



Sonoma Coal Mine Progressive Rehabilitation and Closure Plan

QCoal Sonoma Pty Ltd

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Sonoma Coal Mine Progressive Rehabilitation and Closure Plan

1 Introduction

This transitional Progressive Rehabilitation and Closure Plan (PRC Plan) has been prepared for the Sonoma Coal Mine (SCM) in accordance with the requirements of the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act), the *Environmental Protection Act 1994* (EP Act) and the *Progressive Rehabilitation and Closure Plan Guideline* (PRC Plan Guideline, DES 2024).

This PRC Plan comprises two parts:

- Rehabilitation Planning Part (this part) - providing information about the site, the rehabilitation plans, and evidence and justification to support the development of the proposed PRC Plan Schedule.
- PRC Plan Schedule (**Appendix A**) - including maps of rehabilitation and closure outcomes for the site, and tables of time-based rehabilitation milestones.

Technical studies used to support development of this plan are also included as appendices.

A Progressive Rehabilitation and Closure Plan Transition Notice for SCM was issued to QCoal Sonoma Pty Ltd by (then) DES on 26 March 2021. The Notice required QCoal Sonoma Pty Ltd to submit a PRC Plan to the administering authority by 30 September 2022.

2 Project Planning

2.1 Project Description

The Sonoma Coal Mine (SCM) is an open cut coal mine within the northern Bowen Basin in Central Queensland, located within the Whitsunday Regional Council (WRC) Local Government Area, approximately seven kilometres south of the town of Collinsville, and approximately 110km by road to the southwest of the regional centre of Bowen (see **Figure 1**). The SCM is bisected by the state-controlled Bowen Developmental Road (which is the primary access to the site) and the Newlands Rail line.

SCM is one of four adjoining coal mines managed by QCoal Pty Ltd (QCoal), the others being the Cows Coal Mine (CCM), the Drake Coal Mine (DCM) and the Jax Coal Mine (JCM). Each mine has a separate Environmental Authority (EA) and EA holder. However, the four mines are collectively operated and managed by QCoal under a co-development agreement as an integrated mining operation referred to as the QCoal Northern Hub (QNH). Pits, spoil dumps, haul roads and other infrastructure are shared by the four mines and span tenure boundaries.

SCM is wholly contained within three granted Mining Leases (MLs) 10325, 10326, 10327 and one ML application with grant pending (ML700075). The existing SCM MLs cover a total of 2,140.1Ha, while ML700075 will comprise a further 74.07Ha.

Mining commenced at SCM in mid-2007, using conventional open-cut mining methods to target the Moranbah Coal Measures (MCM). Mine waste is placed in out-of-pit waste rock dumps until sufficient void is available within the pits to allow for in-pit dumping via and advancing low-wall (progressively backfilling).

The other QNH mines utilise processing and support infrastructure at SCM, including the Coal Handling and Preparation Plant (CHPP), rejects management system (co-disposal facility), train load-out, Run of Mine (ROM) pad, product stockpile area, heavy vehicle workshop, offices and fuel storage. Other infrastructure at SCM includes access tracks, haul roads, park-up areas; and water management structures (creek diversions, dams and drains).

Ongoing and planned activities at SCM include the continued mining of waste rock and coal, dumping of waste rock within in-pit and out of pit waste rock dumps, haulage of ROM coal via existing haul roads, processing of coal, management of rejects, rehabilitation activities in available areas and environmental monitoring. New mining areas/pits are opened as required by the mine plan, subject to relevant EA constraints, resource location and economics.

2.1.1 Project Ownership

The ownership structure for each QNH mine is as follows:

- SCM is a joint venture between QCoal Sonoma Pty Ltd, JS Sonoma Pty Ltd, CSC Sonoma Pty Ltd and Watami (Qld) Pty Ltd.
- CCM is owned by Bowen River Coal Pty Ltd;
- DCM is owned by Northern Hub (Drake) Pty Ltd and Drake Coal Pty Ltd; and
- JCM is owned by Jax Coal Pty Ltd (Jax Coal).

QCoal Sonoma Pty Ltd, Bowen River Coal Pty Ltd, Northern Hub (Drake) Pty Ltd, Drake Coal Pty Ltd, and Jax Coal Pty Ltd are wholly or majority owned subsidiaries of QCoal Pty Ltd. The owner and Managing Director of QCoal Pty Ltd is Mr Christopher Wallin.

QCoal Sonoma Pty Ltd is hereafter referred to in this document as 'QCS'.

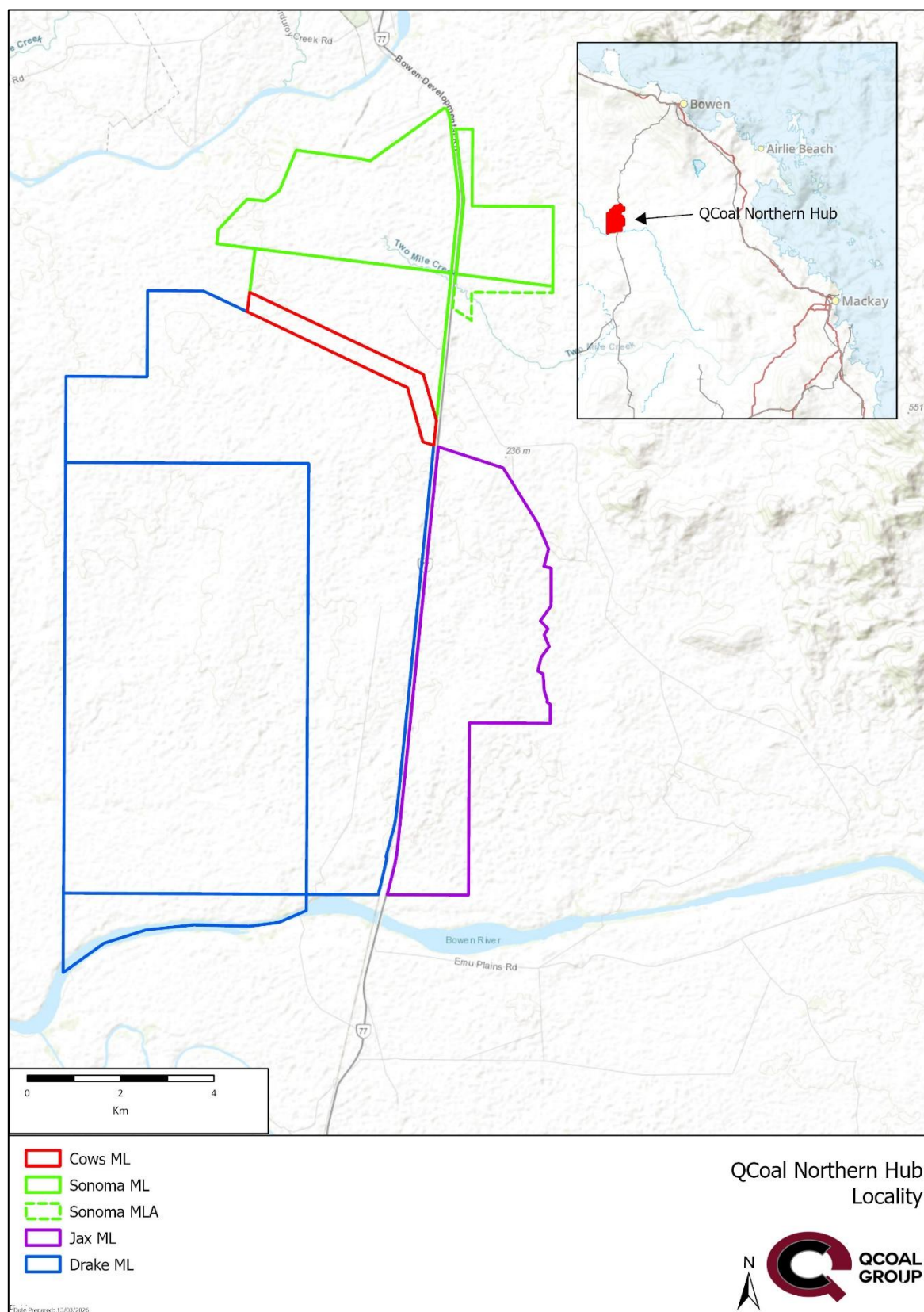


Figure 1 – SCM Regional Location

2.1.2 Sonoma Coal Mine Approvals

The exploration tenements held by QCoal (and its subsidiaries) underlying SCM include Exploration Permit Coal (EPC) 586 (held since 1995) and EPC 639 (held since 2001). Exploration within these EPCs defined coal resources which has led to the progressive development of the QNH (SCM, CCM, JCM and DCM) since 2006. The progressive nature of the development of the mines, along with the different ownership structure for each of the QNH mines, has required separate MLs and EAs for each mine, with the approval process required for each individual mine dependent on the proposed scale and the level of impact to environmental values. The completed QNH approval processes include the following:

- SCM – Level 1 Non-Code Compliant EA application assessed by Environmental Impact Statement (EIS), process completed in 2006;
- CCM – Level 1 Non-Code Compliant EA application assessed by Environmental Management Plan (EMP), process completed in 2012;
- JCM – Level 1 Non-Code Compliant EA application assessed by EMP, process completed in 2013;
- DCM – Level 1 Non-Code Compliant EA application assessed by EIS, process completed in 2014.

QCS submitted applications for MLs 10325, 10326 and 10327 to the (then) Department of Natural Resources and Mine (DNRM) in November 2005, and the MLs were subsequently granted in April 2007 (ML10325) and September 2007 (ML10326 and ML10327).

In May 2005, an application to prepare a voluntary EIS was submitted to, and accepted by, the (then) Qld Environmental Protection Agency (EPA). The SCM EIS was submitted in February 2006, with a Supplementary Report (prepared in response to submissions during the EIS public notification period) submitted in June 2006. An EIS Assessment Report was issued by the EPA in August 2006 and the original EA EPML00707713 was subsequently granted in March 2007.

An application for ML700075 was lodged with (then) Department of Resources (DoR) in November 2022, the grant of which remains pending. A major EA amendment application was lodged with (then) DESI on 1 December 2022 to include ML700075 and the related activities. The amended EA including ML700075 was granted on 19 July 2024. The current version of the SCM EA took effect on 29 November 2024 and is attached as **Appendix B**.

Table 1 provides further details on the SCM MLs and EA.

Table 1 – SCM ML and EA Details

Details	ML10325	ML10326	ML10327	ML700075	EPML00707713
Permit Type	Mining Lease	Mining Lease	Mining Lease	Mining Lease	Environmental Authority
Permit Status	Granted	Granted	Granted	Application	Granted
Lodgment Date	21/11/2005	21/11/2005	21/11/2005	25/11/2022	-
Grant Date	12/4/2007	13/09/2007	13/09/2007	-	Current 29/11/2024
Expiry Date	30/04/2037	30/09/2037	30/09/2037	-	-
Authorised Holder	QCoal Sonoma Pty Ltd				
Area	716.7 ha	1,063 ha	360.4 ha	74.07	All MLs
Permit ID	108618	108619	108620	700075	EPML00707713
Native Title Category	100% Exclusive Land	100% Exclusive Land	100% Exclusive Land	100% Exclusive Land	-

Condition A2 of EA EPML00707713 authorises QCS to extract a maximum of 6.5 million tonnes per annum of ROM coal at the SCM in any calendar year. The Environmentally Relevant Activities (ERAs) authorised under EA EPML00707713 are listed in **Table 2**:

Table 2 – SCM ERAs

ERA	Description	Status
Resource Activity, Schedule 3, 13	Mining black coal	This ERA has been undertaken at the SCM
Ancillary 08 – Chemical Storage 1	Storing a total of 50t or more of chemicals of dangerous goods class 1 or class 2, division 2.3 under subsection (1)(a)	This ERA has been undertaken at the SCM
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)	This ERA has been undertaken at the SCM
Ancillary 31 – Mineral Processing 2(b)	Processing, in a year, more than 100,000t of mineral products, other than coke	This ERA has been undertaken at the SCM
Ancillary 60 - Waste disposal, 2(e)	Operating a facility for disposing of, in a year, more than 20,000t but not more than 50,000t	This ERA has been undertaken at the SCM
Ancillary 62 – Resource recovery and transfer facility operation, 1(c)	Operating a facility for receiving and sorting, dismantling, baling or temporarily storing category 2 regulated waste	This ERA has been undertaken at the SCM
Ancillary 62 – Resource recovery and transfer facility operation, 1(d)	Operating a facility for receiving and sorting, dismantling, baling or temporarily storing category 1 regulated waste	This ERA has been undertaken at the SCM

ERA	Description	Status
Ancillary 63 – Sewage Treatment 1(a-i)	Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	This ERA has not been undertaken

The SCM project was referred to the (then) Department of Environment, Water, Heritage and the Arts in April 2005 under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). QCS was notified in June 2005 that the SCM project was determined to be ‘not a controlled action’ under the EPBC Act.

A major amendment to the SCM EA was applied for and granted in 2012 to authorise the Sonoma North pit and the associated diversion of Coral Creek in the north of ML10326. This change was also referred to the (then) Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) under the EPBC Act and was determined to be a controlled action due to impacts on listed threatened species (namely the *Eucalyptus Raveretiana*). Approval under the EPBC Act was granted in February 2013.

SCM previously operated under a Plan of Operations (the most recent version of which was valid from 15 March 2019 – 15 March 2021) and associated financial assurance calculator. The financial assurance requirement was replaced by the Estimated Rehabilitation Calculator and accordingly a replacement ERC decision notice was issued to QCS on 12/03/2021.

SCM is part of the integrated QNH with adjoining MLs, overlapping catchments and study areas, contiguous geology, soils, vegetation, groundwater and other matters across the sites. As such, information from the adjoining mines within the QNH is routinely utilised as a source of baseline and impact assessment. This approach has been accepted by DETSI as appropriate for the QNH mines in other QNH PRC Plans.

Technical studies and data from operational activities within the four QNH mines are also applied across the QNH, including geological, hydrogeological, geochemical, and soil assessments. This is particularly appropriate considering that a single mining pit on the QNH can span two or three individual mines, and that the QNH mines share common upstream and downstream hydrology and catchments.

Due to the integrated nature of the operations, a number of key management plans required under the various QNH EAs have been developed as integrated QNH-wide documents in consideration of cumulative impact assessment, rather than as an individual document for each mine. Key documents which encompass the entire QNH operations include:

- QNH Rehabilitation Management Plan (2020, See **Appendix C**)
- QNH Weed Management Plan (2020)
- QNH Water Management Plan (2025)
- QNH Receiving Environmental Management Program Design (2016)
- QNH Residual Voids on the QCoal Northern Hub Mining Complex (2020)
- QNH Residual Void Hydrology Study – QCoal Northern Hub Mines (2020)

- QNH Mine Waste Management Plan (2021)

2.1.3 Land Outcome Documents

SCM is an existing mine that was approved and commenced operations prior to the PRC Plan commencement date (1 November 2019). Therefore, the transitional arrangements detailed in Section 6 of the PRCP Guideline apply to this PRC Plan. This includes the use of existing Land Outcome Documents (LODs) to facilitate the transition of existing mines with existing landforms and mine plans into the PRC Plan framework. LODs are nominated documents related to rehabilitation and closure which have previously been approved by the regulatory authority for continued implementation on the site.

Under section 750 of the EP Act, the relevant LODs for the SCM are detailed in **Table 3**.

Table 3 – SCM Land Outcome Documents

Land Outcome Document	Approval Date	Disturbance Area	Document Reference	Outcome and Detail
EA EPML00707713	Original grant: 05/03/2007	Residual Voids	Condition H1, H11 and Table H1	Outline the residual voids that are to be permitted to be retained and other requirements
	Current: 29/11/2024	'All other areas'	Condition H1	Condition H1 nominates that all areas other than residual voids will have a PMLU of grazing pasture
QNH Rehabilitation Management Plan	Notification of DES Acceptance: 2/07/2020	-	-	Subordinate LOD to the EA but provides further detail regarding the rehabilitation methodology, completion criteria, etc. Provides rationale for voids being unable to sustain a PMLU and therefore being NUMAs.

The EP Act requires that all areas disturbed for mining activities under an EA within a relevant mining tenure be rehabilitated to either a specified PMLU, or where a PMLU cannot be sustained, be retained as a NUMA.

Under **Condition H1** of the SCM EA, all areas significantly disturbed by mining activities must be rehabilitated to achieve a PMLU of grazing pasture with the exception of residual voids. The additional exception is for infrastructure that is to be retained by written agreement with the landholder. **Table 4** details the PMLU and the relevant LOD for each domain at the SCM.

Table 4 – SCM Domain PMLU and Source LOD

Domain	PMLU	LOD
Residual voids	- Residual void unable to sustain a post-mining land use.	EA/QNH RMP
Overburden Dumps	- Grazing pasture	EA/QNH RMP

Domain	PMLU	LOD
Mine Infrastructure	- Grazing pasture; or - retained by the landholder with written agreement (Belmore West only)	EA/QNH RMP
Out of pit Co-disposal Facility	- Grazing Pasture (grassland community)	EA/QNH RMP
In-pit co-disposal	- Part of Residual void, unable to sustain a post-mining land use.	EA/QNH RMP
ROM and product stockpiles	- Grazing pasture; or - retained by the landholder with written agreement (Belmore West only)	EA/QNH RMP
Haul Roads and Access tracks	- Grazing pasture; or - retained by the landholder with written agreement (Belmore West only)	EA/QNH RMP
Sediment dams and water management infrastructure	- Grazing pasture; or - retained by the landholder with written agreement (Belmore West only)	EA/QNH RMP
Watercourse diversions	- Permanent Infrastructure previously approved under the Water Act/currently approved under the EP Act	EA/QNH RMP

Residual voids permitted to be retained at SCM are addressed by Condition H1 and H11 of the EA, with further detail provided in Table H1 of the EA (reproduced as **Table 5**), including the specific voids to be retained and relevant details including void area and the maximum highwall and low-wall slopes.

Table 5 – Existing EA Residual Void Details

Residual Void	Void Area	Maximum Slope
Sonoma Main Pit	120 ha	High wall – Maximum slope of 70° with the top 10m having a maximum of 45° including a 1m bund Low wall – 17°-37°
Sonoma East Pit	29 ha	

Residual Void	Void Area	Maximum Slope
Sonoma Q-Pit	N/A - backfilled	N/A - backfilled
Sonoma B-Pit	N/A - backfilled	N/A - backfilled
Total	149 ha	-

The QNH Rehabilitation Management Plan (RMP) was submitted to (then) DES on 27 April 2020 and was subsequently approved as an LOD on 2 July 2020. The RMP reflects the approach that has been adopted for rehabilitation works to date at SCM and includes the approved rehabilitation methodology, adopted parameters for design of the final landforms, and acceptance and completion criteria to demonstrate achievement of the PMLU for rehabilitated areas at SCM.

