open cut and underground coal mines and grazing land. The nearest protected area is Junee National Park which occurs 30 km to the east. Bundoora State Forest is located approximately 25 km to the south-west of the study area.

2.2 Land Use and Disturbance History

Pastoral properties dominate the local land use along with a number of open cut and underground coal mines. No cropping or fruit growing areas are known to occur in the locality.

Clearing for cattle grazing in the region has been extensive, and the study area contains cleared areas that have been grazed in the past. No recent evidence of cattle grazing was noted in the study area. Cattle grazing has also required the establishment of fences and stock dams in the study area which has facilitated further clearing. As a result of this clearing and grazing, vegetation in the region is highly fragmented and exists as a mosaic of remnant and regrowth woodland and derived pasture grassland.

No recent fires are known to have occurred on the study area and no charcoal was observed on any tree trunks during the field survey.

2.3 Soils, Topography and Geology

The study area is located on a relatively flat landform with elevation ranging from approximately 170-180 metres (m) Australian Height Datum. The highest point in the study area is in the southwest corner near Dysart-Middlemount Road. No distinct geological features such rocks outcrops, cliffs or escarpments occur on the study area (Figure 3).

The main topographic feature of the study area is Roper Creek which is an ephemeral creek line. This runs roughly west to east across the southern portion of the study area. A second creek line, named Thirteen Mile Gully, feeds into Roper Creek in the study area (Figure 4).

The study area contains three Land Zones as per Wilson and Taylor (2012). Alluvial formations associated with the Roper Creek floodplain fall in to Land Zone 3 which is defined as recent Quaternary alluvial systems. This zone typically comprises fertile alluvial soils including Vertosols and Sodosols. In the study area, this zone supports Eucalypt woodland and Brigalow vegetation. Land Zone 3 covers the majority of the study area.

The level sandy plains which cover the eastern portion of the study area fall into Land Zone 5 which is described as Tertiary to early Quaternary loams and sandy plains and plateaus. In western Qld, this land zone typically contains sandy to loamy red Kandosols and Tenosols (Wilson and Taylor 2012). Soils encountered on the study area were well drained and contained a high sand content with a shallow organic layer. This zone typically supports Poplar Box woodland in the study area, however most of this community has been cleared and exists as derived grassland.

An elevated area is located in the southwest of the study area which is located on Land Zone 7. This zone is described as Cainozioc duricrusts formed on a variety of rock types. Landforms are usually steep sided mesas, buttes and edges of dissected tablelands and plateaus. Soils are either absent or shallow Rudosols and Tenosols. These usually have minimal development potential as they are typically shallow infertile soils or exposed rock (Wilson and Taylor 2012). In the study area, this land zone supports Lancewood (*Acacia shirleyi*) shrubland and Eucalypt woodland.

The study area is underlain by the Burngrove Formation as part of the Bowen Basin. The dominant lithology of this formation is described as mudstone, siltstone, sandstone, coal and tuff (Department of Natural Resources and Mines [DNRM] 2015), as shown in Figure 3.

2.4 Drainage Features

The study area is located in the Roper Creek catchment within the Fitzroy River Basin, which drains an area of approximately 150,000 square km (DNRM 2015).

The main drainage feature of the study area is Roper Creek (Figure 4). This is defined as a watercourse under the Qld *Water Act 2000*. This runs west to east and south-east across the southern portion of the study area. It comprises an ephemeral creek that has running water in the wet season and is generally dry throughout the rest of the year, with some small pools usually remaining in places. Roper Creek was flowing at the time of the field survey. As part of the Project, Roper Creek would be diverted south of its current path.

A small section of Thirteen Mile Gully is located in the east of the southern portion of the study area. This contained pools of water during the survey, with a larger pool located just south of the study area boundary. This feeds into Roper Creek within the study area. A large section of this creek has been diverted into Roper Creek approximately 3.5 km to the northwest of the study area and the creek has been largely removed upstream from the site. A drainage is also located to the east of the study area (Figure 4).

Localised depressions (gilgai) occur within the patches of Brigalow in the study area. These contain a shallow layer of clay and hold water after heavy rains. Standing water was present in many of these Brigalow patches during the field surveys, and some contained submergent and floating aquatic plants.

A localised depression is also located in the south-east of the study area which had a groundcover of sedge species at the time of the survey. This is not mapped as a palustrine wetland.

2.5 Previous Relevant Ecological Investigations

2.5.1 Parsons Brinckerhoff 2010

Parsons Brinckerhoff Pty Ltd (PB) (2010a) undertook the Environmental Impact Statement for the Middlemount Coal Mine Stage 1 and 2 areas. Part of their area of investigation extended onto the current study area.

The field survey methodology employed by PB involved a comprehensive terrestrial flora and fauna survey. A brief outline of the methods and major findings of this study are described below.

A flora survey was undertaken based on the methods described in Neldner *et al.* (2020) in November 2009 and February/March 2010. A combination of secondary, tertiary and quaternary survey sites were used to sample vegetation and validate RE mapping. Targeted searches for threatened flora were also undertaken.

Figure 3: Geology of the study area

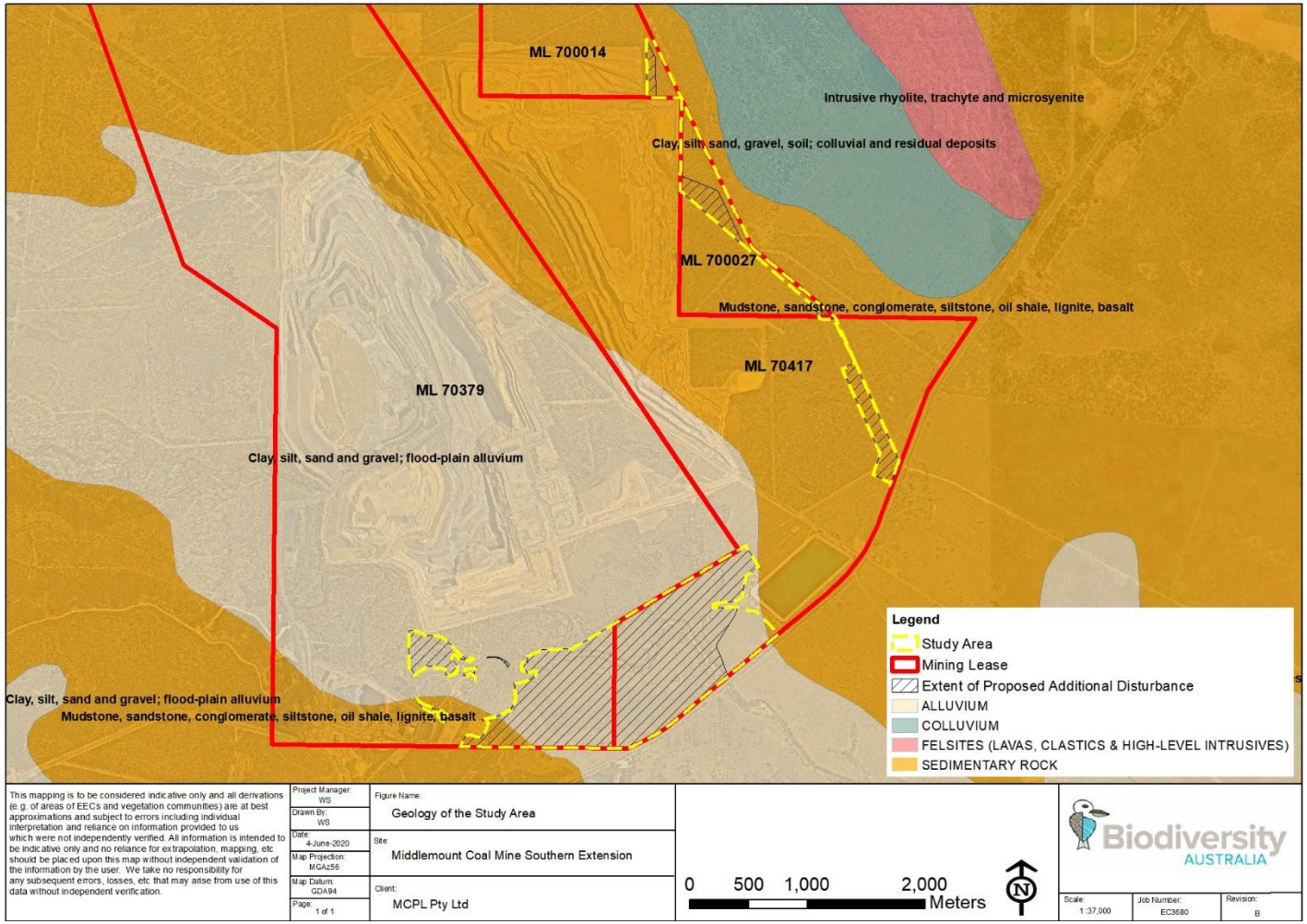
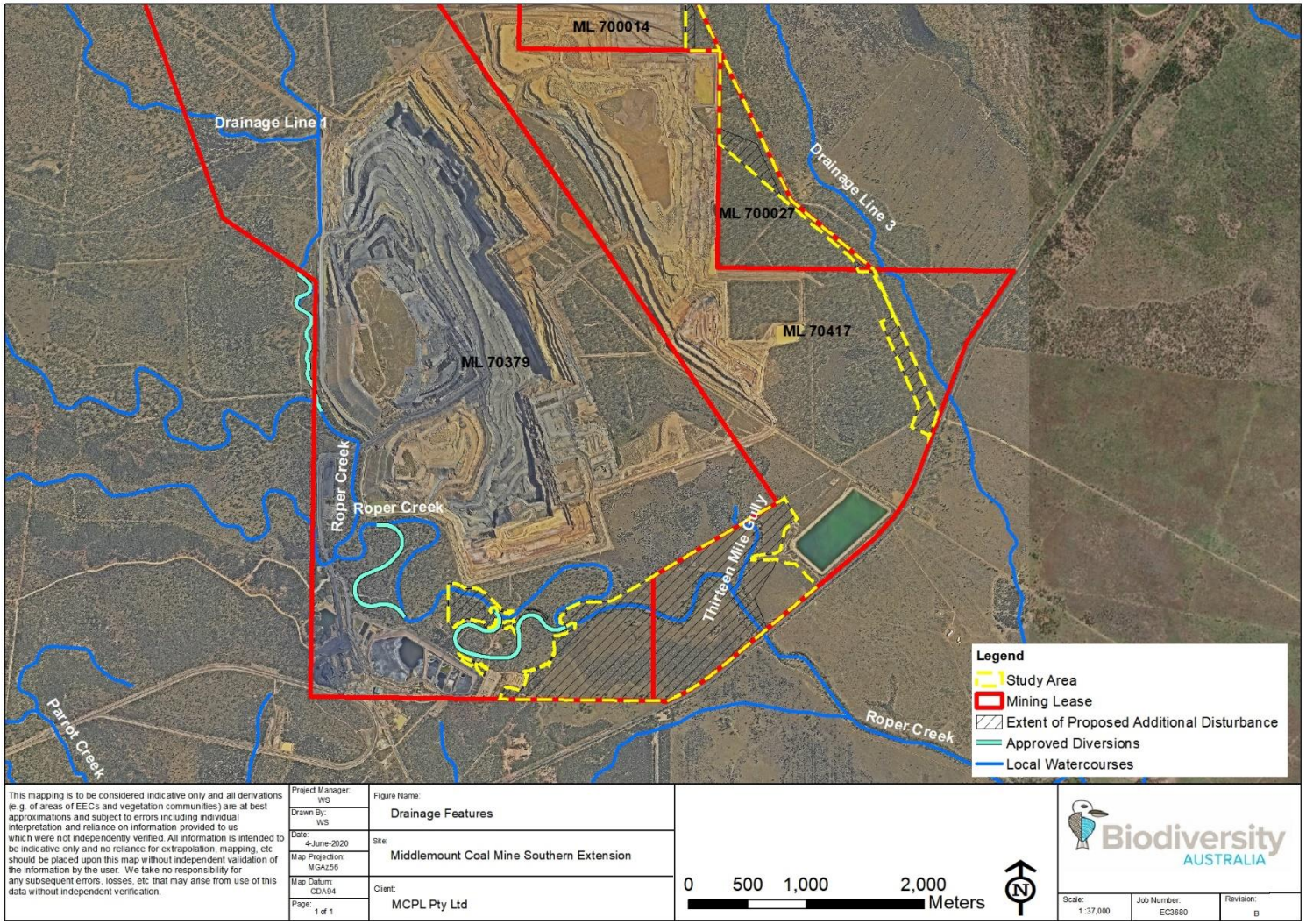


Figure 4: Drainage features in the study area



This resulted in the validation and mapping of 15 REs in the Stage 2 mine area. Three of these communities are listed as Endangered under the VM Act and the EPBC Act, with a further two listed as 'Of Concern'.

Two threatened flora species listed as 'Near Threatened' under the NC Act were detected in the Project area, these being *Desmodium macrocarpum* and *Cerbera dumicola*. *Desmodium macrocarpum* has since been de-listed.

PB's (2010a) fauna survey used a range of survey techniques to sample fauna species and their habitats in the Project area. These included habitat classification and assessment, bird census, herpetofauna searches, spotlighting, live animal trapping and ultrasonic bat call detection. These were undertaken over two survey periods in November 2009 and February/March 2010.

The PB (2010a) fauna survey detected 165 species of vertebrate animal, including eight introduced species. Three threatened species were detected; these being the Squatter Pigeon (southern), Ornamental Snake and the Little Pied Bat (*Chalinolobus picatus*). The Little Pied Bat has since been de-listed under the NC Act.

2.5.2 Ecology and Heritage Partners 2012

Ecology & Heritage Partners (EHP) (2012) conducted ecological investigations within the Offset Area for the Stage 2 Middlemount Coal Mine Project (shown on Figure 3-7 of the Main Text). The scope of work for the investigations were to verify the REs and high value regrowth present within the Offset Area, quantify the area of each RE, identify the status of REs under the VM Act, conduct surveys for threatened flora and fauna species and conduct surveys for weeds and pest species.

Field surveys were conducted by a team of four botanists from 10-14 July, 29 July-3 August and 13-17 August 2012. The main survey methodology employed was quaternary vegetation surveys. Targeted surveys for threatened flora species were undertaken via foot traverses along random 50 m transects along with opportunistic searches in potential habitat. Fauna survey methods involved opportunistic surveys and habitat assessments.

The Stage 2 Offset Area was found to contain 17 distinct REs. Approximately half of the Offset Area qualified as remnant vegetation with the remainder comprising non-remnant vegetation. The only endangered REs found in the Offset Areas were Brigalow woodlands (REs 11.3.1, 11.3.1b, 11.4.3, 11.4.8, 11.4.9a and 11.9.1), which are also listed as Endangered Brigalow TEC under the EPBC Act.

Two threatened flora species listed under the VM Act were detected during the surveys comprising *Desmodium macrocarpum* (no longer listed as a threatened species) and *Cerbera dumicola*. Two threatened fauna species listed under the NC Act were detected comprising the Koala and Squatter Pigeon (southern). These species are now both listed as Vulnerable under the EPBC Act. The Koala was found in the southwest of the Stage 2 Offset Area while the Squatter Pigeon (southern) was recorded in roughly the centre of the Stage 2 Offset Area.

Four vertebrate pest species were recorded comprising the Pig (*Sus scrofa*), Dog (*Canis lupus familiaris*), Rabbit (*Oryctolagus cuniculus*) and Cat (*Felis catus*). Three weed species listed under the former Qld *Land Protection (Pest and Stock Route Management) Act 2002* were recorded comprising the Harissia Cactus (*Harrisia martini*), Velvety Tree Pear (*Opuntia tomentosa*) and Parthenium Weed (*Parthenium hysterophorus*).

2.5.3 Biodiversity Australia (Naturecall)

2.5.3.1 Biodiversity Australia 2013-2019

Biodiversity Australia (formerly Naturecall Environmental [Naturecall]) conducts annual monitoring of the Middlemount Coal Offset Areas comprising the Stage 2 Offset, Rail Loop and Spur, Parrot Quarry and Thirteen Mile Gully Diversion offset areas, which are all located on MCPL land adjacent to the Middlemount Coal Mine (Naturecall 2013, 2014a, 2015a, 2016a, 2017a, Biodiversity Australia 2018a, 2019). Monitoring is undertaken in accordance with the MCPL Offset Management Plan (MCPL 2012 and its revision in 2019) and comprises annual vegetation monitoring surveys photo monitoring, as well as visual inspections and assessment of threats to the success of the Offset Areas. Three of the BioCondition survey points are located within the current Western Extension study area.

In accordance with the MCPL Offset Management Plan, dedicated fauna surveys were undertaken in the offset areas in May 2014 and May 2017. The following fauna survey techniques were employed:

- spotlighting;
- diurnal bird surveys;
- diurnal herpetofauna searches;
- installation of Passive Infrared (PIR) cameras;
- amphibian searches;
- opportunistic observations; and
- assessment of habitat features and complexity.

The fauna surveys have detected three threatened fauna species within the offset areas comprising the following:

- Greater Glider (*Petauroides volans*) – Vulnerable NC Act and EPBC Act.
- Koala (*Phascolarctos cinereus*) – Vulnerable NC Act and EPBC Act.
- Squatter Pigeon (southern) (*Geophaps scripta scripta*) - Vulnerable NC Act and EPBC Act.

2.5.3.2 Naturecall 2014

Naturecall (2014c) prepared an ecological assessment report for the realignment of the Bingegang Pipeline which is located to the north and east of the Middlemount Coal Mine. A section of the realigned pipeline runs through the eastern study area.

The ecological survey was conducted in July 2014 and consisted of RE verification and mapping, passive fauna surveys along with habitat and weed mapping.

The RE mapping and field validation found the majority of vegetation along the realigned pipeline route consisted of Poplar Box Woodland analogous to RE 11.5.3. Small patches of a Brigalow community were detected along the realigned pipeline route which qualified as the State and Commonwealth listed Brigalow (*Acacia harpophylla* dominant and co-dominant [RE 11.5.16]) threatened ecological community (Brigalow TEC), listed as Endangered under the NC Act and the EPBC Act. No threatened flora species were detected.

The fauna surveys detected a single threatened species – the Squatter Pigeon (southern) (*Geophaps scripta scripta*) which is listed as Vulnerable under the NC Act and the EPBC Act.

2.5.3.3 Naturecall 2015

Naturecall (2015b) conducted field surveys and prepared a Terrestrial Ecological Impact Assessment for the North-eastern Extension Project, located to the north of the current study area. The surveys were undertaken over one week in October 2015. The field survey methodology comprised the following:

- *Flora and Habitat Quality Surveys* – RE verification and mapping, threatened flora transects, Terrestrial Habitat Quality Assessments.
- *Fauna Surveys* – Spotlighting, call playback, PIR cameras, diurnal bird surveys, herpetofauna searches, scat and track searches.

The flora and habitat quality surveys confirmed that the entire site comprised Poplar Box Woodland analogous to RE 11.5.3. Several small localized depressions were also recorded which were mapped as 11.5.3b. No threatened flora species were recorded during the surveys and none were considered potential occurrences.

2.5.3.4 Biodiversity Australia 2018

Biodiversity Australia conducted field surveys and prepared a Terrestrial Ecological Impact Assessment for the Western Extension Project, located to the north and northwest of the current study area.

Field surveys were conducted in May and July of 2017 and comprised vegetation sampling and mapping, active fauna surveys (including but not limited to spotlighting, harp trapping, herpetofauna searches and camera stationing) and passive fauna surveys (i.e. habitat quality assessments).

The surveys conducted did not detect any threatened flora species however threatened REs were found to occur within the study area. Two of the REs recorded (RE 11.3.1 and RE 11.4.9) consisted of Brigalow forest which are listed as Endangered under the Qld *Vegetation Management Act, 1999* (VM Act) and EPBC Act. Two other REs occurring within the study area comprised of open woodland on alluvial plains are listed as Of Concern under the VM Act (RE 11.3.2 and RE 11.3.4).

Three threatened fauna species were recorded during the field surveys, the Koala (*Phascolarctos cinereus*) (scat only), Greater Glider (*Petauroides volans*) and Squatter Pigeon (Southern). These species are listed as Vulnerable under the NC Act and EPBC Act. Two additional threatened fauna species, the Ornamental Snake (*Denisonia maculata*) and Powerful Owl (*Ninox strenua*), were considered potential occurrences in the study area based on local records identified in the literature and database searches and presence of suitable habitat.

3. Methodology

3.1 Desktop Study and Literature Review

A desktop assessment was initially conducted to identify any changes in Remnant RE mapping or benchmarks since the establishment of the Offset Area (EHP 2012). The following data sources and GIS layers were reviewed:

- Atlas of Living Australia (2020).
- BirdLife Australia Atlas (2020).
- Department of Agriculture, Water and the Environment (DAWE) Protected Matters Database search for MNES listed under the EPBC Act for a radius of 10 km of the study area (2020a).
- Department of Environment and Science (DES) (2020d) Regional Ecosystems digital data layer (Version 11).
- DES (2018) Biodiversity Planning Assessment for the Brigalow Belt Bioregion - Version 2.1.
- DES (2020b): Matters of State Environmental Significance (MSES) - Environmental Reports online.
- Department of Natural Resources, Mines and Energy (2020b): Wildlife Online and Biomaps searches for Endangered, Vulnerable and Near Threatened species within a 10 km radius of the study area.
- Department of State Development, Infrastructure and Planning (2020) State Planning Policy interactive mapping system.
- Department of Sustainability, Environment, Water, Population and Communities (2012b) Environment Protection and Biodiversity Conservation Act Offsets Assessment Guide.
- Queensland Herbarium (2019a) BioCondition Benchmarks for Regional Ecosystem Condition Assessment: Brigalow Belt.
- Queensland Herbarium (2019b) Regional Ecosystem Description Database (REDD).

The results of these searches are presented in Section 4.

In addition to the desktop assessment, the following literature was reviewed for ecological information such as previous records of threatened flora and fauna, and survey techniques:

- Biodiversity Australia (2019). Ecological Monitoring for Middlemount Coal Offset Areas.
- Biodiversity Australia (2018a). Ecological Monitoring for Middlemount Coal Offset Areas.
- Biodiversity Australia (2018b). Ecological Impact Assessment: Western Extension Project, Middlemount Coal Mine.
- Biodiversity Australia (2018c). Western Extension Project Offset Area Baseline Report, Middlemount Coal Mine.
- EHP (2013a). Vegetation Offsets for Middlemount Rail Spur and Loop.
- EHP (2013b). Vegetation Offsets for Parrot Quarry.
- EHP (2013c). Vegetation Offsets for Middlemount Coal Mine Thirteen.
- EHP (2012). Ecological Investigations within the Offset Area for Stage 2 of the Middlemount Coal Mine, Queensland.
- Eyre *et al.* (2015). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2.

- Eyre *et al.* (2011). Method for the Establishment and Survey of Reference Sites for BioCondition. Version 2.0.
- FRC Environmental (2010). Middlemount Coal Project EIS, Stage 2: Aquatic Ecology
- GHD (2012). Rail Spur Environmental Offset Package.
- MCPL (2019). Middlemount Coal Mine Offset Management Plan/Vegetation Management Plan.
- MCPL (2013a). Middlemount Coal Mine Offset Management Plan/Vegetation Management Plan.
- MCPL (2013b). Middlemount Coal Mine Rail Loop and Spur Vegetation Offset Proposal.
- MCPL (2013c). Parrot Quarry Vegetation Offset Proposal.
- MCPL (2013d). Thirteen Mile Gully Diversion Vegetation Offset Proposal.
- MCPL (2017b). Middlemount Coal Mine – Drainage Lines in Mining Leases 70379.
- Naturecall (2014c). Ecological Assessment Report for Bingegang Pipeline Relocation.
- Naturecall (2015b). Terrestrial Ecological Impact Assessment. – North East Extension.
- Naturecall (2016b). Vegetation Validation and Terrestrial Habitat Assessment for North-east Extension Offset Area.
- Naturecall (2017a). North-eastern Extension Offset Area Baseline Report.
- Naturecall (2017b). Ecological Monitoring for Offset Area, Middlemount Coal Mine – BioCondition Monitoring Survey.
- Naturecall (2016a). Ecological Monitoring for Offset Area, Middlemount Coal Mine – BioCondition Monitoring Survey.
- Naturecall (2015a). Ecological Monitoring for Offset Area, Middlemount Coal Mine – BioCondition Monitoring Survey.
- Naturecall (2014a). Ecological Monitoring for Offset Area, Middlemount Coal Mine – Fauna and Pest Species Survey.
- Naturecall (2014b). Ecological Monitoring for Offset Area, Middlemount Coal Mine.
- Owen Foley (2014). Residual Void Flora and Fauna Capability Study.
- PB (2010a). Middlemount Coal Project, Stage 2: Terrestrial Ecological Impact Assessment. In MCPL (2011) Middlemount Coal Project Stage 2 Environmental Impact Statement.
- PB (2010b). Middlemount Coal Project Stage 2 Aquatic Ecological Impact Assessment. In MCPL (2011) Middlemount Coal Project Stage 2 Environmental Impact Statement.
- WRM Water and Environment (2018). Middlemount Coal Mine – Western Extension Project Surface Water Impact Assessment.

3.2 Field Survey

The field surveys were proportionate to the relatively small area of proposed clearance (less than 10% of the approved footprint) and in consideration of the large number of previous surveys at the Middlemount Coal Mine.

3.2.1 Flora Surveys

Field surveys for these assessments were undertaken by two ecologists. Field surveys dates were 3-6 March 2020 and 20-21 June 2020.

The primary aims of the field survey were to verify the Department of Natural Resources, Mines and Energy RE mapping for the study area; refine previous RE mapping by PB (2010a); identify and describe MSES and MNES (e.g. threatened flora species, REs and Commonwealth listed TECs); and collect sufficient data to conduct a terrestrial habitat quality assessment in accordance with the Guidelines (DES 2020a). Details of the flora and habitat quality surveys are provided in the following sections.

3.2.1.1 Flora Sampling and Vegetation Mapping

REs in the study area were surveyed and field verified as per the *Methodology for Surveying and Mapping Regional Ecosystems and Vegetation Communities in Queensland Version 5.1* (Neldner *et al*. 2020). This consisted of quaternary flora survey methods.

Four quaternary surveys were undertaken over the study area. The location of each survey site is shown in Figure 7. The following information was collected at Quaternary sites:

- Date.
- Collector.
- Coordinates.
- Remnant or regrowth.
- RE map unit.
- Height and cover of each layer.
- Land Zone.
- Species present.

REs were also verified during field traverses and through conducting Terrestrial Habitat Quality assessments.

Changes to RE mapping were made in the field using a tablet loaded with GIS Kit Pro (Garafa Inc.). This allowed highly accurate mapping of vegetation boundaries live in the field. This was followed by desktop mapping using ArcGIS 10.2 for Windows and recent satellite imagery (September 2019) supplied by MCPL.

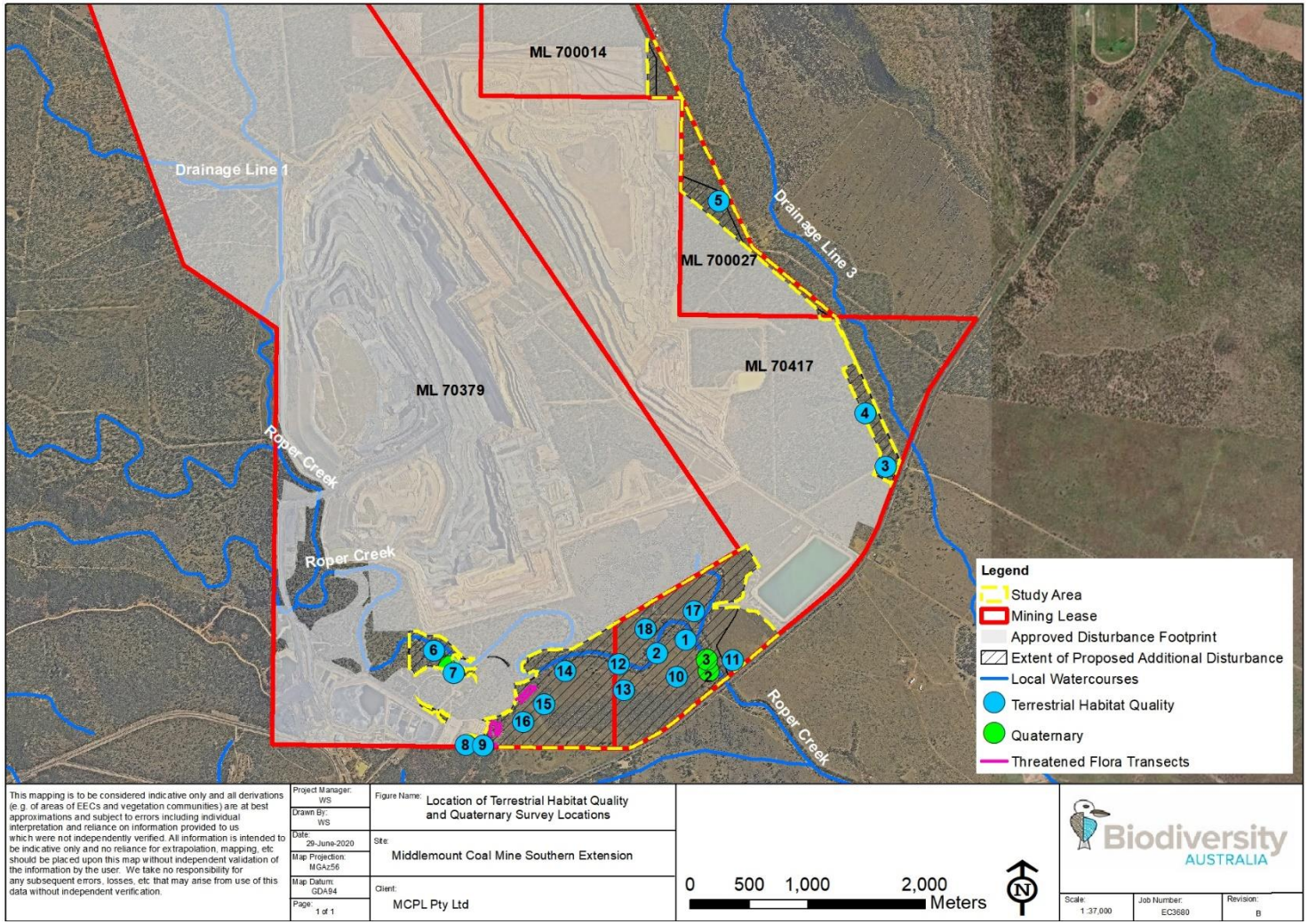
3.2.1.2 Targeted Searches for Threatened Flora Species

The DES *Flora Survey Guidelines - Protected Plants* (DES 2019) states that threatened flora surveys are required if the site falls within a high-risk area (as defined by an online mapping tool) or if a threatened species is known to occur within the study area. The study area does not fall within a high-risk area (see map in Appendix A-4-1) and no threatened flora species are known to occur in the study area.

A survey for threatened flora species was still carried out given the time elapsed since previous surveys and to provide more certainty on presence/absence of threatened flora species. This was achieved via conducting three timed meander transect searches (DES 2019) which were undertaken in suitable habitats for the target threatened flora species.

These undertaken in the southwest of the study area in RE 11.7.2, 11.7.4 and 11.3.1 on 20 June 2020. The location of the threatened flora surveys is shown in Figure 5.

Figure 5: Location terrestrial habitat quality and quaternary survey sites



3.2.1.3 Threatened Ecological Community Identification

Vegetation communities identified during the surveys were assessed for their conservation status under the EPBC Act, VM Act and DES Biodiversity Status. Brigalow communities were assessed according to the *Approved Conservation Advice* for the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community (Department of the Environment [DotE] 2013a) and Poplar Box Woodland on alluvial soils was assessed according to the Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains (Department of the Environment and Energy [DEE] 2019) as well as the Species Profile and Threats Database (DAWE 2020b).

3.2.1.4 Groundwater Dependant Ecosystems Identification

A groundwater dependent ecosystem is any ecosystem that relies on access to groundwater, either permanently or intermittently, to meet some or all of their water requirements so as to sustain resident flora and fauna compositions and ecological processes (Richardson et al. 2011).

An investigation of vegetation communities within the study area that potentially use groundwater was conducted in consideration of the *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody *et al.* 2019) and *Methods for the Identification of High Probability Groundwater Dependent Vegetation Ecosystems* (Department of Primary Industries - Water 2016).

The *Groundwater Dependent Ecosystems Atlas* (GDE Atlas) (BOM 2020) was consulted to identify potential GDEs within the study area, which uses modelling to map and allocate any potential GDE with a value on a scale of Low to High potential.

The final determination of GDE presence within the study area is based on the presence of flora species within the vegetation communities that have potential to be dependent on groundwater either permanently or intermittently, as well as consideration of groundwater information provided by Australasian Groundwater and Environment Consultants (AGE).

3.2.1.5 Habitat Quality Assessment

The survey methodology outlined in the *Guide to Determining Terrestrial Habitat Quality Version 1.3* (DES 2020a) was used to collect field attributes and determine terrestrial habitat quality scores for the study area and known/potential threatened species. This methodology uses BioCondition plots to collect field data (Eyre *et al.* 2015).

A total of 18 site condition assessments (plots and transects) were undertaken in the study area. The location of these plots is shown in Figure 5. Site selection was based on field verified RE mapping and analysis of high-resolution satellite imagery and aimed to sample a representative coverage of the site vegetation.

- The following information was recorded at each of the field sampling sites:
- Observer, location and date.
- RE map unit.
- Photographic record of vegetation.
- Habitat description.
- Tree canopy and subcanopy height.
- Native plant species richness in each layer.
- Number of large trees.
- Recruitment.

- Course woody debris.
- Non-native plant cover.
- Percent cover of each layer.

The data collected was also used to determine terrestrial habitat quality scores for the study area and known/potential threatened species, in accordance with the *Guide to Determining Terrestrial Habitat Quality Version 1.3* (DES 2020a) and to assist in determining offset requirements for the Project.

3.2.1.6 Flora Survey Limitations

The field surveys were undertaken in early autumn (post-wet season).

The post-wet season survey in March 2020 was preceded by heavy rains, as well as some rainfall during the survey period, and most grass species were in seed at this time making them easily detectable. This allowed for a high rate of detection of flora species. Locally recorded threatened flora species would be easily detectable either year-round (e.g. *Cerbera dumicola* – near threatened) or during the March survey period.

3.2.2 Fauna Surveys

Fauna surveys were undertaken over the study area by two ecologists from 3-6 March 2020 and 20-21 June 2020.

Weather conditions for the survey periods are detailed in Section 3.2.3.

Fauna surveys were conducted in accordance with the following guidelines:

- Terrestrial Vertebrate Fauna Survey Guidelines for Qld v3 (Eyre *et al.* 2018).
- Survey Guidelines for Australia's Threatened Reptiles (Department of Sustainability, Environment, Water, Population and Communities [DSEWPC] 2011a).
- Survey Guidelines for Australia's Threatened Mammals (DSEWPC 2011b).
- Survey Guidelines for Australia's Threatened Birds (Department of the Environment, Water, Heritage and the Arts [DEWHA] 2010a).
- Survey Guidelines for Australia's Threatened Bats (DEWHA 2010b).
- EPBC Act referral guidelines for the vulnerable Koala (combined Qld, New South Wales [NSW] and the Australian Capital Territory) (DotE 2014).
- EPBC Act Draft Referral Guidelines for the nationally listed Brigalow Belt reptiles (DSEWPC 2011c).
- Species Profile and Threats Database (DAWE 2020b).

Fauna surveys targeted threatened species listed under the NC Act and EPBC Act, as well as pest species, however common species were also surveyed. The following fauna surveys methods were utilised:

- Terrestrial and aquatic habitat assessments.
- Spotlighting.
- Microbat call recording and analysis.
- Herpetofauna surveys.
- Diurnal bird surveys.
- PIR camera stations.

- Koala surveys.
- Scat, track and secondary evidence searches.

These survey methods are described in detail in the following sections.

3.2.2.1 Terrestrial Habitat Assessment

Habitat assessments were undertaken across the study area at the terrestrial habitat quality survey plots and during foot traverses over the study area.

Habitats were defined according to parameters such as:

- Structural and floristic characteristics of the vegetation (e.g. understorey type and development, crown depth, groundcover density, etc.).
- Degree and extent of disturbance (e.g. fire, logging, weed invasion, modification to structure and diversity, etc.).
- Presence of water in any form (e.g. dams, creeks, drainage lines, soaks).
- Size and abundance of hollows and fallen timber.
- Availability of shelter (e.g. rocks, logs, hollows, undergrowth).
- Wildlife corridors, refuges and proximate habitat types (i.e. connectivity between suitable habitats).
- Presence of resources (e.g. mistletoe, nectar, gum, seed, sap, etc.).

This information, along with information obtained from the desktop assessment was used to formulate a list of potentially occurring threatened fauna species for the study area.

3.2.2.2 Spotlighting

Spotlighting was conducted for 2 hours per night for five nights across the study area.

This involved driving transects from a vehicle moving at walking pace along roads and tracks and walking transects using hand-held spotlights through both vegetated areas and along tracks.

All habitat components (i.e. understorey/canopy trees for arboreal fauna), the ground and terrestrial strata (e.g. logs, areas with good leaf litter accumulations, etc.) were searched for terrestrial fauna.

Spotlighting was conducted approximately one hour after dusk. Conditions varied between clear and overcast, and wind ranged from placid to light. Light rain was experienced on the second night of spotlighting.

3.2.2.3 Microbat Call Recording and Analysis

Microbat call detection was undertaken using two Anabat Express units (Titley Scientific). The units were deployed overnight at two locations, one facing a track near Roper Creek and the other on the edge of Poplar Box Woodland (see Figure 6 and Figure 7). Six-unit nights of recording was conducted in the study area. This resulted in >60 hours of recording.

The recordings were forwarded to Greg Ford of Balance! Environmental, a bat call identification consultant, for identification of the bat species.

3.2.2.4 Herpetofauna Searches

Searches primarily targeting the Ornamental Snake, Yakka Skink (*Egernia rugosa*), Brigalow Scaly-foot (*Paradelma orientalis*), Dunmall's Snake (*Furina dunmalli*) and Golden-tailed Gecko (*Strophurus taenicauda)* were undertaken within 50 m x 50 m quadrats. These were conducted at six locations within the study area (Figure 6 and Figure 7).

Herpetofauna searches involved active diurnal lifting up and rolling of timber and debris, inspection of dense vegetation and leaf litter and observation of likely basking sites for a total of 60-person minutes per site. Nocturnal herpetofauna torch searches were carried out in suitable habitat in conjunction with walking spotlight transects.

3.2.2.5 Diurnal Bird Surveys

Birds were surveyed by detecting calls and searching using binoculars at point positions or along a walking transect within two hours of dawn when peak activity usually occurs.

Specific bird censuses were undertaken each morning during the survey periods for 30 minutes with two observers. A total of eight bird surveys were carried out in the study area (Figure 6 and Figure 7).

Incidental observations of birds were also recorded during other survey activities. This provided short-term seasonal data on bird occurrences in the area for the particular seasons.

3.2.2.6 Passive Infrared Camera Stations

Six infra-red cameras were deployed at various locations over the study area. Cameras were set for three nights (Figure 6 and Figure 7).

The cameras were set either in forested areas or facing a road/track and were baited with either a mixture of oats, peanut butter and apple, or a meat bait consisting of chicken necks and tinned cat food.

Target species were the Northern Quoll (*Dasyurus hallucatus*), arboreal mammals, raptors and feral species such as European Red Foxes (*Vulpes vulpes*), dogs/dingoes (*Canis spp.*), feral cats and pigs.

3.2.2.7 Koala Surveys

Two dedicated Koala Spot Assessment Technique (SAT) surveys were undertaken in the study area on 21 June 2020. One was undertaken in the south of the study area adjacent to Roper Creek and the second was undertaken in the east of the study area adjacent to the Bingegang Pipeline road. The location of the SAT surveys is shown in Figure 6 and 7.

The SAT surveys were undertaken as per the method described by Phillips and Callahan (2011). This consisted of identifying a centre tree which is known to be frequented by the Koala, known to contain faecal pellets of the Koala or is likely to be considered as a potentially important tree for the Koala. In the event that a tree of this criteria was not located, a centre tree was randomly selected in an area of habitat most likely to support this species.

Once a centre tree was selected, active searches for Koala scats were undertaken under this tree and under the 29 nearest trees. Searches involved checking the ground and leaf litter within a 1 m radius of each tree, for a period of two minutes per tree or until a scat was found.

Opportunistic Koala scat searches were also undertaken across the study area under preferred food trees in areas of suitable habitat. Diurnal and nocturnal searches for Koalas were undertaken along Roper Creek. This consisted of searching trees for Koalas and searching for indicative Koala scratch marks on trees.

3.2.2.8 Track, Scat and Sign Searches

Searches for scats, tracks, feeding signs and scratch marks on trees were undertaken opportunistically along roads/tracks and within forested areas at the herpetofauna survey sites.

The sandy roads within and around the study area provided ideal locations for track searches, and any tracks found were photographed and identified using the methodology outlined in Triggs (1996). Predator scats were targeted for survey as remains can provide records of cryptic fauna.

3.2.2.9 Fauna Survey Limitations

Heavy rains preceded and occurred during the survey and Roper Creek was flowing during the survey. Standing water was present in the gilgai habitats and along low-lying tracks. This allowed for high detection rates of amphibians (and species which prey on them). As evident in the survey results, a broad range of fauna species were detected during the survey, and the methods used are considered effective for detecting a range of threatened species in the region.

Figure 6: Location of fauna surveys - southern portion of study area

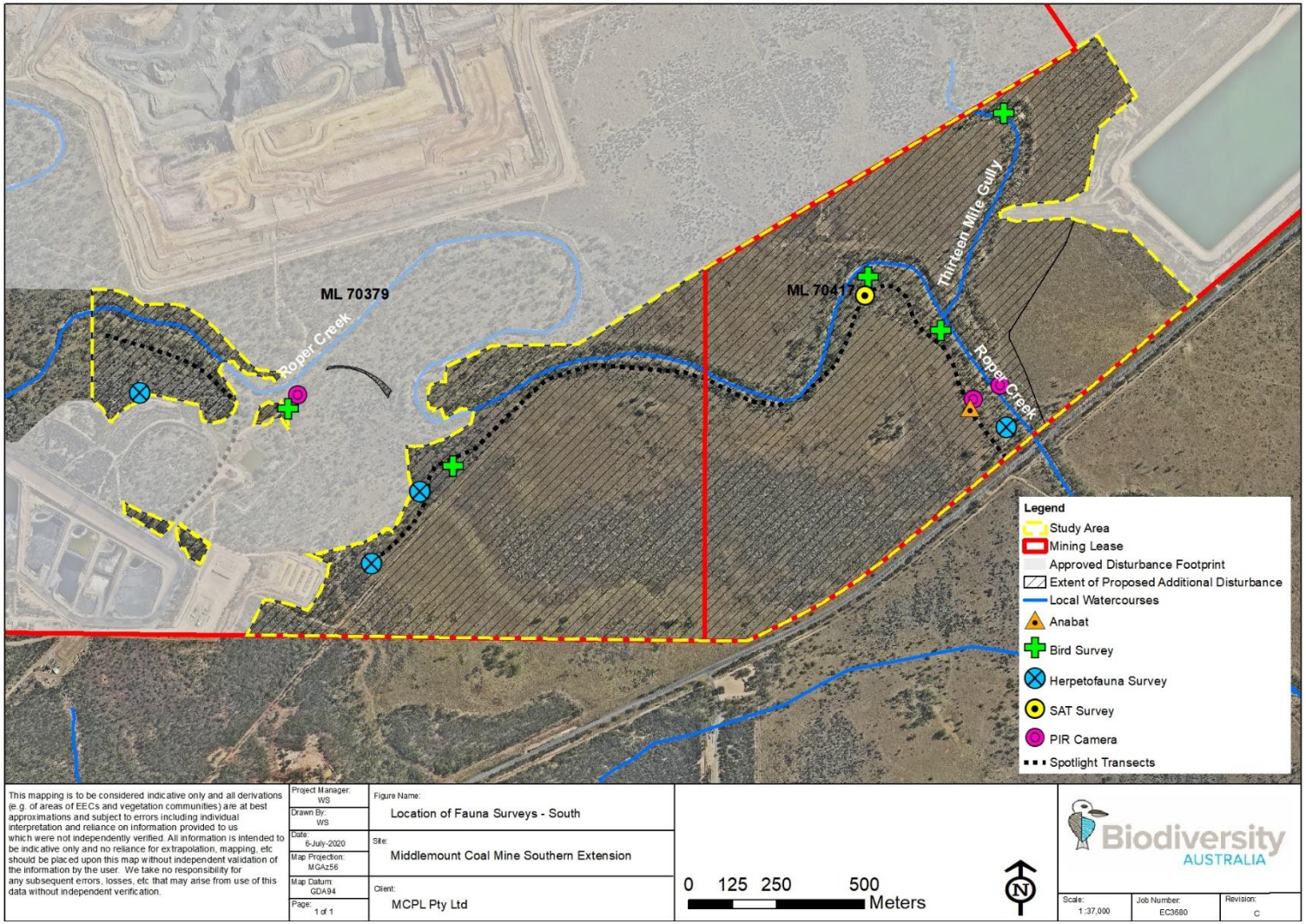
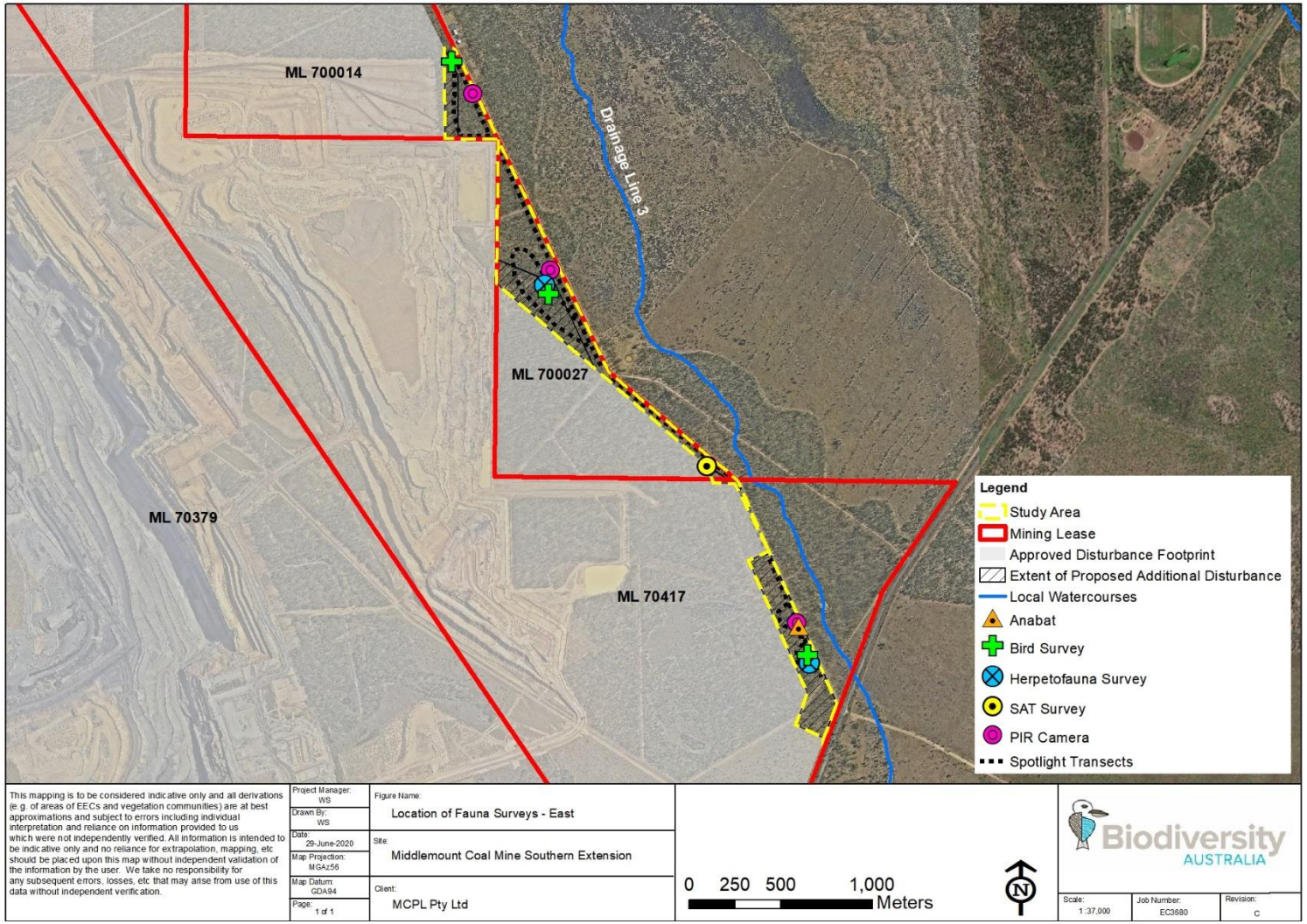


Figure 7: Location of fauna surveys - eastern portion of study area



3.2.3 Weather Conditions During the Survey

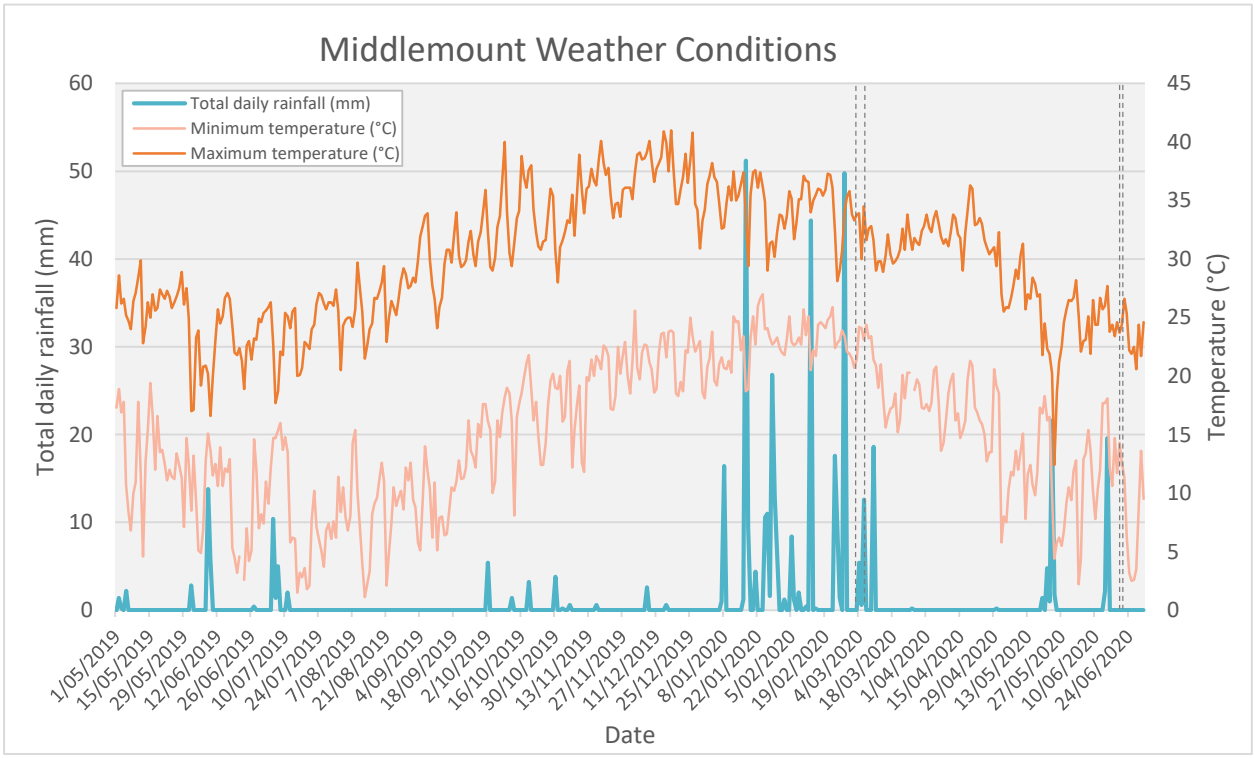
The main survey period survey was conducted during a period of warm, wet weather. The initial survey day comprised the only day where dry conditions were experienced with light showers between 0.6 and 12.6 millimetres (mm) per day experienced throughout the remaining survey. According to Middlemount Mine rainfall data, the survey period was conducted at the end of a two-month long wet season of which three heavy rainfall events occurred (51.2 mm on 17/01/2020; 44.4 mm on 13/02/2020; 49.8 mm on 27/02/2020).

Temperatures during the survey period ranged from a minimum of 21.5°C to a maximum of 34.5°C. These temperatures were typical of the slowly declining temperatures expected as the seasons progressed from summer to autumn.

The second survey period was conducted during a dry period with declining winter temperatures. This survey period fell over two survey days with temperatures ranging from a minimum of 12.6°C to a maximum of 24.4°C.

Middlemount rainfall and temperature data from the past year is graphed in relation to the survey period in Figure 8.

Figure 8: Precipitation/temperature recorded at Middlemount over the previous year (survey period marked with dotted line)



4. Results

4.1 Flora

The study area was found to have reasonable floristic diversity, however exotic grasses have outcompeted native species over large areas of the study area, which has led to changes in forest structure and composition.

A total of 155 flora species were recorded during the survey. Fifteen of these were introduced species with the remainder being native. The highest flora diversity was found in remnant Poplar Box and Brigalow communities which had an intact ground layer. Groundcover along Roper Creek primarily comprised introduced species. No threatened flora species were recorded during the surveys. The flora list for the study area is provided in Appendix A-2.

RE descriptions are provided in the following section.

4.1.1 Regional Ecosystems

Vegetation surveys ground-truthed eight distinct REs in the study area. Minor changes to existing RE mapping by PB (2010a) and Queensland Herbarium (2017) were made by the field validation process described in Section 3.2.1, by refining RE boundaries and separating out mixed REs.

A description of the ground-truthed REs in the study area are provided in Tables 2 to 9. The communities are named as per the REDD V11.1 (Queensland Herbarium 2019b). The Queensland Herbarium RE mapping is shown in Figure 9 and a field verified RE map has been produced and is shown in Figure 10.

Photos 1 to 8 following the description illustrate the vegetation communities within the study area.

Table 2: Regional Ecosystem 11.3.1 description

RE Type	11.3.1: *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains
Extent on Site	Occurs as several small patches in the south-west of the study area close to Roper Creek. Total area is 2.2 ha (Photo 1).
General Description	**a) Canopy:** *Structure and Species:* Consists of a mid-dense tree layer ranging from 8-12 m in height. Brigalow (*Acacia harpophylla*) is the dominant species. Uncommon canopy associates include Queensland Ebony (*Lysiphyllum caronii*) and Yellow-wood (*Terminalia oblongata*). **b) Subcanopy:** *Structure and Species:* A low tree/tall shrub layer to 6 m in height is present in some patches. Common to occasional species in this layer include juvenile Brigalow, False Sandalwood (*Eremophila mitchellii*) and Sandalwood (*Santalum lanceolatum*). **c) Shrub layer:** *Structure and Species:* A patchy shrub layer to 1 m in height is sometimes present. Consists of Currant Bush (*Carissa ovata*), Nepine (*Capparis lasiantha*) and Ellangowan Poison Bush (*Eremophila deserti*). **d) Ground layer:** *Structure and Species:* Groundcover is generally open with patches of leaf litter and bare ground present. Exotic grasses dominant the groundcover in some patches. Species recorded include a range of grasses including Slender Chloris (*Chloris divaricata*), *Paspalidium distans,* Hairy Panic (*Panicum effusum*), *Enteropogon acicularis*; and forbs such as Ruby Saltbush (*Enchylaena tomentosa*) and Soft Roly-poly (*Salsola australis)*. Exotic species which dominate in some areas include Buffell Grass (*Cenchrus ciliaris*), Green Panic *(Megathyrsus maximus)* and Sesbania Pea (*Sesbania cannabina).* Occasional aquatic species were recorded in areas of Brigalow with gilgai present. These areas had standing water present during the survey and aquatic species recorded include Water Primrose *(Ludwigia peploides),* Water Snowflake *(Nymphoides indica)* and Swamp Lily *(Ottelia ovalifolia).*

Condition	Generally in poor condition due to small patch sizes which experience high edge effects and weed invasion. Patches of non-remnant Brigalow also occur adjacent to remnant patches and across a large area between Roper Creek and Middlemount Road which were cleared approximately 3 years ago. The recently cleared areas feature a dense layer of young Brigalow to 1m in height with mostly exotic groundcover.
Conservation Status	'Endangered' under VM Act and 'Endangered' Biodiversity Status. Also qualifies as Endangered Brigalow TEC under the EPBC Act.

Photo 1: RE 11.3.1

Table 3: Regional Ecosystem 11.3.2 description

RE Type	11.3.2: *Eucalyptus populnea* woodland on alluvial plains
Extent on Site	Occurs along the Roper Creek floodplain in the east and west of the study area. Total area is 19.5 ha (Photo 2).
General Description	**a) Canopy:** *Structure and Species:* The canopy comprises an open tree layer which is dominated by Poplar Box (*Eucalyptus populnea*). Other canopy associates include Moreton Bay Ash (*Corymbia tessellaris*) and Clarkson's Bloodwood (*Corymbia clarksoniana*). Height ranges from 15-18 m. **b) Subcanopy:** *Structure and Species:* A low tree layer ranging from 6-10 m in height is occasionally present. This consists of young Poplar Box, Leichardt Bean (*Cassia brewsteri)* and occasional Native Willow (*Acacia salicina*) and Quinine Tree (*Petalostigma pubescens*). **c) Shrub layer:** *Structure and Species:* This community features an open to mid-dense tall shrub layer ranging from 0.5-1.5 m in height. Commonly recorded species in this layer include Dysentery Bush (*Grewia latifolia*), Coffee Bush (*Breynia oblongifolia*), Currant Bush (*Carissa ovata*) and Western Boobialla (*Myoporum montanum*). **d) Ground layer:** *Structure and Species:* In most situations the groundcover is dense, however it is sometimes open and patchy. Height ranges from 0.05 to 0.5 m. Dominant species recorded in this layer include Buffel Grass, Green Panic, Sabi Grass, Black Speargrass (*Heteropogon contortus*), *Sida cordifolia* and Yellow Buttons (*Chrysocephalum apiculatum*).
Condition	Good remnant condition overall, with most disturbance occurring in the ground layer as a result of cattle grazing. Weed cover increases closer to Roper Creek where exotic grasses begin to dominate the ground layer. Buffel Grass (*Cenchrus ciliaris*) is also a dominant weed throughout. Large non-remnant areas of this community also occur in the south of the study area. Some areas feature a regenerating layer of canopy trees to approximately 2 m height while other areas do not have any eucalypt regeneration. The groundcover is largely dominated by exotic pasture grasses.
Conservation Status	'Of concern' under VM Act and 'Of concern' Biodiversity Status. Some patches within the study area qualify as Endangered Poplar Box Woodland TEC under the EPBC Act.

Photo 2: RE 11.3.2

Table 4: Regional Ecosystem 11.3.2b description

RE Type	11.3.2b: *Eucalyptus camaldulensis* (sometimes *E. populnea* and or *E. tereticornis*) woodland in drainage depressions
Extent on Site	One small patch occurs in the south-east of the study area. Area is 1.03 ha.
General Description	**a) Canopy:** *Structure and Species:* The canopy comprises an open to sparse tree layer which is dominated by Poplar Box (*Eucalyptus populnea*). A couple of Queensland Blue Gum (*Eucalyptus tereticornis*) are also present. Height ranges from 16-18 m. **b) Subcanopy:** *Structure and Species:* A sparse sub-canopy from 8-12 m in height is present. This consists of young Poplar Box, and scattered Leichardt Bean (*Cassia brewsteri*) and Queensland Ebony (*Lysiphyllum carronii).* **c) Shrub layer:** *Structure and Species:* Absent. **d) Ground layer:** *Structure and Species:* Consists of a dense layer of grasses and herbs. Some depressions also present which feature sedges. Dominant species are *Juncus usitatus,* Giant Sedge (*Cyperus exaltatus*), Common Fringe Rush (*Fimbristylis dichotoma*) and Pigweed (*Portulaca oleracea*).
Condition	Good condition with few disturbances noted. Weeds are common in the ground layer, especially around the edges of the community.
Conservation Status	'Of concern' under VM Act and 'Of concern' Biodiversity Status. Patch within the study area does not qualify as Endangered Poplar Box Woodland TEC under the EPBC Act.

Photo 3: RE 11.3.2b

Table 5: Regional Ecosystem 11.3.25 description

RE Type	11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines
Extent on Site	Occurs as a thin band along Roper Creek. Area on site is 14.06 ha (Photo 4).
General Description	**a) Canopy:** *Structure and Species:* The canopy comprises an open tree layer which is dominated by Qld Blue Gum (*Eucalyptus tereticornis*), River Oak (*Casuarina cunninghamiana)* and Moreton Bay Ash (*Corymbia tessellaris*) with occasional Poplar Box (*Eucalyptus populnea*) located around the edges. Height ranges from 18-25 m. **b) Subcanopy:** *Structure and Species:* A sparse lower tree layer ranging from 6-12 m in height occurs throughout. This largely consists of young Qld Blue Gum and River Oak. Other species recorded include Sandpaper Fig (*Ficus opposita*), White Cedar (*Melia azedarach*), Yellow-wood (*Terminalia oblongata*) and Castor Oil Plant (*Ricinus communis*). **c) Shrub layer:** *Structure and Species*: Occasional shrub species present ranging from 0.5-1.5 m in height. Species include Currant Bush (*Carissa ovata*) and Dysentery Bush *(Grewia latifolia*). **d) Ground layer:** *Structure and Species:* A dense layer of grasses and herbs is present and largely consists of exotic species. These include Morning Glory (*Ipomoea indica*), Green Panic (*Megathyrsus maximus*), Buffel Grass (*Cenchrus ciliaris*) and Red Natal Grass (*Melinis repens*). Native species recorded include *Commelina cyanea*, Crinum Lily (*Crinum flaccidum*) and Spiny Matrush (*Lomandra longifolia*).
Condition	Moderate to poor condition. Weed invasion has degraded most of the community and erosion from previous cattle grazing was also noted.
Conservation Status	'Least concern' under VM Act and 'Of concern' Biodiversity Status.

Photo 4: RE 11.3.25

Table 6: Regional Ecosystem 11.3.7 description

RE Type	11.3.7: *Corymbia* spp. woodland on alluvial plains
Extent on Site	Occurs on the level plain adjacent to Roper Creek, generally in the west of the study area. Covers an area of 6.18 ha.
General Description	**a) Canopy:** *Structure and Species:* Comprises an open canopy ranging in height from 17-23 m. Moreton Bay Ash (*Corymbia tessellaris*) is the dominant species, with canopy associates including Clarkson's Bloodwood (*Corymbia clarksoniana*) and Poplar Box (*Eucalyptus populnea*). **b) Subcanopy:** *Structure and Species:* Consists of a lower tree layer of canopy juveniles ranging from 8-13 m in height. **c) Shrub layer:** *Structure and Species:* Occasional patches of shrubs are present. Common to dominant species include Currant Bush (*Carissa ovata*), Coffee Bush (*Breynia oblongifolia*) and Dysentery Bush (*Grewia latifolia*). Height ranges from 0.5-1 m. **d) Ground layer:** *Structure and Species:* Consists large of exotic grasses including Buffel Grass (*Chenchrus ciliaris*), Sabi Grass (*Urochloa mosambicensis*) and Green Panic (*Megathyrsus maximus*). Occasional native species recorded include Comet Grass (*Perotis rara*), Dark Wiregrass (*Aristida calycina*), Yellow Rattlepod (*Crotalaria mitchellii*) and Flannel Weed (*Sida hackettiana).*
Condition	Occurs in poor to moderate condition due to high edge effects and weed invasion.
Conservation Status	'Least concern' under VM Act and 'Of concern' Biodiversity Status.

Photo 5: RE 11.3.7

Table 7: Regional Ecosystem 11.5.3 description

RE Type	11.5.3: *Eucalyptus populnea* ± *E. melanophloia* ± *Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces.
Extent on Site	Only occurs in the northern section of the study are adjacent to the Bingegang Pipeline. The total area within the study area is 44.61 ha.
General Description	**a) Canopy:** *Structure and Species:* The canopy consists of an open layer of generally even aged mature trees ranging from 15-20 m in height. Poplar Box (*Eucalyptus populnea*) is the dominant species. Common to occasional canopy associates include Clarkson's Bloodwood (*Corymbia clarksoniana*), Reid River Box (*Eucalyptus brownii*), Moreton Bay Ash (*Corymbia tessellaris*) and Ghost Gum (*Corymbia dallachiana*). **b) Subcanopy:** *Structure and Species:* The subcanopy generally consists of an open to sparse tall shrub/small tree layer from 4-10 m in height dominated by Leichardt Bean (*Cassia brewsteri*), Quinine Tree (*Petalostigma pubescens*), Ironwood (*Acacia excelsa*), Native Willow (*Acacia salicina*) and False Sandalwood (*Eremophila mitchellii*). Other less common species in this layer include Silver Oak (*Grevillea parallela*), Dead Finish (*Archidendropsis basaltica*), Bootlace Oak (*Hakea lorea*) and Red Ash (*Alphitonia excelsa*). **c) Shrub layer:** *Structure and Species:* A low shrub layer to 0.7 m in height is occasionally present and consists of patches of Currant Bush (*Carissa ovata*) along with other species such as Stylo (*Stylosanthes scabra*), Dysentery Bush (*Grewia latifolia*), Fine Sida (*Sida filiformis*) and *Sida cordifolia*. **d) Ground layer:** *Structure and Species:* The groundcover ranges from dense to open with height usually ranging from 0.1-0.5 m in height. Introduced grasses such as Buffel Grass (*Cenchrus ciliaris*), Sabi Grass (*Urochloa mosambicensis*) and Red Natal Grass (*Melinis repens*) are the dominant species overall, however less disturbed areas also existed that feature an open groundcover of native grasses such as Black Speargrass (*Heteropogon contortus*), Native Millet (*Panicum decompositum*), Queensland Bluegrass (*Dichanthium sericeum*), and Forest Bluegrass (*Bothriochloa blahdii*).
Condition	Good condition overall with most areas featuring an intact canopy and understorey. Grazing has impacted the ground layers however via trampling and spreading exotic grasses. Weed cover is moderate to high but limited to exotic grass infestations in the ground layer and occasional Prickly Pear (*Opuntia stricta*). Large non-remnant areas of this community also occur in the west of study area. Some areas feature a regenerating layer of canopy trees to approximately 4 m in height while other areas do not have any eucalypt regeneration. The groundcover is largely dominated by exotic pasture grasses.
Conservation Status	'Least concern' under VM Act and 'Not of concern' Biodiversity Status.

Photo 6: RE 11.5.3

Table 8: Regional Ecosystem 11.7.2 description

RE Type	11.7.2: *Acacia* spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone
Extent on Site	Occurs in two small patches in the south-west of the study area. Area is 0.76 ha.
General Description	**a) Canopy:** *Structure and Species:* Comprises a moderately dense canopy layer ranging from 10-12 m in height. Lancewood (*Acacia shirleyi*) is the dominant species. **b) Subcanopy:** *Structure and Species:* A small tree layer is present in the community. This is dominated by Turkey Bush (*Erythroxylum australe)*, Quinine Tree (*Petalostigma pubescens*), Red Ash (*Alphitonia excelsa*) and *Psydrax attenuata*. Height generally ranges from 3-6 m. **c) Shrub layer:** *Structure and Species:* Absent. **d) Ground layer:** *Structure and Species:* Comprises an open cover of native grasses and herbs to 0.3 m in height. The dominant species in this layer are Tableland Couch (*Calyptochloa gracillima)* and Hooky Grass (*Ancistrachne uncinulata).*
Condition	Occurs in good remnant condition with only minor disturbances from road construction nearby. Weed cover is very low.
Conservation Status	'Least Concern' under VM Act and 'Not of Concern' Biodiversity Status.

Photo 7: RE 11.7.2

Table 9: Regional Ecosystem 11.7.4 description

RE Type	11.7.4: *Eucalyptus decorticans* and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* woodland on Cainozoic lateritic duricrust
Extent on Site	Occurs in two small patches in the south-west of the study area. Total area is 1.63 ha.
General Description	**a) Canopy:** *Structure and Species:* Comprises an open canopy dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*). Occasional Dawson's Gum (*Eucalyptus cambageana*), Clarkson's Bloodwood (*Corymbia clarksoniana*) and Poplar Box (*Eucalyptus populnea*) are also present in low abundance. Height is generally in the range of 13-18 m. **b) Subcanopy:** *Structure and Species:* Features a well-developed and diverse subcanopy layer of tall shrubs and small tree species. Species recorded in this layer include *Psydrax attenuata*, Turkey Bush (*Erythroxylum australe*), Quinine Tree (*Petalostigma pubescens*), Red Ash (*Alphitonia excelsa*), Chalky Wattle (*Acacia cretata*), Lancewood (*Acacia shirleyi*) and Leichardt Bean (*Cassia brewsteri*). Height ranges from 4-8 m. **c) Shrub layer:** *Structure and Species:* A patchy shrub layer is present, however is sparse overall. Dominant species include Sticky Hop Bush (*Dodonaea viscosa*), Currant Bush (*Carissa ovata*) and Dysentery Bush (*Grewia latifolia*). A few Prickly Pear (*Opuntia stricta*) are also present. **d) Ground layer:** *Structure and Species:* Consists of an open layer of grasses and herbs. Dominant species are Tableland Couch (*Calyptochloa gracillima*), Wattle Matrush (*Lomandra filiformis*), Native Wandering Jew (*Commelina diffusa*), Tropical Speedwell (*Evolvulus alsinoides*) and Pigweed (*Portulaca oleracea*). Some exotic grasses such as Buffel Grass (*Cenchrus ciliaris*) and Green Panic (*Megathyrsus maximus*) are also present.
Condition	Occurs in good remnant condition with only minor disturbances and edge effects from tracks and clearings nearby. Weed cover is low.
Conservation Status	'Least concern' under VM Act and 'Not of concern' Biodiversity Status.

Photo 8: RE 11.7.4

Figure 9: Mapped Regional Ecosystems

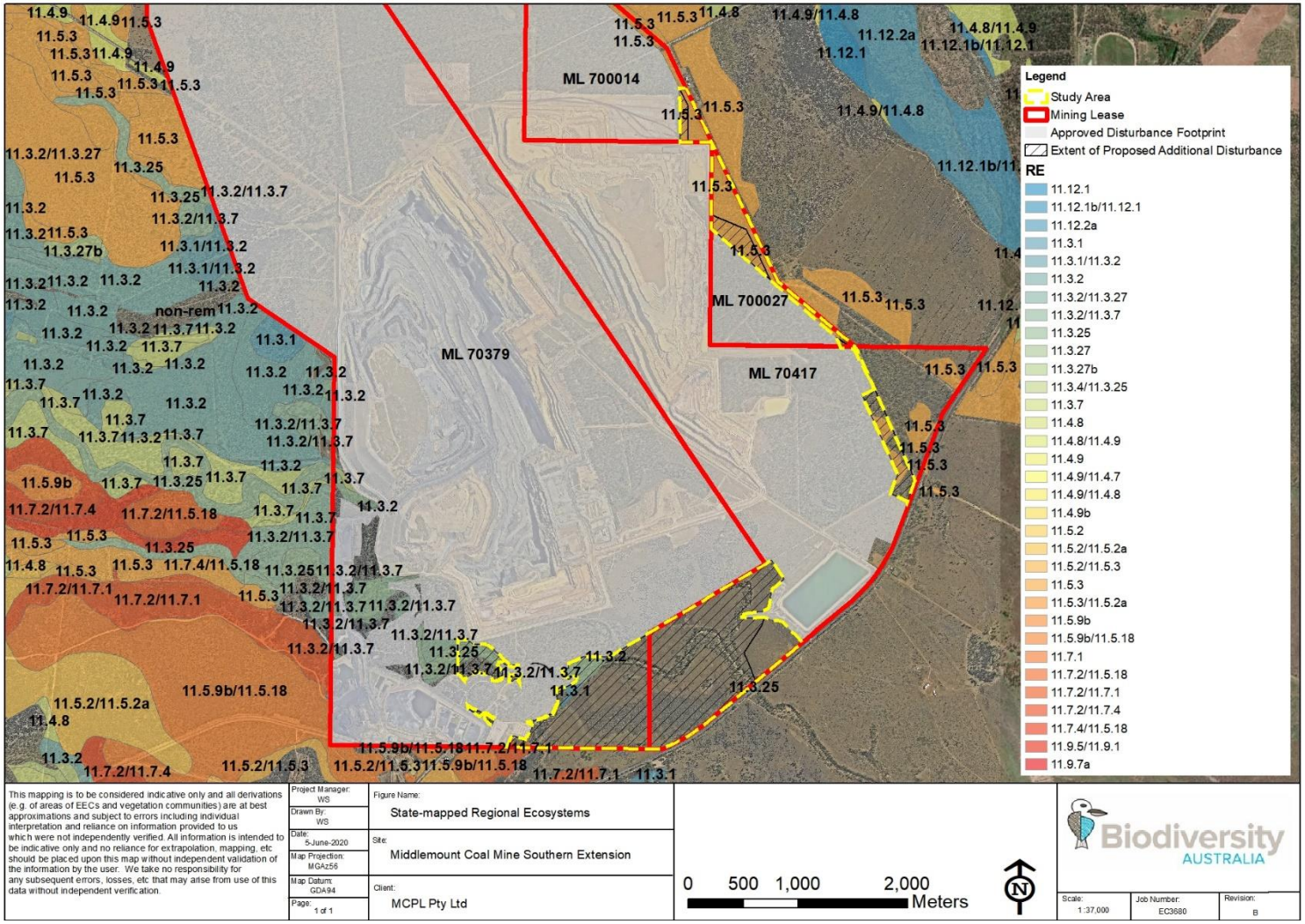
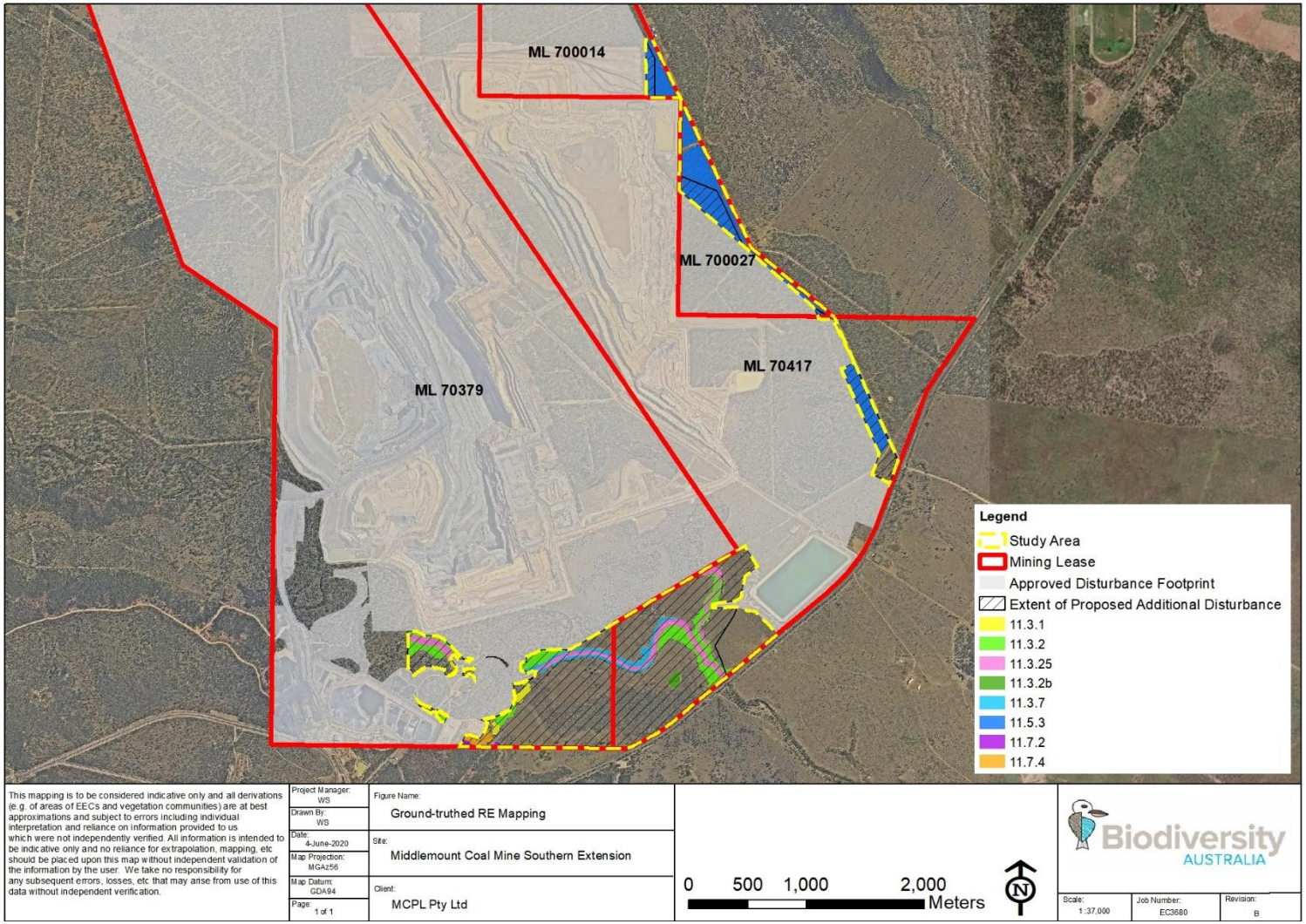


Figure 10: Field verified Regional Ecosystems



4.1.1.1 Endangered and Of Concern Regional Ecosystems

Desktop assessments identified the following threatened REs listed in Table 10 have been mapped in the study area.

Table 10: Endangered and Of Concern Regional Ecosystems recorded in database searches

Regional Ecosystem	Code	VM Act **Status**	Source
Acacia harpophylla and/or *Casuarina cristata* open forest on alluvial plains	11.3.1	Endangered	Qld Herbarium 2017
Eucalyptus populnea woodland on alluvial plains	11.3.2	Of concern	Qld Herbarium 2017

All patches of Brigalow and Poplar Box Woodland communities in the study area were assessed to determine if they qualified as remnant vegetation using the criteria in Neldner *et al*. 2020. This was achieved using analysis of satellite imagery to determine disturbance history and analysis of canopy cover and canopy height compared to published benchmarks.

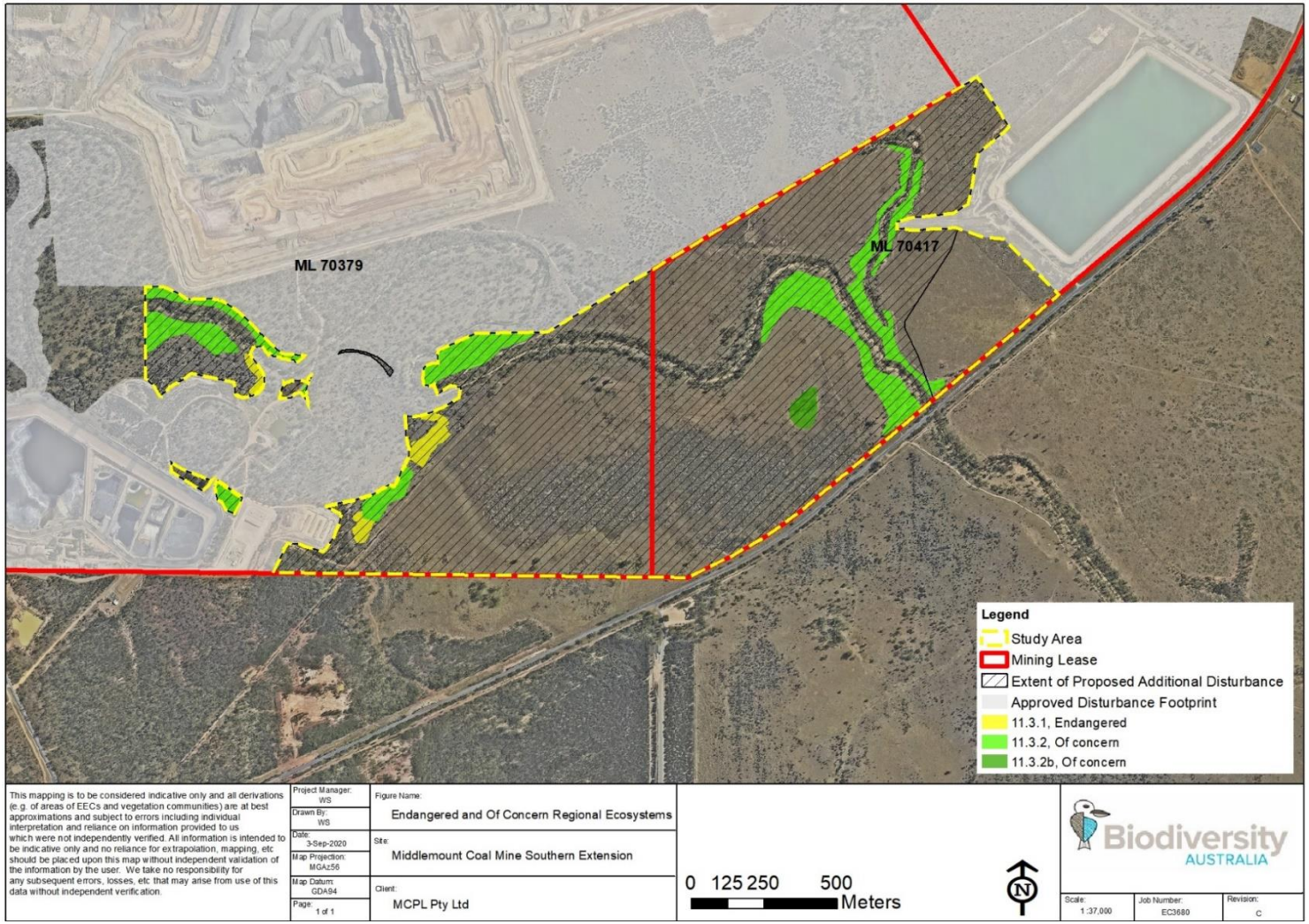
Two REs listed as Endangered or Of Concern under the VM Act were recorded during the field surveys. The details of these are provided in Table 11. Figure 11 shows the location of these communities in the study area. Section 4.1.3 provides a description of these communities.

Areas of non-remnant Brigalow and Poplar Box woodland were also recorded in the study area. Most of these patches had been cleared in the past five years and were readily determined to be non-remnant.

Table 11: Endangered and Of Concern Regional Ecosystems recorded in the study area

Regional Ecosystem	Code	VM Act **Status**	Area
Acacia harpophylla and/or *Casuarina cristata* open forest on alluvial plains	11.3.1	Endangered	2.23 ha
Eucalyptus populnea woodland on alluvial plains	11.3.2 and 11.3.2b	Of concern	20.61 ha

Figure 11: Endangered and Of Concern Regional Ecosystems listed under the VM Act



4.1.2 Groundwater Dependant Ecosystems

A Groundwater Dependent Ecosystem (GDE) is an ecosystem in which the plant and/or animal community is dependent on the availability of groundwater to maintain its structure and function. Desktop mapping of potential GDEs throughout Qld (Bureau of Meteorology [BoM] 2020) indicates that areas with high, moderate and low potential for groundwater interaction occur within the Project locality. The desktop GDE mapping (BoM 2020) indicates:

- Terrestrial vegetation associated with part of Roper Creek is mapped as a low potential Terrestrial GDE.
- Woodland areas adjacent to the Bingegang Pipeline Road are also mapped as a low potential Terrestrial GDE.
- The same areas mapped as terrestrial GDEs are mapped as moderate to high potential Inflow Dependant Ecosystems.

No other terrestrial vegetation is mapped as potential GDEs (BoM 2020). The desktop BoM GDE mapping (not ground-truthed) is shown in Appendix A-4-6.

The accuracy of the desktop GDE mapping (BoM 2020) of the Project locality has been reviewed by Biodiversity Australia, with the following conclusions made in relation to the presence/absence of GDEs based on detailed site surveys and assessments:

- The majority of the terrestrial vegetation associated with Roper Creek and Thirteen Mile Gully 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. The RE 11.3.25 along Roper Creek contains Qld 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 m below ground level (mbgl) and 22.7 mbgl (AGE 2020). 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.
- Aquatic habitat associated with Roper Creek and Thirteen Mile Gully is unlikely to be dependent on groundwater given the ephemeral nature of the drainage features.
- All other terrestrial vegetation is unlikely to be dependent on groundwater given that there is no evidence that any vegetation surrounding the Project has experienced any impacts (i.e. dieback) from the existing operations to the north and west of the study area.

4.1.3 Threatened Ecological Communities

4.1.3.1 Brigalow

The Brigalow communities within the study area have been assessed against the diagnostic and condition criteria listed in the *Approved Conservation Advice* (DotE 2013a) and the Species Profile and Threats Database (DAWE 2020b). This is provided in Table 12.

Table 12: Brigalow TEC assessment

Criteria	Result
1) The presence of *Acacia harpophylla* as one of the most abundant tree species in the patch. *A. harpophylla* is either dominant in the tree layer, or co-dominant with other species (notably *Casuarina cristata*, other species of *Acacia*, or species of *Eucalyptus*).	Yes – Brigalow (*Acacia harpophylla*) is dominant in the patches in the study area (see vegetation descriptions in Section 4.1.1).
2a) In Qld - the patch is in one of the following Qld bioregions (including outliers) and it meets the description of one of 16 Qld REs determined at the time of the national listing of the Brigalow ecological community under the EPBC Act. The 16 REs are, as described by the Qld Herbarium (Wilson and Taylor 2012): In the Qld Brigalow Belt Bioregion – REs 11.3.1, 11.4.3, 11.4.7, 11.4.8, 11.4.9, 11.4.10, 11.5.16, 11.9.1, 11.9.5, 11.9.6, 11.11.14 and 11.12.21.	Yes – Patches of Brigalow in the study area conform to 11.3.1.
2b) In NSW - the patch meets one of the following NSW Vegetation Classification and Assessment (VCA) community descriptions. The NSW VCA communities are: VCA IDs 29, 31 and 35; as described in Benson *et al.* (2006).	Not applicable.
2c) The vegetation in the patch is Brigalow regrowth with species composition and structural elements broadly typical of one of the identified Qld REs or NSW vegetation communities (although species density may be reduced). This can be assumed to be the case where it has been at least 15 years since it was last comprehensively cleared (not just thinned); unless direct evidence proves otherwise.	Yes – All of the remnant patches of Brigalow meet this criterion. Regrowth patches have been cleared within the last 15 years (determined through analysis of historic satellite imagery and communication with former landowner) and do not have typical structure and composition. These areas have been excluded.
3) The patch is 0.5 ha or more in size	Yes - All patches of Brigalow in the study area are >0.5 ha in area.
4) Exotic perennial plants comprise less than 50% of the total vegetation cover of the patch, as assessed over a minimum sample area of 0.5 ha (100 m by 50 m), that is representative of the patch.	Yes – exotic perennial plants comprised <50% cover in all remnant Brigalow patches in the study area. Percentages of exotic species recorded at three individual remnant Brigalow patches were: – 28% (THQ7) – 20% (Q4) – 30% (Rapid plot 42)
Result	All remnant Brigalow communities in the study area qualify as Brigalow TEC.

The above assessment confirms that Brigalow communities in the study area qualifies as Brigalow TEC listed under the EPBC Act. The location of the TECs in the study area is shown in Figure 12.

4.1.3.2 Poplar Box Woodland

The Poplar Box Woodland communities within the study area have been assessed against the diagnostic and condition criteria listed in the *Approved Conservation Advice* (DEE 2019) and the Species Profile and Threats Database (DAWE 2020b). This is provided in Table 13.

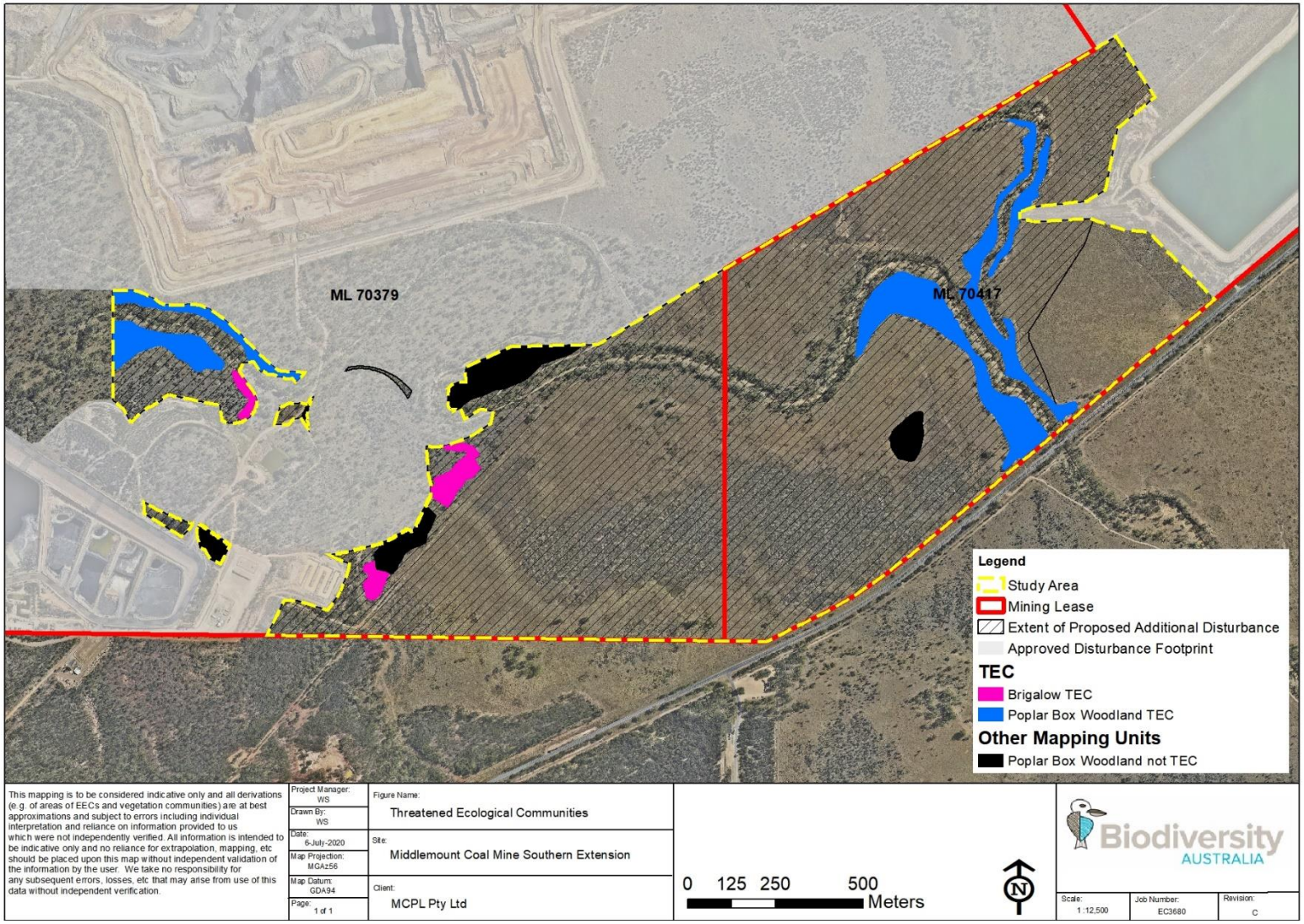
Table 13: Poplar Box Woodland TEC assessment

Criteria	Result
Occurs in the Brigalow Belt North, Brigalow Belt South, Southeast Qld, Cobar Peneplains, Darling Riverine Plains, NSW South Western Slopes, Riverina and Murray Darling Depression Interim Biogeographic Regionalisation of Australia (IBRA) Bioregions.	Yes – site occurs in the Brigalow Belt North Bioregion.
Associated with ancient and recent depositional alluvial plains with clay, clay-loam, loam and sandy loam, typically duplex soils or sodosols. This includes areas that may not be part of currently defined floodplains.	Yes – the community is located on alluvial deposits associated with Roper Creek.
A grassy woodland to grassy open woodland with a tree crown cover of 10% or more at patch scale.	Yes – has open woodland structure with canopy cover of >10%. Cover at individual patches surveyed is as follows: – 44.4% (THQ6) – 28% (THQ1) – 20% (Q2)
A tree canopy must be present that shows these features: • Canopy tree species are capable of reaching 10 m or more in height; • *Eucalyptus populnea* (Poplar Box) must be present in the canopy and is the dominant tree species; and • Where hybrids of Poplar Box with other *Eucalyptus* spp. are present, they should be counted as part of the *Eucalyptus populnea* component of the tree canopy when assessing the previous criterion.	The community present in the study area meets these requirements. The canopy height is around 15-18 m and is dominated by Poplar Box. Refer to vegetation description in Section 4.1.1.
Mid layer (1-10 m) crown cover of shrubs to small trees is low, about 30% or less.	Yes – community has low shrub cover <30%. Shrub cover at individual patches surveyed is as follows: – 0.6% (THQ6) – 3.3% (THQ1) – 5% (Q2)
A ground layer (<1 m) mostly dominated across a patch by native grasses, other herbs and occasionally chenopods (during extended dry periods), ranging from sparse to thick (in response to canopy development, soil moisture, disturbance and/or management history).	The community features a ground layer which contains a mix of native and exotic grasses and herbs. Field observations noted a mosaic of native and exotic dominated groundcover patches across the community. Typical exotic species include Buffel Grass (*Cenchrus ciliaris*), Sabi Grass (*Urochloa mosambicensis*), Green Panic (*Megathyrsus maximus*) and Red Natal Grass (*Melinis repens*). Patches of native grass included species such as Black Speargrass (*Heteropogon contortus*), *Aristida spp.,* Comet Grass (*Perotis rara*) and Brown's Lovegrass (*Eragrostis brownii*). Percentage exotic cover at survey sites were: – 80% (THQ6) – 80% (THQ1) – 75% (Q2)

Criteria	Result
A list of diagnostic native plant species and some of the key native fauna that make up the ecological community is given at Appendix A; although particular species may be abundant or rare, or not necessarily present, at every location.	The community contains a range of diagnostic native plant species. These include Poplar Box (*Eucalyptus populnea*), Wilga (*Geijera parviflora*), False Sandalwood (*Eremophila mitchellii*), Whitewood (*Atalaya hemiglauca*), Black Speargrass, *Aristida spp.* and Australian Bluebell (*Wahlenbergia gracilis*).
Condition classes and minimum patch size thresholds: • Class A (Highest quality): >1 ha • Class B (Good quality): >5 ha • Class C (Moderate quality): >5 ha	Remnant patches in the study area would fall within the Class C category (moderate quality) due to the prevalence of exotic species in the ground layer. This class must have a minimum patch size of >5 ha. Most patches that occur along Roper Creek form part of a larger extent of the community that occurs beyond the study area and are >5 ha. One 2.4 ha patch adjoins areas approved to be cleared and has been excluded. All other patches along Roper Creek are > 5 ha. Two isolated patches occur further form Roper Creek and do not meet the minimum patch size. These have been excluded. Non-remnant areas of the community in the study area would not meet the diagnostic criteria and minimum condition thresholds and would therefore not qualify as the TEC.
Result	Most of the Poplar Box Woodland on alluvial communities in the study area qualify as the TEC.

The above assessment confirms that Polar Box Woodland communities in the study area occurring on Land Zone 3 qualify as the TEC listed under the EPBC Act. The location of the TEC's in the study area is shown in Figure 12.

Figure 12: Threatened Ecological Communities listed under the EPBC Act



4.1.4 Threatened Flora

Database and literature searches returned records of one flora species within a 10 km radius of the study area as shown in Table 14 below. The complete online search results are provided in Appendix 5.

Table 14: Locally recorded threatened flora species

Common Name	Scientific Name	NC Act Status	EPBC Act Status	Source
-	*Cerbera dumicola*	NT	-	DES 2020b
Key: Near Threatened (NT).				

No threatened flora species were recorded during the field surveys. There are no previous records of threatened flora species within the study area. The study area does not occur within a high-risk trigger area (see report in Appendix A-4-1).

A small extent of potential habitat for *Cerbera dumicola* is present within the south-west of the study area in REs 11.7.2 and 11.7.4, however the species was not identified here during these or previous field surveys despite targeted surveys.

Due to the disturbance history over most of the study area (e.g. grazing, weed invasion), lack of local records and limited habitat types present, the potential for threatened flora to occur would be significantly reduced and no threatened flora species are considered potential occurrences.

4.1.5 Declared Weeds

As detailed in Section 4.1, a total of 15 exotic flora species were recorded within the study area. Weed invasion is common throughout the study area, especially in disturbed areas, however it is largely limited to the groundcover stratum. Naturalised introduced pasture species such as Buffel Grass (*Cenchrus ciliaris*), Sabi Grass (*Urochloa mosambicensis*) and Red Natal Grass (*Melinis repens*) along with herbs including *Sida* spp., Cobblers Pegs (*Bidens pilosa*), Gomphrena Weed (*Gomphrena celosioides*) and Stylo (*Stylosanthes scabra*) were the main weeds encountered. These species dominated the ground layer in the derived grassland habitats, and incursion of these species into adjacent Eucalypt woodlands was common.

Table 15 lists the noxious weeds declared under the Qld *Biosecurity Act 2014* recorded within the study area. Prickly Pear (*Opuntia stricta*) and Harrisia Cactus (*Harissia martini*) were recorded. The distribution of these species was patchy and these species are unlikely to pose a significant risk to the ecological integrity of the study area due to their low density.

Table 15: Noxious Weeds recorded within the study area

Scientific Name	Common Name	*Biosecurity Act* Category	Weed of National Significance	Abundance
Opuntia stricta	Prickly Pear	Class 2,3,4,5	Yes	Low
Opuntia tomentosa	Velvety Tree Pear	Class 3	Yes	Low
Harrisia martini	Harrisia Cactus	Class 3	No	Low

4.2 Fauna

4.2.1 Broad Fauna Habitats

Fauna habitats within the study area were categorised and mapped into six broad habitat types. The broad fauna habitat types present in the study area are:

- 1. Eucalypt woodland/forest;
- 2. Riparian Eucalypt woodland;
- 3. *Acacia harpophylla* woodland/forest;
- 4. *Acacia shirleyi* forest;
- 5. Regrowth vegetation; and
- 6. Cleared grassland.

Table 16 details the REs which make up each broad fauna habitat type in the study area along with the area (in ha) of each. Broad fauna habitat mapping is shown in Figure 13.

Table 16: Broad fauna habitat types

Broad Fauna Habitat Type	Regional Ecosystem	Field Verified Area (ha)
Eucalypt Woodland	11.3.2/11.3.2b	20.53
	11.3.7	6.18
	11.5.3	44.61
	11.7.4	1.63
Subtotal (Eucalypt Woodland)		72.95
Riparian Eucalypt Woodland	11.3.25	14.06
***Acacia harpophylla* Woodland/forest**	11.3.1	2.22
***Acacia shirleyi* Forest**	11.7.2	0.76
Regrowth Vegetation	-	92.68
Cleared Grassland	-	91.83
Total		274*

* denotes a rounded number

Table 17 describes the habitat values per category, with focus on habitat value and suitability for foraging, nesting, roosting, and breeding requirements for potentially occurring threatened species listed under the NC Act and EPBC Act.

Figure 13: Fauna habitat type mapping of the study area

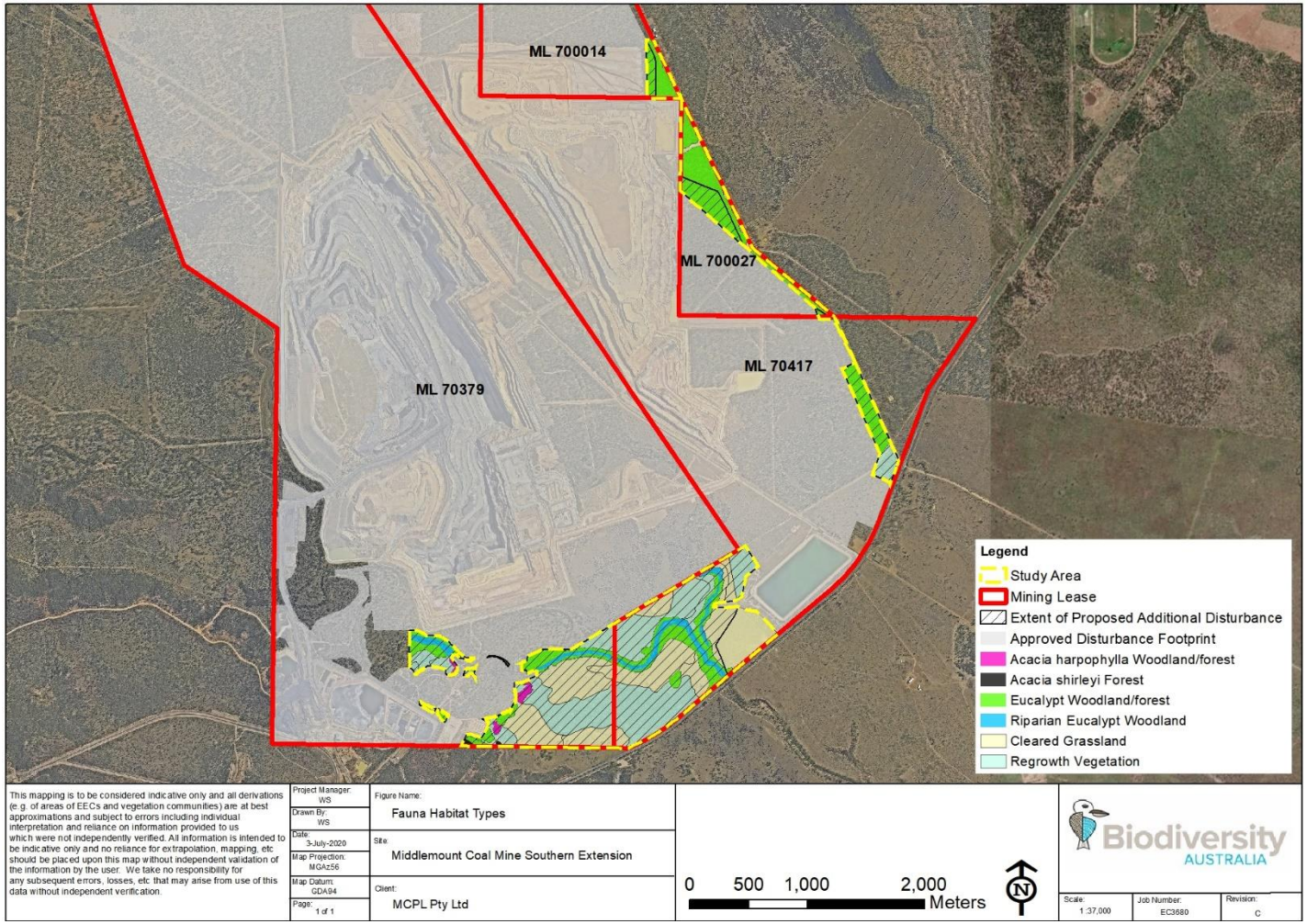


Table 17: Fauna habitat assessment

Habitat attribute / Category	Site Values					
	1. Eucalypt Woodland	**2. Riparian Eucalypt Woodland**	**3. *Acacia harpophylla* Woodland/forest**	**4. *Acacia shirleyi* Forest**	**5. Regrowth Vegetation**	**6. Cleared Grassland**
Groundcover	Variable density and composition depending on disturbance history. Some areas feature a moderately dense cover of exotic grasses while some are more open and dominated by native grasses and shrubs. A number of native grass species provide a potential food resource for the Squatter Pigeon (southern). Some areas also have a mosaic of open sandy areas and native grasses which is preferred habitat for this species.	Generally consists of a dense layer of herbs and grasses, with exotic species dominant.	Sparse to open ground cover of mostly native grasses, with areas of bare ground. Provides potential shelter and prey habitat for threatened reptiles.	A moderately dense and low groundcover layer of native grasses is present. Low diversity and mainly consists of Tableland Couch.	Dominant ground cover composition of exotic grasses with native grasses and herbs being less common (Photos 13 and 14). Dense areas of Brigalow regrowth have a sparse groundcover.	Dominated by exotic grasses and herbs throughout. Occasional patches of native grass such as Black Speargrass.
Leaf Litter	High under canopy trees and scattered throughout the mixed grass undergrowth.	Only low extent of leaf litter under canopy trees and most is overgrown with weeds.	Mature Brigalow habitats contained accumulations of leaf litter which would provide shelter and prey habitat for a range of small reptiles. Some patches had less leaf litter do a patchy canopy and exotic grass invasion.	Well-developed leaf litter accumulations occur in some places. Foraging substrate for common reptiles and small mammals.	Very sparse leaf litter due to absence of canopy and understorey trees.	No leaf litter present due to absence of trees and shrubs.

Habitat attribute / Category	Site Values					
	1. Eucalypt Woodland	**2. Riparian Eucalypt Woodland**	**3. *Acacia harpophylla* Woodland/forest**	**4. *Acacia shirleyi* Forest**	**5. Regrowth Vegetation**	**6. Cleared Grassland**
Logs and Debris	Reasonable abundance of hollow logs and debris present due to the nature of Eucalyptus shedding limbs. Larger logs provide shelter and prey habitat for ground dwelling reptiles.	A few habitat logs occur along the banks and within Roper Creek. These would provide shelter for fauna and snags in the creek when it contains water.	Moderate to high density of coarse woody debris, which is typical of this habitat type. Could provide potential shelter and prey habitat for the Ornamental Snake (Photo 11). Hollow logs are however rare.	High density of coarse woody debris from fallen Acacias. No hollow logs present. (Photos 9 and 10).	Very few logs observed. Some log and debris piles occur as a result of past clearing. These would likely provide refuge for common species only, as well as feral species such as the Fox and Feral Cat.	Logs and fallen timber generally sparse, however some large logs are present as a result of past clearing. These would likely provide refuge for common species only, as well as feral species such as the Fox and Feral Cat.
Rocky outcrops	Absent	Absent	Absent	Extensive rock outcropping and surface rocks are present in this habitat type. This would provide ideal reptile shelter and foraging habitat.	Absent	Absent
Aquatic habitat	Aquatic habitats in this habitat type is limited to small ephemeral soaks that would only hold water for short periods. No value to aquatic species.	Roper Creek is an ephemeral creek line and flow is restricted to high rainfall periods. The creek was flowing at the time of the survey. Water was highly turbid and flowing rapidly. Some pools of water remain in the creek for longer periods after the wet season and would provide fish and aquatic invertebrate habitat.	Brigalow habitats contain gilgai that hold water during the wet season and provide habitat for amphibians. Water was present in gilgai during the survey and a range of amphibian species were recorded using these habitats.	Absent	Absent aside from a few soaks and drainage depressions that would hold water temporarily after rain. Habitat for common frog species which could potentially attract Ornamental Snake.	Absent

Habitat attribute / Category	Site Values					
	1. Eucalypt Woodland	**2. Riparian Eucalypt Woodland**	**3. *Acacia harpophylla* Woodland/forest**	**4. *Acacia shirleyi* Forest**	**5. Regrowth Vegetation**	**6. Cleared Grassland**
Hollows	Hollow-bearing trees and stags are common within this habitat type. A range of hollow-sizes are present i.e. <5 cm to >20 cm diameter cavities. Hollows provide known denning habitat for the Greater Glider as well as a range of common species.	Occasional Blue Gums in this community contain hollows. These would provide a denning resource for the Greater Glider as well as common birds, microbats and arboreal mammals.	Low occurrence of tree hollows in occasional eucalyptus species present.	Absent	Absent	Absent
Nectar sources	Woodland habitats contain a range of nectar producing species e.g. eucalypts, acacias and grevilleas. Only some Poplar Box were in flower during the survey, with most species not flowering.	Eucalypts in this community would provide a seasonal nectar source.	*Acacia harpophylla* is the primary nectar source and would provide foraging resources for fauna when in flower.	*Acacia shirleyi* is the primary nectar source and would provide foraging resources for fauna when in flower.	This habitat type does not provide a significant nectar source due to the lack of mature trees.	Absent
Koala food trees	Moreton Bay Ash, Reid River Box and Poplar Box are the main Koala browse species in this community (DotE 2014). Koala scats were recorded in this habitat type.	Queensland Blue Gum is the dominant Eucalypt and is a preferred Koala browse species.	Absent	Absent	Absent aside from Eucalypt saplings which do not provide a foraging resource to Koalas at present.	Absent

Habitat attribute / Category	Site Values					
	1. Eucalypt Woodland	**2. Riparian Eucalypt Woodland**	**3. *Acacia harpophylla* Woodland/forest**	**4. *Acacia shirleyi* Forest**	**5. Regrowth Vegetation**	**6. Cleared Grassland**
Connectivity values	Woodland in the south along Roper Creek consists or narrow linear remnants that are bisected by roads and mining areas Woodland is more contiguous in the east of the study area, however is becoming split into smaller patches as a result of the advancing mine and is fragmented by several roads and fence lines. This habitat type would benefit the local movements of a range of fauna species, including arboreal species such as the Koala and Greater Glider.	This community consists of a narrow linear remnant along Roper Creek. It would provide good connectivity values for arboreal species such as Gliders and the Koala. Many species, including Feral Dogs and Cats also move along the creek lines.	The small patches of Brigalow habitats would contribute to the connectivity values of the other site habitats; however it is generally isolated, and would not provide any specific connectivity values for fauna.	Provides minor connectivity values due to small patch size and limited connectivity to larger areas of habitat. Would allow some facilitation of fauna movement in the southwest of the study area and extending beyond to the southwest.	Poor values at present and would be mainly used by small terrestrial species. No connectivity values for arboreal species and only highly mobile fauna would use these habitats.	Poor values at present and would be mainly used by small terrestrial species. No connectivity values for arboreal species and only highly mobile fauna would use these habitats.

Photo 9: Riparian Eucalypt woodland along Roper Creek (habitat 2)

Photo 10: Coarse woody debris *in Acacia shirleyi* Forest (Habitat 4)

Photo 11: Coarse woody debris in *Acacia harpophylla* Woodland/forest (Habitat 3)

Photo 12:Gilgai present in *Acacia harpophylla* Woodland/forest (Habitat 3)

Photo 13: Typical regrowth vegetation (Habitat 5)

Photo 14: Dense exotic groundcover in Cleared Grassland (Habitat 6)

4.2.2 Local Corridors and Habitat Linkages

The Eucalypt woodland/riparian eucalypt woodland in the southern portion of the study area continues along Roper Creek (downstream) to the south of ML 70417. The habitat associated with Roper Creek to the west (upstream) is already approved to be cleared (and already offset) as part of the Middlemount Coal Mine.

The Eucalypt woodland habitat in the eastern portions of the study area is located on the edge of the existing/approved East Dump. This Eucalypt woodland is part of larger patches.

4.2.3 Observed and Detected Fauna

A total of 79 fauna species were detected during the survey either opportunistically or during targeted surveys. Birds were the most common fauna group observed with a total of 51 species detected. Twenty-four (24) mammals, three amphibians and seven reptiles were also detected. Photos 15-16 were taken during the surveys of the study area.

Mammal species recorded largely comprised microbats, however three Glider species were also recorded. The Echidna was observed during the June survey period in the southwest of the study area.

Three threatened species were recorded during the surveys. These comprised the Greater Glider, Koala (scat only) and Squatter Pigeon (southern). These species are further discussed in Section 4.2.5.

Three pest species were also recorded during surveys comprising the Wild Dog, Feral Cat and Rabbit. These are further discussed in Section 4.2.6.

Appendix A-3 provides the total fauna list for the study area and the method of detection.

Photo 15: Rough-collared Frog

Photo 16: Bynoe's Gecko

4.2.4 Fauna Assemblages

The fauna detected on the site generally consisted of common, generalist and wide-ranging species capable of persisting in modified habitats. Native mammals were reasonably well represented in the survey results, especially microbats. A total of 13 microbat species were positively identified through the Anabat analysis. The diverse range of habitats would provide a good foraging base and numerous hollows present in the study area would provide a range of roosting and breeding opportunities for these species.

Of note was the detection of three different Glider species comprising the Greater Glider (listed as Vulnerable under the NC Act and EPBC Act), Squirrel Glider and Sugar Glider. The Poplar Box woodland communities in the study area provide good foraging and breeding habitat for these species.

Bird diversity was high with a relatively diverse range of passerines detected across the study area. Three raptor species were also detected which indicates the study area has a reasonable prey base. The results are considered an indication of the range of foraging resources present (e.g. flowering canopy and understorey trees, fruiting species) and good understorey development in places providing shelter.

Ideal conditions for amphibian surveys were experienced during the March survey period, however a limited number of frog species were detected at this time. Amphibians would provide a good prey base for snakes.

Reptiles were poorly represented in the survey considering the above average survey effort employed. This is likely to be an indication of poor habitat quality and lack of habitat components such as rock outcrops and cracking clays (Wilson 2003). The presence of Cane Toads and other feral species (i.e. cats, dogs) may have impacted on reptile abundance.

4.2.5 Threatened Fauna Species

Database and literature searches returned records of four fauna species within a 10 km radius of the study area as shown in Table 18 below. The complete online search results are provided in Appendix A-4-2. The location of previously recorded threatened species in close proximity to the study area is provided in Figure 14.

Table 18: Locally recorded threatened fauna species

Common Name	Scientific Name	NC Act Status	EPBC Act Status	Source
Squatter Pigeon (southern)	*Geophaps scripta scripta*	V	V	EHP 2012, PB 2010a, Naturecall 2014b, Naturecall 2013-2017, Biodiversity Australia 2018b
Greater Glider	*Petauroides volans*	V	V	DEHP 2020, Naturecall 2013-2017, Biodiversity Australia 2018b
Koala	*Phascolarctos cinereus*	V	V	EHP 2012, DEHP 2020, Naturecall 2013-2017, Biodiversity Australia 2018b
Ornamental Snake	*Denisonia maculata*	V	V	PB 2010a
Key: Vulnerable (V).				

Three of these previously recorded, listed threatened fauna species were recorded during the field surveys. These comprised the Greater Glider and Koala (scat only) within the study area; and the Squatter Pigeon (southern) to the north-west of the study area. These are discussed in the following sections, and Figure 15 displays their recorded location. Although not recorded during field surveys, the potentially occurring Ornamental Snake has been recorded in nearby areas during surveys undertaken by PB (see Section 2.5.1) and in various literature and databases, and is therefore discussed in Section 4.2.5.4. The White-throated Needletail is also considered a low potential occurrence as the study area contains broadly suitable habitat. This has not been recorded on MCPL land during previous surveys.

No additional threated fauna species were recorded within the study area during the survey.

4.2.5.1 Greater Glider

The Greater Glider occurs in forests and woodlands across eastern Australia where it forages on eucalypt leaves and occasionally flowers (Threatened Species Scientific Committee [TSSC] 2016). It requires large tracks of remnant forests which contain old growth trees containing hollows which it uses for denning.

Conservation advice (TSSC 2016) details that the Greater Glider is largely restricted to eucalypt forests and woodland, with its diet comprising mostly eucalypt leaves. Consistent with this, previous observations of this species on MCPL owned land have noted that it prefers Eucalypt woodlands and open forest associated with major creeks and drainage lines, equivalent to RE types 11.3.2, 11.3.25, 11.3.4 and 11.3.7. It has also been occasionally noted in Poplar Box woodland equivalent to RE 11.5.3. Based on these previous observations, preferred forage species appear to be Moreton Bay Ash, Silver-leaved Ironbark and Poplar Box.

The Greater Glider (Vulnerable – EPBC Act) was detected during the survey period via spotlighting surveys. The Glider was detected on four nights in vegetation fringing Roper Creek (RE 11.3.25 and 11.3.2) in the southern portion of the study area. A maximum of four individuals, including a juvenile Glider, were recorded here in one night. Another individual was recorded on one night immediately north of the eastern portion of the study area adjacent to the Bingegang Pipeline Road within RE 11.5.3. This individual would utilise vegetation within the study area. Two Gliders were also recorded on 20th June next to a track located 200m north of the study area.

Greater Gliders have small home ranges ranging between 1.3 and 4 ha (Comport *et al.* 1996, Pope *et al.* 2005, TSSC 2016). The study area would therefore encompass entire home ranges of the Gliders, and they would also be expected to extend off site to the east of the eastern portion of the study area.

The Greater Glider has been previously recorded on MCPL lands during fauna surveys and clearing supervision works. BioCondition monitoring surveys of the existing offset areas observed at least 16 Greater Gliders in 2017, which were primarily recorded along Roper Creek (Naturecall 2017b).

4.2.5.2 Koala

The Koala is an obligate folivore that predominantly feeds on leaves from *Eucalyptus* trees (DAWE 2020). Koalas feed on a wide range of eucalypt species, however they have a small number of preferred food trees. These preferred tree species vary depending on location. A review of available literature and information from previous surveys within MCPL lands (see Section 2.5) have found that the following trees are preferred species in the local area:

- Reid River Box (*Eucalyptus brownii*).
- Narrow-leaved Ironbark (*Eucalyptus crebra*).
- Queensland Peppermint (*Eucalyptus exserta*).
- Queensland Blue Gum (*Eucalyptus tereticornis*).
- Moreton Bay Ash (*Corymbia tessellaris*).

Four of these preferred species were recorded within the study area. Reid River Box was recorded within the study area, however was scarce and only present within RE 11.5.3. Narrow-leaved Ironbark was commonly recorded within RE 11.7.4. Queensland Blue Gum was common within vegetation fringing Roper Creek (RE 11.3.25). Moreton Bay Ash was also commonly recorded throughout the study area with frequent records of this species in RE 11.3.2/11.3.2b, RE 11.3.25 and RE 11.3.7. Queensland Peppermint was not detected within the study area, however is found on MCPL owned land to the west of the Middlemount Coal Mine.

Although preferred Koala food trees were common throughout the Eucalypt woodland/forest communities within the study area, these communities were sparse and open, providing an overall scarcity of foraging resources.

No Koalas were observed or heard calling despite targeted surveys, however the presence of the Koala within the study area was detected via opportunistic scat searches and an SAT plot. Koala scats were identified under a single Reid River Box within a eucalypt forest/woodland in the eastern portion of the study area (Photo 17). The age of the scats from visual identifiers was estimated at six months old.

An SAT survey was undertaken here, however only one scat was recorded giving an activity level of 3%. The SAT plot undertaken along Roper Creek in the south of the study area did not yield any results.

Koala scats were previously recorded in a similar location during surveys for the Western Extension Project in 2017 (Biodiversity Australia 2018b). Koala scats recorded during this study were also recorded under a Reid River Box and verified by a scat analysis expert, Luke Forster of Trace Ecology. The 2017 record marked the first confirmed record of the Koala in the eastern part of MCPL lands. At the time, it was not known if this record formed part of the habitat for a resident Koala population or if it was merely a transient Koala moving through the area. Recent anecdotal reports of Koala activity in this area were obtained through MCPL in June 2020 who reported seeing a Koala during fauna spotting works (K. Hall pers. comm.) as well as Koala tracks along a dirt road (D. Statham pers. comm,). With the identification of Koala scats a similar location to the 2017 record, and recent reports of observations and tracks, it now appears more likely an indication of a resident Koala.

Photo 17: Koala scats located within the study area

A number of additional historic records of the Koala have been recorded in MCPL owned land. In 2012, EHP recorded an individual Koala in the south of the Stage 2 Offset Area and Biodiversity Australia recorded an individual adjacent to Parrot Quarry Road in 2014 (Naturecall 2014a).

Given the limited evidence of the Koala recorded in this survey and sparse records in the area (despite numerous past surveys and ongoing offset monitoring/management), it appears that a low-density Koala population is present on MCPL lands and surrounding areas. Given the general low nutrient soils and scarcity of preferred foraging trees, Koala home ranges would be very large.

A large portion of the REs mapped within the study area would provide potential foraging habitat for the Koala based on the occurrence of known and potential Koala food trees including preferred species described above (i.e. Reid River Box, Narrow-leaved Ironbark, Queensland Blue Gum and Moreton Bay Ash). This includes RE 11.3.2/11.3.2b, RE 11.3.25, RE 11.3.7, RE 11.5.3 and RE 11.7.4, equating to approximately 63.27 ha of Koala habitat across the disturbance footprint. These areas would provide beneficial movement corridors (i.e. connectivity) for the Koala throughout the landscape, particularly areas of contiguous habitat.

4.2.5.3 Squatter Pigeon (southern)

A single Squatter Pigeon (southern) was opportunistically recorded along the roadside, north of the mine. This species was not recorded within the study area during the survey period.

Although not recorded within the study area during this current survey, the Squatter Pigeon (southern) has been recorded within the study area historically. Fauna surveys conducted by Biodiversity Australia in 2017 for the Western Extension Project identified the Squatter Pigeon (southern) along the Bingegang Pipeline Road (Biodiversity Australia 2018b). This species has also been previously recorded on MCPL owned land in 2010, 2013 and 2015 (Will Steggall pers obs., Naturecall 2013, PB 2010a).

A number of habitat attributes which would provide suitable habitat for the Squatter Pigeon (southern) are present. These include a number of native grass species, permanent water resources and a mosaic of open sandy areas. Within the study area, suitable habitats are likely to comprise RE 11.3.1, RE 11.3.2/11.3.2b, RE 11.3.25, RE 11.3.7, RE 11.5.3 and RE 11.7.4. In addition to these remnant habitats, the Squatter Pigeon (southern) is regularly sighted foraging in non-remnant habitats including pasture grassland, regrowth woodland and roadside clearings (PB 2010a, Naturecall 2013, 2014a). There a number of ephemeral water bodies within the study area which would provide a suitable water source for the Squatter Pigeon (southern).

4.2.5.4 Ornamental Snake

The Ornamental Snake was not recorded in the study area during the surveys despite targeted surveys. It has, however, been recorded by PB in 2010 on MCPL owned land on gilgai soils approximately 400 m north of the study area near Roper Creek.

The southern portion of the study area provides small patches of suitable habitat for the Ornamental Snake in the form of Brigalow habitats (RE 11.3.1) with gilgai and drainage depressions which provide habitat for preferred prey species (i.e. frogs). The habitats in the study area have, however, been substantially modified as a result of clearing, weed invasion and cattle grazing. This has reduced the quality of habitat available for the Ornamental Snake and has led to fragmentation and isolation of habitats.

4.2.5.5 Habitat Quality scores

Terrestrial habitat quality assessments (plots) were undertaken in the study area during the field survey. The data collected in the field was analysed to produce species habitat attribute scores and a site-based attribute score as per the *Guide to Determining Terrestrial Habitat Quality Version 1.3* (DES 2020a) methodology.

Species habitat assessment scores were calculated for all threatened species listed under the NC Act (and EPBC Act) that are known to or potentially occur within the study area. The following table details the results of this assessment for each species. Species habitat scores are presented as a number out of ten, with zero indicating habitat unable to support the specified species and ten having an extremely high ability to support the fauna species.

Table 19: Species habitat scoring

Species Habitat Attribute	Greater Glider	Koala	Squatter Pigeon (southern)	Ornamental Snake
Quality and availability of food and habitat required for foraging	16.7	15	18.3	12.5
Quality and availability of habitat required for shelter and breeding	12.5	10	22.5	15
Quality and availability of habitat required for mobility	12.5	12.5	20	10
Absence of threats	8	8	10	8
Species Habitat Score /10	**4.97**	**4.55**	**7.08**	**4.55**

Species assessment scores were calculated using a rating system out of five, which was then multiplied to give a score out of 25 for each indicator. Appendix A-5 provides the scorings for each species for which these species habitat scores were based.

Figure 14: Previously recorded threatened fauna

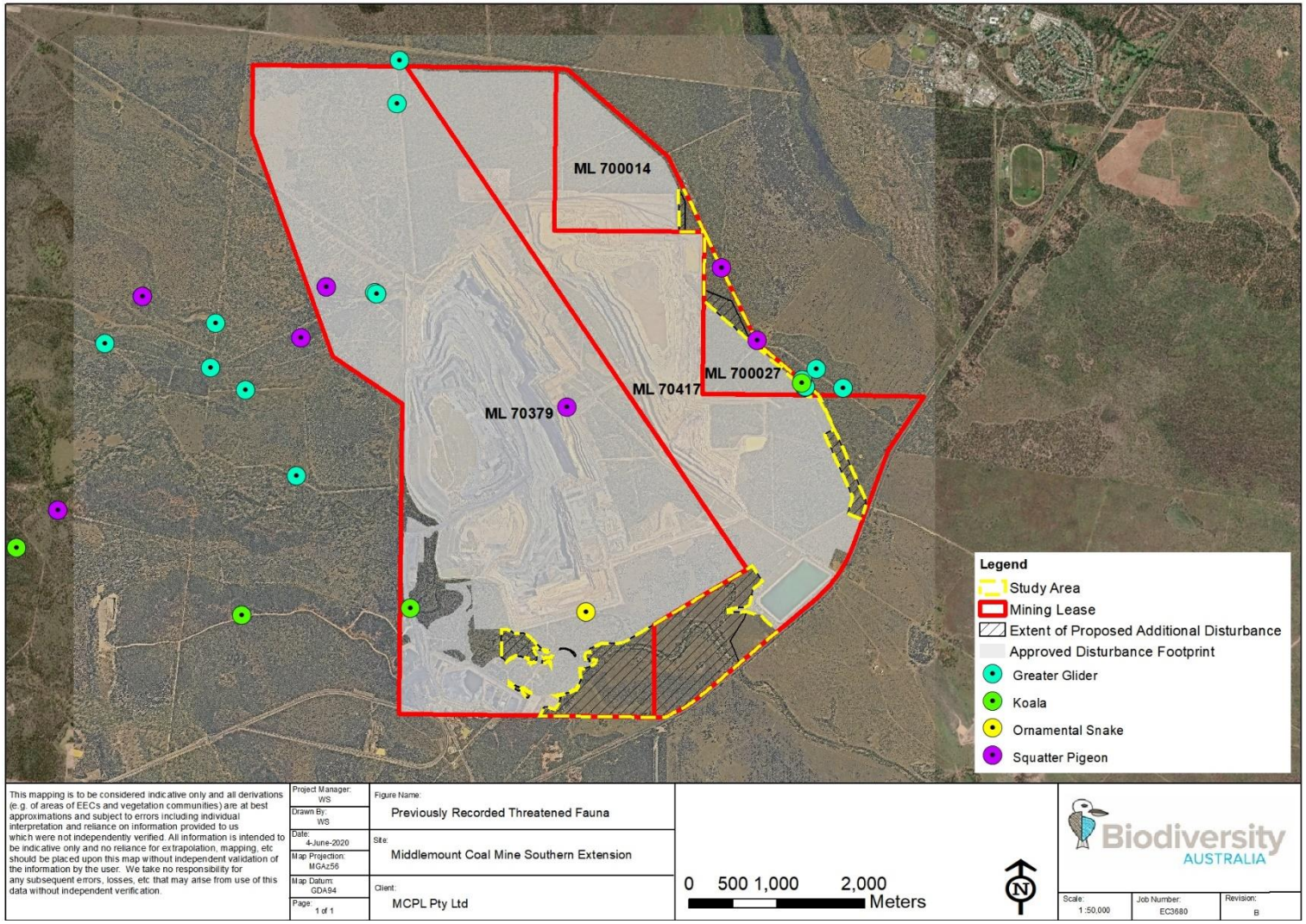
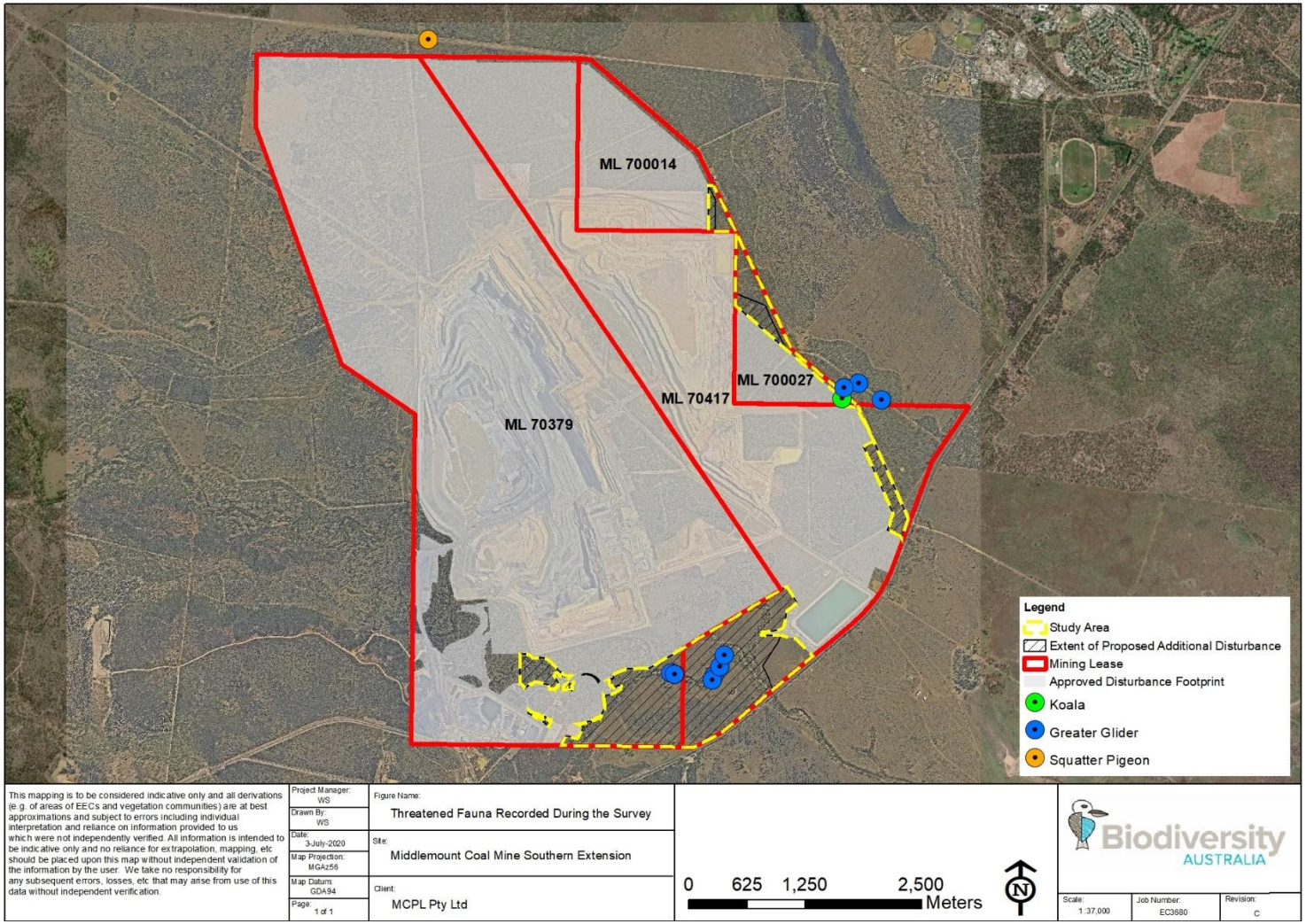


Figure 15: Location of recorded threatened fauna species within the study area in 2020



Data obtained from the terrestrial habitat quality assessments was also used to determine sampling site BioCondition scores. Habitat quality assessments were undertaken at 18 locations. The following table details the assessment unit delineation for the habitat quality score assessment and the survey plot associated with each unit. Non-remnant vegetation analogous to RE 11.7.2 could not be assessed as the assessment unit was too small to sample with a habitat quality plot.

Table 20: Assessment unit delineation

Assessment Unit	RE	Broad Condition State	Area (ha)	Related Plot
AU1	11.3.1	Remnant	2.22	T7
AU2	11.3.2/11.3.2b	Remnant	20.53	T1, T6, T10
AU3	11.3.25	Remnant	14.06	T2
AU4	11.3.7	Remnant	6.18	T12
AU5	11.5.3	Remnant	44.61	T4, T5
AU6	11.7.2	Remnant	0.76	T8
AU7	11.7.4	Remnant	1.63	T9
AU8	11.3.1	Non-remnant	57.13	T13, T15
AU9	11.3.2	Non-remnant	88.64	T14, T16, T17, T18
AU10	11.5.3	Non-remnant	38.69	T3, T11

The results of the sampling-site BioCondition scores are tabulated in Appendix A-5. The overall site-based attribute score is 4.45.

This and the species assessment scores are to inform DES of the habitat quality within the study area; and either one, or a combination of both, will be used as the basis for measuring the conservation outcome and suitability of offset areas.

4.2.6 Animal Pests

Evidence of four feral species were noted within the study area during surveys. These species comprise the following:

- Wild Dog (*Canis lupus familiaris*);
- European Rabbit (*Oryctolagus cuniculus*);
- Feral Cat (*Felis catus*); and
- Cane Toad (*Rhinella marina*).

The presence of these species was noted via a combination of track identifications and via direct observation. The European Rabbit and the Cane Toad were directly observed within the study area, whilst the Wild Dog and Feral Cat were identified by the presence of tracks. These species are not uncommon throughout MCPL owned land, with numerous records of each species in previous surveys (Naturecall 2017b, Biodiversity Australia 2018a, 2018b, 2019). Although undetected during the current survey, the Red Fox (*Vulpes vulpes*) and Feral Pig (*Sus scrofa*) have also been historically recorded in the general area.

4.3 Matters of State Environmental Significance

The results of the MSES search identified areas of threatened species habitat for the Ornamental Snake mapped in the south of the study area. Habitat for three additional threatened species was identified during surveys. Regulated vegetation occurs in patches in the study area.

The Roper Creek watercourse within the study area is not classified as a high ecological value waterway.

High ecological value wetlands are described in the Qld State Planning Policy as follows:

- Wetland in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;
- Wetlands and watercourses in high ecological value waters as identified under the Environmental Protection (Water) Policy 2009, Schedule 2.

No high ecological value wetlands are mapped or were located within the study area.

Table 21 defines the MSES that are relevant to the Project.

Table 21: Matters of State Environmental Significance

Prescribed Environmental Matter	Location of Impact
Regulated Vegetation	
RE 11.3.1 *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	Figure 16
RE 11.3.2/11.3.2b *Eucalyptus populnea* woodland on alluvial plains	Figure 16
Remnant vegetation within 5 m of the defining bank of Roper Creek	Figure 16
Connectivity Areas	
Connectivity Areas	Figure 17
Protected Wildlife Habitat	
Habitat for an animal that is vulnerable wildlife: • Ornamental Snake • Greater Glider • Koala • Squatter Pigeon (southern)	 Figure 17 Figure 18 Figure 19 Figure 20
Habitat for an animal that is Special Least Concern Wildlife: • Echidna	 -

4.3.1 Regulated Vegetation

Regulated vegetation mapped on the study area includes Endangered (RE 11.3.1) and Of Concern (RE 11.3.2/11.3.2b) REs listed under the VM Act.

Remnant vegetation within 5 m of the defining bank of Roper Creek in the study area is also regulated vegetation. This is shown in Figure 16.

4.3.2 Protected Wildlife Habitat

The field surveys identified three species which are listed threatened species in Qld under the NC Act and hence qualify as MSES. These were the Koala (scat only) and Greater Glider which were recorded within the study area, and the Squatter Pigeon (southern) which was recorded nearby. The Echidna was also recorded which is a Special Least Concern species.

Based on local records and presence of suitable habitat within the study area, the NC Act listed Ornamental Snake and White-throated Needletail are also considered as potentially occurring (Table 22). The potential for these species to occur on the site is also reviewed in Appendix A-1.

Table 22: Potentially occurring threatened species under the NC Act

Group	Species	Listing Status		Likelihood of Occurrence
		NC Act	EPBC Act	
Reptiles	Ornamental Snake (*Denisonia maculata*)	V	V	Low to fair chance of occurrence given historic records and disturbance history of preferred habitat.
Birds	White-throated Needletail (*Hirundapus caudacutus*)	V	V	No local records, however this species could use the air space above the site as it wide ranging. Low chance of occurrence.

4.3.3 Connectivity Areas

The landscape fragmentation and connectivity tool (DEHP 2018) has been applied to the Project. The results are provided in Section 5.14.2.

4.4 Matters of National Environmental Significance

The results of the MNES search are provided in Table 23. The search was undertaken using a 10 km search radius from the study area.

Table 23: Matters of National Environmental Significance search results

Category	Result	Description
World Heritage Properties	No	-
National Heritage Places	No	-
Wetlands of International Importance	No	-
Great Barrier Reef Marine Park	No	-
Commonwealth Marine Area	No	-
Listed TECs	3	Two listed TECs are known to occur within the area and one is likely to occur within the locality.
Listed Threatened Species	23	Species or species habitat known/likely/may occur within the area.
Listed Migratory Species	12	Migratory wetland, terrestrial and marine species or species habitat known/likely/may occur within the area

The protected matters search tool (DAWE 2020a) identified a range of MNES that could potentially occur in the locality. Threatened species and ecological communities listed as MNES were recorded in the study area during the field surveys. These are discussed in the following sections.

Figure 16: Regulated vegetation

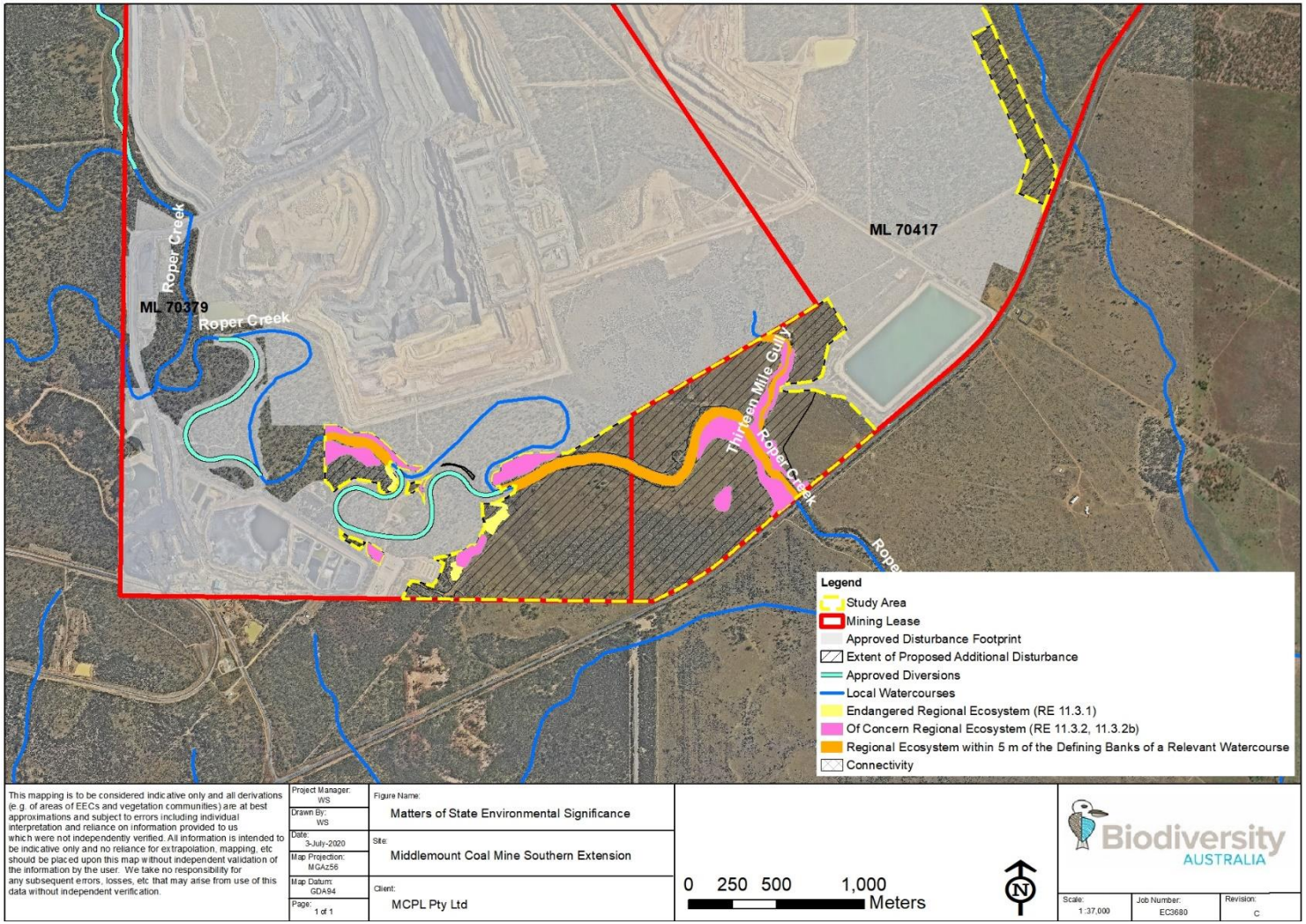


Figure 17: Protected wildlife habitat – Ornamental Snake

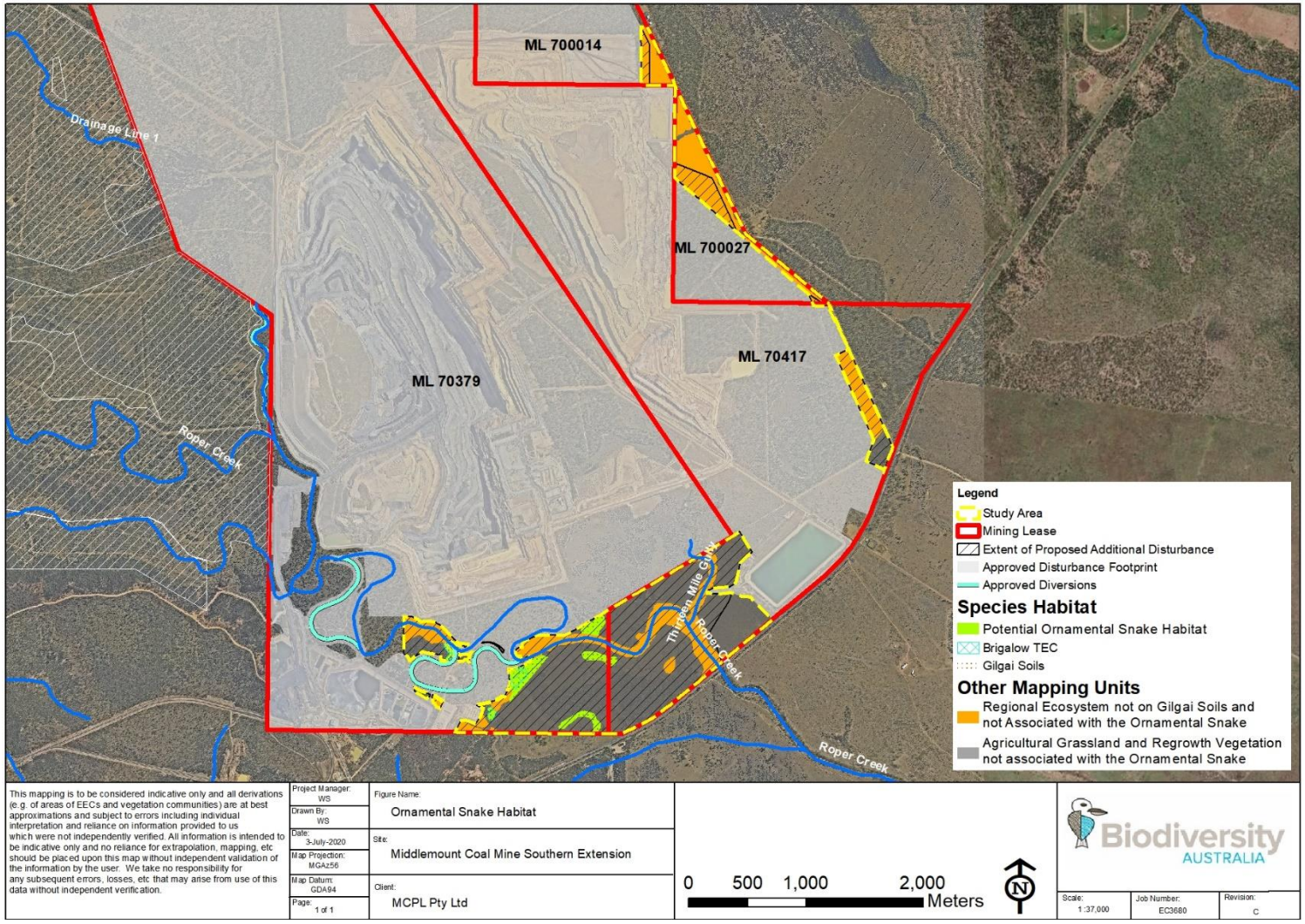


Figure 18: Protected wildlife habitat – Greater Glider

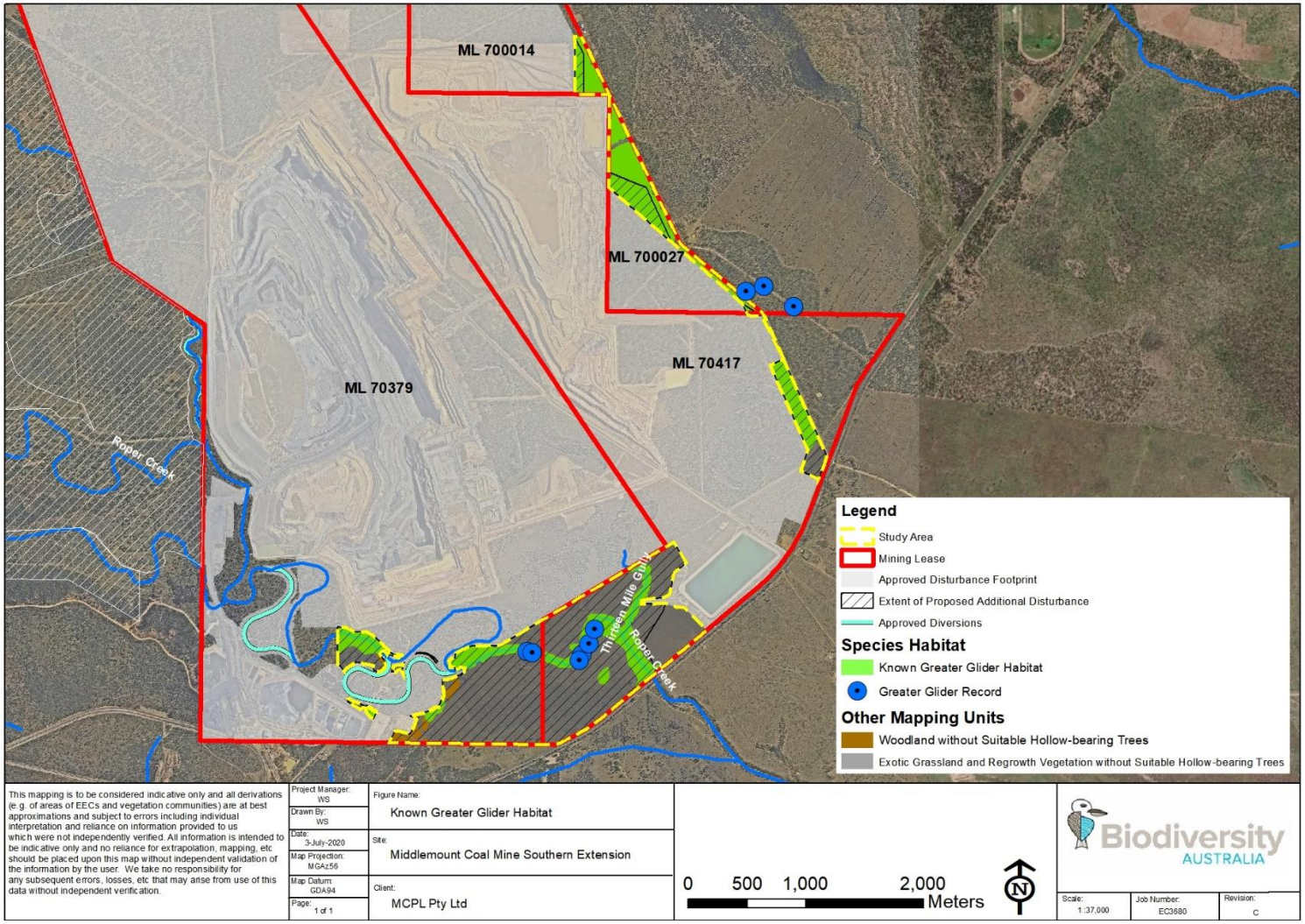


Figure 19: Protected wildlife habitat – Koala

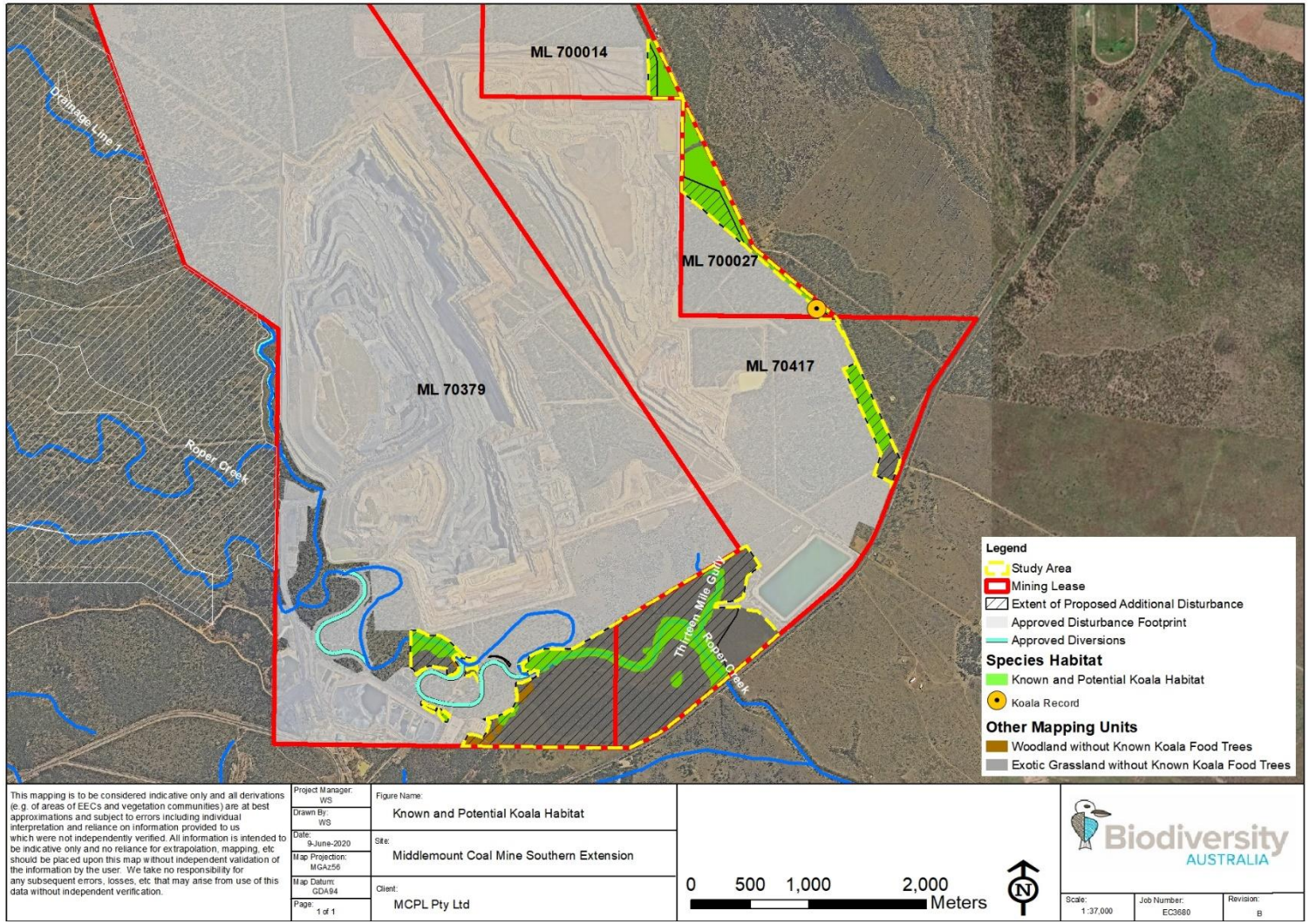
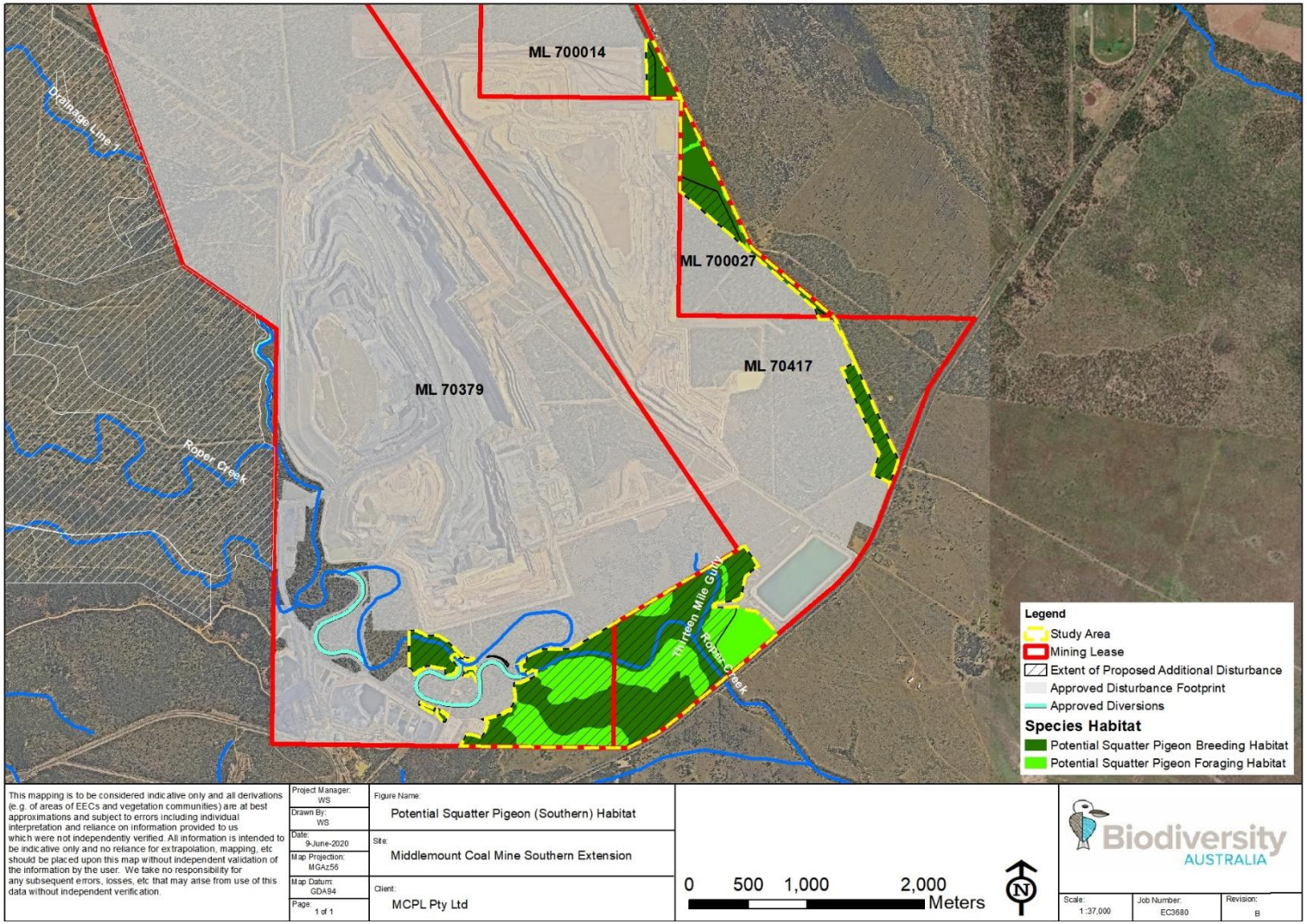


Figure 20: Protected wildlife habitat – Squatter Pigeon (southern)



4.4.1 Threatened Ecological Communities

Vegetation conforming to the Brigalow and Poplar Box TECs were recorded in the study area during the field survey. The process used to identify these TECs is described in Section 3.2.1.3.

The Brigalow community within the study area is equivalent to RE 11.3.1 (2.23 ha). Only remnant Brigalow in the study area meets the diagnostic and condition criteria for this TEC (DotE 2013a). Young regrowth Brigalow growing to approximately 1 m in height also occurs in the study area; however, it is not characteristic of the TEC and has few indicator species.

Field surveys also identified the presence of Poplar Box Woodland on alluvial soils community within the study area. This is comprised of RE 11.3.2 (19.5 ha). Areas of regrowth Poplar Box woodland occur in the study area; however, it only comprises young regrowth growing from approximately 1-4 m in height and does not meet the diagnostic or condition criteria for the TEC.

Further description of these communities is provided in Section 4.1.3 with Figure 12 displaying the distribution of these TECs over the study area.

4.4.2 Threatened Species

Three federally listed threatened species were recorded during the field surveys – the Greater Glider, Koala (scat only) and Squatter Pigeon (southern). These are all listed as Vulnerable under the EPBC Act. The occurrence and distribution of these species on site has been discussed in Section 4.2.5.

As shown in Table 24 below, two additional fauna species listed as Vulnerable under the EPBC Act are considered to potentially occur in the study area. The potential for threatened species to occur in the study area is also reviewed in Appendix A-1.

Table 24: Potentially occurring threatened fauna species

Group	Species	Predicted Type of Occurrence	Listing Status		Likelihood of Occurrence
			NC Act	EPBC Act	
Aves	White-throated Needletail *(Hirundapus caudacutus)*	Species or species habitat likely to occur within area	V	V	Low chance of occurring as not previously recorded on MCPL land and presence of large areas of similar and higher quality habitat in the locality.
Reptiles	Ornamental Snake (*Denisonia maculata*)	Species or species habitat likely to occur within area	V	V	Low to fair chance of occurrence given historic records and disturbance history of preferred habitat.

4.4.3 Migratory Species

One migratory species, the Crested Tern (*Thalasseus bergii*) was recorded during the survey. Migratory birds listed under international agreements (and the EPBC Act) are also 'Special Least Concern' fauna species listed under the NC Act.

5. Potential Impacts

5.1 Native Vegetation and Habitat Clearance

The disturbance footprint of the Project covers an area of approximately 233 ha, of which the majority (165 ha) is cleared or non-remnant vegetation. Over the life of the Project, a total of 67.88 ha of remnant vegetation would be cleared. Table 25 details the type and status of remnant vegetation that is required to be removed for the Project.

Table 26 details the classification and extent of non-remnant vegetation to be removed.

Table 25: Details on remnant vegetation to be removed

Field-verified RE	Biodiversity Status	VM Act Status	TEC Status under EPBC Act[1]	Habitat type	Area (ha)
11.3.1	Endangered	Endangered	Brigalow TEC	*Acacia harpophylla* Woodland/forest	2.22
11.3.2	Of Concern	Of Concern	Poplar Box Woodland TEC[2]	Eucalypt woodland/forest	19.5
11.3.2b	Of Concern	Of Concern	Not TEC	Eucalypt woodland/forest	1.03
11.3.25	Of Concern	Least Concern	Not TEC	Riparian Eucalypt woodland	14.06
11.3.7	Of Concern	Least Concern	Not TEC	Eucalypt woodland/forest	6.18
11.5.3	Not of Concern	Least Concern	Not TEC	Eucalypt woodland/forest	22.69
11.7.2	Not of Concern	Least Concern	Not TEC	*Acacia shirleyi* Forest	0.76
11.7.4	Not of Concern	Least Concern	Not TEC	Mixed Woodland/forest	1.63
				Total	**68.07**

[1] All TECs within the Project footprint are listed as 'Endangered' under the EPBC Act.

[2] Poplar Box Woodland TEC does not occur over the full extent of RE 11.3.2 within the Project footprint.

Table 26: Details on regrowth and cleared vegetation to be removed

Field-verified Pre-clear RE	Habitat type	Area (ha)
11.3.1	*Acacia harpophylla* woodland/forest	52.77
11.3.2	Eucalypt woodland/forest	29.27
11.5.3	Eucalypt woodland/forest	10.19
11.7.2	*Acacia shirleyi* forest	1.04
Cleared land	-	71.64
	Regrowth	**93.2**
	Total	**164.84**

The vegetation that would be removed contains a number of fauna habitat components such as potential nesting/denning/roosting habitat for hollow-obligate species in hollow-bearing trees, shelter provided by dense vegetation and fallen timber, foraging resources (e.g. nectar and sap sources), fruiting resources, seeds and grains along with prey habitat.

The vegetation proposed to be removed by the Project includes known or potential habitat resources for the following threatened fauna species:

- Greater Glider (63.27 ha, comprising only of remnant vegetation).
- Koala (63.27 ha, comprising only of remnant vegetation).
- Squatter Pigeon (southern) (233 ha, comprising 68.07 ha of remnant vegetation and 164.84 ha of regrowth).
- Ornamental Snake (12.81 ha, comprising 2.22 ha of remnant vegetation and 10.59 ha of regrowth; within this remnant and regrowth vegetation).

The RE's associated with the habitat types for each of the threatened fauna species listed above are described in Section 4.2.5.

5.2 Individual Fauna Mortality and Injury

The removal of native vegetation associated with the Project, particularly hollow-bearing trees and logs, has the potential for direct mortality of fauna species. This potential risk is increased during the breeding seasons (generally spring to late autumn), and cooler seasons when mammals and reptiles enter torpor.

To reduce the likelihood of direct mortality to native fauna species, MCPL would implement the vegetation clearance protocol described in Section 6.2.

5.3 Habitat Fragmentation

The vegetation communities in the disturbance footprint are largely patchy and fragmented, providing limited connectivity for fauna. The vegetation within the north-eastern portion of the disturbance footprint is more contiguous and provides some degree of connectivity, however is fragmented by several roads and fence lines.

The Project is adjacent to the approved mine surface disturbance footprint, and clearance of vegetation within the Project footprint is not likely to isolate any external habitats (only increase the size of the existing footprint). The removal of vegetation from the disturbance footprint would, however, increase the level of local fragmentation and reduce connectivity between remaining habitats in the locality.

The Project would also increase the barrier already presented by the existing mine for terrestrial fauna species which would generally avoid crossing cleared land. This would have the greatest impact on less mobile species, including herpetofauna (e.g. snakes, lizards and frogs), arboreal mammals (e.g. Sugar Glider, Squirrel Glider and Greater Glider) and small mammals (e.g. rodents).

While fragmentation at the local scale would be high, the loss of habitat resulting from the Project in the wider area would only incrementally increase fragmentation in an already highly fragmented landscape. Many of the fauna groups represented in the area are highly mobile (e.g. birds, bats macropods), and would be accustomed to the level of fragmentation. Post-mine landforms are proposed to be progressively rehabilitated to include woodland habitat, except for residual voids.

5.4 Edge Effects

Changes to the edges of vegetation communities have been attributed to a range of detrimental effects on different ecosystems. These changes have been linked to effects such as the alteration of environmental conditions, changes in species abundance and distributions and changes in species interactions (Murcia 1995).

Existing vegetation in the Project area and adjacent land is currently fragmented from pastoral areas, the existing mining works, roads and easements; hence any edge effects are likely to have already manifested. The Project would extend the range of edge effects to areas surrounding the disturbance footprint. Newly exposed edges created by clearing works may be subject to higher levels of weed invasion.

Further, given the open nature of the adjacent woodland habitats, no alterations to microclimate or species assemblage are likely to occur as a result of the Project.

5.5 Vehicle Strike

Studies have shown a significant increase in fauna vehicle strike incidents where road densities and vehicle speeds are high, which can result in the direct mortality of fauna (Clevenger *et al.* 2002, Gurriga *et al.* 2012). The Project would contain new haul roads which would increase the risk of road strike to the site, however all roads on the mine site are limited to 40 km/hour which would greatly reduce this risk.

5.6 Surface Water

The Project would result in changes to the natural flow regimes of the local drainage features, as a result of the following activities:

- the capture and re-use of drainage from operational disturbance areas;
- the re-positioning of the approved southern flood levee and water management infrastructure; and
- the realignment and extension of the approved (but not yet constructed) eastern diversion of Roper Creek inside the ML.

5.7 Groundwater Dependent Ecosystems

As discussed in Section 4.1.2, some of the vegetation within the study area is mapped as being a low potential GDE. The Project would involve further diversion of Roper Creek which may lead to reduced groundwater flows. Given that the vegetation along the existing path of Roper Creek would be removed and the creek would be diverted to the south, changes in groundwater would not affect the mapped potential GDEs in the disturbance footprint.

Potential impacts to downstream vegetation communities as a result of changes to the groundwater and surface water regime are unlikely to be significant and no adverse impacts have been noted as a result of existing operations.

5.8 Invasive Weeds

The exposure of new vegetation edges and an increase in vehicle and foot traffic within the study has potential to introduce and increase the spread of weeds. The introduction of weeds can have a significant impact on native flora and fauna by altering natural features and ecological processes within ecosystems and outcompeting native flora for necessary sunlight, shade, nutrients and space (NSW Department of Planning, Industry and Environment [DPIE] 2019).

Newly exposed edges created by clearing works have the potential to be subject to higher levels of weed invasion, however the likelihood that weeds would spread into adjoining native woodland/forest vegetation as a result of the Project would be low as declared weeds would be controlled as per management measures outlined in the existing Offset Management Plan/Vegetation Management Plan (MCPL 2019). Further, construction areas and the post-mine landforms would be progressively rehabilitated with native vegetation (limiting opportunities for weeds to grow).

5.9 Feral Animals

Mining, industrial and rural developments are often associated with the introduction of non-native fauna species (e.g. rodents, foxes and rabbits) by incidentally creating favourable conditions and habitat niches. Feral cats and foxes are significant predators of native fauna species and have severely reduced populations of birds (including the Squatter Pigeon [southern]) and small mammals (National Parks and Wildlife Service 2001, Dickman 1996, May and Norton 1996, Department of Agriculture and Fisheries 2016). Wild Dogs are significant threats to species such as the Koala (Wilkes and Snowden 1998, Connell Wagner 2000, Department of Agriculture and Fisheries 2016), while other feral animals, such as rabbits, are linked to severe land degradation and soil erosion, threatening habitats critical to many endangered native species (Department of Agriculture and Fisheries 2019).

These species are known to have a negative impact on native fauna by competing for food and shelter, destroying habitat, hyper-predation and by spreading disease (Department of Agriculture and Fisheries 2016). Additionally, the mere presence of these predators alone has been shown to affect fauna behaviour, e.g. avoidance of predator-inhabited areas that otherwise provide suitable habitat and range contraction. If unmitigated, the potential for an increase in feral animals surrounding the disturbance footprint would pose a substantial risk to native fauna in areas surrounding the Project.

Four feral species were detected during the survey, the Feral Cat, Wild Dog, European Rabbit and Cane Toad. Feral pests that are already present in the Project area are likely to displace into adjoining areas during construction, however, the number of feral pests that would be displaced would be reduced by controlling feral pests. As outlined in Section 6.6, the control of feral pests is an existing measure that would be adopted for the Project.

5.10 Bushfire Risk

Bushfire is an essential component of vegetation dynamics in Australia (particularly in eucalypt forests), but the frequency and intensity must be appropriate to each vegetation type, and most accidental wildfires are not likely to be beneficial.

An increase in mine activities and mine vehicles could potentially increase the risk of starting wildfires through hot exhausts, hot works or human error. The Project area is contiguous with areas of vegetated land that are largely dry and contain flora species that are conducive to catching fire (e.g. eucalypts), and as such is both prone to wildfire incursion and a potential source of fire.

Bushfire prevention and management measures are described in Section 6.9.

5.11 Noise, Dust and Lighting

The Project would result in the generation and distribution of dust from Project-related activities such as blasting, materials handling and vehicle movements (Katestone 2018). The Project would also result in the generation of noise from Project-related activities such as blasting, materials handling and vehicle movements (Renzo Tonin 2018). The scale of dust and noise impacts would increase in comparison to the existing operations, as operational noise sources and the extent of blasting would be extended into the new mining areas (Renzo Tonin 2018).

Potential dust impacts on flora and/or fauna in surrounding habitats associated with the Project is likely to increase as a result of a larger extent of mining activities than existing operations.

Any potential noise-related impact on fauna residing in surrounding habitat would likely be localised and minor given fauna often readily habituate to continuous noise, and sudden noises from blasting would only occur in intervals. This has been evidenced during the current and previous survey work surrounding the existing operations through sightings of fauna using habitat adjacent to active mining areas. Some more sensitive fauna species are known to be discouraged by loud noise, however, and may avoid habitat areas surrounding the disturbance footprint.

The Project would result in an increase (relative to the existing operations) in the use of artificial lighting within the Project locality. Despite this, the incremental impact of this additional night-lighting is expected to be minor given the lights would be operated in accordance with the relevant Australian Standard.

5.12 Erosion and Sedimentation

The Project has the potential to increase the natural rate of erosion and sedimentation surrounding the Project and downstream of Roper Creek, due to the additional disturbance areas associated with the extension to the open cut pit. MCPL would revise the existing Erosion and Sediment Control Plan (WRM Water and Environment [WRM] 2012) to manage erosion and sedimentation in and around the disturbance footprint and downstream.

With the continuation of these management measures, it is unlikely that the Project would result in significant erosion or sedimentation impacts that would adversely impact native flora and/or fauna within or downstream of the Project area.

5.13 Cumulative Impacts

Removal of vegetation and habitat for the Project would add to cumulative loss of vegetation from past land uses and significant clearing associated with the existing/approved Middlemount Coal Mine. The Project would also contribute to the cumulative impacts of vegetation clearance associated with a number of operational mines within the wider locality, these include:

- German Creek East – located approximately 5 km south of the Project area;
- Foxleigh – located approximately 15 km south-east of the Project area;
- Lake Lindsay – located approximately 15 km south south-east of the Project area; and
- Norwich Park – located approximately 20 km north-west of the Project area.

At a site level, the proposed clearance associated with the Project would result in an increase in remnant vegetation clearance of approximately 10% when compared to the existing/approved Middlemount Coal Mine.

Approximately 630 ha of native vegetation has been approved to be cleared for previous stages of the Middlemount Coal Mine, however, the loss of vegetation associated with the approved mining operations has already been offset in accordance with the relevant State and Commonwealth legislation.

On a larger scale, the native vegetation communities/regional ecosystems to be cleared during the life of the Project all occur more widely in surrounding landscapes and subregions (after Accad *et al.* 2017). The Project would result in the loss of approximately 0.015% of the remnant vegetation remaining within the Isaac Comet Downs subregion, based on 2017 remnant vegetation cover estimates (Accad *et al.* 2017).

The proposed offset areas for the Project would significantly increase the area of protected habitat that would be managed for conservation. The existing and proposed offset areas provide habitat for a number of common and threatened species as demonstrated from monitoring surveys (EHP 2012, Naturecall 2014-2017, Biodiversity Australia 2018-2019) and their continued regeneration would help offset biodiversity losses from the Middlemount Coal Mine. In addition, the progressive rehabilitation of mining areas over the life of the Project would provide habitat in the medium to long term.

Given the above, the additional clearance associated with the Project is considered to represent only a minor increase in cumulative vegetation loss. Accordingly, the Project is not anticipated to have a significant cumulative impact on terrestrial ecology.

5.14 Matters of State Environmental Significance

The *Queensland Environmental Offsets Policy* (DEHP 2017) has a *Significant Residual Impact Guideline* (DEHP 2014) to determine if a prescribed activity would have a significant residual impact on MSES. A significant residual impact is defined as an adverse impact, whether direct or indirect, of a prescribed activity on all or part of a prescribed environmental matter that:

a) *remains, or will or is likely to remain, (whether temporarily or permanently) despite onsite avoidance and mitigation measures for the prescribed activity; and*

b) *is, or will or is likely to be, significant.*

Table 27 provides a significant residual impact assessment summary on MSES for the Project.

Table 27: Matters of State Environmental Significance - Significant Residual Impact Assessment

Prescribed Environmental Matter	Presence on site	Significant Residual Impact Likely?
Regulated Vegetation		
Endangered or Of Concern RE	The Project area contains Endangered and Of Concern REs.	Yes. Refer to Section 5.14.1.
REs (not within an urban area) that intersect a wetland on the vegetation management wetlands map.	No	-
REs (not within an urban area) within the defined distance from the defining banks of a relevant watercourse on the vegetation management watercourse map.	Yes. RE 11.3.25 and thin sections of 11.3.2 along Roper Creek and Thirteen Mile Gully fall in this category.	Yes. Refer to Section 5.14.1.
Connectivity areas		
Connectivity area that is a RE (not in urban area). The disturbance footprint contains remnant vegetation that forms part of a corridor mapped as being of State biodiversity significance.	The disturbance footprint contains remnant vegetation.	Yes. Refer to Section 5.14.2 for discussion.
Wetlands and Watercourses		
A wetland of HES shown on the map of referable wetlands	No HES wetlands occur in the study area.	-
Protected wildlife habitat		
Habitat for an animal that is vulnerable wildlife.	Three species listed as vulnerable under the NC Act were recorded on site during the survey (Koala [scat only], Greater Glider and Squatter Pigeon [Southern]). One additional threatened fauna species (Ornamental Snake) is considered to have potential to occur on the site and be potentially impacted by the Project.	Yes. Assessment in Section 5.14.3 has determined that a significant residual impact on the Koala and Greater Glider is likely.
Habitat for an animal that is special least concern wildlife.	One species listed as special least concern fauna was recorded during the survey (Echidna)	No significant residual impact is likely.

Legally secured offset area		
Any areas declared as an environmental offset protection area, high nature conservation value under the VM Act or another area prescribed under a regulation.	No	-

5.14.1 Regulated Vegetation

Regulated vegetation is a 'prescribed regional ecosystem' that:

- is an Endangered or Of Concern RE;
- intersects with an area shown on the vegetation management wetlands map; or
- is located within the defined distance from the defining banks of a watercourse identified on the vegetation management watercourse map.

For clearing other than clearing for linear infrastructure, a significant residual impact is triggered if the following thresholds are exceeded

Table 28: Significant residual impact criteria – regulated vegetation

		Clearing in a regional ecosystem that is: *endangered*, or *of concern*	Clearing in the portion of a regional ecosystem that lies within a mapped wetland	Clearing in a regional ecosystem that is within the defined distance of a watercourse
1	**For clearing for linear infrastructure:** – greater than 25m wide in a grassland (structural category) regional ecosystem; or – greater than 20m wide in a sparse (structural category) regional ecosystem; or – greater than 10m wide in a dense to mid-dense (structural category) regional ecosystem. **For clearing other than clearing for linear infrastructure:** – area greater than 5 ha where in a grassland (structural category) regional ecosystem; or – area greater than 2 ha where in a sparse (structural category) regional ecosystem; or – area greater than 0.5 ha where in a dense to mid-dense(structural category) regional ecosystem.	✓	✓	✓
2	Clearing within 50m of the defining bank	N/A	✓	N/A
3	Clearing within 5m of the defining bank	N/A	N/A	✓

Source: (DEHP 2014)

5.14.1.1 Residual Impact Assessment

The Project would involve the removal of Endangered and Of Concern REs, and vegetation within the defined distance from the banks of Roper Creek. The area of impact and trigger thresholds for a significant residual impact are shown in Table 29.

Table 29: Significant residual impact test – regulated vegetation

Field-verified RE	VMA Status	Category	Structural category	Area to be removed	Significant impact?
11.3.1	Endangered	Regulated Vegetation	Mid dense	2.22 ha	Yes
11.3.2 and 11.3.2b	Of Concern	Regulated Vegetation	Sparse	20.35 ha	Yes
11.3.25	Least Concern	Regulated Vegetation	Mid dense	14.06 ha	Yes

Clearing of regulated vegetation for the Project would exceed the threshold a trigger a significant residual impact for RE 11.3.1 and 11.3.2.

5.14.2 Connectivity Areas

As mentioned in Table 27, the landscape fragmentation and connectivity tool (DEHP 2018) was applied to the Project. The output from the tool showed that the Project exceeded the threshold for an impact on connectivity and fragmentation (see log file in Appendix A-6).

5.14.3 Protected Wildlife Habitat

5.14.3.1 Components to be Assessed - Endangered and Vulnerable Wildlife

The following species are subject to the significant residual impact test:

- Koala.
- Greater Glider.
- Squatter Pigeon (southern).
- White-throated Needletail.
- Ornamental Snake.

An action is likely to have a significant impact on endangered and vulnerable wildlife if the impact on the habitat is likely to (DEHP 2014):

- *lead to a long-term decrease in the size of a local population; or*
- *reduce the extent of occurrence of the species; or*
- *fragment an existing population; or*
- *result in genetically distinct populations forming as a result of habitat isolation; or*
- *result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat; or*
- *introduce disease that may cause the population to decline, or*
- *interfere with the recovery of the species; or*
- *cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.*

A *population* for a species is defined by the guidelines (DEHP 2014) as an occurrence of the species in a particular area. In relation to endangered, vulnerable and special least concern species, occurrences include but are not limited to:

- a geographically distinct regional population, or collection of local populations; or
- a population, or collection of local populations, that occurs within that particular bioregion.

The following addresses each of the previous points listed.

a) Lead to a long-term decrease in the size of a local population.

Koala

A scat from a Koala was recorded in the disturbance footprint during the survey. No Koalas were observed and only a few old scats were found under a tree near the Bingegang Pipeline Road. Ancedotal reports of a Koala in this area within 3 months prior to the survey were provided by MCPL. The Koala has also been previously recorded on MCPL lands to the west in 2012 and 2014 (Naturecall 2014a). Sparse local records and poor local soil quality (and hence low-quality habitat) would mean Koalas in the area would have large home ranges which are likely to be associated with riparian areas where preferred browse trees are common. This is consistent with Koala sightings on MCPL lands on alluvial flats and riparian areas associated with Roper Creek (Naturecall 2014a).

The Project would remove approximately 63.27 ha of known and potential habitat for the Koala. Due to limited abundance of preferred browse species and poor soils, the habitat to be removed is, however, considered lower quality habitat that would only form part of the marginal home range of a Koala.

Two diversions to Roper Creek are already approved at the Middlemount Mine which would fragment the riparian vegetation along Roper Creek and reduce connectivity for the Koala. As an offset for this impact, the Stage 2 Offset Area was established by MCPL in 2013 and it includes enhancement and conservation of an 11 km stretch of the Roper Creek immediately to the west of the mine. This offset has been secured under a Voluntary Declaration and is managed for conservation purposes. The Project would increase disturbance to the riparian vegetation along Roper Creek for the realignment and extension of the eastern diversion of Roper Creek, however, it would not involve a new barrier to Koala movement (that impact would occur as a result of the approved mine), and the diversion would be revegetated with similar flora species as part of its construction. Further removal of vegetation along Roper Creek would require Koalas to cross more open ground while moving throughout their home range, potentially leading to higher risk of dog attack.

The removal/modification of a portion of habitat for the Koala is unlikely to lead to a long-term decrease in the size of a local population of Koala given:

- the Koala has not been directly observed within the Project area (only scats);
- similar potential habitat for this species is more widespread in the landscape outside the Project area; and
- Koala records are widespread in the landscape outside the Project area.

Greater Glider

The Greater Glider was recorded in several locations in the study area. It has also been extensively recorded in the Stage 2 Offset Area to the west of the site (Naturecall 2017b). Greater Gliders have small home ranges ranging between 1.3 and 4 ha (Comport *et al.* 1996, Pope *et al.* 2005, TSSC 2016). The disturbance footprint would therefore encompass entire home ranges of the Gliders, and they would be also expected to extend off site.

The Project would remove approximately 63.27 ha of known habitat for this species, comprised of open woodlands. This habitat would be used for both foraging and denning/breeding within hollow-bearing trees. Considering the loss of hollow-bearing trees (breeding habitat) and small range of this species, the Project has the potential to decrease the local population until such time that additional breeding resources are available in the offset areas.

Squatter Pigeon (southern)

The Squatter Pigeon (southern) has been recorded in the east of the disturbance footprint during previous surveys for the Western Extension Project (Naturecall 2017). During recent field surveys it was detected to the north of the disturbance footprint on the pipeline road.

The disturbance footprint contains suitable habitat for this species in the form of woodland habitat as well as non-remnant woodland vegetation and disturbed areas which are also frequently used for foraging (DEE 2017a). This species has large home ranges and is seasonally nomadic (TSSC 2015), hence the local population would extend well beyond the Project area.

The Project would remove of approximately 233 ha of known/potential habitat for this species. In terms of the large home range of this species, its high mobility and the presence of extensive alternative habitat in the locality, the Project is unlikely to lead to a decrease in the local population.

Ornamental Snake

This species was not recorded in the disturbance footprint, despite targeted surveys. It has, however, been recorded by PB in 2010 on MCPL owned land on gilgai soils approximately 400 m north of the disturbance footprint near Roper Creek.

The southern portion of the disturbance footprint provides small patches of suitable habitat for the Ornamental Snake in the form of Brigalow habitats with gilgai and drainage depressions which provide habitat for preferred prey species (i.e. frogs).

The Project would remove 12.8 ha of potential habitat which comprises remnant Brigalow habitats and drainage depressions (gilgai) in non-remnant areas. Given that a number of targeted surveys undertaken by Biodiversity Australia and other consultants since 2010 have not detected this species within the disturbance footprint, it is considered to be a low to fair chance of occurrence within the potential habitat in the disturbance footprint. The removal of a relatively small extent of potential habitat in the disturbance footprint while a negative impact, is unlikely to lead to a long-term decrease in the local population.

White-throated Needletail

The Project is unlikely to have an impact on White-throated Needletail given this species is almost exclusively aerial.

b) Reduce the extent of occurrence of the species.

The extent of occurrence of a species is the overall distribution of a species (TSSC n.d.). The Project is not near the edge of the known distribution of the Koala, Greater Glider, Squatter Pigeon (south), Ornamental Snake or White-throated Needletail and therefore the Project would not reduce the extent of occurrence of these species.

c) Fragment an existing population.

The Squatter Pigeon (southern) and White-throated Needletail are highly mobile species and known to be capable of crossing human-modified habitat. The Project would thus offer no barrier to movement and hence would not fragment an existing population.

The Koala is also relatively mobile, able to cross clearings and roads, though is highly susceptible to other threats such as dog attack and vehicle strike. The Project would reduce connectivity for the Koala population, especially in the south of the study area along Roper Creek. Some connective habitat would still remain around the disturbance footprint to the east to facilitate local movements. As such, while the Project would lead to further fragmentation of habitat and reduce connectivity, there is no potential for fragmentation of an existing Koala population.

The Greater Glider relies on canopy connection to move throughout its home range and would rarely come to the ground and cross clearings and open ground. The Project would remove connective habitat for this species, and in conjunction with approved mining activities in MCPL leases, is likely to fragment populations of the Greater Glider, especially those which occur along Roper Creek in the south of the disturbance footprint.

Removal of habitat for the Project would lead to further habitat fragmentation of potential habitat for the Ornamental Snake. Most of the habitat to the north where it was previously recorded will be removed as it is part of the existing Middlemount Coal Mine disturbance footprint, leaving only small patches of marginal habitat remaining.

d) Result in genetically distinct populations forming as a result of habitat isolation.

The Project would be unlikely to isolate an existing population of the Squatter Pigeon (southern), White-throated Needletail or Koala, as they are more mobile.

It is possible that any potential population of Ornamental Snake within the impact area are already genetically isolated as a result of previous clearing for agriculture and mining in the area. The removal of Ornamental Snake habitat for the Project would be likely to further fragment and isolate any remaining populations.

The Project has the potential to further isolate populations of the Greater Glider, however due to the scale of the project, and re-establishment of linkages with eventual rehabilitation, it would be unlikely to result in the formation of genetically distinct populations.

e) Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat.

The Project area currently has a number of introduced and invasive species including predators such as the Feral Cat and Fox and weed species including Prickly Pear. No new invasive species that are likely to affect any endangered or vulnerable species would likely be introduced as a result of the Project.

f) Introduce disease that may cause the population to decline.

Due to the nature of the Project, the risk of a new disease (relevant to the species) being introduced to the site would be unlikely.

g) Interfere with the recovery of the species.

Ideally, the goal in threatened species recovery is to increase the abundance and range of the threatened species, so that it is not at risk of becoming extinct. As detailed previously, the Project would lead to habitat loss and contribute to threatening processes which would interfere with the recovery of threatened species to varying degrees. This includes directly reducing habitat for the species known to occur and reducing the amount of available potential habitat for other species.

h) Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.

For the Squatter Pigeon (southern) and White-throated Needletail, the habitat in the Project area has an evident disturbance history and is unlikely to qualify as an ecologically significant location, especially given the extent of identical and higher quality habitat that occurs in the wider area.

The Koala and Greater Glider have been recorded within and surrounding the disturbance footprint, and habitats within the disturbance footprint would provide foraging and breeding habitat, as well as habitat linkages. Therefore, the Project would disrupt potential foraging, breeding and resting sites for the Koala and Greater Glider.

The Ornamental Snake has not been recorded in the disturbance footprint, and it is unlikely that the habitats present would constitute ecologically significant locations for this species due to the marginal habitat present and its isolation form areas of higher quality habitat.

5.14.3.2 Conclusion

The Project is not considered to result in a significant residual impact on the Squatter Pigeon (southern), due to its highly mobile nature and the large extent of suitable habitat in the wider area that is readily accessible.

Given that the Ornamental Snake was not recorded in the disturbance footprint and has not been reliably recorded on MCPL land since 2010, the impact of the Project is unlikely to be significant given the small area of potential habitat to be cleared relative to the wider extent of habitat (including habitat in the offset areas).

The Project is likely to result in a significant residual impact on the Koala and Greater Glider in the context of the assessment requirements under DEHP (2014) due to clearance of habitat known to be used by both species potentially for breeding, feeding, nesting and resting.

The Project is unlikely to have an impact on White-throated Needletail given this species is almost exclusively aerial.

Thus, as per the Significant Residual Impact Guideline (DEHP 2014), the Project would require an offset for the Koala and Greater Glider.

5.14.3.3 Components to be Assessed - Special Least Concern Animals

The Echidna is listed as a Special Least Concern species under the NC Act and was recorded in the study area during the survey.

An action is likely to have a significant impact on a special least concern (non-migratory) animal wildlife habitat if it is likely that it will result in (DEHP 2014):

- *a long-term decrease in the size of a local population; or*
- *a reduced extent of occurrence of the species; or*
- *fragmentation of an existing population; or*

- *result in genetically distinct populations forming as a result of habitat isolation; or*
- *disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species.*

5.14.3.4 Assessment of Significance

This section addresses each of the previous points listed.

a) a long-term decrease in the size of a local population; or

The Echidna was observed during the survey in the southwest of the disturbance footprint within RE 11.7.4. The Echidna has also been recorded previously on MCPL land in the Western Extension Project area, within the Stage 2 offset area and near Parrot Quarry Road during previous surveys (Naturecall 2016a). A local population of the Echidna would extend well beyond the disturbance footprint given these previous records and that suitable habitat also occurs on adjacent land to the south and west.

The Project would impact the Echidna via removing approximately 161 ha of habitat which includes open woodland, Acacia forest and less suitable regrowth vegetation. The Project would not result in the clearance of any ecologically significant locations. This would affect foraging habitat and connectivity would also be reduced (but not be fragmented). However given that the local population would extend well beyond the disturbance footprint, and that large areas of suitable habitat significantly greater than the additional surface disturbance area for the Project would remain on directly adjoining MCPL land to the west and south of the disturbance footprint, as well approximately 5,861 ha of suitable habitat in the existing Offset Areas, the Project is only likely to affect a few individuals of the overall population and would be unlikely to lead to a decline.

b) a reduced extent of occurrence of the species; or

The Project would remove habitat that may be used by the local population of this species. This would result in a minor contraction of the extent of occurrence**.**

c) fragmentation of an existing population; or

The Echidna is a mobile species and would be able to cross disturbed areas and open ground. Sufficient connectivity for this species outside the disturbance footprint would remain after clearance and no populations are likely to become fragmented as a result of the Project.

d) result in genetically distinct populations forming as a result of habitat isolation; or

As discussed above, no fragmentation or isolation of the local population is likely to result from the Project.

e) disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species.

The Project would affect generic foraging and potentially breeding habitat for the local Echidna population. Given the extent of similar and higher quality habitat located on adjacent and nearby lands, the habitat on site is unlikely to be of any specific significance to the local population.

5.14.3.5 Conclusion

Given the above, the Project is unlikely to have a significant impact on the habitat or local population of the Echidna.

6. Impact Avoidance, Mitigation and Management Measures

MCPL has minimised potential impacts associated with land clearance through the use of existing infrastructure and facilities (where possible) and minimising out-of-pit waste emplacements via backfilling of the open cut pit void.

The Project would be subject to a number of mitigation measures to reduce the overall impact of the Project on biodiversity and ensure potential off-site impacts are minimised. The conclusions of the impact assessments undertaken have assumed that the following mitigation measures would be implemented.

6.1 Refinement of the Mine Design to Avoid Land Clearance

The following refinements to the mine design have resulted in minimising additional land disturbance:

- use of existing infrastructure and facilities at the Middlemount Coal Mine, where possible, to avoid the need for additional clearance works;
- optimising the backfilling of the open cut pit to minimise the overall mine footprint (i.e. reduce the size of the out-of-pit waste emplacement); and
- locating the proposed waste emplacements to be continuous with the existing/approved waste emplacements to minimise the total disturbance footprint.

6.2 Vegetation Clearing Management

The following measures would be implemented to manage clearing on site:

- The sequence of vegetation clearing would be undertaken in a manner to ensure fauna is not isolated from adjacent habitat preventing their escape.
- Approved disturbance limits would be clearly marked (e.g. via pegging and/or flagging tape) before clearing in order to prevent any inadvertent clearance. Site induction would specify that no clearing is to occur beyond the marked area and any machinery or materials associated with the development are not to be parked/stored in adjacent retained vegetation.
- Where possible, timing of vegetation clearing would avoid the breeding season for the Greater Glider (i.e. April to June).
- The area of clearing work is to be inspected for fauna by a fauna spotter immediately prior to commencement of any vegetation removal. Pre-clearing checks would include searches of habitat (e.g. lifting and destructive searches of logs) and searches for bird nests. Trapping surveys for capture of arboreal species is also recommended. If possible, any detected fauna is to be relocated to nearby suitable areas outside of the disturbance footprint or other approved clearing areas prior to clearing.
- During the pre-inspection, all hollow-bearing trees, stags and large hollow logs are to be clearly marked with flagging tape to allow easy identification during clearing.
- A fauna spotter is to remain on site to supervise clearing to retrieve any fauna detected during works and undertake appropriate action (e.g. euthanize severely injured animals and/or relocate uninjured animals where possible).
- A release area for any fauna captured prior to or during clearing is to be identified prior to commencement of clearing works. Consideration should be given to the following factors when selecting release areas:
  - Presence of suitable foraging and breeding habitat for the species;

  - Connectivity to other habitats and populations (e.g. do not select release areas that are isolated pockets of vegetation);
  - Whether the habitat will be cleared or modified in the future; and
  - Distance from disturbances associated with the mine e.g. noise, light, dust.
- If a Koala is present in the proposed clearing area, it would be left to move away from the clearance area on its own accord.
- Measures described in the Middlemount Coal Species Management Program would continue to be followed.

6.3 De-watering Management

Any waterbodies which require diversion or de-watering for the Project are to be subject to the following measures:

- Capture of as many aquatic fauna species as possible in the waterbody through electrofishing, scoop netting, trapping etc. prior to de-watering.
- Selection of suitable release area for any aquatic fauna.
- Presence of an aquatic ecologist during de-watering activities to capture and relocate stranded aquatic fauna.

6.4 Rehabilitation

Consistent with Environmental Authority (EA) EPML00716913, the rehabilitation goals for the existing Middlemount Coal Mine would remain unchanged for the Project. These areas are:

- to ensure the final landform is safe to humans and wildlife;
- to ensure the site is non-polluting;
- to ensure the final landform is stable; and
- to ensure the site is able to sustain an agreed post-mining land use.

Rehabilitation progress and rehabilitation activities would regularly be re-evaluated, and the results would inform future rehabilitation initiatives. All post-mine landforms, except final voids and sections of the low wall, would have a self-sustaining vegetation or rock mulch cover.

6.5 Weed Management

MCPL currently implements weed control measures at the existing operations in accordance with the Middlemount Coal Mine Environmental Management Plan (MCPL 2017a). These measures would be continued for the Project and include spot spraying of *Biosecurity Act 2014* listed weed species.

6.6 Feral Animal Management

MCPL currently implements feral animal control measures at the existing operations in accordance with the Middlemount Coal Mine Environmental Management Plan (MCPL 2017a). These measures would be continued for the Project and include wild dog and cat control.

6.7 Erosion and Sedimentation

MCPL currently implements standard erosion and sedimentation control measures at the existing operations. These measures would be continued for the Project and would be applied as per an Erosion and Sediment Control Plan (WRM 2012).

6.8 Artificial Lighting

Artificial lighting would be required during the operation of Project. This would not be directed into adjacent retained habitat to reduce impacts on nocturnal fauna potentially using this habitat.

6.9 Bushfire Prevention and Management

MCPL would aim to maintain vegetation structure and composition, protect mine assets and safeguard human life through the implementation of bushfire management techniques, including:

- physical protection of assets through clean firebreaks;
- active fire suppression of unplanned and potentially destructive fires (to vegetation and built assets); and
- pro-active fuel and ecosystem management to sustain ecological fire regimes as much as possible.

7. Offset Strategy

Avoidance and mitigation measures from the Project on terrestrial flora and fauna (including State significant biodiversity values) are described in Section 6. This section describes an offset strategy to address residual impacts on matters that are not able to be avoided as part of the Project.

7.1 Existing Offset Areas

An *Offset Management Plan/Vegetation Management Plan* (MCPL 2019) has been prepared to manage offsets delivered under previous stages of the Middlemount Coal Mine. Eight designated offset areas currently exist on MCPL owned land to the west of the Project (shown on Figure 3-7 of the Main Text), which covers approximately 5,861.4 ha. This includes three Commonwealth Offset Areas under the EPBC Act:

- Middlemount Coal Stage 2 Project Commonwealth Offset Area;
- North-eastern Extension Project Commonwealth Offset Area; and
- Western Extension Project Commonwealth Offset Area.

Five State (Qld) Offset Areas are also covered in this plan:

- Rail Loop and Spur Offset Area;
- Parrot Quarry Offset Area;
- Thirteen Mile Gully Diversion Offset Area;
- North-eastern Extension State Offset Area; and
- Western Extension State Offset Area.

Proposed offsets for the Project would consider the existing offset areas and the *Offset Management Plan/Vegetation Management Plan* (MCPL 2019).

7.2 Offset Policies

MCPL propose to offset significant residual impacts on MSES in accordance with the *Queensland Environmental Offsets Policy Version 1.8* (DES 2020c). Impacts to MNES would be addressed as part of the MSES offset strategy as they both address the same matters.

7.3 Significant Residual Impacts

MCPL propose to offset all matters that would be significantly residually impacted by the Project. Significant residual impacts to MSES that are associated with the Project have been outlined in Section 5, and are summarised in Table 30.

Table 30: Summary of terrestrial ecology matters relevant to the Project

Prescribed Environmental Matter	Approved Maximum Extent of Impact (ha)	Proposed Additional Significant Residual Impact (ha)
Regulated Vegetation		
Regional Ecosystems (not within an urban area) that intersect a watercourse on the vegetation management watercourse map – RE 11.3.25e	1	0
Endangered Regional Ecosystem – RE 11.4.9	0.5	0
Endangered Regional Ecosystem – RE 11.3.1	15	2.22
Of Concern Regional Ecosystem (not within an urban area) – RE 11.3.2	43.5	19.5
Of Concern Regional Ecosystem (not within an urban area) – RE 11.3.2/11.3.4	1.5	0
Regional Ecosystems (not within an urban area) that intersect a wetland on the vegetation management wetlands map – RE 11.3.27d	1.9	0
Of Concern Regional Ecosystem (not within an urban area) – RE 11.3.2b	0	1.03
Regional Ecosystems (not within an urban area) that intersect a wetland on the vegetation management wetlands map – Res 11.3.2 and 11.3.25	0	3.7
Connectivity areas		
Connectivity area that is a regional ecosystem (not in urban areas)	371.5	67.95
Wetlands and Watercourses		
A wetland of high ecological significance shown on the Map of Referable Wetlands	0.75	0
Protected wildlife habitat		
Habitat for an animal that is vulnerable wildlife – *Denisonia maculata* (ornamental snake)	15.5	12.81
Habitat for an animal that is vulnerable wildlife – *Geophaps scripta scripta* (squatter pigeon)	569.5	233
Habitat for an animal that is vulnerable wildlife – *Petauroides volans* (greater glider)	175	63.27
Habitat for an animal that is vulnerable wildlife – *Phascolarctos cinereus* (koala)	175	63.27
Habitat for an animal that is special least concern wildlife – *Tachyglossus aculeatus* (short-beaked echidna)	190.5	0
Legally Secured Offset Areas		
Legally secured offset area – Stage 2 Offset Area*	32	0
Legally secured offset area – Rail Loop and Spur Offset Area	22	0

7.4 Offset Timing

EA EPML00716913 Condition F35 states that "*A notice of election for the environmental offset, must be provided to the administering authority no less than three (3) months before the proposed commencement of the significant residual impacts to the prescribed environmental matters*."

As such, an offset proposal would be lodged with the State (Qld) and Commonwealth Governments at least three months prior to the commencement of construction activities in accordance with the relevant offsets policies (i.e. the *EPBC Act Environmental Offsets Policy* [DSEWPC 2012a] and *Queensland Environmental Offsets Policy Version 1.8* [DES 2020c]).

7.5 Offset Approach

A land-based proponent-driven offset is proposed to address all impacts associated with the Project. All efforts would be made to identify and secure offsets that would provide the same or similar vegetation/habitat characteristics as the matters in the Project area. The offset area for protected wildlife would contain, or be capable of containing (after rehabilitation management), a self-sustaining population of the impacted species. Habitat quality assessments would be undertaken in accordance with the *Guide to determining Terrestrial Habitat Quality Version 1.3* (DES 2020a). Identification of TEC communities would be assessed in accordance with the relevant conservation advices.

7.6 Offset Reporting Framework

The offset reporting framework would be determined in the offset proposal in accordance with relevant offset policies at the time, and with consideration of the existing *Offset Management Plan/Vegetation Management Plan* (MCPL 2019).

8. Conclusion

This report has assessed the impacts of a southern extension to the approved Middlemount Coal Mine, which would see an extension of the mine by approximately 233 ha, along with additional associated actions.

This assessment and survey has identified that the site and surrounding area is generally in a modified state as a result of a number of past and current disturbances such as clearing, mining activities and cattle grazing. This has fragmented the landscape and reduced the support value of the habitat on site for locally recorded and potentially occurring species and resulted in indirect impacts that may have discouraged them from using habitat in the area.

The study area for this assessment covers an area of 274 ha and comprises multiple areas of land immediately surrounding the existing mine boundary. The majority of these are situated directly south of the existing open cut mine, with an additional area located to the east. Field surveys were undertaken by two ecologists in March and June 2020. The vegetation field survey methods utilised included Terrestrial Habitat Quality Surveys, Quaternary vegetation surveys and targeted threatened flora searches. Fauna survey methods utilised included herpetofauna searches, diurnal bird surveys, Koala SAT surveys, PIR cameras, microbat call recording and analysis and spotlighting surveys.

Field verifications of REs confirmed that one RE within the study area consists of Brigalow forest (RE 11.3.1) which is listed as Endangered under the VM Act and EPBC Act (Brigalow TEC); and two REs comprised a Poplar Box woodland (REs 11.3.2 and 11.3.2b) which is listed as Of Concern under the VM Act and Endangered under the EPBC Act (Poplar Box Woodland TEC). No threatened flora species were recorded on the site during surveys, and none were considered to be potential occurrences.

Targeted fauna surveys undertaken on the study area detected three threatened fauna species listed as Vulnerable under the NC Act and EPBC Act. These comprised the Greater Glider, Koala [scat only] and Squatter Pigeon (southern). Due to the presence of suitable habitat/vegetation associations and local records, two threatened fauna species listed as Vulnerable under the NC Act and EPBC Act (Ornamental Snake and White-throated Needletail) were considered to be potential occurrences in the study area. One Special Least Concern species comprising the Echidna was also recorded during the field surveys.

The recorded and potentially occurring threatened fauna species were assessed under the relevant State legislation. Impact assessment for the identified MSES determined that the Project would have a significant residual impact on regulated vegetation, connectivity and on the Koala and Greater Glider.

Mitigation measures for the Project are expected to be consistent with existing Environmental Authority (EA) conditions and MCPL plans (e.g. Erosion and Sediment Control Plan and Rehabilitation Management Plan). Specific measures to reduce impacts on biodiversity include marking clearing limits, pre-clearing surveys and clearing supervision, and reducing light spillage into adjacent retained habitat. Offsets for the Project are expected to be consistent with existing EA conditions.

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10. Appendices

A-1 Potential Occurrence Assessment

The following tables are used as a summary to address threatened species in terms of potential occurrence and requirement for formal assessment. A threatened species has been assessed if it is:

1) Recorded on-site; or

2) Not recorded on site, but recorded within a 10 km radius (the locality), and may occur to some degree on-site due to potential habitat, key habitat component, etc.;

3) Not recorded in the locality as yet, but recorded in the bioregion, and thus may occur in the locality, and possibly to some extent, may occur on the site, due to potential habitat.

Likelihood of occurrence is based on the probability of occurrence in terms of:

- Habitat extent (e.g. sufficient to support an individual or the local population; comprises all of home range; forms part of larger territory, etc.); quality (i.e. condition, including an assessment of threats, historical land uses on and off-site, and future pressures); interconnectivity to other habitat; and ability to provide all the species life-cycle requirements (either the site alone, or other habitat within its range);
- Occurrence frequency (i.e. on-site resident; portion of larger territory or seasonal migrant); and
- Usage i.e. breeding or non-breeding; opportunistic foraging (e.g. seasonal, migratory or opportunistic); marginal fringe of core range; refuge; roosts; etc.

An indicative 1-5 scale used by the author to indicate the likelihood of the species to potentially occur in the habitat on the study sites (if they have not been recorded in the locality) is as follows:

- 0: *Unlikely* (<1% probability) - no potentially suitable habitat; too disturbed; or habitat is very poor. No or few records in region or records/site very isolated e.g. by pastoral land, urbanisation, etc.
- 1: *Low* (1-25%) - few minor areas of potential habitat; highly modified site/habitat; or few habitat parameters present, but others absent or relatively insignificant (sub-optimum habitat). Usually very few records in locality.
- 2: *Fair* (25-50%) - some significant areas of potential habitat, but some habitat parameters limited. Potential for occasional foraging e.g. from nearby more optimal areas or known habitat. Records at least within 10-15 km radius of site.
- 3: *Moderate* (50-75%) - quite good potentially suitable habitat on and adjacent to the site, and/or good quality and abundance of some vital habitat parameters. Records within <10km, or adjacent to site, or adjacent to high quality habitat where species likely to occur.
- 4: *High* (>75%) - very good to optimum habitat occurring on or adjacent to the site (support breeding pair or population). Recorded within 5-10 km of site in same or similar habitat.

A-1-1 Flora

Searches of relevant literature and databases (DES 2020b) only found records of a single flora species in the locality. A number of other species have the potential to occur within the locality based on regional records and presence of suitable habitat. In the table below, these species are evaluated for their potential to occur on the site.

Table 31: Potential occurrence assessment - flora

Species	No. of Records	NC Act	EPBC Act	Link to Profile	Likelihood of Occurrence
Cerbera dumicola	1	NT	-	http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/species/?cerbera-dumicola	Recorded in the locality and in the Stage 2 Project to the west of the site (PB 2010a). The southwest corner of the study area contains a small extent of suitable habitat for this species, however it was not found during surveys. Expected to be readily detected if present. Unlikely to occur.
Cycas megacarpa	0	E	E	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=55794	No preferred habitat on site and not recorded locally. This distinctive species would be expected to be readily detected if present. Unlikely to occur.
Dichanthium queenslandicum	0	V	E	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=5481	Only small areas of preferred habitat on site and not recorded locally or on MCPL lands during previous surveys. Site disturbance history would also reduce potential to occur. Unlikely to occur.
Dichanthium setosum	0	-	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=14159	Woodland areas on site may broadly qualify as suitable habitat, however there are no local records and no known populations in the region. Unlikely to occur.
Digitaria porrecta	0	NT	-	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=12768	Only small areas of preferred habitat on site and not recorded locally or on MCPL lands during previous surveys. Site disturbance history would also reduce potential to occur. Unlikely to occur.
Picris evae	0	V	V	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=10839	Site may broadly qualify as potential habitat; however, no local records and site occurs beyond known population extent. Unlikely to occur.
Cadellia pentastylis	0	V	V	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=9828	No suitable habitat on site and no local records. Expected to be readily detected if present. Unlikely to occur.
Key: Endangered (E), Vulnerable (V), Near Threatened (NT).					

A-1-2 Fauna Species Eligibility for Test of Significance and MNES Assessment

As previously noted, a number of threatened and migratory fauna have been recorded in the locality, and a number of others are considered potential occurrences. In the table below, these species are evaluated for their potential to occur on the site.

Table 32: Potential occurrence assessment - fauna

Species	No. of Records	NC Act	EPBC Act	Link to Profile	Likelihood of Occurrence
Aves					
Glossy Black Cockatoo (*Calyptorhynchus lathamii*)	0	V	-	http://www.birdsinbackyards.net/species/Calyptorhynchus-lathami	No suitable foraging habitat is present in the study area. Not recorded locally or on MCPL lands during previous surveys. Unlikely chance of occurrence.
Red Goshawk (*Erythrotriorchis radiatus*)	0	E	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=942	Site, and general area, comprises low quality foraging habitat due to lack of permanent waterways. No local or regional records. Unlikely to occur.
Powerful Owl (*Ninox strenua*)	0	V	-	http://www.birdlife.org.au/bird-profile/powerful-owl	Site contains potential foraging and nesting habitat as part of a wider area. No local records and not recorded on MCPL lands during this or previous surveys. Very low to unlikely chance of occurrence.
Australian Painted Snipe (*Rostratula australis*)	0	E	E	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=77037	No large permanent wetlands occur on site, and no local records, hence this species is unlikely to occur.
Black-throated Finch (*Poephila cincta cincta*)	0	E	E	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64447	Site represents poor potential habitat for this species. No local records; and site occurs beyond known distribution. Unlikely to occur.
Star Finch (eastern subspecies) (*Neochimia ruficauda ruficauda*)	0	E	E	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=26027	Site represents poor potential habitat for this species due to lack of permanent water and disturbance history. No local records. Unlikely to occur.
Painted Honeyeater (*Grantiella picta*)	0	V	V	http://www.birdlife.org.au/bird-profile/painted-honeyeater	Site provides generic foraging habitat for this species. Lack of local and regional records, disturbance history or site and locality would however reduce potential to occur. Unlikely to occur.

Species	No. of Records	NC Act	EPBC Act	Link to Profile	Likelihood of Occurrence
Eastern Osprey (*Pandion cristatus*)	0	-	M	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=952	No suitable foraging habitat occurs on site. Unlikely to occur.
Latham's Snipe (*Gallinago hardwickii*)	1	-	M	http://birdlife.org.au/bird-profile/lathams-snipe	No large permanent wetlands or waterways occur on site, and no local records, hence this species is unlikely to occur.
Glossy Ibis (*Plegadis falcinellus*)	1	-	M	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=991	Some potential habitat occurs on site. **Moderate chance of occurrence.**
Fork-tailed Swift (*Apus pacificus*)	0	-	M	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=678	**Fair potential**, as transient, between Oct-April
White-throated Needletail *(Hirundapus caudacutus)*	0	V	V, M	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682	No local records, however site contains broadly suitable habitat. **Low chance of occurrence.**
Rufous Fantail (*Rhipidura rufifrons*)	0	-	M	http://birdlife.org.au/bird-profile/Rufous-Fantail	No suitable habitat on site. Unlikely to occur.
Satin Flycatcher (*Myiagra cyanoleuca*)	0	-	M	http://birdlife.org.au/bird-profile/Satin-Flycatcher	Broadly suitable habitat occurs on site. **Low chance of occurrence.**
Black-faced Monarch (*Monarcha melanopsis*)	1	-	M	http://www.birdlife.org.au/bird-profile/black-faced-monarch	Broadly suitable habitat occurs on site. **Low chance of occurrence.**
Yellow Wagtail (*Motacilla flava*)	0	-	M	http://www.birdlife.org/datazone/speciesfactsheet.php?id=8411	No suitable habitat on site. Unlikely to occur.
Oriental Cuckoo (*Cuculus optatus*)	0	-	M	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=710	Broadly suitable habitat on site. **Low chance of occurrence.**
Mammalia					
Northern Quoll (*Dasyurus hallucatus*)	0	-	E	http://www.wildlife.org.au/wildlife/speciesprofile/mammals/northern_quoll.html	Site may provide generic foraging and denning habitat, however disturbance history of site and general area, presence of feral predators, coupled with lack of records would significantly reduce potential. Unlikely to occur.
Bridled Nail-tail Wallaby (*Onychogalea fraenata*)	0	E	E	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=239	Site habitat generally unsuitable and beyond known distribution. Unlikely to occur.

Species	No. of Records	NC Act	EPBC Act	Link to Profile	Likelihood of Occurrence
Grey-headed Flying Fox (*Pteropus poliocephalus*)	0	-	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186	Site contains a generic nectar foraging resource; however, no potential roosting habitat occurs in the study site or adjacent. There are no local records of this species and it has not been recorded on MCPL lands to date. The nearest database record for this species is located approximately 200 km east of the study site in Rockhampton (ALA 2020). Unlikely to occur.
South-eastern Long-eared Bat (*Nyctophilus corbeni*)	0	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=83395	Site contains generic potential foraging habitat for this species, however no preferred foraging habitats are present. Not detected on site during targeted surveys, or during previous surveys on MCPL land. Expert advice suggests that the site is beyond the known distribution of this species (Greg Ford pers comm.). Unlikely to occur.
Large-eared Pied Bat (*Chalinolobus dwyeri*)	0	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=183	Site contains generic potential foraging habitat for this species, however the study area is beyond the known range of the species. Unlikely to occur.
Ghost Bat (*Macroderma gigas*)	0	E	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=174	Site unlikely to comprise suitable and no caves or mine tunnels which offer roosting habitat are known to occur in the study area. Unlikely to occur.
Reptilia					
Ornamental Snake (*Denisonia maculata*)	1	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1193	Recorded 600 m to the north of the study in 2010. Not found in the study area or during this or previous surveys by Biodiversity Australia despite targeted searches. The site contains some preferred Brigalow and gilgai habitats. However, these habitats have been disturbed as a result of cattle grazing and weed invasion. **Low to fair chance of occurrence.**
Yakka Skink (*Egernia rugosa*)	0	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1420	Site contains broadly suitable vegetation associations and habitat components for this species however it has not been recorded on site despite targeted surveys or on MCPL lands during previous surveys. Unlikely to occur.

Species	No. of Records	NC Act	EPBC Act	Link to Profile	Likelihood of Occurrence
Golden-tailed Gecko (*Strophurus taenicauda*)	0	NT	-	https://www.ehp.qld.gov.au/wildlife/threatened-species/near-threatened/goldentailed_gecko.html	Site contains broadly suitable vegetation associations and habitat components for this species however it has not been recorded on MCPL lands during previous surveys. Disturbance history of the locality and presence of feral predators would also reduce potential to occur. Unlikely to occur.
Dunmall's Snake (*Furina dunmalli*)	0	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59254	Some potential habitat occurs on site however no local records and not recorded on MCPL lands to date. Disturbance history, local fragmentation and modification of surrounding habitats would also reduce potential to occur. Unlikely to occur.
Collared Delma (*Delma torquata*)	0	V	V	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1656	As for Dunmall's Snake. Unlikely to occur.
Common Death Adder (*Acanthophis antarcticus*)	0	V	-	https://www.ehp.qld.gov.au/wildlife/animals-az/common_death_adder.html	No typical or preferred habitat for this species is present on site and no local records. Unlikely to occur.
Southern Snapping Turtle (*Elseya albagula*)	0	E	CE	https://www.ehp.qld.gov.au/wildlife/animals-az/whitethroated_snapping_turtle.html	No suitable habitat occurs on the site or adjacent. Unlikely to occur.
Retro Slider (*Lerista allanae*)	0	E	E	https://www.ehp.qld.gov.au/wildlife/animals-az/allans_lerista.html	No suitable habitat occurs on the site or adjacent. Unlikely to occur.
Fitzroy River Turtle (*Rheodytes leukops*)	0	V	V	https://www.ehp.qld.gov.au/wildlife/animals-az/fitzroy_river_turtle.html	No suitable habitat occurs on the site or adjacent. Unlikely to occur.
Key: Critically Endangered (CE), Endangered (E), Vulnerable (V), Near Threatened (NT), Migratory (M).					

A-2 Site Flora Species List

Table 33: Comprehensive flora list

Common Name	Scientific Name	Frequency
Canopy Trees		
Brigalow	*Acacia harpophylla*	U
Clarkson's Bloodwood	*Corymbia clarksoniana*	O
Ghost Gum	*Corymbia dallachiana*	R
Moreton Bay Ash	*Corymbia tessellaris*	C
Brown Bloodwood	*Corymbia trachyphloia*	R
Reid River Box	*Eucalyptus brownii*	R
Dawson's Gum	*Eucalyptus cambageana*	U
Narrow-leaved Ironbark	*Eucalyptus crebra*	U
Poplar Box	*Eucalyptus populnea*	D
Queensland Blue Gum	*Eucalyptus tereticornis*	C
Weeping Paperbark	*Melaleuca leucadendra*	R
Small Trees and Shrubs		
Chalky Wattle	*Acacia cretata*	R
Ironwood	*Acacia excelsa*	U
Mimosa Bush	*Acacia farnesiana**	U
Native Willow	*Acacia salicina*	O
Lancewood	*Acacia shirleyi*	O
Red Ash	*Alphitonia excelsa*	U
Bitter Bark	*Alstonia constricta*	U
Dead Finish	*Archidendropsis basaltica*	U
Whitewood	*Atalaya hemiglauca*	O
Coffee Bush	*Breynia oblongifolia*	O
Wild Orange	*Capparis canescens*	O
Nepine	*Capparis lasiantha*	C
-	*Capparis loranthifolia*	C
Wild Orange	*Capparis mitchelii*	U
Currant Bush	*Carissa ovata*	C
Leichardt Bean	*Cassia brewsteri*	C
River Oak	*Casuarina cunninghamiana*	U
Limebush	*Citrus glauca*	R
Lollybush	*Clerodendrum floribundum*	O
Medicine Bush	*Coelospermum reticulatum*	R
-	*Denhamia cunninghamii*	R
Sticky Hop Bush	*Dodonaea viscosa*	O
Ellangowan Poison Bush	*Eremophila deserti*	O

Common Name	Scientific Name	Frequency
False Sandalwood	*Eremophila mitchellii*	O
Turkey Bush	*Erythroxylum australe*	U
Scrub Leopardwood	*Flindersia dissosperma*	U
Sandpaper Fig	*Ficus opposita*	U
Wilga	*Geijera parviflora*	O
Silver Oak	*Grevillea parallela*	U
Beefwood	*Grevillea striata*	U
Dysentery Bush	*Grewia latifolia*	C
Bootlace Oak	*Hakea lorea*	O
Harrisia Cactus	*Harrisia martini**	R
Queensland Ebony	*Lysiphyllum carronii*	R
Black Tea Tree	*Melaleuca bracteata*	R
White Cedar	*Melia azaderach*	R
Western Boobialla	*Myoporum montanum*	
Prickly Pear	*Opuntia stricta**	U
Velvet Tree Pear	*Opuntia tomentosa**	U
Emu Apple	*Owenia acidula*	R
Quinine Tree	*Petalostigma pubescens*	U
-	*Psydrax attenuata*	U
Castor Oil Plant	*Ricinus communis**	U
Sandalwood	*Santalum lanceolatum*	U
Potato Bush	*Solanum ellipticum*	U
Bead Bush	*Spartothamnella juncea*	R
Yellow-wood	*Terminalia oblongata*	R
Vine Tree	*Ventilago viminalis*	U
Grasses		
Cockatoo Grass	*Alloteropsis semialata*	U
Hooky Grass	*Ancistrachne uncinulata*	
Dark Wiregrass	*Aristida calycina*	O
Bunched Kerosene Grass	*Aristida contorta*	U
Jericho Wiregrass	*Aristida jerichoensis*	O
Purple Wire-grass	*Aristida personata*	U
Forest Blue Grass	*Bothriochloa bladhii*	U
Pitted Bluegrass	*Bothriochloa decipiens*	U
Tableland Couch	*Calyptochloa gracillima*	U
Buffel Grass	*Cenchrus ciliaris**	D
Slender Chloris	*Chloris divaricata*	O
Rhodes Grass	*Chloris gayana**	U
Windmill Grass	*Chloris truncata*	C

Common Name	Scientific Name	Frequency
Golden Beard Grass	*Chrysopogon fallax*	U
Barbed Wire Grass	*Cymbopogon refractus*	U
Couch Grass	*Cynodon dactylon*	O
Queensland Bluegrass	*Dichanthium sericeum*	C
Umbrella Grass	*Digitaria divaricatissima*	U
-	*Enteropogon acicularis*	U
Wiry Panic	*Entolasia stricta*	R
Brown's Lovegrass	*Eragrostis brownii*	U
Clustered Lovegrass	*Eragrostis elongata*	U
Purple Lovegrass	*Eragrostis lacunaria*	U
Silky Browntop	*Eulalia aurea*	U
Black Speargrass	*Heteropogon contortus*	O
Swamp Ricegrass	*Leersia hexandra*	U
Green Panic	*Megathyrsus maximus**	C
Red Natal Grass	*Melinis repens**	C
Native Millet	*Panicum decompositum*	O
Hairy Panic	*Panicum effusum*	O
Yabila Grass	*Panicum queenslandicum*	U
Brigalow Grass	*Paspalidium caespitosum*	U
-	*Paspalidium distans*	U
Freshwater Couch	*Paspalum distichum*	R
Vasey Grass	*Paspalum urvillei*	O
Comet Grass	*Perotis rara*	U
Fairy Grass	*Sporobolus caroli*	R
Kangaroo Grass	*Themeda triandra*	R
Sabi Grass	*Urochloa mosambicensis**	D
Groundcovers		
Chaff Flower	*Achyranthes aspera*	U
Khaki Weed	*Alternanthera pungens**	U
-	*Alternanthera sp.*	R
Prickly Poppy	*Argemone ochroleuca*	U
Cobbler's Pegs	*Bidens pilosa**	O
Blue Trumpet	*Brunoniella australis*	C
Mother of Millions	*Bryophyllum delagoense**	U
-	*Calotis sp.*	U
Yellow Buttons	*Chrysocephalum apiculatum*	C
-	*Commelina cyanea*	O
Native Wandering Jew	*Commelina diffusa*	O
Scurvy Grass	*Commelina ensifolia*	U

Common Name	Scientific Name	Frequency
Darling Lily	*Crinum flaccidum*	U
Gambia Pea	*Crotalaria goreensis**	O
Yellow Rattlepod	*Crotalaria mitchellii*	O
Ruby Saltbush	*Enchylaena tomentosa*	U
Winter Apple	*Eremophila debilis*	O
Tropical Speedwell	*Evolvulus alsinoides*	C
Gomphrena Weed	*Gomphrena celosioides*	O
-	*Goodenia rotundifolia*	U
Slender Violet-bush	*Hybanthus monopetalus*	U
Narrow-leaved Indigo	*Indigofera linifolia*	U
Spiny Matrush	*Lomandra longifolia*	O
Wattle Matrush	*Lomandra filiformis*	U
Phasey Bean	*Macroptilium lathryodes*	C
-	*Oxalis perennans*	U
Hairy Pigweed	*Portucaca pilosa*	O
Pigweed	*Portulaca oleracea*	C
-	*Rostellularia adscendens*	O
Soft Roly-poly	*Salsola australis*	O
-	*Sauropus hirtellus*	U
Sesbania Pea	*Sesbania cannabina*	O
-	*Sida cordifolia*	O
Fine Sida	*Sida filiformis*	O
Flannel Weed	*Sida hackettiana**	C
Paddy's Lucerne	*Sida rhombifolia**	U
Spiked Sida	*Sida subspicata*	C
Grass Trigger Plant	*Stylidium graminifolium*	U
Stylo	*Stylosanthes scabra**	D
Caltrop	*Tribulus terrestris*	O
Australian Bluebell	*Wahlenbergia gracilis*	U
Climbers and Orchids		
Headache Vine	*Clematis glycinoides*	U
Pepper Vine	*Clematacissus opaca*	U
Tiger Orchid	*Cymbidium canaliculatum*	U
Caustic Vine	*Cynanchum viminale*	U
Siratro	*Macroptilium atropurpureum**	O
Bush Banana	*Marsdenia viridiflora*	U
Morning Glory	*Ipomoea indica*	O
Red Passionflower	*Passiflora aurantia*	U
Native Tick Trefoil	*Rhynchosia australis*	U

Common Name	Scientific Name	Frequency
Aquatics		
Giant Sedge	*Cyperus exaltatus*	U
-	*Cyperus sp.*	U
-	*Cyperus gracilis*	
Common Fringe-Rush	*Fimbristylis dichotoma*	C
-	*Juncus usitatus*	U
Water Primrose	*Ludwigia peploides*	O
Bog Hyacinth	*Monochoria cyanea*	U
Water Snowflake	*Nymphoides indica*	R
Swamp Lily	*Ottelia ovalifolia*	U
Key: Dominant (D), Common (C), Occasional (O), Uncommon (U), Rare (R), Exotic Species (*).		

A-3 Site Fauna Species List

Table 34: Comprehensive fauna list

Common Name	Scientific Name	Detection Method
Amphibia		
Rough-collared Frog	*Cyclorana verrucosa*	OBS
Desert Tree Frog	*Litoria rubella*	HC
Cane Toad*	*Rhinella marina**	OBS
Aves		
Indian Mynah	*Acridotheres tristis*	OBS
Pacific Black Duck	*Anas superciliosa*	OBS
Red-winged Parrot	*Aprosmictus erythropterus*	OBS, HC
Wedge-tailed Eagle	*Aquila audax*	OBS
Sulphur-crested Cockatoo	*Cacatua galerita*	OBS, HC
Pheasant Coucal	*Centropus phasianinus*	OBS, HC
Wood Duck	*Chenonetta jubata*	OBS
Golden-headed Cisticola	*Cisticola exilis*	HC
Grey Strike-thrush	*Colluricincla harmonica*	OBS, HC
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	OBS, HC
Torresian Crow	*Corvus orru**	HC
Pied Butcherbird	*Cracticus nigrogularis*	OBS, HC
Black Swan	*Cygnus atratus*	OBS
Blue-winged Kookaburra	*Dacelo leachii*	HC
Laughing Kookaburra	*Dacelo novaeguineae*	OBS
Blue-faced Honeyeater	*Entomyzon cyanotis*	OBS, HC
Eastern Koel	*Eudynamys orientalis*	HC
Dollar Bird	*Eurystomus orientalis*	OBS, HC
Nankeen Kestrel	*Falco cenchroides*	OBS
Australian Hobby	*Falco longipennis*	OBS
Squatter Pigeon (southern subspecies)	***Geophaps scripta scripta***	**OBS**
Bar-shouldered Dove	*Geopelia humeralis*	OBS
Peaceful Dove	*Geopelia placida*	OBS
White-throated Gerygone	*Gerygone albogularis*	HC
Magpie Lark	*Grallina cyanoleuca*	OBS
Australian Magpie	*Gymnorhina tibicen*	HC
Whistling Kite	*Haliastur sphenurus*	OBS
Singing Honeyeater	*Lichenostomus virescens*	OBS
Chestnut-breasted Mannikin	*Lonchura castaneothorax*	OBS
Superb Fairy Wren	*Malurus cyaneus*	OBS
Variegated Fairy Wren	*Malurus lamberti*	OBS

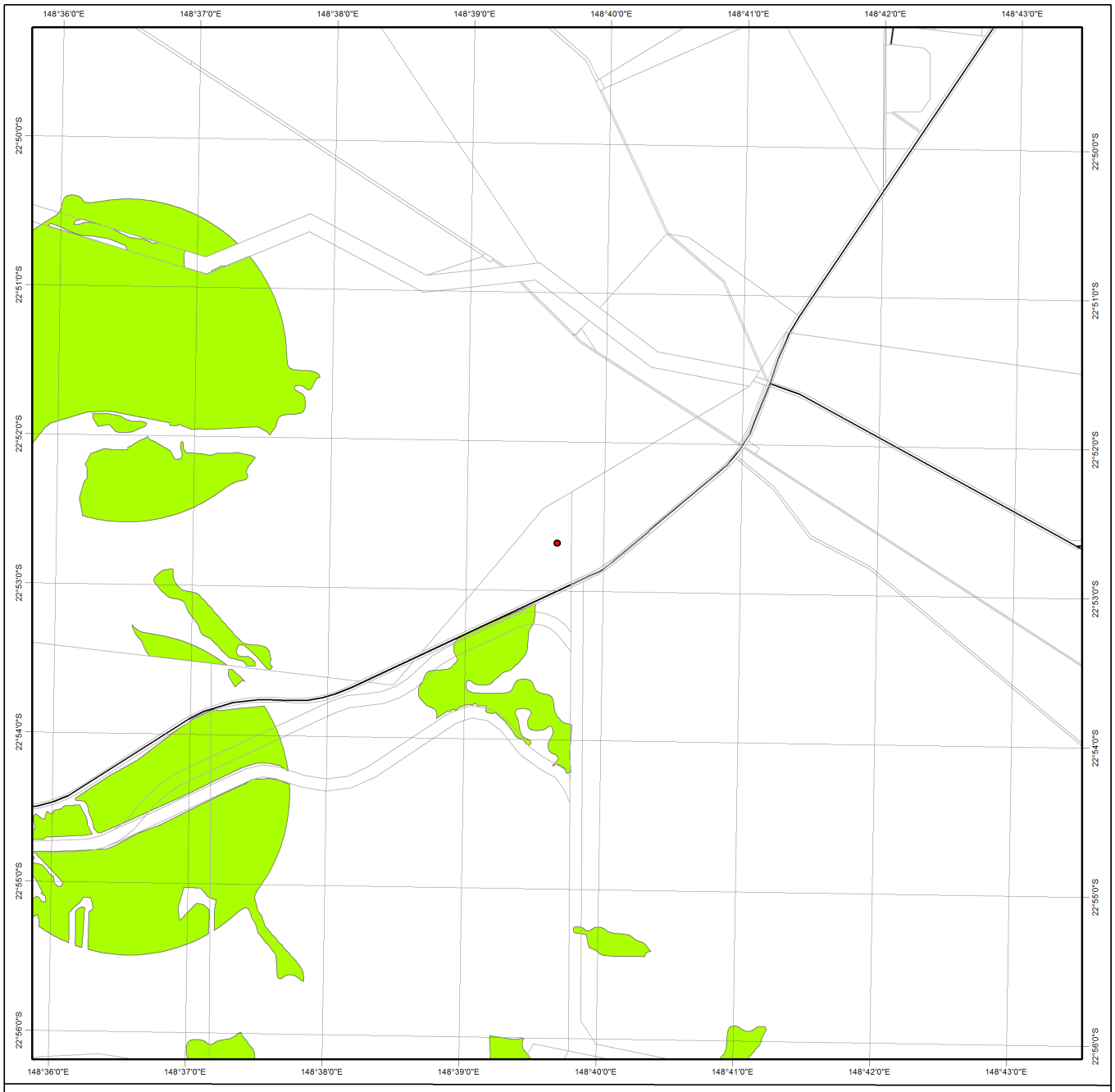
Red-backed Fairy-wren	*Malurus melanocephalus*	OBS
Noisy Miner	*Manorina melanocephala*	OBS, HC
Rainbow Bee-eater	*Merops ornartus*	HC
White-naped Honeyeater	*Melithreptus lunatus*	HC
Black Kite	*Milvus migrans*	OBS
Southern Boobook	*Ninox boobook*	OBS
Crested Pigeon	*Ocyphaps lophotes*	OBS
Rufous Whistler	*Pachycephala rufiventris*	OBS
Striated Pardalote	*Pardalotus striatus*	OBS, HC
Little Friarbird	*Philemon citreogularis*	OBS, HC
Noisy Friarbird	*Philemon corniculatus*	OBS
Pale-headed Rosella	*Platycercus adscitus*	OBS
Tawny Frogmouth	*Podargus strigoides*	OBS
Grey-crowned Babbler	*Pomatostomus temporalis*	HC
Willie Wagtail	*Rhipidura leucophrys*	OBS
Weebill	*Smicrornis brevirostris*	HC
Double-barred Finch	*Taeniopygia bichenovii*	OBS
Crested Tern[1]	*Thalasseus bergii*[1]	OBS
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	OBS
Rainbow Lorikeet	*Trichoglossus haematodus*	OBS, HC
Masked lapwing	*Vanellus miles*	OBS
Mammalia		
Rufous Bettong	*Aepyprymnus rufescens*	OBS, CAM
Wild Dog*	*Canis lupus familiaris**	TR
Northern Freetail Bat	*Chaerephon jobensis*	ANA
Gould's Wattled Bat	*Chalinolobus gouldii*	ANA
Chocolate Wattled Bat	*Chalinolobus morio*	ANA
Little Pied Bat	*Chalinolobus picatus*	ANA
Feral Cat*	*Felis catus**	TR
Eastern Grey Kangaroo	*Macropus giganteus*	OBS
Little Bent-wing Bat	*Miniopterus australis*	ANA
Long-eared Bat	*Nyctophilus sp.*	ANA
European Rabbit*	*Oryctolagus cuniculus**	OBS
Northern Free-tailed Bat	*Ozimops lumsdenae*	ANA
Eastern Free-tailed Bat	*Ozimops ridei*	ANA
Greater Glider	***Petauroides volans***	**OBS**
Sugar Glider	*Petaurus breviceps*	OBS
Squirrel Glider	*Petaurus norfolcensis*	OBS
Koala	***Phascolarctos cinereus***	**SC**
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*	ANA

Inland Broad-nosed Bat	*Scotorepens balstoni*	ANA
Little Broad-nosed Bat	*Scotorepens greyii*	ANA
Short-beaked Echidna	*Tachyglossus aculeatus*	OBS
Common Brushtail Possum	*Trichosurus vulpecula*	OBS
Inland Forest Bat	*Vespadelus baverstocki*	ANA
Eastern Cave Bat	*Vespadelus troughtoni*	ANA
Reptilia		
Lined Rainbow Skink	*Carlia jarnoldae*	OBS
Fence Skink	*Cryptoblepharus virgatus*	OBS
Copper-tailed Skink	*Ctenotus taeniolatus*	OBS
Chain-backed Dtella	*Gehrya catenata*	OBS
Bynoe's Gecko	*Heteronotia binoei*	OBS
Ocellated Velvet Gecko	*Oedura monilis*	OBS
Eastern Brown Snake	*Pseudonaja textilis*	OBS
Key: Observed (OBS), Heard Call (HC), PIR Camera (CAM), Scat (SC), Anabat Recording (ANA), Tracks (TR), Introduced Species (*), Threatened Species under EPBC Act and/or NC Act (bold), Migratory Species ([1]).		

A-4 Database Search Results

A-4-1 High Risk Vegetation Trigger Report

05/09/2019 11:52:32
Longitude: 148.661 Latitude: -22.878



Protected Plants Flora Survey Trigger Map

Legend

- Coordinates
- High risk area
- Cadastral line
  Property boundaries shown are provided as a locational aid only
- Freeways / motorways / highways
- Secondary roads / streets

N

0 480 960 1,440 1,920 2,400 m

This product is projected into:
GDA 1994 Queensland Albers

This map shows areas where particular provisions of the Nature Conservation Act 1992 apply to the clearing of protected plants.

This map is produced at a scale relevant to the size of the area selected and should be printed as A4 size in portrait orientation.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Science at palm@ehp.qld.gov.au

Disclaimer:
While every care is taken to ensure the accuracy of the data used to generate this product, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damages) and costs which might be incurred as a consequence of reliance on the data, or as a result of the data being inaccurate or incomplete in any way and for any reason.

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Queensland Government

Protected plants flora survey trigger map

The protected plants flora survey trigger map identifies 'high risk areas' where endangered, vulnerable or near threatened plants are known to exist or are likely to exist. Under the *Nature Conservation Act 1992* (the Act) it is an offence to clear protected plants that are 'in the wild' unless you are authorised or the clearing is exempt, for more information see section 89 of the Act.

Please see the Department of Environment and Science webpage on the clearing of protected plants for information on what exemptions may apply in your circumstances, whether you may need to undertake a flora survey, and whether you may need a protected plants clearing permit.

Updates to the data informing the flora survey trigger map

The flora survey trigger map will be reviewed, and updated if necessary, at least every 12 months to ensure the map reflects the most up-to-date and accurate data available.

Species information

Please note that flora survey trigger maps do not identify species associated with 'high risk areas'. While some species information may be publicly available, for example via the Queensland Spatial Catalogue, the Department of Environment and Science does not provide species information on request. Regardless of whether species information is available for a particular high risk area, clearing plants in a high risk area may require a flora survey and/or clearing permit. Please see the Department of Environment and Science webpage on the clearing of protected plants for more information.

Queensland Government

A-4-2 Wildlife Online

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: -22.878
Longitude: 148.665
Distance: 10
Email: will.steggall@biodiversityaust.com.au
Date submitted: Tuesday 10 Mar 2020 15:53:24
Date extracted: Tuesday 10 Mar 2020 16:00:02

The number of records retrieved = 3

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	1
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	3
plants	land plants	Apocynaceae	*Cerbera dumicola*			NT		2/2

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

A-4-3 Regional Ecosystem Report

Queensland Government

Department of Environment and Science

Environmental Reports

Regional Ecosystems

Biodiversity Status

For the selected area of interest
Longitude: 148.665 Latitude: -22.878 with 2 kilometre radius

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the classes used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Natural Resources, Mines and Energy website

https://www.dnrme.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@dsiti.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

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Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Area of interest details: Longitude: 148.665 Latitude: -22.878 with 2 kilometre radius

Size (ha)	1,256.55
Local Government(s)	Isaac Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Isaac - Comet Downs
Catchment(s)	Fitzroy

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" regional ecosystems classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	45.69	3.64
Of concern	134.32	10.69
No concern at present	61.52	4.9
Total remnant vegetation	241.53	19.22

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil (Sattler and Williams 1999). Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem classification and descriptions are reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and are usually distinguished by differences in dominant species, frequently in the shrub or ground layers and are denoted by a letter following the regional ecosystem code (e.g. a, b, c). Vegetation communities and regional ecosystems are amalgamated into a higher level classification of broad vegetation groups (BVGs).

A published methodology for survey and mapping of regional ecosystems across Queensland (Neldner et al 2017) provides further details on regional ecosystem concepts and terminology.

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium's Regional Ecosystem Mapping, and not the regulated mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Natural Resources, Mines and Energy website.

https://www.dnrme.qld.gov.au/

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 per cent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (1000 ha); or patch size (100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI and provides their short descriptions, Biodiversity Status, and remnant extent within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
11.3.1	Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains	Endangered	20.13	1.6
11.3.2	Eucalyptus populnea woodland on alluvial plains	Of concern	35.31	2.81
11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Of concern	37.18	2.96
11.3.7	Corymbia spp. woodland on alluvial plains	Of concern	13.88	1.1
11.4.9b	Acacia harpophylla shrubby woodland with Terminalia oblongata on Cainozoic clay plains	Endangered	25.56	2.03
11.5.18	Micromyrtus capricornia open shrubland on Cainozoic sand plains and/or remnant surfaces	Of concern	3.41	0.27
11.5.2	Eucalyptus crebra, Corymbia spp., with E. moluccana woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces	No concern at present	1.92	0.15
11.5.3	Eucalyptus populnea +/- E. melanophloia +/- Corymbia clarksoniana woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	1.43	0.11
11.5.9b	Eucalyptus crebra and other Eucalyptus spp. and Corymbia spp. woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	5.12	0.41
11.7.1	Acacia harpophylla and/or Casuarina cristata and Eucalyptus thozetiana or E. microcarpa woodland on lower scarp slopes on Cainozoic lateritic duricrust	Of concern	44.54	3.54
11.7.2	Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	No concern at present	53.05	4.22
non-rem	None	None	1,015.02	80.78

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before clearing.

Table 4 provides further information in regards to the remnant regional ecosystems present within the AOI. Specifically, the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.3.1	Pre-clearing 781000 ha; Remnant 2017 78000 ha	25a	None	Low
11.3.2	Pre-clearing 1926000 ha; Remnant 2017 506000 ha	17a	Contains palustrine wetland (e.g. in swales).	Low
11.3.25	Pre-clearing 795000 ha; Remnant 2017 512000 ha	16a	Riverine wetland or fringing riverine wetland.	Low
11.3.7	Pre-clearing 139000 ha; Remnant 2017 62000 ha	9e	None	Low
11.4.9b	Pre-clearing 999000 ha; Remnant 2017 90000 ha	25a	None	Low
11.5.18	Pre-clearing 7000 ha; Remnant 2017 4000 ha	29b	None	Medium
11.5.2	Pre-clearing 360000 ha; Remnant 2017 190000 ha	18b	None	Low
11.5.3	Pre-clearing 981000 ha; Remnant 2017 372000 ha	17a	None	Low
11.5.9b	Pre-clearing 365000 ha; Remnant 2017 238000 ha	18b	None	Low
11.7.1	Pre-clearing 201000 ha; Remnant 2017 78000 ha	25a	None	Low
11.7.2	Pre-clearing 565000 ha; Remnant 2017 366000 ha	24a	None	Low
non-rem	None	None	None	None

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

The distribution of mapped wetland systems within the area of interest is displayed in **Map 6**.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
11.3.1	Habitat for threatened fauna species including painted honeyeater, Grantiella picta particularly in subregion 35 (Oliver et al. 2003).
11.3.2	Habitat for threatened flora species Homopholis belsonii.
11.3.25	Shown to be associated with a high fauna species richness in the Taroom area (Venz et al. 2002). Within parts of the Fitzroy catchment, this RE is known habitat for the threatened freshwater turtle Rheodytes leukops. Known to be important habitat for other riparian freshwater turtle species.
11.3.7	Habitat of the endangered northern hairy-nosed wombat, Lasiorhinus krefftii.
11.4.9b	Potential habitat for NCA listed species: Cadellia pentastylis, Solanum adenophorum, Solanum dissectum, Solanum elachophyllum, Solanum johnsonianum, Xerothamnella herbacea
11.5.18	None
11.5.2	Potential habitat for NCA listed species: Acacia storyi
11.5.3	Potential habitat for NCA listed species: Sannantha brachypoda

Regional Ecosystem	Special Values
11.5.9b	Potential habitat for NCA listed species: Cerbera dumicola, Cossinia australiana, Cycas ophiolitica, Solanum elachophyllum
11.7.1	Habitat for threatened plant species including Cadellia pentastylis.
11.7.2	Habitat for threatened plant species including Acacia wardellii.
non-rem	None

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional) scales.

A comprehensive description of BVGs is available at:

https://publications.qld.gov.au/dataset/redd/resource/

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
None	None	1,015.02	80.78
16a	Open forest and woodlands dominated by Eucalyptus camaldulensis (river red gum) (or E. tereticornis (blue gum)) and/or E. coolabah (coolabah) (or E. microtheca (coolabah)) fringing drainage lines. Associated species may include Melaleuca spp., Corymbia tessellaris (carbeen), Angophora spp., Casuarina cunninghamiana (riveroak). Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded. (land zone 3) (MGD, BRB, GUP, CHC, MUL, DEU, EIU, NWH, SEQ, [NET, WET]) (All bioregions except CYP and CQC)	37.18	2.96
17a	Woodlands dominated by Eucalyptus populnea (poplar box) (or E. brownii (Reid River box)) on alluvium, sand plains and footslopes of hills and ranges. (land zones 3, 5, 10, 9, 4, 11, 12, [8]) (BRB, MUL, DEU, MUL, EIU)	36.74	2.92
18b	Woodlands dominated Eucalyptus crebra (sens. lat.) (narrow-leaved red ironbark) frequently with Corymbia spp. or Callitris spp. on flat to undulating plains. (land zones 5, 3) (BRB, DEU, EIU, GUP, CYP)	7.04	0.56
24a	Low woodlands to tall shrublands dominated by Acacia spp. on residuals. Species include A. shirleyi (lancewood), A. catenulata (bendee), A. microsperma (bowyakka), A. clivicola, A. sibirica, A. rhodoxylon (rosewood) and A. leptostachya (Townsville wattle). (land zones 7, 10, 5, 12, 11, [9, 3]) (MUL, CHC, BRB, GUP, EIU, MGD, DEU, NWH, [CYP])	53.05	4.22
25a	Open forests to woodlands dominated by Acacia harpophylla (brigalow) sometimes with Casuarina cristata (belah) on heavy clay soils. Includes areas co-dominated with A. cambagei (gidgee) and/or emergent eucalypts (land zones 4, 9, 3, 11, 7, 12, [5, 8]) (BRB, MUL, MGD, DEU, [SEQ])	90.22	7.18

BVG (1 Million)	Description	Area (Ha)	% of AOI
29b	Open shrublands to open heaths in montane frequently rocky locations. (land zones 7, 12, 11, 5, 8, 10) (BRB, NWH, WET, CYP, EIU, SEQ, DEU, [NET, CQC])	3.41	0.27
9e	Open forests, woodlands and open woodlands dominated by Corymbia clarksoniana (grey bloodwood) (or C. novoguinensis or C. intermedia (pink bloodwood) or C. polycarpa (long-fruited bloodwood)) frequently with Erythrophleum chlorostachys (red ironwood) or Eucalyptus platyphylla (poplar gum) predominantly on coastal sandplains and alluvia. (land zones 3, 5, 2) (CYP, BRB, CQC, WET, EIU)	13.88	1.1

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium's CORVEG database. Distribution maps, representative images (if available) and the pre-clearing and remnant extent (hectares) of each vegetation community derived from the regional ecosystem mapping data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Technical descriptions include data on canopy height, canopy cover and native plant species composition of the predominant layer, which are attributes relevant to assessment of the remnant status of vegetation under the *Vegetation Management Act 1999*. However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used for remnant assessment where possible (Neldner et al. 2012 (PDF))* section 3.3.1 of:

https://publications.qld.gov.au/dataset/redd/resource/

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community.

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

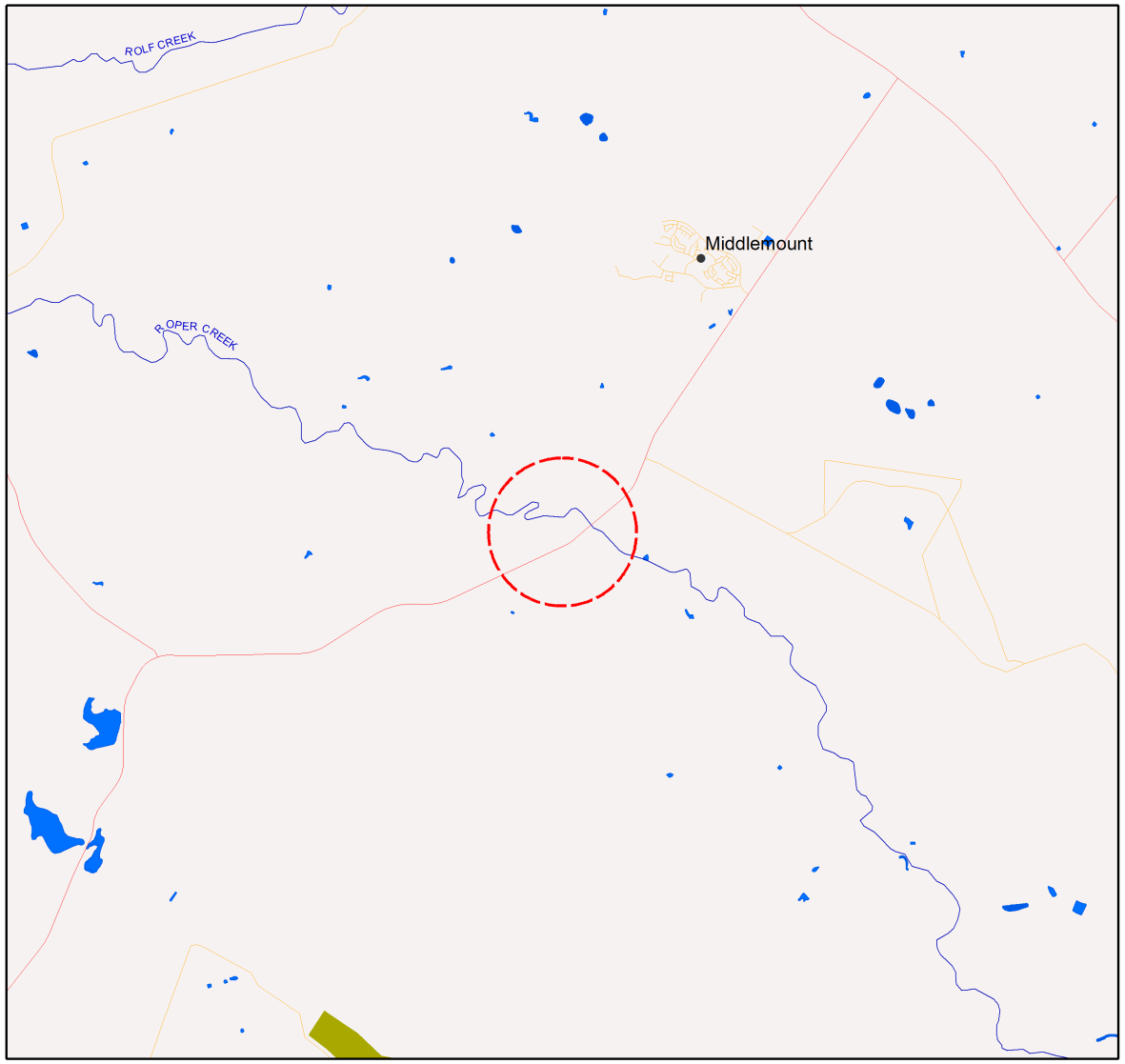
Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
11.3.1	Available	Not currently available
11.3.2	Available	Not currently available
11.3.25	Available	Not currently available
11.3.7	Available	Not currently available
11.4.9b	Available	Not currently available
11.5.18	Available	Not currently available

Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
11.5.2	Available	Not currently available
11.5.3	Available	Not currently available
11.5.9b	Available	Not currently available
11.7.1	Available	Not currently available
11.7.2	Available	Not currently available
non-rem	Not currently available	Not currently available

Maps

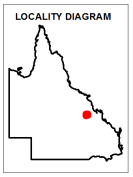
Map 1 - Location



Locality Map

Legend

- 2 kilometre buffer
- Towns
- Highway
- Connector
- Street/Local Road
- Reservoirs
- Lakes
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Coordinated Conservation Areas
- Major rivers/creeks
- Queensland



N

0 1600 3200 4800 6400 8000 m

This product is projected into GDA 1994 Queensland Albers

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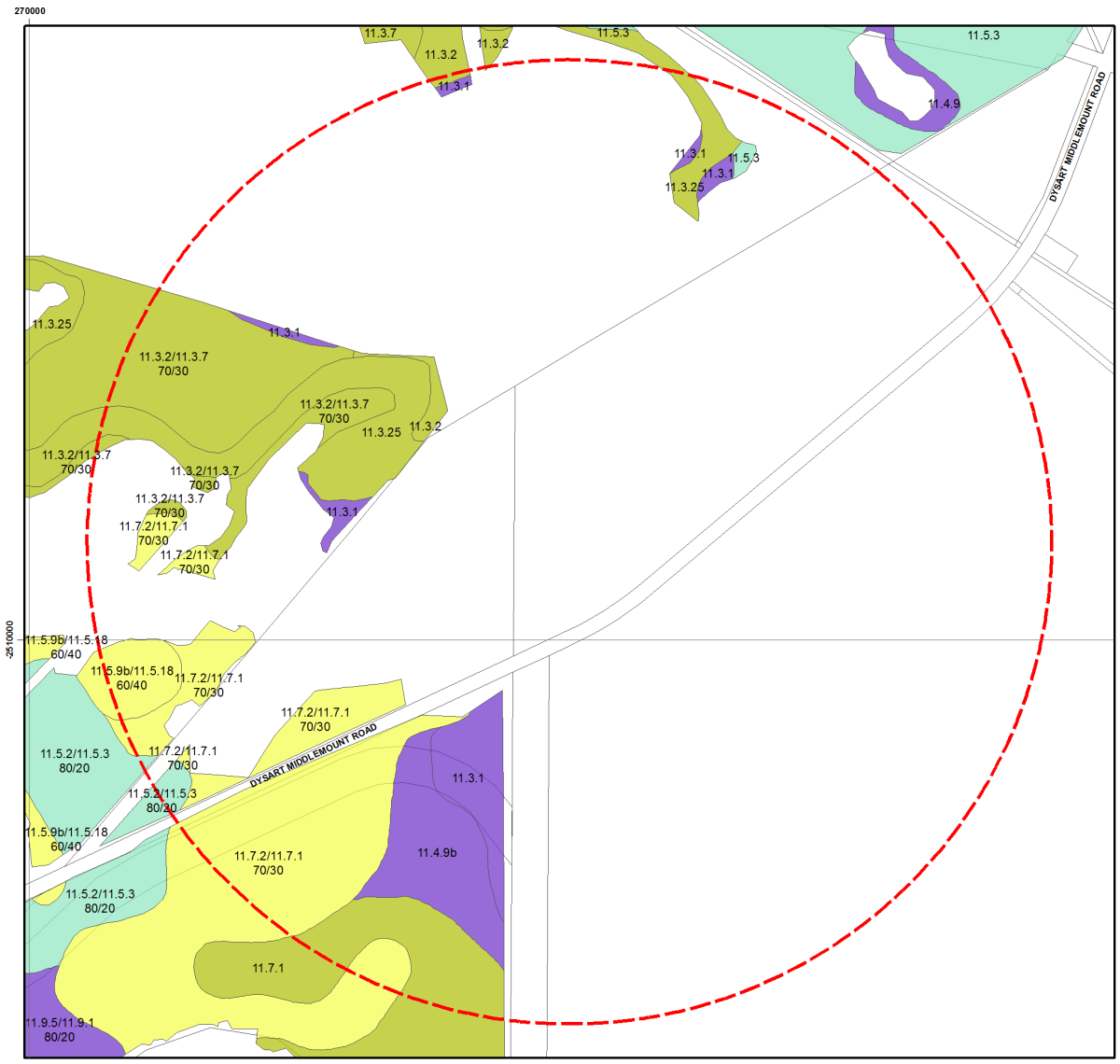
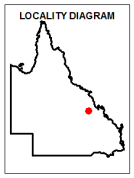
Map 2 - Remnant 2017 regional ecosystems



Remnant 2017 Regional Ecosystems

Biodiversity Status

- 2 kilometre buffer
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries



N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

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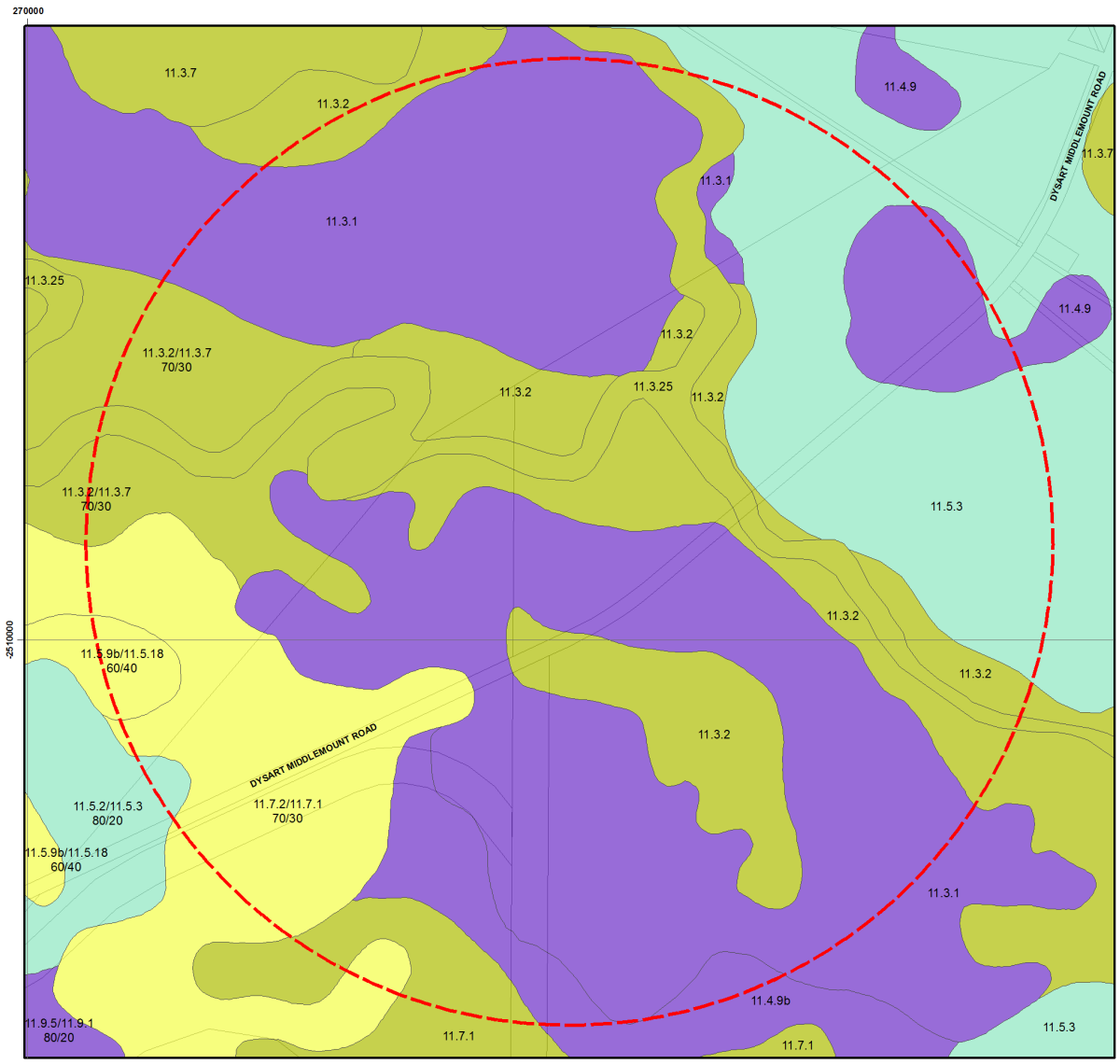
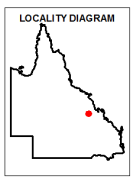
Map 3 - Pre-clearing regional ecosystems



Pre-clearing Regional Ecosystems

Biodiversity Status

- 2 kilometre buffer
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries



N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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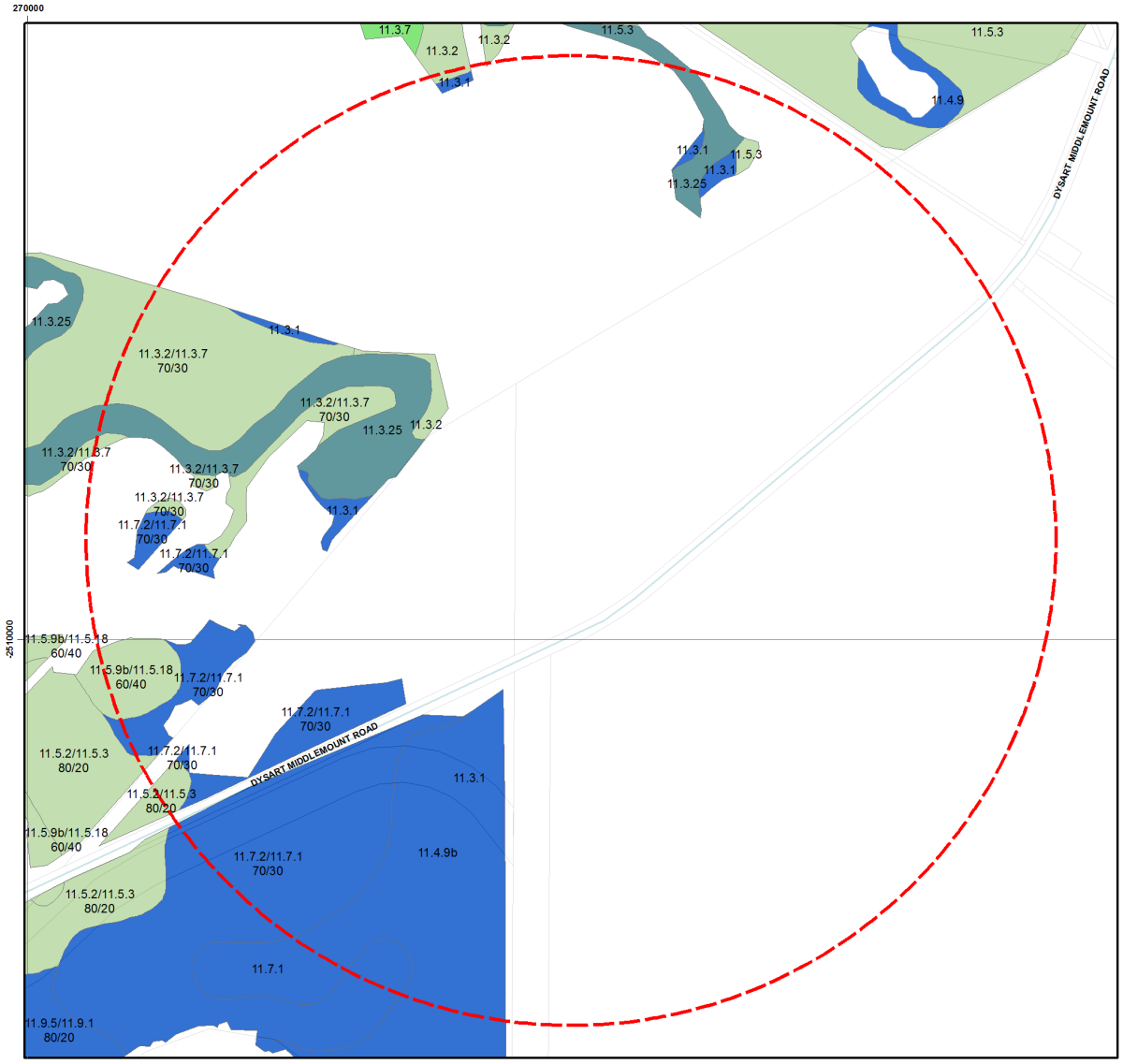
Map 4 - Remnant 2017 regional ecosystems by BVG (5M)



Remnant 2017 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 2 kilometre buffer
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Non-remnant vegetation, cultivated or built environment
- Water
- Cadastral Boundaries

N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

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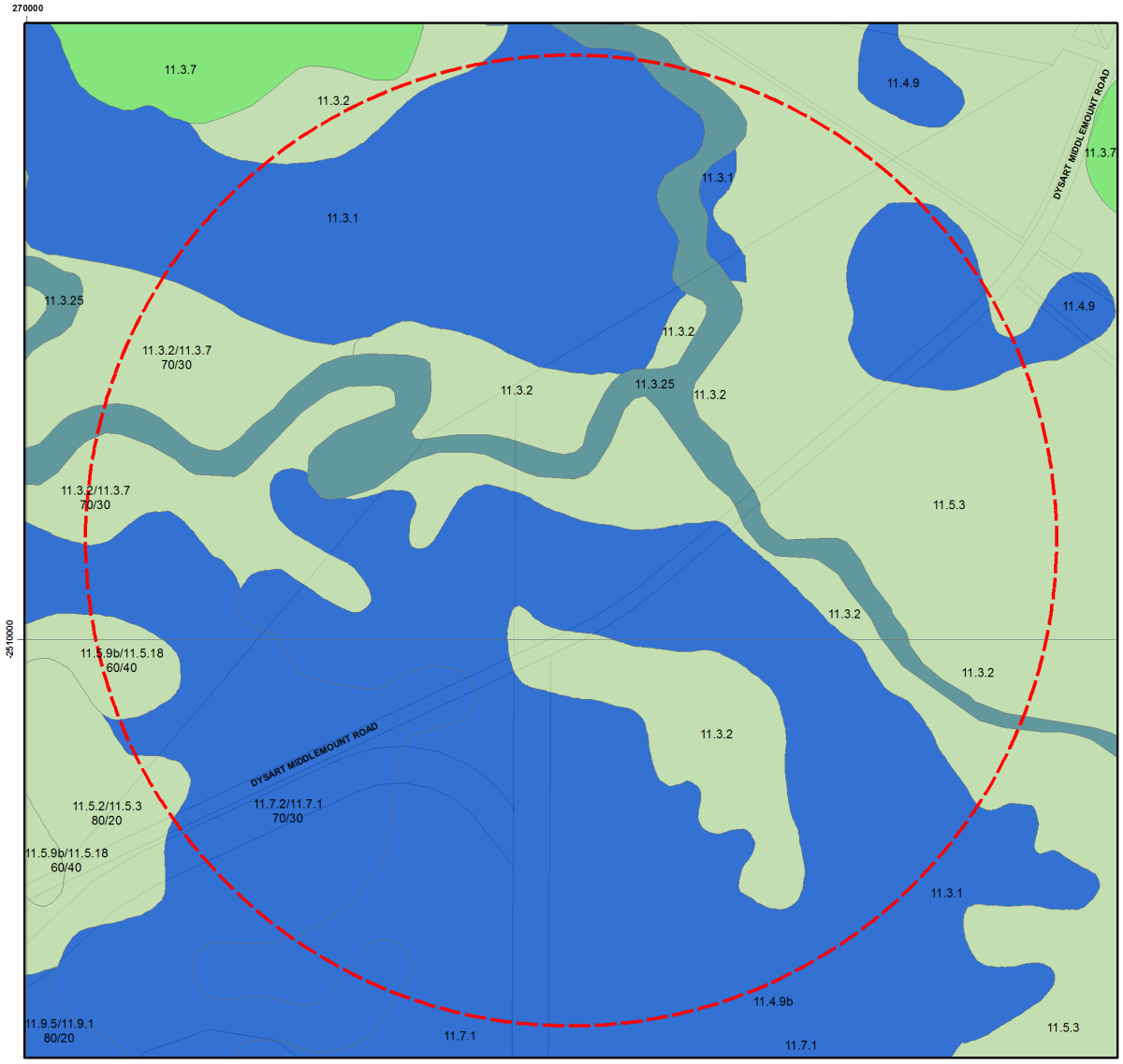
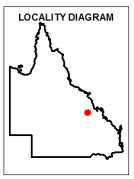
Map 5 - Pre-clearing regional ecosystems by BVG (5M)



Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 2 kilometre buffer
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Water
- Cadastral Boundaries



N

0 0.25 0.5 0.75 1 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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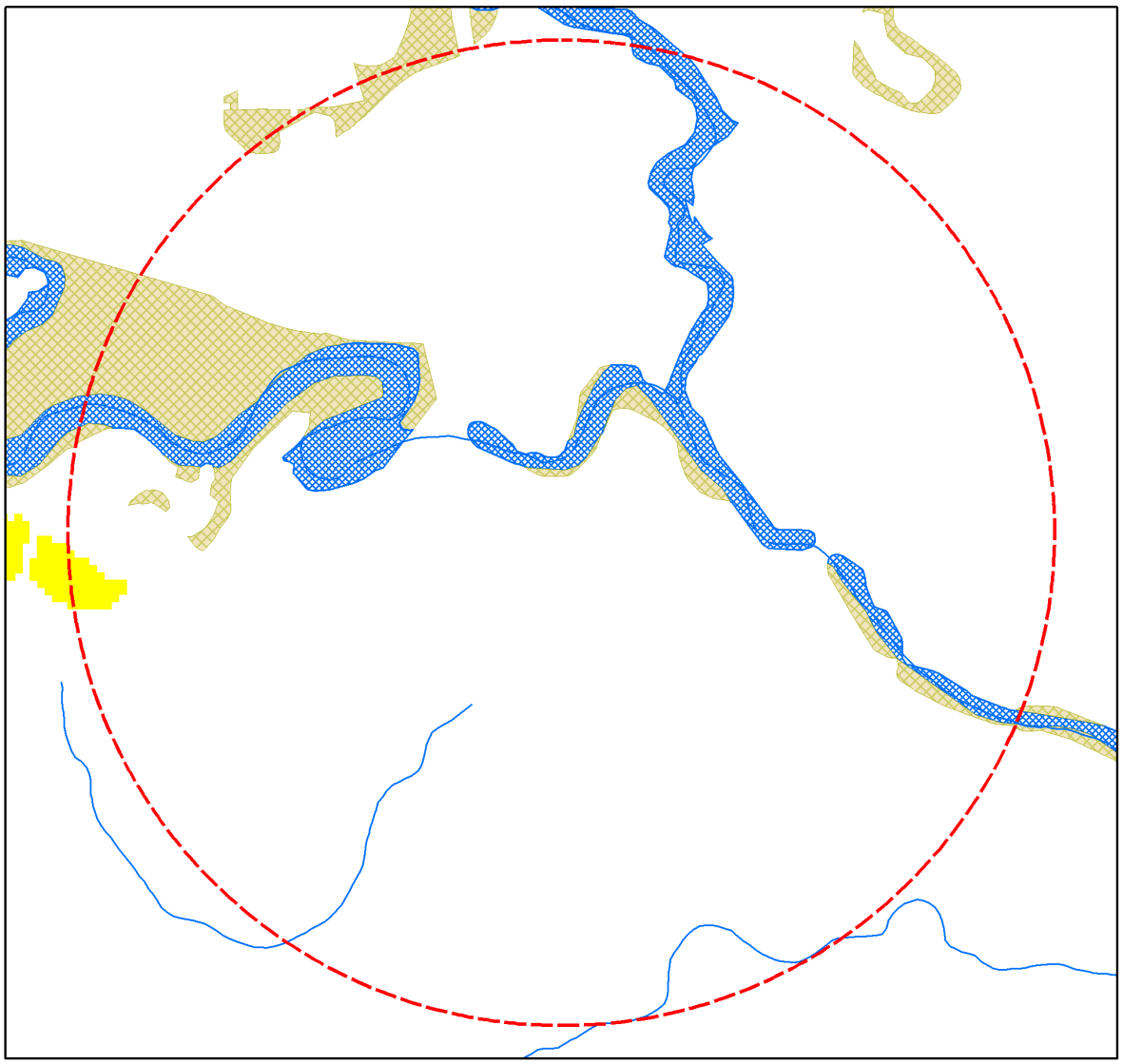
Map 6 - Wetlands and waterways



Queensland Wetland Data

Legend

- 2 kilometre buffer
- Towns

Queensland Wetland Data

- Riverine Drainage Lines
- Springs

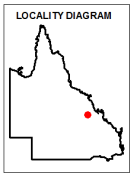
Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)

LOCALITY DIAGRAM



N

0 240 480 720 960 1200 m

This product is projected into GDA 1994 Queensland Albers

Accuracy information: The positional accuracy of wetland data mapped at a scale of 1:100,000 is +/-100m with a minimum polygon size of 5ha or 75m wide for linear features, except for areas along the east coa st which are mapped at the 1:50,000 scale with a positional accuracy of +/-50m, with a minimum polygon size of 1ha or 35m wide for linear features. Wetlands smaller than 1ha are not delineated on the wetland data. Consideration of the effects of mapped scale is necessary when interpret ing data at a larger scale, e.g. 1:25,000. For property assessment, digital linework should be used as a guide only. The extent of wetlands depicted on this map is based on rectified 2013 Landsat ETM+ imagery supplied by Statewide Landcover and Trees Study (SLATS), Department of Environment and Science. The extent of water bodies is based on the maximum extent of inundation derived from available Landsat imagery up to and including the 2013 imagery.

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Links and Other Information Sources

The Department of Environment and Science's Website -

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

The methodology for mapping regional ecosystems can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

Technical descriptions for regional ecosystems can be obtained from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from:

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, refer to the metadata associated with the Biodiversity status of pre-clearing and Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) which is available through the Queensland Government Information System portal,

http://dds.information.qld.gov.au/dds/

The Queensland Globe is a mapping and data application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link:

http://www.dnrm.qld.gov.au/mapping-data/queensland-globe

References

Neldner, V.J., Niehus R.E., Wilson, B.A. McDonald, W.J.F., Ford, A.J. and Accad, A. (2017) The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 3.0. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(https://publications.qld.gov.au/dataset/redd/resource/78209e74-c7f2-4589-90c1-c33188359086)

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S. and Butler, D.W. (2017) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 4.0. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(https://publications.qld.gov.au/dataset/redd/resource/6dee78ab-c12c-4692-9842-b7257c2511e4)

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

The dataset listed below is available for download from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

The datasets listed below are available for download from:

http://dds.information.qld.gov.au/dds/

- Biodiversity status of pre-clearing and 2017 remnant regional ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
VMA	- *Vegetation Management Act 1999*

A-4-4 Regulated Vegetation Report

07/07/2020 14:27:58
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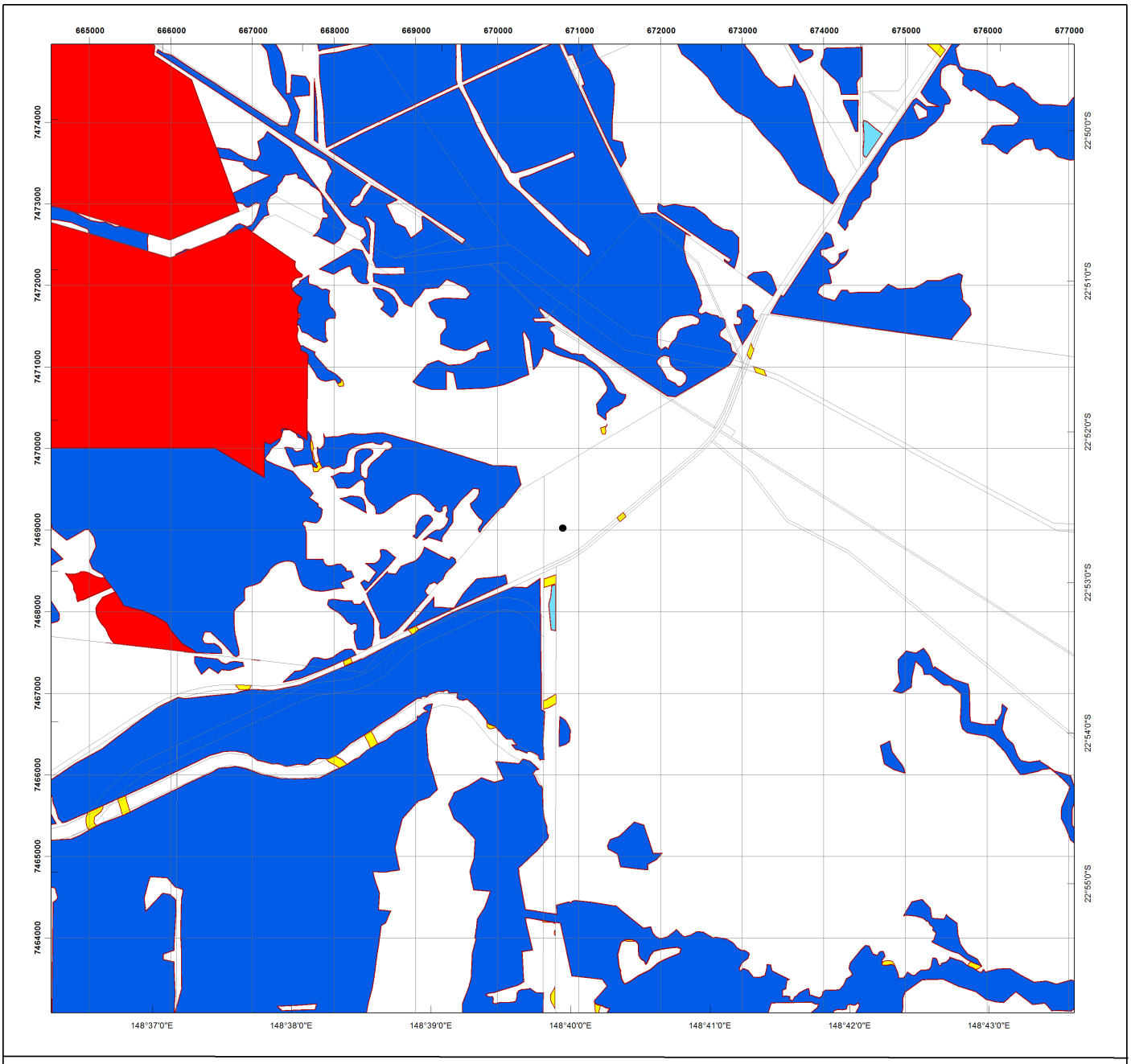
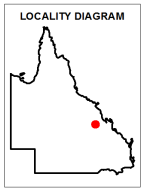
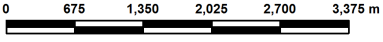


Regulated Vegetation Management Map

Legend

- Coordinates
- Category A area (Vegetation offsets/compliance notices/VDecs)
- Category B area (Remnant vegetation)
- Category C area (High-value regrowth vegetation)
- Category R area (Reef regrowth watercourse vegetation)
- Category X area (Exempt clearing work on Freehold, Indigenous and Leasehold land)
- Water
- Area not categorised
- Other land parcel boundaries





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Additional information required for the assessment of vegetation values is provided in the accompanying "Vegetation Management Supporting map". For further information go to the web site: www.dnrme.qld.gov.au or contact the Department of Natural Resources, Mines and Energy.

Digital data for the regulated vegetation management map is available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

Land parcel boundaries are provided as locational aid only.

This map is updated on a monthly basis to ensure new PMAVs are included as they are approved.

This product is projected into:
GDA 1994 MGA Zone 55

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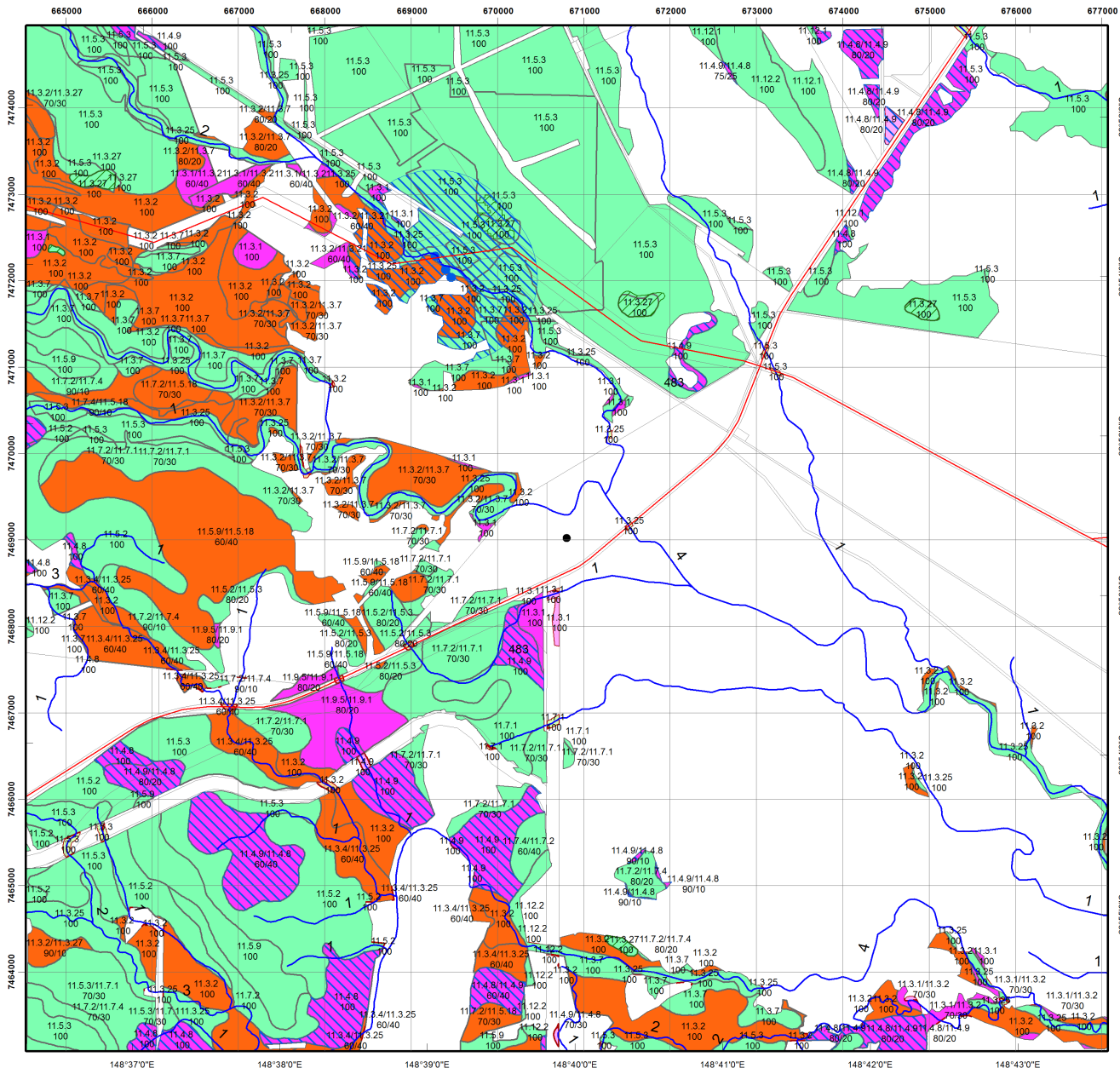
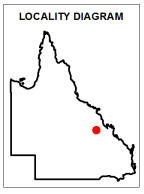


Vegetation Management Supporting Map

Legend

- Coordinates
- Category A or B area containing endangered regional ecosystems
- Category A or B area containing of concern regional ecosystems
- Category A or B area that is a least concern regional ecosystem
- Category A or B area under Section 20AH
  These areas are edged in yellow and filled with the remnant RE Status
- Category C or R area containing endangered regional ecosystems
- Category C or R area containing of concern regional ecosystems
- Category C or R area that is a least concern regional ecosystem
- Category C area under Section 20AI
  These areas are edged in purple and filled with the remnant RE Status
- Category X area
- Water
- Wetland on the vegetation management wetlands map
- Essential habitat on the essential habitat map
- Essential habitat species record
- Watercourses and drainage features on the vegetation management watercourse and drainage features map
  (Stream order shown as black number against stream where available)
- Roads
- National Parks, State Forest and other reserves
- Other land parcel boundaries



0 480 960 1,440 1,920 2,400 m

This product is projected into:
GDA 1994 MGA Zone 55

Labels for Essential Habitat are centred on the area of enquiry.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/- 100 metres.

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Natural Resources, Mines and Energy makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

Additional information may be required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.dnrme.qld.gov.au or contact the Department of Natural Resources, Mines and Energy.

Digital data for the vegetation management watercourse and drainage feature map, vegetation management wetlands map, essential habitat map and the vegetation management remnant and regional ecosystem map are available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

Land parcel boundaries are provided as locational aid only.

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Vegetation Management Act 1999 - Extract from the essential habitat database

Essential habitat is required for assessment under the:

- State Development Assessment Provisions - State Code 16: Native vegetation clearing which sets out the matters of interest to the state for development assessment under the *Planning Act 2016*; and
- Accepted development vegetation clearing codes made under the *Vegetation Management Act 1999*

Essential habitat for one or more of the following species is found on and within 1.1 km of the identified subject lot/s on the accompanying essential habitat map.

This report identifies essential habitat in Category A, B and Category C areas.

The numeric labels on the essential habitat map can be cross referenced with the database below to determine which essential habitat factors might exist for a particular species.

Essential habitat is compiled from a combination of species habitat models and buffered species records.

The Department of Natural Resources, Mines and Energy website (http://www.dnrme.qld.gov.au) has more information on how the layer is applied under the State Development Assessment Provisions - State Code 16: Native vegetation clearing and the *Vegetation Management Act 1999*.

Regional ecosystem is a mandatory essential habitat factor, unless otherwise stated.

Essential habitat, for protected wildlife, means a category A area, a category B area or category C area shown on the regulated vegetation management map-

1) that has at least 3 essential habitat factors for the protected wildlife that must include any essential habitat factors that are stated as mandatory for the protected wildlife in the essential habitat database; or

2) in which the protected wildlife, at any stage of its life cycle, is located.

Protected wildlife includes endangered, vulnerable or near-threatened native wildlife prescribed under the *Nature Conservation Act 1992*.

Essential habitat in Category A and/or Category B and/or Category C

Label	Scientific Name	Common Name	NCA Status	Vegetation Community	Altitude	Soils	Position in Landscape
483	Denisonia maculata	ornamental snake	V	Riparian woodland/open forest and shrub/woodland including Brigalow Acacia harpophylla; into drier habitats in summer.	100-450m.	Cracking clay with gilgai/soil crack microrelief and sandy loam substrates.	Near freshwater waterholes/creeks and low lying poorly drained areas that are frequently inundated by freshwater.

Label	Regional Ecosystem (mandatory unless otherwise specified)
483	10.3.2, 10.3.3, 10.3.4, 10.3.7, 10.3.13, 10.3.14, 10.3.15, 10.3.16, 10.3.27, 10.3.30, 10.3.31, 10.4.1, 10.4.2, 10.4.3, 10.4.4, 10.4.5, 10.4.6, 10.4.7, 10.4.8, 10.5.5, 10.9.1. 10.9.6. 10.9.7, 11.3.1, 11.3.2, 11.3.3, 11.3.4, 11.3.6, 11.3.9, 11.3.10, 11.3.12, 11.3.15, 11.3.21, 11.3.23, 11.3.24, 11.3.25, 11.3.27, 11.3.28, 11.3.31, 11.3.34, 11.3.37, 11.3.38, 11.3.40, 11.4.2, 11.4.3, 11.4.4, 11.4.6, 11.4.7, 11.4.8, 11.4.9, 11.4.11, 11.5.2, 11.5.3, 11.5.16, 11.8.11, 11.9.1, 11.9.2, 11.9.3, 11.9.5, 11.9.7, 11.9.11, 11.9.12, 11.9.14, 11.11.15, 11.12.6

A-4-5 Matters of National Significance Report

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

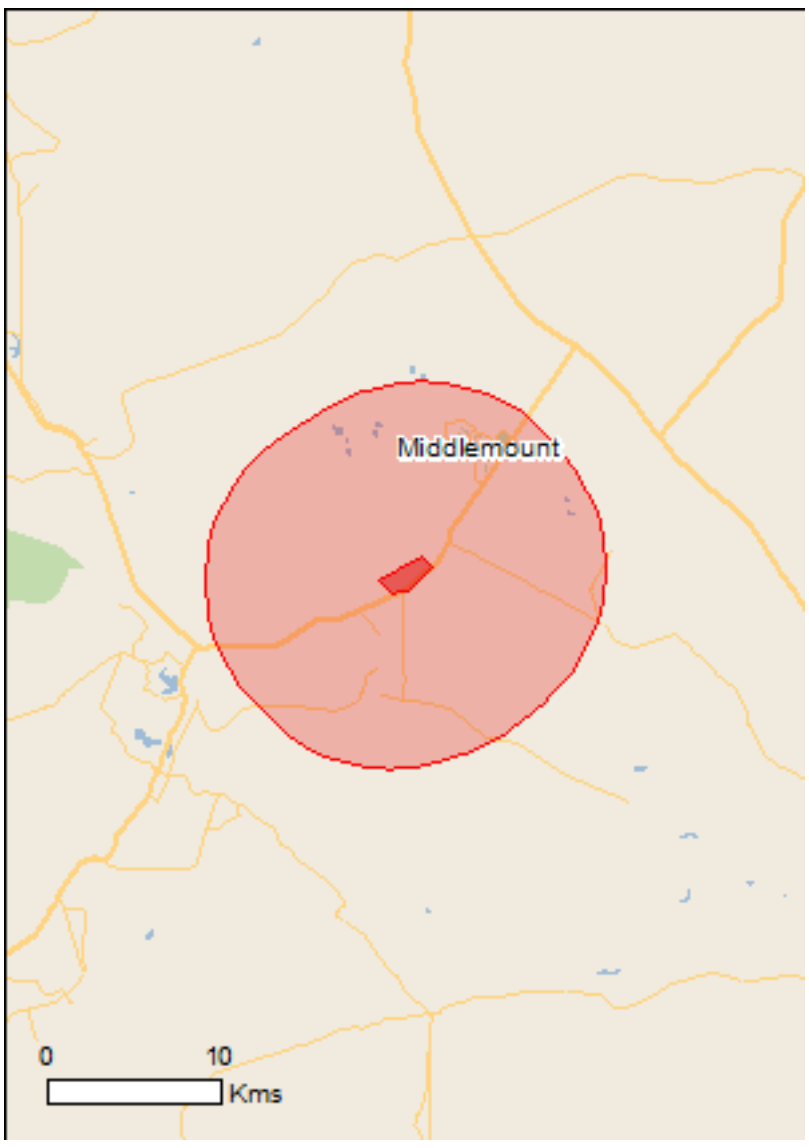
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 08/05/20 09:34:57

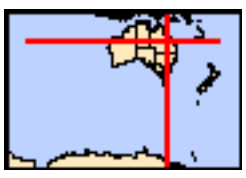
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	23
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	15
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-	Vulnerable	Species or species

Name	Status	Type of Presence
eared Bat [83395]		habitat may occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		
Cadellia pentastylis		
Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum		
King Blue-grass [5481]	Endangered	Species or species habitat may occur within area
Dichanthium setosum		
bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Delma torquata		
Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Denisonia maculata		
Ornamental Snake [1193]	Vulnerable	Species or species habitat likely to occur within area
Egernia rugosa		
Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Elseya albagula		
Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat likely to occur within area
Furina dunmalli		
Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Lerista allanae		
Allan's Lerista, Retro Slider [1378]	Endangered	Species or species habitat may occur within area
Rheodytes leukops		
Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species	[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.	
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-22.884111 148.65788,-22.877547 148.651357,-22.865369 148.673758,-22.871458 148.678479,-22.881739 148.66569,-22.884111 148.65788

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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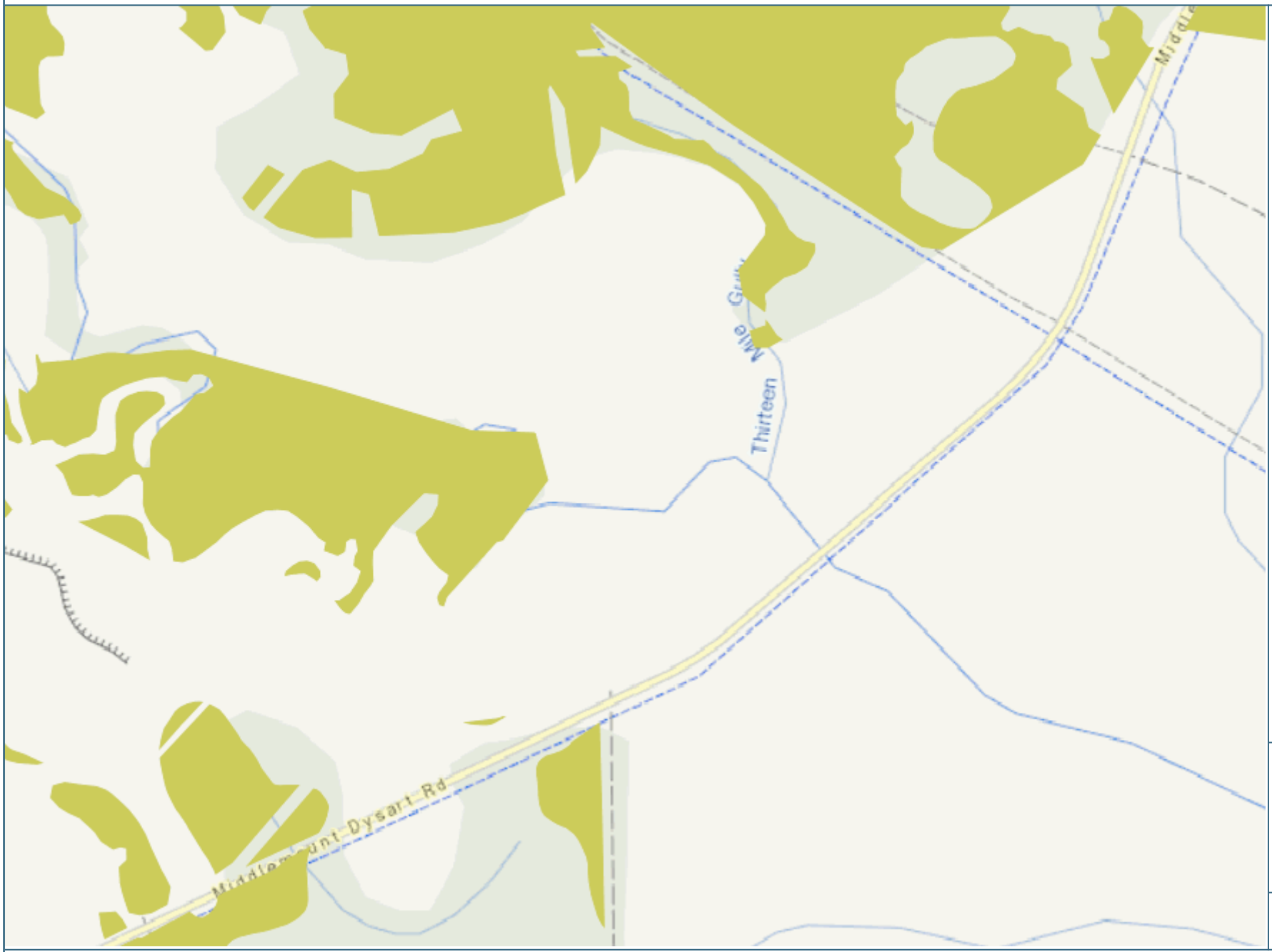
A-4-6 Groundwater Dependant Ecosystems

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas



Terrestrial GDE (no data)

No ecosystems analysed

Terrestrial GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

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Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

CC BY

Date: 12 May, 2020

Australian Government
Bureau of Meteorology

Groundwater Dependent Ecosystems Atlas

Terrestrial GDE (no data)

No ecosystems analysed

Terrestrial GDE

- Known GDE (regional study)
- High potential GDE (regional study)
- Moderate potential GDE (regional study)
- Low potential GDE (regional study)
- Unclassified potential GDE (regional study)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)
- Unclassified potential GDE (national assessment)

N

1:27,842

Kilometres 0.5 1.0

Data Source: Bureau of Meteorology, Geoscience Australia and State/Territory lead water agencies. Refer to metadata for further information: Click here

Australian Albers GDA94

CC BY

Date: 12 May, 2020

A-5 Habitat Quality Assessment Data

A-5-1 Species Habitat Attribute Scoring

Table 35: Species attribute scoring

Species Habitat Attribute	Score
Greater Glider	
Quality and availability of food and habitat required for foraging	
Abundance of preferred foraging species	4
Extent of preferred riparian habitat	4
Access to foraging habitat	2
Average	**3.33**
Quality and availability of habitat required for shelter and breeding	
Abundance of hollows	4
Patch sizes	2
Connectivity to other populations to maintain genetics	1
Level of stressors/threats	3
Average	**2.50**
Quality and availability of habitat required for mobility	
Connectivity	2
Width of corridors	2
Local barriers	2
Level of threats when mobile	4
Average	**2.50**
Absence of threats	
Abundance of feral predators	1
Barbed wire fences	2
Habitat clearing and fragmentation	2
Average	**1.67**
Koala	
Quality and availability of food and habitat required for foraging	
Abundance of Koala food trees	2
Soil quality	4
Access to foraging habitat	3
Average	**3.00**
Quality and availability of habitat required for shelter and breeding	
Abundance of Koala food trees	2
Patch sizes	2
Connectivity to other Koalas and populations to maintain genetics	2
Level of stressors/threats	2
Average	**2.00**

Quality and availability of habitat required for mobility	
Connectivity	2
Width of corridors	2
Local barriers	3
Risk of car strike and dog attack when mobile	3
Average	**2.50**
Absence of threats	
Abundance of feral predators	1
Risk of vehicle strike	2
Habitat clearing and fragmentation	2
Average	**1.67**
Squatter Pigeon (southern)	
Quality and availability of food and habitat required for foraging	
Abundance of preferred foraging habitat	4
Extent of native grass seeds	2
Access to foraging habitat	5
Average	**3.67**
Quality and availability of habitat required for shelter and breeding	
Extent of shelter	4
Connectivity to other populations to maintain genetics	5
Average	**4.50**
Quality and availability of habitat required for mobility	
Connectivity	5
Width of corridors	2
Local barriers	5
Average	**4.00**
Absence of threats	
Abundance of feral predators	1
Rick of road strike	3
Habitat clearing and fragmentation	2
Average	**2.00**
Ornamental Snake	
Quality and availability of food and habitat required for foraging	
Abundance of preferred foraging habitat	3
Extent of gilgai habitat	2
Access to foraging habitat	2
Prey abundance	3
Average	**2.50**
Quality and availability of habitat required for shelter and breeding	
Extent of shelter and CWD	4

Connectivity to other populations to maintain genetics	2
Average	**3.00**
Quality and availability of habitat required for mobility	
Connectivity	2
Width of corridors	2
Local barriers	2
Average	**2.00**
Absence of threats	
Abundance of feral predators	1
Rick of road strike	3
Habitat clearing and fragmentation	1
Average	**1.67**

A-5-2 Site Attribute Scoring

Table 36: Habitat quality calculations

Attributes/Scores	AU1		AU2				AU3		AU4		AU5			
	-	Remnant	-	Remnant			-	Remnant	-	Remnant	-	Remnant		Regrowth
	Benchmark	Score (T7)	Benchmark	Score (T1)	Score (T6)	Score (T10)	Benchmark	Score (T2)	Benchmark	Score (T12)	Benchmark	Score (T4)	Score (T5)	Score (T3)
Number of large native trees	170	0	22	5	5	15	21	10	10	15	10	15	10	5
Tree canopy height	-	5	-	5	5	5	-	5	16	5	-	5	2.5	2.5
Recruitment of woody perennial species	100	5	100	5	5	3	100	5	100	5	100	5	5	5
Tree canopy cover (%)	-	2.5	-	5	5	5	-	3	24	3	-	2.5	2.5	1
Native shrub layer cover (%)	8	3	2	3	3	0	1	3	2	3	3	3	3	3
Coarse woody debris	1752	2	307	5	2	5	375	2	164	5	314	2	2	2
Native plant species richness: Tree	3	5	2	5	5	5	4	5	5	5	6	5	5	5
Native plant species richness: Shrub	5	2.5	2	5	5	2.5	2	5	3	2.5	6	2.5	2.5	2.5
Native plant species richness: Grass	4	0	9	0	2.5	2.5	8	0	7	2.5	6	2.5	5	2.5
Native plant species richness: Forbs/others	8	5	17	0	2.5	2.5	12	2.5	9	2.5	10	2.5	2.5	2.5
Non-native plant cover	0	3	0	0	0	3	0	0	0	0	0	0	3	0
Native perennial grass cover (%)	8	0	35	0	1	1	12	0	14	0	19	1	5	1
Organic litter cover	34	5	30	5	5	5	15	5	17	3	20	5	3	3
BioCondition Score - Sampling Site		0.48		0.54	0.58	0.68		0.57		0.64		0.64	0.64	0.44
BioCondition Score - Assessment Unit		0.48		0.60				0.57		0.64		0.64		0.44
Weighted BioCondition Score		0.004		0.045				0.029		0.014		0.104		0.016

Attributes/Scores	AU6		AU7		AU 8			AU 9					AU 10		
	-	Remnant	-	Remnant	-	Non-remnant		-	Non-remnant				-	Non-remnant	
	Benchmark	Score (T8)	Benchmark	Score (T9)	Benchmark	Score (T13)	Score (T15)	Benchmark	Score (T14)	Score (T16)	Score (T17)	Score (T18)	Benchmark	Score (T10)	Score (T3)
Number of large native trees	36	5	21	10	170	0	0	22	0	0	0	0	10	0	5
Tree canopy height	-	2.5	-	5	-	0	0	-	0	0	0	0	-	0	2.5
Recruitment of woody perennial species	100	5	100	5	100	5	5	100	5	5	5	5	100	5	5
Tree canopy cover (%)	-	1.5	-	2.5	-	0	0	-	0	0	2	0	-	0	1
Native shrub layer cover (%)	4	0	7	5	8	3	3	2	3	3	3	3	3	3	3
Coarse woody debris	1214	5	320	5	1752	2	2	307	5	2	5	2	314	5	2
Native plant species richness: Tree	3	5	4	5	3	2.5	2.5	2	5	5	5	5	6	5	5
Native plant species richness: Shrub	4	2.5	6	2.5	5	2.5	2.5	2	5	5	5	5	6	2.5	2.5
Native plant species richness: Grass	5	2.5	7	2.5	4	2.5	0	9	2.5	0	2.5	2.5	6	2.5	2.5
Native plant species richness: Forbs/others	5	5	9	5	8	2.5	2.5	17	0	2.5	0	0	10	2.5	2.5
Non-native plant cover	0	5	0	5	0	3	0	0	0	0	0	0	0	0	0
Native perennial grass cover (%)	15	5	12	3	8	0	0	35	1	0	0	0	19	5	1
Organic litter cover	20	3	50	3	34	5	5	30	3	3	5	5	20	5	3
BioCondition Score - Sampling Site		0.59		0.73		0.35	0.28		0.37	0.32	0.41	0.34		0.44	0.44
BioCondition Score - Assessment Unit		0.59		0.73		0.32			0.36					0.44	
Weighted BioCondition Score		0.002		0.004		0.064			0.115					0.065	
BioCondition Score (/10)	**4.45**														

A-6 Landscape Fragmentation and Connectivity Tool Output

Department of Environment and Heritage Protection (DEHP)

Landscape Fragmentation and Connectivity (LFC) Tool version 1.4 LOGFILE

Process started at 29-06-2020 01:10:21 PM

Python version: 2.7.14 (v2.7.14:84471935ed, Sep 16 2017, 20:19:30) [MSC v.1500 32 bit (Intel)]

Arcpy version: 10.6

Username: Libby

INPUT PARAMETERS

Output Workspace: H:\LFC Tool\Middlemount_SE_Run1

Threshold lookup table: H:\LFC Tool\LFC_TOOL_June2020\LFC_data.gdb\tbl_Regional_frag_local_threshold

Remnant cover layer: H:\LFC Tool\LFC_TOOL_June2020\LFC_data.gdb\QLD_VEG_RVM_100K_v2p0_EDITED

Remnant cover layer edited: True

Regional buffer extent: 20 kilometres

Local buffer extent: 5 kilometres

Impact layer: H:\LFC Tool\Middlemount_SE_Run1\SE_DisturbanceExtent.shp

layer projection: GCS_GDA_1994

Raster cell resolution for analysis: 10 metres

Edge Width: 50 metres

(The distance from non-remnant landscapes through to the core ecosystem - the edge of remnant ecosystems)

Default projection: H:\LFC Tool\LFC_TOOL_June2020\scripts\QLD Albers Equal Area Conic.prj

13:10:21 Checking out the spatial analyst tool - required for LFC

13:10:21 _____BEGINNING LANDSCAPE FRAGMENTATION AND CONNECTIVITY ANALYSIS_____

13:10:21 This tool will categorise the landscape into:

{0: 'non-rem', 1: 'patch', 2: 'edge', 3: 'perforated', 4: 'core (< 100 hectares)', 5: 'core (100-500 hectares)', 6: 'core (> 500 hectares)', 7: 'water'}

13:10:25 H:\LFC Tool\Middlemount_SE_Run1\lyr_file does not exist, creating it now.

13:10:26 Copying across impact site feature(s) and calculating area in hectares (AreaHA)

13:10:27 Making a local copy of the impact site

13:10:28 Preparing remnant cover layer for analysis

13:10:30 Created regional scale buffer of 20 kilometres

13:10:34 Created local scale buffer of 5 kilometres

13:10:43 Clipped the remnant cover to the regional buffer extent

13:10:45 Unioned the pre impact remnant layer with the impact site

13:10:51 Attributed the impact area as not RVM Cat B

13:10:51 Area of RVM Cat B clearing is 68.05 hectares

13:10:51 SQL selection used is "RVM_CAT" = 'B' and "Cover" = 'Not RVM Cat B' on shapefile H:\LFC Tool\Middlemount_SE_Run1\main_output\clip_remcover_post.shp

13:10:54 Categorised the cover attributes in clip_remcover_pre.shp ready for raster conversion

13:11:10 Converted clip_remcover_pre.shp to raster

13:11:14 Categorised the cover attributes in clip_remcover_post.shp ready for raster conversion

13:11:30 Converted clip_remcover_post.shp to raster

13:11:30 Run Landscape fragmentation analysis on the pre impact regional landscape

REGULATED VEGETATION TYPES BEING EXTRACTED FROM LAND COVER

IDENTIFICATION OF CORE, PATCH, EDGE AND PERFORATIONS

COMBINING FRAGMENTATION CLASSES

CLASSIFYING CORE FOREST PATCHES BY AREA

COMPOSING FINAL FRAGMENTATION MAP

COMPOSING FINAL FRAGMENTATION MAP

(FRAGMENTATION CALCULATION TIME WAS 7.4 MINUTES)

13:18:53 Run Landscape fragmentation analysis on the post impact regional landscape

REGULATED VEGETATION TYPES BEING EXTRACTED FROM LAND COVER

IDENTIFICATION OF CORE, PATCH, EDGE AND PERFORATIONS

COMBINING FRAGMENTATION CLASSES

CLASSIFYING CORE FOREST PATCHES BY AREA

COMPOSING FINAL FRAGMENTATION MAP

COMPOSING FINAL FRAGMENTATION MAP

(FRAGMENTATION CALCULATION TIME WAS 6.8 MINUTES)

Extracting a local subset of lfc_regional_pre_impact

Extracting a local subset of lfc_regional_post_impact

Collating pre and post impact statistics and trigger assessment

13:26:11 Summarising area statistics for: lfc_localmsk_pre_impact

13:26:11 Summarising area statistics for: lfc_localmsk_post_impact

13:26:11 Summarising area statistics for: lfc_regional_pre_impact

13:26:12 Summarising patch count for lfc_localmsk_pre_impact

13:26:20 Summarising patch count for lfc_localmsk_post_impact

Analysing impact on Connectivity Areas

SIGNIFICANCE TEST ONE

The regional total area is 158182.91

The regional extent of core remnant is 36952.14

The regional extent of core remnant is 23.36 percent

This level of regional fragmentation sets a local impact threshold of: 5.0 percent

The table below lists the local impact thresholds for categories of regional core remnant extent:

REGIONAL CORE CATEGORY	LOCAL IMPACT THRESHOLD
< 10	2.0
10 - 30	5.0
30 - 50	10.0
50 - 70	20.0
70 - 90	30.0
>90	50.0

Area of core at the local scale (pre impact): 3408.06

Area of core at the local scale (post impact): 3389.09

Percent change of core at the local scale (post impact): 0.56 percent

SIGNIFICANCE TEST TWO

The number of core remnant areas occurring on the site: 7

The number of core remnant areas remaining on the site post impact: 3

(Only core polygons greater than or equal to 1 hectare are included)

RESULT

13:26:36 This analysis has determined a SIGNIFICANT impact on connectivity areas

(A significant reduction in core remnant at the local scale is False OR a change from core to non-core remnant at the site scale is True)

(Total area of RVM Cat B clearing is 68.05 hectares)

The significance table has been written to: ..\main_output\lfc_significance_assessment.csv

The local scale summary table has been written to: ..\main_output\lfc_local_scale_summary.csv

The site scale summary table has been written to: ..\main_output\lfc_site_scale_summary.csv

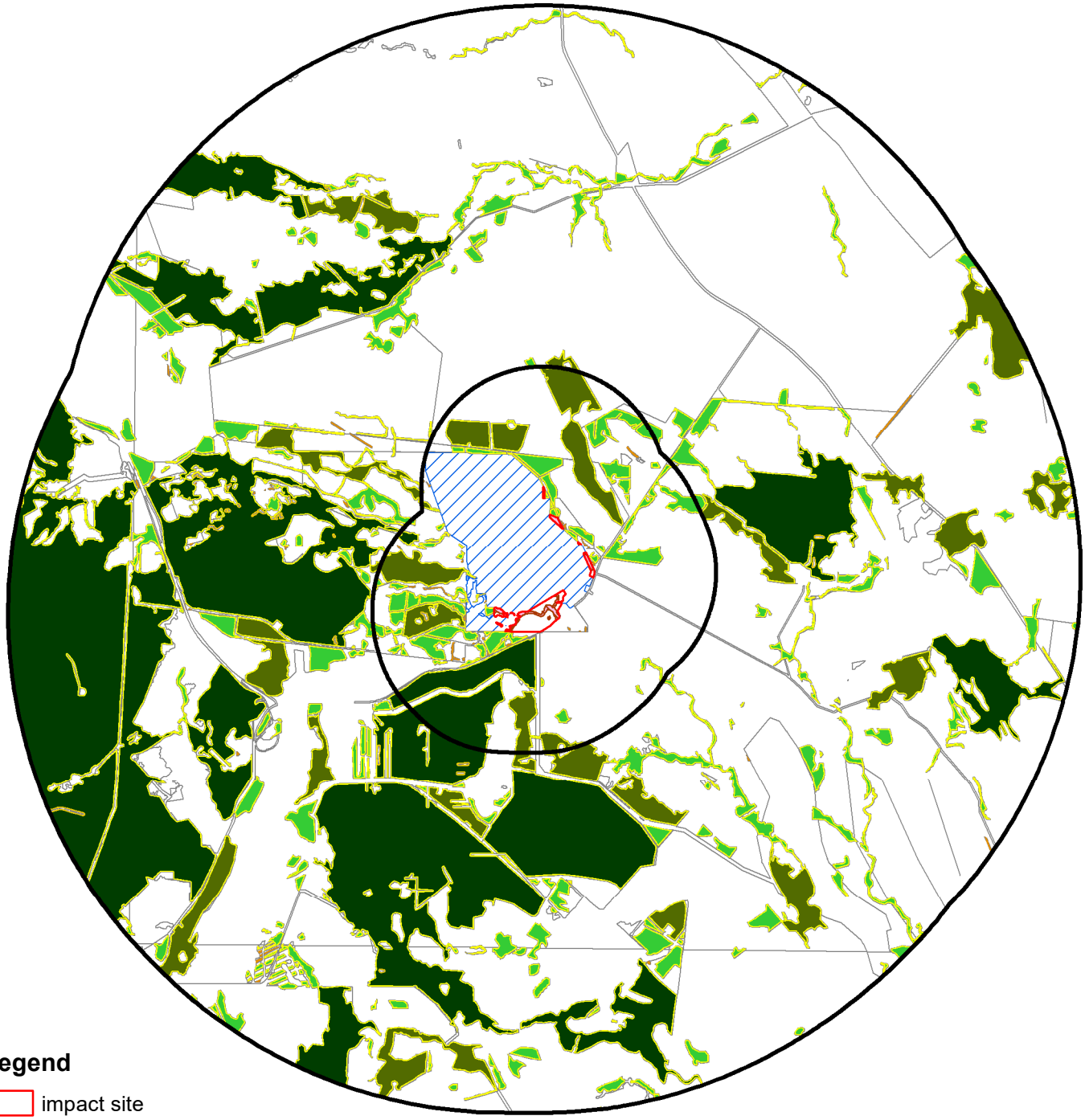
GIS layer files copied into folder \lyr_file within the project folder.

View layers in ArcMAP using..\H:\LFC Tool\Middlemount_SE_Run1\lyr_file\lyr_file\Connectivity Area Impact Assessment.lyr

Please scrutinise the output tables and spatial layers to confirm the desktop modelling of connectivity area impact

This analysis used an edited version of the Regulated Vegetation layer.

13:29:12 _____COMPLETED LANDSCAPE FRAGMENTATION AND CONNECTIVITY ANALYSIS_____



Legend

- impact site
- Cleared regulated vegetation (Cat. B)
- impact site local buffer
- impact site regional buffer
- patch
- edge
- perforated
- core (< 100 hectares)
- core (100-500 hectares)
- core (> 500 hectares)
- other

clip_remcover_pre

Cover

- Regulated vegetation (Cat. B)
- Not regulated vegetation (Cat. B)
- Water
- Approved MCO Footprint

N

0 10

Kilometres

GDA 1994 MGA Zone 55

MIDDMOUNT COAL MINE
Southern Extension Project
LFC Run 1

A-7 Anabat Analysis Report

Microbat Call Identification Report

Prepared for ("Client"):	Biodiversity Australia
Survey location/project name:	Middlemount, Qld
Survey dates:	3-6 March 2020
Client project reference:	EC3680
Job no.:	BIA-2002
Report date:	17 April 2020

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Methods

Data received

Balance! Environmental received seven ZCA data files and associated log files, recorded on two Anabat Express detectors deployed over three consecutive nights (3-6 March 2020).

Prior to analysis, the ZCA files were converted to zero-crossing analysis sequence files (ZC files) using *Anabat Insight* (Version 1.9.2; Titley Scientific, Brisbane). The conversion process applied a noise filter to separate those ZC files that contained only non-bat background noise.

Call identification

Call analysis and identification was performed in *Anabat Insight*. All ZC files that passed the noise filter were processed manually and species identities confirmed by comparing the spectrograms and derived call metrics of each file with those of regionally relevant reference calls and/or with published call descriptions (*e.g.* Reinhold *et al.* 2001; Pennay *et al*. 2004). Identification was also guided by considering probability of species' occurrence based on published distribution information (*e.g.* Churchill 2008; van Dyck *et al.* 2013) and on-line database records (e.g. http://www.ala.org.au).

Where calls could not be reliably allocated to a single species due to overlapping characteristics ("unresolved calls"), they were assigned to a multi-species group.

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015).

Results & Discussion

The ZCA conversion process yielded 9304 ZC files; however, noise filtering excluded 8391 of those files from further analysis. The remaining 913 files contained 955 identifiable bat calls.

More than 75% (725) of the identifiable calls were positively attributed to one of 12 species or the undifferentiated *Nyctophilus* genus (see upper portion of **Table 1**). The other 229 calls could not be reliably identified and were allocated to seven unresolved species groups, all of which represented species that were positively identified from other calls (see lower half of **Table 1**).

Appendix 1 contains sample sonograms extracted from the data set for each identified species or unresolved group.

Table 1 Bat species recorded during the Middlemount survey, 3-6 March 2020.
Number of calls allocated to each species or unresolved species group.

Detector:	Unit 1_SN428712			Unit 2_SN428732			Species total
Night:	3-Mar	4-Mar	5-Mar	3-Mar	4-Mar	5-Mar	
Positively identified calls							
Chalinolobus gouldii	10	16	3	31	3	37	100
Chalinolobus morio				5	1	3	9
Chalinolobus picatus	6	10	16	3	15		50
Nyctophilus sp.		1	2		3	1	7
Scotorepens balstoni	1	3	2	10	4	1	21
Scotorepens greyii		5	1	26	23	5	60
Vespadelus baverstocki	1	1		10	5	2	19
Vespadelus troughtoni	2			9	20	21	52
Miniopterus australis				1	1		2
Chaerephon jobensis	63	14	2	79	79	20	257
Ozimops lumsdenae	4	1	1	32	8	14	60
Ozimops ridei	1	5		8	4	5	23
Saccolaimus flaviventris	18	5		30	4	9	66
Unresolved calls							
C. gouldii / O. ridei	10	14	6	17	9	11	67
C. gouldii / S. balstoni		3			6	5	14
C. morio / V. troughtoni	1			2	5	10	18
C. picatus / S. greyii	3	8	4	9	17	14	55
C. picatus / V. baverstocki		26	1	6	1	1	35
S. flaviventris / C. jobensis	7	4	7	10	2	4	34
S. flaviventris / O. lumsdenae	2	2		2			6
Detector-night total	129	118	45	290	209	163	955

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.

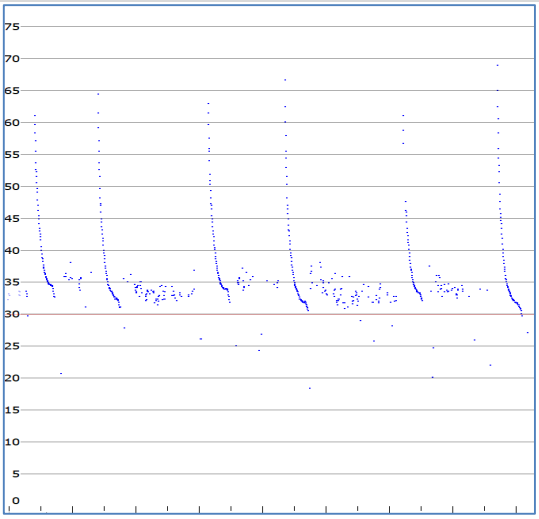
Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**: 41-43.

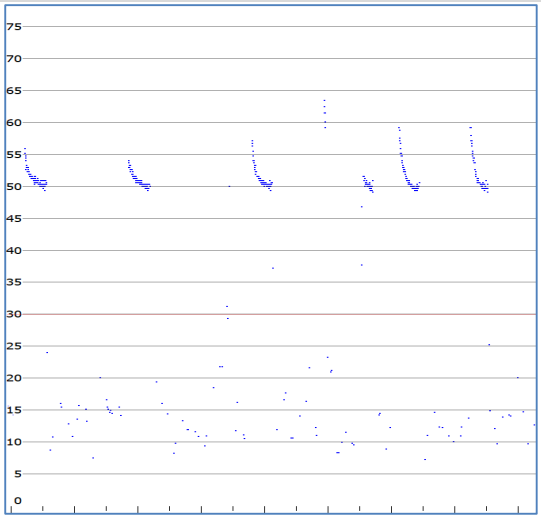
Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

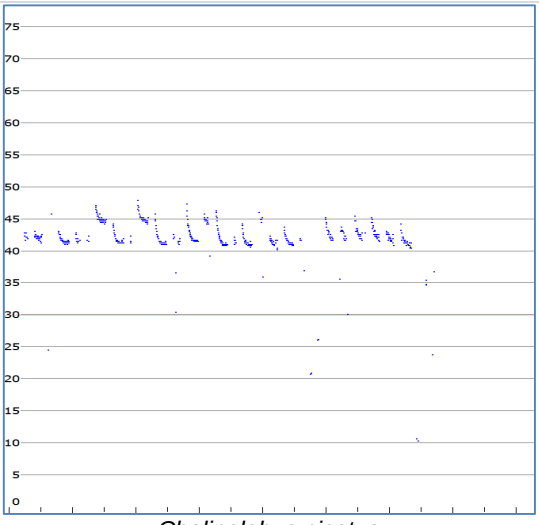
Appendix 1 Representative call sequences from the Middlemount survey, 3-6 March 2020.
x-axis (time) = 0.01 sec per tick (time between pulses removed); *y*-axis = frequency (kHz)



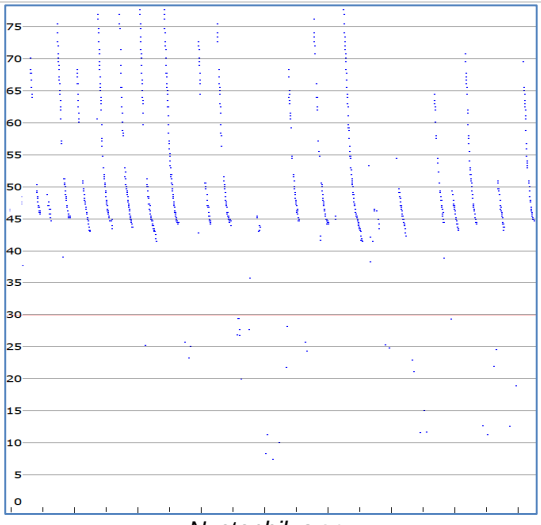
Chalinolobus gouldii



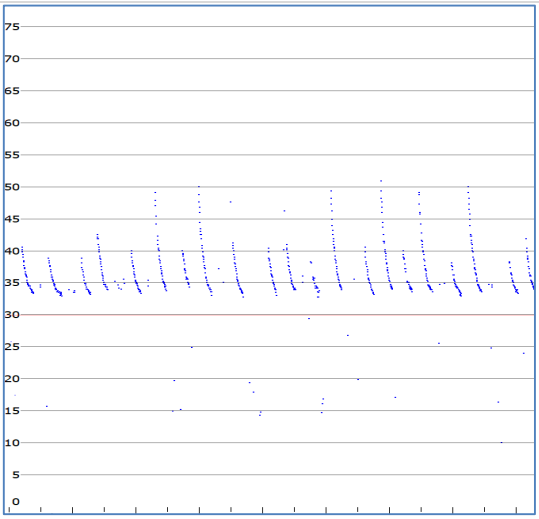
Chalinolobus morio



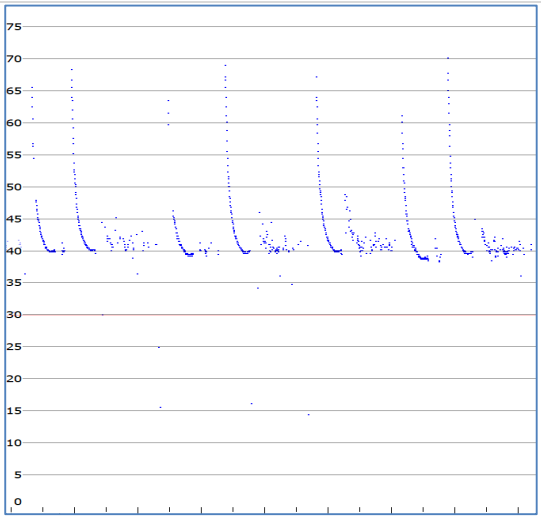
Chalinolobus picatus



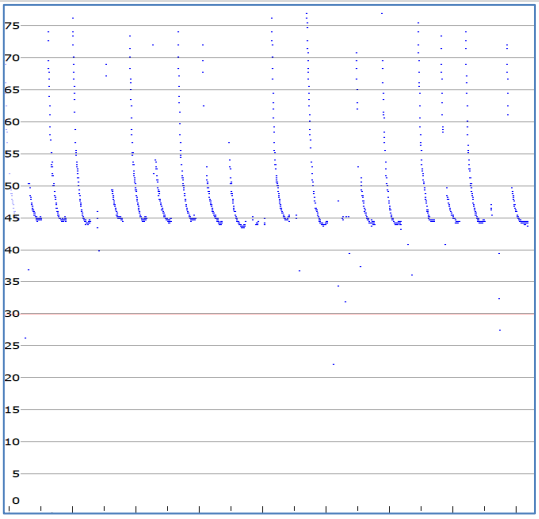
Nyctophilus sp.



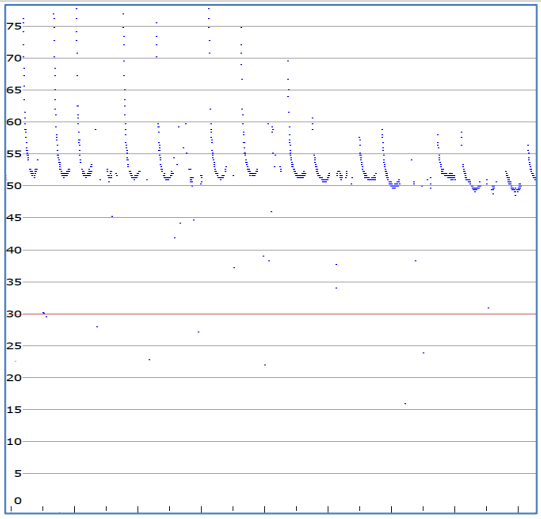
Scotorepens balstoni



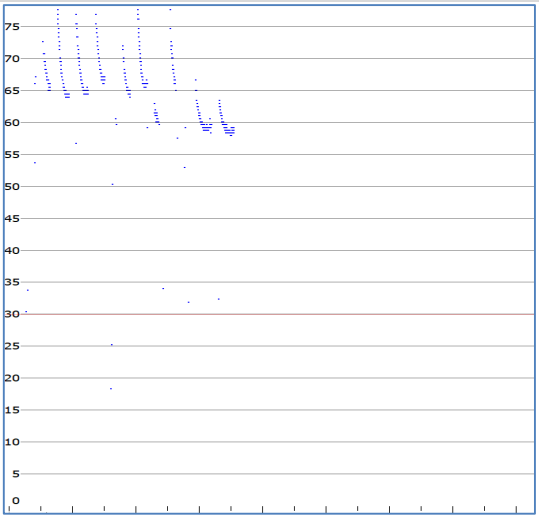
Scotorepens greyii



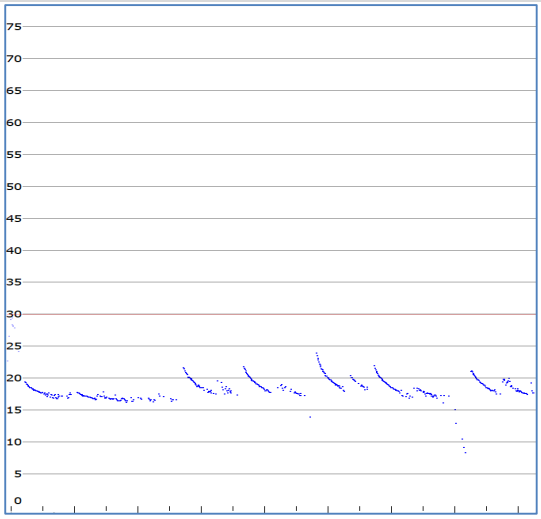
Vespadelus baverstocki



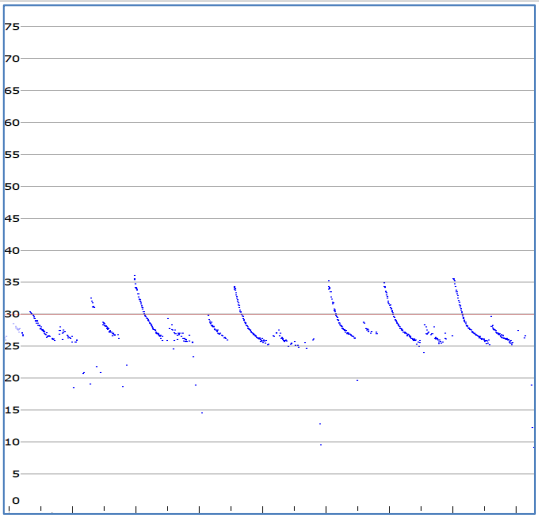
Vespadelus troughtoni



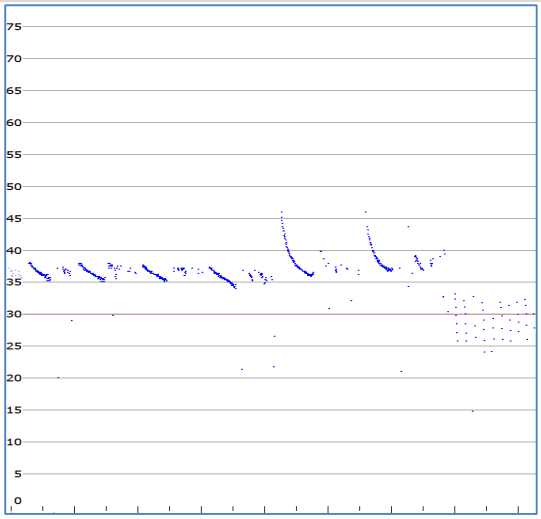
Miniopterus australis



Chaerephon jobensis



Ozimops lumsdenae



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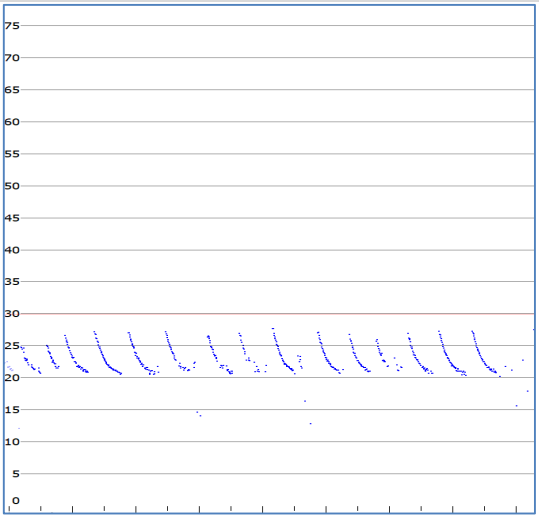

Saccolaimus flaviventris

DPM ENVIROSCIENCES

Middlemount Coal Mine Southern Extension Project Aquatic Ecology Assessment

September 2020

Middlemount Coal Mine Southern Extension Project – Aquatic Ecology Assessment

September 2020

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Middlemount Coal Mine Southern Extension Project – Aquatic Ecology Assessment

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EXECUTIVE SUMMARY

DPM Enviросciences Pty Ltd was engaged by Middlemount Coal Pty Ltd (MCPL) to undertake aquatic ecological surveys and to prepare an impact assessment for the proposed Middlemount Coal Mine Southern Extension Project (herein referred to as the Project).

The Project includes:

- extension of the open cut pit to the south within Mining Lease (ML) 70379;
- continued extraction of run-of-mine 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 (West Dump and East Dump) and within the mined-out void;
- minor extensions to waste rock emplacements footprint;
- progressive development of sediment dams, pipelines and other water management equipment and structures;
- re-positioning of the approved southern flood levee and water management infrastructure;
- realignment of the approved (but not yet constructed) eastern diversion of Roper Creek (Roper Creek Diversion 2) inside the MLs;
- 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;
- extension of the approved mine life by approximately seven years (to 2044); and
- a change to the final landform for the end of the mine life.

In a regional context, the Project is located within the headwaters of the Mackenzie River drainage sub-basin of the greater Fitzroy Basin. Roper Creek transects the Study area, as does Thirteen Mile Gully and an unnamed tributary, both of which flow into Roper Creek. Roper Creek flows into Oaky Creek approximately 37 kilometres (km) downstream of the Study area, which flows into the Mackenzie River approximately 20 km further downstream.

In a local context, the Project lies within the Bowen Basin mining area. Land use within this area typically comprises agriculture and coal mining activities, which have led to large-scale vegetation clearing and habitat fragmentation. The Study area primarily comprises cleared land for agriculture or regrowth vegetation, with small tracts of remnant vegetation throughout.

The scope of this assessment was to describe the aquatic values of the Study area, identify any conservation significant species under the Queensland *Nature Conservation Act 1992* (NC Act), *Fisheries Management Act 1994* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), identify the presence of surface expression or subterranean groundwater-dependent ecosystems (GDEs), identify and describe any aquatic Matters of State Environmental Significance (MSES) or Matters of National Environmental Significance (MNES), and to propose impact avoidance and mitigation measures to protect natural values.

The findings discussed in this aquatic ecology assessment are based on a desktop assessment of readily available information on the aquatic characteristics of the Study area (including annual monitoring data from the existing mine), supplemented by a dry season survey in October 2019 and a wet season survey in February 2020.

Aquatic habitat assessments were undertaken in accordance with the Australian River Assessment System (AusRivAS) protocols for Queensland streams. In addition, the Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (Queensland Department of Science, Information Technology and Innovation [DSITI] 2015) and the *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems* (Doody et al. 2019) were applied and a desktop review undertaken to assist in determining the likelihood and significance of surface expression and subterranean GDEs potentially occurring within the Study area. The assessment of subterranean GDEs was supplemented by sampling of 11 representative bores in October 2019 and 10 representative bores in February 2020.

The waterways of the Study area are ephemeral and expected to experience flow only after sustained or intense rainfall and runoff in the catchment. The streambed of Roper Creek is comprised of unconsolidated (loosely arranged and unpacked) sands and silts forming a relatively flat stream bed void of pool or riffle sequences. The transient flow, lack of pools and lack of dry season refuge limits the ability of Roper Creek to provide sustained habitat for native fish and turtles. Thirteen Mile Gully has a smaller catchment, although a more consolidated stream bed of silts and clays, providing a more natural channel profile. Roper Creek and Thirteen Mile Gully may provide temporary foraging habitat for common (Least Concern) native fish and turtle species, and very limited breeding habitat for native fishes adapted to the transient flow conditions.

Waterways providing for fish passage are an MSES only if the construction, installation or modification of waterway barrier works will limit the passage of fish along the waterway. As part of the Project, Roper Creek Diversion 2 (an existing approved diversion) would need to be realigned to allow for the southern extension of the open cut within ML 70379. A diversion is proposed to maintain its ecological function, including for fish habitat and passage and therefore the Project is unlikely to result in a significant impact this MSES. Other potentially relevant MSES are addressed in the terrestrial ecology assessment.

There are no wetlands of International Importance, National Importance or High Ecological Significance within the Study area. No conservation significant aquatic flora or fauna species listed under the NC Act and / or EPBC Act were recorded within the Study area, nor are they expected to occur considering their required habitats are not present. In addition, no MNES species or habitat relevant to aquatic ecology were identified.

Field surveys in October 2019 and February 2020 found no evidence of river-base flow systems or groundwater-fed wetlands in the Study area. No potential surface GDEs are mapped in the Queensland GDE Mapping (DES 2019c) for the Study area, nor are they likely to occur. Quaternary alluvium is distributed within the Middlemount Coal Mine from Roper Creek in the south to Thirteen Mile Gully in the north, and is comprised of clay, silt and sand (AGE 2018). Where it occurs, the alluvium is thin, usually less than 5 metres (m) (Parsons Brinkerhoff 2010, cited in AGE 2020). Groundwater levels at the site are typically below the base of the alluvium, indicating that the alluvium is typically unsaturated (AGE 2018).

No stygofauna were detected in a pilot survey conducted within and surrounding the Study area in October 2019 and February 2020. It is unlikely that subterranean GDEs occur within the Study area. The Study area is already subject to groundwater impacts and its aquifers are unlikely to represent particularly natural or unique habitat for stygofauna that doesn't otherwise occur in the broader area. Accordingly, in the unlikely event that subterranean GDEs do occur in the Study area or surrounds, they would be attributed a low ecological value. Further, any impacts would be insignificant when placed in the context of the wider extent of similar habitat.

Indirect impacts that have been considered in this assessment include potential impacts associated with changes in water quality, hydrological changes, impacts to groundwater dependant ecosystems and potential cumulative impacts. It is concluded that the Project is unlikely to have a significant impact on aquatic ecology as a result of these potential indirect impacts.

In conclusion, the Project is unlikely to result in a significant impact on any MNES or MSES, including conservation significant aquatic species listed under the NC Act and EPBC Act, aquatic ecological communities or their habitats.

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Appendix D: Aquatic Macroinvertebrate Data

Acronyms

Acronym	Description
ACA	Aquatic Conservation Assessment (associated with AquaBAMM)
ACARP	Australian Coal Association Research Program
ALA	Atlas of Living Australia
AquaBAMM	Aquatic Biodiversity Assessment Mapping Methodology
AusRivAS	Australian River Assessment System
BoM	Bureau of Meteorology
BoT	Back on Track
CE	Critically Endangered (threatened fauna species conservation status)
CHAH	Council of Heads of Australasian Herbaria
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Queensland Department of Agriculture and Fisheries
DAFF	Queensland Department of Agriculture, Fisheries and Forestry
DEE	Commonwealth Department of the Environment and Energy
DEHP	Queensland Department of Environment and Heritage Protection
DERM	Queensland Department of Environment and Resource Management
DES	Queensland Department of Environment and Science
DNRM	Queensland Department of Natural Resources and Mines
DNRME	Queensland Department of Natural Resources, Mines and Energy
DO	Dissolved Oxygen
DPI	New South Wales Department of Primary Industries
DSEWPC	Department of Sustainability, Environment, Water, Populations and Communities
DSITI	Queensland Department of Science, Information Technology and Innovation
E	Endangered (threatened species conservation status)
EA	Environmental Authority
EC	Electrical Conductivity
EO Act	Queensland *Environmental Offsets Act* 2014
EO Policy	Queensland *Environmental Offsets Policy*
EO Regulation	Queensland Environmental Offsets Regulation 2014
EPP 2019	Environmental Protection (Wetland and Water Biodiversity) Policy 2019
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EVNT	Endangered, Vulnerable or Near Threatened (threatened fauna species)
GBR	Great Barrier Reef
GDA	Geocentric Datum of Australia
GDE	Groundwater Dependent Ecosystem
GES	General Ecological Significance
HES	High Ecological Significance
HEV	High Environmental Value
IECAA	International Erosion Control Association Australasia
IESC	Independent Expert Scientific Committee
LC	Least Concern species conservation status under the NC Act
mbgl	Metres Below Ground Level
MCPL	Middlemount Coal Pty Ltd
ML	Mining Lease
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
Mtpa	Million tonnes per annum
MQWEV	The Map of Queensland Wetland Environmental Values

NC Act	Queensland *Nature Conservation Act 1992*
NRM	Natural Resource Management
NSW	New South Wales
NT	Near Threatened (species conservation status)
PET	Plecoptera, Ephemeroptera and Trichoptera macroinvertebrate richness
QA / QC	Quality assurance / quality control
RPD	Relative Percent Difference
RE	Regional Ecosystem
REMP	Receiving Environment Monitoring Program
SIGNAL2	Stream Invertebrate Grade Number – Average Level Version 2
SLC	Special Least Concern
TEC	Threatened Ecological Community
SPP	State Planning Policy 2017
V	Vulnerable (threatened species status)
WoNS	Weeds of National Significance
WPA	Wetland Protection Area
WQO	Water Quality Objective

Definitions

Term	Description
Aquatic fauna	An aquatic animal is either a vertebrate or invertebrate that lives in water for most or all of its life. It does not include amphibians or waterbirds (which are considered terrestrial fauna).
Aquatic flora	Plants that have adapted to living in aquatic environments (saltwater or freshwater). They are also referred to as hydrophytes or macrophytes. These plants require special adaptations for living submerged in water, or at the water's surface.
Biosecurity matter	A living thing, other than a human or part of a human; or a pathogenic agent that can cause disease in a living thing, other than a human, or a pathogenic agent that can cause disease in a human, by the transmission of a pathogenic agent from an animal to a human; or a disease; or a contaminant.
Groundwater Dependent Ecosystem	Groundwater-dependent Ecosystems (or GDEs) are ecosystems that rely upon groundwater for their continued existence. They may be 100% dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas.
Hyporheic zone	The region of sediment and porous space beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water. The flow dynamics and behaviour in this zone (termed hyporheic flow or underflow) is recognized to be important for surface water / groundwater interactions, as well as fish spawning, among other processes.
Restricted matter	Listed in Schedule 2 of the Queensland *Biosecurity Act 2014*, and refers to biosecurity matter that are currently found in Queensland and that are known to have a significant impact on human health, social amenity, the economy or the environment.
Stygofauna	Stygofauna are aquatic fauna that live part or all of their lives in groundwater systems such as aquifers or underground caves. Stygofauna are found in aquifers and caves, inhabiting the water filled pore spaces, voids, cracks and fissures.
Waterway	Waterways include riverine systems, watercourses, waterways or drainage lines identified in the Queensland Wetlands Map, *Fisheries Act 1994*, Queensland Waterways for Waterway Barrier Works, or DNRM Watercourse identification map (*Water Act 2000*).
Wetland	Wetlands include marine, estuarine, riverine, lacustrine and palustrine waterbodies and wetland REs in Qld identified in the Queensland Wetlands Map, Wetlands of International Importance (EPBC Act), Wetlands of National Importance (EPBC Act) and GES, HES and WPA wetlands identified in the Queensland Environmental Values mapping.

1 INTRODUCTION

1.1 Background

Middlemount Coal Pty Ltd (MCPL) owns and operates the Middlemount Coal Mine, an open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and approximately 3 km south-west of the Middlemount Township within the Fitzroy Natural Resource Management (NRM) region, Queensland (Figure 1).

The Middlemount Coal Mine currently operates under Environmental Authority (EA) EMPL00716013, which permits the relevant mining operations to take place within the mining leases (MLs) ML 70379, ML 70417 and ML 700014. MCPL propose to seek approval for changes to the approved Middlemount Coal Mine, herein referred to as the Southern Extension Project (the Project).

1.2 Project Description

The Project involves extending open cut mining of the Middlemount Coal Mine to the south of the existing operations. The main activities associated with the development of the Project would include:

- extension of the open cut pit to the south within ML 70379;
- continued extraction of run-of-mine 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 (West Dump and East Dump) and within the mined-out void;
- minor extensions to waste rock emplacements footprint;
- progressive development of sediment dams, pipelines and other water management equipment and structures;
- re-positioning of the approved southern flood levee and water management infrastructure;
- realignment and extension of the approved (but not yet constructed) eastern diversion of Roper Creek (Roper Creek Diversion 2) inside the MLs;
- 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;
- extension of the approved mine life by approximately seven years (to 2044); and
- a change to the final landform for the end of the mine life.

The approximate extent of proposed additional disturbance is shown on Figure 2.

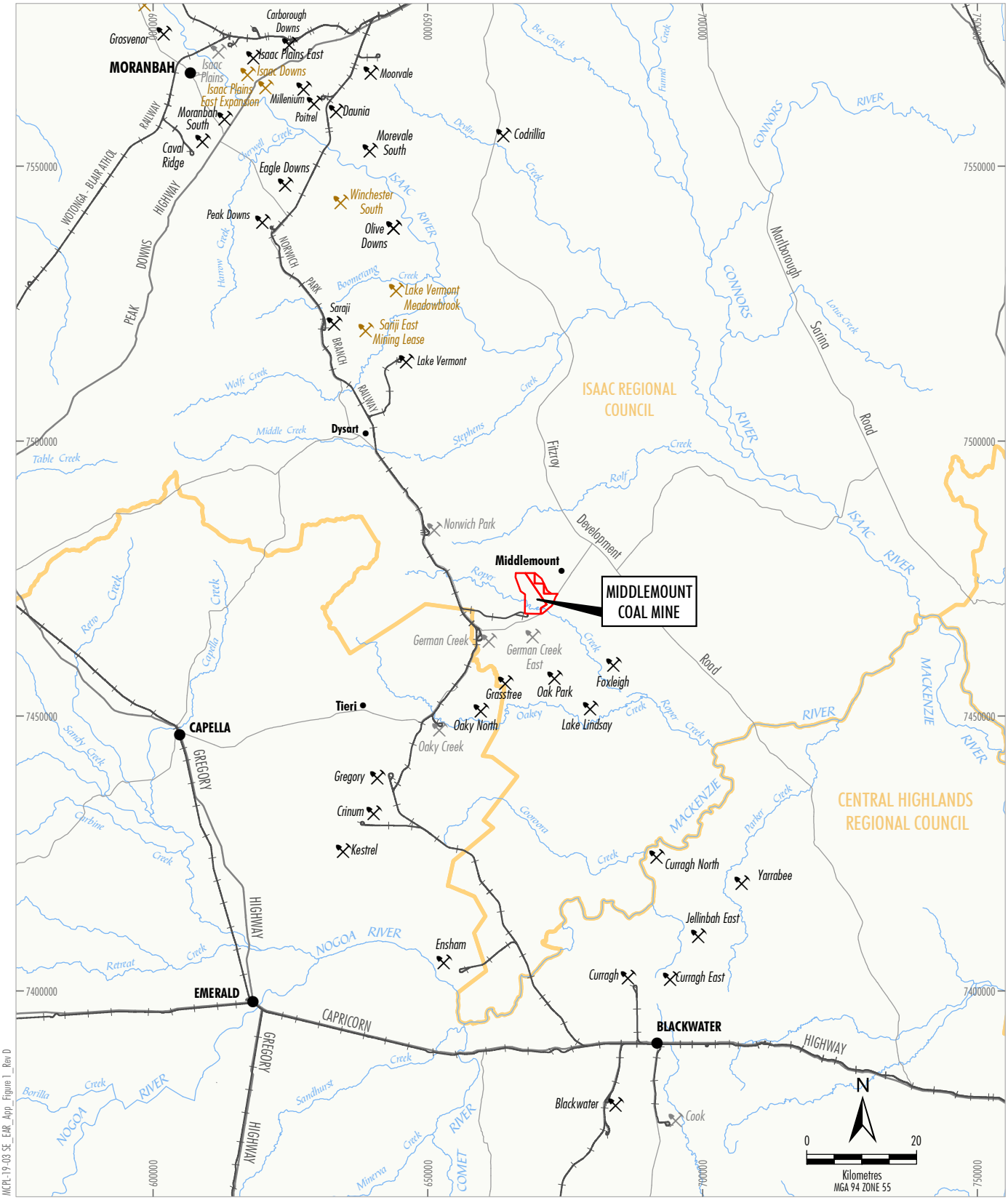
1.3 Purpose

The purpose of the Aquatic Ecology Assessment is to describe the aquatic values of the Study area (shown in Figure 3) as relevant to current Commonwealth and State legislation, assess the impacts of the proposed actions on these values and present strategies to avoid, minimise or mitigate impacts to significant aquatic values. The Study area comprises the majority of the additional surface development area associated with the Project (Figure 2), and extends upstream along Roper Creek (Figure 3).

1.4 Scope of work

The scope of work for this aquatic ecology assessment includes the following tasks:

- conduct a desktop review of available literature and previous studies in the vicinity of the Study area, and conduct database searches for conservation significant aquatic species;
- undertake aquatic ecology surveys throughout the Study area using appropriate methodology to:
  - describe aquatic habitats and their value and importance, including features such as substrate, stream type, water quality condition, and surrounding land uses;
  - describe aquatic flora and fauna (including mammals, fish, reptiles and aquatic invertebrates) present, or likely to be present at any time of the year;
  - identify and describe any listed threatened aquatic species, and any introduced aquatic species, that are present or likely to be present in the Study area and identify their habitat resources;
  - consider relevant State and Commonwealth guidelines associated with threatened species likely to occur in the Study area;
  - identify and describe wetlands present, and their value and importance;
  - identify and describe subterranean and surface expression groundwater-dependent ecosystems (GDEs); and
- prepare an aquatic ecology assessment report that identifies the methods and results of the desktop and field studies, assesses the potential impacts of the Project, and present mitigation measures and any offset requirements.