The RMP also references the residual voids listed in **Table 5** above. It is noted that the RMP references the single 29 ha Sonoma East void approved in the SCM EA, as two smaller immediately adjacent voids “Sonoma East 1 (14 Ha)” and “Sonoma East 2 (15 Ha)”. The RMP also notes that the SCM voids are groundwater sinks which will have degrading void lake water quality, therefore they are unable to sustain a PMLU and are considered to be NUMAs.

Unless otherwise stated, a reference to the ‘SCM EA’ in this PRC Plan is a reference to the SCM EA dated 29/11/2024, which was in place at the time of preparing this PRC Plan. It is noted that following the approval of the SCM PRCP Schedule, EA conditions in Schedule H related to rehabilitation will be removed from the EA by an amendment by agreement as they will be largely redundant (as per the PRCP Guideline). The references to relevant EA conditions are retained in this PRC Plan however, as they reflect the approved LOD requirements in place at the time of writing and the transitional arrangements that apply to this PRC Plan – Rehabilitation Planning Part.

Similarly, references to specific LOD conditions/sections have been retained within the document, as assist in contextualising the original justification for the PMLU, specific rehabilitation criteria (e.g. landform slopes) and rehabilitation methodologies that are outlined in this PRC Plan.

2.1.4 Mining Methods

The QNH, including SCM, operates as a conventional truck and excavator mining operation, using the industry standard model of contract mining. At SCM, the surface Cenozoic waste material is free dug, while the remaining waste is blasted, excavated by large hydraulic excavators and hauled by rear dump trucks. An additional fleet of ancillary plant (dozers, graders, loaders, water trucks, etc) is also used in the mining operations as required.

ROM coal is excavated by hydraulic excavator and hauled by dump truck to either pit ROM stockpile areas at SCM (e.g. the Q-Pit ROM pad) or directly hauled to the CHPP ROM pad via dedicated haul roads. ROM coal from the other QNH mines is also transported to the SCM ROM pad via dedicated haul roads which traverse DCM, CCM and SCM MLs. ROM coal is then

washed at the SCM CHPP, before reporting to the product stockpile for subsequent transport via the SCM train load-out.

2.1.5 Primary Mine Features / Infrastructure

SCM LOM layout includes, but is not limited to, the following elements:

- Mining Areas:
 - Sonoma Main Pit Area
 - Main Pit (now utilised for in-pit co-disposal) and associated waste rock dump
 - Associated internal ramps/haul roads.
 - Water management infrastructure;
 - Sonoma North Pit Area
 - North Pit and waste rock dump (co-located with Sonoma Main dump;
 - Associated internal ramps/haul roads.
 - Water management infrastructure;.
 - Sonoma Q-Pit Area
 - Q-Pit and associated waste rock dump;
 - Associated internal ramps/haul roads .
 - Water management infrastructure;
 - Q-Pit ROM pad;
 - Sonoma B-Pit Area
 - B-Pit and associated waste rock dump;
 - Associated internal ramps/haul roads ;
 - Water management infrastructure.
 - Sonoma East Pit Area (not yet developed)
 - Sonoma East Pit and associated waste rock dumps;
 - Associated internal haul roads;
 - Satellite crib hut and go-line area;
 - Water management infrastructure.
- Infrastructure:
 - Coal Handling and Processing:
 - Run of Mine (ROM) Stockpile Pad
 - CHPP

- Product coal stockpiles
 - Rail loop and train loading facilities
- MIA:
 - Workshops
 - Administration Facilities
 - Ablutions Blocks and
 - Car Parking
- Out-of-Pit Co-disposal Area (CDA)
- Haul Roads not associated with the above areas
- Light vehicle access tracks not associated with the above areas
- Orica compound
- Two Mile Creek Diversion
- Coral Creek Diversion
- Water management infrastructure not associated with the above areas including:
 - Sediment Basins
 - Clean Water Diversions
- Utilities and Services, including
 - Water pipelines (raw and mine-affected)
 - Overhead power supply (33kV feeder)
- Undisturbed Areas:
 - Land that has not been impacted by mining operations.

2.1.6 Integration with Other QNH Mines

As previously noted, SCM is operated as part of the integrated QNH operations. All four mines at the QNH utilise the existing infrastructure (processing, maintenance, administration and train loading facilities) at SCM, being the northern-most mine within the QNH.

Figure 2 Error! Reference source not found. shows the extent to which SCM is currently integrated with the other QNH Mines, including the location of key infrastructure and mining areas. Activities at SCM which are integrated with other QNH mines include:

- Ongoing access for ROM coal haulage and light and heavy vehicle access from the Drake 1 and Drake 2 mining areas via existing and new haul roads and ramps, through the SCM B-Pit area to the SCM CHPP, workshop and MIA. This will require the retention of haul roads and ramps (as well as areas above the haul road batters to enable eventual

battering of these slopes), which provide access from the Drake 1 and Drake 2 Expanded areas, across the CCM B-Pit area, and into the SCM.

- Ongoing access for waste rock haulage and light and heavy vehicle access from the Drake 1 via existing and new haul roads and ramps through the SCM B-Pit area to the SCM out-of-pit CDA for capping material. This will require the retention of haul roads and ramps (as well as areas above the haul road batters to enable eventual battering of these slopes), which provide access from the Drake 1 area, across the CCM B-Pit area, and into the SCM.
- Ongoing access for ROM coal haulage and light and heavy vehicle access from the Drake 5 mining area through the SCM Q-Pit area to the SCM CHPP workshop and MIA. This will require the retention of existing haul roads (as well as areas above the haul road batters to enable eventual battering of these slopes), which provide access from the Drake pits to the south-west of the CCM, across the CCM Q-Pit area, and into the SCM.
- Ongoing access for ROM coal haulage and light and heavy vehicle access from the Drake 3, Drake 4 and Jax Main and Jax East mining areas to the SCM CHPP workshop and MIA. This will require the retention of existing haul roads (as well as areas above the haul road batters to enable eventual battering of these slopes), which provide access from the JCM through the DCM, CCM and into the SCM.
- Ongoing use of and access to the SCM MIA, workshop, and associated infrastructure for the LOM of the QNH.
- Ongoing use of and access to the SCM Main Pit in-pit co-disposal facility for the LOM of the QNH for the deposition of reject material and recovery of decant water for re-use.

As such, a number of areas within the SCM will not become available for rehabilitation or improvement until the cessation of mining and processing activities at the other QNH sites.

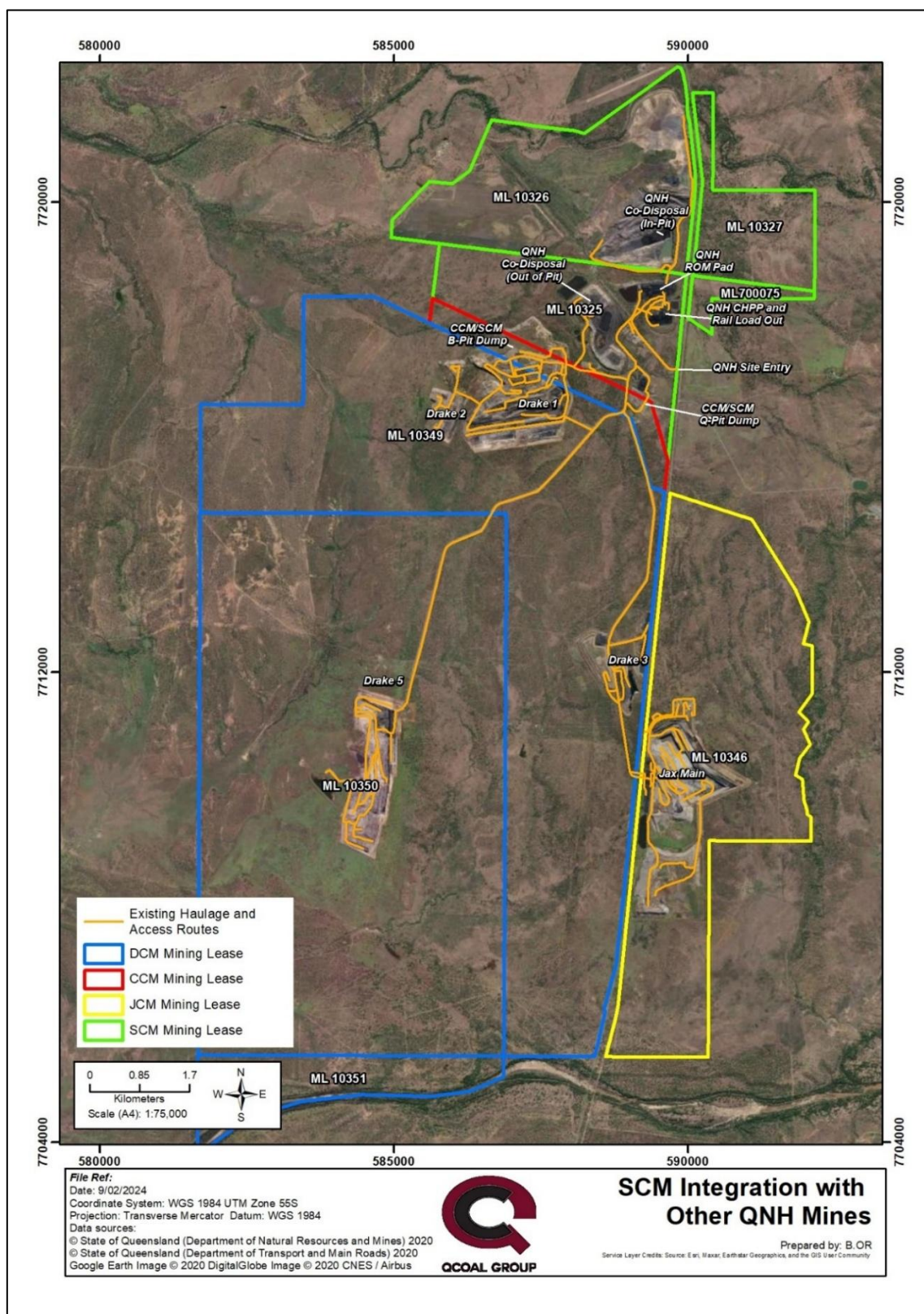


Figure 2 – Existing Integration of the SCM with Other QNH Mines

2.2 Baseline Information

2.2.1 Underlying Properties and Landholders

Land tenure details for the real property within and adjoining SCM are shown in **Table 6. Figure 3** shows the location of the property boundaries and land tenure within and adjoining SCM. The SCM MLs are primarily located within Lot 25 on SP190745 (known as Sonoma Station) and Lot 1 on SP190745 (known as Belmore West). Lot 21 on DK160 is a leasehold lot for a Sunwater water pipeline which bisects the eastern portion of Sonoma Station within ML10327 and ML700075. Easement A on DK116 is located over part of Lot 25 on SP190745 within ML10327.

Sonoma Station is a 14,448.1Ha freehold pastoral property located to the south and east of Collinsville, with 1,400.7Ha being located under the SCM MLs. Sonoma Station is bounded to the north and north-west by Pelican Creek and is bisected by the Bowen Development Road and Newlands Rail Line corridor. A number of services corridors also run through the property, including a Sunwater Pipeline (located within Lot 21 on DK160) and a Powerlink high voltage power line easement (Easement A on DK116).

Collinsville Airport is located immediately to the north of the SCM MLs on a reserve (Lot 26 on DK276) which is largely surrounded by Sonoma Station. Sonoma Station is owned by a private landowner, with whom compensation agreements are in place.

Belmore West is a 738.5 Ha freehold pastoral property located to the south of Sonoma Station and west of the Bowen Development Road and Newlands Rail Line corridor. ML10325 is located entirely within the Belmore West property, and a small part of ML10326 also falls within the property boundary. The southern boundary of Belmore West adjoins an undeveloped road corridor which coincides with CCM operations (ML10345). Since 2012 Belmore West has been owned by Mr Chris Wallin (the owner and Managing Director of QCoal, of which QCS is a wholly owned subsidiary).

An agreement is in place with the landowner of Belmore West to retain the following SCM infrastructure within the Belmore West property following the completion of mining activities:

- All haul and access roads;
- Hardstand areas;
- Water management infrastructure (e.g. dams and drains).

Belmore Station is a 3,452Ha freehold property located to the south and east of Sonoma Station and east of the Bowen Development Road and Newlands Rail Line corridor. Only a small portion (74.1 Ha) of Belmore Station is overlain by the SCM ML70075 area.

Table 6 – SCM Underlying and Adjoining Land Tenure

Name	Lot/Plan	Tenure	Holder	Type	Total Area (Ha)	SCM ML Overlap Area (Ha)
Sonoma Station	Lot 25 on SP190745	Freehold	Privately Owned	Underlying/ Adjacent Property	14,448.1	1,400.7
Belmore West	Lot 1 on SP190745	Freehold	Mr Chris Wallin	Underlying Property	738.5	738.5
Belmore Station	Lot 4 on SP234989	Freehold	Privately Owned	Underlying/ Adjacent Property	3,452	74.1
Sunwater Pipeline	Lot 21 on DK160	Lands Lease	Sunwater	Underlying/ Adjacent Property (Infrastructure Corridor)	5.7	4.8
Powerlink Easement	Easements A & B on DK116	Easement (Power)	Powerlink	Underlying/ Adjacent Property (Infrastructure Corridor)	8.3	8.3
Collinsville Airport	Lot 26 on DK276	Reserve	Whitsunday Regional Council (Operator)	Adjacent Infrastructure	171.3	0
Collinsville - Newlands Branch Railway Corridor	Lot 1 on DK202	Lands Lease	Qld Government (TMR)	Adjacent Infrastructure Corridor	-	0
Bowen Development Road	-	-	Qld Government (TMR)	Adjacent Infrastructure Corridor	-	0
Closed Road (Underlying Property for CCM)	Lot A on AP2839	Lands Lease (Road)	Mr Chris Wallin (Holder of Permit to Occupy)	Adjacent Property	339	0
			Whitsunday Regional Council (Underlying Road Owner)			
-	Lot 10 on DK7	Reserve	Whitsunday Regional Council	Adjacent Property	136	0

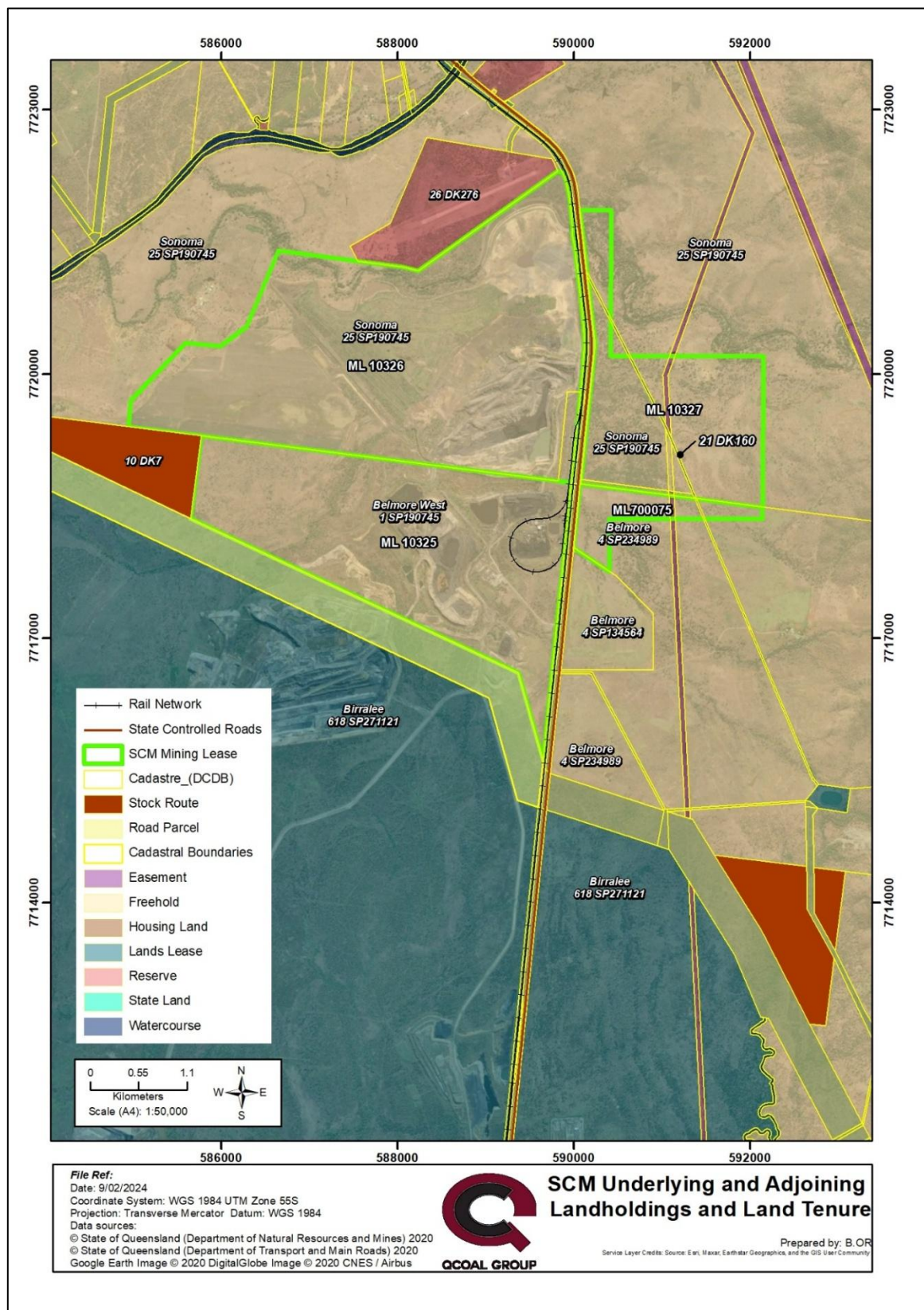


Figure 3 – Adjoining Landholdings and Land Tenure

2.2.2 Pre-Mining Land Use

SCM is located within the Collinsville region which has supported the production of beef, sugar and gold since the late 1800s. Coal mining commenced at Collinsville in the early 1900s and has continued in the region through to the current day. Other land uses in the region include quarrying and power generation (coal-fired and solar). As a result of these land uses, the natural landscape in the region has undergone considerable disturbance and modification.