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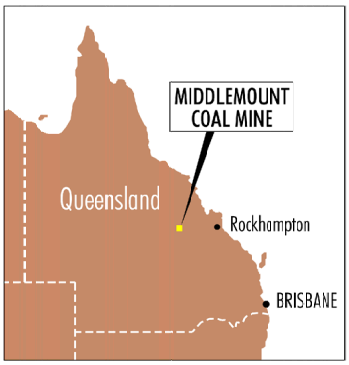

LEGEND

- Mining Lease Boundary
- Local Government Area Boundary
- Approved/Operating Coal Mine
- Under Care and Maintenance
- Proposed Mining Operation

Source: The State of Queensland (2020)

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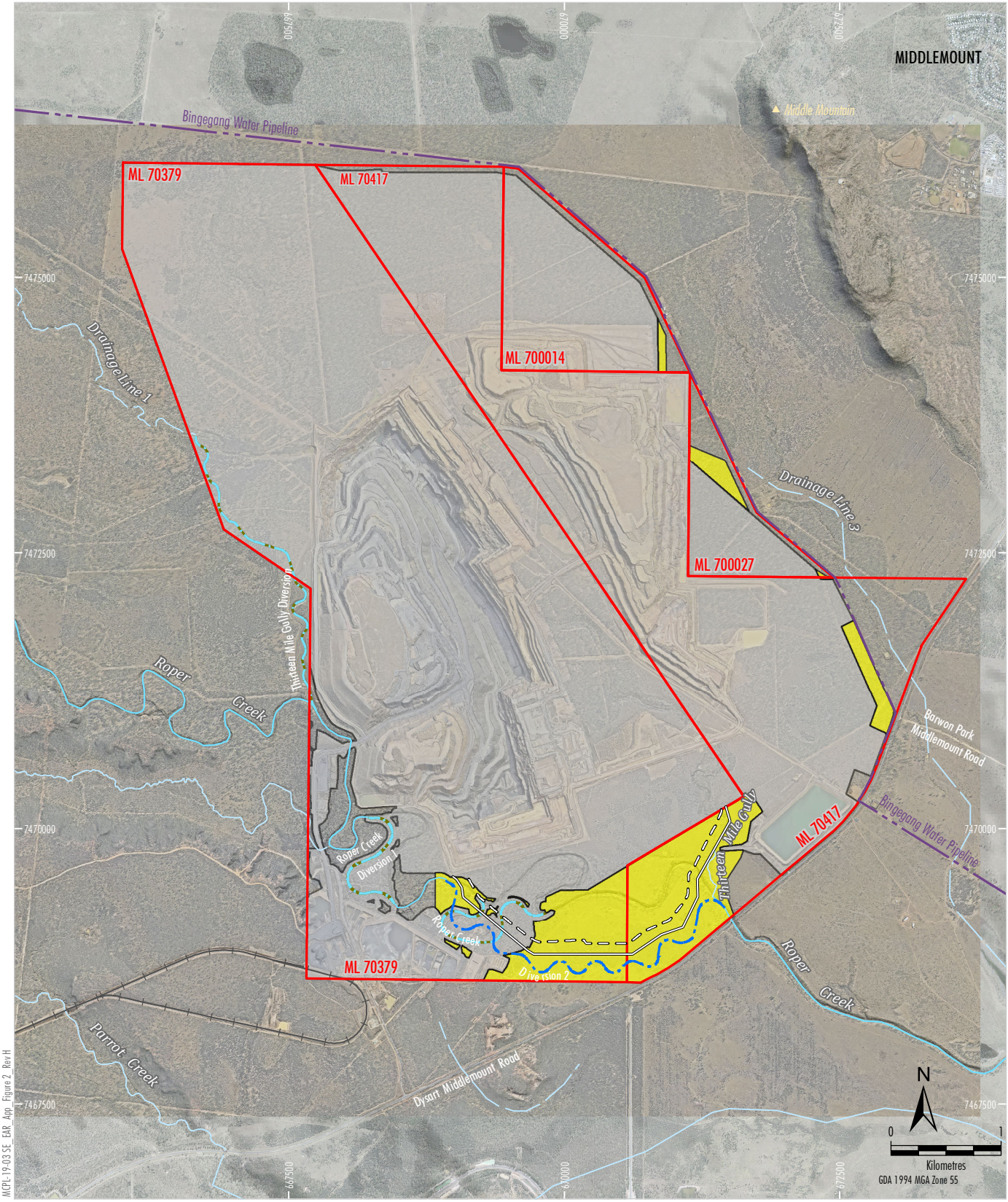
SOUTHERN EXTENSION PROJECT

Regional Location

Figure 1



LEGEND

- Mining Lease Boundary (ML)
- Middlemount Rail Spur and Loop
- Approved Disturbance Footprint
- Approved Diversion Structure
- Realigned Diversion Structure
- Levee
- Open Cut Pit Extension
- Approximate Extent of Additional Disturbance

Source: MCPL (2020); The State of Queensland (2020)
Orthophoto: MCPL (September 2019)

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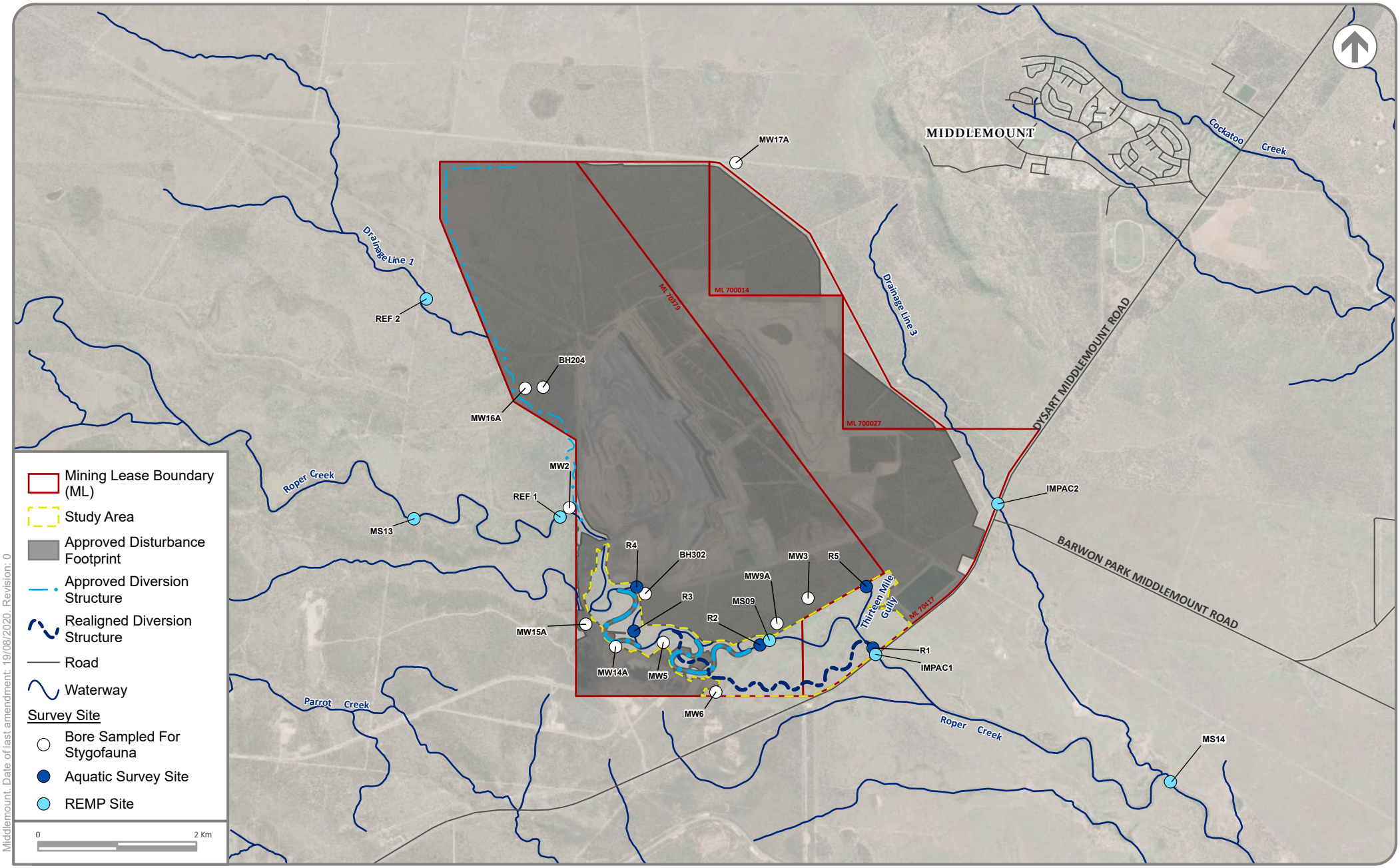
SOUTHERN EXTENSION PROJECT

Approximate Project Footprint

Figure 2

DPM Enviroscience does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. DPM Enviroscience shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information. **Data Sources:** DPM Enviroscience 2019; MCPL 2019, State of Queensland 2019, Image: World Imagery: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



Middlemount. Date of last amendment: 19/08/2020. Revision: 0

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STUDY AREA AND RELEVANT SAMPLING SITES

Middlemount Coal Mine Southern Extension Project

FIGURE 3

2 EXISTING ENVIRONMENT

2.1 Regional setting

The Study area is located within the Isaac Regional Council Local Government Area. It is approximately 6 km south-west of Middlemount and 40 km south east of Dysart within the Brigalow Belt Bioregion. The context of the Study area on a regional scale is shown in Figure 1.

2.2 Rainfall

The aquatic habitat in the Study area is subject to seasonality, which can be broadly categorised as either dry season or wet season. Rainfall across the Middlemount Coal Mine is expected to be greatest in mid-summer, with the lowest rainfall expected to occur in early spring, as inferred from data collected at the Booroondarra Bureau of Meteorology (BoM) monitoring station 35109 (BoM 2019) (Figure 4), located approximately 15 km west of the Middlemount Coal Mine. Rainfall records from the Middlemount Coal Mine meteorological station (active since 2008) also reflect this seasonality.

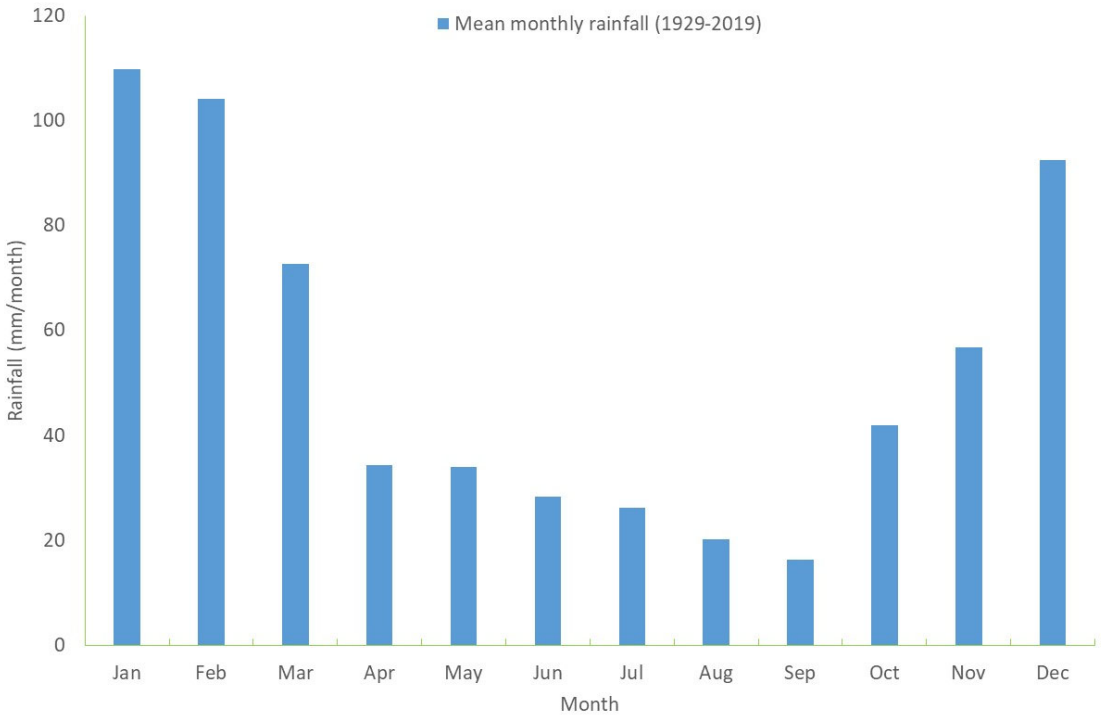


Figure 4 Historical rainfall at Booroondarra Meteorological Station 35109 (BoM 2019)

The waterways in the Study area (including Roper Creek and Thirteen Mile Gully) are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels expected to dry out during winter to early spring when rainfall and runoff is historically low. During these times, aquatic fauna are likely to concentrate in senescing pools. As a consequence, physical attributes, water quality, and the composition of aquatic floral and faunal communities are expected to be highly variable over time.

2.3 Streamflow

From 1971 to 1988, the Queensland Government operated a streamflow gauge on Roper Creek at Barwon Park (Station No. 130107A), located approximately 28 km downstream of the Middlemount Coal Mine (WRM 2020). The total catchment area draining to the Barwon Park streamflow gauge is approximately 2,126 km^2 (WRM 2020), compared to approximately 389 km^2 for Roper Creek at the Middlemount Coal Mine (GHD 2019). Analysis of monthly runoff versus rainfall for Roper Creek at the Barwon Park stream gauge indicates that very little runoff is generated by the catchment for monthly rainfall below about 100 mm, and that once monthly rainfall exceeds about 200 mm, the volume of surface runoff increases substantially (WRM 2020). The stream flows recorded at Barwon Park provide a good indication of the behaviour of streamflow in Roper Creek following rainfall events, although it is noted that the magnitude of stream flows in Roper Creek at the Middlemount Coal Mine would be substantially less than that recorded at Barwon Park.

Since the waterways of the Study area are ephemeral and have sandy substrates, it is expected that most pooling water is unlikely to remain for longer than a few months without follow-up rainfall and runoff in the catchment.

MCPL operate a gauging station (Ref 1) on Roper Creek, just upstream of the Study Area (Figure 3). The gauging station was installed in December 2012 and data recording commenced in July 2014. Data from this gauging station demonstrate that only periodic flows are recorded in Roper Creek in response to rainfall runoff flow events, with flows then separated by long periods up to 11 months of essentially no flow (AGE 2018).

2.4 Land use

The Study area has been largely cleared through past agricultural practices; however, some tracts of remnant vegetation exist, particularly along the riparian corridor of Roper Creek.

The Study area is located within the Bowen Basin where open cut coal mining is a key land use. Coal and petroleum (e.g. coal seam gas) mining exploration activities have been conducted within the Study area and surrounds for decades, and continue.

3 METHODS

3.1 Taxonomic nomenclature

Scientific names of fauna used in this report follow the Commonwealth Scientific and Industrial Research Organisation (CSIRO) List of Australian Vertebrates (Clayton et al. 2006). Scientific names of flora used in this report follow the Australian Plant Census (CHAH 2014).

3.2 Determination of significance level

Endangered, Vulnerable or Near Threatened (EVNT) species are defined as those taxa listed in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or Queensland *Nature Conservation Act 1992* (NC Act) as Critically Endangered (CE), Endangered (E), Vulnerable (V) or Near Threatened (NT). Priority species are those listed as such in the Back on Track (BoT) Actions for Biodiversity for the Fitzroy NRM Region (Queensland Department of Environment and Resource Management [DERM] 2010) or in the Expert Panel Reports of the Aquatic Conservation Assessments (ACA) for riverine and non-riverine wetlands of the Fitzroy section of the Great Barrier Reef (GBR) catchment (Inglis and Howell 2009; Rollason and Howell 2012). All other native fauna species are Special Least Concern (SLC) or Least Concern (LC) under the NC Act.

3.3 EVNT species likelihood of occurrence

EVNT species identified from the desktop assessment (and subsequent field surveys) were assigned a likelihood of occurrence based on the criteria identified in Table 1. Targeted searches were undertaken in the field for species identified as either being likely to occur, or having potential to occur within the Study area, based on the desktop sources. The methodology was applied again after surveys to determine the likelihood of occurrence once site-based information became available.

Table 1 Criteria adopted for the likelihood of EVNT species, identified from the desktop assessment, occurring within the Study area

Likelihood of occurrence	Criteria
Unlikely	▪ species or species habitat may occur, is likely to occur or is known to occur from the broader search area (based on database searches); but ▪ preferred habitat has not been identified within the Study area; and ▪ there are no confirmed species records within 10 km of the Study area. ▪ preferred habitat occurs within the Study area, but there are no confirmed species records within 50 km of the Study area.
Potential	▪ species or species habitat may occur, is likely to occur or is known to occur from the broader search area (based on database searches); and ▪ preferred habitat occurs within the Study area; and ▪ there are no confirmed species records within 10 km of the Study area; however, there are confirmed species records within 50 km of the Study area; OR ▪ species indicated as likely during desktop assessment, but field surveys revealed no evidence of occurrence in the Study area.
Likely	▪ preferred habitat occurs within the Study area; and ▪ confirmed species records within 10 km of the Study area; however ▪ species not yet confirmed as occurring within the Study area.
Known	▪ confirmed species records within the Study area (generally as a result of subsequent field survey).

3.4 Desktop assessment

3.4.1 Surface aquatic ecosystems

Desktop searches were undertaken in September 2019 (and revised in 2020 where relevant). This included a review of the following:

- Department of the Environment and Energy (DEE), EPBC Act Protected Matters Search Tool, to identify aquatic Matters of National Environmental Significance (MNES) within approximately 10 km of the Study area (Appendix A) (DEE 2020a).
- Department of Environment and Science (DES), mapping of Matters of State Environmental Significance (MSES) (DES 2019a), to identify aquatic matters of state interest under the State Planning Policy 2017 (SPP).
- DES (2019b) Queensland Wetland Data Version 5 series – Queensland Wetlands Map (DES 2019b), to determine the classification, extent and significance of lacustrine, palustrine and riverine systems within the Study area.
- DES (2020a) Wetland*Info* Wetland Summary Information (including species listings) for the Fitzroy Basin, incorporating data from the DES Wildlife Online database, Queensland Museum and Queensland Herbarium.
- Atlas of Living Australia (ALA) (2020), to interrogate existing species records.
- Queensland Waterways for Waterway Barrier Works mapping 2016 (Queensland Department of Agriculture and Fisheries [DAF] 2019).
- Queensland Groundwater Dependent Ecosystems (GDE) and Potential GDE Aquifer Mapping 2018 (DES 2019c).
- The Fitzroy Natural Resource Management Region Back-on-Track Actions for Biodiversity (Queensland Department of Environment and Resource Management [DERM] 2010).
- Aquatic Conservation Assessments (ACAs) for the riverine (Inglis and Howell 2009) and non-riverine (Rollason and Howell 2012) wetlands of the GBR catchment.
- Published ecological information on EVNT and SLC aquatic flora and fauna species.
- Previous studies relating to the Middlemount Coal Mine and adjoining mines, including:
  - Middlemount Coal Mine Western Extension Project Environmental Assessment Report (MCPL 2018);
  - Middlemount Coal Pty Ltd Middlemount Stygofauna Pilot Study Data Report (GHD 2013);
  - Middlemount Coal Mine Western Extension Project: Groundwater Assessment (AGE 2018);
  - Middlemount Coal REMP 2019 monitoring report, prepared for Middlemount Coal Pty Ltd (GHD 2019); and
  - Middlemount Coal Project EIS, Stage 2: Aquatic Ecology (FRC Environmental 2010).
- Relevant survey guidelines, including:
  - the Australian River Assessment System (AusRivAS) protocols for Queensland streams (Queensland Department of Natural Resources and Mines [DNRM] 2001); and
  - *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems*. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2019 (Doody TM, Hancock PJ, Pritchard JL 2019).

3.4.2 Stygofauna

A desktop review was conducted to assess the likely presence and composition of subterranean aquatic faunal communities in the Study area and the likely degree of impact on subterranean aquatic fauna from proposed activities. This included a review of:

- the Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (Queensland Department of Science, Information Technology and Innovation [DSITI] 2015); and
- the *Monitoring and Sampling Manual: Environmental Protection (Water) Policy* (DES 2018).

The desktop review involved:

- assessing the suitability of local habitat for subterranean aquatic fauna based on local geological and hydrological conditions; and
- determining the presence and composition of subterranean aquatic fauna in the region and Project locality based on previous studies.

3.5 Field survey of surface aquatic ecosystems

3.5.1 Survey timing and site selection

A dry season survey was undertaken across the Study area by DPM Envirosciences 14-16 October 2019, aligning with the AusRivAS 'early wet' sampling season (October to December). No surface water was encountered within the Study area during the October 2019 surveys. Follow-up wet season surveys were undertaken 18-21 Feb, four weeks following substantial rainfall in mid-January that produced high flows (but not flooding) in Roper Creek.

Desktop investigations, including review of available aerial imagery and review of the Queensland Wetlands Map (DES 2019b), were used to identify representative stream reaches for field assessment. Detailed aquatic survey was attempted at five locations (Figure 5), comprising:

- five riverine system drainage lines:
  - four stream order 4 sites (Roper Creek); and
  - one stream order 2 site (Thirteen Mile Gully).

No wetlands are mapped as occurring with the Study area.

The sampling sites and survey effort are identified in Table 2.

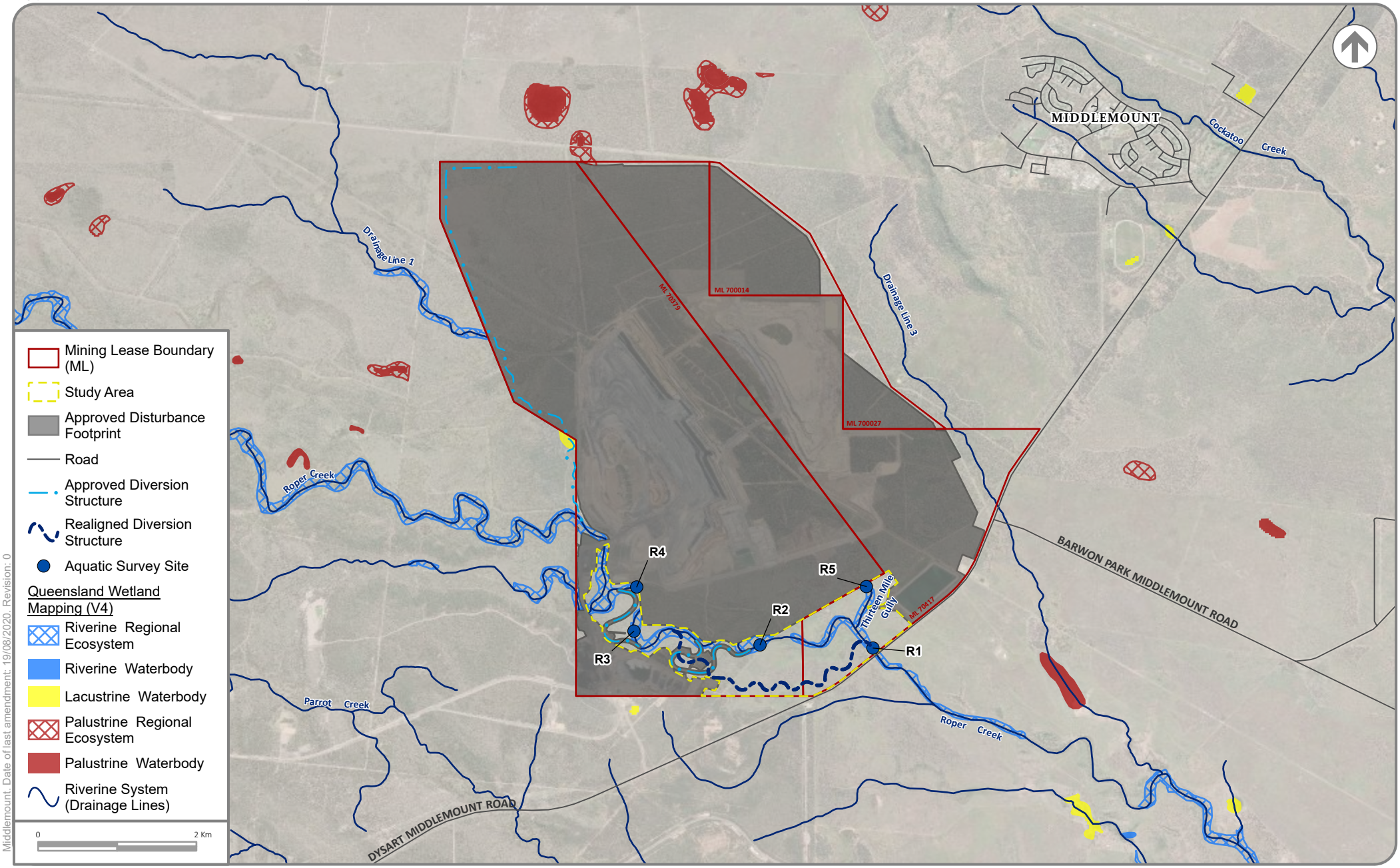
3.5.2 Aquatic habitats

Aquatic habitats were described in accordance with AusRivAS protocols for Queensland streams (DNRM 2001). This established a general description of the environment of each site and its immediate surrounds. The classifications are based on flow level, depth, velocity, width, canopy cover, substrate types, habitat attributes, local catchment erosion, sediment deposits, water colour, algae, water odour, substrate odour, presence of large woody debris, riparian zone width and cover, and general signs of disturbance.

Habitat assessment scores (out of 135) were made for each site based on the nine AusRivAS categories (Table 3). Aquatic habitat at each site was classified as Poor, Fair, Good or Excellent based on the overall scores.

A detailed description of the aquatic habitat encountered at each site is included in the site profiles in Appendix B.

DPM Enviroscienses does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. DPM Enviroscienses shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information. **Data Sources:** DPM Enviroscienses 2019; MCPL 2019, State of Queensland 2019, Image: World Imagery: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



Middlemount. Date of last amendment: 19/08/2020. Revision: 0

DPM ENVIROSCIENCES

WATERWAYS AND WETLANDS OF THE STUDY AREA AND SURROUNDS

Middlemount Coal Mine Southern Extension Project

FIGURE 5

Table 2 Survey effort for surface aquatic ecosystems of the Study area

Site	Site ID	Date	Stream order (Strahler)	Lat. (GDA 1994)	Long. (GDA 1994)	Fish survey effort			Turtle survey effort		Aquatic macro-invert. sampling		Water quality	Aquatic flora survey	Habitat assess.
						Electro-fishing	Fyke nets	Box traps	Cathedral traps	Fyke nets	Bed habitat	Edge habitat			
Dry season survey															
Roper Creek	R1	14/10/19	4	-22.8758	148.6715	Dry								✓	✓
Roper Creek	R2	14/10/19	4	-22.8754	148.6575	Dry								✓	✓
Roper Creek	R3	14/10/19	4	-22.8737	148.6417	Dry								✓	✓
Roper Creek	R4	14/10/19	4	-22.8681	148.6420	Dry								✓	✓
Thirteen Mile Gully	R5	14/10/19	2	-22.8681	148.6705	Dry								✓	✓
Wet season survey															
Roper Creek	R1	18/02/20	4	-22.8758	148.6715	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Roper Creek	R2	19/02/20	4	-22.8754	148.6575	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Roper Creek	R3	18/02/20	4	-22.8737	148.6417	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
Roper Creek	R4	18/02/20	4	-22.8681	148.6420	✓	-	-	-	-	✓	✓	✓	✓	✓
Thirteen Mile Gully	R5	19/02/20	2	-22.8681	148.6705	Dry								✓	✓

Notes:

Water depth at site R4 too shallow for deployment of fyke nets or box traps. Water depth at sites R1-R4 too shallow for deployment of cathedral traps.

Table 3 Aquatic habitat assessment variables and categories

Habitat variable	Poor	Fair	Good	Excellent
Bottom substrate / available cover	0 – 5	6 – 10	11 – 15	16 – 20
Embeddedness	0 – 5	6 – 10	11 – 15	16 – 20
Velocity / depth category	0 – 5	6 – 10	11 – 15	16 – 20
Channel alteration	0 – 3	4 – 7	8 – 11	12 – 15
Bottom scouring and deposition	0 – 3	4 – 7	8 – 11	12 – 15
Pool / riffle, run / bend ratio	0 – 3	4 – 7	8 – 11	12 – 15
Bank stability	0 – 2	3 – 5	6 – 8	9 – 10
Bank vegetative stability	0 – 2	3 – 5	6 – 8	9 – 10
Streamside cover	0 – 2	3 – 5	6 – 8	9 – 10
Total	**0 – 38**	**39 – 74**	**75 – 110**	**111 – 135**

3.5.3 Water quality

No surface water was encountered during the October 2019 dry season survey. As such, no dry season water quality measurements were obtained.

In-situ water quality

In-situ water quality measurements were obtained in February 2020 as a component of the AusRivAS aquatic habitat assessments, to inform initial equipment settings for backpack electrofishing, and to assist in the interpretation of collected macroinvertebrate data. The ionic composition of surface water was also assessed to assist in characterising surface waters of the Project site, including their likely interaction with groundwater.

In-situ measurements

In-situ water quality parameters were measured at each wetted survey site using a YSI Professional Plus multi-parameter water quality meter and an Hach Turbidimeter 2100Q, each calibrated both prior to and following sampling. Water quality parameters measured included:

- temperature (°C);
- pH;
- electrical conductivity (EC; µS/cm);
- turbidity (NTU); and
- dissolved oxygen (mg/L and % saturation).

For the purposes of this assessment, salinity descriptors are based on the following EC ranges (Department of Agriculture, Fisheries and Forestry [DAFF] 2012):

- fresh – <800 µS/cm;
- marginal – 800 to 1,600 µS/cm;
- brackish – 1,600 to 4,800 µS/cm;
- slightly saline – 4,800 to 10,000 µS/cm;
- moderately saline – 10,000 to 20,000 µS/cm; and
- saline – >20,000 µS/cm.

Major ions

Water samples were obtained from each wetted site in accordance with the *Monitoring and Sampling Manual: Environmental Protection (Water) Policy* (DES 2018). Samples were chilled and delivered to ALS Environmental (a NATA accredited laboratory) and were analysed for the following major ions to assist in characterising surface waters of the Project site:

- major anions (Cl, SO4, F and Alkalinity); and
- major cations (Ca, Mg, Na and K) and hardness.

Duplicate and field blank samples were collected and analysed for quality assurance purposes to demonstrate sampling integrity.

Data analysis

In-situ water quality measurements were compared against Water Quality Objectives (WQOs) for developed areas of the Mackenzie north-western tributaries nominated in *Environmental Protection (Water) Policy 2009: Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (DEHP 2011).

Quality assurance / quality control

Quality assurance / quality control (QA/QC) measures included the collection and analysis of a field duplicate sample to confirm the analytical reliability of the laboratory results, and a field blank to confirm the reliability of field handling procedures, to demonstrate that no cross-contamination had occurred.

Relative Percent Differences (RPDs) between the sample and duplicate analytes were calculated. The Queensland *Monitoring and Sampling Manual* (DES 2018) stipulates that an acceptable RPD of ≤ 20% between field duplicate sample concentrations generally indicates an acceptable result for aqueous samples where the result is five to ten times the Limit of Reporting (LOR). In those instances where the result is close to the LOR, the RPD may exceed 20% (DES 2018).

Field blanks were prepared in the same manner as the samples, but using deionized water. Results were reviewed with the expectation that all analytes will be below or close to the LOR.

3.5.4 Fish

No surface water was encountered in the October 2019 dry season survey. As such, no dry season fish survey was undertaken. Instead, habitat assessment was undertaken to infer habitat usage in times of flow.

Fish were surveyed at four wetted sites (R1, R2, R3 and R4) in February 2020 using a combination of backpack electrofishing, dip-netting, and overnight deployment of baited box traps and fyke nets where sufficient depth was encountered.

Fish survey effort employed at most fished sites (exceptions indicated below) included:

- backpack electrofishing using a Smith-Root LR-24 electrofisher for up to 1200 seconds power-on time (100Hz frequency; 20% duty cycle; 300-350v, to suit conductivity);
- dip-netting in combination with backpack electrofishing, using an Environet® manoeuvred through the water column;
- fyke netting – with 2 x fyke nets, dual wing, 4 metres (m) wing lengths, 0.6 m drop, 3 millimetre (mm) mesh, baited with beef heart, rinsed sardines, banana and apple – deployed overnight to capture active fish (and turtles); and

- box traps – with 5 x traps, 22 cm x 22 cm x 40 cm, 2 mm mesh, 50 mm opening, baited with dry cat food.

Fish survey at site R4 was restricted to backpack electrofishing and dip-netting, due to insufficient depth for deployment of fyke nets or box traps. However, this survey reach was thoroughly fished using backpack electrofishing techniques.

Captured fish were identified, with native species released at the point of capture. No pest fish species were encountered.

3.5.5 Turtles

No surface water was encountered in the October 2019 dry season survey. As such, no dry season turtle survey was undertaken. Instead, habitat assessment was undertaken to infer habitat usage in times of flow.

The Survey Guidelines for Australia's Threatened Reptiles (Department of Sustainability, Environment, Water, Population and Communities [DSEWPC] 2011) suggest that the Fitzroy River turtle (*Rheodytes leukops*) can be readily observed in riffle zones by diving with a face mask and snorkel, or collected by seine netting, and also that the partly carnivorous diet of this species indicates it might be attracted to meat baits in traps. Survey guidelines for the southern snapping turtle (*Elseya albagula*) are not identified in DSEWPC 2011, due to the subsequent listing of this species as Critically Endangered (from common / Least Concern) in November 2014. However, DPM Enviroscience has successfully captured this species using baited cathedral traps on other projects in the Fitzroy River Basin.

The Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Eyre et. al. 2014) suggest that freshwater turtle surveys should employ one or more of the following capture techniques:

- visual survey;
- snorkelling;
- spotlighting;
- trapping; and
- seine netting.

Freshwater turtles were surveyed at sites (R1, R2 and R3) by overnight deployment of baited fyke nets. Searches for turtles at sites R1, R2, R3 and R4 included observations of the bank and water surface for sunning and breaching turtles. Suitable habitat for the deployment of cathedral traps (i.e. trees or snags overhanging deep pools) was not encountered.

Water clarity was too poor to enable snorkelling surveys at any sites.

3.5.6 Platypus

Habitat suitability for platypus (*Ornithorhynchus anatinus*) was assessed at each site. This included targeted searches for burrows along banks.

3.5.7 Aquatic macroinvertebrates

Aquatic macroinvertebrate sampling was undertaken only in the February 2020 wet season survey, since no surface water was encountered in the October 2019 dry season survey. Aquatic macroinvertebrate samples were collected from suitable habitat at sites R1, R2, R3 and R4 to gain an improved understanding of the health, trophic interactions and ecological values of representative aquatic sites. Samples were collected by an AusRivAS accredited ecologist following AusRivAS protocols for Queensland streams (DNRM 2001). AusRivAS protocols specify a standardised, qualitative, rapid bioassessment method that aims to consistently sample a wide diversity of macroinvertebrates within a defined timeframe. The bed and edge habitats were sampled separately at each site in accordance with AusRivAS protocols.

A standard sized dip net with 250 µm mesh was used to sample macroinvertebrates. Following collection, the samples were transferred to plastic sorting trays where the contents were sorted and live-picked for 30 minutes. Picked specimens were placed into specimen jars with 70% ethanol.

Samples were identified by an AusRivAS accredited taxonomist to AusRivAS taxonomic level in the laboratory under stereomicroscope. AusRivAS taxonomic identification is primarily to Family level, with the exception of lower Phyla such as Porifera, Nematoda and Nemertea, Oligochaetes (freshwater worms), Acarina (mites), and microcrustacea such as Ostracoda, Copepoda and Cladocera. Chironomids (midges) are identified to sub-family taxonomic level.

Data analysis

The macroinvertebrate data was used to calculate a number of community descriptors as described in the following sections.

Taxonomic richness

Taxonomic richness was calculated from the number of taxa present in each sample, providing an indication of community diversity at the site, with richness typically increasing with ecological condition.

PET

The Plecoptera, Ephemeroptera and Trichoptera (PET) richness was calculated from the number of taxa belonging to the three PET orders. These three orders are widely accepted as being most sensitive to environmental change, such as habitat degradation and pollution (DEHP 2009). A low PET richness score, due to the absence of these pollution-sensitive taxa, suggests that a site may be impacted by degradation or pollution. Conversely, a high PET richness suggests a system free from degradation or pollution.

Pollution-tolerant taxa

The percentage of pollution-tolerant taxa was calculated based on the SIGNAL2 indices. Tolerant taxa are classified as those with a SIGNAL2 score of 3 or less (Marshall et al. 2001). Macroinvertebrate families in this group are expected to tolerate changes to their environment, including habitat degradation and some pollution. An absence of more sensitive taxa suggests environmental conditions may be too harsh for sensitive taxa (those with SIGNAL2 scores above 3) to tolerate.

SIGNAL2

SIGNAL2 (Stream Invertebrate Grade Number – Average Level Version 2) indices were calculated, with each taxon allocated a score from 1 to 10 based on Chessman (2003). Taxa with low scores are most tolerant of a range of environmental conditions, and those with high scores are more sensitive to pollution. The presence / absence data of each taxon were used to calculate the SIGNAL2 average for the site, in accordance with the protocols described by Chessman (2003).

3.5.8 Aquatic flora

Aquatic plants were surveyed at each site (100 m reach) in both October 2019 and February 2020. Aquatic plants were identified to species using available literature and taxonomic keys where needed. The abundance of each species was estimated using the AusRivAS categories: extensive (>75% cover), moderate (50-75%), some (10-50%) or little (1-10%).

3.5.9 Aquatic values ratings

An aquatic values rating of High, Moderate or Low was assigned to each site based on the summation of all available information from the desktop and field assessments (Table 4). When assessing each site the overall aquatic value criteria that fit the situation best is applied. The criteria in Table 4 are listed from most to least important.

Table 4 Adopted criteria for assigning aquatic values ratings

Aquatic Values / Sensitivity	Criteria
High	▪ Semi-permanent or permanent waterbody
	▪ Wetland of High Ecological Significance
	▪ EVNT species habitat present
	▪ Known presence of platypus breeding place
	▪ Near natural / excellent in-stream habitat
	▪ Excellent habitat bioassessment score (111 – 135)
Moderate	▪ Ephemeral or semi-permanent waterbody
	▪ Wetland of General Ecological Significance
	▪ Priority flora species cover moderate or extensive
	▪ Priority fauna species present
	▪ Platypus habitat present
	▪ Some good quality in-stream habitat
	▪ Regional conduit for fish passage (mapped major / high)
	▪ Good habitat bioassessment score (75 – 110)
	▪ Dry season refuge for common (Least Concern) species
Low	▪ Ephemeral waterbody
	▪ No EVNT species or platypus habitat
	▪ In-stream habitat highly modified / disturbed
	▪ Poor to Fair habitat bioassessment score (0 – 74)

3.6 Field survey of stygofauna

3.6.1 Consideration of bores for sampling

A review of the Queensland Department of Natural Resources, Mines and Energy (DNRME) (2019) groundwater database and the *Middlemount Coal Mine Western Extension Project Groundwater Bore Census* (4T 2012, appended to AGE 2020) identified 44 bores within 10 km of the Study Area. This includes mine monitoring bores installed within and surrounding the Middlemount Coal Mine in 2008, 2012, 2015 and 2019, mine monitoring bores associated with Foxleigh Plains Mine to the east and German Creek Grasstree Mine to the south, landfill monitoring bores at Middlemount, and private landholder bores to the north.

Bore reports and available bore construction logs were reviewed to assess the suitability of bores for sampling and their likelihood of containing stygofauna.

The *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITI 2015) requires that bores sampled for stygofauna be at least six months old. The *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody, Hancock and Pritchard 2019) identifies characteristics of bores most likely to yield stygofauna, including slot widths of at least 1 mm wide in the screened interval to allow entry of larger taxa such as amphipods. It is noted that some bores incorporate slot widths of 1 mm into the screened interval, and some incorporate slot widths of only 0.5 mm, but were still the best available option for sampling (Table 5).

4T Consultants Pty Ltd (4T 2012) prepared a desktop assessment of at least 13 stygofauna studies in Queensland and established water quality conditions in which stygofauna were more likely to be found. In fractured rock, stygofauna were more likely where the aquifer was <50 metres below ground level (mbgl), pH 6.5-8.5 and Electrical Conductivity <5,000 µS/cm (4T 2012). In alluvium, stygofauna were more likely where the aquifer was <20 mbgl, pH 6.5-8.5 and EC <2,000 µS/cm (4T 2012). Bores with these characteristics, or similar, were prioritised for field sampling.

Table 5 Characteristics of groundwater monitoring bores considered suitable for stygofauna sampling

Bore ID^	Registered number	Lithology at screened interval	Inferred aquifer type / age	Casing diameter (mm)	Bore depth (mBGL)	Screen interval (mBGL)	Screen aperture size (mm)	SWL (mBGL) *	pH	EC (µS/cm)
MW2^	151043	Sandy clay and sand	Tertiary	50	30.0	21.0-29.0	-	20.77	7.4	2772
MW3	151336	Clay and sandy clay		50	48.0	39.0-47.0	-	-	-	-
MW6	132459	Clay		50	42.0	37.0-42.0	-	23.3	-	-
MW9A	161064	Sandstone and siltstone		50	52.0	40.0-52.0	0.5	-	-	-
MW11A	NR	Clay and mudstone		50	13.5	10.5-13.5	-	-	-	-
MW14A	NR	Sand, clayey sand and mudstone		50	14.0	6.0-9.0	-	-	-	-
MW15A	NR	Sand, sandy clay and mudstone		50	12.5	7.0-10.0	-	-	-	-
BH302	187170	Sandstone		50	41.0	28.1-31.0	0.5	24.1	6.8	3900
BH203	187165	Sandstone		150	50.0	44.0-50.0	0.5	21.8	6.7	2050
BH204	187169	Sandy clay and mudstone		50	50.0	37.5-43.5	0.5	24.5	6.9	2750
BH202	187168	Sand and clay		50	44.2	14.0-17.0	0.5	12.8	6.8	3020
MW4^	151335	Weathered igneous rock, coal and sandy coal	Permian	50	50.0	41.0-50.0	-	37.12	7.12*	23151*
MW5^	151658	Coal		50	46.0	40.0-46.0	-	17.62	6.38*	763*
MW17A	NR	Claystone and sandstone		50	43.0	36.5-42.5	-	-	-	-

Notes:

^ Indicates bores in which subterranean fauna were detected by GHD in 2012 (GHD 2013); * Indicative level represented by either as drilled or standing water level in developed bore in subsequent sampling; NR = Not Registered.

3.6.2 Field sampling

In-situ water quality

A groundwater sample was retrieved from each bore using a disposable groundwater bailer immediately prior to stygofauna sampling. EC and pH were measured using a YSI Professional Plus multi-parameter water quality meter, calibrated prior to and following sampling.

For the purposes of this assessment, the measure of salinity is based on the following EC ranges (DAFF 2012):

- fresh – water with EC <800 µS/cm;
- marginal – 800 to 1,600 µS/cm;
- brackish – 1,600 to 4,800 µS/cm;
- slightly saline – 4,800 to 10,000 µS/cm;
- moderately saline – 10,000 to 20,000 µS/cm; and
- saline – >20,000 µS/cm.

Stygofauna

Stygofauna sampling was undertaken in accordance with the *Monitoring and Sampling Manual* (DES 2018). Three sizes of phreatobiological nets were carried in the field for stygofauna sampling, with diameters of 40 mm, 90 mm and 130 mm. Nets were constructed of 50 µm monomesh and weighted at the bottom. The nets tapered to a removable collection chamber at the base, allowing ease of collection for replicate samples following each haul. Nets were lowered to the bottom of the bore, bounced five to ten times to dislodge resting animals, then retrieved. The collection chamber was rinsed into a 50 µm mesh sieve at the top of each haul. Once five hauls were completed, the entire sieve contents were transferred to a labelled sample jar and preserved in ethanol.

Nets were washed thoroughly three times in deionised water between sampling locations.

3.6.3 Sample processing

Field samples were sorted in the laboratory under a stereomicroscope. Each sample container was drained of ethanol and washed into a channelled counting tray to create a thin layer of sediment spread across the bottom of the tray. Aquatic animals were picked under the stereomicroscope. Samples yielding aquatic animals were placed in labelled, polyethylene containers filled with ethanol and sent to Dr Peter Hancock for specialist identification.

3.6.4 Personnel

Field sampling was conducted by David Moore, an aquatic ecologist with over 15 years' experience on both surface water and groundwater projects across Australia, including stygofauna sampling. Laboratory processing was undertaken by Chris Pietsch, an aquatic ecologist with 14 years' experience in aquatic assessments across Australia, including processing of stygofauna samples. Taxonomic identifications of stygofauna were undertaken by Dr Peter Hancock, an aquatic and groundwater ecologist with over 25 years of experience.

3.7 Framework for assessing GDEs

The assessment of aquatic and subterranean GDEs followed the framework identified in the *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody, Hancock and Pritchard 2019). Sections of the framework addressed by this report are shown in Table 6.

Table 6 Framework for assessing GDEs in an environmental impact assessment

Step	Section in this report
Define the project impact area, including the footprint of surface infrastructure and the extent of groundwater depressurisation	Section 2
Undertake a desktop assessment to identify potential GDEs and potential risks to GDEs in the project impact area	Section 4.9
Assess the level of groundwater dependence for each GDE and the potential pathways of cause and effect	Section 4.9
Identify the baseline ecological condition and value of each GDE	Section 4.9
Assess the likelihood, frequency and magnitude of potential impacts on GDEs and determine the risks related to the activity	Section 4.9
Prioritise options to avoid or mitigate impacts on GDEs and establish a monitoring plan to test the effectiveness of mitigation strategies.	Not applicable (Section 4.9)

3.7.1 Ecological value of GDEs

Ecological value ratings were assigned to relevant GDEs following the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov, Kuginis and Williams 2012), as referred to in the *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody, Hancock and Pritchard 2019).

Table 7 Criteria adopted for assigning GDE ecological values ratings (based on Serov et al. 2012)

Ecological value	Criteria
High	▪ GDE communities (including stygofauna) where only slight changes in key groundwater attributes below or above a threshold would result in their loss; i.e. entirely dependent ecosystems.
	▪ GDEs or aquifers that are partly or wholly located within a State or Federal Reserve System; e.g. National Park / Reserve, or a high conservation area.
	▪ Any GDE or aquifer that is relatively unaltered and in good condition.
	▪ Any natural GDE that is habitat for any endemic, relictual, rare or endangered biota (fauna or flora), populations or communities as listed under State or Commonwealth legislation or identified as above by an acknowledged expert taxonomist / ecologist.
Moderate	▪ GDE communities where moderate change in groundwater discharge or water tables is required to cause change in their distribution, composition and / or health (the value is based on the potential vulnerability / sensitivity to change).
	▪ Any natural GDE systems that is habitat for any vulnerable or threatened biota (fauna or flora), populations or communities as listed under State or Commonwealth legislation.
	▪ Any GDE or aquifer that provides ecological services to other ecosystems such as rivers, wetlands and estuaries.
	▪ GDE communities that exhibit either a threshold or proportional response to changes in groundwater attributes. Moderate systems can include highly dependent systems which can exhibit a threshold response.

Ecological value	Criteria
	▪ Any GDE or aquifer that is regarded as in moderate to good condition from its natural state but not covered by state or federal legislation.
	▪ Ecosystems where groundwater appears only to play a minor role in the water balance of such ecosystems such as at the end of a dry season or during extreme drought.
Low	▪ Any aquifer or GDE type that is highly modified from that of its natural state (that don't otherwise contain High or Moderate value attributes).
	▪ Would likely involve a high cost to rehabilitate, if even possible, and there are other similar GDE types in moderate to good condition; i.e. have little need of rehabilitation, existing within the catchment / aquifer.

4 RESULTS – AQUATIC ECOLOGY CHARACTERISTICS OF THE STUDY AREA

4.1 Waterways

The Queensland Wetlands Map (DES 2019b) identifies riverine systems, watercourses, waterways or drainage lines (here referred to collectively as waterways) for the Study area. There are three waterways mapped within the Study area, comprising:

- Roper Creek – stream order 4;
- Thirteen Mile Gully – stream order 2; and
- an unnamed tributary of Roper Creek – stream order 1.

The waterways of the Study area are ephemeral, only flowing after largely unpredictable rainfall and runoff, ceasing to flow within days, hence supporting aquatic life whose life cycles are adapted to these conditions. The DNRME (2019) Watercourse Identification Map 2018 is shown on Figure 6.

The Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) (Clayton et al. 2006), was developed to assess conservation values of wetlands and waterways in Queensland. It is a comprehensive method that uses available data (including data resulting from expert opinion), to identify relative non-social, non-economic conservation / ecological values within a specified Study area. The criteria in AquaBAMM are: naturalness (aquatic); naturalness (catchment); diversity and richness; threatened species and ecosystems; priority species and ecosystems; special features; connectivity and representativeness. The Aquatic Conservation Assessment (ACA) for the riverine (Inglis and Howell 2009) and non-riverine (Rollason and Howell 2012) wetlands of the Great Barrier Reef catchment (produced by DERM) is a product of applying this method. The ACA data for the Study area identifies the waterways to be of medium conservation value. No wetlands are identified within the Study area. These data are shown in Figure 7.

4.1.1 Waterways for fish passage

Waterways, as defined by the *Fisheries Act 1994*, include rivers, creeks, streams, watercourses or inlets of the sea. The upstream limits of waterways are identified by Peterken et al. (2009) as including features relevant to fisheries resources, such as the following physical and hydrological attributes:

- defined bed and banks – the bed and banks need to be continuous rather than isolated and broken sections of a depression;
- an extended, if non-permanent, period of flow – flow must continue for a reasonable period after rain ceases and have some reliability commensurate with rainfall; and
- flow adequacy – the flow needs to be sufficient to sustain basic ecological processes and to maintain biodiversity within the feature.

The DAF (2019) *Queensland Waterways for Waterway Barrier Works 2016* mapping (Figure 8) indicates the level of 'risk' associated with undertaking waterway barrier works within Queensland waterways. Waterways with higher stream orders, steeper slopes, higher flow rates, greater numbers of fish present, and fish with stronger swimming abilities obtain a higher level of risk (DAFF 2013).

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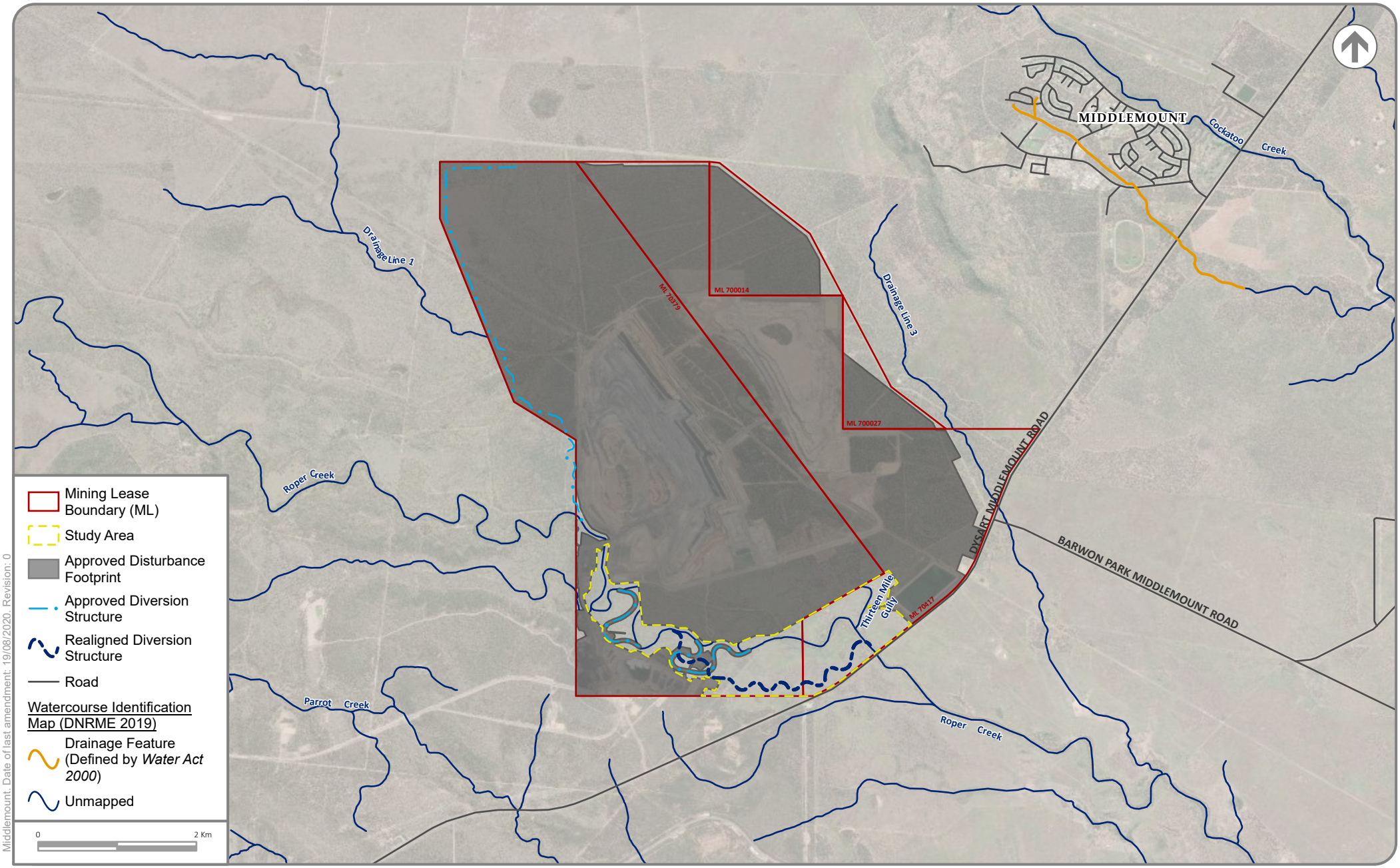

Middlemount. Date of last amendment: 19/08/2020. Revision: 0

DPM ENVIROSCIENCES

WATERCOURSE IDENTIFICATION MAP

Middlemount Coal Mine Southern Extension Project

FIGURE 6

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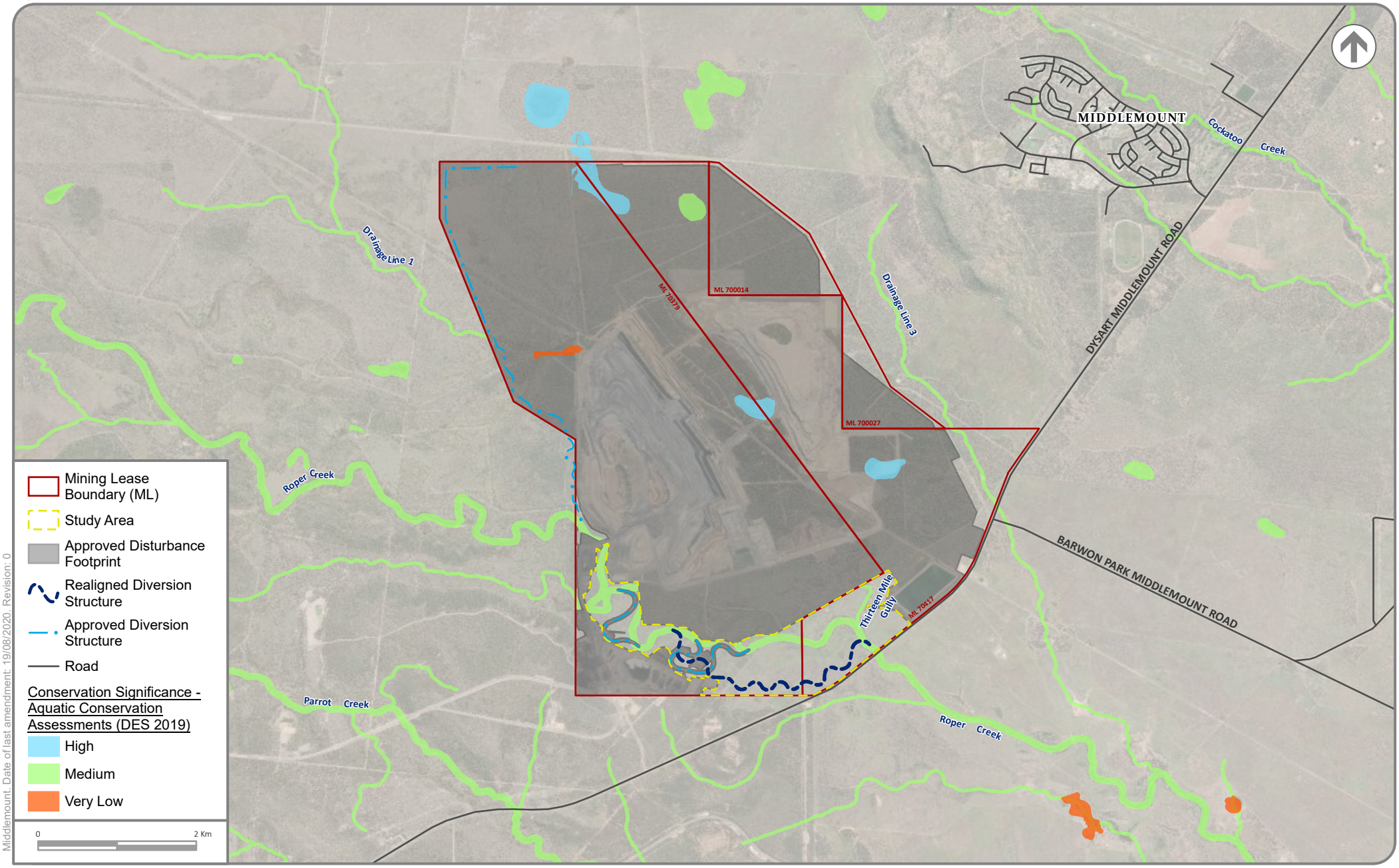

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DPM ENVIROSCIENCES

AQUATIC CONSERVATION ASSESSMENT MAPPING OF THE STUDY AREA AND SURROUNDS

Middlemount Coal Mine Southern Extension Project

FIGURE 7

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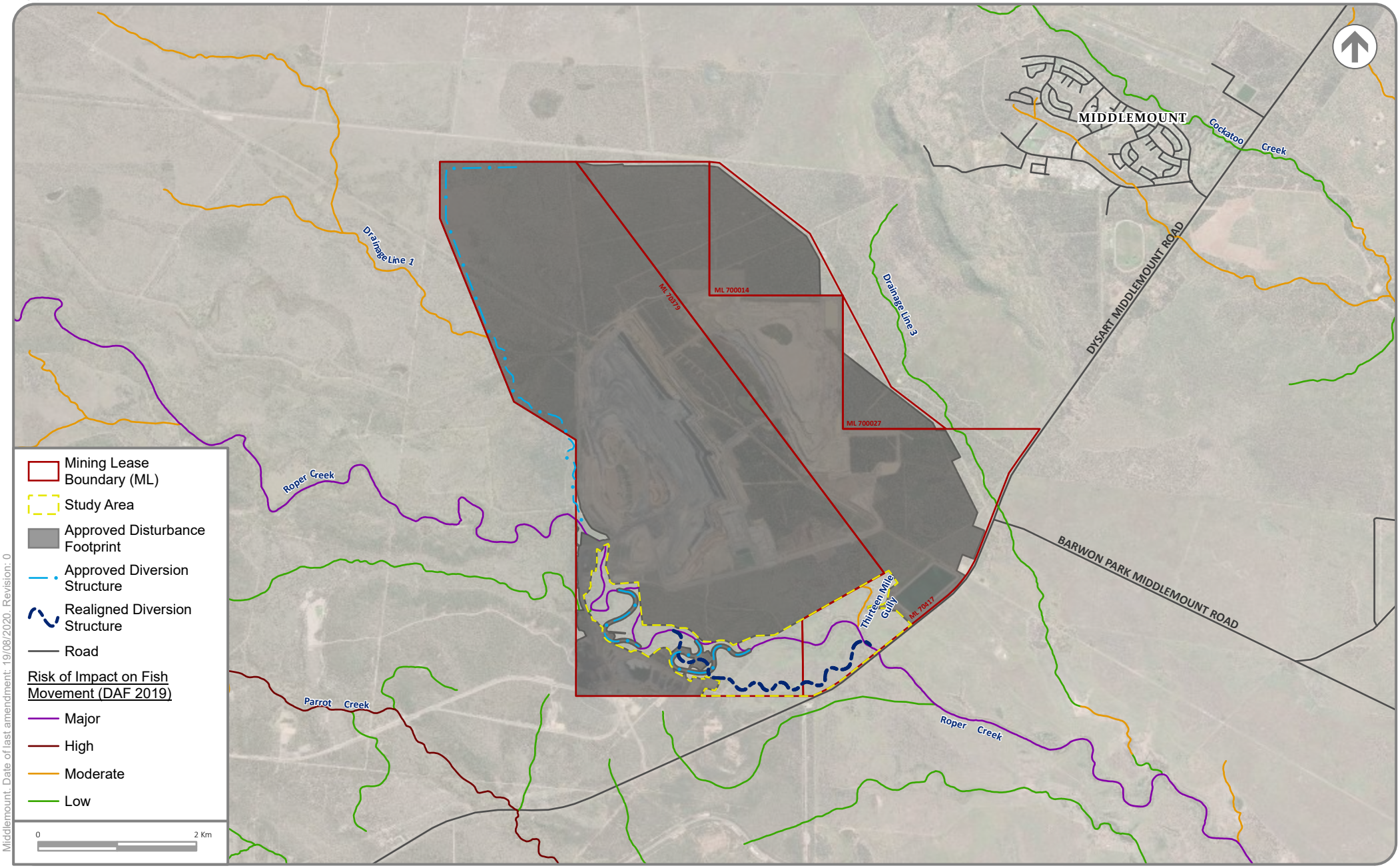

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DPM ENVIROSCIENCES

WATERWAYS FOR WATERWAY BARRIER WORKS

Middlemount Coal Mine Southern Extension Project

FIGURE 8

In consideration of these factors, Roper Creek is mapped as being at 'major risk' of adverse impact from waterway barrier works on fish movement, Thirteen Mile Gully is indicated as being of 'moderate risk' of adverse impact, and the unnamed tributary as being of 'low risk' of adverse impact from waterway barrier works on fish movement (DAF 2019) (Figure 8). Thirteen Mile Gully is now diverted along the western boundary of ML 70379 (Figure 8). Consequently, the downstream reach of Thirteen Mile Gully within the Study area is no longer connective with its natural catchment and now represents a waterway at 'low risk' of adverse impact from waterway barrier works on fish movement.

4.2 Aquatic habitat

4.2.1 Waterways

The waterways of the Study area are ephemeral and expected to experience flow only after sustained or intense rainfall and runoff in the catchment. Stream flows are expected to be highly variable, with pooled water unlikely to remain longer than a few months without follow-up rainfall and runoff in the catchment. As a consequence, physical attributes, water quality, and the composition of aquatic flora and fauna communities are highly variable over time.

4.2.2 Surface water quality

Receiving Environment Monitoring Program

In-situ water quality measurements

Physico-chemical water quality has been monitored at the MCM as part of the Receiving Environment Monitoring Program (REMP) since 2010. Monitoring was undertaken twice-yearly to 2013, then once in 2015, 2016 and 2019. During 2017 and 2018, low rainfall and dry sites prevented monitoring (DPM Envirosciences 2019).

Water quality in Roper Creek is characterised by high and variable turbidity, moderate and variable EC, and low dissolved oxygen (DO) concentrations at times (WRM 2020). Historically (over the 2010 to 2019 period), EC has exceeded the relevant trigger value on several occasions, with the highest values generally observed at upstream sites and spikes occurring in the earlier years of monitoring (DPM Envirosciences 2019). pH has generally been within the recommended range and there has been no consistent pattern between sites upstream and downstream in Roper Creek. DO saturation has varied between sampling events and levels have often been below the lower trigger values. No consistent difference in DO between upstream and downstream sites was found over the 2010 to 2019 period (DPM Envirosciences 2019).

Turbidity has varied dramatically over time at all Roper Creek sites and in the unnamed tributary. On multiple occasions, it has exceeded 1,000 NTU at both upstream and downstream sites, exceeding the relevant Water Quality Objectives (WQOs) (EHP 2011) on most occasions (DPM Envirosciences 2019).

Analytical water quality

Concentrations of metals were generally low in most samples collected from the Roper Creek monitoring locations by GHD during the January / February 2019 monitoring round. Dissolved aluminium and iron exceeded the Release Contaminant Trigger Investigation Levels at all upstream and downstream monitoring locations, and there was one exceedance for dissolved copper at IMPAC2 (GHD 2019) (REMP sites shown on Figure 3).

For most metals with measurable concentrations, some differences were observed between reference, impact and potentially impacted sites. However, dissolved aluminium and iron are the only metals for which concentrations at impact sites appear consistently higher than at references sites (GHD 2019).

Levels of all nutrients were below the relevant trigger level / WQO in the January / February 2019 REMP monitoring, except for total phosphorus, which exceeded the trigger level / WQO at all sites, the highest level being at IMPAC2. Sodium and sulphate concentrations were slightly higher at the downstream sites than at upstream sites (GHD 2019), but remained below the relevant EA triggers.

In-situ water quality

No surface water was encountered at the time of the October 2019 dry season survey. As such, in-situ water quality measurements were not obtained in October 2019. The following paragraphs relate to measurements obtained at the time of sampling in February 2020. Complete results are provided in the site profiles (Appendix C).

Surface water temperatures at the time of assessment ranged from 26.9°C to 30.7°C (Table 8). Water temperatures were likely influenced by time of day, shading and waterbody depth.

pH levels ranged from 7.1 (neutral) to 7.4 (mildly alkaline) (Table 8), reflecting the recent rainfall and runoff and relatively low contact time with substrates. pH levels fell within the WQO guideline range of 6.5-8.5 for moderately disturbed aquatic ecosystems of the Mackenzie Sub-basin (DEHP 2011).

Each wetted site exhibited ‘fresh’ (<800 µS/cm) water, with EC levels ranging from 204 to 290 µS/cm (Table 8). EC levels fell favourably below the WQO guideline of <310 µS/cm for moderately disturbed aquatic ecosystems of the Mackenzie Sub-basin (DEHP 2011).

Surface water DO levels were relatively low across the Study area, ranging from 41.0% to 68.4%, falling below the WQO guideline range of 85-110% for moderately disturbed aquatic ecosystems of the Mackenzie Sub-basin (DEHP 2011) (Table 8). However, exceedances of this guideline range are typical for ephemeral systems. The relatively low DO levels likely reflect a number of factors including time of day, temperature, shading, turbidity (poor light penetration for photosynthetic respiration), organic load, biological activity and rate of transfer from the atmosphere (Appendix B).

Turbidity levels ranged from 390 NTU (poor clarity) to 842 NTU, exceeding the conservative WQO of 50 NTU at each site (Table 8). The turbidity levels reflect a high washload (silts and clays held in suspension) typical of waterways of the region.

Water hardness ranged from 50 mg/L (soft) at site R3 to 74 mg/L (moderate) at site R1 (Table 8), reflecting the recent rainfall and runoff and relatively low contact time with substrates.

Dissolved sulphate levels slightly exceeded the WQO guideline of 10 mg/L at sites R2 (14 mg/L), R3 (12 mg/L), and R4 (15 mg/L), but remained well below the EA receiving waters contaminant trigger level of 250 mg/L.

Table 8 Surface water quality measurements, February 2020

Parameter	Units	WQO	Riverine sites			
		ANZG	R1	R2	R3	R4
Date	DD/MM	-	18/02	19/02	18/02	18/02
Time	00:00	-	7:55	9:35	15:15	11:50
In-situ water quality						
Temperature	°C	-	26.9	27.5	30.7	29.2
pH	pH units	6.5-8.5	7.4	7.3	7.1	7.4
Electrical conductivity	µS/cm (@25C°)	<310^	290	264	204	258
DO	% saturation	85-110*	**51.9**	**47.4**	**41.0**	**68.4**
	mg/L	-	4.1	3.7	3.1	4.8
Turbidity	NTU	50	**390**	**842**	**810**	**398**
Hardness (as $CaCO_3$)#	mg/L	-	74	59	50	68
Total alkalinity (as $CaCO_3$)#	mg/L	-	83	61	55	77
Major cations#						
Calcium (Ca^{2+})	mg/L	-	15	12	10	14
Magnesium (Mg^{2+})	mg/L	-	9	7	6	8
Sodium (Na^{+})	mg/L	-	28	30	27	33
Potassium (K^{+})	mg/L	-	7	6	5	6
Major anions#						
Chloride (Cl^{-})	mg/L	-	24	29	26	31
Sulphate (SO_4^{2-})	mg/L	<10	10	14	12	15
Fluoride (F^{-})	mg/L	-	0.2	0.2	0.2	0.2
Bicarbonate (HCO_3^{-})	mg/L	-	83	61	55	77
Carbonate (CO_3^{2-})	mg/L	-	<1	<1	<1	<1

Notes:

Analysed by the laboratory.

^ Applies to baseflow conditions (as opposed to high flow conditions).

* DO levels for fresh waters only apply to flowing waters. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation (DEHP 2011).

Major ions

The concentration and proportion of ions in surface waters depends on the location of the waterway (geology, land-use and topography), climate and the proportionate contributions of groundwater flow, interflow and overland flow (Boulton and Brock 1999). These proportionate contributions will vary depending on seasonal and climatic patterns and so the source of ions will also vary. In low to no flow conditions, groundwater sources and / or evaporative processes may dominate, and during high flows, catchment and atmospheric sources will dominate.

The concentration of major anions and cations in surface water (and groundwater) samples collected from the survey area are provided in Appendix C. The relative proportions of these major cations and anions are presented as a Piper plot in Figure 9 and as a Schoeller diagram in Figure 10, to aid interpretation.

Surface water samples collected from sites R1, R2, R3 and R4 on Roper Creek in February 2020 were fresh, mixed-type waters – slightly dominated by sodium cations, and co-dominated by chloride and bicarbonate anions (Figure 9). Groundwater samples collected from across the site were slightly saline to saline sodium chloride type waters (Figure 9). The Schoeller diagram (Figure 10) further highlights the distinction between surface waters and groundwaters of the Study area.

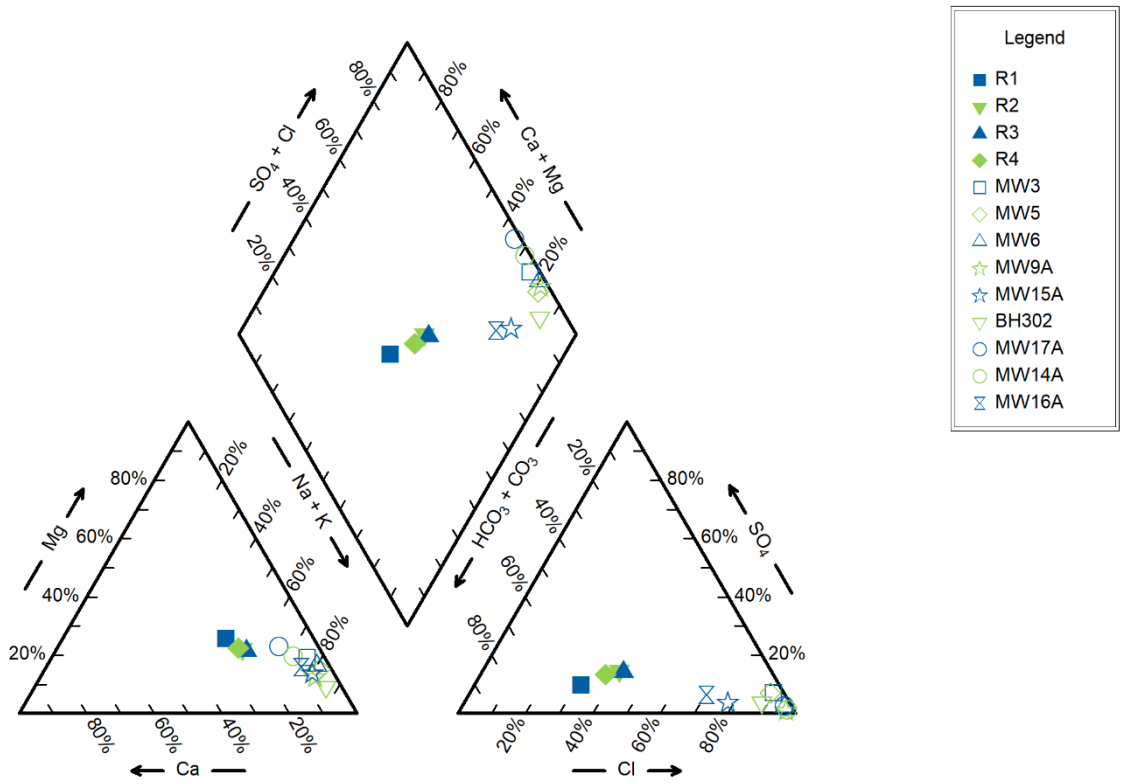


Figure 9 Piper plot showing relative abundance of major cations and anions from surface water and groundwater samples collected from the Study area, February 2020

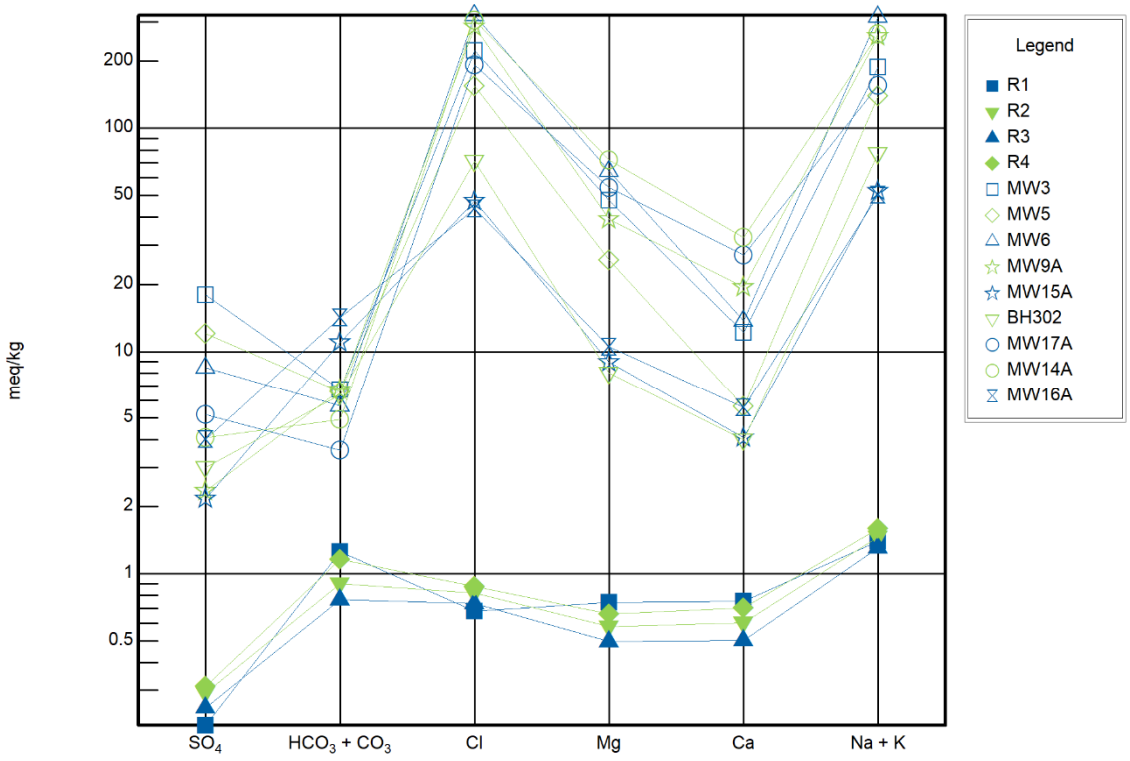


Figure 10 Schoeller diagram showing relative concentrations of major cations and anions from surface water and groundwater samples collected from the Study area, February 2020

Quality assurance / quality control

Sample holding times

The February 2020 samples were received and analysed by ALS Environmental within the recommended sample holding times (Appendix C).

Field blank

Analytical results for the field blank samples (Appendix C) indicate that all analytes were below the LOR, with the exception of low levels of bicarbonate alkalinity close to the LOR. The results confirm that sample handling integrity has been maintained.

Duplicate

Two sets of water samples were collected from site R1 for QA/QC purposes in February 2020. The RPD was calculated for all analytical parameters (Table 9). The RPD scores were within the acceptance criteria (Section 3.5.3) for all parameters, confirming the analytical reliability of the results.

Table 9 Quality assurance / control duplicate water analysis, February 2020

Parameter	Units	LOR	Replicate 1 (R1)	Replicate 2 (DUP)	RPD (%)	Within RPD acceptance
Hardness (as $CaCO_3$)	mg/L	1	74	74	0	✓
Total alkalinity (as $CaCO_3$)	mg/L	1	83	82	1	✓
Bicarbonate alk. (HCO_3^-)	mg/L	1	83	82	1	✓
Calcium (Ca^{2+})	mg/L	1	15	15	0	✓
Magnesium (Mg^{2+})	mg/L	1	9	9	0	✓
Sodium (Na^+)	mg/L	1	28	28	0	✓
Potassium (K^+)	mg/L	1	7	7	0	✓
Chloride (Cl^-)	mg/L	1	24	24	0	✓
Sulphate (SO_4^{2-})	mg/L	1	10	10	0	✓
Fluoride (F^-)	mg/L	0.1	0.2	0.2	0	✓

4.2.3 Instream habitat

Instream (aquatic) habitat assessment scores for the riverine sites within the Study area ranged from 31 (poor) to 56 (fair) in the October 2019 dry season survey, and from 36 to 56 in the February 2020 wet season survey (Table 10).

All four sites on Roper Creek scored poor in October 2019. The site on Thirteen Mile Gully scored fair. Bottom substrate / available cover was rated poor at each site in both seasons, owing to the dominance of fine sediments (sand and silt/clay) and general lack of gravel, pebble, cobble and boulder substrates. However, each site exhibited at least some detritus, sticks, branches and/or logs, providing some instream habitat and refugia for aquatic fauna in times of flow. Embeddedness also rated poor at all sites in both seasons. Velocity / depth category rated poor at each site in October 2019 due to lack of flow, increasing to Fair at sites R1, R2 and R3 in February 2020 owing to the presence of both shallow and deep (>0.5 m) pools. Site R5 on Thirteen Mile Gully scored high for channel alteration and bottom scouring, as it was not subject to the extensive sand and silt deposition observed in Roper Creek. Aquatic habitat assessment scores for Thirteen Mile Gully in October 2019 remained unchanged in February 2020.

Table 10 Aquatic habitat assessment scores for sites across the Study area

Habitat variable	R1	R2	R3	R4	R5
Dry season – October 2019					
Bottom substrate / available cover	P (2)	P (2)	P (2)	P (2)	P (4)
Embeddedness	P (2)	P (1)	P (2)	P (2)	P (1)
Velocity / depth category	P (0)	P (0)	P (0)	P (0)	P (0)
Channel alteration	F (4)	P (2)	P (3)	P (2)	E (12)
Bottom scouring and deposition	P (3)	P (2)	P (2)	P (2)	E (12)
Pool / riffle, run / bend ratio	P (3)	P (2)	P (2)	F (4)	F (4)
Bank stability	G (6)	G (8)	G (8)	G (6)	G (6)
Bank vegetative stability	E (10)	E (9)	E (10)	E (9)	G (8)
Streamside cover	F (4)	F (5)	E (9)	E (9)	E (9)
Total (out of 135)	**34**	**31**	**38**	**36**	**56**
Rating (Section 3.5.2)	**Poor**	**Poor**	**Poor**	**Poor**	**Fair**
Wet season – February 2020					
Bottom substrate / available cover	P (2)	P (2)	P (2)	P (2)	P (4)
Embeddedness	P (2)	P (2)	P (2)	P (2)	P (1)
Velocity / depth category	F (6)	F (6)	F (6)	P (2)	P (0)
Channel alteration	P (3)	P (2)	P (3)	P (2)	E (12)
Bottom scouring and deposition	P (3)	P (2)	P (2)	P (2)	E (12)
Pool / riffle, run / bend ratio	P (3)	P (2)	P (2)	F (4)	F (4)
Bank stability	G (6)	G (6)	G (8)	G (6)	G (6)
Bank vegetative stability	E (10)	E (9)	E (10)	E (10)	G (8)
Streamside cover	F (4)	F (5)	E (9)	E (9)	E (9)
Total (out of 135)	**39**	**36**	**38**	**39**	**56**
Rating (Section 3.5.2)	**Fair**	**Poor**	**Poor**	**Fair**	**Fair**

4.2.4 Bank stability

Bank vegetative stability ranged from good to excellent at each site, indicating that at least 50% of the streambanks were covered by vegetation at the time of assessment. Banks were moderately stable at each site, with only small, infrequent areas of erosion mostly healed over. There remains some potential for erosion in extreme flooding at all sites.

4.2.5 Adjacent land use

Land use across the Study area comprised former cattle grazing country. Riparian zone widths (single bank measurements from the edge of stream bed) ranged from approximately 10 m at site R5 on Thirteen Mile Gully to approximately 35 m at site R2 on Roper Creek. Trees commonly encountered in riparian zones across the Study area included Queensland blue gum (*Eucalyptus tereticornis*), river she-oak (*Casuarina cunninghamiana*), poplar box (*E. populnea*), carbeen (*Corymbia tessellaris*) and sally wattle (*Acacia salicina*). The shrub layer was sparse to very sparse across the site. Groundcover was mid-dense in both October 2019 and February 2020 (Appendix B).

4.2.6 Aquatic values

Aquatic values for each site are presented in the site profiles in Appendix B. Ratings for aquatic values were determined for each site based on the criteria in Section 3.5.9 and are presented in Table 11. The four sites on Roper Creek were rated as having moderate aquatic values, due to the importance of Roper Creek as a regional conduit for fish passage (Section 4.1.1). Site R5 on Thirteen Mile Gully was rated as having low aquatic values.

Table 11 Aquatic values ratings for the Study area

Site	Waterway	Stream order	Key aquatic values / criteria	Aquatic values rating (Section 3.5.9)
R1	Roper Creek	4	▪ Ephemeral stream ▪ Poor to Fair quality instream habitat ▪ No EVNT species or platypus habitat detected ▪ Little cover of Priority flora species ▪ Regional conduit for fish passage	Moderate
R2	Roper Creek	4	▪ Ephemeral stream ▪ Poor quality instream habitat ▪ No EVNT species or platypus habitat detected ▪ Little cover of Priority flora species ▪ Regional conduit for fish passage	Moderate
R3	Roper Creek	4	▪ Ephemeral stream ▪ Poor quality instream habitat ▪ No EVNT species or platypus habitat detected ▪ Little cover of Priority flora species ▪ Regional conduit for fish passage	Moderate
R4	Roper Creek	4	▪ Ephemeral stream ▪ Poor to Fair quality instream habitat ▪ No EVNT species ▪ Little cover of Priority flora species ▪ Regional conduit for fish passage	Moderate
R5	Thirteen Mile Gully	2	▪ Ephemeral stream ▪ Fair quality instream habitat ▪ No EVNT species or platypus habitat detected ▪ Little cover of Priority flora species ▪ Local conduit for fish passage	Low

4.3 Wetlands

4.3.1 Wetlands of International Importance

There are no wetlands of International Importance identified within the Study area or broader search area in the EPBC Act Protected Matters Report (DEE 2020a). Wetlands of International Importance nearest to the Study area include those of the Shoalwater and Corio Bays Area, approximately 160 km east-north-east.

4.3.2 Wetlands of National Importance

No nationally important wetlands occur in the Mackenzie River sub-basin (DES 2020a). The nearest wetland of National Importance is Broad Sound, located approximately 95km east-north-east of the Study area (DEE 2020a).

4.3.3 Referrable wetlands

Wetland Protection Areas

The *Map of Great Barrier Reef Wetland Protection Areas* (DES 2019d) shows the location of Wetland Protection Areas (WPAs), comprising wetlands of High Ecological Significance (HES) and their trigger area buffers. These wetlands have been assessed as containing high ecological values by a bioregional aquatic conservation assessment, the AquaBAMM (Rollason and Howell 2012).

No WPAs are mapped as occurring within the Study area (DES 2019d; Figure 11).

Queensland Wetland Environmental Values

The Map of Queensland Wetland Environmental Values (MQWEV) identifies the location and ecological significance of wetlands using the environmental values for wetlands in section 7 of the *Environmental Protection (Wetland and Water Biodiversity) Policy* (EPP) 2019 . Wetlands are considered either HES or of General Ecological Significance (GES) for the purpose of allocating environmental values. The MQWEV also shows High Ecological Values waters management intent under Schedule 2 of the EPP 2019.

No HES wetlands or High Environmental Value (HEV) waters are mapped as occurring within the Study area (DES 2019e; Figure 11). State-mapped RE 11.3.25 on Roper Creek is mapped as a GES wetland on the MQWEV (DES 2019e; Figure 11).

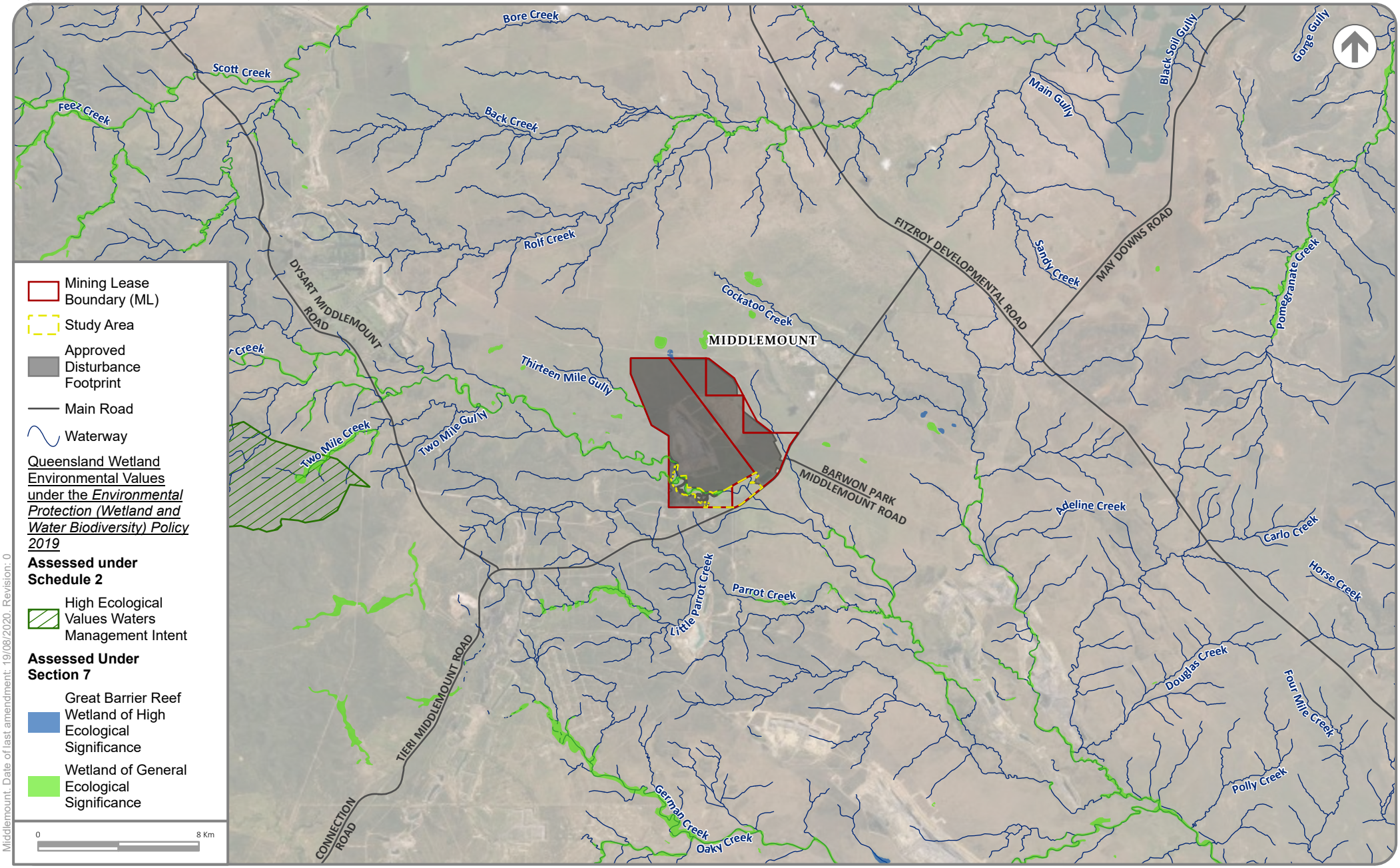
4.3.4 Other mapped wetlands

The Queensland Wetlands Map (DES 2019b) identifies marine, estuarine, riverine, lacustrine and palustrine waterbodies and wetland REs in Queensland. Within the Study area, this mapping includes:

- riverine wetland RE 11.3.25 on Roper Creek and Thirteen Mile Gully; and
- areas of floodplain RE 11.3.2 and 11.3.7.

No palustrine or lacustrine wetlands or waterbodies are mapped for the Study area (Figure 5). The site visits in October 2019 and February 2020, including on-ground assessment and aerial assessment using a remotely piloted aircraft (drone), found no evidence of floodplain wetlands. Riparian woodland RE 11.3.25 was prevalent along Roper Creek and Thirteen Mile Gully.

DPM Enviroscienses does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. DPM Enviroscienses shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information. **Data Sources:** DPM Enviroscienses 2019; MCPL 2019, State of Queensland 2019, Image: World Imagery: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



Middlemount. Date of last amendment: 19/08/2020. Revision: 0

DPM ENVIROSCIENCES

QUEENSLAND WETLAND ENVIRONMENTAL VALUES

Middlemount Coal Mine Southern Extension Project

FIGURE 11

4.4 Aquatic flora

Only five species of semi-aquatic macrophytes were recorded from the Study area during the October 2019 dry season survey (Table 12), reflecting the harsh physical conditions. More diverse aquatic communities were encountered at each site in the February 2020 wet season survey, with 11 species of semi-aquatic macrophytes recorded.

All aquatic flora species detected are listed as Least Concern under the NC Act. One Priority aquatic floral species was detected, being tall flatsedge (*Cyperus exaltatus*), which was recorded at each site. Tall flatsedge is considered a Priority species in non-riverine wetlands of the GBR catchments due to its tendency to form significant macrophyte beds, providing important habitat and a food source for fauna (Rollason and Howell 2012). Little (1-10%) coverage of tall flatsedge was recorded at each riverine site in the October 2019 and February 2020 surveys, and the species seems to be of little ecological significance.

Table 12 Aquatic flora recorded from the Study area

Scientific name	Common name	Site				
		R1	R2	R3	R4	R5
Dry season survey – October 2019						
Cyperus difformis	Rice sedge			L		
Cyperus exaltatus	Tall flatsedge	L	L	L	L	L
Eclipta prostrata	White eclipta*		L	L	L	
Juncus usitatus	Common rush			L	L	L
Ludwigia octovalvis	Willow primrose		L			
Species richness		**1**	**3**	**4**	**3**	**2**
Wet season survey – February 2020						
Cyperus betchei	-					L
Cyperus difformis	Rice sedge			L		
Cyperus exaltatus	Tall flatsedge	L	L	L	L	L
Cyperus iria	-					L
Cyperus polystachyos	Bunchy sedge		L			
Cyperus victoriensis	-	L	L	S	L	
*Echinochloa colona**	Awnless barnyard grass					L
Eclipta prostrata	White eclipta*	L	L	L	L	
Juncus usitatus	Common rush		L	L	L	L
Leptochloa digitata	Umbrella canegrass					L
Ludwigia octovalvis	Willow primrose		L	L		
Species richness		**3**	**6**	**6**	**4**	**6**

Notes: * denotes introduced species; L = 1-10% (little); S = 10-50% (some); M = 50-75% (moderate); E = >75% (extensive), as per AusRivAS categories (DNRM 2001).

4.5 Aquatic fauna

4.5.1 Fish

No surface water was encountered at the time of the October 2019 dry season survey. Consequently, habitat assessment was undertaken in place of fish survey. Three species were recorded from 320 fishes captured across four locations on Roper Creek during the February 2020 surveys (Table 13). This comprised only juveniles of the Least Concern species: spangled perch (*Leiopotherapon unicolor*) (20-40 mm), eastern rainbowfish (*Melanotaenia splendida splendida*) (15-30 mm) and Hyrtyl's tandan (*Neosilurus hyrtlii*) (30-40 mm), which had likely migrated upstream from downstream dry season refuges following the flow event approximately four weeks prior.

The waterways of the Study area are ephemeral and experience flow only after sustained or intense rainfall and runoff in the catchment. The streambed of Roper Creek is comprised of unconsolidated (loosely arranged and unpacked) sands and silts forming a relatively flat stream bed void of pool or riffle sequences. The transient flow and lack of dry season refuge limits the ability of Roper Creek to provide breeding habitat for native fishes.

Thirteen Mile Gully has a smaller catchment than Roper Creek, although the more consolidated silts and clays of the streambed provide a more natural channel profile, with less deepening or infilling. Following a flow event, wetted habitat is likely to persist in pools located on Thirteen Mile Gully for longer than in Roper Creek.

Roper Creek and Thirteen Mile Gully provide temporary foraging habitat but very limited breeding habitat for common (Least Concern) native fishes adapted to these conditions. Longer periods of rainfall and subsequent flows would likely result in greater fish diversity in the Study area, including other Least Concern species such as gudgeons (*Hypseleotris* spp.), Agassiz's glassfish (*Ambassis agassizii*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), bony bream (*Nematalosa erebi*) and barred grunter (*Amniataba percoides*), each known from the broader Mackenzie River drainage sub-basin (DES 2020a).

Table 13 Fishes recorded from the Study area, February 2020

Scientific name	Common name	Site				
		R1	R2	R3	R4	R5
Leiopotherapon unicolor	Spangled perch	93	87	99	26	-
Melanotaenia splendida splendida	Eastern rainbowfish	3	-	3	-	-
Neosilurus hyrtlii	Hyrtyl's tandan	3	-	6	-	-
Number of individuals		**99**	**87**	**108**	**26**	**-**
Species richness		**3**	**1**	**3**	**1**	**-**

4.5.2 Freshwater turtles

No surface water was encountered at the time of the October 2019 dry season survey. As such, habitat assessment was undertaken in place of turtle survey. No turtles were recorded during targeted surveys in February 2020.

FRC Environmental (2010) recorded Krefft's river turtle (*Emydura macquarii krefftii*) from two wetland sites approximately 3 km north and north-west of the Study area. The waterways of the Study area may provide transient foraging habitat for Least Concern turtle species such as Krefft's river turtle, broad-shelled river turtle (*Chelodina expansa*) and eastern snake-necked turtle (*C. longicollis*). However, these waterways are unlikely to provide suitable breeding habitat.

No EVNT turtles were detected within the Study area, nor was suitable habitat for EVNT turtles encountered (Section 3.5.5).

4.5.3 Platypus

The platypus (*Ornithorhynchus anatinus*) is listed as Special Least Concern (SLC) for cultural reasons under the NC Act. The Wetland*Info* database identifies the platypus as having previously been recorded from the Mackenzie River drainage sub-basin. However, the seasonal nature of the waterways of the Study area are not conducive to sustaining a population of platypus. No platypus burrows were encountered during the surveys, despite targeted searches. The platypus is considered unlikely to occur within the Study area.

4.5.4 Aquatic invertebrates

Receiving Environment Monitoring Program

Aquatic macroinvertebrate communities have been monitored at the Middlemount Coal Mine as part of the REMP since 2010. Monitoring was undertaken twice-yearly to 2013, then once in 2015, 2016 and 2019 (GHD 2019). During 2017 and 2018, low rainfall and dry sites prevented monitoring (GHD 2019).

The aquatic macroinvertebrate community of sites both upstream and downstream in Roper Creek and the unnamed tributary exhibited signs of stress in January/February 2019, with taxa richness, PET macroinvertebrate richness and Stream Invertebrate Grade Number – Average Level Version 2 (SIGNAL 2) generally below the DEHP (2011) guideline range for Mackenzie River freshwaters (GHD 2019). Given the ephemeral nature of Roper Creek, changes in metrics over time associated with macroinvertebrate communities are to be expected (White et. al. 2017, cited in GHD 2019).

In January/February 2019, there was no clear difference in macroinvertebrate composition or community condition between Roper Creek reference, impact and recovery sites (Figure 2), with no indication of impacts from Middlemount Coal Mine operations on the macroinvertebrate community of Roper Creek in 2019 (GHD 2019).

Historically, there have been some differences in macroinvertebrate metrics between reference and impact sites, although greater variability has been observed between sampling events (GHD 2019). In most cases, the temporal trend was similar between reference and impact sites, suggesting that the macroinvertebrate community responds to environmental conditions such as rainfall and temperature (GHD 2019). Macroinvertebrate metrics at both reference and impact sites have frequently been observed to be below the guideline range for Mackenzie River freshwaters, which is to be expected in this water and habitat limited system (GHD 2019).

Aquatic macroinvertebrates and stream health

No surface water was encountered at the time of the October 2019 dry season survey. As such, aquatic macroinvertebrate sampling was not undertaken in October 2019.

A total of 34 aquatic macroinvertebrate taxa were identified from 618 specimens collected from four sites on Roper Creek in February 2020. Raw macroinvertebrate data are presented in Appendix D.

Taxonomic composition

The most taxa-rich orders of aquatic macroinvertebrates collected from the Study area were Coleoptera (beetles) and Hemiptera (true bugs), each with six families identified. Diptera (true flies) was also well represented, with five families identified. Other taxa included Ephemeroptera (mayflies), Trichoptera (caddis flies), Zygoptera (damselflies), Epiprocta (dragonflies), Acarina (mites), Decapoda (yabbies, crabs and river prawns), Gastropoda (snails), Cladocera (water fleas), Copepoda (copepods) and Ostracoda (seed shrimp).

Aquatic macroinvertebrate taxa richness ranged from 8 to 16 taxa in samples collected from bed habitats, and from 16 to 24 taxa in samples collected from edge habitats (Figure 12). Data is presented alongside the DEHP WQOs for moderately disturbed aquatic ecosystems of the 'Mackenzie River Sub-basin waters' (DEHP 2011).

Taxa richness was greater in the edge habitat of each site than in the bed habitat, likely owing to the greater habitat complexity and food sources. Taxa richness in the bed habitat samples collected from sites R1 and R2 and in the edge habitat sample collected from site R1 fell within the DEHP (2011) 20:80 percentile guideline range (Figure 12). Taxa richness in all other samples fell below the DEHP (2011) 20:80 percentile guideline range (Figure 12).

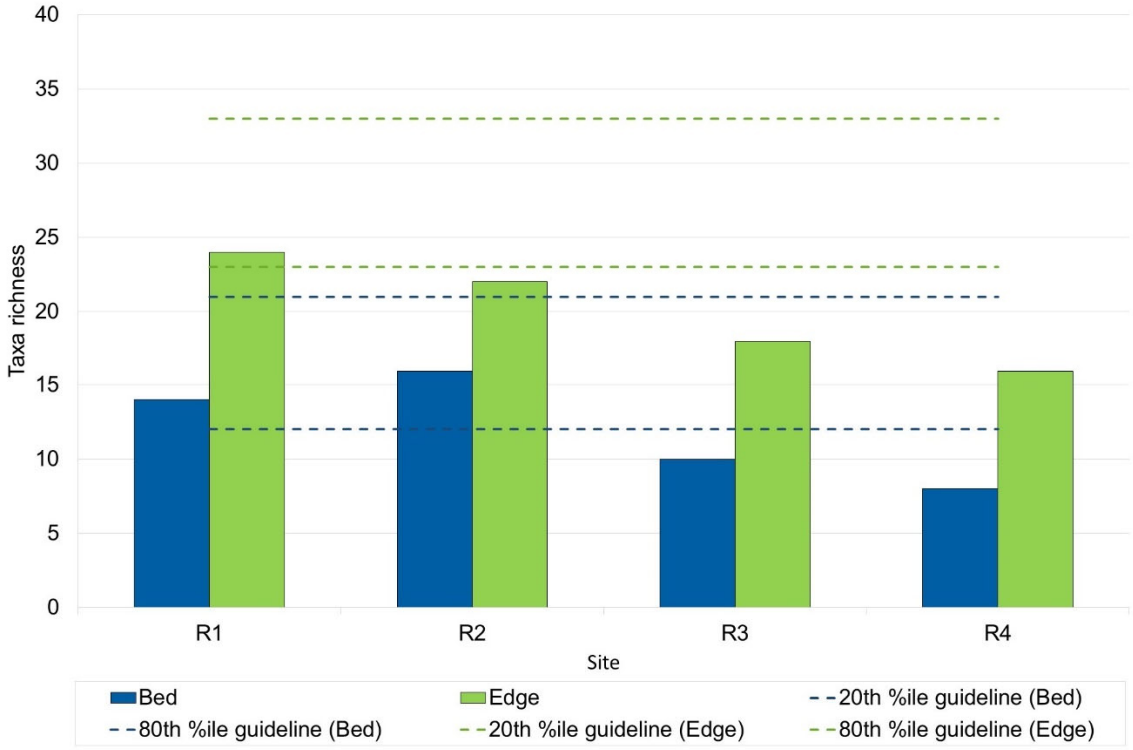


Figure 12 Taxa richness of aquatic macroinvertebrate samples collected from the Study area, February 2020

PET taxa

Three PET taxa were recorded in samples collected from the Study area, including Ephemeroptera (mayfly) families (Baetidae and Caenidae) and one Trichoptera (caddisfly) family (Leptoceridae). No Plecoptera (stoneflies) families were recorded, nor are they expected to occur due to lack of suitable habitat.

PET taxa richness ranged from 0 to 2 taxa in both the bed and edge samples (Figure 13). Data is presented alongside the DEHP WQOs for moderately disturbed aquatic ecosystems of the 'Mackenzie River Sub-basin waters' (DEHP 2011).

PET taxa richness in the bed habitat samples collected from sites R1 and R2 and in the edge habitat sample collected from site R2 aligned with the DEHP (2011) 20:80 percentile guideline range, indicating an expected number of pollutant sensitive taxa. PET taxa richness in all other samples fell below the guideline range.

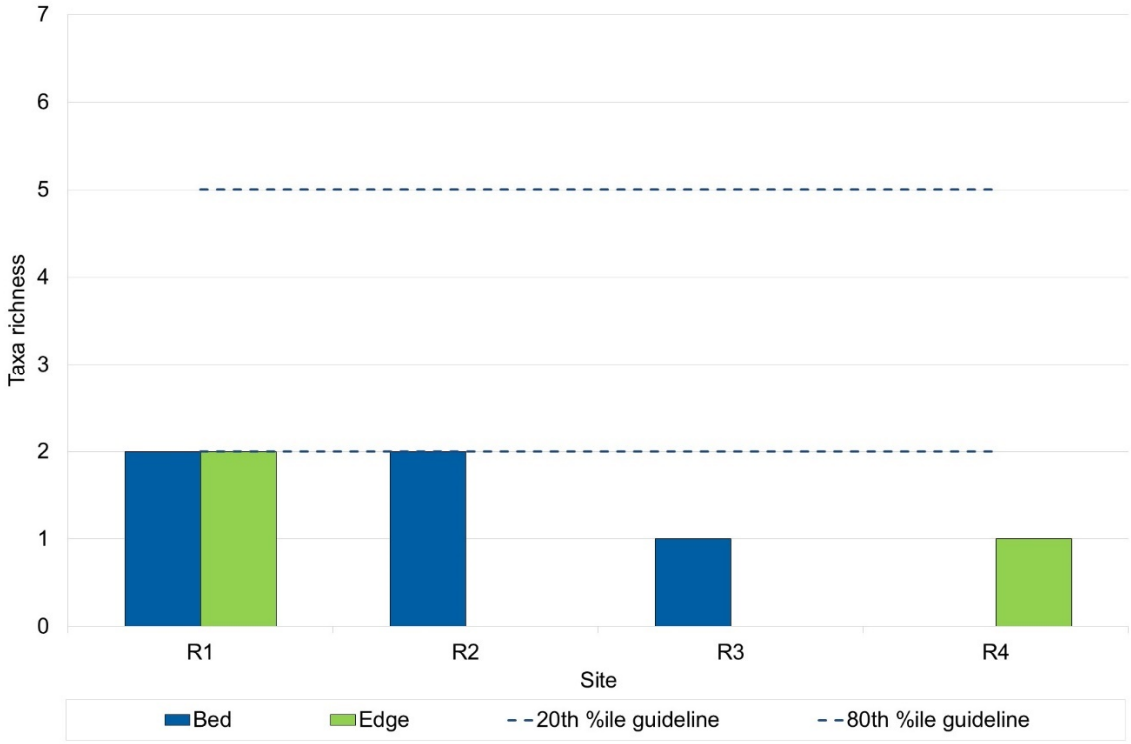


Figure 13 PET taxa richness of aquatic macroinvertebrate samples collected from the Study area, February 2020

Pollution-tolerant taxa

The percentage of pollution-tolerant taxa (SIGNAL 2 score of 1-3) ranged from 45% to 80% in the bed habitat samples and from 47% to 57% in the edge habitat samples (Figure 12). Data is presented alongside the DEHP WQOs for moderately disturbed aquatic ecosystems of the 'Mackenzie River Sub-basin waters' (DEHP 2011).

The percentage of pollution tolerant taxa in the bed habitat samples collected from site R1 and the edge habitat samples collected from sites R1 and R3 fell favourably within the DEHP (2011) 20:80 percentile guideline range. All other samples exceeded the DEHP (2011) 20:80 percentile guideline range, indicating unfavourable physical conditions and / or reduced habitat quality.

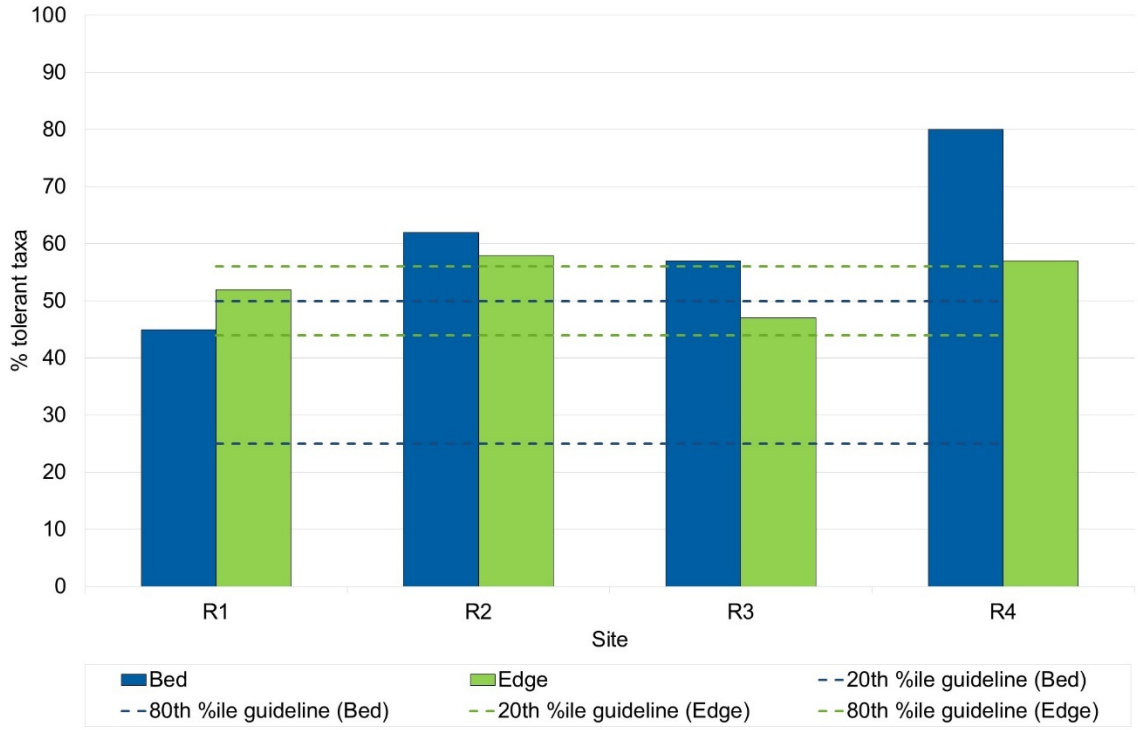


Figure 14 Percentage of pollution-tolerant taxa in aquatic macroinvertebrate samples collected from the Study area, February 2020

SIGNAL 2 scores

Average SIGNAL2 scores ranged from 2.60 to 3.55 for samples collected from bed habitats and from 3.14 to 3.53 for samples collected from edge habitats (Figure 15). SIGNAL2 results are presented against the DEHP WQOs for moderately disturbed aquatic ecosystems of the 'Mackenzie River Sub-basin waters' (DEHP 2011).

The SIGNAL2 scores for the bed habitat sample collected from site R1 and the edge habitat samples collected from sites R2 and R3 fell within the DEHP (2011) 20:80 percentile guideline range, reflecting the expected composition of pollution sensitive taxa. SIGNAL 2 scores for the bed habitat samples collected from sites R2, R3 and R4, and the edge habitat samples collected from sites R1 and R4 fell below the DEHP (2011) 20:80 percentile guideline range, reflecting a lower composition of pollution sensitive taxa (and a higher composition of pollutant tolerant taxa) than what is expected for moderately disturbed aquatic ecosystems in the Mackenzie Sub-basin waters.

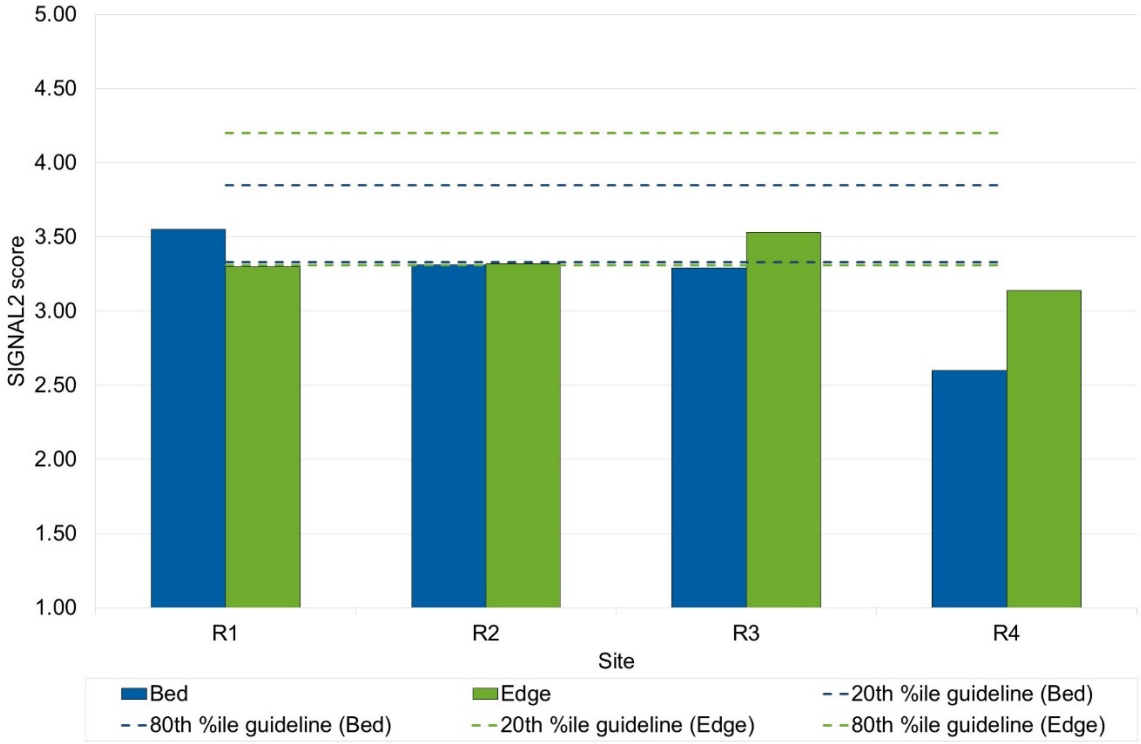


Figure 15 SIGNAL2 scores for aquatic macroinvertebrate samples collected from the Study area, February 2020

Macro-crustaceans

Three macro-crustacean families were encountered within the Study area, including Gercarcinucidae (inland freshwater crab *Austrothelphusa transversa* [Plate 1]), Palaemonidae (freshwater prawn *Macrobrachium australiense*) and Parasticidae (yabby *Cherax* sp. [Plate 1]).

Inland freshwater crab (*Austrothelphusa transversa*)

Yabby (*Cherax* sp.)

Plate 1 Macro-crustaceans captured and identified from the Study area, February 2020

4.7 Conservation significant species

4.7.1 Aquatic flora

No aquatic flora species listed under the EPBC Act and/or NC Act were recorded during the surveys. The Wetland*Info* database identifies five EVNT species that have previously been recorded from the broader Fitzroy Basin (DES 2020a), none of which are likely to occur within the Study area (Table 14).

4.7.2 Fishes

The Wetland*Info* database identifies 53 fish species that have previously been recorded from the Fitzroy Basin (DES 2020a). Of these, two are listed as EVNT:

- Silver perch (*Bidyanus bidyanus*) – Critically Endangered (EPBC Act); and
- Murray cod (*Maccullochella peelii*) – Vulnerable (EPBC Act).

Due to habitat requirements and distributional range, it is highly unlikely these EVNT species occur within waterbodies of the Study area as either resident or transient occurrences.

An additional EVNT fish species, the Vulnerable (EPBC Act and NC Act) honey blue-eye (*Pseudomugil mellis*), is identified in the ACA Expert Panel Report for non-riverine wetlands in the Fitzroy section of the GBR catchment (Rollason and Howell 2012). However, this species is not listed by Wetland*Info* as having been recorded from the Fitzroy Basin (DES 2020a) and is also unlikely to occur in the Study area.

The BoT Actions for Biodiversity for the Fitzroy NRM region (DERM 2010) report lists the ornate rainbowfish (*Rhadinocentrus ornatus*) as a Priority species (Table 15). An additional 11 Priority fish species are recorded by the ACA Expert Panel Reports for the Fitzroy section of the GBR catchment (Inglis and Howell 2009; Rollason and Howell 2012) (Table 15). No Priority fish species are likely to occur within the Study area based on consideration of their habitat requirements and distribution (Table 15).

4.7.3 Freshwater turtles

The Wetland*Info* database identifies seven freshwater turtle species as having previously been recorded from the Fitzroy Basin (DES 2020a). Of these, two are listed as EVNT:

- southern snapping turtle (*Elseya albagula*) – Critically Endangered (EPBC Act), Endangered (NC Act); and
- Fitzroy River turtle (*Rheodytes leukops*) – Vulnerable (EPBC Act and NC Act).

The southern snapping turtle and Fitzroy River turtle are also identified in the EPBC Act Protected Matters Report for the search area (DEE 2020a). There are no Priority turtle species identified in the BoT Actions for Biodiversity for the Fitzroy NRM region (DERM 2010) or ACA Expert Panel Reports for the Fitzroy section of the GBR catchment (Inglis and Howell 2009; Rollason and Howell 2012) that aren't also listed under the EPBC Act or NC Act (Table 16).

Due to habitat requirements and distributional range, it is unlikely that these EVNT turtle species occur within waterbodies of the Study area as either resident or transient occurrences (Table 16).

4.7.4 Freshwater invertebrates

No aquatic invertebrates are identified in the EPBC Act Protected Matters Report, nor in the BoT Actions for Biodiversity for the Fitzroy NRM region (DERM 2010).

The Wetland*Info* database for the Fitzroy Basin (DES 2020a) identifies two macro-crustaceans and 23 wetland indicator insects as having previously been recorded from the Fitzroy Basin, none of which are listed in the EPBC Act or NC Act.

The ACA Expert Panel Report (riverine wetlands) for the Fitzroy sub-catchment of the GBR catchment (Rollason and Howell 2012) lists two Priority aquatic invertebrates: the spiny crayfish (*Euastacus monteithorum*) and the Eungella spiny crayfish (*E. eungella*). Due to their distributional range and high altitude requirements, it is unlikely these species occur in the Study area (Table 17).

Table 14 EVNT and Priority aquatic flora recorded from the desktop searches

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
EVNT species													
Eriocaulon carsonii (including subsp. *orientale*)	salt pipewort / button grass	E	E	H/H		Restricted to saturated soil adjacent to flowing mound springs (Sainty and Jacobs 2003).	**Unlikely**. Current known distribution (ALA 2020) is not in proximity to the Study area. Mound springs not known to occur within the Study area. Preferred habitat is not present within the Study area.	**Unlikely**. Not detected during field surveys.				✓	✓
Maundia triglochinoides	-		V			Grows in coastal freshwater swamps and streams (Sainty and Jacobs 2003), in waters up to 0.5 m deep, or shallow waters that may dry up seasonally.	**Unlikely**. Current distribution (ALA 2020) is not in proximity to the Study area. Preferred habitat is not present within the Study area.	**Unlikely**. Not detected during field surveys.					✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Myriophyllum artesium	-		E	H/H	R & T	Wetlands and creek lines associated with springs emanating from the Great Artesian Basin and associated basins (DES 2020b).	**Unlikely**. Current known distribution (ALA 2020) is not in proximity to the Study area. Spring fed wetlands and creeks not known to occur within the Study area. Preferred habitat is not present within the Study area.	**Unlikely**. Not detected during field surveys.		✓		✓	✓
Phaius australis	lesser swamp-orchid	E	E	C/C	R & T	Grows in sandy areas where soils are almost always damp, but not flooded for lengthy periods; occurring in southern Queensland and northern NSW (DES 2020c).	**Unlikely**. Current known distribution (ALA 2020) is not in proximity to the Study area. Preferred habitat is not present within the Study area.	**Unlikely**. Not detected during field surveys.		✓	✓	✓	✓
Thelypteris confluens	swamp fern		V		R & T	Found in permanently swampy areas and mound springs (DES 2020d). Occurs in the Queensland pastoral districts on	**Unlikely**. Current known distribution (ALA 2020) is not in proximity to the Study area. Preferred habitat is not present within the Study	**Unlikely**. Not detected during field surveys.		✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						Leichhardt, Moreton and Wide Bay (DES 2020d).	area.						
Priority species													
Aponogeton queenslandicus	-				R & T	Temporary freshwater non-riverine waterbodies on clay substrates in drier regions (DES 2020e).	**Unlikely**. The species habitat may occur in the Study area; however, there are no records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Baumea articulata	jointed twigrush		L		P	Grows in standing water <1 m deep. Inhabits coastal lagoons, deeper swamps and slow-moving streams. Scattered occurrence in inland wetlands (Fielder et al. 2011).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Baumea rubiginosa	soft twigrush		L		P	Grows in damp environments such as ephemeral swamps, lagoons and creek banks (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are no records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Cyperus exaltatus	tall flatsedge		L		P	Forms extensive stands along inland rivers and creeks, in areas which are often flooded. Grows in swamps and wetland margins (Sainty and Jacobs 2003).	**Potential**. The species habitat is known to occur in the broader search area and there are records within 50 km of the Study area.	**Known**. Detected at each site.		✓			✓
Eleocharis blakeana	-		L	H/M	R	Occurs on plains and low undulating country on poorly drained, clayey soils; commonly in ephemeral wet habitats in gilgai country and in small depressions along drainage lines in open forest and woodland	**Potential**. The species habitat is known to occur in the broader search area and there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓			✓	✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						communities (Halford 1996; and Wilson 2006, cited in DES 2020f).							
Eleocharis dulcis	water chestnut		L		P	Grows in shallow lagoons and floodplains, on heavy soils (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Eleocharis sphacelata	tall spikerush		L		P	Grows in stationary or slow-moving water bodies of the coast and inland; occurring in shallow water up to 2m depth (Sainty and Jacobs 2003).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Gahnia sieberiana	sword grass		L		P	Swamps and wet heaths (Melzer and Plumb 2011).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Leersia hexandra	swamp rice grass		L		P	Edges of billabongs, in swamps and constructed wetlands. Forms dense stands, often excluding other plant species (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Monochoria cyanea	monochoria		L		P	Generally rooted in the mud; preferring stationary or slow-flowing nutrient-rich water, but will survive for short periods on drying mud (Sainty and Jacobs 2003).	**Potential**. The species habitat may occur in the broader search area and there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓
Myriophyllum simulans	-		L		P	Grows in still water, or more frequently, fully emergent on mud (Harden 2002).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓				✓
Myriophyllum verrucosum	water milfoil		L		P	Various habitats, from deep water to exposed	**Unlikely**. The species habitat may occur in the	**Unlikely**. Not detected during field	✓				✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						mud (Harden 2002).	Study area; however, there are records within 50 km of the Study area.	surveys.					
Najas tenuifolia	water nymph		L		P	Fresh water less than 3 m deep, widespread; submerged aquatic species (Fielder et al. 2011).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Nelumbo nucifera	pink waterlily		L		P	Deep lagoons and deep slow-moving streams (Fielder et al. 2011).	**Unlikely**. Preferred habitat does not occur within Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Nymphaea gigantea	giant waterlily		L		P	Permanent deep water with muddy substrates (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Nymphoides exiliflora	-		L		P	Saturated soils or clear shallow (to 5cm) fresh water; low heath and edge swamps on sandy soils (Stanley and Ross 1983).	**Unlikely**. Preferred habitat does not occur within Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Nymphoides indica	water snowflake		L		P	Stationary and slow-moving water bodies (Sainty and Jacobs 2003).	**Unlikely**. Preferred habitat does not occur within Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Ottelia alismoides	-		L		P	Margins of lakes, ponds and backwaters; usually submerged, but may be partly emergent in shallow water (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Paspalum distichum	water couch		L		P	Damp areas and margins of waterbodies, creeks, streams, channels and drains on the coast and inland (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Phragmites australis	common reed		L		P	Stationary or slow-moving waterbodies, margins of creeks, streams, channels and drains, swamps, areas with high water or that are seasonally inundated;	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						tolerant of slightly brackish water (Sainty and Jacobs 2003). May grow in deep and permanent waters, or shallow, seasonally inundated lowlands, or where there is a permanently high watertable not far below the surface (Romanowski 1998).							
Schoenoplectus mucronatus	schoenoplectus		L		P	Creek and river banks, periodically inundated floodplains and in billabongs. Banks of stationary or slow-moving waterbodies and floodplains (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.		✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Typha orientalis	broad-leaved cumbungi		L		P	Stationary or slow-moving waterbodies, margins of creeks and rivers of the inland and coast; fresh or brackish water up to 2 m deep (Sainty and Jacobs 2003).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓
Vallisneria nana	ribbonweed		L		P	Still to fast-flowing waters of streams, lakes, ponds and irrigation channels (Stephens and Dowling 2002).	**Unlikely**. The species habitat may occur in the Study area; however, there are records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			✓

Notes:

E = Endangered, V = Vulnerable, L = Least Concern, C = Critical Priority, H = High Priority, M = Medium Priority, P = Priority, R&T = Rare and Threatened.

1. EPBC Act = status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
2. NC Act = status under the Queensland *Nature Conservation Act 1992*.
3. Back on Track = status under the DERM (2010) Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
4. ACA = status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009; Rollason and Howell 2012).

* *Aponogeton queenslandicus* is listed as Rare in the ACA for the riverine wetlands of the Great Barrier Reef catchment: Fitzroy region. However, as of May 2010, this species is a Least Concern species under the NC Act.

References:

- Inglis and Howell 2009, Aquatic Conservation Assessments using AquaBAMM for the riverine wetlands of the Great Barrier Reef catchment: Fitzroy region.
- Rollason and Howell 2012, Aquatic Conservation Assessments using AquaBAMM for the non-riverine wetlands of the Great Barrier Reef catchment: Fitzroy region
- Commonwealth Department of the Environment and Energy (DEE) 2019, EPBC Act Protected Matters Report – created 26/09/2019.
- Queensland Department of Environment and Resource Management (DERM) 2010, Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
- Queensland Department of Environment and Science (DES) 2020a, Wetland*Info* – Fitzroy Basin – Wetland Summary Information.

Table 15 EVNT and Priority fish species recorded from the desktop search area

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
EVNT species													
Pseudomugil mellis	Honey blue-eye	V	V		R&T	Found in coastal lowland wallum, inhabiting flowing and still waterbodies. Generally found in areas with little or no flow, and where emergent and submerged aquatic plants are abundant (Pusey et al. 2004).	**Unlikely**. Outside of natural area of distribution (ALA 2020). Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.		✓			
Priority species													
Hephaestus fuliginosus	Sooty grunter		LC		✓	Found across a range of stream types from small tributaries to large lowland rivers, preferring flowing water of moderate depth, with juveniles most abundant in riffles and runs. Structural woody habitat, submerged root masses and bank	**Unlikely**. Not previously recorded from the Mackenzie River drainage sub-basin (DES 2020a). Natural distribution is outside of the Study area, although species has been translocated into an area encompassing the Study area. Preferred habitat	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						undercuts are important habitat features (Pusey et al. 2004). Translocated populations in Fitzroy catchment are widely distributed (Pusey et al. 2004).	does not occur within the Study area.						
Kuhlia rupestris	Jungle perch		LC		✓	Patchily distributed in fast-flowing streams and rivers; however, also known to occur within floodplain lagoons. Usually occurs in coastal rainforest drainages from the tip of the Cape York Peninsula south to Fraser Island (Allen et al. 2002).	**Unlikely**. Outside of natural area of distribution (ALA 2020). Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓				
Lates calcarifer	Barramundi		LC		✓	Young live in freshwater upper reaches of rivers, favouring undercut banks, submerged logs and overhanging vegetation.	**Unlikely**. Outside of natural area of distribution (ALA 2020). Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						Adults typically found in or near estuaries, often around mangroves in clear or turbid water (Allen et al. 2002).							
Macquaria ambigua	Golden perch		LC		✓	Predominantly found in lowland warmer, turbid, slow-flowing rivers, often in association with structural woody habitat and other cover. A wide-ranging species with a natural distribution throughout the Murray-Darling, Fitzroy, Lake Eyre and Bullaroo River basins (Pusey et al. 2004).	**Potential**. The species habitat is known to occur in the broader search area, having been previously recorded by the project team within 10 km away.	**Known**. Species or species habitat not detected during field surveys.	✓				✓
Megalops cyprinoides	Oxeye herring/ tarpon		LC		✓	Juveniles and small adults occasionally occur within the freshwater reaches of coastal streams of Queensland; however,	**Unlikely**. Outside of normal area of distribution (ALA 2020). Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
						most commonly occurs in estuarine and marine waters (Allen et al. 2002).							
Mugil cephalus	Sea mullet		LC		✓	Found around the entire mainland coast of Australia, primarily occurring in brackish waters, although known to enter lower reaches of freshwater rivers (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓
Ophiocara porocephala	Spangled gudgeon		LC		✓	Distributed in brackish estuaries and river mouths; however, also found in freshwater bodies at low elevations around the northern and eastern coasts of Australia (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Rhadinocentrus ornatus	Ornate rainbowfish		LC	H/ H	✓	Coastal lowland wallum and rainforest ecosystems; often in association with dense emergent and submerged vegetation / woody debris, leaf litter and undercut banks (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.				✓	✓
Scleropages leichardti	Southern saratoga		LC		✓	Billabongs or large pools in slow-flowing streams, usually in turbid conditions. Often associated with abundant large in-stream wood, undercut banks and overhanging vegetation. Endemic to the Fitzroy River basin (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Scortum hillii	Leathery grunter		LC		✓	Endemic to the Fitzroy River where it occurs in flowing freshwater streams and still pools. Most common in lower reaches of larger rivers and estuaries (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓
Strongylura krefftii	Freshwater longtom		LC		✓	Variety of habitats, including floodplain lagoons, main channels of rivers, sandy bed creeks and perennial escarpment streams (Pusey et al. 2004).	**Potential**. Natural distribution encompasses the Study area. Preferred habitat may occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓
Trachystoma petardi	Pinkeye mullet		LC		✓	Deep, gently flowing rivers; as well as estuaries and coastal seas on the east coast of Australia (Allen et al. 2002).	**Unlikely**. Preferred habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

Notes:

E = Endangered, V = Vulnerable, LC = Least Concern, C = Critical priority, H = High Priority, M = Medium Priority, P = Priority, R&T = Rare and Threatened.

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2. NC Act = status under the Queensland *Nature Conservation Act 1992*.
3. Back on Track = status under the DERM (2010) Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
4. ACA = status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009; Rollason and Howell 2012).

References:

- Inglis and Howell 2009, Aquatic Conservation Assessments using AquaBAMM for the riverine wetlands of the Great Barrier Reef catchment: Fitzroy region.
- Rollason and Howell 2012, Aquatic Conservation Assessments using AquaBAMM for the non-riverine wetlands of the Great Barrier Reef catchment: Fitzroy region
- Commonwealth Department of the Environment and Energy (DEE) 2019, EPBC Act Protected Matters Report – created 26/09/2019.
- Queensland Department of Environment and Resource Management (DERM) 2010, Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
- Queensland Department of Environment and Science (DES) 2020a, Wetland*Info* – Fitzroy Basin – Wetland Summary Information.

Table 16 EVNT and Priority aquatic reptiles recorded from the desktop search area

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Rheodytes leukops	Fitzroy River turtle	V	V	H/ H	R & T	Fast-flowing water of the Fitzroy River and its tributaries (Cogger 2014). Rivers with large deep pools and rocky, gravelly or sandy substrates, connected by shallow riffles. Preferred areas have high water clarity and are often associated with ribbonweed (*Vallisneria* sp.) (DEE 2020b).	**Unlikely**. Potential habitat does not occur within the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓		✓	✓	✓
Elseya albagula	Southern snapping turtle	C E	E	H/ H	P	Permanent flowing water habitats where there are suitable shelters and refuges (DES 2020g); clear, flowing, well-oxygenated waters (Todd et al. 2013) of the Fitzroy, Mary and Burnett catchments.	**Unlikely**. Potential habitat does not occur within Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓		✓	✓	✓

Notes:

E = Endangered, V = Vulnerable, LC = Least Concern, C = Critical Priority, H = High Priority, M = Medium Priority, P = Priority, R&T = Rare and Threatened, Mi = Migratory.

1. EPBC Act = status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
2. NC Act = status under the Queensland *Nature Conservation Act 1992*.
3. Back on Track = status under the DERM (2010) Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.

4. ACA = status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009; Rollason and Howell 2012).

References:

- Inglis and Howell 2009, Aquatic Conservation Assessments using AquaBAMM for the riverine wetlands of the Great Barrier Reef catchment: Fitzroy region.
- Rollason and Howell 2012, Aquatic Conservation Assessments using AquaBAMM for the non-riverine wetlands of the Great Barrier Reef catchment: Fitzroy region
- Commonwealth Department of the Environment and Energy (DEE) 2019, EPBC Act Protected Matters Report – created 26/09/2019.
- Queensland Department of Environment and Resource Management (DERM) 2010, Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
- Queensland Department of Environment and Science (DES) 2020a, Wetland*Info* – Mackenzie Sub-basin – Wetland Summary Information.

Table 17 Priority invertebrate species recorded from the desktop search area

Scientific name	Common name	Status				Preferred habitat	Likelihood of occurrence within Study area based on desktop	Likelihood of occurrence within Study area post field survey	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]				Inglis and Howell 2009	Rollason and Howell 2012	DEE 2020a	DERM 2010	DES 2020a
Euastacus eungella	Eungella spiny crayfish				✓	Only a small population restricted to localities >740 m above sea level in tropical rainforest headwaters and seepages in the Clarke Range, 65km west of Mackay (Coughran and Furse 2010).	**Unlikely**. Outside of known distributional range.	**Unlikely**. Species or species habitat not detected during field surveys.		✓			
Euastacus monteithorum	A spiny crayfish				✓	Cool, clear, fast-flowing headwaters in rainforest areas at >800 m above sea level. Prefers heavily shaded, well oxygenated waters where it can burrow under logs and rocks. Known from only one location: Kroombit Tops National Park, 62 km south-west of Gladstone (Coughran and Furse 2010).	**Unlikely**. Outside of known distributional range.	**Unlikely**. Species or species habitat not detected during field surveys.		✓			

Notes:

1. EPBC Act = status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
2. NC Act = status under the Queensland *Nature Conservation Act 1992*.
3. Back on Track = status under the DERM (2010) Fitzroy Natural Resource Management Region – Back on Track Actions for Biodiversity.
4. ACA = status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009; Rollason and Howell 2012).

4.8 Introduced Species

4.8.1 Introduced aquatic flora

There are 21 three introduced wetland indicator plant species known from the Fitzroy Basin (DES 2020a). Only one of these species was recorded in the Study area, being white eclipta (*Eclipta prostrata*). Those invasive species considered to pose a particular threat to aquatic biodiversity, and that could potentially occur within the Study area, are listed in Table 18 as either a Weed of National Significance (WoNS) (DEE 2020c) or Restricted matter category 3 under the Queensland *Biosecurity Act 2014*. No aquatic WoNS or Restricted matter species were detected in the Study area.

Table 18 Introduced wetland indicator plants known to occur in the desktop search area, and potentially in the Study area

Scientific name	Common name	National status^	Biosecurity Act status*
Arundo donax			
Cyperus esculentus	Yellow nutgrass		
Cyperus involucratus			
Cyperus papyrus	Papyrus		
Diplachne fusca var. uninervia			
Echinochloa colona	Awnless barnyard grass		
Echinochloa crus-galli	Barnyard grass		
Eclipta prostrata	White eclipta		
Eichhornia crassipes	water hyacinth	WoNS	Restricted 3
Eleocharis minuta			
Hymenachne aplexicaulis	Olive hymenachne	WoNS	Restricted 3
Juncus bufonius	Toad rush		
Nymphaea caerulea	Cape waterlily		
Pistia stratiotes	Water lettuce		Restricted 3
Polypogon monspeliensis	annual beardgrass		
Rorippa nasturtium-aquaticum	Watercress		
Salix babylonica	Weeping willow		
Salvinia molesta	Salvinia	WoNS	Restricted 3
Sparganium erectum subsp. stoloniferum	Erect bur-reed		
Stenotaphrum secundatum	Buffalo grass		
Urochloa mutica	Para grass		

Notes:

^ Species listed as WoNS; * species listed under the Queensland *Biosecurity Act 2014*.

4.8.2 Pest fish species

Six introduced fish species have been recorded from the Fitzroy Basin: mosquitofish (*Gambusia holbrooki*), guppy (*Poecilia reticulata*), goldfish (*Carassius auratus*), European carp (*Cyprinus carpio*) (DES 2020a), as well as more recent records of tilapia (*Oreochromus mossambicus*) (Catchment Solutions 2015; DPM Enviros ciences 2018) and platy (*Xiphophorus maculatus*) (Catchment Solutions 2015) (Table 19). One pest fish species – mosquitofish – was recorded from the Mackenzie River Sub-basin (near Blackwater) in late 2019 (DPM Enviros ciences 2020). No pest fishes are yet recorded for the Mackenzie River Sub-basin in Wetland*Info* (DES 2020a).

An additional two pest fish species are identified in the ACA Expert Panel reports for the Fitzroy section of the GBR catchments (Inglis and Howell 2009; Rollason and Howell 2012): swordtail (*Xiphophorus helleri*) and spotted tilapia (*Tilapia mariae*). Each of these species are unlikely to occur in the Study area (Table 19).

4.8.3 Introduced aquatic reptiles

No introduced reptile species were recorded during the surveys and none were identified from the desktop review as having potential to occur in the Study area.

Table 19 Introduced fish species recorded from the Fitzroy Basin

Scientific name	Common name	Preferred habitat	Negative impacts on native fish	Likelihood of occurrence in the Study area based on desktop	Likelihood of occurrence in the Study area post field survey	Data Source				
						Inglis and Howell	Rollason and Howell	DES 2020a	DPM Enviro. 2018	Catchment Sol. 2015
Carassius auratus	Goldfish	Inhabits still or slow-flowing water. Able to withstand high temperatures and low dissolved oxygen. Often associated with aquatic flora (Lintermans 2007).	Typically referred to as a "benign" species, with few impacts recorded. However, introduced the "goldfish ulcer" disease to other fish (Lintermans 2007).	**Potential**. The species habitat is known to occur in the broader search area and there are records within 50 km of the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓	✓		
Cyprinus carpio	European carp	Warm, slow-flowing lowland rivers or lakes; rarely found in clear, cool fast-flowing streams (Lintermans 2007).	Their feeding behaviour can increase turbidity and undermine banks; alter zooplankton and algal levels; and compete with native fish for food and space (Lintermans 2007)..	**Unlikely**. Preferred habitat does not occur within the Study area, and there are no records within 50 km of the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.			✓		
Gambusia holbrooki	Mosquito fish	Often found in lakes or still/slow flowing water; typically around edges or vegetation. Tolerant of a wide range of water temperatures, oxygen	High ability to breed leads to plague number in many habitats. Aggressive species, chasing and fin-nipping other species. Prey on	**Potential**. The species habitat is known to occur in the broader search area and there are records within 50 km of the Study	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓	✓	✓	

Scientific name	Common name	Preferred habitat	Negative impacts on native fish	Likelihood of occurrence in the Study area based on desktop	Likelihood of occurrence in the Study area post field survey	Data Source				
						Inglis and Howell	Rollason and Howell	DES 2020a	DPM Enviro. 2018	Catchment Sol. 2015
		levels, salinities and turbidity (Lintermans 2007).	eggs of native fish and frogs, and native fish larvae. Implicated in the decline of over 30 fish species worldwide (Lintermans 2007).	area.						
Oreochromis mossambicus	Tilapia	Habitat variable, including reservoirs, lakes, ponds, rivers, creeks, drains, swamps and tidal creeks. Usually over mud bottoms, often in well-vegetated areas (Allen et al. 2002).	Competition with native species for food and space; predation upon the eggs and young of native species; aggressive behaviour toward native species; and destructive nest building by males (NSW DPI 2017).	**Unlikely**. Preferred habitat may occur within the Study area, but there are no records within 50 km of the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.				✓	✓
Poecilia reticulata	Guppy	Wide variety of habitats – pristine to turbid, high to low elevations, fresh to brackish water; usually in small streams and amongst vegetation	No negative impacts yet known.	**Unlikely**. Preferred habitat may occur within the Study area, but there are no records within 50 km of the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓	✓		

Scientific name	Common name	Preferred habitat	Negative impacts on native fish	Likelihood of occurrence in the Study area based on desktop	Likelihood of occurrence in the Study area post field survey	Data Source				
						Inglis and Howell	Rollason and Howell	DES 2020a	DPM Enviro. 2018	Catchment Sol. 2015
		(Lintermans 2007).								
Tilapia mariae	Spotted tilapia/ Black mangrove cichlid	Inhabits still or flowing waters in rocky or muddy substrates, tolerating a wide range of environmental conditions. Has little habitat requirements, variable dietary requirements and an ability to rapidly colonise a variety of habitats, including disturbed ecosystems (Bradford et al. 2011).	Competes for resources. Aggressive towards other fish species (Bradford et al. 2011).	**Unlikely**. Although identified in the ACAs (Inglis and Howell 2009, Rollason and Howell 2012), ALA (2020) identifies *T. mariae* as currently restricted to Brisbane, Townsville and Cairns.	**Unlikely**. Not detected during field surveys.	✓	✓			

Scientific name	Common name	Preferred habitat	Negative impacts on native fish	Likelihood of occurrence in the Study area based on desktop	Likelihood of occurrence in the Study area post field survey	Data Source				
						Inglis and Howell	Rollason and Howell	DES 2020a	DPM Enviro. 2018	Catchment Sol. 2015
Xiphophorus helleri	Swordtail	Favours warm water near edges of creeks and drains amongst weeds (Allen et al. 2002).	Competes with native fishes for resources. High fecundity and can quickly become the dominant species in a waterbody as a result (Allen et al. 2002).	**Unlikely**. Preferred habitat may occur within the Study area, but there are no records within 50 km of the Study area.	**Unlikely**. Not detected during field surveys.	✓	✓			
Xiphophorus maculatus	Platy	Occurs in a few creeks and swamps around Queensland, favouring warmer, static waters (Allen et al 2002).	Competes with native fishes for resources. High fecundity and can quickly become the dominant species in a waterbody as a result (Allen et al. 2002).	**Unlikely**. Preferred habitat may occur within the Study area, but there are no records within 50 km of the Study area.	**Unlikely**. Species or species habitat not detected during field surveys.	✓	✓			✓

References:

- Inglis and Howell 2009, Aquatic Conservation Assessments using AquaBAMM for the riverine wetlands of the Great Barrier Reef catchment: Fitzroy region.
- Rollason and Howell 2012, Aquatic Conservation Assessments using AquaBAMM for the non-riverine wetlands of the Great Barrier Reef catchment: Fitzroy region
- Queensland Department of Environment and Science (DES) 2020a, Wetland*Info* – Fitzroy Basin – Wetland Summary Information.

4.9 Groundwater-dependent ecosystems

The EPBC Act lists 'a water resource, in relation to coal seam gas development and large coal mining development' as a MNES. A water resource is defined under the Commonwealth *Water Act 2007* and incorporates ecosystems that contribute to the physical state and environmental value of the water resource. As such, environmental assessments for large coal mines are required to identify the potential GDEs and assess and manage potential impacts to GDEs (Independent Expert Scientific Committee [IESC] 2018).

GDEs are classed as either:

- surface GDEs – ecosystems dependent on the surface expression of groundwater, including:
  - river-base flow systems – aquatic and riparian ecosystems that exist in or adjacent to streams (including the hyporheic zone) fed by groundwater;
  - wetlands – aquatic communities and fringing vegetation dependent on groundwater-fed lakes and wetlands, including palustrine, lacustrine and riverine wetlands that receive groundwater discharge and can include some spring ecosystems;
  - ecosystems which rely on submarine discharge of groundwater for nutrients and/or physico-chemical attributes;
- subterranean GDEs – aquifer and cave ecosystems; and
- terrestrial GDEs – Ecosystems dependent on subsurface presence of groundwater (refer to the Terrestrial Ecology Assessment).

4.9.1 Surface expression GDEs

Quaternary alluvium is distributed within the Middlemount Coal Mine from Roper Creek in the south to Thirteen Mile Gully in the north, and is comprised of clay, silt and sand (AGE 2018). Where it occurs, the alluvium is thin, usually less than 5 m (Parsons Brinkerhoff 2010, cited in AGE 2020). Groundwater levels at the site are typically deeper than 10 m below ground level, which is below the base of the alluvium, indicating that the alluvium is typically unsaturated (AGE 2018).

Desktop mapping of potential surface GDEs throughout Queensland (DES 2019c) indicates aquatic ecosystems with moderate potential for groundwater interaction may occur approximately 3.8 km south of the Study area and 6 km west of the Study area (Figure 16). These are further identified as 'moderate confidence' 'Quaternary alluvial aquifers overlying sandstone ranges with fresh, intermittent groundwater connectivity regime' (DES 2019c). Neither are hydraulically connected to the Study area. No surface GDEs are mapped for the Study area (DES 2019c).

The Queensland Wetlands Map (DES 2019b) indicates no wetlands mapped for the Study area.

There are no known springs or seeps within the Study area and no obligatory surface GDEs have been identified within the Study area. The nearest mapped spring is associated with the Blackdown Tablelands National Park approximately 100 km south-south-east of the Study area.

Regionally, groundwater flow within the underlying aquifers is towards the south east (AGE 2018). Groundwater levels are generally in excess of 25 mbgl and separated from surface waters, limiting potential to support surface GDEs (AGE 2018). There are no springs from these deep confined aquifers within the Study area or surrounds that would support surface GDEs (AGE 2018).

No surface expression of groundwater (nor any other surface water) was encountered within Roper Creek or Thirteen Mile Gully at the time of assessment in October 2019. Surface water was encountered within Roper Creek at each of four sites assessed in February 2020, approximately four weeks following a rainfall and runoff event. Distinct differences in surface water and groundwater ionic compositions in samples collected in February 2020 further highlight the unlikely interaction of surface water and groundwaters of the Study area (Figure 9 and Figure 10, Section 4.2.2).

Prolonged dry conditions in the lead-up to the October 2019 surveys provided ideal conditions for detecting groundwater surface expressions. However, no flows, salt seeps, hydrophytes or other obvious indicators of surface expression GDEs were encountered within the Study area. The October 2019 and February 2020 surveys identified species of semi-aquatic macrophytes typical of ephemeral drainage lines of the broader Fitzroy River catchment, with no evidence of river-base flow systems or groundwater-fed wetlands within the Study area.

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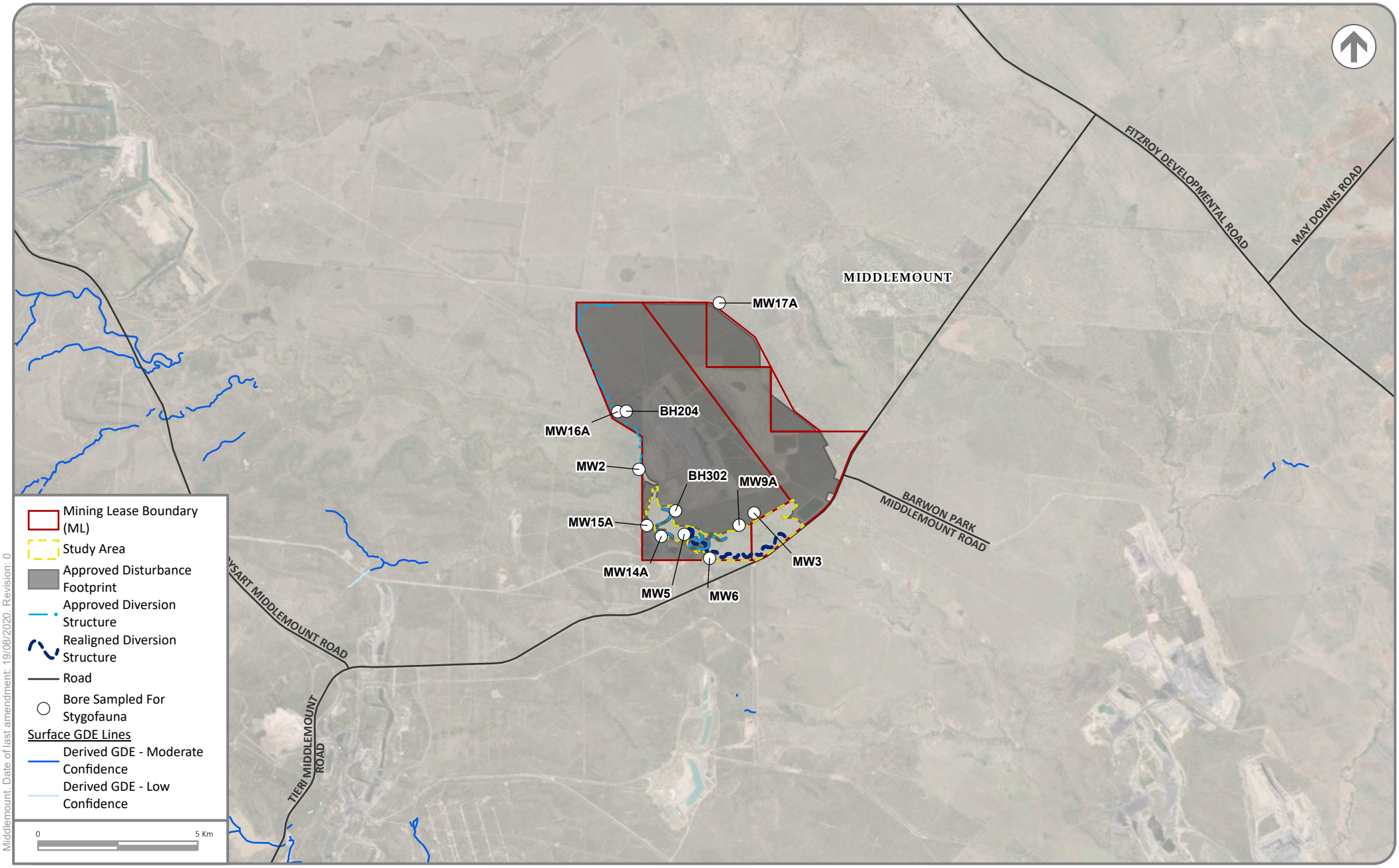

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DPM ENVIROSCIENCES

STATE MAPPED SURFACE EXPRESSION GROUNDWATER DEPENDENT ECOSYSTEMS

Middlemount Coal Mine Southern Extension Project

FIGURE 16

4.9.2 Subterranean GDEs

Desktop review results

As described in Section 3.4.2, the desktop review involved:

- assessing the suitability of local habitat for stygofauna based on local geological and hydrological conditions; and
- determining the presence and composition of stygofauna in the region and Study area based on previous studies.

Aquifers of the Study area

The surface geology of the Study area is dominated by Quaternary alluvium, with some Tertiary sedimentary rock in the south (Figure 17). This is underlain by Permian age coal measures. Broad-scale potential GDE aquifer mapping for Queensland (DES 2019c) identifies a 'low confidence' unconsolidated sedimentary aquifer beneath most of the Study area (Figure 18); more specifically, a 'Quaternary alluvial aquifer with fluctuating, intermittent groundwater connectivity regime and unknown pH'.

Site-specific assessments indicate that aquifers of the Study area and surrounds can be separated into the following three key hydro-stratigraphic units based on their hydraulic properties and lithology (AGE 2018):

- Quaternary alluvial aquifer – consists of localised stream channel deposits and associated floodplain 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. The Quaternary alluvium is not a productive aquifer within the Study area and no monitoring bores have been installed within the Quaternary alluvium.
- Tertiary Duaringa Formation aquifer / aquitard – 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 coal measures aquifer – the bulk of the Permian coal measures strata is sandstone, siltstone and mudstone (interburden / overburden) with typically low permeability, generally forming aquitards. Coal seams form low to moderate yielding aquifers confined by the interburden / overburden units.

Stygofauna Potential Presence

GHD conducted a stygofauna pilot study at Middlemount Coal Mine in 2012 in accordance with guidelines relevant at the time (WA EPA 2003 and WA EPA 2007, cited in GHD 2013). The sampling was undertaken to fulfil condition W69 of EA MIN100646307 at the time. The pilot study involved sampling ten bores within and surrounding the current Study area, detecting groundwater invertebrates in seven out of ten bores sampled, including:

- Cladocerans (water fleas) in the taxonomic family Chydoridae – a component of wetlands and still waterbodies with certain taxa also occurring in groundwater environments; however, the specimens collected had eyes, and are therefore not specifically adapted to permanently occupying the hyporheic or deep groundwater environments (GHD 2013).
- Copepods in the taxonomic family Cyclopidae – normally associated with fine to course sandy substrates of still water environments of rivers, wetlands, the hyporheic zone and shallow groundwaters (GHD 2013).

- Oligochaetes (segmented worms) in the family Naididae – members of the community that occurs within the shallow to deep sand and gravel beds associated with areas of groundwater discharge (Gilbert et al. 1994, cited in GHD 2013), representing a common group of worms existing in all Australian States and Territories (GHD 2013). However, subsequent studies now consider Oligochaetes as part of the soil fauna (Halse and Pearson 2014).

GHD (2013) concluded that the relative consistency of the faunal composition across the bores sampled suggests that the subterranean community diversity was naturally low, at least at the family level.

AGE (2018) conducted a groundwater assessment for the adjoining Western Extension Project, including consideration of bores installed up to 2015. AGE (2018) report that a number of bores around the MCM were sampled for stygofauna in 2011 (presumably by AGE). Invertebrate fauna from two classes / subclasses (Copepoda and Oligochaeta) were identified from bores in and outside the maximum zone of drawdown (e.g. some 5-7 km north-west and south-east) (AGE 2018). It is not known what bores AGE refer to. However, AGE (2018) concluded that the Western Extension Project is unlikely 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 subterranean fauna in and outside the maximum zone of drawdown (AGE 2018).

Previous studies undertaken by GHD (2013) and AGE (2018 [2011]) detected subterranean fauna (including potential stygofauna) in bores of the Study area and surrounds. Consequently, further sampling was undertaken with the aim of achieving better taxonomic resolution of any captured stygofauna required by the current guideline (DSITI 2015).

Stygofauna sampling results

Of the seven bores (MW2, MW4, MW5, MW5M, MW7M, TRI and DERM 1) determined by GHD (2013) to contain subterranean fauna in 2012, three were targeted for sampling in October 2019 – MW2, MW4 and MW5 (Table 5 and Table 20). Bores MW5M and MW7M were considered unsuitable for sampling, as although standing water levels of approximately 37 mbgl and 35 mgbl were encountered at the time of sampling in 2012, their screened intervals of 127-130 mbgl and 132-134.5 mbgl make them unsuitable. The invertebrate fauna collected from these bores is unlikely to reflect fauna in the aquifer. The location or construction details of TRI and DERM 1 could not be located in the Queensland Globe bore mapping, nor in the groundwater assessment (AGE 2018).

October 2019 sampling

A total of 11 groundwater bores were sampled for stygofauna in October 2019, as shown in Table 20. Standing water levels ranged from 8.57 mbgl at MW15A to 40.64 mbgl at MW5. pH levels ranged from 6.6 (neutral) at bore MW17A to 7.8 (mildly alkaline) at bore BH204 (Table 20). EC levels ranged from 5,261 µS/cm (slightly saline) at bore BH204 to 32,240 µS/cm (saline) at bore MW6.

The sample collected from bore MW2 contained segments of ants and subterranean termites. Bore MW3 contained segments of termites. Bore MW6 contained segments of ants. The sample collected from MW15A contained a terrestrial thrip (Thysanopteran), a segmented worm (Oligochaete) from the family Enchytraeidae, and two millipedes (Diplopods) from the family Paradoxosomatidae. The sample from bore MW17A contained a terrestrial springtail (Collembolan) from the family Isotomidae, as well as fragments of ants.

Although a number of invertebrates were identified from the samples collected in October 2019, no stygofauna were detected.

February 2020 sampling

Ten groundwater bores were sampled for stygofauna in February 2020, as shown in Table 21. Standing water levels ranged from 8.62 mbgl at MW15A to 45.01 at MW5. pH levels ranged from 6.3 (slightly acidic) at bore MW17A to 7.9 (moderately alkaline) at bore MW2 (Table 21). Specific conductivity levels ranged from 6,452 µS/cm (slightly saline) at bore MW16A to 31,846 µS/cm (saline) at bore MW6.

The sample collected from bore MW2 contained a terrestrial springtail (Collembolan) from the family Isotomidae and a soil-dwelling pseudo-centipede of the class Symphyla (Plate 2). Bore MW6 contained an astigmatid soil mite (Plate 2) and terrestrial invertebrate segments. Bore MW9A contained terrestrial insect head capsules. The sample collected from MW15A contained a toothed section of terrestrial invertebrate, possibly part of a cricket [Gryllactididae] leg. Bore MW17A contained another terrestrial insect segment.

Terrestrial Symphylan collected from bore MW2

Terrestrial astigmatid soil mite from bore MW6

Plate 2 Terrestrial invertebrates sampled from bores in the Study area, February 2020

Although a number of invertebrates were identified from the samples collected in February 2020, no stygofauna were detected.

The lack of Cladocerans (water fleas) and Copepods in the samples collected in October 2019 and February 2020 (when compared to those collected by GHD in December 2012) may be due to a number of factors, including varying climatic conditions affecting these common taxa known for their boom and bust cycles (James et al. 2008).

Table 20 Characteristics of groundwater monitoring bores sampled for stygofauna, October 2019

Bore ID^	Lithology at screened interval	Bore depth (mBGL)	Screen (mBGL)	SWL (mBGL)	Date sampled	pH	EC* (µS/cm)	Stygo. sampling	Notes
MW2^	Tertiary sandy clay and sand	27.37	21-29	17.51	15/10/19	7.01	9,254	✓	Six hauls off bottom. Purged by 4T 18/09/19.
MW3	Tertiary clay and sandy clay	46.80	39-47	23.56	16/10/19	6.86	22,682	✓	Six net hauls off the bottom of bore.
MW4^	Permian coal / weathered basalt	50.45	41-50	37.80	15/10/19	-	-	x	No sample. Impassable obstruction 27.5 mbgl.
MW5^	Permian coal	45.88	40-46	40.64	16/10/19	6.80	16,078	✓	Poor sample. Obstruction 35 mbgl. One bailer and one haul only.
MW6	Tertiary clay	41.15	37-42	28.98	16/10/19	6.89	32,240	✓	Six net hauls off the bottom of bore.
MW9A	Tertiary sandstone / siltstone	52.27	40-52	26.33	15/10/19	7.00	28,480	✓	Six net hauls off the bottom of bore.
MW11A	Tertiary clay / mudstone	13.47	10.5-13.5	Dry	15/10/19	-	-	x	No sample. Dry.
MW14A	Tertiary sand / mudstone	13.97	6-9	8.64	16/10/19	6.74	25,014	✓	Six net hauls off the bottom. Abundant root matter.
MW15A	Tertiary sand / sandy clay / mudstone	11.20	7-10	8.57	14/10/19	7.36	5,294	✓	Six net hauls off the bottom of bore.
MW16A	Tertiary sandstone	51.90	44-50	26.17	16/10/19	7.19	8,494	✓	Six net hauls off bottom. Coal fines. Sulphurous.
MW17A	Permian claystone / sandstone	42.68	36.5-42.5	35.95	15/10/19	6.55	19,116	✓	Six net hauls off the bottom of bore.
BH204	Tertiary sandy clay and mudstone	50.15	37.5-43.5	26.53	15/10/19	7.75	5,261	✓	Poor sample. Obstruction. One bailer and one haul only.
BH302	Tertiary sandstone	40.93	28.1-31.0	39.07	14/10/19	6.76	5,890	✓	Six net hauls off bottom. Sulphurous.

Notes: ^ Indicates bores in which subterranean fauna were detected by GHD in 2012 (GHD 2013); * EC = Electrical Conductivity, standardised to 25˚C (i.e. Specific Conductivity).

Table 21 Characteristics of groundwater monitoring bores sampled for stygofauna, February 2020

Bore ID^	Lithology at screened interval	Bore depth (mBGL)	Screen (mBGL)	SWL (mBGL)	Date sampled	pH	EC (µS/cm)	Ion sample	Stygo. sampling	Notes
MW2^	Tertiary sandy clay and sand	27.37	21-29	17.47	21/02/20	7.94	11,770	#	✓	Six hauls off bottom, then purged/filtered 20 L.
MW3	Tertiary clay and sandy clay	46.80	39-47	23.57	19/02/20	6.77	22,653	✓	✓	Six hauls off bottom, then purged/filtered 20 L.
MW4^	Permian coal / weathered basalt	50.45	41-50	38.18	21/02/20	6.79	21,683	x	x	Obstruction at about 40 mbgl.
MW5^	Permian coal	45.88	40-46	45.01	21/02/20	7.08	16,212	✓	✓	Net obstructed at 35 mbgl. 1.5 L extracted with bailer.
MW6	Tertiary clay	41.15	37-42	30.12	20/20/20	6.98	31,846	✓	✓	Six hauls off bottom, then purged/filtered 20 L.
MW9A	Tertiary sandstone / siltstone	52.27	40-52	27.01	20/02/20	7.18	27,938	✓	✓	Six hauls off bottom, then purged/filtered 20 L until dry.
MW14A	Tertiary sand / mudstone	14.00	6-9	9.06	21/02/20	6.84	30,182	✓	✓	Six hauls off bottom, then purged/filtered 9.5 L until dry.
MW15A	Tertiary sand / sandy clay / mudstone	11.18	7-10	8.62	20/02/20	7.42	7,250	✓	✓	Six hauls off bottom, then purged/filtered 13 L until dry.
MW16A	Tertiary sandstone	51.90	44-50	26.06	21/02/20	7.84	6,452	✓	✓	Six hauls off bottom, then purged/filtered 20 L.
MW17A	Permian claystone / sandstone	42.68	36.5-42.5	36.01	20/02/20	6.34	18,836	✓	✓	Six hauls off bottom, then purged/filtered 20 L.
BH302	Tertiary sandstone	40.93	28.1-31.0	39.24	20/02/20	6.86	8,018	✓	✓	Six hauls off bottom, then purged/filtered 3 L until dry.

Notes:

^ Indicates bores in which subterranean fauna were detected by GHD in 2012 (GHD 2013);

* EC = Electrical Conductivity, standardised to 25˚C (i.e. Specific Conductivity);

Sampled, but sample integrity compromised when left out of fridge; subsequently discarded.

Ecosystem value of potential subterranean GDEs

No stygofauna were detected in targeted sampling by DPM Enviros ciences within and surrounding the Study area in October 2019 and February 2020.

Previous studies undertaken by GHD (2013) and AGE (2018 [2011]) detected Oligochaetes (segmented worms), cladocerans (water fleas) and copepods in groundwater bores within the Study area and surrounds. GHD (2013) concluded that the relative consistency of the faunal composition across the bores sampled suggests that the subterranean community diversity was naturally low. Oligochaetes are no longer considered stygofauna (Halse and Pearson 2014). Cladoceran and copepod micro-crustacea are prevalent throughout waterways, wetlands, hyporheic zones and shallow groundwaters of Australia, and their detection in floodplain bores is not evidence of a subterranean GDE.

It is unlikely that subterranean GDEs occur within the Study area. However, should they occur, they would be attributed a Low Ecological Value based on the following considerations, consistent with Serov 2012:

- uniqueness – lack of distinct or unique features, animals or habitats that aren't otherwise found in the broader area;
- condition – unlikely to be considered natural, considering potential drawdown impacts associated with the adjoining approved mining operation;
- vital habitat – unlikely to provide vital habitat for species of conservation significance in Queensland;
- representativeness – unlikely to represent an especially outstanding example of a subterranean GDE.
- Lack of *High Ecological Value* or *Moderate Ecological Value* attributes identified by Serov (2012).

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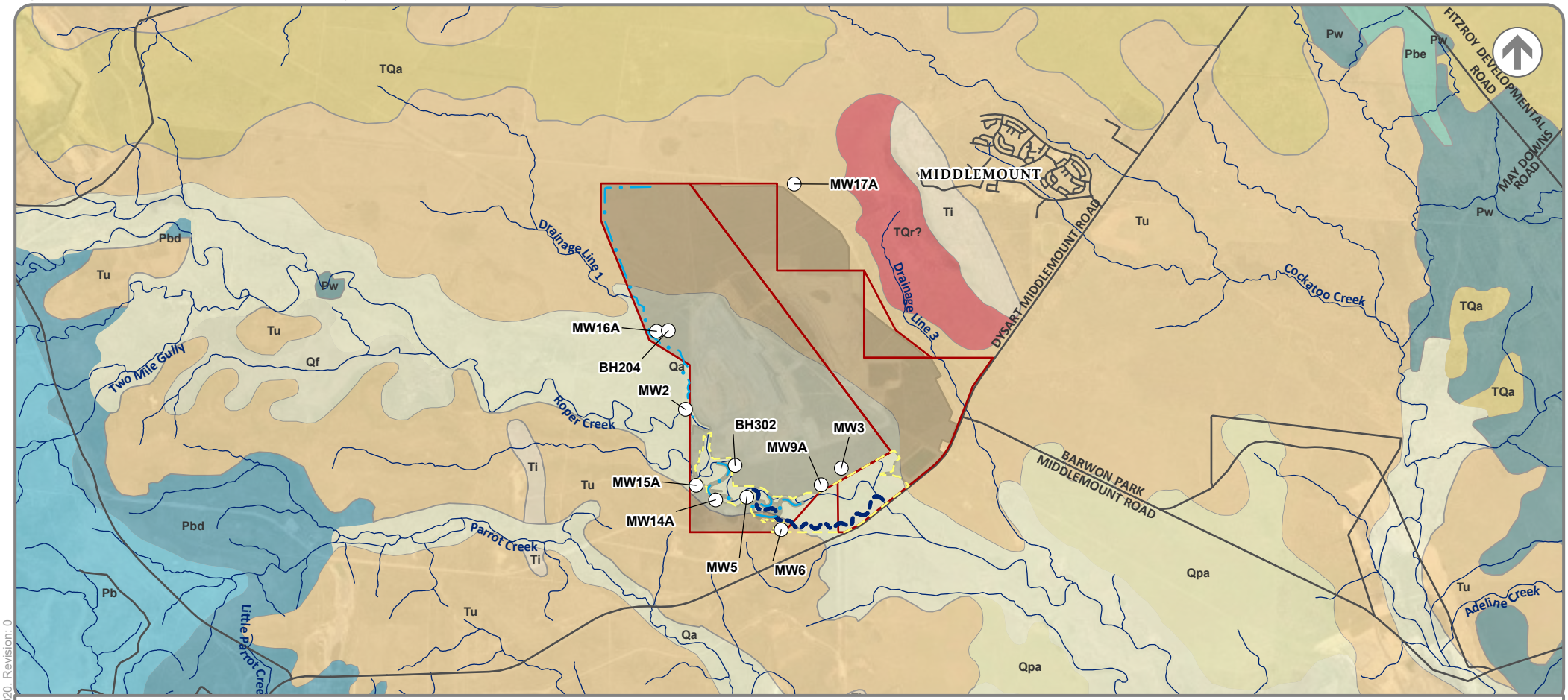

Mining Lease Boundary (ML)
Study Area
Approved Disturbance Footprint
Realigned Diversion Structure
Approved Diversion Structure
Bore Sampled For Stygofauna
Waterway
Road

Surface Geology

Pb - Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite

Pbd - Quartzose to sublabile, locally argillaceous sandstone, lithic and feldspathic sandstone, siltstone, mudstone, carbonaceous mudstone and coal

Pbe - Carbonaceous and micaceous labile sandstone, siltstone, shale, coquinite, minor conglomerate

Pw - Feldspathic and lithic sandstone, silty sandstone, calcareous sandstone, ashstone and cherty mudstone, carbonaceous mudstone and coal; commonly abundant plant fossils and fossil wood

Qa - Clay, silt, sand and gravel; flood-plain alluvium

Qf - Clay, silt, sand and clayey to sandy gravel; alluvial fans, sheetwash and floodout sheets

Qpa - Clay, silt, sand and gravel; flood-plain alluvium on high terraces

TQa - Locally red-brown mottled, poorly consolidated sand, silt, clay, minor gravel; high-level alluvial deposits (generally related to present stream valleys but commonly dissected)

TQr? - Clay, silt, sand, gravel, soil; colluvial and residual deposits

Ti - Intrusive rhyolite, trachyte and microsyenite

Tu - Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite, basalt

0 4 Km

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DPM ENVIROSCIENCES

SURFACE GEOLOGY AND STYGOFAUNA SAMPLING LOCATIONS

Middlemount Coal Mine Southern Extension Project

FIGURE 17

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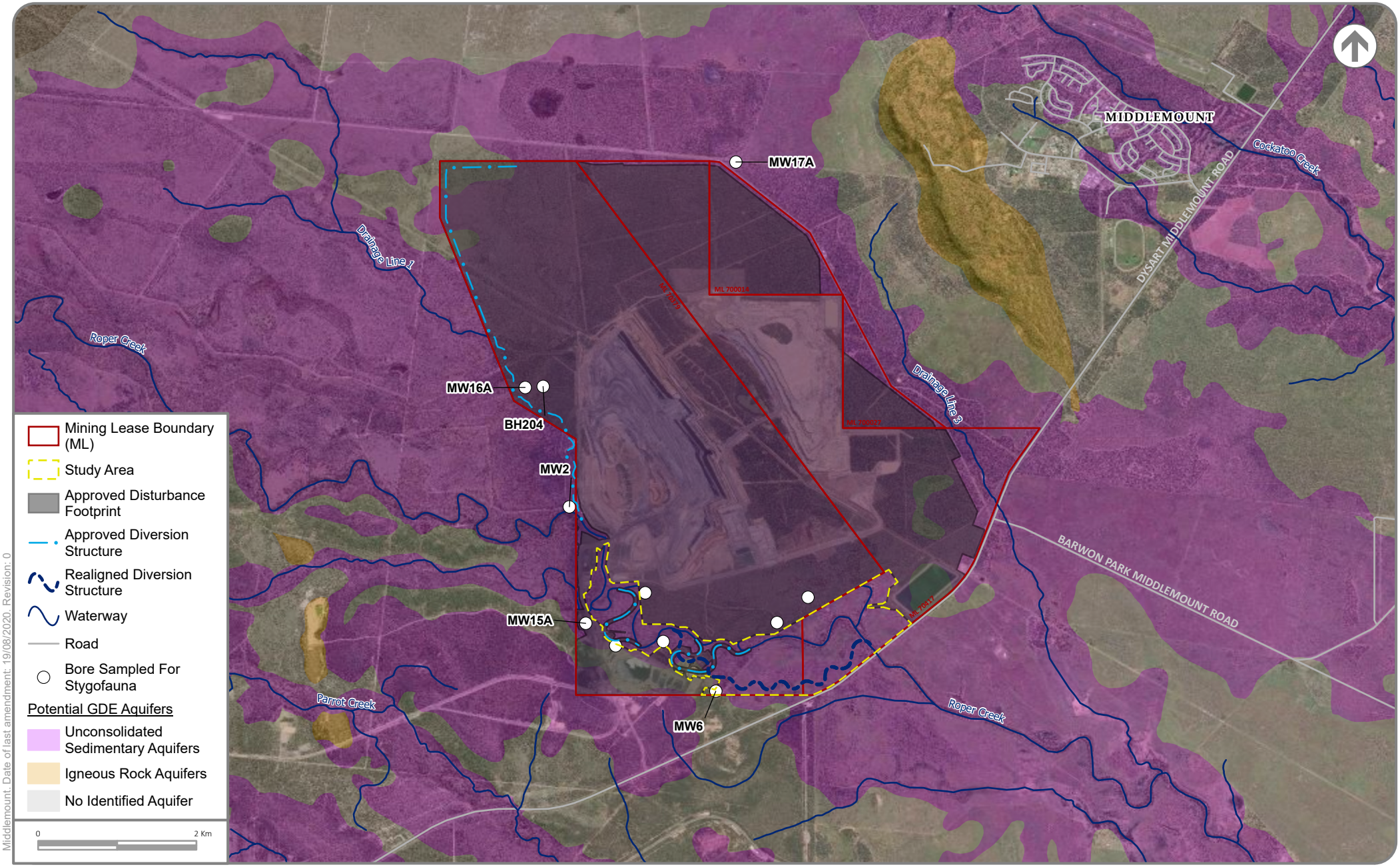

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STATE MAPPED POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEM AQUIFERS AND STYGOFAUNA SAMPLING LOCATIONS

Middlemount Coal Mine Southern Extension Project

FIGURE 18

4.10 Matters of National Environmental Significance

World and National Heritage properties

No World Heritage Properties or National Heritage Places are identified for the search area in the EPBC Act *Protected Matters Report* (DEE 2020a, Appendix A).

Wetlands of International Importance

No wetlands of International Importance are identified within the search area in the EPBC Act *Protected Matters Report* (DEE 2020a). Wetlands of International Importance nearest to the search area include those of the Shoalwater and Corio Bays Area, approximately 160 km east-north-east of the Study area. These wetlands are well removed from the Study area, and are hydraulically connected only with the Coral Sea.

Threatened Ecological Communities

No EPBC Act listed Threatened Ecological Communities (TECs), relevant to aquatic ecology, are identified from the search area (DEE 2020a). No aquatic TECs are expected to occur within the Study area, and none were identified during the field surveys.

Threatened species

No MNES aquatic flora or fauna were detected during surveys.

Aquatic faunal species that are MNES are 'likely' to occur in the broader desktop search area (DEE 2020a). This includes the Critically Endangered southern snapping turtle (*Elseya albagula*) and the Vulnerable Fitzroy River turtle (*Rheodytes leukops*), each listed under the EPBC Act. However, due to habitat requirements, it is unlikely these species occur within waterbodies of the Study area as either resident or transient occurrences since habitat for these species was not encountered within the Study area.

No MNES aquatic flora species are likely to occur within the Study area.

Migratory species

No aquatic migratory species (i.e. migratory species that live in water for most or all of their lives) were identified from the search area.

Commonwealth Marine Areas

The Study area is located approximately 120 km south-west of any marine area and is separated hydraulically by the Fitzroy River drainage sub-basin. Commonwealth marine areas are well removed from the Study area.

Nuclear actions (including uranium mines)

The Action does not involve any nuclear actions.

Water resource

A water resource, in relation to coal seam gas development and large coal mining development, has been indicated as a controlling provision in the referral decision notice for the Middlemount Coal Mine Southern Extension Project. It will be addressed in a separate report as per the Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals (IESC 2018).

4.11 Matters of State Environmental Significance

The environmental offsets framework in Queensland includes the *Environmental Offsets Act 2014* (EO Act), the *Environmental Offsets Regulation 2014* (EO Regulation) and the *Queensland Environmental Offsets Policy* (EO Policy). MSES are defined in the EO Regulation and are a component of the biodiversity state interest identified in the Queensland State Planning Policy.

A number of MSES were identified during the desktop review as occurring within the Study area. MSES of relevance to this aquatic ecology assessment comprise 'waterways providing for fish passage' (Table 22).

Table 22 Matters of State Environmental Significance

Prescribed Environmental Matter	Present in the Study area	Detail
Regulated vegetation	Yes	Refer to Terrestrial Ecology Assessment.
Connectivity areas	-	Refer to Terrestrial Ecology Assessment.
Wetlands and watercourses	No	The Study area does not contain any wetlands or watercourses in 'high ecological value waters' nor 'high ecological significance wetlands'.
Protected Wildlife Habitat	No	Refer to terrestrial ecology assessment.
Koala Habitat in South-East Queensland	No	The Study area is not located in South-east Queensland
Protected Areas	No	The Study area does not contain protected areas.
Fish Habitat Areas and Highly Protected Zones of State Marine Parks	No	The Study area is not located in a State Marine Park.
Waterway providing for fish passage	Yes	Waterways within the Study area provide for fish passage (Figure 8).
Marine Plants	No	The Study area is not located in a marine environment.
Secured Offset Area	No	The Study area does not contain legally secured offset areas.

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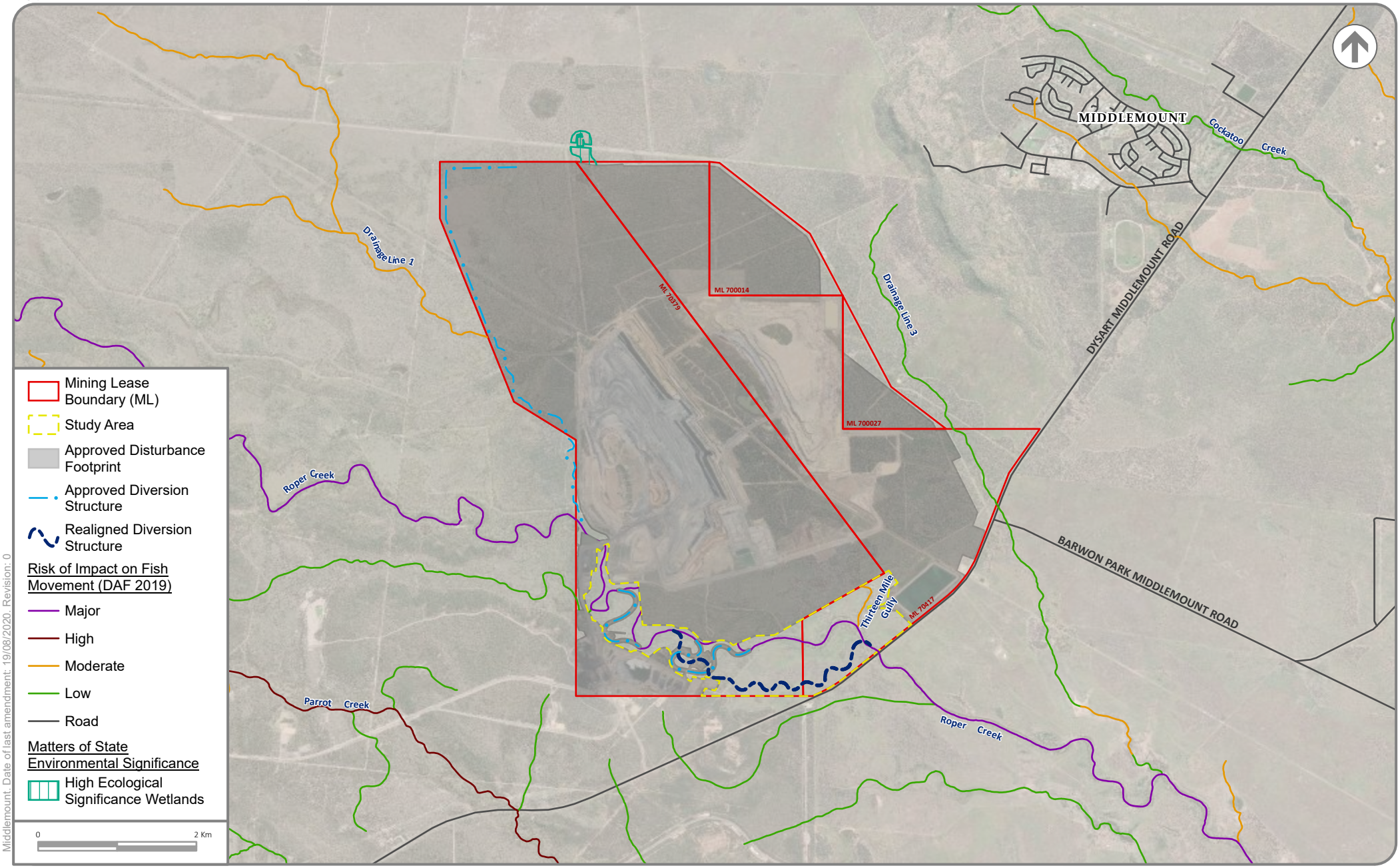

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DPM ENVIROSCIENCES

AQUATIC MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

Middlemount Coal Mine Southern Extension Project

FIGURE 19

5 POTENTIAL IMPACTS

5.1 Aquatic habitat clearance

The transient flow, lack of pools and lack of dry season refuge in the Project area limits the ability of Roper Creek and Thirteen Mile Gully to provide sustained habitat for native fish and turtles. These habitats are not expected to support aquatic species of conservation significance listed under the NC Act or EPBC Act, given the lack of suitable habitat features (Section 4.7). However, the Project would still remove or otherwise interfere with aquatic habitat in the Project area, comprising ephemeral watercourses and drainage lines.

5.1.1 Aquatic habitat

Direct impacts as a result of the Project would include the removal of aquatic and riparian habitat within an approximate 4.5 km reach of Roper Creek and development of a diversion for this section of Roper Creek, which would be approximately 3.8 km long. It is noted however that the approved Roper Creek Diversion 2 will remove approximately 1.9 km of aquatic and riparian habitat (i.e. the Project would result in an additional 2.6 km of Roper Creek being diverted).

The Project would also include removal of a small section (approximately 1 km) of the old Thirteen Mile Gully, the upstream catchment of which has previously been diverted along the western boundary of ML 70379 (Figure 8) (Section 4.1.1).

5.1.2 Aquatic flora

All aquatic floral species detected during the surveys are ‘Least Concern’ under the NC Act. No conservation significant aquatic floral species listed under the NC Act were detected within the Project area.

One Priority aquatic floral species was detected, being tall flatsedge (*Cyperus exaltatus*), recorded at each survey site. Tall flatsedge is considered a Priority species in non-riverine wetlands of the GBR catchments due to its tendency to form significant macrophyte beds, providing important habitat and a food source for fauna (Rollason and Howell 2012). Aquatic flora present within the Project area would be impacted by a loss of habitat along the 4.5 km impacted reach of Roper Creek, and the 1 km reach of Thirteen Mile Gully.

5.1.3 Aquatic fauna

All aquatic fauna species detected during the surveys are Least Concern under the NC Act. No aquatic fauna species listed under the NC Act, or Priority fauna species, were detected. Aquatic fauna present within the Project area would be impacted by a loss of habitat along the 4.5 km impacted reach of Roper Creek, and the 1 km reach of Thirteen Mile Gully.

The species detected within the Project area are common and have a broad distribution in the region. Hence, the removal of these habitat areas from the Project area is unlikely to have a significant impact on these species.

Waterways for fish passage

Roper Creek is mapped as being at ‘major’ risk of adverse impact from waterway barrier works on fish movement (Figure 8), necessitating the need for diverted stream reaches to be as similar to the existing channels as possible in accordance with Australian Coal Association Research Program (ACARP) stream diversion design criteria.

5.2 Surface water

Surface water quality and flows are relevant to the health and productivity of aquatic ecosystems. The following sections (5.2.1 and 5.2.2) discuss surface water and potential impacts of the Project on surface water from an ecological perspective. These sections draw on the key conclusions from the *Middlemount Coal Mine Southern Extension Project Surface Water Assessment* (WRM 2020) and the *Middlemount Coal Mine Southern Extension Project: Groundwater Impact Assessment* (AGE 2020).

5.2.1 Water quality

The physico-chemical water quality in Roper Creek is characterised by high and variable turbidity, moderate and variable EC, pH levels generally within the recommended range, and low DO concentrations at times (DPM Enviroscienses 2019). These fluctuations in physico-chemical water quality may be temporary in nature and may be explained by the ephemeral nature of Roper Creek, high intensity rainfall events, upstream activities or localised impacts from cattle accessing waterways, or a combination of these factors.

Erosion and Sedimentation

Contaminated runoff can impact receiving environments. An operation and monitoring plan would be developed for the proposed realignment of the Roper Creek Diversion 2 as part of detailed design. This plan would be consistent with the monitoring program previously developed for the existing Thirteen Mile Gully Diversion to address the potential for such impacts. A 'best practice' approach would be adopted which is consistent with the International Erosion Control Association Australasia (IECAA) recommendations. The following broad principles would apply:

- minimise the area of disturbance;
- where possible, apply local temporary erosion control measures;
- intercept runoff from undisturbed areas and divert around disturbed areas; and
- where temporary measures are likely to be ineffective, divert runoff from disturbed areas to sedimentation basins prior to release from the site.

If implemented effectively, water quality impacts are expected to be minimal and hence environmental risks to water quality from disturbed area runoff are expected to be low.

Mine Water Discharge

There are seven licensed release points that each discharge into Roper Creek, either directly or via an unnamed drainage feature upstream of Roper Creek (DES 2019f). No additional mine affected water discharge points are proposed.

Leaks and Spills

Leaks or spills of hydrocarbon-based fluids from construction equipment and spread of coal dust represents a potential risk to aquatic habitat downstream of the Project. However, Middlemount Coal Mine has well established procedures to handle inadvertent leaks and spills. Given the implementation of suitable management measures, including implementation of a spill response and appropriate water management system, there is a low risk of this event (or one similar) occurring. The Project is unlikely to result in leaks / spills that would eventuate in serious environmental harm to aquatic species or their habitat.

5.2.2 Water flow

The waterways of the Project area are ephemeral, only flowing after largely unpredictable rainfall and runoff, ceasing to flow within days, supporting aquatic life whose life cycles are adapted to these conditions (Section 4.1). Intermittent pools persist at some locations for a matter of weeks following a flow event. These surface flows are enough for some semi-aquatic plants and macroscopic animals to complete the aquatic stages of their life cycles, as well as allowing for fish passage upstream and downstream of the Project area.

The flow of water in Roper Creek would be affected by the construction of a permanent watercourse diversion. During active mining operations, the mine water management system would capture runoff from areas that would have previously flowed to Roper Creek. The maximum captured catchment areas represent less than 0.3% (WRM 2020) of the Roper Creek catchment to the downstream boundary of the Middlemount Coal Mine.

5.3 Groundwater dependent ecosystems

5.3.1 Surface expression GDEs

No indicators of surface expression GDEs were encountered within the Study area as part of the desktop assessment or field surveys (Section 4.9.1). Desktop mapping of potential surface expression GDEs throughout Queensland (DES 2019c) indicates that aquatic ecosystems with moderate potential for groundwater interaction may occur approximately 3.8 km south of the Project area and 6 km west of the Project area (Figure 16). These are further identified as ‘moderate confidence’ ‘Quaternary alluvial aquifers overlying sandstone ranges with fresh, intermittent groundwater connectivity regime’ (DES 2019c). Since, neither are hydraulically connected to the Project area, no measurable impacts on these or other potential surface expression GDEs are likely to occur.

5.3.2 Subterranean GDEs

No stygofauna were detected from targeted sampling within and surrounding the Study area (Section 4.9.2). It is unlikely that subterranean GDEs occur within the Study area. However, should they occur, they would be attributed a Low Ecological Value based on considerations of Serov 2012 (Section 4.9.2).

The Project is unlikely to significantly impact stygofauna, considering the Project would only incrementally increase the groundwater drawdown from the approved mine (AGE 2020), the groundwater aquifer (similar potential habitat) is extensive outside of the maximum zone of drawdown, and the non-detection suggests that stygofauna are unlikely to occur within the Project area.

5.4 Cumulative impacts

The Project is located within the headwaters of the Mackenzie River drainage sub-basin of the greater Fitzroy Basin. The major rivers and tributaries of the Fitzroy catchment include the Fitzroy, Dawson, Nogoa, Comet, Isaac and Mackenzie Rivers.

Roper Creek transects the Project area, as does Thirteen Mile Gully and an unnamed tributary, both of which flow into Roper Creek. Downstream of Middlemount Coal Mine, Roper Creek passes through Foxleigh Coal Mine which flows into Oaky Creek approximately 37 km downstream of the Project area, before reaching the Mackenzie River approximately 20 km further downstream.

The site water management system has been designed such that the risk of off-site uncontrolled release of mine affected water during operations will be very low and sediment inputs can be controlled through drainage, and erosion and sediment control measures. On this basis, the Project is not expected to make a significant contribution to cumulative sediment loads in the Fitzroy River Basin (WRM 2020).

Given that the Project mine affected water releases would be managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the Project is expected to have negligible cumulative impact on surface water quality and associated aquatic habitat values (WRM 2020).

The Project is unlikely to result in a significant cumulative impact to the aquatic flora and fauna of the Mackenzie River system, given the limited potential impacts associated with the Project and the implementation of mitigation and management measures described in Section 6.

5.5 Impacts on Matters of National Environmental Significance

There were no MNES related to aquatic ecology recorded within the Project area or surrounds. As such, it is concluded that the Project is unlikely to have a significant impact on MNES relevant to aquatic ecology.

5.6 Impacts on Matters of State Environmental Significance

The Queensland Environmental Offsets Policy Significant Residual Impact Guideline (DEHP 2014) is used to determine if a prescribed activity would have a significant residual impact on MSES. A significant residual impact is defined as an adverse impact, whether direct or indirect, of a prescribed activity on all or part of a prescribed environmental matter that:

a) remains, or will or is likely to remain (whether temporarily or permanently), despite on-site avoidance and mitigation measures for the prescribed activity; and

b) is, or will or is likely to be significant.

There is one potential MSES relevant to aquatic ecology that is known to occur in the Project area that may be subject to impacts from the Project, being Waterways Providing for Fish Passage (Section 4.11). Potential impacts on this MSES is discussed below.

Table 23 Waterways Providing for Fish Passage Significant Residual Impact Assessment

Criteria	Assessment / consideration
An action is likely to have a significant impact on a waterway providing fish passage if there is a real possibility that the action will:	
Result in the mortality or injury of fish	The Project is unlikely to result in barriers that cause the mortality or injury of native fish because: ▪ waterway (including diversion channel) crossings would be constructed with consideration to fish passage requirements in the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF 2017), so as not to create a barrier to fish movement; and ▪ the diversion of Roper Creek would be sensitively designed to replicate natural features where possible and provide similar conditions to the original waterway, including stream hydraulics, geomorphology, instream habitat, bank profiles and bank vegetation, to provide habitat and refuge for fish inhabiting or passing through the diversion of Roper Creek.
Result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage such as through the depletion of fishes energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish.	The Project is unlikely to result in conditions that would substantially increase risks to the health, wellbeing and productivity of fish seeking passage because: ▪ waterway (including diversion channel) crossings would be constructed so as not to create a barrier to fish movement; and ▪ the diversion of Roper Creek would be designed to replicate similar conditions to the original waterway, including stream hydraulics, geomorphology, instream habitat, bank profiles and bank vegetation, to provide habitat and refuge for fish inhabiting or passing through the diversion of Roper Creek.
Reduce the extent, frequency or duration of fish passage previously found at a site.	The Project is unlikely to reduce the extent, frequency or duration of fish passage because: ▪ waterway (including diversion channel) crossings would be constructed with consideration to the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF 2017), so as not to create a barrier to fish movement; and ▪ the diversion of Roper Creek would be sensitively designed to replicate natural features where possible and provide similar conditions to the original waterway, including stream hydraulics, geomorphology, instream habitat, bank profiles and bank vegetation, to provide habitat and refuge for fish inhabiting or passing through the diversion of Roper Creek. Further, the Surface Water Assessment (WRM 2020) concludes that the loss of catchment flows due to the Project in Roper Creek would be indiscernible.
Substantially modify, destroy or fragment areas of fish habitat (including, but not limited to in-stream vegetation, snags and woody debris, substrate, bank or riffle formations)	Roper Creek (mapped as 'Major risk' of impact on fish movement) would be diverted to the south of its existing alignment to allow for mining operations in this area (Figure 2). This diversion is unlikely to result in a significant impact to fish passage given the proposed diversion would be sensitively

Criteria	Assessment / consideration
necessary for the breeding and/or survival of fish.	designed to replicate natural features where possible and to simulate aquatic habitat attributes of the affected reach of Roper Creek and allow the free passage of fish both upstream and downstream in a safe manner.
Result in a substantial and measurable change in the hydrological regime of the waterway, for example, a substantial change to the volume, depth, timing, duration and frequency of flows.	Surface water hydrology would be slightly altered by the Project as a result of capturing water in dams, water loss due to use for Project operation or pond evaporation, and releasing water during flow events. The volume, depth, timing, duration and frequency of flows would continue to reflect the ephemeral and variable flow nature of Roper Creek. The seasonality of fish movements is unlikely to be affected.
Lead to significant changes in water quality parameters such as temperature, dissolved oxygen, pH and conductivity that provide cues to movement in local fish species.	The Project is unlikely to lead to an abrupt or otherwise significant change in water quality parameters that would be expected to cue local fish movement. Any water releases required by the Project would continue to be managed in accordance with the EA Conditions (DES 2019f). The risk of deteriorating water quality would be mitigated by monitoring stream and release water quality and quantity in accordance with the EA.

6 MITIGATION MEASURES

Consistent with DES' management hierarchy, the mitigation strategy for the Project has focused on a hierarchy of:

1. avoidance;
2. minimisation;
3. mitigation; then
4. offset residual impacts.

The avoidance or minimisation of adverse impacts is most relevant to the design phase of the Project, where information collected through desktop analysis and field surveys can be incorporated into the planning and preliminary engineering work (Section 6.1). Mitigation of impacts (including the implementation of monitoring and management plans) is most relevant to the construction and operational phases of the Project. Table 24 provides a summary of the mitigation strategies for the Project, with a brief description of potential impacts and measures that can be implemented at each stage in the life of the Project.

No offset requirements relevant to aquatic ecology have been identified for the Project.

6.1 Measures to avoid and minimise impacts

The following measures would be implemented to avoid and / or minimise impacts on aquatic ecology:

- The Conceptual Southern Extension Footprint (Figure 2) incorporates sufficient area for a meandering diversion of Roper Creek within the ML to replicate natural features and provide similar conditions to the original waterway, including stream hydraulics, geomorphology, instream habitat, bank profiles and bank vegetation.
- The location of the mine and pits are informed by geological surveys and largely determined by the location of the natural resource, as a result the location of mine impacts are relatively inflexible. The Roper Creek diversion, however, has been avoided in the mine design and a minimum buffer of 200 m between the open cut pit extension and the Roper Creek diversion (defined bank) has been implemented.

6.2 Impact mitigation

Mitigation measures proposed to be implemented for the Project are detailed in Table 24.

Table 24 Mitigation measures

Potential impact	Mitigation measures
1. Aquatic habitat clearing	▪ Clearing of native vegetation undertaken progressively over the life of the mine and only in areas required for mining activities within the following year. This would have the effect of minimising the area of exposed land. ▪ The diversion of Roper Creek would be designed to replicate natural features where possible and provide similar conditions to the original waterway. ▪ Implement a Diversion Monitoring Program for Roper Creek, including: – monitoring of bed conditions following flow events; and – measures to monitor the success of the diversion channel design and construction, including post-construction survey of aquatic and riparian vegetation composition to demonstrate that effective cover has been achieved. ▪ Use of existing infrastructure and facilities to avoid the need for additional clearance works. ▪ Update and implement the Environmental Management Plan (EMP) (MCPL 2018) to include vegetation management measures, including: – demarcate exclusion zones to protect areas of vegetation to be retained prior to clearing; and – clearing of native vegetation to be undertaken progressively. ▪ Implement the Erosion and Sediment Control Plan (WRM 2019a), and: – where possible, construction works to be undertaken in the drier months of the year when rainfall and runoff is less likely. ▪ Update and implement the EMP (MCPL 2018) to include fauna species management measures, including: – use of suitable fauna spotter-catchers for relocation of animals, including any native fish isolated in the original channel when commissioning the Roper Creek diversion channel; – habitat retention and replacement, where possible; and – salvage of microhabitat features (e.g. boulders and logs) from the impacted reach of Roper Creek for use in the Roper Creek diversion channel. ▪ Temporarily clearing native vegetation, excavating, or placing fill in a watercourse necessary for and associated with mining operations would be undertaken in accordance with DNRM's (2012) *Guideline – Activities in a Watercourse, Lake or Spring Associated with Mining Operations*.
2. Removal of fish passage	▪ Design and construct waterway (including diversion channel) crossings with consideration to the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF 2017).
3. Alteration to surface water quality and / or quantity	▪ Controlled release of treated water from sediment dams (designed in accordance with the Best Practice Erosion and Sediment Control [IECAA 2008]) to the downstream environment would only occur in accordance with the EA conditions which is unlikely to have a measurable impact on receiving water quality. ▪ Continued monitoring of surface water quality for receiving water to be undertaken in accordance with the EA. ▪ Implement the Receiving Environment Monitoring Program (DPM Enviros ciences 2019).

Potential impact	Mitigation measures
	▪ Implement the Water Management Plan (WRM 2019b).
4. Surface runoff and sedimentation	▪ Installation of permanent drainage waste rock emplacement areas to minimise capture of surface runoff into the final voids and areas rehabilitated allowed to drain back to Roper Creek. ▪ Implementation of sediment dams to capture runoff. ▪ Sediment dam monitoring to be undertaken to validate the anticipated quality of water runoff to sediment dams.
5. Inundation	▪ Changes to the existing flood protection levee to prevent inundation of the open cut throughout the life of the project.
6. Alteration to groundwater quality	▪ Coal rejects continuously placed with overburden in the open cut pits and progressively rehabilitated during mining to minimise and mitigate generation of acid over time. ▪ A groundwater monitoring network has been established which includes groundwater level and quality monitoring locations within and surrounding the mine site, in accordance with the EA.
7. Chemical contamination	▪ All chemicals would be transported, handled and stored in accordance with relevant Australians Standards. The controls that will be implemented represent standard practice and a legislated requirement at mine sites for preventing the contamination.
8. Pest invasions (flora and fauna)	▪ Restrict or reduce existing infestations. ▪ Avoid introduction of new weeds to the Project area. ▪ Update and implement the EMP (MCPL 2018) to include pest management measures.

7 CONCLUSION

The scope of this assessment was to describe the aquatic values, identify any conservation significant aquatic species under the NC Act and EPBC Act, to identify the presence of surface expression or subterranean GDEs, identify and describe any MSES and MNES; and to identify proposed impact avoidance and mitigation measures to protect natural values.

Aquatic ecology surveys were undertaken in accordance with the AusRivAS protocols for Queensland streams. In addition, the Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITI 2015) and the *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems* (Doody et al. 2019) were applied and a desktop review was undertaken to assist in determining the likelihood and significance of surface expression and subterranean GDEs potentially occurring within the Study area. The assessment of subterranean GDEs was supplemented by sampling of 11 representative bores in October 2019 and 10 representative bores in February 2020.

The waterways of the Project area are ephemeral and experience flow only after sustained or intense rainfall and runoff in the catchment. The streambed of Roper Creek is comprised of unconsolidated (loosely arranged and unpacked) sands and silts forming a relatively flat stream bed void of pool or riffle sequences. The transient flow, lack of pools and lack of dry season refuge limits the ability of Roper Creek to provide sustained habitat for native fish and turtles. Thirteen Mile Gully has a smaller catchment, although a more consolidated silt and clay stream bed, providing a more natural channel profile. Following a flow event, wetted habitat is likely to persist in pools located on Thirteen Mile Gully for longer duration than Roper Creek. Roper Creek and Thirteen Mile Gully may provide temporary foraging habitat for common (Least Concern) native fish and turtle species, and limited breeding habitat for native fishes adapted to these transient flow conditions.

Waterways providing for fish passage are a MSES only if the construction, installation or modification of waterway barrier works will limit the passage of fish along the waterway. As part of the Project, Roper Creek Diversion 2 (an approved diversion) would need to be realigned to allow for the southern extension of the open cut within ML 70379. A diversion is proposed for Roper Creek to maintain its ecological function, including for fish habitat and passage. The diversion would be constructed and commissioned prior to impacting the affected reach of Roper Creek. Consequently, the Project is not expected to result in a significant impact on fish passage. Other potentially relevant MSES are addressed in the terrestrial ecology assessment.

There are no wetlands of International Importance, National Importance or High Ecological Significance within the Study area. No conservation significant aquatic flora or fauna species listed under the NC Act and / or EPBC Act were recorded within the Study area, nor are they expected to occur considering their required habitats are not present. In addition, no MNES relevant to aquatic ecology were identified.

Field surveys in October 2019 and February 2020 found no evidence of river-base flow systems or groundwater-fed wetlands in the Study Area. No potential surface GDEs are mapped in the Queensland GDE mapping (DES 2019c) for the Study area, nor are they likely to occur. Quaternary alluvium is distributed within the Middlemount Coal Mine from Roper Creek in the south to Thirteen Mile Gully in the north, and is comprised of clay, silt and sand (AGE 2018). Where it occurs, the alluvium is thin, usually less than 5 m (Parsons Brinkerhoff 2010, cited in AGE 2020). Groundwater levels at the site are typically below the base of the alluvium, indicating that the alluvium is typically unsaturated (AGE 2018).

No stygofauna were detected in a pilot survey conducted within and surrounding the Study area in October 2019 and February 2020. It is unlikely that subterranean GDEs occur within the Study area. The Study area is already subject to groundwater impacts and its aquifers are unlikely to represent particularly natural or unique habitat for stygofauna that doesn't otherwise occur in the broader area. Accordingly, in the unlikely event that subterranean GDEs do occur in the Study area or surrounds, they would be attributed a low ecological value. Further, any impacts would be insignificant when placed in the context of the wider extent of similar habitat.

Indirect impacts that have been considered in this assessment include potential impacts associated with changes in water quality, hydrological changes, impacts to groundwater dependant ecosystems and potential cumulative impacts. It is concluded that the Project is unlikely to have a significant impact on aquatic ecology as a result of these potential indirect impacts.

In conclusion, the Project is unlikely to result in a significant impact on any MNES or MSES, including conservation significant aquatic species listed under the NC Act and EPBC Act, aquatic ecological communities or their habitats.

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WRM 2020, *Middlemount Coal Mine Southern Extension Project Surface Water Impact Assessment.*

Appendix A: EPBC Act Protected Matters Report

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

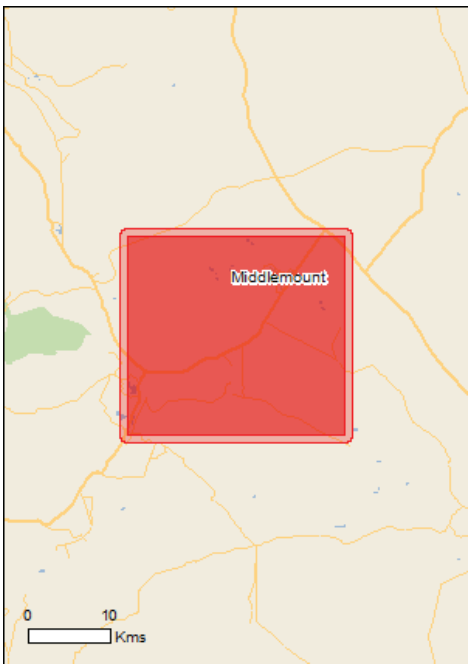
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 10/03/20 13:16:43

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



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Coordinates
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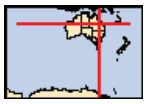

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	24
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum King Blue-grass [5481]	Endangered	Species or species habitat may occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Lerista allanae Allan's Lerista, Retro Slider [1378]	Endangered	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-22.77294 148.53829,-22.77294 148.77362,-22.97187 148.77362,-22.97187 148.53829,-22.77294 148.53829

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix B: Aquatic Survey Site Profiles

Season: Dry

Site Code: R1 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8758 **Longitude:** 148.6715 **Date:** 14/10/2019

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; dry at the time of assessment; well defined bed and banks; some local catchment erosion (gullying); infilled channel as a result of extensive sand deposition; bank shape convex; banks moderately stable; vegetative stability excellent; bankfull width approx. 30 m and bankfull height approx. 5 m; lacking in-stream habitat features; bed substrates comprised approximately 1% pebble (4-64 mm), 4% gravel (2-4 mm) and 95% sand (0.05-2 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but no evidence of current grazing.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as non-remnant; riparian zone approximately 20 m on the left bank and 20 m on the right, with sparse woodland dominated by Queensland blue gum (*Eucalyptus tereticornis*), with abundant river oak (*Casuarina cunninghamiana*); adjoining plain dominated by poplar box (*Eucalyptus populnea*); very sparse shrub layer, including wilga (*Geijera parviflora*), dead finish (*Archidendropsis basaltica*), currant bush (*Carissa ovata*) and velvet tree pear (*Opunita tomentosa*)*; ground layer of upper bank dominated by buffel grasss (*Cenchrus ciliaris*)*, with occasional kangaroo grass (*Themeda triandra*), *Sida* sp. and black spear grass (*Heteropogon contortus*); ground layer of lower bank dominated by common couch (*Cynodon dactylon*) and speargrass (*Heteropogon* sp.), with frequent spiny-head mat-rush (*Lomandra longifolia*), occasional kangaroo grass, bluegrass (*Bothriochloa* sp.), lesser joyweed (*Alternanthera denticulata*), *Sporobolous* sp. and Mexican poppy (*Argemone ochroleuca*)*; semi-aquatic macrophytes included little (1-10%) tall flatsedge (*Cyperus exaltatus*).

Erosion risk

Moderate – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered – NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). However, the study reach is unlikely to provide suitable habitat for these species.

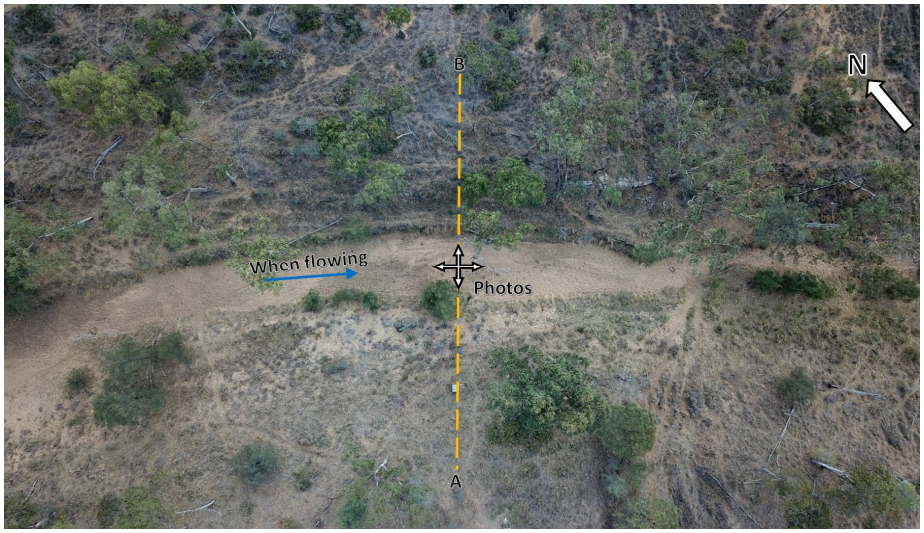
Physico-chemical water quality

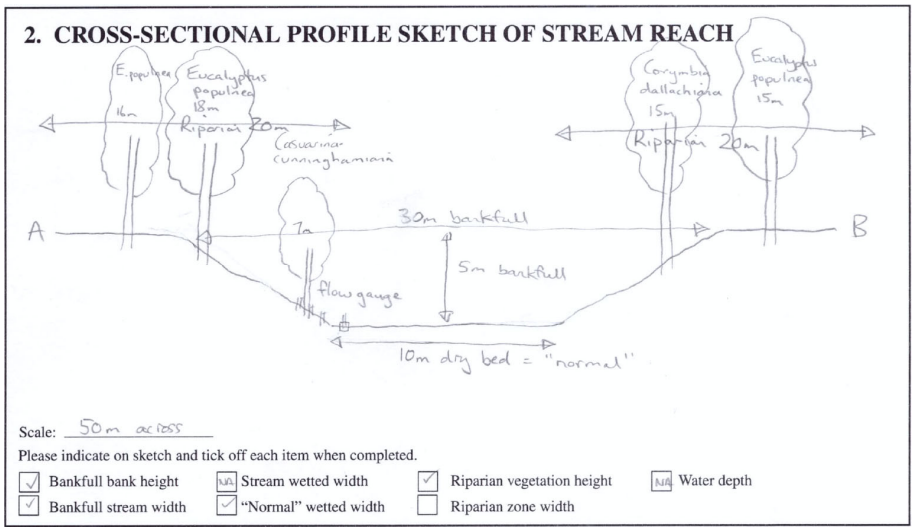
Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Poor (33).

Overall aquatic values – Dry season: **Moderate**.





Season: Wet

Site Code: R1 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8758 **Longitude:** 148.6715 **Date:** 18/02/2020

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; isolated shallow pools at the time of assessment; well defined bed and banks; some local catchment erosion (gullying); infilled channel as a result of extensive sand deposition; bank shape convex; banks moderately stable; vegetative stability excellent; bankfull width approx. 30 m and bankfull height approx. 5 m; in-stream habitat features included shallow (<0.5 m deep) pools; bed substrates comprised approximately 1% pebble (4-64 mm), 4% gravel (2-4 mm) and 95% sand (0.05-2 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but no evidence of current grazing.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as non-remnant; riparian zone approximately 20 m on the left bank and 20 m on the right, with sparse woodland dominated by Queensland blue gum (*Eucalyptus tereticornis*), with abundant river oak (*Casuarina cunninghamiana*); adjoining plain dominated by poplar box (*Eucalyptus populnea*); very sparse shrub layer, including wilga (*Geijera parviflora*), dead finish (*Archidendropsis basaltica*), currant bush (*Carissa ovata*) and velvet tree pear (*Opunita tomentosa*)*; ground layer of upper bank dominated by buffel grasss (*Cenchrus ciliaris*)*, with occasional kangaroo grass (*Themeda triandra*), *Sida* sp. and black spear grass (*Heteropogon contortus*); ground layer of lower bank dominated by green panic (*Megathyrsus maximus*)* and common couch (*Cynodon dactylon*), with frequent blady grass (*Imperata cylindrica*), speargrass (*Heteropogon* sp.) and spiny-head mat-rush (*Lomandra longifolia*), occasional kangaroo grass, bluegrass (*Bothriochloa* sp.), lesser joyweed (*Alternanthera denticulata*), *Sporobolous* sp. and poison pratia (*Pratia concolor*); semi-aquatic macrophytes included little (1-10%) *Cyperus victoriensis*, tall flatsedge (*Cyperus exaltatus*) and white eclipta (*Eclipta prostrata*)*.

Erosion risk

Moderate – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

The reach provides foraging habitat for fish. Unlikely foraging habitat for turtles or platypus. Unlikely breeding habitat for fish, turtles or platypus. Aquatic vertebrate fauna detected by backpack electrofishing and overnight deployment of two baited fyke nets and five baited box traps included juvenile spangled perch (*Leiopotherpon unicolor*), eastern rainbowfish (*Melanotaenia splendida*) and Hyrtl's tandan (*Neosilurus hyrtlii*).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered – NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). However, the study reach is unlikely to provide suitable habitat for these species.

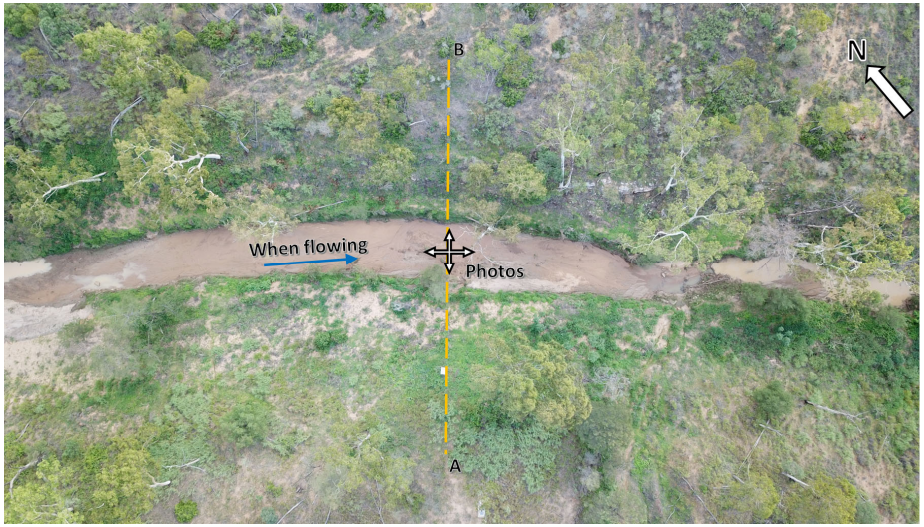
Physico-chemical water quality

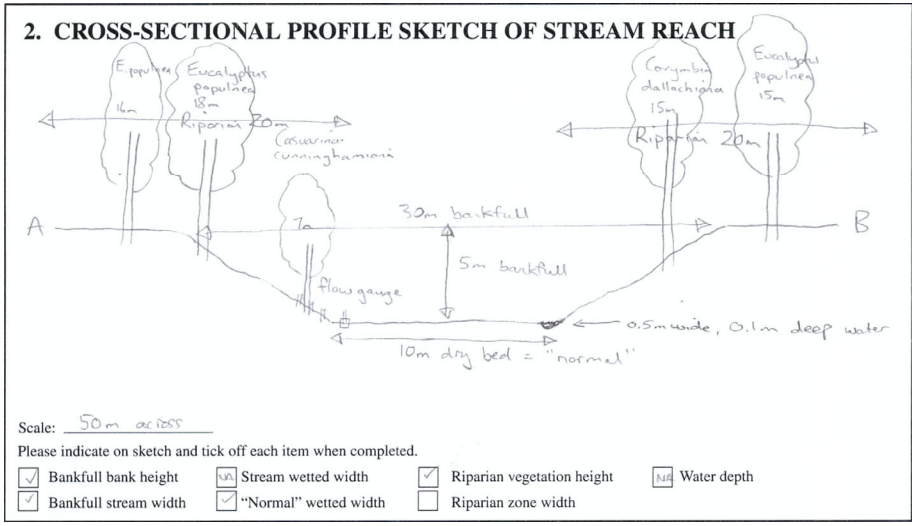
Collection time: 07:55; water temp.: 26.9˚C; specific conductivity: 290 µS/cm (fresh); turbidity: 390 NTU (poor clarity); dissolved oxygen: 51.9%, 4.1 mg/L (low, but typical for time of day); pH: 7.4 (mildly alkaline). Comments: Normal.

Bioassessment scores

Habitat assessment score for dry season: Fair (39).

Overall aquatic values – Wet season: **Moderate**.





Season: Dry

Site Code: R2 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8754 **Longitude:** 148.6575 **Date:** 14/10/2019

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; dry at the time of assessment; well defined bed and banks; no local catchment erosion detected; infilled channel as a result of extensive sand deposition; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 80 m and bankfull height approx. 10 m; lacking in-stream habitat features; bed substrates comprised approximately 3% gravel (2-4 mm), 92% sand (0.05-2 mm) and 5% silt/clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 35 m on the left bank and 35 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with frequent river oak (*Casuarina cunninghamiana*), occasional carbeen (*Corymbia tessellaris*) and Dallachy's gum (*C. dallachiana*); adjoining plain dominated by poplar box (*E. populnea*); very sparse shrub layer, including whitewood (*Atalaya hemiglauca*), sally wattle (*Acacia salicina*), bean tree (*Cassia brewsteri*) and red bauhinia (*Lysiphyllum carronii*); ground layer of the upper bank dominated by buffel grasss (*Cenchrus ciliaris*)*, with frequent cobbler's pegs (*Bidens pilosa*)*, *Sida* sp. and shrubby stylo (*Stylosanthes scabra*)*; ground layer of the lower bank dominated by speargrass (*Heteropogon* sp.), with frequent spiny-head mat-rush (*Lomandra longifolia*) and bluegrass (*Bothriochloa* sp.); semi-aquatic macrophytes included little (1-10%) tall flatsedge (*Cyperus exaltatus*), willow primrose (*Ludwigia octovalvis*) and white eclipta (*Eclipta prostrata*)*.

Erosion risk

Low – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered – NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). However, the study reach is unlikely to provide suitable habitat for these species.

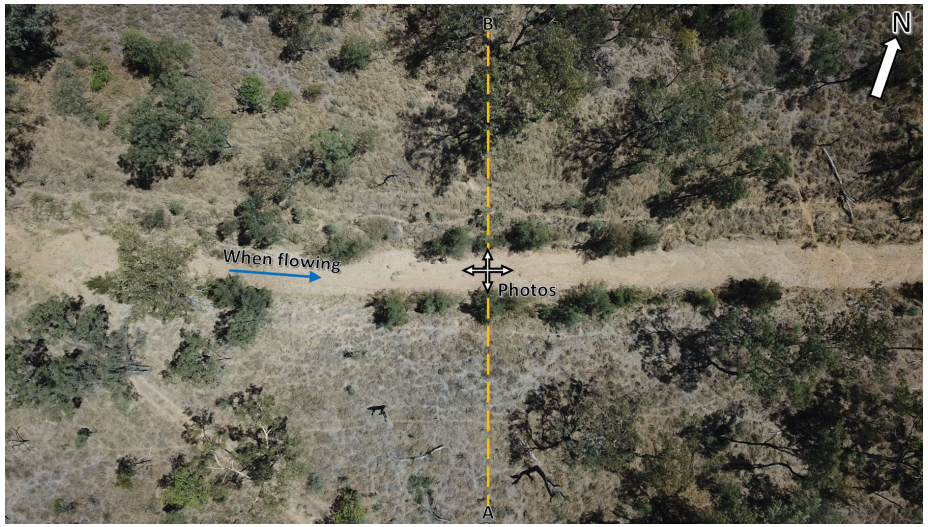
Physico-chemical water quality

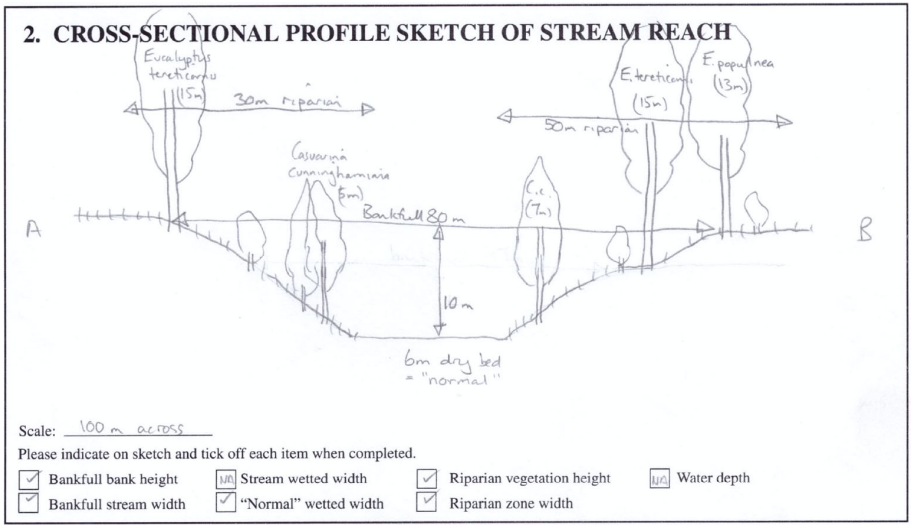
Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Poor (31).

Overall aquatic values – Dry season: **Moderate**.





Season: Dry

Site Code: R2 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8754 **Longitude:** 148.6575 **Date:** 19/02/2020

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; isolated shallow pools at the time of assessment; well defined bed and banks; no local catchment erosion detected; infilled channel as a result of extensive sand deposition; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 80 m and bankfull height approx. 10 m; in-stream habitat features include shallow pools; bed substrates comprised approximately 3% gravel (2-4 mm), 92% sand (0.05-2 mm) and 5% silt/clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 35 m on the left bank and 35 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with frequent river oak (*Casuarina cunninghamiana*), occasional carbeen (*Corymbia tessellaris*) and Dallachy's gum (*C. dallachiana*); adjoining plain dominated by poplar box (*E. populnea*); very sparse shrub layer, including whitewood (*Atalaya hemiglauca*), sally wattle (*Acacia salicina*), bean tree (*Cassia brewsteri*), red bauhinia (*Lysiphyllum carronii*), castor oil plant (*Ricinus communis*)* and lantana (*Lantana camara*)*; ground layer of the upper bank dominated by green panic (*Megathyrsus maximus*)* and buffel grasss (*Cenchrus ciliaris*)*, with frequent cobbler's pegs (*Bidens pilosa*)*, *Sida* sp. and shrubby stylo (*Stylosanthes scabra*)*; ground layer of the lower bank dominated by green panic, with frequent spiny-head mat-rush (*Lomandra longifolia*), bluegrass (*Bothriochloa* sp.), and occasional speargrass (*Heteropogon* sp.), sneezeweed (*Centipeda minima*), lesser joyweed (*Alternanthera denticulata*), musk basil (*Basilicum polystachyon*) and poison pratia (*Pratia concolor*); semi-aquatic macrophytes included little (1-10%) *Cyperus victoriensis*, tall flatsedge (*C. exaltatus*), bunchy sedge (*C. polystachyos*), white eclipta (*Eclipta prostrata*)*, common rush (*Juncus usitatus*) and willow primrose (*Ludwigia octovalvis*).

Erosion risk

Low – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

The reach provides foraging habitat for fish. Unlikely foraging habitat for turtles or platypus. Unlikely breeding habitat for fish, turtles or platypus. Aquatic vertebrate fauna detected by backpack electrofishing and overnight deployment of two baited fyke nets and five baited box traps included juvenile spangled perch (*Leiopotherpon unicolor*). Three freshwater snakes / keelbacks (*Tropidonophis mairii*) also captured in fyke nets.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered – NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). However, the study reach is unlikely to provide suitable habitat for these species.

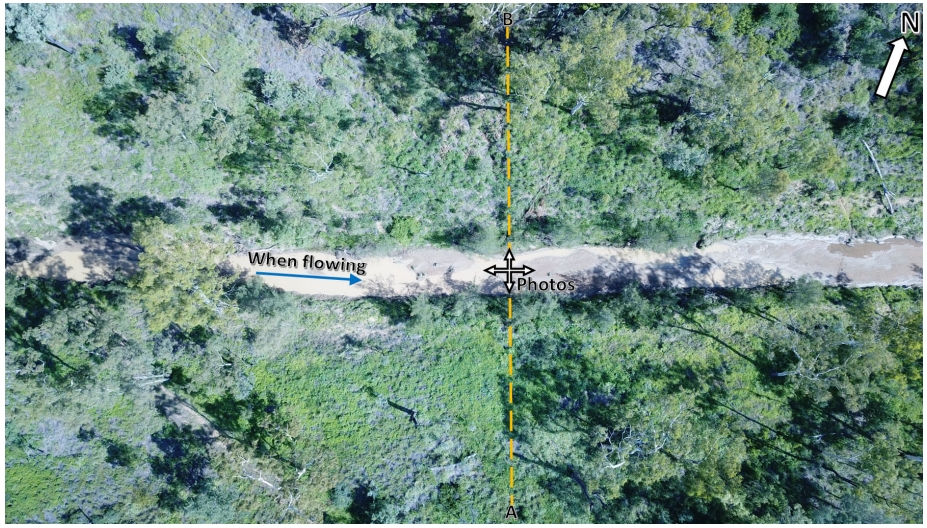
Physico-chemical water quality

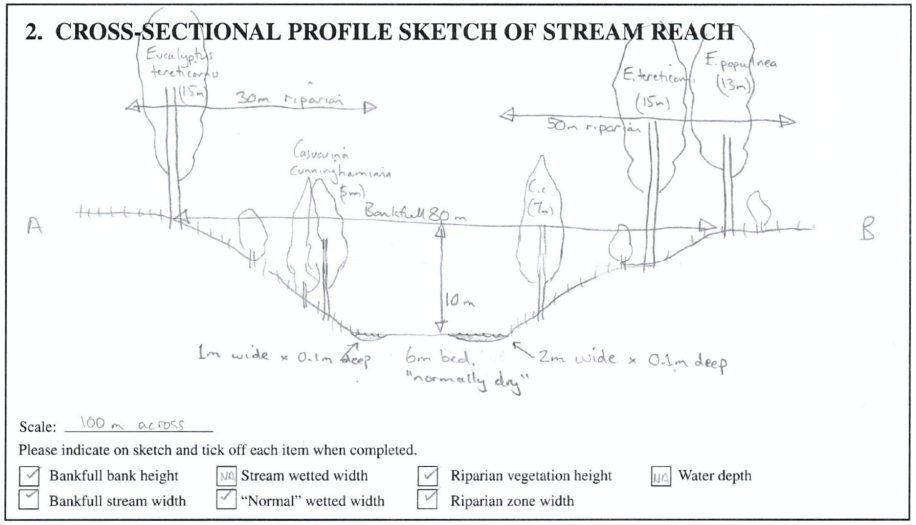
Collection time: 09:35; water temp.: 27.5˚C; specific conductivity: 264 µS/cm (fresh); turbidity: 842 NTU (poor clarity); dissolved oxygen: 47.4%, 3.7 mg/L (low, but typical for time of day); pH: 7.3 (neutral). Comments: Normal.

Bioassessment scores

Habitat assessment score for dry season: Poor (37).

Overall aquatic values – Dry season: **Moderate**.





Season: Dry

Site Code: R3 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8737 **Longitude:** 148.6417 **Date:** 14/10/2019

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; dry at the time of assessment; well defined bed and banks; no local catchment erosion detected; infilled channel as a result of sand deposition; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 40 m and bankfull height approx. 5 m; lacking in-stream habitat features; bed substrates comprised approximately 95% sand (0.05-2 mm) and 5% silt / clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing on partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as RE 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 25 m on the left bank and 25 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*) and river oak (*Casuarina cunninghamiana*), with abundant poplar box (*E. populnea*) and carbeen (*Corymbia tessellaris*); very sparse shrub layer, including castor oil plant (*Ricinus communis*)*, bean tree (*Cassia brewsteri*), and new growth Queensland blue gum and river oak; ground layer of upper bank dominated by buffel grass (*Cenchrus ciliaris*)*, with frequent green panic (*Megathyrsus maximus*)* and occasional cobbler's pegs (*Bidens pilosa*)*; ground layer of lower bank dominated by speargrass (*Heteropogon* sp.), with occasional spiny-head mat-rush (*Lomandra longifolia*) and Mexican poppy (*Argemone ochroleuca*)*; semi-aquatic macrophytes included little (1-10%) tall flatsedge (*Cyperus exaltatus*), rice sedge (*C. difformis*), common rush (*Juncus usitatus*) and white eclipta (*Eclipta prostrata*)*.

Erosion risk

Low – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

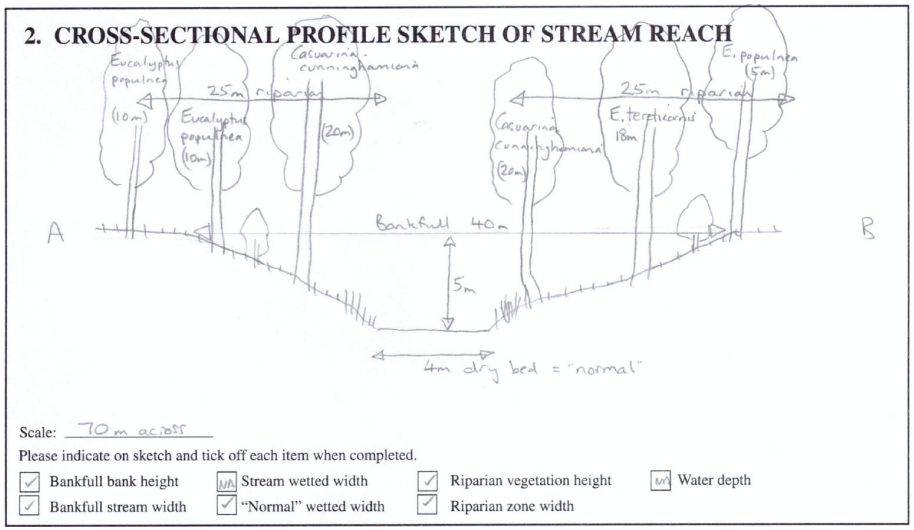
Physico-chemical water quality

Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Poor (38).

Overall aquatic values – Dry season: **Moderate**.



Season: Dry

Site Code: R3 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8737 **Longitude:** 148.6417 **Date:** 18/02/2020

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; shallow pool habitat along the 100 m reach at the time of assessment; no discernible flow; well defined bed and banks; no local catchment erosion detected; infilled channel as a result of sand deposition; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 40 m and bankfull height approx. 5 m; lacking in-stream habitat features; bed substrates comprised approximately 95% sand (0.05-2 mm) and 5% silt / clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing on partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as RE 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 25 m on the left bank and 25 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*) and river oak (*Casuarina cunninghamiana*), with abundant poplar box (*E. populnea*) and carbeen (*Corymbia tessellaris*); sparse shrub layer, including castor oil plant (*Ricinus communis*)*, bean tree (*Cassia brewsteri*), whitewood (*Atalaya hemiglauca*) and new growth Queensland blue gum and river oak; ground layer of upper bank dominated by buffel grass (*Cenchrus ciliaris*)* and green panic (*Megathyrsus maximus*)*, with frequent cobbler's pegs (*Bidens pilosa*)*; ground layer of lower bank dominated by green panic*, with frequent *Cyperus victoriensis*, occasional speargrass (*Heteropogon* sp.), spiny-head mat-rush (*Lomandra longifolia*), musk basil (*Basilicum polystachyon*), sneezeweed (*Centipeda minima*) and lesser joyweed (*Alternanthera denticulata*); semi-aquatic macrophytes included some (10-50%) *Cyperus victoriensis*, little (1-10%) tall flatsedge (*C. exaltatus*), rice sedge (*C. difformis*), white eclipta (*Eclipta prostrata*)*, common rush (*Juncus usitatus*) and willow primrose (*Ludwigia octovalvis*).

Erosion risk

Low – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

The reach provides foraging habitat for fish. Unlikely foraging habitat for turtles or platypus. Unlikely breeding habitat for fish, turtles or platypus. Aquatic vertebrate fauna detected by backpack electrofishing and overnight deployment of two baited fyke nets and five baited box traps included juvenile spangled perch (*Leiopotherpon unicolor*), eastern rainbowfish (*Melanotaenia splendida*) and Hyrtl's tandan (*Neosilurus hyrtlii*).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

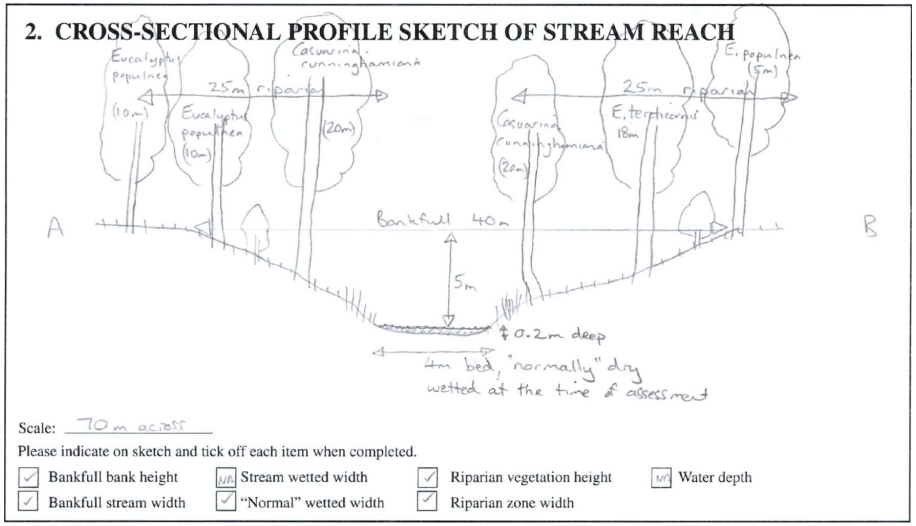
Physico-chemical water quality

Collection time: 15:15; water temp.: 30.7˚C; specific conductivity: 204 µS/cm (fresh); turbidity: 842 NTU (poor clarity); dissolved oxygen: 41.0%, 3.1 mg/L (low for time of day, but reflective of shading, poor light penetration and likely oxygen consumption associated with the breakdown of organic matter); pH: 7.1 (neutral). Comments: Normal.

Bioassessment scores

Habitat assessment score for dry season: Fair (44).

Overall aquatic values – Dry season: **Moderate**.



Season: Dry

Site Code: R4 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8681 **Longitude:** 148.6420 **Date:** 14/10/2019

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; dry at the time of assessment; well defined bed and banks; little (1-10%) stream bank erosion, mostly healed over; infilled channel as a result of sand deposition, with silt veneer; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 40 m and bankfull height approx. 6 m; lacking in-stream habitat features; bed substrates comprised approximately 30% sand (0.05-2 mm) and 70% silt/clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as RE 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 20 m on the left bank and 20 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with abundant carbeen (*Corymbia tessellaris*) and river oak (*Casuarina cunninghamiana*), and frequent poplar box (*E. populnea*); very sparse shrub layer, including whitewood (*Atalaya hemiglauca*), bean tree (*Cassia brewsteri*) and new growth river oak; ground layer of the upper bank dominated by buffel grass (*Cenchrus ciliaris*)*, with frequent cobbler's pegs (*Bidens pilosa*)*; ground layer of the lower bank dominated by speargrass (*Heteropogon* sp.) and common couch (*Cynodon dactylon*), with occasional windmill grass (*Chloris* sp.), blady grass (*Imperata cylindrica*) and spiny-head mat-rush (*Lomandra longifolia*); semi-aquatic macrophytes included little (1-10%) tall flatsedge (*Cyperus exaltatus*), common rush (*Juncus usitatus*) and white eclipta (*Eclipta prostrata*)*.

Erosion risk

Low – Banks appeared to be moderately stable, and with >80% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

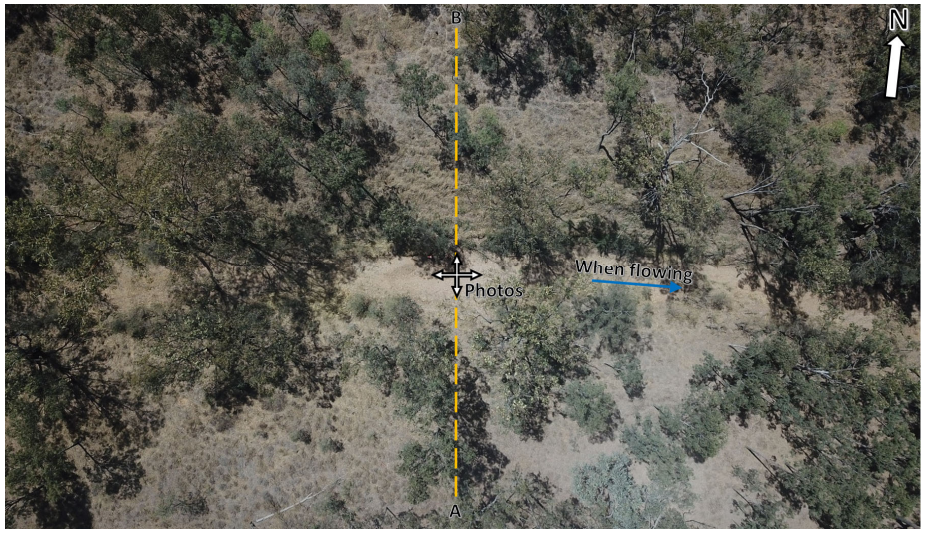
Physico-chemical water quality

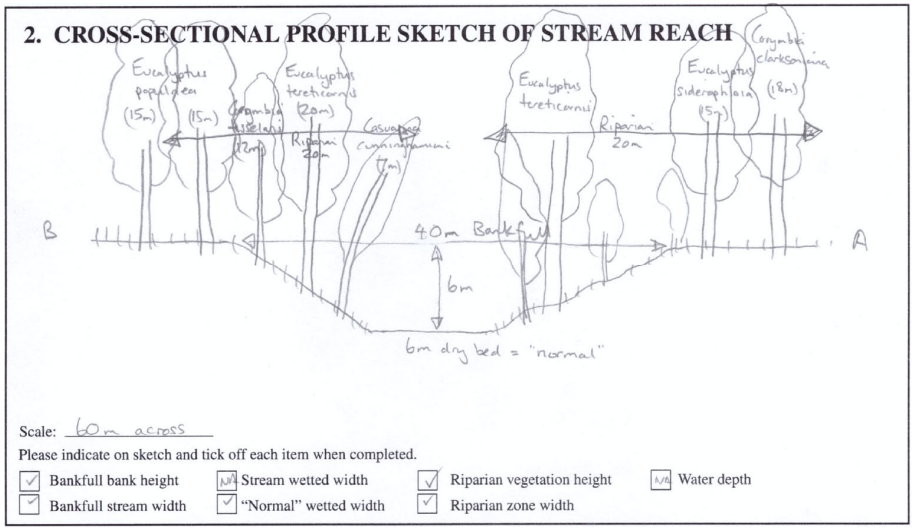
Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Poor (36).

Overall aquatic values – Dry season: **Moderate**.





Season: Dry

Site Code: R4 **Location:** Roper Creek **Stream order:** 4 **Latitude:** -22.8681 **Longitude:** 148.6420 **Date:** 18/02/2020

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral fourth order drainage line; isolated shallow pools at the time of assessment; well defined bed and banks; little (1-10%) stream bank erosion, mostly healed over; infilled channel as a result of sand deposition; highly mobile stream bed; bank shape convex; banks moderately stable; bank vegetative stability excellent; bankfull width approx. 40 m and bankfull height approx. 6 m; lacking in-stream habitat features; bed substrates comprised approximately 2% gravel (2-4 mm), 70% sand (0.05-2 mm) and 28% silt/clay (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as RE 11.3.25 – '*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'; riparian zone approximately 20 m on the left bank and 20 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), abundant carbeen (*Corymbia tessellaris*), river oak (*Casuarina cunninghamiana*), and frequent poplar box (*E. populnea*); sparse shrub layer, including whitewood (*Atalaya hemiglauca*), bean tree (*Cassia brewsteri*), castor oil plant (*Ricinus communis*)* and new growth river oak; ground layer of the upper bank dominated by buffel grass (*Cenchrus ciliaris*)*, with frequent cobbler's pegs (*Bidens pilosa*)*; ground layer of the lower bank dominated by green panic (*Megathyrsus maximus*)* and common couch (*Cynodon dactylon*), with occasional speargrass (*Heteropogon* sp.), windmill grass (*Chloris* sp.), blady grass (*Imperata cylindrica*) and spiny-head mat-rush (*Lomandra longifolia*); semi-aquatic macrophytes included little (1-10%) *Cyperus victoriensis*, tall flatsedge (*C. exaltatus*), common rush (*Juncus usitatus*) and white eclipta (*Eclipta prostrata*)*.

Erosion risk

Low – Banks appeared to be moderately stable, and with >95% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

The reach provides foraging habitat for fish. Unlikely foraging habitat for turtles or platypus. Unlikely breeding habitat for fish, turtles or platypus. Aquatic vertebrate fauna detected by backpack electrofishing comprised juvenile spangled perch (*Leiopotherpon unicolor*).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

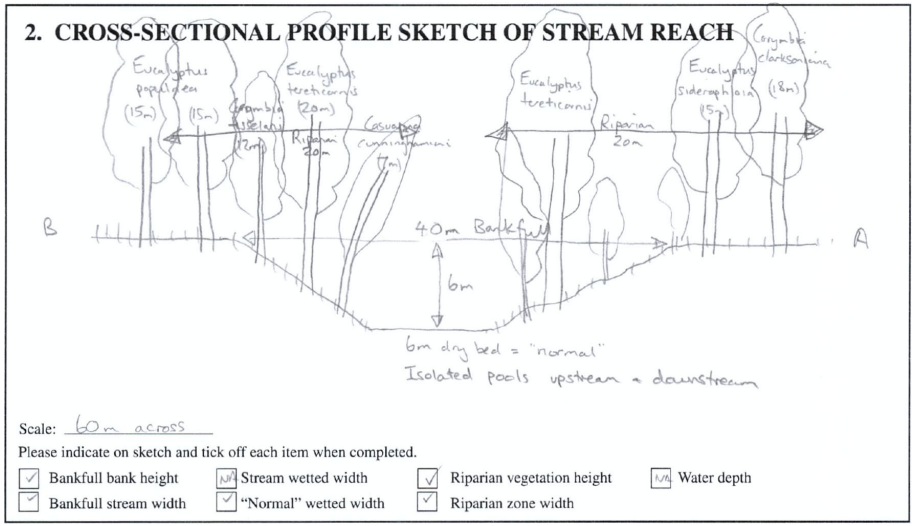
Physico-chemical water quality

Collection time: 11:50; water temp.: 29.2˚C; specific conductivity: 258 µS/cm (fresh); turbidity: 398 NTU (poor clarity); dissolved oxygen: 68.4%, 4.8 mg/L (low for time of day, but reflective of shading, poor light penetration and likely oxygen consumption associated with the breakdown of organic matter); pH: 7.4 (mildly alkaline). Comments: Normal.

Bioassessment scores

Habitat assessment score for dry season: Fair (39).

Overall aquatic values – Dry season: **Moderate**.



Season: Dry

Site Code: R5 **Location:** Thirteen Miles Gully **Stream order:** 2 **Latitude:** -22.8681 **Longitude:** 148.6705 **Date:** 14/10/2019

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral second order drainage line; dry at the time of assessment; well defined bed and banks; little (1-10%) stream bank erosion; U shaped channel; bank shape concave; banks moderately stable; good bank vegetative stability; bankfull width approx. 7 m and bankfull height approx. 2 m; in-stream habitat features in times of flow would include snags and large woody debris; bed substrates comprised approximately 20% sand (0.05-2 mm), 80% silt (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as non-remnant; riparian zone approximately 10 m on the left bank and 10 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with frequent river oak (*Casuarina cunninghamiana*), yellowwood (*Terminalia oblongata*), and occasional brigalow (*Acacia harpophylla*); sparse shrub layer, including bean tree (*Cassia brewsteri*), baunhinia (*Lysiphyllum* sp.), mimosa bush (*Vachellia farnesiana*)* and new growth Queensland blue gum; ground layer of the upper bank dominated by buffel grass (*Cenchrus ciliaris*)*; ground layer of the lower bank dominated by sneezeweed (*Centipeda minima*), with occasional green panic (*Megathyrsus maximus*)*, speargrass (*Heteropogon* sp.), fleabane (*Conyza bonariensis*)* and windmill grass (*Chloris* sp.); semi-aquatic macrophytes included little (1-10%) common rush (*Juncus usitatus*) and tall flatsedge (*Cyperus exaltatus*).

Erosion risk

Low – Banks appeared to be moderately stable, and with 50-79% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

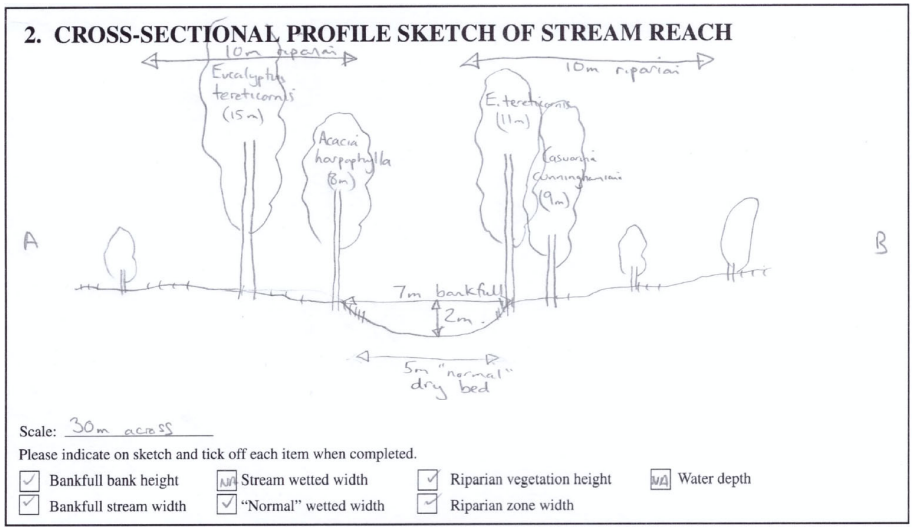
Physico-chemical water quality

Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Fair (56).

Overall aquatic values – Dry season: **Low**.



Season: Dry

Site Code: R5 **Location:** Thirteen Miles Gully **Stream order:** 2 **Latitude:** -22.8681 **Longitude:** 148.6705 **Date:** 19/02/2020

Upstream

Left Bank

Downstream

Right Bank

General Site Description

Site attributes

Ephemeral second order drainage line; dry at the time of assessment; well defined bed and banks; little (1-10%) stream bank erosion; U shaped channel; bank shape concave; banks moderately stable; good bank vegetative stability; bankfull width approx. 7 m and bankfull height approx. 2 m; in-stream habitat features in times of flow would include snags and large woody debris; bed substrates comprised approximately 20% sand (0.05-2 mm), 80% silt (<0.05 mm); upstream landuse includes coal mining and cattle grazing in partly cleared, partly remnant vegetation; adjacent land previously grazed, but not current.

Aquatic and riparian vegetation

Study reach positioned within riparian woodland State-mapped as non-remnant; riparian zone approximately 10 m on the left bank and 10 m on the right, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with frequent river oak (*Casuarina cunninghamiana*), yellowwood (*Terminalia oblongata*), and occasional brigalow (*Acacia harpophylla*); sparse shrub layer, including bean tree (*Cassia brewsteri*), baunhinia (*Lysiphyllum* sp.), mimosa bush (*Vachellia farnesiana*)* and new growth Queensland blue gum; ground layer of the upper bank dominated by buffel grass (*Cenchrus ciliaris*)*; ground layer of the lower bank dominated by sneezeweed (*Centipeda minima*), with frequent hairy carpet weed (*Glinus lotoides*), occasional green panic (*Megathyrsus maximus*)*, black speargrass (*Heteropogon contortus*), fleabane (*Conyza bonariensis*)*, windmill grass (*Chloris* sp.), lesser joyweed (*Alternanthera denticulata*), perennial cupgrass (*Eriochloa pseudoacrotricha*) and button grass (*Dactyloctenium radulans*); semi-aquatic macrophytes included little (1-10%) *Cyperus betchei*, *Cyperus iria*, tall flatsedge (*Cyperus exaltatus*), awnless barnyard grass (*Echonochloa colona*)*, common rush (*Juncus usitatus*) and umbrella canegrass (*Leptochloa digitata*).

Erosion risk

Low – Banks appeared to be moderately stable, and with 50-79% of streambank surfaces covered by vegetation or tree roots.

Aquatic fauna, including breeding habitat

No aquatic fauna detected. May provide suitable foraging habitat for fish in times of flow. No fish, turtle or platypus breeding habitat detected.

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species detected. The Critically Endangered (EPBC Act; Endangered under NC Act) southern snapping turtle (*Elseya albagula*) and Vulnerable (EPBC Act and NC Act) Fitzroy River turtle (*Rheodytes leukops*) are recorded from the Mackenzie River Sub-basin (DES 2019). The study reach is unlikely to provide suitable habitat for these species.

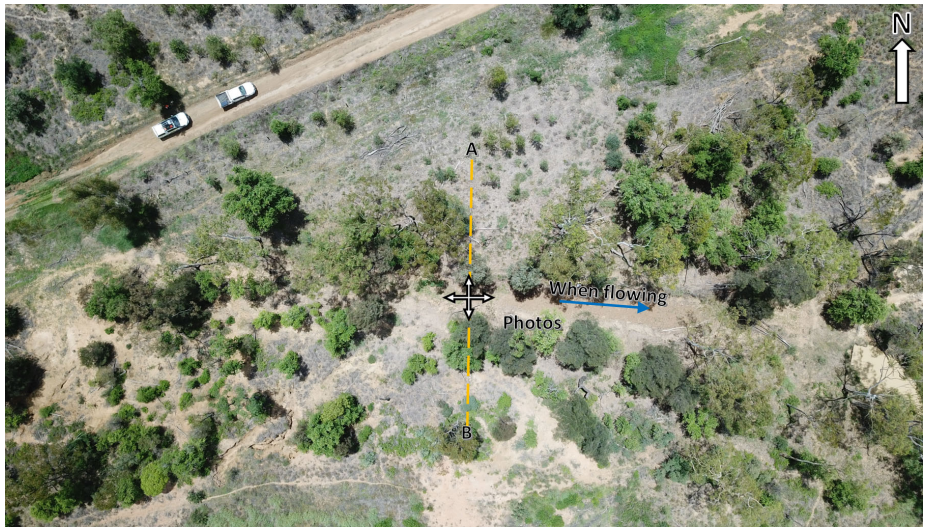
Physico-chemical water quality

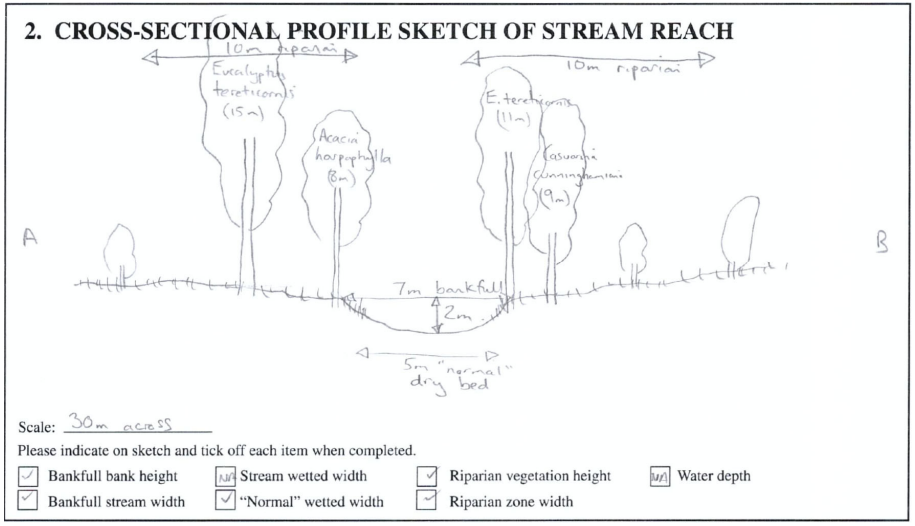
Dry at the time of assessment.

Bioassessment scores

Habitat assessment score for dry season: Fair (56).

Overall aquatic values – Dry season: **Low**.





Appendix C: Water Sampling Analytical Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2005513**	Page	: 1 of 5
Client	: **DPM ENVIROSCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVID MOORE	Contact	: Customer Services EB
Address	: PO BOX 1298 MOOLOOLABA QLD, AUSTRALIA 4557	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: DPM19015 Middlemount Coal Mine Southern Extension Project	Date Samples Received	: 27-Feb-2020 12:09
Order number	: ----	Date Analysis Commenced	: 02-Mar-2020
C-O-C number	: ----	Issue Date	: 05-Mar-2020 15:38
Sampler	: DAVID MOORE		
Site	: ----		
Quote number	: BN/558/14		
No. of samples received	: 15		
No. of samples analysed	: 15		

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ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Mark Hallas	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 sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

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.

- Ionic Balance out of acceptable limits for samples due to analytes not quantified in this report.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	R1	R2	R3	R4	FB
				Client sampling date / time	18-Feb-2020 00:00	19-Feb-2020 00:00	18-Feb-2020 00:00	18-Feb-2020 00:00	18-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		EB2005513-001	EB2005513-002	EB2005513-003	EB2005513-004	EB2005513-005
					Result	Result	Result	Result	Result
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**83**	**61**	**55**	**77**	**5**
Total Alkalinity as CaCO3	----	1	mg/L		**83**	**61**	**55**	**77**	**5**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**10**	**14**	**12**	**15**	<1
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**24**	**29**	**26**	**31**	<1
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**15**	**12**	**10**	**14**	<1
Magnesium	7439-95-4	1	mg/L		**9**	**7**	**6**	**8**	<1
Sodium	7440-23-5	1	mg/L		**28**	**30**	**27**	**33**	<1
Potassium	7440-09-7	1	mg/L		**7**	**6**	**5**	**6**	<1
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		**74**	**59**	**50**	**68**	<1
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.2**	**0.2**	<0.1
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**2.54**	**2.33**	**2.08**	**2.72**	**0.10**
ø Total Cations	----	0.01	meq/L		**2.89**	**2.63**	**2.30**	**2.94**	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DUP	MW3	MW5	MW6	MW9A
				Client sampling date / time	18-Feb-2020 00:00	19-Feb-2020 00:00	21-Feb-2020 00:00	20-Feb-2020 00:00	20-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		EB2005513-006	EB2005513-008	EB2005513-009	EB2005513-010	EB2005513-011
					Result	Result	Result	Result	Result
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		82	526	459	408	456
Total Alkalinity as CaCO3	----	1	mg/L		82	526	459	408	456
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		10	868	582	411	114
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		24	7970	5500	11500	10200
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		15	246	114	279	393
Magnesium	7439-95-4	1	mg/L		9	581	313	793	480
Sodium	7440-23-5	1	mg/L		28	4330	3220	7310	6000
Potassium	7440-09-7	1	mg/L		7	10	7	22	19
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		74	3010	1570	3960	2960
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.2	0.4	0.7	0.6	0.3
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		2.52	253	176	341	299
ø Total Cations	----	0.01	meq/L		2.89	249	172	398	320
ø Ionic Balance	----	0.01	%		----	0.94	1.36	7.66	3.45

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MW15A	BH302	MW17A	MW14A	MW16A
				Client sampling date / time	20-Feb-2020 00:00	20-Feb-2020 00:00	20-Feb-2020 00:00	21-Feb-2020 00:00	21-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		EB2005513-012	EB2005513-013	EB2005513-014	EB2005513-015	EB2005513-016
					Result	Result	Result	Result	Result
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		720	481	409	384	889
Total Alkalinity as CaCO3	----	1	mg/L		720	481	409	384	889
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		104	144	251	198	193
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		1680	2530	6830	10900	1550
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		82	80	547	659	112
Magnesium	7439-95-4	1	mg/L		109	97	664	887	128
Sodium	7440-23-5	1	mg/L		1200	1770	3580	6120	1150
Potassium	7440-09-7	1	mg/L		6	8	26	13	16
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		654	599	4100	5300	807
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	1.2	0.2	1.0	0.7
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		63.9	84.0	206	319	65.5
ø Total Cations	----	0.01	meq/L		65.4	89.2	238	372	66.6
ø Ionic Balance	----	0.01	%		1.14	3.00	7.26	7.68	0.80

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB2005513**	Page	: 1 of 5
Client	: **DPM ENVIROSCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVID MOORE	Contact	: Customer Services EB
Address	: PO BOX 1298 MOOLOOLABA QLD, AUSTRALIA 4557	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: DPM19015 Middlemount Coal Mine Southern Extension Project	Date Samples Received	: 27-Feb-2020
Order number	: ----	Date Analysis Commenced	: 02-Mar-2020
C-O-C number	: ----	Issue Date	: 05-Mar-2020
Sampler	: DAVID MOORE		
Site	: ----		
Quote number	: BN/558/14		
No. of samples received	: 15		
No. of samples analysed	: 15		

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This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Mark Hallas	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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 2888061)									
EB2005513-003	R3	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	55	56	2.78	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	55	56	2.78	0% - 20%
EB2005504-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	650	658	1.25	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	650	658	1.25	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2888062)									
EB2005537-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	47	42	10.6	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	47	42	10.6	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2889416)									
EB2005362-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	19	19	0.00	0% - 50%
EB2005513-006	DUP	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	10	10	0.00	0% - 50%
ED045G: Chloride by Discrete Analyser (QC Lot: 2889417)									
EB2005362-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	45	41	9.04	0% - 20%
EB2005513-006	DUP	ED045G: Chloride	16887-00-6	1	mg/L	24	24	0.00	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2885155)									
EB2005316-008	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	35	36	2.90	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	18	19	0.00	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	226	227	0.682	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	91	95	4.31	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 2885155) - continued									
EB2005504-007	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	22	21	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	17	17	0.00	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	36	36	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.00	No Limit
ED093F: Dissolved Major Cations (QC Lot: 2885158)									
EB2005572-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	752	777	3.29	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	2100	2150	2.68	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	12000	12300	2.98	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	205	210	2.35	0% - 20%
EK040P: Fluoride by PC Titrator (QC Lot: 2888060)									
EB2005513-003	R3	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.2	0.2	0.00	No Limit
EB2005504-006	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2888063)									
EB2005537-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED037P: Alkalinity by PC Titrator (QCLot: 2888061)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	96.5	80.0	120
ED037P: Alkalinity by PC Titrator (QCLot: 2888062)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	108	80.0	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2889416)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	107	85.0	118
				<1	100 mg/L	107	85.0	118
ED045G: Chloride by Discrete Analyser (QCLot: 2889417)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	93.7	90.0	115
				<1	1000 mg/L	102	90.0	115
ED093F: Dissolved Major Cations (QCLot: 2885155)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	112	70.0	130
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	121	70.0	130
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	123	70.0	130
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	116	70.0	130
ED093F: Dissolved Major Cations (QCLot: 2885158)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	95.2	70.0	130
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	104	70.0	130
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	105	70.0	130
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	98.0	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 2888060)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	92.8	80.0	117
EK040P: Fluoride by PC Titrator (QCLot: 2888063)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	108	80.0	117

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**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2889416)							
EB2005362-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	82.8	70.0	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*
ED045G: Chloride by Discrete Analyser (QCLot: 2889417)							
EB2005362-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	108	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 2888060)							
EB2005504-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	96.8	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 2888063)							
EB2005513-015	MW14A	EK040P: Fluoride	16984-48-8	5 mg/L	91.2	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB2005513**	Page	: 1 of 6
Client	: **DPM ENVIROSCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVID MOORE	Telephone	: +61-7-3243 7222
Project	: DPM19015 Middlemount Coal Mine Southern Extension Project	Date Samples Received	: 27-Feb-2020
Site	: ----	Issue Date	: 05-Mar-2020
Sampler	: DAVID MOORE	No. of samples received	: 15
Order number	: ----	No. of samples analysed	: 15

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.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**02-Mar-2020**	03-Mar-2020	✓
Clear Plastic Bottle - Natural (ED037-P) R2, MW3	**19-Feb-2020**	**----**	----	----	**02-Mar-2020**	04-Mar-2020	✓
Clear Plastic Bottle - Natural (ED037-P) MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**02-Mar-2020**	05-Mar-2020	✓
Clear Plastic Bottle - Natural (ED037-P) MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**02-Mar-2020**	06-Mar-2020	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**03-Mar-2020**	17-Mar-2020	✓
Clear Plastic Bottle - Natural (ED041G) R2, MW3	**19-Feb-2020**	**----**	----	----	**03-Mar-2020**	18-Mar-2020	✓
Clear Plastic Bottle - Natural (ED041G) MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**03-Mar-2020**	19-Mar-2020	✓
Clear Plastic Bottle - Natural (ED041G) MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**03-Mar-2020**	20-Mar-2020	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**03-Mar-2020**	17-Mar-2020	✓
Clear Plastic Bottle - Natural (ED045G) R2, MW3	**19-Feb-2020**	**----**	----	----	**03-Mar-2020**	18-Mar-2020	✓
Clear Plastic Bottle - Natural (ED045G) MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**03-Mar-2020**	19-Mar-2020	✓
Clear Plastic Bottle - Natural (ED045G) MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**03-Mar-2020**	20-Mar-2020	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**02-Mar-2020**	17-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) R2, MW3	**19-Feb-2020**	**----**	----	----	**02-Mar-2020**	18-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**02-Mar-2020**	19-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**02-Mar-2020**	20-Mar-2020	✓
ED093F: SAR and Hardness Calculations							
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**02-Mar-2020**	17-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) R2, MW3	**19-Feb-2020**	**----**	----	----	**02-Mar-2020**	18-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**02-Mar-2020**	19-Mar-2020	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**02-Mar-2020**	20-Mar-2020	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P)							
R1, R3, R4, FB, DUP	**18-Feb-2020**	**----**	----	----	**02-Mar-2020**	17-Mar-2020	✓
Clear Plastic Bottle - Natural (EK040P)							
R2, MW3	**19-Feb-2020**	**----**	----	----	**02-Mar-2020**	18-Mar-2020	✓
Clear Plastic Bottle - Natural (EK040P)							
MW6, MW9A, MW15A, BH302, MW17A	**20-Feb-2020**	**----**	----	----	**02-Mar-2020**	19-Mar-2020	✓
Clear Plastic Bottle - Natural (EK040P)							
MW5, MW14A, MW16A	**21-Feb-2020**	**----**	----	----	**02-Mar-2020**	20-Mar-2020	✓

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	3	30	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	3	24	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	3	29	**10.34**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB2005513**

Client	: **DPM ENVIROSCIENCES**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVID MOORE	Contact	: Customer Services EB
Address	: PO BOX 1298 MOOLOOLABA QLD, AUSTRALIA 4557	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: dmoore@dpm-enviro.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: ----	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: DPM19015 Middlemount Coal Mine Southern Extension Project	Page	: 1 of 2
Order number	: ----	Quote number	: EB2014DPMENV0001 (BN/558/14)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: DAVID MOORE		

Dates

Date Samples Received	: 27-Feb-2020 12:09	Issue Date	: 27-Feb-2020
Client Requested Due Date	: 05-Mar-2020	Scheduled Reporting Date	: **05-Mar-2020**

Delivery Details

Mode of Delivery	: Client Drop Off	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 18.3°C
Receipt Detail	: MED ESKY	No. of samples received / analysed	: 15 / 15

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- **Please be advised that sample "MW2" was not received at the laboratory (denoted SNR on the scanned COC).**
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If 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

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - NT-01D & 02A Major Cations & Anions (Ca, Mg, Na, K, Cl, SO4,
EB2005513-001	18-Feb-2020 00:00	R1	✓
EB2005513-002	19-Feb-2020 00:00	R2	✓
EB2005513-003	18-Feb-2020 00:00	R3	✓
EB2005513-004	18-Feb-2020 00:00	R4	✓
EB2005513-005	18-Feb-2020 00:00	FB	✓
EB2005513-006	18-Feb-2020 00:00	DUP	✓
EB2005513-008	19-Feb-2020 00:00	MW3	✓
EB2005513-009	21-Feb-2020 00:00	MW5	✓
EB2005513-010	20-Feb-2020 00:00	MW6	✓
EB2005513-011	20-Feb-2020 00:00	MW9A	✓
EB2005513-012	20-Feb-2020 00:00	MW15A	✓
EB2005513-013	20-Feb-2020 00:00	BH302	✓
EB2005513-014	20-Feb-2020 00:00	MW17A	✓
EB2005513-015	21-Feb-2020 00:00	MW14A	✓
EB2005513-016	21-Feb-2020 00:00	MW16A	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

DAVID MOORE

- *AU Certificate of Analysis - NATA (COA)	Email	dmoore@dpm-enviro.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	dmoore@dpm-enviro.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	dmoore@dpm-enviro.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	dmoore@dpm-enviro.com.au
- A4 - AU Tax Invoice (INV)	Email	dmoore@dpm-enviro.com.au
- Chain of Custody (CoC) (COC)	Email	dmoore@dpm-enviro.com.au
- EDI Format - ENMRG (ENMRG)	Email	dmoore@dpm-enviro.com.au
- EDI Format - XTab (XTAB)	Email	dmoore@dpm-enviro.com.au

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
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate 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)
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)
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)

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 3/1 Burma Road Pooraka SA 5095 Ph: 08 8162 5130 E: adelaide@alsglobal.com

☐BRISBANE 2 Byth Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

☐GLADSTONE 48 Callemondah Drive Gladstone QLD 4680 Ph: 07 4978 7944 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com

☐MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com

☐MUDGEE 1/29 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Road Mayfield West NSW 2304 Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com

☐NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 02 4423 2063 E: nowra@alsglobal.com

☐PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.c

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

'ollongong NSW 2500

5/3.

Environmental Divisio'
Brisbane

Work Order Reference
EB2005513

Telephone : + 61-7-3243 7222

CLIENT: DPM Envirosciences Pty Ltd	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☒ Standard TAT (List due date):	
OFFICE: 12 Lauren Drive, Buderim QLD 4556		☐ Non Standard or urgent TAT (List due date):	
PROJECT: Middlemount Coal Mine Southern Extension Projec PROJECT NO DPM19015	ALS QUOTE NO.: BN/558/14	COC SEQUENCE NUMBER (Circle)	
ORDER NUMBER: PURCHASE ORDER NO.:	COUNTRY OF ORIGIN: Australia	COC: 1 2 3 4 5 6	
PROJECT MANAGER: David Moore	CONTACT PH: 0427 694 433	OF: 1 2 3 4 5 6	
SAMPLER: David Moore	SAMPLER MOBILE: 0427 694 433	RELINQUISHED BY: P. MOORE	RECEIVED BY: S Butler
COC Emailed to ALS? (YES / NO)	EDD FORMAT (or default):	DATE/TIME: 27/2/20 12-09	DATE/TIME: 27/2/2020 12:04
Email Reports to (will default to PM if no other addresses are listed): dmoore@dpm-enviro.com.au			
Email Invoice to (will default to PM if no other addresses are listed): dmoore@dpm-enviro.com.au			

No N/A
No N/A
°C
BY:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION										Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-1D (Major cations [Ca, Mg, Na, K] + Hardness)	NT-2A (Major anions [Cl, SO4, F, Alkalinity])							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	R1	18/02/2020	W	P, N	2	✓	✓							
2	R2	19/02/2020	W	P, N	2	✓	✓							
3	R3	18/02/2020	W	P, N	2	✓	✓							
4	R4	18/02/2020	W	P, N	2	✓	✓							
5	FB	18/02/2020	W	P, N	2	✓	✓							
6	DUP	18/02/2020	W	P, N	2	✓	✓							
SNR 7	MW2	21/02/2020	W	P, N	2	✓	✓							
8	MW3	19/02/2020	W	P, N	2	✓	✓							
9	MW5	21/02/2020	W	P, N	2	✓	✓							
10	MW6	20/02/2020	W	P, N	2	✓	✓							
11	MW9A	20/02/2020	W	P, N	2	✓	✓							
12	MW15A	20/02/2020	W	P, N	2	✓	✓							
				TOTAL										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CUSTODY

Laboratory: please tick →

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DPM Envirosciences Pty Ltd	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☒ Standard TAT **(List due date):** ☐ Non Standard or urgent TAT **(List due date):**
OFFICE: 12 Lauren Drive, Buderim QLD 4556		
PROJECT: Middlemount Coal Mine Southern Extension Projec **PROJECT NO** DPM19015	**ALS QUOTE NO.:** BN/558/14	**COC SEQUENCE NUMBER (Circle)** COC: 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7
ORDER NUMBER: **PURCHASE ORDER NO.:**	**COUNTRY OF ORIGIN:** Australia	
PROJECT MANAGER: David Moore	**CONTACT PH:** 0427 694 433	
SAMPLER: David Moore	**SAMPLER MOBILE:** 0427 694 433	
COC Emailed to ALS? (YES / NO)	**EDD FORMAT (or default):**	
Email Reports to (will default to PM if no other addresses are listed): dmoore@dpm-enviro.com.au		
Email Invoice to (will default to PM if no other addresses are listed): dmoore@dpm-enviro.com.au		

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:		°C	
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
P.MOORE	JB		
DATE/TIME: 27/2/20 12:09.	DATE/TIME: 29/2/2020 12:04	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION										Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	NT-1D (Major cations [Ca, Mg, Na, K] + Hardness)	NT-2A (Major anions [Cl, SO4, F, Alkalinity])							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
13	BH302	20/02/2020	W	P, N	2	✓	✓							
14	MW17A	20/02/2020	W	P, N	2	✓	✓							
15	MW14A	21/02/2020	W	P, N	2	✓	✓							
16	MW16A	21/02/2020	W	P, N	2	✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
			W	P, N		✓	✓							
				TOTAL	32									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Appendix D: Aquatic Macroinvertebrate Data

DPM19015 - Middlemount Coal Mine Southern Extension Project - Wet season 2020

Sample picked by			DM	CP	DM	CP	DM	CP	DM	CP
Date sampled			18/02/2020	18/02/2020	19/02/2020	19/02/2020	18/02/2020	18/02/2020	18/02/2020	18/02/2020
Sample processed by			CP	CP	CP	CP	CP	CP	CP	CP
Date processed			27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020	27/02/2020
Site name			R1	R1	R2	R2	R3	R3	R4	R4
Habitat type	**SIGNAL 2**	**AUSRIVAS**	**EDGE**	**BED**	**EDGE**	**BED**	**EDGE**	**BED**	**EDGE**	**BED**
ph. Porifera	4	IA019999								
cl. Hydrozoa										
Clavidae	3	IB029999								
Hydridae	2	IB019999								
ph. Nematoda	3	II999999								
ph. Nemertea	3	IH999999								
ph. Nematomorpha	6	IJ999999								
Gordiidae	5	IJ019999								
ph. Platyhelminthes										
Dalyelliidae										
Dugesiidae	2	IF619999								
Provorticidae										
cl. Temnocephalidea	5	IF419999								
s.c. Hirudinea										
Erpobdellidae	1	LH059999								
Glossiphoniidae	1	LH019999								
Hirudinidae	4	LH999999								
ph. Annelida										
s.c. Oligochaeta	2	LO999999								
cl. Bivalvia										
Corbiculidae	4	KP029999								
Hyriidae	5	KP019999								
Sphaeriidae	5	KP039999								
cl. Gastropoda										
Ancylidae	4	KG069999								
Bithyniidae	3	KG039999								
Glacidorbidae	5	KG099999								
Hydrobiidae	4	KG029999								
Lymnaeidae	1	KG059999								
Physidae	1	KG089999								
Planorbidae	2	KG079999			6		2			
Thiaridae	4	KG049999								
Viviparidae	4	KG019999								
cl. Arachnida										
s.c. Acarina	6	MM999999		1	1	2	1			
o. Araneae	-	-								
s.c. Branchiura	1	OK999999								
o. Cladocera	-	OG999999		20	5	47	5	35	1	23
s.c. Copepoda	-	OJ999999	4	15	3	37	6	6	5	15
o. Conchostraca	1	OF999999								
cl. Ostracoda	-	OH999999		3	2	1	6	1		3
o. Amphipoda										
Corophiidae	4	OP059999								
Hyalidae	3	-								
Paramelitidae	4	OP069999								
Talitridae	3	OP019999								
o. Isopoda										
Cirolanidae	2	OR129999								
Oniscidae	2	OR259999								
Sphaeromatidae	1	OR139999								
su.o. Syncarida										
Psammaspididae	-	ON059999								
o. Decapoda										
Atyidae	3	OT019999								
Palaemonidae	4	OT029999	5		5					

Parastacidae	4	OV019999					1			
Gecarcinucidae	3	OX519999	4		2	1	3		2	2
s.c. Collembola	1	QA999999							1	
o. Lepidoptera										
Crambidae	2	QL999999								
o. Megaloptera										
Corydalidae	7	QM019999								
Sialidae	5	QM029999								
o. Neuroptera										
Sisyridae	3	QN059999								
o. Coleoptera										
Carabidae	3	QC059999								
Chrysomelidae	2	QCAH9999								
Curculionidae	2	QCAN9999								
Dytiscidae	2	QC099999	1	4	5	12	5	5	4	
Elmidae	7	QC349999								
Georissidae	-	-								
Gyrinidae	4	QC109999								
Haliplidae	2	QC069999								
Heteroceridae	1	QC369999								
Hydraenidae	3	QC139999	9	1	6	1	3	1	9	
Hydrochidae	4	QCAO9999	1		1				1	
Hydrophilidae	2	QC119999	7						1	
Hygrobiidae	1	QC079999								
Limnichidae	4	QC359999								
Nanophyidae	3	-								
Noteridae	4	QC089999	2		2		1			
Psephenidae	6	QC379999								
Ptilodactylidae	10	QC399999								
Scirtidae	6	QC209999								
Spercheidae	2	-	1		2				2	
Sphaeriusidae	7	-								
Staphylinidae	3	QC189999								
o. Diptera										
Athericidae	8	QD229999								
Blephariceridae	10	QD049999								
Ceratopogonidae	4	QD099999	1	1			1		2	
Chaoboridae	2	QD059999				1				
s.f. Aphroteniinae	8	QDAA9999								
s.f. Chironominae	3	QDAJ9999	4	1	16	1	5	8	4	1
s.f. Orthocladiinae	4	QDAF9999								
s.f. Tanypodinae	4	QDAE9999	4	2	7	3	3	12	3	3
Corethrellidae	-	-								
Culicidae	1	QD079999				1				1
Dixidae	7	QD069999								
Dolichopodidae	3	QD369999								
Empididae	5	QD359999								
Ephydridae	2	QD789999								
Muscidae	1	QD899999								
Pelecorhynchidae	10	QD209999								
Psychodidae	3	QD129999								
Sciomyzidae	2	QD459999								
Simuliidae	5	QD109999								
Stratiomyidae	2	QD249999								
Syrphidae	2	QD439999								
Tabanidae	3	QD239999								
Tanyderidae	6	QD039999								
Thaumaleidae	7	QD119999								
Tipulidae	5	QD019999								
o. Ephemeroptera										
Ameletopsidae	7	QE049999								
Baetidae	5	QE029999	1			4		1	3	
Caenidae	4	QE089999		1						
Leptophlebiidae	8	QE069999								

Teloganodidae	9	QE079999								
o. Hemiptera										
Aphelocheiridae	-	-								
Belostomatidae	1	QH629999								
Corixidae	2	QH659999								
Dipsocoridae	-	-								
Gelastocoridae	5	QH649999								
Gerridae	4	QH579999	5		5		4		5	
Hebridae	3	QH539999								
Hydrometridae	3	QH549999	2		1					
Leptopodidae	-	QH589999								
Mesoveliidae	2	QH529999								
Micronectidae	2	-	14	19	5	5	5			11
Naucoridae	2	QH669999								
Nepidae	3	QH619999								
Notonectidae	1	QH679999	3	1		2		2		
Ochteridae	2	QH639999	1							
Pleidae	2	QH689999								
Saldidae	1	QH609999								
Veliidae	3	QH569999	6		13		2		1	
s.o. Zygoptera										
Argiolestidae	5	-								
Calopterygidae	-	QO109999								
Chlorocyphidae	-	-								
Chorismagrionidae	-	QO189999								
Coenagrionidae	2	QO029999	1		1					
Diphlebiidae	6	QO099999								
Hemiphlebiidae	-	QO019999								
Isostictidae	3	QO039999			1					
Lestidae	1	QO059999								
Lestoideidae	9	QO069999								
Platycnemididae	4	QO049999								
Synlestidae	7	QO089999								
s.o. Epiprocta										
Aeshnidae	4	QO129999	1							
Archipetaliidae	-	QO199999								
Austrocorduliidae	10	QO279999								
Austropetaliidae	-	QO209999								
Brachytronidae	-	-								
Cordulephyidae	5	QO289999								
Corduliidae	5	QO169999								
Gomphidae	5	QO139999								
Gomphomacromiidae	-	QO249999								
Hemicorduliidae	5	QO309999	6		4	3	1	2		
Libellulidae	4	QO179999	6	1	4		6		1	
Lindeniidae	3	QO229999								
Macromiidae	8	QO269999								
Oxygastridae	-	QO299999								
Petaluridae	-	QO159999								
Pseudocorduliidae	-	QO259999								
Synthemistidae	2	QO239999								
Telephlebiidae	9	QO219999								
o. Plecoptera										
Gripopterygidae	8	QP039999								
o. Trichoptera										
Antipodoeciidae	8	QT169999								
Atriplectididae	7	QT239999								
Calamoceratidae	7	QT249999								
Calocidae	9	QT189999								
Conoesucidae	7	QT159999								
Dipseudopsidae	9	QT269999								
Ecnomidae	4	QT089999								
Glossosomatidae	9	QT029999								
Helicophidae	10	QT199999								

Helicopsychidae	8	QT069999								
Hydrobiosidae	8	QT019999								
Hydropsychidae	6	QT179999								
Hydroptilidae	4	QT039999								
Kokiriidae	3	QT209999								
Leptoceridae	6	QT259999	1	2		1				
Limnephilidae	8	QT109999								
Odontoceridae	7	QT229999								
Oeconesidae	8	QT129999								
Philopotamidae	8	QT049999								
Philorheithridae	8	QT219999								
Plectrotarsidae	-	QT119999								
Polycentropodidae	7	QT079999								
Psychomyiidae	-	QT099999								
Stenopsychidae	-	QT059999								
Tasimiidae	8	QT139999								
Summary										
Taxa count			**24**	**14**	**22**	**16**	**18**	**10**	**16**	**8**
No. Individuals			**90**	**72**	**97**	**122**	**60**	**73**	**45**	**59**
PET taxa			**2**	**2**	**0**	**2**	**0**	**1**	**1**	**0**
Plecoptera			**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Ephemeroptera			**1**	**1**	**0**	**1**	**0**	**1**	**1**	**0**
Trichoptera			**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**
SIGNAL2 average (Family)			**3.30**	**3.55**	**3.32**	**3.31**	**3.53**	**3.29**	**3.14**	**2.60**
Taxa with SIGNAL2 scores			**23**	**11**	**19**	**13**	**15**	**7**	**14**	**5**
Tolerant taxa (≤3)			**12**	**5**	**11**	**8**	**7**	**4**	**8**	**4**
% tolerant taxa			**52**	**45**	**58**	**62**	**47**	**57**	**57**	**80**

Mining Waste Management Plan

Middlemount Coal Mine

Prepared for: **Middlemount Coal Pty Ltd**

LEADERS IN MINING GEOCHEMISTRY

Mining Waste Management Plan

Middlemount Coal Mine

Prepared for: **Middlemount Coal Pty Ltd**

DOCUMENT CONTROL			
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Definitions

Acronym	Definition
Acid and Metalliferous Drainage (AMD)	Any contaminated discharge resulting from mining and associated processing, which is formed through a series of chemical, physical and biological reactions when geological strata is exposed to oxygen and moisture as a result of ground disturbance activities.
ANC	Acid Neutralising Capacity, expressed as kg H_2SO_4 per tonne of sample.
CHPP	Coal Handling and Preparation Plant
Coarse Reject	Coarse coal waste produced through coal processing sourced from the D&R screen and the spirals rejects dewatering screen.
EA	Environmental Authority (EPML00716913)
EDMS	Environmental Database Management System
Hazardous substance	A substance which has the potential to harm the health of persons in the workplace and/or adversely impact the environment.
Mining Waste	Any mining and coal handling and processing related waste, including: overburden, interburden, partings, coarse reject, tailings and miscellaneous waste rock material;
Mining By-Product	Any mining and coal handling and processing related waste, including: overburden, interburden, partings, coarse reject, tailings and miscellaneous waste rock material;
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acidic conditions.
NAF (Barren)	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acidic conditions. Barren of oxidisable sulfur.
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acidic conditions.
ROM	Run of Mine
SSE	Site Senior Executive
Tailings	Fine coal waste produced through coal processing sourced from the Tailings Thickener underflow.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.

1 INTRODUCTION

1.1 Purpose

RGS Environmental Pty Ltd (RGS) has prepared this Mining Waste Management Plan (MWMP) for Middlemount Coal Pty Ltd (MCPL) operations at Middlemount Coal Mine (MCM). This MWMP details how MCPL will manage its mining wastes (ie. overburden, interburden, coarse rejects and tailings) during mining operations. The plan aims to ensure all mining wastes are managed in accordance with Queensland coal mining industry standards and regulatory requirements including the requirements of Environmental Authority (EA) number EPML 00716913[1], to align with relevant technical guidelines[2,3,4,5] and in a manner that minimises the environmental and health risks.

1.2 Background

MCPL owns and operates MCM, an existing open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and approximately 3 km to the south-west of the Middlemount Township, Queensland (Qld) (**Figure 1-1**).

In May 2017, ML 70379 was extended to the north-west of the currently approved operations at the MCM (via a realignment of the ML 70379 boundary) (**Figure 1-2**).

On 21 March 2019, MCPL obtained state approval (via amendment of the EA) to expand its mining activities within the expanded ML 70379 area (ie. the Western Extension Project). MCPL is currently seeking federal approval for the Western Extension Project under the *Environment Protection and Biodiversity Conservation Act, 1999*.

In the past MCPL has not been required to prepare a MWMP, however some elements similar to the requirements to the MWMP have been previously captured within the MCPL's Plan of Operations[6] and other internal site documents (ie. sampling and characterisation of mine waste). Under Condition C30 of the EA (Acid Rock Drainage), MCPL must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage. Under Condition E3 of the EA, a MWMP is required to be developed and implemented by 29 June 2019 for review and comment. Under Condition E4, the MWMP must be updated within 20 business days of receiving comments from the administering authority (ie. the Queensland Department of Environment and Science [DES]).

1.3 Summary

This MWMP addresses how mining waste materials will be managed as part of the current and planned mine operations as described in the EA[1] and Plan of Operations[6].

[1] DES (2019). Environmental Authority EPML00716913 – Middlemount Coal Mine. Permit issued by the Queensland Department of Environment and Science (DES). 21 March
[2] COA, 2016. *Leading Practice Sustainable Development Program for the Mining Industry. Managing Acid and Metalliferous Drainage*. September. Commonwealth of Australia, Canberra ACT.
[3] DEHP, 2013. *Application Requirements for Activities with Impacts to Land Guideline.* Queensland Department of Environment and Heritage Protection (DEHP).
[4] DME, 1995. *Draft Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, Technical Guideline – Assessment and Management of Acid Drainage and Saline/Sodic Wastes*. Queensland Department of Minerals and Energy (DME).
[5] INAP, 2009. *Global Acid Rock Drainage Guide (GARD Guide)*. Document prepared by Golder Associates on behalf of the International Network on Acid Prevention (INAP). June 2009 (http://www.inap.com.au/).
[6] MCPL (2019). Plan of Operations. Middlemount Coal Mine (EPML00716913). Middlemount Coal Pty Ltd. Period 1 January 2019 to 31 December 2020. 29 March.

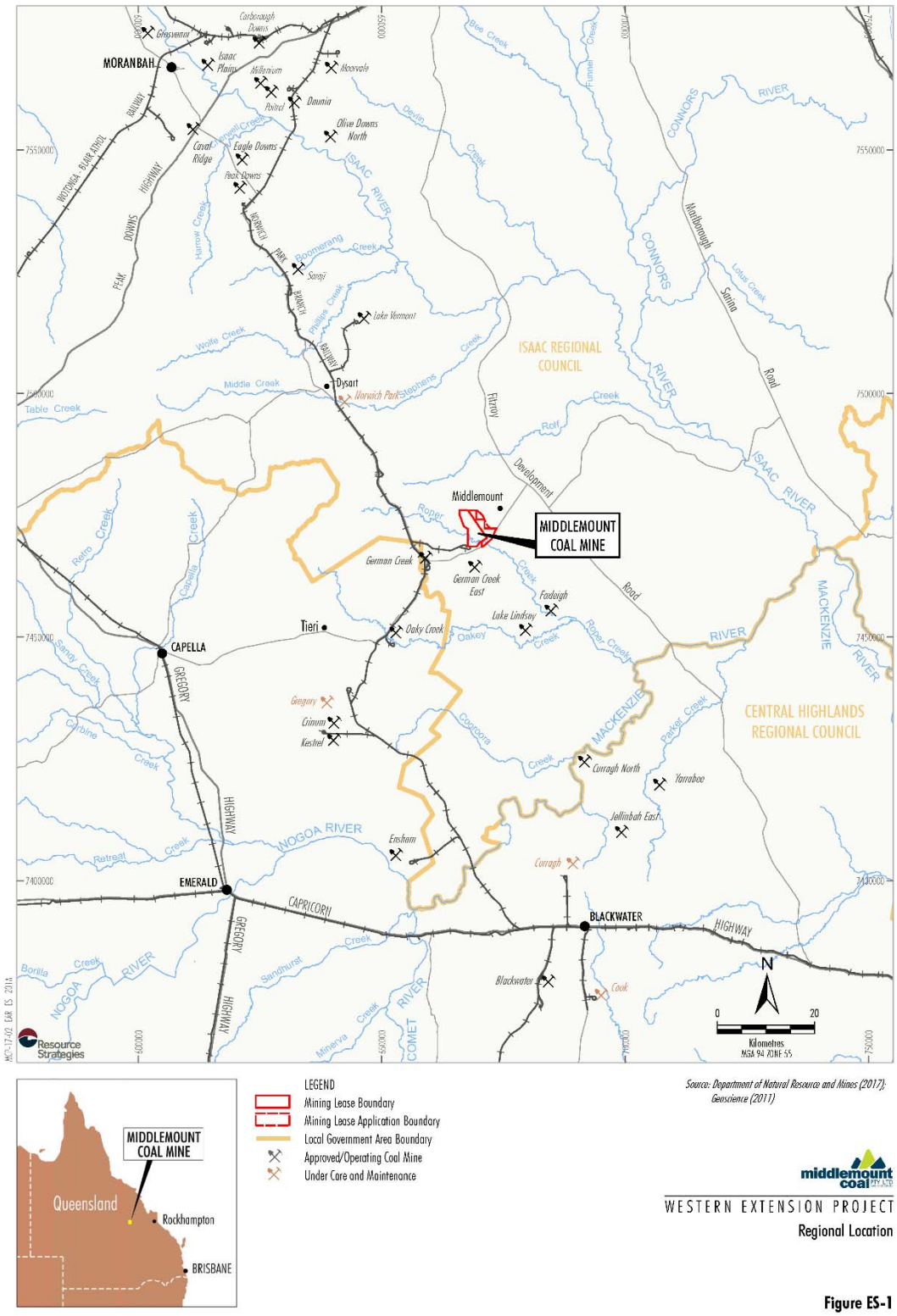

Figure 1-1: MCM Location (figure supplied by Resource Strategies)

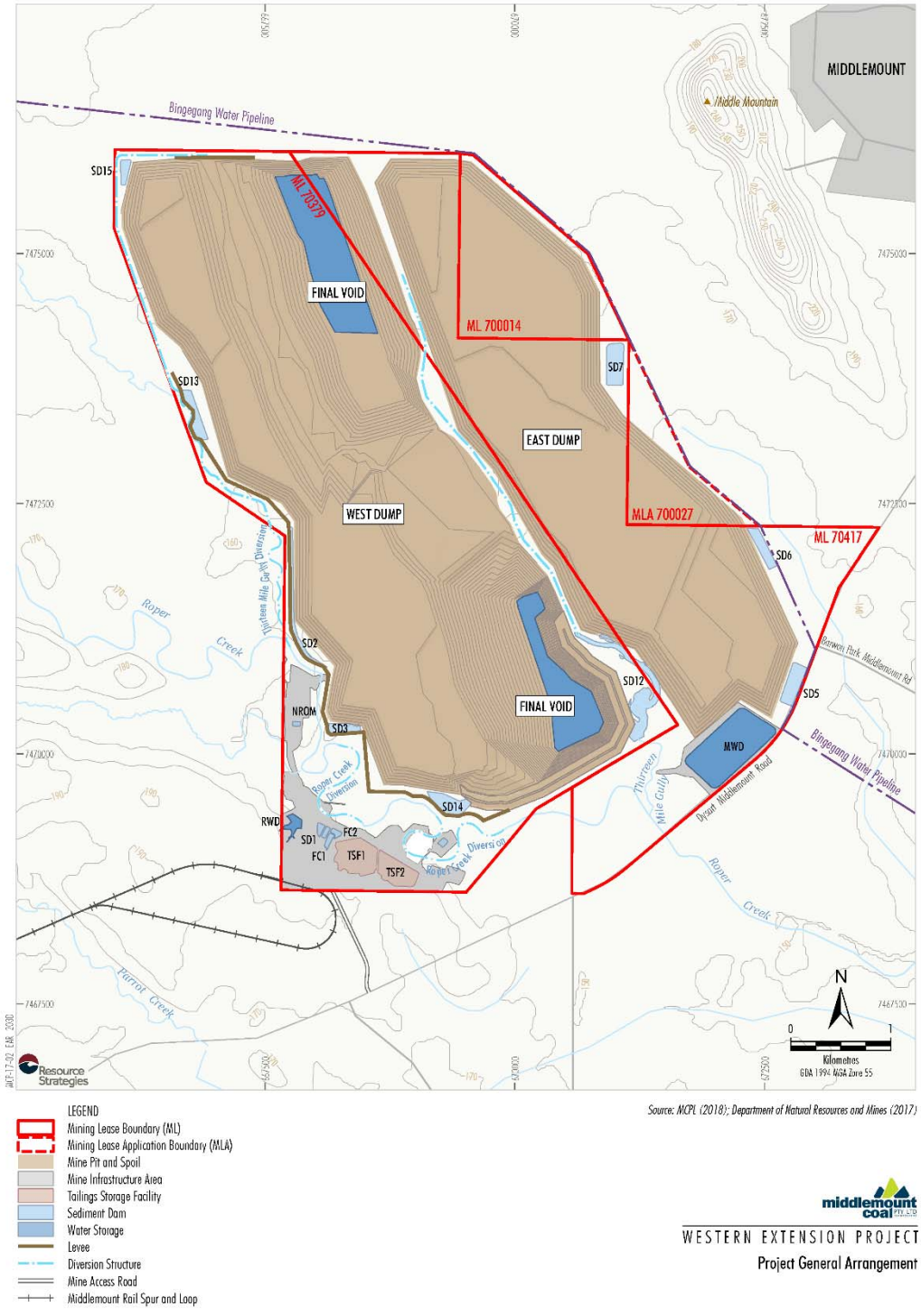

Figure 1-2: Project General Arrangement (figure supplied by Resource Strategies)

1.4 Regulation and license conditions

1.4.1 Environmental Authority EPML00716913 - MCPL

MCPL operates the MCM under EA EPML00716913 and the Plan of Operations and has approval for coal extraction at a rate of up to 5.7 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal.

This MWMP also addresses the conditions of the EA relating to Mining Waste Management: Conditions C30, E3 and E4.

1.4.2 Acid Rock Drainage: Condition C30

Under Condition C30, MCPL must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage.

1.4.3 Mining Waste Management: Conditions E3 and E4

Under Condition E3, a MWMP must be developed and implemented by an appropriately qualified person for every stage of the mining activities. The MWMP must be submitted to the administering authority by 29 June 2019 for review and comment. Under Condition E4, the MWMP must be updated within 20 business days of receiving comments from the DES. The MWMP must at a minimum include:

a) characterisation programs to ensure that all mining waste is progressively characterised during disposal for net acid producing potential, salinity and the following contaminants: pH, Electrical Conductivity (EC), Acid Neutralising Capacity (ANC), Net Acid Generation (NAG) (reporting NAG capacity and NAG pH after oxidation), Total Sulfur (S), Chromium Reducible Sulfur (Scr), Boron (B) Cadmium (Cd), Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na), Zinc (Zn) and Sulfate (SO_4);

b) characterisation programs to ensure that the physical properties of the mining waste are progressively characterised during disposal;

c) the availability or leachability of metals from the mining waste;

d) quantification of Potentially Acid Forming (PAF) mining waste from mining waste present;

e) review impacts of the PAF mining waste on the rehabilitation;

f) management actions for mining waste that has been identified as having a high availability or leachability of metals;

g) management actions for mining waste that has been defined as PAF;

h) identification of environmental impacts and potential environmental impacts;

i) control measures for routine operations to minimise likelihood of environmental harm;

j) contingency plans and emergency procedures for non-routine situations;

k) periodic review of environmental performance and continual improvement;

l) containment of tailings;

m) records to indicate locations and characteristics of tailings stored within the tailings storage facility;

n) the management of seepage and leachates from tailings storages both during operation and the foreseeable future;

o) the control of fugitive emissions to air; and

p) a program for progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings.

1.4.4 Potential Future Requirements: Progressive Rehabilitation and Closure Plan

The Queensland government is seeking better mine rehabilitation, improvement in financial assurance and assessment and action on residual risk. The mining rehabilitation reforms include:

- Financial assurance reform;

- Mining rehabilitation reforms;
- Mineral and Energy Resources (Financial Provisioning) Bill 2018; and
- Financial Assurance under the Environmental Protection Act 1994 Guideline

The reforms are being developed to reduce environmental harm and ensure that there is adequate financial provisioning. The need to develop a robust and defensible life of mine plan is being driven by:

- amendments to the Queensland Government Mineral and Energy Resources (Financial Provisioning) Bill 2018 (the Bill); and
- amendments to the Environmental Protection Act 1994 (EP Act) that will require a Progressive Rehabilitation and Closure Plan (PRC Plan)[7].

A PRC Plan will have mandatory content including:

- A rehabilitation **planning component** which documents the:
  - consultation processes undertaken to develop the plan;
  - the proposed design of the mine;
  - the final landform including encapsulation and cover design requirements;
  - different post-mining land uses or non-use management areas for the site,
  - methodologies and trials for rehabilitation;
  - and any post-closure management requirements for the site.
- A PRC Plan **schedule component** which includes:
  - all mined units (not just mining waste);
  - maps of final rehabilitation outcomes for each area;
  - tables of time-based milestones for achieving each post-mining land use or non-use management areas, and,
  - any conditions imposed on the schedule by the administering authority.

The content in this MWMP (and the current MCPL Rehabilitation Management Plan[8]) will cover some of the planning and scheduling components required within a potential future PRC Plan.

1.5 Document Control and Review Process

This MWMP will be reviewed and updated every two years by a suitably qualified person and the MCPL Environment Department and progressively updated and implemented to align with the Geology Department drilling programs.

Revision 001 of this MWMP is a draft document dated 20 June, 2019 and was approved by Daniel Jones, Environmental Superintendent at MCM. The current revision of the Plan (**Revision 002**) was certified by RGS on the (27 June, 2019). The information in **Table 1-1** documents the version control and sign off by RGS and MCM.

Table 1-1: MWMP Version Control and Approval

Document Control			
Revision	**Signatory**	**Role**	**Company approval (Signed and dated)**
Revision 001	Daniel Jones (MCPL)	Document Owner	
Revision 002	Alan Robertson (RGS)	Document Author	
Revision 003			

[7] DES (2019). Public Consultation Draft. Guideline. Progressive Rehabilitation and Closure Plans (PRCP plans). Department of Environment and Science (DES).

[8] MCPL (2012). Middlemount Coal Project Stage 2 Rehabilitation Management Plan. Document. August.

Table 1-2 allows for future amendments to the MWMP to be progressively tracked, over the life of the mine, and, if any substantive changes have been made or are proposed to be recorded in the Plan.

It is advisable to document how and why changes are made to the Plan to allow subsequent managers to understand the history of the site and follow the progressive management and operation of the mine areas.

Table 1-2: Management Plan Amendments

Document Control			
Revision	**Signatory**	**Requirement for amendment**	**Reference to amendment**
Revision 001			
Revision 002			
Revision 003			

Changes made to the MWMP will be documented to allow subsequent managers to understand the history of the site and follow the progressive management and operation of the mine areas.

RGS certifies that this MWMP is feasible and would meet the intent of the EA conditions (ie. the MWMP will enable MCM to continue to progressively characterise, mine and place the mined materials so that their potential to contribute to (or to mitigate) environmental harm can be determined.

In addition to the geochemical characterisation of materials currently being mined and processed, the MWMP includes information on project based characterisation work required for the management of the future mine materials (eg. the Western Extension Project), which are expected to be based on existing landforms construction techniques to contain future PAF mining wastes that will limit the extent of any adverse impact on the receiving environment.

1.6 Integration of the MWMP with other Departments

Effective management of mining waste materials including materials that will be required to initiate and then maintain sustainable vegetation, requires communication between the environmental, geology, mine planning and technical services departments.

Without effective communication and clear workflow designation the MWMP will not meet its objectives. The information in **Table 1-3** shows the potential workflow and communication within and between MCPL departments.

Table 1-3: MWMP departmental workflow

Department	Role	Tasks and responsibilities	Connections
Environment Department	Document control	Owner of the MWMP	→ Geology,
		Compilation and updating the MWMP and ensuring that the aim and objectives will be met ie. auditing process	
		Ensuring the MWMP is integrated with the Plans being managed by other departments eg. the PRC Plan and Water Management Plan	→ Planning, → Environmental, → Geology, → Tech. Services
		Ensure scheduled mining waste material sampling and analytical programs are planned, ahead of mining, on an as-required basis.	← Planning, ←→ Geology
		Work with the Geology Department to develop the MWMP to obtain necessary samples from in-fill drilling programs and/or blast hole drilling programs.	←→ Geology
		Document how changes to the MWMP will be tracked over time.	
	Life of mine planning	There will be a future regulatory requirement for a PRC Plan that must align with the short, medium, and long-term rehabilitation goals for the site.	← Planning
		The Environment Department must work with other departments and guide them to ensure that the operational mine plans to mine and produce coal align the legislative requirements of the Queensland Government *Mineral and Energy Resources (Financial Provisioning) Bill 2018* and the amendments to the *Environmental Protection Act 1994.*	←→ Planning ←→ Geology
	Material characterisation	Define the material types that will be mined (or processed) and need to be managed and rehabilitated to attain minimal financial liability and relinquishment. In general, all materials from the topsoil to the deepest mined surface should be included in the MWMP.	← Geology
		Document the specific sampling processes and the physical and geochemical analytical methods that will be adopted in consultation with the Geology Department.	←→ Geology
		Define the geochemical and physical criteria that will be used to classify the samples from drilling and sampling programs in consultation with the Geology Department.	←→ Geology
		Manage the interpretation and classification of the analytical data.	← Geology
	Financial Provisioning	Environmental Departments are typically required to manage environmental provisioning for rehabilitation and closure, and this requires reliable outputs from short, medium and long-term mine plans.	← Planning
Geology Department	Drilling and sampling	Utilise the MWMP to develop scheduled exploration and operational drilling and sampling plans.	← Environmental, (←→ Planning)
		Implement the exploration and operation drilling and sampling plans.	
	Update geology models	Compile the material characterisation data into the geology model(s).	← Environmental
		Provide the raw data and interpreted data to the Environmental Department.	→ Environmental
		Develop and report annual material balances and provide these to Environmental Department.	→ Environmental
		Provide the revised geology model to the mine planning team.	→ Planning
	Issue geology model and material balances	Provide updated material balances for all mined units to the Environment team to verify that the overall aim of the rehabilitation and closure plan can continue to be met eg. for the active (current iteration) of the mine plan is there enough topsoil, subsoil and other necessary material to achieve complete rehabilitation over the life of mine.	→ Environmental
Mine Planning Department	Life of mine planning	Development and maintenance of schedule in the Operational Mine Plan and PRC Plan	←→ Geology, ←→ Environmental
	Scheduling	Utilise revised geology models to develop short, medium and long-term mine plans including plans for progressive rehabilitation and closure.	← Geology
		Mine planners will need to align with environmental design criteria associated with constructed landforms to ensure that the landforms are rehabilitated to a safe and stable landform that does not cause environmental harm and will conform to the objectives of the *Mineral and Energy Resources (Financial Provisioning) Bill 2018* (the Bill).	→ Environmental
		Mine planners will provide the numerical basis from the Operational Mine Plan and PRC Plan to the environmental department for annual financial reporting (internally and externally).	→ Environmental
		Mine planners will provide the schedules and plan to technical services to implement on the ground.	→ Tech. Services
Technical Services	Design and construction	Operation of the mine including implementation of rehabilitation plans.	← Planning, ← Environmental, ← Geology

2 SCOPE, AIM AND OBJECTIVES OF THE MWMP

2.1 Scope

The scope of the MWMP is to manage all mined units including overburden/interburden, coal, and coal reject streams. Although not explicitly stated in the EA, the MWMP should also include sub-units for topsoil, subsoil and extremely weathered to weathered regolith that are present above the pre-mining groundwater level and that are potentially critical units required for successful rehabilitation.

Effective management leading to successful rehabilitation that will attain regulatory relinquishment or be considered as fit-for-purpose by a subsequent landowner will integrate the mining, placement and rehabilitation of the mined units.

To achieve effective management of the mining waste materials, this MWMP addresses the following conditions of the EA, and/or will reference where more detailed information is available:

- characterisation of the mined units and coal rejects (EA Condition E3 a, b, c and p) (Section 4);
- geological modelling and volumetric estimations of non-coal materials to develop material balances to satisfy (EA Condition E3 d) (ie. quantification of PAF from mining waste present) (Section 4);
- a defensible disposal plan for PAF materials that identifies potential environmental impacts and includes scheduling of material movement, placement and landform re-shaping, to appropriately and economically place material for maximum benefit and to minimise the likelihood of environmental harm (EA Condition E3 f, g, h, i, l and o) (Sections 5 and 6);
- location records and post placement verification of the mine scheduling to ensure that the placement and landform design criteria have been met (EA Condition E3 d and k) (Sections 6 and 7);
- contingency plans and emergency procedures for non-routine situations (Section 8);
- Management of seepage from mining waste materials (EA Condition E3 n - details contained in the MCM Water Management Plan) (Sections 4 and 5);
- rehabilitation strategy documenting what the overall goal for rehabilitation will be over the life of mine (details contained in the MCM Rehabilitation Management Plan);
- rehabilitation objectives, design criteria, indicators for success and completion criteria (details contained in the MCM Rehabilitation Management Plan);
- review programs to check environmental performance and continuous improvement, and ensure that rehabilitation has achieved the overall aim of the MWMP (EA Condition E3 k) details contained in the MCM Rehabilitation Management Plan); and
- document control defining how the document will be managed and how changes will be tracked over time.

2.2 Aim

The aim of the MWMP is to enable mining, coal processing and rehabilitation to be completed economically with minimal adverse environmental and social impacts on the land and water resources, and to lead to successful post-rehabilitation beneficial reuse. To achieve this aim there will be an integrated planning approach coupling the work programs undertaken by environmental, exploration and operational geology and short, medium and long term mine planning departments.

With an integrated, cross-discipline planning approach at the site, implementation of the management aims will be effective and eliminate any subsequent environmental issues.

The MWMP is the central focal point of a broader set of plans and procedures that will be used to achieve the intent of the Plan. The site procedures for some tasks such as material characterisation would be documented and managed by the custodian of the Plan.

Other tasks such as exploration and operational geological programs, short, medium and long-term mine planning (including landform design), water management (including seepage, sediment and

erosion control), and rehabilitation (ecological) programs are detailed in other MCM management plans and managed by other departments.

2.3 Objectives

The objectives of the MWMP are to document and map out:

- why the Plan is required;
- when the Plan will need to be updated
- how changes to the MWMP will be tracked to enable the reasons for changes to the Plan over the life of mine to be understood;
- who will plan and implement the tasks required to be undertaken by each department;
- how the data collected from departmental tasks such as waste characterisation or developing material balances will be stored and made accessible to other departments who are required to make use of the data;
- how the data are to be used and which other plans the data and the Plan will need to integrate with other Management Plans (eg. Water Management Plan, Mine Plan, Mine Rehabilitation Plan or future PRC Plan); and
- when the tasks in the MWMP are required to be undertaken and what the outputs will be.

2.4 Data Management

The material characterisation program will compile geochemical, physical and nutrient data. Typically, this data is provided by a commercial laboratory in pdf and spreadsheets that are then stored on a server. This can lead to the eventual loss of the data.

All geochemical, physical and any other relevant (eg. nutrient) data associated with the characterisation of coal, coal roof, coal floor, coal partings, rejects, tailings, topsoil, subsoil, regolith units in the overburden and interburden will be stored in the Geology Department geological database or in the environmental database management system (EDMS).

3 GEOLOGY

MCM resources form part of the wider Bowen Basin coalfields. Nearby open-cut coal mines to the south of Middlemount include German Creek East and Foxleigh. The coal deposition in this particular region of the Bowen Basin has both a marine and non-marine geological history. The presence of an oceanic environment in the early to middle Permian age is evident, and this was eventually followed by some volcanic/fault-line (tectonic) activity and a receding shoreline during the late Permian. At this time, and up until the early Triassic, the region was covered by swamps and shallow-lakes which acted like an internal drainage system, and the formation of fluvial floodplains occurred. Continental sedimentation was the primary method of coal deposition in and around the Middlemount area until a period of folding occurred in the stratigraphic profile in the late Triassic. In the following Jurassic age, the Bowen Basin was collectively exposed to a time when natural erosion processes exceeded the rate of deposition, and this resulted in a variety of geological structural formations across the region (eg. dykes, sills).

Permian coal deposits are ideally suited for the manufacture of prime coking coal and the Bowen Basin contains up to 70% of Queensland's state reserves. Extensive research into the geology of the Bowen Basin has occurred in recent years, and the geology is generally predictable and well understood. Coal deposits from this sequence are typically diverse in terms of rank/quality, thickness and associated economic-grade, and are widely distributed across the Bowen Basin. They are also typically characterised by (relatively) low sulfur content and a low propensity for spontaneous combustion.

Three Permian coal-bearing horizons are mined by Middlemount (the Middlemount, Tralee and Pisces seams). The coal seams mined by Middlemount are part of the Rangal Coal Measures and Burngrove Formation and the typical stratigraphy of the Project area is provided in **Figure 3-1**. The Roper, Middlemount Lower and Upper, Tralee and Pisces Upper seams (in descending order) belong to the Rangal Coal Measures, while the Pisces Lower seam belongs to the Burngrove Formation. Seams strike north-northwest and dip to the east generally at 3 to 7 degrees.

Two types of coal are produced for export markets: a semi-hard, low phosphorous coking coal, and a low-volatile Pulverised Coal Injection (PCI) coal. Mining at the open cut uses conventional truck-excavator techniques, and the raw coal is washed at the CHPP facility to render the products suitable for commercial export.

The Middlemount seam is the uppermost seam, which subcrops about 40 m below the natural surface through the middle section of ML70379. The seam thickness ranges from 2 to 7 m (average 4 m) and the upper plies are used as PCI coal and the lower as coking coal. The Pisces seam lies 30 to 50 m below the Middlemount seam and subcrops about 40 m below the natural surface through the western section of ML70379. The seam thickness ranges from 2 to 6 m (average 4.8 m) of coking coal.

The Rangal coal measures are overlain by Permian, and then by Tertiary and Quaternary (Alluvium) materials progressing to surface. The Permian and Tertiary materials consist mostly of weathered and fresh sandstone and siltstone with occasional mudstone and claystone. The Project area is typically covered by unconsolidated tertiary and Quaternary (alluvium) clayey and sandy sediments. Weathering depth is variable but is typically around 35 to 45 m.

The uniform stratigraphy/geology at MCM is typical of coal mines in the Northern Bowen Basin, where the stratigraphic profile in the lateral direction at the open pit is consistent and predictable.

MCM will generate a significant volume of coal and mining waste materials. For spoil, it is expected that approximately 1.171 million bank cubic metres (mbcm) will be produced over the life of mine. For coal rejects, the total mass of coarse reject and tailing materials is 27 Mt with a waste to product coal ratio (m/m) of 0.35:1. The total coarse reject and tailing masses are predicted to be 15 and 12 Mt (dry), respectively.

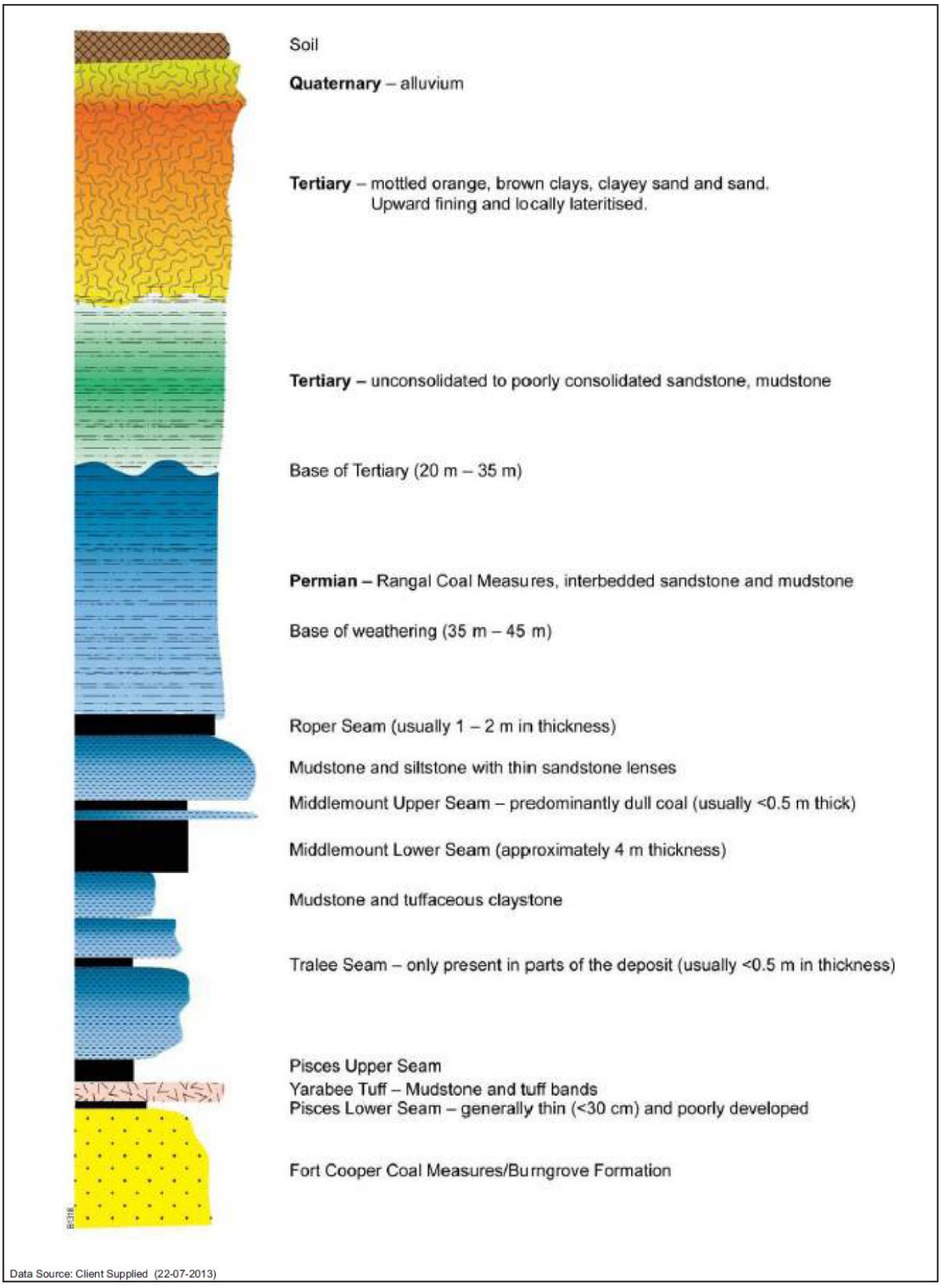

Figure 3-1: Typical Stratigraphic Profile

4 MATERIAL CHARACTERISTICS

A summary of the characteristics of the range of MCM coal and mining waste materials is provided graphically in **Figure 4-1** in accordance with the classification system presented in **Table 4-1**. This information is reproduced from RGS (2013)[9] and is based on the characterisation of 103 samples.

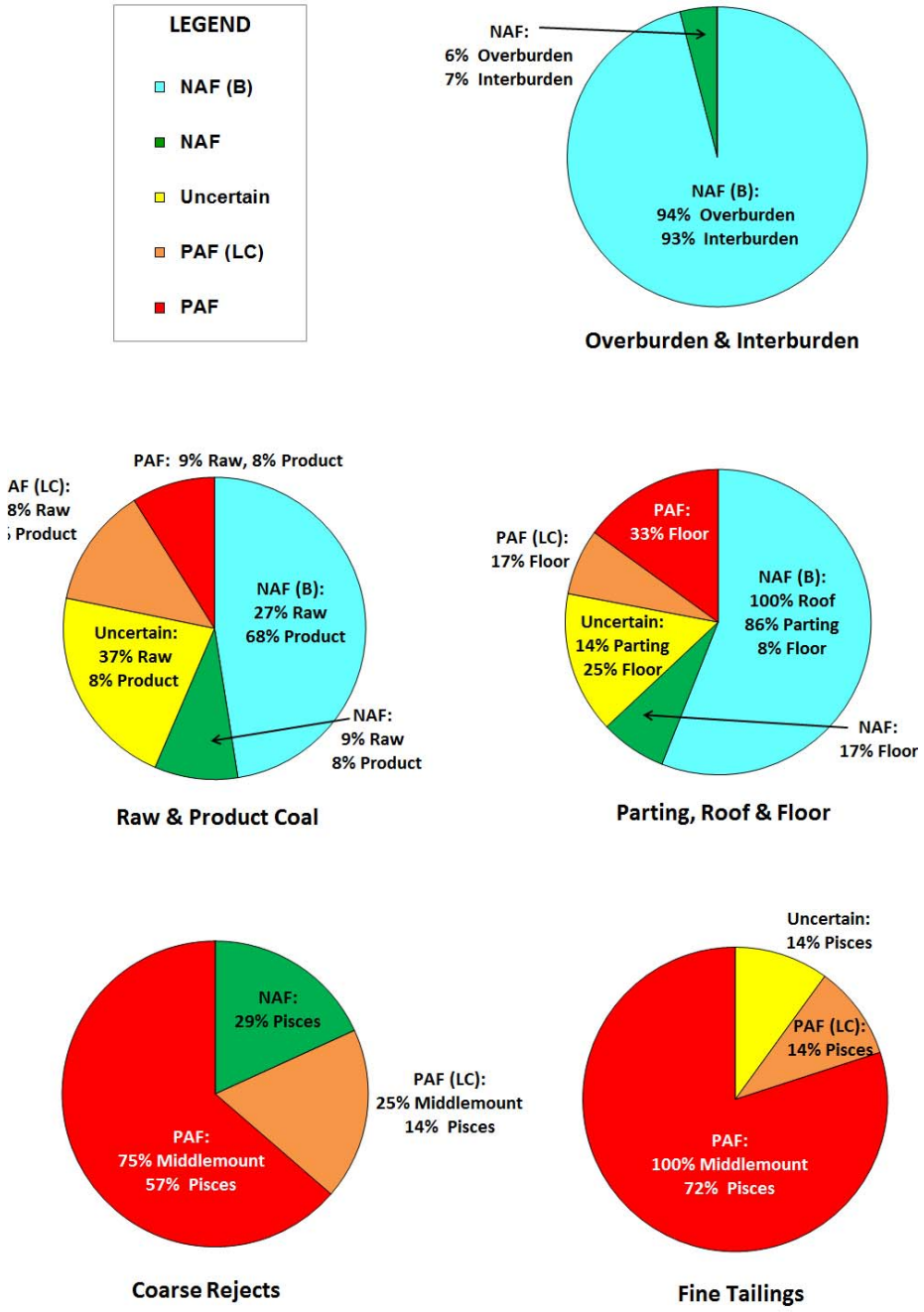

Figure 4-1: Geochemical classification of coal and mining by-product materials (from RGS 2013[9])

[9] RGS (2013). Middlemount Coal Project – Geochemical Assessment of Coal and Mining Waste Materials. Document prepared for Middlemount Coal Pty Ltd by RGS Environmental Pty Ltd (RGS). 16 August.

Table 4-1: Geochemical classification criteria for mine materials (from RGS, 2013[9])

Geochemical Classification	Total or Sulfide Sulfur(%)[1]	NAPP (kg H_2SO_4/t)	ANC: MPA Ratio	NAG_{pH}	NAG Capacity (kg H_2SO_4/t)
Non-Acid Forming (NAF) – Barren[2]	≤ 0.1	-	-	-	-
Non-Acid Forming (NAF)	> 0.1	≤ -5	≥ 2	-	-
Uncertain	> 0.1	> -5 and ≤ 5	< 2	≥ 4.5	≤ 5
Potentially Acid Forming (PAF) - Low Capacity	> 0.1	> 5 and ≤ 10	< 2	< 4.5	≤ 10
Potentially Acid Forming (PAF)	> 0.1	> 10	< 2	< 4.5	> 10

Notes:
1. If total sulfur or sulfide sulfur is less than or equal to 0.1 %, the NAPP and ANC/MPA ratio are not required for material classification as the sample is essentially barren of oxidisable sulfur.
2. A sample classified as NAF can be further described as 'barren' if the total sulfur and/or sulfide sulfur content is less than or equal to 0.1 per cent, as the sample essentially has negligible acid generating capacity.

4.1 Spoil

The available information on overburden and interburden (spoil) material[9, 10, 11] at MCM suggests that spoil is essentially barren of sulfur, is classified as Non-Acid Forming (NAF), and has a high factor of safety with respect to any potential to generate Acid and Metalliferous Drainage (AMD).

The Permian interburden material, in particular, has significant excess acid neutralising capacity (ANC), which is readily available, to more than adequately buffer the negligible amount of acid that could theoretically be produced from this material. This material is classified as NAF but is also be considered to be acid consuming. The Permian interburden material covers a depth interval of some 30 to 50 m in the stratigraphic profile and therefore a large volume of material mined from the open pit has readily available ANC to provide acid buffering. Hence, the Permian spoil materials provide a useful source of acid buffering material that is used as part of the management (encapsulation) strategy for other Potentially Acid Forming PAF materials which occur at the site (eg. coarse reject and tailings).

The concentration of total metals in most spoil is typically well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with rehabilitation and final land use. Surface runoff and seepage from spoil is predicted to be pH neutral to slightly alkaline and show relatively low levels of salinity following surface exposure. The concentration of soluble trace metals and major ions in runoff and seepage from spoil is likely to be low, remain within applied water quality guideline criteria, and is unlikely to present any significant environmental risks for on-site or downstream water quality.

In common with most coal mines in the Northern Bowen Basin, some spoil materials are sodic and have a moderate to high dispersion potential. Spoil materials are used at the MCM for general applications such as rehabilitation, although Permian interburden appears to be less prone to dispersion than Tertiary materials.

4.2 Coal, Roof, Parting, Floor, Coarse Rejects and Tailings

The available information on coal, roof, parting, floor, coarse rejects and tailings materials[9, 10, 11, 12] confirms that most of the coarse reject and tailings materials generated from processing the Middlemount and Pisces seams, and some of the floor material from the Middlemount seam, are likely to be PAF.

The concentration of total metals in PAF materials is typically below applied guideline criteria for soils. Surface runoff and seepage from PAF materials left exposed to oxidising conditions is likely to be acidic, with increased levels of salinity due to soluble sulfate, calcium and magnesium concentrations caused

[10] Parsons Brinkerhoff, 2011. Middlemount Coal Project – Stage 2 EIS.
[11] RGS (2016). Middlemount Coal Mine – Review of Geochemical Monitoring Data. Document prepared for Middlemount Coal Pty Ltd by RGS Environmental Pty Ltd (RGS). 21 April.
[12] RGS (2012). Geochemical Assessment of Coarse Reject and Tailings Materials - Middlemount Coal Mine. RGS Report No. 101116, 18 July.

by sulfide oxidation and neutralisation. The concentration of some soluble trace metals and major ions in runoff and seepage from PAF materials could be elevated if exposed to oxidising conditions.

4.3 Risk Assessment

The results summarised in **Figure 4-1** and discussed in this section demonstrate that the materials which carry the most significant risk of acid generation and poor quality leachate at MCM are the coarse reject and tailings materials generated at the Coal Handling and Processing Plant (CHPP). These findings align well with the MCPL operating experience over the past decade and would be expected given the predictable geology and stratigraphy of the open cut mining area previously described in **Section 3**.

5 ENVIRONMENTAL ISSUES, IMPACTS AND CONTROLS

The environmental issues, impacts and controls associated with mining waste materials at MCM are described in **Table 5-1**. The potential for AMD from coarse reject and tailing materials is considered to be the major risk and the following hierarchical of control strategies in order of priority can be categorised as:

- prevention of impact;
- minimisation of impact and/or likelihood through active or passive treatment impact; and
- interception and control of impact.

The control measures will depend on topography, mining method, material type, soil/rock types, mineralogy, and available neutralisation resources. Control measures are documented in **Table 5-1** and have been integrated into the operational management measures described in **Section 6**.

Table 5-1: Environmental Issues, Impacts and Controls

Potential Issue	Potential Impact	Control Measures
AMD	• Contamination of surface water from spoil emplacement areas and stockpiles. • Contamination of stock, irrigation and domestic groundwater supplies. • Degradation of aquatic ecosystems. • Impact on recreation and aesthetics. • AMD from incorrect placement of PAF material.	• Minimise exposure of PAF materials to wetting and drying cycles by limiting rehandling of PAF mining waste, coarse rejects and tailings material and progressive covering of PAF material. • Selective handling and placement of materials, including neutralisation of PAF materials by mixing of PAF material with spoil with excess acid neutralisation capacity (eg. PAF with Permian spoil). Factor of safety applied to mixing with minimum of 3 Permian to 1 PAF by weight (target of 5 parts Permian to 1 part PAF material), based on geochemical characterisation assessment (RGS, 2013). • Development and communication of PAF disposal areas and methods. • Rehandling of incorrectly placed material (eg. within 10 m of final landform surface). • Diversion of run-on water from PAF disposal locations. • Minimisation of water pondage on dump surfaces and subsequent infiltration. • Placement of PAF material at least 10 m from final landform with NAF/Permian cover to minimise water movement through material and provide neutralising material. • Rapid dewatering of tailings and recycling of decant water to minimise the volume of decant water and the duration of exposure. Possible through mechanical dewatering or in-line flocculant cells. • RPEQ designed and certified tailings decant storages. • Chemical amelioration, eg. lime dosing, where required. • Disposal locations to be within the in-pit spoil and are internally draining to the mine pit. • Containment of mine affected water including leachate from PAF disposal locations and coal stockpiles. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Progressive characterisation of mining wastes, specifically coarse and tailings. • Tracking of PAF disposal locations. • Monitoring of leachate from in-pit disposal locations and coal stockpiles. • Monitoring of groundwater resources, specifically aquifers suitable for human or stock consumption. • Monitoring of upstream reference and downstream impact points and REMP monitoring. • Adoption of emergency response plans, including consideration of downstream landholders.

Potential Issue	Potential Impact	Control Measures
Dust from PAF materials	• Toxicity to the receiving environment. • Transport of contaminants to the receiving environment.	• Minimise exposure of PAF materials to wetting and drying cycles by limiting rehandling of PAF rejects and waste and progressive covering of PAF material. • Dust suppression of PAF disposal locations. • Neutralisation of PAF materials by mixing of PAF material with spoil with excess acid neutralisation capacity (eg. PAF with Permian spoil). Factor of safety applied to mixing with a minimum of 3 Permian to 1 PAF based on geochemical characterisation assessment (RGS, 2013). • Placement of PAF material at least 10 m from final landform with NAF/Permian cover. • Rapid dewatering of tailings and recycling of decant water to minimise the volume of decant water and the duration of exposure. Possible through mechanical dewatering or in-line flocculant cells. To provide working surfaces for tailings reclamation without wet/boggy sub-stratum. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Monitoring and analysis of dust emissions. • Dewatering of tailings prior to transport to minimise spills of wet material.
Release of tailings from Tailings Storage Facilities	• Release of tailings and/or tailings decant water to Roper creek. • Sediment load increased in Roper Creek. • Contamination of water from release of water with some or all of the following; low pH, high EC, elevated metal or sulfate concentration • Metal accumulation in plants and animals. • Contamination of stock drinking supplies. • Contamination of soil. • Loss of human and/or animal life.	• Certified design and construction of the Tailings Storage Facilities. • Annual inspection by Registered Professional Engineer of Queensland (RPEQ). • Routine inspections and repairs. • Maintenance of Design Storage Allowance. • Reclamation of tailings and/or alternative dewatering of tailings prior to placement within in-pit spoil with available acid neutralisation capacity.
Interaction of PAF with rehabilitation	• Interaction of PAF with rehabilitation.	• PAF material to be co-disposed with spoil with acid neutralisation potential. • 10 m buffer maintained from PAF disposal locations to the final rehabilitation profile. • Rehabilitation monitoring.
Metals/metalloids leachate	• Leaching of metals/metalloids via AMD.	• Mining waste characterisation and contact testing (RGS 2013). • Progressive characterisation of coal and mining waste and review to determine the potential leachate risk (RGS, 2016). • Disposal of PAF material with spoil with available acid neutralisation capacity.

Potential Issue	Potential Impact	Control Measures
Dust from Overburden	• Toxicity to the receiving environment	• Progressive recontouring and rehabilitation of spoil dumps. • Dust suppression. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Monitoring and analysis of dust emissions.
Spoil run-off	• Contamination of surface water from spoil run-off	• Progressive recontouring and rehabilitation of spoil dumps. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Installation and maintenance of drainage and sediment and erosion control structures to control and treat run-off from spoil piles.

6 MATERIAL MANAGEMENT

6.1 Material Definition

At the MCM coarse rejects and tailings are co-disposed in pit at the site along with spoil materials in accordance with the EA[1], Plan of Operations[6], In-Pit Disposal Site Procedure[13] and the Environmental Management Plan (EMP)[14]. It should be noted that historically at MCM mining waste materials have been termed 'mining by-products'.

The previous MCM Mining By-Products Management Plan[15] states that '*Mining waste is generated through the coal excavation process and includes overburden, interburden. It can also contain coal seam partings, roof and floor materials if these do not report with coal to the CHPP. All these mining waste components are disposed of within the mining pit and need to be treated in accordance with the risk of acid generation. Generally, overburden is placed in ex-pit spoil and interburden is placed in in-pit spoil*'.

6.2 Coal Processing

The mining materials flow at the MCM CHPP is presented in **Figure 6-1** below.

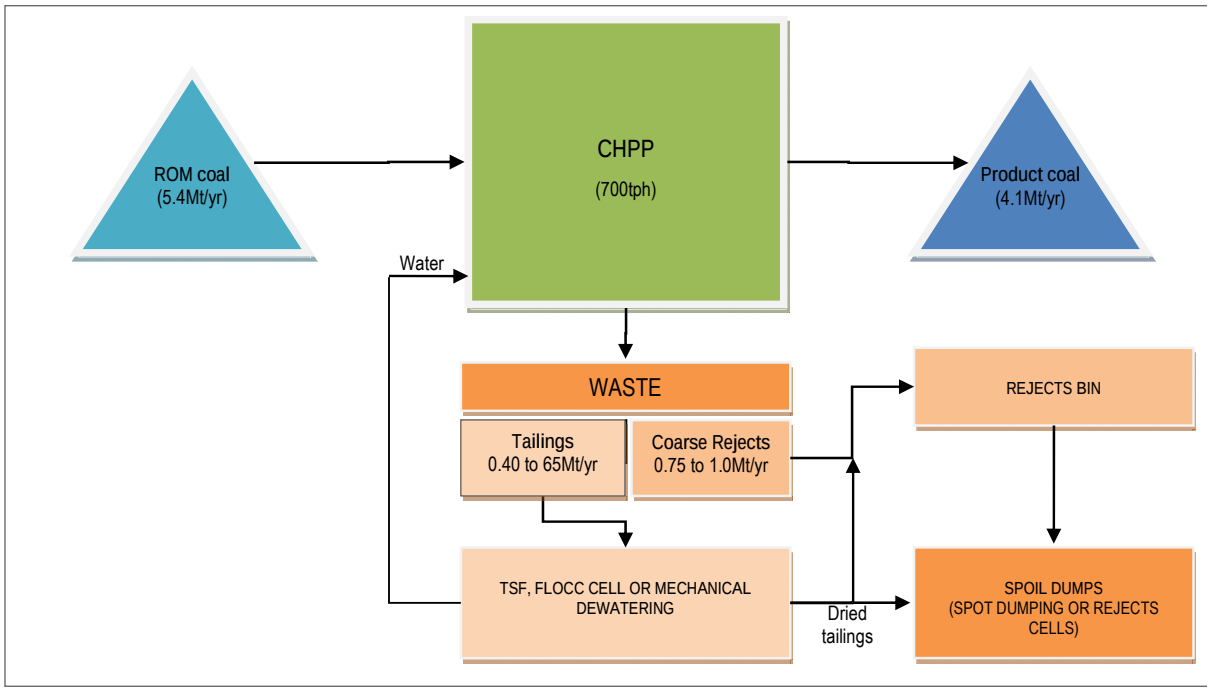

Figure 6-1: Materials process flow (adapted from Stage 2 EIS (PB, 2012[10]))

Coal processing of coal at the CHPP produces two waste products: ie. coarse rejects and tailings.

Coarse rejects: are produced from the spirals/spirals reject dewatering screen and Dense Medium Cyclone via a drain and rinse screen. Coarse rejects report via the rejects conveyor to the 240 t rejects bin prior to trucking to the disposal locations within spoil in-pit.

[13] Middlemount Coal (2018a). Mining By-Product In-Pit Disposal Site Practice. Document SP-212-004 Version 2. 24 April.
[14] Middlemount Coal (2018b). Environmental Management Plan. Management Plan 003. 17 October.
[15] Middlemount Coal (2018c). Mining By-Products Management Plan. Document MP-212-001 Version 7. 24 April

Tailings: (fine rejects) are produced from the CHPP thickener underflow and are then pumped to one of the following locations:

- Tailings Storage Facility (TSF) 2 In Line Flocculation (ILF) Cells consists of four cells within the existing and permitted TSF 2 footprint. The cells are used to hold tailings that have been flocculated in the pipeline prior to deposition, for a short period prior to it being excavated and hauled for disposal within spoil in-pit.
- In-line flocculant cells – consists of two emergency cells located between TSF 1 and Sediment Dam 1. These two cells are yet to be utilised, and if required, tailings will be pumped to in-line flocculant cells with flocculant added prior to discharge to accelerate dewatering of the material.

6.3 Operational Management

All mining waste at the open pit is mined by excavator and truck or dozer push. As previously described in **Section 4**, most mining waste is classified as NAF or acid consuming with the exception of the Middlemount and Pisces seam floor. Coarse rejects and tailings (process wastes) have the potential to form AMD. To mitigate the risk from PAF material, the mining waste, coarse rejects and tailings disposal options are shown in **Table 6-1** . Each option is documented in more detail in this section.

6.3.1 Overburden and interburden

Overburden is classified as NAF and is placed in any in-pit or ex-pit spoil dump. Dispersive material is preferentially placed away from the final landform surface.

Interburden is preferentially placed in-pit to provide the acid neutralisation capacity for spot-dumping of PAF materials and creation of Permian caps and bunds on coal reject cells. Placement in ex-pit spoil can be used to neutralise any PAF material that is placed in the ex-pit spoil.

6.3.2 Coal seam partings and roof

Coal seam partings and roof material is preferentially placed in in-pit spoil at least 10 m from the final landform surface. Where required, this material may be placed in ex-pit spoil at least 10 m from the final landform.

6.3.3 Coal seam floor

Coal seam floor material is placed at least 10 m from the final landform surface and preferentially spot dumped with Permian material within in-pit spoil. In the event it is necessary to place the material in ex-pit spoil the floor material is lime dosed and covered with 10 metres of Permian spoil

6.3.4 Coarse rejects

Coarse rejects are discharged to the 240 t rejects bin via the rejects conveyor. Mine Haul trucks haul the rejects from the bin for disposal within the in-pit spoil dump. Where production of rejects exceeds haulage to in-pit disposal or wet-weather constrains pit access, rejects are temporarily stored on rejects pads. Stockpiled rejects are then loaded into haul trucks using front-end loaders or excavator for haulage to the disposal location in-pit.

To prevent hang-ups of material and minimise temporary stockpiling of rejects, the Coarse Rejects Bin is kept below 75 % capacity and drawn down regularly when operating with coarse rejects only while the CHPP is running. The Coarse Rejects Bin is emptied prior to any planned shut-downs.

In the event that tailings are co-mingled with the coarse rejects on the rejects conveyor, the rejects bin is maintained below 50% capacity and is emptied regularly.

Drainage from coarse rejects storage areas (rejects bin and temporary rejects storage locations) is contained on site (as detailed in the MCM Water Management Plan). Water is returned to the Raw Water Dam for reuse as soon as practicable.

Table 6-1: Mining Waste Disposal Options used at MCM

Material	MCM Mining Waste Disposal Options					
	Ex Pit Spoil	**In-Pit Spoil**	**In-Pit spot dump in Permian** (10 m from final landform surface)	**Ex-Pit spot dump** (10 m from final landform surface)	**In-Pit Cells** (10 m from final landform surface)	**TSF**
Overburden	Preferred	Preferred	N/A	N/A	N/A	N/A
Interburden	Preferred	Preferred	N/A	N/A	N/A	N/A
Coal Seam Partings & Roof (All Seams)	Acceptable (10 m from final landform)	Preferred	Preferred	Acceptable	N/A	N/A
Coal Seam Floor (All Seams)	Avoid (Lime dosing and 1 0m of Permian cover)	Acceptable (10 m from final landform)	Preferred	Avoid (Lime dosing and 10 m of Permian cover)	N/A	N/A
Coarse Rejects	No	No	Preferred (Ideal 5:1, Minimum 3:1 Permian to Rejects)	Avoid (Minimum 10:1 Permian spoil to rejects, lime dosing and 10 m Permian cover required)	Acceptable (Lime dose as required)	N/A
Tailings	No	No	Acceptable (Lime Dose as required) – Caution – Tip head stability	No	Preferred (Dried and Lime dosed as required)	Acceptable
Co-mingled Coarse Rejects & Tailings	No	No	Preferred (Ideal 5:1, Minimum 3:1 Permian to Rejects)	Avoid (10:1 Permian spoil to rejects, lime dosing and 10 m Permian cover required)	Acceptable (Lime dose as required)	N/A

6.3.5 Tailings

At the MCM, MCPL uses earth bunded structures as ILF cells designed to hold flocculated tailings temporarily whilst dewatering takes place and excavation/reclamation of dried tailings can occur. The ILF cells have a minimum capacity of one week of CHPP production with additional allowance (freeboard) for rainfall and water management. Cells are designed with no external catchment to minimise flooding potential, environmental risk and Design Storage Allowance (DSA) requirements and will include sufficient DSA capacity in addition to the operational volumes. All water produced is returned to the CHPP or the Raw Water Dam to supply plant make-up water.

The tailings are dosed with flocculant to accelerate the dewatering process prior to placement in the ILF cells. The dewatered tailings are allowed to dry and are then excavated and trucked to the pit for placement within the in-pit spoil dump. The CHPP is responsible for the operation of the tailings discharge and return water. Mine operations are responsible for tailings reclamation.

6.4 PAF waste placement

PAF waste material (coarse rejects and tailings) is preferentially placed within in-pit spoil via spot dumping with Permian interburden or placed within in-pit cells. In both cases the ANC of the Permian spoil is used to neutralise the potential acid forming capacity of the PAF material. All PAF material is placed at least 10 m from the final landform surface (**Figure 6-2**).

Where placement of in ex-pit spoil is required, PAF material is lime dosed, spot dumped and covered with Permian interburden.

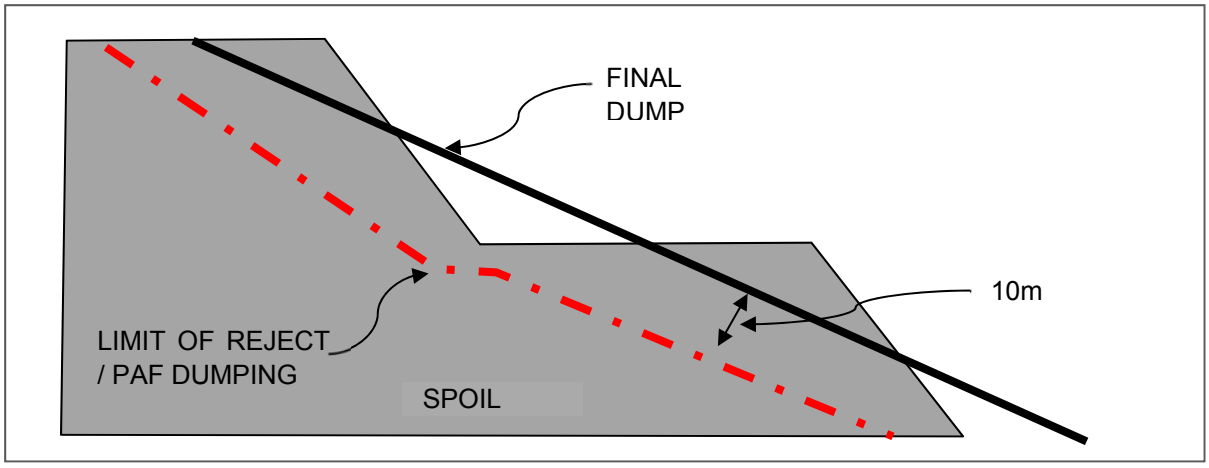

Figure 6-2: Typical Cross-section of spoil dump and 10m minimum cover.

6.4.1 Spot Dumping – In-pit spoil

Spot dumping of PAF coarse rejects/tailings materials and Permian spoil occurs within the boundaries of the open pit area (ie. internally draining bounds of the open pit spoil). The objective of the spot dumping is to enable the ANC of the spoil to neutralise the potential acid formation. To provide a suitable factor of safety, PAF material is mixed with a minimum of 3 parts Permian spoil by weight (Target of 5 parts Permian to 1 part PAF material).

All Spot dumping locations drain internally to the open pit and are at least 10 m from the final landform. No coarse rejects or co-mingled coarse and fine rejects are used as part of a tip head safety bund, haul road or ramp.

In-pit spot dumping is designed in accordance with the Mining By-Product In-Pit Disposal Site Practice[13].

6.4.2 In-pit cell operations

As an alternative to spot dumping, cell based in-pit emplacements are progressively constructed. These emplacements are created within the Permian spoil in progressive in-pit dump designs. Cells include a permeable floor for basal drainage and containing embankments of Permian spoil. PAF material is

tipped over dedicated tip heads and covered with 10m of Permian spoil. Cells are designed in accordance with the Mining By-Product In-Pit Disposal Site Practice[13].

6.4.3 Spot dumping – Ex-pit spoil

In certain unusual circumstances placement of PAF in ex-pit spoil may be required. Under this eventuality, PAF material will be spot dumped with Permian spoil at a ratio of 10:1 (Permian to PAF). The PAF material will be lime dosed and covered with 10 m of Permian spoil. Specific approval from MCM's Environment Department is required prior to placement of PAF in Ex-pit spoil.

No coarse rejects or co-mingled coarse and fine rejects will be used as part of a tip head safety bund, haul road or ramp.

6.5 NAF Waste Placement

NAF coarse rejects and tailings materials are treated the same as PAF coarse and fine rejects; and are preferentially placed within in-pit spoil via spot dumping with Permian interburden. The ANC of the Permian spoil is used to provide a factor of safety to NAF categorised coarse and fine rejects. All NAF coarse and fine rejects and coal seam floor material will be placed at least 10 m from the final landform surface.

NAF overburden, interburden and coal seam partings and floor may be placed in in-pit or ex-pit spoil. Partings and floor are preferentially placed in-pit.

6.6 Coarse Rejects and Tailings Disposal Recording

A record of coarse rejects and tailings properties is maintained by MCPL in the EDMS, including Acid Base Account and monitoring results as described in **Section 2.5**. Additionally, monthly tonnages of coarse rejects and thickened tailings disposed are also recorded in the production database.

7 MONITORING

Monitoring of water and solid materials forms an important part of the on-site management of mining waste materials and is completed in accordance with the EA[1], Plan of Operations[6], EMP[14], Water Management Plan[16], and this MWMP.

The monitoring program is primarily aimed at identifying PAF coarse reject and tailing materials and potential impacts to ensure that management practices are appropriate or are modified accordingly. Monitoring is conducted by trained on site personnel or by specialist consultants as engaged by MCPL.

Ongoing characterisation of coarse rejects and tailings materials is completed in accordance with relevant site plans and procedures. Leachate from coarse rejects and tailings placed at spoil disposal areas and tailings decant water is included in the site water quality monitoring program.

On-going characterisation of the coal and mining waste materials (including overburden, interburden, floor, roof and partings) is completed on a project basis in accordance with relevant site plans and procedures, if new areas of the site are planned to be mined that have not been previously characterised (eg. the Western Extension Project described in **Section 1.2**).

The routine and project-based MCM monitoring program schedules are provided in **Table 7-1**. The monitoring program is revised as part of data and management plan reviews and as more site-specific data becomes available.

On a project basis, drill core/chip samples representing overburden, interburden, coal seam, coal seam roof, parting and floor materials from new areas of the site that are planned to be mined will be taken and subjected to geochemical screening tests according to this MWMP; and selected samples will be subjected to water extract water quality tests and kinetic tests, if required, as described in **Table 7-1**. Some input from an experienced geochemist will be required to assist with the sample selection and testing program and interpretation of results.

Drill core intervals will cover up to 0.5 m whereas drill chip intervals may cover up to 3 m intervals and be limited to a single lithology or material type, where possible, to assist in later interpretation of results. Drill core/chip samples will weigh approximately 1-2 kg and samples will be double bagged and clearly labelled with the sample name and date of collection. A list of all samples collected will be prepared and include the drill hole number, sample depth interval and any visual observations of key minerals (eg. pyrite, calcite). Drill logs will be geophysically corrected and provided to the geochemist interpreting the project based geochemical assessment program.

The drill core/chip samples described above will be stored in a cool dry place prior to being sent to an appropriate commercial laboratory for geochemical characterisation. Each sample batch will be accompanied by a completed laboratory Chain of Custody (COC) form, which identifies the samples and details the analyses required to be completed (**Table 7-1**).

7.1 Monitoring Records

Sampling and characterisation of coal and mining waste from the open pit (overburden, interburden, floor, partings and roof materials) and from coal processing (coarse rejects and tailings) is undertaken periodically as part of the monitoring program to assess the risk of AMD associated with any PAF materials. The aim the program is to quantify the characteristics of materials, assess potential impacts and confirm or modify management strategies associated with the material.

Additional monitoring to that described in **Table 7-1** includes routine ground water, regulated structures (TSF) inspections and rehabilitation monitoring.

[16] Middlemount Coal (2019). Draft Water Management Plan MP 207-001. 23 April.

Table 7-1: Routine and Project-Based MCM Coal, Mining Waste and Water Quality Monitoring Program

Frequency	Sample Source	Sample Point	Analysis	Comments
Quarterly	Middlemount Seam, Tralee Seam Pisces Seam or blend.	1. Tailings thickener underflow 2. Coarse rejects	pH, EC, total sulfur, ANC and Scr. 1:5 water extract water quality (dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4).	Source of coal to be recorded to develop spatial understanding of rejects by source. Frequency to be reviewed annually or if materials are consistently NAF.
	TSF and ILF cell decant water	TSF 1, ILF Cell 1 & 2 and TSF 2 if receiving tailings.	pH, EC, dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4 as per EA Table C3).	
	Middlemount Seam, Tralee Seam Pisces Seam	ROM Coal	pH, EC, total sulfur, ANC and Scr.	
Opportunistic	Leachate from disposal locations		pH, EC, dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4 (as per EA Table C3).	If possible. Locations to include in-pit cells and pit water.
Project Based	Overburden, interburden, floor, partings and roof of all seams	Overburden, interburden, floor, partings and roof from exploration drill core.	pH, EC, total sulfur and Scr, as required. 1:5 water extract water quality (dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4). Column leach testing as required.	One-off sampling for new project areas to focus on spatial distribution rather than strict timing.
As Required	All sample sources	Additional sampling will be undertaken on an as-needs basis.		

[#]ICPMS/CV FIMS – analytical methods required to achieve laboratory Limit of Reporting (LOR).

Monitoring records for coal and mining waste materials are maintained by MCPL and stored in the EDMS and include the following:

- Sample date and time;
- Sampler
- Sample location
- Sample source (seam, strip and block)
- In-situ parameters pH, EC and temperature (water only)
- Visual observations. Key indicators of AMD presence include (but are not limited to):
  - Turbidity
  - Colour, (eg. particularly red coloured, unnaturally clear water;
  - Odour, (eg. sulfurous);
  - Precipitate formation (eg. orange-brown iron oxide precipitates);
  - Corrosion of concrete or steel structures.
  - Laboratory results for the range of analyses described in **Table 7-1**.

7.2 Saline and Sodic Potential

EA Condition E3 requires characterisation programs to ensure that both the geochemical and physical properties of the mining waste are progressively characterised. The physical test parameters are typically focussed on rehabilitation and more information on this issue is contained in the Rehabilitation Management Plan[8]. During disposal, spoil material is characterised to identify dispersive and non-dispersive spoil and saline drainage potential. The primary source of salts that can leach from soil, sub-soil, regolith units, transition material and fresh rock can be sodium chloride (brought inland from the ocean in rain and leached through the geological profile over geological timescales) or primary and secondary minerals.

Saline drainage levels in surface runoff and seepage from spoil associated with sodium chloride (NaCl), sodium bi-carbonate ($NaHCO_3$) or sulfate (SO_4^{2-}) can be elevated and may not achieve with water quality targets and limit the ability to release water from site.

Soil and spoil dominated by NaCl or $NaHCO_3$ can be sodic (the clay minerals disperse making them highly erodible-when the clays settle, and they can have very low permeability) and this can reduce the ability to use the soil or spoil for rehabilitation.

MCPL will ensure that a program for sampling and testing of soil and overburden at new mining areas, such as the Western Extension Project, includes methods which allow identification and management of saline drainage potential and/or sodic potential. This will be done as part of rehabilitation field trials.

7.3 Integrated Monitoring and Management

Other monitoring that may interact with mining waste management includes groundwater, regulated structures, rehabilitation monitoring and general inspections. Items considered include:

- Water quality – groundwater;
- Water quality – surface water;
- Seepage/leachate production and quality;
- Visual inspections;
- Soil geochemistry; and,
- Vegetation coverage and establishment.

All monitoring results are used to assist with continuous improvement of the mining waste management strategies.

7.4 MWMP Review

The MCM Environment Department is responsible for communicating the outcomes of an independent review of the risk of AMD, to site personnel and contractors. Reviews will be undertaken by the MCM Environment Department and/or a suitably qualified specialist consultants on a two-yearly basis. If management practices are not effective, changes to the management will be made and implemented.

In addition to the MWMP review process described above, additional reviews will occur on an 'as needs' basis if mining waste management issues arise. Reviews will include consideration of monitoring results. Any changes in operational practices will be incorporated into the documentation and communicated to responsible employees and contractors.

Suitable criteria to establish whether mining waste management practices are effective are as follows:

- no complaints in relation to mining by-products management;
- full compliance with the requirements of this MWMP;
- no uncontrolled release of contaminated leachate; and
- continual improvement in mining waste management practices.

All matters relating to Mining by-products are referred to and managed by the MCM Environment Department.

All relevant personnel employed at MCM will undergo training in relation to mining waste management.

8 CONTINGENCY AND EMERGENCY PLANS

8.1 Operational Contingencies

MCPL has developed operational contingencies for scenarios that may occur throughout the life of the operation. Each scenario may have more than one contingency of which a portion of the contingencies may be enacted in that event based on the site conditions at the time. The scenarios and contingencies are presented in **Table 8-1**.

Table 8-1: Operational Contingencies

Scenario	Possible Contingencies
Insufficient Permian for spot placement of PAF material	• In-pit cell construction and possible lime dosing. • Ex-pit spot dumping with lime dosing. • Tailings diverted to TSF 1 or 2.
Incorrect placement of PAF within 10 m of final landform	• Incident Investigation. • Removal and relocation of PAF material to suitable dump location. • Assessment of potential or real impacts.
Wet-weather preventing access to disposal locations	• Temporary storage of rejects at temporary rejects stockpiles. • Review CHPP production rates.
Mechanical dewatering equipment malfunction	• Temporary placement of tailings in the TSF 1 or 2. • Future reclamation to provide sufficient emergency capacity in TSF 1 or 2.
Abnormal monitoring results	• Investigation into cause of results and mitigation measures required.
AMD indicators found	• Soil and water sampling to be conducted. • AMD source treated (removed, ameliorated, etc). • Interception/mitigation measures installed based on expert advice.