As discussed in **Section 2.2.1**, SCM is primarily situated on the Sonoma and Belmore West properties, with a small portion located on Belmore Station. These three properties have been previously used over a prolonged period for beef cattle grazing and as a result, the natural landscape had undergone considerable disturbance and modification prior to the commencement of mining activities. The land within the SCM MLs was largely cleared for grazing in the 1950s and 1960s, with property improvements undertaken on the land including fencing, thinning of the remnant vegetation and the establishment of improved pasture. A number of small pockets of remnant native vegetation and regrowth have been retained, with the vegetation communities including mixed eucalypt woodlands and acacia shrublands. Several areas within the SCM MLs continue to be utilised for cattle grazing.

Pre-mining infrastructure on the Sonoma, Belmore West and Belmore Station properties underlying the SCM MLs, included fences, dams, other watering points and access tracks. Where not impacted by mining activities, the majority of this infrastructure has been maintained to support grazing activities within the SCM MLs.

Figure 4 shows the pre-mining aerial imagery of the landholdings within the site (June 2000), demonstrating the extent of historical disturbance prior to the commencement of mining activities at the site.

The land within the SCM MLs was previously assessed as Land Suitability Class 2 for beef cattle grazing (refer to **Section 2.2.9.5**), indicating suitable land for grazing on native and improved pastures with minor limitations. The land was found to not be suitable for cultivation on a regular basis due to a combination of limitations including slope, soil, erosion and climate.

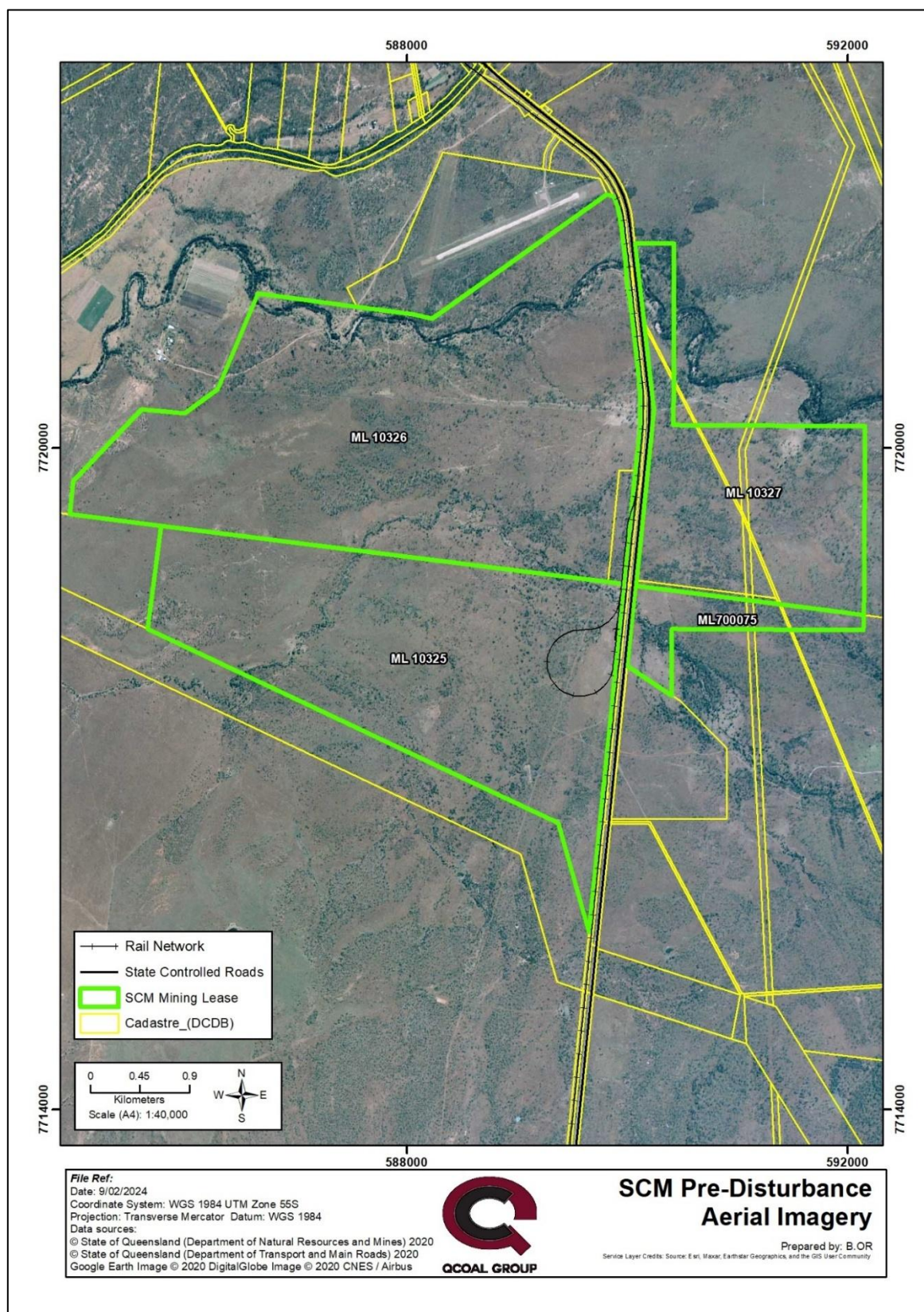


Figure 4 – SCM Pre-Disturbance Aerial Imagery (2000)

2.2.3 Sensitive Places

SCM is bordered by active MLs to the south (CCM, DCM and JCM), while the third-party Collinsville Mine is located to the north-west. *Sensitive Places* and *Commercial Places* relevant to SCM are defined in the SCM EA.

The nearest sensitive places, commercial places and population centres relative to current or future operational areas within SCM are detailed in **Table 7** and **Figure 5**.

Table 7 - Proximity of Sensitive and Commercial Places to the SCM

Description	Type	Distance from Operational Area	Notes
Sonoma Homestead	Sensitive Place	1km	Privately Owned
Pelican Creek Residence #1	Sensitive Place	1.8km	Privately Owned
Pelican Creek Residence #2	Sensitive Place	2.0km	Privately Owned
Pelican Creek Residence #3	Sensitive Place	1.9km	Privately Owned
Pelican Creek Residence #4	Sensitive Place	2.1km	Privately Owned
Belmore Homestead	Sensitive Place	2.1km	Privately Owned
Collinsville Airport	Commercial Place	0.5km	Operated by WRC
Belmore Bulk Materials Quarry	Commercial Place	3.7km	Privately Owned
Scottsville	Township	4.2km	Within WRC area
Collinsville	Township	4.6km	Within WRC area

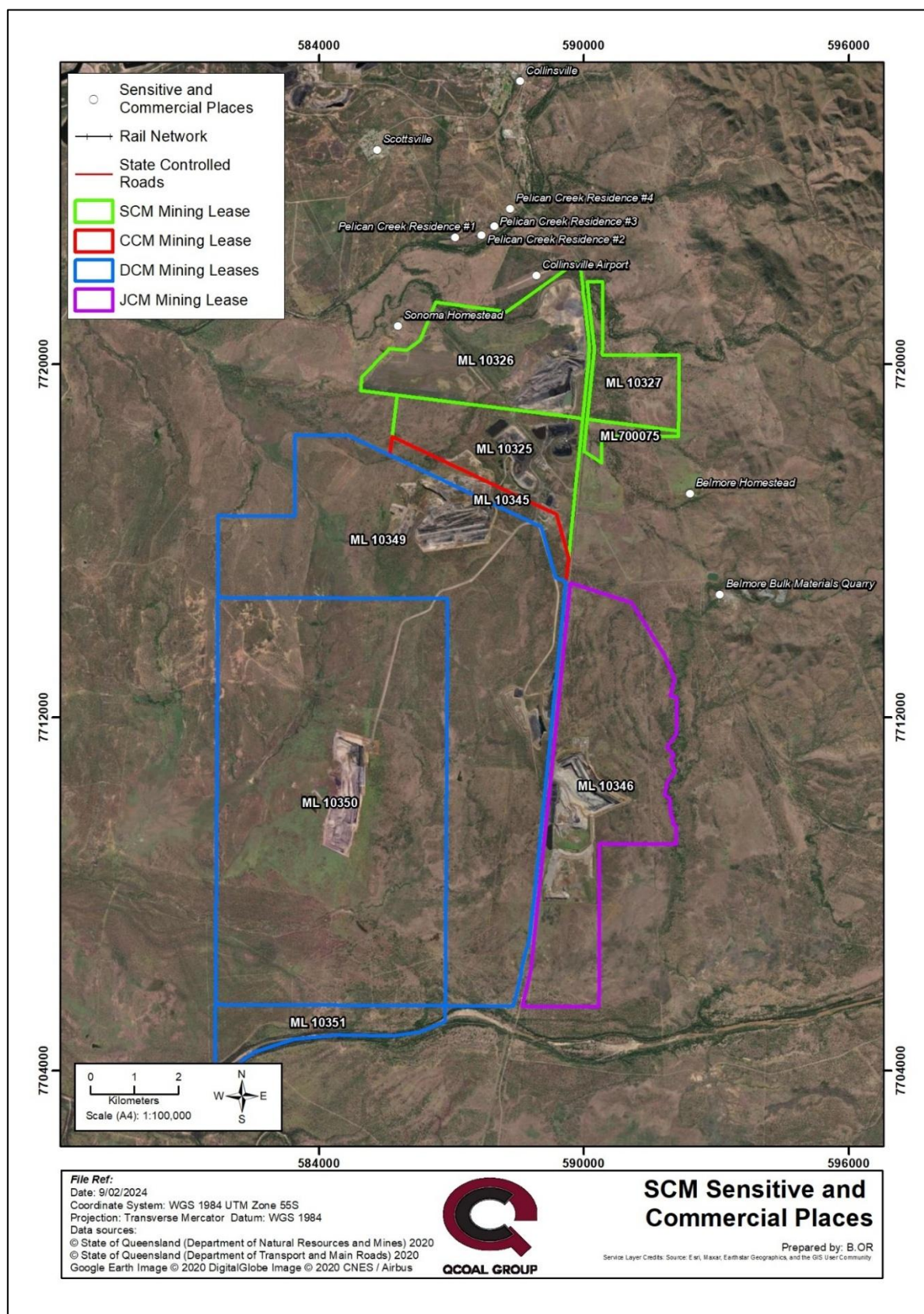


Figure 5 – SCM Sensitive and Commercial Places

2.2.4 Site Topography

SCM is located in the northern Bowen Basin, which extends over 60,000km² (approx.) of Central Queensland from the town of Collinsville in the north to Theodore in the south. The QNH MLs cover approximately 13,500Ha of that area, of which the SCM MLs cover approximately 2,140Ha. The topography of the broader QNH is characterised as a flat-to-undulating landscape of alluvial plains and terraces bordering Coral Creek in the north, Two Mile Creek in the centre and the Bowen River in the south.

The pre-mining contours and drainage lines within the SCM area are shown in **Figure 6**, (overlain with the February 2020 aerial for context). The topography within the SCM area is generally characterised by subdued topographical relief intermittently marked by a series of low ridges broadly trending north-south in the southern and central sections, deviating to an almost northeast orientation in the north. Slopes within SCM are generally less than 3%, although locally steeper slopes adjacent to gullies, drainage lines, and watercourses are also present.

Elevation ranges from 200m AHD in the east to 140m AHD in the west.

SCM is located within the Pelican Creek sub catchment of the of the Bowen Broken Bogie basin, within the wider Burdekin Catchment. The northern part of SCM drains into Coral Creek which flows northwest, off the SCM MLs and discharges into Pelican Creek approximately 4.5km downstream. The southern part of SCM drains into Two Mile Creek which flows north-east into Pelican Creek, and ultimately discharges into the Bowen River approximately 28km downstream of the site (refer to **Section 2.2.7.2** for further details).

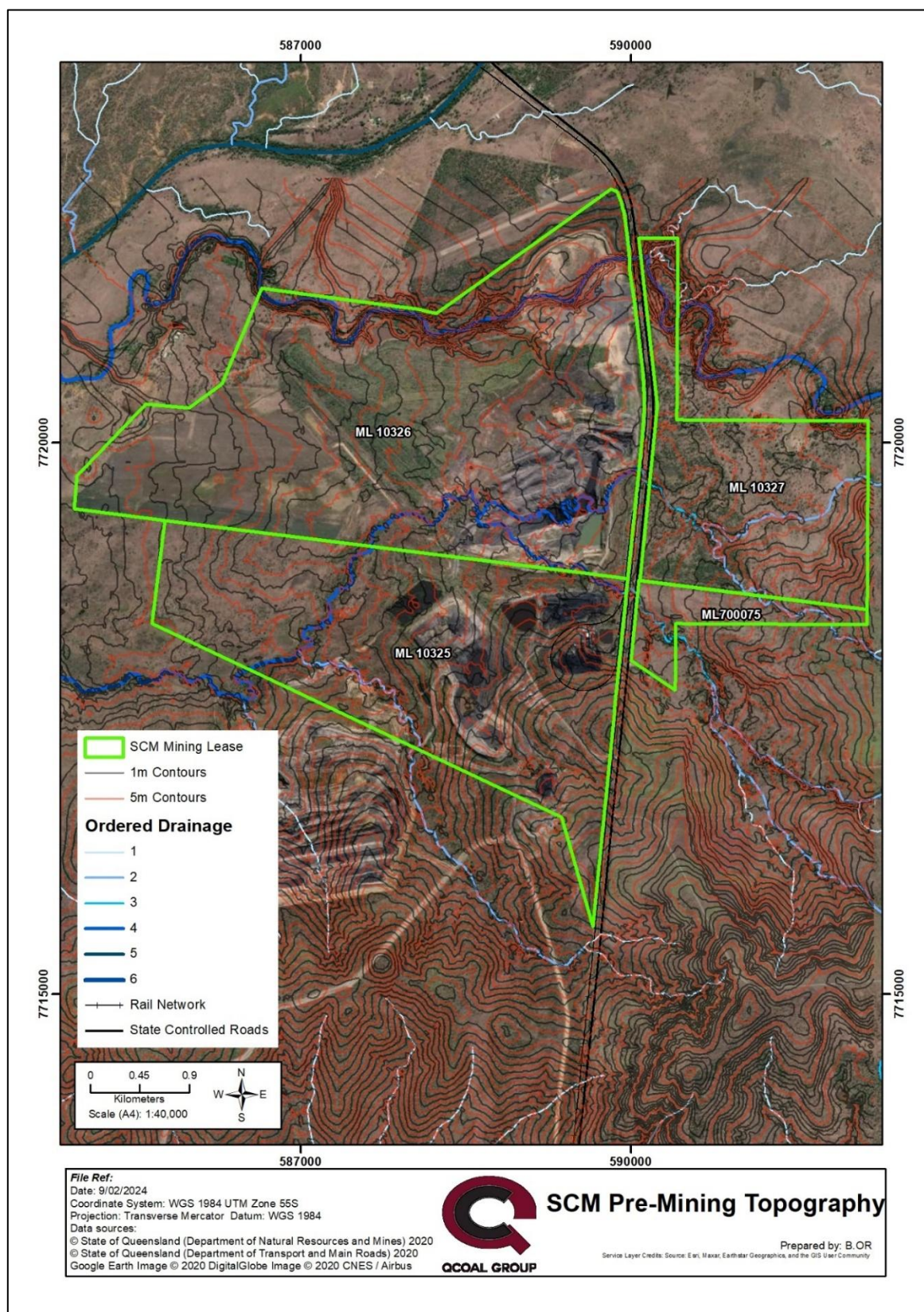


Figure 6 – SCM Pre-Mining Topography

2.2.5 Climate

The Collinsville region is characterised by distinct wet and dry seasons, with the majority of rainfall occurring during the summer months, along with higher temperatures and evaporation rates. Average monthly temperature, rainfall and evaporation statistics, as collected at the Bureau of Meteorology's (BoM) Collinsville Post Office Station (no. 033013) are presented in **Figure 7**.

The average annual rainfall for the Collinsville area is 701.6 mm and the average annual evaporation is 1,861.5 mm (BoM, 2019). As such, the region is subject to net annual evaporation, and is dry for much of the year. The rainfall averages indicate a distinct wet season between December and March and dry season between June and October. Predominant winds are south-easterly for the majority of the year.

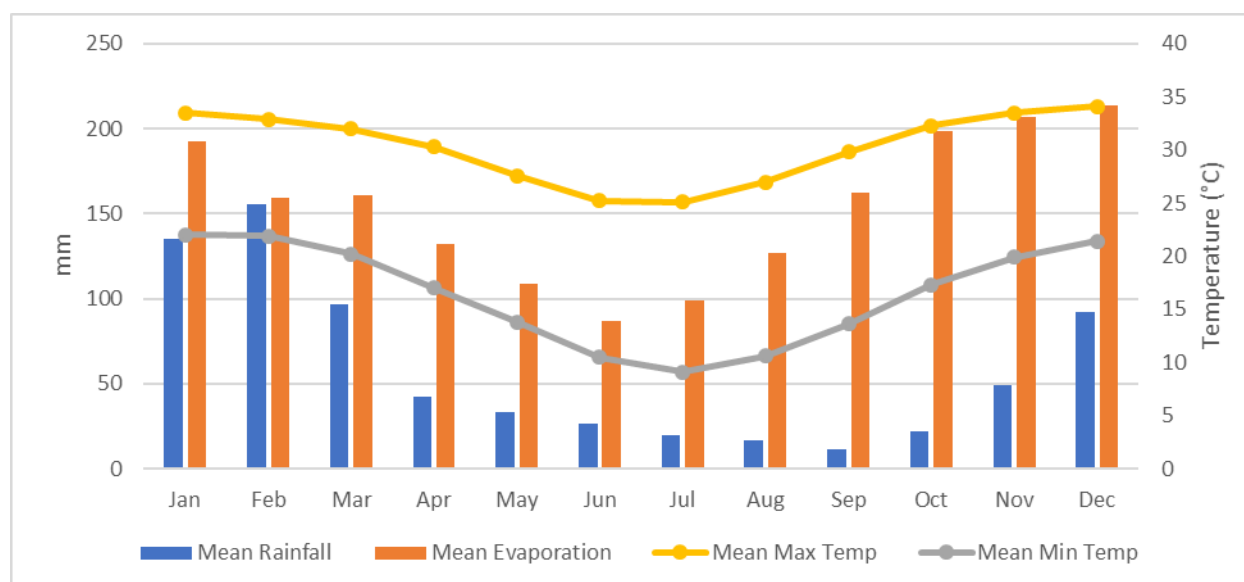


Figure 7 – Collinsville Climate Averages

2.2.6 Geological Setting

SCM is located in the northern Bowen Basin, with the target seams forming part of the Moranbah Coal Measures (MCM). The stratigraphic sequence for the QNH represents a continuation of the same geology from SCM through CCM and into DCM and JCM. As such the stratigraphy (coal seams, overburden and interburden sequences) and the associated characteristics of the various stratigraphic units is generally consistent across the four QNH mines. Geotechnical, geochemical and coal quality characteristics observed at one QNH mine can therefore be adopted for the same material throughout the QNH.