8.2 Emergency Response

If any MCPL personnel suspect the presence of AMD, it is reported to the Site Senior Executive (SSE) and the MCM Environment Department as soon as practicable and within 24 hours. The Emergency Preparedness and Response Management Plan (ERMP) is also consulted. Emergencies relating to regulated dams are managed in accordance with regulated dam guidelines and operational plans.

Any uncontrolled release of contaminants is managed in accordance with the following general principles:

1. **Isolate**
   - Isolate access to the spill and sources of spill (valves, etc), where possible.
2. **Notify**
   - Notify Supervisor and Environment Department or SSE.
   - The MCM Environmental Department, in consultation with the SSE, will consider the need to contact downstream landholders, DES and other stakeholders. The ERMP should also be consulted.
3. **Contain**
   - Prevent spill spreading or entering waterways (eg. by bunding). Amelioration with lime, if required.
4. **Control the release**
   - Control the release source (drain, etc). May be completed in conjunction with Principle 3.
5. **Reclaim**
   - Reclaim released material and/or contaminated material where the impact is justified. Caution is to be applied around watercourses and with potentially acidic water/material and specialist advice may need to be sought.

The MCM Environment Department will commence an investigation into the reported AMD and may include visual inspections, soil and water monitoring and possible test pits. Where AMD is deemed likely, the MCM Environment Department will engage a suitably qualified consultant to advise on appropriate actions that may include sampling programs to determine if AMD is occurring as well as containment, mitigation and

remedial actions to prevent further AMD impacts. The MCM Environment Department will review this MWMP, site procedures and monitoring records. If required, management plans and site procedures will be amended.

Where an incident occurs that results in an emergency or incident which results in, or may result in, environmental harm or the release of contaminants not in accordance with the sites EA, the administering authority will be notified in writing within 24 hours (EA Condition A8).

Written advice will be provided to the administering authority (EA Condition A9 and A10), no more than 10 business days following the initial notification of an emergency, incident or information about circumstances which result or may result in environmental harm or the release of contaminants, or within 24 hours after receiving the results from analysed samples.

9 CERTIFICATION

As described in **Section 1.5**, RGS certifies that this MWMP is feasible and would meet the intent of the EA conditions (ie. the MWMP will enable MCM to continue to progressively characterise, mine and place the mined materials so that their potential to contribute to (or to mitigate) environmental harm can be determined. The Qualifications of the RGS personnel suitably qualified to certify this MWMP are provided below.

9.1 Suitably Qualified Persons – RGS Company Details

The core business of RGS is to undertake static and kinetic chemical and physical material characterisation studies and produce certified mine material, mine rehabilitation and mine closure plans that include sampling, analytical and monitoring programs.

RGS is an owner-operated leading environmental consulting company that has been operating successfully for the past twelve years. We provide timely and cost-effective solutions to complex environmental management issues from exploration through the planning, operational and closure phases of small to large scale mining projects. RGS has gained an international reputation as a leading provider of environmental management services to the mining and mineral processing industry and takes pride in being flexible, practical and innovative. RGS is committed to delivering on time and within budget; technical excellence; consistent quality; and continual improvement of our service delivery and skills.

RGS personnel have provided services to more than 500 mining and mineral processing projects in Algeria, Argentina, Australia, Bangladesh, Brazil, China, Ghana, India, Indonesia, Laos, Malaysia, Mozambique, New Caledonia, New Zealand, Papua New Guinea, Philippines, Romania, Thailand, Turkey and Vietnam. RGS has worked on more than 100 coal mine projects in Queensland, New South Wales, Western Australia, Africa, New Zealand, Indonesia, Laos and Bangladesh. Our clients range from small to large mining companies including Anglo American, BHP Billiton, CS Energy, Evolution Mining, MMG, Rio Tinto, Stanwell Corporation, Vale and Glencore.

9.2 Suitably Qualified Persons – Relevant Experience

RGS Personnel

Alan Robertson has a PhD in Pure and Applied Chemistry and has over 25 years' experience completing geochemical studies for the mining and mineral processing industry. He has worked on projects for major mining companies (*e.g.* Anglo American, BHP Billiton, Glencore and Vale) in Australia, Asia, Africa, Europe and South America for both coal and hard rock mines. Alan has expertise in mine waste characterisation, development of AMD management plans, and design of mine waste storage facilities from conception through to closure. Alan is regularly engaged directly by Regulators to provide independent environmental advice on mine closure and rehabilitation aspects of mining operations.

Greg Maddocks has a PhD in Geochemical Engineering, over 15 years' mining sector experience and has worked on various open pit and underground mining projects in Australia and South-East Asia. Greg has developed Mining Waste and Rehabilitation Management Plans compliant with the requirements of Australian industry guidelines and standards. Mine closure work ranges from evaluating and selecting optimal water and waste management strategies to developing management plans for tailings and overburden storage facilities and open pits.

LEADERS IN MINING
GEOCHEMISTRY

TR9.1.V5

Geology, Soils and Land Resource Assessment

Middlemount Coal Project, Stage 2
Geology, Soils and Land Resource Assessment

October 2010

Middlemount Coal Pty Ltd

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Attachment A Test pit logs, borehole logs and explanatory notes
Attachment B Laboratory test results
Attachment C Land suitability assessment criteria
Attachment D Representative profiles of soils from Burgess (2003)

Glossary

A horizon	See topsoil.
Acid generating potential	Potential of spoil material to form acid conditions when oxidised (i.e. contact with air).
Alluvium	Any stream laid sediment deposit found in a stream channel and in low parts of a stream valley subject to flooding.
Anthropogenic	Caused or influenced by humans.
Australian Height Datum (AHD)	A level datum, uniform throughout Australia, based on an origin determined from observations of mean sea level at tide gauge stations, located at more than 30 points along the Australian coastline.
Borehole	A hole produced in the ground by drilling or driving.
Bushland	A functional, multi layered, semi-natural plant community including a permanent tree layer, natural or established (e. g. on spoil). The area would be capable of sustaining flora and fauna habitats.
CHPP	Coal handling and preparation plant
Chromosol	Soils with strong texture contrast between A horizons and B horizons, in which the B horizons are not strongly acid and are not sodic, as defined by Isbell (1998).
Clay	Particles with a diameter less than 0.002 mm (McDonald *et al.*1998) comprising of various clay minerals.
Competent spoil	Non acid, non dispersive durable spoil with potential characteristics to resist erosion.
Competent rock	Rock that is considered suitable for the intended use.
Cover material	Soil or other suitable plant growth medium placed on reshaped spoil surfaces; typically non crusting and low salinity.
Dermosol	Soil with a structured B2 horizon and lacking strong texture contrast between the A and B horizons, as defined by Isbell (1998).
Diversions/diversion channels	Structures for the controlled re-direction of drainage lines and watercourses around open cut pits and infrastructure areas.
DTPA	Diethylene triamine pentaacetic acid. A chemical used for the extraction of metal ions during chemical analysis.
Dyke	Sheet-like igneous intrusion cross cutting bedding planes, commonly sub-vertical.
EC	Electrical conductivity, an indirect measure of dissolved salts in a substance.
Erosional stability	The ability of a rehabilitated area to resist the natural forces of soil erosion.
Externally drained	Rainfall runoff water that reports to the external environment of a structure via local drainage systems.
Feldspar	A group of abundant rock forming minerals of the general formula MAl (Al, $Si)_3O_8$, where M can be potassium (K), sodium (Na), calcium (Ca), barium (Ba), rubidium (Rb), strontium (Sr) or iron (Fe).
FoS	Factor of Safety
Functional vegetation	Vegetation that consists of species able to survive and regenerate under specific conditions, providing soil erosion control and fauna habitat.
Geochemistry	The chemical characteristics of a soil or rock material.
Geomorphology	Study of the characteristics, origin and development of land forms and the processes that act on them.
Geotechnical stability	Resistance of a natural slope or earth structures to mass movement and erosion.

Gilgai	The phenomena of an irregular land surface with mounds and depressions formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles.
Graded banks	Cross slope earthen banks constructed on reshaped spoil areas, typically at horizontal intervals of approximately 50 m and 1 to 1.5% longitudinal gradient, to reduce the effective slope length and control the runoff flow rate.
Holocene	The most recent epoch of geological time.
Hostile spoil	Acid, sodic or saline spoil deleterious to seed emergence, geotechnical and geochemical stability of spoil.
Incident register	A database of environmental incidents, causes and remedial actions.
Internal drainage	Drainage of rainfall runoff from reshaped spoil areas confined and ponded within the spoil area.
Leaching profile	Vertical change in chemical concentrations down the soil profile due to leaching.
MLA	Mining Lease Application
Mt/y	Million tonnes per year
NATA	National Association of Testing Authorities Australia
Overburden	The soil or other mineral matter which has to be removed to gain access to the underlying material.
PAWC	Plant available water capacity.
Permian	The geological period of time from 245 million to 290 million years ago.
Plan	Set of actions required to ensure the achievement of a stated objective/program.
Plant growth medium	Material which is typically non crusting and has low salinity levels, in which plant seed will germinate and establish.
Policy	Stated commitment to achieving objectives.
Program	Management supported work commitment, budget and time frame to achieve a stated objective.
Quaternary	The geological period of time from the present to two million years ago.
Refuse dump	Site to be used for the permanent placement of waste.
Rehabilitation	Reshaping of a disturbed area to a geotechnically and geochemically stable condition, followed by revegetation.
Regional ecosystems	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil, As defined by Sattler & Williams (1999) in *The Conservation Status of Queensland's Bioregional Ecosystems*.
Revegetation	Establishment of suitable plant species to support the agreed post mining land use and control soil erosion to sustainable levels.
Rock mulch	Durable or competent rock purposely placed on an area under rehabilitation to provide additional resistance to erosion.
Sand	Natural mineral particles with a diameter between 0.02 mm to 2.0 mm (McDonald *et al.*1998)
Saline	Presence of salts, in water or spoil, generally undrinkable or in sufficient concentration to impair plant growth.
Sediment dams	Large impoundment structures used to retain rainfall runoff to allow settlement of suspended particles, prior to discharge.
Sill	Sheet-like igneous intrusion within coal seams or along bedding planes.
Silt	Mineral particles with a diameter between 0.002 mm to 0.02 mm (McDonald *et al.*1998)
Silt traps	Small impoundment structures built within a drainage line, which retard water flow and allow suspended solids to settle out.

Sodic	A soil is considered sodic when the exchangeable sodium percent (ESP) is greater than six. Sodic conditions usually result in clay dispersion and surface crust formation.
Sodosol	Soils with a strong texture contrast between A horizons and sodic B horizons with are not strongly acid, as defined by Isbell (1998).
Soil	That part of the upper weathered layer of the earth's crust which can support plant growth
Soil horizons	Soil horizons as defined by McDonald *et al.* (1998) are: O — surface layer dominated by organic material in varying stages of decomposition A — one or more surface mineral horizons with some organic accumulation A1 — mineral horizon at or near the surface with some accumulation of humified organic matter. It is usually darker than underlying horizons A2 — mineral horizon having less organic matter, sesquioxides and/or silicate clay than immediately adjacent horizons. It is usually paler in colour than the A1 or B horizon. A3 — transition horizon between the A and B horizons, which is similar to the A horizon B — one or more mineral soil layers characterised by a concentration of silicate clay, iron, aluminium and/or organic material; and/or a differing structure, consistency or colour of the A horizon. B1 — transitional horizon between the A and B horizon which is similar to the B horizon B2 — horizon dominated by an illuvial, residual or other concentration of silicate clay, iron, aluminium and/or humus, and/or maximum development of pedological organisation. B3 — transitional horizon between the B and C horizon which is similar to the B horizon C — consolidated and unconsolidated material below the A and B horizon. Usually partially weathered and little affected by pedological processes.
Spoil area	Area where overburden has been dumped.
Sump	Temporary excavation for the storage of water.
Subsoil	The B horizon within the soil profile which lies immediately below the topsoil or A horizon. The subsoil is not enriched with organic material as is the topsoil. It may also be subject to clay and/or salt accumulation.
Suitably qualified person	A person whose professional training or experience is relevant to the matter being considered (EPA 2007)
Tension cracks	Cracks at the ground surface, which occurs due to tensional forces in the soil or rock mass.
Tertiary	The geological period of time from the 2 million to 65 million years ago.
Test pit	An excavation for examination of subsurface soil conditions
Topsoil	The uppermost horizon (or A horizon) of the soil profile which usually contains the organic matter, biota and a concentration of the nutrients.
Exploration track	Temporary vehicle traffic route used for exploration or infrequent access from which topsoil has not been removed.
Vertosol	Clay soil with high shrink swell properties as defined by Isbell (1998)
Waters	River, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, bed and bank of any waters, dams, non-tidal or tidal waters or any part-thereof.
Wetland	Areas of marsh, fen, peat or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt as defined by The National Committee on Soil and Terrain (2009).

Executive summary

This study was undertaken as a technical study to support the Environmental Impact Statement and identify the existing physical environment, including the characteristics of geology, soils, overburden and land resources for Stage 2 of the Middlemount Coal Project (the Project). This report also identifies potential impacts of the Project on the existing environment and mitigation measures related to those impacts.

The study identified and mapped the broad soil types and characterised overburden material within the Project area. Based on existing literature and findings of the field assessment including soil sampling and laboratory testing, the Project area appears to be covered by six different soils, derived from sedimentary or alluvial parent material. Assessment of land suitability was also conducted over the entire Project area.

Based on the findings of this assessment, overburden in the Project area is not anticipated to be acid forming nor is likely to produce heavy metal contamination. The overburden is considered dispersive, and will require specific management techniques to control the erosion potential. Rehabilitation planning should take into consideration these overburden characteristics as these materials are to form the substrate for future vegetation. Selection of revegetation strategies, including species mix, provision of growth media, early stage plant support and ecosystem planning, should be adjusted to enable successful and sustainable revegetation of these areas. Alternatively, some areas may require engineering solutions to achieve long term geotechnical stability.

Subsoils over much of the Project area are alkaline, sodic and dispersive will require specific management techniques, such as minimising exposure, to prevent erosion including tunnel erosion. Soils most susceptible to erosion include Yellow duplex, Grey-brown duplex and Alluvial soils.

It is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation, although with limitations. Depth limitations exist in some soils, and slope gradient may impact the ease of stripping on steeper slopes. Topsoils from the Red lithosols are not considered appropriate for use in rehabilitation due to their surface rockiness.

Based on previous assessment and the results of the this investigation, the Project area is currently assessed to be within land suitability classes between Class 2 and 5 for both dry land cropping and cattle grazing but mostly is classified as Class 3 for beef cattle grazing and Class 4 for dry land cropping. The Project area is considered to be predominantly Class C good quality agricultural land (GQAL) except for the Red lithosols which are not considered GQAL and Brown uniform clays which are considered to be Class B GQAL, however the Brown uniform clays have limited extent within the Project area.

Following the assessment, it is understood that the undisturbed land will be returned to (or retained in) its pre-mining land suitability class. Land used for infrastructure components of the Project (roads, MIA, etc) will have limitations related to water availability (through compaction and breakdown of the subsoil structure), and will generally be Class 4 cropping land or Class 3 cattle grazing land. Spoil stockpiles and tailings storage facility will have limitations related to water availability, salinity, gradient, erosion and nutrient content, and will generally be Class 5 cropping land or Class 4 or 5 grazing land. The final void will be unsuitable for agricultural use (e.g. Class 5 for cropping and cattle grazing).

1. Introduction

1.1 Project background

The Middlemount Mine comprises the development of coal resources marketed as coking and pulverised injection coal in the central Bowen Basin, approximately 270 km north-west of Rockhampton and about 6 km south-west of Middlemount, a town built specifically for the coal mining industry (refer Figures 1.1 and 1.2). The Middlemount Mine is currently approved for production of 1.8 million tonnes per year (Mt/y) of run of mine (ROM) coal, designated under Mining Lease ML70379, and an amended Environmental Authority (Mining Activities) Non Code Compliant Level 1 MIN100646307 – Middlemount Coal Mine. A further amendment to the Environmental Authority has been applied for to include mining lease application area (MLA) 70417 to allow for placement of overburden spoil from the 1.8 Mt/y operation.

The approved Stage 1 of the Middlemount Mine has commenced with land clearing underway in for the construction of the Mine Infrastructure Area (MIA), the Coal Handling and Preparation Plant (CHPP), a water management system, and tailings storage facilities (TSF). A bulk sample program was also completed by taking a bulk sample of approximately 200,000 ROM tonnes of coal from the Pisces Upper seam using standard truck and excavator methods.

Stage 2 proposes to expand the mine to produce up to 5.4 Mt/y ROM coal. Stage 2 forms the basis of the Middlemount Coal Project (the Project) that is the focus of this report. The coal resources will continue to be developed as an open cut mine with related infrastructure.

The Project is being developed by Middlemount Coal Pty Ltd (MCPL).

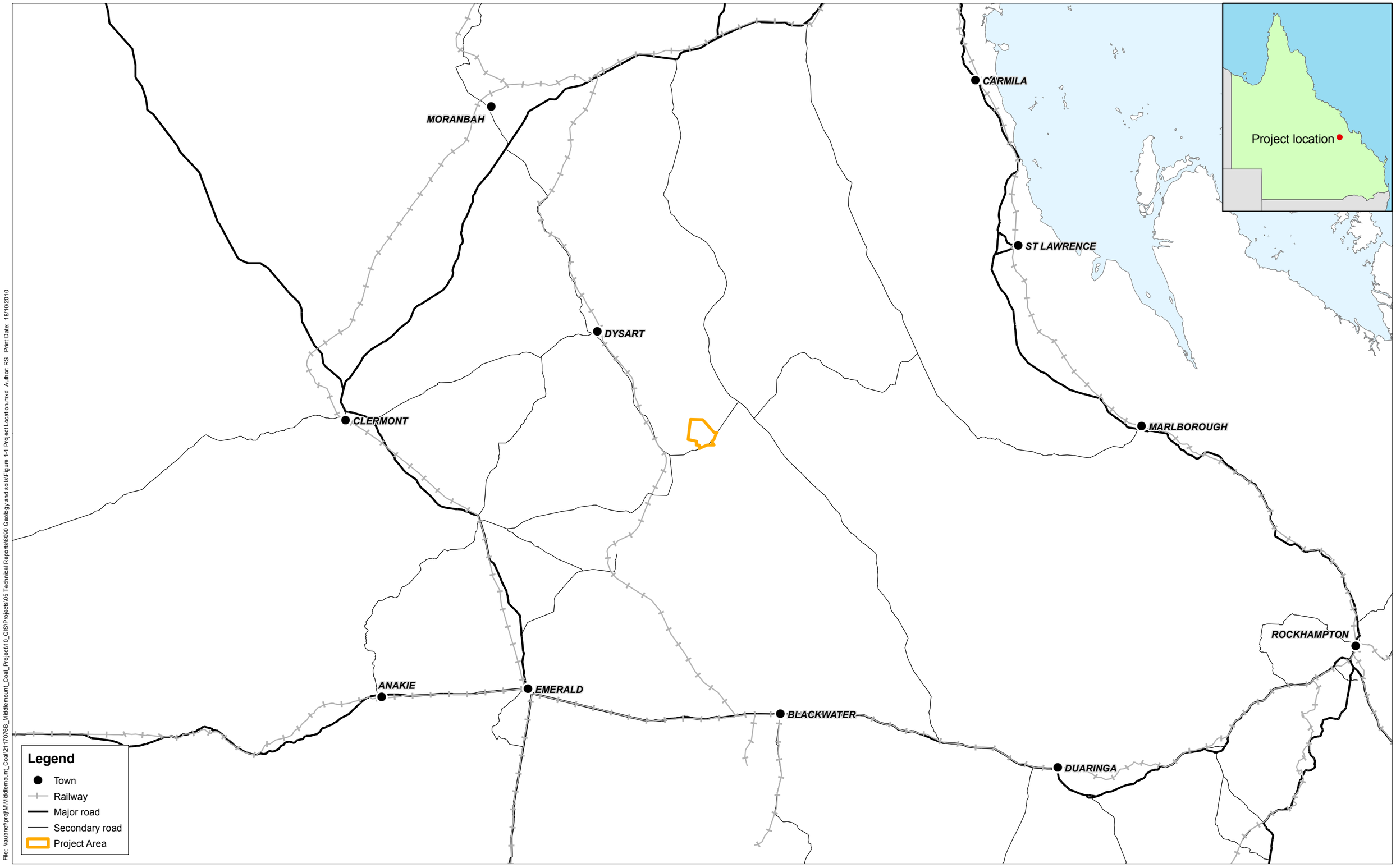
Parsons Brinkerhoff Pty Ltd (PB) has been commissioned by MCPL to prepare an Environmental Impact Statement (EIS) for the Project. This study was undertaken as a technical study to support the EIS and identify the existing physical environment, including the characteristics of geology, soils, overburden and land resources for Stage 2 of the Middlemount Coal Project (the Project). This report also identifies potential impacts of the Project on the existing environment and mitigation measures related to those impacts.

1.2 Description of Project area

The Project area for this geology, mineral resources, overburden and soils assessment includes the current mining lease area (ML70379) for Stage 1 of the mine and the footprint of Stage 2 (refer Figure 1.2).

The Project area is located in a landscape that has experienced some modification by past land uses, including clearing to allow limited agricultural activity (i.e. grazing and cropping), infrastructure corridors and the current construction for Stage 1 of Middlemount Mine. The landscape is relatively flat throughout the site with small rises and rocky elevated areas in the south of the Project area. Vegetation in the local area is cleared in areas of current construction and through infrastructure corridors in the Project area. The hydrology on the Project area is dominated by two creeks draining the site to the south-east via Roper Creek and Thirteen Mile Gully and ultimately into Mackenzie River further downstream.

Figure 1.1



File: \\aubnefpro\M\Middlemount_Coal\2117076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 1-1 Project Location.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 12.5 25 50 75 100
Kilometres

Project Location

Figure 1.2

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

THIRTEEN MILE GULLY

DYSART MIDDLEMOUNT ROAD

ROPER CREEK

PARROT CREEK

BARWON PARK MIDDLEMOUNT ROAD

Project location

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop

File: \\aubnet\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 1-2 Project Area.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Project Area

The site is accessible via the sealed Dysart-Middlemount Road and unsealed farm tracks.

The Saraji water supply pipeline crosses the site diagonally from the south-east to the north-west, roughly parallel and north to the alignment of Thirteen Mile Gully.

2. Methodology

2.1 Relevant legislation and guidelines

2.1.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is the key legislation for environmental management and protection in Queensland. The environmental values of land resources in Queensland are protected under the EP Act.

2.1.2 Protecting Queensland's strategic cropping land: A policy framework

The Policy Framework was formulated following a review of State Planning Policy 1/92. The Policy Framework is not a finalised government policy, and was open for comments until 30 September 2010.

Under the framework, legislative and planning instruments will be developed to implement the policy, being:

- a new act specifically for strategic cropping land resources. The legislation will describe how strategic cropping land is identified and will include an indicative map of where strategic cropping land resources may exist. Criteria will then be used for validating on-site whether the land is in fact strategic cropping land. The legislation will provide a consistent process for assessing and deciding whether development can proceed on strategic cropping land
- a new State Planning Policy under the *Sustainable Planning Act 2009*
- amendments to existing resources legislation. Amendments to resources legislation will be made to recognise the requirements of the new Act for strategic cropping land resources.

While the new laws are yet to be enacted, the Government expects that proponents will take this framework into account in advancing their projects (Page 9 of the Policy Framework).

2.1.3 State planning policy 1/92: Development and conservation of agricultural land 1992

State planning policy 1/92 is based on the principle that land suitable for agricultural purposes is limited in Queensland, and that suitable 'good quality' land should be protected for agricultural uses.

The state planning policy makes allowances for developments on high quality agricultural land where the project provides an overriding public benefit and there are no other suitable sites for the purpose.

The state planning policy 1/92 is largely implemented at the local government level, and requires local governments to include maps of good quality agricultural land (GQAL) in their planning schemes.

2.1.4 Planning guidelines: The identification of good quality agricultural land, 1993

The planning guidelines assists in the implementation of state planning policy 1/92, through the provision of a methodology for assessing and identifying agricultural land classes and subsequently GQAL.

Under the planning guidelines, land is classified into classes, ranging from Class A being cropping land with moderate to no production limitations, to Class D being land not suitable for agriculture due to extreme limitations. Which agricultural land classes are considered GQAL within each local government areas was established during the preparation of the planning guidelines in 1993, based on publicly available land resource mapping such as Department of Primary Industries manuals and CSIRO reports. The planning guidelines acknowledge that much of this mapping is at a broad scale, and that site-specific assessments may be needed to confirm the distribution of QGAL.

2.1.5 Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy (EPP (Water)) is a policy under the *Environmental Protection Act 1994*. The policy defines and protects environmental values of Queensland waterways.

2.1.6 Land suitability classification for cropping and grazing in the semi-arid sub-tropics of Queensland

The land suitability classification system used in this assessment was produced by the Department of Mines and Energy and was published as part of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* in 1995.

It provides a framework for the assessment of the suitability of land for cropping and grazing purposes, based on a range of soil and landscape characteristics. The guidelines were prepared for use in relation to mining and exploration projects for the assessment of pre-disturbance and post-disturbance land capability, but have now been widely adopted as a tool to assess land use potential relating to a range of infrastructure projects.

2.1.7 Draft guidelines for the assessment and management of contaminated land in Queensland

The draft guidelines for the assessment and management of contaminated land in Queensland were prepared to assist in the implementation of the *Environmental Protection Act 1994.* The draft guidelines contain trigger values for various contaminants including heavy metal concentrations that may indicate a hazard to human or environmental health, and above which site specific investigations are required.

2.1.8 Guideline 18 Rehabilitation requirements for mining projects (EPA 2008)

Guideline 18 was developed by the Environmental Protection Agency (EPA) to assist mining companies to establish rehabilitation outcomes and strategies, for the planning, operational and final rehabilitation stages of a mine. The guideline outlines rehabilitation goals, objectives and outcomes that are likely to be satisfactory to the EPA, and how the EPA accesses whether rehabilitation strategies are satisfactory.

2.2 Methodology of assessment

The soils and land suitability investigation comprised a review of available published data, fieldwork and laboratory testing. Locations of test pits were selected based on location of existing soil assessment sites, geological and topographic features of the landscape, access and land ownership issues and proposed layout of the mining operations. A laboratory testing program was carried out to determine chemical and physical characteristics of soils relevant for land suitability assessment, construction design and rehabilitation.

2.2.1 Previous investigations

Previous investigations that provided information for this report regarding soil and landscape characteristics in the Middlemount area have included:

- *Burgess, J 2003, The Land Resource Assessment of the Windereyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland, Queensland Government, Brisbane.*
- *GSS Environmental 2007, Draft Middlemount Project, Soil Survey and Land Resource Assessment Report, Hamilton.*
- *Parsons Brinckerhoff (PB) 2005, Lake Lindsay Project – Overburden, soils and land capability assessment report, Brisbane.*

2.2.2 Field work

The field work for the assessment was undertaken between 11 and 13 May 2010 and comprised:

- excavation and sampling of 12 test pits within the Project area
- walk-over survey to observe soil types/characteristics and landform of the site
- selection of overburden samples for laboratory assessment.

2.2.2.1 Test pits

Locations of test pits were surveyed by use of a Garmin hand held GPS unit, and checked against site features and map readings. The accuracy of this surveying method is considered to be within approximately 7 m in plan. Details of test pit locations are shown on Figure 2.1.

Test pits were excavated using either a 20 tonne Komatsu track mounted excavator or 25 tonne Hitachi track mounted excavator. Test pits were identified MM01 to MM13, except MM05. Test pit logs and explanatory notes are contained in Attachment A.

Test pits were excavated to between about 1.8 m and 6.0 m depth. Selected disturbed samples of surface and subsurface soils were obtained at regular intervals or at the change of strata for material identification and laboratory testing.

Test pit log records are attached in Attachment A, together with a set of explanatory notes, which define the terms and symbols used in their preparation. Topsoil (A1) consistency and pedality descriptions used were in accordance with those used in *Australian Soil and Land Survey, Field Handbook* (*The National Committee on Soil and Terrain* 2009).

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MW5P

MM11

MM10

MM12

MM09

MM08

MM07

MM06

MM04

MM03

MM02

MM01

MM13

MW9A

MW9M

9048

9049

9020

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- PB groundwater borehole (2010)
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- No spoil dumping area

File: \\aubnefspro\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 2-1 Test Pit Locations.mxd Author: RS Print Date: 04/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Test pit locations

2.2.3 Soil mapping and classification

Classification of soils for the Project area was based on field observations, laboratory analytical data, aerial photography, and published soil classification data as listed in Section 2.2.1 of this report. Mapping included reference to soil profiles assessed by GSS Environmental (2007) and Burgess (2003). Soil log profiles within the Project area from Burgess (2003) are included in Attachment D.

The adopted soil classification system is based on the Australian Soils Classification (Isbell 1996). Where soil descriptions correlate with soil types in the references in Section 2.2.1, soil names from these references have been adopted. Soil names outlined by GSS Environmental (2007) have been adopted to provide easy correlation between the assessment for Stage 1 of Middlemount Mine and the current assessment.

2.2.4 Laboratory testing methods

Selected soil and rock samples were tested in a National Association of Testing Authorities. (NATA) registered laboratory for the following physical and chemical properties:

- electronic conductivity (EC)
- pH
- total nitrogen and phosphorous
- cation exchange capacity (CEC)
- exchangeable sodium percentage (ESP) of soil
- total sulphate (SO_4)
- total organic carbon
- heavy metals
- net acid generation (NAG)
- net acid production potential (NAPP).

All laboratory tests were conducted using verified test methods.

Detailed laboratory test result sheets are attached in Attachment B and a summary is provided in Table 3.4.

2.2.5 Overburden assessment

An overburden assessment was conducted to characterise overburden material within the Project area. The following characteristics of the overburden and interburden were assessed:

- erosion potential
- acid generation potential and heavy metal content.

The overburden and interburden assessment included laboratory analysis of rock chip samples from three boreholes that were drilled as part of the groundwater investigation program as well as overburden samples collected from the bulk sample pit and test pits. Sampling locations are shown in Figure 3.1.

Heavy metal concentrations within the overburden were assessed against the *Draft Guidelines for the Assessment of Contaminated Land in Queensland* (Environmental Protection Agency 1998) for environmental investigation levels and health-based investigation levels (Department of the Environment 1998).

The potential for acid drainage was based on the requirements of the *Assessment and Management of Acid Drainage* (Department of Mines and Energy 1995b).

2.2.6 Land suitability assessment

A land suitability assessment was carried out over the Stage 1 portion of Middlemount Mine by GSS Environmental (2007). A land suitability assessment was also carried out as part of this investigation, incorporating the Stage 2 area, based on the requirements of the *Attachment 2 of Land Suitability Assessment Techniques* (Department of Mines and Energy 1995a).

The Project area was assessed for its suitability for various uses including dry-land cropping and cattle grazing on improved pasture. The criteria used for assessing the suitability of land for specific agricultural uses are included in Attachment C. The land was then classified into one of five land suitability classes for each potential land use assessed, relating to the land use limitations.

The land suitability classes and their definitions are shown in Table 2.1 below:

Table 2.1 Land suitability classes

Land suitability class	Description
Class 1	suitable land with negligible limitations and is highly productive requiring only simple management practices
Class 2	suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use
Class 3	suitable land with moderate limitations — land which is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use
Class 4	marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long-term
Class 5	unsuitable land with extreme limitations that preclude its use.

There is no existing GQAL mapping covering the Project area. An assessment of GQAL was undertaken as part of this investigation, in accordance with *Planning Guidelines: The Identification of Good Quality Agricultural Land* (Department of Primary Industry and Department of Housing, Local Government and Planning 1993).

A post-mining land suitability assessment was also conducted based on the proposed final landform, as indicated on concept stage mine plans. However, developments in mine rehabilitation techniques, changes in legislative requirements and other developments not foreseen in this report could influence the proportion of various land suitability classes that could be achieved through rehabilitation over the life of the Project.

Consideration has been given to the draft *Protecting Queensland's strategic cropping land: A policy framework* (Department of Environment and Resource Management 2010).

2.3 Limitations

The assessment has been based on the excavation of 12 test pits, field observations, and review of existing information, including 18 test pits reported by GSS Environmental (2007) and three test locations and regional mapping reported by Burgess (2003).

Soils have been classified into broad soil types. Soils are not discrete units, and variation of properties will occur within each of these soil types. The scale of mapping also will not identify small isolated occurrences of difference soils within each mapped unit.

Boundaries between soil units have been assigned based on test pit profiles and landscape features such as topography, gradient and drainage lines. Soil boundaries are not discrete, and may grade between soil types over a distance of a few hundred metres, in these areas soils could display properties of all or none of adjacent soil types.

The overburden assessment has been conducted to provide a broad overview of overburden properties within the Project area to identify potential risk during operation and rehabilitation of the mine. The assessment does not detail the horizontal or vertical distribution of overburden substrates (e.g. siltstone, mudstone), and does not differentiate the properties of individual substrates. Ongoing assessment work during the operational phase of the Project, such as overburden sampling and testing for material characterisation will be required to adequately delineate various overburden units which may occur locally and may require different management techniques. For the purpose of this assessment the term 'overburden' refers to all overburden and interburden within the Project area.

3. Existing environment

3.1 Topography

The topography map of the Project area is shown on Figure 3.1. The majority of the Project area is relatively flat to very gently undulating terrain (refer Photo 3.1). Slope lengths are very long and gradients are generally less than 5% (refer Photo 3.2). Surface levels (RL) are between approximately 140 m to 160 m Australian height datum (AHD) with a gentle down-slope gradient from the north-west towards the south-east. The site is within a broad alluvial valley of Roper Creek. The northern and southern edges of the valley are near the northern and southern lease boundaries.

The southern valley edge is marked by topographically slightly higher areas consisting of a rocky escarpment where elevations rise up to about 15 m above the alluvial plain. The CHPP and other infrastructure elements are located on these topographically higher areas in the south.

The Project area is drained by Roper Creek and Thirteen Mile Gully. The creek channels are defined and incised into the landscape with some steep banks. Evidence of lateral channel migration via meanders was noted. Flood outs and localised erosion channels due to flooding are also common. Riparian vegetation is present along the creek and gully lines.

Vegetation

Low density grazing land and infrastructure corridors (i.e. Saraji water supply pipeline) have been cleared in the past, before mining activities began on-site. Current construction of Stage 1 of the Project required land clearing in the southern sections of the ML70379. Some areas of the Project area for Stage 2 have been cleared to create grazing land.

According to descriptions by Burgess (2003) and the Terrestrial Ecology technical report TR17.1.V5, the majority of the Project area is dominated by Eucalypt woodland vegetation communities. The topographically higher areas in the south of the Project area are characterised by Lancewood and Eucalypt woodland with Bull Oak. Brigalow regrowth was reported within the central Project area on clay flats north of Roper Creek.

The improved pastures over the grazing land are mainly covered with buffel grass and other grasses.

A detailed description of the vegetation in the Project area is also found in Chapter 17 Terrestrial Ecology of the EIS.

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

PARROT CREEK

ROPER CREEK

MM01
MM02
MM03
MM04
MM06
MM07
MM08
MM09
MM10
MM11
MM12
MM13
MW5P
MW9M
MW9A

Project location

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- GSS Environmental test pit (2007)
- PB Groundwater Boreholes (2010)
- Burgess (2003)
- PB test pit (2010)
- Contours 10m
- No spoil dumping area

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

PARSONS BRINCKERHOFF

Topography of the project area

File: \\aubnet\proj\MM\Middlemount_Coal\21170786_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-1 Topography of the Project Area.mxd Author: RS Print Date: 04/10/2010

Photo 3.1 Flat terrain in western section of the Project area

Photo 3.2 Flat to gently undulating terrain in eastern section of site showing long slope length and low gradient

3.2 Geology

3.2.1 Regional geology

Reference to the Geological Survey of Queensland's 1:250,000 series St Lawrence sheets, Queensland Department of Employment, Economic Development and Innovation interactive resource and tenure map (*http://www.webgis.dme.qld.gov.au-/mines/tenure_maps.cfm*, accessed on 2 June 2010) and previous investigations indicate that soils and rocks of Project area are from the following main geological units:

- Fort Cooper Coal Measures/Burngrove Formation – Late Permian age sedimentary rocks comprising feldspathic and lithic sandstone, siltstone, carbonaceous mudstone, siliceous siltstone, banded coal seams, and tuff. These rocks do not outcrop within the site and were encountered only in the existing exploration boreholes.

- Rangal Coal Measures – Late Permian age sedimentary rocks comprising carbonaceous mudstone, siltstone, coal, feldspathic and lithic sandstone, and tuff. These rocks do not outcrop within the site and were encountered in the existing trial pit and exploration boreholes.

- Early Tertiary age sandstone, siltstone, claystone, conglomerate, oil shale and minor basalt.

- Tertiary/Quaternary age clay, sand and gravel that is likely to be reworked (colluvial and high level alluvial) laterite.

- Quaternary age alluvial sediments comprising silt, sand and gravel.

The field investigation confirmed the presence of these units. The sedimentary rocks encountered underlying the Rangal Coal Measures could be part of either the Fort Cooper Coal Measures or the Burngrove Formation, which are similar but occur in the northern and central Bowen Basin respectively.

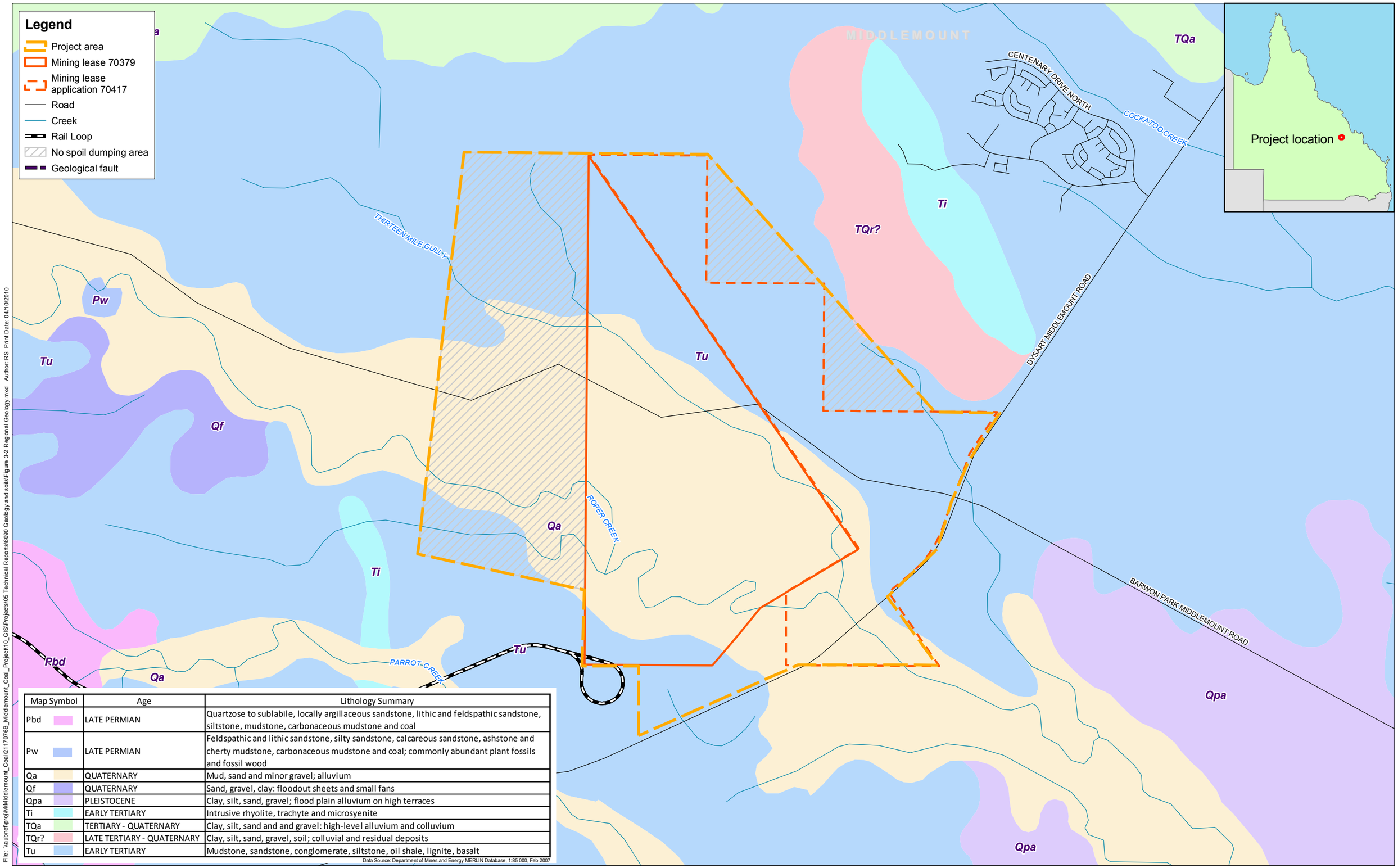
The major regional geological structure is the north-north-west trending Jellinbah Fault, a thrust fault with a throw of up to several hundreds of metres. This fault is interpreted to be located in the eastern portion of the Project area.

A map illustrating the geology of the Project area is shown on Figure 3.2, and schematic stratigraphic column is provided in Figure 3.3.

3.2.2 Local geology

Existing published geology data indicates that over the Project area, the Quaternary age alluvial sediments are distributed in a 2 km to 3 km wide belt on the southern and northern side of Roper Creek. However, field work indicated that the Recent alluvium is mainly present in a few hundred metres wide belt along the northern banks of Roper Creek and in isolated patches elsewhere within the floodplain. In the north and south, the generally less than about 5 m thick alluvium onlaps onto the Tertiary sedimentary rocks and reworked laterites.

Locally, especially in the south-western portion of ML70379, the Tertiary age sedimentary rocks are lateritised with hard caprock and form topographic high areas. Thickness of the Tertiary cover is generally between about 15 m and 35 m.



Map Symbol	Age	Lithology Summary
Pbd	LATE PERMIAN	Quartzose to sublabile, locally argillaceous sandstone, lithic and feldspathic sandstone, siltstone, mudstone, carbonaceous mudstone and coal
Pw	LATE PERMIAN	Feldspathic and lithic sandstone, silty sandstone, calcareous sandstone, ashstone and cherty mudstone, carbonaceous mudstone and coal; commonly abundant plant fossils and fossil wood
Qa	QUATERNARY	Mud, sand and minor gravel; alluvium
Qf	QUATERNARY	Sand, gravel, clay: floodout sheets and small fans
Qpa	PLEISTOCENE	Clay, silt, sand, gravel; flood plain alluvium on high terraces
Ti	EARLY TERTIARY	Intrusive rhyolite, trachyte and microsyenite
TQa	TERTIARY - QUATERNARY	Clay, silt, sand and and gravel: high-level alluvium and colluvium
TQr?	LATE TERTIARY - QUATERNARY	Clay, silt, sand, gravel, soil; colluvial and residual deposits
Tu	EARLY TERTIARY	Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite, basalt

Data Source: Department of Mines and Energy MERLIN Database, 1:85 000, Feb 2007

File: \\aubnefpro\MMiddlemount_Coal\21\7078B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-2 Regional Geology.mxd Author: RS Print Date: 04/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

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Kilometres

Regional geology

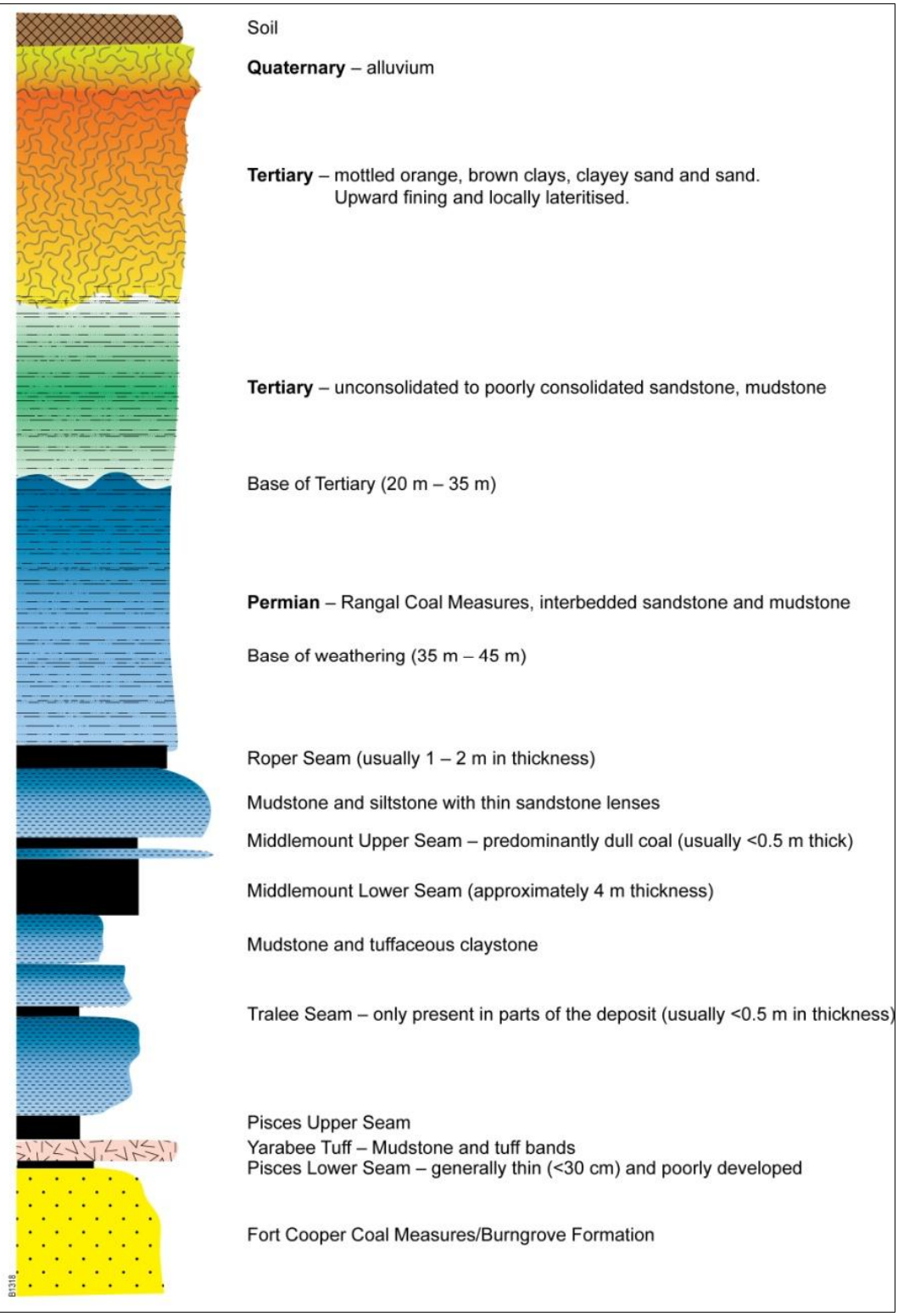


Figure 3.3 Schematic geological cross section

Coal targeted in ML 70379 occurs within the Rangal Coal Measures and Burngrove Formation. The Roper, Middlemount Lower and Upper, Tralee and Pisces Upper seams (in descending order) belong to the Rangal Coal Measures, while the Pisces Lower seam belongs to the Burngrove Formation.

Seams strike north-northwest and dip to the east-north-east, generally at less than seven degrees (Ward, 2010). Locally steeply dipping coals seams are anticipated to occur adjacent to the Jellinbah Fault.

Depth of weathering is generally between about 35 m and 45 m.

3.3 Mineral resources

A number of individual coal tenures are present within the Project area as shown on Figure 3.4 below. Exploration permits for coal (EPC), and mining leases (MLs) exist over the Project area. The Project will involve the extraction of coal from mining tenements ML70379 (granted) and MLA70417 (application).

Two Petroleum exploration permits overlap the mining tenements, with both held by Arrow Energy.

3.4 Geomorphology

The Project area is within the Mackenzie River catchment in the Bowen Basin. Drainage over the Project area is generally towards the south-east through Roper Creek and Thirteen Mile Gully towards Oakey Creek and then the Mackenzie River.

The wide floodplain, gentle slopes and meanders of drainage lines suggest the landscape within the Project area is geologically stable. The creeks are slowly cutting into and eroding the landscape, with lateral erosion of the valleys being the main large-scale landscape altering activity, together with channel deepening. Temporary deposition of eroded material occurs in the creek channels and on the floodplain during large rainfall and flood events before moving further downstream. Erosion rates are anticipated to be low due to the low topographic gradient and relatively dry climate. Most erosion will occur during high rainfall events.

The Project area is considered ‘erosional’ with temporary sediment storage on the alluvial plains.

Figure 3.4

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

Project location

EPC747

EPP1031

EPP364

EPP811

EPC1033

EPC1014

THIRTEEN MILE GULLY

EPC1225

ML70417

DYSART MIDDLEMOUNT ROAD

ML70379

ML1831

ROPER CREEK

EPP688

EPP748

EPP364

MDL282

BARWON PARK MIDDLEMOUNT ROAD

EPC855

EPC1139

PARROT CREEK

ML70429

EPC747

EPC1669

EPC1455

ML1998

ML70310

EPC726

EPC1669

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- MDL
- EPC
- ML
- EPP
- No spoil dumping area

File: \\aubnet\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-4 Mineral Resources.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Mineral resources

3.5 Overburden

Overburden in the Project area has not been previously investigated.

Overburden in the Project area consists mostly of weathered and fresh sandstone, siltstone, mudstone and claystone of Tertiary and Permian age, together with Tertiary and Quaternary unconsolidated clayey and sandy sediments. Upward fining sequences are common in each geological unit, and vertical and lateral changes of facies were observed, indicating a terrestrial, fluvial sedimentary environment.

For the purpose of this investigation, for the remainder of this report it is considered that the term 'overburden' refers to all overburden and interburden within the Project area. Interburden is defined as rocks between mineable coal seams.

Based on published data and PB's experience in the southern and central Bowen Basin, the siltstones and the lithic or feldspathic sandstones of both Tertiary and Permian age are anticipated to produce soil material high in clay content and possibly dispersive. The sodic and potentially dispersive clays are anticipated to be also present in the reworked unconsolidated sediments.

The unconsolidated sediments are generally removed during pre-stripping while the weathered and fresh rocks are drilled and blasted prior to excavations. This method allows the separate management of the two main overburden types, if required.

3.5.1 Acid production potential

The oxidation of sulfidic material is a natural process resulting from the exposure of minerals such as pyrite (iron sulfide) to atmospheric conditions (Environment Australia 1997), and is calculated as the acid producing potential and expressed in kg H_2SO_4/t (H_2SO_4 = sulphuric acid). This process can be accelerated during mining operations if large volumes of sulfidic material are exposed. The resulting acidity may also dissolve metals within overburden rock. Transport by water can generate highly acidic runoff with high concentrations of dissolved salts of heavy metals. The acidic runoff or leachate is referred to as acid mine drainage (AMD). Solubility of most metals is increased in low pH environment.

Carbonate minerals and exchangeable bases, on the other hand, have the ability to neutralise acid (calculated as the acid neutralising capacity in kg H_2SO_4/t). Carbonate minerals (mainly calcite, aragonite and dolomite) have the most significant acid neutralising capacity.

Selected overburden samples were tested for AMD generating potential, actual acidity and electrical conductivity. The parameters assessed and their brief description is detailed below:

- **pH – Actual acidity –** The acidity of the soil or rock as it occurs (i.e. without any induced oxidation or treatment).
- **pH after oxidation** – Actual acidity of the sample is determined after rapid oxidation by hydrogen peroxide. The process is simulating prolonged exposure to atmospheric conditions. Materials with values below pH 4.0 are considered acid producing and above pH 4.0 not acid producing.
- **Acid production potential (APP)** – This is measured by oxidation of a sample using hydrogen peroxide and measuring the acidity by titration.

- **Acid neutralising capacity (ANC)** – This is due to the presence of carbonate minerals, exchangeable bases and silicate minerals that may break down in the subsurface material. Carbonate minerals (calcite, aragonite and dolomite) are the most significant in terms of acid neutralisation.

  Laboratory test involves digesting the sample in hot acid and then titrating with a base to determine how much acid was consumed.

- **Net acid producing potential (NAPP)** – NAPP is the difference between APP and ANC (i.e. NAPP=APP-ANC) and gives an indication of subsurface materials potential to generate acid. A positive result shows acid generating potential and a negative result indicates that the material is non-acid producing.

- **Total Sulphur (%)** – Total sulphur is the measure of the total sulphur content of the rock. Materials with more than 0.5% total sulphur could have a potential to produce acidic materials.

- **Net acid generation (at pH 4.5 and pH 7) (NAG)** – NAG differs from NAPP by measuring actual acid production and neutralisation of the rock and not the total theoretical potential.

- **Acidity and conductivity** – Actual field acidity and electrical conductivity was determined on selected overburden samples. Electrical conductivity is used as a proxy for salinity of the assessed rocks.

Laboratory test results (refer Table 3.1 below) indicated that all overburden samples tested have near zero or negative NAPP in the range of 0.8 to -122 kg H_2SO_4/t. These results indicate that the maximum theoretical acid production potential is equal or less than the theoretical capacity of the rock to neutralise the produced acid.

All overburden samples tested have some ANC, ranging between very low (i.e. <0.5 kg H_2SO_4/t) to high (i.e. up to 122 kg H_2SO_4/t). The samples with low ANC correspond with the near zero NAPP results.

NAG results of overburden samples indicate that when exposed to oxidising conditions the spoil material will not generate acid or the generated acid will be neutralised by other materials present in the rock. NAG results of tested samples are <0.1 kg H_2SO_4/t for NAG at pH 4.5 and vary between <0.1 kg H_2SO_4/t and 2.9 kg H_2SO_4/t for NAG at pH 7. These NAG results are considered very low and are supported by the after oxidation pH values measured to be between 6.0 and 10.7. The after oxidation pH values indicate that the rocks have no or negligible potential to produce AMD.

The chart shown in Figure 3.5 below is used for estimating overburden characteristics and resulting potential for acid production. All results for samples tested as part of this investigation plot in the upper and lower right quadrant, indicating that the overburden has negligible to low acid forming potential.

Non acid forming high sulphur high neutralising capacity >0.5 %S	<0.5 %S Not acid forming low sulphur; high neutralising capacity
Potential acid forming low neutralising capacity high suphur	Low acid forming potential low neutralising capacity low sulphur

Figure 3.5 Classification of acid production potential

Table 3.1 Analytical test results of typical overburden materials from each geological unit

	Unconsolidated Quaternary sediments	Unconsolidated/weathered Tertiary sediments				Fresh Tertiary sedimentary rocks	Weathered Permian sediments	Fresh Permian sediments		
Sample origin and ID (depth below ground level) Parameter	**MM01 5.9-6.0 m**	**Bulk sample pit ~10 m**	**MW5P 18.0-19.0 m**	**MW9A 19.0-20.0 m**	**MW9A 40.0-41.0 m**	**Bulk sample pit ~35 m**	**MW9A 49.0-50.0 m**	**Bulk sample pit ~45-50 m**	**MW9M 69.0-70.0 m**	**MW5P 78.0-79.0 m**
pH	8.2	8.7	9.6	8.2	8.4	7.6	9.7	7.6	10.0	9.8
Electrical conductivity – **EC** (µS/cm)	202	334	567	878	537	2080	610	2440	331	523
Net Acid Production Potential – **NAPP** (kg H_2SO_4/t)	-4.9	-3.5	-122	<0.5	-6.8	0.8	-14.4	0.7	-28.2	-52.2
Net acid generation (pH 4.5) – **NAG** (kg H_2SO_4/t)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Net acid generation (pH 7.0) – **NAG** (kg H_2SO_4/t)	1.1	1.0	<0.1	2.9	1.9	1.6	<0.1	0.9	<0.1	<0.1
pH after oxidation	6.1	5.9	9.1	6.0	5.6	6.0	7.3	6.2	9.2	10.7
Acid neutralising capacity – **ANC** (kg H_2SO_4/t)	4.9	4.0	122	2.2	7.6	<0.5	14.9	<0.5	28.7	53.6
Total Sulphur (%)	<0.01	0.02	<0.01	0.06	0.03	0.03	0.02	0.02	0.02	0.04

3.5.2 Dispersion, salinity and erosion potential

Salinity and acidity/alkalinity data of overburden materials is used as indication of their erosion, slaking and dispersion potential. Mildly alkaline to very strongly alkaline overburden materials (pH values above 7.6), as encountered on site, are considered as sodic materials. Sodium dominated multi-layer clays tend to disperse when in contact with water. Dispersion is when the clays form colloids and remain in suspension in water.

The laboratory pH test results (Table 3.1 above) indicates that the clay component of the overburden has a high potential to be dispersive. Dispersive clays are anticipated to be present both in the Tertiary soils and weathered rocks and in the weathered Permian age rocks.

The dispersion potential of the soils and weathered rocks was also indicated by laboratory slake tests results reported by Ward (2010). The Durability Index (I) test results reported varied between 0% and 97.8%. Rocks with 'I' value below about 60% are considered to have low durability and are anticipated to disintegrate upon exposure to surface conditions and water. While not all rocks with low durability are dispersive, the erosion potential of low durability rocks is also high.

It is assumed that the overburden has moderate to high dispersion potential as observed during the site visit in the existing bulk sample pit. Existing soils and geology information for the Middlemount area (Minserve 2004, PB 2005), also suggests the overburden is likely to be highly dispersive and highly susceptible to erosion. Signs of existing erosion, interpreted to be present due to dispersive characteristics of exposed clays and non-cohesive, Tertiary age, and sands at the bulk sample pit, were noted and are shown in Photo 3.3 below.

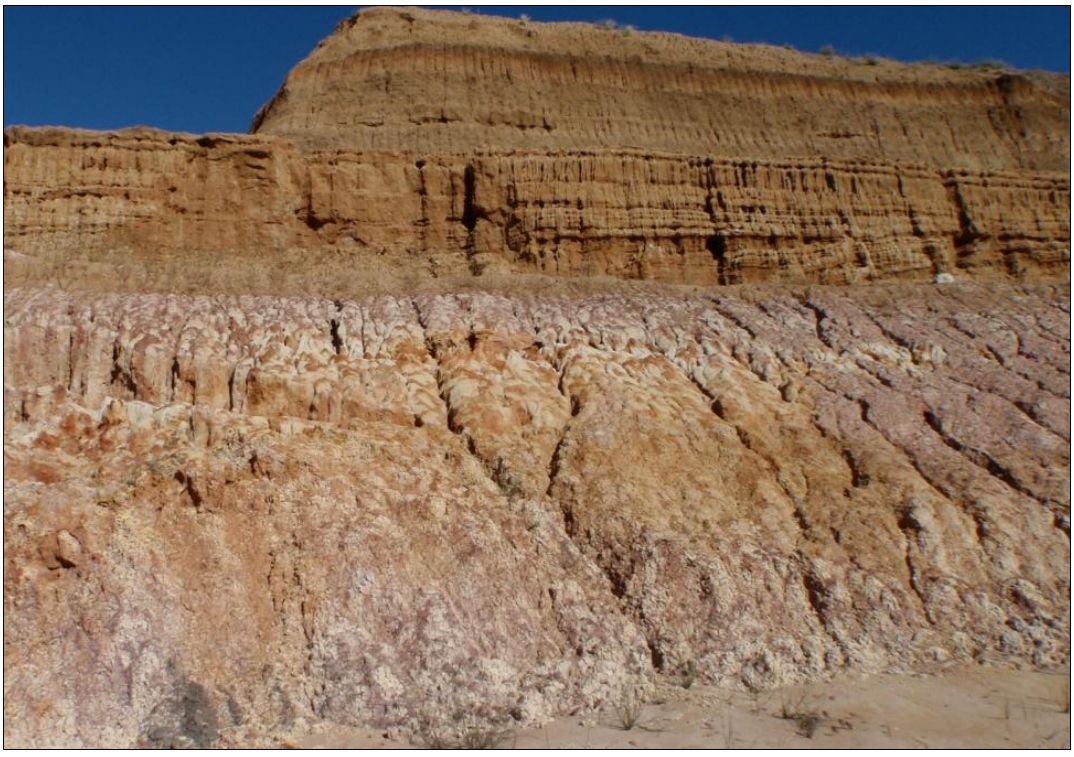


Photo 3.3 Existing rill erosion in the bulk sample pit; the clayey soils appear to be dispersive and the sands are non-cohesive

Low to extreme salinity values, between 202 µS/cm and 2,440 µS/cm, were recorded for the various overburden samples (refer Tables 3.1 and 3.8). The highest values appear to be related to fresh Tertiary and Permian age rocks and the lowest value was recorded for a sample from the unconsolidated surficial sediments. The low salinity values in the surficial unconsolidated sediments were also similar to the low EC values reported for the surface soils (refer Table 3.5).

3.5.3 Heavy metals

Schedule B (1) 'Guideline on the Investigation Levels for Soil and Groundwater' in *The National Environment Protection (Assessment of Site Contamination) Measure 1999* (National Environment Protection Council (NEPC) 1999) suggests trigger 'investigation level' concentrations for various heavy metals. If concentrations are higher than the investigation level, there is a need for additional, site specific detailed assessment.

Laboratory heavy metal concentration results of the overburden samples were assessed against the 'environmental investigation levels' and 'health-based investigation levels' (National Environment Protection Council, 1999) to provide an indication of the potential for overburden dumps to be a source of heavy metal contaminated leachate, based on the concentrations in the in-situ overburden material.

Relevant environmental and health-based investigation levels are shown in Table 3.2 below.

Table 3.2 Investigation thresholds for heavy metal contaminants in soil

Substance	Typical background levels (mg/kg)	Environmental investigation level (mg/kg)	Health-based investigation level[1] (mg/kg)
Arsenic	1–50	20	100
Cadmium	1	3	20
Copper	2–100	100	1,000
Chromium (III)	5–1,000	400	12%[2]
Chromium (VI)	–	1	100
Lead	2–200	600	300
Nickel	5–500	60	600
Zinc	10–300	200	7,000

Source: National Environment Protection Council 1999, Table 5-A.

Notes: 1. based on 'Standard' residential use as defined in Department of the Environment 1998. This includes garden/accessible soil (home-grown produce contributing less than 10% of fruit and vegetable intake; no poultry); this category includes children's day-care centres, preschools and primary schools.

2. % of total chromium in all speciations.

The Queensland Department of the Environment (1998) recommend a site specific assessment of land with levels above the environmental investigation level, and remediation or a detailed environmental and health risk assessment if levels are above the health based investigation levels.

The laboratory results for heavy metal analysis in overburden are provided in Attachment B and a summary is provided in Table 3.3 below.

As shown in Table 3.3, heavy metal concentrations within the overburden are below the concentrations requiring investigating under the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 1999).

Table 3.3 Heavy metal concentrations in overburden samples

Substance	Number of samples analysed	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Samples exceeding environmental investigation level[1]
Arsenic	5	<5	7	None
Cadmium	5	<1	<1	None
Copper	5	<5	47	None
Chromium III	5	5	38	None
Chromium VI	5	<0.5	<0.5	None
Lead	5	<5	13	None
Nickel	5	7	42	None
Zinc	5	12	81	None

1. based on 'Standard' residential use of soil as defined in Department of the Environment, 1998 (QLD). This includes garden/accessible soil (home-grown produce contributing less than 10% of fruit and vegetable intake; no poultry); this category includes children's day-care centres, preschools and primary schools.

The above results indicate that overburden materials do not contain levels of heavy metals, which exceed the environmental investigation limits set out by the Queensland Department of Environment (1998). Based on the above test results the risk for overburden dumps to be a source of heavy metal contaminated leachate is considered negligible.

3.5.4 Nutrients and trace elements

The nutrient and trace element content of overburden material was not assessed as part of this study. Laboratory pH values of overburden material indicates that it is alkaline and sodic (refer Table 3.1) and it is considered poor growth media for plants due to low nutrient availability. High alkalinity and sodicity renders the nutrients present in the rock mass unavailable to plants.

All disturbed areas are anticipated to be covered with topsoil to achieve rehabilitation. No overburden is proposed to be used as plant growth media.

3.5.5 Fossil material

As discussed in Section 3.3.1, the coal bearing strata present in the Project area together with the overlying rock are of Permian, Tertiary and Quaternary age and of sedimentary origin. There is a potential for fossils to be present. However, based on experience in other open cut coal mines in the area the potential for location of significant fossils is expected to be low.

3.6 Soils

3.6.1 Soil description and mapping

Classification of soils in the Project area was based on field observations, laboratory analytical data and re-interpretation of previous classifications (e.g. by GSS Environmental 2007).

The adopted soil classification system is based on the classification by GSS Environmental (2007) and *The Land Resource Assessment of the Windeyers Hill Area, Isaac – Connors and Mackenzie River Catchments, Central Queensland* (Burgess 2003). However, soils have also been correlated with the *Australian Soil Classification System* (Isbell 1996).

Soils encountered on site by the current investigation and assessed by GSS Environmental (2007) have mainly developed on either reworked Tertiary/Quaternary age unconsolidated sediments or on Quaternary age alluvial sediments as mapped by Burgess (2003). Based on the field investigation and review of existing information, six soil types have been adopted from previous investigations by GSS Environmental (2007) and Burgess (2003) to allow easy correlation between previous assessments and this work. The identified soil types are as follows:

- yellow duplex
- alluvial soils
- grey brown duplex
- brown uniform clay
- red lithosol
- warwick.

These soil units are discussed in the following sections and presented on Figure 3.6. There were some variations to those soils described by GSS Environmental encountered in this investigation which have been described in following sections. Three test locations from Burgess (2003) and 18 locations from GSS Environmental (2007) were also included in this assessment and are shown on Figure 3.6.

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

THIRTEEN MILE GULLY

DYSART MIDDLEMOUNT ROAD

ROPER CREEK

PARROT CREEK

BARWON PARK MIDDLEMOUNT ROAD

Project location

MW5P

MW9A

MW9M

9048

9049

9020

MM01

MM02

MM03

MM04

MM06

MM07

MM08

MM09

MM10

MM11

MM12

MM13

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 1
- Option 2
- Option 3
- PB groundwater borehole (2010)
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Soil types

- Yellow Duplex
- Grey-Brown Duplex
- Brown Uniform Clay
- Red Lithosol
- Alluvial Soils
- Warwick Soils

File: \\aubnet\proj\MM\Middlemount_Coal\21170768_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-6 Soil Types.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Soil types

Where possible, soils have been correlated with those described in the assessment by GSS Environmental (2007) and the Australian Soil Classification (Isbell 1996). Relationship between soil types is outlined in Table 3.4 below.

Soils with similar physical or chemical properties have been grouped together as soil associations as shown in Figure 3.6 to make the map easier to use and more practical for soil management planning. While Figure 3.6 shows discrete boundaries between soil types, the soils actually grade into each other (i.e. properties of both soils occur) over a distance of a few hundred metres.

Abrupt boundaries between soils types generally do not occur in the Project area, except occasionally along drainage lines (Roper Creek and Thirteen Mile Gully).

Table 3.4 Interpreted relationship between soils described by Burgess (2003), GSS Environmental (2007) and the Australian Soil Classification (Isbell 1996)

Classification Systems		
GSS Environmental (2007)	**Burgess (2003)**	**Isbell (1996)**
Yellow duplex	Foxleigh and Foxleigh Loam	Yellow-brown sodosol
Grey-brown duplex	Parrot	Grey-brown sodosol
Brown uniform clay	Tralee	Grey-brown vertosol
Alluvial soils	Roper	Grey-brown chromosol
Red lithosols	Bellarine	Leptic rudosol
Not mapped	Warwick	Grey-brown vertosol

The mapped soils are described in detail in Section 3.7.3 below.

3.6.2 Laboratory results

Selected near surface soil samples were tested to assess their acidity, salinity, dispersion potential, and nutrient content. The results were used to aid classification of individual soil types and to assess reuse potential of soils for future rehabilitation purposes. The analytical results are summarised in Table 3.5 and the ratings used in the assessment are provided in Tables 3.6, 3.7 and 3.8. Laboratory test report sheets are in Attachment B.

Descriptions of some of the parameters assessed include:

- exchangeable sodium percentage (ESP) – Chemically exchangeable sodium can weaken the bonds between clay particles thus acts as a dispersing agent. Soils with an ESP of more than 15% are considered dispersive and soils with an ESP less than 5% are commonly considered as non-dispersive

- cation exchange capacity (CEC) – The soil's capacity to hold nutrients is estimated by CEC. Low values (below 5) indicate the soil is infertile and prone to leaching and therefore is likely to be a poor growth medium requiring nutrient application.

Tables 3.6 to 3.8 below provide values related to the fertility, acidity and salinity of soil. Values shaded in Table 3.5, representing land suitability and rehabilitation constraints have been based on values contained in Tables 3.6 to 3.8.

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM01 (0.0-0.1)	MM01 (0.1-0.2)	MM01 (0.32-0.4)	MM02 (0.0-0.1)	MM02 (0.15-0.25)	MM02 (0.7-0.8)	MM03 (0.0-0.1)	MM04 (0.15-0.25)
pH	6.3	6.7	6.4	6.8	7.2	6.9	6.0	7.1
Electrical conductivity (µS/cm)	22	38	113	7.5	44	37	25	23
Moisture Content (%)	5.9	5.3	11.7	5.7	7.4	12.2	6.1	6.9
Exchangeable calcium (meq/100g)	7.9	4.3	3.7	8.6	6.6	11.1	4.4	12.6
Exchangeable magnesium (meq/100g)	6.8	2.7	4.5	1.7	1.8	3.6	1.6	4.6
Exchangeable potassium (meq/100g)	0.6	1.2	0.5	1.4	1.4	1.2	1.5	1.3
Exchangeable sodium (meq/100g)	4.5	0.3	2.6	0.2	0.2	0.2	0.2	0.2
CEC (meq/100g)	19.8	8.5	11.2	11.8	10.0	16.2	7.6	18.7
ESP (%)	22.6	3.5	22.8	1.4	2.0	1.4	2.2	1.0
Sulphur as SO_4 (mg/kg)	130	120	110	200	150	160	150	190
Chloride (mg/kg)	220	270	490	130	130	290	220	220
Total Kjeldahl nitrogen (mg/kg)	460	520	530	1350	550	490	650	860
Total phosphorus (mg/kg)	280	289	216	315	285	302	262	537
Organic Matter (%)	1.3	1.4	0.9	3.1	1.4	1.0	1.9	2.4
Total Organic Carbon (%)	0.8	0.8	0.5	1.8	0.8	0.6	1.1	1.4

Note: Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or Cl^-:SO_4 ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10).

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM06 (0.0-0.1)	MM06 (0.45-0.55)	MM07 (0.0-0.1)	MM07 (0.2-0.3)	MM08 (0.0-0.1)	MM08 (0.2-0.3)	MM09 (0.0-0.1)	MM10 (0.0-0.1)
pH	6.4	8.7	6.7	6.7	6.6	6.2	6.1	5.9
Electrical conductivity (µS/cm)	20	422	17	8	20	3	10	8
Moisture Content (%)	1.8	10.2	2.9	3.6	2.1	2.1	1.7	1.4
Exchangeable calcium (meq/100g)	1.6	8.7	3.0	1.3	2.8	0.8	1.4	1.6
Exchangeable magnesium (meq/100g)	0.7	5.8	0.6	0.3	0.6	0.6	0.4	0.5
Exchangeable potassium (meq/100g)	0.5	0.3	0.4	0.2	0.3	0.3	0.2	0.2
Exchangeable sodium (meq/100g)	<0.1	3.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CEC (meq/100g)	2.9	18.2	4.2	1.8	3.7	1.7	2.1	2.4
ESP (%)	1.6	18.0	2.0	1.5	0.6	2.1	2.3	1.4
Sulphur as SO_4 (mg/kg)	<100	200	<100	<100	<100	<100	<100	<100
Chloride (mg/kg)	50	560	50	20	130	<10	20	50
Total Kjeldahl nitrogen (mg/kg)	310	140	220	110	340	100	190	180
Total phosphorus (mg/kg)	122	89	139	73	87	62	58	127
Organic Matter (%)	0.9	<0.5	0.5	<0.5	0.9	0.9	0.5	<0.5
Total Organic Carbon (%)	0.5	<0.5	<0.5	<0.5	0.5	0.5	<0.5	<0.5

Note: Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or Cl^-:SO_4 ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10)

Table 3.5 Soil nutrient and chemical analytical test results

Analyte/Sample (depth)	MM11 (0.0-0.1)	MM12 (0.15-0.25)	MM12 (0.4-0.5)	MM13 (0.0-0.1)	MM13 (0.2-0.3)
pH	6.6	6.7	8.6	5.4	5.3
Electrical conductivity (µS/cm)	14	8	243	9	20
Moisture Content (%)	2.6	3.3	9.4	2.1	5.2
Exchangeable calcium (meq/100g)	1.8	1.9	11.6	1.4	1.4
Exchangeable magnesium (meq/100g)	0.4	1.0	6.6	1.8	2.4
Exchangeable potassium (meq/100g)	0.3	0.4	0.6	0.3	0.1
Exchangeable sodium (meq/100g)	<0.1	<0.1	1.9	0.1	0.2
CEC (meq/100g)	2.5	3.4	20.7	3.6	4.1
ESP (%)	1.1	1.9	9.0	4.1	5.6
Sulphur as SO_4 (mg/kg)	<100	<100	120	<100	120
Chloride (mg/kg)	20	50	250	100	130
Total Kjeldahl nitrogen (mg/kg)	250	170	180	350	940
Total phosphorus (mg/kg)	54	78	116	163	135
Organic Matter (%)	1.0	0.5	<0.5	0.9	0.9
Total Organic Carbon (%)	0.6	<0.5	<0.5	0.5	0.5

Note:Shaded results represent samples that are either strong pH, contain excessive amount of dissolved solids (i.e. salts, EC > 600 µS/cm or chloride:sulfate ratio more than 600) or are considered having moderate to high potential for dispersivity (ESP >10).

Table 3.6 Ratings used for interpretation of soil analyses

	Ratings				
Soil test (units)	**Very low**	**Low**	**Medium**	**High**	**Very high**
Total nitrogen (mg/kg)	<500	500 – 1,500	1500 – 2,500	2500 – 5,000	>5,000
Total phosphorus (mg/kg)	<50	50 – 200	200 – 500	500 – 1,000	>1,000
Extractable potassium (meq%)	<0.1	0.1 – 0.2	0.2 – 0.5	0.05 – 1.0	>1.0
SO_4 (mg/kg)	—	<4	4 – 10	>10	—
CI- (mg/kg)	<100	100 – 300	300 – 600	600 – 2,000	>2,000
Cu (mg/kg)	<0.1	0.1 – 0.3	0.3 – 5	5 – 15	>15
Mn (mg/kg)	<1	1 – 2	2 – 50	50 – 500	>500
Zn (mg/kg) pH >7	<0.3	0.3 – 0.8	0.8 – 5	5 – 15	>15
Zn (mg/kg) pH <7	<0.2	0.2 – 0.5	0.5 – 5	5 – 15	>15
Total organic carbon (%)	<0.5	0.5 – 1.6	1.5 – 2.5	2.5 – 5.0	>5.0

(after Biggs, Coutts and Harris 1999)

Note: For total nitrogen, total phosphorus, extractable potassium and total organic matter, low values represent a nutrient deficiency, and medium to high values are preferential. For other parameters in the above table, high to very high values represent levels at which plant toxicities may occur, and low to medium values are preferential. Very low values may result in deficiencies in some plants

Table 3.7 Ratings used for interpretation of pH

Rating	pH
Extremely acid	<4.5
Very strongly acid	4.5–5.0
Strongly acid	5.1–5.5
Medium acid	5.6–6.0
Slightly acid	6.1–6.5
Neutral	6.6–7.3
Mildly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	>9.0

(after Biggs, Coutts and Harris, 1999)

Table 3.8 Ratings for interpretation of electrical conductivity

Salinity rating	Root zone salinity (EC µS/cm)			
	10–20% clay	20–40% clay	40–60% clay	60–80% clay
Very low	<50	<80	<120	<180
Low	100	165	250	370
Medium	250	400	580	850
High	450	670	1,000	1,500
Very high	700	1,050	1,580	2,400
Extreme	>700	>1,050	>1,580	>2,400

(after Biggs, Coutts and Harris, 1999)

3.6.3 Soil types

Soil types encountered on site during this or previous investigations (refer Table 3.4) are described in detail below.

3.6.3.1 Yellow duplex

This soil was encountered on the flat plains away from drainage lines and on very gently inclined slopes associated with Poplar box (*Eucalyptus populnea*) vegetation community. Under the Australian Soil Classification, this soil type is classified as yellow-brown sodosol and is similar to the soil descried by Burgess (2003) as the Foxleigh and Foxleigh Loam soil.

This soil was encountered at test locations MM07 to MM12 from the current investigation and soils mapped as 'Yellow duplex' soils according to GSS Environmental (2007). One test location with this soil type was identified by Burgess within the Project area (refer site 9020 on Figures 2.1 and 3.6).

The soil profile of the Yellow duplex soils is described below.

The approximately 0.3 m to 0.45 m deep topsoil comprises pale brown and yellow-brown to brown sandy loam or sand, with blocky or platy peds in the A1 and A2 horizons (refer Photo 3.4).

The B2 horizon generally consists of grey or brown and yellow-brown sandy clay with orange and black mottles and blocky peds. Locally, in poorly drained areas, calcareous concretions may be present. Fine grained gravel size, rounded, ferruginous nodules in a sandy clay matrix were encountered in test pits MM07 to MM09 and MM10 forming a layer of between 0.1 m and 0.25 m thick at the top of the B2 horizon. In test pits MM11 and MM12 the top of the B horizon comprised sand or clay with sand and the ferruginous nodules were encountered lower in the profile not in a distinct horizon. Cementation and fissures with polished surfaces were common in the lower B horizons.

The C horizon, when encountered, occurred from below 1.5 m depth comprising sandy or silty clay. The encountered soil profiles correlate well with the Foxleigh/Foxleigh Loam and Yellow duplex soil described by Burgess (2003) and GSS Environmental (2007).

Laboratory test results indicate that the topsoil of the Yellow duplex is neutral to moderately acidic, has very low salinity levels and very low organic carbon content. This soil also has very low nitrogen and low phosphorous content. These topsoils are considered to have a negligible or slight potential for dispersivity but moderate to high potential for erosion due to their non-cohesive characteristics.

The B horizon soils are strongly alkaline, have low salinity, high CEC and are considered to have a moderate to high potential for dispersivity.

Photo 3.4 **Typical view of a Yellow duplex (site MM12), including the vegetation community (i.e. poplar box) and landscape in which the soil mostly occurred**

3.6.3.2 Grey-brown duplex

This soil occurs on flat plains and on very gently inclined slopes (<2%–5%), associated with scattered re-growth of Poplar box woodland vegetation in improved pastures with grass cover in north-west to south-east trending belts, sub-parallel with the streams. The grey-brown duplex appears to be mainly located between the alluvial soils and Yellow duplex soils. This soil was encountered at test locations MM01, MM03, MM06 and MM13 during the current investigation and was mapped as 'Grey-brown duplex' soils previously (GSS Environmental 2007). Under the Australian Soil Classification, this soil type is classified as Brown-grey sodosol and correlates well with the description of the 'Parrot' soils mapped by Burgess (2003).

The soil profile of the Grey-brown duplex soil is described below.

The topsoil is between about 0.30 m to 0.45 m deep, and consists of pale brown to grey-brown sandy loam to clayey loam, with blocky or platy peds in the A1 and A2 horizons (Photo 3.5).

The upper B horizons generally comprise pale grey or brown silty or sandy clay with prismatic, blocky or platy peds. The lower B horizons comprise sandy or silty clay, grey to dark brown with orange-brown, brown or black mottles with prismatic peds. Calcareous concretions and fissures with polished surfaces are common in lower subsoils.

The C horizon encountered in MM01, MM03 and MM13 comprised sandy or silty clay or clay with sand, grey, red-orange and brown in colour. These materials are of inferred Tertiary age reworked sediments origin. In test pit MM06 the C horizon comprised extremely weathered, extremely low strength, fine to medium grained sandstone of inferred Tertiary age.

Photo 3.5 Typical view of a Grey-brown duplex soil (site MM03), including the vegetation community and landscape in which the soil mostly occurred

Laboratory test results indicate that the topsoil of the Grey-brown duplex is neutral to slightly acidic, has very low salinity and low organic carbon content. This soil also has very low to low nitrogen and low to medium phosphorous content. These topsoils are considered to have a slight to moderate potential for dispersivity but moderate to high potential for erosion due to their non-cohesive characteristics.

Subsoils are strongly alkaline, have low to moderate salinity, high CEC and are considered to have a moderate to high potential for dispersivity. Due to the strong alkalinity of the subsoils the plant available nutrient level of this soil horizon is considered low.

3.6.3.3 Brown uniform clay

This soil occurs on the generally flat plain between Roper Creek and Thirteen Mile Gully, just upstream from their confluence, in a poorly drained area. The soil is associated with open Poplar box woodland vegetation cleared areas covered by buffel grass. Poorly developed gilgai may be present within this soil.

Under the Australian Soil Classification, this soil type is classified as Brown-grey vertosol and correlates well with the Tralee soils, as described and mapped by Burgess (2003). This soil was not encountered within the area of this investigation but was mapped as 'Brown uniform clay' soils in the report by GSS Environmental (2007). This soil is not anticipated to occur in the areas of Stage 2 however, its description is provided here for completeness.

The following soil profile was provided in the previous assessments (Burgess and GSS Environmental) (Burgess and GSS Environmental) for Brown uniform clay soils and Tralee soils:

- the topsoil is between 0.10 m to 0.15 m deep, and consists of brown to dark coloured sandy clay with angular-blocky peds
- dark brown or dark grey-brown sand clay subsoils with angular blocky peds underlay the topsoil to about 0.28 m to 0.45 m depth. The lower subsoil, below about 0.45 m depth, comprises brown to dark brown massive heavy clay.

Laboratory test results from previous assessments (Burgess 2003; and GSS Environmental 2007) indicate that the topsoils of the brown uniform clay is mildly to moderately alkaline and has very low salinity. Topsoils are also considered to have very high potassium and phosphorous content, with high CEC. Based on ESP results the subsoils are strongly alkaline and are considered to have a high potential for dispersivity. The salinity and the alkalinity increases in the subsoil with high chloride content. Due to the strong alkalinity of the subsoils the plant available nutrient level of this soil horizon is considered low.

3.6.3.4 Alluvial soils

This soil occurs on the flat alluvial plain surrounding Roper Creek and some sections of Thirteen Mile Gully, associated with remnant riparian vegetation dominated by buffel grass pasture cover and open Poplar box woodland (GSS Environmental 2007). Under the Australian Soil Classification, this soil type is classified as Grey-brown chromosol and roughly matches the description and mapping by Burgess (2003) for the Roper soil. This soil was encountered at test location MM02 and MM04 from the current investigation and soils mapped as 'Alluvial soils' according to GSS Environmental (2007).

The Alluvial soils encountered had the following generalised soil profile:

The topsoil is between about 0.35 m to 0.45 m deep, comprising pale brown or grey-brown sandy loam, with angular blocky or platy peds in the A1 and A2 horizons (Photo 3.6).

Underlying the topsoil is a clayey B horizon of inferred alluvial origin, generally comprising dark brown silty clay with prismatic peds. The lower B horizon in test pit MM02 comprised sandy clay. Black (mangano-ferrugionous) mottling was common in the lower B horizons, which graded into alluvial material not affected by soil forming processes (C horizon).

Photo 3.6 Example of an alluvial soil (site MM04), including the vegetation community and landscape in which the soil mostly occurred

Laboratory test results indicate that the topsoil of the alluvial soils is neutral, has very low salinity and medium organic carbon content. This soil also has low to medium nitrogen and medium phosphorous content with very high potassium content in the topsoil horizons. These topsoils have low to medium CEC and are considered to have a negligible potential for dispersivity but high erosion potential due to dominance of non-cohesive sands.

The subsoils of the alluvial soils are neutral, have very low salinity, and are considered to have a negligible to slight potential for dispersivity.

3.6.3.5 Red lithosol soils

A Red lithosol was identified by GSS Environmental (2007), on the topographically higher areas in the south and south-western corner of Project area, associated with native trees and shrubs, including Narrow-leafed ironbark (*Eucalyptus crebra*), Lancewood (*Acacia shirleyi*) and grasses.

Under the Australian Soil Classification, this soil type is classified as Leptic Rudosol and roughly matches the description and mapping by Burgess (2003) for the Bellarine soil and mapped by GSS Environmental (2007) as a 'Red lithosol.' This soil was not encountered during the current investigation.

The following soil profile was provided in the previous assessments (Burgess and GSS Environmental) for Red lithosols and Bellarine soils:

- the topsoil is between 0.05 m to 0.15 m deep, and comprises of pale brown to brown granular clay sandy loam to clay loam. A surficial gravel armour layer comprising weathered rock fragments is generally present and the rock fragments are present throughout the profile

- underlying the topsoil is either weathered rock substrate or a residual B2 or C horizon generally consists of sandy clay to clay loam, white, grey and red with massive structure.

According to previous assessments (Burgess 2003; and GSS Environmental 2007) laboratory test results indicate that the topsoils of the red lithosol is neutral to very strongly acidic and has very low salinity. These soils are considered to have a negligible or slight potential for dispersivity. Subsoils are very strongly acidic, have very low salinity, and are considered to have a negligible to slight potential for dispersivity.

3.6.3.6 Warwick

This soil is classified by profiles encountered by Burgess (2003) at locations labelled 9048 and 9049 as shown on Figure 3.6. The Warwick soil occurs on the topographically higher areas in the north-west of Project area, associated with Brigalow (*Acacia harpophylla*) vegetation communities (Burgess 2003). Under the Australian Soil Classification, this soil type is classified as Brown-grey vertosol. This soil was not encountered in other portions of the site during this investigation.

The following soil profile was described by Burgess (2003) for the Warwick soil:

- the topsoil is between 0.03 m to 0.20 m deep, and consists of grey-brown to dark brown sandy clay to clay, with platy and blocky structure in the A1 and A2 horizons

- underlying the topsoil is a residual B2 horizon generally consists of clay, brown with lenticular and blocky peds. Calcareous concretions are also common in this layer.

According to previous assessments Burgess (2003), laboratory test results indicate that the topsoils of the Warwick soil is neutral to very strongly acidic and has very low salinity. These soils are also considered to have a negligible or slight potential for dispersivity. Subsoils are strongly acidic, have very low salinity, and are considered to have a moderate to high potential for dispersivity.

3.7 Land suitability assessment

At the time of the field investigation the Project area was used for low intensity cattle grazing. The infrastructure of Stage 1 of Middlemount Mine was also under construction in the southern portion of the site. The Project area is generally cleared or has been cleared in the past and mostly covered with pasture grasses and re-growth vegetation.

A land suitability assessment for Stage 1 of Middlemount Mine was undertaken by GSS Environmental (2007) to assess the land suitability for beef cattle grazing. A land suitability classification has been undertaken as part of this assessment for beef cattle grazing and dry land cropping for the encountered soils over both stages of the Project to create a uniform classification for the entire site.

The classification was based on the assessment technique described in *'Land Suitability Assessment Techniques'* (Department of Mines and Energy 1995a). The results of the assessment are shown in Tables 3.9 and 3.10 below:

Table 3.9 Land suitability assessment for dry land cropping

	Yellow duplex	Grey-brown duplex	Brown uniform clay	Alluvial soils	Red lithosol	Warwick
Water availability	4	4	3	2	5	4
Nutrient deficiency	4	3	1	1	4	3
soil physical factors	2	2	2	2	2	2
workability	2	2	2	2	2	2
salinity	1	1	1	1	1	1
rockiness	1	1	1	1	5	2
wetness	2	2	2	2	1	3
topography	2	2	2	3	1	2
Water erosion	2	2	2	4	3	2
Flooding	2	2	2	4	1	3
Land suitability class	**4**	**4**	**3**	**4**	**5**	**4**

Table 3.10 Land suitability assessment for beef cattle grazing

	Yellow duplex	Grey-brown duplex	Brown uniform clay	Alluvial soils	Red lithosol	Warwick
Water availability	4	3	2	1	5	3
Nutrient deficiency	2	2	1	2	4	1
soil physical factors	1	1	2	1	1	2
salinity	1	1	2	1	2	3
rockiness	1	1	1	1	4	1
micro relief	1	1	2	1	1	2
pH	2	3	2	2	3	2
ESP	3	3	1	2	1	2
wetness	2	2	2	2	1	2
topography	1	1	1	4	4	1
Water erosion	2	2	2	3	4	2
Flooding	2	2	2	2	1	2
vegetation regrowth	2	2	2	2	2	2
Land suitability class	**3**	**3**	**2**	**3**	**5**	**3**

The land suitability classes for the current assessment were derived from a combination of the identified soil types and geomorphic/topographic position, and not simply a reflection of spatial distribution of the various soils. Tables showing all criteria are provided in Attachment C.

This assessment incorporates results of the current field assessment, data from GSS Environmental (2007) and Burgess (2003). In most cases the land suitability class for a soil/landscape position relates to the highest (i.e. poorest) ranking criteria for the assessment. Land suitability maps of the Project area for dry land cropping and beef cattle grazing are shown in Figures 3.7 and 3.8 respectively.

The Yellow duplex, Grey-brown duplex, Alluvial soils and Warwick soils have been classified as Class 4 soils for dry land cropping due to their low plant available water capacity and nutrient deficiency. Class 4 soils are considered marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.

The Alluvial soils are classified as Cass 3 for beef cattle grazing due to the topographic position and high erosion potential. The Yellow duplex, Grey-brown duplex and Warwick soils have been classified as Class 3 for beef cattle grazing due to their poor plant available water capacity, high pH and sodic subsoils.

The Brown uniform clays were classified Class 3 for dry land cropping and Class 2 for beef cattle grazing. This differs to GSS Environmental (2007) classification of Class 2 soils as the Tralee soils, reported by Burgess (2003) as included in the assessment of the Brown uniform clays, have a reported lower plant available water capacity. Class 3 is suitable land with moderate limitations – land which is mostly suited to a proposed use but which requires significant inputs to ensure sustainable use. Class 2 is suitable land with minor limitations which either reduce production or require more than simple management practices to sustain the use.

The Red lithosols are Class 5 for both dry land cropping and cattle grazing due to surface rockiness, poor plant available water capacity, shallow soils with weathered substrate close to the surface and nutrient deficiency. Class 5 soils are unsuitable land with extreme limitations that preclude its use.

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

THIRTEEN MILE GULLY

ROPER CREEK

PARROT CREEK

Project location

MM01 MM02 MM03 MM04 MM06 MM07 MM08 MM09 MM10 MM11 MM12 MM13

9048 9049 9020

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 3
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Land suitability for dry land cropping

- Class 3
- Class 4
- Class 5

File: \\aubnefpro\MM\Middlemount_Coal\21\17076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-7 Land Suitability Classes for Dry Land Cropping.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Land suitability classes for dry land cropping

Figure 3.8

MIDDLEMOUNT

CENTENARY DRIVE NORTH

COCKATOO CREEK

THIRTEEN MILE GULLY

DYSART MIDDLEMOUNT ROAD

BARWON PARK MIDDLEMOUNT ROAD

ROPER CREEK

PARROT CREEK

Project location

MM01 MM02 MM03 MM04 MM06 MM07 MM08 MM09 MM10 MM11 MM12 MM13

9048 9049 9020

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Legend

- Project area
- Mining lease 70379
- Mining lease application 70417
- Road
- Creek
- Rail Loop
- Saraji Pipeline

Saraji Proposed Realignment

- Option 3
- Burgess (2003)
- PB test pit (2010)
- GSS Environmental test pit (2007)
- No spoil dumping area

Land suitability for Beef Cattle Grazing

- Class 2
- Class 3
- Class 5

File: \\aubnefpro\MM\Middlemount_Coal\21\17076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-8 Land Suitability Classes for Beef Cattle Grazing.mxd Author: RS Print Date: 18/10/2010

PB PARSONS BRINCKERHOFF 125 YEARS

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Land suitability classes for beef cattle grazing

3.8 Good quality agricultural land

In accordance with Section 2 and Attachment 2 of '*The Planning Guidelines: The Identification of Good Quality Agricultural Land*' (Department of Primary Industries and Department of Housing, Local Government and Planning Queensland 1993), agricultural land Classes A, B and C are considered GQAL in the Project area. A GQAL map is shown on Figure 3.9 below.

Agricultural land Classes are defined as follows:

- **Class A**: **crop land** — land that is suitable for current and potential cropping with limitations to production which range from none to moderate level.
- **Class B**: **limited crop land** — land that is marginal for current and potential cropping due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered for cropping.
- **Class C**: **pasture land** — land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment.
- **Class D**: **non-agricultural land**.

Current GQAL mapping does not cover the Project area however; GSS Environmental (2007) undertook a GQAL assessment for Stage 1 area of Middlemount Mine. The findings of that assessment classify Brown uniform clay soils as Class B, the Yellow duplex, Grey-brown duplex, Alluvial soils are considered to be Class C and the rocky Red lithosol soils are considered Class D.

The findings of this land suitability assessment presented in Section 3.8 above confirm the existing GSS Environmental GQAL assessment for Stage 1 area of Middlemount Mine. The Warwick soil was not assessed by GSS Environmental however, based on the findings of this land suitability assessment it is considered to be Class C.

From all soils encountered within the Project area the Brown uniform clay soil is considered as GQAL.

No Brown uniform clay soils are anticipated to be encountered within Stage 2 area.

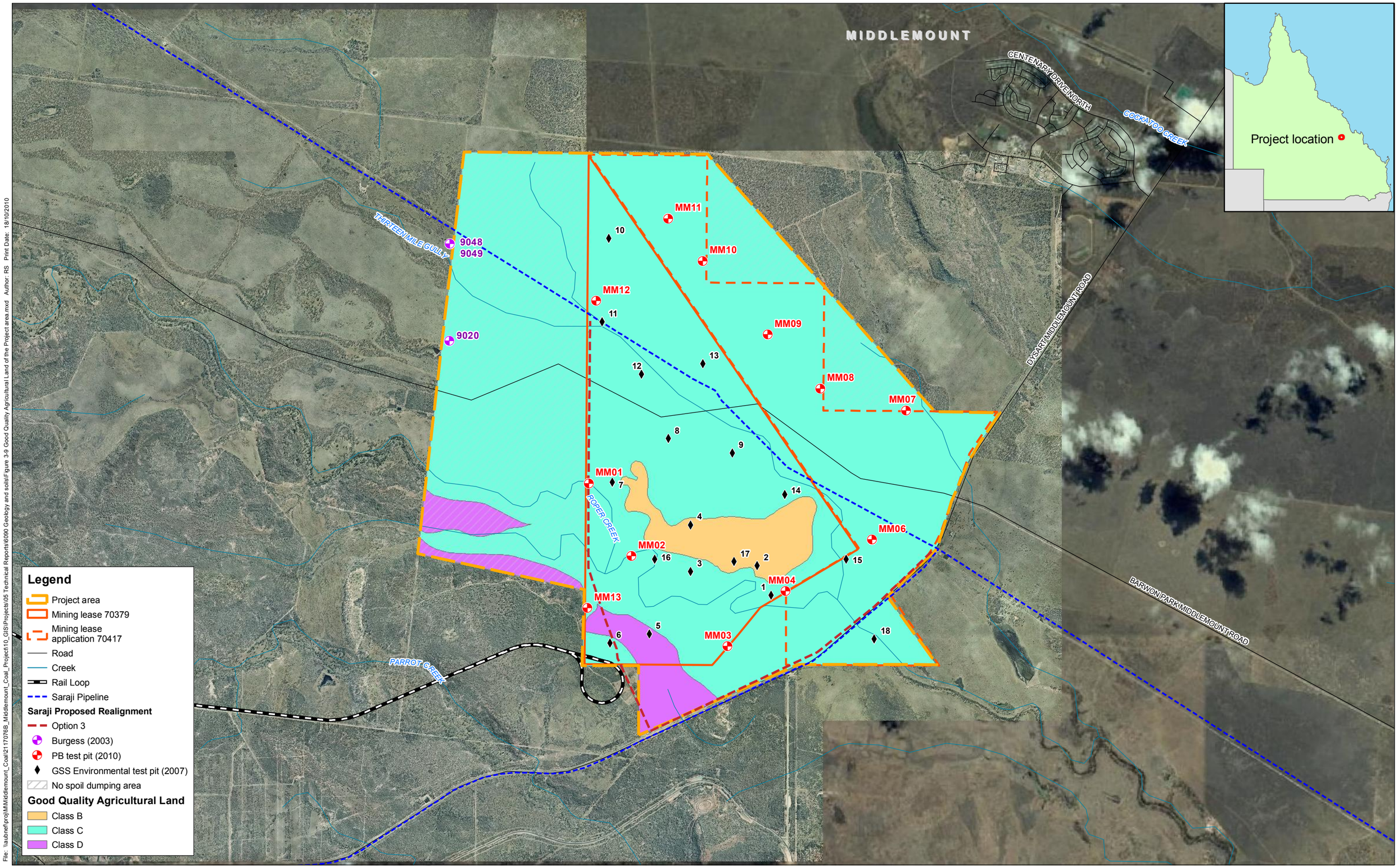
3.9 Strategic cropping land

In accordance with *Protecting Queensland's strategic cropping land: A policy framework* (Department of Environment and Resource Management 2010), the Project area was assessed for presence of strategic cropping land.

According to Strategic Cropping Land – Draft Trigger Map C4 (Department of Environment and Resource Management 2010) the Project area is not considered strategic cropping land. Therefore, no further action or assessment is required under the *Sustainable Planning Act 2009.*

Middlemount Coal Project, Stage 2

Figure 3.9



File: \\aubnef\proj\M\Middlemount_Coal\2117076B_Middlemount_Coal_Project\10_GIS\Projects\05 Technical Reports\6090 Geology and soils\Figure 3-9 Good Quality Agricultural Land of the Project area.mxd Author: RS Print Date: 18/10/2010

PARSONS BRINCKERHOFF

Source: Google Earth, 2010.
StreetPro Version 2008, Pitney Bowes Software, 2008.
1:250,000 Topographic Map, GeoScience Australia 2001.

0 0.5 1 2 3 4 5
Kilometres

Good Quality Agricultural Land of the Project area

4. Description of the Project

The Middlemount Coal Project involves the development of an open cut pit over an expected lifespan of about 22 to 23 years. Stage 1 of the Project has already commenced and Stage 2 involves an extended mine plan and Project area. Mining will occur by strip mining and will target the Middlemount and Pisces coal seams. Overburden, interburden and coal will generally be removed by truck and shovel methods. At the time collation of this report, an alternative mining method involving use of a dragline to remove the Pisces interburden was also considered.

In addition to the mine pit, the Project includes various items of infrastructure as described in Chapters 5 Project Construction and 6 Project Operations of the EIS.

The open cut mining pit will be excavated to target the Pisces and Middlemount coal seams to depths up to and potentially exceeding approximately 100–120 m below natural surface. Prior to the initial box cut, vegetation will be cleared, and topsoil will be stripped and stockpiled for use in future rehabilitation and revegetation. Mine benches are generally proposed to be up to 300 m wide and bench heights are proposed to be a maximum of 35 m high.

As mining progresses, void space will be filled with overburden and interburden, however a final void will remain at the end of mining. Over the life of the mine, overburden and interburden will be placed in in-pit overburden dumps (ML70379) and out-of-pit overburden dumps (MLA70417). Overburden spoil dumps will be progressively levelled, shaped, capped and rehabilitated as the mine progresses. Rehabilitation and revegetation of the landform is anticipated to commence within two years following a pit strip being mined.

A single final void will remain after completion of mining of the pit. The final void will be shaped to increase the pit floor towards the natural topographical surface. Chapter 26 Rehabilitation and Decommissioning of the EIS outlines of the proposed final void and landscape design. Depths of the final void will vary across the pit. A final landform will be developed for approval by relevant administrative authorities closer to the proposed closure of the mine.

5. Potential impacts

5.1 Topography

As discussed in Section 3.1, the site currently consists of flat to very gently undulating hills generally less than 1% and alluvial floodplains varying in width between 500 m and 2 km.

The mining activities will result in topographical changes to the Project area during mine operation and post-mining, through the disturbance of existing topographical relief during overburden stripping and mining, the creation of new topographic highs through the placement of overburden dumps, and topographic lows in the form of the void. Changes to the location and width of the floodplains will also occur as a result of mining and creek diversions.

5.2 Overburden

Overburden material was assessed for acid mine drainage, heavy metal leaching and erosion potential in relation to their suitability for use as capping or rock cladding layer for overburden dumps, and suitability as a sub-soil growth medium in stockpile capping layers.

5.2.1 Acid production potential

The overburden rocks are generally not acid forming material (refer Table 3.1) and are not expected to pose a risk in forming acid mine drainage.

5.2.2 Heavy metals

Heavy metal concentrations in all overburden samples tested were below environmental investigation levels (refer Table 3.2 and Table 3.3). The excavation and dumping of overburden is expected to have a low risk of producing heavy metal contamination from leachate seepage or surface runoff from the overburden dumps.

5.2.3 Dispersion, slaking and erosion potential

When environmental factors (e.g. vegetation cover, climate etc) are equal, the erosion potential of dumped overburden is dependent on the chemical and physical characteristics of the material and the topography (natural or created) of the terrain.

As discussed in section 3.6.4, the overburden is considered to be highly dispersive and therefore will readily disperse when left exposed on the soil surface or otherwise exposed to water, which will lead to erosion, including tunnel erosion. The greater the period bare spoil is exposed, the higher its erosion potential. Sandy, non-cohesive materials are also considered to have moderate to high potential for erosion by flowing water.

5.2.4 Uncovering fossil material

There is potential for fossilised material to be discovered during drilling, excavation and mining activities. These activities have the potential to damage or destroy fossils.

Most fossils uncovered by the mining activities will be common. The significance of a fossil is not indicated by the fossil size, with fossils such as budding plants, uncommon plants or insects being of interest to the Queensland Museum. See Section 6.3 of this report which deals with the measures to be implemented upon the discovery of fossil materials.

5.3 Soils

5.3.1 Alkalinity, sodicity and dispersivity

Yellow duplex, grey-brown duplex soils have moderate alkalinity and sodicity within the subsoils and are moderately to highly dispersive. Brown uniform clays have strongly alkaline subsoils, but are not considered dispersive, whereas the Warwick soils are considered to have subsoils with high dispersivity potential.

Alkaline and sodic soils are generally dispersive, and have high erosion potential if exposed. Sodic, alkaline soils are also poor plant growth mediums due to low nutrient availability, and should not be used as such in rehabilitation of disturbed areas. The topsoil portion of all encountered soils, other than the Red lithosol, are considered suitable for use in rehabilitation however, all soils have some limitations.

5.3.2 Erosion

All soils in the Project area will be subject to erosion if vegetation is removed and rehabilitation is not undertaken within an appropriate timeframe. Soils most susceptible to wind erosion are soils with sandy or loamy topsoils, which include yellow duplex, grey-brown duplex, alluvial soils and some red lithosols.

Soils most susceptible to erosion by flowing water are those with dispersive (sodic) topsoil or upper subsoil as discussed in Section 5.3.1 above. Soils on steep and moderate upper slopes, as occur on the undulating terrain and overburden dumps, have higher risk from erosion by water than soils on gentle slopes and floodplain. Exposure of dispersive subsoils as described in Section 5.4.1 has the potential to cause gully erosion problems, even if only small areas of subsoil are exposed.

5.3.3 Salinity

Soil salinity in the Project area is of limited extent and is not considered a high risk. However, the subsoils of brown-grey duplex are moderately saline and changes to the soil moisture regime due to vegetation removal or other impacts may increase near surface soil salinity.

5.4 Land suitability

During the operation of the mine, existing land uses, such as cattle grazing and broad acre cropping, may be able to continue within the Project area in areas not directly impacted by mining. Areas required for the operation of mining and associated activities will be excluded from agricultural purposes during the operation of the mine.

Land disturbed by mining will be rehabilitated following mining. Without mitigation measures, long term impacts to the land suitability classes, as defined in Section 3.5, are expected as follows:

- undisturbed land will be returned to (or retained in) its pre-mining land suitability class

- land used for infrastructure components of the Project (roads, MIA, etc) will have limitations related to water availability (through compaction and breakdown of the subsoil structure), and will generally be Class 4 cropping land or Class 3 cattle grazing land

- overburden dumps and the tailings storage facility (TSF) will have limitations related to water availability, salinity, gradient, erosion and nutrient content, and will generally be Class 5 cropping land or Class 4 or 5 grazing land

- final voids will be unsuitable for agricultural use (e.g. Class 5 for cropping and cattle grazing).

Planned rehabilitation and mitigation measures to obtain better land suitability classification are detailed in Chapter 26 of the EIS.

6. Mitigation measures

6.1 Topography

The design of the post-mining landform should consider, and where practicable to replicate, the topographic elements discussed in Section 3.1 of this report. This does not infer that the topography should be returned to the pre-mining profile, but where hills (e.g. overburden dumps) are formed, they should be constructed to a similar height, slope angle and profile (shape) as occur naturally in the area, and if floodplains are formed as part of the final landform, they should be of similar width and slope angle to those in the Project area pre-mining if practicable. In general, these measures can be described as:

- concave slope profile
- average slope gradients of around 4% (the erosion potential of longer slopes will need to be considered)
- irregular dump shapes (e.g. with uneven heights, ridgelines and spurs)
- overburden dump relief (height) of up to 64 m between the floor of the floodplain and the hill crest
- less than 2% gradient in floodplains.

The area of the final void should be minimised. Rehabilitation and landform design should consider access ramps to the final voids suitable for wildlife.

6.2 Overburden

6.2.1 Acid production potential

As discussed in Section 5.2.1 of this report, there is a low to negligible risk of development of acid mine drainage from the overburden. Despite this, the following measures should be implemented:

- laboratory characterisation of selected samples of overburden material should be conducted during overburden stripping to confirm the acid generation potential prior to removal. This characterisation should be in accordance with the *Assessment and Management of Acid Drainage* (Department of Primary Industries 1995)
- coarse rejects should be fully characterised and a management strategy for this material developed with regards to potential acid production potential
- layers of coal roof and floor material, partings, coarse rejects and any material that is visually assessed at the time of mining as containing pyrite, should be assessed for acid producing potential prior to placing within the overburden dump
- layers of coal roof and floor material, partings, coarse coal rejects and any material that is visually assessed at the time of mining as containing pyrite should not be placed near the surface of the overburden dumps unless laboratory testing confirms that the material is non acid forming

- any potentially acid forming material, as identified by visual assessment or laboratory characterisation, should not be used as capping material and should be buried within the overburden dump together with waste rock that has a positive acid neutralising capacity.

6.2.2 Dispersion

As discussed in Section 5.2.4, much of the overburden is considered to have high susceptibility to dispersive behaviour and erosion prone. The following measures should be implemented in regard to overburden:

- testing of dispersion and slaking potential should be conducted during overburden stripping. Less dispersive overburden should be managed for use as capping material
- appropriate designs and locations for overburden dump erosion and drainage control measures should be established based on the results of dispersion and slaking testing, spoil management plans, and through the use of drainage and erosion potential trials. Designs may include the use of 'durable rock' lined drains, or the encouragement of water infiltration into the overburden dumps (subject to overburden characteristics)
- rock mulching techniques should be used during rehabilitation to reduce impacts of dispersion. Rock mulching is described extensively in Chapter 26 Rehabilitation and Decommissioning of the EIS.
- due to the potential susceptibility of the overburden to tunnel erosion, the detailed design and management of benches and/or contour banks on overburden dumps should consider this risk, and should be undertaken by a suitably qualified person
- trials at varying slope angles should be conducted in relation to erosion from dispersion and slaking. These trials will assist in establishing suitable final landform gradients
- sediment control structures should be used to control surface runoff from all rehabilitated and disturbed areas to reduce the amount of final sediment loads. An assessment of available technologies should be undertaken prior to selection of sediment control structures
- all out of pit overburden dumps should be shaped, topsoiled and re-vegetated to reduce potential for concentration of surface runoff and erosion of dumped material
- rehabilitation strategies should be monitored and adjusted as required to reduce the risk of spoil erosion and destabilisation of spoil stockpiles.

6.3 Uncovering fossil material

As discussed in Section 5.3 of this report, there is potential for fossils to be located during mining activities. In the event potentially significant fossilised material is located, the following measures should be implemented:

- if potentially significant fossils, such as large dinosaur bones, are discovered during mining activities, then work in the vicinity of the find should stop, to preserve the potential fossil
- the Queensland Museum is immediately alerted to the find.

6.4 Soils

6.4.1 Dispersivity and erosion

As discussed in Section 5.4.2 of this report, Yellow duplex and Grey-brown duplex have moderate to extreme alkalinity and sodicity within the subsoils and are moderately to highly dispersive and the Warwick soils are considered to have highly dispersive subsoils. Generally wind and water erosion control measures should be applied to all soils in the Project area, which include:

- a sediment and erosion control plan should be prepared and implemented for Middlemount Mine prior to the commencement of mining, specifying the locations and types of sediment and erosion control measures to be used, and consider the changes to the mine water management system as part of Stage 2
- design of all drainage around proposed structures and permanent landforms should consider the presence of dispersive soils and apply suitable erosion reduction methods. All disturbed areas should be revegetated, or covered with material that has low erosion potential, to minimise the potential for erosion
- for disturbed or cleared land, including infrastructure areas:
  - unnecessary exposure of alkaline or sodic subsoils should be avoided, and should be limited to the minimal amount of time practicable. Any exposure should be covered with non-dispersive soil or other suitable material to minimise the infiltration of water into these soils. Sub-soils from these areas should be buried within the overburden dumps and covered in accordance with site overburden management procedures
  - clear the minimal amount of vegetation (including grass cover) required for Project works
  - minimise disturbance of the ground layer of vegetation by controlled operation of machinery and equipment selection
  - site drainage, and erosion and sediment controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation
  - water runoff should be directed around topsoil stockpile areas using diversion bunds, contours, and catch drains as appropriate
  - divert clean water away from disturbed areas
  - revegetate exposed soils as soon as practical after works have been completed. This includes the rehabilitation of overburden dumps
  - use watering trucks during windy conditions for dust suppression
  - install temporary and permanent erosion and sediment control measures such as rock mulching (refer Chapter 26 of the EIS), contour banks, etc. on disturbed natural or constructed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils.

- for infrastructure areas:
  - sediment and erosion control should be implemented in accordance with Middlemount Coal' s Sediment and Erosion Control Management Plan (Middlemount Coal 2010) and Erosion and Sediment Control (Site Practice) (Middlemount Coal 2009) for each area of infrastructure to be constructed. This plan should specify the locations and types of sediment and erosion control measures to be used
  - minimise areas cleared during earthworks, by delineating areas to be cleared with survey markers or other suitable marking
  - install sediment traps and silt fences or other suitable sediment control measures where overland runoff cannot be diverted to sediment dams
  - confine traffic to maintained roads
  - minimise slope grade within infrastructure areas where possible based on results of geotechnical data obtained during detailed design phase
  - construct hardstands from erosion resistant material
  - install scouring protection works in drains and intensely gullied areas adjacent to proposed infrastructure
  - revegetate disturbed areas surrounding infrastructure sites
  - control drainage and divert away from infrastructure.
- for stockpiles and dumps:
  - long-term stockpiles of topsoil and overburden should be planted with vegetation to minimise entrainment of soil particles into the air and minimise erosion through raindrop impact
  - when areas with topsoil susceptible to wind erosion (e.g. yellow duplex and grey-brown duplex) are stripped and stockpiled, even if for only a few months, the stockpiles should be covered by grass, other vegetation, geofabric or less erosive topsoil to minimise wind erosion
  - divert clean water from areas upslope of all topsoil, subsoil and overburden stockpiles/dumps around stockpile areas using contour banks or diversion channels, thereby reducing water flowing into the stockpile area
  - all topsoil, subsoil and overburden stockpiles/dumps should be bunded by earthen bunds or similar, with sediment dams installed downslope of stockpiles to prevent eroded sediment entering waterways.
- dispersive, clayey soils are suitable for use as embankment materials for water management structures, provided strict construction quality control measures are implemented

- gypsum or lime could be considered in the treatment of sodic alkaline soils to improve geotechnical/rehabilitation characteristics.

6.4.2 Salinity

As discussed in Section 5.4.3 of this report, saline topsoils are unlikely to be encountered in the Project area, high salinity levels are toxic to many plant species, and rehabilitation of saline soils can be difficult and costly. The subsoils of Grey-brown duplex soils are saline and should be buried within overburden dumps and covered with materials that are more stable. The subsoils of Grey-brown duplex should not be used in rehabilitation.

6.4.3 Compaction

The compaction of soil increases the potential for rainwater induced erosion, and reduces seed germination and root establishment of vegetation. The following measures should be applied in relation to compaction:

- compaction of topsoil can be reduced by selection of appropriate earthmoving machinery when working with these soils (i.e. light weight vehicles with large wheel/track size)
- soils that will be trafficked or compacted during the operation of the mine should have water control measures and sediment dams installed to minimise potential erosion and sediment entering into waterways
- previously compacted areas that are to be rehabilitated should be remediated by ripping the top layer of soil/overburden material, and then applying layers of subsoil and topsoil as required to establish a suitable plant growth environment. The depth of ripping/reworking required is dependent on the impact, and should be assessed at the time or rehabilitation
- ripping the top layer of soil breaks down the soil structure, and as a result protection of these areas from re-compaction (i.e. vehicles or grazing animals) after ripping is required to allow the soil structure to reform.

6.4.4 Topsoil reuse

Topsoils and subsoils are anticipated to be stripped from all disturbed areas and should be stockpiled for use in rehabilitation of disturbed areas. Suggested stripping depths and identified constraints for various encountered soil types are provided in Table 6.1 below.

Table 6.1 Topsoil stripping depths and potential constraints for reuse

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Yellow duplex	Sandy loam or sand	0.3	▪ highly alkaline subsoil ▪ dispersive subsoil
Grey-brown duplex	Sandy to clay loam	0.1	▪ acidic A2 horizon in some locations ▪ low nutrient availability in topsoil ▪ highly alkaline subsoil ▪ dispersive subsoil

Soil type	Surface soil composition	Topsoil stripping depth (m)	Potential constraints
Brown uniform clay	Loamy Clay	0.2	▪ high clay content topsoil ▪ poor workability when wet ▪ sodic subsoil
Alluvial soil	Clay loam	0.3	▪ patches of high clay content topsoil
Red lithosol	Clay	Unsuitable for re-use	▪ surface rockiness ▪ weathered rock at shallow depth
Warwick	Clay	0.3	▪ alkaline topsoil ▪ high clay content topsoil

Topsoil stripping may be affected by localised topographic constraints such as incised gullies and shallow soil depth, especially in the upper slope area of the undulating terrain. However, it is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation of disturbed areas.

Considering the topsoil and subsoil properties identified above, the following measures should be applied in relation to topsoil:

- the stripping of topsoil should be conducted in accordance with the existing Middlemount Coal Topsoil Management Plan (2010) and Topsoil Management Site Practice (2010)
- topsoil should be stripped separately from subsoil and stockpiled during clearing
- topsoil should be stored in stockpiles no more than 2 m–3 m high to retain seed germination potential (EPA 2001)
- topsoil should be stored for the shortest period practicable, and/or reused as soon as possible to maximise the retention of the seed bank in the soil
- the placement of topsoil should consider the landscape position the topsoil was stripped from, with soils of the undulating topography, used on slopes and hilltops, and the alluvial soils used in lower slopes and areas where water accumulation may occur
- the site topsoil register should be kept up to date for the Project, recording the locations and volumes of topsoil stockpiles

7. Recommended changes to existing environmental management plan

An existing environmental management plan (EM Plan) has been compiled for Stage 1 of the Project (2009). Based on this geology, soils and land suitability assessment, changes are proposed to be included in the 'Land Management' section of an amended EM Plan to cover both Stage 1 and Stage 2 of the Project. This assessment should be included as an appendix to the EM Plan to cover both stages of the Project.

These changes are outlined in sections 7.1 to 7.3 below.

7.1 Changes to description of environmental values described in current EM Plan

The following changes to the existing 'description of environmental values' section of the EM Plan are also recommended:

- updated pre-mine land suitability to refer to this assessment in the appendix of the EM Plan
- update soils assessment details to include six soil types that are identified in this report and include updated map into EM Plan

  A total of six soil types were identified as Yellow duplex, Alluvial soils, Grey-brown duplex, Brown uniform clay, Red lithosols and Warwick. The spatial distribution of these soil types is shown in Figure 3.6 of this report.
- land suitability assessment described in the EM Plan should reflect the findings of Section 3.8 of this report

  A detailed assessment of land suitability classes for both stages of Middlemount Mine was undertaken for beef cattle grazing and dry land cropping. In general the Project area is Class 3 beef cattle grazing and Class 4 dry land cropping. Details of the assessment are contained within this report.
- topsoil stripping depths should be updated in the EM Plan (Table 16) and should include potential limitations for each soil type according to Table 6.1 of this report.

7.2 Changes to potential impacts on environmental values described in current EM Plan

The following changes to the *existing 'Potential impacts on environmental values – land management'* section of the EM Plan are recommended:

- include impacts on topography and landform as in Section 5.1 of this report

  The mining activities will result in topographical changes to the Project area during mine operation and post-mining, through the disturbance of existing topographical relief during overburden stripping and mining, the creation of new topographic highs through the placement of overburden dumps, and topographic lows in the form of the void.

Changes to the location and width of the floodplains will also occur as a result of mining and creek diversions.

- include impacts related to overburden and interburden material as described in section 5.2 of this report including:
  - acid production potential
  - heavy metals
  - dispersion, slaking and erosion potential.

  The overburden rocks are generally not acid forming material and are not expected to pose a risk in forming acid mine drainage.

  Heavy metal concentrations in all overburden samples tested were below environmental investigation levels. The excavation and dumping of overburden is expected to have a low risk of producing heavy metal contamination from leachate seepage or surface runoff from the overburden dumps.

  When environmental factors (e.g. vegetation cover, climate etc) are equal, the erosion potential of dumped overburden is dependent on the chemical and physical characteristics of the material and the topography (natural or created) of the terrain.

  The overburden is considered to be highly dispersive and therefore will readily disperse when left exposed on the soil surface or otherwise exposed to water, which will lead to erosion, including tunnel erosion. The greater the period bare spoil is exposed, the higher its erosion potential. Sandy, non-cohesive materials are also considered to have moderate to high potential for erosion by flowing water.

7.3 Changes to commitments (control strategies) described in current EM Plan

All mitigation measures described in Section 6 above are recommended to be incorporated into this section of the EM Plan. Some of these are already incorporated however, Section 6 contains further detail on these as well as some additional control measures not currently considered in the EMP and therefore are recommended to be adopted/included into an updated EMP for the Project as follows.

Topsoil Management

- *topsoil should be stored in stockpiles no more than 2 m–3 m high to retain seed germination potential (EPA 2001)*
- *topsoil should be stored for the shortest period practicable, and/or reused as soon as possible to maximise the retention of the seed bank in the soil*
- *the placement of topsoil should consider the landscape position the topsoil was stripped from, with soils of the undulating topography, used on slopes and hilltops, and the alluvial soils used in lower slopes and areas where water accumulation may occur*
- *the site topsoil register should be kept up to date for the Project, recording the locations and volumes of topsoil stockpiles*

Land Management

- *target landform slopes should be 1(V):3(H) as outlined in Chapter 26 Rehabilitation and Decommissioning of the EIS*
- *testing of dispersion and slaking potential should be conducted during overburden stripping. Less dispersive overburden should be managed for use as capping material*
- *appropriate designs and locations for overburden dump erosion and drainage control measures should be established based on the results of dispersion and slaking testing, spoil management plans, and through the use of drainage and erosion potential trials. Designs may include the use of 'durable rock' lined drains, or the encouragement of water infiltration into the overburden dumps (subject to overburden characteristics)*
- *sediment control structures should be used to control surface runoff from all rehabilitated and disturbed areas to reduce the amount of final sediment loads. An assessment of available technologies should be undertaken prior to selection of sediment control structures*
- *rehabilitation strategies should be monitored and adjusted as required to reduce the risk of spoil erosion and destabilisation of spoil stockpiles*
- *soils that will be trafficked or compacted during the operation of the mine should have water control measures and sediment dams installed to minimise potential erosion and sediment entering into waterways*
- *previously compacted areas that are to be rehabilitated should be remediated by ripping the top layer of soil/overburden material, and then applying layers of subsoil and topsoil as required to establish a suitable plant growth environment. The depth of ripping/reworking required is dependent on the impact, and should be assessed at the time or rehabilitation*
- *for disturbed or cleared land, including infrastructure areas:*
    - *unnecessary exposure of alkaline or sodic subsoils should be avoided, and should be limited to the minimal amount of time practicable. Any exposure should be covered with non-dispersive soil or other suitable material to minimise the infiltration of water into these soils. Sub-soils from these areas should be buried within the overburden dumps and covered in accordance with site overburden management procedures*
    - *clear the minimal amount of vegetation (including grass cover) required for Project works*
    - *minimise disturbance of the ground layer of vegetation by controlled operation of machinery and equipment selection*
    - *site drainage, and erosion and sediment controls should be implemented and in place prior to, or as soon as possible, following the removal of vegetation*
    - *water runoff should be directed around topsoil stockpile areas using diversion bunds, contours, and catch drains as appropriate*
    - *divert clean water away from disturbed areas*

- *revegetate exposed soils as soon as practical after works have been completed. This includes the rehabilitation of overburden dumps*
- *use watering trucks during windy conditions for dust suppression*
- *install erosion and sediment control measures such as rock mulching (refer Chapter 26 of the EIS) on disturbed natural or constructed slopes to minimise erosion and sediment released into waterways. This is especially important for soils with dispersive subsoils.*

- *for infrastructure areas:*
  - *sediment and erosion control should be implemented in accordance with Middlemount Coal's Sediment and Erosion Control Managment Plan (Middlemount Coal 2010) and Erosion and Sediment Contol (Site Practice) (Middlemount Coal 2009) for each area of infrastructure to be constructed. This plan should specify the locations and types of sediment and erosion control measures to be used*
  - *minimise areas cleared during earthworks, by delineating areas to be cleared with survey markers or other suitable marking*
  - *install sediment traps and silt fences or other suitable sediment control measures where overland runoff cannot be diverted to sediment dams*
  - *confine traffic to maintained roads*
  - *minimise slope grade within infrastructure areas where possible based on results of geotechnical data obtained during detailed design phase*
  - *construct hardstands from erosion resistant material*
  - *install scouring protection works in drains and intensely gullied areas adjacent to proposed infrastructure*
  - *revegetate disturbed areas surrounding infrastructure sites*
  - *control drainage and divert away from infrastructure.*
- *for stockpiles and dumps:*
  - *long-term stockpiles of topsoil and overburden should be planted with vegetation to minimise entrainment of soil particles into the air and minimise erosion through raindrop impact*
  - *when areas with topsoil susceptible to wind erosion (e.g. yellow duplex and grey-brown duplex) are stripped and stockpiled, even if for only a few months, the stockpiles should be covered by grass, other vegetation, geofabric or less erosive topsoil to minimise wind erosion*

- *divert clean water from areas upslope of all topsoil, subsoil and overburden stockpiles/dumps around stockpile areas using contour banks or diversion channels, thereby reducing water flowing into the stockpile area*

- *all topsoil, subsoil and overburden stockpiles/dumps should be bunded by earthen bunds or similar, with sediment dams installed downslope of stockpiles to prevent eroded sediment entering waterways.*

- *dispersive, clayey soils are suitable for use as embankment materials for water management structures, provided strict construction quality control measures are implemented*

- *gypsum or lime could be considered in the treatment of sodic alkaline soils to improve geotechnical/rehabilitation characteristics.*

8. Recommended amendments to the existing environmental authority

There are currently two conditions in the current environmental authority (EA) directly relating to this assessment. These two conditions both relate to topsoil management as follows:

1. Topsoil must be strategically stripped ahead of mining in accordance with a Topsoil Management Plan (condition F1).

2. A topsoil inventory which identifies the topsoil requirements for the Middlemount Mine Project and availability of suitable topsoil on site must be detailed in the Plan of Operations (condition F2).

Based on the findings of this assessment, the existing EA conditions are achievable. No changes to the existing EA are recommended.

9. Residual impacts

Following mitigation, the residual impacts are anticipated to be as follows:

- change to the land use, both during the mine operation and post-mining. The main post mining land uses are envisaged to be nature conservation with some cattle grazing compared to mainly cattle grazing pre-mining
- redistribution of existing landforms diversion of sections of Roper Creek and Thirteen Mile Gully that traverse the mining tenements, including change in landscape form
- addition of a final void into the landscape. This may fill with some water and become wetlands.

10. Conclusions

This study has identified and mapped the broad soil types and characterised overburden material within the Middlemount Coal Project area. Based on existing literature and findings of the field assessment, the Project contains six different soils derived from sedimentary or alluvial parent material.

Overburden in the Project area is not anticipated to be acid forming or pose a risk of heavy metal contamination. The overburden is considered dispersive, and will require specific management techniques to control the erosion potential. Rehabilitation planning should take into considerations these overburden characteristics as these materials are to form the substrate for future vegetation. Selection of revegetation strategies, including species mix, provision of growth media, early stage plant support and ecosystem planning, should be adjusted to enable successful and sustainable revegetation of these areas.

Alternatively, some areas may require engineering solutions to achieve long term geotechnical stability.

Subsoils over much of the Project area are alkaline, sodic and dispersive (refer sections 5.3.1 and 5.3.3) and will require specific management techniques, such as minimising exposure, to prevent erosion including tunnel erosion. Soils most susceptible to erosion include yellow duplex, grey-brown duplex and some alluvial soils.

It is anticipated that most topsoil from the proposed disturbed areas will be recovered and will be available for use in rehabilitation, although with limitations. Depth limitations exist in some soils, and slope gradient may impact the ease of stripping on steeper slopes. Topsoil from the red lithosols were not considered appropriate for use in rehabilitation due to their surface rockiness.

Based on previous assessment and the results of the this investigation, the Project area is currently assessed to be within land suitability classes between Classes 2 and 5 for both dry land cropping and cattle grazing, but mostly is classified as Class 3 for beef cattle grazing and Class 4 for dry land cropping. The Project area is considered to be predominantly Class C good quality agricultural land (GQAL), except for the Red lithosols which are not considered GQAL, and Brown uniform clays which are considered to be Class B GQAL. However the Brown uniform clays have limited extent within the Project area.

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Attachment A

Test pit logs, borehole logs and explanatory notes

TEST PIT ENGINEERING LOG

TEST PIT NO.

MM01

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**13/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**13/5/10**
Test Pit Location:	**Flat terrain adjacent to spoil pile north-west of trial pit**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	IW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 667725 N 7471236 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.10		D			**TOPSOIL (Clay LOAM):** pale brown, fine grained sand, grass rootlets	D			TOPSOIL
	0.30		D			**TOPSOIL (LOAM):** pale brown, fine grained sand, platy peds				A_1
					CH	**CLAY with Sand**: medium to high plasticity, brown, fine grained sand, prismatic peds	MC<PL			A_2
	0.65		D			... 0.65 m: colour change to dark brown, fissured				TERTIARY B_{21}
	1.00		D		CL	**Sandy CLAY:** medium plasticity, brown with orange-brown and grey mottling, calcareous concretions, massive				B_{22}
	2.50		D		CL	**Sandy CLAY:** medium plasticity, grey, red-orange and brown, fine to medium grained sand				B_{23}
										C
			D							
			D							
			D							* Horizontal survey determined using hand held GPS
										Limit of investigation

END OF TEST PIT AT 6.00 m

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

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM02

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, 10 m from banks of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 668343 N 7470183 MGA***

Test Pit Information				Field Material Description							
1	2	3	4	5	6	7	8	9	10	11	
WATER	DEPTH(m) / RL(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS	
	0		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds, grass rootlets	D			TOPSOIL A_1	
	0.45		D			... 0.45 m: colour change to brown, trace tree roots				A_3	
	0.70		D		CH	**Silty CLAY:** medium to high plasticity, dark brown with brown mottling, prismatic peds	MC<PL			ALLUVIUM B_{21}	
	1										
	1.80				CL	**Sandy CLAY:** low plasticity, brown with dark brown and black mottling, fine grained sand				B_{22}	
	2		D								
						... 2.6 m: no black mottling	MC~PL			B_{23}	
	3		D								
						... 3.5 m: colour change to interbedded dark brown and brown				C	
	4		D								
	5.00		D		CH	**CLAY:** medium to high plasticity, grey with orange mottling, medium to high plasticity	MC<PL			TERTIARY C	
	5					END OF TEST PIT AT 5.10 m				Limit of Investigation * Horizontal survey determined using hand held GPS	

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

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM03

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, south of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 669733 N 7468871 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.15		D			**TOPSOIL (Sandy LOAM):** fine grained sand, brown, small blocky peds, grass rootlets	D-M			TOPSOIL A_1
			D			**TOPSOIL (Sandy CLAY):** high plasticity, brown, fine grained sand, massive, fissured with polished surfaces, grass rootlets	MC<PL			A_2
	0.40				CH	**CLAY with Sand:** low to medium plasticity, orange-brown, prismatic and blocky peds, fissured with polished surfaces				TERTIARY B_1
			D							
	0.80				CH	**Silty CLAY:** medium plasticity, brown, massive				$B_{21\ k}$
	1		D			... 0.9 m - 1.1 m: calcareous concretions				
						... 1.2 m: black and orange mottling				$B_{22\ s/h}$
	2									
						END OF TEST PIT AT 2.60 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.
MM04
SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north of Roper Creek**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Hitachi 250 excavator**	Surface RL:	
		Co-ords:	**E 676576 N 7469674 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
			D			**TOPSOIL (Sandy LOAM):** grey-brown, angular blocky and platy peds, grass rootlets, trace fine grained sand	MC<PL			TOPSOIL A_1
			D							
	0.35		D		CH	**Silty CLAY:** medium to high plasticity, pale grey, blocky peds, bleached				Gradational Change ALLUVIUM B_{21e}
	0.50				CH	**Silty CLAY:** high plasticity, dark brown, blocky and prismatic peds				B_{22}
	1					... 1.1 m: colour change to brown and pale grey				B_{23}
	1.30				CH	**Silty CLAY:** high plasticity, dark grey and brown, massive, horizontal laminations of sandy clay, fine grained sand, appears very stiff to hard				Gradational Change C
	2		D							
						END OF TEST PIT AT 2.30 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM06

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east of Thirteen Mile Gully**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW

Excavation Method: **Hitachi 250 excavator**

Surface RL:

Co-ords: **E 671832 N 7470419 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.10		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds	D			TOPSOIL A_1
			D			**TOPSOIL: (Clayey SAND):** fine grained, pale brown-grey, poorly developed peds, low plasticity fines, grass rootlets				A_2
			D			... 0.25 m: colour change to pale grey, bleached				$A_{3\,e}$
	0.32		D		CL	**Sandy CLAY:** medium plasticity, grey, prismatic peds	MC<PL			RESIDUAL SOIL B_1
	0.45		D		CH	**CLAY with Sand:** medium to high plasticity, brown-grey with black mottling, prismatic peds				$B_{21\,s/h}$
	1.00 1				CL	**Sandy CLAY:** medium plasticity, brown, fissured with polished surfaces, calcareous concretions, massive, vertical cracking, appears hard				$B_{22\,k}$
	2.00 2		D			**SANDSTONE:** fine grained, orange-brown with grey mottling, extremely weathered, extremely low strength, consistency of clayey sand, low plasticity fines				WEATHERED ROCK C
	3					END OF TEST PIT AT 2.20 m				Limit of Investigation * Horizontal survey determined using hand held GPS

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM07

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW

Excavation Method: **Hitachi 250 excavator**

Surface RL:

Co-ords: **E 672327 N 7472294 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.20		D			**TOPSOIL (Clay LOAM):** fine grained sand, pale brown, small angular blocky peds, grass rootlets	D-M			TOPSOIL A_1
	0.35		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, platy peds, grass rootlets				A_2
	0.45					... 0.35 m: fine grained gravel, rounded ferruginous nodules, purple and black				B_{21c}
			D		CL	**Sandy CLAY:** medium plasticity, orange-brown and grey, fine grained sand	MC<PL			TERTIARY B_{22}
	1.00 1				CL	**Sandy CLAY:** medium plasticity, grey-brown with black mottling, massive, fine to medium grained sand, calcareous concretions, fissured with polished surfaces				B_{23k}
			D							
			D			... 1.8 m: colour change to grey with black, orange and white mottling				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM08

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**12/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**12/5/10**
Test Pit Location:	**Flat to gently undulating terrain, eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW

Excavation Method: **Hitachi 250 excavator**

Surface RL:

Co-ords: **E 671080 N 7472610 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.20		D			**TOPSOIL (Sandy LOAM):** fine grained sand, angular blocky peds, grass rootlets	D			TOPSOIL A_1
	0.45		D			**TOPSOIL (Sandy LOAM):** fine grained sand, blocky peds	D			A_2
	0.55		D			... 0.45 m - 0.55 m: fine to medium grained gravel size, rounded ferruginous nodules, black and purple				B_{1c}
	1		D		CH	**Silty CLAY:** medium to high plasticity, grey and orange-brown, prismatic peds	MC<PL			TERTIARY B_{21}
						... 1.6 m: trace calcareous concretions				B_{22k}
	1.75		D		CH	**Silty CLAY:** medium to high plasticity, grey with white and orange-brown mottling, massive				C
	2					END OF TEST PIT AT 1.90 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM09

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	IW

Excavation Method: **Komatsu 20 tonne excavator**

Surface RL:

Co-ords: **E 670319 N 7473392 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0.15		D			**TOPSOIL (Sandy LOAM):** fine grained, pale brown, blocky peds, grass rootlets	D			TOPSOIL A_1
			D			**TOPSOIL (SAND with Clay and Gravel):** fine grained, pale brown-grey, with low plasticity fines and fine grained, rounded ferruginized rock fragments				A_{2c}
	0.35				CH	**Sandy CLAY:** medium to high plasticity, grey with orange-brown mottling, small blocky peds, appears hard	MC<PL			TERTIARY B_{21}
	1		D			... 1.65 m: colour change to grey-brown and black, with calcareous concretions				B_{22k}
	2					END OF TEST PIT AT 1.80 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENGINEERING LOG

TEST PIT NO.

MM10

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north-eastern "no spoil dump"**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	RW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 669377 N 7474460 MGA***

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
F G W E			D			**TOPSOIL (Sandy LOAM):** fine to medium grained sand, grey, thin platy peds	D			TOPSOIL, surface crust A_1
	0.45		D		CH	**Sandy CLAY:** medium to high plasticity, grey-brown and orange with black mottling, trace black rounded gravel size ferruginous nodules, fine grained sand, small blocky peds	MC<PL			TERTIARY $B_{21\ c}$
	0.60				CH	**Silty CLAY:** medium to high plasticity, grey and brown-orange with black mottling, trace calcareous concretions, fissured				$B_{22\ s/h\ k}$
	1									
	1.50		D		CH	**Silty CLAY:** medium plasticity, grey, black, white and orange, massive, fissured with polished surfaces				C
						END OF TEST PIT AT 1.80 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	2									
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM11

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, north-east**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 668874 N 7475078 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E			D			**TOPSOIL (SAND with Clay):** fine grained, pale grey, small blocky peds	D			TOPSOIL A_1
						... 0.15 m: colour change to grey, granular				A_2
	0.30		D		SP	**SAND:** fine grained, pale brown, apedal, granular	M			TERTIARY B_{21}
	0.70				CH	**Sandy CLAY:** medium to high plasticity, grey and orange-brown, trace fine grained sand, sub-rounded, fine grained gravel size ferruginous nodules	MC<PL			$B_{22\,k}$
			D							
	1					... 1.0 m: colour change to grey with orange and red mottling				B_{23}
						... 1.8 m: colour change to grey with white and red mottling				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM12

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Flat to gently undulating terrain, east of Thirteen Mile Gully, north**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 667830 N 7473884 MGA***

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0		D			**TOPSOIL (Sandy LOAM):** fine grained sand, pale brown, poorly developed blocky peds	M			TOPSOIL A_1
	0.40		D		CL	**CLAY with Sand:** low to medium plasticity, brown with black mottling, fine grained sand, small prismatic peds, fissured with polished surfaces	MC<PL			ALLUVIUM/TERTIARY(?) $B_{21\ s/h}$
	0.70		D		CL	**Sandy CLAY:** low to medium pasticity, brown with black mottling, calcareous concretions, fissured with poliched surfaces				$B_{22\ k\ s}$
	1									
	1.70				CL	**Silty CLAY:** medium plasticity, grey				C
	2					END OF TEST PIT AT 2.00 m				Limit of Investigation * Horizontal survey determined using hand held GPS
	3									

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

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TEST PIT ENVIRONMENTAL LOG

TEST PIT NO.

MM13

SHEET 1 OF 1

Client:	**Middlemount Coal Pty Ltd**	Date Commenced:	**11/5/10**
Project:	**Middlemount Coal EIS**	Date Completed:	**11/5/10**
Test Pit Location:	**Gently undulating terrain, bottom of raw water dam spillway**	Recorded By:	**RB**
Project Number:	**2117076B**	Log Checked By:	KW
Excavation Method:	**Komatsu 20 tonne excavator**	Surface RL:	
		Co-ords:	**E 667702 N 7469430 MGA***

Test Pit Information				Field Material Description							
1	2	3	4	5	6	7	8	9	10	11	
WATER	RL(m) / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS	
N F G W E	0.20		D			**TOPSOIL (Sandy LOAM):** fine grained sand, low plasticity fines, pale brown, irregular blocky peds, grass rootlets	D			TOPSOIL (Patchy Gravel Armour) Surface cracks A_1	
			D			**TOPSOIL (Sandy CLAY):** medium plasticity, pale brown, platy peds, appears poorly cemented, fine grained sand ... 0.3 m: with medium gravel size, rounded, ferruginous nodules	MC<PL			A_2 B_{21c}	
	0.40				CH	**CLAY with Sand:** medium to high plasticity, brown with red and orange mottling, fine grained sand				TERTIARY B_{22}	
	1		D			... 1.1 m: colour change to grey with red and orange mottling				B_{23}	
			D								
	2					END OF TEST PIT AT 1.70 m				Limit of Investigation * Horizontal survey determined using hand held GPS	
	3										

This test pit 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	PB Borehole No.:		Date Commenced:	06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	
Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 667796 N 7475130 MGA94 Zone 55
		TOC (RL):	175 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD / DEPTH(m)	6 FIELD TEST	7 SAMPLE
RB			Monument cover with PVC cap, Cement 0 to 6.5m bgl (below ground level) 80mm ID, Class 18 uPVC casing, 0 to 165m bgl Backfill, 6.5 to 160.5m bgl	172 (2.00) 2; (3.00); 170 4; 168 (6.00) 6; 166 8; 164 (10.00) 10; 162 12; 160 14; (15.00); 158 16; (17.00); 156 18; (19.00); 154 20; 152 22; (23.00); 150 (24.00) 24; 148 (26.00) 26; (27.00); 146 (28.00) 28; (29.00); 144 30; 142 32; 140 (34.00) 34; 138 36; 136 38; 134 (40.00) 40; (41.00); 132 42; (43.00); 130 (44.00) 44; (45.00); 128 (46.00) 46; 126 (48.00) 48		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, moist, firm.	M		200mm Diameter, 0 to 52m bgl
	CL	**CLAY:** grey and red, moist, firm.			
	CL/SP	**CLAY:** grey and red, moist, firm and **SAND:** fine grained, brown.			
		SANDSTONE very fine grained, brown, extremely weathered, moist.			
		distinctly weathered.			
		SILTSTONE: yellow-brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, brown, distinctly weathered, moist.			
		CLAYSTONE: grey and red, distinctly weathered, moist.			
		Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.			
		SANDSTONE: fine grained, brown, distinctly weathered.			
		Sandy CLAYSTONE: brown, distinctly weathered, very fine grained sand.			
		SANDSTONE: fine grained, yellow, extremely weathered, moist.			
		Clayey SANDSTONE: fine grained, yellow, extremely weathered, moist.			
		Silty CLAYSTONE: grey and brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, red-brown, distinctly weathered, moist.			
		SILTSTONE: red-brown, distinctly weathered, moist.			
		SANDSTONE: fine grained, red-brown, distinctly weathered, moist.			
		grey			
		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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW5P

SHEET 2 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RB / RAB				122	52		
				52.00			
				120	54		
				55.00			
				118	56		
				57.00			
				116	58		
				116.00			
				114	60		
				112	62		
				112.00			
				63.00			
				110	64		
				108	66		
				106	68		
				69.00			
				104	70		
				102	72		
				73.00			
				100	74		
				74.00			
				98	76		
				96	78		
				78.00			
				94	80		
				80.00			
				92	82		
				90	84		
				84.00			
				88	86		
				87.00			
				86	88		
				88.00			
				84	90		
				90.00			
				82	92		
				80	94		
				78	96		
				96.00			
				76	98		
				98.00			
				99.00			

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SILTSTONE: grey, slightly weathered, dry. *(continued)*	D		
		SANDSTONE: fine grained, grey, slightly weathered, dry.			140mm Diameter, 52 to 174m bgl
		SILTSTONE: grey, slightly weathered, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: very fine grained, grey, fresh, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, dry.			
		SILTSTONE: grey, fresh, dry.			
		SANDSTONE: fine grained, grey, fresh, dry.			
		slightly weathered, wet.	W		
		fresh, wet.			
		SILTSTONE: grey, fresh, wet.			
		SANDSTONE: fine grained, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			

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 3 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RAB				101.00			
				72	102		
				70	104		
				105.00			
				68	106		
				66	108		
				64	110		
				62	112		
				113.00			
				60	114		
				58	116		
				56	118		
				54	120		
				52	122		
				50	124		
				125.00			
				48	126		
				127.00			
				46	128		
				44	130		
				131.00			
				42	132		
				133.00			
				40	134		
				38	136		
				36	138		
				34	140		
				32	142		
				30	144		
				28	146		
				26	148		
				149.00			

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB S F VL L ST MD VST D H VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: fine grained, grey, fresh, wet. *(continued)*	W		
		SILTSTONE: dark grey, fresh, wet.			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: fine grained, grey, fresh, wet.			
		fine grained.			
		SILTSTONE: dark grey, fresh, wet.			
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		SILTY COAL: black, fresh, wet, (Middlemount Seam).			Airlift yield: 0.12 L/S
		COAL: black, fresh, wet.			
		SILTSTONE: dark grey, fresh.			Airlift yield: 0.14 L/S
		SANDSTONE: fine grained, grey, fresh, wet.			Airlift yield: 0.14 L/S
		SILTSTONE: black, fresh, wet.			

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 4 OF 4

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 06.07.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 24.07.2010
Borehole Location:	MW5P - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller: S Baker	Surface RL: 174 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No: 3046	Co-ords: E 667796 N 7475130 MGA94 Zone 55
		TOC (RL): 175 m AHD	Local Co-ords:

Borehole Information

Field Material Description

1	2	3	4	5		6	7	8	9	10	11	12	13
METHOD	SUPPORT	WATER	WELL CONSTRUCTION TOC 1 m	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY VS S F ST VST H FB VL L MD D VD	STRUCTURE AND ADDITIONAL OBSERVATIONS
RAB			Bentonite, 160.5 to 164m bgl 3mm Filter gravel, 164 to 169m bgl 80mm ID, Class 18 uPVC, 0.5mm Slotted screen from 165 to 168m bgl, 1m uPVC sump Bentonite, 169 to 171m bgl Backfill, 171 to 174m bgl	22 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -12 -14 -16 -18 -20 -22 -24	152 154 156 158 160 162 164 166 168 170 172 174 176 178 180 182 184 186 188 190 192 194 196 198					**SILTSTONE:** black, fresh, wet. *(continued)* **SANDSTONE:** fine grained, dark grey, fresh, wet. **CLAYSTONE:** black, fresh, carbonaceous, wet. **COAL:** black, fresh, wet, (Pisces Seam). **SILTSTONE:** dark grey, fresh, carbonaceous, wet. **SANDSTONE:** very fine grained, grey, fresh, wet. fine grained. END OF BOREHOLE AT 174.00 m	W		Airlift yield: 0.29 L/S Airlift yield: 0.31 L/S Airlift yield: 0.34 L/S

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9A

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:	IRTH 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 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB S VL F L ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB			Monument cover with PVC cap, Cement 0 to 6.5m bgl (below ground level) 50mm ID, Class 12 uPVC casing, 0 to 40m bgl						CL	**Silty CLAY:** brown, dry, firm.	D		143mm Diameter, 0 to 52m bgl
				154 2.00	2					moist.	M		
				3.00					CL	**CLAY:** brown	D		
				152	4								
				5.00					SC	**Clayey SAND:** fine grained, pale brown, moist.	M		
				150 6.00	6				SP	**SAND:** fine grained, pale brown, dry.	D		
			Backfill, 6.5 to 31m bgl	7.00					SC	with clay, moist.	M		
				148 8.00	8				CL	**CLAY:** pale grey, moist, firm and **Sandy CLAY:** brown, fine grained sand, moist.			
				9.00					SC	**Clayey SAND:** fine to medium grained, grey and orange, moist.			
				146	10								
				11.00					CL/ ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
				144	12								
				13.00					CL	**CLAY:** grey, orange and pink, firm, trace very fine grained pink sand, moist.			
				142	14								
				140 16.00	16				CL/ ML	**Clay:** pale 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								
			Bentonite, 31 to 34m bgl	124 32.00	32				ML/ CL	**SAND:** very fine grained, yellow, moist and **CLAY:** yellow brown, moist, firm.			
				33.00					CL	**CLAY:** brown, with pale brown silt, moist, firm.			
			3mm Filter gravel, 34 to 52m bgl	122 34.00	34				ML	**SILT:** yellow, with firm grey clay, moist.			
				120 36.00	36					**SANDSTONE:** very fine grained, yellow brown, extremely weathered, moist.			
				118	38								
			50mm ID, Class 12 uPVC, 0.5mm Slotted screen from 40 to 52m bgl	116	40								
				114	42								
				112 44.00	44					grey, distinctly weathered, moist.			
				110	46								
				108 46.00	48					**SILTSTONE:** dark grey, slightly weathered, moist.			

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

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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:	IRTH 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

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
RB				104	52		
				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		

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
		SILTSTONE: dark grey, slightly weathered, moist. *(continued)*	M		Airlift yield: 0.01 L/S
		END OF BOREHOLE AT 52.00 m			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 1 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1	2	3	4	5		6	7
METHOD	SUPPORT	WATER	WELL CONSTRUCTION (TOC 1 m)	RL(m) AHD	DEPTH(m)	FIELD TEST	SAMPLE
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	154 152 150 148 146 144 142 140 138 136 134 132 130 128 126 124 122 120 118 116 114 112 110 108	2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48		

Field Material Description

8	9	10	11	12	13
GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	CL	**Silty CLAY:** brown, dry, firm.	D		200mm Diameter, 0 to 51m bgl
	SL	**CLAY:** brown, dry, firm.			
	SC	**Clayey SAND:** medium grained, brown, moist.	M		
	CL/SC	**CLAY:** grey, moist, firm and **Sandy CLAY:** brown, fine grained sand, moist.			
	SC	**Clayey SAND:** fine to medium grained, grey and orange, moist.			
	CL/ML	**CLAY:** grey, moist, firm and **Clayey SAND:** fine grained, orange, moist.			
	CL	**CLAY:** pale grey, orange and pink, moist, firm, trace very fine grained pink sand.			
	CL/ML	**CLAY:** grey, pink and orange, moist, firm and **SAND:** very fine grained, pink, moist.			
	CL	**CLAY:** brown, moist, firm.			
	ML	**SILT:** yellow-brown, with firm grey clay, moist.			
		SANDSTONE: very fine grained, yellow-brown, extremely weathered, moist.			
		red, distinctly weathered.			
		CLAYSTONE: brown and orange, distinctly weathered, moist.			
		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.

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

Client:	MACARTHUR COAL	PB Borehole No.:		Date Commenced:	30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT			Date Completed:	27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE			Recorded By:	Malcolm Graham
Project Number:	2117076B			Log Checked By:	

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information | **Field Material Description**

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE	8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB S VL F L ST MD VST D H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
RB				50.00						**CLAYSTONE:** grey, distinctly weathered, moist.	M		140mm Diameter, 51 to 144m bgl
RAB				104	52								
				53.00						**SANDSTONE:** very fine grained, grey, fresh, dry.	D		
				102	54								
				100	56								
				57.00						**CLAYSTONE:** dark grey, fresh, dry.			
				98 58.00	58					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				96	60								
				94	62								
				92 64.00	64					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				90 66.00	66					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				88	68								
				86 70.00	70					**SANDSTONE:** very fine grained, dark grey, fresh, carbonaceous, dry.			
				71.00						**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				84	72								
				73.00						**CLAYSTONE:** dark grey, distinctly weathered, carbonaceous, dry.			
				82 74.00	74					**SILTSTONE:** dark grey, fresh, carbonaceous, dry.			
				80	76								
				77.00						extremely weathered, clayey, wet.	W		
				78 78.00	78					slightly weathered, clayey, wet.			
				76	80								
				74	82								
				72	84								
				70	86								
				87.00						**SANDSTONE:** very fine grained, dark grey, fresh, wet.			
				68 88.00	88					fine grained.			
				66	90								
				64	92								
				62	94								
				60 96.00	96					very fine grained.			
				97.00						**SILTSTONE:** dark grey, fresh, wet.			
				58 98.00	98					**SANDSTONE:** very fine grained, dark grey, fresh, wet.			

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

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GROUNDWATER BOREHOLE LOG

BOREHOLE NO.

MW9M

SHEET 3 OF 3

Client:	MACARTHUR COAL	PB Borehole No.:	Date Commenced: 30.06.2010
Project:	MIDDLEMOUNT COAL PROJECT		Date Completed: 27.07.2010
Borehole Location:	MW9M - MIDDLEMOUNT MINE		Recorded By: Malcolm Graham
Project Number:	2117076B		Log Checked By:

Drill Model/Mounting:	IRTH 60	Driller:	S Baker	Surface RL:	156 m AHD
Borehole Diameter:	200mm to 140mm	Driller Lic No:	3046	Co-ords:	E 670244 N 7469619 MGA94 Zone 55
		TOC (RL):	157 m AHD	Local Co-ords:	

Borehole Information

1 METHOD	2 SUPPORT	3 WATER	4 WELL CONSTRUCTION (TOC 1 m)	5 RL(m) AHD	5 DEPTH(m)	6 FIELD TEST	7 SAMPLE
RAB			Bentonite, 129 to 134m bgl 3mm Filter gravel, 134 to 139.5m bgl 80mm ID, Class 12 uPVC, 0.5mm Slotted screen from 135 to 138m bgl, 1.5m uPVC sump Bentonite, 139.5 to 142m bgl Backfill, 142 to 144m bgl	54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8	102.00 104 105.00 106.00 106 107.00 108.00 108 109.00 110 112 114 116.00 116 118 119.00 120.00 120 121.00 122 124 126 128 130 132 133.00 134.00 134 136 138.00 138 140.00 140 142 144 146 148		

Field Material Description

8 GRAPHIC LOG	9 USC SYMBOL	10 SOIL/ROCK MATERIAL FIELD DESCRIPTION	11 MOISTURE	12 RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	13 STRUCTURE AND ADDITIONAL OBSERVATIONS
		SANDSTONE: very fine grained, dark grey, fresh, wet. *(continued)*	W		
		SILTSTONE: dark grey, fresh, wet.			
		SANDSTONE: very fine grained, dark grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, wet.			
		SHALE: black, fresh, carbonaceous, wet.			
		STONY COAL: fresh, carbonaceous, wet, (Roper Seam).			
		SANDSTONE: fine to medium grained, pale grey, fresh, bands of carbonaceous, claystone and quartz veins, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			
		SILTSTONE: dark grey, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet and **SILTSTONE:** dark grey, fresh, carbonaceous, wet.			Airlift yield: 0.014 L/S
		CLAYSTONE: black, fresh, carbonaceous, wet.			
		COAL: black, fresh, wet, (Middlemount Seam)			
		SILTSTONE: black, fresh, carbonaceous, wet.			
		SANDSTONE: very fine grained, grey, fresh, wet.			Airlift yield: 0.017 L/S
		END OF BOREHOLE AT 144.00 m			

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

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Explanatory Notes - Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$\text{TCR (\%)} = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$\text{RQD (\%)} = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

CLAY

SILT

SAND

GRAVEL

BOULDERS / COBBLES

PEAT (Organic)

Minor Components

Clayey

Silty

Sandy

Gravelly

Other Symbols

TOPSOIL

FILL

ASPHALT

CONCRETE

NO CORE

Rock Symbols

Sedimentary Rocks

SANDSTONE

SILTSTONE

CLAYSTONE, MUDSTONE

SHALE

LAMINITE

CONGLOMERATE

BRECCIA

TILL

COAL

LIMESTONE

Igneous Rocks

PLUTONIC IGNEOUS (eg: Granite)

VOLCANIC IGNEOUS (eg: Basalt)

PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks

SLATE, PHYLLITE, SCHIST

GNEISS

QUARTZITE

List of abbreviations used in bore logs

D	Dry
ID	Internal Diameter
L/s	Litres per second
M	Moist
mAHD	metres Australian Height Datum
mBGL	metres Below Ground Level
MGA94	Map Grid of Australia 1994
RAB	Rotary Air Blast
RB	Rotary Blade
RL	Reduced Level (height relative to given datum)
TOC	Top Of Casing
W	Wet

Attachment B

Laboratory test results

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1009101**	Page	: 1 of 9
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR R BARLOW	Contact	: Greg Vogel
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 07 3854 6456	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 38314223	Facsimile	: +61-7-3243 7218
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 20-MAY-2010
Sampler	: Rhys Barlow	Issue Date	: 04-JUN-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 25
Quote number	: EN/008/10	No. of samples analysed	: 25

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Myles.Clark	Acid Sulfate Soils Supervisor	Bne Acid Sulphate Soils
Myles.Clark	Acid Sulfate Soils Supervisor	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics

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 insuffient 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 date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

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

- **EG005T (Total Metals): Sample EB1009029-001 shows poor duplicate results for Zinc due to sample heterogeneity. Confirmed by visual inspection.**
- **EK067G (Total Phosphorus): Sample MM10 0.0-0.1 shows poor matrix spike recovery due to matrix interference. Confirmed by visual inspection.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	Trial Pit- Weathered Tertiary	Trial Pit-Fresh Tertiary	Trial Pit-Fresh Permian	MM01 5.9-6.0	MM01 0.0-0.1
				Client sampling date / time	11-MAY-2010 11:00	11-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00
					EB1009101-001	EB1009101-002	EB1009101-003	EB1009101-004	EB1009101-005
EA002 : pH (Soils)									
pH Value	---	0.1	pH Unit		8.7	7.6	7.6	8.2	6.3
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	---	0.5	kg H2SO4/t		-3.5	0.8	0.7	-4.9	---
EA010: Conductivity									
Electrical Conductivity @ 25°C	---	1	µS/cm		334	2080	2440	202	22
EA011: Net Acid Generation									
pH (OX)	---	0.1	pH Unit		5.9	6.0	6.2	6.1	---
NAG (pH 4.5)	---	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	---
NAG (pH 7.0)	---	0.1	kg H2SO4/t		1.9	1.6	0.9	1.1	---
EA013: Acid Neutralising Capacity									
ANC as H2SO4	---	0.5	kg H2SO4 equiv./t		4.0	<0.5	<0.5	4.9	---
^ ANC as CaCO3	---	0.1	% CaCO3		0.4	<0.1	<0.1	0.5	---
Fizz Rating	---	0	Fizz Unit		0	0	0	0	---
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	---	1.0	%		2.3	---	---	3.8	5.9
ED007: Exchangeable Cations									
^ Exchangeable Calcium	---	0.1	meq/100g		---	---	---	---	7.9
^ Exchangeable Magnesium	---	0.1	meq/100g		---	---	---	---	6.8
^ Exchangeable Potassium	---	0.1	meq/100g		---	---	---	---	0.6
^ Exchangeable Sodium	---	0.1	meq/100g		---	---	---	---	4.5
^ Cation Exchange Capacity	---	0.1	meq/100g		---	---	---	---	19.8
^ Exchangeable Sodium Percent	---	0.1	%		---	---	---	---	22.6
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		---	---	---	---	130
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	---	0.01	%		0.02	0.03	0.02	<0.01	---
ED045: Chloride									
Chloride	16887-00-6	10	mg/kg		---	---	---	---	220
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		6	---	---	<5	---
Cadmium	7440-43-9	1	mg/kg		<1	---	---	<1	---
Chromium	7440-47-3	2	mg/kg		18	---	---	6	---
Copper	7440-50-8	5	mg/kg		9	---	---	<5	---

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: Trial Pit- Weathered Tertiary	Trial Pit-Fresh Permian (Ferruginised)	Trial Pit-Fresh Permian	MM01 5.9-6.0	MM01 0.0-0.1
			Client sampling date / time	11-MAY-2010 11:00	11-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00	13-MAY-2010 11:00
				EB1009101-001	EB1009101-002	EB1009101-003	EB1009101-004	EB1009101-005
EG005T: Total Metals by ICP-AES - Continued								
Lead	7439-92-1	5	mg/kg	**10**	----	----	<5	----
Nickel	7440-02-0	2	mg/kg	**18**	----	----	**7**	----
Zinc	7440-66-6	5	mg/kg	**34**	----	----	**12**	----
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	----	----	----	----	<0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	----	----	----	----	**460**
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	----	----	----	----	**460**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	----	----	----	----	**280**
EP004: Organic Matter								
Organic Matter	----	0.5	%	----	----	----	----	**1.3**
^ Total Organic Carbon	----	0.5	%	----	----	----	----	**0.8**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM01 0.1-0.2	MM02 0.0-0.1	MM02 0.15-0.25	MM03 0.0-0.1	MM04 0.15-0.25
Client sampling date / time				13-MAY-2010 11:00	12-MAY-2010 15:00	12-MAY-2010 15:00	11-MAY-2010 15:00	12-MAY-2010 15:00
				EB1009101-006	EB1009101-007	EB1009101-008	EB1009101-009	EB1009101-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.7	6.8	7.2	6.0	7.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	38	75	44	25	23
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	5.3	5.7	7.4	6.1	6.9
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	4.3	8.6	6.6	4.4	12.6
^ Exchangeable Magnesium	----	0.1	meq/100g	2.7	1.7	1.8	1.6	4.6
^ Exchangeable Potassium	----	0.1	meq/100g	1.2	1.4	1.4	1.5	1.3
^ Exchangeable Sodium	----	0.1	meq/100g	0.3	0.2	0.2	0.2	0.2
^ Cation Exchange Capacity	----	0.1	meq/100g	8.5	11.8	10.0	7.6	18.7
^ Exchangeable Sodium Percent	----	0.1	%	3.5	1.4	2.0	2.2	1.0
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	120	200	150	150	190
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	270	130	130	220	220
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	5.7	0.6	0.1	0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	520	1350	550	650	860
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	520	1360	550	650	860
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	289	315	285	262	537
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.4	3.1	1.4	1.9	2.4
^ Total Organic Carbon	----	0.5	%	0.8	1.8	0.8	1.1	1.4

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM06 0.0-0.1	MM07 0.0-0.1	MM07 0.2-0.3	MM11 0.0-0.1	MM08 0.2-0.3
Client sampling date / time				12-MAY-2010 15:00	12-MAY-2010 11:00	12-MAY-2010 11:00	11-MAY-2010 11:00	12-MAY-2010 11:00
				EB1009101-011	EB1009101-012	EB1009101-013	EB1009101-014	EB1009101-015
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.7	6.7	6.6	6.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	20	17	8	14	3
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	1.8	2.9	3.6	2.6	2.1
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.6	3.0	1.3	1.8	0.8
^ Exchangeable Magnesium	----	0.1	meq/100g	0.7	0.6	0.3	0.4	0.6
^ Exchangeable Potassium	----	0.1	meq/100g	0.5	0.4	0.2	0.3	0.3
^ Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	2.9	4.2	1.8	2.5	1.7
^ Exchangeable Sodium Percent	----	0.1	%	1.6	2.0	1.5	1.1	2.1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	<100	<100	<100	<100
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	50	50	20	20	<10
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.7	1.2	0.2	1.5	<0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	310	220	110	250	100
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	310	220	110	250	100
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	122	139	73	54	62
EP004: Organic Matter								
Organic Matter	----	0.5	%	0.9	0.5	<0.5	1.0	0.9
^ Total Organic Carbon	----	0.5	%	0.5	<0.5	<0.5	0.6	0.5

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM09 0.0-0.1	MM12 0.15-0.25	MM10 0.0-0.1	MM13 0.0-0.1	MM13 0.2-0.3
				Client sampling date / time: 11-MAY-2010 15:00	11-MAY-2010 15:00	11-MAY-2010 15:00	11-MAY-2010 11:00	11-MAY-2010 11:00
				EB1009101-016	EB1009101-017	EB1009101-018	EB1009101-019	EB1009101-020
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	6.7	5.9	5.4	5.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	8	8	9	20
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	1.7	3.3	1.4	2.1	5.2
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.4	1.9	1.6	1.4	1.4
^ Exchangeable Magnesium	----	0.1	meq/100g	0.4	1.0	0.5	1.8	2.4
^ Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.2	0.3	0.1
^ Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.1	0.2
^ Cation Exchange Capacity	----	0.1	meq/100g	2.1	3.4	2.4	3.6	4.1
^ Exchangeable Sodium Percent	----	0.1	%	2.3	1.9	1.4	4.1	5.6
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	<100	<100	<100	120
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	20	50	50	100	130
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	<0.1	<0.1	0.3	0.1
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	190	170	180	350	940
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	190	170	180	350	940
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	58	78	127	163	135
EP004: Organic Matter								
Organic Matter	----	0.5	%	0.5	0.5	<0.5	0.9	0.9
^ Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	0.5	0.5

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MM06 0.45-0.55	MM02 0.7-0.8	MM12 0.4-0.5	MM01 0.32-0.4	MM08 0.0-0.1
Client sampling date / time				12-MAY-2010 15:00	12-MAY-2010 15:00	11-MAY-2010 15:00	13-MAY-2010 11:00	13-MAY-2010 11:00
				EB1009101-021	EB1009101-022	EB1009101-023	EB1009101-024	EB1009101-025
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.7	6.9	8.6	6.4	6.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	422	37	243	113	20
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	10.2	12.2	9.4	11.7	2.1
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	8.7	11.1	11.6	3.7	2.8
^ Exchangeable Magnesium	----	0.1	meq/100g	5.8	3.6	6.6	4.5	0.6
^ Exchangeable Potassium	----	0.1	meq/100g	0.3	1.2	0.6	0.5	0.3
^ Exchangeable Sodium	----	0.1	meq/100g	3.3	0.2	1.9	2.6	<0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	18.2	16.2	20.7	11.2	3.7
^ Exchangeable Sodium Percent	----	0.1	%	18.0	1.4	9.0	22.8	0.6
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	200	160	120	110	<100
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	560	290	250	490	130
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	0.2	0.7	0.5	1.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	140	490	180	530	340
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	140	490	180	530	340
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	89	302	116	216	87
EP004: Organic Matter								
Organic Matter	----	0.5	%	<0.5	1.0	<0.5	0.9	0.9
^ Total Organic Carbon	----	0.5	%	<0.5	0.6	<0.5	0.5	0.5

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1013621**	Page	: 1 of 4
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR RHYS BARLOW	Contact	: Greg Vogel
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: brisbane.enviro.services@alsglobal.com
Telephone	: +61 07 3854 6456	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 38314223	Facsimile	: +61 7 3243 7218
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 03-AUG-2010
Sampler	: Rhys Barlow	Issue Date	: 10-AUG-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 6
Quote number	: EN/008/10	No. of samples analysed	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Myles.Clark	Acid Sulfate Soils Supervisor	Bne Acid Sulphate Soils
Stephen Hislop	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Stafford Minerals - AY

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 insuffient 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 date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

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

- **ANC Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong.**
- **EG005T (Total Metals): Sample EB1013524-026 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MW9A 19.0-20.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-001	Client sample ID: MW9A 40.0-41.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-002	Client sample ID: MW9A 49.0-50.0m Client sampling date / time: 05-JUL-2010 15:00 EB1013621-003	Client sample ID: MW9M 69.0-70.0m Client sampling date / time: 30-JUN-2010 15:00 EB1013621-004	Client sample ID: MW5P 18.0-19.0m Client sampling date / time: 06-JUL-2010 15:00 EB1013621-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.2**	**8.4**	**9.7**	**10.0**	**9.6**
EA009: Nett Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	**-6.8**	**-14.4**	**-52.2**	**-122**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**878**	**537**	**610**	**523**	**567**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**6.0**	**5.6**	**7.3**	**10.7**	**9.1**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**2.9**	**1.9**	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**2.2**	**7.6**	**14.9**	**53.6**	**122**
^ ANC as CaCO3	----	0.1	% CaCO3	**0.2**	**0.8**	**1.5**	**5.5**	**12.4**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**2**	**2**
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	**11.3**	----	**6.5**	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.06**	**0.03**	**0.02**	**0.04**	<0.01
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**7**	----	<5	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	<1	----	----
Chromium	7440-47-3	2	mg/kg	**42**	----	**21**	----	----
Copper	7440-50-8	5	mg/kg	**17**	----	**45**	----	----
Lead	7439-92-1	5	mg/kg	<5	----	**10**	----	----
Nickel	7440-02-0	2	mg/kg	**19**	----	**42**	----	----
Zinc	7440-66-6	5	mg/kg	**23**	----	**78**	----	----

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: MW5P 78.0-79.0m	----	----	----	----
				Client sampling date / time: 06-JUL-2010 15:00	----	----	----	----
				EB1013621-006	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**9.8**	----	----	----	----
EA009: Nett Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	**-28.2**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**331**	----	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**9.2**	----	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**28.7**	----	----	----	----
^ ANC as CaCO3	----	0.1	% CaCO3	**2.9**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**2**	----	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	**3.3**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.02**	----	----	----	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**25**	----	----	----	----
Copper	7440-50-8	5	mg/kg	**47**	----	----	----	----
Lead	7439-92-1	5	mg/kg	**13**	----	----	----	----
Nickel	7440-02-0	2	mg/kg	**37**	----	----	----	----
Zinc	7440-66-6	5	mg/kg	**81**	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1015092**	Page	: 1 of 3
Client	: **PARSONS BRINCKERHOFF AUST P/L (QLD)**	Laboratory	: Environmental Division Brisbane
Contact	: MR RHYS BARLOW	Contact	: Bryn Stephens
Address	: GPO BOX 2907 BRISBANE QLD, AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: rbarlow@pb.com.au	E-mail	: Bryn.Stephens@alsglobal.com
Telephone	: +61 07 3854 6456	Telephone	: +617 3243 7125
Facsimile	: +61 07 38314223	Facsimile	: +617 3243 7181
Project	: 2117076B	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 7490		
C-O-C number	: ----	Date Samples Received	: 20-AUG-2010
Sampler	: R.Barlow	Issue Date	: 01-SEP-2010
Site	: Middlemount Coal Mine		
		No. of samples received	: 5
Quote number	: EN/008/10	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Nikki Stepniewski	Non-metallic Supervisor	Inorganics

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.

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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 date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

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

- **EG048: EB1015092 #2 matrix spike failed for Total Hexavalent Chromium by Alkaline Digestion due to possible sample matrix interference. This has been confirmed by re-digestion and re-analysis.**

Analytical Results

Sub-Matrix: SOIL	Client sample ID	MW9A 19.0-20.0	MW9A 49.0-50.0	MW5P 78.0-79.0	Trial Pit Weathered Tertiary (~10m)	MM01 5.9-6.0
	Client sampling date / time	05-JUL-2010 15:00	05-JUL-2010 15:00	06-JUL-2010 15:00	13-MAY-2010 15:00	13-MAY-2010 15:00
Compound / CAS Number / LOR / Unit		EB1015092-001	EB1015092-002	EB1015092-003	EB1015092-004	EB1015092-005
EA055: Moisture Content						
^ Moisture Content (dried @ 103°C) ---- 1.0 %		11.3	5.8	4.5	1.8	3.2
EG005T: Total Metals by ICP-AES						
Chromium 7440-47-3 2 mg/kg		38	16	16	13	5
EG048: Hexavalent Chromium (Alkaline Digest)						
Hexavalent Chromium 18540-29-9 0.5 mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
EG049: Trivalent Chromium						
^ Trivalent Chromium 16065-83-1 2 mg/kg		38	16	16	13	5

Attachment C

Land suitability assessment criteria

Attachment C – Land suitability criteria

Table D.1 Suitability criteria for rainfed broadacre cropping

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >150 mm	PAWC 125-150 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC <75 mm
Nutrient deficiency	Bicarbonate P >10 ppm	Bicarbonate P 5-10 ppm and Exchangeable K >0.3 meq. %	Bicarbonate P 5-10 ppm and Exchangeable K ≤0.3 meq. % or pH <5 60-90 cm below surface or pH >9 60-90 cm below surface	Bicarbonate P <10 ppm and Exchangeable K ≤0.3 meq. %, and Exchangeable Ca <3 meq.%, or pH <5 30-60 cm below surface, or pH >9 30-60 cm below surface	pH <5 within 30 cm of surface or pH >9 within 30 cm of surface
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm)	Cracking clays with coarse self-mulch (peds 10-20 mm) or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds at the surface (≥20 mm)	
Soil workability	Friable cracking clays (indicated by very fine self-mulch), or Rigid soils with a loose, soft or firm surface when dry	Firm cracking clays (indicated by fine self-mulch) or Rigid soils with a hard setting surface when dry	Stiff cracking clays (indicated by coarse self-mulch with peds>10 mm, crusting or hard setting surface)		
Salinity	Rootzone EC <0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15 -0.3 mS/cm or Rootzone Cl 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm, or Rootzone Cl 900-1,500 ppm	Rootzone EC >1.2 mS/cm or Rootzone Cl ≥1,500 ppm
Rockiness	<10% coarse surface gravel (>6 cm diameter) and rock outcrop	10-20% coarse surface gravel and rock outcrop	20-50% surface cobble (6-20 cm diameter) and rock outcrop	50-90% surface cobble and rock outcrop, or 20-50% stone and boulders (>20 cm diameter)	>90% surface cobble and rock outcrop, or >50% stone and boulders and rock outcrop
Microrelief	No melonholes (semi-circular depressions <30 cm deep and usually	Melonholes 30-60 cm deep cover <20% surface area or	Melonholes 30-60 cm deep cover 20-50% of surface area or	Melonholes 60-100 cm deep cover 50% surface area	Melonholes at least 100 cm deep cover 50% surface area

Limitation	Land suitability class				
	1	**2**	**3**	**4**	**5**
	surrounded by mounds)	Melonholes >60 cm deep cover <10% surface area	Melonholes >60 cm deep cover 10-20% surface area		
Wetness	Undulating terrain or elevated plains	Low-lying level plains with melonholes covering <25% surface area, or Rigid soils with sodic subsoil (ESP 6-14) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 75 cm of the surface	Low-lying level plains with melonholes covering 25-50% surface area, or Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface	Seasonal swamps and lowlying run-on areas	Permanent swamps and lakes
Topography	No gully dissection	Occasional deep gullies impede cultivation slightly	Many deep gullies reduce arable area by <33% or require major changes to cultivation practices	Many deep gullies make the arable areas too small to cultivate	Abundant deep gullies prevent any practical cultivation
Water erosion	Slopes <0.5% on cracking clays without melonholes, or Slopes <1% on melonhole clays, or Slopes <1% on nonsodic rigid soils, or Slopes <0.5% on sodic rigid soils	Slopes 0.5-1% on cracking clays without melonholes or Slopes 1-3% on melonhole clays, or Slopes 1-2% on non-sodic rigid soils, or Slopes 0.5-1% on sodic rigid soils	Slopes 1-3% on cracking clays without melonholes or Slopes 2-4% on non-sodic rigid soils or Slopes 1-2% on sodic rigid soils	Slopes 3-5% on all cracking clays or Slopes 4-6% on non-sodic rigid soils or Slopes 2-3% on sodic rigid soils	Slopes >5% on all cracking clays or Slopes >6% on nonsodic rigid soils or Slopes >3% on sodic rigid soils
Flooding	No flooding	Rare flooding (only during abnormal 1 in 50 to 100 year events)	Infrequent flooding (inundation occurs <half the times that stream flow increases)	Occasional flooding (inundation occurs ≥half the times that stream flow increases)	Regular flooding (inundation occurs whenever stream flow increases)

Table D.2 Suitability criteria for beef cattle grazing

Limitation	Land suitability class				
	1	2	3	4	5
Water availability	PAWC >125 mm	PAWC 100-125 mm	PAWC 75-100 mm	PAWC 50-75 mm	PAWC ≤50 mm
Nutrient deficiency	Brigalow, gidgee, blackwood or softwood scrub soils and former scrub soils with Bicarbonate P >10 ppm	Eucalypt vegetation and downs with Bicarbonate P >10 ppm	Other soils with Bicarbonate P 5-10 ppm except Sands and loams at least 75 cm deep or overlying rock at shallow depth	Sands and loams at least 75 cm deep or overlying rock at shallow depth, with Bicarbonate P 5-10 ppm, or Bicarbonate P ≤4 ppm	
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), or Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm), or Rigid soils with a hard setting surface when dry	Cracking clays with coarse peds (peds ≥10 mm) or crust on the surface		
Salinity	Rootzone EC < 0.15 mS/cm or Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone Cl 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm or Rootzone Cl 900-1500 ppm	Rootzone EC >1.2 mS/cm or Rootzone Cl ≥1500 ppm
Rockiness	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	20-50% coarse surface gravel and rock outcrop	50-90% surface cobble and rock outcrop	>90% surface cobble and rock outcrop	Rock outcrop and surface coarse fragments cover total area
Microrelief	Melonholes cover <20% surface area (semi-circular depressions at least 30 cm deep and usually surrounded by mounds)	Shallow melonholes (30-60 cm deep) cover 20-50% surface area	Deep melonholes (>60 cm deep) cover 20-50% of surface area		
pH (1:5)	5.6-6.6	6.6-8.0 5.0-5.6	8.0-9.0 4.5-5.0	9.0-10.0 4.0-4.5	>10.0 < 4.0
ESP (10 cm)% Exchangable Sodium Percentage	<5.0	5-10	10-15	15-30	>30
Wetness	Undulating terrain or elevated plains	Low-lying level plains , or Rigid soils with strongly sodic subsoil	Shallow seasonal and permanent swamps		Permanent lakes and deep swamps

Limitation	Land suitability class				
	1	2	3	4	5
		(ESP≥15) within 60 cm of the surface, or Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface			
Topography				Many deep gullies make cultivation for sowing pastures impractical, or Slopes >15% make cultivation along contours impractical	Strongly dissected terrain over ≥75% of the area preventing adequate herd management
Water erosion	Slopes <1% on sodic rigid soils or Slopes <3% on all other soils	Slopes 1-3% on sodic rigid soils or Slopes 3-6% on cracking clays, or Slopes 3-12% on non-sodic rigid soils	Slopes 3-6% on sodic rigid soils or Slopes 6-9% on cracking clays, or Slopes 12-20% on nonsodic rigid soils	Slopes 6-12% on sodic rigid soils or Slopes 9-15% on cracking clays or Slopes 20-45% on non-sodic rigid soils	Slopes >45%
Flooding	No flooding	Periodic flooding (from once in 50 years to whenever stream flow increases)			
Vegetation regrowth (management limitation)	Softwood, brigalow, gidgee or blackwood scrub without melonholes , or Queensland bluegrass grasslands, or Mountain coolabah, bloodwood and ironbark open woodlands	Brigalow, gidgee or blackwood scrub with melonholes, or Box and ironbark woodlands without wattle understorey, or Coolabah woodlands on flooded country		Eucalypt woodlands with wattle understorey or Broad-leaved teatree woodlands	

Attachment D

Representative profiles of soils from Burgess (2003)

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9020

Soil Name: **Foxleigh (Fx)**

Location: 665700 mE 7473300 mN ZONE 55
Described By: Burgess, J **Date:** 18–Jun–1992

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins)
Landform Pattern: plain
Runoff: slow
Microrelief: absent
Drainage: moderately well drained
Surface Coarse Fragments: no coarse fragments
Surface Condition: firm, hard setting
Substrate Lithology: unconsolidated material (relict)
Element: hillcrest
Permeability: very slowly permeable
Microrelief Component: absent
Slope: 1 %

Classifications:

ASC: Hypercalcic, Subnatric, Brown, SODOSOL, Thick, Non Gravelly, Sandy, Clayey, Very Deep
GSG: Solodized solonetz **PPF:** Dy5.43

Vegetation:

Tallest Stratum: Tall woodland (12.01–20m)
Eucalyptus populnea (poplar box); *Acacia excelsa* (ironwood)

Mid Stratum: Low open woodland (3.01–6m)
Eremophila mitchellii (false sandalwood); *Cassia brewsteri* (Leichhardt bean, bean bush)

Lower Stratum: Low sparse tussock grassland (<0.25)
Chrysopogon fallax (golden beardgrass); *Aristida* species

Veg. Association: Poplar box (VA20) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A11	0.00 to 0.15	Dark yellowish brown (10YR34) moist colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; weak 10–20mm platy parting to massive structure; dry weak; dry when sampled; diffuse to;
A12	0.15 to 0.32	Brown (10YR43) moist colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; massive structure; dry weak; dry when sampled; clear to;
A2e	0.32 to 0.35	Brown (10YR43) moist colour, very pale brown (10YR73) dry colour; loamy sand; very few < 2% small pebbles 2–6mm subrounded ironstone and quartz coarse fragments; massive structure; dry weak; dry when sampled; abrupt to;
B21t	0.35 to 0.70	Light olive brown (2.5Y54) moist colour; common 10–20% fine < 5mm faint orange mottles; fine sandy medium clay (heavy); very few < 2% small pebbles 2–6mm rounded ironstone coarse fragments; strong 100–200mm columnar parting to weak 20–50mm angular blocky structure; few 2–10% fine <2mm manganiferous soft segregations; dry strong; diffuse to;
B22	0.70 to 1.00	Yellowish brown (10YR54) moist colour; fine sandy light medium clay; weak 10–20mm angular blocky structure; few 2–10% medium 2–6mm calcareous soft segregations, very few < 2% fine <2mm manganiferous soft segregations; dry strong; dry when sampled; clear to;
B23k	1.00 to 1.30	Yellowish brown (10YR54) moist colour; few 2–10% fine < 5mm faint grey mottles; fine sandy light medium clay; moderate 10–20mm angular blocky structure; many 20–50% coarse 6–20mm calcareous soft segregations, few 2–10% medium 2–6mm calcareous nodules; dry strong; dry when sampled; clear to;
B24	1.30 to 1.55	Brown (10YR43) moist colour; few 2–10% fine < 5mm faint orange, few 2–10% fine < 5mm faint grey mottles; fine sandy light clay; moderate 10–20mm angular blocky structure; few 2–10% medium 2–6mm calcareous soft segregations, very few < 2% medium 2–6mm calcareous nodules; moderately moist strong; moderately moist when sampled.

Effective Rooting Depth (ERD): 0.35 m (strong columnar structure)

Plant Available Water Capacity (PAWC): 40 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water pH @ 40 C	1:5 Soil/Water EC (dS/m) @ 40 C	1:5 Soil/Water Cl (mg/kg) @ 40 C	Cation Exchange Capacity/Exchangeable Cations # (meq/100g) CEC/ECEC @ 105 C	Ca	Mg	Na	K	Exchange Acidity (meq/100g) Al @ 105 C	H	Cation Dominance ESP (%)	Ca/Mg Ratio	Dispersion R1 Ratio	Particle Size (%) Coarse Sand @ 105 C	Fine Sand	Silt	Clay	Moisture (%) 15 Bar @ 105 C	Clay Mineralogy CEC/Clay% Ratio	Total Elements (%) P @ 65 C	K	S
A11	0	0.1	6.7	0.02	10	5	3.2	1.1	0.09	0.39			1.8	2.91	0.51	22	66	4	10	3	0.50	0.027	0.288	0.019
	0.1	0.2	6.5	0.01	10																			
A12	0.2	0.3	6.5	0.01	10	3	1.4	1.0	0.01	0.25			0.3	1.40	0.64	24	64	5	9	2	0.33	0.023	0.287	0.016
A2e	0.3	0.35	7	0.02	10																			
B21t	0.35	0.4	7.5	0.07	50																			
	0.4	0.5	8.1	0.10	76	16	5.5	7.2	1.6	0.43			10.0	0.76	0.72	13	36	2	50	16	0.32	0.023	0.728	0.017
	0.5	0.6	8.6	0.12	105	14	4.7	7.0	1.6	0.36			11.4	0.67	0.81	14	40	4	42	14	0.33	0.022	0.666	0.018
	0.6	0.7	8.8	0.13	102																			
B22	0.7	0.8	9.1	0.27	169																			
	0.8	0.9	9.3	0.37	222	12	3.7	7.4	2.1	0.29			17.5	0.50	0.92	17	48	5	30	10	0.40	0.021	0.556	0.019
	0.9	1	9.4	0.44	294																			
B23k	1	1.1	9.5	0.50	341																			
	1.1	1.2	9.4	0.57	432	14	3.6	9.8	3.4	0.37			24.3	0.37	–	14	47	6	32	–	0.44	0.019	0.620	0.026
	1.2	1.3	9.4	0.59	447																			
B24	1.3	1.4	9.4	0.62	466																			
	1.4	1.5	9.5	0.63	478	17	3.2	10	4.0	0.34			23.5	0.32	0.99	18	42	8	30	12	0.57	0.021	0.724	0.028
	1.5	1.6	9.3	0.58	404																			

CEC/Alcoholic Cations @ pH 8.5 [Methods 15I3,15C1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg) Acid P	Bicarb. P	Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg) Fe	Mn	Cu	Zn	Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
9020	0	0.10	6.6	0.60	0.03	20	–	4	0.35	19	17	0.46	0.21	–	2

Air dry data @ 40 C

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9048

Soil Name: **Warwick (Ww)**

Location: 665710 mE 7474710 mN ZONE 55
Described By: Burgess, J **Date:** 20–Apr–1994

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins) **Substrate Lithology:** unconsolidated material (relict)
Landform Pattern: plain **Element:** plain
Runoff: slow **Permeability:** very slowly permeable
Microrelief: normal gilgai – VI 0.3 m, HI 8 m **Microrelief Component:** mound
Drainage: moderately well drained **Slope:** 0.5 %
Surface Coarse Fragments: very few < 2%, medium pebbles 6–20mm, quartz and silcrete
Surface Condition: hard setting, firm, periodic cracking

Classifications:

ASC: Episodic–endoacidic, Epipedal, Brown, VERTOSOL, Non Gravelly, Fine, Medium Fine, Very Deep
GSG: Brown clay **PPF:** Ug5.34

Vegetation:

Tallest Stratum: Mid-high closed forest (6.01–12m)
Acacia harpophylla (brigalow)

Mid Stratum: Tall sparse shrubland (1.01–3m)
Carissa ovata (currant bush, baroom bush); *Terminalia oblongata* (yellowwood)

Lower Stratum: Mid-high sparse tussock grassland (0.26–0.5m)
Cenchrus ciliaris (buffel grass); *Enteropogon acicularis* (curly windmill grass); *Paspalidium caespitosum* (brigalow grass); *Bothriochloa bladhii* (forest bluegrass)

Veg. Association: Brigalow (VA1) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A11	0.00 to 0.03	Very dark greyish brown (10YR32) moist colour; fine sandy light medium clay; very few < 2% medium pebbles 6–20mm subrounded quartz and silcrete coarse fragments; weak 10–20mm platy parting to moderate 2–5mm angular blocky structure; dry strong; dry when sampled; clear to;
A12	0.03 to 0.20	Dark brown (10YR33) moist colour; medium heavy clay; strong 10–20mm angular blocky parting to moderate 2–5mm angular blocky structure; moderately moist strong; moderately moist when sampled; gradual to;
B21	0.20 to 0.70	Brown (10YR43) moist colour; medium heavy clay; moderate 10–20mm lenticular structure; moderately moist very strong; moderately moist when sampled; diffuse to;
B22	0.70 to 1.60	Brown (10YR43) moist colour; few 2–10% fine < 5mm faint grey, very few < 2% fine < 5mm faint red mottles; medium heavy clay; moderate 20–50mm lenticular structure; moderately moist rigid; moderately moist when sampled.

Effective Rooting Depth (ERD): 0.2 m (Cl >1000 ppm, ESP >20%)

Plant Available Water Capacity (PAWC): 35 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water			Cation Exchange Capacity/Exchangeable Cations # (meq/100g)					Exchange Acidity (meq/100g)		Cation Dominance		Dispersion	Particle Size (%)				Moisture (%)	Clay Mineralogy	Total Elements (%)		
			pH	EC (dS/m)	Cl (mg/kg)	CEC/ECEC	Ca	Mg	Na	K	Al	H	ESP (%)	Ca/Mg Ratio	R1 Ratio	Coarse Sand	Fine Sand	Silt	Clay	15 Bar	CEC/Clay Ratio	P	K	S
			@ 40 C			@ 105 C					@ 105 C					@ 105 C				@ 105 C		@ 65 C		
A11	0	0.03	6.6	0.07	21	17	7.9	6.2	0.56	0.49			3.3	1.27	0.55	16	45	12	30	10	0.57	0.038	0.305	0.046
A12	0.03	0.1	7.5	0.20	142	28	11	14	3.0	0.35			10.7	0.79	0.82	11	33	10	45	17	0.62	0.028	0.349	0.047
	0.1	0.2	8.7	0.67	621																			
B21	0.2	0.3	8.8	0.92	1106	31	9.1	16	6.2	0.31			20.0	0.57	0.91	9	30	12	50	19	0.62	0.024	0.354	0.044
	0.3	0.4	8.5	0.93	1251																			
	0.4	0.5	8	0.92	1310																			
	0.5	0.6	6.6	0.88	1256	33	6.9	16	7.3	0.35			22.1	0.43	0.99	5	28	12	54	21	0.61	0.021	0.378	0.031
	0.6	0.7	5.7	0.87	1280																			
B22	0.7	0.8	5.4	0.88	1305																			
	0.8	0.9	5.3	0.91	1359	34	5.8	15	8.3	0.31			24.4	0.39	0.99	5	27	13	56	22	0.61	0.021	0.404	0.025
	0.9	1	5.2	0.88	1325																			
	1	1.1	5.1	0.92	1374																			
	1.1	1.2	5.1	0.92	1376	33	5.4	15	8.9	0.34			27.0	0.36	–	4	26	14	56	–	0.59	0.021	0.404	0.024
	1.2	1.3	5	0.93	1376																			
	1.3	1.4	5	0.93	1361																			
	1.4	1.5	5	0.95	1381																			
	1.5	1.6	5	0.94	1374																			

CEC/Alcoholic Cations @ pH 8.5 [Methods 15I3,15C1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg)		Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg)				Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
							Acid P	Bicarb. P		Fe	Mn	Cu	Zn		
9048	0	0.10	7.5	0.84	0.06	14	–	3	0.62	21	16	0.66	0.21	19	13

Air dry data @ 40 C

Appendix 3 – Profile morphology, landscape characteristics, vegetation & analytical data (continued)

Representative Profile: 9049

Soil Name: **Warwick (Ww)**

Location: 665710 mE 7474710 mN ZONE 55

Described By: Burgess, J **Date:** 20–Apr–1994

Landscape:

Geology: TQa – unconsolidated sediments (sedimentary origins) **Substrate Lithology:** unconsolidated material (relict)

Landform Pattern: plain **Element:** plain

Runoff: very slow **Permeability:** very slowly permeable

Microrelief: normal gilgai – VI 0.3 m, HI 8 m **Microrelief Component:** depression

Drainage: moderately well drained **Slope:** 0.5 %

Surface Coarse Fragments: no coarse fragments

Surface Condition: firm, self-mulching, surface flake, periodic cracking

Classifications:

ASC: Endoacidic, Epipedal, Grey, VERTOSOL, Non Gravelly, Fine, Fine, Very Deep

GSG: Grey clay **PPF:** Ug5.25

Vegetation:

Tallest Stratum: Mid-high closed forest (6.01–12m)
Acacia harpophylla (brigalow)

Mid Stratum: Tall sparse shrubland (1.01–3m)
Carissa ovata (currant bush, baroom bush); *Terminalia oblongata* (yellowwood)

Lower Stratum: Mid-high sparse tussock grassland (0.26–0.5m)
Cyperus species

Veg. Association: Brigalow (VA1) – uncleared

Profile Morphology:

Horizon	Depth (m)	Description
A1	0.00 to 0.03	Very dark greyish brown (10YR32) moist colour; fine sandy medium clay; moderate <2mm granular structure; dry firm; dry when sampled; clear to;
B21	0.03 to 0.40	Dark greyish brown (10YR42) moist colour; medium heavy clay; moderate 10–20mm lenticular structure; moderately moist very firm; moderately moist when sampled; gradual to;
B22	0.40 to 0.80	Brown (10YR43) moist colour; sandy medium heavy clay; weak 20–50mm lenticular structure; very few < 2% fine <2mm manganiferous veins; moderately moist strong; moderately moist when sampled; diffuse to;
B23	0.80 to 1.60	Dark yellowish brown (10YR44) moist colour; sandy medium heavy clay; moderate 20–50mm lenticular structure; dry very strong; dry when sampled.

Effective Rooting Depth (ERD): 0.7 m (profile salinity in equilibrium)

Plant Available Water Capacity (PAWC): 90 mm

Analytical Data:

Horizon	Upper Depth (m)	Lower Depth (m)	1:5 Soil/Water			Cation Exchange Capacity/Exchangeable Cations # (meq/100g)					Exchange Acidity (meq/100g)		Cation Dominance		Dispersion	Particle Size (%)				Moisture (%)	Clay Mineralogy	Total Elements (%)		
			pH	EC (dS/m)	Cl (mg/kg)	CEC/ECEC	Ca	Mg	Na	K	Al	H	ESP (%)	Ca/Mg Ratio	R1 Ratio	Coarse Sand	Fine Sand	Silt	Clay	15 Bar	CEC/Clay% Ratio	P	K	S
			@ 40 C			@ 105 C					@ 105 C					@ 105 C				@ 105 C		@ 65 C		
A1	0	0.03	6.6	0.07	11	20	10	9.0	0.24	0.85			1.2	1.11	0.61	13	32	13	42	13	0.48	0.034	0.365	0.044
B21	0.03	0.1	6.4	0.07	8	22	10	10	1.0	0.55			4.5	1.00	0.74	12	31	12	45	16	0.49	0.029	0.323	0.039
	0.1	0.2	6.8	0.14	70																			
	0.2	0.3	6.7	0.32	334	23	8.9	11	2.3	0.38			10.0	0.81	0.89	14	33	10	44	15	0.52	0.023	0.328	0.037
	0.3	0.4	6.4	0.51	623																			
B22	0.4	0.5	6.2	0.48	622																			
	0.5	0.6	6.2	0.47	660	21	6.1	11	4.0	0.32			19.0	0.55	0.99	15	33	7	43	16	0.49	0.022	0.322	0.031
	0.6	0.7	5.9	0.46	677																			
	0.7	0.8	5.6	0.52	805																			
B23	0.8	0.9	5.6	0.52	787	19	4.9	10	3.1	0.30	0.31	0.31	16.3	0.49	0.99	16	35	7	41	15	0.46	0.020	0.332	0.025
	0.9	1	5.5	0.55	810																			
	1	1.1	5.4	0.55	805																			
	1.1	1.2	5.5	0.56	810	16	4.0	8.6	2.8	0.28	0.41	0.51	17.5	0.47	–	17	36	7	40	–	0.40	0.019	0.323	0.026
	1.2	1.3	5.2	0.59	810																			
	1.3	1.4	5.1	0.61	810																			
	1.4	1.5	5.1	0.61	796																			
	1.5	1.6	5.2	0.57	694																			

ECEC/Aqueous Cations @ pH 7 [Methods 15J1,15A1 – Rayment and Higginson (1992)]

Site #	Upper Depth (m)	Lower Depth (m)	pH (1:5)	Org. C (%)	Tot. N (%)	C/N Ratio	Extr. P (mg/kg)		Acid Extr. K (meq/100g)	DTPA Extr. Micronutrientients (mg/kg)				Phos. Extr. S (mg/kg)	Water Sol. NO3–N (mg/kg)
							Acid P	Bicarb. P		Fe	Mn	Cu	Zn		
9049	0	0.10	6.1	1.5	0.10	15	–	19	0.47	114	45	1.5	0.69	12	15

Air dry data @ 40 C

MINING BY-PRODUCTS MANAGEMENT PLAN

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1. PURPOSE

This Mining By-Products Management Plan details how Middlemount Coal Pty Ltd (hereafter referred to as MCPL) will manage its mining by-products (ie. mining waste, coarse rejects and tailings) during mining operations. The plan aims to ensure all mining by-products are managed in accordance with Queensland coal mining industry standards and regulatory requirements including the requirements of Environmental Authority (EA) number EPML 00716913 (DEHP, 2017), to align with relevant technical guidelines (COA, 2016; DME; 1995 and DEHP, 2013), and in a manner that minimises the environmental and health risks.

2. SCOPE

This Management Plan applies to the management, placement and monitoring of mining by-products (mining waste, coarse rejects, and tailings) produced over the project life including:

- Characterisation of mining waste (overburden, inter-burden, floor, roof and partings), coarse rejects, and tailings;
- Placement, drying and reclamation of tailings in cells;
- Transport and placement of coarse rejects and dried tailings in the mine pit;
- Transport and placement of mining waste (spoil);
- Control of any environmental impacts;
- Emergency procedures;
- Recording of coarse rejects and tailings disposal; and,
- Periodic review.

This procedure must not be implemented by any site personnel without the involvement of the MCPL Environment Department.

3. DEFINITIONS

Acronym	Definition
Acid and Metalliferous Drainage	Any contaminated discharge resulting from mining and associated processing, which is formed through a series of chemical, physical and biological reactions when geological strata is exposed to oxygen and moisture as a result of ground disturbance activities.
AMD	Acid and Metalliferous drainage
ANC	Acid neutralising capacity, expressed as kg H_2SO_4 per tonne of sample.
CHPP	Coal Handling and Preparation Plant
Coarse Reject	Coarse coal waste produced through coal processing sourced from the D&R screen and the spirals rejects dewatering screen.
EA	Environmental Authority (EPML00716913)
EDMS	Environmental Database Management System
Hazardous substance	A substance which has the potential to harm the health of persons in the workplace and/or adversely impact the environment.
Mining By-Product	Any mining and coal handling and processing related waste, including: overburden, partings, coarse reject, tailings and miscellaneous waste rock material;
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acidic conditions.
NAF (Barren)	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acidic conditions. Barren of oxidisable sulfur.
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acidoc conditions.
ROM	Run of Mine
SSE	Site Senior Executive
Tailings	Fine coal waste produced through coal processing sourced from the Tailings Thickener underflow.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.

4. BACKGROUND

The primary risk associated with mining by-products such as mine spoil and coal processing waste (coarse rejects and tailings) is the potential to form leachate known as Acid and Metalliferous Drainage (AMD). AMD may be described as a process involving a series of chemical, physical and biological reactions that take place within material that has been disturbed from its natural state, with the resulting products potentially including acidic, metalliferous and saline leachate.

This mining by-products management plan summarises the reactions involved in AMD in basic and non-scientific terms. It should be noted that there are many site-specific variables and highly complex chemical, physical and biological interactions that influence the process and outputs.

4.1. FORMATION OF AMD DUE TO DISTURBANCE

Ground disturbance and excavation results in material being exposed to atmospheric and climatic influences that are not present, or very limited, when the material is in its undisturbed state. In addition, the process of excavation breaks up the structure of the material from a compacted form to a loose form, which increases the surface area exposed to atmospheric and climatic influences.

If sulfide mineralisation is present in the material, it can react with oxygen and water when excavated. The reaction between sulfide mineralisation, oxygen and water results in oxidation of the sulfides. The oxidation process alters the chemistry of the sulfides and associated minerals and can release hydrogen ions into solution. This, in turn, lowers the pH of the water, producing an acidic leachate and can also mobilise sulfate salts.

The resulting acidic leachate has the potential to mobilise and dissolve metals/metalloids that are present in the excavated material. Metal mobilisation into solution occurs as a result of the low pH acid leachate. The lower the pH, the higher the likelihood that metals/metalloids will be mobilised into a dissolved form.

If sufficient buffering capacity exists in surrounding material and water, the acidity released into solution by the oxidation process can be neutralised, therefore effectively raising the pH which prevents the acid leachate and consequent mobilisation of metals/metalloids.

It is possible that the same reactions may be taking place in-situ prior to disturbance, however the reaction rates are likely to be minimal or nil due to the compacted nature of material and limited exposure to oxygen and/or water.

4.2. AMD CONCERNS

The primary concern with mining by-products is whether they will potentially generate acidic and saline leachate, which may impact surrounding watercourses. Furthermore, if metals/metalloids are present in the materials they may be mobilised into solution by the acidic leachate, further increasing environmental impacts. If AMD enters waterways, it can potentially have significant impacts on aquatic life; riparian vegetation; and water quality for substantial distances downstream. If not appropriately managed, AMD can occur during mining operations and continue for a substantial period after mine closure. The management of mining by-products should focus on the prevention or minimisation of AMD wherever possible as management and control can be difficult and costly.

Potential sources of AMD at Middlemount Mine may include (but is not limited to): coal seam partings, roof and floor, coarse rejects, tailings, ROM and product coal, and exposed coal faces in the pit.

5. PROCESS OVERVIEW

5.1. MINING WASTE

Mining waste is generated through the coal excavation process and includes overburden, interburden. It can also contain coal seam partings, roof and floor materials if these do not report with coal to the CHPP. All these mining waste components are disposed of within the mining pit and need to be treated in accordance with the risk of acid generation. Generally, overburden is placed in ex-pit spoil and interburden is placed in in-pit spoil.

5.2. COAL REJECTS (COARSE REJECTS AND TAILINGS)

5.2.1. General

The MCPL CHPP has a design capacity of 700tph and produces two product coal stream (PCI and Coke) and two waste streams (Coarse rejects and tailings). The CHPP materials flow is presented in Figure 1 below and rejects production statistics are presented in Table 1.

MCPL expects to produce approximately 27 Mt of rejects (coarse and tailings) with a rejects-to-product coal ratio (m/m) of 0.35:1. The total coarse reject and tailing masses are predicted to be approximately 15 and 12 Mt (dry), respectively.

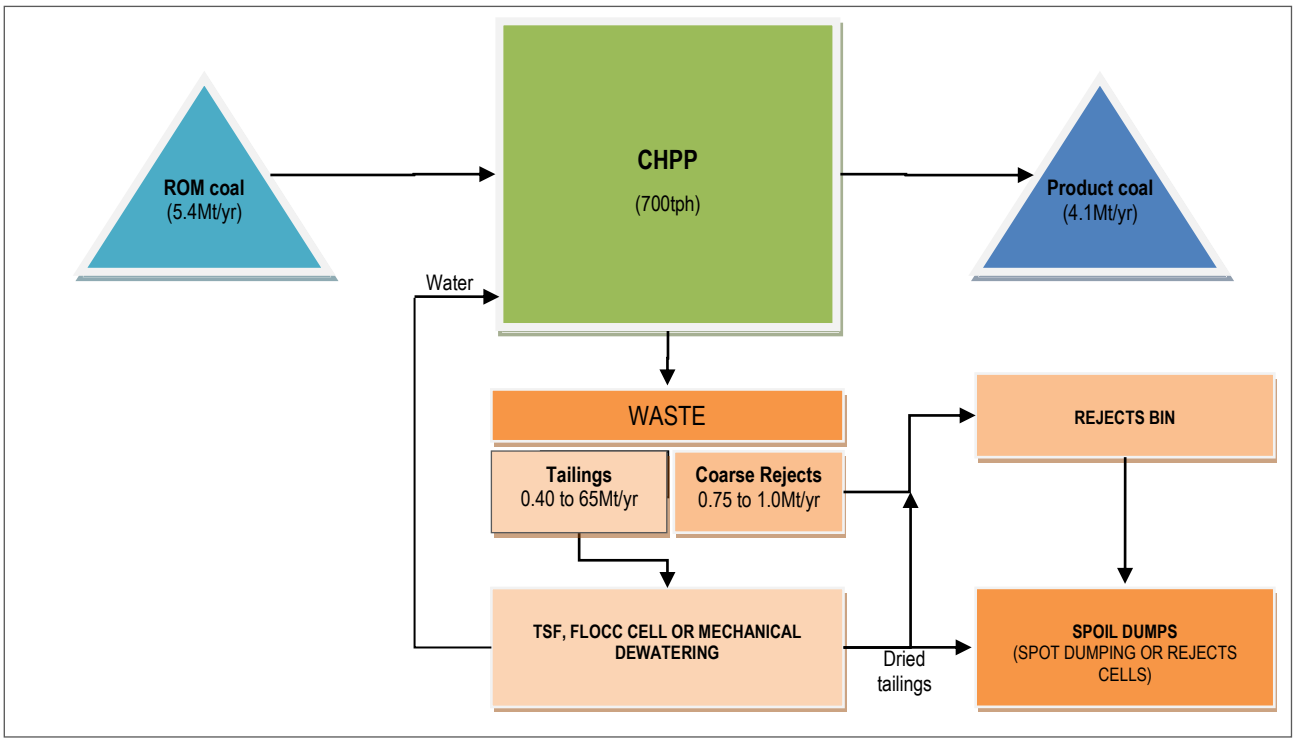

Figure 1: Materials process flow (adapted from Stage 2 EIS (PB, 2012))

Table 1: Rejects processing statistics

	Average	Maximum	Comments
ROM feed rate (tph)	**700**		**As received**
Coarse Rejects (tph)	**96**	**235**	**Rejects weigher**
Tailings (tph)	**58 to 70**	**120**	**Solids mass**
Rejects Belt Capacity (tph)	**-**	**450**	

5.2.2. Coarse Rejects

Coarse rejects are produced from the spirals/spirals reject dewatering screen and Dense Medium Cyclone via the drain and rinse screen. Rejects report via the rejects conveyor to the 240t rejects bin prior to trucking to the disposal locations in pit.

5.2.3. Tailings

Tailings (fine rejects) are produced from the CHPP thickener underflow. The tailings material is sourced from three plant processes (nominal flows shows):

- Flotation cell underflow (68tph);
- Screen bowl centrifuge effluent (6tph); and,
- Spiral rejects dewatering screen underflow (1tph).

Each of the three sources reports to the de-aeration tank prior to delivery to the Tailings Thickener. The tailings underflow (tailings) is pumped by a VSD drive pump to one of the following locations:

- TSF 2 ILF Cells (In Line Flocculation) consists of four cells within the existing and permitted TSF 2 footprint. The cells are used to hold tailings that have been flocculated in the pipeline immediately prior to deposition, for a short period prior to it being excavated and hauled for disposal in-pit.
- In-line flocculant cells – Consists of two emergency cells located between TSF 1 and Sediment Dam 1. These two cells are yet to be utilised, and if required, tailings will be pumped to in-line flocculant cells with flocculant added prior to discharge to accelerate dewatering of the material.

More detail on each of these options can be found in Section 7.

Tailings properties vary with the seam processed and associated product yield. The following provides a summary of recent properties:

Tailing Thickener underflow density	1.06 to 1.30 (avg. 1.11) t/m^3
Solids Mass flow	25 to 120 (avg 69) tph.

Other tailings data from German Creek includes (AMEC, 2000):

Tailings Permeability	$4x\ 10^{-8}$ m/s
Tailings Shear Strength (Ø)	32 Degrees
Tailings Cohesion (c)	0kPa

6. MINING BY-PRODUCT CHARACTERISATION

6.1. OVERVIEW

MCPL has completed a geochemical assessment of mining by-product materials with the following objectives:

- Characterising the mining by-product materials.
- Assess potential impacts associated with mining by-product materials.
- Develop management strategies for mining by-product materials.

MCPL engaged RGS Environmental Pty Ltd (RGS) to complete the study and the RGS report should be read where more material characterisation detail is required (RGS, 2013). The RGS report builds on previous work undertaken by RGS as well as work completed during the Stage 1 development and Stage 2 EIS (PB, 2011).

The RGS study included a detailed sampling (103 samples collected and analysed) and characterisation program including overburden, interburden, coal seams, coal seam roof/partings and floor, product coal, coarse rejects and tailings. Assessments included mine water contact testing, Acid Base Accounting, Kinetic Leach Column testing, Acid Neutralisation Capacity availability determination, multi-element composition of samples and leachate, site water and ground water quality assessment and recommendations of management strategies.

RGS was subsequently commissioned by MCPL to complete a review of geochemical monitoring data at Middlemount Coal Mine (RGS, 2016).

6.2. CHARACTERISATION RESULTS

The conclusions from the RGS 2013 study are:

- The majority of coal and mining waste materials are classified as Non-Acid Forming (NAF), have excess acid buffering capacity, and a high factor of safety with respect to potential for acid generation. Permian Interburden provides a useful source of acid buffering material that could be used as part of an improved management strategy for other Potentially Acid Forming (PAF) materials at the site.
- Most of the coarse reject and tailings material generated from processing coal from the Middlemount and Pisces seams, and some of the floor material from the Middlemount seam, are likely to be PAF and will require management.
- Surface runoff and seepage from most coal and mining waste materials generated on site is predicted to be pH neutral to slightly alkaline and show relatively low levels of salinity following surface exposure. Salinity levels in the mine water system and sediment dams may increase over time due to evapo-concentration of ongoing salt loads from coal and mining waste materials.
- Surface runoff and seepage from PAF coal and mining waste materials (including coarse rejects and tailings) generated at the site is expected to be acidic, with increased levels of salinity due to soluble sulfate, calcium and magnesium concentrations caused by sulfide oxidation and neutralisation.
- The concentration of soluble trace metals and major ions in runoff and seepage from most coal and mining waste materials is likely to be low, remain within applied water quality guideline criteria, and is unlikely to present any significant environmental risks for on-site or downstream water quality.
- The concentration of some soluble trace metals and major ions in runoff and seepage from PAF coal, coarse reject and tailings materials could be elevated if exposed to ongoing oxidising conditions.
- It is recommended that PAF materials (coarse rejects, tailings and Middlemount floor) be placed in-pit where practicable and mixed with Permian and/or covered with Permian spoil. PAF disposal locations should be placed at least 10 metres from the final landform and drain to the pit.
- Any PAF materials disposed of ex-pit should be mixed with Permian spoil at a ratio of 1:10, incorporate lime dosing and be covered with at least 10m of Permian prior to the final landform.

The conclusions from the RGS 2016 study are:

- The management of coarse reject and tailing materials at Middlemount Coal Mine by MCPL appears to be proceeding according to plan and there is currently no indication of significant AMD occurring either at the TSF or in-pit disposal areas.
- Monitoring data (ABA and NAG test results) confirm that coal, coarse rejects and tailings represent a range of material types ranging from NAF to PAF. The NAG test can significantly overestimate the acid generating capacity of PAF samples.
- Whilst initially pH neutral to alkaline, a significant proportion of the coarse rejects and tailings samples tested (76 %) have a reduced factor of safety and carry some risk of acid generation over time, if left unmanaged. Notwithstanding, it is expected that the management measures for coarse reject and tailing materials employed by MCPL are sufficiently robust to avoid significant potential impacts to surface water and groundwater resources at the site.
- Most coal samples are initially pH neutral to alkaline, but theoretically have a reduced factor of safety with respect to potential acid generation (albeit that most sulfur is likely to be present in a non-acid generating form (eg. organic sulfur). In addition, coal materials are stockpiled for a limited time at site prior to transport off-site to export markets. Therefore, the current measures for managing coal stockpile surface water and seepage (collection and monitoring - with lime dosing, if required) employed by MCPL are expected to be appropriate to address the relatively low level of risk to surface water and groundwater resources posed by these materials.
- Multi-element test results for coarse reject and tailing samples indicate that metals/metalloids are not significantly enriched in these materials compared to average crustal abundance.
- Surface water quality results at the TSF indicated that from April 2011 to January 2016, surface water remained pH neutral with excess alkalinity and within the required EA pH range (6.5 to 9.0). Surface water at the TSF was brackish and generally had elevated salinity and sulfate values towards the end of the monitoring period, most likely due to a combination of evapo-concentration of salts at the TSF and oxidation of sulfides in near-surface tailings. Dissolved (filterable) trace metal/metalloid concentrations at the TSF were low, which suggests that metal/metalloids are sparingly soluble in pH neutral surface contact water at the TSF.
- Despite the increased salinity and sulfate concentration in surface water at the TSF during the monitoring period, there was no corresponding increase in these parameters in groundwater at monitoring wells between the TSF embankment and Roper Creek, and both parameters remained within EA groundwater investigation trigger levels. The concentration of dissolved (filterable) trace metals/metalloids in groundwater was typically below the laboratory LoR and generally well below the EA groundwater investigation trigger levels.

A summary of the material characterisations of the coal and mining by-product materials tested in 2013 is provided in Table 2 and summarised graphically in Figure 2 and in accordance with the classification system presented in Table 3 (from RGS 2013). General classifications may change with on-going monitoring and characterisation.

Table 2: Material characterisation summary

Material	pH[1]	EC[1] (µs/cm)	Acid-Base Accounting[2]	ANC (kg H_2SO_4) & Availability	Leachate Risk	Acid Production Risk	Acid Neutralising Potential
Overburden Sandy & clayey alluvium	8-9	150-700	NAF (Barren)	2-14	Low	Low	Low
Weathered & unweathered tertiary sandy clays and clays	7-9	250 - 1000	NAF (Barren)		Low	Low	Low
Inter-burden – Permian siltstone / sandstone	9-10	250-500	NAF (Barren)	>55 kg (88.5%)	Low	Low	High
Roof, Parting, Floor Middlemount	7.5-8.5	350-700	Roof – NAF (Barren)	N/A	Low	Low	Low
	6-8	300-950	Parting - NAF (Barren)		Low	Low	Low
	3.5-5.5	450-800	Floor - PAF		Low	High	Low
Pisces	9-10	300-450	Roof – NAF (Barren)		Low	Low	Low
	9-10	400-1000	Floor – NAF to PAF (Variable. Treat as PAF)		Low	Moderate	Low
ROM Coal – Middlemount	3-8	170-850	PAF (Low Capacity) Variable Results		Low	Low	Low
Pisces	7-9	100-500	NAF to Uncertain		Low	Low	Low
Product Coal Middlemount	2.5-8.5	100-2500	NAF (Barren) to PAF (Variable. Treat as PAF)		Low	Low	Low
Pisces	7-9	100-250	NAF (Barren)		Low	Low	Low
Coarse Rejects Middlemount	2.5-7.5	300-2250	PAF		Low[3]	High	Low
Pisces	7-9.5	400-550	NAF to PAF (Variable. Treat as PAF)	(92%)	Low[3]	High	Low
Tailings Middlemount	6.3-7.2	450-800	PAF		Low[3]	High	Low
Pisces	7-9.5	150-800	PAF	(91%)	Low[3]	High	Low

[1] pH and EC for 1:5 sample:water extracts. [2] Refer to Section 3 for more definitions. [3] To be confirmed by field testing.

Table 3: Geochemical classification criteria for mine materials (RGS, 2013)

Geochemical Classification	Total or Sulfide Sulfur(%)[1]	NAPP (kg H_2SO_4/t)	ANC: MPA Ratio	NAG_{pH}	NAG Capacity (kg H_2SO_4/t)
Non-Acid Forming (NAF) – Barren[2]	≤ 0.1	-	-	-	-
Non-Acid Forming (NAF)	> 0.1	≤ -5	≥ 2	-	-
Uncertain	> 0.1	> -5 and ≤ 5	< 2	≥ 4.5	≤ 5
Potentially Acid Forming (PAF) - Low Capacity	> 0.1	> 5 and ≤ 10	< 2	< 4.5	≤ 10
Potentially Acid Forming (PAF)	> 0.1	> 10	< 2	< 4.5	> 10

Notes:
1. If total sulfur or sulfide sulfur is less than or equal to 0.1 %, the NAPP and ANC/MPA ratio are not required for material classification as the sample is essentially barren of oxidisable sulfur.
2. A sample classified as NAF can be further described as 'barren' if the total sulfur and/or sulfide sulfur content is less than or equal to 0.1 per cent, as the sample essentially has negligible acid generating capacity.

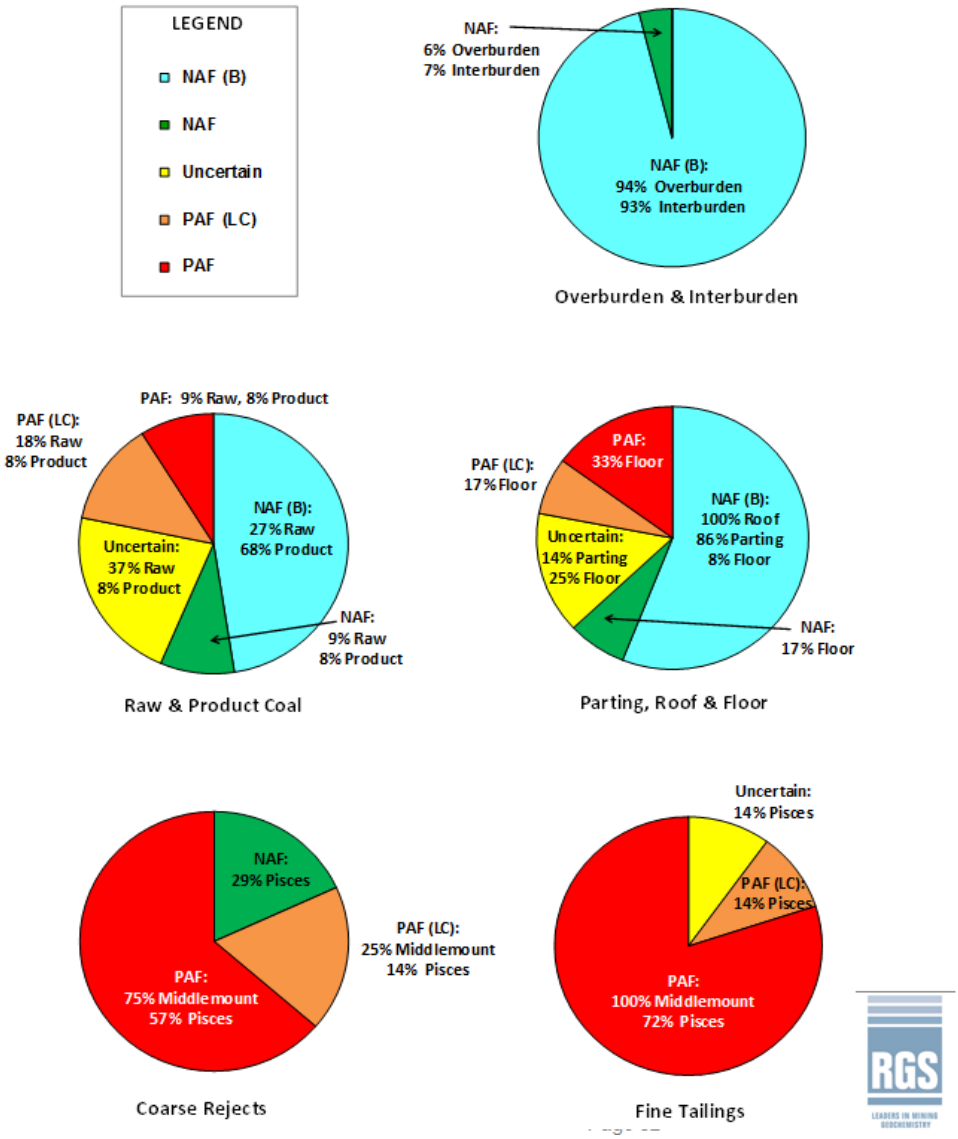

Figure 2: Geochemical classification of coal and mining by-product materials (from RGS 2013)

7. OPERATIONAL MANAGEMENT

7.1. MINING WASTE AND PROCESS WASTE DISPOSAL

All mining waste at the open pit is mined by excavator and truck or dozer push. As shown in Section 6, mining waste is NAF or acid neutralising with the exception of the Middlemount and Pisces seam floor. Coarse rejects and tailings (process wastes) have the potential to form AMD. To mitigate the risk from PAF material, the mining waste, coarse rejects and tailings disposal options are shown in Table 4 below. Each option is documented in more detail in this section.

On-going characterisation of the mining waste materials (including overburden, interburden, floor, roof and partings) will be completed on a project basis if new areas of the site are planned to be mined that have not been previously characterised. Ongoing characterisation of coarse rejects and tailings will be undertaken periodically to ensure that the material treatment suits the categorisation. This monitoring is discussed in Section 9.

Table 4: Mining waste and process waste disposal options

Material	Disposal Options					
	Ex Pit Spoil	**In-Pit Spoil**	**In-Pit spot dump in Permian** (10m from final landform surface)	**Ex-Pit spot dump** (10m from final landform surface)	**In-Pit Cells** (10m from final landform surface)	**TSF**
Overburden	Preferred	Preferred	N/A	N/A	N/A	N/A
Interburden	Preferred	Preferred	N/A	N/A	N/A	N/A
Coal Seam Partings & Roof (All Seams)	Acceptable (10m from final landform)	Preferred	Preferred	Acceptable	N/A	N/A
Coal Seam Floor (All Seams)	Avoid (Lime dosing and 10m of Permian cover)	Acceptable (10m from final landform)	Preferred	Avoid (Lime dosing and 10m of Permian cover)	N/A	N/A
Coarse Rejects	No	No	Preferred (Ideal 5:1, Min 3:1 Permian to Rejects)	Avoid (Min. 10:1 Permian spoil to rejects, lime dosing and 10m Permian cover required)	Acceptable (Lime dose as required)	N/A
Tailings	No	No	Acceptable (Lime Dose as required) – Caution – Tip head stability	No	Preferred (Dried and Lime dosed as required)	Acceptable
Co-mingled Coarse Rejects & Tailings	No	No	Preferred (Ideal 5:1, Min 3:1 Permian to Rejects)	Avoid (10:1 Permian spoil to rejects, lime dosing and 10m Permian cover required)	Acceptable (Lime dose as required)	N/A

7.1. OVERBURDEN AND INTERBURDEN

Overburden is classified as NAF and may be placed in any in-pit or ex-pit spoil dump. Dispersive material is to be preferentially placed away from the final landform surface.

Interburden is to be preferentially placed in-pit to provide the acid neutralisation capacity for spot-dumping of PAF materials and creation of Permian caps and bunds on rejects cells. Placement in ex-pit spoil may be used to neutralise any PAF material that is placed in the ex-pit spoil.

7.2. COAL SEAM PARTINGS AND ROOF

Coal seam partings and roof material is to be preferentially placed in in-pit spoil at least 10 metres from the final landform. Where required, this material may be placed in ex-pit spoil at least 10 metres from the final landform.

7.3. COAL SEAM FLOORS

Coal seam floor material is to be placed at least 10 metres from the final landform and preferentially spot dumped with Permian material within in-pit spoil.

In the event it is necessary to place the material in ex-pit spoil the floor material is to be lime dosed and covered with 10 metres of Permian spoil.

7.4. COARSE REJECTS

7.4.1. Handling

Coarse rejects are discharged to the 240t rejects bin via the rejects conveyor. Mine Haul trucks haul the rejects from the bin for disposal within the in-pit spoil dump.

Where rejects production exceeds haulage to in-pit disposal or wet-weather constrains pit access, rejects may be temporarily stored on the rejects pads. Stockpiled rejects are then loaded into haul trucks using front-end loaders or excavator for haulage to the disposal location in-pit.

To prevent hang-ups of material and minimise temporary stockpiling of rejects, the Coarse Rejects Bin is to be kept below 75% full and drawn down regularly when operating with Coarse Rejects only while the CHPP is running. The Bin is to be emptied prior to any planned shut-downs.

In the event that tailings are co-mingled with the coarse rejects on the rejects conveyor, the rejects bin is to be maintained below 50% capacity and is to be emptied regularly.

7.4.2. Water Management

Drainage from coarse rejects storage areas (rejects bin and temporary rejects storage locations) is to be contained on site. Water is to be returned to the Raw Water Dam for reuse as soon as practicable.

7.5. TAILINGS – IN-LINE FLOCCULANT CELLS

7.5.1. Cell Design Details

In-line flocculant (ILF) cells will be earth bunded structures designed to hold flocculated tailings temporarily whilst dewatering takes place and excavation/reclamation of dried tailings can occur. The ILF cells will have a minimum capacity of 1 week of CHPP production with additional allowance for rainfall and water management. All water produced is to be returned to the CHPP or the Raw Water Dam to supply plant make-up water.

Cell batters will be a maximum of 1:2 and a half metre base of coarse rejects or rock on the cell floor as a working surface sloping to the decant location. Access ramps will be less than 1:10 grade to enable truck access. Decant walls will be used if required to assist with dewatering.

Maintenance and repairs will be conducted at the completion of excavation cycles on an as required basis. This may include but is not limited to:

- Batter repairs
- Decant wall replacement
- Access ramp repairs

7.5.2. Operation

In-line flocculation cells are utilised whereby the tailings are dosed with flocculant to speed the dewatering process prior to placement in the cells. The dewatered tailings will then be excavated and transported to the pit for placement.

The addition of flocculant will accelerate the dewatering process and produce solids content ranging from 55 to 65%. Each cell will include a number of discharge points to enable sequential placement of tailings (DP1, then DP2 then DP3) to progress from towards the decant end of the cells as shown in Figure 3 and Figure 4. Sequential placement will allow the continual dewatering of tailings material as it accumulates to the cell operating capacity. Water liberated from the tailings will flow downhill to the decant pump.

The cells will be continually dewatered from the decant end to minimise drying time. Decanted water will be pumped to TSF1 from where it will be returned to the plant for make-up water. Water may also be recycled to the raw water dam.

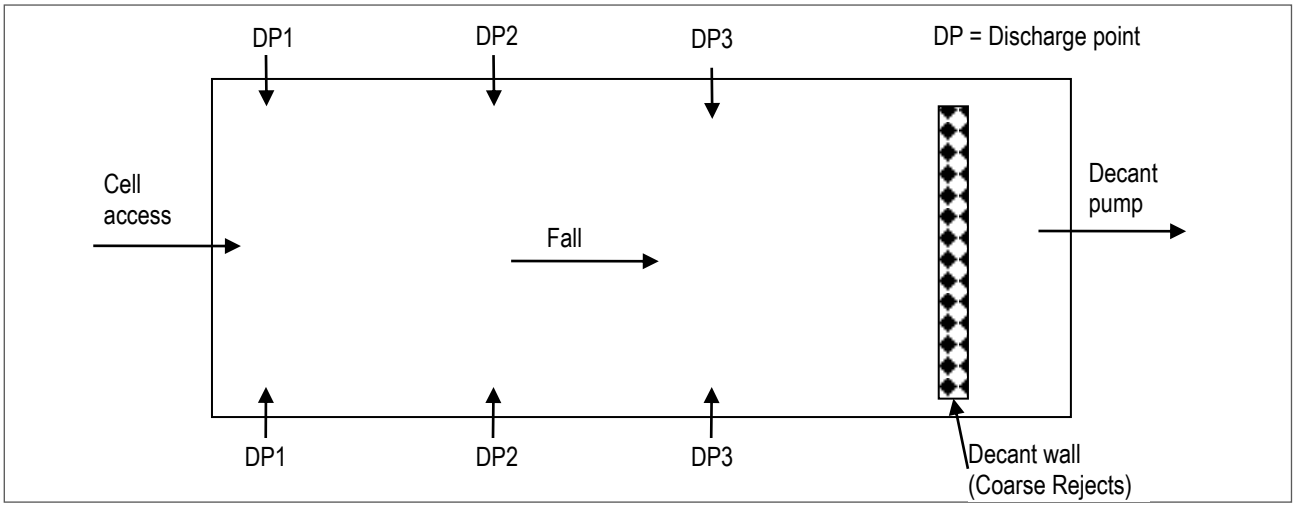

Figure 3: In-Line Flocculation Cell Schematic – Plan View

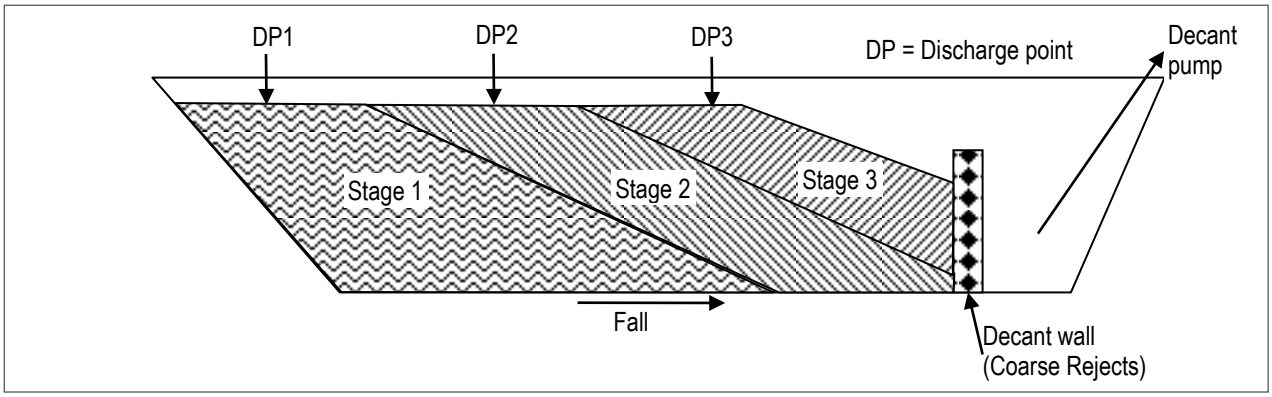

Figure 4: In-Line Flocculation cell schematic section view and placement stages (left to right)

Table 5: In-Line Flocculation cell details

ILF Cell	Design Capacity (includes DSA allowance) (m^3)	Operating Capacity (Tailings) (m^3)	Days to Fill (days)#	Drying Time (days)	Excavation Time (days)
1	TBC	Min 7 Days	7 Days (min)	7 Days (Est)	6 Days (Est)
2	TBC	Min 7 Days	7 Days (min)	7 Days (Est)	6 Days (Est)

Solids Specific Gravity – 1.6t/m^3, Plant operation 700tph for 23.5hrs per day

Following placement, cells will be dewatered and allowed to dry. Upon drying of the cells, the tailings will be excavated using excavators and trucks and trucked to the in-pit spot dumping or cell disposal locations as discussed in Section 7.7. Excavation will commence with trucks backing to the excavator, with cells wide enough for 40t, 6 wheel drive trucks to turn around on the cell floor. No out of sequence excavation of tailings will occur unless specifically authorised.

The in-line flocculation cells will operate in conjunction with TSF 1, where tailings will be placed in TSF 1 when insufficient capacity is available within the in-line flocculation cells.

Operational responsibilities will be as follows:

- Tailings discharge, including flocculation
- Dewatering

7.5.3. Water Management

Cells will include dedicated de-watering infrastructure including pumps, pipes and valving. Decant water will be continually drawn off and pumped to TSF 1 from where it will be returned to the plant or the Raw Water Dam.

Cells are designed with no external catchment minimise flooding potential, environmental risk and DSA requirements and will include sufficient DSA capacity in addition to the operational volumes.

7.6. TAILINGS - TAILINGS STORAGE FACILITY 1 AND 2

7.6.1. Operation and placement strategies

The peak tailings production at MCM is about 58 200 t/month of tailings. It is estimated the settled dry density of the tailings will be around 0.9 t/m^3, requiring 64 620m^3 of storage per month. Tailings will be placed into TSF2 Flocculation Cells in a manner that enables the decant water to be reclaimed and returned to the CHPP. This will involve discharge points being installed around the cells and grading to the return water pump(s). Placement will work progressively around the cell to facilitate dewatering and beaching towards the return water pump.

Where practicable, tailings may be reclaimed once dewatered in a cycle of fill, dry, reclaim (Table 6) and trucked to the in-pit spot dumping or cell disposal locations as discussed in Section 7.7.

The CHPP will be responsible for the operation of the tailings discharge and return water. Mine operations will be responsible for any reclamation.

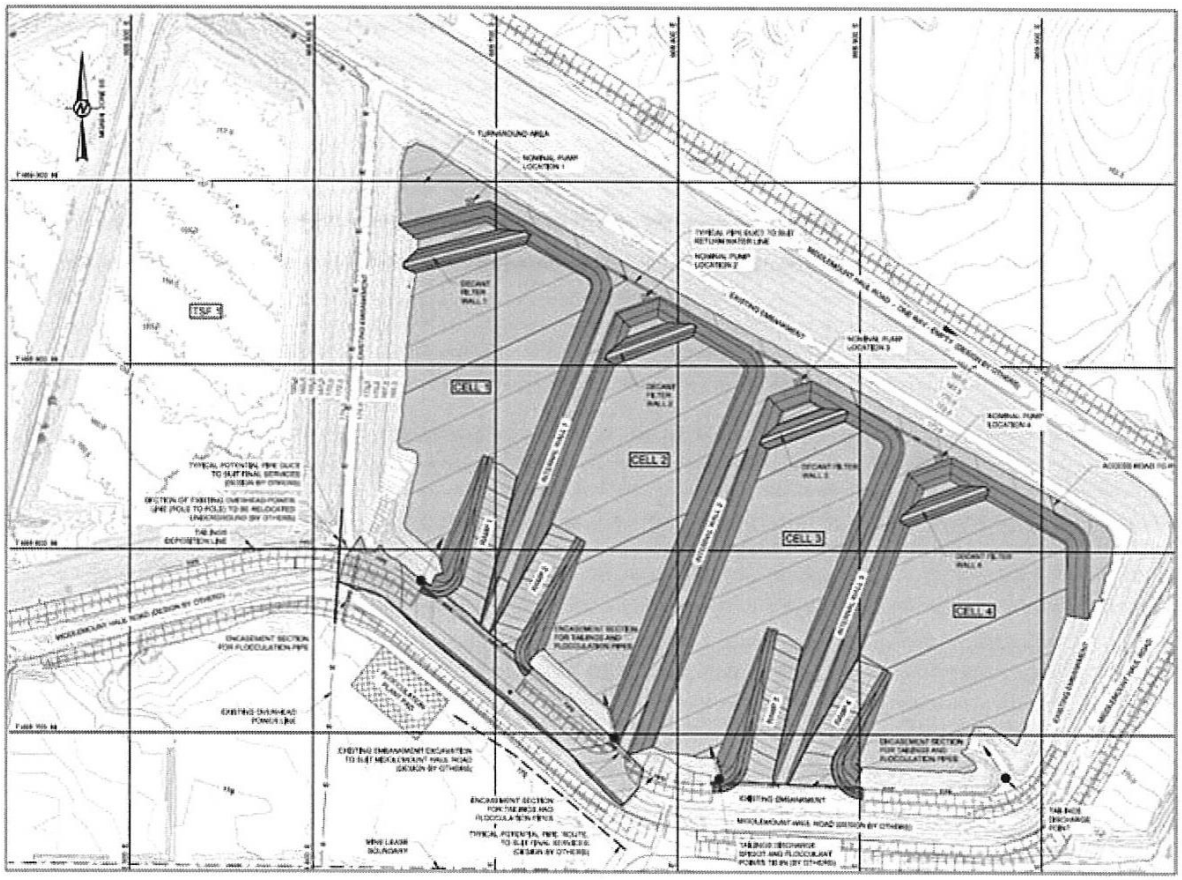

Figure 5: TSF 1 and TSF 2 showing the four-flocculation cell layout encapsulated within TSF 2

Table 6: Cell activities planning

Period	Cell 1	Cell 2	Cell 3	Cell 4
1	Fill	-	-	-
2	Drying	Fill	-	-
3	Reclaim	Drying	Fill	-
4	Reclaim/maintenance	Reclaim	Drying	Fill
5 – cycle restarts	Fill	Reclaim/maintenance	Reclaim	Drying

7.6.2. Water Management

Decant water will be drawn off the cells by the pontoon-based return water pump. Return water will be supplied to the plant in preference to raw water from the raw water dam. It is expected that 50% of the CHPP plant make-up water will be sourced from the TSF 1 return water with the remainder from the raw water dam.

7.7. PAF Waste Placement

PAF waste material (including coarse rejects and tailings) will be preferentially placed within in-pit spoil via spot dumping with Permian inter-burden (Section 7.7.1) or disposed of in-pit cells (Section 7.7.2). In both cases the acid neutralisation capacity of the Permian spoil will be used to neutralise the potential acid formation capacity of the PAF material. All PAF material will be placed at least 10 metres from the final landform (Figure 6).

Where placement in ex-pit spoil is required, PAF material will be lime dosed, spot dumped and covered with Permian interburden. (Section 7.7.3)

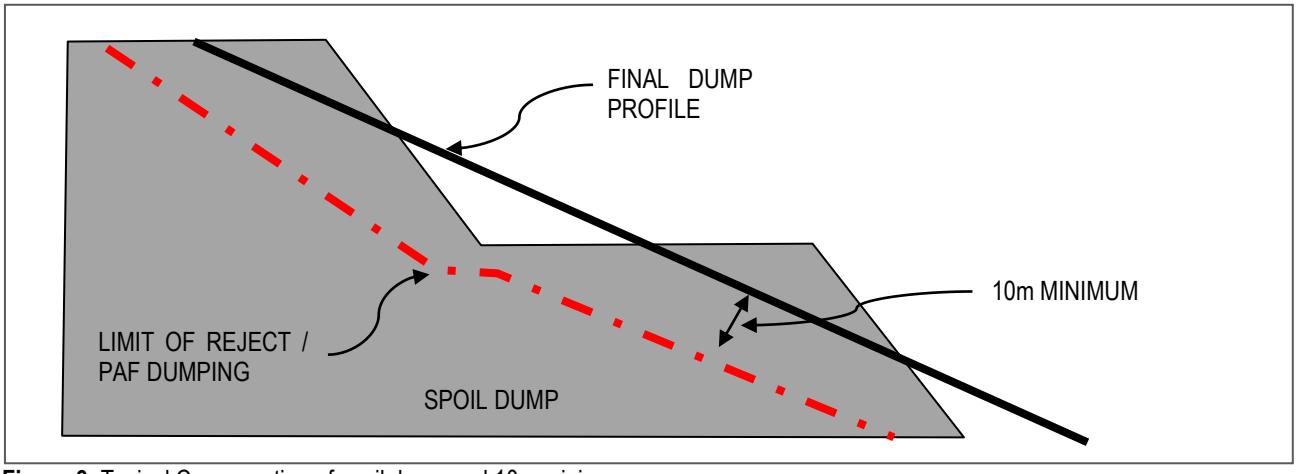

Figure 6: Typical Cross-section of spoil dump and 10m minimum cover.

7.7.1. Spot Dumping – In-pit Spoil

Spot dumping of PAF coarse reject/tailings materials and Permian spoil will occur within the boundaries of the open pit area (ie. internally draining bounds of the open pit spoil). The objective of the spot dumping is to enable the acid neutralising capacity of the spoil to neutralise the potential acid formation. As shown in Section 6, the Permian interburden has sufficient neutralising capacity to offset the potential acid formation. To provide a suitable factor of safety, PAF material will be mixed with a minimum of 3 parts Permian spoil by weight (Target of 5 parts Permian to 1 part PAF material).

All Spot dumping locations will drain internally to the open pit and be placed at least 10 metres from the final landform.

No coarse rejects or co-mingled coarse and fine rejects will be used as part of a tiphead safety bund, haul road or ramp.

In-pit spot dumping is to be designed in accordance with SP-212-004 Mining By-Products In-Pit Disposal.

7.7.2. In-Pit Cell Operations

As an alternative to spot dumping, cell based in-pit emplacements will be progressively constructed. These emplacements will be created within the Permian spoil in progressive in-pit dump designs. Cells will include a permeable floor for basal drainage and containing embankments of Permian spoil. Material will be tipped over dedicated tipheads and covered with 10m of Permian spoil. Cells are to be designed in accordance with SP-212-004 Mining By-Products In-Pit Disposal.

7.7.3. Spot Dumping - Ex-Pit Spoil

In certain circumstances placement of PAF in ex-pit spoil may be required. To control the PAF nature of the material, the PAF material will be spot dumped with Permian spoil at a ratio of 10:1 (Permian to PAF). The PAF material will be lime dosed and covered with 10 metres of Permian spoil.

No coarse rejects or co-mingled coarse and fine rejects will be used as part of a tiphead safety bund, haul road or ramp.

Specific approval from the Environment Department is required prior to placement of PAF in Ex-pit spoil

7.8. NAF Waste Placement

NAF coarse rejects and tailings materials will be treated the same as PAF coarse and fine rejects, being preferentially placed within in-pit spoil via spot dumping with Permian inter-burden (Section 7.7.1). The acid neutralisation capacity of the Permian spoil will be used to provide a factor of safety to NAF categorised Coarse and fine rejects. All NAF Coarse and fine rejects and coal seam floor material will be placed at least 10 metres from the final landform (Figure 6).

NAF overburden, interburden and coal seam partings and floor may be placed in in-pit or ex-pit spoil. Partings and floor are preferentially placed in-pit.

7.9. Coarse Rejects and Tailings Disposal Recording

A record of coarse rejects and tailings properties will be maintained, including Acid Base Account and monitoring results.

Monthly tonnages of coarse rejects and thickened tailings disposed will be recorded.

8. ENVIRONMENTAL ISSUES, IMPACTS AND CONTROL MEASURES

The environmental issues, impacts and controls are described in Table 7 below. The potential for AMD is considered to be the major risk and the following hierarchical of control strategies in order of priority can be categorised as:

1. prevention of impact;
2. minimisation of impact and/or likelihood through active or passive treatment impact; and
3. interception and control of impact.

The control measures will depend on topography, mining method, material type, soil/rock types, mineralogy, and available neutralisation resources. Control measures are documented in Table 7 below and have been integrated into the operational management as presented in Section 7.

Table 7: Environmental Issues, Impacts and Controls

Potential Issue	Potential Impact	Control Measures
AMD	• Contamination of surface water from spoil emplacement areas and stockpiles. • Contamination of stock, irrigation and domestic groundwater supplies. • Degradation of aquatic ecosystems. • Impact on recreation and aesthetics. • AMD from incorrect placement of PAF material.	• Minimise exposure of PAF materials to wetting and drying cycles by limiting rehandling of PAF mining waste, coarse rejects and tailings material and progressive covering of PAF material. • Selective handling and placement of materials, including neutralisation of PAF materials by mixing of PAF material with spoil with excess acid neutralisation capacity (eg. PAF with Permian spoil). Factor of safety applied to mixing with minimum of 3 Permian to 1 PAF by weight (target of 5 parts Permian to 1 part PAF material), based on geochemical characterisation assessment (RGS, 2013). • Development and communication of PAF disposal areas and methods. • Rehandling of incorrectly placed material (eg. within 10m of final landform surface). • Diversion of run-on water from PAF disposal locations. • Minimisation of water pondage on dump surfaces and subsequent infiltration. • Placement of PAF material at least 10 metres from final landform with NAF/Permian cover to minimise water movement through material and provide neutralising material. • Rapid dewatering of tailings and recycling of decant water to minimise the volume of decant water and the duration of exposure. Possible through mechanical dewatering or in-line flocculant cells. • RPEQ designed and certified tailings decant storages. • Chemical amelioration, eg. lime dosing, where required. • Disposal locations to be within the in-pit spoil and are internally draining to the mine pit. • Containment of mine affected water including leachate from PAF disposal locations and coal stockpiles. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Progressive characterisation of mining wastes, specifically coarse and tailings. • Tracking of PAF disposal locations. • Monitoring of leachate from in-pit disposal locations and coal stockpiles. • Monitoring of groundwater resources, specifically aquifers suitable for human or stock consumption. • Monitoring of upstream reference and downstream impact points and REMP monitoring. • Adoption of emergency response plans, including consideration of downstream landholders.

Potential Issue	Potential Impact	Control Measures
Dust from PAF materials	• Toxicity to the receiving environment. • Transport of contaminants to the receiving environment.	• Minimise exposure of PAF materials to wetting and drying cycles by limiting rehandling of PAF rejects and waste and progressive covering of PAF material. • Dust suppression of PAF disposal locations. • Neutralisation of PAF materials by mixing of PAF material with spoil with excess acid neutralisation capacity (eg. PAF with Permian spoil). Factor of safety applied to mixing with a minimum of 3 Permian to 1 PAF based on geochemical characterisation assessment (RGS, 2013). • Placement of PAF material at least 10 metres from final landform with NAF/Permian cover. • Rapid dewatering of tailings and recycling of decant water to minimise the volume of decant water and the duration of exposure. Possible through mechanical dewatering or in-line flocculant cells. To provide working surfaces for tailings reclamation without wet/boggy sub-stratum. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Monitoring and analysis of dust emissions. • Dewatering of tailings prior to transport to minimise spills of wet material.
Release of tailings from Tailings Storage Facilities	• Release of tailings and/or tailings decant water to Roper creek. • Sediment load increased in Roper Creek. • Contamination of water from release of water with some or all of the following; low pH, high EC, elevated metal or sulfate concentration • Metal accumulation in plants and animals. • Contamination of stock drinking supplies. • Contamination of soil. • Loss of human and/or animal life.	• Certified design and construction of the Tailings Storage Facilities. • Annual inspection by Registered Professional Engineer of Queensland (RPEQ). • Routine inspections and repairs. • Maintenance of Design Storage Allowance. • Reclamation of tailings and/or alternative dewatering of tailings prior to placement within in-pit spoil with available acid neutralisation capacity.
Interaction of PAF with rehabilitation	• Interaction of PAF with rehabilitation.	• PAF material to be co-disposed with spoil with acid neutralisation potential. • 10 metre buffer maintained from PAF disposal locations to the final rehabilitation profile. • Rehabilitation monitoring.
Metals/metalloids leachate	• Leaching of metals/metalloids via AMD.	• Waste characterisation and contact testing (RGS 2013). • Progressive characterisation of coal and mining waste and review to determine the potential leachate risk (RGS, 2016). • Disposal of PAF material with spoil with available acid neutralisation capacity.

Potential Issue	Potential Impact	Control Measures
Dust from Overburden	• Toxicity to the receiving environment	• Progressive recontouring and rehabilitation of spoil dumps. • Dust suppression. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Monitoring and analysis of dust emissions.
Spoil run-off	• Contamination of surface water from spoil run-off	• Progressive recontouring and rehabilitation of spoil dumps. • Rehabilitation of spoil dumps to minimise leaching of water through spoil. • Rehabilitation of tailings dams and coal stockpiles. • Installation and maintenance of drainage and sediment and erosion control structures to control and treat run-off from spoil piles.

9. MONITORING

Monitoring of water and solid materials will form an important part of the on-site management of mine by-products. The monitoring program is primarily aimed at identifying PAF coarse reject and tailing materials and potential impacts to ensure that management practices are appropriate or are modified accordingly. Monitoring will be conducted by trained on site personnel or by specialist consultants as engaged by MCPL.

Ongoing characterisation of coarse rejects and tailings materials will be completed. Leachate from coarse rejects and tailings placed at spoil disposal areas and tailings decant water will be included in the site water quality monitoring program.

Monitoring will include characterisation of mining waste materials (including overburden, interburden, floor, roof and partings) on a project basis, if new areas of the site are planned to be mined that have not been previously characterised.

This monitoring program schedule is provided in Table 8. For samples of solid materials, approximately 2kg should be collected and placed in appropriately labelled plastic sample buckets before sending to the laboratory. All sample batches should be accompanied by a hard copy of a completed laboratory Chain of Custody document.

The monitoring program will be revised as part data and management plan reviews and as more site-specific data becomes available.

9.1. COAL PROCESSING AND MINING WASTE SAMPLING AND CHARACTERISATION

Sampling and characterisation of mining waste (overburden, interburden, floor, partings and roof materials), coal processing waste (coarse rejects and tailings) and coal will be undertaken periodically as part of the monitoring program to assess the risk of AMD associated with any PAF materials. The aim the program is to quantify the characteristics of materials, assess potential impacts and confirm or modify management strategies associated with the material.

Table 8 below details the monitoring program. Additional monitoring will include routine ground water, regulated structures (TSF) inspections and rehabilitation monitoring.

Table 8: Mining waste, process waste, coal and water quality monitoring program

Frequency	Sample Source	Sample Point	Analysis	Comments
Monthly	Middlemount Seam, Tralee Seam Pisces Seam or blend.	1. Tailings thickener underflow 2. Coarse rejects	pH, EC, total sulfur, ANC and chromium reducible sulfur (CRS).	Source of coal (seam, strip) to be recorded to develop spatial understanding of rejects by source. Frequency to be reviewed annually or if materials are consistently NAF.
	TSF and ILF cell decant water	TSF 1, ILF Cell 1 & 2 and TSF 2 if receiving tailings.	pH, EC in-situ	
Quarterly	Middlemount Seam, Tralee Seam Pisces Seam or blend.	1. Tailings thickener underflow 2. Coarse rejects	pH, EC, total sulfur, ANC and CRS. 1:5 water extract water quality (dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4).	Source of coal to be recorded to develop spatial understanding of rejects by source. Frequency to be reviewed annually or if materials are consistently NAF.
	TSF and ILF cell decant water	TSF 1, ILF Cell 1 & 2 and TSF 2 if receiving tailings.	pH, EC, dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4 as per EA Table C3).	
	Middlemount Seam, Tralee Seam Pisces Seam	ROM Coal	pH, EC, total sulfur, ANC and CRS.	

Frequency	Sample Source	Sample Point	Analysis	Comments
Opportunistic	Leachate from disposal locations		pH, EC, dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4 (as per EA Table C3).	If possible. Locations to include in-pit cells and pit water.
Project Based	Overburden, interburden, floor, partings and roof of all seams	Overburden, interburden, floor, partings and roof from exploration drill core.	pH, EC, total sulfur and CRS, as required. 1:5 water extract water quality (dissolved Ag, Al, As, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Pb, Hg, K, Ni, Mg, Mn, Mo, Na, Se, U, V, Zn and SO_4). Column leach testing as required.	One-off sampling for new project areas to focus on spatial distribution rather than strict timing.
As Required	All sample sources	Additional sampling will be undertaken on an as-needs basis.		

#ICPMS/CV FIMS – analytical methods required to achieve laboratory Limit of Reporting (LOR).

Coarse rejects, tailings and potential PAF mining waste material monitoring records shall be kept including the following:

- Sample date and time
- Sampler
- Sample location
- Sample source (seam, strip and block)
- In-situ parameters pH, EC and temperature (water only)
- Visual observations. Key indicators of AMD presence include (but are not limited to):
    - Turbidity
    - Colour, (eg. particularly red coloured, unnaturally clear water;
    - odour, (eg. sulfurous);
    - precipitate formation (eg. orange-brown iron oxide precipitates);
    - corrosion of concrete or steel structures.
- Lab results as per Table 8 above.

Form FR-212-003 will be used for material characterisation sampling

9.2. Related Monitoring

Other monitoring that may interaction with mining by-product management includes groundwater, regulated structures, rehabilitation monitoring and general inspections. Items considered include:

- Water quality – groundwater;
- Water quality – surface water;
- Seepage/leachate production and quality;
- Visual inspections;
- Soil geochemistry; and,
- Vegetation coverage and establishment.

All monitoring results will be used to assist with the ongoing development and implementation of mining by-products management strategies. The Environment Department will be responsible for communicating the outcomes of review and risk of AMD. If management practices are not effective, changes to the management will be made and implemented. All relevant personnel employed at the site will undergo training in relation to mining by-products management.

9.3. Monitoring Data Recording

All monitoring data shall be kept in the EDMS database.

10. CONTINGENCY AND EMERGENCY PLANS

If any personnel suspect AMD, it should be reported to the Site Senior Executive (SSE) and Environment Department immediately.

10.1. OPERATIONAL CONTINGENCIES

Contingencies have been developed for scenarios that may occur throughout the life of the operation. Each scenario may have more than one contingency of which a portion of the contingencies may be enacted in that event based on the site conditions at the time. The scenarios and contingencies are presented in Table 9.

Table 9: Operational Contingencies

Scenario	Possible Contingencies
Insufficient Permian for spot placement of PAF material	• In-pit cell construction and possible lime dosing. • Ex-pit spot dumping with lime dosing. • Tailings diverted to TSF 1 or 2.
Incorrect placement of PAF within 10m of final landform	• Incident Investigation. • Removal and relocation of PAF material to suitable dump location. • Assessment of potential or real impacts.
Wet-weather preventing access to disposal locations	• Temporary storage of rejects at temporary rejects stockpiles. • Halt CHPP production.
Mechanical dewatering equipment malfunction	• Temporary placement of tailings in the TSF 1 or 2. • Future reclamation to provide sufficient emergency capacity in TSF 1 or 2.
Abnormal monitoring results	• Investigation into cause of results and mitigation measures required.
AMD indicators found	• Incident investigation. • Soil and water sampling to be conducted. • AMD source treated (removed, ameliorated, etc). • Interception/mitigation measures installed based on expert advice.

10.2. EMERGENCY RESPONSE

If any personnel suspect the presence of AMD, it should be reported to the Site Senior Executive (SSE) and the Environment Department as soon as practicable and within 24 hours. The Emergency Preparedness and Response Management Plan (MP-104-001) should also be consulted. Emergencies relating to regulated dams shall be managed in accordance with regulated dam guidelines and operational plans.

Any uncontrolled release of contaminants shall be managed in accordance with the following general principles:

1. **Isolate**
   - Isolate access to the spill and sources of spill (valves, etc) where possible.
2. **Notify**
   - Notify Supervisor and Environment Department or SSE.
   - The Environmental Department, in consultation with the SSE, shall consider the need to contact downstream landholders, DEHP and other stakeholders. The Emergency Preparedness and Response Management Plan (MP-104-001) should also be consulted.
3. **Contain**
   - Prevent spill spreading or entering waterways (eg. by bunding). Amelioration with lime may also be required.
4. **Control the release**
   - Control the release source (drain, etc). May be completed in conjunction with Item 3.
5. **Reclaim**
   - Reclaim released material and/or contaminated material where the impact is justified. Caution is to be applied around watercourses and with potentially acidic water/material and specialist advice may need to be sought.

The Site Environment Department shall commence an investigation into the reported AMD and may include visual inspections, soil and water monitoring and possible test pits. Where AMD is deemed likely, the Environment Department will engage a suitably

qualified consultant to advise on appropriate actions that may include sampling programs to determine if AMD is occurring as well as containment, mitigation and remedial actions to prevent further AMD impacts. The Environment Department should review the current Mining By-Products Management Plan, site practices and monitoring records. Management plans and site practices are to be amended as required.

Where an incident occurs that results in an emergency or incident which results in, or may result in, environmental harm or the release of contaminants not in accordance with the sites environmental authority, the administering authority must be notified in writing within 24 hours (EA Condition A8).

Furthermore, not more than 10 business days following the initial notification of an emergency, incident or information about circumstances which result or may result in environmental harm or the release of contaminants, or within 24 hours after receiving the results from analysed samples, written advice must be provided to the administering authority (EA Condition A9 and A10).

11. PERIODIC REVIEW & CONTINUAL IMPROVEMENT

This Management Plan will be reviewed every two years in addition to on an 'as needs' basis if mining by-product management issues arise. Reviews will include consideration of monitoring results. Any changes in operational practices will be incorporated into the documentation and communicated to responsible employees and contractors.

Suitable criteria to establish whether mining by-products management practices are effective are as follows:

- no complaints in relation to mining by-products management;
- full compliance with the requirements of this Mining By-Products Management Plan;
- no uncontrolled release of contaminated leachate; and
- continual improvement in mining by-products management practices.

Reviews will be undertaken by the Environment Department and/or specialist consultants and will include discussions with site personnel and contractors.

12. COMMUNICATION / TRAINING

All matters relating to Mining by-products must be referred to and managed by the MCPL Environment Department.

All relevant personnel employed at the Middlemount Coal Project will undergo training in relation to coarse rejects and tailings management.

13. REFERENCES

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MCPL's HSEC Standards

- Environmental Management Plan, Middlemount Coal Mine
- Environmental Authority Number EPML00716913
- SP-207-002 Water Management Site Practice
- SP-212-004 Mining By-Products In-Pit Disposal.
- MP-214-001 Regulated dams operational management plan
- MP-104-001 Emergency Preparedness and Response
- FR-212-003 – Mining By-Products Sampling Form
- Plan of Operations – as amended from time to time

14. RECORDS

All records associated with the Mining By-Products Management Plan will be maintained in a central location.

Records relating to this standard shall be maintained in accordance with MP-500-001 Document Control, Development and Data Management and SP-505-001 Records Management.

15. INDEXING AND KEYWORDS

Document Type	Vocation	Process	Regulation	AS4804
Management Plan	Mining	Exploration		Policy
SOP	Mechanical	Overburden		Planning
Site Practices	Electrical	Coal		Implement
Form	Technical	CHPP		Measure
Risk Assessment	Administration	Engineering		Review

16. RECORD OF REVIEW

Rev	Date	Revision description	By	Check	Approved
0	08.03.10	Draft	KH	PT	
1	08.05.10	Initial	KH	SS	SS
2	24.06.10	Name changed from Mining Waste Management Plan to Mining By-Products Management Plan	AC	SS	SS
3	02.08.10	Inclusion of reference to new SP-212-002 Coarse and Fine Rejects	AC	SS	SS
4	06.01.11	New logo	AC	SS	SS
5	21.08.13	Major revision. Inclusion of Geochemical characterisation work on mining waste, coarse rejects and tailings	GC	LW	
6	25.06.16	Update to include diagram of TSF 2 Flocculant Cells	LW	LW	
7	09.04.18	Review and update of Mining By-Products Management Plan by RGS Environmental	RGS	SF	

Revegetation Management Plan

Progressive Rehabilitation and Closure Plan

Prepared for Middlemount Coal Pty Ltd

Date: 23 June 2022

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23 June 2022

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Revision history

Revision	Author/Reviewer	Date	Status/Remarks[1]
0.1	L. McCallum / D. Waterson	01 November 2021	Working draft
0.2	G. Dale	15 November 2021	Approved for release
0.3	D. Waterson	16 November 2021	Issued for Client Review
0.4	L. McCallum / T. Roscoe	06 December 2021	Edits
1.0	L. McCallum	09 December 2021	Final
1.1	L. McCallum	26 May 2022	Revision for approval
2.0	T. Roscoe	30 May 2022	Final
2.1	L. McCallum	31 May 2022	Issued at Client Request awaiting finalisation.
2.2	L. McCallum	01 June 2022	Updated at Client Request awaiting finalisation
3.0	L. McCallum	23 June 2022	Final

1. Working draft; Draft for approval; Approved for release; Issued for Client Review; Final; Edits; Revision for approval; Issued at Client Request and awaiting finalisation, Updated at Client Request awaiting finalisation.

Distribution list

Date	Revision	Name	Title
16 November 2021	0.3	Middlemount Coal PL	-
16 November 2021	0.3	Resource Strategies	-
09 December 2021	1.0	Middlemount Coal PL	-
09 December 2021	1.0	Resource Strategies	-
30 May 2022	2.0	Middlemount Coal PL	-
30 May 2022	2.0	Resource Strategies	-
31 May 2022	2.1	Middlemount Coal PL	-
31 May 2022	2.1	Resource Strategies	-
01 June 2022	2.2	Resource Strategies	-
23 June 2022	3.0	Resource Strategies	

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Glossary

EM	Electromagnetic
EOPD	Eastern Out of Pit Dump
RE	Regional Ecosystem
MCM	Middlemount Coal Mine
MCPL	Middlemount Coal Pty Ltd
MSES	Matters of State Environmental Significance
PCRP	Progressive closure and rehabilitation plan
PMLU	Post mining land use
TEC	Threatened ecological community
TSF	Tailings storage facility
TFC	Tailings flocc cell
MIA	Mining infrastructure area
CHPP	Coal handling and preparation plant

1. Introduction

1.1 Background

The Middlemount Coal Mine (MCM) is an existing open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and approximately 3 kilometres (km) to the south-west of the Middlemount Township, Queensland (QLD). The MCM is owned and operated by Middlemount Coal Pty Ltd (MCPL), an incorporated joint venture between Peabody Energy Australia (Peabody) and Yancoal Australia (Yancoal).

On 27 May 2021, the Department of Environment and Science (DES) issued MCPL a transition notice requiring a Progressive Rehabilitation and Closure Plan (PRCP) for the MCM, to be submitted to the administering authority by 30 June 2022. The PRCP is to be prepared to meet the requirements of section 126C and 126D of the *Environmental Protection Act 1994* (EP Act) and the *Guideline – Progressive Rehabilitation and Closure Plans (PRC Plans)* (the PRCP Guideline).

Consistent with the requirements of section 3.6.1 of the *PRCP Guidelines* (DES, 2021) a Revegetation Plan is required to be prepared and included in the rehabilitation planning part of the PRCP.

1.2 Guideline Requirements

This Revegetation Plan has been prepared consistent with the PRCP Guideline, and the requirements under section 126C and 126D of the EP Act. The relevant sections of this Revegetation Plan, which satisfy these requirements, are provided in Table 1.

Table 1: Cross reference of Guideline requirements

Guideline Requirement	Section
Clearly articulate revegetation objectives for the site that are consistent with the Post mining land use (PLMU), Non-use management areas (NUMAs), and rehabilitation milestones identified in the PRCP schedule.	Section 3.1
Identify key flora species including pasture plants and tree and shrub species representative of the proposed PMLU.	Section 7.1.2
Identify any species of conservation significance relevant to the mine's approval.	Section 0
Identify any fauna habitat and use requirements - where fauna habitat is proposed, a management and monitoring plan to describe how the rehabilitated areas will be utilised by fauna and what other management measures would need to be implemented.	N/A
Include evidence and justification for any analogue sites of the monitoring plan.	Section 9.1
Describe the works for establishing and managing the revegetation, including a description of proposed site preparation and the timeframe for works.	Section 5.1 and Section 5.2
Identify what plant/seed mixes are appropriate for the PMLU and where the mixes will be sourced – locally sourced seed should be used where appropriate.	Section 7.1.2 and Section 7.1.3
Identify seed density application rate and timing of seeding.	Section 7.1.2
Identify the proposed location of any infrastructure required to protect revegetation.	N/A

Guideline Requirement	Section
Identify the growth media that would be suitable to sustain the PMLU and whether this is available on site.	Section 6.2.1
Identify topsoil depth requirements for revegetation success and sustainable PMLU.	Section 6.3

In addition to the above requirements, the following detail has been provided in this revegetation plan:

- Application and incorporation of ameliorants (if required for chemical balance) and bulk ameliorants such as gypsum, lime, and other organic materials.
- Spreading of a growth medium layer (topsoil, topsoil / rock mix, or suitable waste rock material, if appropriate) to a depth suitable for the target vegetation.
- Application of seed and fertiliser.

2. Site Details

2.1 Location

The MCM is an operational open cut coal mine located in the Bowen Basin (QLD), 3 km south-west of Middlemount and 90 km north-east of Emerald. The MCM is owned and operated by MCPL, an incorporated joint venture between Peabody and Yancoal. Operations at the MCM commenced in 2011 with an initial coal production of 1.8 million tonnes per annum (Mtpa) increasing to 5.7 Mtpa by 2016. Mining is undertaken at the MCM by conventional open cut strip mining using truck, shovel, and dozer operations. Coal is processed at the on-site coal handling and preparation plant (CHPP) and transported by rail to port for export (MCPL, 2020).

2.2 Climate

The MCM experiences a sub-tropical climate, with a hot and wet summer followed by a distinct dry winter (BOM, 2021). Average annual rainfall is approximately 600 millimetres (mm) per annum, with a distinct wet season occurring in the summer months, between November and March (Figure 1). Mean temperatures shown in Figure 1 indicate a hot summer (20 degrees Celsius [°C] to 40°C) and a mild winter (5°C - 25°C).

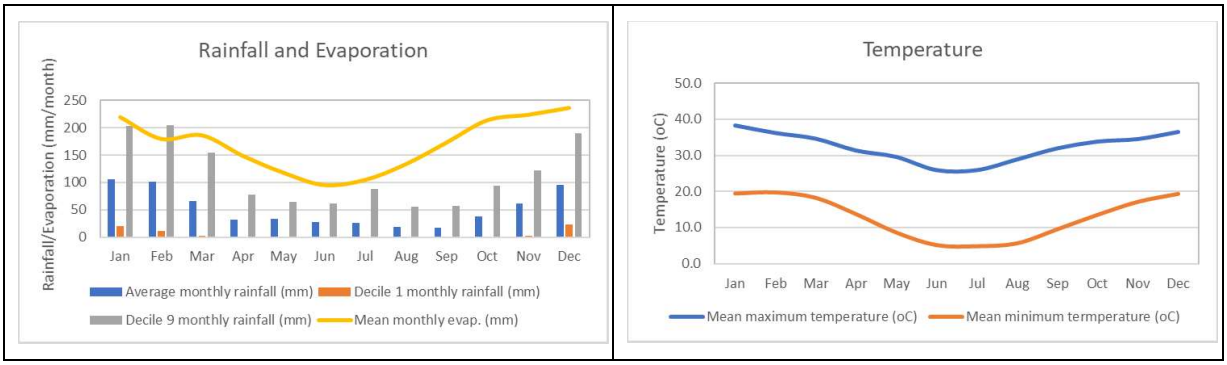

Figure 1: Average rainfall and temperature conditions (after BOM, 2021)

2.3 Pre-clearing vegetation

A broad bioregional description of vegetation communities on, and surrounding, the MCM includes narrow-leaved ironbark *(Eucalyptus crebra)* woodland on undulating plateaus, and bendee *(Acacia catenulate)* or lancewood *(Acacia shirleyi)* on the rocky hills and mesas.

Tertiary sediments are dominated by brigalow *(Acacia harpophylla)* and Dawson gum *(Eucalyptus cambageana)* communities on undulating clay or texture contrast soils. These communities dominate the Isaac-Comet Downs biogeographic sub-region.

Quaternary alluvium is also prominent with fine-textured soils carrying brigalow or coolabah *(Eucalyptus coolabah)* woodlands. Permian sediments are exposed in some areas, supporting grasslands, open woodland, and areas of brigalow (Sattler and Williams, 1999).

A total of 18 Regional Ecosystems (REs) have been recorded and ground-truthed within the MCM Mining Lease Boundaries (ML 70379, ML 70417, ML 700027 and ML 700014) and progressively refined through successive surveys since 2014. Ground-truthed REs are generally represented by Eucalypt woodlands and small patches of Acacia dominated woodland. Of the 18 REs, three are listed as Endangered, and six as Of Concern under the Vegetation Management Act 1999. These are:

1. 11.3.1b (Endangered) – *Acacia harpophylla* and/or *Casuarina cristata* open forest.
2. 11.3.2 (Of Concern) – *Eucalyptus populnea* woodland on alluvial plains.
3. 11.3.2b (Of Concern) – *Eucalyptus camaldulensis* (sometimes *E. populnea* and or *E. tereticornis*) woodland on drainage depressions.
4. 11.3.2c (Of Concern) – *Eucalyptus populnea* woodlands on floodplains.
5. 11.3.2/11.3.4 (Of Concern) – *Eucalyptus populnea* woodland on alluvial plains / *Eucalyptus tereticornis* and/or *Eucalyptus spp.* woodland on alluvial plains.
6. 11.3.7 – *Corymbia spp*. open woodland on alluvial plains.
7. 11.3.21 (Of Concern) – *Dichanthium sericeum* and/or *Astrebla spp*. grassland on alluvial plains. Cracking clay soils.
8. 11.3.25 – *Eucalyptus tereticornis* or *E.camaldulensis* woodland fringing drainage lines.
9. 11.3.25e – *Eucalyptus camaldulensis*, *E. tereticornis* woodland fringing larger, permanent water courses.
10. 11.3.27d - *Eucalyptus camaldulensis* and/or *E. tereticornis woodland.*
11. 11.4.9 (Endangered) – *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains.
12. 11.5.3 – *Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces.
13. 11.5.3b – *Eucalyptus populnea* woodland on closed depressions.
14. 11.5.9d – *Corymbia citriodora* and/or *E. crebra* woodland.
15. 11.5.18 (Of Concern) – *Micromyrtus capricornia* open shrubland on Cainozoic sand plains and/or remnant surfaces.
16. 11.7.1 – *Acacia harpophylla* and/or *Casuarina cristata* and *Eucalyptus thozetiana* or *E. microcarpa* woodland on lower scarp slopes on Cainozoic lateritic duricrust.
17. 11.7.2 – *Acacia spp*. woodland on Cainozoic lateritic duricrust. Scarp retreat zone.
18. 11.7.4 – *Eucalyptus decorticans* and/*or Eucalyptus spp*., *Corymbia spp*., *Acacia spp*., *Lysicarpus angustifolius* woodland on Cainozoic lateritic duricrust.

2.4 Species of conservation significance

2.4.1 Native vegetation

The MCM Southern Extension Project Environmental Values Assessment (EVA) (MCPL, 2020) identified two vegetation communities within the Approved Disturbance Footprint which conform to the threshold criteria to constitute forming threatened ecological communities (TECs) (i.e. Matters of National Environmental Significance [MNES]). Namely, Brigalow (*Acacia harpophylla* dominant and co-dominant) Endangered Ecological Community (Brigalow TEC) and Poplar Box Grassy Woodland on alluvial plains Endangered Ecological Community (Poplar Box TEC).

2.4.2 Fauna species

The EVA (MCPL, 2020) also identified four conservation significant fauna species that were recorded within the Approved Disturbance Footprint that constitute both Matters of State Environmental Significance and MNES:

- Koala (*Phascolarctos cinereus*) – listed as vulnerable under the *Nature Conservation Act 1992* (NC Act) and Vulnerable under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Greater glider (*Petauroides volans*) – listed as vulnerable under the NC Act and Vulnerable under the EPBC Act;
- Ornamental snake (*Denisonia maculata*) – listed as vulnerable under the NC Act and Vulnerable under the EPBC Act, and
- Squatter pigeon (southern subspecies) (*Geophaps scripta scripta*) – listed as vulnerable under the NC Act and Vulnerable under the EPBC Act.

3. Rehabilitation Considerations

3.1 Objectives

The primary revegetation objective for the MCM is to establish a self-sustaining vegetation cover suited to the target post-mining land use (PMLU) of mixed-use open woodland (Section 3.4). Revegetation, achieving the target PMLU, will assist in establishing a safe, stable, self-sustaining, and non-polluting landform consistent with the requirements of Condition G9 of the MCM Environmental Authority (EA) EPML00716913.

3.2 Vegetation community description

Vegetation communities selected for revegetation of the MCM will primarily utilise a species palette suited to achieving the target PMLU, such as grasses known for preventing erosion and also being highly palatable, as well as native shrubs and tree species found in the Middlemount region. Vegetation communities will be selected in consideration of the MCM's climatic conditions, typical chemical characteristics of disturbed soils in the Bowen Basin (e.g., salt tolerance capabilities) and also with respect to the new topography, aspect and drainage of the post-mining landscape. Native tree and shrub species will be planted in areas such as steep slopes and riparian corridors, to maximise biodiversity, ground stability, provide corridors for wildlife, shelter belts for stock (from sun and wind), aesthetic enhancement and other ecosystem services that will complement the PMLU of mixed-use open woodland.

3.3 Pre-mining land use

The predominant pre-mining land use over the MCM area was low density cattle grazing of native and modified pastures, Land Use Classification 2.1 and 3.2 (ABARES, 2016). Large areas of the pre-existing native woodland were historically subject to broadacre clearing for grazing. This is consistent with areas adjoining the MCM, and within the broader region in general, which has been extensively developed for beef grazing since the 1800's. It is likely that surrounding areas will continue to be used for the purpose of grazing of improved pastures, consisting of exotic and native grasses. Areas of remnant native shrubs and trees predominantly remain on ridges, in riparian zones and other areas that were difficult for graziers to clear.

3.4 Post-mining land use

The target PMLU for the MCM is mixed use open woodland. The target PMLU has been selected to achieve the rehabilitation objectives described in Section 3.1.

The MCM has six primary domains;

- in-pit and out-of-pit waste rock emplacement areas (includes the western and eastern emplacement areas);
- infrastructure areas (includes CHPP, haul roads, workshops, and associated other mine infrastructure activities);
- water management areas (includes mine water dams and sediment dams_;
- tailings storage facility (includes two flocculation cells);
- diversions; and
- residual voids (includes the northern and southern voids).

MCPL proposes that the majority of the MCM will have a PMLU of mixed-use open woodland, in association with other PMLUs including:

- Mixed use open woodland;
- Grazing (retained water management infrastructure); and
- Native ecosystem.

3.5 Non-use management areas

There are two approved residual voids at the MCM, located in the north (i.e., North Void) and south (i.e., South Void) of the Approved Surface Disturbance Footprint. The North Void will be approximately 358 hectares (ha) in area and the South Void will be approximately 163 ha in area. The residual voids including high-wall and portions of the low-wall are all approved NUMAs.

The maximum slope of the residual void is as per Plate 1 below, and the maximum slope of the residual void low wall is 37° (1V:3H). Due to physical and safety constraints, natural recruitment of native species is recommended on the high-wall slopes where practicable.

Table 5 Recommended slope geometry for the final voids

Material	Overall Slope Angle (°)	Bench Height (m)	Berm Width (m)	Batter Angle (°)
Surficial Soils	20	NA	NA	NA
Weathered Permian	NA	30	25	55
Fresh Permian	NA	60	60	60

Table 6 Recommended slope geometry for lowwalls

Material	Overall Slope Angle (°)~	Max. Bench Height (m)	Berm Width (m)*	Batter Angle (°)
Lowwall CAT3 Spoil	27	40	12 to 25	37

~This is the maximumOSA allowed for lowwall designs

*The bench geometries maybe changed to satisfy the OSA, this include bench height and berm width

Plate 1: Residual Void and Longwall slope geometry

The high-wall and the low wall of the residual voids may be revegetated, where safe and practicable to do so, to improve stability. As residual voids form approved NUMAs neither will be used for grazing due to safety concerns for the cattle (i.e., the steep slopes).

4. Risk Assessment

4.1 Erosion risk modelling approach

4.1.1 Modelling overview

Erosion risk was assessed by applying the Australian Coal Association Research Program (ACARP) *Dispersive Spoil Decision Support Tool* (Dale et al., 2018a, 2018b, 2018c, 2021) (the model). This decision support system is built based on assessment of QLD and New South Wales (NSW) mine sites. The tool employs a Bayesian modelling approach. Bayesian modelling allows exploration of the conditional probability of an outcome given the prior probability or state of other interacting factors.

The ACARP *Dispersive Spoil Decision Support Tool* integrates the complex interaction of 104 variables. These are grouped into five sub-models:

1. climate (rainfall amount, intensity and timing);
2. waste rock material characteristics (chemical, physical, plus waste rock material amelioration interventions);
3. management practices (including landform design - slope, slope shape, slope length; and erosion mitigation – surface roughness, armouring, run-on controls, contours banks, etc);
4. vegetation management factors; and
5. tunnel initiation factors.

The model is structured around a standard risk assessment approach, where the risk of surface and tunnel erosion is quantified by combining assessments of:

- ***Vulnerability*** comprising the combination of inherent soil erodibility (resistance/susceptibility to erosion) landform design, soil and vegetation management practices that modify erodibility; and
- ***Exposure*** comprising exposure to erosive energy forces (cumulative rainfall, rainfall intensity, frequency, duration).

In this way, the model presents the outputs of surface erosion risk and tunnelling risk as a matrix of exposure by vulnerability in a similar manner to the intersection between likelihood and consequence in a conventional risk assessment matrix. In the absence of erosive forces, no erosion will occur. Conversely, a site that is highly vulnerable to erosion will not erode unless erosive forces are applied, or a site that has a low vulnerability to erosion will only be likely to erode when exposed to extreme erosive forces.

4.1.2 Modelling scenarios

A total of 11 treatment scenarios were explored using the *Dispersive Spoil Decision Support Tool* to determine the likelihood of surface and tunnel erosion (Table 2) and the changes over time. Each modelling scenario varied the treatments to ascertain changes in erosion. Topsoil treatment to address dispersive properties and nutrient deficiencies, and waste rock material amelioration to address dispersive properties. The variables utilised were:

- use of rock mulch;
- placement of topsoil;
- treatment of topsoil;

- waste rock material treatment depth (variable depths); and
- waste rock material treatment rate (variable rates).

Key differences between scenarios are summarised in Table 2.

Each of the 11 modelling scenarios listed in Table 2 was simulated:

- with no vegetation to reflect site conditions at the point of rehabilitation completion (i.e., pre-vegetation); and
- with target vegetation cover levels anticipated two years post rehabilitation (i.e., post-vegetation).

The pre- and post-vegetation scenarios enable exploration of the change in erosion risk over time.

Table 2: Erosion risk modelling scenarios

Amendment Scenario	1	2	3	4	5	6	7	8	9	10	11
Rock mulch	-	✓	✓	-	-	-	-	✓	✓	✓	✓
Placement of topsoil	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓
Treatment of topsoil	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Full exchangeable sodium percentage (ESP) treatment rate	-	-	-	✓	✓	-	-	✓	✓	-	-
Half ESP treatment rate	-	-	-	-	-	✓	✓	-	-	✓	✓
Waste rock material treated with gypsum to 300mm (full depth)	-	-	-	✓	-	✓	-	✓	-	✓	-
Waste rock material treated with gypsum to 150mm (half depth)	-	-	-	-	✓	-	✓	-	✓	-	✓

4.1.3 Modelling results interpretation

Unlike many other modelling approaches, Bayesian networks use probabilistic, rather than deterministic expressions to characterise the strength of relationships between variables. This allows Bayesian network models to integrate a range of data types (including expert opinion) where data are limiting, thereby facilitating identification of key knowledge gaps and enabling explicit analysis of uncertainty associated with potential management and/or environmental scenarios.

All data (both categorical and continuous) entered into a Bayesian model is reduced to a series of "states" or categories. Consequently, the output from a Bayesian model is the probability of each possible state. For surface gullying and tunnelling risk, the model output is the probability of each possible state or level of erosion severity classified as:

- Low;
- Medium;
- High; or
- Very high.

The specific probability of any state is less important than the relative probability of any given state between treatments and the other overall average of states. This is important as the minimum or maximum probability of low erosion is not 0% or 100% respectively. It is also important, as scenario modelling necessarily looks at the outcome of varying a small number of parameters while maintaining the majority of "background" conditions constant. Varying one of the background conditions will change the probability of each of the "treatment" outcomes. Hence, the relative change between treatment outcomes is more important than their specific probabilities.

4.1.4 Erosion risk modelling results

Verterra undertook modelling at the MCM in 2021 (Verterra, 2021) of a subset of soils located in the 2021 rehabilitation areas in the east of the MCM. Modelling in these areas indicated that the risk of high/very high surface erosion is decreased with vegetation establishment. This highlights the importance in establishing vegetation cover early in rehabilitation works at the MCM. It was also found that the risk of high/very high surface erosion was reduced in scenarios where the full depth of waste rock material was treated with ameliorants. Relative erosion risk by scenario is presented in Table 3 and absolute risk by scenario in Appendix 1.

Results indicated that across each scenario, the primary activity impacting the modelled tunnel erosion is the inclusion of ripping in scenarios where ameliorants have been included. Whilst ripping can provide benefits in terms of reducing compaction, ripping on the contour may lead to ponding and seepage resulting in tunnelling. Furthermore, deep ripping on rocky, dispersive profiles may result in dispersive material being brought to the surface, creating the opportunity for ponding and preferential flow paths. It can also create channels leading to preferential flow and ponding leading to tunnelling. Additionally, ripping when the soil profile is too dry may create open channels with the potential for seepage, ponding, and preferential flow paths following rain.

These modelling results indicated that treating the waste rock material chemistry to the full recommended depth was important and that the addition or omission of rock mulch had little impact on the surface erosion risk.

Table 3: Relative erosion risk of each amendment scenario

Scenario	1	2	3	4	5	6	7	8	9	10	11
Relative surface erosion risk (Pre-vegetation)	1.35	1.33	1.33	1.02	1.13	1.02	1.13	1.00	1.11	1.00	1.11
Relative surface erosion risk (Post-vegetation)	1.58	1.46	1.46	1.00	1.13	1.00	1.13	1.06	1.19	1.06	1.19
Relative tunnel erosion risk (Pre-vegetation)	1.00	1.18	1.18	1.36	1.46	1.36	1.46	1.36	1.46	1.36	1.46
Relative tunnel erosion risk (Post-vegetation)	1.00	1.17	1.17	1.35	1.45	1.35	1.45	1.35	1.45	1.35	1.45

4.2 Rock armour study

A study of the MCM undertaken by Landloch in 2019 relating to the erodibility and assessment of landform designs using rock armour (Landloch, 2019) indicated that achieving soil erosion targets, particularly at steeper gradients, was closely associated with sufficient vegetation ground cover. Furthermore, the Landloch study suggested that the rock:soil mix used in rock armouring required a layer thickness of 1.5 to 2 times the mean diameter (D_{50}) of the rock used (Landloch, 2019). It was also noted that the very steep slopes (>33%) required the addition of rock and a minimum of 40% vegetation cover for long-term stability. Additionally, it was recommended that while a topsoil-only approach could be successful, it should be restricted to gradients of less than approximately 16%.

5. Revegetation Strategy

The MCM rehabilitation strategy described below consists of five components:

- rehabilitation overview (this Section 5);
- soil management (Section 6);
- revegetation (Section 7);
- maintenance (Section 8); and
- monitoring (Section 9).

5.1 Revegetation approach

The revegetation approach for the MCM is consistent with the rehabilitation objective to attain a final landform that is safe, stable, self-sustaining, and non-polluting (Section 3.1), as well as the outcomes of site-specific studies undertaken by Verterra (2021) and Landloch (2019) (Section 4). Revegetation to achieve the target PMLU of mixed-use open woodland will be undertaken primarily through direct seeding. The recommended revegetation approach is to chemically ameliorate the waste rock material (substrate) and topsoil (growth medium) to conditions that will promote seed germination and sustain long-term vegetation growth.

Aligned with leading practice revegetation techniques, and based on previous site specific risk modelling and rock mulching studies (Sections 4.1.4 and 4.2), the proposed landform batters (with slope angles of less than or equal to 16%) would not require the application of rock mulch. Soils placed on slopes ≤16% may require amelioration to achieve chemical stability and germination suitability; specific soils will be analysed at an accredited laboratory to determine the required amelioration strategy. By not applying rock mulch to large areas of the MCM, greater consistency will be achieved between the revegetation approach and the target PMLU of mixed-use open woodland.

Slopes with angles > 16% require rock mulch to stabilise the landform.

5.2 Revegetation sequence

The revegetation sequence comprises the following 11 steps which are described in detail within Table 4 below:

1. Infrastructure Decommissioning and Removal.
2. Landform Establishment.
3. Spoil and Soil Characterisation.
4. Spoil Waste Treatment.
5. Growth Medium Application.
6. Final trimming of topsoil (areas of slopes <16%) or rock mulching.
7. Application of soil ameliorants.
8. Seed application plus harrow.
9. Application of cover mulch.
10. Monitoring.
11. Maintenance.

Table 4: Revegetation sequence and proposed timeframes

Step	Activity	Timeframe and optimal season
1. Infrastructure decommissioning and removal	Decommission and remove all infrastructure as per PRCP.	Prior to landform reshape.
2. Landform Establishment	Reshape of waste rock material dumps as per final landform design (e.g. Dozer Push), including implementation of drainage to residual voids and other erosion and sediment controls.	As soon as practicable after wet season (April – June).
3. Waste rock and soil characterisation	Sampling, Analysis, Amelioration Recommendation, and Seed Selection. Waste rock and soil sampling and analysis should be completed from the landform (prior to topsoil placement) and topsoil stockpiles. Historic data should not be relied upon. Sufficient samples should be taken and analysed to enable physical and chemical characterisation of the materials used in the rehabilitation process. This data is then used for erosion risk modelling, amelioration recommendations and species selection.	As soon as material is available to analyse (dry season). Early seed ordering enhances probability of acquiring the desired seed.
4. Waste rock material treatment	*In situ* waste rock material amelioration, spreading of ameliorants over reshaped landscape, ripping of ameliorants into waste rock material – ripping should not be deep enough to pull up large boulders from the surface.	As soon as practicable after analysis data available to inform amelioration recommendation (dry season).

Step	Activity	Timeframe and optimal season
5. Growth medium application	**Areas ≤16% slope** • Spread stockpiled topsoil. • Apply ameliorants (fertiliser, gypsum and/or organic matter) to dumped topsoil, where possible. **Areas >16% slope** • Truck and dump topsoil and rock mulch on upslope area of target rehabilitation area. • Apply ameliorants (fertiliser, gypsum and/or organic matter) to dumped topsoil, where possible. • Mix rock mulch and topsoil. • Push this ameliorated mixture down slope to spread topsoil.	In dry season. In sequence with, or immediately following waste rock material treatment
6. Final trimming of topsoil (<16%) or rock mulching	**Areas <16% slope** • Remove vertical rills and troughs created by downslope topsoil push by traversing grader or dozer across slope, when assessed as safe to do so. **Areas >16% slope** • Apply rock mulch.	In dry season. In sequence with, or immediately following growth medium application.
7. Application of soil ameliorants	Where it has not been possible to apply and mix ameliorants before the topsoil push, it is recommended that this step is completed before final trim of topsoil and/or rock mulching. Additional detail on the soil amelioration process is described in Section 6.	In dry season. In sequence with, or immediately following growth medium application

Step	Activity	Timeframe and optimal season
8. Seed application plus harrow (very shallow incorporation)	Additional detail on the revegetation process is provided in Section 7. **Areas <16% slope** • Apply seed and harrow to incorporate seed to average depth of approximately 50 mm (Section 7.2) – this may be completed with a tractor mounted seeder, when assessed as safe to do so. **Areas >16% slope** • Apply seed over rock mulch using tracked equipment (e.g., dozer mounted seeder). • Note: ripping is not required after seeding over rock mulch.	Preferably immediately prior to wet season. In sequence with, or immediately following final trim of topsoil or application of rock mulch.
9. Application of cover mulch (if applicable).	**Areas <16% slope** • Apply cover mulch such as weed free hay or straw to defined rate. **Areas >16% slope** Note: cover mulch is not required after seeding over rock mulch.	Immediately after wet season.
10. Monitoring	Monitoring to ensure suitable growth/development of revegetation (Section 9)	Ecological monitoring: immediately after wet season and annually thereafter. Survival monitoring: initially and then at three, six and twelve-month intervals thereafter.
11. Maintenance	Maintenance to sustain revegetation (Section 10)	Immediately after monitoring has been completed

5.3 Treatment Zones

The MCM Final Landform has been stratified into Treatment Zones corresponding with landscape characteristics (such as slope) to allow for the application specific landform establishment approaches (Section 5.1) (Figure 2).

Each Treatment Zone will be revegetated through the general sequence described in Table 4, soil amelioration will be undertaken as per Section 6 and revegetation as per Section 7.

5.3.1 Treatment Zone 1 – Low slope areas (≤ 16%, 9°)

Treatment Zone 1 consists of all revegetation areas with low slopes (i.e., slopes of less than 16%) (indicated by green areas in Figure 2). The upper surface of the in-pit and out-of-pit waste rock (pale orange areas in Figure 2) are also included in Treatment Zone 1. This zone does not require rock mulch if the waste rock material (substrate) and topsoil is chemically treated for dispersive properties. Treatment Zone 1 includes portions of:

- in-pit and out-of-pit waste rock emplacements (both upper surface and slopes if ≤16%);
- rehabilitated infrastructure areas (including mine infrastructure area (MIA), CHPP, water storage infrastructure, and roads); and
- rehabilitated Tailings Storage Facilities and Tailings Flocc Cell (i.e., Flocc Cell [FC]1and FC2).

5.3.2 Treatment Zone 2 – High slope areas (>16%, 9°)

Treatment Zone 2 consists of all revegetation areas with high slopes (i.e., slopes of greater than 16%) (indicated by dark orange areas in Figure 2), noting this zone does not include the high-walls and some portions of the low-walls for the residual voids (refer to Treatment Zone 4).

Treatment Zone 2 requires the addition of rock mulch to stabilise the steep slope and includes portions of in-pit and out-of-pit waste rock emplacements (where slope >16%)

5.3.3 Treatment Zone 3 – Riparian areas

Treatment Zone 3 consists of all revegetation areas associated with creek diversions (blue area adjacent to the blue creek line shown in Figure 2). This includes:

- Roper Creek Diversions 1 and 2; and
- Thirteen Mile Gully Diversion.

5.3.4 Treatment Zone 4 – Non-use Management Areas

Treatment Zone 4 consists of the residual voids at end of mine life (i.e., approved NUMAs as described in Section 3.5). This includes residual void:

- equilibrated void waterbody;
- high wall; and
- portions of the low wall.

Revegetation of the low walls and high walls will be undertaken, where safe and practicable to do so, to stabilise the landform (consistent with the approach for Treatment Zone 2 [i.e., slopes >16%]). Where revegetation cannot be facilitated, it will occur by natural recruitment, and will drain internally to the residual void, to prevent sediment leaving site. The NUMAs will not be used for grazing and will therefore not form a PMLU.

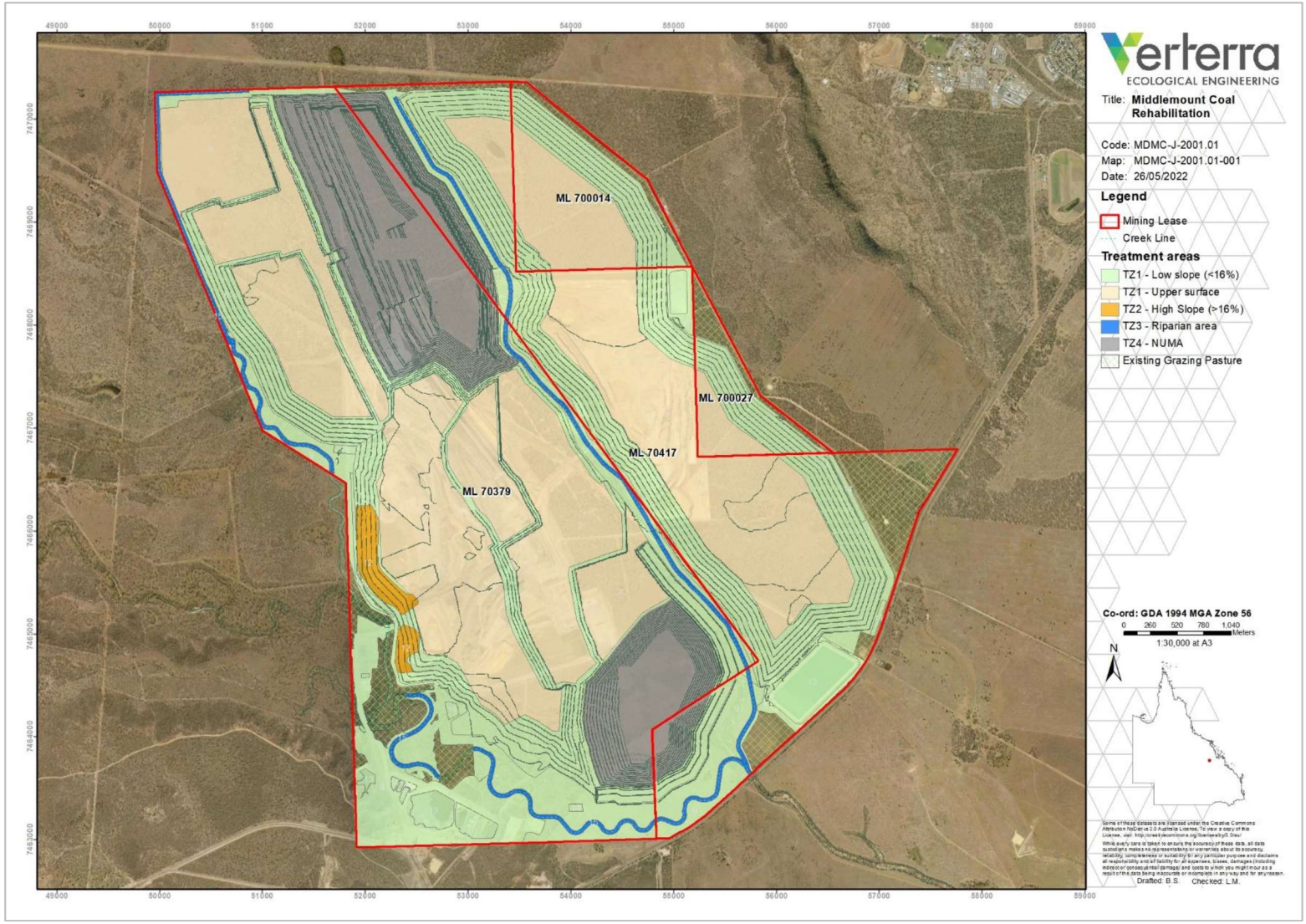

Figure 2: Treatment Zones

5.4 Rehabilitation Areas

The MCM final landform has been further stratified into Rehabilitation Areas (RAs). RAs consider the relevant Treatment Zone (described Section 5.3) and additionally consider the underlying mining domain prior to rehabilitation. RAs will assist in informing the rehabilitation success criteria required to progress through the rehabilitation sequence (Section 5.2). RAs at the MCM are as follows (Figure 3):

- RAs 1, 2, 3, 4, 5, 6
    - Mining Domain: Waste Rock Emplacement.
    - Treatment Zone: Zone 1.
    - PMLU: Mixed use open woodland.
- RAs 7, 8, 9, 10, 11
    - Mining Domain: Infrastructure Area (including MIA and TSF).
    - Treatment Zone: Zone 1.
    - PMLU: Mixed use open woodland.
- RA 12 (slopes >16%)
    - Mining Domain: Waste Rock Emplacement.
    - Treatment Zone: Zone 2.
    - PMLU: Mixed use open woodland.
- RA 13
    - Mining Domain: Water Management Infrastructure (Mine Water Dams).
    - Treatment Zone: Zone 1.
    - PMLU: Grazing (retained water management infrastructure).
- RA 14
    - Mining Domain: Water Management Infrastructure (Sediment Dams).
    - Treatment Zone: Zone 1.
    - PMLU: Grazing (retained water management infrastructure).
- RA 15
    - Mining Domain: Creek diversion.
    - Treatment Zone: Zone 3.
    - PMLU: Native ecosystem.

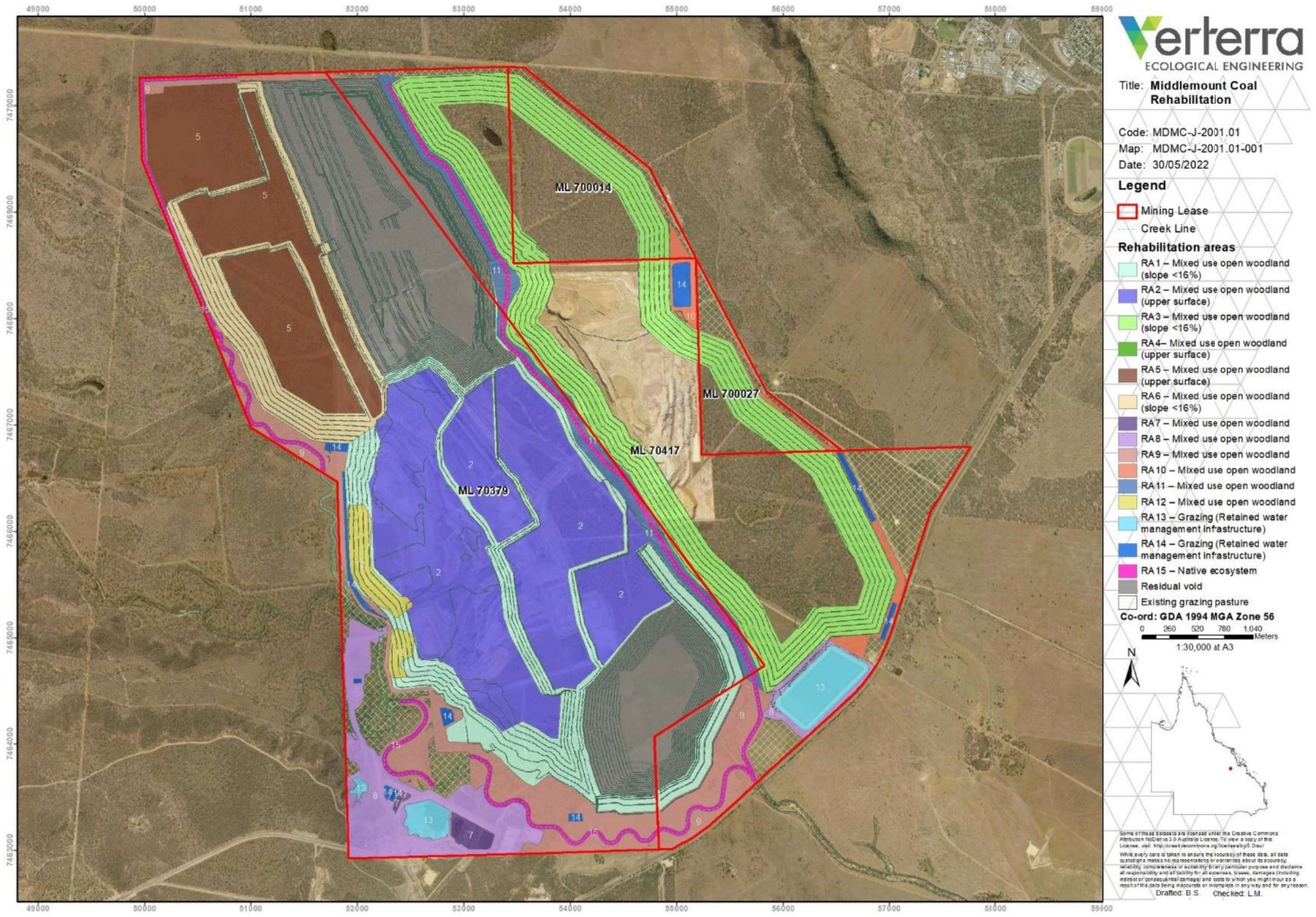

Figure 3: Rehabilitation Areas

6. Soil Management

6.1 Amelioration approach

In situ waste rock material should be treated prior to placement and spreading of topsoil material to enable incorporation of ameliorants to a greater depth than can be achieved after topsoil application. (Section 5.2).

Treated in situ waste rock material, which underlies placed topsoil, will provide a buffer to erosion and tunnel formation, particularly in the early stages of the rehabilitation sequence, prior to full exchange of gypsum in the growth medium and establishment of vegetation. This process will further improve the capacity of the underlying waste rock material to support vegetation root growth.

Treatment of waste rock material will involve the incorporation of gypsum prior to placement and spreading of topsoil. This approach of waste rock material amelioration aims to create a substantial depth of growth medium that contains waste rock material combined with topsoil and attains reduced dispersive properties.

Amelioration of topsoil material will also be undertaken to minimise chemical and physical properties, which may limit the establishment and growth of vegetation cover. Topsoil amelioration will involve:

- application of fertiliser to remove macro and micro-nutrient deficiencies;
- balancing nutrient ratios to ensure no induced deficiencies or toxicities;
- neutralisation of pH to ensure plant availability of in situ and applied nutrients;
- treatment of dispersive topsoil chemistry to reduce risk of erosion and improve topsoil structure; and
- organic matter to assist priming re-initiation of soil biological processes, including organic matter accumulation, soil particle aggregation, and nutrient mineralisation in order to improve soil water holding capacity, soil permeability, soil structure, resistance to surface crusting, resistance to erosion, and capacity to support healthy plant growth.

6.2 Waste rock material, topsoil chemistry and plant nutrition

6.2.1 Waste rock material and topsoil sampling program

To further inform the amelioration approach (Section 6.1) and input requirements, a soil sampling program (including laboratory analysis) should be undertaken for both the waste rock material and stockpiled topsoil material. Investment in laboratory analyses (Step 3 of the revegetation sequence, Section 5.2) may significantly reduce potential costs and/or reduce risk of future rehabilitation failure.

The nature of mine site rehabilitation, involving stripping and replacement of waste rock material and topsoil materials, may homogenise materials but, equally, often leads to placement of heterogenous materials, with significant changes in chemical and physical characteristics over short distances. Therefore, a comprehensive sampling program is required to identify spatial variability.

Where spatial survey data is available to provide an indication of the variability in waste rock properties (e.g., electromagnetic (EM) surveys, multispectral surveys), point-sampling is recommended given the capacity to correlate lab results with the spatial data, and capacity to use the spatial data to ensure representative sample collection across the range of variability.

When spatial survey data is not available, or not appropriate (as for topsoil stockpiles) composite sampling is recommended to provide a reliable representation of the relevant material on a sample number per unit volume basis.

All samples should be submitted to a National Association of Testing Authorities (NATA) approved laboratory and analysed for an agronomic suite of analytes (Table 5), noting that a different suite of analytes is required for topsoil and waste rock material samples. This suite of analyses and methodology are to inform agronomic requirements and do not address any contaminant assessment requirements.

Table 5: Agronomic nutrients for laboratory analysis

Suite/ Analyte	Parameter	Reference Method [1]	Topsoil	Sub-soil (Spoil)
Physico-chemical	pH (H_2O) & pH ($CaCl_2$)	RL Method 4A1	✓	✓
	Electrical conductivity	RL Method 3A1	✓	✓
	Texture	Field texture (Northcote, 1979)	✓	✓
Cations	Exchangeable Cations (Na, K, Ca, Mg) + CEC	RL Method 15D3 [2]	✓	✓
	Exchangeable Al	RL Method 15G1	✓	✓
Anions	Total Carbonate	RL Method 19A1	✓	✓
	Chloride	RL Method 5A2	✓	✓
Nitrogen	Ammonia-N (KCl)	RL Method 7C2a or 7C2b	✓	×
	Nitrate/Nitrite Nitrogen, NOx as N	RL Method 7B1	✓	×
	Total Nitrogen	RL Method 7A5 (Leco)	✓	×
Phosphorous	Phosphorus (Colwell)	RL Method 9B2	✓	×
	PBI	RL Method 9I2a or 9I2b	✓	×
	Total Phosphorous [3]	RL Method 9A3a or 17B1	✓	×
Sulphur	Sulphur (KCl)	RL Method 10D1	✓	×
Carbon	Organic Carbon	RL Method 6A1 (Walkley-Black)	✓	×
Trace Elements	Boron ($CaCl_2$)	RL Method 12C2	✓	×
	DTPA extract (Cu, Fe, Mn, Zn)	RL Method 12A1	✓	×

[1] "RL Method" reference: Rayment and Lyons, 2011.

[2] With correction for water soluble cations in the event EC1:5 is greater than 0.3dS/m.

[3] Optional. Only carry out if included in other analyses.

6.2.1.1 Waste rock material point sampling methodology

Where a spatial survey of waste rock material variation is available (e.g., EM survey, multi or hyperspectral survey), point sampling locations should be selected to sample the full range of survey variation. This will involve sampling at locations corresponding to each extreme of the survey data, and a roughly even distribution of samples corresponding to intermediate survey values. Sampling to achieve a mapping scale of approximately 1:25,000 is recommended (McKenzie et al., 2008), corresponding to a minimum of five samples, or one sampling point per 6.25 ha.

Where possible, point waste rock analysis data should be statistically correlated with spatial survey data, to allow spatial representation of the waste rock analysis results which, in turn, will inform site specific management.

6.2.1.2 Waste rock material composite sampling methodology

Where survey data to inform spatial variation is not available, a composite sampling methodology is proposed to average out variability at each sampling location.

Sampling to achieve a mapping scale of approximately 1:25,000 is recommended (McKenzie et al., 2008), corresponding to a minimum of five samples for analysis, or one sample for analysis per 6.25 ha.

To reduce the risk of bias and improve the likelihood of a representative sample, grid sampling is recommended. To achieve one sample for analysis per 6.25 ha, samples should be on a maximum grid of 250 metres (m) x 250 m.

Each sample for analysis should consist of a composite of five sub-samples. The first sub-sample of each sample for analysis should be at the designated grid location, and four other sub-samples should be collected from the corners of an imaginary square around this point at a distance of approximately 5 m.

When collecting sub-samples to compile a composite sample, an equal measure of soil (e.g., a 250 mm cup) should be collected at each sampling location and placed in a large container or bucket. When all the sub-samples for a bulk have been collected, the combined sample should be thoroughly mixed, and a suitable amount submitted to the laboratory for analysis (minimum 500 grams (g)).

Sample depth should be a minimum of 200 mm below the surface and preferably to 300 mm in the higher risk soils expected to be highly dispersive and requiring higher amelioration rates.

Where sample results indicate abrupt or disparate differences between adjacent samples, additional samples should be collected in the areas of disparity.

6.2.1.3 Stockpiled topsoil

The number of sub-samples required to make up a representative composite sample is informed by the size of the topsoil stockpile. Each topsoil stockpile should be treated separately as their origin is likely to be different. For a 95% confidence level, the New South Wales Environmental Protection Agency's (EPA) recommendations are presented in Table 6. This EPA guideline is informed by Australian Standards AS4481.1 and AS 4481.2 (Standards Australia, 1999, 2005). Section 579B of the EP Act provides for sampling under alternative methods defined in Australian Standards where an appropriate protocol has not been defined, such is the case in Queensland. Samples should be collected from at least 150 mm below the surface of the stockpile (EPA, 2009).

Table 6: Number of laboratory samples per volume of topsoil stockpile

Stockpile size	Number of sub-samples	Number of laboratory samples
< 2,500 m^3	1 sub-sample per 25 m^3 (a minimum of 10)	20–40 sub-samples = 1 lab (minimum 1 lab/stockpile)
> 2,500 m^3	1 sub-sample per 250 m^3	20–40 subsamples = 1 lab sample
Example: 5,685 m^3	23	1

6.2.1.4 *In situ topsoil*

If sampling of topsoil material is only possible after it has been placed over waste rock material, the sampling rate should be as per waste rock material sampling procedure (i.e. as per Section 6.2.1.1 where spatial survey data is available, and as per Section 6.2.1.2 where spatial data is unavailable). Samples should be collected to a depth of 100–150 mm below the surface to avoid mixing with underlying waste rock material.

6.2.2 Growth medium nutrient targets

After laboratory analyses are complete and the existing nutrient levels within the growth medium are known, amelioration rates can be calculated. Target ranges for each parameter are presented in Table 7 and are considered to be levels at which vegetation nutrient deficiencies are relieved and vegetation growth will be promoted (Hazelton and Murphy, 2017; Lambert and Turner, 2000; Noble, 1996; Baker and Eldershaw, 1993).

Table 7: Target ranges for growth medium nutrients

Suite/Analyte	Parameter	Units [1]	Target range [2]
Physico-chemical	pH (H_2O)	pH units	6.5–7.5
	pH ($CaCl_2$)	pH units	5.5–6.5
	Electrical conductivity	dS/m	*see ECe*
	EC (saturated extract) ECe	dS/m	< 2.0
	Texture	-	N/A
Exchangeable Cations	Exchangeable Sodium (Na)	cmol/kg	< 0.3 (<1% of cation-exchange capacity [CEC])
	Exchangeable Potassium (K)	cmol/kg	> 0.3 (1-5% of CEC)
	Exchangeable Magnesium (Mg)	cmol/kg	> 1.0 (10-15% of CEC)
	Exchangeable Calcium (Ca)	cmol/kg	> 5.0 (65-80% of CEC)
	Exchangeable Aluminium (Al)	cmol/kg	*Significant if pH < 5.5*
	Cation exchange capacity (CEC)	cmol/kg	> 12.0
	Exchangeable Sodium Percentage (ESP)	%	< 6.0
	Ca:Mg	-	4.0–6.0
Anions	Total Carbonate	mg/kg	N/A
	Chloride	mg/kg	N/A
Nitrogen	Ammonia-N (KCl)	mg/kg	> 3.0
	Nitrate	mg/kg	> 30
	Total Nitrogen	mg/kg	> 1,500
	C:N ratio	-	10–25
Phosphorous	Phosphorus (Colwell)	mg/kg	> 20
	PBI	-	N/A
	Total Phosphorous *(optional)*	mg/kg	N/A
Sulphur	Sulphur (KCl)	mg/kg	> 117
Carbon	Organic Carbon	%	> 1.0
	Organic Matter	%	> 1.7

Suite/Analyte	Parameter	Units [1]	Target range [2]
Trace Elements	Boron ($CaCl_2$)	mg/kg	1.0–5.0
	DTPA extract Copper (Cu)	mg/kg	> 0.3
	DTPA extract Iron (Fe)	mg/kg	-
	DTPA extract Manganese (Mn)	mg/kg	> 2.0
	DTPA extract Zinc (Zn)	mg/kg	> 0.8 (pH >= 7.0) > 0.5 (pH < 7.0)

[1] dS = 0.1 Siemens; m = metre; cmol = 0.01 mol; kg = 1 kilogram; mg = 0.001gram

[2] There are no target ranges for Texture, Total Carbonate, Chloride, PBI, Total Phosphorous, or DTPA extract Iron. They are included in Table 7 for consistency with Table 5.

6.3 Incorporation of ameliorants

6.3.1 Waste rock material amelioration

After sampling and analysis, waste rock material substrate should be ameliorated with the required rate of gypsum to reduce dispersive chemical characteristics. Two distinct layers of amended topsoil and waste rock material (herein referred to as amended subsoil) should be created, with a total depth of 500 mm. Assuming topsoil will be placed to a depth of 200 mm, 300 mm of subsoil should be amended with gypsum in the following sequence:

1. calculate gypsum rate from laboratory analysis and target ESP (Table 7);
2. spread gypsum on the waste rock material surface (prior to topsoil placement); and
3. incorporate to 300 mm:
   a. ripping with a bulldozer, or similar, with tynes spaced at 500 mm centres;
   b. ripping on the contour; and
   c. incorporate soon after spreading to avoid loss by wind or overland flow.

The aim of creating a layer of growth medium comprising of amended subsoil and topsoil in the upper 500 mm of the reconstructed profile is to resist erosion, particularly in the initial stages post rehabilitation when soil is bare, before vegetation is fully established, and while the rehabilitation is most vulnerable.

6.3.2 Topsoil amelioration

If sampling indicates that topsoil material requires the application of ameliorants (Section 6.2), the recommended sequence for topsoil amelioration and spreading is as follows:

1. spread topsoil;
2. apply gypsum and organic matter at rates calculated from topsoil testing/sampling and targets:
   a. harrow to the full depth (up to 200 mm) with offset disc harrows or similar; and
   b. harrow on the contour and avoid exposing dispersive subsoil;
3. apply fertiliser and seed together:
   a. integrate into topsoil with scarifiers or chain harrows (to a maximum of 50 mm depth), or tracking chains, which will assist with seed incorporation; and
4. if required to aid in water retention and erosion protection, spread hay or other weed free mulch across the surface, to a maximum depth of 50mm.

7. Revegetation

7.1 Revegetation requirements

Revegetation to achieve the target PMLU of mixed-use open woodland will be undertaken primarily through direct seeding. Tubestock planting may be used to augment direct seeding in the revegetation of the creek diversions, drainage lines, other areas that require rapid establishment of shrubs and trees to halt erosion, improve habitat and amenity value, or where grasses have established and broadscale seeding may cause more disturbance than targeted planting. If tubestock planting is undertaken, it is recommended that a detailed design plan is developed prior to revegetation as tubestock will require intensive maintenance.

To achieve rapid stabilisation of the growth medium, to assist with progression to mixed use open woodland, a successional seed mix is required. Such a mix should include:

- a fast-establishing cover crop species;
- a deep-rooted legume to bind the soil and contribute nitrogen;
- improved pasture grass species comprising a mix of species with a stoloniferous habit to stabilise the landform and rapidly cover bare areas, as well as species with a tussock habit to provide palatable grass for grazing and increase capacity to accumulation of soil organic matter;
- native tree species; and
- native grass species.

7.1.1 Revegetation timing

For the majority of the MCM revegetation process, dryland seeding is proposed, with no manual watering activities or irrigation planned to promote soil moisture and sustain vegetation growth. Therefore, it is important to time the seeding to coincide with expected optimal rainfall and an established soil moisture profile. Given the scale of areas to be revegetated, and the appropriate reshaping and topsoil spreading during the dry season, it will be necessary to ameliorate and seed immediately prior to the wet season (September to November, Figure 1). Noting that winter dryland seeding should be avoided as average winter rainfall (Figure 1) is insufficient to support revegetation establishment.

As native seed procurement has a long lead time and requires adequate seed storage facilities (i.e., controlled conditions) the timing of supply or re-supply and application of native seed is important to reduce on-site storage requirements. As the MCM currently lacks adequate on-site native seed storage facilities, procurement timing and storage capability should be considered when scheduling rehabilitation works prior to the wet season.

7.1.2 Seed mix

Based on the target PMLU of mixed-use open woodland, the recommended proportion of seed by species lifeform is shown in Table 8 and candidate species for each lifeform are shown in Table 9.

Table 8: Seed mix proportion by stratum/lifeform

Stratum	Treatment Zone 1 (Slope ≤16%)	Treatment Zone 2 (Slope >16%)	Treatment Zone 3 (Riparian)	Treatment Zone 4 (NUMA)
Target application rate	35kg/ha	55kg/ha	20kg/ha	Nil [1]
Cover crop	28.5%	33.0%	25.0%	-
Non-native grass	43.0%	45.5%	25.0%	-
Pasture legume	11.5%	-	5.0%	-
Native grass	14.0%	18.0%	20.0%	-
Native tree and shrub	3.0%	3.5%	15.0%	-
Native sedge	-	-	10.0% [2]	-

[1] Where portions of the low wall can be revegetated, but not grazed, revert to Treatment Zone 2 mix.

[2] Sedge species are important to riparian vegetation establishment but are sensitive to soil moisture content. There may be greater success if supplemented or replaced with tubestock planting.

Table 9: Candidate species suitable for inclusion in the revegetation seed mix for each lifeform

Scientific name	Common name	Recommended rate (kg/ha)	Target species number by stratum
Cover crops			
Echinochloa esculenta	Japanese Millet (summer)	5.0–15.0	1–2 species
Panicum miliaceum	White French Millett (summer)	5.0–15.0	
Avena sativa	Wintaroo Oats (winter)	5.0–15.0	
Hordeum vulgare	Barley (winter)	5.0–15.0	
Lolium rigidum	Annual ryegrass (winter-spring)	5.0–15.0	
Non-native grasses			
Bothriochloa insculpta	Creeping bluegrass	2.5–5.0	3–5 species
Bothriochloa pertusa	Indian bluegrass	4.0–6.0	
Cenchrus ciliaris	Buffel grass	2.5–5.0	
Chloris gayana cv Reclaimer	Rhodes grass (Reclaimer)	2.5–5.0	
Cynodon dactylon	Green couch	4.0–6.0	
Digitaria eriantha	Digit grass		
Melinis repens	Red Natal grass	1.0–3.0	
Urochloa mosambicensis	Sabi grass	2.5–5.0	
Legumes			
Clitoria ternatea	Butterfly pea	2.5–10	1–2 species
Desmanthus progardes	Progardes	2.5–10	
Stylosanthes hamata	Verano	2.5–10	
Stylosanthes scabra	Seca Stylo	2.5–10	

Scientific name	Common name	Recommended rate (kg/ha)	Target species number by stratum	
Native grasses (grazing)				
Bothriochloa bladhii	Forest bluegrass	1.0–3.0	3–5 species	
Bothriochloa decipiens	Pitted bluegrass	0.5–2.0		
Bothriochloa ewartiana	Desert bluegrass	0.5–2.0		
Cymbopogon refractus	Barbwire grass	0.5–2.0		
Dichanthium sericeum	Queensland bluegrass	1.0–3.0		
Enteropogon acicularis	Curly windmill grass	1.0–2.0		
Heteropogon contortus[1]	Black spear grass	0.5–1.0		
Panicum decompositum	Native millet	0.5–2.0		
Themeda triandra	Kangaroo grass	0.5–2.0		
Native trees/shrubs – Treatment Zones 1 and 2		**Recommended rate (g/ha)**		
Corymbia erythrophloia	Variable barked bloodwood	75–125	Priority species	3–5 species
Eucaluptus exerta	Queensland peppermint	25–75		
Eucalyptus microcarpa	Grey Box	25–75		
Eucalyptus melanophloia	Silver leaved ironbark	25–75		
Eucalyptus orgadophila	Mountain coolibah	25–75		
Acacia harpophylla	Brigalow	100–150		
Casaurina cristata	Belah	25–75		
Corymbia citriodora	Lemon-scented gum	50–100		
Corymia clarksoniana	Clarkson's bloodwood	75–125		
Corymbia dallachiana	Dallachy's gum	75–125		
Eucalyptus cambageana	Dawson River blackbutt	25–75		
Eucalyptus crebra	Narrow leaved ironbark	25–75		
Eucalyptus populnea	Poplar box	25–75		
Geijera parviflora	Wilga	50–100		

[1] Important to note that unless threshed and coated, *Heteropogon contortus* is very difficult to mix and can cause problems with spreading machinery.

7.1.2.1 Riparian vegetation

Vegetation located adjacent to creek diversions and drainage lines within the final landform would form riparian vegetation. Revegetation of riparian areas (Treatment Zone 3) requires a detailed design and implementation plan specific to the MCM, due to the variability in soil, adjacent vegetation and channel flow energy characteristics.

Riparian environments have a high level of risk associated with retaining soils in concentrated flow, which require integration of traditional controls, such as rock chutes, as well as advanced revegetation strategies, such as the application of suitable seed mix and/or planting of tubestock that are quick to establish with the aid of irrigation. Germination and sustained growth of the quick to establish vegetative erosion protection blanket is essential to ensure that the revegetation develops suitable root mass to reduce the risk of soil loss before the channel is exposed to erosive forces brought about by wet season rainfall.

Consistent with the above, creek diversions and drainage lines within the MCM final landform (i.e., Treatment Zone 3) would be rehabilitated to achieve the target PMLU of mixed use open woodland. However, as described above, riparian areas would require a quick to establish seed mix more suited to a riparian environment. Seed species required would vary from the toe of the bank to the overbank area and, while utilising some species noted in Table 9, seed mixes would require species such as:

- Native trees:
  - *Casuarina cunninghamiana* (River she-oak);
  - *Eucalyptus camaldulensis* (River red gum);
  - *Eucalyptus tereticornis* (Forest red gum);
  - *Melaleuca viminalis* (Dawson River bottlebrush); and
- Native sedge-rushes:
  - *Lomandra longifolia* (Spiny-head mat-rush);
  - *Cyperus exaltatus* (Tall flatsedge).

7.1.3 Seed quality

Seed should be sourced from reputable suppliers with documented quality control procedures. Germination and purity testing by a certified laboratory are desirable, but visual inspections by a suitably qualified person (e.g., agronomist or reputable seed supplier) would also be acceptable.

7.2 Seeding

7.2.1 Mechanical seeding

A range of tractor drawn, and dozer mounted seeding equipment can be utilised to sow seed. Final landform slope and roughness will determine the requirements for final site preparation and suitable equipment configuration. Beds prepared for seeding that have become crusted must have the surface broken up by scarifiers or coulter discs. Seed sowing delivery options include:

- mounted box seeders with GPS tracking and electronically metered seed delivery eg. Seabrook (preferred);
- direct drill air-seeders;
- drum seeders; and
- surface spreaders (e.g., Marshall spreader).

Each of the above options should also be integrated with scarifiers, harrows, or tracking chains, which will assist with seed incorporation. Seed incorporation to a depth of approximately 50 mm is desirable to ensure adequate soil moisture is attained before germination is initiated, and that seed is not too deep to penetrate the soil surface.

Seeding equipment should be capable of adjustment to:

- place seed at the recommended depth ensuring the seed is covered by topsoil, and
- achieve required application rate (Table 8).

Other forms of seeding, such as manual or hydroseeding, are less desirable due to their lower success rate in dry climates. Application of seed at the surface without incorporation into

topsoil/growth medium may result in germination following light rains, and subsequent failure of germinants, if there is inadequate soil moisture to sustain initial growth.

7.2.2 Irrigation

If practical, the vegetative erosion protection blanket of cover crop, stoloniferous grasses and legumes can be irrigated for at least six to eight weeks before the start of the wet season. This is to maintain soil moisture at field capacity and to significantly increase plant survival. MCM has a tropical climate, which experiences large variation between wet and dry season rainfall, resulting in low vegetation growth in the dry season, and high erosion risk in the wet season. Therefore, in specific high-risk areas, such as creek diversions and drainage channels, irrigation is required in the dry season, to establish vegetation prior to peak rainfall events.

7.3 Habitat creation

Given the high erodibility factors of the chemically problematic waste rock material and soil typical in the Bowen Basin, the primary objective of the revegetation component of the rehabilitation process is to rapidly establish a vegetation cover that will stabilise the post-mining landform, utilising ecological engineering in addition to more traditional rock mulching methodologies.

Once successfully established, the ecological erosion protection blanket of carefully selected cover crop, grasses and legumes will significantly reduce the risk of erosion soon after the first rains of the wet season. This cover crop has similar habitat values to the surrounding grazing land that is common in the Middlemount region and is a key component of the PMLU.

The MCM final landform will have anthropogenic slope and aspect components that have not previously existed at the MCM. These anthropogenic factors are likely to vary the suitability of the revegetated landscape away from the pre-mining upper stratum of vegetation species.

In the region surrounding the MCM, the geomorphology of the mesa landscape of the Peak Range National Park has different parent geology, however, similar slopes to those within the MCM final landform do occur. For this reason, tree species present in the Peak Ranges National Park, such as *Eucalyptus orgadophila* (mountain coolabah), *Eucalyptus exserta* (Queensland peppermint), *Eucalyptus microcarpa* (grey box), and *Eucalyptus melanophloia* (silver-leaved ironbark) have been selected in this Revegetation Management Plan.

Whilst it is not the objective of this revegetation plan, it is hoped that, given the necessary time for habitat connectivity to occur and hollows to form, that the inclusion of the abovementioned tree species in the post mining landscape of the rehabilitated MCM will offer habitat values capable of supporting woodland birds and native mammals known to have existed at the MCM prior to the commencement of mining (Section 2.4.2).

8. Rehabilitation Milestones

Table 10: Indicative revegetation milestones

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM1	Infrastructure Decommissioning and Removal	Zone 1	a) All services disconnected and decommissioned. b) Contaminated land and water (e.g. affected by hydrocarbons, metals, brine, etc) is treated to ensure consistency with upstream water quality characteristics, or removed off site. c) All wastes removed from site and lawfully disposed. d) All infrastructure water storages demolished and removed, unless agreed in writing by the landholders and relevant agencies. e) All haul roads and access tracks to be ripped and removed to reduce compaction unless agreed in writing by landholders and relevant agencies. f) Risk assessment undertaken to ensure that all infrastructure has been appropriately disconnected and decommissioned.	3 months
RM2	Remediation of Contaminated Land (Characterisation)	Zone 1 Zone 2	a) Detailed site investigation report, as required under the *Environmental Protection Act 1994*, completed. b) Contaminated and hazardous materials (e.g. PCBs, Mercury, hydrocarbon contaminated soils, Dioxins etc.) have been removed and appropriately disposed of or remediated. c) Hydrocarbon, heavy metal, or other contaminants are within allowable departmental limits, has been certified by an appropriately qualified person. d) A site suitability statement confirms the uses or activities for which the land is suitable and aligns to the approved PMLUs for the site. e) Validation testing confirms that contaminated soils have been removed or remediated.	3 months
RM3	Remediation of Contaminated Land (Waste Rock Material Treatment)	Zone 1 Zone 2	a) Site added to the Environmental Management Register, if required. b) Remediation of contaminated soil materials such as hydrocarbon has been undertaken as required. c) Validation testing confirms that contaminated soils have been removed or remediated. d) No acid rock drainage is occurring or has the potential to occur.	3 months
RM4	Landform Establishment (Capping, Development and Reshaping/Re-profiling)	Zone 1 Zone 2	a) Engineering and design plans for TSF and emplacement areas finalised. b) Tailings have settled before capping. c) Non-acid forming (NAF) waste rock or other identified capping materials such as clay will be compacted with suitable oxygen diffusion control properties to reduce the minimum encapsulation thickness. d) All major earthworks completed. e) Landform recontoured to conform with adjacent landforms. f) Out-of-pit coal emplacement slopes no greater than 10%, or up to 18.5% where rock mulch or other stabilisation controls are used. g) Infrastructure area slope angles do not exceed 5%. h) Slopes of >16% have been treated with rock mulch to assist with maintaining slope stability. i) Installation of contour or graded drains as per construction design which has been certified by an appropriately qualified person. j) Final voids certified by a suitably qualified and experienced person as geotechnically stable. k) Final landform is stable and has been certified by an appropriately qualified person.	6 months

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM5	Growth Medium Application (Surface preparation and application of ameliorants)	Zone 1 Zone 2	a) An assessment of soil health and suitability has been completed by an appropriately qualified person to confirm soil is suitable for target vegetation growth. b) Waste rock material ripped to a maximum of 300 mm depth via grader tynes or equivalent to incorporate gypsum (as required). c) Topsoil placed to a minimum depth of 200 mm, to achieve 500 mm of amended material. d) Topsoil amelioration and fertilisation process completed to minimise chemical and physical limitations of establishment and growth of vigorous vegetation cover. Approach involves the application of gypsum and organic matter prior to applying chemical fertiliser (as required) (target Nitrate as N: >30 milligram [mg] per kg [mg/kg], Phosphate (Collwell P): >20 mg/kg). e) Use of offset disc harrows, or similar, to harrow gypsum and organic matter into full depth (maximum 200 mm) and on the contour. Use of scarifiers or chain harrows (maximum 50 mm depth) to apply fertiliser and seed incorporation. No deep ripping of topsoil. f) Installation of fencing (if required) completed. g) Evidence, certified by an appropriately qualified person, that topsoil/growth medium has been spread to a suitable depth in rehabilitated areas to sustain the post mining land use. h) Amelioration of topsoil undertaken to minimise chemical and physical properties limiting establishment and growth of vegetation cover. i) For areas < 16 % slope, vertical rills and troughs removed, and topsoil applied to a minimum depth of 200 mm. j) Seed applied and harrowed to average depth of approximately 50 mm. k) For areas > 16 % slope, seed over rock mulch applied to a minimum depth of 1 m. l) Soil surface crusting occurs in less than 2% of the rehabilitated domain area.	3 months
RM6	Revegetation (mixed use[1] – grazing)	Zone 1	a) Direct seeding of cover crop and pasture species completed on relevant rehabilitation areas (seed mix proportions specified in Revegetation Management Plan). b) Use of tractor drawn, or dozer mounted seeding equipment to sow seed. c) Seed incorporated to a depth of approximately 50 mm to ensure adequate soil moisture is stored before germination is initiated and so that the seed is not penetrated too deep in the soil surface. Use of scarifiers, chain harrows or tracking chains to incorporate seed. d) Seed sourced from reputable seed suppliers with documented quality control procedures. e) Stock fencing to protect early stages of revegetation instalment. f) A minimum of 70 % vegetation cover is present, and evidence of generational succession of trees and shrubs is evident. g) Bare surface areas are not to exceed 100 m2 in area, and exceed a length of 10 m along slope, based on a five year average period.	12 months
RM7	Revegetation (mixed use open woodland)	Zone 1 Zone 2 Zone 3	a) Direct seeding of cover crop, pasture species and native vegetation completed (seed mix proportions specified in Revegetation Management Plan). b) Use of tractor drawn, or dozer mounted seeding equipment to sow seed. c) Seed incorporated to a depth of approximately 50 mm to ensure adequate soil moisture is stored before germination is initiated and so that the seed is not penetrated too deep in the soil surface. Use of scarifiers, chain harrows or tracking chains to incorporate seed. d) Seed sourced from reputable seed suppliers with documented quality control procedures. e) Germination and purity visual inspections by a certified professional undertaken (e.g., agronomist or reputable seed supplier). f) Stock fencing to protect early stages of revegetation instalment. g) Till along the contour with a tyned implement with tyne spacing no greater than 500 mm. h) Non-vegetation cover (stones, rock cover, litter, logs etc) does not cover greater than 30% of the total area. i) A minimum of 70% vegetation cover is present, and evidence of generational succession of trees and shrubs is apparent in rehabilitated areas. j) Pasture grass and woodland species are comparable in cover to designated vegetation reference sites.	12 months

[1] The proposed PMLU of mixed use open woodland comprises areas grazing surfaces, as well as open woodland, therefore two separate rehabilitation milestones have been implemented to account for the mix uses in revegetation (i.e. grazing pasture and grasses, and open woodland tree and shrub species).

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM8	Surface Conditions	Zone 1 Zone 2	a) No evidence of slumping and erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. b) Hydraulic and geomorphic characteristics of rehabilitated portions of Roper Creek (Diversion 1 and 2), and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of undisturbed sections of Roper Creek and Thirteen Mile Gully channels. c) Target ranges for chemical and physico-chemical nutrients are considered to be at levels in which plant nutrient deficiencies are relieved and plant growth is encouraged (refer to Revegetation Management Plan). d) Hydrocarbon, heavy metals or other contamination levels are within appropriate DES limits.	5 years
RM9	Achievement of PMLU to Stable Condition (mixed use – grazing)	Zone 1	**Safe:** a) Certification that slopes are safe and predicted to remain safe. b) Certification that the relevant specified cover thickness has been obtained. c) Evidence that any site contamination has been resolved and relevant measures implemented, resulting in removal of the site from the Environmental Management Register (if required). d) Receiving water system water quality monitoring results comply with EA EPML 00716913 or are comparable with upstream values, for an ongoing period of time. e) A Bushfire Management Plan developed in accordance with relevant Queensland Fire and Emergency Services is in place. **Stable:** f) Active erosion (t/ha/year) is less than 110% of the levels present in designated vegetation reference sites. g) Erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. h) No evidence of severe erosion[2]. i) Persistent groundcover greater than or equal to 70 % established as assessed against comparable reference sites. j) Evidence of effective pest management with pest species abundance being comparable to designated vegetation reference sites. k) Evidence of effective weed management with weed diversity and density being less than 110 % of baseline survey results and abundance being comparable to designated vegetation reference sites. **Self-sustaining land use:** l) Meets land suitability class 3[3] for beef cattle grazing. m) Assessed stocking rates in rehabilitated pasture areas are comparable to designated vegetation reference sites. n) Pasture grass species are comparable in cover and composition to designated vegetation reference sites. o) Pasture grass species show evidence of seed set, germination and emergence. p) Salinity levels of less than 2.0 dS/m in soil root zone or less than 110 % of designated vegetation reference sites. q) Cation exchange capacity levels are greater than 10 to 12 in soil root zone or less than 110 % of designated vegetation reference sites. **Non-polluting:** r) Hydrocarbon, heavy metal or other contamination levels are within relevant DES limits. s) Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for an ongoing period of time. t) Groundwater quality monitoring results comply with EA EPML00716913, for an ongoing period of time.	Up to 20 years

[2] Severe erosion has any of the following characteristics – Loss of surface horizons, root exposure, etc. (sheet erosion), >30 rills and/or any >0.3 m deep (rill / gully erosion); presence of tunnel erosion; or evidence of mass soil movement.

[3] Land suitability class should be measured at a landscape / paddock scale. It is recognised that the wider rehabilitated landform may contain small areas of Class 5 land.

Milestone Reference	Rehabilitation Milestone	Treatment Zone	Milestone Criteria	Approximate Timeframe
RM10	Achievement of PMLU to Stable Condition (mixed use – open woodland)	Zone 1 Zone 2 Zone 3	**Safe:** a) Certification that slopes are safe and predicted to remain safe. b) Certification that the relevant specified cover thickness has been obtained. c) Evidence that any site contamination has been resolved and relevant measures implemented, resulting in removal of the site from the Environmental Management Register (if required). d) A Bushfire Management Plan developed in accordance with relevant Queensland Fire and Emergency Services is in place. **Stable:** e) Rehabilitation area has remained stable when comparing photographs from successive monitoring events, for a period of at least five years post-mining. f) Active erosion (t/ha/year) is less than 110% of the levels present in designated vegetation reference sites. g) Erosion maintenance requirements are comparable to designated vegetation reference sites, for a period of at least five years post-mining. h) Nutrient cycling processes are comparable to designated reference sites which are representative of the PMLU. i) Pest species abundance comparable to designated reference sites. j) Weed diversity and density less than 110% of the levels present in the designated reference sites, for a period of at least two years. k) Vegetative material layer(s) (e.g. leaf litter) is evident and contributing to nutrient cycling and development of microbial mass. l) Hydraulic and geomorphic characteristics of rehabilitated portions of Roper Creek (Diversion 1 and 2), and Thirteen Mile Gully (Diversion) reviewed by a suitably certified person and confirmed that it is trending towards the hydraulic and geomorphic characteristics of undisturbed sections of Roper Creek and Thirteen Mile Gully channels. **Self-sustaining land use:** m) Assessed stocking rates in rehabilitated woodland areas are comparable to designated vegetation reference sites. n) Litter density comparable to vegetation reference sites. o) Declared weed species cover is comparable to designated vegetation reference sites. p) Tree and shrub species are comparable to designated vegetation reference sites. q) Tree and shrub species show evidence of flowering, viable seed setting, germination and emergence. r) Persistent cover greater than or equal to 70 % as assessed against comparable reference sites. **Non-polluting:** s) Hydrocarbon, heavy metal or other contamination levels are within relevant DES limits. t) Receiving water system water quality monitoring results comply with EA EPML00716913 or are comparable with upstream values, for a period of at least two years. u) Groundwater quality monitoring results comply with EA EPML00716913, for an ongoing period of time.	Up to 20 years
RM11	Retained Water Structures[4]	Zone 1	**Stable:** a) Certification of structural integrity. b) Water quality within the retained water structures is comparable with upstream values. **Non-polluting:** c) Water quality monitoring results comply with EA EMPL00716913 for an ongoing period of time.	2 years

[4] Retained water structures (i.e. water storage and water management areas) will be retained within the final landform and are not proposed to be revegetated, not withstanding, these areas will be rehabilitated to be safe, stable, non-polluting prior to the completion of rehabilitation activities (Section 3.5.7).

9. Rehabilitation Monitoring Program

The MCM Rehabilitation Monitoring Program will be implemented over the life of the MCM and designed to quantify revegetation success, track revegetation progress, identify and inform timely mitigation and/or intervention actions (e.g., supplementary seeding) for areas of revegetation that have not met the rehabilitation completion criteria for the domain.

The rehabilitation objective of the MCM is to establish a self-sustaining vegetation cover suited to mixed use open woodland, which is safe, stable, and non-polluting. To meet compliance requirements, and provide useful data on the sustainability and productivity of the revegetated landscape accurate, consistent, representative, and repeatable assessments of land and vegetation condition will be required.

MCPL currently undertakes rehabilitation monitoring and reports the outcomes in an annual report. The rehabilitation monitoring reports describe the state of the land prior to the reporting period (i.e., baseline state) and evaluates key indicators of long-term land conditions. This baseline state is then used to track rehabilitation progress and continual improvement against previous monitoring reports.

Additionally, MCPL should undertake further assessments of the condition of existing pasture used for grazing adjacent to the MCPL to provide a valuable benchmark to assess MCM rehabilitation progress and success against (Section 9.1). Benchmarks should be developed using similar and adjoining environments where grazing remains the predominant land use (i.e., analogue sites, Section 9.1).

With the emergence of higher resolution satellite-based remote sensing capabilities and Un-manned Aerial Vehicle (UAV) based spectral analyses, alternative approaches may complement existing ground-based surveys and enable non-biased, whole-of-landscape, assessments to be undertaken.

9.1 Analogue sites

It is recommended that the following three initial vegetation analogue sites (i.e., vegetation reference sites) should be established on land owned by MCPL. These sites are consistent with the PMLU of mixed-use open woodland.

The following sites are recommended (coordinates are provided in GDA94, MGA Zone 55):

- Analogue Site 01: 662883E, 7475606N (preclear RE: 11.5.3).
- Analogue Site 02: 664591E, 7468202N (preclear RE: 11.12.2).
- Analogue Site 03: 663833E, 7471263N (preclear RE: 11.3.25).

The above vegetation reference sites, in addition to the initial sites, may be established once additional areas of the MCM have undergone rehabilitation works and monitoring reports can provide data which can be compared to the initial three reference sites.

9.2 Performance indicators

Field surveys should be undertaken annually to measure success against performance indicators, with early intervention and additional remedial works key to the success of the revegetation work.

Relevant performance indicators include:

- vegetation groundcover and canopy cover;
- vegetation density and health;
- vegetation diversity and structure;
- in situ species recruitment (self-sustaining);
- signs of land disturbance, degradation, or erosion; and
- weed density and diversity.

Independent of any monitoring survey outcomes, remedial revegetation (e.g., seed re-sowing) may be required on revegetated areas up to the end of the revegetation maintenance period within any Treatment Zone if the following conditions are present:

- any contiguous bare area greater than 100 m^2; and/or
- any contiguous area of 200 m^2 with less than 65% groundcover.

If the above requirements are not met, it is recommended that these areas undergo remedial revegetation to achieve:

- a minimum ground cover of 65%; and/or
- a minimum vegetation survival rate in line with analogue survey sites.

The above thresholds provide guidance for vegetation management in all Treatment Zones.

9.3 Monitoring methodology and objectives

The establishment of a number of representative monitoring plots including photo points, within each treatment zone of the rehabilitated landform should be undertaken upon completion of revegetation work. Plots should be established at an intensity of one plot per 50 ha, with a minimum of at least three plots per landform/soil type/stratum.

Monitoring methodology should align with the current MCM Rehabilitation Monitoring Program, assessing at a minimum:

- Species richness by stratum (i.e., native tree, shrub, grass species)
- Ground cover distribution (i.e., the percentage of each cover type)
- Introduced/weed species
- Tree height
- Tree cover
- Stocking and survival (derived)

A number of reference sites, reflecting similar surface soil conditions to each zone (Section 9.1), must be included to ensure any external environmental influences outside the rehabilitation area, are reflected in on-site assessments and to provide a comparison for benchmarking rehabilitation success.

Outlined below are the parameters recommended for monitoring in addition to those outlined above:

- Ground level assessment:
  - Native and/or pasture species (ground cover) and growth phase - 3P grasses (i.e., palatable, perennial and productive), native grasses, legumes, low shrubs.
  - Ground cover density (e.g., isolated, sparse, mid-dense, dense) and distribution (even distribution, unevenly distributed).
  - Land surface ground cover, including organic material (litter), soil and rock.
  - Ground cover density (isolated, sparse, mid-dense, dense) and distribution (even distribution, unevenly distributed).
- Mid and upper strata assessment:
  - Understory layer, including species and density of shrubs and juvenile trees (0-3 m).
  - Native tree species, density, height greater than threshold in Monitoring Program).
  - Tree and shrub species diversity.
  - Land surface (sheet erosion, rills, gullies) and density (percentage of site).
  - Weeds (species listed in the Biosecurity Act 2014) and pest animal impacts (species and density).
  - Grazing pressure (species).
  - Other site impacts (e.g., fire, drought, periodic inundation).

9.4 Survival monitoring and supplementary seeding

Initial monitoring of the survival in seeded areas will commence immediately after the wet season to obtain baseline data and then at three, six and twelve-month intervals thereafter.

Ground cover will be used as a surrogate for survival. Using a 1 m^2 quadrat, evaluate the successful germination (ground cover) at five evenly spaced locations along a 100m transect. The transect is to be established, initially, at random within a newly rehabilitated area and then revisited at every assessment.

In alignment with Section 9.2, if ground cover averages less than 65% in the five transects after 12 months of growth, supplementary seeding may be required.

Survival monitoring need not be undertaken by an ecologist.

9.5 Monitoring schedule and reporting

Monitoring and associated reporting of revegetation areas should be carried out annually post wet season consistent with the current MCM Rehabilitation Monitoring Program.

The annual monitoring report should include the methodology used to collect the monitoring parameters recommended in Section 9.3, outline monitoring results including any identification of pest/weed species and describe the rehabilitation works undertaken since the last monitoring report. The monitoring report should be supported by maps, georeferenced photographs, remote sensing and/or data analyses, any unintended site disturbances, and any appropriate management or intervention recommendations.

10. Maintenance

10.1 Weed management

To maintain and preserve the quality of the revegetated pasture (once established) and as a general environmental duty of care, weed management is undertaken at the MCM. Through both the monitoring program (Section 9) and incidental monitoring, weed occurrence is noted, particularly when weeds of environmental significance are observed/recorded. Management activities include:

- vehicle and machinery wash down before entering the rehabilitation works;
- monitoring and treatment of any significant infestations;
- revegetation occurring as soon as practicable in rehabilitation areas to minimise the emergence of undesirable weed species; and
- recording and mapping infestations/treatments.

10.2 Feral animal control

To maintain and preserve the quality of the revegetated pasture (once established), MCM has developed a feral animal management plan to monitor, and where necessary control, feral animals. Left unchecked, feral animals can mix with livestock and act as a vector for disease, destroy large areas of vegetation, cause soil erosion, and contaminate feed and water causing disease (Farm Biosecurity, ND). The following actions are included in the feral animal management plan:

- Protect feed and water sources.
- Regularly check and mend broken fences.
- Ensure any buildings are in good repair.
- Dispose of any carcasses properly and promptly.
- Work with neighbours and other producers in the area to implement a coordinated approach to feral animal control.
- Keep records as part of your control program.
- Refer to any Regional, State or National action plans.

10.3 Livestock management

Livestock should be excluded from areas undergoing active revegetation. If native trees are included with the pasture seed mix, these may require several years before they can tolerate cattle presence and browsing stress on the trees should be considered before allowing cattle access to the area. Livestock should be excluded from areas of unsuitable areas of revegetation through the use of fencing.

Once rehabilitation has been established there is benefit in allowing low density beef cattle grazing to occur in established areas, including nutrient recycling, stimulation of active growing phases and fire risk reduction. The following management options should be considered for keeping land in good condition with a high proportion and density of preferred groundcover species:

- manage total grazing pressure;
- use appropriate utilisation/stocking rates;
- implement appropriately timed spelling and herd management strategies;
- monitor pasture composition;
- use of hay, supplements, fodder trees and shrubs in a strategic manner;
- manage the tree/grass balance to avoid woodland thickening;
- implement forage budgeting strategies;
- use climate and seasonal forecasting resources;
- use appropriate fire management practices;
- fence according to land types; and
- manage the distance stock must travel to water.

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Appendix 1: Risk modelling results

Erosion risk modelling of a subset of soils located in the 2021 rehabilitation areas in the east of the MCM indicated that the risk of high/very high surface erosion is decreased with vegetation establishment (Verterra, 2021). It was also found that the risk of high/very high surface erosion was reduced in scenarios where the full depth of waste rock material was treated with ameliorants. Relative erosion risk by scenario is presented in Table 3 (Section 4.1) and absolute risk by scenario below.

MDMC-2002 Revegetation Management Plan_v3

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For Yancoal's Middlemount Coal Pty Ltd

Middlemount Coal Mine – Progressive Rehabilitation and Closure Plan Risk Assessment Report June 2022

Risk Mentor Pty Ltd
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1 EXECUTIVE SUMMARY

Middlemount Coal Pty Ltd (MCPL) operates the Middlemount Coal Mine (MCM) located approximately 7 kilometres (km) to the south-west of the Middlemount Township within the Isaac Regional Local Government Area, Queensland. MCPL operates the MCM in accordance with Environmental Authority (EA) EPML00716913.

On 27 May 2021, the Queensland Department of Environment and Science (DES), pursuant to section 754 of the *Environmental Protection Act 1994* (the EP Act), issued Ribfield Pty Ltd and MCPL a Progressive Rehabilitation and Closure Plan Transition Notice (PRCP Transition Notice). The PRCP Transition Notice requires the preparation of a Progressive Rehabilitation and Closure (PRC) Plan for the MCM that satisfies the requirements of sections 126C and 126D of the EP Act by 30 June 2022.As a component of the PRC Plan, MCPL is required to consider risks related to rehabilitation. This report has been prepared to describe the rehabilitation risk assessment process undertaken and to report the outcomes from the risk assessment.

The risk assessment team identified the following risk scenarios as having the potential to affect successful rehabilitation of the MCM:

- Market or other conditions leading to a move to care and maintenance or premature closure of the operation – which could compromise the ability to effect rehabilitation in line with community expectations.
- Problems with achieving a stable final landform arising from poor physical performance of rehabilitated dumps, dams, or slopes.
- Impacts on water off the site due to excursions of contaminated or sediment laden water flows.
- Decommissioning challenges leaving either contaminated or dangerous materials on the site after the conclusion of rehabilitation works.
- Impacts on ecology (flora or fauna) arising from failing to achieve the target landform and species mix on the site.
- Control related issues in Rehabilitation Management – related to insufficient resourcing or experience or inadequate execution of the works.

Control strategies are described in detail in Section 12.

A Risk Treatment Plan has been developed which describes the risk treatment measures or controls that are, or will be, implemented to reduce the level of risk for the identified potential risks/issues to levels that are As Low As Reasonably Practicable (ALARP) or tolerable to MCM.

The team understood that MCPL personnel will track and review the performance of the identified controls and, as required, update this Rehabilitation Risk Assessment Report with information on any modified controls. These processes should support an ongoing move to continuously conducting and improving rehabilitation works and rehabilitated areas on the site.

Mostly the controls noted in the Risk Treatment Plan are in place – although a number of follow up actions were identified and are presented in Table 1 below.

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Table 1 – Improvement Opportunities

Issue	Action (s)	Responsible	Status
MCPL.03.A Landform aspect not suitable for intended target plant species - not meeting required habitats for woodland fauna. With causes including the establishment of overly steep slopes (18.5 degrees may be too steep for ongoing leading practice works on site).	Review the inclusion of more realistic approaches. Apply ecological engineering principles to stabilise the landform - particularly angles of spoil dumps and void position/size.	A Heap	Underway MCPL is reducing rehab grades as much as practically allowable. For existing spoil dumps that had been dumped for 18.5% rebab grades, MCPL is achieving approx. 12.5% average grades for rehabilitation. This requires either significantly longer dozer push and or additional spoil dumping to assist with a reduced rehab grade. Also MCPL is using ecological engineering techniques of spoil chemical amelioration and topsoil chemical amelioration improvements with organic matter (compost), soil bacterial (compost/biosolids) and erosion and moisture retention with hay/straw mulching in an attempt to improve vegetation establishment, reduce raindrop erosion and improve stability.
	Identify suitable vegetation based on a digital landscape model - which will address both erosion as well as vegetation establishment (transition away from steeper slopes with rock mulch). Detailed geochemistry/soil chemistry to better characterise the terrain to support plant growth.	A Heap	Addressed in Revegetation Plan.
	Review topsoil management, covering landform design, creation and appropriate topsoil management to optimise outcomes from the topsoil stores.	A Heap	Ongoing through FY23.
	Seek approval for ongoing development of dumps at 10% batters (with rescheduled backfilling of final voids and use of 10% ramps as a natural guide for slope construction).	A Heap	This process is underway and ongoing.