2.2.6.1 Regional Geology

SCM is located in the northern Bowen Basin, where active subsidence and deposition during the Permo-Triassic was centred within an extensional terrain known as the Taroom Trough. This deposition centre was situated marginal to the Collinsville Shelf in the west, which typically behaved as a stable platform throughout. The deformed Taroom Trough is defined by the Nebo Synclinerium, where contained sediments and volcanics of the western two-thirds dip gently toward the major synclinal axis in the east. Post-depositional compression has resulted in a fold-and-thrust style of deformation, particularly on the eastern side of the basin where sediments along this margin tend to dip steeply westward.

Economic coal measures within the Bowen Basin have been classified into four groups (Mutton, 2003):

- I. The oldest (Early Permian) coals
- II. The Group II (Early Permian) coal measures
- III. The Group III (Late Permian) coals
- IV. Group IV (Late Permian) coal measures

The wide variety of depositional environments is reflected in the diversity of coal measures (seam thickness, lateral extent and coal quality) within the Bowen Basin, however for the Group III coals (as targeted at the QNH), the physical and chemical characteristics of the non-productive geological sequences (waste rock or spoil materials) are similar throughout the basin.

2.2.6.2 Site Geology

The local stratigraphy in the SCM area comprises the basal Blenheim Formation overlain by the marine Exmoor Formation, non-marine Blackwater Group, and Tertiary sediments of the Suttor Formation and equivalents (refer to **Figure 8**). The Blackwater Group includes the MCM, several seams of which form the primary coal resources at the SCM.

As previously noted, the stratigraphic sequence for SCM is generally repeated at the other three QNH mines (with the addition of several of the lower FCCM seams which overlie the MCM and are present in mineable quantities at the DCM and JCM). The coal seams and associated waste rock are readily correlated between all four sites. Accordingly, analysis of the waste rock at each of the mines has confirmed similar waste rock characteristics (see **Section 6.4**). As an example, the SCM B-Pit continued along strike into the CCM (CCM B-Pit) and DCM (Drake 1 pit), separated only by the tenure boundaries, with the advancing pit having the same stratigraphy and mining the same coal seam within each site.

Geological detail in the QNH area is intermittently obscured by a cover of alluvium and gravel, particularly adjacent to drainage lines and watercourses. This recent (Cainozoic) cover comprises unconsolidated fine to very coarse-grained sand, along with occasional irregularly interbedded silt, clay and gravel lenses. The most persistent gravel bed occurs at the base of the unit and generally comprises markedly rounded pebble to cobble-sized clasts of

predominantly andesitic to basaltic composition, set in a silt to clay-rich matrix. The alluvial unit ranges in thickness from a thin veneer in the south of SCM to a maximum of 24m in the north of SCM.

2.2.6.3 Coal Geology

The MCM at the northern extent of the Bowen Basin contain a number of coal seams dipping to the south and to the east, labelled alphabetically from the “A” seam (the deepest) to the uppermost “Q” seam (refer to **Figure 9** which also highlights the seams of economic importance at SCM). SCM primarily targets the “B” and “Q” Seams within the MCM, although coal from other MCM seams is recovered opportunistically. The relatively thick, low-ash seams distinguish the MCM unit from the overlying FCCM. Interburden rocks consist of quartz-poor lithic sandstones, siltstone, shale, and mudstone. The waste rock sequences have been named based on the underlying and overlying coal seam nomenclature for identification purposes.

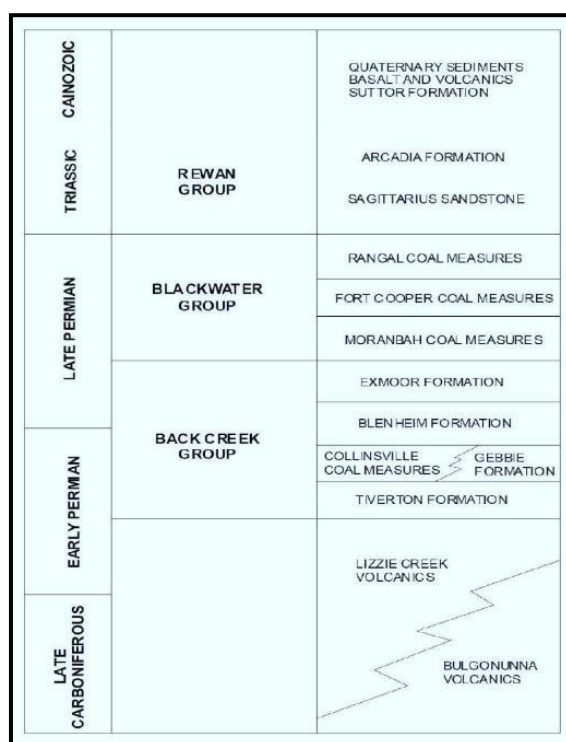


Figure 8 – Bowen Basin Stratigraphy

CENOZOIC		CENOZOIC ALLUVIUM		CENZ
PERMIAN	BLACKWATER GROUP	FORT COOPER COAL MEASURES		S Waste S Seam RS Waste R Seam
		MORANBAH COAL MEASURES		QR Waste Q Seam - Upper Goonyella PQ Waste P Rider P Seam (+ P Tuff) EP Waste E seam - Middle Goonyella CE Waste C Seam BC Waste B Seam (Lower Goonyella) AB Waste A Seam
	BACK CK GROUP			Exmoor Seam

Figure 9 – MCM Coal Seams within the SCM Area

Throughout the QNH area, the geological structure has been subject to igneous intrusions which, where present, have either intruded or otherwise rendered sections of the MCM seams uneconomic. Exploration programs (including airborne magnetic surveys, radiometric surveys, and particularly exploration drilling) were successful in defining several areas of sub-cropping shallow un-intruded coal. The main target seams at SCM are described as follows:

- The B seam (known elsewhere as the Lower Goonyella seam) is separated from the underlying A seam by 15m to 24m of dark grey, fine-grained sandstone, siltstone and carbonaceous mudstone. The B seam at the QNH sub-crops at the northern end of the SCM in the vicinity of Coral Creek, where it occurs as a single ply 12-16m thick. The seam consistently dips at approximately 5° to 7° towards the south and south-southeast and splits into a number of plies with a cumulative thickness of ~5m;
- The Q seam (known elsewhere as the Upper Goonyella seam) overlies the B seam and sub-crops to the east of the B seam. Q Seam deposits are typically small deposits of hard coking coal, with examples being the SCM/CCM Q-Pit, the DCM 3-Q Pit and the Belmore – Pipeline deposit which was mined by the Collinsville Coal Company (now Glencore) in the early 2000s. At the SCM, the Q seam sub-crops in the east of the MLs and dips to the south and south-east. The Q-Seam occurs as 3 plies with a cumulative thickness of ~9m.

2.2.7 Surface Water

2.2.7.1 Regional Catchment Description

The SCM is located within the Burdekin catchment, which is the second largest in Queensland occupying some 133,000km². The Burdekin catchment itself comprises eight major catchments and 52 sub-catchments. Typical annual average rainfalls are 600-700 mm in the upper Burdekin catchment and 800-1000 mm in the lower catchment coastal plains. Dominated by wet summers and dry winters, waterways in the catchment are generally ephemeral and experience peak flows from December to April, with low or negligible flows from May to November.

As shown in **Figure 10**, SCM is situated within the Pelican Creek sub-catchment of the Bowen Broken Bogie basin, which is located in the upper reaches of the Burdekin catchment. Waterways in the Pelican Creek sub-catchment are highly ephemeral, with flow only occurring after significant rainfall events.

The *Burdekin Region Water Quality Improvement Plan 2016* identifies priority actions for the management of the Pelican Creek sub-catchment including the management of grazing, mining, industry, and other infrastructure.

2.2.7.2 Local Catchment Description

The drainage features within the wider QNH and SCM are shown in **Figure 11** and **Figure 12**. The majority of the SCM area is drained by two major drainage systems, with the southern and central portion of the site (~70% of the total SCM area) draining into Two Mile Creek (part of the Pelican Creek sub-catchment) and the northern part of the site draining into Coral Creek (also part of the Pelican Creek sub-catchment).

Coral Creek flows west through the northern SCM area and discharges into Pelican Creek approximately 4.5km downstream of SCM. Two Mile Creek flows south-west through the central SCM area before flowing into CCM and then turning northwest, ultimately discharging into Pelican Creek 7km downstream of SCM. The flat-lying topography within SCM has resulted in only one other drainage feature, which is a minor drainage feature flowing northwest from CCM into the southern SCM and discharging into Two Mile Creek, as shown in **Figure 12**.

The water features within SCM have been previously inspected by representatives from the (then) Department of Environment and Resource Management (DERM). It was determined that a number of reaches of the several mapped waterways within SCM are 'watercourses' as defined under the *Water Act 2000*; with the remainder considered to be 'drainage features'. The identified watercourse reaches within SCM include the following:

- Two Mile Creek (SO3/4) (within ML10325 and ML10326 only);
- Coral Creek (SO4) (within ML10327 and ML10326).

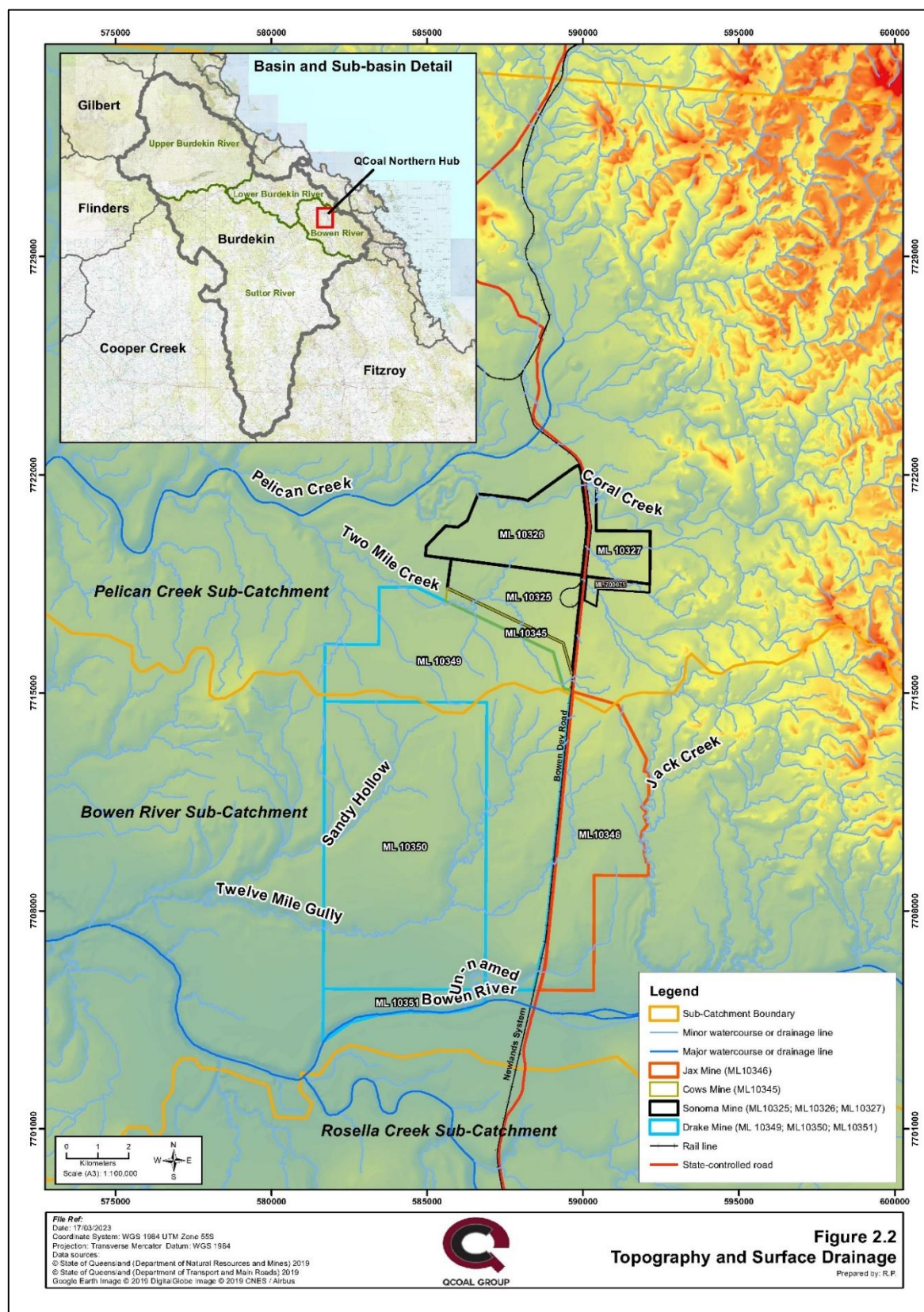


Figure 10 – QNH Topography and Major Drainage Catchments

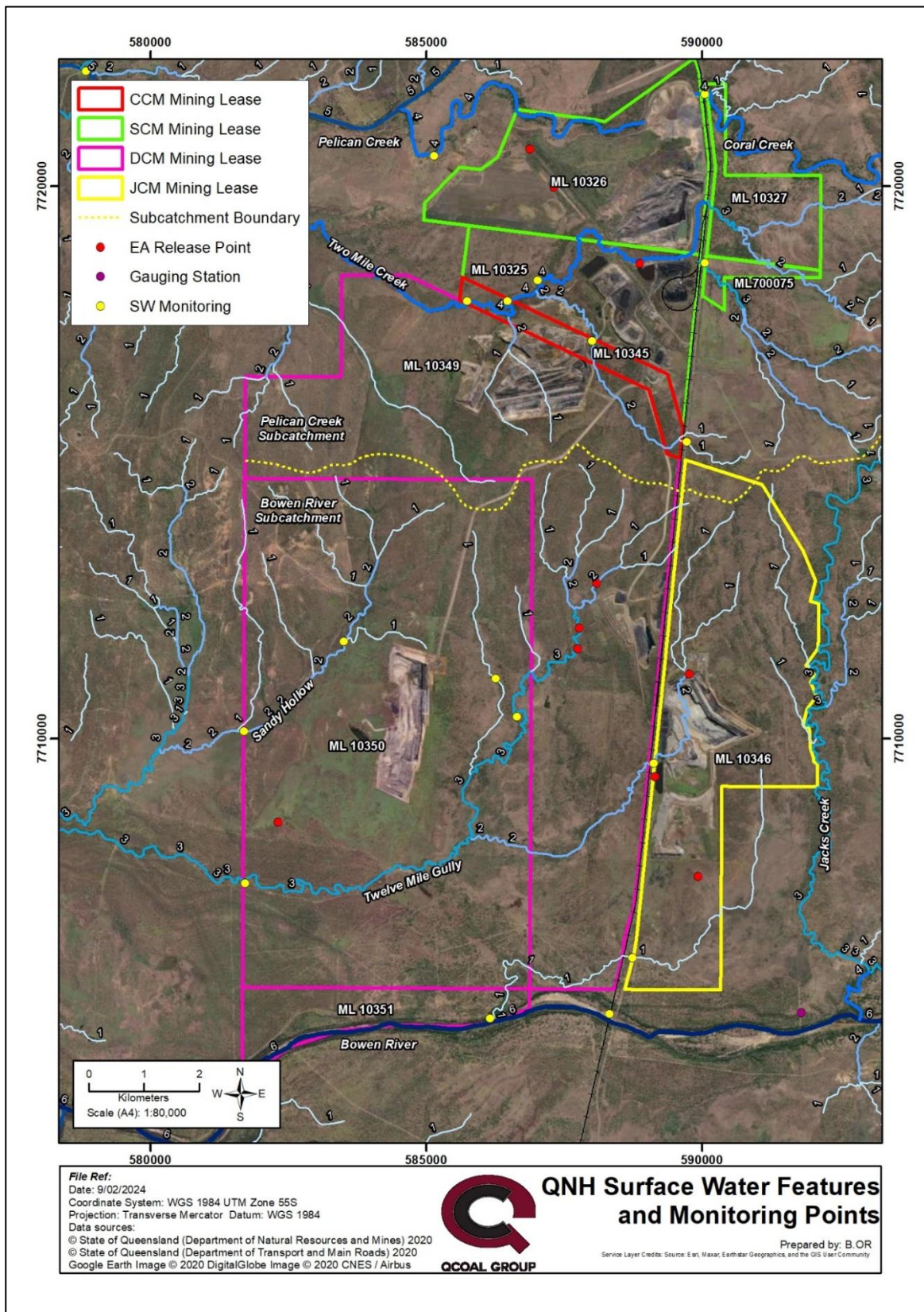


Figure 11 – QNH Surface Water Features

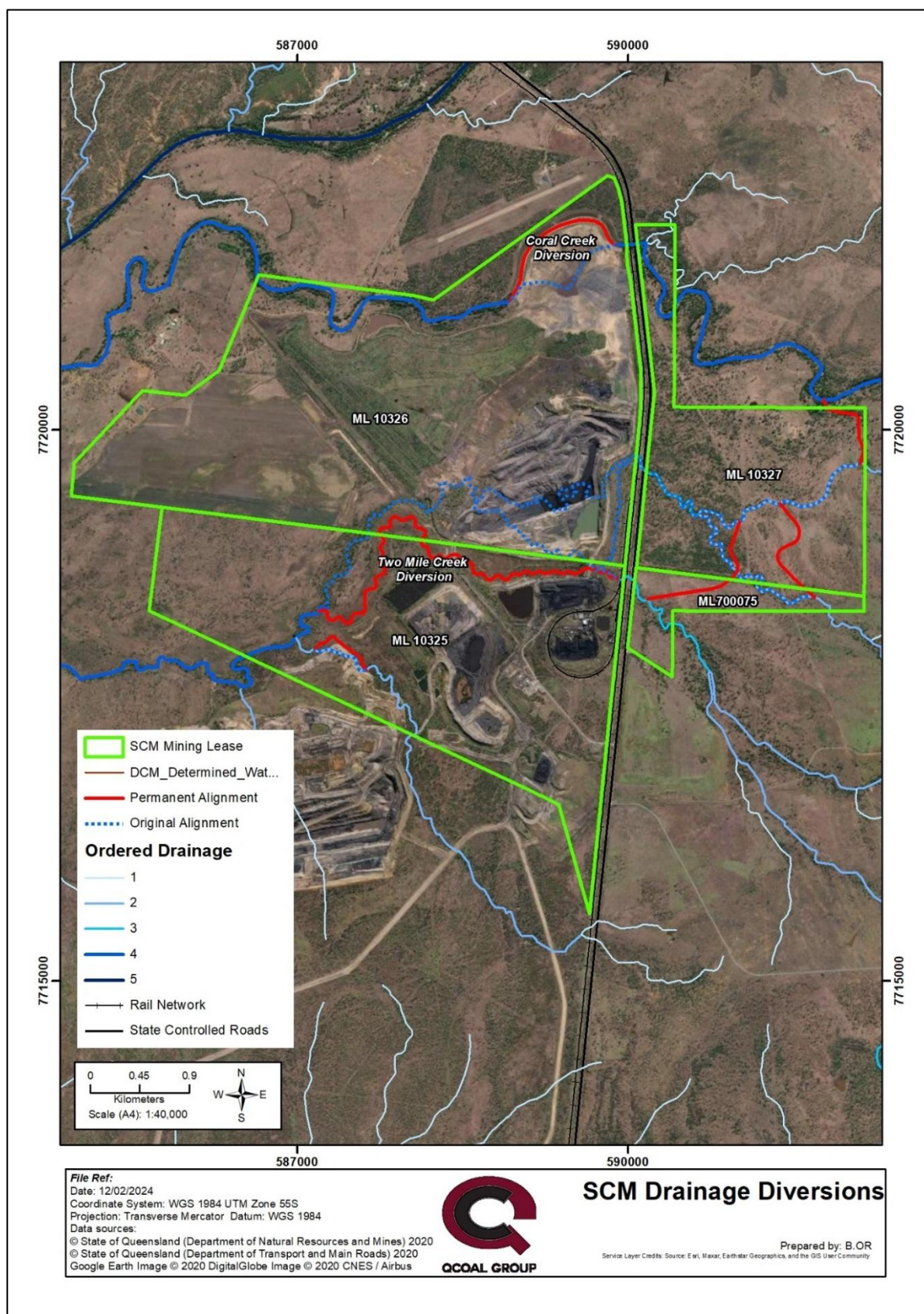


Figure 12 – SCM Drainage Diversions

During the progressive development of SCM, both Two Mile Creek and Coral Creek have been permanently diverted to enable mining of identified coal resources under the original creek alignments (for further detail refer to **Section 2.2.7.6**). Both diversions are permanent diversions initially authorised under a Water Licence issued under the *Water Act* 2000, with those approvals subsequently transferred into the *EP Act* and the SCM EA with specific conditions added. Relevant details for the diversions are outlined in **Table 8**, with the original and diverted alignments of Two Mile Creek and Coral Creek shown in **Figure 12**.

Table 8 – SCM Diversion Details

	Two Mile Creek	Coral Creek
Water Licence Number:	607257	607384
Date Issued:	13/10/2012	3/12/2012
Status:	Surrendered (replaced by SCM EA Schedule J)	Surrendered (replaced by SCM EA Schedule J)
Certified Documentation (as listed in SCM EA):	<i>Design of Two Mile Creek Diversion</i> (BSM, March 2012); <i>Design of Two Mile Creek Diversion Addendum Report</i> (BSM, September 2012); <i>Two Mile Creek Diversion Addendum report for Temporary Crossing</i> (Engeny, December 2020); and <i>Two Mile Creek Diversion Addendum Report for Final Landform</i> (Engeny, February 2022).	<i>Design of Coral Creek Diversion</i> (BSM, May 2011) <i>Design of Coral Creek Diversion Addendum Report</i> (BSM, November 2011) <i>North Sonoma Creek Diversion Design Plan</i> (Engeny, May 2018)

The original alignments of Two Mile Creek and Coral Creek have been replaced by the approved diversions and no longer exist. Any further consideration of local surface water catchments must therefore treat the watercourse diversions as the permanent watercourse alignments. Under the current mine plan there are no additional watercourse diversions planned for the LOM at the SCM.

Other than these watercourse diversions, the only other notable mining-related drainage works is for a minor realignment of a Stream Order 2 drainage feature around the toe of the SCM B-Pit dump batter, which was completed in 2013 and a number of diversions (SO2) of upstream tributaries to Two Mile Creek within ML10327 and ML700075 (also shown in **Figure 12**).

2.2.7.3 Flood Modelling

Section 3.4 of the PRCP Guideline requires flood plain modelling to be undertaken for all sites with a void proposed as a NUMA to determine if the void is located within a flood plain (defined as the 0.1% Annual Exceedance Probability (AEP) peak water level for a relevant watercourse), unless a LOD has a pre-approved outcome for a void with a location specified.

As previously noted, during the progressive development of SCM, both Two Mile Creek and Coral Creek (both classed as watercourses under the *Water Act 2000*) have been permanently diverted within the SCM MLs to enable the mining of identified coal resources under the original alignments.

The following relevant watercourses have been identified within the SCM:

- Two Mile Creek (Stream Order 4 section) – as permanently diverted under a water licence under the *Water Act 2000* (conditions subsequently transferred to the SCM EA); and
- Coral Creek (Stream Order 4) – as permanently diverted under a water licence under the *Water Act 2000* (conditions subsequently transferred to the SCM EA).

2.2.7.4 Pre-Approved Void Outcomes

As per Section 3.4 of the PRCP Guideline, despite the presence of a relevant watercourses within the site, where a LOD has a pre-approved outcome for a void with a location specified, flood plain modelling is not required.

The SCM EA (a LOD) does not nominate a PMLU or other outcome for the SCM voids. Specifically, Condition H1 of the SCM EA states that unlike all other areas significantly disturbed by the mining activities, the approved SCM residual voids do not require rehabilitation to a PMLU of grazing pasture, while Condition H11 and Table H1 specify the residual voids to be retained. The approved QNH RMP¹ (also a LOD) provides further detail regarding the SCM voids, and states that the SCM residual voids are unable to sustain a PMLU and are therefore NUMAs.

As such, there is a pre-approved outcome for the voids at SCM. The location of the voids is implicit in the names and areas within SCM EA Table H1 (e.g. the Sonoma Main Pit residual void is located within the Sonoma Main Pit mining area). As such, the voids at the SCM have a pre-approved outcome and location specified, and flood modelling is therefore not required for the PRC Plan.

¹ It is noted that the RMP references the single 29 ha Sonoma East void approved in the SCM EA, as two smaller immediately adjacent voids “Sonoma East 1 (14 ha)” and “Sonoma East 2 (15 ha)”

2.2.7.5 SCM Flood Modelling

Despite flood modelling not being explicitly required for the SCM PRC Plan, flood modelling has been undertaken previously for the relevant watercourses within SCM. The modelling outlines the extent of the relevant watercourse floodplains within SCM, the impact of the flood levels on the SCM voids and on final landforms more generally.

The diversions of Two Mile Creek and Coral Creek were designed in accordance with relevant industry guidelines in place at that time, being:

- *Guideline: Waterway Diversions, Central Queensland Mining Industry (NRW, 2008)*
- *Design and Rehabilitation Criteria for Bowen Basin Diversions (ACARP, 2001)*

More recent addendums/updates to both creek diversions were documented in submitted Design Reports, and were undertaken in accordance with the contemporary guidelines currently in place:

- *Guideline: Works that interfere with water in a watercourse for a resource activity — watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).*
- *Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).*

The design of the creek diversions included modelling of flow rates, heights, velocities for various flood events in each watercourse, which formed the basis for the designed diversion channel alignments, geometry and stabilisation requirements. One of the key requirements for the creek diversions was that the diversion channels must be capable of conveying a 0.1% AEP flow event without overtopping.

The flood modelling undertaken as part of the design for each of the creek diversions within the SCM is further discussed in the following sections.

2.2.7.5.1 Two Mile Creek Flood Modelling

The original alignment of Two Mile Creek was located within the footprint of the Sonoma Main Pit coal resource and required diversion to enable the Sonoma Main Pit to progress to the eastern and southern extents of the economic resource. As shown in **Figure 12**, Two Mile Creek was permanently diverted within ML10326, with the diversion alignment being approximately 5.4km long (as measured in the low flow channel). The diversion runs along the eastern highwall of the Sonoma Main Pit residual void towards the south into ML10327, and then towards the west along the southern highwall, before turning south to re-join the downstream reach of the original Two-Mile Creek alignment. Construction and introduction of flows into the Two-Mile Creek diversion was completed in 2013.

Two Mile Creek was previously assessed and found to be a watercourse under the *Water Act* (2000) within SCM (however the extent of the watercourse was found not to extend upstream into ML10327). As such, the Two Mile Creek diversion required a Water Licence for interfering

with flow in a watercourse. As part of the application process, a certified Design Plan was provided which addressed the required content. A number of addendums to the Design Plan have since been added (as outlined in **Table 8**), such that the original Design Plan and the three certified addendums are all approved as part of the Design Plan required under SCM EA Condition J3.

The most recent flood modelling undertaken for Two Mile Creek is reported in the *Two Mile Creek Diversion Addendum Report for Final Landform* (Engeny, 2022) (included as **Appendix D**). Engeny (2022), which is a certified addendum to the certified Two Mile Creek Design Report. This addendum builds on the previous modelling undertaken for the Two Mile Creek Diversion by assessing a number of scenarios, including the existing case, a baseline closure scenario, and a ultimate closure case. The ultimate closure case is the relevant scenario for this PRC Plan. This scenario includes future realignment of upstream drainage tributaries to Two Mile Creek within ML10327 and ML700075. While Engeny (2022) was not undertaken specifically for this PRC Plan, the methodology utilised is nonetheless in accordance with DES (2024) and has been undertaken in accordance with the ARR2019 guidelines.

The Engeny (2022) modelling scope included the use of the existing calibrated RORB hydrologic model of the Two Mile Creek catchment system to obtain design hydrographs; and the update of the existing TUFLOW hydraulic model for the Two Mile Creek catchment system to determine the relevant flood levels and velocities for the nominated scenarios during the operation and closure of the SCM. The digital terrain model (DTM) of the site, which formed the basis of the hydraulic model, was generated using a range of LIDAR and other available topographic data for the wider catchment. Upstream features including third-party infrastructure (culverts/bridges for the Newlands rail line/ Bowen Development Road) were also included in the model. Simulations were then undertaken for various flow events to produce flood maps detailing the flood extent and depth within and adjacent to the Two Mile Creek diversion alignment.

The existing scenario 0.1% AEP flood extent is shown in **Figure 13**. The modelling clearly demonstrates that the Two Mile Creek diversion in its current configuration (including three culvert crossings certified as part of the diversion) contains the 1:1000 AEP flow event within the high banks without overtopping. The Sonoma Main Pit and the SCM mine infrastructure are therefore immune to a 0.1% flood event from Two Mile Creek in its existing configuration. The lack of any flood impact from the 0.1% AEP event for the existing scenario indicates that flooding from Two Mile Creek is not a relevant consideration for the rehabilitation and closure of SCM.

Engeny (2022) also modelled the ultimate closure scenario for the Two Mile Creek diversion which includes the CDA final landform toe and the removal of the three existing crossings. This modelling is further discussed in **Section 6.3**.

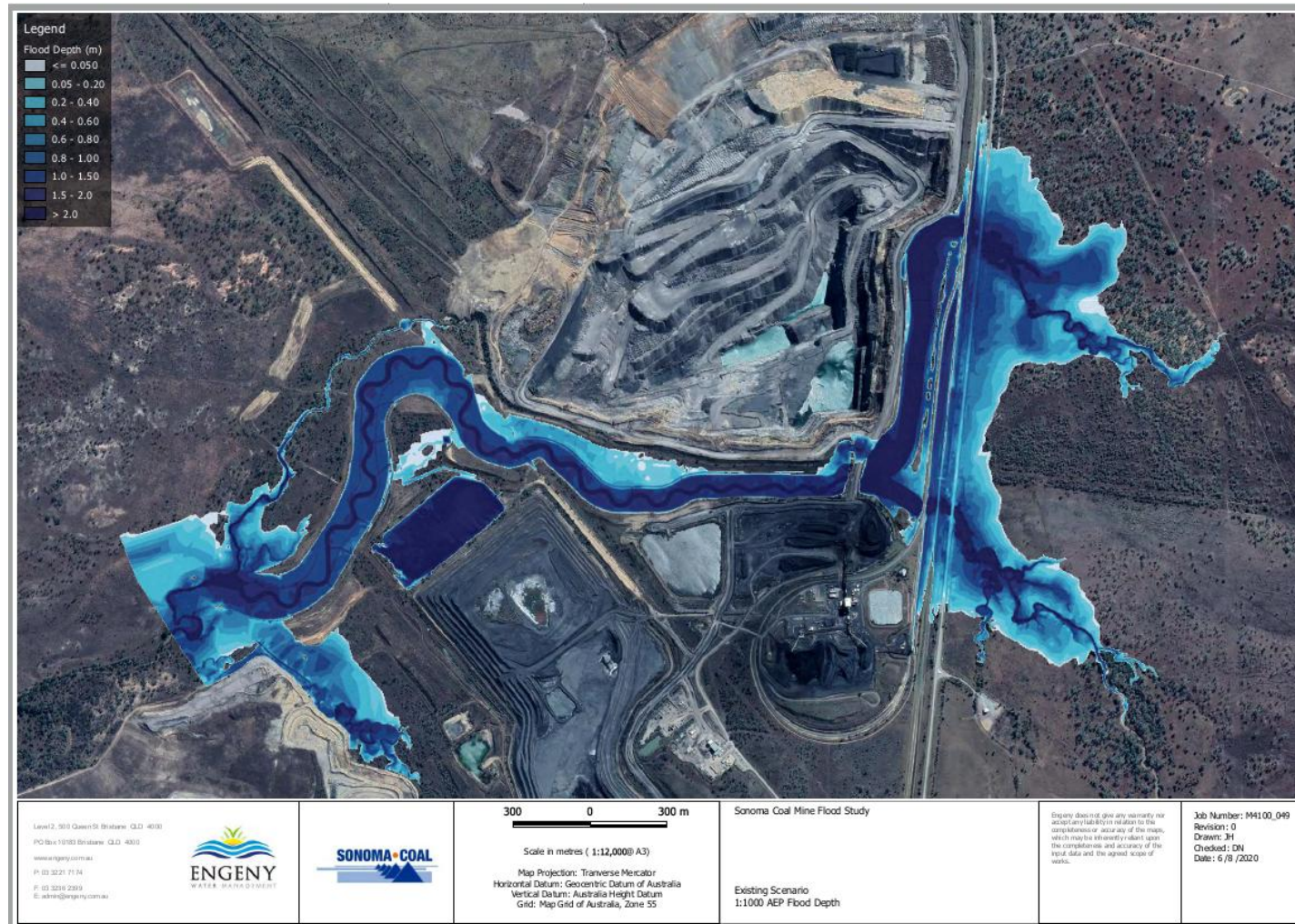


Figure 13 – SCM Two Mile Creek 0.1% AEP Flood Extent (Existing)

2.2.7.5.2 Coral Creek Flood Modelling

Coral Creek is located within the northern extent of the SCM MLs, with the majority of the reach within SCM being mapped Stream Order 4. The original alignment of Coral Creek was located within the footprint of the Sonoma North coal resource and required diversion to enable the Sonoma North Pit to be developed. As shown in **Figure 12**, Coral Creek was permanently diverted within ML10326 for a distance of ~1.5km (as measured in the low flow channel). The diversion runs to the north of the original alignment, curving around the Sonoma North Pit towards the west where it re-joins the downstream reach of the original Coral Creek alignment. Construction and introduction of flows into the Coral Creek diversion were completed in 2018.

Coral Creek within ML10326 and ML10327 was assessed as a watercourse under the *Water Act* (2000) and the diversion therefore required a Water Licence for interfering with flow in a watercourse. As part of the Water Licence application process, a certified Design Plan was developed which addressed the required content, and a Water Licence for the Coral Creek diversion was issued in 2012.

An updated Design Plan with updated hydraulic modelling and minor changes to the channel geometry and other aspects was prepared in 2018 (*North Sonoma Creek Diversion Design Plan* (Engeny 2018) (included as **Appendix E**). Engeny 2018 forms part of the current Design Plan for the Coral Creek Diversion, as required under EA Condition J3. While Engeny (2018) was not undertaken specifically for this PRC Plan, the methodology utilised is nonetheless in accordance with the DES (2024) and was undertaken in accordance with previous ARR guidelines. The use of previous ARR guidelines rather than ARR 2019 is not expected to have a material difference on the modelling outputs.

The Engeny 2018 modelling scope included the use of the existing calibrated RORB hydrologic model of the Coral Creek catchment system to obtain design hydrographs. A hydraulic model of the Coral Creek system was developed using the TUFLOW hydraulic modelling software to determine the relevant flood levels and velocities for the nominated scenarios during the operation and closure of the SCM. The digital terrain model (DTM) of the site, which formed the basis of the hydraulic model, was generated using a LIDAR survey. Upstream features including third-party infrastructure (bridges for the Newlands rail line/ Bowen Development Road) were also included in the model. Simulations were then undertaken for various flow events to produce flood maps detailing the flood extent and depth within and adjacent to the Coral Creek diversion alignment.

The 0.1% AEP flood extent for the Coral Creek diversion is shown in **Figure 14**. The modelling clearly demonstrates that the Coral Creek diversion in its current configuration contains the 0.1% AEP flow event within the high banks without overtopping. The Sonoma North Pit (prior to backfilling) was therefore immune to a 0.1% AEP flood event from Coral Creek in its diverted configuration. The lack of any flood impact from the 0.1% AEP event indicates that flooding from Coral Creek is not a relevant consideration for the rehabilitation and closure of SCM.