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Issue	Action (s)	Responsible	Status
MCPL.03.C Tree species established along creek diversions are not suited to riparian environment.	Document the priority of diversion design in planning documentation - that is stress the diversion design and construction QA/QC for long term stability.	A Heap	To be completed during detailed design of diversion.
	Confirm and document the availability of clean water for irrigation of the diversions to promote long term establishment of advantageous species mix.	A Heap	To be completed during detailed design of diversion.
MCPL.03.D Inappropriate revegetation species mix for targeted final land use.	Confirm there is a documented transition plan for the post relinquishment land user - for management and maintenance requirements (stock movements and loadings to minimise erosion and loss of revegetated species).	A Heap	To be prepared in consultation with potential land user.
	Confirm the targeting of species that will suit a grazing PMLU.	A Heap	Addressed in Revegetation Plan.
MCPL.03.E Poor quality Topsoil available and spread in areas for revegetation (with contributing factors from relatively young site and limited understanding of requirements by operational teams).	Review the topsoil execution practices on site (better QA and understanding for avoiding stockpiling of poor quality sub-soil materials).	A Heap	Ongoing through FY23.
MCPL.04.J Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is mixed use ecosystem services and low density beef cattle grazing, with a mixture of grasses and native woodland – minimal infrastructure required.	Develop a transition plan for the post relinquishment land user – for management and maintenance requirements (stock movements and loadings to minimise erosion and loss of revegetated species). Consider soil carbon and conditioning elements of the transition plan (which is a market mechanism that will provide a revenue incentive as part of the transition to the post mining land holder).	A Heap	To be prepared in consultation with potential land user.

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Issue	Action (s)	Responsible	Status
	Confirm revegetation planning includes targeting of species that will suit a grazing PMLU.	A Heap	
MCPL.05.B Lack of availability and quality of seed resources.	Confirm species selection based on local species and a database of available items that could flourish on the site. The selection should consider Brigalow seed – as a key target for selection and establishment.	A Heap	Addressed in Revegetation Plan.
MCPL.05.I Adverse/less well understood geotechnical/geochemical issues associated with dumps and process waste storage facilities (e.g. tailings, reject emplacements, presence of sodic sub-soils) overburden and waste rock dumps etc.	Review the available soil data to confirm if the holdings are sufficient.	A Heap	Ongoing through FY23.
	Confirm/develop/document the site environmental processes and procedures provide an ongoing legacy for the site to maintain a knowledge base through to the completion of mining.	A Heap	Ongoing through FY23.
MCPL.05.P Adoption of inappropriate or inadequate rehabilitation techniques, timing and scheduling including allocation of the equipment fleet.	Reforecast rehabilitation execution program to produce a quality product in a wetter season and match schedules to what is achievable. Include the PRCP as part of critical decision making for MCPL (and potential for bringing in external providers to increase the pace of earthmoving activities).	A Heap	Ongoing through FY23.
	Document (and seek approval for) trials of leading practice revegetation techniques – flag the benefits of specialist contractors with appropriate equipment for spreading ameliorants, etc. Obtain ERM input on rehabilitation monitoring programs (with intended peer review from Verterra).	A Heap	Ongoing through FY22.
MCPL.06.B	Confirm that species selection and timing to minimise run off and growing period potential to provide cover for the cyclone season.	A Heap	Addressed in Revegetation Plan.

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Issue	Action (s)	Responsible	Status
Diversion of surface water runoff away from catchment areas.	Confirm that site erosion and sedimentation controls are documented and include soil amelioration and additional organic matter incorporation and placement of hay over the rehabilitated areas.	A Heap	Addressed in PRCP.

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2 DEFINITIONS

Table 2 provides guidance on terms used throughout this report.

Table 2 – Definition of Terms

Term	Explanation
ALARP	"As Low As Reasonably Practicable". The level of risk between tolerable and intolerable levels that can be achieved without disproportionate expenditure in relation to the benefit gained.
Aspect	A classification of risk normally applied to environmental matters. "Aspects" are best thought of as mechanisms of harm – or causes of loss. Typical aspects are: surface water contamination or loss; land changes; or fauna/flora changes. Each of these aspects produces a subsequent environmental "impact".
Causal Pathway	A term used to describe the "flow" of events beginning from a root cause and leading to an unwanted outcome. The flow is typically causes prevented from becoming incidents by preventative controls and incidents reduced in severity by mitigating controls which lead to different severity outcomes. A causal pathway is a cause *to* failed preventative controls *to* incident *to* successful mitigating controls *to* outcome.
Guideline	Abbreviation – Guideline – Progressive rehabilitation and closure plans, QLD Department of Environment and Science, March 2021.
Hazard	A thing or a situation with potential to cause loss.
HAZOP	Method of analysing mining operations, plant or processes to identify potential causes of incidents and prompt for required controls. Guidance on the method is available in AS/IEC 61882-2003 Hazard and operability studies (HAZOP).
Impact	A result of risk normally used when considering environmental matters. Impacts are the end result of the realisation of an "aspect". For example – surface water changes have an impact that includes loss of habitat for water dwelling fauna and flora.
Incident	A step in the causal pathway which describes the point at which control of pathway is lost. System required preventative controls have failed or been circumvented when an incident occurs. An incident is NOT a risk as it should not be described as a consequence.
Inspection	A regular check of workplace equipment, working environment and practices, to identify hazards and deficiencies.
Instrument	Term used to describe either statute, standards, policies or other legal or corporate document which imposes obligations on the site and the personnel filling roles in the organisation.
Issue	Is used in the document to describe any point raised by the team or in the risk review process generally. An issue can be any of cause, hazard, incident, control, outcome (risk), requirement, background information or general point related to the subject area.
MCM	Middlemount Coal Mine
MCPL	Abbreviation – Middlemount Coal Pty Ltd
NUMA	Acronym – Non-Use Management Area. An area of land the subject of a PRC Plan that can't be rehabilitated to a stable condition after all relevant activities for the PRC Plan carried out on the land have ended.
Personnel	Includes all people working in and around the site (e.g. all contractors, sub-contractors, visitors, consultants, project managers, etc.).
Practicable	The extent to which actions are technically feasible, in view of cost, current knowledge and best practices in existence and under operating circumstances of the time.
PRC Plan/PRCP	Abbreviation – Progressive Rehabilitation and Closure Plan.
Residual Risk	The risk associated with an unwanted event *after* consideration of the existing control measures is considered.
Review	An examination of the effectiveness, suitability and efficiency of a system and its components.

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Term	Explanation
Risk	The combination of the potential consequences arising from a specified hazard together with the likelihood of the hazard resulting in an unwanted event.
Risk Management	The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risk.
Risk Mentor	Risk Mentor Pty Ltd.
TSF	Abbreviation – Tailings Storage Facility. The location where fines from the coal handling and preparation plant will be/are deposited.

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3 INTRODUCTION

3.1 *Purpose and Scope*

On 27 May 2021, the Queensland Department of Environment and Science (DES), pursuant to section 754 of the *Environmental Protection Act 1994* (the EP Act), issued Ribfield Pty Ltd and Middlemount Coal Pty Ltd (MCPL) a Progressive Rehabilitation and Closure Plan Transition Notice (PRCP Transition Notice). The PRCP Transition Notice requires the preparation of a Progressive Rehabilitation and Closure (PRC) Plan for the MCM that satisfies the requirements of sections 126C and 126D of the EP Act by 30 June 2022.As part of preparing this plan, MCPL commissioned and completed a rehabilitation risk assessment workshop on 4 March 2021 involving a team of MCPL operational, technical and environmental staff and specialist consultants with knowledge of, and experience in, MCPL rehabilitation planning and implementation.

This report has been prepared to describe the rehabilitation risk assessment process undertaken during the risk assessment workshop and to report the outcomes from the risk assessment. The process is also intended to address the key requirements for a Risk Assessment in the PRCP Guideline.

The scope of the rehabilitation risk assessment workshop was to meet the guideline requirements to identify:

- the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks; and
- the risks of the NUMA causing environmental harm and not being safe and structurally stable and detail how the applicant intends to manage and minimise the identified risks.

Consistent with the *AS NZS ISO 31000:2018 Risk Management – Guidelines* the risk assessment workshop included:

- establishing the context including review of supporting information and objectives;
- identifying risks via several risk management techniques, including:
  - brain writing;
  - modified hazard and operability analysis; and
  - gap analysis against the issues contained in the Guideline;
- analysis of identified risks and nomination of key potential environmental issues; and
- ranking of the risks, including consideration of prevention and mitigation measures.

3.2 *Objectives and Deliverables*

The primary objectives of this report are to:

- use the risk assessment to identify items to be addressed in the MCPL PRC Plan (and other related environmental management plans, procedures and site processes);
- involve a cross section of MCPL personnel, key contractor representatives, subject matter experts, decision makers and key stakeholders in the issue (hazard) identification process;
- prioritise identified issues;
- identify recommended actions for follow up; and
- document the risk assessment process and the results.

3.3 *External Facilitation*

The risk assessment workshop team session was facilitated by Dr Peter Standish of Risk Mentor Pty Ltd – a company specialising in risk assessment and risk management processes.

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3.4 *The Team*

The rehabilitation risk assessment team met on 4 March 2021 via a Microsoft Teams conference call. A team-based approach was utilised to incorporate an appropriate mix of skills and experience to identify the potential issues/risks relating to successful rehabilitation of MCPL. Details of the team members and their relevant qualifications and experience are shown in Table 3. The team's goals were also captured at the start of the team session and the status of these is presented in the fifth column (Status) of the table below.

Table 3 – Team Members

Name	Role and Affiliation	Skills and Experience	Goals	Status
Joseph Flanagan	Environmental Project Manager - Resource Strategies	5 years' experience in environmental management	Gain a better technical understanding of the rehab at Middlemount	Achieved - good input from Adam and this will benefit the ongoing PRCP development
Tom MacKillop	Principal, Resource Strategies	12 years' experience in environmental management, Bachelor of Environmental Engineering and Science	Identify the opportunities to develop the strategic approach to improving rehabilitation conditioning at the site. Build up some good arguments to improve conditioning outcomes.	Issues identified - write up will help achieve. Putting forward the threats of current conditioned/approved approach identified and will be stressed in write ups.
Adam Heap	Environment and Community, Health, Safety and Training Manager - Middlemount Coal Ltd	12 years experience in mining industry. Bachelor of Environment and Urban Planning	Meet the requirements of the PRCP and identify any risks and gaps and additional controls required. Make it happen	Highlighted the limited current verification evidence - but the process has highlighted opportunities to address this and identified engagement opportunities to achieve with stakeholders
Laura McCallum	Senior Environmental Scientist - Verterra	11 years' experience in environmental science; bio-condition monitoring; ecology; environmental approvals; planning and permits; water use and salinity modelling for beneficial re-use CSG water; water modelling for irrigated cropping; soils modelling and monitoring. Bachelor of Science (Honours) Ecology, Environment and Conservation.	Understand more of the site context and where the PRCP will fit in and where Verterra will integrate with the whole	Covered off - site understanding has improved

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Name	Role and Affiliation	Skills and Experience	Goals	Status
Dave Waterson	Senior Environmental Scientist and Land Rehabilitation Specialist - Verterra	Over 17 years land management an erosion sediment control experience in the civil, mining and natural resources industry. Project Experience related to soil conservation, degraded land rehabilitation, erosion and sediment control, mine rehabilitation, water monitoring, environmental monitoring, environmental management planning and revegetation strategies. Masters Environmental Management (NRM); Bachelor of Applied Science (Protected Area Management); Associate Diploma of Applied Science (Marine Resources)	As for Laura and what we will be contributing to the Reveg strategy and identify any issues we're not currently aware of	Achieved goals - will be good to have data gathered which will highlight improvements going forwards
Michael Moore	Environment and Community Manager (Acting) - Yancoal	25 years' experience, BSc Honours Geophysics, MSc Environmental Management, MSc Groundwater Management Hydrogeology.	As for others - with key goals around sharing strategy and get the outcomes in line with what was achieved for Cameby	Enjoyed the session - but will have more time to focus on the next one
Megan Dawson	Coordinator, Environmental Standards (Corp E&C)	14 years' experience in mining industry (environmental approvals, consulting, geology). BA Environmental Geology.	As for Adam - plus validating the understanding of the existing risks and pick up on any new issues identified. Provide some corporate oversight and input knowledge from other projects	Covered off ok.
Toby Roscoe	Environmental Manager - Verterra	Experienced Environmental Manager with demonstrated history of innovating solutions to achieve environmental compliance in hard rock, coal mining and coal seam gas industries. Skills in environmental risk management, effective mine site rehabilitation, gas infrastructure rehabilitation, contaminated land rehabilitation, environmental monitoring systems, environmental compliance, project management, change management and environmental management systems. Bachelor of Science in Resource and Environmental Management.	Understand what Dave indicates we have available and identify inputs to the planning process and what risks we might be facing. Contribute from the knowledge base we already have to achieve a practical plan	Largely covered - some additional controls will need checking around landform design and geochem implications

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Name	Role and Affiliation	Skills and Experience	Goals	Status
Josh Peters	Initial meet and greet	18 years experience in environmental approvals and strategy for the mining industry. Formal environmental management qualifications and professional affiliations. Certified Impact Assessment Specialist by the Environment Institute of Australia and New Zealand.	As for Meg - support Yancoal's broader strategy and make sure learnings are transferred	Covered off ok.
Peter Standish	Facilitator	Over 35 years mining industry experience and facilitating risk assessments for over 15 years. Formal engineering qualifications and professional affiliations	Capture all the information from the team, confirm the level of rigour and that a valid process has been applied.	Steps along the way

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4 ESTABLISH THE CONTEXT

4.1 *Project Context*

The MCM is an approved and operating open cut coal mine located approximately 90 kilometres (km) north-east of Emerald and some 7 kilometres from the township of Middlemount in Queensland's Bowen Basin in the Isaac Regional Council (IRC) local government area (Figure 1).

The MCM is owned by Peabody Energy and Yancoal Australia and is operated and managed by Yancoal Australia Limited in accordance with Environmental Authority EPML00716913.

The MCM has been operating for approximately 10 years, with mining of overburden commencing in 2011. The coal handling and preparation plant (CHPP) was commissioned in November 2012, with first product coal railed in December 2012. Figure 1 provides an overview of the approved layout of the MCM.

The primary activities associated with the MCM include:

- open cut truck and shovel mining operations at a mining rate of 5.7 million tonnes per annum run of mine (ROM) coal;
- processing of ROM coal at the Coal Handling and Processing Plant (CHPP);
- disposal of waste rock, comprising of overburden and interburden, in-pit or in out-of-pit waste rock emplacements as mining progresses;
- disposal of coarse coal reject material within in-pit waste emplacements;
- temporary storage of fine coal reject material in existing tailings storage facility (TSF) cells for drying and reclaim for in-pit co-disposal;
- loading of product coal using rail loading infrastructure;
- transport of product coal via the existing rail system from the Middlemount Coal Mine to the Dalrymple Bay Coal Terminal, Abbot Point Port or Wiggins Island Coal Export Terminal for export;
- construction and operation of ancillary infrastructure in support of mining operations, including:
  - haul and access roads;
  - electricity supply and communications infrastructure; and
  - water management infrastructure;
- diversion of Roper Creek;
- development of soil stockpiles, laydown areas and borrow areas;
- 24-hour seven-days per week operations until 2044;
- peak operational workforce of over 500 personnel;
- ongoing exploration activities within mining tenements;
- other associated minor infrastructure, plant and activities, where required; and
- progressive rehabilitation, as well as ultimate rehabilitation of the entire Middlemount Coal Mine area once the site has been decommissioned.

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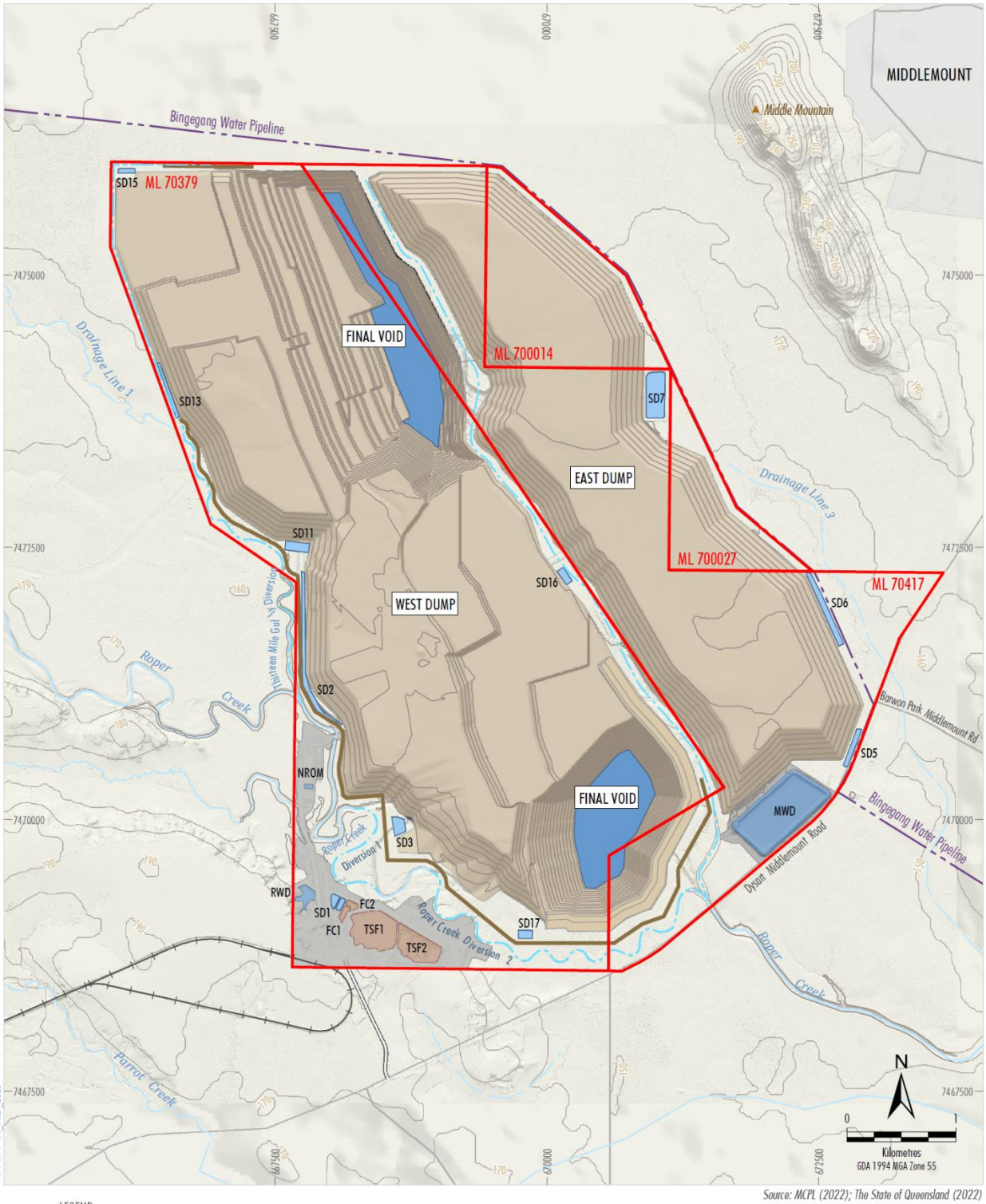
Figure 1: Approved General Arrangement



Source: MCPL (2022); The State of Queensland (2022)

LEGEND
- Mining Lease Boundary (ML)
- Mine Pit and Spoil
- Mine Infrastructure Area
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Middlemount Rail Spur and Loop
- Mine Access Road
- Diversion Structure
- Levee

middlemount coal PTY LTD

MIDDLEMOUNT COAL MINE
Project General Arrangement

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4.1 *Risk Assessment Context*

MCPL are required to prepare and submit a PRCP.

Rehabilitation risks are currently documented in a broad-brush risk analysis but an improvement opportunity to provide additional detail was identified by MCPL and is actioned in this study and report.

4.2 *Risk Management and Organisational Context*

The approved general arrangement shown in Figure 1 presents the intended location of each of the material streams generated and infrastructure items related to operation of the MCM.

Figure 2 describes the intended end state of the site. Key items in this figure are the location of the NUMAs (i.e. the final voids), with the remainder of the site being returned to light intensity grazing with areas of vegetation.

4.3 *Key Assumptions*

The identification of key assumptions is a critical part of the risk assessment process – forming the basis for many engineering/project decisions. It is important that these assumptions are validated and reviewed as part of the risk management process. Key assumptions applied during the risk assessment process were:

- the risk assessment relates to rehabilitation at MCM and covers all MCM areas, not just the main rehabilitation areas; and
- risk ranking was undertaken on the basis of consequences being in excess of approved levels and in consideration of preventative and mitigating controls.

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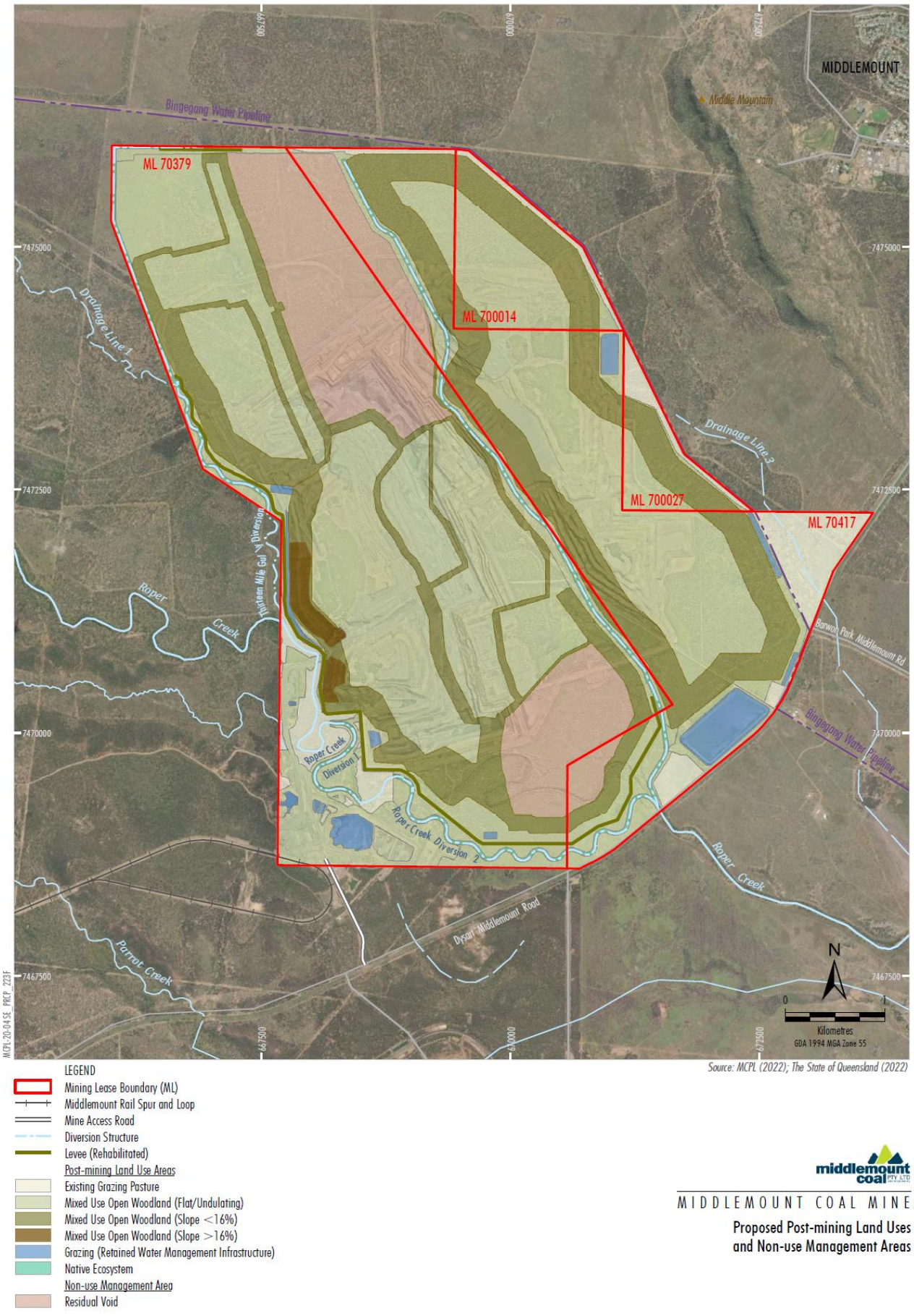
Figure 2: Post Mining Land Use and Non-Use Management Areas



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5 METHOD

5.1 *Key Steps*

The key steps in the risk assessment process were:

1. Background analysis on any existing rehabilitation issues at MCPL and potential risks to successful rehabilitation of the MCM.
2. Facilitation of a team-based analysis to evaluate and treat risks, comprising:
    a. an open discussion with the team on “what do we want to achieve” in relation to the analysis;
    b. presentation on the context for the risk assessment;
    c. brain writing to capture general issues identified by the team;
    d. modified HAZOP - reviewing an aerial photo view of the mine to identify potential mine features which could contribute to rehabilitation risk (included as a stimulus for team members during the brain-writing activity);
    e. development of a matrix of issues relevant to rehabilitation areas;
    f. risk ranking of the identified issues/risks shown in Table 4 later in this document;
    g. identification of planned (existing) controls and additional (required) controls to mitigate risk levels to a tolerable state; and
    h. generation of an action plan to facilitate implementation of the identified additional required controls.
3. Complete draft report to AS/NZS ISO 31000: 2018 standard for review and signoff from participating personnel.
4. Finalise the report and issue as a controlled copy for ongoing use.

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6 IDENTIFYING HAZARDS AND ISSUES

6.1 *Background Analysis of Documents*

The previous broad brush risk assessments and site context briefing were reviewed to determine the nature of specific threats to rehabilitation at the MCPL and the existing controls in place at the MCPL.

6.2 *Brain Writing*

Brain writing is a technique based on the work of Edward de Bono[1] (who built on the work of Alex Faickney Osborne) and is intended to promote creative thought amongst a group of people. As applied by Risk Mentor, the process involves:

1. Quiet reflection – where individuals write their thoughts on the subject onto paper or card(s).
2. Group discussion – with each person in the team taking a turn to read out one of their issues – and then refinement of each issue based on input from other team members who had similar items on their list.
3. Key word association (where relevant) to identify additional Issues for the risk register based on connection with the subject.

The team confirmed that all the issues identified in this brain writing phase were either addressed in the risk treatment analysis (Table 4) or have been referred to the Client (on the day of the team session).

6.3 *Modified HAZOP*

An aerial photograph (Figure 1 with and without the overlays) of the MCPL was used to identify existing rehabilitation areas and potential areas that may involve a risk to rehabilitation outcomes – with key word prompts connected with the various aspects of potential harm. The output from this process was added to the over-arching risk register from the team session (shown in Table 4 later in this report).

6.4 *Guideline Cross Map*

The main guidance information considered for the risk assessment comprised the elements presented in the Guideline. This requires the following key points be addressed:

- The reasons for selecting the treatment option (with each control having a nominated reason/purpose in Table 5 later in this report).
- Those responsible for approval and implementation of the plan (nominated roles in Table 5).
- Proposed actions (refer to Table 1 earlier in this report).

The additional points in the requirements around resource requirements, performance measures, reporting and monitoring, and timing and scheduling are intended for inclusion in the finalised PRC Plan in preparation at the time of this draft.

[1] De Bono, Edward – Six Thinking Hats. Penguin Books 2009 ISBN 9780141033051

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7 ANALYSE RISK

Analysis of identified issues requires the stakeholders to determine the risk that the identified threat poses to the organisation or the importance of the potential control. Risk is the product of the consequence and the likelihood of the event occurring with and without controls in place.

Risk analysis involves determining the consequences or impact of a potential event occurring in combination with the likelihood of that event occurring. The result is a "level of risk" defined by the following:

Level of Risk = Consequence x Likelihood

The elements of risk level determination are as follows:

1. Consider the causal pathway – the balance between the intensity and frequency of the cause(s) and the preventative controls in place to prevent them from becoming incidents.
2. Identify existing mitigating control strategies and tactics that act to minimise negative outcomes from an incident.
3. Determine the consequences of the outcome reached by the causal pathway using the ratings in Table 6– with a negative impact or an opportunity. Where appropriate, the causal pathway considered should identify the dimension upon which is impacted (e.g., outcome is related to harming people, natural environment, property, process continuity, etc.).
4. Determine the likelihood of the outcome being reached using the ratings in Table 6 – giving balance to the cause, preventative and mitigating controls for a negative consequence or positive opportunity occurring. Likelihood is defined as the product of the probability of the event occurring and the overall exposure to the event.
5. Estimate the level of risk of an outcome by combining the consequence and likelihood rankings using the risk matrix shown in Table 6.
6. Identify and consider any uncertainties in the estimates, validate these where appropriate.

This technique was applied to reach the risk scores shown in Table 4. Note that in some instances the risk levels were not scored – which flows from guidance including:

- Uncertainty – if the causal pathway cannot be clearly described – any estimation of risk levels would be misleading, and the matter should be referred as an action to the Client to determine the level of risk more clearly.
- Being Control Related – where an issue such as failing to follow a procedure or a detection system not functioning are identified. In this case it is impossible to generate a meaningful risk score, as it requires the combination of the probability of the control failing AND the causal pathway being "traversed" at the same instant in time – which is rarely assessable in a team environment.
- Being Undefined – where a causal pathway has no clear outcome and so no meaningful risk score can be assigned.

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8 ASSESS RISK

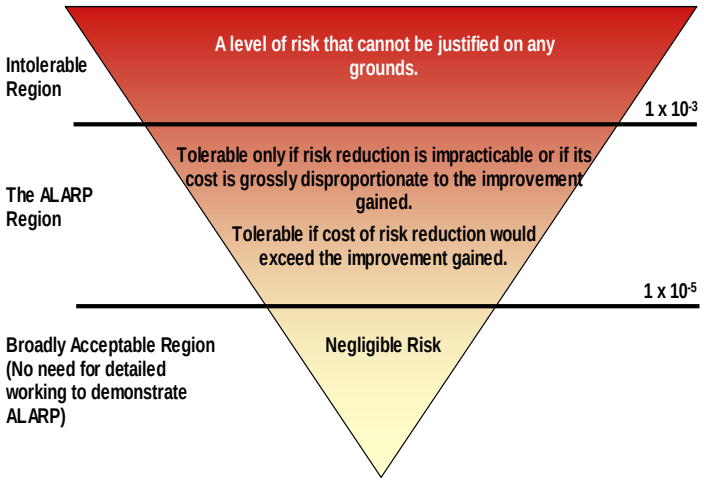
8.1 *Risk Acceptability and Risk Criteria*

The 'tolerability' of a risk is the willingness to live with a risk to secure benefits, on the understanding that the risk is being properly controlled (HB 203:2006 – *Environmental Risk Management – Principles and Process*). Legislation and good practice are targeted to reduce risk to "*As Low as Reasonably Practicable"* (ALARP). ALARP is often interchanged with "*As Low as Reasonably Achievable"* (ALARA).

The purpose of risk criteria is to allow the organisation to clearly define unacceptable levels of risk, or conversely the level of risk which is acceptable or tolerable. The risk criterion enables the organisation to prioritise actions proposed to control the risk during the risk assessment – leading to the development of the Risk Treatment Plan (Table 4).

The ALARP principle, as represented in the diagram below, was developed to assist in the definition of the acceptability of risk and to demonstrate that an organisation has done all that is practical in reducing the level of exposure to a risk. More often this is done qualitatively rather than as a quantitative probability as shown on the right-hand side of the diagram presented in Figure 3. A risk may be tolerable in the ALARP zone if the cost of removing the risk is disproportionate to the benefits gained.

Figure 3: Risk Criteria "ALARP"



8.2 *Risk Ranking*

The risk ranking likelihood, consequences, risk matrix and risk classifications considered by the team during the ranking process are outlined in Table 6 of this report. The teams considered cumulative impacts throughout all loss scenarios.

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9 TREAT RISKS

A systems approach to the treatment of risks involves consideration of three aspects:

1. Areas of Intervention (Prevention, Monitoring, Mitigation, Response/Recovery);
2. Wheel of Safe Production (Nertney Wheel); and
3. Sequence of Barriers (Hierarchy of Controls).

Additional information is provided in the Appendices, in Section 12.2.

A selection of controls to reduce the likelihood of the risks associated with the topic under review were made with due regard to their prospective reliability. That is, installing engineering modifications is a superior control to relying on operator training efforts. As part of the process, existing controls are assessed and recommendations for amendments or additions made where these existing controls are deemed unacceptable or inadequate.

Further, the prospective reliability of the controls identified as issues were also reviewed. These controls were qualitatively reviewed by considering their position on the hierarchy of controls, the ability to detect any deterioration in the control and the ability to mitigate this deterioration.

9.1 *Risk Treatment Plan*

The Risk Treatment Plan given in Table 4 shows the risk evaluation results.

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10 MONITOR AND REVIEW

10.1 *Nominated Coordinator and Report Review*

The nominated coordinator is the MCPL Health, Safety, Training, Environment & Community Manager. The coordinator should encourage all parties who attended the risk assessment team session to review this report and the identified hazards/issues – commenting as needed.

The nominated coordinator should also:

1. review the report to confirm the accuracy of the material recorded from the team session;
2. provide feedback to the parties who attended the risk assessment on any decisions which may be different from team expectations/recommendations raised on the day; and
3. monitor the completion of the additional actions to confirm there is close out of each action.

10.2 *Implementation of Risk Treatment Plan*

It is important to confirm the controls and actions identified are appropriately implemented and managed. The expectation of the team was that:

1. appropriate personnel would be allocated for implementation of recommended actions in a timely manner for completion;
2. any assumptions are validated; and
3. action items would be appropriately resourced and implemented.

MCPL managers can make modifications to the recommended actions, but these should be done in light of the risk management framework. Where a change is required, the basis for the change and a desktop review to assess if the risk of the underlying hazard remains tolerable is required.

It is also understood that the results from the risk analysis in this report would be incorporated into the MCPL PRC Plan.

10.3 *Communication and Consultation*

Communication and consultation form an integral part of the risk management process. It is the Client's responsibility to confirm that this report is shared with all participants involved in the process and other stakeholders as appropriate throughout the life cycle of the study subject area.

10.4 *Concluding Remarks*

A significant goal of the risk assessment process was to identify and analyse the rehabilitation related hazards/issues with rigour. The desired outcome was to prevent the identified hazards/issues from affecting successful rehabilitation of the MCM and to prevent losses to people, equipment, the environment, and consequential business, by evaluating the causal pathways and developing recommended controls for inclusion into an action plan.

This outcome was achieved by following the risk assessment process described within this document.

Ongoing review will be needed to implement and manage the additional required controls identified, and to ensure that subsequent risk management activities are conducted as required.

Dr Peter Standish would like to thank all personnel who arranged for the pre-session resources, team sessions and resources provided – and other team members who contributed to the risk assessment.

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11 REFERENCES

Department of Industry and Investment (2011) *MDG1010 – Minerals Industry Safety and Health Risk Management Guideline*.

Queensland Department of Environment and Science (2019) *Guideline: Progressive Rehabilitation and Closure Plans (PRC Plans)*.

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12 APPENDICES

12.1 *Risk Treatment Plan*

The following Risk Treatment Plan was developed by the team during the session on 17 September 2021.

Table 4 is presented in subject order.

The team identified control measures for the risks in Table 4 which are presented in full in Table 5. In line with the requirements of the PRC Plan guideline the issue being addressed is presented both in text form in the third column (addressing) and by specific items in the fifth column (Issues/Risks Covered).

Note that the coded values at the start of each control were entered by the author to assist in identifying the unique controls present on the site. There is some logic applied to these codes. Each of the controls related to a quality phase (Plan, Do, Check, Act) of Design (01D), Operation (02P), Supervisory Control and Data Acquisition (03S) or Abnormal Threat Response (04T). The controls are also related to different system aspects Personnel (R), Equipment/Built Items (E), Work Environment (V), Work Group Interaction (I), or System Optimisation (Y). Each logical grouping of these items is then numbered – so 01DV.01 is the first design control related to the environment identified in Table 4, etc.

12.2 *Assessment Basis*

Risks associated with successful progressive rehabilitation at MCM were considered by a review team of subject matter experts and site operational workers on 17 September 2021. The goal of the process was to describe credible hazards/issues and apply a risk ranking score to them. Table 6, drawn from the Yancoal Risk and Control Assessment Criteria appendix of the Risk Management Framework, was used during the risk ranking process.

Risks that were considered to be a result of controls failing could not be ranked during the team session and are flagged as such in Table 4. The basis here is that a failed control has an indeterminant outcome. For example, a failed fire extinguisher has no outcome unless there is a fire occurring. Maintenance and testing measures for the extinguisher are relevant – and would be stated as controls for these.

The potential for a fire is still a valid risk, however, and would be ranked (but separate to the specifics of the failed fire extinguisher).

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Table 4 – Risk Treatment Plan

Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.01.A	1	A	General	Insufficient resourcing (including skills and experience of rehabilitation personnel; funding for, or prioritisation of, rehabilitation activities; ongoing maintenance of rehabilitation requirements).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact (R) Impact on Reputation	01DV.06 - Reduced area for final rehabilitation 01DY.03 - Offset arrangements 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	Considers the reputation impacts related to failing to execute rehabilitation
MCPL.01.B	1	B	General	Lack of clearly defined responsibilities.	Rehabilitation inadequate, requiring further works.	(O) Asset Damage and Other (R) Impact on Reputation	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	
MCPL.01.C	1	C	General	Care and maintenance/premature closure.	Delayed rehabilitation.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	
MCPL.01.D	1	D	General	Poor monitoring records management, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PE.08 - Drainage minimises water reporting to voids on site 02PV.07 - Timing for access to rehabilitated areas 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	
MCPL.01.E	1	E	General	Inadequate consultation with key stakeholders.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	
MCPL.01.F	1	F	General	Change in Isaac Regional Council Planning Scheme.	Final land use no longer aligns with local planning scheme.	(E) Environmental Impact	01DV.06 - Reduced area for final rehabilitation 02PV.07 - Timing for access to rehabilitated areas 03SV.04 - Change management for rehabilitation 04TV.03 - Government rehabilitation bonds in place			**2**	**C**	**Moderate (6)**	**(6)**	
MCPL.02.A	2	A	Decommissioning	Generation of waste products from demolition process (e.g., conveyors, electrical substations, compressors, services [pipes/cables], stores, laydown areas, etc.).	Inappropriate disposal of waste products (e.g., at licensed disposal facility).	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols			**2**	**D**	**Low (4)**	**(4)**	Localised consequences, unlikely to occur

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.02.B	2	B	Decommissioning	Failure to remove all infrastructure that is not to be retained post-closure (e.g., services, infrastructure, roads, carparks, hardstand areas, concrete footings).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors			**2**	**D**	**Low (4)**	**(4)**	
MCPL.02.C	2	C	Decommissioning	Failure to remove all hazardous materials (e.g., carbonaceous material on the surface, hazardous wastes, other wastes).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 02PY.02 - Specific guidelines for hazardous chemicals 03SY.05 - Contractor Management Plan and Protocols			**2**	**D**	**Low (4)**	**(4)**	
MCPL.02.D	2	D	Decommissioning	Land contamination sites not successfully identified or remediated resulting in impacts to the environment.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols			**2**	**D**	**Low (4)**	**(4)**	
MCPL.02.E	2	E	Decommissioning	Failure of borehole or gas well seals.	Resealing of boreholes or gas wells required.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols 04TV.01 - Guidance on gas borehole decommissioning			**2**	**D**	**Low (4)**	**(4)**	
MCPL.02.F	2	F	Decommissioning	Lack of structural integrity of buildings and infrastructure to be retained in final land use.	Collapse/failure of infrastructure to be retained (e.g. dams).	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols			**2**	**D**	**Low (4)**	**(4)**	
MCPL.02.G	2	G	Decommissioning	Impacts on European/ historic heritage items.	Damage to heritage items. Prosecution.	(E) Environmental Impact	02PV.01 - Processes to identify all heritage items 02PV.02 - Site land disturbance permits 02PV.03 - Work is occurring within already disturbed footprints 03SV.01 - Database which tracks all known heritage items			**1**	**E**	**Low (1)**	**(1)**	Very limited extent of heritage items present and finding and damaging them would be rare
MCPL.02.H	2	H	Decommissioning	Impacts on Aboriginal heritage items.	Damage to heritage items. Prosecution.	(E) Environmental Impact	01DV.01 - Surveyed plans of all mine features 01DY.01 - Planning for decommissioning works 02PY.01 - Works conducted by suitable contractors 03SV.01 - Database which tracks all known heritage items			**1**	**E**	**Low (1)**	**(1)**	Very limited extent of archaeological items present and finding and damaging them would be rare

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.03.A	3	A	Ecology - flora and fauna	Landform aspect not suitable for intended target plant species - not meeting required habitats for woodland fauna. With causes including the establishment of overly steep slopes (18.5 degrees may be too steep for ongoing leading practice works on site)	Inability to meet post-mining land use criteria.	(E) Environmental Impact	01DV.10 - Selection of appropriate analogue and reference sites 01DY.02 - Revegetation plan (in line with PRCP). 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator. 04TV.02 - Internal reporting of any non-compliances	Action - Review the inclusion of more realistic approaches. Apply ecological engineering principles to stabilise the landform - particularly angles of spoil dumps and void position/size. Action - Identify suitable vegetation based on a digital landscape model - which will address both erosion as well as vegetation establishment (transition away from steeper slopes with rock mulch). Detailed geochemistry/soil chemistry to better characterise the terrain to support plant growth. Action - Review topsoil management, covering landform design, creation and appropriate topsoil management to optimise outcomes from the topsoil stores. Action - Seek approval for ongoing development of dumps at 10% batters (with rescheduled backfilling of final voids and use of 10% ramps as a natural guide for slope construction).	A Heap	**1**	**C**	**Low (3)**	**(3)**	Very minor impact – but could arise under current, approved landform
MCPL.03.B	3	B	Ecology - flora and fauna	Tree species established are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP). 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator. 04TV.02 - Internal reporting of any non-compliances			**1**	**C**	**Low (3)**	**(3)**	

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.03.C	3	C	Ecology - flora and fauna	Tree species established along creek diversions are not suited to riparian environment.	Rehabilitation inadequate, requiring further works and compromising long term stability of diversions	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP). 02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator. 04TV.02 - Internal reporting of any non-compliances	Action - Document the priority of diversion design in planning documentation - that is stress the diversion design and construction QA/QC for long term stability. Action - Confirm and document the availability of clean water for irrigation of the diversions to promote long term establishment of advantageous species mix.	A Heap	1	C	Low (3)	(3)	
MCPL.03.D	3	D	Ecology - flora and fauna	Inappropriate revegetation species mix for targeted final land use.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DY.02 - Revegetation plan (in line with PRCP). 01DV.10 - Selection of appropriate analogue and reference sites02PV.04 - Rehabilitation of appropriate species of vegetation 02PV.05 - Long mine life (>20 years) 03SY.01 - Monitoring and adaptive management programs 03SY.02 - Milestone and completion criteria 03SY.03 - Annual reporting of PRCP progress to the Regulator. 04TV.02 - Internal reporting of any non-compliances	Action - Confirm there is a documented transition plan for the post relinquishment land user - for management and maintenance requirements (stock movements and loadings to minimise erosion and loss of revegetated species). Action - Confirm the targetting of species that will suit a grazing PMLU.	A Heap	1	C	Low (3)	(3)	
MCPL.03.E	3	E	Ecology - flora and fauna	Poor quality Topsoil available and spread in areas for revegetation (with contributing factors from relatively young site and limited understanding of requirements by operational teams)	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan	Action - Review the topsoil execution practices on site (better QA and understanding for avoiding stockpiling of poor quality sub-soil materials)	A Heap	1	C	Low (3)	(3)	
MCPL.04.A	4	A	Final Landform	Unknown characterisation of spoil material.	Tertiary spoil material is highly susceptible to erosion which could lead to landform instability, landform failure and insufficient revegetation to meet PMLUs.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			2	D	Low (4)	(4)	Localised impact, unlikely to occur

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.04.B	4	B	Final Landform	Insufficient permian rock material for rock mulching and capping of relevant surfaces.	Landform instability, landform failure and insufficient revegetation to meet PMLUs.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control 03SV.06 - Rehabilitation management plan			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.C	4	C	Final Landform	Final landform instability (e.g. in and out of pit dumps, steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use.	Landform failure (public safety risk).	(P) Harm to People	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.D	4	D	Final Landform	Final landform instability (e.g. NUMAs, final voids, etc.) affecting post-mining land use.	Landform failure (public safety risk) and NUMAs causing environmental harm.	(P) Harm to People (E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.E	4	E	Final Landform	Final landform instability (e.g. steep slopes, erosion, highwalls, low walls etc.) affecting post-mining land use (e.g. due to insufficient amelioration of dispersive tertiary spoil and soils).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.F	4	F	Final Landform	Final landform unsuitable for final land use (e.g. large rocks present affecting cultivation, settlement and surface subsidence leading to extended ponding etc.).	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.G	4	G	Final Landform	Final landforms are not consistent with and do not complement the topography of the surrounding region.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.H	4	H	Final Landform	Erosion and failure of drainage and water management/storage structures.	Impacts on water quality and potential discharge.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	

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										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.04.I	4	I	Final Landform	Failure of the tailings storage facility over time.	Impact on surrounding landform and movement of tailings off site (Pollution of land or surface water by tailings).	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.06 - Capping of TSF 03SV.03 - RQP involvement in TSF design			**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.J	4	J	Final Landform	Lack of infrastructure to support intended final land use (e.g. dams, fences, watering facilities, etc.). Note: Intended final land use is mixed use ecosystem services and low density beef cattle grazing, with a mixture of grasses and native woodland - minimal infrastructure required.	Farm dams retained insufficient to support grazing and additional dams required.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control	Action - Develop a transition plan for the post relinquishment land user - for management and maintenance requirements (stock movements and loadings to minimise erosion and loss of revegetated species). Consider soil carbon and conditioning elements of the transition plan (which is a market mechanism that will provide a revenue incentive as part of the transition to the post mining land holder). Action - Confirm revegetation planning includes targeting of species that will suit a grazing PMLU.	A Heap	**2**	**D**	**Low (4)**	**(4)**	
MCPL.04.K	4	K	Final Landform	Landform (excluding final void domains) not free draining.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 01DV.03 - Geomorphic design protocols 01DV.04 - Factor of safety applied to designs 01DV.05 - Longitudinal study of erosion performance 02PV.06 - Erosion and sediment control			**2**	**D**	**Low (4)**	**(4)**	
MCPL.05.A	5	A	Rehabilitation Management	Loss of biological and habitat resources (e.g. subsoil, topsoil, vegetative material, seedbank, rocks, etc.) through clearing, salvage and handling practices.	High quality vegetation / habitat resources lost.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Note - these issues are control related - so are not ranked

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.05.B	5	B	Rehabilitation Management	Lack of availability and quality of seed resources.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.02 - External supplier of seeds 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan	Action - Confirm species selection based on local species and a database of available items that could flourish on the site. The selection should consider Brigalow seed - as a key target for selection and establishment.	A Heap					Control related
MCPL.05.C	5	C	Rehabilitation Management	Weed and pest control (or lack thereof), including damage from insects, plant disease, fauna and livestock.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.07 - Weed and Pest Control Management Plan							Control related
MCPL.05.D	5	D	Rehabilitation Management	Weather and climatic influences (e.g. drought, intense rainfall events/flooding, bushfire, etc.).	Damage or delays to rehabilitation, requiring further works.	(E) Environmental Impact	01DV.07 - Dump designs allow for rainfall events 02PE.08 - Drainage minimises water reporting to voids on site 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan							Control related
MCPL.05.E	5	E	Rehabilitation Management	Insufficient establishment or cover of vegetation due to high plant mortality.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan							Control related
MCPL.05.F	5	F	Rehabilitation Management	Overgrazing of pasture rehabilitation areas.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SY.04 - Third party agreements							Control related
MCPL.05.G	5	G	Rehabilitation Management	Vandalism to revegetation areas.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related
MCPL.05.H	5	H	Rehabilitation Management	Inadvertent or unauthorised access to rehabilitated areas by mining equipment and vehicles.	Damage or delays to rehabilitation (e.g. collapse of soil structure), requiring further works.	(E) Environmental Impact	02PE.03 - Site security, fencing, etc. 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related

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										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.05.I	5	I	Rehabilitation Management	Adverse/less well understood geotechnical/geochemical issues associated with dumps and process waste storage facilities (e.g. tailings, reject emplacements, presence of sodic sub-soils) overburden and waste rock dumps etc.	Failing to meet completion criteria, significant erosion and poor quality runoff/infiltration from rehabilitated surfaces effecting surface water and groundwater quality.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring	Action - Review the available soil data to confirm if the holdings are sufficient. Action - Confirm/develop/document the site environmental processes and procedures provide an ongoing legacy for the site to maintain a knowledge base through to the completion of mining.	A Heap					Control related
MCPL.05.J	5	J	Rehabilitation Management	Inadequate capping or removal of carbonaceous material.	Spontaneous combustion event.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan							Control related
MCPL.05.K	5	K	Rehabilitation Management	Availability of suitable materials for capping of hazardous materials and tailings.	Unable to cap due to lack of suitable material on site.	(E) Environmental Impact	01DE.01 - Tailings and dam designs and management systems 01DV.08 - Mine design considers carbonaceous material in dumps 01DV.09 - Mine plan makes allowances for rehabilitation of the TSF 02PE.01 - Flocculant use achieving a stiff tailings deposition 02PE.05 - Stockpiling rock material for use as an erosion control 02PE.06 - Capping of TSF 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PV.09 - Stripping and stockpiling procedures 03SV.05 - Topsoil management plan							Control related
MCPL.05.L	5	L	Rehabilitation Management	Insufficient spreading of topsoil (not to required thickness) and/or development of soil crusting.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related
MCPL.05.M	5	M	Rehabilitation Management	Availability of suitable topsoil for growth medium to support revegetation.	Rehabilitation inadequate, requiring further works/importing of topsoil.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related

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										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.05.N	5	N	Rehabilitation Management	Topsoil or rock/soil mixture (in particular for dispersive tertiary spoil) unsuitable as growth medium.	Rehabilitation inadequate, requiring further works such as additional treatment/amelioration.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related
MCPL.05.O	5	O	Rehabilitation Management	Substrate inadequate to support revegetation or agricultural land capability (e.g. lack of organic matter, nutrient deficiency, lack of soil biota, adverse soil chemical properties, exposed hostile geochemical materials, overly compacted, and any other factors impeding the effective rooting depth).	Soil quality insufficient to support revegetation.	(E) Environmental Impact	As for MCM.04.I 01DE.01 - Tailings and dam designs and management systems 02PE.04 - Gypsum remediation to improve run-off 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.08 - Water quality monitoring							Control related
MCPL.05.P	5	P	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation techniques, timing and scheduling including allocation of the equipment fleet.	Rehabilitation inadequate, requiring further works and potentially compromising position with Regulators.	(E) Environmental Impact (R) Reputation	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 02PY.01 - Works conducted by suitable contractors 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan 03SY.05 - Contractor Management Plan and Protocols	Action - reforecast rehabilitation execution program to produce a quality product in a wetter season and match schedules to what is achievable. Include the PRCP as part of critical decision making for MCPL (and potential for bringing in external providers to increase the pace of earthmoving activities). Action - document (and seek approval for) trials of leading practice revegetation techniques - flag the benefits of specialist contractors with appropriate equipment for spreading ameliorants, etc. Obtain ERM input on rehabilitation monitoring programs (with intended peer review from Verterra)	A Heap	**2**	**C**	**Moderate (6)**	**(6)**	Ranked to reflect relative severity of failing to implement effective rehabilitation on the site

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.05.Q	5	Q	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation monitoring to inform maintenance program.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.02 - Biannual environmental audits 03SV.04 - Change management for rehabilitation 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan							Control related
MCPL.05.R	5	R	Rehabilitation Management	Adoption of inappropriate or inadequate rehabilitation monitoring to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related
MCPL.05.S	5	S	Rehabilitation Management	Rehabilitation doesn't align with analogue/reference site, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	01DV.10 - Selection of appropriate analogue and reference sites 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SV.06 - Rehabilitation Management Plan							Control related
MCPL.05.T	5	T	Rehabilitation Management	Vegetation not self-sustaining, unable to demonstrate compliance with completion criteria.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan 03SY.02 - Milestone and completion criteria 04TV.01 - Guidance on gas borehole decommissioning							Control related
MCPL.05.U	5	U	Rehabilitation Management	Public/livestock access to void.	Risk to public safety and livestock.	(P) Harm to People	02PE.03 - Site security, fencing, etc. 02PE.07 - Bunding and barricading of voids and steep slopes 02PV.02 - Site land disturbance permits 02PV.08 - Cleared vegetation is mulched or burnt 03SV.05 - Topsoil management plan							Control related
MCPL.05.V	5	V	Rehabilitation Management	Legacy exploration bore holes not rehabilitated at end of mine life.	Rehabilitation inadequate, requiring further works.	(E) Environmental Impact	03SV.09 - Mine voids are ground water sinks 04TV.04 - Response to third party audits							Control related
MCPL.05.W	5	W	Rehabilitation Management	Discharge of particulates to the atmosphere during rehabilitation earthworks	Air pollution by discharge of particulates	(E) Environmental Impact	02PV.02 - Site land disturbance permits 03SV.06 - Rehabilitation Management Plan 03SY.05 - Contractor Management Plan and Protocols 04TV.02 - Internal reporting of any non-compliances							Control related

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Ref	Aspect ID	Risk ID	Mine Closure / Rehabilitation Aspect	Risk Source	Potential Events / Consequences	Loss Type	Existing / Proposed Risk Treatment / Control	Risk Assessment Follow-up Action	Person Responsible for Action	Ranking With Controls				Ranking Discussion
										Consequence	Likelihood	Residual Risk Level	Residual Risk Rank	
MCPL.06.A	6	A	Water	Contamination resulting from adjacent mining activities (e.g. storage and use of hydrocarbons/chemicals, drilling fluids, spillage of dirty or produced saline water, brine, sewage, tailings emplacement etc.).	Contamination of waterways or land resulting in infringement notice.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 02PY.02 - Specific guidelines for hazardous chemicals 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan			**2**	**D**	**Low (4)**	**(4)**	Impacts will be localised and are unlikely to occur
MCPL.06.B	6	B	Water	Diversion of surface water runoff away from catchment areas.	Loss of water flow downstream due to capture of water in voids.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PV.06 - Erosion and sediment control 03SY.06 - Water Management Plan	Action - Confirm that species selection and timing to minimise run off and growing period potential to provide cover for the cyclone season. Action - Confirm that site erosion and sedimentation controls are documented and include soil amelioration and additional organic matter incorporation and placement of hay over the rehabilitated areas.	A Heap	**2**	**D**	**Low (4)**	**(4)**	
MCPL.06.C	6	C	Water	Water accumulation in residual voids.	Overtopping/discharge to receiving environment.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 02PE.09 - Over-topping buffer in site voids 03SV.09 - Mine voids are ground water sinks			**2**	**D**	**Low (4)**	**(4)**	
MCPL.06.D	6	D	Water	Failure of final landform embankments in proximity to the southern residual void.	Inundation of the southern residual void and potential discharge to receiving environment.	(E) Environmental Impact	01DV.02 - Geotechnical analysis and design 02PY.01 - Works conducted by suitable contractors 03SY.05 - Contractor Management Plan and Protocols			**2**	**D**	**Low (4)**	**(4)**	
MCPL.06.E	6	E	Water	Groundwater seepage from residual voids.	Impact to receiving environment.	(E) Environmental Impact	02PE.08 - Drainage minimises water reporting to voids on site 03SV.09 - Mine voids are ground water sinks			**2**	**D**	**Low (4)**	**(4)**	
MCPL.06.F	6	F	Water	Poor water quality/excessive discharges (e.g. acid-drainage, high salinity, etc.).	Impact to receiving environment.	(E) Environmental Impact	02PV.09 - Stripping and stockpiling procedures 03SV.09 - Mine voids are ground water sinks 03SY.06 - Water Management Plan			**2**	**D**	**Low (4)**	**(4)**	

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Table 5 – Rehabilitation Control/Business Input Information

Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
01DE.01 - Tailings and dam designs and management systems	01DE.01 - Tailings and other dams appropriately designs - to contain material and any affected water	Executive General Manager/SSE	Addressing potential for collapse or uncontrolled release of site fluids	MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials MCPL.05.O - Substrate insufficient for revegetation
01DV.01 - Surveyed plans of all mine features	01DV.01 - Surveyed plans (and all infrastructure included in the PRCP) (to confirm that all locations, structures and features of substance are identified).	Senior Environment & Community Advisor	Preventing key items or built features not being addressed during rehabilitation as their physical locations are known and mapped	MCPL.02.A - Generation of wastes during decommissioning MCPL.02.B - Failure to remove all infrastructure MCPL.02.C - Failure to remove hazardous materials MCPL.02.D - Failure to identify contaminated lands MCPL.02.E - Failure of borehole or gas well seal MCPL.02.F - Unstable structure remaining on site MCPL.02.H - Impact on Aboriginal heritage items
01DV.02 - Geotechnical analysis and design	01DV.02 - Geotechnical analyses and implementation of designs to achieve long term stable landforms. As new materials are identified this leads to review and updating (as required) of designs.	Executive General Manager/SSE	Protection against changes in geotechnical conditions leading to final landform instability.	MCPL.04.A - Unknown characterisation of spoil material MCPL.04.B - Insufficient rock mulching material available MCPL.04.C - Final landform instability MCPL.04.D - Instability of NUMAs MCPL.04.E - Instability of steeper elements MCPL.04.F - Landform unsuited to final land use MCPL.04.G - Landform inconsistent with region MCPL.04.H - Sediment release from final landform MCPL.04.I - Tailings storage instability MCPL.04.J - Lack of supporting infrastructure. in final landform MCPL.04.K - Final landform does not free drain MCPL.06.D - Failure of final landform embankments near mining areas
01DV.03 - Geomorphic design protocols	01DV.03 - Current designs are aligned with relevant QLD design principles. Planned to implement geomorphic design principles being applied to the design of the final landform	Executive General Manager/SSE	Protection against longer term instability of the final landform	MCPL.04.A - Unknown characterisation of spoil material MCPL.04.B - Insufficient rock mulching material available MCPL.04.C - Final landform instability MCPL.04.D - Instability of NUMAs MCPL.04.E - Instability of steeper elements MCPL.04.F - Landform unsuited to final land use MCPL.04.G - Landform inconsistent with region MCPL.04.H - Sediment release from final landform MCPL.04.J - Lack of supporting infrastructure in final landform MCPL.04.K - Final landform does not free drain
01DV.04 - Factor of safety applied to designs	01DV.04 - Factor of safety of 2 applied to the void design - to address the weathering expected within 10's of years	Executive General Manager/SSE	Protection against longer term instability of the final landform	MCPL.04.A - Unknown characterisation of spoil material MCPL.04.B - Insufficient rock mulching material available MCPL.04.C - Final landform instability MCPL.04.D - Instability of NUMAs MCPL.04.E - Instability of steeper elements MCPL.04.F - Landform unsuited to final land use MCPL.04.G - Landform inconsistent with region MCPL.04.H - Sediment release from final landform MCPL.04.J - Lack of supporting infrastructure in final landform MCPL.04.K - Final landform does not free drain

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
01DV.05 - Longitudinal study of erosion performance	01DV.05 - Prior studies of erosion potential of dumps and rehabilitation methodology has been developed.	Health, Safety, Training, Environment & Community Manager	Addressing potential for using incorrect inputs in final landform designs	MCPL.04.A - Unknown characterisation of spoil material MCPL.04.B - Insufficient rock mulching material available MCPL.04.C - Final landform instability MCPL.04.D - Instability of NUMAs MCPL.04.E - Instability of steeper elements MCPL.04.F - Landform unsuited to final land use MCPL.04.G - Landform inconsistent with region MCPL.04.H - Sediment release from final landform MCPL.04.J - Lack of supporting infrastructure in final landform MCPL.04.K - Final landform does not free drain
01DV.06 - Reduced area for final rehabilitation	01DV.06 - Progressive rehabilitation (in conformance with the PRCP) minimising the amount of land to rehabilitate	Health, Safety, Training, Environment & Community Manager	Addressing potential for extensive works being required at the end of mine life	MCPL.01.A - Insufficient resourcing for rehabilitation MCPL.01.B - Responsibilities not assigned MCPL.01.C - Premature mine closure MCPL.01.D - Poor monitoring records management MCPL.01.E - Inadequate Stakeholder consultation MCPL.01.F - Change in IRC Planning Scheme
01DV.07 - Dump designs allow for rainfall events	01DV.07 - Dump designs covering modelled rainfall events	Executive General Manager/SSE	Addressing potential for excessive erosion in heavy rainfall	MCPL.05.D - Appropriate weather events not considered
01DV.08 - Mine design considers carbonaceous material in dumps	01DV.08 - Mine design/mine planning identifies carbonaceous material and manages this appropriately	Senior Environment & Community Advisor	Addressing potential for spontaneous combustion in dumps or stockpiles	MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials
01DV.09 - Mine plan makes allowances for rehabilitation of the TSF	01DV.09 - Mine plan has significant time-frame for rehabilitating TSF whilst ongoing mining of the pit is occurring	Executive General Manager/SSE	Addressing potential for incomplete capping of the tailings storage facility	MCPL.05.K - Inadequate storage of capping materials
01DV.10 - Selection of appropriate analogue and reference sites	01DV.10 - Selection of appropriate analogue and reference sites - Verterra have reviewed the reference sites to confirm suitability and present a monitoring strategy based on which site suits which domain on site	Health, Safety, Training, Environment & Community Manager	Addresses potential to not achieve desired rehabilitation performance due to a lack of understanding of species mix and micro-climate impacts	MCPL.05.S - Poor selection of analogue/reference sites
01DY.01 - Planning for decommissioning works	01DY.01 - Appropriate planning and decommissioning works	Health, Safety, Training, Environment & Community Manager	Specifically identifies waste products to allow for their safe disposal on or off site	MCPL.02.A - Generation of wastes during decommissioning MCPL.02.B - Failure to remove all infrastructure MCPL.02.C - Failure to remove hazardous materials MCPL.02.D - Failure to identify contaminated lands MCPL.02.E - Failure of borehole or gas well seal MCPL.02.F - Unstable structure remaining on site MCPL.02.H - Impact on Aboriginal heritage items
01DY.02 - Revegetation plan (in line with PRCP).	01DY.02 - Revegetation plan (in line with PRCP) to identify appropriate species, purchase in line with the plan and arrange for planting and relevant nurturing to meet requirements	Health, Safety, Training, Environment & Community Manager	Achieve a species mix which will allow the completion criteria to be met	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix
01DY.03 - Offset arrangements	01DY.03 - Provisions in place to provide like for like habitat to replace any degraded habitats on the mine site.	Health, Safety, Training, Environment & Community Manager	Minimise environmental impacts	MCPL.01.A - Insufficient resourcing for rehabilitation
02PE.01 - Flocculant use achieving a stiff tailings deposition	02PE.01 - Operational strategy is the use of flocculant - leading to a very stiff material - which would constrain any release.	Executive General Manager/SSE	Addresses long term escape of stored tailings	MCPL.04.I - Tailings storage instability MCPL.05.K - Inadequate storage of capping materials

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
02PE.02 - External supplier of seeds	02PE.02 - External supplier of seeds	Executive General Manager/SSE	Addresses potential for poor germination rates and inappropriate seed mix	MCPL.05.B - Insufficient quality seed available
02PE.03 - Site security, fencing, etc.	02PE.03 - Site security, including rural fencing of lease, demarcation and signage, and exclusion of stock.	Executive General Manager/SSE	Addressing potential for overgrazing, access by unwanted third parties or feral animal access to the site	MCPL.05.F - Overgrazing of pastures MCPL.05.G - Failing to provide security against vandalism MCPL.05.H - Damage to rehabilitated areas from mining activities
02PE.04 - Gypsum remediation to improve run-off	02PE.04 - Gypsum remediation assists in improving run-off quality	Executive General Manager/SSE	Addressing poor quality run-off from the site	MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.O - Substrate insufficient for revegetation
02PE.05 - Stockpiling rock material for use as an erosion control	02PE.05 - Rock material for hydraulic breaks over tailings	Executive General Manager/SSE	Addressing hydraulic erosion of the TSF dam wall (and other dam walls, drains, etc.)	MCPL.05.K - Inadequate storage of capping materials
02PE.06 - Capping of TSF	02PE.06 - Rehab management plan includes procedures for and description of capping requirements for the TSF	Senior Environment & Community Advisor	Addressing potential for incomplete capping of the tailings storage facility	MCPL.05.K - Inadequate storage of capping materials
02PE.07 - Bunding and barricading of voids and steep slopes	02PE.07 - Bunding and barricading - Construct a safety bund wall of competent rock and/or fencing to limit human and livestock/animal access	Senior Environment & Community Advisor	Addressing potential for injury to members of the public or livestock at the site	MCPL.05.U - Void is not isolated
02PE.08 - Drainage minimises water reporting to voids on site	02PE.08 - Executed designs minimise the catchment reporting to the void	Executive General Manager/SSE	Addressing the unwanted build up of water stocks in site voids	MCPL.06.A - Contamination of water due to site activities MCPL.06.B - Water diverted from catchment into voids MCPL.06.C - Water from voids discharging to the environment MCPL.06.E - Groundwater seepage from voids
02PE.09 - Over-topping buffer in site voids	02PE.09 - Significant buffer before over-topping and final void water balance indicates a very low risk of spill (<1% annual exceedance probability)	Health, Safety, Training, Environment & Community Manager	Addressing potential for over-topping of site voids post mining	MCPL.06.A - Contamination of water due to site activities MCPL.06.C - Water from voids discharging to the environment
02PV.01 - Processes to identify all heritage items	02PV.01 - Planning and survey process to identify all heritage items so that they can be avoided.	Health, Safety, Training, Environment & Community Manager	Prevent damage to a heritage site degrading environmental values in an area	MCPL.02.G - Impact on historic heritage items

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
02PV.02 - Site land disturbance permits	02PV.02 - Site land disturbance permits	Health, Safety, Training, Environment & Community Manager	Preventing damage to heritage sites, natural features or other sensitive locations	MCPL.02.G - Impact on historic heritage items MCPL.03.E – Quality of available Topsoil is poor MCPL.05.A - Loss of habitat resources MCPL.05.B - Insufficient quality seed available MCPL.05.C - Inadequate weed and pest controls MCPL.05.D - Appropriate weather events not considered MCPL.05.E - Insufficient cover allowed for vegetation MCPL.05.F - Overgrazing of pastures MCPL.05.G - Failing to provide security against vandalism MCPL.05.H - Damage to rehabilitated areas from mining activities MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials MCPL.05.L - Spreading of topsoil insufficient MCPL.05.M - Inadequate topsoil storage MCPL.05.N - Topsoil unsuitable as a growth medium MCPL.05.O - Substrate insufficient for revegetation MCPL.05.P - Selected rehabilitation techniques are inappropriate MCPL.05.Q - Inadequate rehabilitation monitoring and maintenance program adopted MCPL.05.R - Inappropriate monitoring program to demonstrate compliance MCPL.05.S - Poor selection of analogue/reference sites MCPL.05.T - Vegetation inappropriate for area MCPL.05.U - Void is not isolated MCPL.05.W - Discharge of particulates to atmosphere from earthworks
02PV.03 – Work is occurring within already disturbed footprints	02PV.03 - Work is predominantly occurring within already disturbed footprints	Executive General Manager/SSE	Preventing disturbance to less affected items of environmental value	MCPL.02.G - Impact on historic heritage items
02PV.04 - Rehabilitation of appropriate species of vegetation	02PV.04 - Rehabilitation protocols including identifying and planting appropriate species of vegetation	Health, Safety, Training, Environment & Community Manager	Minimise the potential that planted species will not lead to meeting required environmental values at closure	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix
02PV.05 - Long mine life (>20 years)	02PV.05 - The long mine life (>20 years) means there is sufficient time to confirm the appropriate vegetation strategy and implement accordingly (time to trial multiple options in order to get the processes right for long term rehabilitation success).	Executive General Manager/SSE	Having a long mine life addresses the potential for seasonal variations to misrepresent the effectiveness of rehabilitation efforts	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
02PV.06 - Erosion and sediment control	02PV.06 - Erosion and sediment control - informed by geochemistry assessments and site operating knowledge.	Health, Safety, Training, Environment & Community Manager	Protecting against releases to the wider environment during construction and for the longer term landform	MCPL.04.A - Unknown characterisation of spoil material MCPL.04.B - Insufficient rock mulching material available MCPL.04.C - Final landform instability MCPL.04.D - Instability of NUMAs MCPL.04.E - Instability of steeper elements MCPL.04.F - Landform unsuited to final land use MCPL.04.G - Landform inconsistent with region MCPL.04.H - Sediment release from final landform MCPL.04.J - Lack of supporting infrastructure in final landform MCPL.04.K - Final landform does not free drain MCPL.06.B - Water diverted from catchment into voids
02PV.07 - Timing for access to rehabilitated areas	02PV.07 - Subsequent land holders could not access the land until the ML's are relinquished and CDM sells the land to a subsequent party.	Executive General Manager/SSE	Prevents damage to the rehabilitated areas by third parties	MCPL.01.A - Insufficient resourcing for rehabilitation MCPL.01.B - Responsibilities not assigned MCPL.01.C - Premature mine closure MCPL.01.D - Poor monitoring records management MCPL.01.E - Inadequate Stakeholder consultation MCPL.01.F - Change in IRC Planning Scheme
02PV.08 - Cleared vegetation is mulched or burnt	02PV.08 - Vegetation is mulched or burnt	Executive General Manager/SSE	Addresses potential for unwanted species in the rehabilitated areas	MCPL.03.E – Quality of available Topsoil is poor MCPL.05.A - Loss of habitat resources MCPL.05.B - Insufficient quality seed available MCPL.05.C - Inadequate weed and pest controls MCPL.05.D - Appropriate weather events not considered MCPL.05.E - Insufficient cover allowed for vegetation MCPL.05.F - Overgrazing of pastures MCPL.05.G - Failing to provide security against vandalism MCPL.05.H - Damage to rehabilitated areas from mining activities MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials MCPL.05.L - Spreading of topsoil insufficient MCPL.05.M - Inadequate topsoil storage MCPL.05.N - Topsoil unsuitable as a growth medium MCPL.05.O - Substrate insufficient for revegetation MCPL.05.P - Selected rehabilitation techniques are inappropriate MCPL.05.Q - Inadequate rehabilitation monitoring and maintenance program adopted MCPL.05.R - Inappropriate monitoring program to demonstrate compliance MCPL.05.S - Poor selection of analogue/reference sites MCPL.05.T - Vegetation inappropriate for area MCPL.05.U - Void is not isolated
02PV.09 - Stripping and stockpiling procedures	02PV.09 - Stripping processes lead to adequate burial (to prevent any spontaneous combustion threats)	Senior Environment & Community Advisor	Addressing potential for spontaneous combustion in dumps or stockpiles	MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials MCPL.06.F - Poor water quality discharging from the site

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
02PY.01 - Works conducted by suitable contractors	02PY.01 Works conducted by suitably qualified contractors - including permits for disposing of any contaminated materials.	Executive General Manager/SSE	This business input/control is intended to minimise the potential for poor execution of required works. It is supported by appropriate supervision, inspection and test plans, and formal contractual arrangements to optimise the outcomes from any works.	MCPL.02.A - Generation of wastes during decommissioning MCPL.02.B - Failure to remove all infrastructure MCPL.02.C - Failure to remove hazardous materials MCPL.02.D - Failure to identify contaminated lands MCPL.02.E - Failure of borehole or gas well seal MCPL.02.F - Unstable structure remaining on site MCPL.02.H - Impact on Aboriginal heritage items MCPL.05.P - Selected rehabilitation techniques are inappropriate MCPL.06.D - Failure of final landform embankments near mining areas
02PY.02 - Specific guidelines for hazardous chemicals	02PY.02 - Specific guidelines in place - beyond standard planning and execution that address any hazardous materials on site	Senior Environment & Community Advisor	To minimise the outcome from any hazardous materials brought to, used or created by the operating site	MCPL.02.C - Failure to remove hazardous materials
03SV.01 - Database which tracks all known heritage items	03SV.01 - Database which tracks all known heritage items	Health, Safety, Training, Environment & Community Manager	To identify, geo-locate and characterise all items within proximity of the site and workings	MCPL.02.H - Impact on Aboriginal heritage items MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.D - Inappropriate revegetation species mix
03SV.02 - Biannual environmental audits	03SV.02 - Two yearly internal (to the company) independent (to the site) environmental audits commissioned by the company and any recommendations are reviewed and actions tracked.	Executive General Manager/SSE	Challenge any slippage of standards and identify emerging conditions that may require additional resources to be allocated	MCPL.01.D - Poor monitoring records management MCPL.05.Q - Inadequate rehabilitation monitoring and maintenance program adopted
03SV.03 - RQP involvement in TSF design	03SV.03 - RPQ involvement of the TSF as a regulated structure - nominated as a significant risk to ecosystems but with low risk to potential downstream features (harm to humans and environment is low) - and subject to annual inspection	Executive General Manager/SSE	Addressing instability in the tailings storage facility (TSF)	MCPL.04.I - Tailings storage instability
03SV.04 - Change management for rehabilitation	03SV.04 - Processes available for amending PRCP in the event of requirement to close the mine early (meeting requirements of a stable landform).	Executive General Manager/SSE	Reducing the potential for delivered rehabilitation not meeting community expectations	MCPL.01.A - Insufficient resourcing for rehabilitation MCPL.01.B - Responsibilities not assigned MCPL.01.C - Premature mine closure MCPL.01.D - Poor monitoring records management MCPL.01.E - Inadequate Stakeholder consultation MCPL.01.F - Change in IRC Planning Scheme

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
03SV.05 - Topsoil management plan	03SV.05 - Topsoil management plan (includes identifying the resource, addressing/treating any sodic soils, stockpiling to preserve soil quality, site wide topsoil study, monitoring of topsoil pre-rehab to confirm nutrient and soil chemistry levels/requirements) and topsoil balance reporting	Executive General Manager/SSE	Addressing potential for topsoil to not meet rehabilitation growing requirements	MCPL.03.E – Quality of available Topsoil is poor MCPL.05.A - Loss of habitat resources MCPL.05.B - Insufficient quality seed available MCPL.05.C - Inadequate weed and pest controls MCPL.05.D - Appropriate weather events not considered MCPL.05.E - Insufficient cover allowed for vegetation MCPL.05.F - Overgrazing of pastures MCPL.05.G - Failing to provide security against vandalism MCPL.05.H - Damage to rehabilitated areas from mining activities MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.J - Inadequate capping of reactive materials MCPL.05.K - Inadequate storage of capping materials MCPL.05.L - Spreading of topsoil insufficient MCPL.05.M - Inadequate topsoil storage MCPL.05.N - Topsoil unsuitable as a growth medium MCPL.05.O - Substrate insufficient for revegetation MCPL.05.P - Selected rehabilitation techniques are inappropriate MCPL.05.Q - Inadequate rehabilitation monitoring and maintenance program adopted MCPL.05.R - Inappropriate monitoring program to demonstrate compliance MCPL.05.S - Poor selection of analogue/reference sites MCPL.05.T - Vegetation inappropriate for area MCPL.05.U - Void is not isolated
03SV.06 - Rehabilitation Management Plan	03SV.06 - Quantity of required species is in rehab management plan and monitoring of germination rates. The plan also covers monitoring of general rehabilitation performance, offset status/performance, and programmed and as-required maintenance works.	Executive General Manager/SSE	Addressing failure to execute rehabilitation works in line with PRCP and license requirements.	MCPL.04.B - Insufficient rock mulching material available MCPL.05.B - Insufficient quality seed available MCPL.05.D - Appropriate weather events not considered MCPL.05.E - Insufficient cover allowed for vegetation MCPL.05.S - Poor selection of analogue/reference sites MCPL.05.W - Discharge of particulates to atmosphere from earthworks
03SV.07 - Weed and Pest Control Management Plan	03SV.07 - Weed and Pest Control Management Plan	Executive General Manager/SSE	Addressing potential for rehabilitation failure due to weeds or invasive pests	MCPL.05.C - Inadequate weed and pest controls
03SV.08 - Water quality monitoring	03SV.08 - Water quality monitoring for site dams and the receiving environment	Health, Safety, Training, Environment & Community Manager	Addressing potential for cumulative impacts from poor quality water presence or release	MCPL.05.I - Geotechnical conditions not considered for waste storage facilities MCPL.05.O - Substrate insufficient for revegetation
03SV.09 - Mine voids are ground water sinks	03SV.09 - Ground water modelling of long-term performance indicate that voids will continue to act as a ground water sink	Health, Safety, Training, Environment & Community Manager	Addressing unintended releases to or draw from ground water/aquifers	MCPL.05.V - Failing to rehabilitate bore holes MCPL.06.A - Contamination of water due to site activities MCPL.06.C - Water from voids discharging to the environment MCPL.06.E - Groundwater seepage from voids MCPL.06.F - Poor water quality discharging from the site
03SY.01 - Monitoring and adaptive management programs	03SY.01 - Monitoring and adaptive management programs which determine relevant conditions and provide modification (within design parameters) of activities to achieve design goals	Health, Safety, Training, Environment & Community Manager	To prevent changes in performance from becoming more significant by reducing the impact of an emerging condition/threat	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix

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Business Input (Control) Name	Expectation	Responsible	Addressing	Related Failure Mode/Risk
03SY.02 - Milestone and completion criteria	03SY.02 - Milestone and completion criteria to confirm outcomes are being achieved	Health, Safety, Training, Environment & Community Manager	Prevent any long-term slippage of progressive rehabilitation	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix
03SY.03 - Annual reporting of PRCP progress to the Regulator.	03SY.03 - Annual reporting of PRCP progress to the Regulator	Executive General Manager/SSE	Minimise the potential for executed rehabilitation drifting from community expectations	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix
03SY.04 - Third party agreements	03SY.04 - Third party agreements - Any third party grazing would be in accordance with appropriate license terms (Rural licence)	Executive General Manager/SSE	Addressing unmanaged access to rehabilitated areas by third parties conducting rural businesses	MCPL.05.F - Overgrazing of pastures
03SY.05 - Contractor Management Plan and Protocols	03SY.05 - Contract management - confirming site requirements are met	Executive General Manager/SSE	Achieved well executed works being performed by contractors	MCPL.05.P - Selected rehabilitation techniques are inappropriate MCPL.05.W - Discharge of particulates to atmosphere from earthworks MCPL.06.D - Failure of final landform embankments near mining areas
03SY.06 - Water Management Plan	03SY.06 - Water Management Plan with clean and dirty water diversions around the pit	Executive General Manager/SSE	Addressing potential for unwanted collection, storage or release of waters on the site during operations and post closure	MCPL.06.A - Contamination of water due to site activities MCPL.06.B - Water diverted from catchment into voids MCPL.06.F - Poor water quality discharging from the site
04TV.01 - Guidance on gas borehole decommissioning	04TV.01 - Gas borehole guidance on decommissioning - that lead to a removal of any threats	Executive General Manager/SSE	To minimise outcome from encountering any unexpected legacy drill holes and associated features during rehabilitation	MCPL.02.E - Failure of borehole or gas well seal MCPL.05.T - Vegetation inappropriate for area
04TV.02 - Internal reporting of any non-compliances	04TV.02 - Internal reporting of any non-compliances (weekly/monthly) in order to alert management to any emerging threats and required allocation of resources	Health, Safety, Training, Environment & Community Manager	Minimise the extent to which rehabilitation works fail to meet requirements of the PRCP	MCPL.03.A - Landform not suited to targeted species MCPL.03.B - Tree species not suited to riparian conditions MCPL.03.C - Tree species not suited to creek diversions MCPL.03.D - Inappropriate revegetation species mix MCPL.05.W - Discharge of particulates to atmosphere from earthworks
04TV.03 - Government rehabilitation bonds in place	04TV.03 - Government holds bonds - which are sufficient to return the site to a stable, suitable landform in the event of the company failing.	Executive General Manager/SSE	Addresses failure of the company	MCPL.01.A - Insufficient resourcing for rehabilitation MCPL.01.B - Responsibilities not assigned MCPL.01.C - Premature mine closure MCPL.01.D - Poor monitoring records management MCPL.01.E - Inadequate Stakeholder consultation MCPL.01.F - Change in IRC Planning Scheme
04TV.04 - Response to third party audits	04TV.04 - Response to any third party audits - and activation of the exploration rehabilitation requirements	Executive General Manager/SSE	Addressing leaving an ongoing threat when one has been identified	MCPL.05.V - Failing to rehabilitate bore holes

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Table 6 – Risk and Control Assessment Criteria

MCPL RISK MATRIX						
LIKELIHOOD		**RISK LEVEL**				
A **Very Likely** (5)	Likely to occur on site in most circumstances.	MODERATE (5)	MODERATE (10)	HIGH (15)	EXTREME (20)	EXTREME (25)
B **Likely** (4)	Probably will occur on site under certain circumstances.	LOW (4)	MODERATE (8)	HIGH (12)	HIGH (16)	EXTREME (20)
C **Possible** (3)	Could occur on site at some point in time.	LOW (3)	MODERATE (6)	MODERATE (9)	HIGH (12)	EXTREME (15)
D **Unlikely** (2)	May occur but not very likely on this site.	LOW (2)	LOW (4)	MODERATE (6)	MODERATE (8)	HIGH (10)
E **Rare** (1)	Highly unlikely to occur on this site.	LOW (1)	LOW (2)	LOW (3)	LOW (4)	MODERATE (5)

Area of Effect	**ESTIMATED LEVEL OF CONSEQUENCE**				
	Low (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
P Harm to People	Report only Near miss First aid injury (RO, FAI)	Medical treatment injury or restricted work injury (MTI, RWI)	Serious injury or disabling reversible impairment (LTI)	Fatality or disabling irreversible impairment	Multiple fatalities
E Environmental Impact	Environmental nuisance Limited damage to minimal area of low significance	Minor short term medium term material environmental harm to small area(s) of limited significance	Serious short to medium term environmental harm with widespread impacts	Major environmental harm Relatively wide spread medium to long term impacts	Extreme environmental harm Long term wide spread effects on environment
A Asset damage and other consequential business losses	Slight damage <$5,000 No disruption to operations	Minor damage <$50,000 Brief disruption < 12 hours	Localised damage <$500,000 Partial shutdown < 1 day	Major damage <$2,000,000 Major shutdown < 1 week	Extensive damage >$2,000,000 Extensive loss > 1 week
R Impact on Reputation	Slight impact Public aware but no public concern	Limited impact Some local public concern	Considerable impact with potential for wider public concern	National impact with potential for wider public concern	International impact. International public attention

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RISK	ACCEPTABILITY / AUTHORITY TO PROCEED	ACTION TO TAKE
Extreme Risk	**UNACCEPTABLE RISK – STOP – DO NOT START** If an Formal Risk Assessment is being conducted, a Manager is to re-conduct / review risk assessment with a team and identify appropriate controls to reduce the risk to an acceptable level. If a JSEA is being conducted, then a formal Risk Assessment shall be conducted under the guidance of the Department Manger. Upon agreement with findings and the controls the SSE shall formally approve the risk assessment. The SSE may engage more people to review the risk assessment if an acceptable level of risk was not achieved. The SSE must be contacted if not present on the site at the time the hazard / risk are identified.	Cannot proceed until elimination, substitution or engineering controls or a combination of these are implemented to reduce the risk to Moderate or Low. The overall task approach must be under Supervision (minimum the Department Superintendent) when it is undertaken and the most senior personnel at MCPL are aware of the task's occurrence. Emergency Response considerations are documented within the risk assessment. Monitoring of the controls effectiveness (PTO) shall be undertaken and documented by the work's Supervisor throughout the activity.
High Risk	**UNACCEPTABLE RISK – STOP – DO NOT START** If an Formal Risk Assessment is being conducted, Departmental Superintendent is to reconvene the team (option to involve more experts) and review the Risk Assessment. Appropriate controls must be identified to reduce the risk to an acceptable level. If a JSEA is being conducted, then a formal Risk Assessment shall be conducted under the guidance of the Department Superintendent. Upon agreement with findings and the controls the Department Manager shall formally approve the JSEA or RA. The SSE shall review the RA and approve the commencement of the works if the Department Manager is not on site.	Cannot proceed until elimination, substitution or engineering controls or a combination of these are implemented to reduce the risk to Moderate or Low. The task must be Supervised (minimum Supervisor / OCE) while it is being performed and a senior MCPL Manager must be aware that the tsk is being performed. Monitoring of the controls effectiveness (PTO) shall be undertaken and documented by the work's Supervisor throughout the activity.
Moderate Risk	**ACCEPTABLE RISK – CAN START** Provided that identified controls are implemented immediately and the controls effectiveness is being monitored. Relevant OCE / Superintendent shall approve the Risk Assessment / JSEA.	Proceed with task: Requires supervision and monitoring of controls effectiveness.
Low Risk	**ACCEPTABLE RISK – CAN START PROVIDED:** Implement controls are identified. Continue to monitor for changes which may elevate risk score. Relevant OCE / Superintendent shall approve the Risk Assessment / JSEA.	Proceed with agreed controls in place.

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12.3 *About Your Report*

Your report has been developed on the basis of your unique and specific requirements as understood by Risk Mentor and only applies to the subject matter investigated.

We have endeavoured to accurately gather information from observations, document reviews and from site personnel. Analysis has been conducted using the best methods of risk engineering science known to the author(s) and should represent a useful suite of information on which the site can base subsequent actions.

Even with all these efforts made it is possible that due to information reviewed being erroneous or incomplete errors may exist in the document or that the recommendations may not be fully effective in avoiding unwanted risks.

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Laboratory erodibility measurement and assessment of landform designs using rock armour.

Prepared for Middlemount Coal Pty Ltd

September 2019

Disclaimer: All care and diligence has been exercised in testing, interpreting data and the development of recommendations presented in this report. The work has been undertaken in a skilled, professional manner, according to accepted practices. Specific circumstances and research findings after the date of publication may influence the accuracy of the data and recommendations within this report.

The landscape is not uniform. Because of this non-uniformity, no monitoring, testing or sampling technique can produce completely precise results for any site. Any conclusions based on the monitoring and/or testing presented in this report can therefore only serve as a 'best' indication of the environmental condition of the site at the time of preparing this document. It should be noted that site conditions can change with time.

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EXECUTIVE SUMMARY

Middlemount Coal Pty Ltd (MCPL) are currently rehabilitating selected areas on the Middlemount Mine in the Bowen Basin. The current priority is the Eastern Overburden Dump (EOD). This particular dump is close to the lease boundary and requires steep slopes to ensure it will stay within the mining lease area.

Three materials were provided to Landloch for testing. These materials were a good quality Permian rock, quarry rock, and topsoil. From these materials, three mixtures were created for laboratory scale erosion testing. These mixtures were:

- 4:1 Permian rock: topsoil,
- 4:1 quarry rock: topsoil, and
- topsoil.

Due to the size of the rock provided, large flumes with dimensions 0.77 x 3 m were used for erosion testing of the rock soil mixtures. Regular 0.4 x 2 m flumes were used for the topsoil erosion testing. Simulated rain with kinetic energy equivalent to natural rain was applied to plots at an intensity of 90 – 130 mm/h for 25 minutes. Runoff was sampled at 2-3 minute intervals to allow derivation of sediment loads, runoff rate, and infiltration.

For overland flow testing, flumes were set to various gradients and subjected to a sequence of increasing flow rates, each applied for 5 minutes. Runoff samples were collected at 1, 2, 3 and 5 minute intervals. These samples were used to determine sediment concentrations and erosion rates.

Erosion testing results were used to determine erodibility parameters for each of the three materials tested. Erodibility factors were used in WEPP modelling to predict erosion rates from modelled landscapes.

Initial WEPP modelling used two slope gradients of 16.66 and 33.33 %. These gradients were run for both rock: topsoil mixtures and compared to a bare surface with 40 % ground cover. The initial modelling showed that most bare slopes were predicted to have unacceptable erosion rates (>10 t/ha/yr) for both slope gradients. Slopes which had 40 % ground cover had mostly acceptable erosion rates for both materials.

A second modelling scenario was established to test landform height and material characteristics. The new landform parameters included a slope with 65 m height, Permian rock mixes with either 47 Pa or 74 Pa critical shear, and 60 % ground cover. The two slope gradients and surfaces either bare or with 40 % ground cover were also considered.

The revised modelling showed that predicted erosion rates for bare areas were still unacceptable (>10 t/ha/yr) for both slope gradients. Permian rock with 47 Pa shear stress with a slope gradient of 33.33 % and 40% ground cover was the only other scenario with unacceptable modelled erosion.

Simulated slopes and model predictions have been used to make recommendations for slope construction and management.

For short term stability, simulations suggested that a minimum critical shear of 50 Pa needs to be achieved, which is the equivalent to using rock with a D_{50} of approximately 80 mm.

Model outputs showed that ground cover establishment is critical to stabilising slopes over the medium to long term. A minimum of 40 % ground cover is required, with greater than ≥60 % ground cover being preferable. Ground cover species recommended for site include Rhodes grass (Tolgar or Reclaimer cultivars), Saraji Urochloa, Digit grass (*Digitaria eriantha* ssp. eriantha) cv. Premier, and Indian bluegrass or Indian couch (*Bothriochloa pertusa*) cvv. Keppel, Medway, Bowen. It is critical that legumesspecies be included in any seed mix, as the legumes will provide soil nitrogen in the long term.

Rock quality and layer thickness needs to be considered when constructing a slope. Effective rock: soil mixes require a layer thickness of 1.5 to 2 times the D_{50} of the rock used.

Growth medium layer preparation is important to ensure vigorous establishment and continued growth of ground cover on slopes. The aim is to establish plant growth media with pH, electrical conductivity, exchangeable sodium percentage, and chloride within acceptable ranges for plant species chosen. In addition critical plant nutrients, nitrogen, phosphorus, potassium, sulphur, boron, and zinc should be at levels that will ensure vigorous initial plant establishment.

1 BACKGROUND

1.1 Rehabilitation trials using rock mulch – Middlemount Mine

Middlemount Coal Pty Ltd (MCPL) are currently rehabilitating selected areas on the Middlemount Mine in the Bowen Basin, with the Eastern overburden dump being the current rehabilitation priority. The site is spatially constrained within mining leases and the Eastern overburden dump is currently close to the lease boundary, creating a need to be able to construct and stabilise relatively steep batter slopes. Inclusion of rock into a rehabilitated surface is widely recognised as enabling stabilisation of steeper slopes.

Rock mulch trials have been implemented on multiple batters, and store and release cover profiles have been constructed on one dump top. For the existing trials, the source materials have been characterised, as has the rock:soil mix formed. Pit rock used in some mixtures has limited durability and this has constrained the effectiveness of the rock mulch layer in some locations.

Current trials are using two rock types to determine which produces the most durable rock armour and best supports plant growth. A rock:soil mix of 4:1 is used with a settled depth of 1m over sodic and saline overburden. These field trials use a single gradient, which limits the potential for the trials to provide sufficient information to allow a range of slope designs to be matched to site requirements.

Erosion modelling offers the ability to consider the placement of rock:soil mixtures over a wider range of slope gradients and lengths, and has been recommended as a way to greatly extend the value of the current field trials. Consequently, this report presents results of laboratory testing and provides the input parameters needed for runoff and erosion modelling to be used to predict likely performance of rock:soil covers of interest for a range of slope options at the Middlemount Mine.

The modelling identified maximum gradients, slope lengths and drainage methods for the materials on site to inform landform design decisions. This would also help MCPL schedule efficient placement of the materials currently being excavated from the pit.

1.2 Work scope

Erosion modelling and landform design studies to determine safe, stable and non-polluting landform designs have been shown to produce accurate and effective results provided the parameters input to the models are soundly based (Howard and Roddy 2012; Robinson and Finucane 2019). Specifically, the modelling requires parameters derived from erosion experiments on material from site. Use of material from site in erosion laboratory experiments ensures that subsequent modelling and design criteria are directly relevant to the site.

Consequently, the work scope to parameterise and run runoff/erosion modelling to inform landform designs using placement of soil/rock covers on the site included:

- Laboratory measurements of runoff and erosion on rock:soil mixes of materials sourced from the site;

- Derivation of WEPP erosion model parameters from the laboratory data; and
- WEPP simulations to develop landform design rules.

An associated study will be carried out to assess the likely performance of the rock:soil mixes in terms of water retention for plant growth and the quantities of deep drainage that will reach the underlying saline and sodic wastes. It will be reported separately.

Deliverables from the erodibility study were planned to include:

- Detailed infiltration, runoff, and erodibility data for the rock:soil mixtures tested;
- Assessment of mixing ratios of "rock" and soil, and information on potential runoff/erosion impacts of deviations from the specified design;
- Landform design information including:
  - Landform design rules for a range of rock sizes (typically presented as a relationship between maximum gradient and contributing area)
  - Some consideration of the long-term role and management of East dump constructed drains and benches ;

The associated water balance study will provide:

- Information on the likely interactions between rock mulch layer thickness and underlying wastes in terms of:
  - Effects of waste properties on acceptable rock mulch layer thickness for revegetation success; and
  - Interactions of rock mulch layer thickness with waste properties in terms of tunnel erosion risk.

It is anticipated that some form of design document will be generated from this project.

2 MATERIALS AND MIXTURES STUDIED

2.1 Materials supplied

On 2 June 2019, two (2) cubic metres of each of:

- Good quality Permian rock (including fines);
- Parrot Quarry Rock (including fines); and
- Topsoil

were delivered to Landloch's Toowoomba laboratory.

2.2 Mixtures tested

Mixtures and materials fully tested under both simulated rain and overland flow were:

- 4:1 Permian rock : topsoil;
- 4:1 Quarry rock : topsoil; and
- Topsoil.

Infiltration of simulated rain was also measured on a 2:1 mix of Quarry rock:topsoil.

It is Landloch's understanding that the use of Quarry rock has subsequently been ruled out due to cost, unless shown by testing to be a significantly better option in terms of rehabilitation outcomes. Consequently, this report focusses largely on mixture of topsoil with the rocky Permian waste.

2.3 Material properties

2.3.1 Topsoil and rock fine fractions

For each of the mixtures tested and for each individual material, samples of the fine fraction were taken and analysed for key physical and chemical properties. Results are summarised in Tables 1 and 2, and information on ratings from Hazelton and Murphy (2007) applied to the ranges of the properties measured is given in Appendix 1.

Table 1: Chemical properties of the fine component of mixtures and materials. Values shown in red are of concern – largely high – with the exception being for Ca:Mg ratio (too low).

Analyses	Unit	4:1 Quarry: Soil	2:1 Quarry: Topsoil	4:1 Permian: Topsoil	Topsoil	Quarry	Permian
pH - Water	pH units	9.21	9.22	9.88	7.38	9.54	9.95
Electrical Conductivity	dS/m	0.34	0.29	0.47	0.07	0.32	0.50
Chloride	mg/kg	326	208	186	49.2	235	218
Cation Extraction Method	Rayment & Lyons	15C1	15C1	15C1	15C1	15C1	15C1
Cation Exchange Capacity (CEC)	meq/100g	6.2	5.6	4.8	1.4	7.4	5.9
Exchangeable Calcium	%	3.40	5.9	20.1	47.2	1.35	17.7
Exchangeable Magnesium	%	35.8	37.6	40.2	39.6	35.5	41.3
Exchangeable Potassium	%	3.40	3.72	3.08	8.10	2.87	2.93
Exchangeable Sodium	%	57.2	52.5	36.3	4.29	60.2	37.9
Exchangeable Aluminium	%	0.18	0.20	0.26	0.77	0.15	0.19
Ca : Mg Ratio	-	0.10	0.16	0.50	1.19	0.04	0.43

The fine fractions from both rock types show high pH (9.54 – 9.95), which is very strongly alkaline, and likely to cause problems for growth of many plant species.

Similarly, Electrical Conductivity (EC), which is a measure of soil soluble salt content, is rated "moderate" for the Quarry rock and "high" for the Permian rock. For both rock types, chloride is somewhat elevated and may reduce growth of some sensitive species.

Fines from both rock types are highly sodic ,with Exchangeable Sodium Percentage (ESP) of 60.2 and 37.9 for Quarry and Permian rock respectively. As ESP >14 % is normally classed as strongly sodic, fines from both rock types can be expected to be strongly dispersive. Clay dispersion potential is exacerbated by relatively high Magnesium, and low Ca:Mg ratios, particularly for the Quarry rock.

In comparison to fines from the two rock types, the topsoil shows generally suitable chemical properties.

Where topsoil is mixed with rock, the fine fraction of the resulting mixture is generally strongly controlled by the properties of the rock fine fraction, with the end result that the mixtures will reflect the sub-optimal properties of the rock fine fractions.

Table 2: Fine fraction and topsoil particle size distribution

Analyses	Unit	4 Quarry : 1 Topsoil	2 Quarry : 1 Topsoil	4 Permian : 1 Topsoil	Topsoil	Quarry	Permian
Gravel >2.0mm	%	0.0	0.1	0.0	5.0	0.3	1.2
Coarse Sand 0.2-2.0mm	%	55.0	54.5	40.9	30.6	61.5	41.1
Fine Sand 0.02-0.2mm	%	30.2	28.8	34.7	54.4	21.2	35.7
Silt 0.002-0.02mm	%	8.4	6.4	14.1	5.9	6.5	8.2
Clay <0.002mm	%	6.5	10.1	10.3	4.1	10.4	13.8

All of the fine fractions showed low clay and silt contents, indicating that water-holding capacity of the materials and mixtures is likely to be low, especially where a significant proportion of the volume of the upper profile is occupied by rock. It could be expected that vegetation established in soil layers of low water holding capacity is likely to be dominated by deep-rooted species such as shrubs and small trees, with lower abundance of grasses.

2.3.2 Rock durability

Samples of both rock types were analysed for slake durability. Results are shown in Figure 1, and indicate that both materials are quite durable. An ideal slake durability result for a material to be placed on the surface of a

rehabilitated slope would be >90% after two cycles (Santi 2006), whereas both materials, in this case, had durability in the range 96.7 – 98.9%.

Consequently, it appears that either rock type would be suitable for placement on the surface to stabilise rehabilitated areas.

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REPORT ON SLAKE DURABILITY INDEX OF ROCK

Sheet 1 of 1 — Mackay Laboratory

CLIENT:	Landloch Pty Ltd	**JOB NO.:**	M30829	**LAB REF NO:**	Refer below
ADDRESS:	PO Box 57, HARLAXTON QLD 4350				
PROJECT:	Slake Durability Testing	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	Quarry	**TESTED BY:**	LRA	**TEST DATE:**	25-Jun-19
TEST PROCEDURE:	AS 4133.3.4 (2009)	**CHECKED BY:**	AW	**CHECK DATE:**	27-Jun-19

Lab Ref No	Borehole	Client Ref	Corrected Depth From (m)	Corrected Depth To (m)	Slake Durability Index (First Cycle) %	Slake Durability Index (Second Cycle) %	Appearance of Fragments Retained in the drum	Appearance of Fragments Passing the drum
19-3078A	-	Sample 1	-	-	99.2	98.9	Lumps slightly broken down, angular particles present	Fine silt
Before					After			
19-3079A	-	Sample 3	-	-	97.9	96.7	Rock lumps still intact	Fine silt
Before					After			
19-3080A	-	Sample 3	-	-	99.2	98.7	Lumps slightly broken down, angular particles present	Fine silt
Before					After			

Figure 1: Slake soundness testing results.

2.4 Rock size

The size distribution of Quarry and Permian rock was measured from photographs of flume surfaces following applications of flow, which were sent for computer analysis of particle size.

Initial assessment of the rock placed in flumes (which had some large particles >200 mm diameter removed) indicated a median diameter (D_{50}) of approximately 80 mm for the Quarry rock and 77 mm for the Permian rock.

It could be assumed that – in field practice – the effective rock D_{50} values would be at least slightly larger than those measured on material in flumes.

3 EROSION MODELLING METHODOLOGY

3.1 Soil loss targets

This study used runoff and erosion modelling to identify landform options that would erode at rates low enough to provide long-term stability. Effectively, the landforms are planned to be consistent with **tolerable** rates of soil loss. Wischmeier and Smith (1978) defined tolerable soil loss for cropland as "*the maximum rate of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely*."

A value of 11.2 t/ha/yr averaged over an area of interest is often cited as a tolerable soil loss rate, but that value was derived by US soil conservation agencies for deep, fertile cultivated soils, and has little relevance to most rehabilitated minesites. Using similar criteria to those applied for crop land, a lower soil loss tolerance value of 4.5 t/ha/y was developed by US agencies for erosion of rangeland soils and shallow cultivated soils (Wight and Siddoway 1979).

Lower tolerance values are relevant to rangeland and minesite situations, as not only are the soils shallower and more susceptible to fertility decline, but the lack of regular tillage or disturbance means that any rills or points of scour that form are more likely to extend and develop into gullies over time. These are typically of concern for minesite landforms where there is no bedrock layer at depth to limit long-term depths of incision.

For that reason, a key priority in setting a tolerable erosion target is the prevention of significant rill or gully development. On that basis, for slopes where long-term erosion risk (for a range of reasons) is considered low, then an average erosion rate for the slope of 5 t/ha/y and a maximum of 10 t/ha/y has commonly been applied by Landloch. Typically, the low risk category includes slopes where:

- The surface layer contains a significant component of durable rock;
- The material underlying the topsoil layer is not dispersive and unlikely to be highly erodible if exposed;
- The vegetation established is not dominated by buffel grass[1], which tends to divert and concentrate flow around tussocks and increase potential for rill formation;
- Rainfall in the area and soil fertility/productivity are such that there is a reasonable probability of vegetation stabilising any rill lines formed during site establishment[2]; and
- The overall landform height is not great (≤50 metres, for example).

In this case, several aspects of the landform do not meet the "low risk" requirements, but the anticipated presence of durable rock cover is

[1] Dominance of buffel grass would be assessed in terms of the rehabilitated area having >50% of its area covered by stands of buffel grass with little (<10% approximately) or no other grass species present.

[2] This would be assessed on the basis of observations of colonisation of bare areas in existing rehabilitation with similar topsoil and subsoil.

considered to be sufficient to render the landform "low risk" in terms of erosion model targets for batter slope design.

3.2 Strategy adopted

In developing landform designs, the strategy applied was to:

a) measure erodibility of key materials used in mine rehabilitation; and

b) use the WEPP model (Flanagan and Livingston 1995) to consider runoff and erosion from a range of landform and rehabilitation options as its flexibility and detailed output is ideal for that purpose.

WEPP is used to consider 2-dimensional slope profiles, and cannot, therefore, consider impacts of flow concentration over areas of tens of hectares. However, the detail provided by WEPP with respect to runoff and erosion and the location and timing of significant losses makes it an excellent design tool.

See Appendix 2 for greater detail on the WEPP model and its application.

4 ERODIBILITY MEASUREMENTS ON BULK SAMPLES

Measurements were made using simulated rain and overland flows to enable calculation of erodibility parameters for the WEPP runoff/erosion model.

4.1 Rainfall simulation

4.1.1 Rainfall simulator

The rainfall simulator used is of the design described by Loch *et al.* (2001), and applies simulated rain with a kinetic energy equivalent to that of natural rainfall at intensities >40 mm/h. In this case, intensities applied were in the range 90 – 130 mm/h for 25 minutes, which is consistent with storm return periods of 20 years for Tieri. (As the simulated rain study is used to derive infiltration and interrill erosion parameters, the actual intensity applied does not affect the parameters obtained, provided it is sufficient to cause runoff and of appropriate kinetic energy.)

4.1.2 Plot sizes

Due to limitations in the quantity of sample available to enable the various rates of mixing, simulated rainfall was – for most mixtures and materials – applied to flumes rather than to smaller plots. For the topsoil, flumes used are 0.4 X 2.0 m. For the rock:soil mixtures, larger flumes of dimensions 0.77 X 3.0 m were used. Photographs of the various surfaces following application of rain are shown in Figures 2 to 5.

However, for the 2:1 Quarry rock:topsoil mixture, triplicate plots 0.75 m square and 0.2 m deep (Figure 3) were used to measure infiltration rates of simulated rain and interrill erosion.

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4.1.3 Plot preparation and rainfall application

Plots were prepared and lightly compacted during packing so that the re-packed samples were consistent with soil that had consolidated naturally under rainfall, and were subjected to wetting and drying to further consolidate the surface prior to application of simulated rain.

Plots were set at 20% gradient and simulated rain was applied for a period sufficient for the samples to reach steady infiltration/runoff rates.

Runoff generated by simulated rain was sampled at regular intervals (2-3 minutes), and sediment concentrations were measured gravimetrically.

Rain water was used in all measurements to avoid any potential impacts of water quality on infiltration and on the disaggregation of sediment to finer sizes.

Figure 2: Topsoil surface following application of simulated rain, 0.4 m wide flume

Figure 3: Surface of 4:1 Permian spoil:topsoil mix following application of simulated rain, 0.77 m wide flume.

Figure 4: Surface of 2:1 Quarry rock:topsoil mix following application of simulated rain, 0.75 m wide plot.

Figure 5: Surface of 4:1 Quarry rock:topsoil mix following application of simulated rain, 0.77 m wide flume.

4.2 Overland flows in flumes

As noted previously, studies of rill erodibility used flumes 2 m long and 0.4 m wide for the topsoil, and flumes 3 m long and 0.77 m wide for the rock:topsoil mixtures (Figure 6). For all materials, three flumes were run, set at various gradients, ensuring that a wide range of flow tractive force was applied. In all cases, samples were lightly compacted during placement in the flumes (to achieve a field bulk density for the material), then exposed to several wetting and drying cycles over several days to develop a hard, cohesive soil surface crust (consistent with typical field conditions) prior to application of overland flow.

For each flume, a sequence of increasing overland flow rates was applied. Each flow rate was maintained for 5 minutes and samples of runoff were taken at 1, 2, 3, and 5 minutes from the commencement of each flow rate for sediment concentration measurement.

The 4:1 Quarry rock:topsoil mixture was found to be so coarse that overland flow could not be generated effectively, and – consequently – erodibility parameters were not able to be generated for this mixture.

Figure 6: Flumes showing application of flow to (L-R) 4:1 Quarry rock:topsoil mix, 4:1 Permian rock:topsoil mix, and topsoil.

4.3 WEPP parameter derivation

4.3.1 Erodibility parameters

Erodibility parameters required for the WEPP model are K_i (interrill erodibility), K_R (rill erodibility – a detachment parameter), and τ_c (critical shear for rill initiation). These parameters are used to predict changes in erosion processes and rates

in response to changes in runoff, slope length, and land management. Also important are the Hydraulic Conductivity parameter (K_e) used in the model to predict runoff, and sediment settling velocity distributions.

Parameters for the topsoil and the Permian waste:topsoil mix calculated from laboratory measurements are shown in Table 3. The table also shows erodibility parameters for a 2:1 Quarry rock:topsoil mixture, based on a combination of measured and estimated data.

Based on the measured D_{50} value for Permian rock, and assuming a sandstone bulk density of 2.4 g/cc, the Shields equation (Shields 1936) indicates that a critical shear value of approximately 47 Pa should have been measured; considerably larger than the 19.3 Pa actually measured. This is consistent with the observation that the proportion of fine particles in the mixture tested was high, and that the dominance of the fine particle matrix within the mixture was responsible for the poor infiltration and relatively high erodibility measured.

Although the mixture prepared in Landloch's laboratory was comprised of a 4:1 ratio of waste to topsoil, it appears that the functional ratio between coarse and fine particles was closer to 1:1, with the bulk of the additional fines coming from the waste. Consequently, the high proportion of fine particles in the mixture drastically reduced its erosion resistance.

Table 3: WEPP erodibility parameters derived from laboratory measurements.

Parameters	Units	Material tested		
		Topsoil	4:1 Permian waste:topsoil	2:1 Quarry rock:topsoil
Interrill erodibility (K_i)	kg.s.m^{-4}	4,384,058	1,897,066	1,923,735
Rill erodibility (K_R)	s/m	0.00133	0.00206	0.00206[A]
Critical shear for rilling (τ_c)	Pa	11.1	19.3	63.5[B]
Effective hydraulic conductivity (K_e)	mm/h	2.2	1.1	15
Steady infiltration rate	mm/h	7.5	6.5	30.3

[A]: *Assumed to be similar to that of the Permian rock as D_{50} values are similar, and chemical properties of the associated fine fractions are also similar (Table 1).*

[B]: *Calculated using Shields equation and estimated rock density of 2.4 g/cc.*

4.3.2 Sediment properties

To measure properties of "sediment available for detachment", samples of the surface seal layer were taken from plots immediately following application of simulated rain using the method outlined by Loch (1994). Settling velocity

distributions of those samples were measured in a modified top entry settling tube (Loch 2001).

Rain water was used in all measurements to avoid any potential impacts of water quality on infiltration and on the disaggregation of sediment to finer sizes.

Results were expressed as "equivalent sand size distributions", and showed sediment from the topsoil (CR25) to have similar proportions of finer size classes to sediment from the Permian rock:topsoil mix, but to be somewhat finer than the Permian rock mix sediment in the equivalent sand sizes >0.1 mm (Figure 7). Input files detailing the measured equivalent sand size distributions were prepared and input to WEPP for simulations of runoff and erosion.

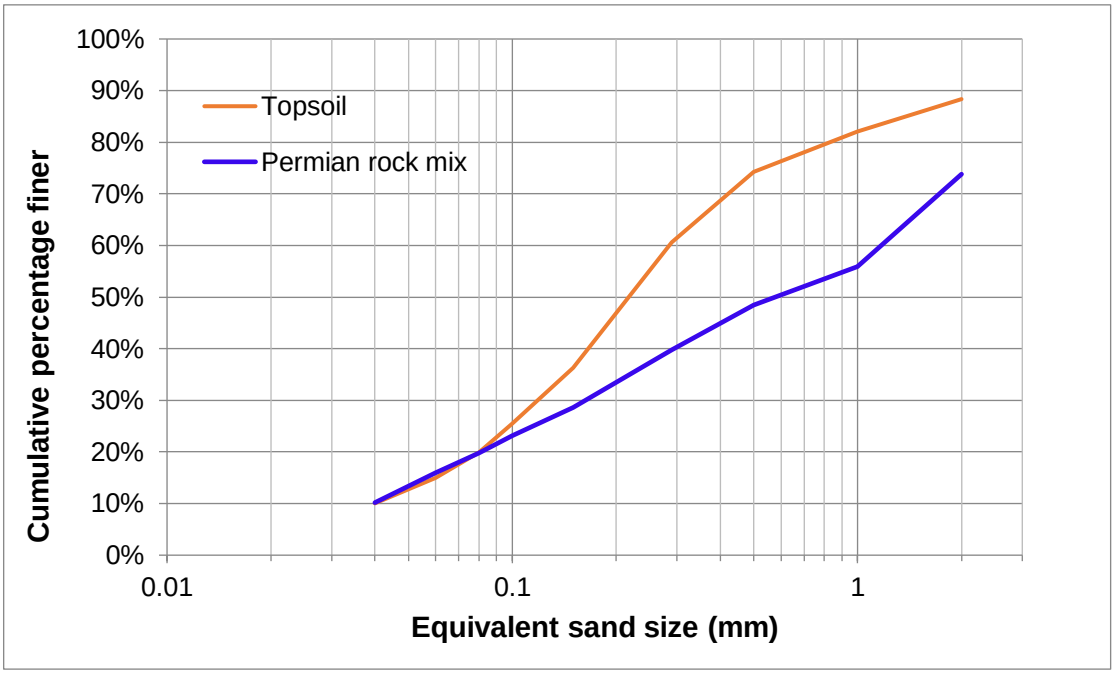

Figure 7: Settling velocity distributions of sediment, presented as equivalent sand sizes.

5 WEPP SIMULATIONS FOR LANDFORM OPTIONS

5.1 Climate file used

For a range of central Queensland mine sites, Landloch has used climate files for either the Comet Post Office, some 80 km to the south of Middlemount Mine, or Moranbah, some 170 km to the north of Middlemount. Both files have reasonably similar annual rainfall amounts, and – when used in simulations – provide reasonably similar predicted erosion amounts. Given the geographic spread between the two locations, it appeared reasonable to consider that variation in rainfall erosion potential across the intervening distance was minimal.

However, after discussion with Middlemount staff, rainfall stations closer to the site were investigated, and the station 35109 Booroondarra was identified;

approximately 20 km west of Middlemount. This site had 98 years of record, and annual rain of 634 mm, considerably higher than that of Comet and Moranbah (578 mm and 553 mm respectively in those climate files).

Consequently, a 100 year climate sequence compatible with WEPP's input requirements was developed for Booroondarra using statistical methods. Two climate datasets were used to prepare the climate file:

(a) SILO Patched Point data for 35109 Booroondarra from 01/01/1921 to 31/12/2018 for rainfall, maximum and minimum temperatures, and solar radiation were sourced from the Australian Bureau of Meteorology (BoM).

(b) The sub-daily pluviograph data used to inform the storm intensity and duration parameters was sourced from 35147 Emerald DPI Field Station from 01/03/1983 to 31/08/2009. Coordinates are -23.4669, 148.1519. This site is 80km south south west of Middlemount. It is the closest pluviograph data available for the site with record longer than 15 years.

The synthetic climate sequence retains the same following characteristics as the observed daily data in terms of:

- Mean daily precipitation on wet days for each month,
- Standard deviation of daily precipitation for each month,
- Skewness coefficient of daily precipitation for each month,
- Probability of a wet day following a dry day for each month,
- Probability of a wet day following a wet day for each month,
- Mean daily maximum temperature for each month,
- Standard deviation of daily maximum temperature for each month,
- Mean daily minimum temperature for each month,
- Standard deviation of daily minimum temperature for each month,
- Mean daily solar radiation for each month and
- Standard deviation of daily solar radiation for each month.
- Mean maximum 30-min rainfall intensity for each month, and
- Probability distribution of the time to peak storm intensity.

A 100-year climate sequence was generated using CLIGEN version 5.1 (Yu 2003). Average annual rainfall for the file is 636 mm, and the CLIGEN file corresponds closely with both measured monthly rain and rainfall return periods (Figures 8 and 9). It contains considerable variation through the 100-year period of data (Figure 10).

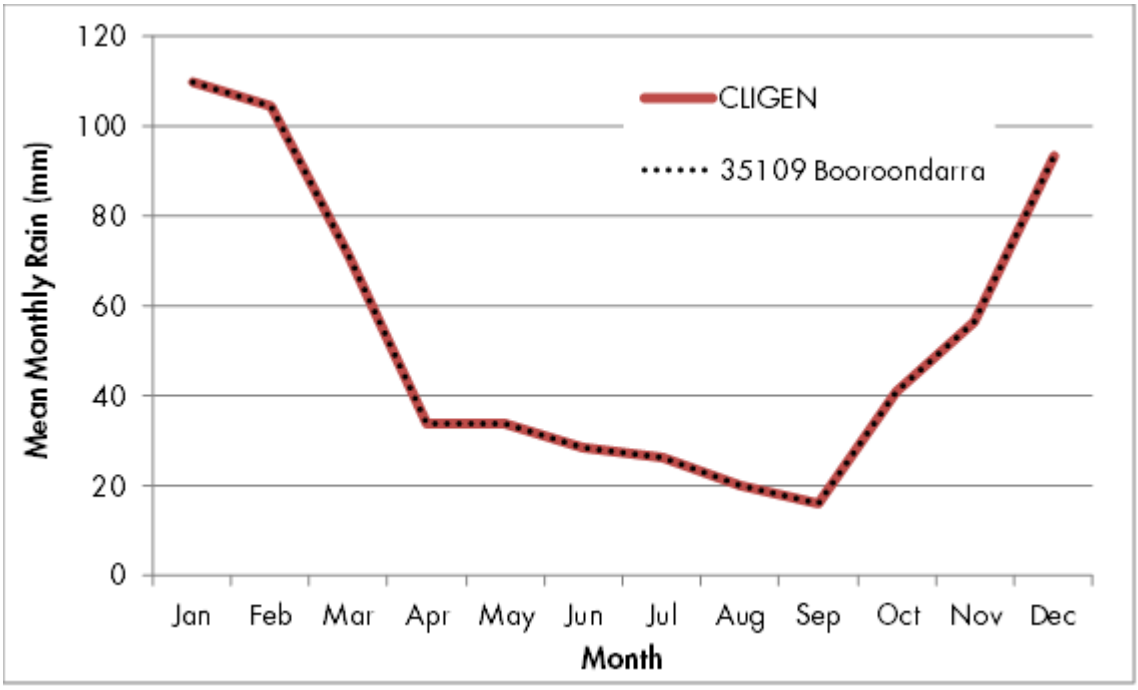

Figure 8: Comparison of average monthly rainfall in measured and synthetic files.

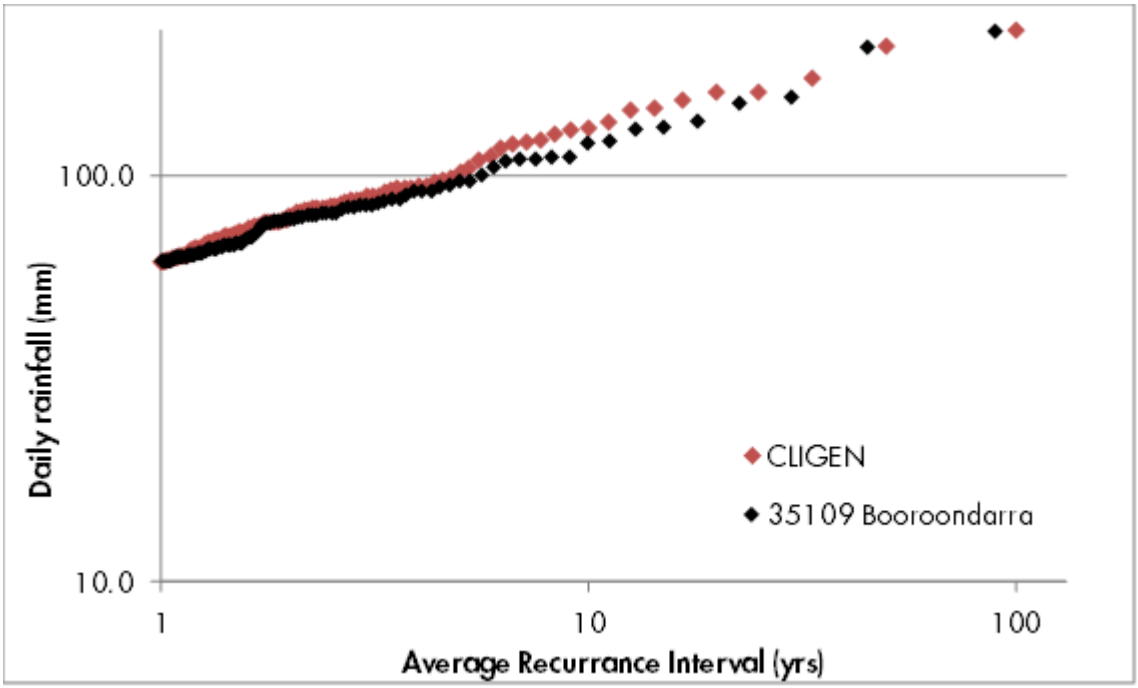

Figure 9: Comparison of rainfall amounts for various return periods for measured and synthetic files.

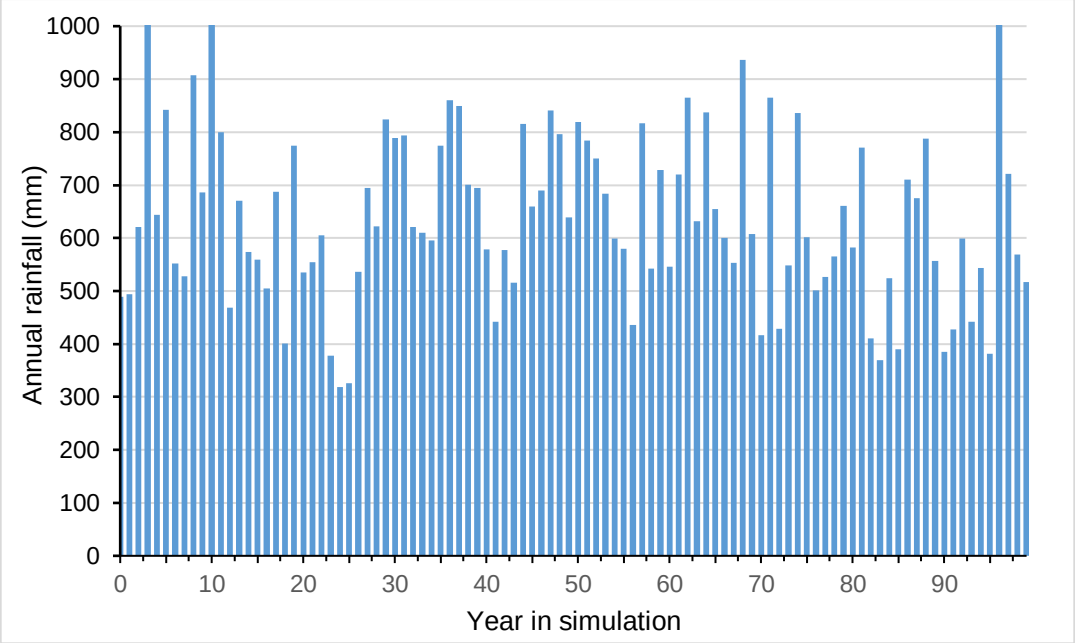

Figure 10: Annual rainfall variation within the 100-year climate file used for WEPP simulations.

5.2 Materials considered

As the 4:1 Permian rock:topsoil mixture was observed to have an unduly high proportion of fine particles, simulations considered not only the mixture tested, but also possible alternative mixtures with parameters estimated on the basis of available data.

For alternative mixtures, it was assumed that methods of handling the Permian rock could be altered such that the fine fraction of that waste, e.g. >20 mm, was able to be excluded, leaving only the coarser fraction. This would require a change in waste handling to exclude fines, which could be achieved through use of a skeleton bucket on the excavator used to load the waste for transfer to the waste landform for placement and mixing with topsoil. However, this practice would be likely to not only remove much of the fines, but also some of the moderate particle sizes (e.g., up to 50 or up to 75 mm diameter), and could result in rock with a somewhat larger D_{50} being delivered for placement on rehabilitated areas. Consequently, a mix of rock with a somewhat larger D_{50} was also considered.

This gave:

- 4:1 Permian rock:topsoil mix as tested (critical shear for rilling of 19.3 Pa);
- 4:1 Permian rock:topsoil mix with a reduced proportion of fines, so that its critical shear for rilling of was 47 Pa, based on rock D_{50} of 77 mm; and
- Permian rock:topsoil mix with rock D_{50} of 120 mm and critical shear (calculated) of 74 Pa.

For all mixtures, infiltration capacity of the mix was not altered, as increasing the proportion of topsoil relative to Permian fines in the mix was not indicated by experimental data to have significant potential to change infiltration rates.

5.3 Surface conditions tested

5.3.1 Slopes

Initial simulations considered linear slopes of 100 m horizontal length, at gradients of 16.66% and 33.33%. Effectively, changing gradient in these simulations did change the height of landform considered.

Subsequent simulations considered a landform 65 m high, with gradients of 16.66% and 33.33%.

Importantly, for all slope options considered, **it was assumed that runoff on the top of the waste landform would NOT be discharged onto the outer batter slopes.** It is assumed that an appropriate perimeter bund and cross-bunding will be installed to contain any rainfall excess on the top of the landform.

5.3.2 Vegetation cover

Three surface conditions were considered:

(a) bare surface with rill spacing set to 3 metres to allow for some spreading of surface flow by the rock.

(b) vegetated surface, assumed to have achieved 40% grass cover. Hydraulic conductivity of the mix was increased to allow for an increase in infiltration rate of 7 mm/h per 10% increase in grass cover (based on data of Kato et al. 2009), though recent data from another site indicate that that level of increase may not be achieved on dispersive soils. Rill spacing was reduced from 3 to 2 metres to account for higher surface hydraulic roughness, and a cover factor of 0.10 applied. This value was taken from the SOILLOSS Manual (Rosewell 1993).

(c) vegetated surface, assumed to have achieved 60% surface cover. Hydraulic conductivity was adjusted to account for the increase in infiltration capacity associated with grass cover, and rill spacing was kept at 2 metres.

Greater detail on the methods used to account for vegetation impacts is given in Appendix 3.

5.4 Model output – initial simulations

5.4.1 Impacts of vegetation on predicted annual runoff

For bare surfaces, predicted annual runoff was 298.5 mm/y, reducing to 49.7 mm/y for 40% vegetation cover, and to 22.5 mm/y for 60% vegetated cover. Consequently, the assumed impact of vegetation on infiltration capacity resulted in a drastic reduction in annual runoff, and would also have consequently also greatly reduced predicted rates of erosion.

5.4.2 Predicted erosion rates – 40% cover and lower test slope

Data on average and peak predicted erosion rates on the test slope used in simulations are shown in Table 4.

Generally, to achieve a sustainable and stable batter slope, Landloch would aim for average erosion rates <5 t/ha/y, and maximum rates at any point on the slope <10 t/ha/y. If a slope is considered high risk, more stringent conditions may be applied, though that has not been considered necessary in this case.

Based on those conditions, cells with erosion rates considered "acceptable" are highlighted green.

The data show that, irrespective of the rock sizes placed, vegetation establishment has a major impact on erosion potential of the slopes considered. However, there is also a large impact of rock size and critical shear on erosion risk.

The initial data – both measured and modelled – indicate that the 4:1 Permian:topsoil mixture,as tested, is unlikely to deliver successful rehabilitation if placed on steep (33.3%) slope gradients. At the lower gradient of 16.66%, there was potential for 100 m long slopes to be stable, provided at least 40% surface vegetation cover was established.

Its relatively high erodibility is due to the relatively high proportion of fine particles in the mixture – almost certainly largely from the Permian waste. If that proportion of fines can be reduced, then the potential for the Permian rock to enable construction of stable rehabilitated slopes is much greater, and slope gradients up to 33.3% could be constructed (provided sufficient vegetation cover was established).

Table 4: Erosion rates predicted by WEPP simulations for a range of material properties, surface conditions, and batter gradients – 4:1 Permian rock:topsoil mixture.

Material tested	Surface condition	Gradient (%)	Average erosion rate (t/ha/y)	Peak erosion rate (t/ha/y)
4:1 Permian waste:topsoil mixture	Bare	33.3	488.7	1061
		16.66	154.4	435
	Vegetated (40% cover)	33.3	9.4	20.8
		16.66	2.7	8.1
4:1 Permian waste:topsoil mixture, but with reduced fines	Bare	33.3	80.2	317
		16.66	7.3	24
	Vegetated (40% cover)	33.3	1.3	4.9
		16.66	0.28	0.37
Increased D_{50} and increased critical shear	Bare	33.3	11.3	43
		16.66	4.8	4.9
	Vegetated (40% cover)	33.3	0.39	0.56
		16.66	0.27	0.27

5.4.3 Increased landform heights and higher levels of vegetation cover

Following discussions of likely final landform options, further WEPP simulations were carried out to consider:

- Landform height of 65 metres

- Gradients of 16.66% and 33.3%
- Permian rock mix with either 47 Pa or 74 Pa critical shear
- Vegetation cover of 40% and 60%

For 60% vegetation (grass) cover, final infiltration rate and effective hydraulic conductivity of the mix was increased to allow for an increase in infiltration rate of 7 mm/h per 10% increase in grass cover. A cover factor of 0.042 was applied, taken from the SOILLOSS Manual (Rosewell 1993).

Results of those simulations are shown in Table 5. In this case, cells with erosion rates considered "acceptable" are highlighted green.

The simulations show large impacts on predicted erosion rates from material properties, gradient, and vegetation cover level.

Table 5: Erosion rates predicted by WEPP simulations for a range of material properties, surface conditions, and batter gradients – 4:1 Permian rock:topsoil mixture and 65 metre high landform.

Material tested	Surface condition	Gradient (%)	Average erosion rate (t/ha/y)	Peak erosion rate (t/ha/y)
Permian rock mix, critical shear of 47 Pa	Bare	33.3	277	872
		16.66	122	451
	40% cover	33.3	4.5	15.1
		16.66	1.5	5.8
	60 % cover	33.3	1.1	3.6
		16.66	0.4	1.3
Permian rock mix, critical shear of 74 Pa	Bare	33.3	57.3	264
		16.66	15.5	73
	40% cover	33.3	0.8	3.4
		16.66	0.3	0.8
	60 % cover	33.3	0.2	0.8
		16.66	0.01	0.2

For 40% grass cover, the simulations indicate that the current Permian rock size distribution – if its fine component can be reduced – will definitely be stable to erosion if placed on a 65 metre high landform at 16.55% gradient, and is likely to be reasonably stable if placed at a gradient of 33.3%. If the rock size becomes coarser (and critical shear increases to 74 Pa) as a result of changed handling practices, then the data show that both slope gradients will be extremely stable for this cover level.

For 60% grass cover, the simulations indicate slopes of either gradient, placed on a 65 metre high landform, will be extremely stable. This highlights the importance, for this landform, of achieving vegetation cover targets and establishment of sustainable and vigorous vegetation cover.

5.5 Alternative materials

5.5.1 Other samples constructed from supplied materials

Other samples analysed were:

- Topsoil (without any added rock);
- 2:1 Quarry rock: soil mix; and
- 4:1 Quarry rock:topsoil mix.

Of those materials, the 4:1 quarry rock:topsoil mix did not register runoff, and the ratio of coarse to fine particles was clearly too high for this mixture to achieve a suitable rehabilitation outcome. Effectively, the proportion of fine particles in the mixture was so low that there is insufficient growth medium to support plant growth.

5.5.2 Topsoil and vegetation

Simulations were carried out to assess:

- Potential rates of erosion of topsoil prior to vegetation establishment; and
- Potential for long-term stability if vegetation is established.

Slope gradients tested were 33.3% and 16.66%, both for 65 m slope height.

Bare soil, and soil with 40% and 60% vegetation cover. For 40% cover, rill spacing was set to 3 metres, as there was no surface roughness from rock. For 60% cover, the spacing was reduced to 2 metres. Infiltration rates were adjusted to account to increased vegetation cover as outlined previously.

For 33.3% gradient, the simulations (Figure 11) showed that the bare soil had extremely high erosion potential, reaching a maximum of 638 t/ha/y and an average along the slope of 446 t/ha/y. It is worth noting that – for the topsoil – the pattern of erosion along the slopes is such that average rates for the slope are not greatly less than the maximum erosion rates. This is in contrast to the situation where rock is added to the surface, where the differences between average and maximum erosion rates are much greater (Tables 4, 5, and 6), a consequence of rill development occurring at longer slope lengths and detachment rates being slower.

The simulations also showed that achievement of 60% cover was essential for the slope to achieve the target erosion rate of <5 t/ha/y.

To control the potentially high erosion rates from bare soil during vegetation establishment, the use of berms (to shorten effective slope length) and contour ripping (to incease surface depression storage and reduce runoff) will be essential to avoid excessive damage to the prepared slope surface during that period.

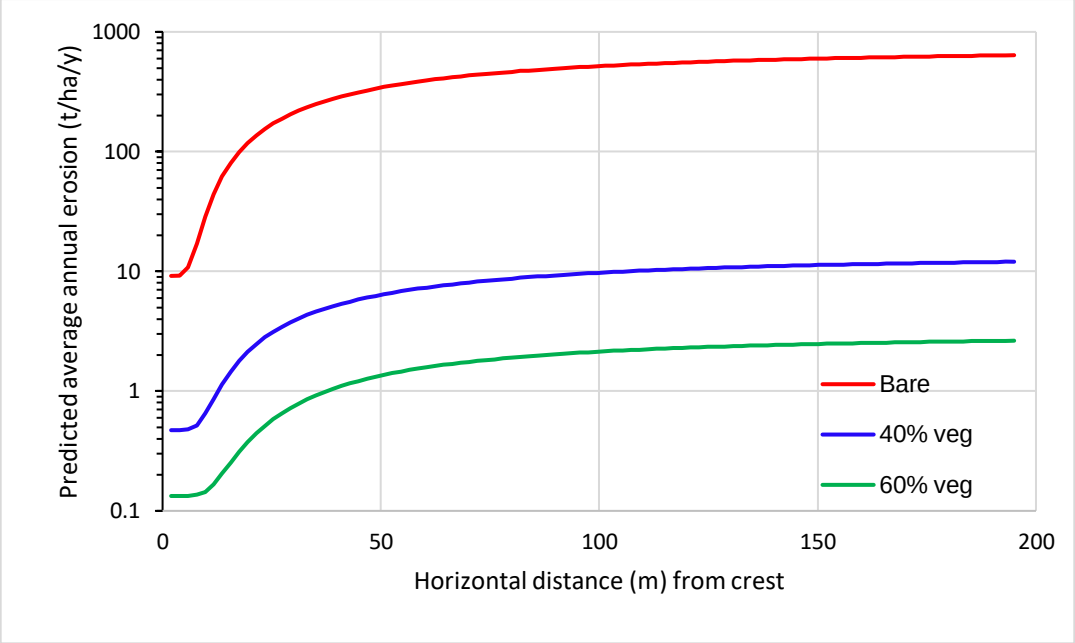

Figure 11: Predicted impacts of vegetation cover and slope length on erosion rates along batter slopes on 33.3% gradient.

At 16.6% gradient, predicted erosion rates were lower (Figure 12), though still high for the bare slope surface, reaching an average of 268 t/ha/y and a maximum rate of 342 t/ha/y. At this gradient, 40% vegetative cover would just be sufficient to achieve the erosion target of <5 t/ha/y.

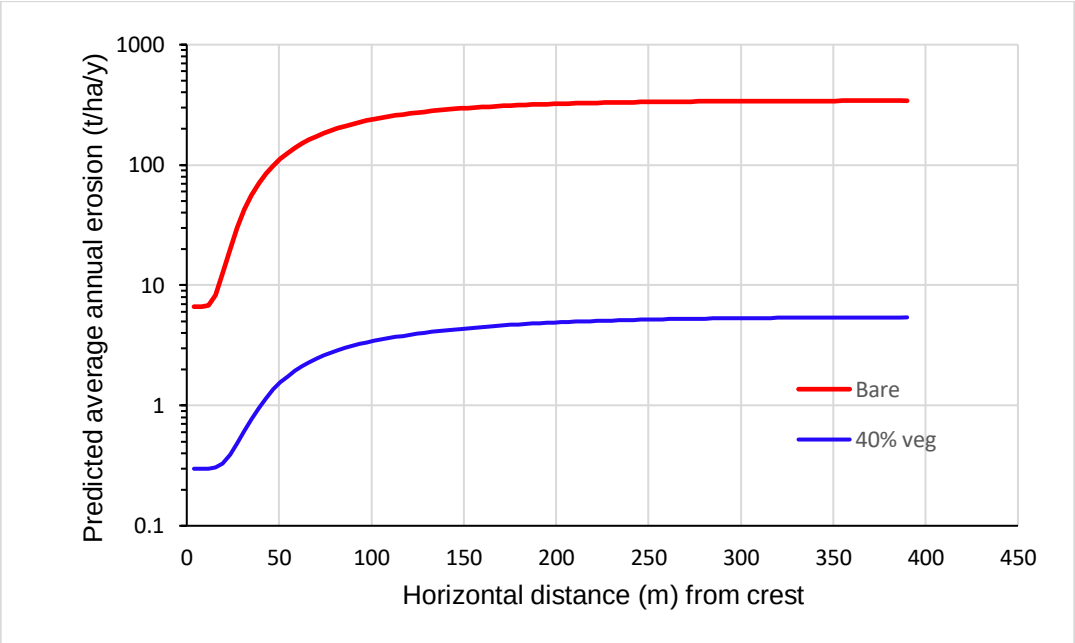

Figure 12: Predicted impacts of vegetation cover and slope length on erosion rates along batter slopes on 16.6% gradient.

5.5.3 Quarry rock:topsoil mix

Not all erodibility parameters were able to be measured for this material with some needing to be inferred. Specifically:

- Measured values were used for interrill erodibility and effective hydraulic conductivity, with the latter being considerably higher than that measured for the topsoil on its own.
- Critical shear of 63.5 Pa was calculated on the basis of measured D_{50} of 90 mm and a rock specific gravity of 2.6 g/cc.
- Rill erodibility was left at the same value as that measured for the 4:1 Permian rock:topsoil mix.

For the same slope options as tested previously (65 m high and gradients of 33.3% and 16.66%), a bare surface (3 m rill spacing) was predicted to produce 59.4 mm runoff per year. Predicted erosion rates for bare and vegetated surfaces are shown in Table 6, with green shading again indicating surfaces for which predicted erosion rates are acceptable. The same procedures for accounting for vegetation impacts were applied.

The data in Table 6 indicate that – in terms of erosion stability – this material offers significant advantages. It should be noted, however, that its agronomic quality is both low and not greatly different to that measured for the 4:1 Permian rock:topsoil mix.

Table 6: Erosion rates predicted by WEPP simulations for the 2:1 Quarry rock:topsoil mixture.

Material tested	Surface condition	Gradient (%)	Average erosion rate (t/ha/y)	Peak erosion rate (t/ha/y)
2:1 Quarry rock:topsoil	Bare	33.3	34.6	130
		16.66	10.7	42
	Vegetated	33.3	0.7	2.7
		16.66	0.24	0.8

5.6 Managing erosion risk during vegetation establishment

For a newly rehabilitated site, in the period – typically September to November – when vegetation is establishing, a once-off total erosion amount of 30-40 t/ha could be acceptable.

5.6.1 Impacts of added rock during vegetation establishment

If the predicted erosion rates for bare soil for a full slope height 65 m and on 33.3% gradient are considered as an indication of erosion risk during vegetation establishment, it is clear that the risk of severe erosion during that period can be quite high.For topsoil without any added rock, predicted erosion in that

period (Figure 13) is in the order of 76 t/ha, much larger than the value of 30-40 t/ha considered acceptable.

For a bare surface with critical shear of 47 Pa due to added rock and infiltration capacity consistent with bare condition, simulations (Figure 13) suggest an average erosion amount in the September to November period of 45 t/ha, slightly higher than the suggested target values. As well, the predicted rate at the lower end of the slope is approximately 4 times the average for the full length of slope, indicating that – for that rock D_{50} - there would be areas at the toe of the long slope for which erosion would be unacceptable and one or more temporary berms would be required to reduce effective slope length while vegetation established.

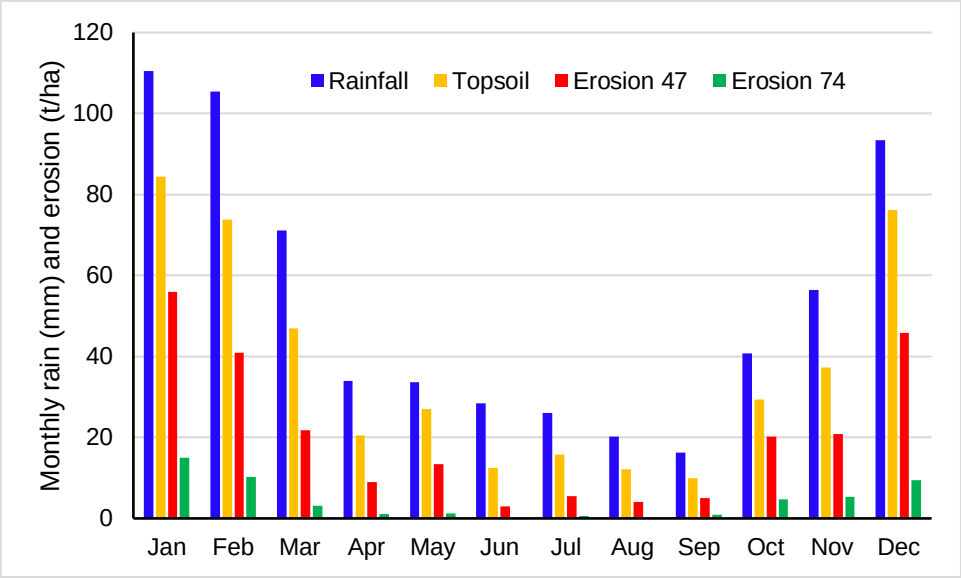

Figure 13: Predicted monthly rainfall and erosion for bare surfaces of topsoil and rock:soil mixes with critical shear of either 47 or 74 Pa. Rill spacing 5 m for topsoil, and 3 m when rock added.

5.6.2 Use of temporary berms

Topsoil only

For topsoil on 33% gradient, the predicted pattern of erosion (Figure 11) shows a rapid increase in erosion rate at a quite short slope length, with erosion rate reaching a maximum determined by sediment properties and sediment transport capacity. For berms to be effective on topsoil at this high gradient, they would need to so closely spaced as to be impractical. Consequently, berms are not recommended for steeper slopes when topsoil is placed without added rock.

For topsoil on 16.6% gradient, predicted erosion in the vegetation establishment period September – November is higher than the target value, indicating that some form of erosion control would be needed for these slopes. Assuming that – based on predicted values – erosion in the critical period is approximately 16% of the total annual erosion, then an annual rate at a point on the slope of ~186 t/ha/y equates to the tolerable amount of 30 t/ha. Based

on that value, simulations indicate a maximum berm spacing of 74 m, which, with allowance for berm width, would be consistent with construction of 4 berms to break the 65 m high slope into 5 equal sections.

Added rock, 47 Pa critical shear

At 33.3% gradient, where added rock increases critical shear to 47 Pa, the predicted rate of erosion for a bare surface at a slope length of 65 m is approximately 30 t/ha for the entire year, and would, therefore, be acceptable. (Erosion in the critical vegetation establishment period would be much lower again.) Installing berms at 65 m slope length would enable the full 65 m high slope to be protected using two temporary berms installed at distances of 65 and 130 m from the crest of the slope.

At 16.6% gradient, erosion at the toe of the slope during the critical revegetation period is slightly more than double the target amount. In this case, a slope length of 280 m is predicted to meet the 30 t/ha target. For slope lengths between 280 and 390 metres, a single, mid-slope berm would be the most practicable option and should provide effective erosion control during the establishment period.

Coarse added rock, critical shear 74 Pa

If rock D_{50} was 120 mm and critical shear increased to 74 Pa, simulations indicate that – for a 65 m high slope with 33.3% gradient - erosion in that critical period of vegetation establishment would be reduced (Figure 13). Predicted erosion in that period then averages 22 t/ha along the complete slope, with the rates of erosion at the toe of the slope being approximately 5 times higher the the slope average. That means that cumulative erosion at the toe of the slope during the period of risk is unlikely to be acceptable and, some additional measures to stabilise the surface would be required.

However, for both 33.3% and 16.6% gradients, a more practicable option would be to rely on use of contour ripping to reduce erosion risk during vegetation establishment rather than to install berms for this material.

5.6.3 Contour ripping

A key impact of ripping on the contour is to increase surface detention storage, thereby reducing runoff. However, Landloch generally only recommends significant contour ripping for rocky materials. Where surface materials contain little rock, cross-slope rip lines tend to overtop easily and establish a rapidly eroding rill network that can increase rates of erosion quite significantly.

Consequently, in this case, impacts of cross-slope ripping were only considered for the surface with 120 mm rock D_{50}, and critical shear of 74 Pa. For that situation, furrow overtopping would be less likely to permanently damage furrows, and the surface detention storage would be more persistent.

Within the WEPP model, detention storage is accounted for by a Random Roughness term (RR), with effective surface storage being related to both RR and slope gradient. Simulations assumed that the "standard" surface ripping treatment for rehabilitation would involve dozer rip lines at approximate spacing of 1 m, with a typical dozer ripping depth of 300 to 400 mm. The assumed furrow cross section was roughly V-shaped, and effective furrow

depth was assumed to be 200 mm. At a 20% slope gradient, that gave surface detention storage of 35 mm and RR value of 13 cm.

For that value of RR, a bare slope 65 m high on 33.3% gradient with critical shear of 74 Pa was predicted to have annual erosion at its toe of 23 t/ha, confirming that – for surfaces with coarser rock – cross-slope ripping would be sufficient to achieve the necessary short-term erosion control and berms would not be required.

(Long-term simulations used a RR value of 3 cm to represent a long-term surface that has smoothed out under raindrop impact and various surface process and that would apply over the large proportion of the time periods simulated.)

5.7 Concave slope options

In this case, the material/vegetation combinations tested generally showed that linear slopes on 33.3% gradient up to 65 m high are likely to be stable, therefore rendering concave slope profiles unnecessary.

The only linear slope/vegetation combination that was shown to be marginally stable was rock with critical shear of 47 Pa, and vegetation cover of 40%. For that combination, a concave slope option was investigated, with the resultant slope 225 m long profile shown in Figure 14. Effectively, the design reduces gradients on the lower 20 m of fall from the top of the slope, with the effect of flattening out the toe of the slope and (probably) giving a slightly smoother transition from the batter slope to the adjoining land surface.

The graph shows gradients for each slope segment, with changes in gradient at slope lengths/elevations (m) of:

- 133/20.7 and
- 180/8.9

Overall, the concave profile, for the critical shear and vegetation levels considered, reduces predicted erosion on the slope (relative to a linear profile of the same height and length) by 44%.

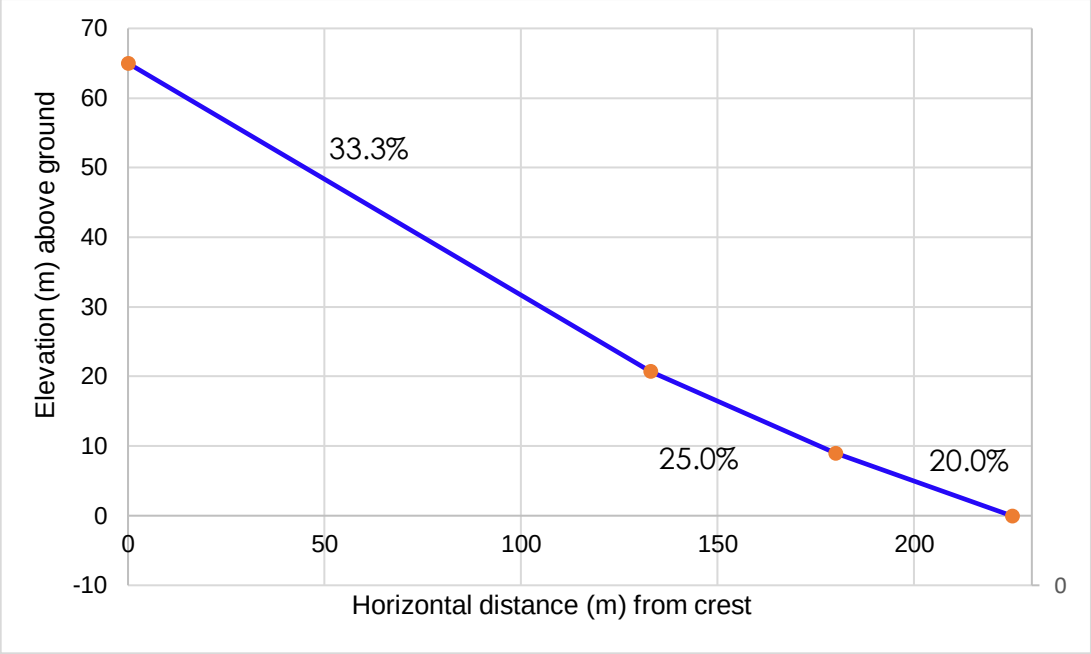

Figure 14: Concave profile developed for material with critical shear of 47 Pa and vegetation cover of 40%.

It may well be more cost-effective for rehabilitation works to focus on delivering higher levels of vegetative cover than on installation of a concave profile.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Priorities for achieving stable batter slopes

6.1.1 Gradients

Simulations demonstrated interactions between slope gradient, critical shear for rilling (as influenced by added rock), and vegetation cover. Generally, at the steeper gradient, achievement of long-term stability required addition of rock and achievement of at least 40% cover and, for some slope options, 60% vegetation cover.

6.1.2 Rock diameters

In the very short term, a major priority for achieving stable slopes is the placement of a rock:topsoil mix that will have appropriate mixing ratios of coarse and fine particles and a suitable critical shear to resist erosion. Simulations in this study suggest that a **minimum** critical shear of approximately 50 Pa – consistent with a rock D_{50} of approximately 80 mm – is desirable.

However, there appears to be significant advantage in terms of initial slope rehabilitation requirements from use of a slightly coarser rock, and a rock D_{50} closer to 120 mm is recommended.

6.1.3 Vegetation

For the medium to long term, the model output shows that establishment of sustainable surface cover of at least 40%, and preferably 60% or greater, is essential. This will be particularly so if, over the longer term, the rock added to the surface layer gradually weathers and effectiveness in controlling erosion reduces.

Importantly, the need for surface (contact) cover puts focus on establishment of grasses, as shrubby vegetation produces canopy cover but generally considerably less contact cover.

However, given the high pH and moderate to high salinity of the fine fractions in the waste rock, it could be considered likely that the vegetation established may become dominated by salt - tolerant shrubby genera such as *Atriplex* if the rock:topsoil mix has chemical properties similar to those measured for the mixtures used in this study (Table 1).

Salt-tolerant grass species that should be suitably adapted include:

- Rhodes grass (Tolgar or Reclaimer cultivars);
- Saraji Urochloa;
- Digit grass (*Digitaria eriantha* ssp. eriantha) cv. Premier; and
- Indian bluegrass or Indian couch (*Bothriochloa pertusa*) cvv. Keppel, Medway, Bowen.

Other grass species should also be trialled.

A range of forb, shrub, and tree species could be included in the seeding mix, preferably with a component of leguminous (N-fixing) species, and a component of highly salt tolerant species such as *Atriplex* sp.

6.2 Rock/soil layer depth

A key consideration for rock layer installation is the depth of layer (and quantity of rock) required.

There is ample logical and observational evidence that the rock layer may not need to be overly deep, provided it is stable (able to resist movement by overland flows). Logically, if a layer of rock does not move, then it is likely to persist for long periods (probably thousands of years).

For placement of rock layers on waste landform slopes, one consideration is that riprap construction typically uses layers 1.5 to 2.0 times the D_{50} of the rock being placed, depending on the degree of variation in rock diameters. Where D_{50}/D_{90} is 0.8, then a layer thickness of 1.6 x D_{50} is recommended (IECA 2010). However, where D_{50}/D_{90} is 0.5, then recommended riprap thickness increases to 2.1 x D_{50}. Because control of larger sizes occurring in waste rock may not be as strict as in supply of rock for engineering construction, the higher ratio is recommended as a minimum.

For example, for a D_{50} of 120 mm, this would indicate a rock/topsoil layer depth of approximately 250 mm. For D_{50} of 77 mm, layer depth would be 161 mm.

However, there are concerns with respect to the depth of rock layer that can be formed reliably. For example, if the accuracy of rock layer placement is ±300 mm, then an average layer depth of 500 mm would have some areas

where layer depth was barely sufficient. Consequently, the accuracy with which layer depth can be controlled during construction will also be a factor in setting a target rock layer depth.

6.3 Preparation of an effective growth medium layer

From the data shown in Table 1, it is clear that exclusion of the fine fraction from the Permian waste so that the mixture created was solely composed of topsoil and Permian rock, would result in a growth medium with greatly improved agronomic properties:

- pH close to neutral;
- lower salinity
- lower chloride
- non-sodic.

As removal of fines from the Permian waste could also be expected to increase the mixture's rock D_{50} and, therefore, erosion resistance, there appear to be considerable benefits from exclusion of fines.

It is likely that, over time, there may be some release of salts from the rock, as Permian rock from the Middlemount pit tends to the either highly saline or highly alkaline (MCPL, 2018). Consequently, the development of vigorous vegetation with strong root development to increase water movement and salt leaching to depth in the profile is important for long-term vegetation sustainability.

Fertilisation to achieve rapid vegetation growth and surface stabilisation will be essential. It will also be advisable to use slow-release formulations as well as the more commonly used soluble products to enable not only greater addition of nutrients, but also to prolong the initial period of vigorous growth.

6.4 Summary

Gradients:

- Gradients ranging from 16.5% to 33.3% could be constructed, provided surface rock diameters and levels of vegetation achieved are consistent with requirements to achieve stability (Table 4 and Figures 11 and 12).

Materials:

- Provided vegetation cover level is sufficient, a range of materials (topsoil and topsoil/rock mixes) could achieve soil erosion targets at gradients up to 33.3%.
- Levels of vegetation required for achievement of long-term stability are reduced by placement of rock and for coarser rock diameters, meaning that achievement of erosion stability is less challenging when coarser rock is placed.
- Handling rock so that the fine component (<5 mm diameter) is discarded prior to placement will enable more reliable delivery of a 2:1 coarse:fine mixture.
- Discarding the fine component (<5 mm diameter) from Permian rock prior to placement is likely to greatly improve the agronomic quality of the rock:soil mixture placed.

Batter stabilisation during revegetation

- For topsoil at 33.3% gradient, it is unlikely that initial erosion rates can be reduced sufficiently for this gradient/material combination. Consequently, the high risks of erosion during vegetation establishment mean that use of topsoil alone is recommended to be restricted to gradients of approximately 16.6%.
- For topsoil at 16.6% gradient, a maximum (temporary) berm spacing of 74 m horizontal distance is recommended.
- For topsoil with added rock, critical shear of 47 Pa, a berm spacing of 65m horizontal is recommended for slopes of 33.3% gradient, increasing to a maximum horizontal distance of 280 m at 16.6% gradient.
- For topsoil with added rock, critical shear of 74 Pa, temporary berms are not recommended; contour ripping should be sufficient to achieve the target erosion rate.

Contour ripping

- Although contour ripping will undoubtedly be applied to all treatments, the only material for which a reduction in runoff was modelled and considered was the rock:topsoil mix with 74 Pa critical shear. It is assumed that – for more erodible materials – overtopping of furrows will rapidly render the ripping treatment ineffective in terms of runoff and erosion control.

Rock layer depth

- The minimum depth of rock:topsoil mixture to be placed is calculated as 2.1 X D_{50}. For a D_{50} of 120 mm, this would indicate a rock/topsoil layer depth of approximately 250 mm. For D_{50} of 77 mm, layer depth would be 161 mm.
- There are concerns with respect to the depth of rock layer that can be formed reliably, and it is possible that operational constraints may dictate placement of a somewhat deeper layer.

Vegetation

- Establishment of sustainable surface cover of at least 40%, and preferably 60% or greater, is essential.
- The need for surface (contact) cover puts focus on establishment of grasses
- A range of salinity and drought-tolerant grass species are recommended in section 6.1.3.
- Forb, shrub, and tree species included in the seeding mix should have a component of leguminous (N-fixing) species and a component of highly salt tolerant species.

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APPENDIX 1: RANGES AND RATINGS OF SOIL PROPERTIES

A range of soil properties were measured in this study to compare materials and, where possible, to identify materials with properties that could be considered "of concern".

The concept that there are "ideal" ranges of soil properties is, itself, of concern. In practice, parent materials, soils, and vegetation adaptation can vary widely, so that a value that is outside the normal range may, in a given situation, actually be "normal". For that reason, we strongly recommended that the following information be regarded as a guide only.

For the properties measured, the following ratings from Hazelton and Murphy (2007) can be applied.

pH	Rating
>9.0	Very strongly alkaline
9.0 - 8.5	Strongly alkaline
8.4 – 7.9	Moderately alkaline
7.8 - 7.4	Mildly alkaline
7.3 – 6.6	Neutral
6.5 – 6.1	Slightly acid
6.0 – 5.6	Mildly acid
5.5 – 5.1	Strongly acid
5.0 – 4.5	Very strongly acid

Soil salinity rating	Electrical conductivity (1:5, dS/m) for 10-20% clay
Very low	<0.07
Low	0.07 – 0.15
Medium	0.15 – 0.34
High	0.34 – 63
Very high	0.63- 0.93
Extreme	>0.93

Chloride concentrations in surface soils would be considered of concern if greater than 300 - 400mg/kg

Sodicity rating	Exchangeable sodium percentage (ESP)
Low	0 – 6
Marginally sodic to sodic	6 - 14
Strongly sodic	>14

Ca:Mg ratios are of concern if <1.0 and of definite concern if <0.5.

Cation exchange capacity (CEC) rating	CEC in m.eq./100g
Very low	<6
Low	6-12
Moderate	12-25
High	25-40
Very high	>40

APPENDIX 2: OVERVIEW OF THE WEPP MODEL

The Water Erosion Prediction Program (WEPP) (Flanagan and Livingston 1995) was developed by the United States Department of Agriculture (USDA) to predict runoff, erosion, and deposition for hillslopes and watersheds. It is a simulation model with a daily input time step, but internal calculations can use shorter time steps. For example, the climate file (for each day) includes information on:

- Amount of rain
- Duration of the rain
- Time to peak intensity
- Ratio between peak intensity and average intensity.

This information is used in infiltration calculations, so that the model takes intensity and duration of rainfall into account. For every day, plant and soil characteristics important to erosion processes are updated. When rainfall occurs, those plant and soil characteristics are considered in determining whether runoff occurs. If runoff is predicted to occur, the model computes sediment detachment, transport, and deposition at points along the slope profile, and, depending on the version used, in channels and reservoirs.

Conceptually, the WEPP model can be divided into six components: climate generation, hydrology, plant growth, soils, management, and erosion.

The erosion component uses a steady-state sediment continuity equation as the basis for the erosion computations. Soil detachment in interrill areas is calculated as a function of the effective rainfall intensity and runoff rate. Soil detachment in rills is predicted to occur if the flow hydraulic shear stress is greater than critical shear and the flow sediment load is below transport capacity. Deposition in rills is computed when the sediment load is greater than the capacity of the flow to transport it.

Validation of WEPP

The WEPP model can be considered "industry standard".

It has been widely used and validated for application in agricultural situations (Nearing and Nicks 1998; Ghidey and Alberts 1996; Liu *et al*. 1997; Zhang *et al*. 1996; Tiwari *et al*. 2000; Yu and Rosewell 2001).

It has also been widely used in design of constructed landforms for minesites across Australia. Erosion of minesite landforms modelled with WEPP using parameters derived using Landloch's methods has shown extremely strong correlation with observed rates for the same time periods, rainfall and surface conditions (Howard and Roddy 2012), confirming the accuracy of WEPP simulations for waste landform designs.

APPENDIX 3: METHODS USED TO DESCRIBE IMPACTS OF VEGETATION

To simulate varying various levels of vegetative cover:

- the WEPP hydraulic conductivity parameter (K_e) was modified to account for impacts of cover on steady infiltration rate as shown by rangeland research (Kato et al. 2009) (Figure A3-1). Effectively, steady infiltration rate generally increases by 7-10 mm/h for each 10% increase in surface cover.
- rill spacing (degree of flow concentration across slope) was modified so that flows were less concentrated as surface cover increased, with spacings of 5 m (bare soil), 3 m (50% cover), and 2 m (75% cover) being applied.

Cover (C) factors for the Revised Universal Soil Loss Equation (RUSLE) (Renard et al. 1997) were derived from reported values for rangeland grass cover (Table D-5 in Rosewell (1993)).

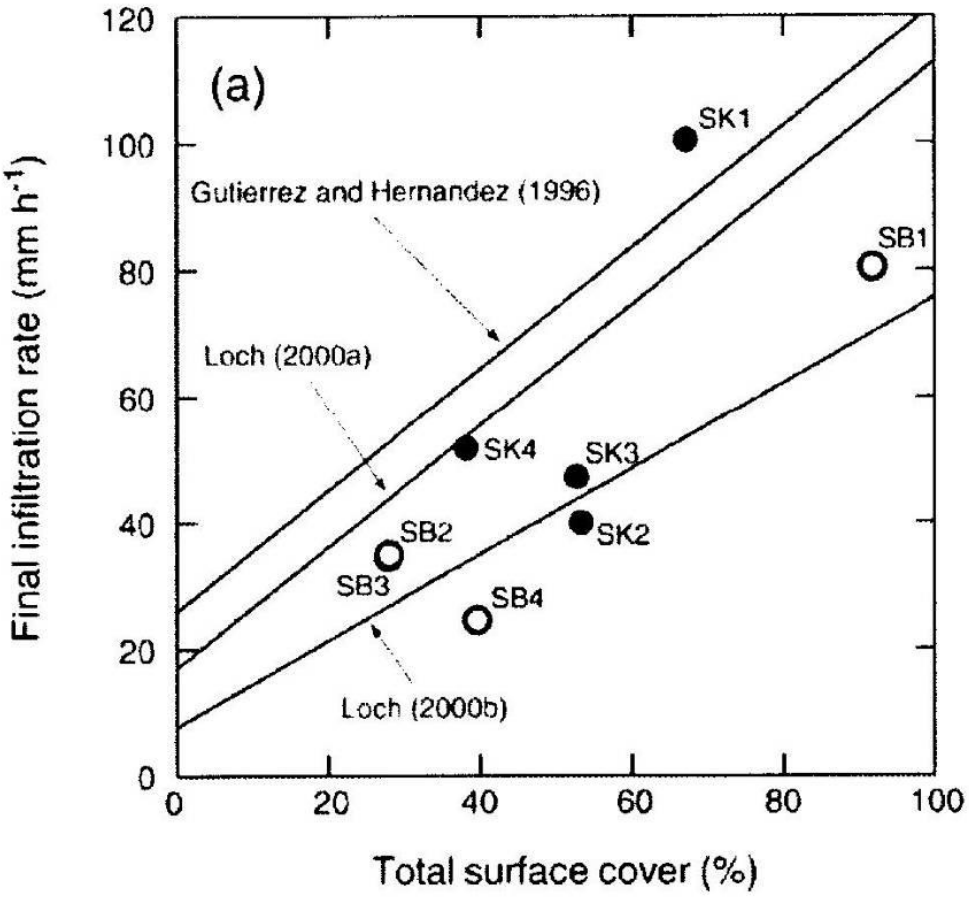

Figure A3-1: Impacts of cover on steady infiltration rate. (Figure based on a number of research studies and taken from Kato et al (2009)).

CARTLEDGE
MINING AND GEOTECHNICS

Middlemount Coal Mine

Geotechnical - Final Void Study

Report No.: MMC010006-BI_Rev 1

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MIDDLEMOUNT COAL MINE

GEOTECHNICAL - FINAL VOID STUDY

Cartledge Mining and Geotechnics

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Rev	Date	Author	RPEQ No.	Reviewer	RPEQ No.	Comment
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Table 6 Recommended slope geometry for lowwalls 17

1 Introduction

Middlemount Coal Mine (MMC) is located approximately 16 kilometres south west of Middlemount; Figure 1. The operations at the northern and southern voids has now entered an interim monitoring period whilst the final Closure Plan is being developed prior to implementation.

At the completion of open cut coal mining, the open cut pit may remain, becoming a final void. Middlemount Coal Mine has a legislative requirement to manage and ensure geotechnical risks related to the mine are minimised to acceptable standards. Thus, the Technical Service department of Middlemount Coal (MMC) requested Cartledge Mining and Geotechnics (CM&G) to undertake a final geotechnical void study of the Northern and Southern Voids at MMC.

This report provides a geotechnical stability assessment of the voids that will remain as permanent depressions following the completion of mining operations within the project area, including stability assessment of the low walls, the endwalls, and the highwalls.

Two final voids will be created by the project herein known as the Northern and the Southern Voids. The location of the voids is shown on Figure 1.

1.1 Background

As part of a Closure Plan, the final landform at the cessation of mining should comprise a final lake void surrounded by safe and stable batters and revegetated areas.

With the operation shutdown, the closure concept for the Mine Closure Plan now requires technical specification, and therefore a technical study of the proposed geotechnical and slope stability aspects is required.

Through separate technical studies, the hydrological aspect of the final Mine Closure Plan is available hence, mine water levels for the Geotechnical and Slope Stability Investigation was based on data presented in the hydrology report of the voids.

1.1.1 Environmental Authority

This Final Void Study has been carried out as per the requirements set out in MIiddlemount Coal Mine Environmental Authority which requires that scheduled geotechnical study dealing with residual voids be undertaken.

1.1.2 Pits History

In recent years, Middlemount mine was experienced incidences of significant pit wall instability. During this period, the mine has moved from relatively benign ground conditions to highly structurally complex ground conditions as it approaches the Jellinbah fault. The Jellinbah fault is a regional scale structure that has upthrown the eastern limb by up to 200 m. The Girrah seam of the Fort Cooper measures have been exposed above the Rangal coal measures in the eastern economic limit of the pit.

Improved structural geological modelling and geotechnical analysis have reduced the frequency of slope failures. The ongoing development of the mine will continue to encounter complex ground conditions and ongoing interpretation and analysis are required to mitigate this risk.

1.2 Purpose

The purpose of this report is to provide a comprehensive analysis is to provide geotechnical advice for the creation of long-term stable slopes for the final void for Middlemount to use as part of their Mine Closure Plan.

1.3 Relevant Information

CM&G have completed the following reports associated with the Final Void at Middlemount Coal Mine and should be read in conjunction with this report:

- Southern Extension Project – Environmental Values Assessment, Report No.: 0469-29-J4, dated 03 September 2020.
- Report by CM&G, 'Geotechnical Review of Residual Void and East Pit Stand-off', document reference: CMG-MC-LET-0001 Rev 0, dated April 23, 2018

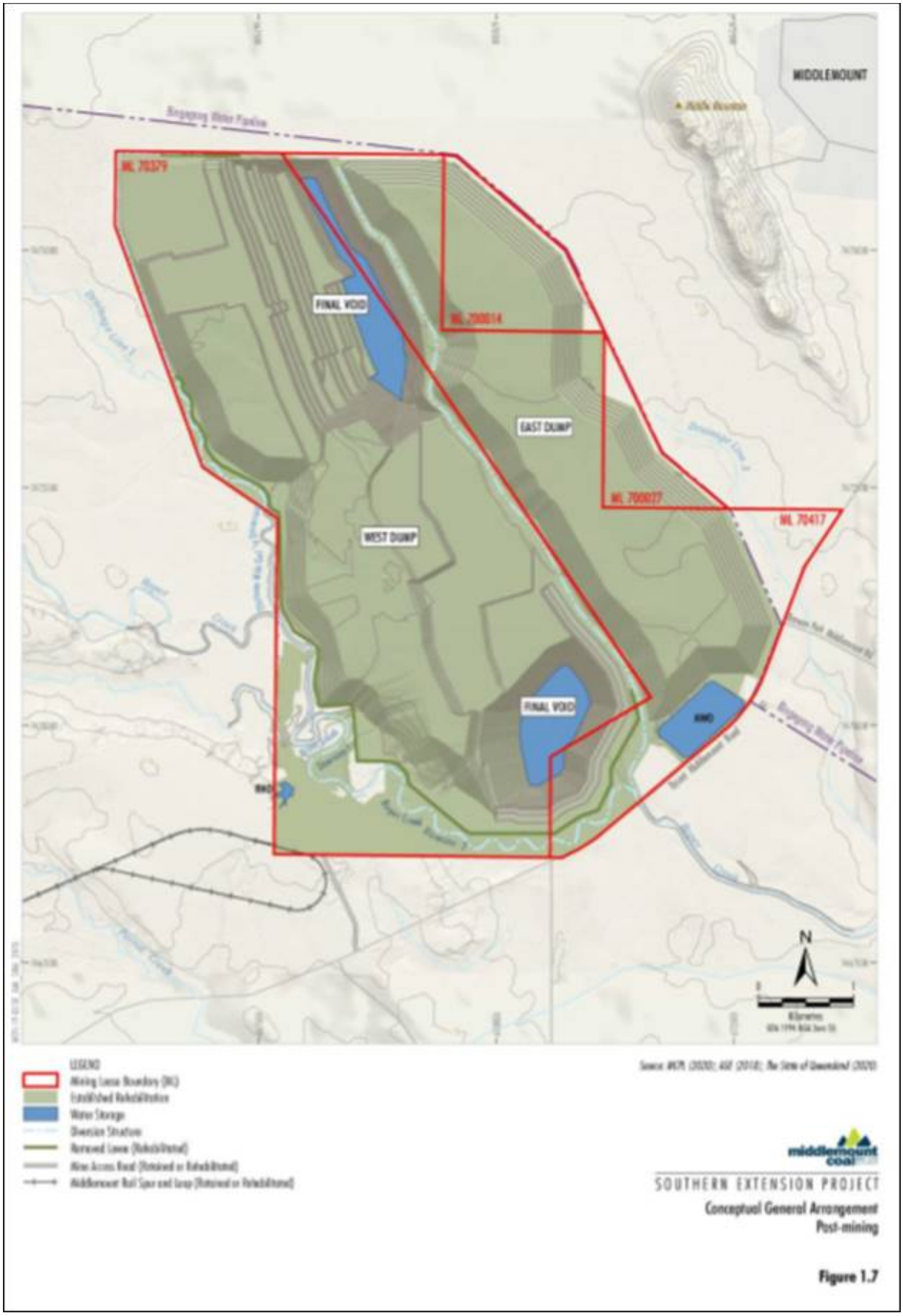


Figure 1 Geographical Location of Middlemount Coal Mine, Bowen Basin QLD

- Report by CM&G, 'Structural Model Update', document reference: MMC010001-AX Rev 1, dated June 2021

1.4 Information Provided

The following information was provided by Middlemount as part of this study:

- Base of Weathering (BoW) and Base of Tertiary (BoT) surfaces received on 07 September 2021 in *dtm* format;
- Final Landform 2502_2020 v8 received on 14 October 2021 in *dtm* format;
- Seam contours received 19 July 2021 in *dxf* format, including Yarrabee Tuff contours in *dtm* format.

2 Methodology

A geotechnical slope stability analysis was conducted to provide a report detailing potential impacts on pit walls if the mine sump level is allowed to recover and eventually reach a theoretical final level. The theoretical maximum level of the final mine lake has been reported to be RL 10.5 mAHD in the Northern Void and RL 35.1 mAHD in the Southern Void.

The methodology includes the followings:

- Undertaking a desktop study by reviewing geological and structural data and plans;
- Structural Geology Assessment;
- Development of geotechnical models;
- Undertake geotechnical stability analyses of the potential failure mechanisms; and,
- Re-evaluation of the tertiary deposits to allows for stability analyses to be carried out and the subsequent assessment of new slope geometries to minimise the failures of the tertiary formation.

2.1 Structural Geology Assessment

Geotechnical failures in coal measure rocks is predominantly controlled by geological structure, e.g. faults and joints. Rarely, if ever, does a slope failure occur due to failure through the rock mass. Hence, assessment and understanding of geological structure in the assessment of known faults is critical to understanding and predicting slope stability.

As the final voids are located at the extent of the reserves, there is limited data available to accurately assess the expected structure contained and daylighting in the final wall. A review of the current structural geology interpretations was completed to assess potential.

2.2 Geotechnical Stability Analyses

Stability analyses were conducted as part of this assessment. Limit equilibrium analysis was carried out on the lowwalls and highwalls in both the Northern and Southern Voids. The following cross-sections were taken in each pit:

- Northern Void
  - 3 No. cross-sections across the lowwall
  - 2 No. cross-sections across the highwall
- Southern Void
  - 1 No. cross-sections across the lowwall
  - 2 No. cross-sections across the highwall

A total of eight (8) cross-sections were taken and assessed for stability.

- Tertiary Deposit
  - Stability analysis of the re-evaluated designs of the tertiary profile was carried out at 30 m and 45 m thicknesses. It is assumed that below 45 m depth, weathered Permian aged material will be present.

  The following overall slope angles (OSA) for the tertiary deposit were investigated:
    - OSA at 20° for 30 thick tertiary deposit;
    - OSA at 20° for 45 thick tertiary deposit;
    - OSA at 25° for 30 m thick tertiary deposit;
    - OSA at 25° for 45 m thick tertiary deposit;
    - OSA at 27° for 30 m thick tertiary deposit; and
    - OSA at 27° for 45 m thick tertiary deposit.

3 Analyses

3.1 Structural Geology Assessment

A structural geology assessment is conducted annually as part of the design process, see report MMC010001-AX by CM&G. This assessment forms part of the mid-term design process for selecting recommended pit slope geometry. This methodology and pit design template is the Geotechnical Reference Report that the mining engineers to select the mid-term and short-term designs.