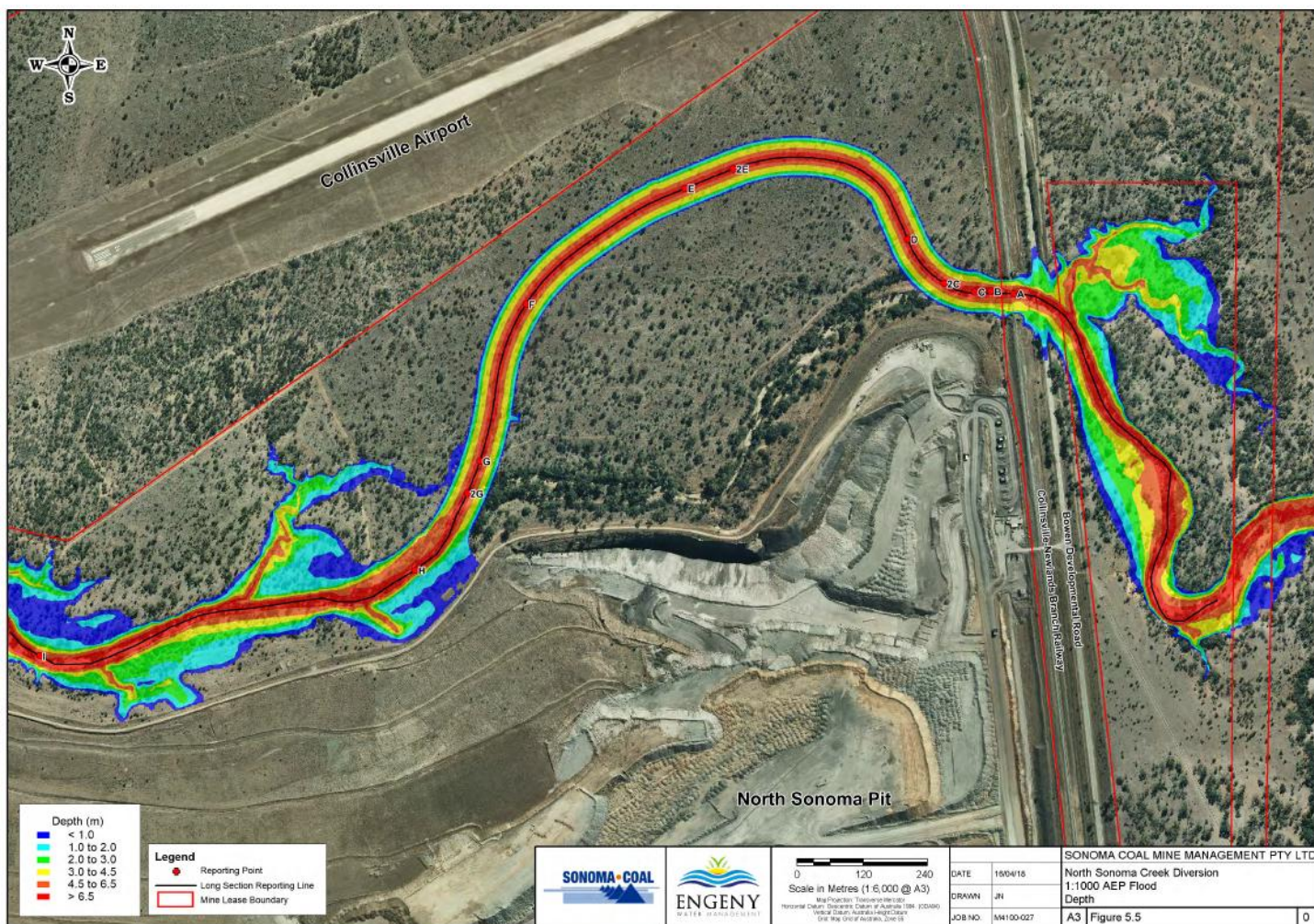


Figure 14 - SCM Coral Creek 0.1% AEP Flood

2.2.7.6 Surface Water Values

Environmental Values (EVs) for surface waters are the pre-existing hydrological processes, ecological functions and human uses, which are present either within the area or downstream, and rely upon the surface water system. Where site activities have the potential to affect any material changes within the surface water system, an assessment is required to determine whether those changes will have any material negative impact on the EV. Monitoring, management, and mitigation is required where material negative impacts on EVs can potentially occur.

Draft EVs for the Pelican Creek sub-catchment are described in the *Burdekin Region Water Quality Improvement Plan 2016*, which is based on the *Environmental Protection (Water and Wetland Diversity) Policy 2019*. The EVs have an associated set of water quality objectives based on the ANZECC (Australian and New Zealand Environment and Conservation Council) *Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000). The SCM EA prescribes the water quality monitoring parameters for the site based on ANZECC, 2000.

The Draft EVs for the Pelican Creek sub-catchment and their relevance to the SCM are detailed in **Table 9**.

Table 9 – Pelican Creek Sub-Catchment Surface Water Draft EVs

EV	Description	Pelican Creek Sub-Catchment – Relevance to SCM
Aquatic Ecosystem	Supporting pristine or modified Aquatic Ecosystems	The local area around the SCM has been cleared and used for long-term grazing and mining, modifying the landscape which has affected the volume and rate of runoff, the flow characteristics of the creeks, and the recharge of groundwater. As such, the aquatic ecosystems near the SCM, including the receiving environment, are considered to be highly disturbed.
Primary Industries - Irrigation	Irrigating crops such as sugar cane, lucerne, etc.	The ephemeral nature and variable water quality of the local drainage features and watercourses near the SCM provide minimal opportunities for usage in irrigation. The land underlying the SCM has been assessed as being of low land suitability for cropping (see 1.14.5).
Primary Industries - Farm Use	Water for farm use such as in fruit packing or milking sheds, etc.	The ephemeral nature and variable water quality of the local drainage features and watercourses near the SCM provide minimal opportunities for farm usage.
Primary Industries - Stock Watering	Water for stock watering	The ephemeral nature and variable water quality of the local drainage features and watercourses near the SCM provides only opportunistic water supply for production of healthy livestock.
Primary Industries - Human Consumption	Human Consumption of wild or stocked fish or crustaceans	The ephemeral nature and variable water quality of the local drainage features and watercourses near the SCM provide limited opportunities for the provision of fish or crustaceans for human consumption.
Recreation - Secondary	Activities with indirect contact with water such as boating, canoeing or sailing	The ephemeral nature of the local drainage features and watercourses near the SCM provide limited recreational opportunities.

EV	Description	Pelican Creek Sub-Catchment – Relevance to SCM
Recreation - Visual	Activities with no contact with water such as picnicking, bushwalking, sightseeing	The ephemeral nature of the local drainage features and watercourses near the SCM provide limited recreational opportunities.
Drinking Water	Raw Drinking Water supplies	Town water for Collinsville is supplied from Eungella Dam via the Bowen River Weir (via the Gattinvale Off stream Storage. This is upstream of the Pelican Creek confluence with the Bowen River and therefore upstream of the SCM receiving waters.
Industrial Uses	Water for Industrial Use such as power generation, manufacturing plants	There are potential demands around Scottville and Collinsville for industrial use of water including for possible expansions in power generation and for coal mining. These would be upstream of the SCM and are unlikely to be sourced directly from Pelican Creek or its tributaries.
Cultural and Spiritual	Cultural and Spiritual values.	There are no known cultural or spiritual values near the SCM

Water is managed onsite at SCM in accordance with the QNH Water Management Plan (WMP), with preference given to retaining water onsite rather than releasing. Mine-affected water has only been actively released from SCM infrequently since the commencement of mining in 2007, with no releases occurring since 2017. Releases are subject to water quality limits and only occur during periods of background flows in the receiving waters. As such, the EVs for the waterways downstream of SCM are unlikely to have been affected by the mining activities.

2.2.7.7 Operational Water Management and Monitoring

Water is managed at SCM in accordance with the QNH WMP, which is integrated across SCM, CCM, DCM and JCM. Several water storages are in place at SCM to support the mining operations, including the Sonoma Main Pit residual void which is available for emergency bulk water storage. Water storages for the LOM at SCM are detailed in **Table 10**. Note that these storages will be available progressively over the LOM as mining in individual pits is completed and may only be available temporarily where the void will be backfilled.

Table 10 – LOM Water Storages at the SCM

Name	Structure Type	Water Type	Status
Sediment Dam 1/2	Catchment Dam	Sediment (non-mine affected)	Catchment dam for rehabilitated catchment
Sediment Dam 3	Catchment Dam	Sediment (non-mine affected)	Catchment dam for rehabilitated catchment
Sediment Dam 4	Catchment Dam	Sediment (non-mine affected)	Catchment dam for rehabilitated catchment
Q-Pit Sediment Basin	Catchment Dam	Sediment (non-mine affected)	Catchment dam within footprint of backfilled pit forming part of ESCP

Name	Structure Type	Water Type	Status
Sonoma North Landform	Internally draining landform with central basin	Sediment (catchment has been topsoiled as at September 2022)	Central basin within internally draining backfilled pit landform forming part of ESCP (under rehabilitation)
Sediment Dam 5	Catchment Dam	Mine-affected	Catchment dam for ROM
Sediment Dam 11	Catchment Dam	Mine-affected	Catchment dam for Q-Pit ROM
MIA Dam 7	Catchment Dam	Mine-affected	Catchment dam for MIA
Raw Water Dam	Turkeys Nest	Raw water	Storage for raw water supplied by Sunwater
Return Water Dam	Catchment Dam	Mine-affected	Catchment dam for decant from out-of pit co-disposal
Sonoma Main Pit	Void	Mine-affected	In-pit co-disposal and decant water storage and recovery
Sonoma East Void	Future Void	Mine-affected	Potential for usage of final void for operational water management if required
CDA Cells 1-4	Out-of-Pit Co-disposal	N/A	Completed CDA cells currently undergoing capping and rehabilitation

As of August 2024, the only structures regulated under the *Manual for assessing consequence categories and hydraulic performance of structures* (DES, 2016), are CDA Cells 1-4 (refer to **Section 5.3.2** for further detail).

There are four mine-affected water release points nominated in the SCM EA, which are active release points associated with sediment/mine-affected water dams. Mine-affected water has only been released infrequently from the SCM since the commencement of mining.

A detailed description of the immediate receiving waters of SCM and the broader QNH are detailed in the *QCoal Northern Hub Receiving Environment Monitoring Program Design* (QNH REMP) (Freshwater Ecology, 2016) and the current version of the QNH WMP.

The QNH REMP outlines the requirements for ongoing collection of baseline monitoring results, including water quality and macroinvertebrate surveys within the watercourses surrounding QNH. The QNH REMP is also designed to identify potential impacts from releases of mine-affected water into the receiving environment; however, as infrequent releases have occurred to date from SCM, most data collected is considered to be representative of baseline conditions.

The QNH WMP outlines the requirements for water quality monitoring within watercourses, creeks and drainage channels in and surrounding the QNH (as conditioned in the EA), and describes the catchments, water storage and water movement infrastructure on the sites. The

QNH WMP is a live document which is reviewed annually and updated to reflect any relevant changes across the site and contains the Erosion and Sediment Control Plan (ESCP) for the QNH sites.

As the QNH WMP and REMP are operational documents which are regularly updated and are mentioned only in this PRC Plan for reference (without relying on the content for justification of rehabilitation methodologies or outcomes) they have not been included as appendices to the PRC Plan.

2.2.7.8 Surface Water Quality

Previous monitoring data for the wider Pelican Creek sub-catchment indicates that water quality parameters display a high degree of spatial and temporal variability is due to seasonal changes in flow, the ephemeral nature of significant flows, high rates of evaporation, stagnation and senescence of retained pools, differences in local geological conditions, and adjacent agricultural activity.

The background water quality in the vicinity of SCM was assessed as part of the SCM EIS and other studies undertaken for the applications for other QNH mines. Regional surface water quality for the area surrounding SCM can be summarised as follows:

- Prosser et al (2002) identified that most of the Bowen-Broken River Catchment was classified as low risk for salinity with a portion of the upper part of the catchment classified as moderate risk. Electrical conductivity within the catchment was noted to increase as surface flows subsided. The first flush wet season flow has the potential to result in initial high electrical conductivity (EC) levels however these high values are temporary.
- The Pelican Creek at Kerale stream gauging station (Station Number 120220A) is known to regularly experience EC values between 1,000 $\mu\text{S}/\text{cm}$ and 1,500 $\mu\text{S}/\text{cm}$, with higher values reaching over 4,000 $\mu\text{S}/\text{cm}$. Brizga et al, 2006 determined that salinity at this site consists mainly of sulphates, which may be a natural effect of the surrounding geology (e.g. associated with groundwater inflow during dry seasons).
- Due to the ephemeral nature of the creeks within SCM catchment and the upstream topography and soils, turbidity levels are consistently high within Coral Creek and Two Mile Creek.
- Surrounding waters as well as observed SCM site waters consistently contain high nitrogen and phosphorus levels, which may be attributed to the long-term agricultural activities within the catchment.
- Some heavy metals, such as aluminium and magnesium, are consistently high within the whole catchment, which may be attributed to the high sediment loads carried by the creeks within the Collinsville area.
- Schulz and Negus (2007) found that the considerable water quality variations naturally seen within and between watercourses in the region highlight that generic guideline values used across wide ranging aquatic systems are unlikely to serve as an appropriate benchmark.

As part of operations, surface water monitoring is undertaken to directly and indirectly satisfy conditions of the four QNH EAs, including during periods of mine-affected water releases, during periods of creek flow, and as part of REMP sampling (as per the QNH REMP).

No material impacts to water quality or aquatic ecology associated with QNH activities have been identified to date. The final landforms are not anticipated to impact adjacent surface water EVs once the rehabilitation criteria are achieved.

2.2.8 Groundwater

As previously noted, the QNH mines are four adjacent open-cut mines located across the same contiguous geology and associated hydrogeology, targeting the same coal measures. Numerous groundwater studies have been undertaken across the QNH, including but not limited to the following:

- Groundwater Impact Assessment Proposed Sonoma Coal Mine (AGE, 2005);
- *Jax Coal Project Groundwater Impact Assessment* (Geoaxiom, 2011)
- *Cows Coal Project Groundwater Impact Assessment* (Geoaxiom, 2011);
- *Drake Coal Project Groundwater Resources Assessment* (GHD, 2012)
- *Groundwater Monitoring and Management Plan – Drake Coal Project* (QCoal, October 2014);
- Drake Coal Project Groundwater Model (AGE, 2015);
- *Northern Hub Groundwater Assessment* (AGE, 2018);
- *Residual Voids on the QCoal Northern Hub Mining Complex – Sonoma Cows, Drake and Jax Coal Mines* (QCoal June 2020);
- *QCoal Northern Hub Groundwater Model Update* (AGE, 2020).
- QCoal Northern Hub Groundwater Modelling Report (AGE, 2023)

Recognising that groundwater impacts from mining activities at the QNH sites are interrelated, the more recent groundwater assessments (in particular AGE 2020 and AGE 2023) have considered the cumulative potential impact of adjacent pits.

AGE (2020) provided a comprehensive groundwater assessment for the LOM QNH plan at that time and for completeness has been appended to this PRC Plan as **Appendix F**. Subsequent changes in LOM planning at the QNH warranted an update to the numerical modelling, which was reported as AGE (2023) which is appended to this PRC Plan as **Appendix G**. AGE (2023) is representative of the SCM layout (and final voids) approved in the current SCM EA.

2.2.8.1 Aquifers and Conceptual Groundwater Model

Groundwater has been observed to be present at SCM intermittently within the quaternary alluvial strata and within the Permian coal measures. The water bearing capacity of these units is highly variable as follows:

- **Quaternary Alluvium**

Geological detail adjacent to watercourses within the SCM area is generally obscured by a cover of quaternary alluvium and gravel, particularly in the vicinity of Pelican Creek and Two Mile Creek. This alluvial cover comprises unconsolidated fine to very coarse-grained sand with occasional and irregularly interbedded silt clay and gravel lenses. The alluvial profile within the SCM ranges from a thin veneer to up to 24m associated with Coral Creek in the north, as reflected by the thickness of the quaternary strata. The groundwater aquifers within the quaternary alluvium are unconfined, but not laterally wide-spread or continuous and are confined to low areas incised in the Permian sediments primarily within and adjacent to the more significant drainage lines through the site.

- **Permian Coal Measures**

The coal seams identified within the SCM were identified as the principal groundwater bearing unit in the Permian sediments in the area. The coal seams are of low porosity and permeability and thrust faulting in the QNH area has resulted in displacements of 20- 40m (AGE, 2005) with minimal associated brecciation. Widespread volcanic intrusions into the coal seams are also present. This has resulted in a limited capacity for transmission of groundwater laterally within and between coal seams, effectively confining the aquifer.

QCoal (2014) summarised the findings of the above in consideration of the geology of the area (further detailed in AGE (2015)), operational pit groundwater inflow data, and, importantly, ongoing groundwater monitoring of bores across the QNH since 2007.

The SCM EIS, DCM EIS and QCoal (2014) concluded that there is limited connectivity between alluvium (where present) and the underlying Permian coal measures across the QNH. This observation is considered consistent with the expected low permeability of the majority of the coal measure's strata. In addition, the major ion chemistry results indicate a difference between groundwater sampled from the coal measures and surface water samples, further suggesting limited interaction between groundwater and surface water.

The above studies conclude that:

- there is limited inter-aquifer connectivity; and
- surface water channels across the QNH are losing-disconnected streams with no notable interconnection between the surface drainage systems and groundwater.

2.2.8.2 Pre-Mining Yields, Levels & Flow Direction

Significant groundwater resources were not encountered during exploration drilling in the SCM area. Groundwater yields were measured during exploration activities at the QNH and were found to be relatively low (typically <2 L/s (litres per second)) and variable. Groundwater monitoring at SCM has demonstrated highly variable yields, ranging from 0 to 5 L/s, with an average yield of 1 L/s. At DCM to the south, 94% of 601 exploration bores recorded yields of

less than or equal to 0.1 L/s. The maximum yield recorded was 5L/s. The results indicate that while the coal seams are the principal aquifers in MCM, they are of low porosity and permeability.

The groundwater investigation conducted at SCM during the EIS (including AGE (2005)) noted that groundwater monitoring across the alluvium in the area suggested that the alluvial aquifer was not continuous and is confined to low areas incised in the Permian sediments immediately adjacent to the more significant drainage features in the area. Due to the highly ephemeral nature of Two Mile Creek and Coral Creek within SCM, the quaternary alluvium associated with these watercourses is considered likely to be dry for the majority of the year.

Mine inflow has been observed at Sonoma Main Pit, where water can be seen seeping through the pit wall. In the pit, the coal seams are wet; however, the interburden is noted as being generally dry when being mined. Evaporation would account for some of this dryness; however, the observation indicates that the interburden is tight with low storage and low hydraulic conductivity.

Groundwater flow direction indicated by recorded water levels as a composite of water bearing units within the Permian strata was determined to be towards the south-south west, while groundwater flow direction in the alluvial sequences (where present) is likely to be consistent with the surface topography and surface drainage features.

The standing groundwater levels across the SCM area were found to be highly variable, consistent with the lack of lateral connectivity within the groundwater units. The majority of alluvial bores are permanently dry, while bores targeting the coal seams typically contain water at a depth dependent on the screen depth and depth of the target seam.

2.2.8.3 Groundwater Recharge

Hydraulic conductivity has previously been measured in four bores at the QNH using falling head tests. These tested zones were within various lithologies within the MCM, including the upper coal seams, intrusive sills, sandstones and sandy siltstones. The estimated hydraulic conductivity ranged from 0.1 m/day to 0.7 m/day. These estimates are considered an upper bound to the Permian due to the shallow depth of the respective lithologies. Hydraulic conductivity is known to decline with depth in coal as increasing overburden pressure closes fractures or cleats in coal seams reducing permeability.

- No data was obtained for the alluvium and the weathered zone; however, the alluvium is expected to have a higher permeability than the measured coal seams due to its unconsolidated nature. The hydraulic conductivity of the weathered zone is expected to be highly variable depending on clay and silt content and fracture networks, but it is not considered to form an aquifer.
- The overburden and interburden units between the coal seams typically have a lower hydraulic conductivity than the coal seams, and thus act as confining layers for the coal seams. This is consistent with observations during mining that these units are particularly dry and tight, which is indicative of a hydraulic conductivity several orders of magnitude lower than the coal seams.

In the SCM area, recharge to the alluvium is likely to occur directly through the base of Coral Creek and Two Mile Creek and their tributaries, and to a lesser extent through deep drainage from overlying soils. Recharge through the clay soils encountered at SCM is likely to be minimal due to the swelling of the clays after rainfall reducing permeability. The varying thickness and discontinuous nature of the gravel and sand lenses within the quaternary alluvium will limit the lateral recharge within this aquifer.

Recharge to the coal seam aquifers is expected to primarily occur via drainage from the alluvial aquifers and also directly through the beds of major creeks/watercourses. Given the low permeability of the overburden, it is expected that vertical recharge is minimal with the dominant recharge mechanism being direct recharge to sub-cropping seams in creek beds.

2.2.8.4 Groundwater Quality

Groundwater quality for the identified groundwater units within SCM and other QNH mines is summarized as follows:

Quaternary Alluvium

The groundwater in local alluvial aquifers is relatively fresh and has a neutral pH. Water quality sampling of bores within the alluvium has historically been difficult due to the frequency in which the alluvium bores are dry (as previously noted, due to the ephemeral nature of the local watercourses and drainage lines, the quaternary alluvium is generally dry for the majority of the year, and in many bores, permanently).

Coal Seam Aquifer

The groundwater in the coal seam aquifers is unsuitable for domestic, irrigation or stock watering use due to the high chloride, sodium and Total Dissolved Solids (TDS) levels. Concentrations of metals are typically below guideline levels for livestock, irrigation and human health, with the exception of barium, selenium and manganese levels recorded in some sampling events.

2.2.8.5 Groundwater Values

The *Environmental Protection (Water and Wetland Diversity) Policy 2019* identifies the environmental values of groundwater that are to be protected or enhanced in Queensland. The groundwater environment in the SCM area was assessed against these values as detailed in **Table 11**.

Table 11 – SCM Groundwater eVs

Environmental Value	Description	Relevance to SCM
Aquatic Ecosystem	Supporting pristine or modified Aquatic Ecosystems	No Groundwater Dependent Ecosystems (GDEs) have been identified within the SCM or the wider QNH area and GDEs are not considered likely to be present due to the vegetation species/communities present, the regional soils and geology, the depth to measured groundwater levels and the lack of springs or seeps in the area. Stygofauna have not been identified in SCM area. The local area around SCM has largely been cleared and used for long-term grazing and mining, modifying the landscape. This has in turn affected the volume and rate of runoff, the flow characteristics of the creeks, and the recharge rate of groundwater. As such, the aquatic ecosystems within SCM area were heavily modified prior to mining activities commencing.
Primary Industries—Irrigation	Irrigating crops such as sugar cane, lucerne, etc.	The groundwater quality data obtained from the monitoring bores installed on and around the SCM indicate that the groundwater contains elevated levels of sodium, chloride, and other parameters that exceed health and/or irrigation guideline values. As such, the SCM is not expected to have any material impact on the use of groundwater for irrigation in the region.
Primary Industries—Farm Use	Water for farm use such as in fruit packing or milking sheds, etc.	There are no significant users of groundwater for farm usage within the local area based on a search of registered bores. Farm users tend to require large volumes of water which would be unsustainable in the SCM area due to the low sustainable yield reported in the aquifers.
Primary Industries—Stock Watering	Water for stock watering	Groundwater from the quaternary alluvium is generally suitable for stock watering; however the alluvium is dry for the majority of the year due to the ephemeral nature of the local watercourses and drainage lines which recharge the aquifer. The lack of continuity within the alluvium and low sustainable yield makes usage of the quaternary alluvium for stock watering unlikely. Groundwater from the coal seam aquifer is generally unsuitable for cattle watering.
Primary Industries—Human Consumption	Human consumption of wild or stocked fish or crustaceans	There are no groundwater springs or seeps that supply surface water bodies in the area that are used for primary industries. Additionally, no production bores used to supply aquaculture are present in the region.
Recreation—Secondary	Activities with indirect contact with water such as boating, canoeing or sailing	There are no groundwater springs or seeps that supply surface water bodies in the area that are used for recreational use.
Recreation—Visual	Activities with no contact with water such as picnicking, bushwalking, sightseeing	There are no groundwater springs or seeps that supply surface water bodies in the area that are used for recreational use.

Environmental Value	Description	Relevance to SCM
Drinking Water	Raw drinking water supplies	The groundwater quality data obtained from the monitoring bores installed on and around the SCM indicate that the groundwater contains elevated levels of sodium, chloride and phosphorus that exceed drinking water guideline values. As such, the SCM is not expected to have any material impact on the use of groundwater for drinking water supply.
Industrial Uses	Water for Industrial Use such as power generation, manufacturing plants	It is believed that there are no industrial users of groundwater within the local area based on a search of registered bores. Industrial users tend to require large volumes of water which would be unsustainable in the SCM area due to the low sustainable yield reported in the aquifers.
Cultural and Spiritual	Cultural and Spiritual values.	There are no known groundwater springs or seeps that supply surface water bodies in the area that may have significant indigenous and/or non-indigenous cultural heritage.

There are 47 registered bores within the immediate QNH area, of which the majority are monitoring or investigation bores, or have been abandoned or destroyed. Only four of the bores are nominated as water supply bores, with the closest bore located approximately 2.4km to the east of the nearest SCM mining activities. Notably, the four water supply bores are located in geological formations that either are not present at SCM (e.g. granite intrusions) or are within upstream shallow alluvial sequences with limited connectivity to the alluvium in SCM.

Based on the nature of the groundwater units present and searches of registered licensed groundwater bores and pre-mining landholder bore surveys, groundwater use (including, but not limited to pastoral, irrigation, mining, stock, domestic, and town water) is not considered a groundwater value across or in the immediate vicinity of SCM.

2.2.9 Soils and Land Suitability

A number of studies relating to soils and land suitability have been undertaken within and adjacent to SCM as part of the application processes for the QNH mines, including:

- *Sonoma Coal Project Land Resource Assessment Report* (GSSE, 2005) undertaken as part of the SCM EIS (attached as **Appendix H**)
- *Cows Project Soils Report* (Tecsol, 2011);
- *Drake Coal Project Soils and Land Suitability Assessment* (GHD, 2012) (attached as **Appendix I**);

GSS Environmental (GSSE, 2005) included both a desktop assessment of the site and the relevant findings of a field survey to determine topsoil resources suitable for salvage and reuse in rehabilitation activities, and to inform the PMLU for the site.

2.2.9.1 Soil Assessment

The Sonoma Project Land Resources Assessment was undertaken generally in accordance with the *Guideline for Land Suitability Assessment Techniques* within the *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland* (DME, 1995) using the following methodology:

- Initial desktop review of available land resource data and preliminary mapping of the soils and terrain;
- Field survey of the site to characterise the soils and landscapes, including laboratory analysis of selected soil samples and classification of the soils in accordance with the Australian Soil Classification; and
- Mapping of the Land Units based on the units of common soils, landforms, geology and vegetation communities.

The field survey was undertaken in June 2004, with a total of 16 soil profile investigations undertaken at representative locations, and additional ground observations undertaken where the soil profile was exposed (eroded banks, access track cuttings, etc).

The soil surveys identified the presence of 3 Soil Units within the SCM MLs, as detailed in **Table 12**. These soil units have also been matched to the equivalent Land Units identified and mapped during the DCM EIS, as reported in GHD, (2012). GHD (2012) presents a more detailed assessment of the soils present within the DCM (which align with the soils identified in GSSE (2005) at the SCM).

Table 12 – SCM Soil Units

Mapped Soil Unit (GSSE, 2005)	Slope	Equivalent DCM Land Unit (GHD, 2012)	Description
Grey Uniform Clay	<3%	Land Unit 1 (LU1): Vertosols on Low Lying Areas	Self-mulching grey medium clay (to 0.2m), grading to a heavier greyish brown clay horizon (to 0.6m) and eventually to a brown clay.
Red Duplex Sandy Loam	<3%	Land Unit 5 (LU5): Dermosols & Vertosols on Undulating Terrain	Reddish brown clay loam (to 0.3m), grading to a yellowish red medium clay subsoil (to 0.7m) and eventually to a weathered sandstone
Brown Gradational Sandy Loam	<3-10%	Land Unit 6 (LU6): Tenosols and Rudosols Adjacent to Intermittent or Permanent Watercourses	Sandy loam topsoil (to 0.2m) grading to a shallow sandy clay loam (to 0.3m) and eventually to a deep clay loam

The SCM Soil Units are further described as follows:

Grey Uniform Clay Soil Unit

This land unit is the primary soil order within the SCM with the distinctive clay soils covering approximately 60% of the area within the SCM MLs. The topography of this land unit is relatively low lying between 160 and 180 m AHD, with level to gently inclined slopes less than 3%. The dominant vegetation is improved pasture and buffel grass. The main evidence of erosion in this land unit is associated with drainage lines; however, these features tend to be partially stabilized to stabilized.

Red Duplex Sandy Loam Soil Unit

This land unit is present on the higher ground along the eastern side of the SCM MLs at elevations between 170 and 190 m AHD. It mostly contains level to gently inclined slopes less than 3%. The dominant soil orders are Dermosols, with Vertosols occurring secondarily and tending to occur in bands in a north south direction. The dominant pre-clearing vegetation cover is open eucalypt woodland. The occurrence of erosion is considered minor, with sheet erosion being the primary form present.

Brown Gradational Sandy Loam:

This land unit forms on the gently undulating alluvial flood plains along major watercourses, often with marked terraces, levees, and shallow drainage depressions. It mostly contains level to gently inclined slopes less than 3% (with steeper slopes associated with eroded banks). These soils formed due to alluvial processes and the dominant soil orders are Tenosols and Rudosols. LU6 occurs in the SCM in a relatively narrow band within and immediately adjacent to the original alignment of Coral Creek.

The mapped distribution of Soil Units within SCM area are shown **Figure 15**.

The field surveys included soil testing on representative topsoil samples for a range of parameters which influence the suitability of the soil to be salvaged for use in rehabilitation. Details of key soil quality parameters for the identified Soil Units summarised from GHD (2012) are presented in **Table 13**.

Table 13 –Soil Quality Assessment (GHD, 2012)

Mapped Soil/Land unit	Depth (m)	Texture	Clay Content Estimate	pH	Electrical Conductivity (µS/cm)	Soil Salinity Rating
SCM: Grey Uniform Clay	0.0-0.15	Medium Clay	45-55%	7.5-8.5	88-220	Low
	0.15-0.3	Heavy Clay	49-58%	8.5-8.9	150-190	Low
	0.3-0.7	Heavy Clay	45-55%	8.5-9.2	160-470	Low-Medium

Mapped Soil/Land unit	Depth (m)	Texture	Clay Content Estimate	pH	Electrical Conductivity (µS/cm)	Soil Salinity Rating
DCM: LU1 – Vertosols on Low Lying Areas	0.7-1.1	Heavy Clay	48-65%	8.8-9.1	480-1380	Medium-Very High
	1.1-1.5	Heavy Clay	46-58%	8.0-8.9	480-1530	Medium-Extreme
SCM: Red Duplex Sandy Loam DCM: LU5— Dermosols and Vertosols on Undulating Terrain	0.0-0.15	Sandy Clay to Clay Loam	20-30%	6.5-8.4	60-210	Low
	0.15-0.3	Sandy Clay Loam to Medium Clay	30-55%	7.1-8.6	40-150	Low
	0.3-0.7	Medium Clay to Heavy Clay	13-46%	7.6-9.2	40-860	Low to High
	0.7-1.0	Medium-Heavy Clay or Weathered Sandstone	11-50%	8.8-9.2	110-1500	Medium to Very High
SCM: Brown Gradational Sandy Loam DCM: LU6— Rudosols and Tenosols	0-0.2	Sandy Loam to Clay Loam	1-10%	6.8-7.7	20-50	Very Low
	0.2-0.6	Sandy Loam to Clay Loam	3-9%	7.2-8.3	10-30	Very Low
	0.6-1.0	Sand to Sandy Loam	6-11%	7.7-8.2	10-20	Very Low
	1.0-1.5	Medium Clay	14%	8.0	30	Very Low

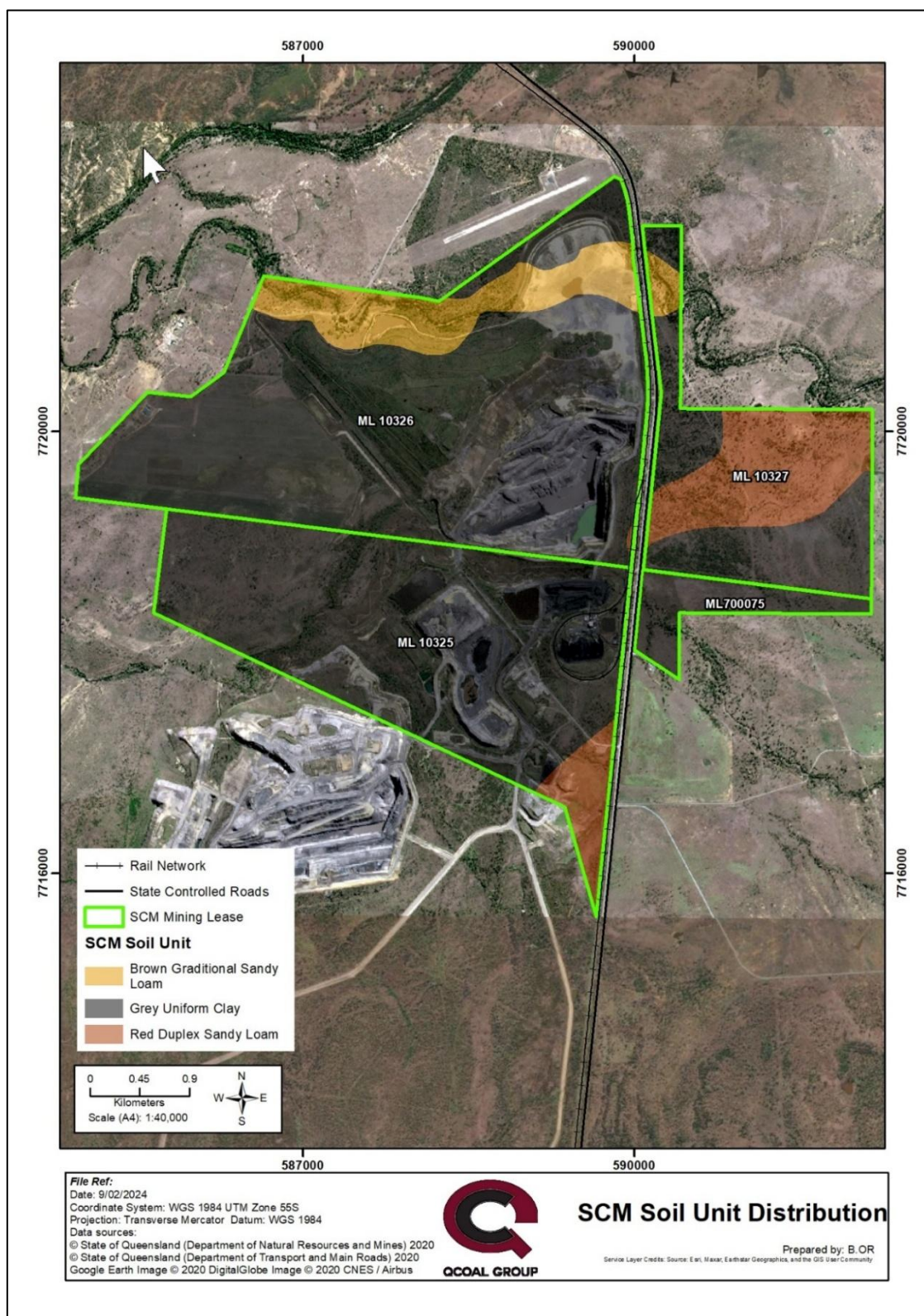


Figure 15 – Distribution of soil units at the SCM

2.2.9.2 Topsoil Stripping

GSSE (2005) considered the physical and chemical characteristics of the identified Soil Units at SCM when determining recommended topsoil stripping depths, for usage in rehabilitation activities (as presented in **Table 14** for each Soil Unit encountered at SCM).

Table 14— Topsoil Stripping Depths

Mapped Soil Unit	Recommended Stripping Depth (mm)
Grey Uniform Clay	200
Red Duplex Sandy Loam	300
Brown Gradational Sandy Loam	200 (subsoil up to 1000 may be salvaged for use as marginally suitable topsoil)

As shown in **Figure 15**, the predominant soil units within the LOM disturbance areas at the SCM is the Grey Uniform Clay (~60%), with smaller areas of Red Duplex Sandy Loam (~25%) and Brown Gradational Sandy Loam (~15%). The entirety of the LOM disturbance area for the SCM is within areas where the topsoil is suited for salvage for reuse in rehabilitation, with a minimum stripping depth of 200mm.