3.2 Design Assumptions

The following design assumptions were adopted for this analysis:

- Failure surface was assumed to develop along or in the vicinity of weak planes in the area. The validity of slip surfaces was tested by deploying the Cuckoo function for each scenario;
- Factor of Safety (FoS) was computed assuming partially saturated ground conditions;
- GSI value of 70 was adopted;
- Spil Category 3 was adopted to allow for long-term creep consolidation of the spoil,
- It is assumed that the Yarrabee Tuff has been ripped and pushed up to the lowwall, in compliance with site procedures
- Other material strengths were adopted from the Middlemount Coal Mine; Ground Control Management Plan, and the BMA Shear Strength Parameters, which are commonly used in the Bowen Basin.

3.3 Material Strength Parameters

Material strength parameters have been taken from the Middlemount Coal; Ground Control Management Plan (GCMP) dated March 2021.

The material strength parameters tabulated in Table 1 were adopted for these analyses.

3.4 Slope Geometries

3.4.1 Northern Void - Highwalls

Middlemount Coal provided the following slope geometries for the final northern highwall, see Figure 5:

- *For Tertiary stratum:*
  - 45 m maximum slope height
  - 45° batter angle
  - 25 m wide berm at the Base of Tertiary
- *For Weathered stratum:*
  - 30 m maximum slope height
  - 65° batter angle
  - 25 m wide berm at the Base of Weathering
- *For fresh (Permian) stratum:*
  - 50 m high benches
  - 65° batter angle
  - 25 m wide berms

- 49^0 maximumOSA
- 250° Slope Dip Direction.

Table 1 Material strength parameters used in limit equilibrium analysis

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)	UCS (KPa)	GSI	mi	D
Dump – Unsaturated Cat 3	Mohr-Coulomb	18	50	30				
Spoil – Saturated Cat 3	Mohr-Coulomb	20	20	25				
Spoil – Unsaturated Cat 2.5	Mohr-Coulomb	18	40	29				
Spoil – Saturated Cat 2.5	Mohr-Coulomb	20	17.5	24				
Alluvium	Shear-Normal	Shear-Normal Function for Fully Softened and Peak Strengths						
Tertiary Clay	Shear-Normal	Shear-Normal Function for Fully Softened and Peak Strengths						
Weathered Permian	Mohr-Coulomb	20	35	23				
MMCM Interburden	Generalised Hoek-Brown	22			11890	70	42.49	0
Coal – MMCM	Mohr-Coulomb	15	30	35				
MMCP1 Interburden	Generalised Hoek-Brown	22			10850	70	35.88	0
Coal – MMCP1	Mohr-Coulomb	15	30	35				
MMCP2 Interburden	Generalised Hoek-Brown	22			10850	70	35.88	0
Coal – MMCP2	Mohr-Coulomb	15	30	35				
YBT	Mohr-Coulomb	24	15	15				
MMCP2 - Underburden	Generalised Hoek-Brown	20			10850	70	35.88	0

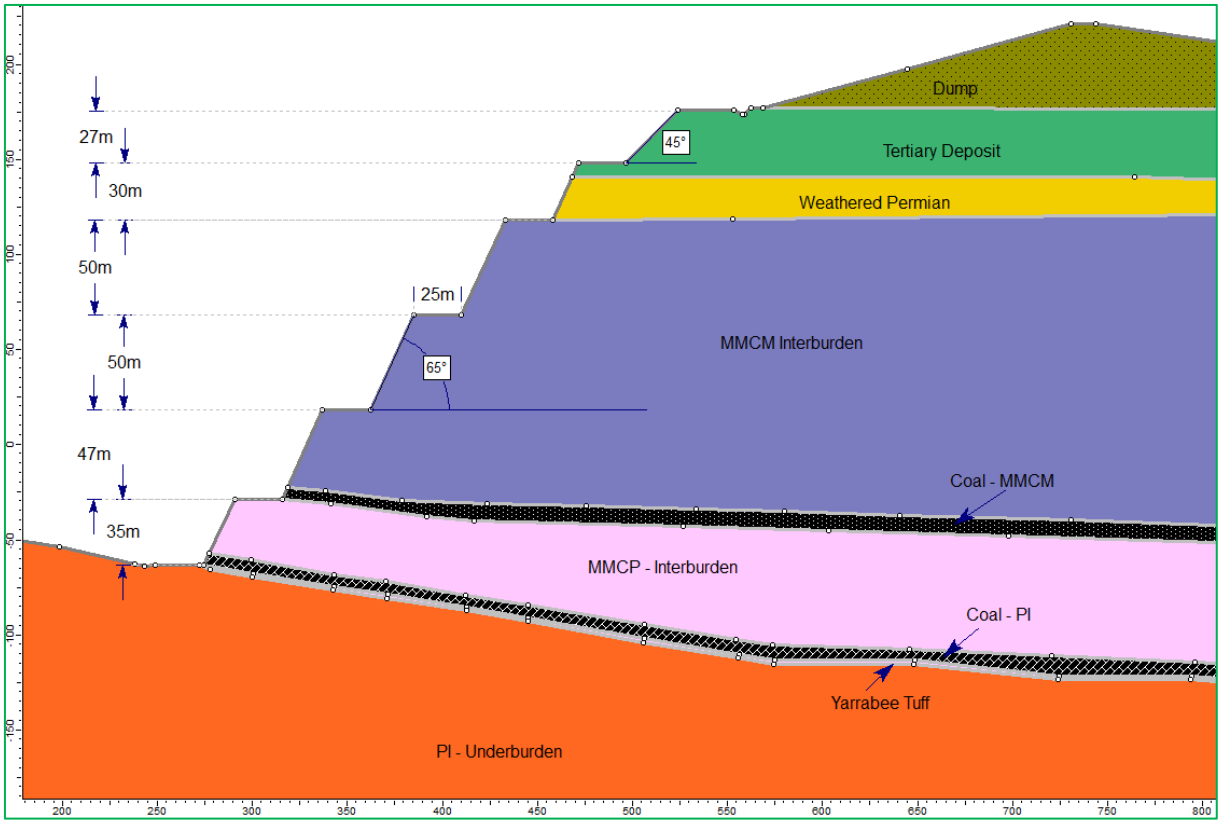


Figure 2 Schematic showing typical slope geometry for the Northern Highwall

3.4.2 Northern Void - Lowwalls

The floor angles at the four different cross-section locations range from 10° to approximately 20°. The maximum floor dip is at cross-section A as represented in Figure 3.

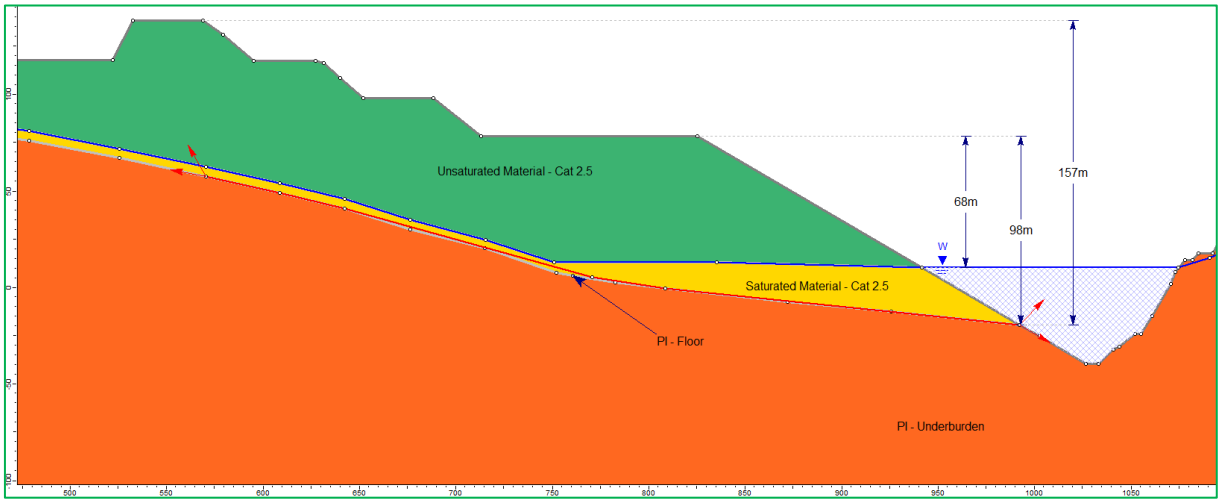


Figure 3 Schematic showing typical slope geometry for the Northern Highwall

3.4.3 Southern Void - Highwalls

The geometry provided by Middlemount Coal Mine is as shown in Figure 4. Category 2.5 spoil parameters were adopted for the dozer pushed profile. The original slope profile was adopted behind the dozer push for conservatism. It is expected that the final geometry will be a partial intact slope and partial dozer push.

Two scenarios were analysed:

- Dozer pushed slope (see Figure 4), and
- Intact slope, where no slope geometry modification is adopted.

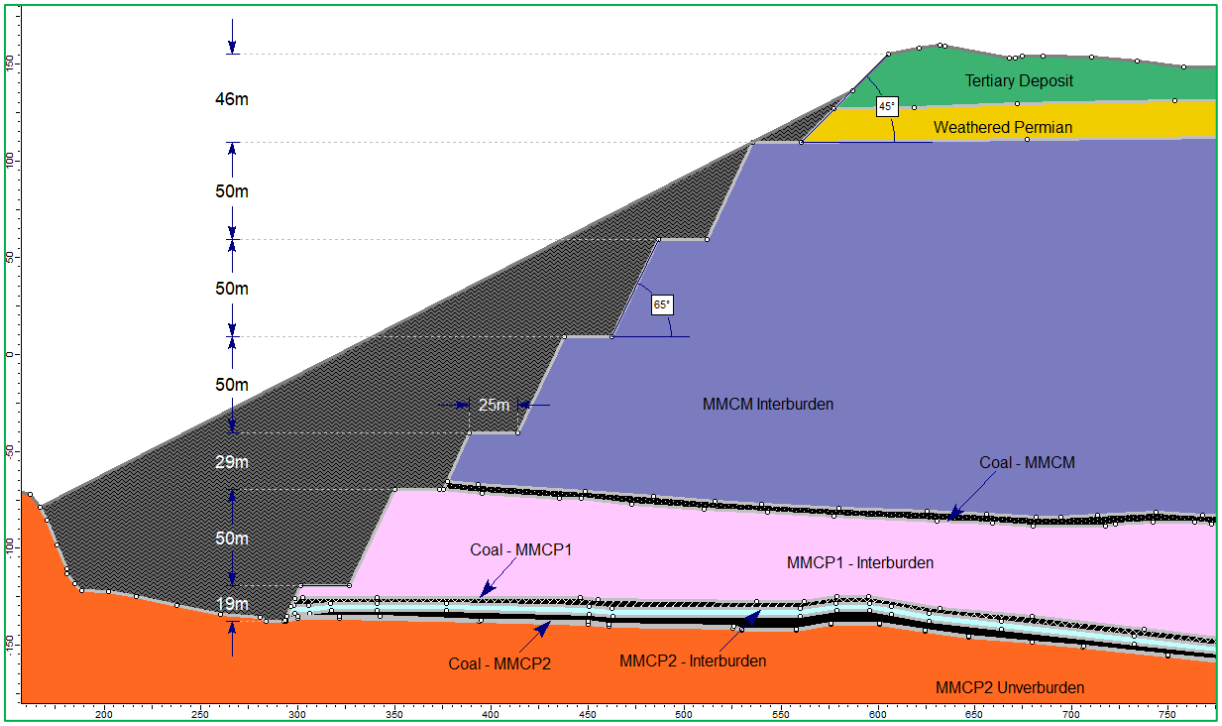


Figure 4 Dozer pushed slope geometry at Southern Void

3.4.4 Tertiary Deposit - Design

A desktop study of the Northern and Southern Voids shows that the tertiary deposit is predominantly about 30 m thick below ground level. However, midway west of the Northern Void shows Tertiary deposit depth of up to 45 m below ground level. Both cases were analysed with corresponding degrees of overall slope cut angles, as shown in Figure 6 and Figure 7.

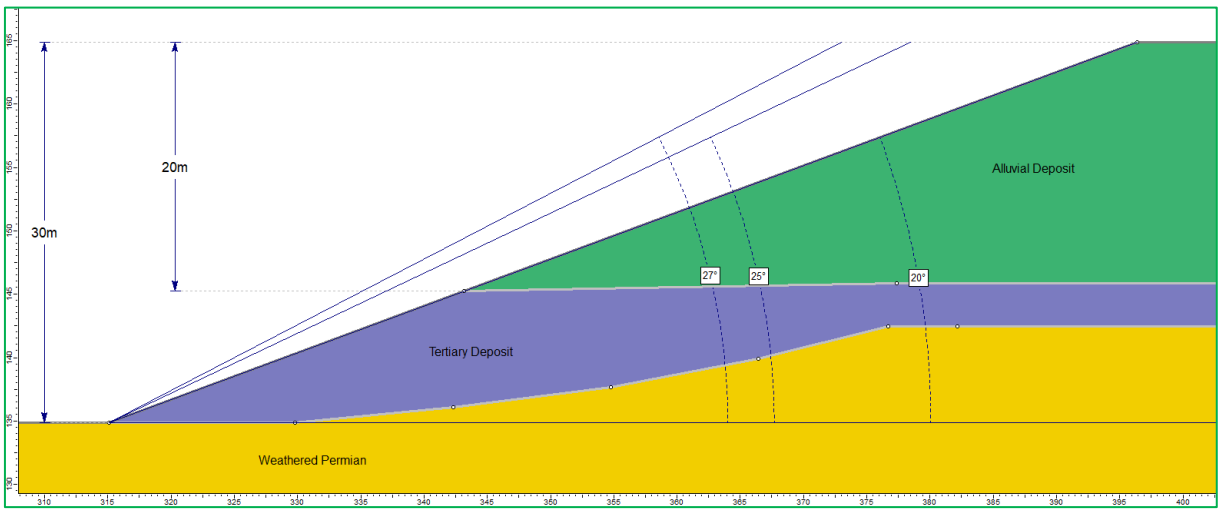


Figure 5 Schematic showing tertiary deposit of 30 m thick profile with various overall slope cut angles

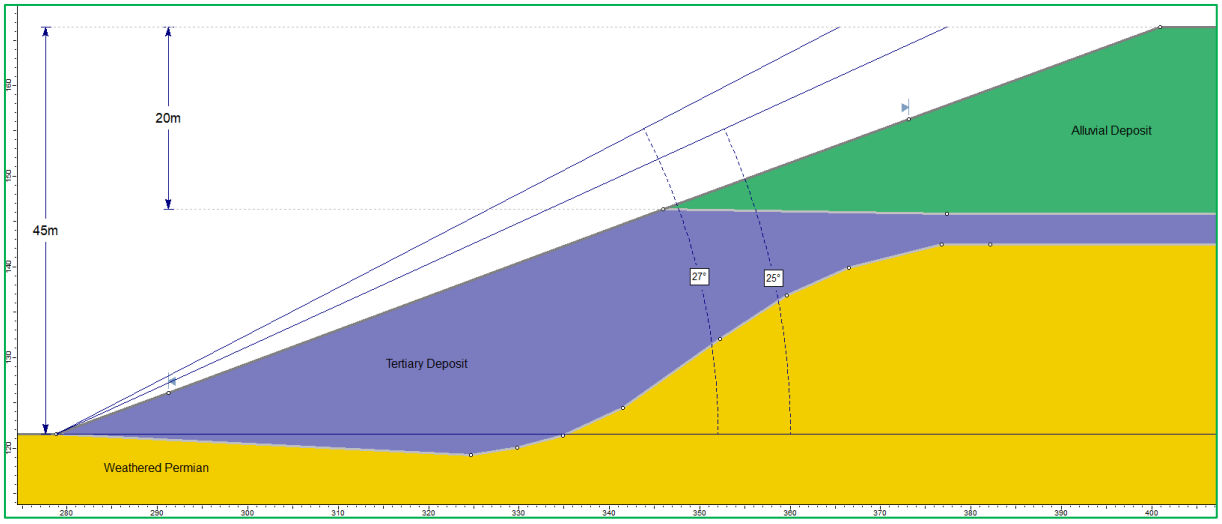


Figure 6 Schematic showing tertiary deposit of 45 m thick profile with various overall slope cut angles

3.5 Limit Equilibrium Analysis

Limit equilibrium analyses were undertaken on the Northern and Southern Highwalls and lowwalls. Stability analysis was undertaken using Rocscience Slide2 2019.011. Spencer and Morgenstern-Price methods were adopted as the most appropriate for the highwalls whereas, the Sarma nopn-vertical slices search function was adopted for the lowwalls.

As part of the progressive reharbitation and closure plan (PRCP), geotechnical analysis is required to ascertain the minimum required factor of safety (FoS) of 1.5.

3.5.1 Northern Void

3.5.1.1 Highwalls

Stability analyses have been carried out with the consideration of a possible deep-seated failure through the Yarrabee Tuff floor. Failures through the coal seam floors were also analysed. Two cross-section were taken along the highwall in the Northern Void as per Figure 8.

To validate the results, the 'line-of-thrust' (LOT) was calculated and assessed. The calculated LOT should be just above the failure surface, about one-third the height of the analysed slice. If the LOT does not satisfy this condition by being above the topographic surface or below the failure surface, the failure surface is considered invalid. The introduction of a tension crack is the most common method to improve the validity of the surface, but where a valid surface cannot be obtained, the Janbu method is adopted, which is considered more conservative than the Morgenstern-Price or Spencer methods.

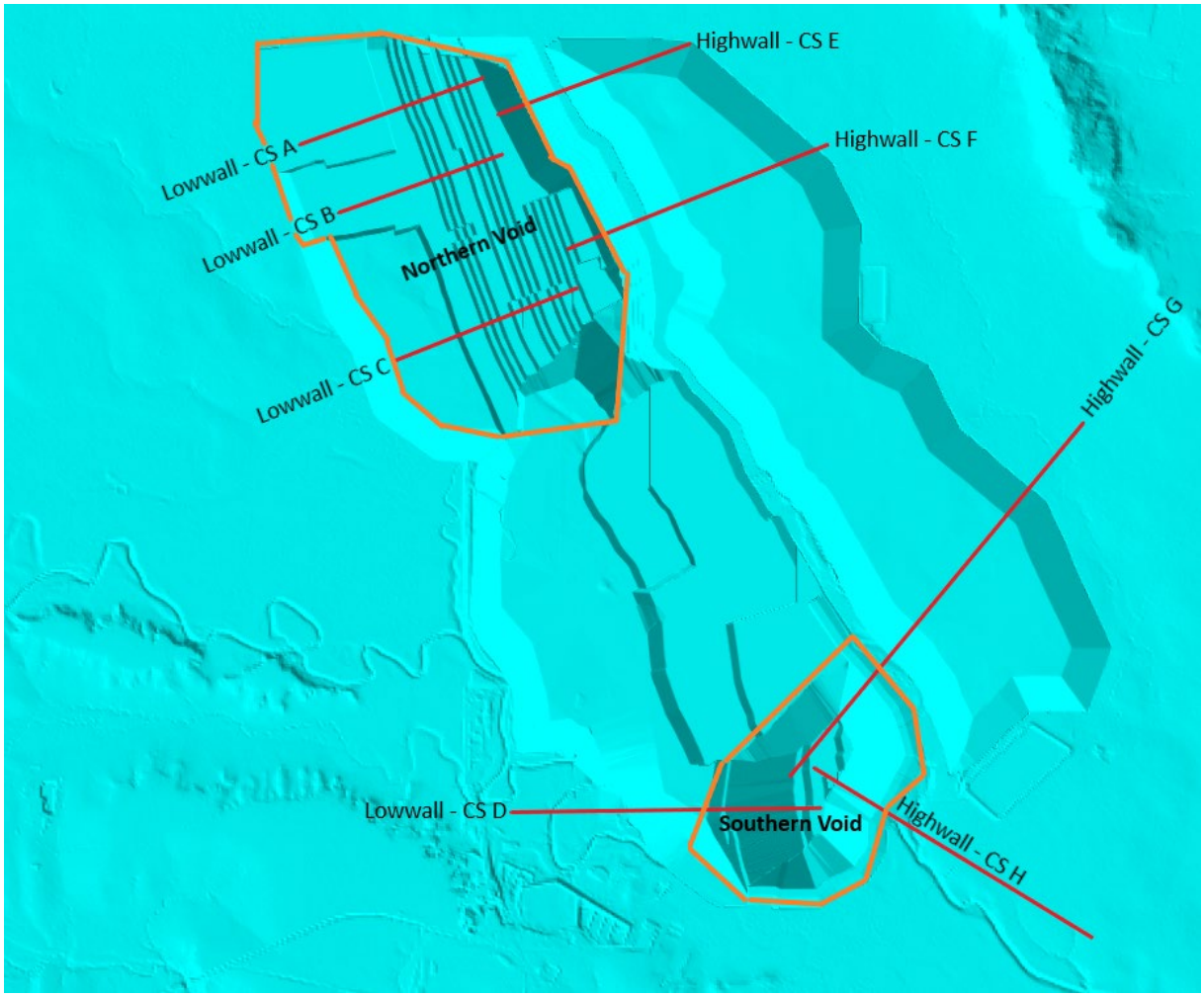


Figure 7 Plan layout showing the location of cross-section for each void

3.5.1.2 Lowwalls

Stability analysis for the Northern Void lowwalls were undertaken to understand the influence of floor cut angle on potential failure mechanisms. Four cross-sections were cut through the lowwalls, refer to Figure 8.

The Sarma non-vertical slice method was used to conduct the limit equilibrium analysis. This method is recommended for lowwall analysis as it mimics the non-vertical slice boundaries that are observed in actual failures (Simmons & McManus, 2004). In addition, the User Defined, Bi-section option was used to define the slice angles. Finally, for the models, a Block Search Polyline was defined to perform a non-circular slip surface search along a known weak layer whereby the failure must occur at set angles. The entry angle was set between 61-64°.

To validate the results, the base normal stress along the slices was calculated and assessed. Negative values indicate that the model is not fully resolved and that the results are invalid. If negative values are produced by the model, tension cracks will be added to the models to resolve the negative normal stress. The model will be re-run and the same process repeated until the results are valid.

3.5.2 Southern Void

3.5.2.1 Highwalls

Two cross-sections were taken in the Southern Void, as shown in Figure 8. The procedure described in Section 3.5.1.1 was adopted in carrying out the stability analysis.

3.5.2.2 Lowall

One cross-section was taken along the lowwall in the Southern Void for stability analysis (Figure 8). The analysis conducted was similar to that described in Section 3.5.1.2.

3.5.3 Summary of Results

3.5.3.1 Northern Void

A summary of the calculated FoS for each scenario and failure mechanism is provided in Table 2. A screenshot of the model with the lowest FoS (Highwall - CS F)) showing the global failure mode is presented in Figure 9. A copy of all results outputs is attached in Appendix A.

The results indicate that all calculated FoS is greater than equal to 1.50.

Table 2 Summary of calculated Factors of Safety for the Northern Void Highwalls and Lowwalls

Wall Type	Cross-section ID	Scale	Search Method (Cuckoo function)	Recommended Minimum (FoS)	FoS
Lowwall	CS - A	Global	Sarma	1.5	1.9
Lowwall	CS - B		Sarma		1.5
Lowwall	CS - C		Sarma		2.5
Highwall	CS - E		Spencer		2.0
			GLE/ Morgenstern- Price		2.0
Highwall	CS - F		Spencer		1.4
			GLE/ Morgenstern- Price		1.5

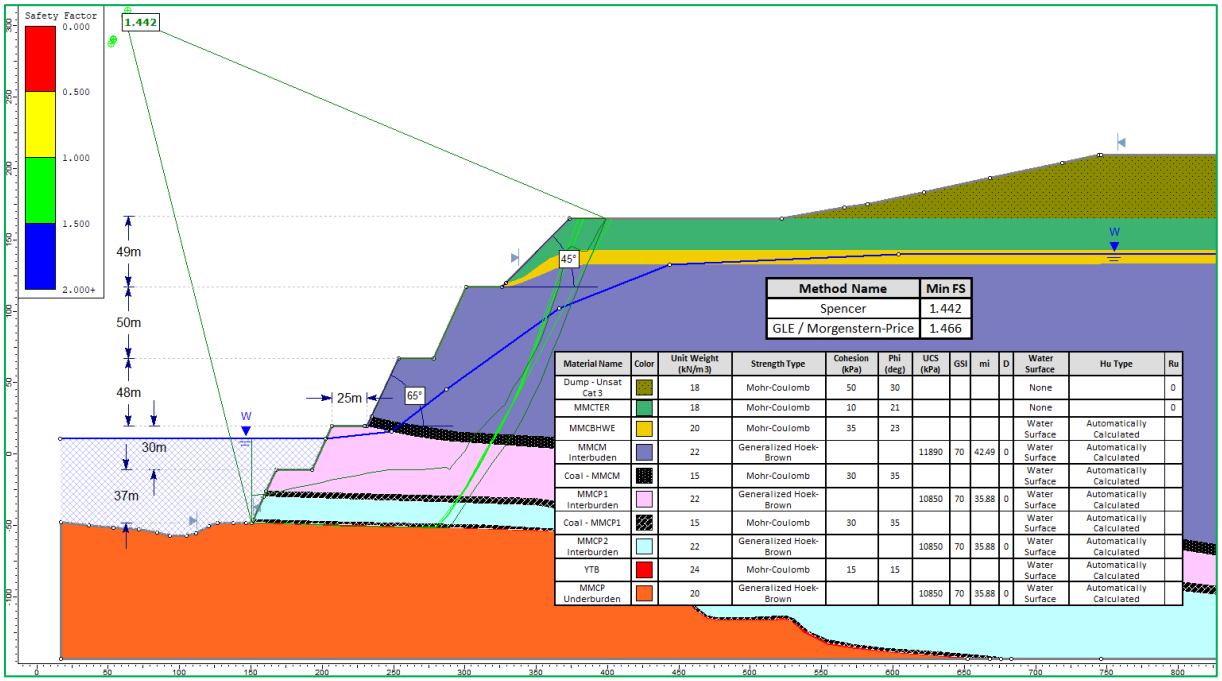


Figure 8 Screenshot of global failure results with 65° cut slope geometry showing failure surfaces with FoS ≥ 1.5 – Cross-section F; Highwall.

3.5.3.2 Southern Void

A summary of the calculated FoS for each scenario and failure mechanism at the Southern Void is provided in Table 3. The detailed limit state analyses output is attached in Appendix A. A screenshot of the model with the lowest FoS (Lowwall - CS D) showing the global failure mode is presented in Figure 10.

The results indicate that not all calculated FoS is greater than equal to 1.50.

Table 3 Factors of Safety (FoS) for the Southern Void highwalls and lowwall

Wall Type	Cross-section ID	Design	Scale	Search Method (Cuckoo function)	Recomm. Min. (FoS)	FoS
Lowwall	CS - D	NA	Global	Sarma	1.5	1.5
Highwall	CS – G	Intact		GLE/ Morgenstern- Price		1.7
				Spencer		1.6
Highwall	CS – H	Intact		GLE/ Morgenstern- Price		1.6
				Spencer		1.6
Highwall	CS - G	Dozer Pushed		GLE/ Morgenstern- Price		1.4
				Spencer		1.4
Highwall	CS - H	Dozer Pushed		GLE/ Morgenstern- Price		1.3
				Spencer		1.3

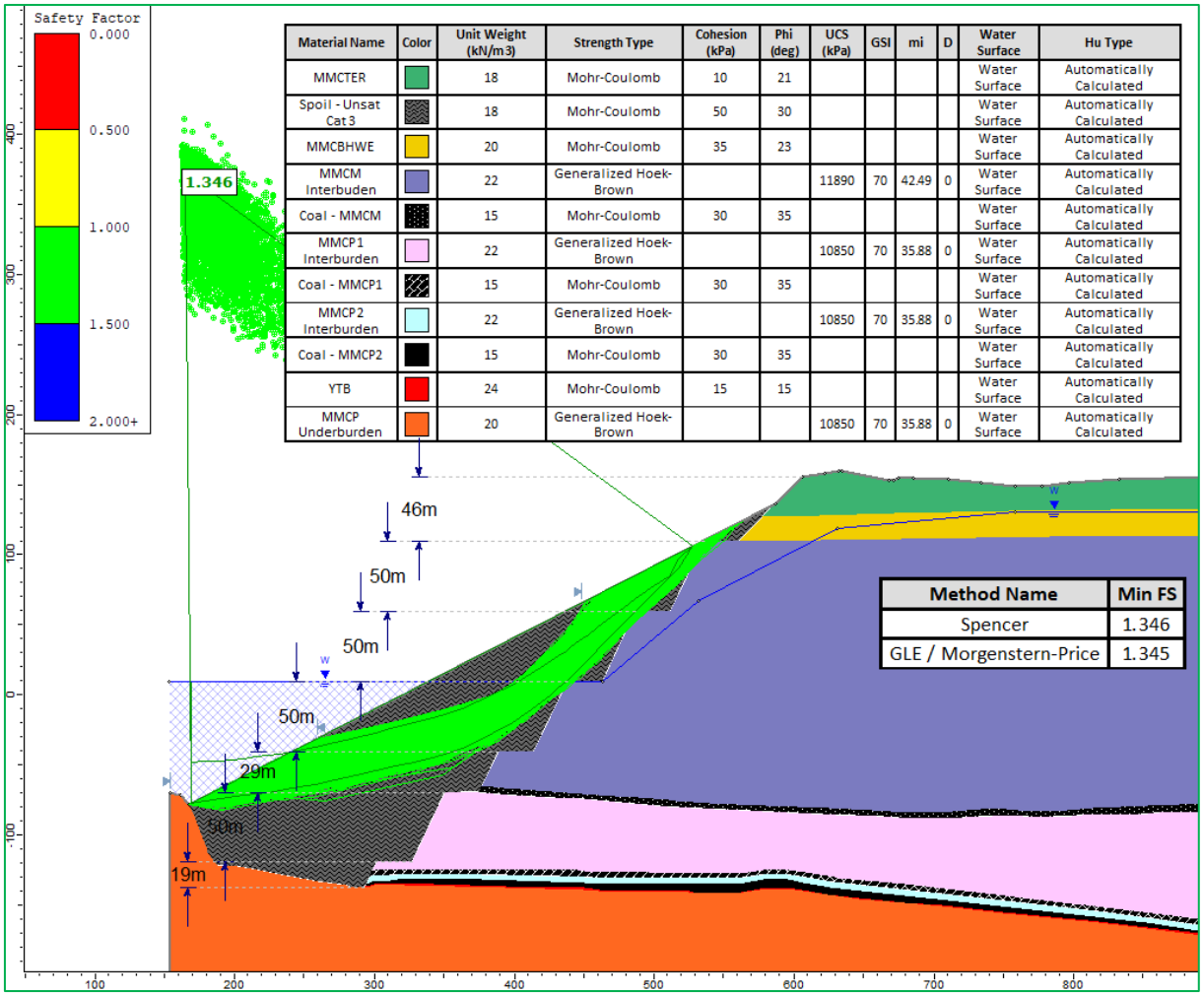


Figure 9 Screenshot of global failure result for the original design highwall slope in the Southern Void with FoS < 1.5 - Section H.

3.5.3.3 Tertiary Slope Design

This study re-evaluated the design for the Tertiary deposit within the Northern and Southern Voids. This re-evaluation allows for stability analyses to be carried out and the subsequent assessment of new slope geometries.

Stability analyses of the new tertiary materials at thicknesses of 30 m and 45 m were carried out. It is assumed that below 45 m depth, fresh Permian aged material will be present.

The results of the various stability analyses in terms of Factor of Safety (FoS) are presented in Table 4 below.

Table 4 Factors of Safety (FoS) for global stability of the surficial soils

Tertiary Thickness (m)	Overall Slope Angle within the Tertiary (deg)	Search Method (Cuckoo function)	Recommended Minimum (FoS)	Achieved FoS - SWL @ 15m bgl	Achieved FoS - SWL @ 20m bgl
30	20	Spencer	1.50	1.5	1.7
		GLE/Morgentern-Price		1.5	1.7
45		Spencer		1.3	1.5
		GLE/Morgentern-Price		1.3	1.5
30	25	Spencer		1.4	1.5
		GLE/Morgentern-Price		1.4	1.7
45		Spencer		1.3	1.5
		GLE/Morgentern-Price		1.3	1.5
30	27	Spencer		1.4	1.6
		GLE/Morgentern-Price		1.4	1.6
45		Spencer		1.2	1.4
		GLE/Morgentern-Price		1.2	1.4

3.6 Recommended Slope Geometry

The results indicate that the intact slopes return a higher FoS than the blasted and flattened slopes, which do not satisfy the minimum FoS requirements. This is expected as the blasted and dozed material will settle and consolidate and variable load conditions, e.g. changes in water level. As discussed in Section 3.1, geotechnical highwall failures in coal measure rocks are predominantly controlled by geological structure. Therefore, where no unfavourable geological structure occurs, then the intact slope will perform adequately in the long-term.

The recommended slope geometries for highwalls and lowwall is provided in Table 5 and Table 6.

Table 5 Recommended slope geometry for the final voids

Material	Overall Slope Angle (°)	Bench Height (m)	Berm Width (m)	Batter Angle (°)
Surficial Soils	20	NA	NA	NA
Weathered Permian	NA	30	25	55
Fresh Permian	NA	60	60	60

Table 6 Recommended slope geometry for lowwalls

Material	Overall Slope Angle (°)~	Max. Bench Height (m)	Berm Width (m)*	Batter Angle (°)
Lowwall CAT3 Spoil	27	40	12 to 25	37

~This is the maximumOSA allowed for lowwall designs

*The bench geometries maybe changed to satisfy the OSA, this include bench height and berm width

4 Discussion

4.1 Structural Geology Complexity

As discussed in Section 3.1, the site is structurally complex due to the proximity to the regional scale Jellinbah fault. The structural geology model is updated annually as part of the mid-term design process. Current there is little structural geology data for the final void areas. Therefore, recommendations for the suitable final void design should be updated as additional data become available.

It is recommended that targeted geotechnical investigations be undertaken to acquire structural geology data. These investigations should include Acoustic Televiewer (ATV) and Optical Televiewer (OTV) scans to obtained oriented core data. Seam and cross-section analyses can be updated as additional resource drilling occurs in these areas to increase the drill hole density.

4.2 Surface Water Management

Management of surface water is critical in preventing ponding water near slope crests. Ponding facilitates the infiltration of meteoric waters into the subsurface, resulting in slope instability within the surficial soil units (e.g. Tertiary clays and Alluvium) due to the temporary reduction of shear strength of the critical unit.

Sloughing failures are shallow surficial failures caused by saturation of these layers due to rainfall. Construction of surface water drainage is critical to reducing the likelihood that such failures will occur by reducing the volume of water moving across the slopes.

Surface water management is critical to ensure the long-term stability of the soil slope and minimisation of erosion and deterioration of the slope condition.

5 Recommendations

Based on the above results and discussion, the following recommendations are provided:

- For future geotechnical and geological drilling campaigns, target select boreholes near the final voids to collect structural geology information (e.g. ATV and OTV scans) and increase resource drilling density.
- Update structural geology model for the pit shells as new data becomes available.
- Update geotechnical model based on new structural model and carry out stability analyses of the highwalls and lowwalls.
- Monitor groundwater levels in the vicinity of the Northern and Southern Voids.
- Develop a surface water management plan to ensure water is not allowed to pond on or near final void crests and drainage on the slope face prevents scour.

6 Conclusion

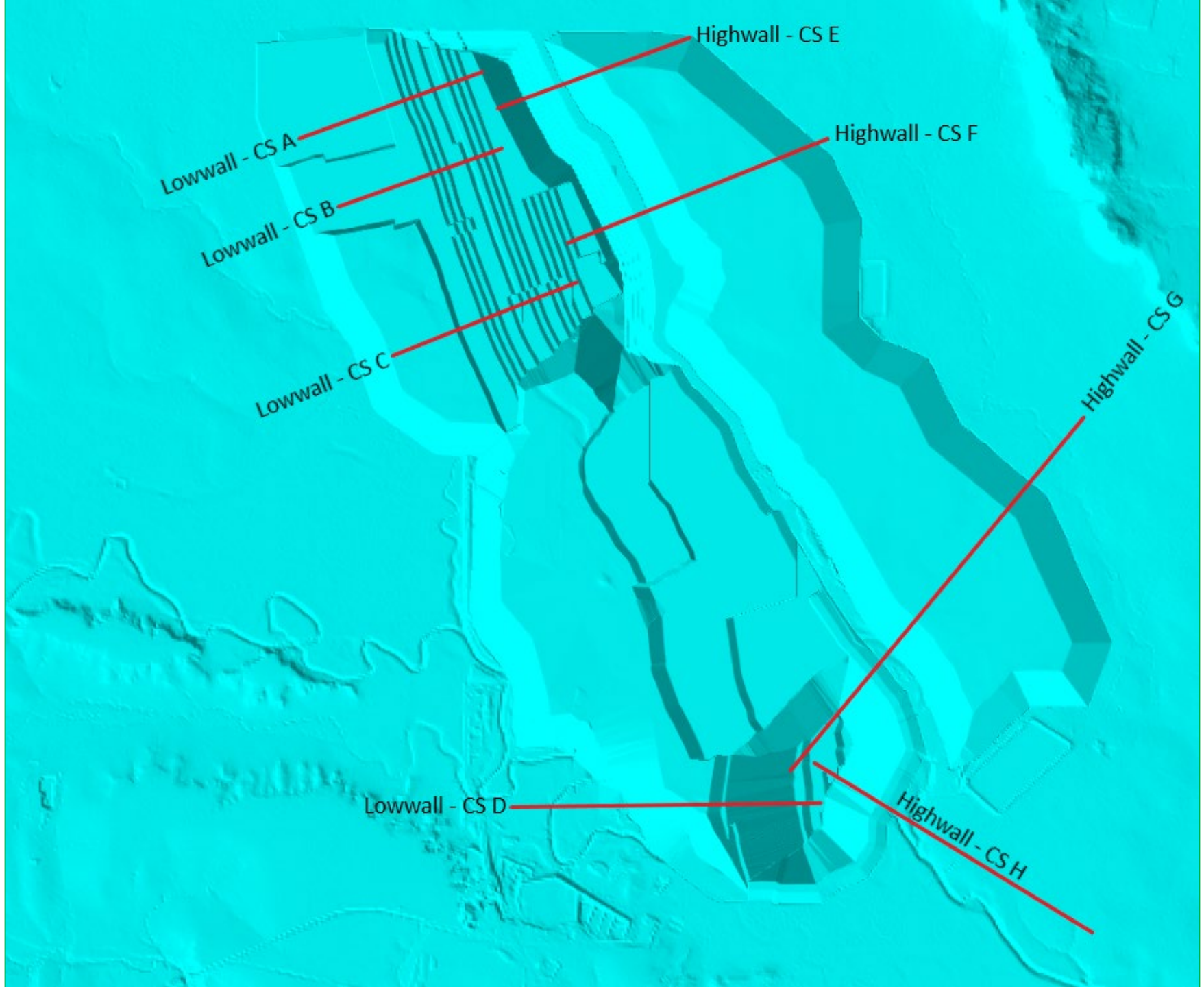
The results indicate that the intact pit slope is suitable for the final void where no unfavourably oriented structure exists. The current mid-term geotechnical design process at Middlemount will provide updates to the structural geology model to improve confidence in the model and confirm the suitability of adopting intact walls prior to the final void exposure.

TheOSA in the alluvium needs to be reduced to 20° due to the thickness of soils and groundwater level. Surface water management will also be critical in managing the stability of the soils slopes in the final void.

Appendix A: Limit Equilibrium Slope Stability Analyses Results

Lowwall

Cross Section A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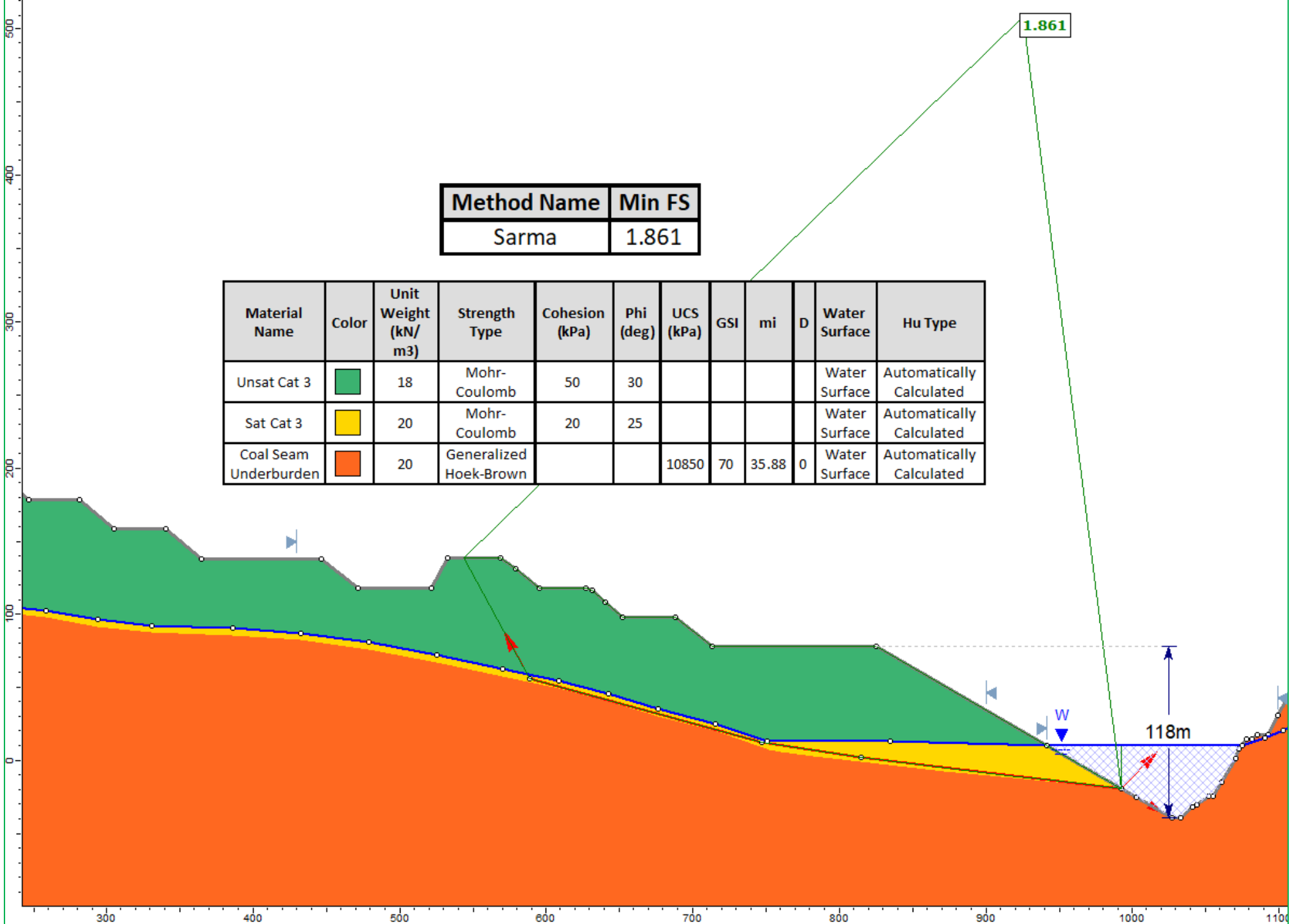
Highwall - CS G
Lowwall - CS D
Highwall - CS H


1.861
Method Name
Min FS
Sarma
1.861
Material Name
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Unit Weight (kN/ m3)
Strength Type
Cohesion (kPa)
Phi (deg)
UCS (kPa)
GSI
mi
D
Water Surface
Hu Type
Unsat Cat 3
18
Mohr-Coulomb
50
30
Water Surface
Automatically Calculated
Sat Cat 3
20
Mohr-Coulomb
20
25
Water Surface
Automatically Calculated
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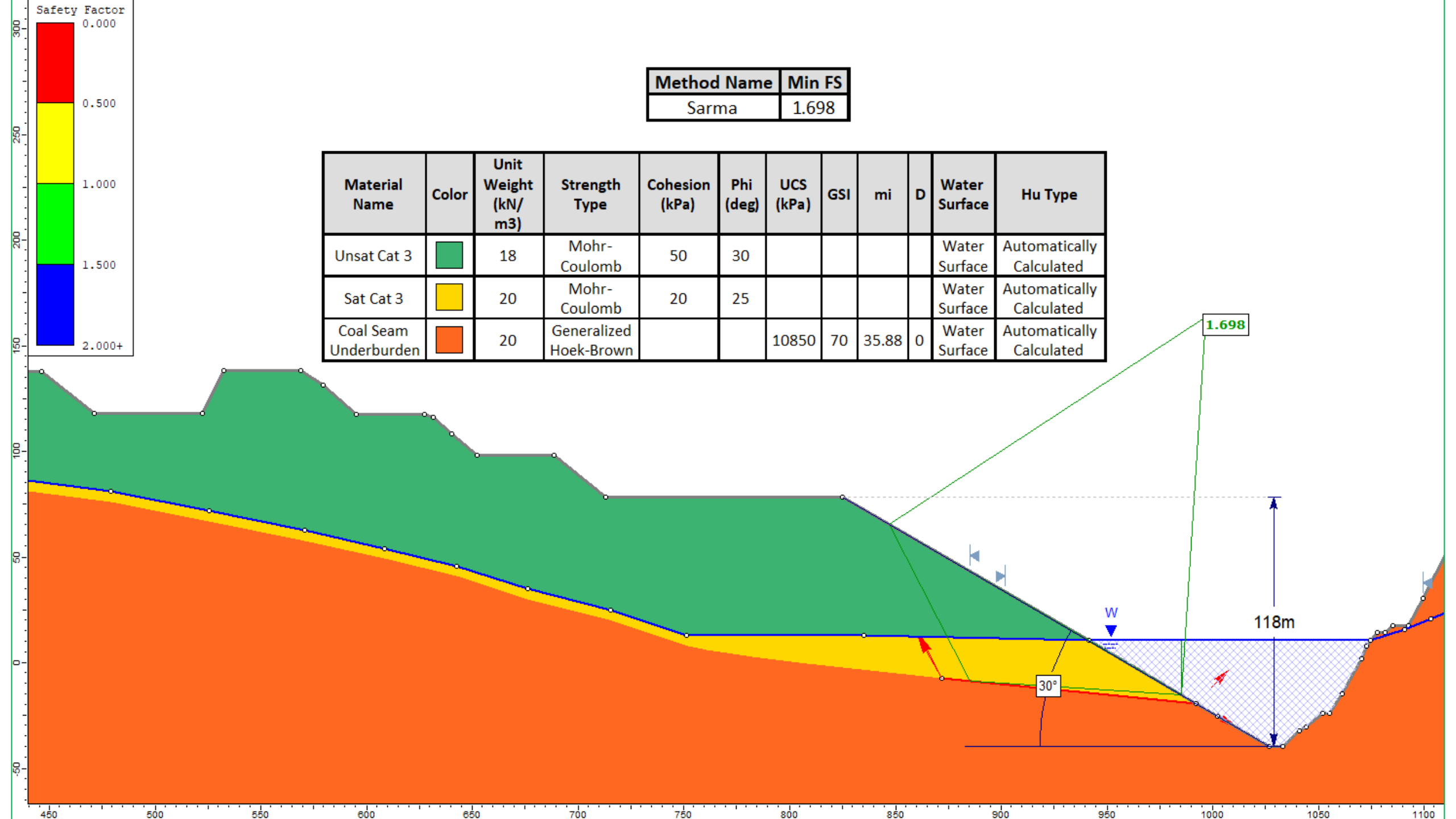
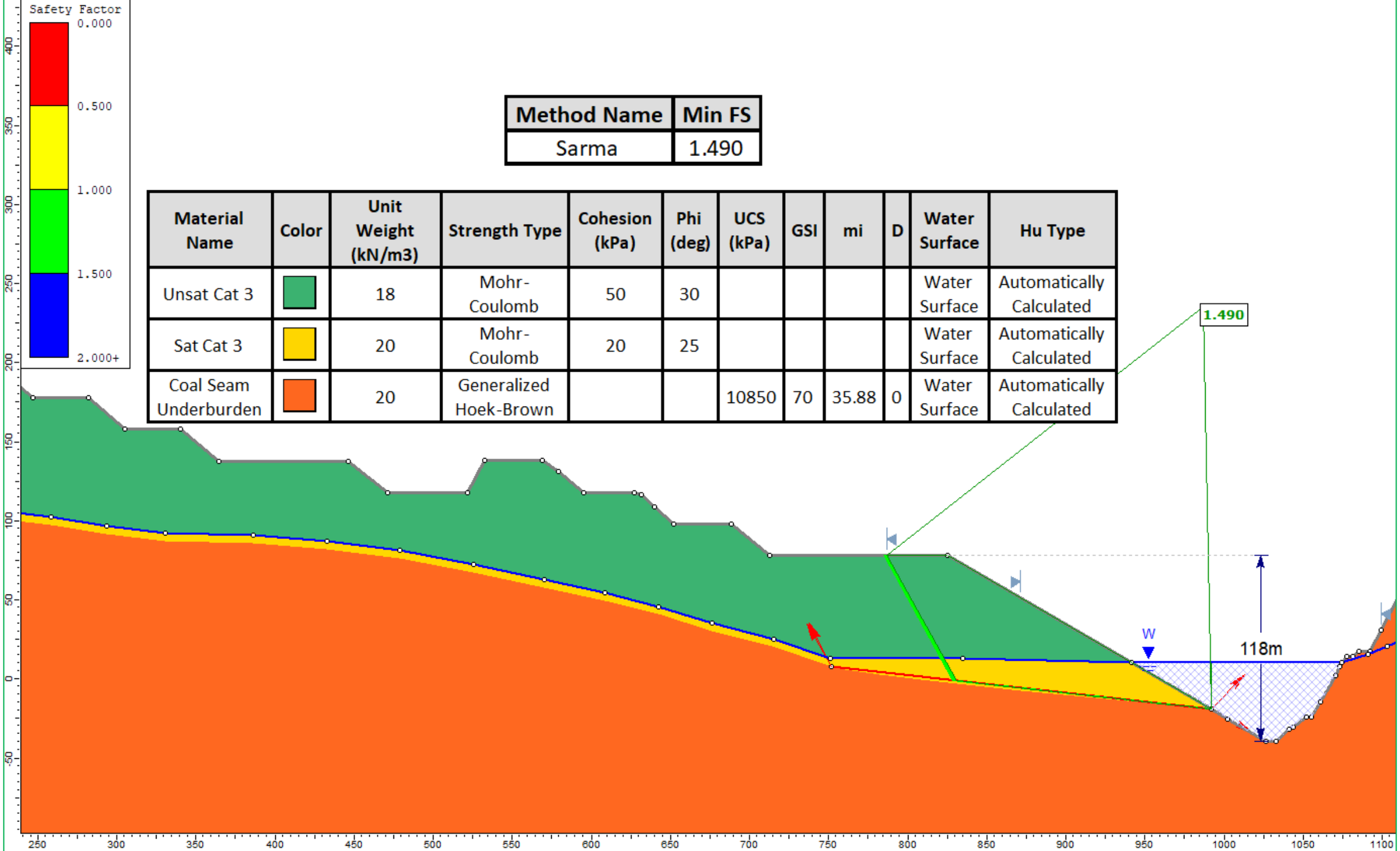


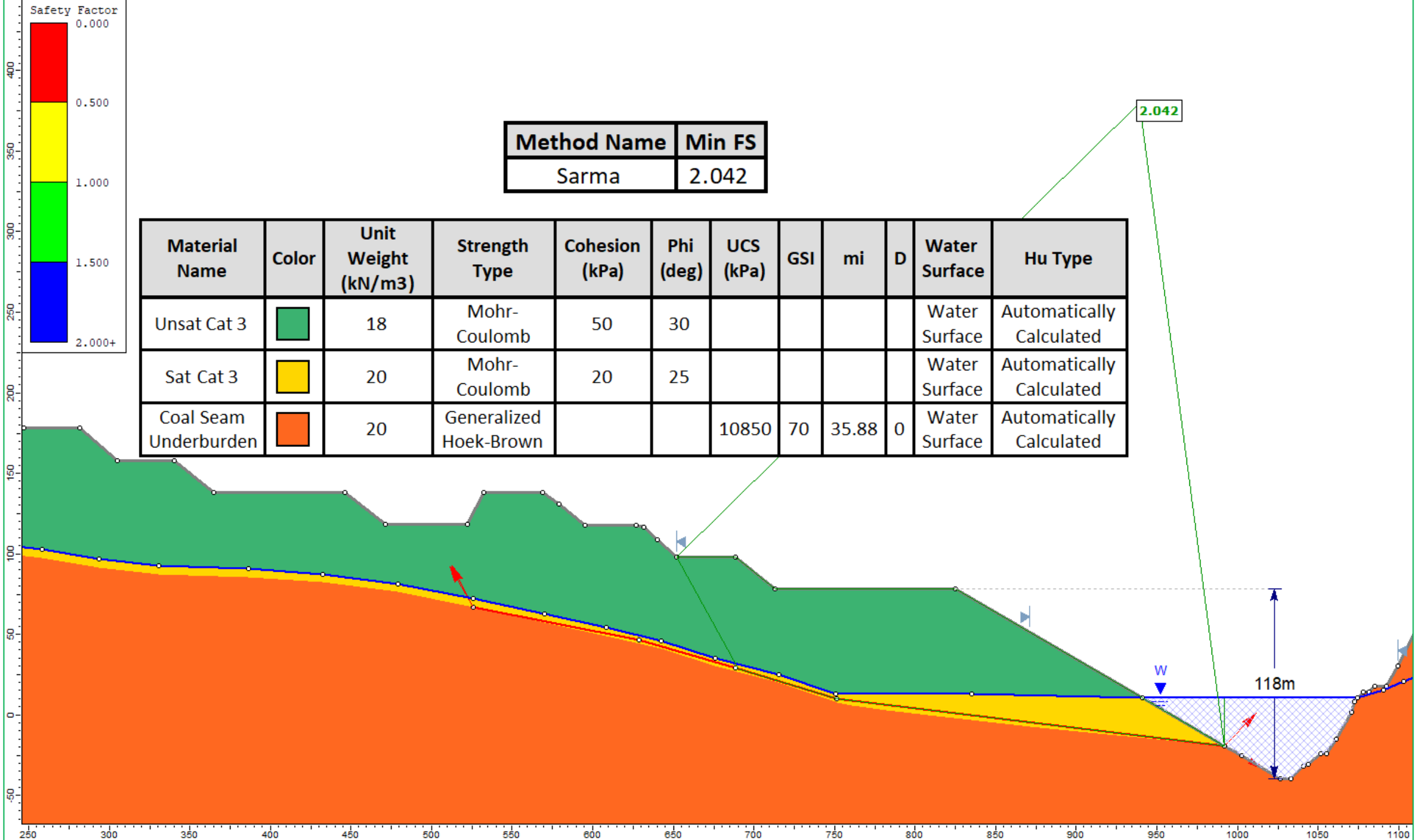
Method Name	Min FS
Sarma	1.698

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
Coal Seam Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



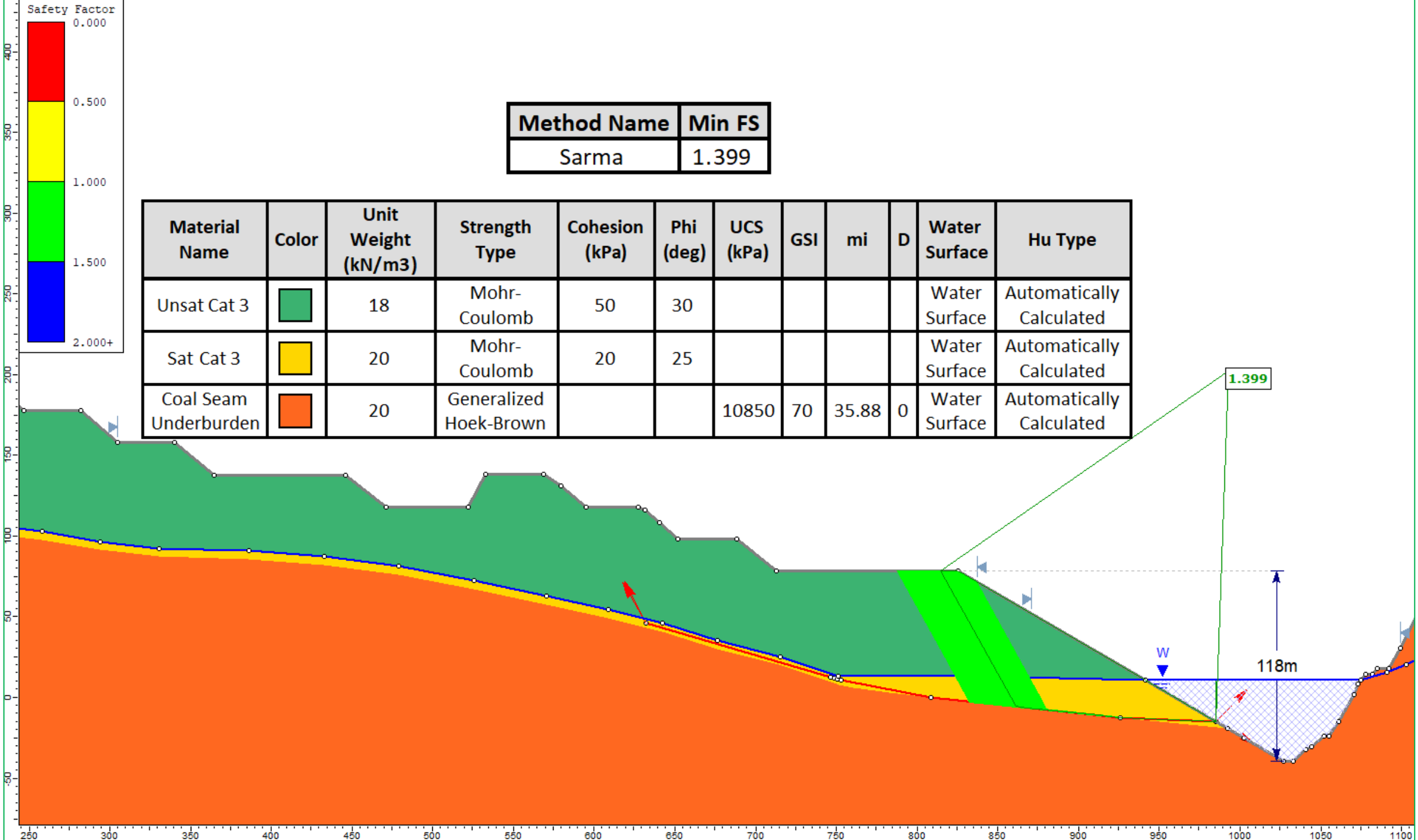
Method Name	Min FS
Sarma	1.490

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
Coal Seam Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



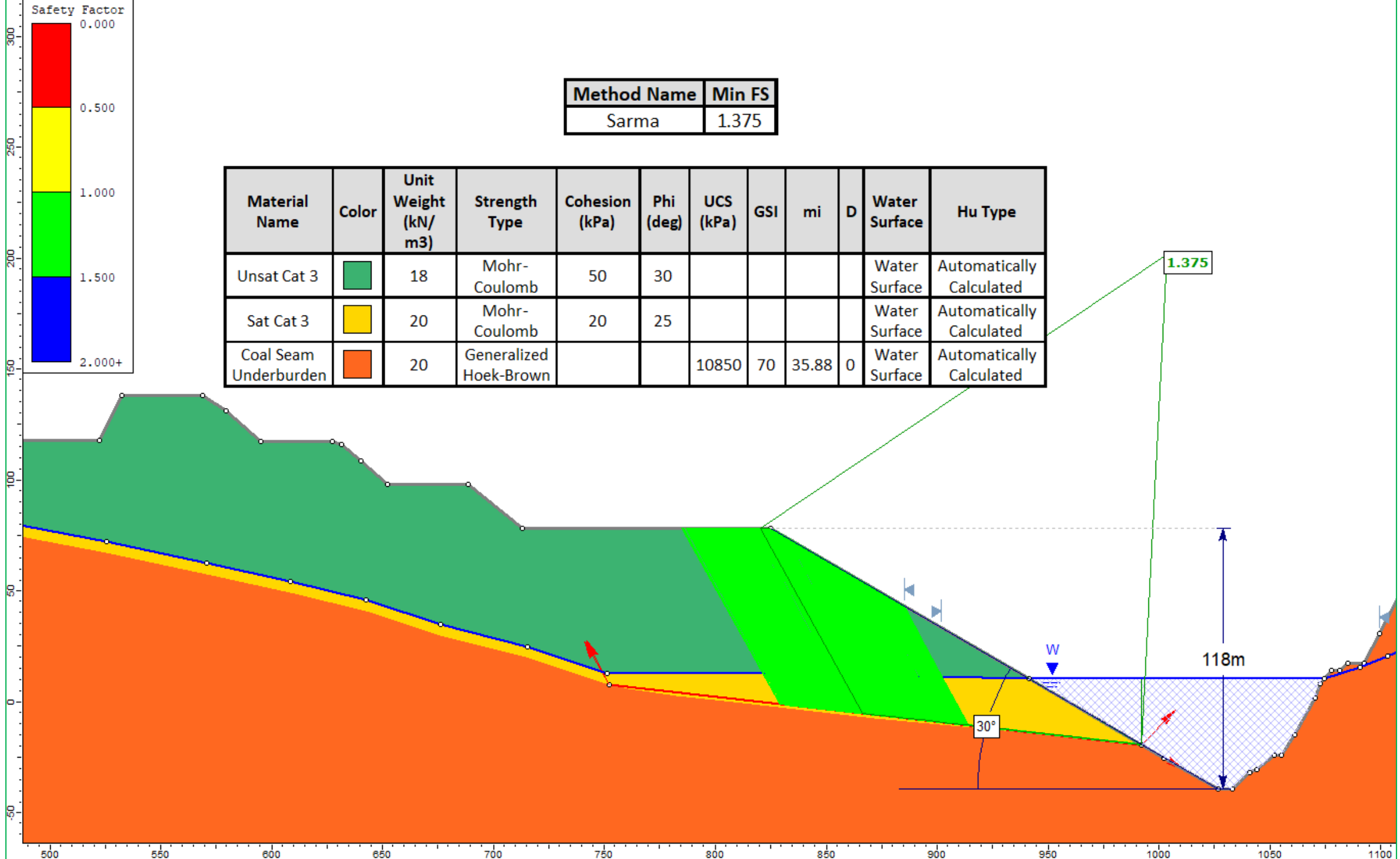
Method Name	Min FS
Sarma	2.042

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
Coal Seam Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



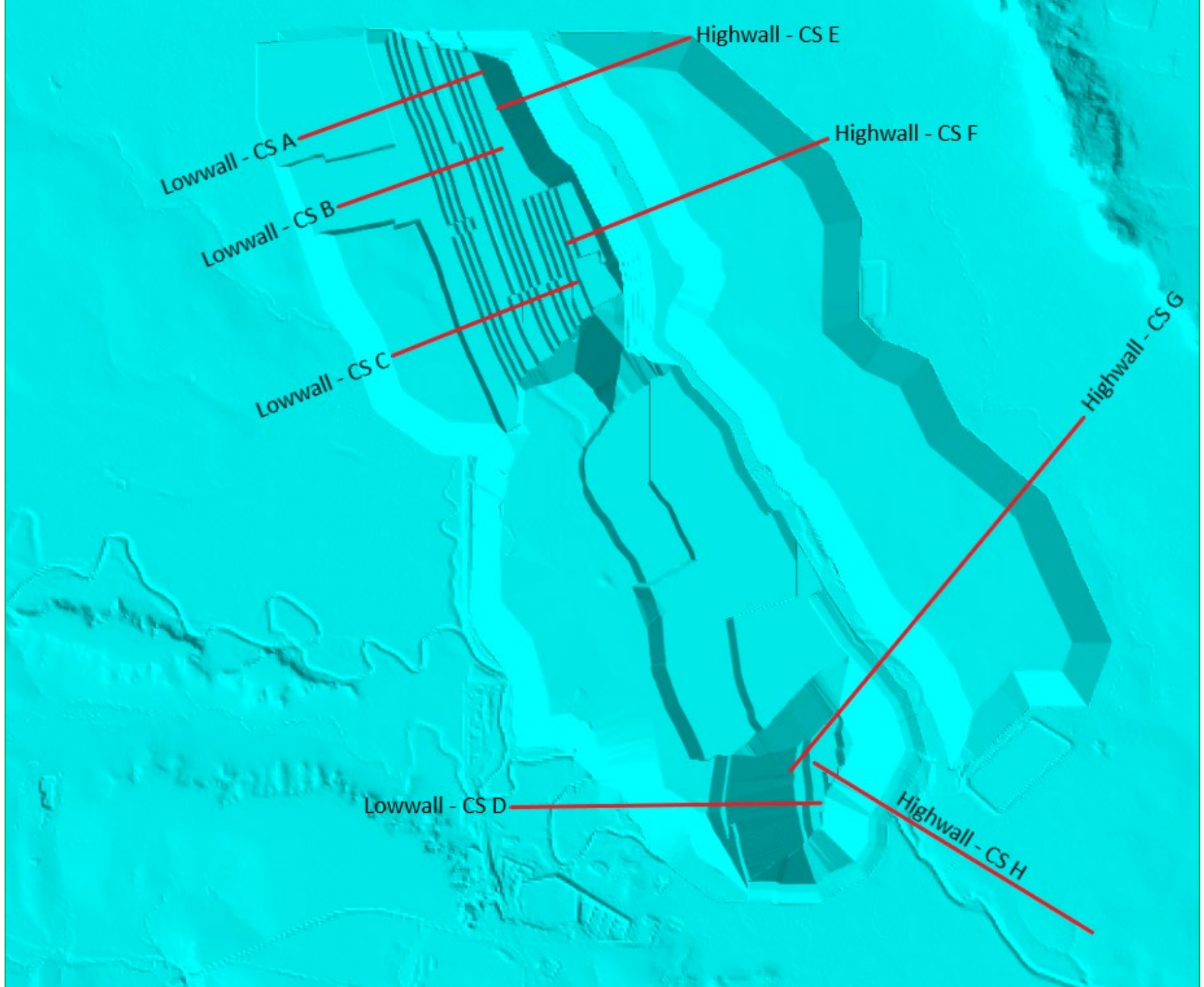
Method Name	Min FS
Sarma	1.399

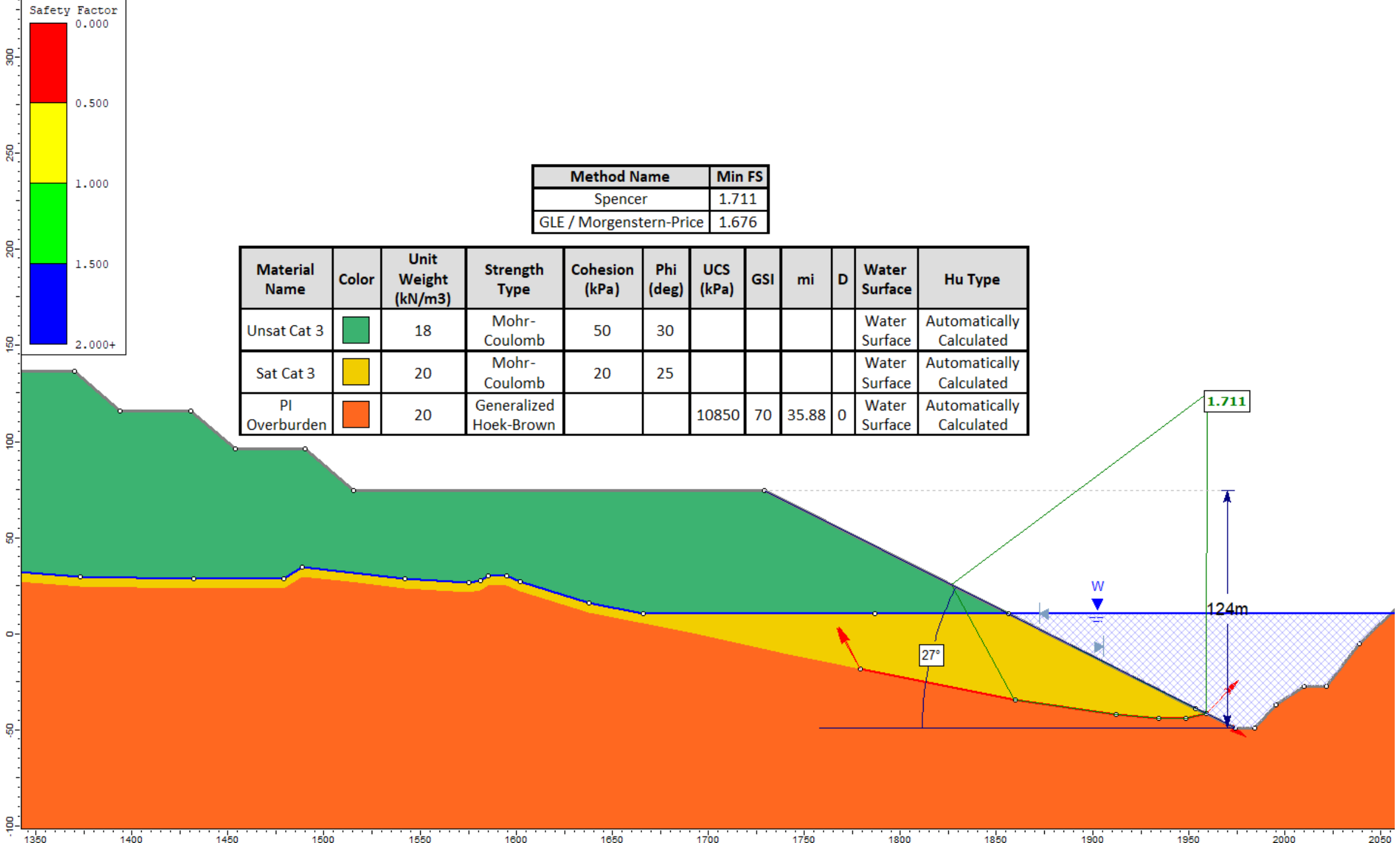
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
Coal Seam Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated


Safety Factor
0.000
0.500
1.000
1.500
2.000+
Method Name
Min FS
Sarma
1.375
Material Name
Color
Unit Weight (kN/ m3)
Strength Type
Cohesion (kPa)
Phi (deg)
UCS (kPa)
GSI
mi
D
Water Surface
Hu Type
Unsat Cat 3
18
Mohr-Coulomb
50
30
Water Surface
Automatically Calculated
Sat Cat 3
20
Mohr-Coulomb
20
25
Water Surface
Automatically Calculated
Coal Seam Underburden
20
Generalized Hoek-Brown
10850
70
35.88
0
Water Surface
Automatically Calculated
1.375
W
118m
30°
300
250
200
150
100
50
0
-50
500
550
600
650
700
750
800
850
900
950
1000
1050
1100

Lowwall

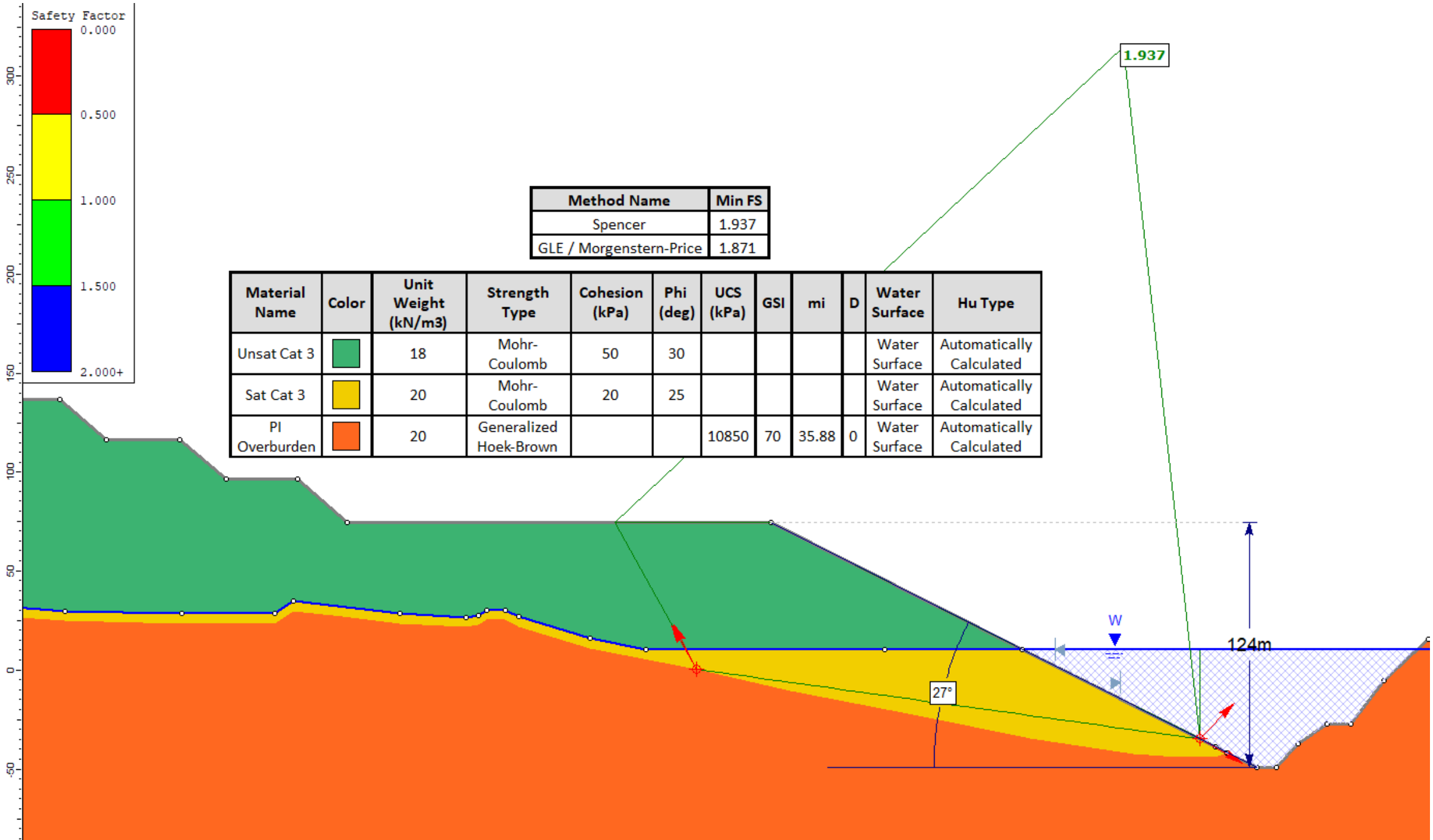
Cross Section B


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H



Method Name	Min FS
Spencer	1.711
GLE / Morgenstern-Price	1.676

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
PI Overburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

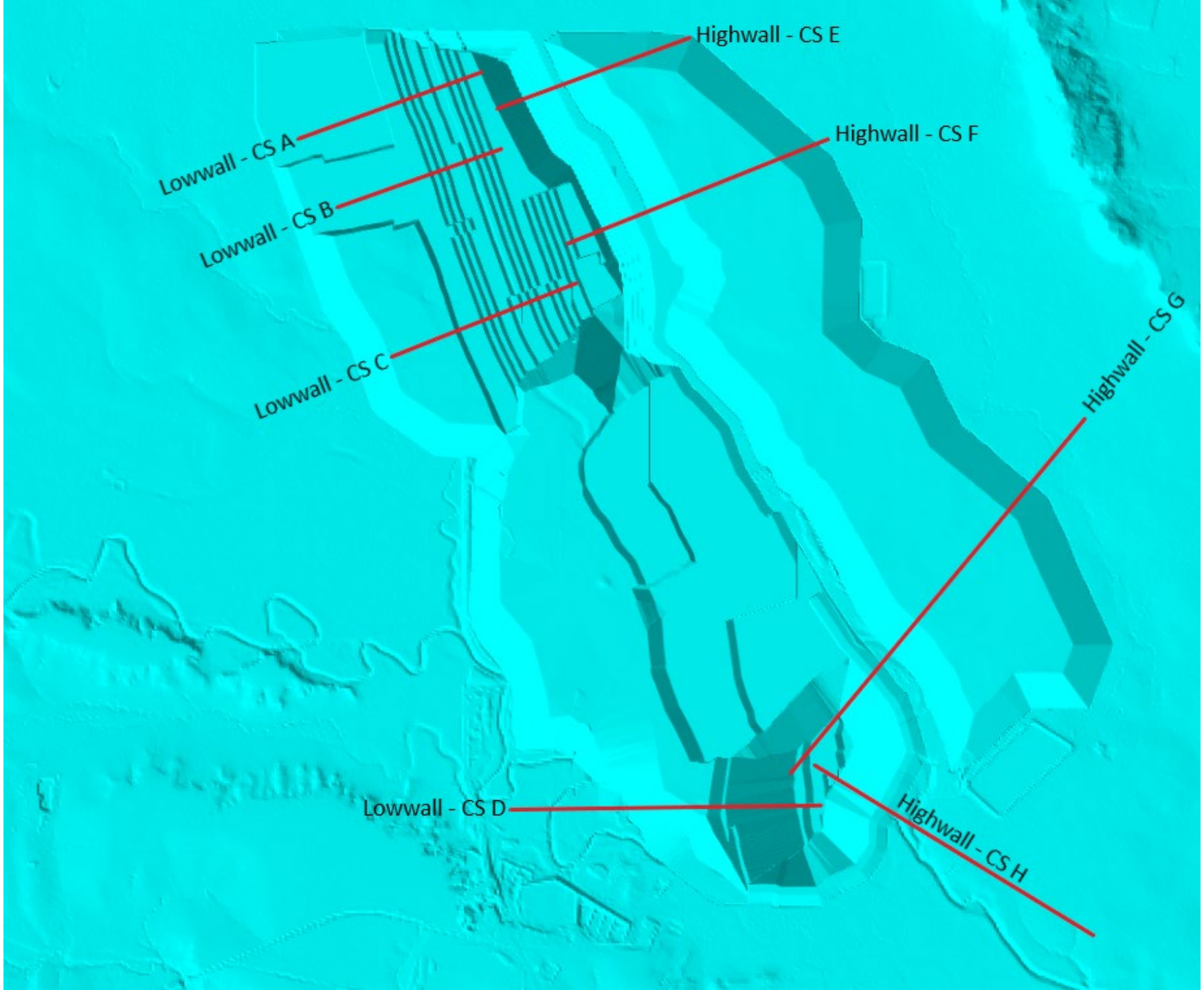


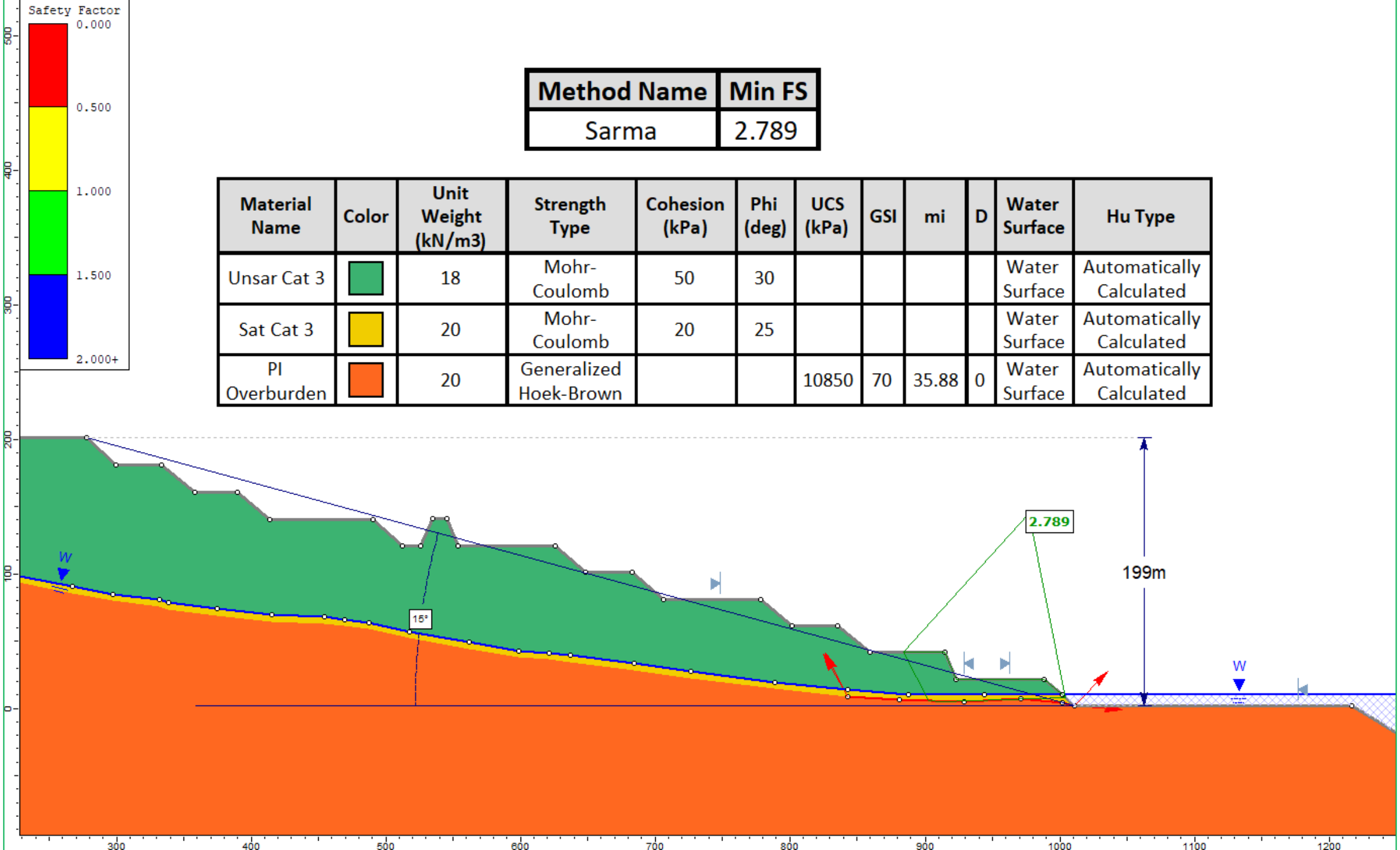
Method Name	Min FS
Spencer	1.937
GLE / Morgenstern-Price	1.871

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
PI Overburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

Lowwall

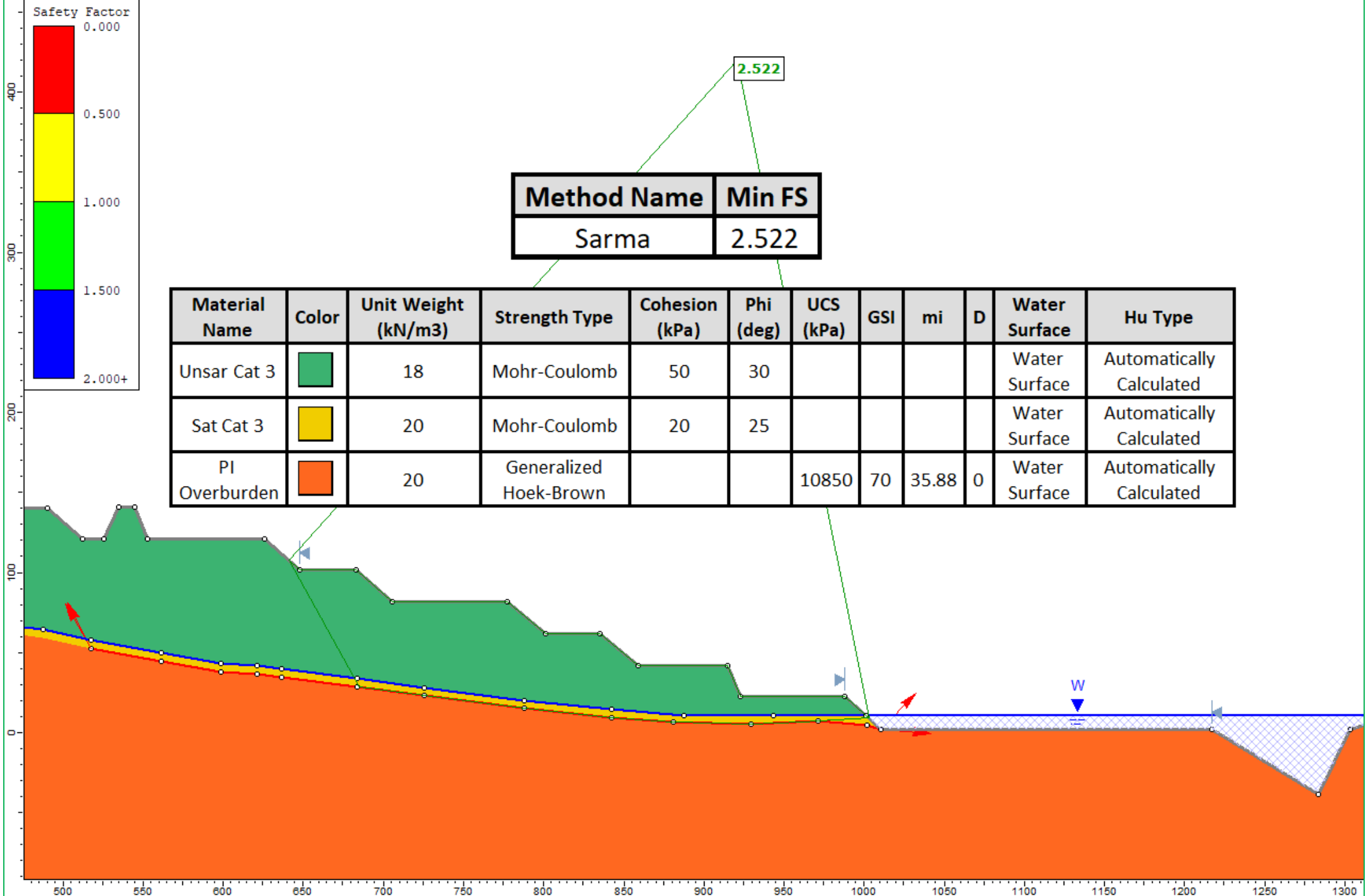
Cross Section C


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H



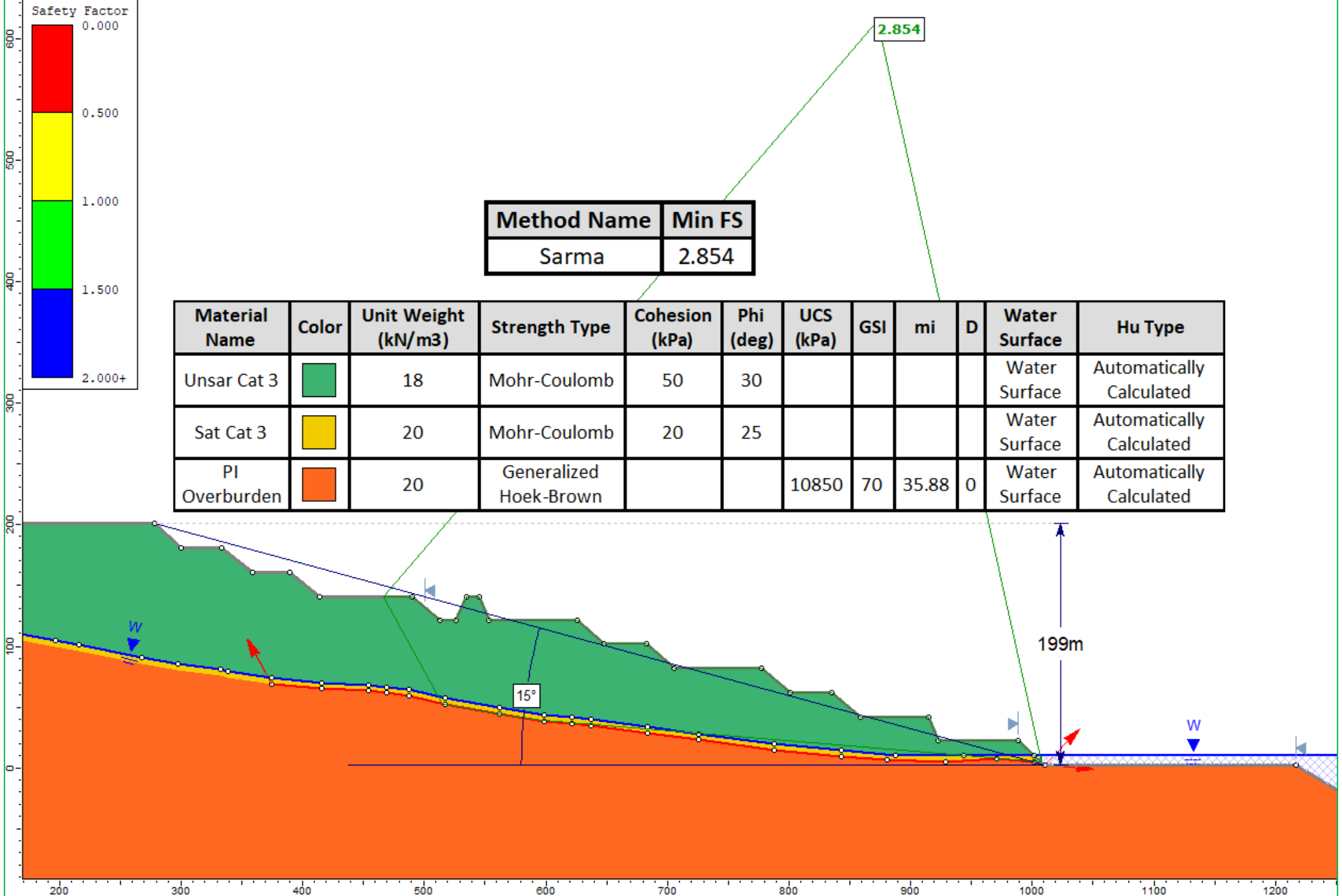
Method Name	Min FS
Sarma	2.789

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsar Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
PI Overburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



Method Name	Min FS
Sarma	2.522

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsar Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
PI Overburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

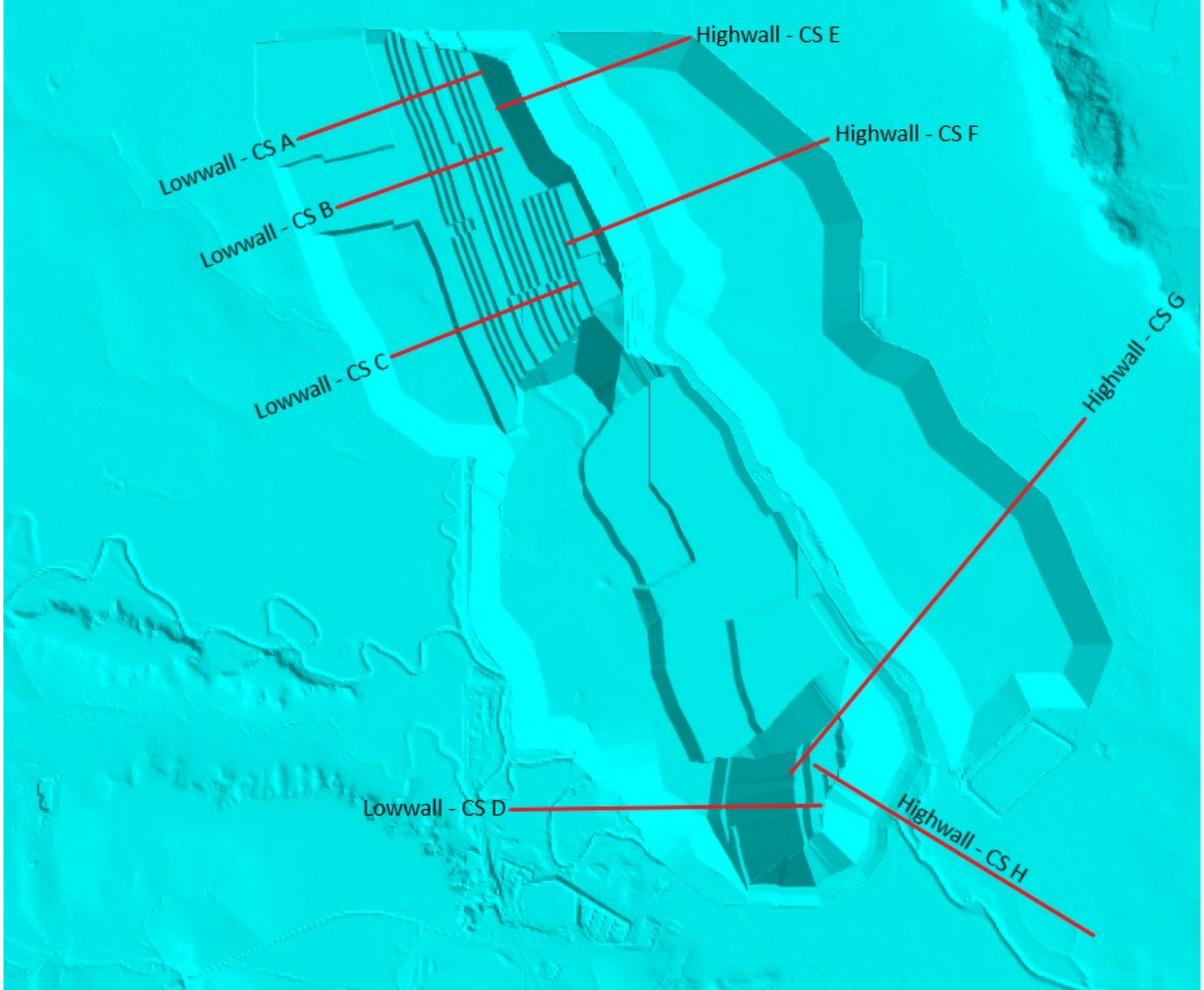


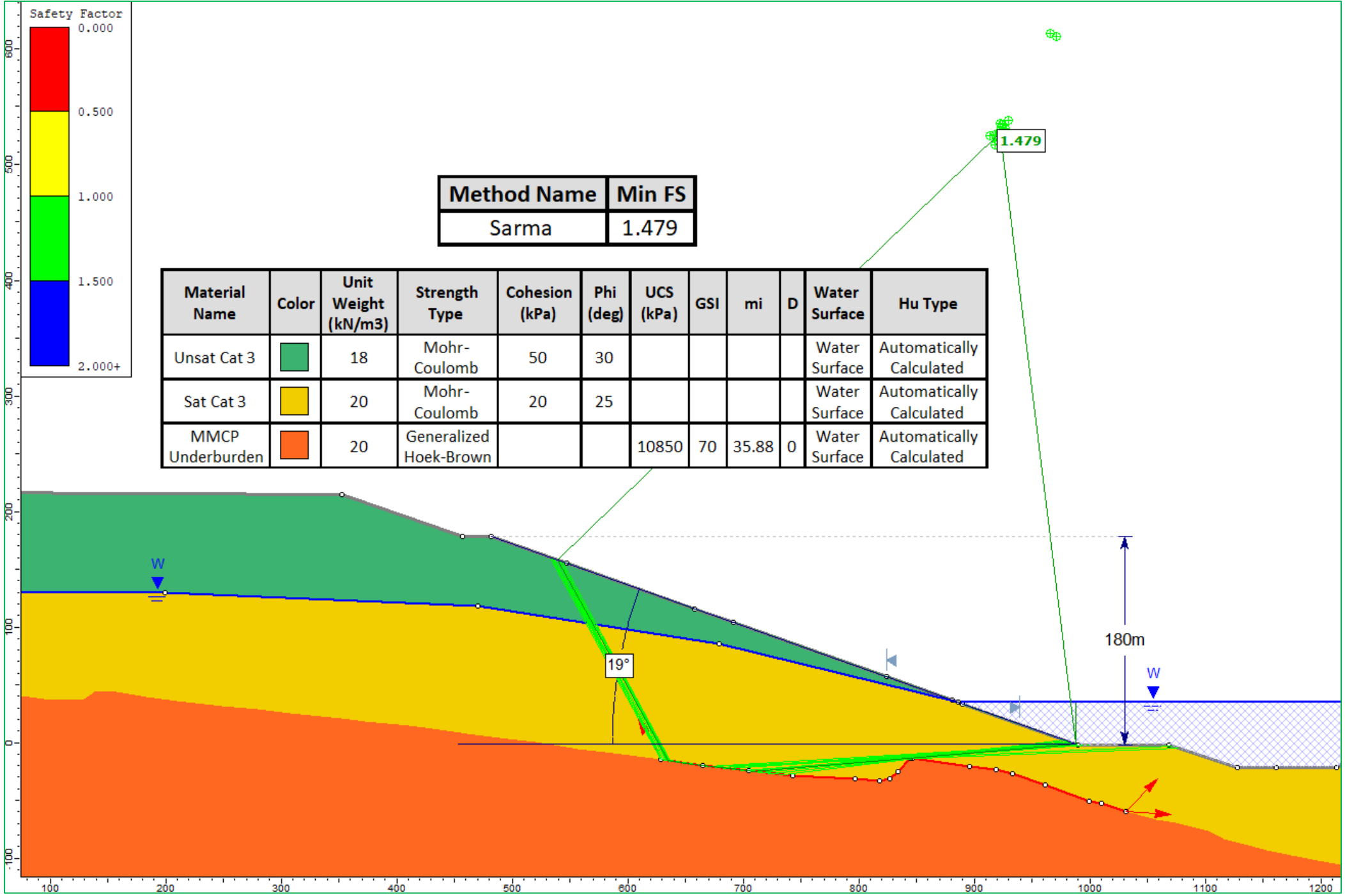
Method Name	Min FS
Sarma	2.854

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsar Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
PI Overburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

Lowwall

Cross Section D


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H

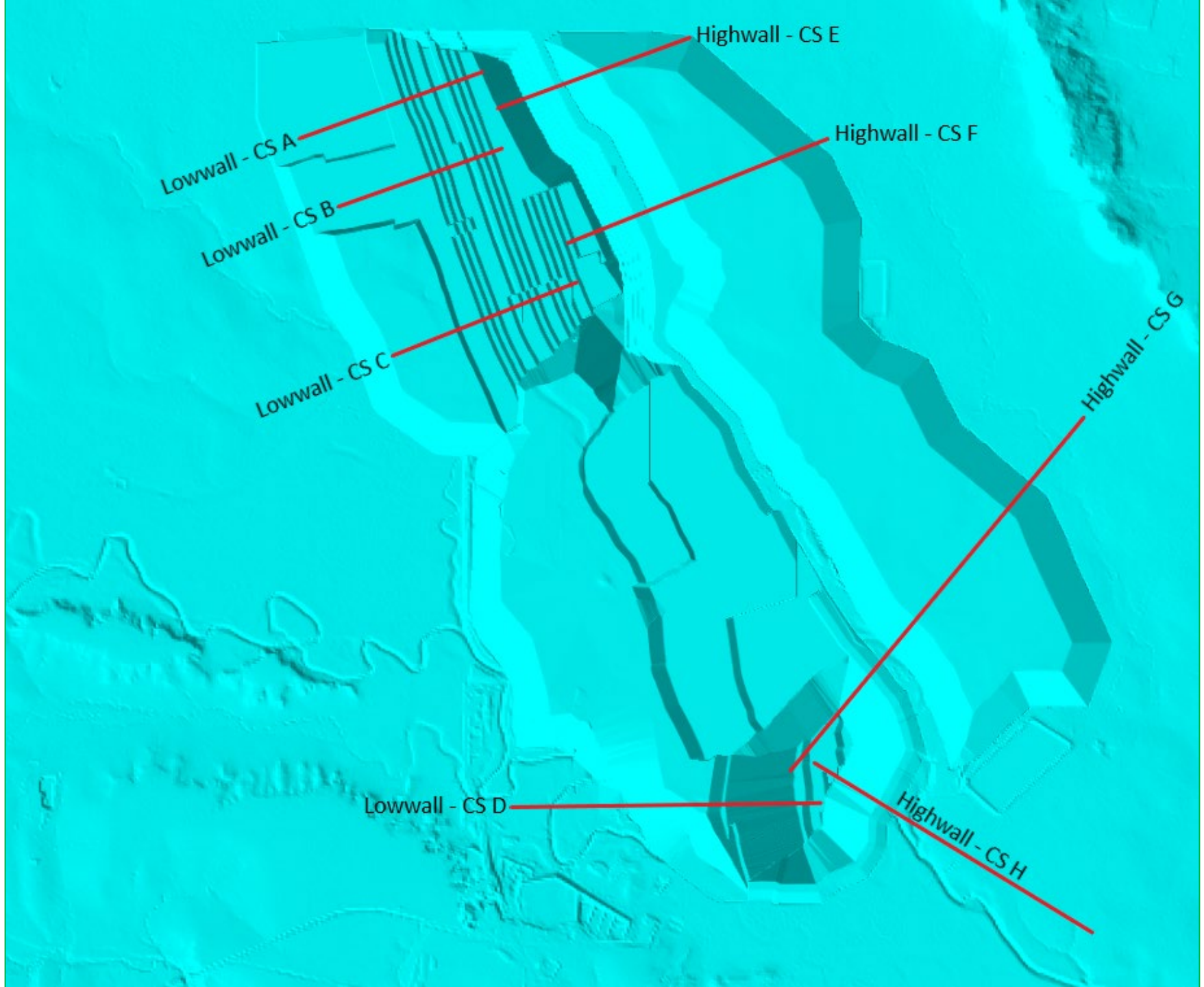


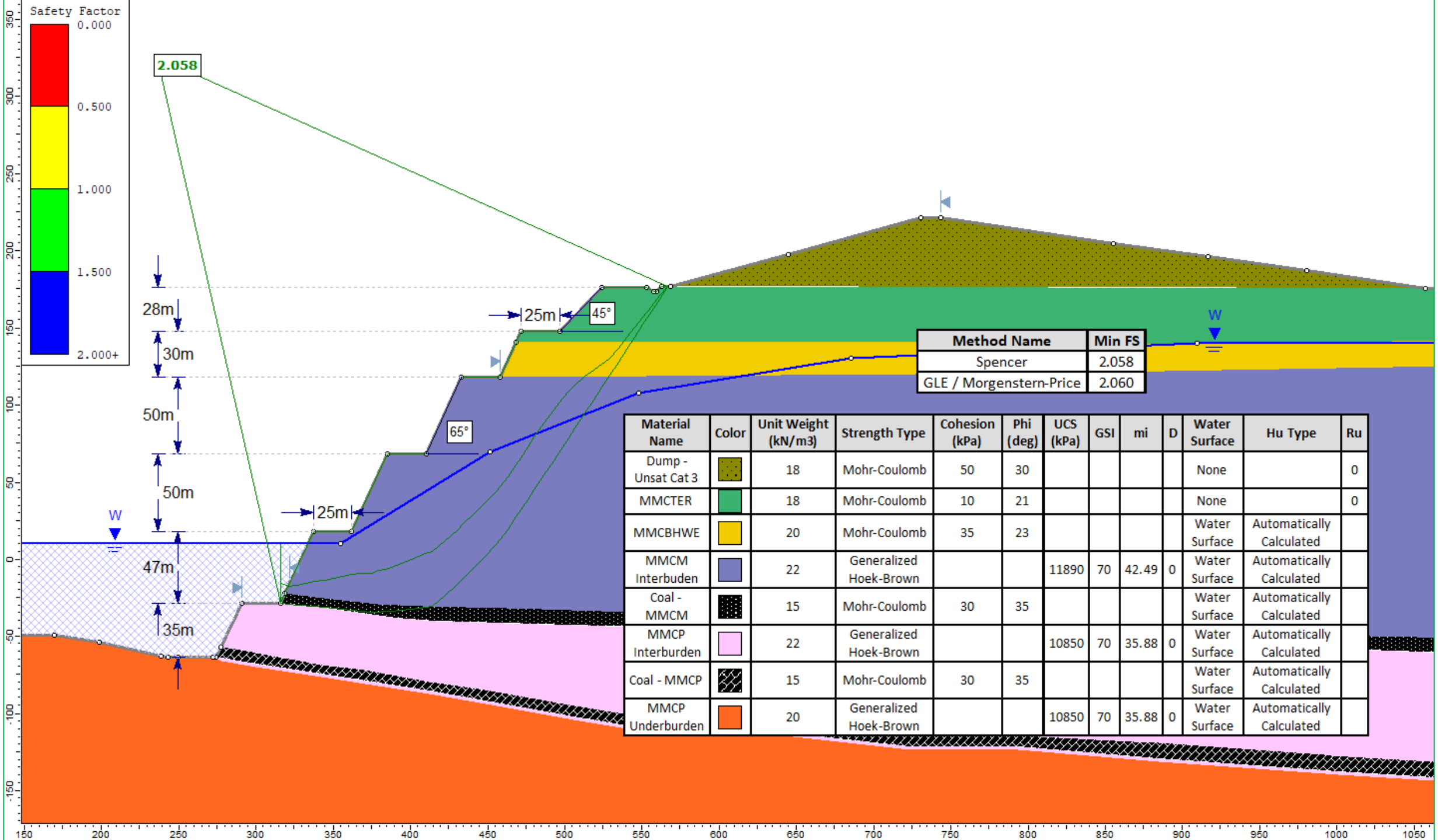
Method Name	Min FS
Sarma	1.479

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
Sat Cat 3		20	Mohr-Coulomb	20	25					Water Surface	Automatically Calculated
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

Highwall

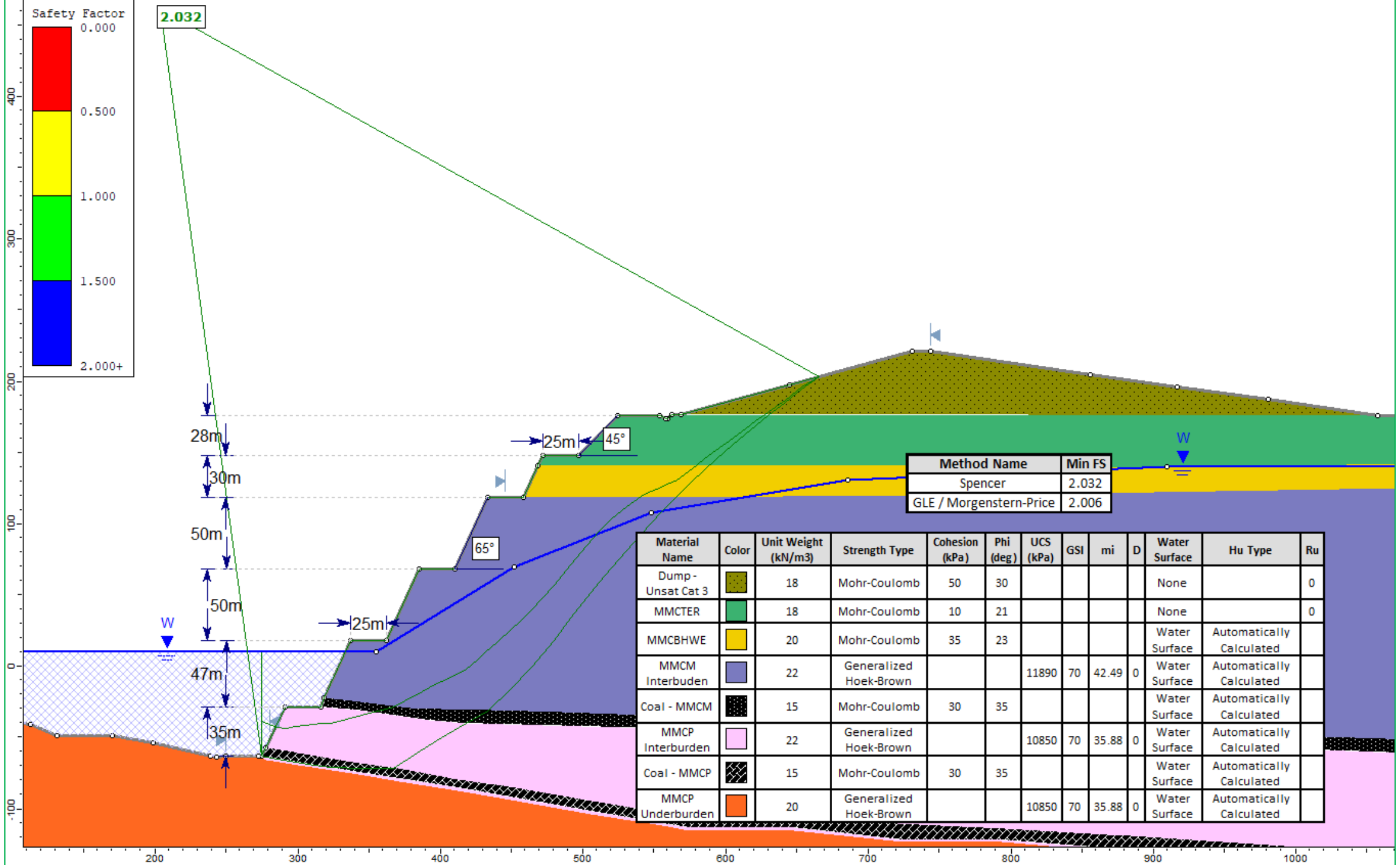
Cross Section E


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H



Method Name	Min FS
Spencer	2.058
GLE / Morgenstern-Price	2.060

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					None		0
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

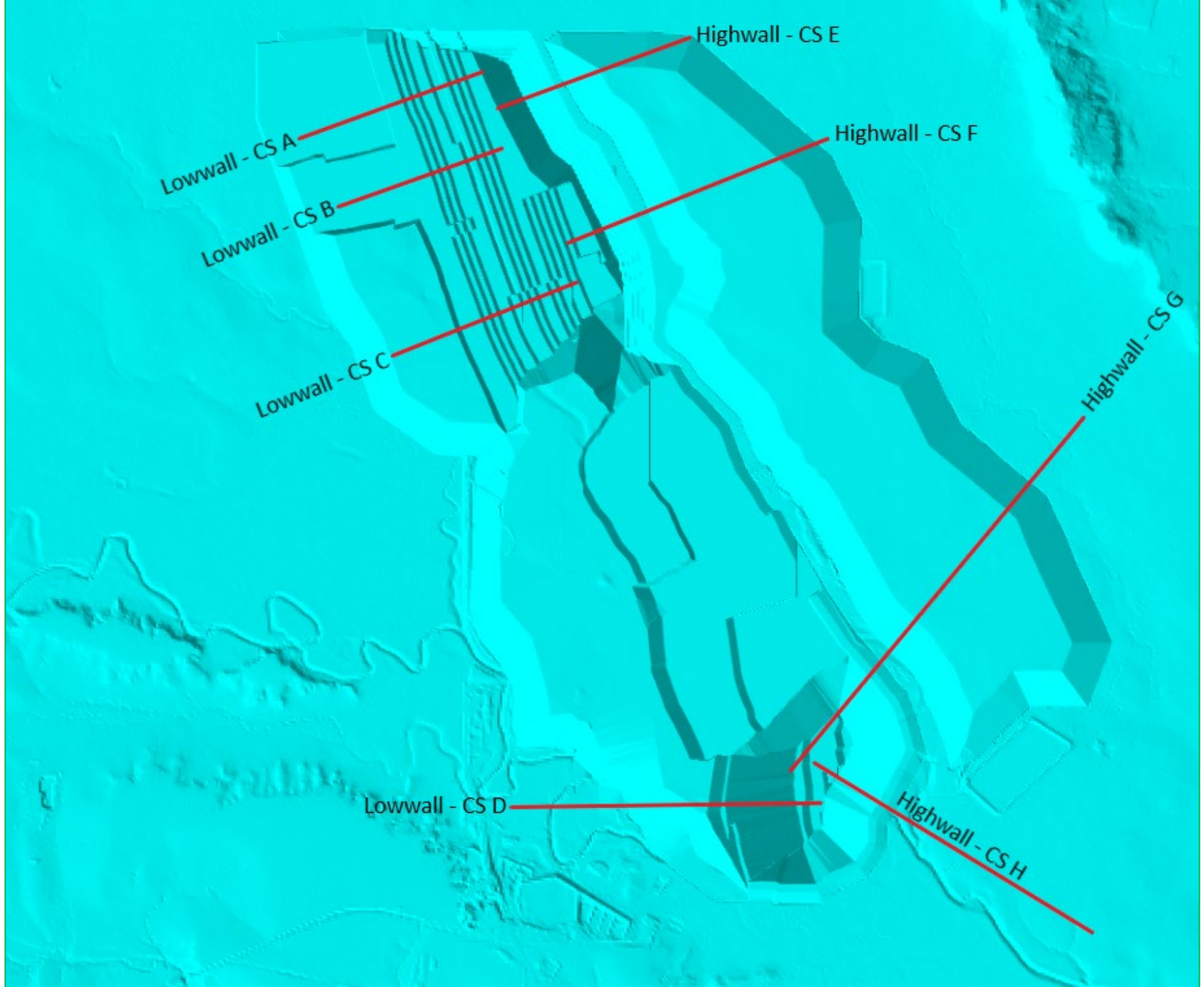


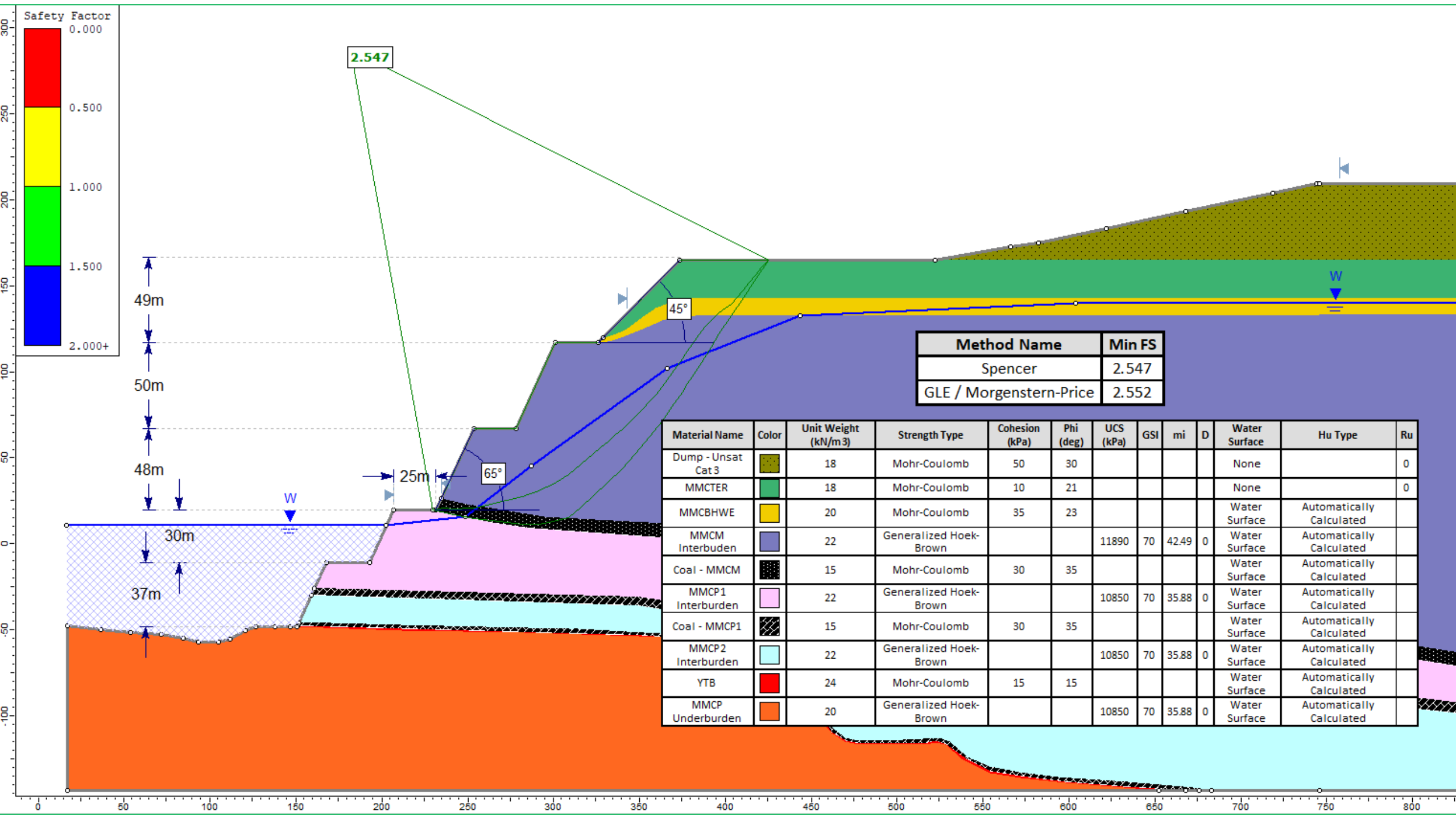
Method Name	Min FS
Spencer	2.032
GLE / Morgenstern-Price	2.006

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					None		0
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

Highwall

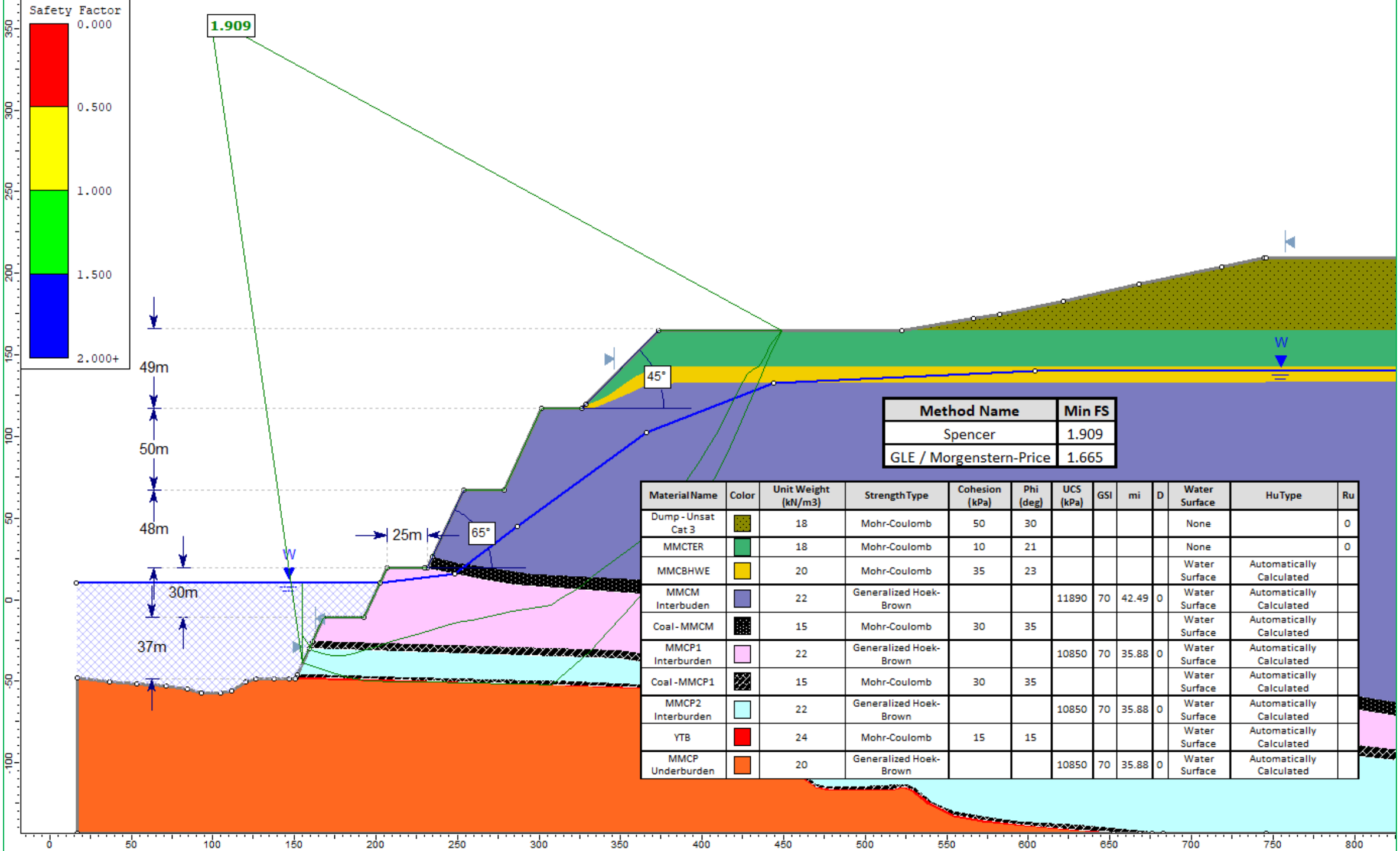
Cross Section F


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H



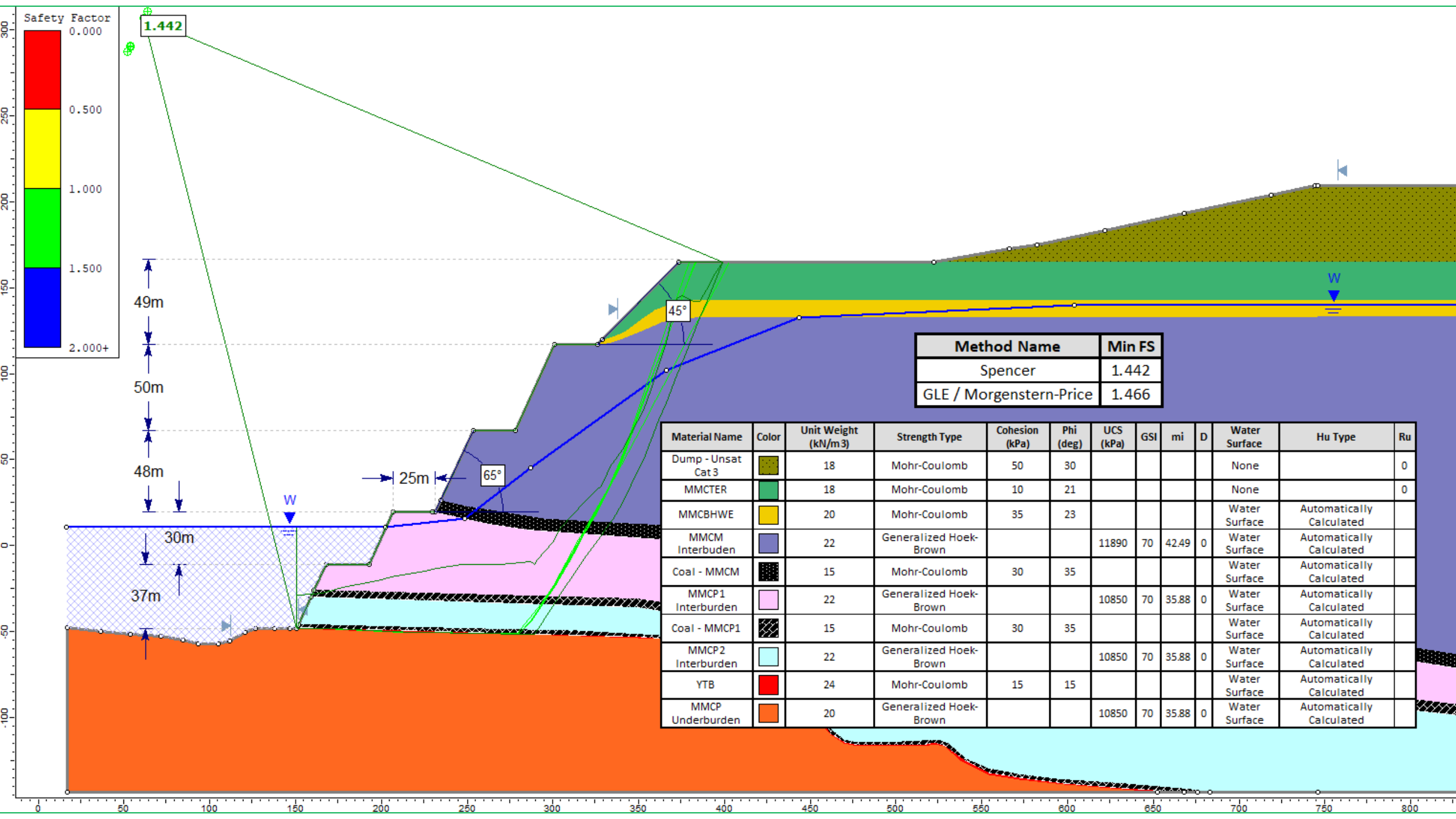
Method Name	Min FS
Spencer	2.547
GLE / Morgenstern-Price	2.552

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					None		0
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	



Method Name	Min FS
Spencer	1.909
GLE / Morgenstern-Price	1.665

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					None		0
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

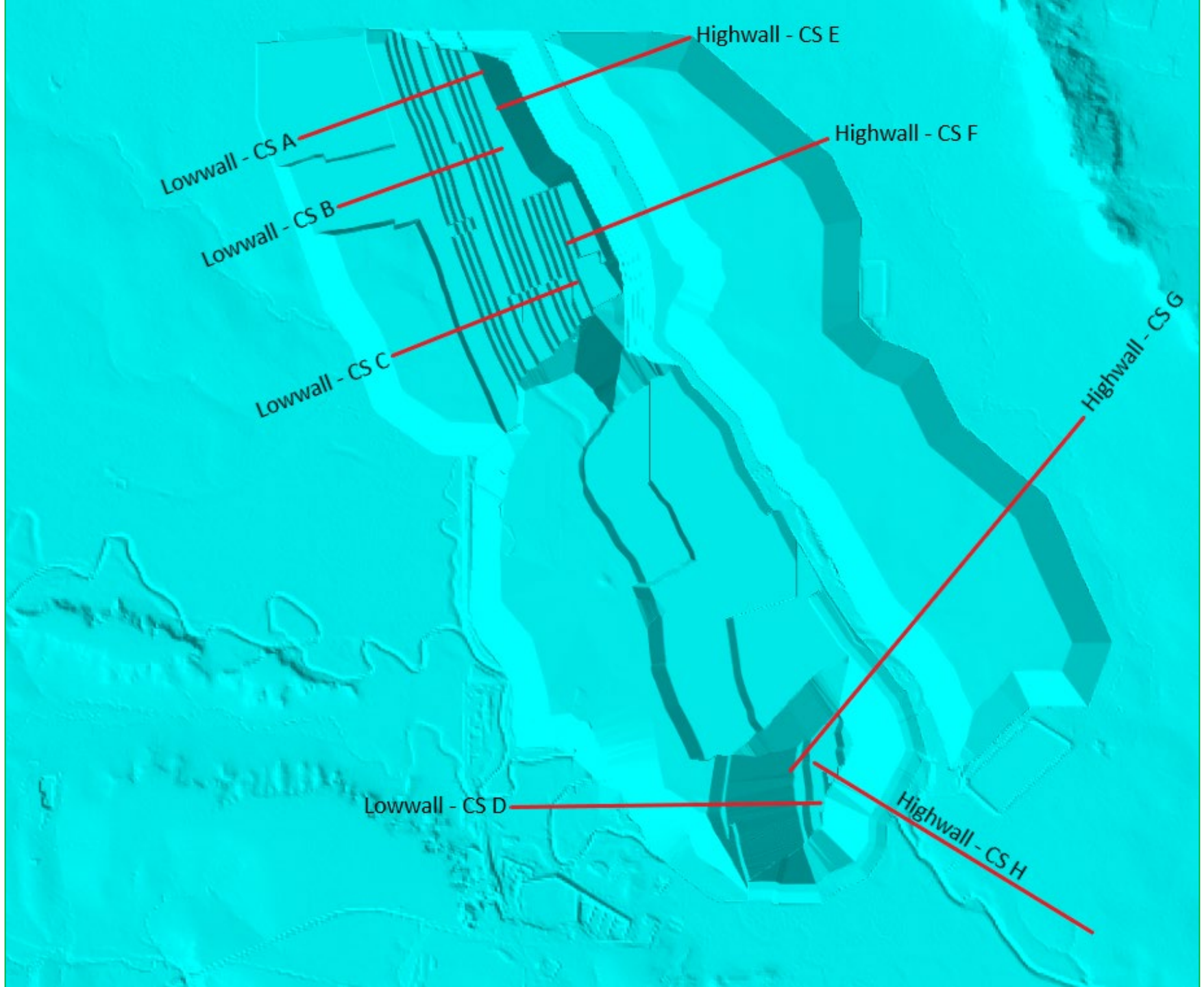


Method Name	Min FS
Spencer	1.442
GLE / Morgenstern-Price	1.466

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					None		0
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

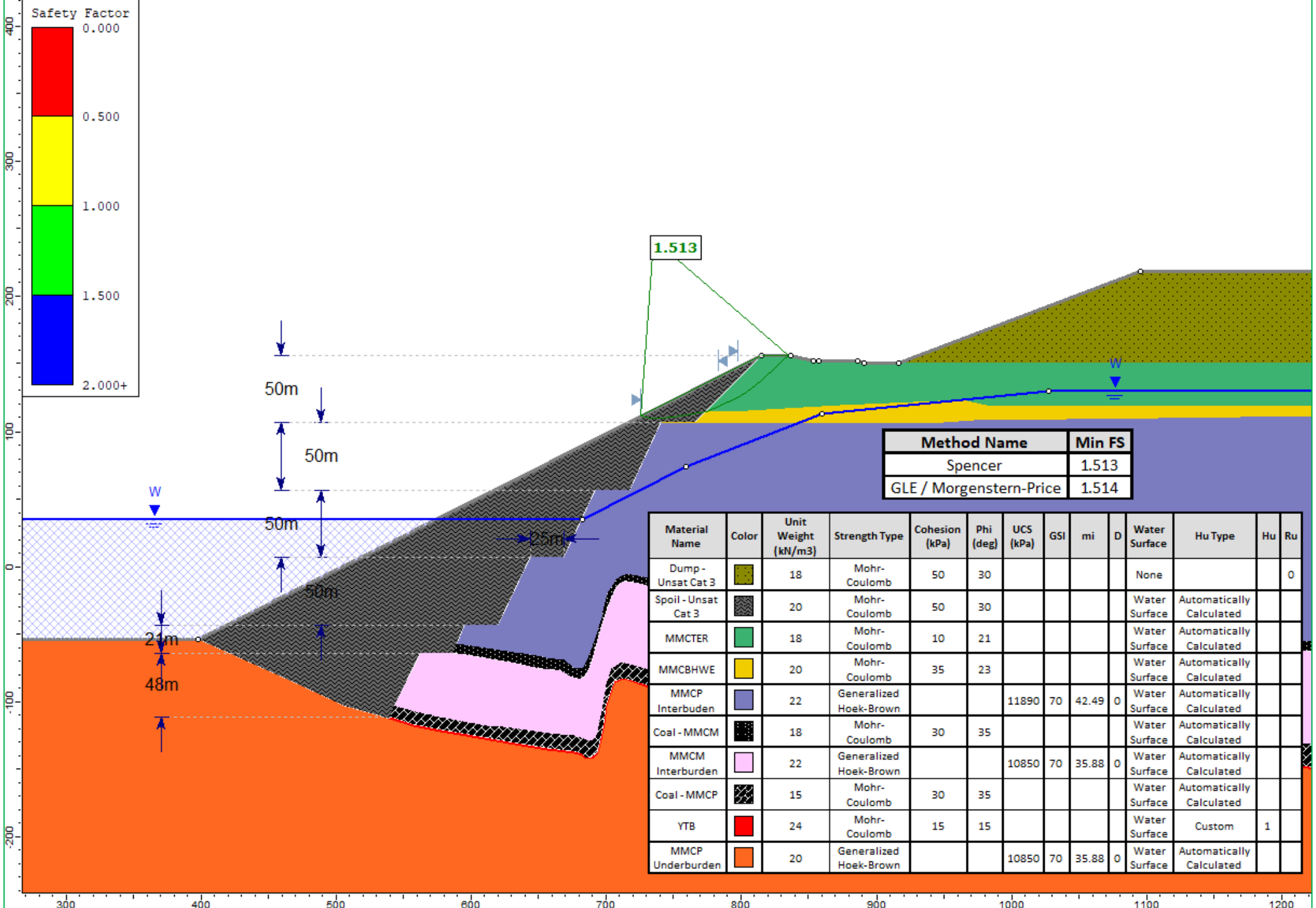
Highwall

Cross Section G


Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H

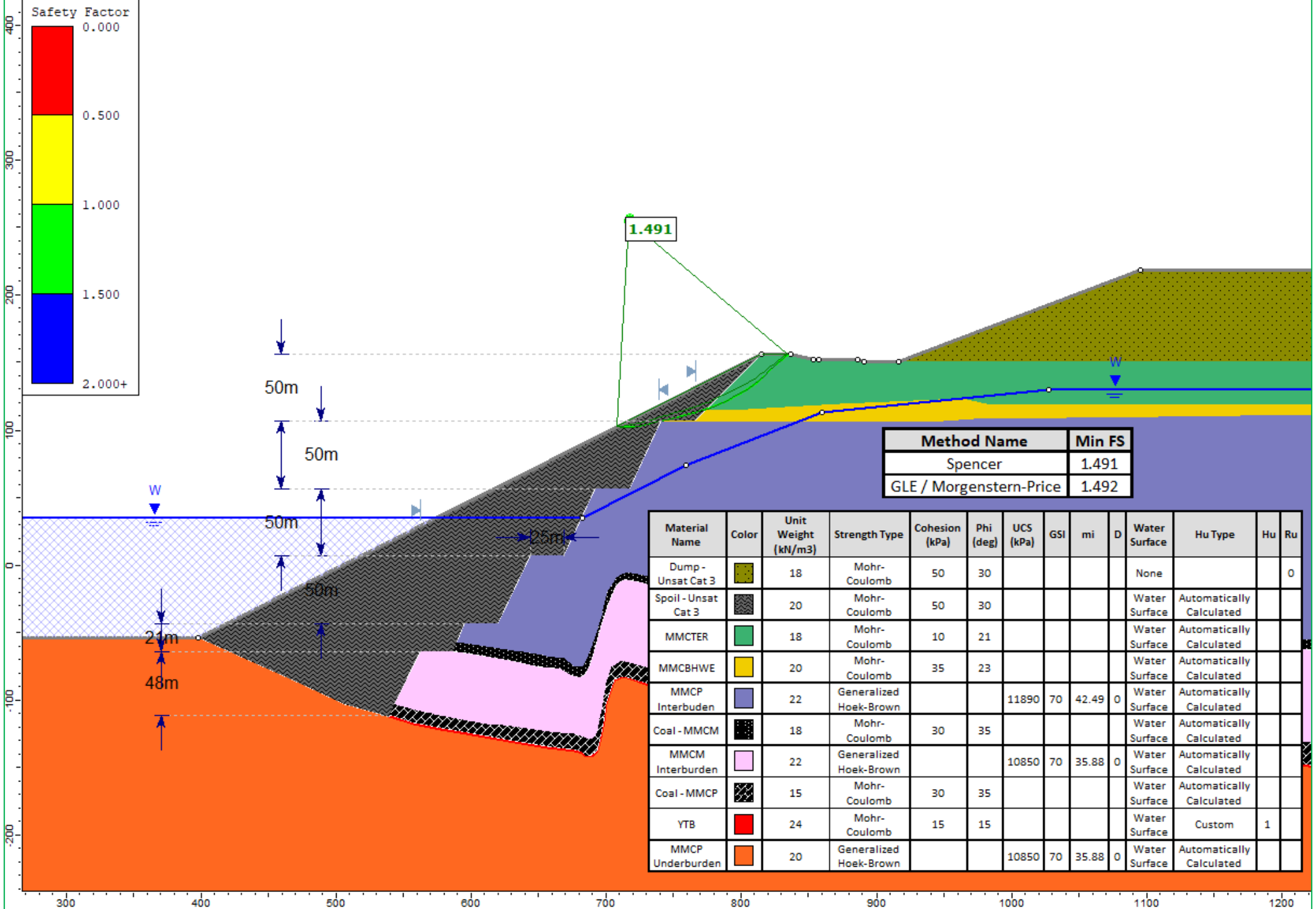
Highwall

Cross Section G – with Spoil



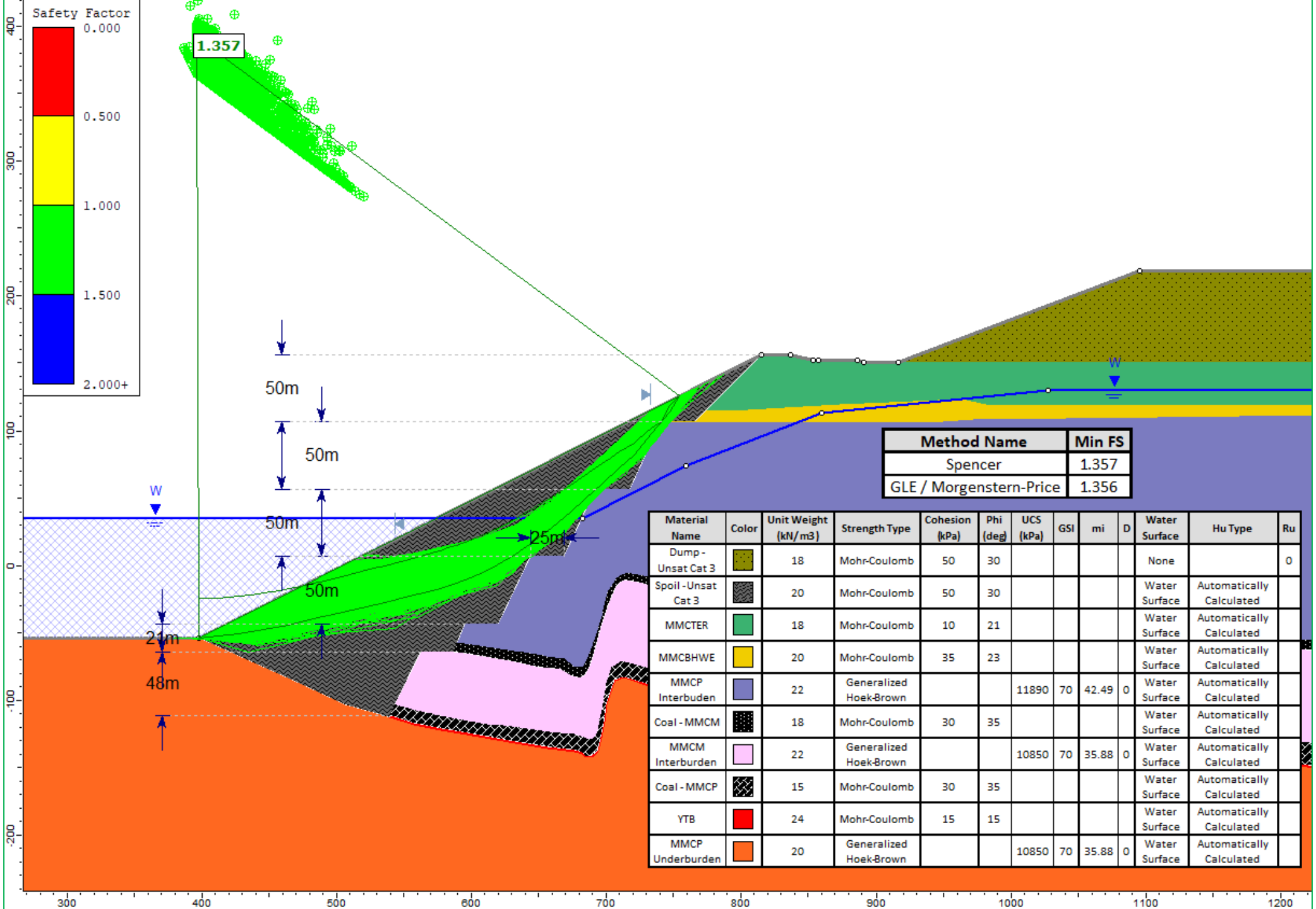
Method Name	Min FS
Spencer	1.513
GLE / Morgenstern-Price	1.514

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None			0
Spoil - Unsat Cat 3		20	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated		
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated		
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated		
MMCP Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated		
Coal - MMCM		18	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated		
MMCM Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated		
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated		
YTB		24	Mohr-Coulomb	15	15					Water Surface	Custom	1	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated		



Method Name	Min FS
Spencer	1.491
GLE / Morgenstern-Price	1.492

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Hu	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None			0
Spoil - Unsat Cat 3		20	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated		
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated		
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated		
MMCP Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated		
Coal - MMCM		18	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated		
MMCM Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated		
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated		
YTB		24	Mohr-Coulomb	15	15					Water Surface	Custom	1	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated		

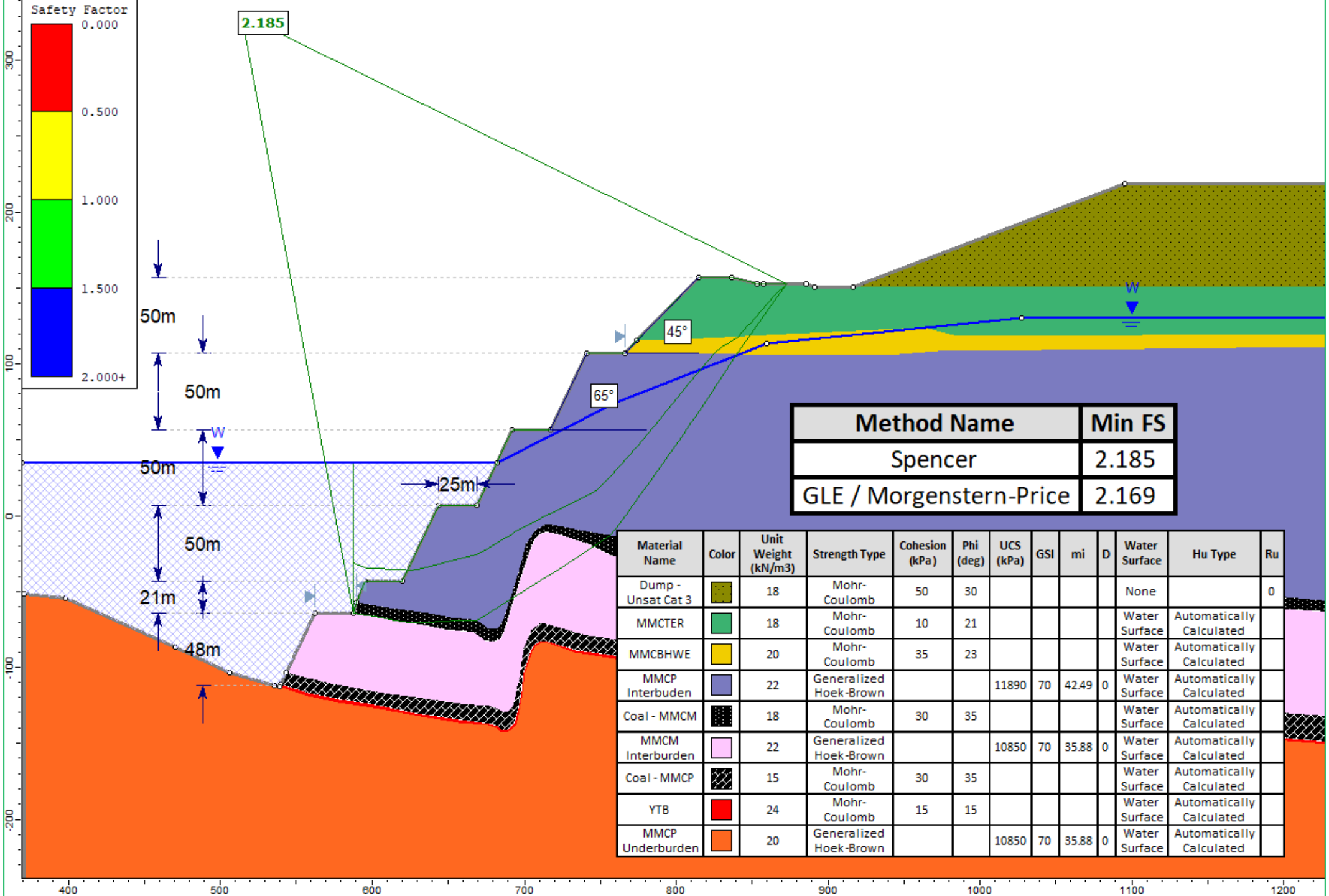


Method Name	Min FS
Spencer	1.357
GLE / Morgenstern-Price	1.356

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
Spoil - Unsat Cat 3		20	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated	
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated	
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCP Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		18	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCM Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

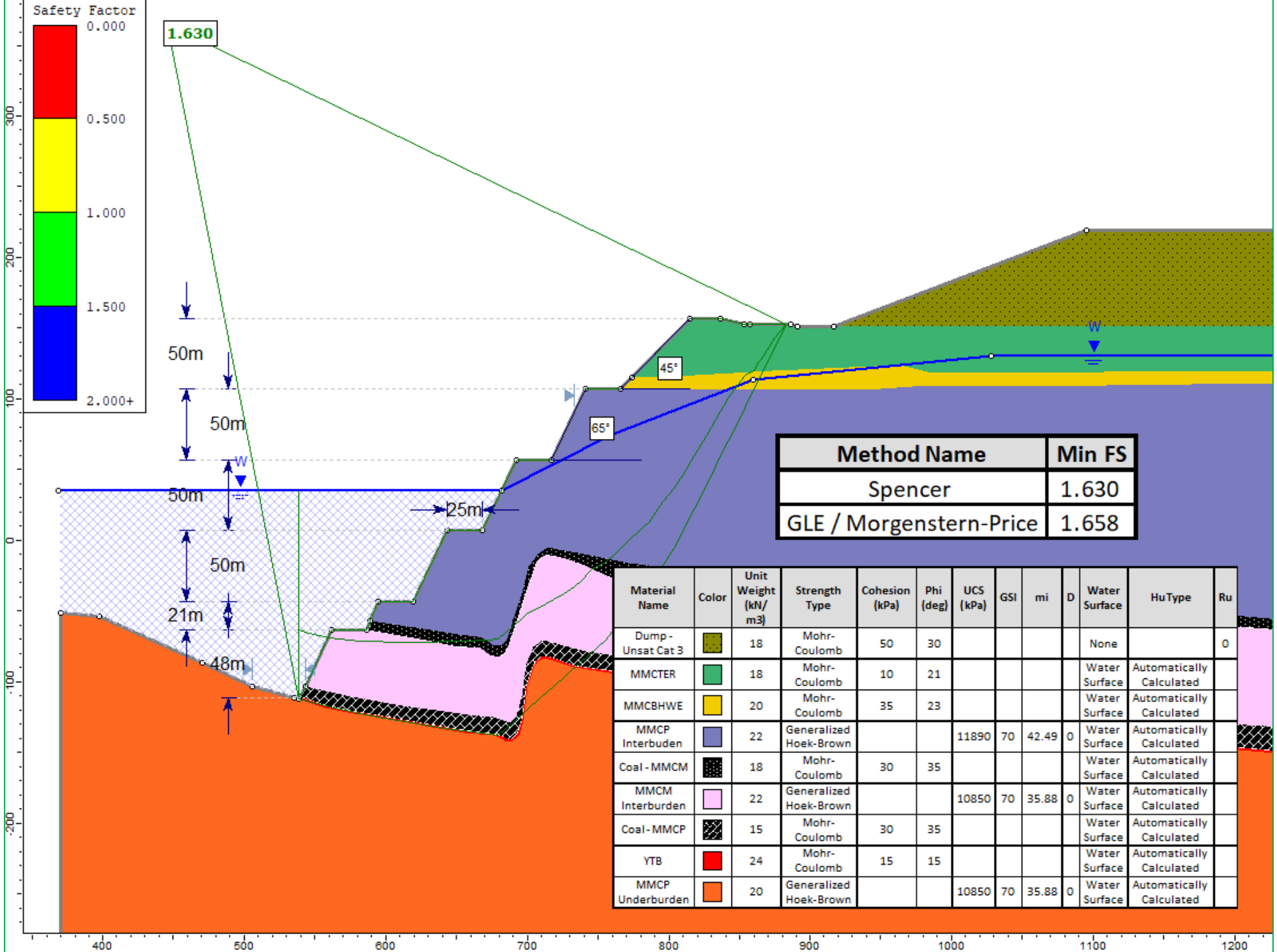
Highwall

Cross Section G – without Spoil



Method Name	Min FS
Spencer	2.185
GLE / Morgenstern-Price	2.169

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated	
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCP Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		18	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCM Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

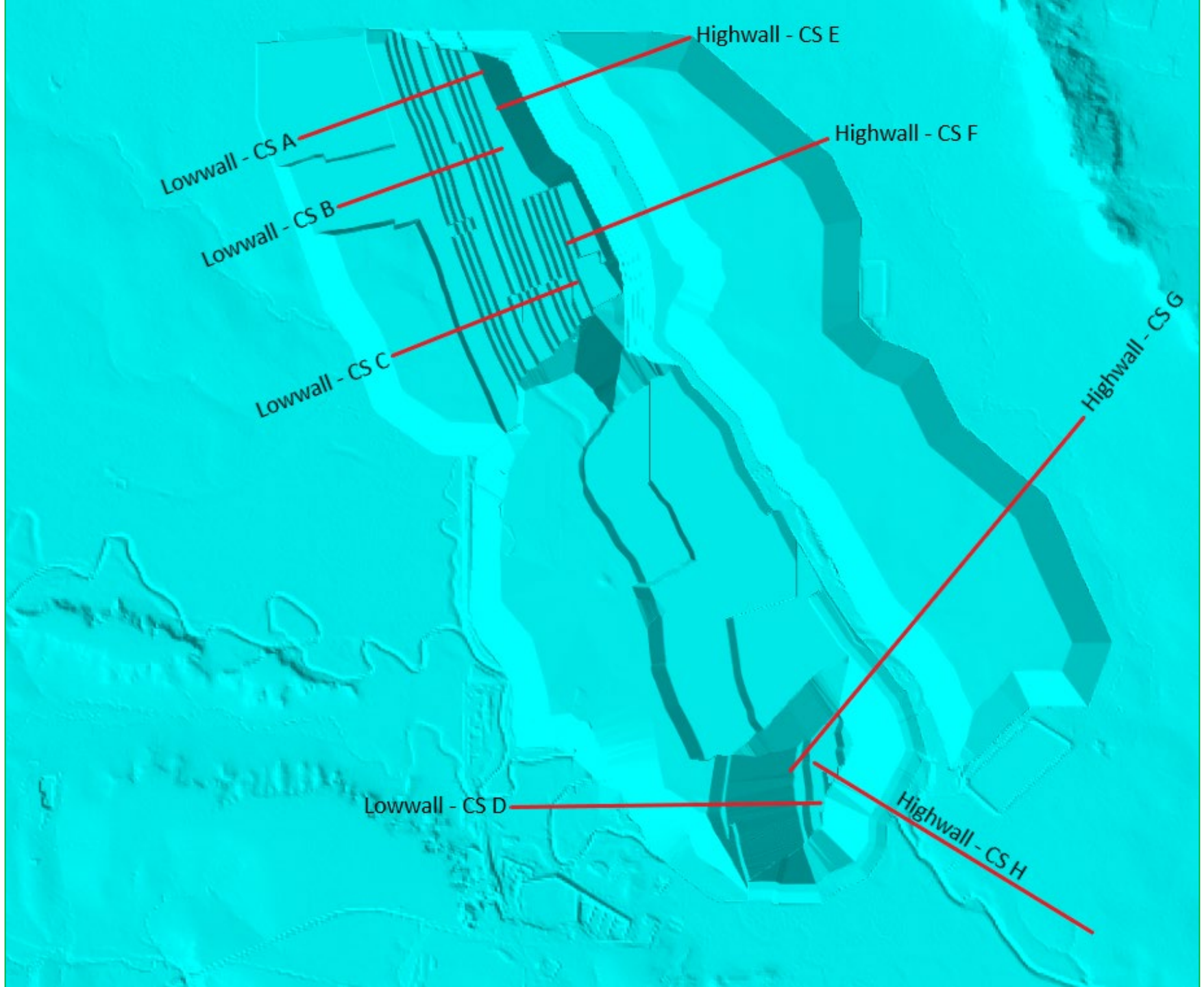


Method Name	Min FS
Spencer	1.630
GLE / Morgenstern-Price	1.658

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	HuType	Ru
Dump - Unsat Cat 3		18	Mohr-Coulomb	50	30					None		0
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated	
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated	
MMCP Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated	
Coal - MMCM		18	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
MMCM Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	
Coal - MMCP		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated	
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated	
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated	

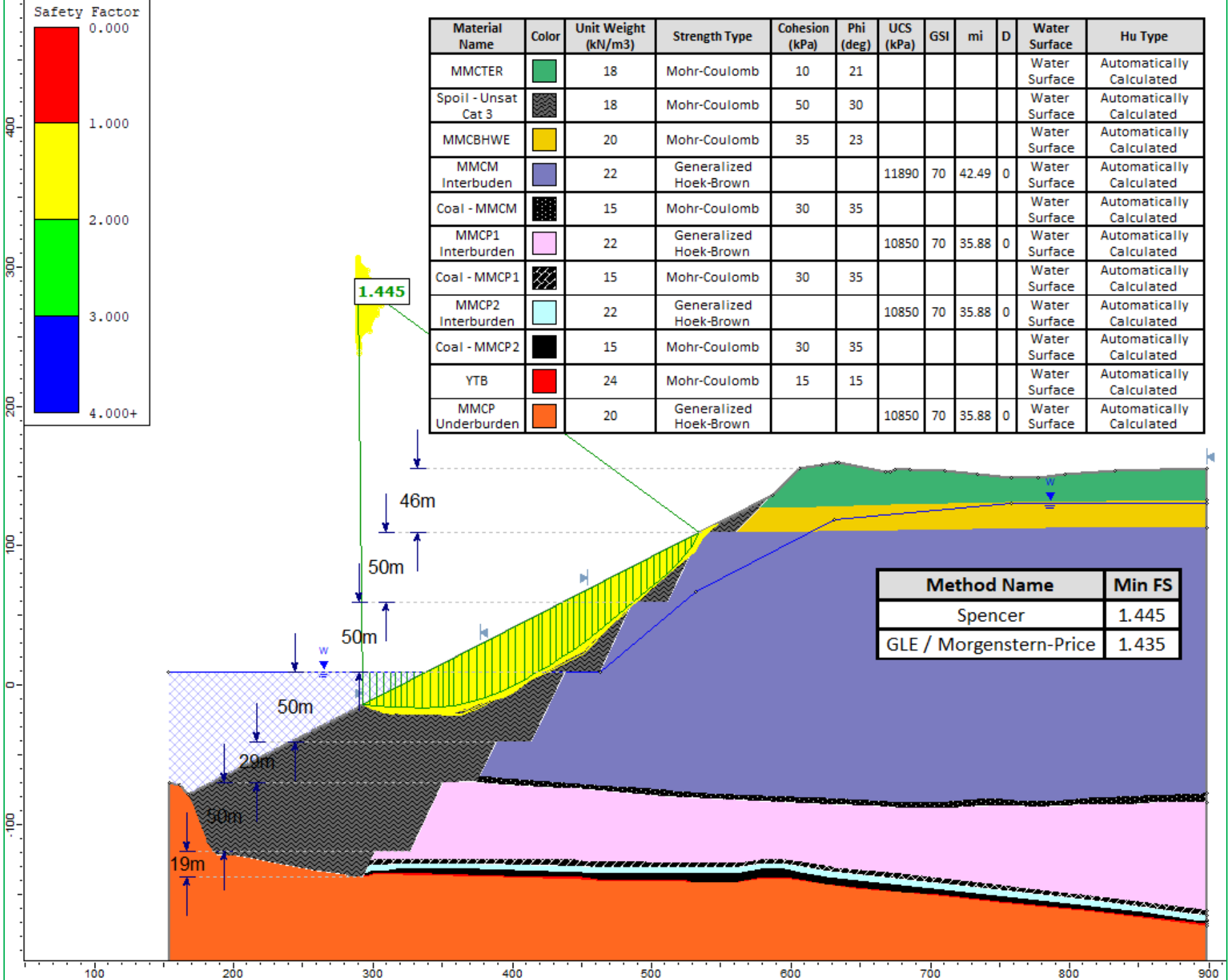
Highwall

Cross Section H

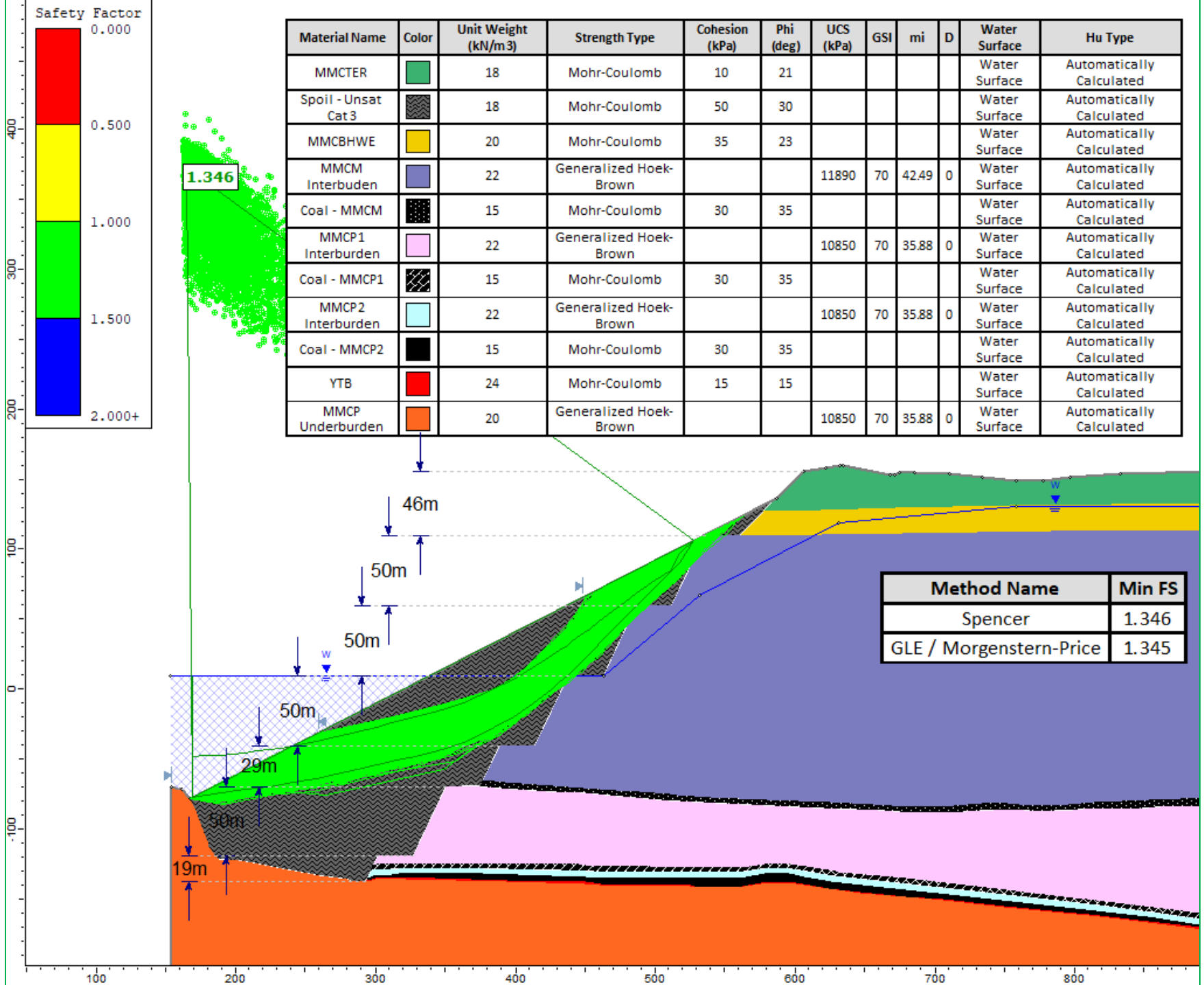

Highwall - CS E
Lowwall - CS A
Highwall - CS F
Lowwall - CS B
Lowwall - CS C
Highwall - CS G
Lowwall - CS D
Highwall - CS H

Highwall

Cross Section H – with Spoil



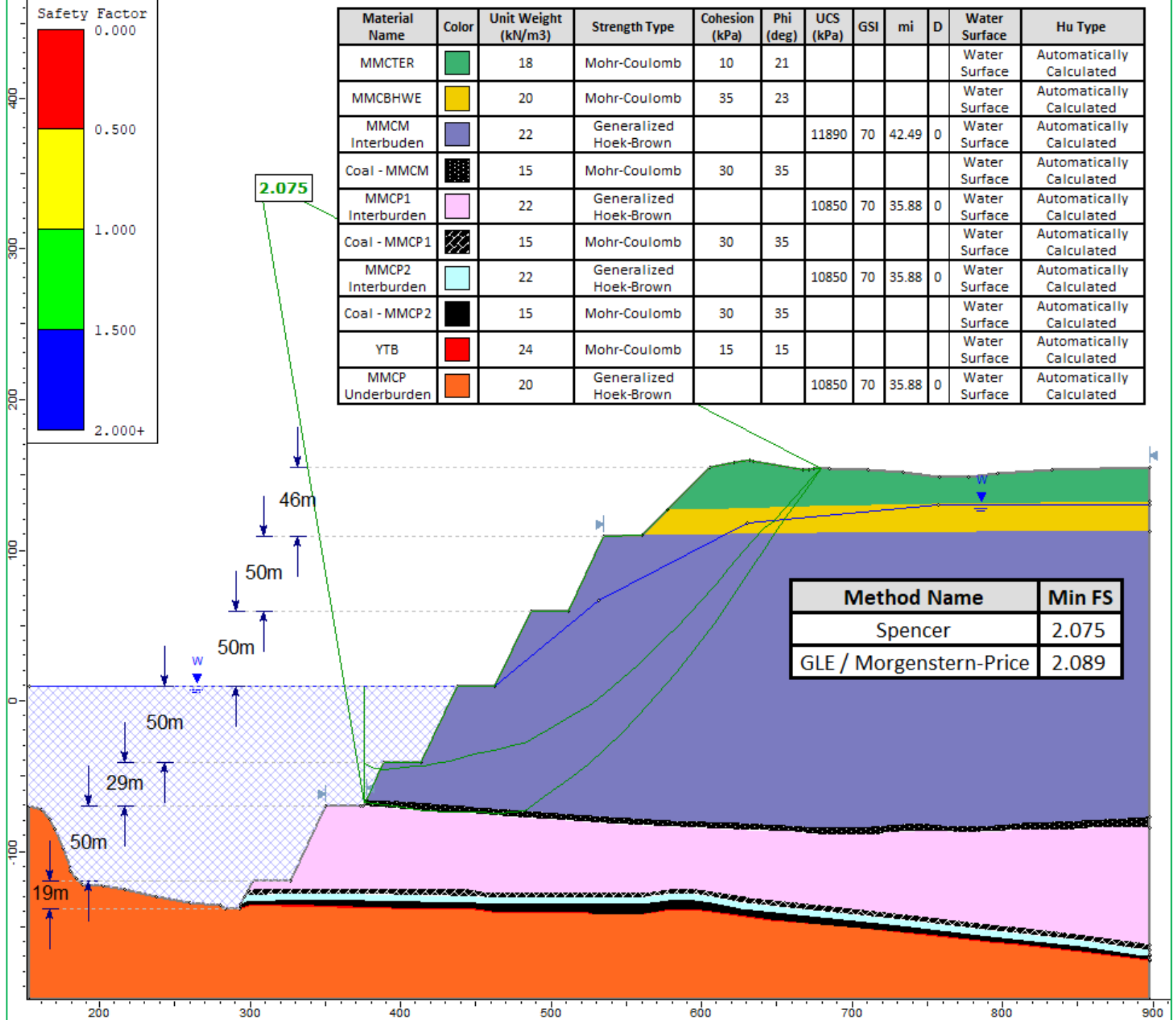
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated
Spoil - Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP2		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



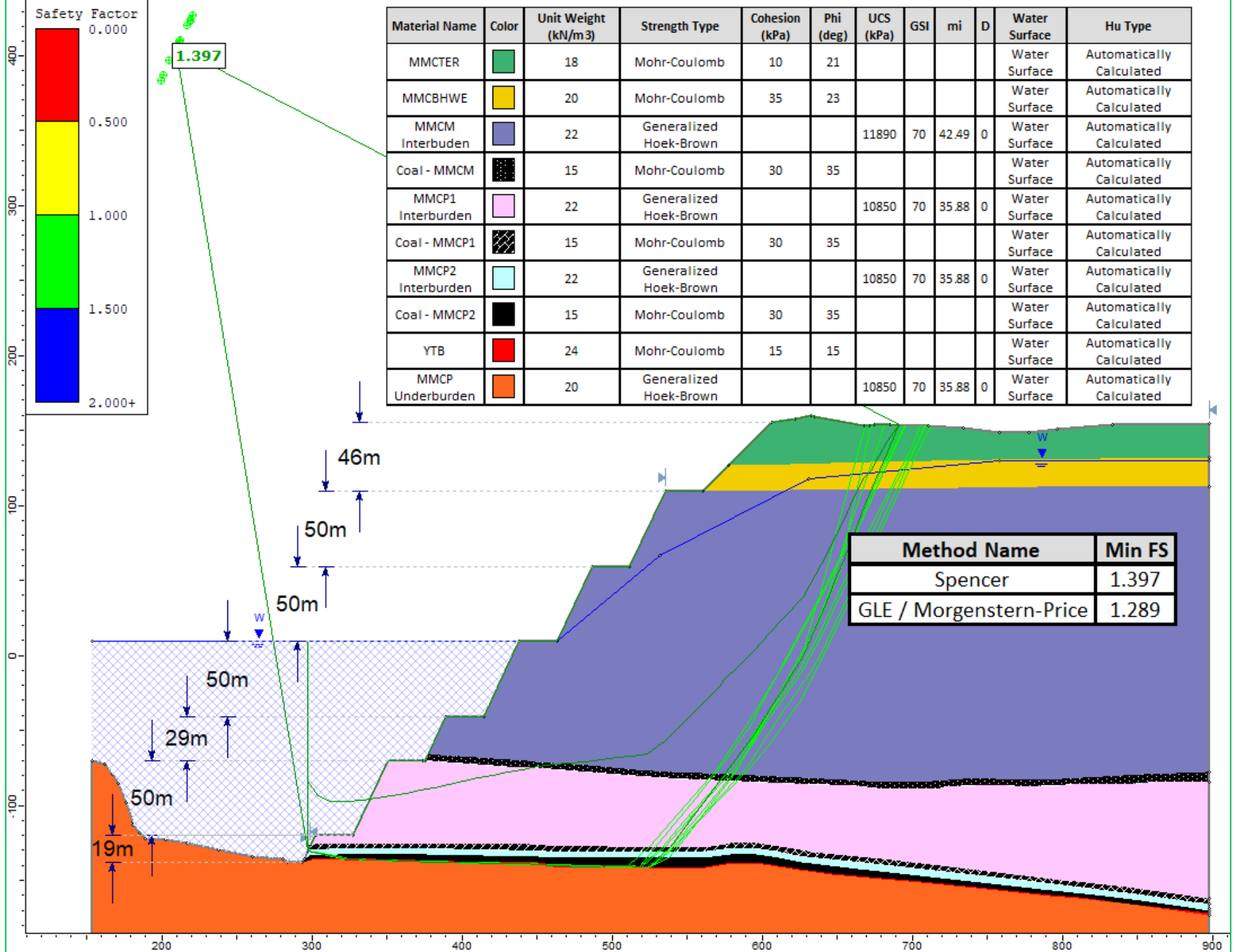
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated
Spoil - Unsat Cat 3		18	Mohr-Coulomb	50	30					Water Surface	Automatically Calculated
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP2		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated

Highwall

Cross Section H – without Spoil



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
MMCTER		18	Mohr-Coulomb	10	21					Water Surface	Automatically Calculated
MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated
Coal - MMCM		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP1 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP1		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP2		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	UCS (kPa)	GSI	mi	D	Water Surface	Hu Type
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MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated
MMCM Interbuden		22	Generalized Hoek-Brown			11890	70	42.49	0	Water Surface	Automatically Calculated
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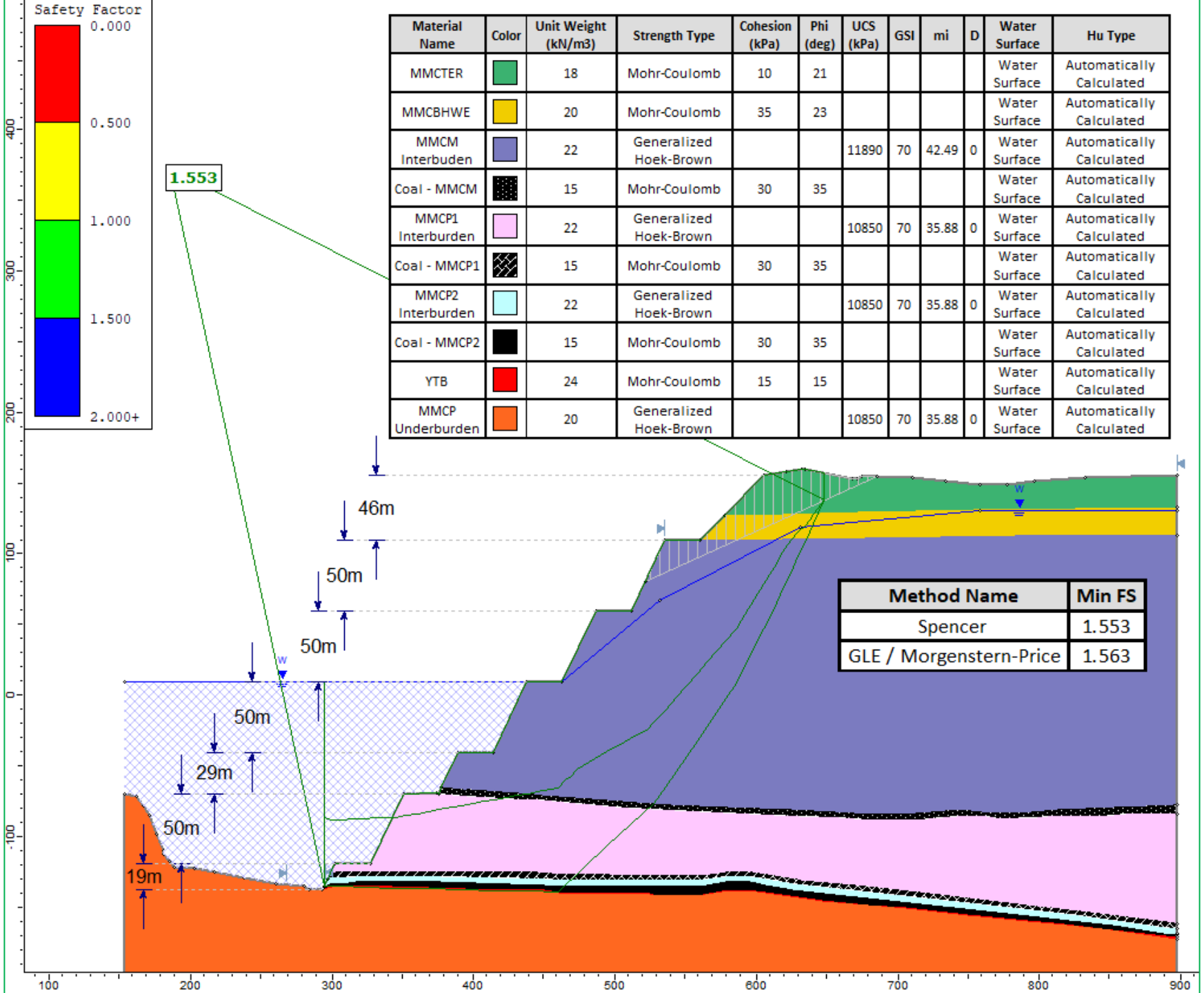
MMCP2 Interburden		22	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated
Coal - MMCP2		15	Mohr-Coulomb	30	35					Water Surface	Automatically Calculated
YTB		24	Mohr-Coulomb	15	15					Water Surface	Automatically Calculated
MMCP Underburden		20	Generalized Hoek-Brown			10850	70	35.88	0	Water Surface	Automatically Calculated



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MMCBHWE		20	Mohr-Coulomb	35	23					Water Surface	Automatically Calculated
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