2.2.9.3 Erosional Stability

During the DCM EIS field survey, testing was undertaken on representative topsoil samples for the land units encountered within the DCM. As previously stated these have been matched to the equivalent SCM Soil Units identified in GSSE (2005), for a range of parameters which influence the erosional stability of the soil. This testing included:

- Exchangeable Sodium Percentage (ESP)— a soil is considered sodic when sodium reaches a concentration where it begins to affect soil structure. When sodic soils are wet the sodium weakens the bonds between soil particles, resulting in clay swelling causing slaking or dispersion. A topsoil is considered sodic when the ESP is >6%.
- Cation Exchange Capacity (CEC)— the total capacity of a soil to hold exchangeable cations, which influences the soil's ability to retain essential nutrients and buffer against soil acidification.
- Calcium/Magnesium Ratio (Ca/Mg Ratio)— this ratio is used as an indication of dispersion potential. Soils that are high in sodium and magnesium tend to show more dispersion than soils that are high in sodium and calcium. The potential for dispersion may be increased in soils with calcium / magnesium ratios less than 2.

Analytical results from the erosional stability testing on representative topsoil samples for the topsoil resources to be stripped at SCM are summarised in **Table 15**.

Table 15 –Erosional Stability Assessment (GHD, 2012)

Mapped Soil/Land Unit	Depth (m)	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio (%)
SCM: Grey Uniform Clay	0-0.15	0.4-1.8	36.7-65.4	3.0-7.3
DCM: LU1 – Vertosols on Low Lying Areas	0.15-0.3	1.4-13.5	37.2-68.2	5.0-5.8
SCM: Red Duplex Sandy Loam	0-0.15	0.2-3.5	14.8-48.6	2.4-7.6
DCM: LU5— Dermosols and Vertosols on Undulating Terrain	0.15-0.3	0.2-1.2	30.1-45.6	2.1-52
SCM: Brown Gradational Sandy Loam	0-0.6	0.3-0.6	1.9-9.9	3.4-3.6
DCM: LU6— Rudosols and Tenosols				

Results for the Grey Uniform Clay Soil Unit indicate the topsoils are generally non-sodic and have a low erodibility rating. This was supported by field observations, where occurrence of erosion for in-situ soils is minor, with partly stabilised/stabilised erosion adjacent to drainage lines the primary form present. LU1 includes cracking clays but minimal gilgai are present within the QNH area.

Results for the Red Duplex Sandy Loam indicate that the topsoils are mainly non-sodic and have a low erodibility rating. This was supported by field observations, where occurrence of erosion for in-situ soils was noted to be minimal, with sheet erosion the primary form present.

Results for the Brown Gradational Sandy Loam indicate that the topsoils are non-sodic and have a low erodibility rating. This was supported by field observations, where occurrence of erosion for in-situ soils was noted to be minimal, with the exception of the incised, eroded banks of Coral Creek caused by concentrated flows.

Analyses of mine waste confirmed the presence of low-medium ESPs and high Ca/Mg ratios within the majority of mine waste lithologies (volumetrically). Therefore, significant dispersion of fine materials from waste rock dumps is not expected to occur.

2.2.9.4 Soil Fertility

Testing was undertaken as part of the DCM EIS field survey on representative topsoil samples from the A1 Horizon (0-0.15m depth) for the land units identified within DCM (which as previously noted, have been matched to the equivalent SCM Soil Units identified in GSSE (2005)). Testing was undertaken for a range of parameters (nutrients, exchangeable cations and trace elements) which influence the overall fertility of the soil. Analytical results from the fertility testing are summarised in **Table 16**.

Table 16 –Topsoil Fertility Analysis-- A1 Horizon (GHD 2012)

Analyte	Unit	Grey Uniform Clay Range	Red Duplex Sandy Loam Range	Brown Gradational Sandy Loam Range
Organic Matter	%	1.9 – 4.0	0.9– 3.8	2.4
Nitrate	mg/kg	8.5	1.7	–*
Total Nitrogen	%	0.07 – 0.22	0.08– 0.21	0.14
Phosphorus	mg/kg	8.0 – 52.0	<5.0– 71	13
Potassium	Meq/100g	0.2 – 0.6	0.13– 0.59	2.6
Magnesium	Meq/100g	7.88	8.52	–*
Calcium	Meq/100g	27.66	21.6	–*
Aluminium	mg/kg	25	26	–*
Sulfate	mg/kg	3.4– 11.0	1.3– 7.5	3.5
Boron	mg/kg	0.73 – 1.1	0.31– 1.5	0.62
Copper	mg/kg	0.56 – 1.7	0.17– 1.7	0.33
Iron	mg/kg	11 – 26	3.9– 57	46
Manganese	mg/kg	3.4 – 17	1.8– 60	16
Zinc	mg/kg	0.14 – 0.69	0.13– 1.4	1.4
Chloride	mg/kg	22.0	17.0	–*

*Not tested

Analytical results for the Grey Uniform Clay soil unit indicated that surface soil nitrate is low to medium. Phosphorus concentrations were low to very high, with soils at the lower end potentially being limiting for improved pasture growth. It is expected that blending of topsoil during stripping will aggregate total nitrogen and phosphorus levels to a narrower range which is suited to improved pasture growth for rehabilitation. Soil aluminium is the dominant cation accounting for about 50% of the CEC, approaching the limit of 60% aluminium saturation. These soils also have a moderate water storage capacity and will readily germinate and support native and improved grasses and trees. Previous rehabilitation at the QNH has shown this soil unit will readily support the establishment of improved pasture without amelioration.

Analytical results for the Red Duplex Sandy Loam and Brown Gradational Sandy Loam soil units indicated that topsoil nitrate and phosphorus concentrations were low and may be limiting for improved pasture growth but as with LU1, it is expected that blending of topsoil during stripping will aggregate total nutrient levels to a narrower range which is suited to improved pasture growth for rehabilitation. These soils typically range between medium to high water storage capacity and will readily germinate and support native and improved grasses and trees. Previous rehabilitation at the QNH has shown this soil unit will also support the establishment of improved pasture without amelioration.

Soil sampling and testing undertaken as part of the QNH Rehabilitation Monitoring Program indicates that all topsoil utilised in rehabilitation to date at the QNH achieves the requirements for Class 4 grazing land as outlined in **Section 4.1**.

2.2.9.5 Land Suitability

GSEE, 2005 included a land suitability assessment of the land units encountered in the SCM area as part of the SCM EIS process. Findings from the assessment were compared against land suitability criteria published in the *Land Suitability Assessment Techniques (LSAT) Guidelines* within the *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland* (DME, 1995).

Land suitability assessments undertaken for the QNH mines have noted that:

- Large areas of the properties underlying the QNH were cleared historically for grazing.
- Logging and ringbarking have been undertaken historically in riparian zones, and mixed woodlands have been thinned, with understories removed to facilitate grazing.
- Soils and landforms are generally suitable for cattle grazing.
- Ongoing pastoral activities by landholders across the QNH MLs and the surrounding region have included agistment/grazing, clearing, regrowth and weed control, and control of feral animals (dogs, pigs, etc).

The land within the SCM MLs was assessed by GSEE, 2005 as Land Suitability Class 2 for beef cattle grazing, indicating suitable land for grazing on native and improved pastures with minor limitations. The land was found to not be suitable for cultivation on a regular basis due to a combination of limitations of slope, soil, erosion and climate.

2.2.10 Terrestrial Ecology

SCM is located within the Brigalow Belt Bioregion, which covers a total area of 135,500 km² and includes coastal areas, rugged ranges and alluvial plains (Young et al., 1999). The Brigalow Belt Bioregion supports a range of flora and fauna including a number of rare and threatened species. Finer variations within bioregions in geology, geomorphology and climate produce characteristic patterns of landforms, soils and vegetation. These distinctive provinces are mapped as subregions (Sattler and Williams, 1999).

At a sub-regional scale, SCM is located within the Northern Bowen Basin Sub-Bioregion, which contains the major areas of outcropping of Triassic and Permian sediments of the Bowen Basin. The regional landscape is predominately undulating, with *Acacia harpophylla* (brigalow) and *Eucalyptus cambageana* (Dawson gum) communities dominant on clay soils. Open woodlands of *Eucalyptus crebra* (narrow-leaved ironbark) or *Eucalyptus populnea* (poplar box), often with a shrubby understorey, are typically present on the shallower texture-contrast soils. There are also areas of *Dichanthium sericeum* (bluegrass) (Young et al., 1999).

As previously noted, cattle grazing has been ongoing within the SCM area and surrounds since the 1950s, and significant areas of native vegetation have been cleared to promote the

establishment of grazing pasture. As a consequence, the majority of the SCM MLs comprises Buffel Grass (*Cenchrus ciliaris*) improved pasture.

A number of studies relating to vegetation communities, flora and fauna have been undertaken within and adjacent to SCM as part of the application processes for the QNH mines, including:

- *Flora and fauna of the proposed Sonoma Coal Mining Lease near Collinsville, Central Queensland* (Central Queensland University (CQU, 2004)
- *Birrilee (EPC 586) Ecological Assessment* (ERM, 2007)
- *Cows Coal Project Ecological Assessment Report* (Tecsol 2011)
- *Drake Coal Project Ecological Assessment Technical Report* (GHD, 2012)

CQU (2004) included both a desktop assessment of the site and the relevant findings of a field survey of the vegetation communities, flora, fauna and weed species present within the SCM MLs in December 2004.

2.2.10.1 Vegetation Communities

Table 17 and **Figure 16** detail the remnant regional ecosystems (REs) currently mapped within SCM, including biodiversity status and *Vegetation Management Act* 1999 (VM Act) status. A significant proportion of the SCM site has been historically cleared of remnant vegetation, with the remaining mapped REs within ML10325 and ML10326 predominantly occurring outside the LOM disturbance area. The majority of the Sonoma East disturbance footprint occurs within vegetation mapped as No Concern at Present, with a small amount of mapped endangered RE within the Sonoma East Pit 2 area.

Prior to the initial clearing for pastoral purposes in the 1950s, the available pre-clearance mapping for the SCM site shows these REs extended across the SCM area. Historic vegetation management since the initial clearing has periodically thinned regrowth within the site.

Table 17 – Mapped Remnant REs within the SCM

Regional Ecosystem	Description	Biodiversity Status	VM Act Status
11.9.10	<i>Eucalyptus populnea</i> open forest with a secondary tree layer of <i>Acacia harpophylla</i> and sometimes <i>Casuarina cristata</i> on fine-grained sedimentary rocks	Endangered	Of Concern
11.9.9	<i>Eucalyptus crebra</i> woodland on fine-grained sedimentary rocks.	No Concern at Present	Least Concern
11.9.2	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks.	No Concern at Present	Least Concern
11.3.25b	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines	Of Concern	Least Concern

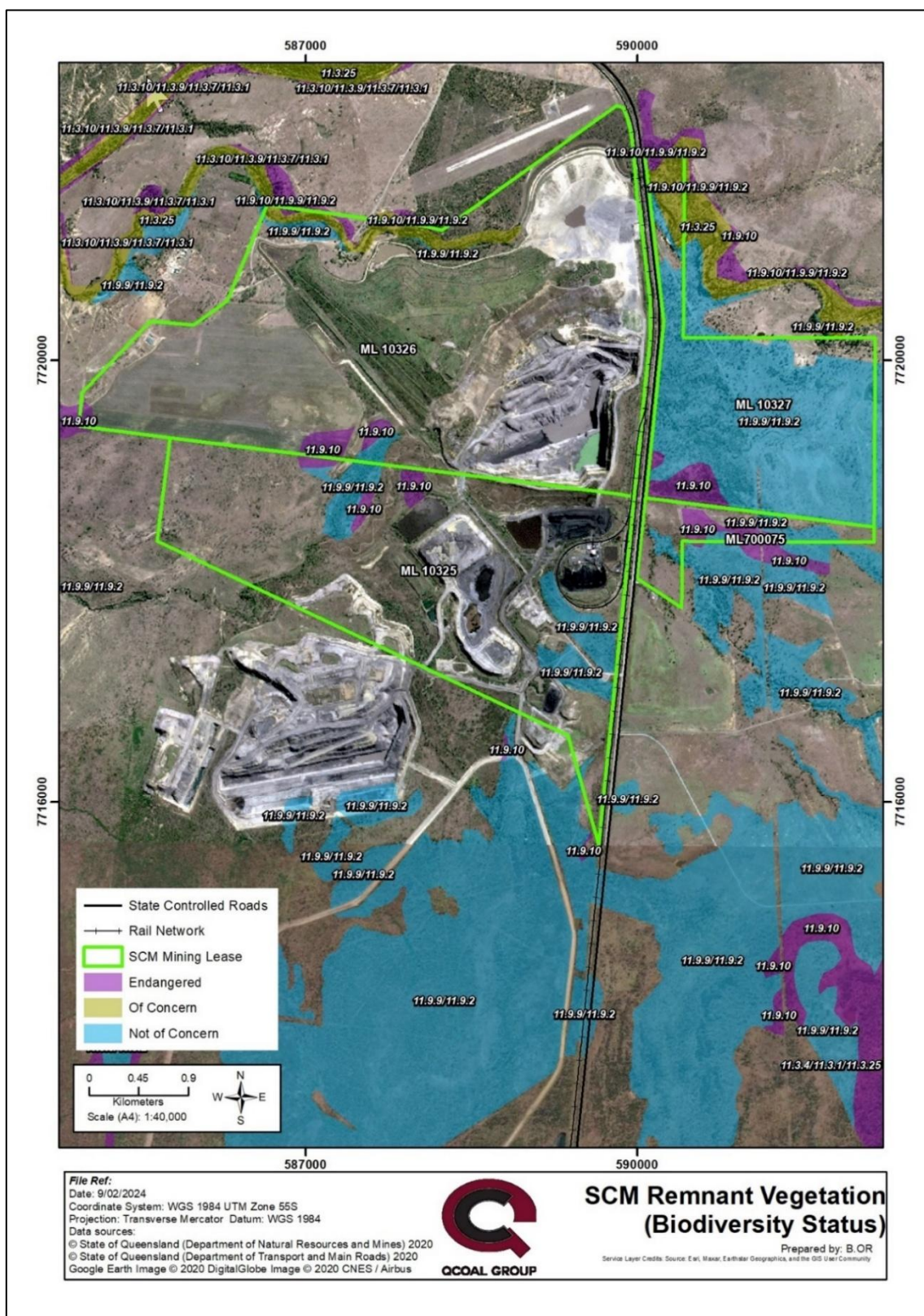


Figure 16 – SCM Mapped Remnant Vegetation Communities

2.2.10.2 Flora

The CQU (2004) pre-development field survey identified 113 plant species within the SCM MLs. Native species associated with the previously described vegetation communities formed the bulk of the native flora noted within the SCM site.

The only individual species of conservation significance identified during SCM field surveys was:

- **Black ironbox (*Eucalyptus raveretiana*)– Vulnerable EPBC and NC Act**

Observed to occur along the Coral Creek riparian corridor within the SCM MLs. A medium-sized tree (up to 25 m) with a high salt tolerance, usually occurring along watercourses, or floodplains/alluvial flats adjacent to watercourses on soils ranging from sandy to heavy clay.

The following conservation significant species was considered likely to occur but was not identified within the SCM area during the field surveys:

- **Bluegrass (*Dichanthium setosum*) – Vulnerable EPBC Act and Near Threatened NC Act**

Due to the highly disturbed nature of the vegetation within the SCM area, introduced species including pasture grasses and a variety of weed species are present within and adjacent to SCM (as identified during the initial field survey and during rehabilitation monitoring), as listed in **Table 18**.

Table 18 – Introduced Species Within SCM

Family	Species	Common Name	LP (PSRM) Act * Declared (Class)	Biosecurity Act 2014 Restricted Matter (Category)	Weed of National Significance
Amaranthaceae	<i>Gomphrena celosioides</i>	Gomphrena Weed	No	No	-
Asclepiadaceae	<i>Cryptostegia grandiflora</i>	Rubber Vine	Yes (2)	Yes (3)	Yes
Asteraceae	<i>Parthenium hysterophorus</i>	Parthenium	Yes (2)	Yes (3)	Yes
Asteraceae	<i>Tridax procumbens</i>	-	No	No	-
Asteraceae	<i>Xanthium pungens</i>	Noogoora Burr	No	No	-
Cactaceae	<i>Eriocereus spp.</i>	Harrisia Cactus	Yes (2)	Yes (3)	Yes
Cactaceae	<i>Opuntia stricta</i>	Prickly Pear	Yes (2)	Yes (3)	-
Malvaceae	<i>Sida spinosa</i>	-	No	No	-
Mimosaceae	<i>Acacia farnesiana</i>	Prickly Mimosa	No	No	-
Mimosaceae	<i>Acacia nilotica</i>	Prickly Acacia	Yes (1)	Yes (3)	Yes
Papaveraceae	<i>Argemone ochroluca</i>	Prickly Poppy	No	No	-
Poaceae	<i>Cenchrus ciliaris</i>	Buffel Grass	No	No	-

Family	Species	Common Name	LP (PSRM) Act * Declared (Class)	Biosecurity Act 2014 Restricted Matter (Category)	Weed of National Significance
Poaceae	<i>Dichanthium annulatum</i>	-	No	No	-
Poaceae	<i>Dichanthium aristatum</i>	-	No	No	-
Poaceae	<i>Echinochloa colona</i>	-	No	No	-
Poaceae	<i>Macroptilium lathyroides</i>	-	No	No	-
Poaceae	<i>Sorghum halepense</i>	-	No	No	-
Poaceae	<i>Urochloa mosambicensis</i>	-	No	No	-
Rhamnaceae	<i>Ziziphus mauritiana</i>	Chinese Apple	Yes (2)	Yes (3)	-

*The Land Protection (Pest and Stock Route Management) Act 2002 has been superseded by the Biosecurity Act 2014

2.2.10.3 Fauna

No mapped essential habitat is present within the SCM area.

A single species of (current) ecological significance under the NC Act and/or EPBC Act was identified within the SCM area during the pre-mining ecological survey:

- **Squatter Pigeon (*Geophaps scripta scripta*) – Vulnerable EPBC and NC Act**

Several squatter pigeons were recorded within the SCM area during the field survey in regrowth brigalow communities and at cattle watering points. Squatter pigeon are expected to occur throughout SCM (and the wider QNH) area, utilising both the grassland and woodland vegetation communities. The species is commonly observed in habitats that are located close to bodies of water and have been commonly observed in the Collinsville area surrounding the QNH.

The following conservation significant species were considered likely to occur but were not identified within the SCM area during the field surveys:

- Red Goshawk (*Erythrotriorchis radiatus*) – Vulnerable EPBC and NC Act
- Ornamental Snake (*Denisonia maculata*) – Vulnerable EPBC and NC Act

The following conservation significant species has been identified at SCM subsequent to the CQU (2004) field survey:

- Little Pied Bat (*Chalinolobus picatus*) – Near Threatened under NC Act

Pest species observed within and adjacent to the SCM area include the following:

- European Rabbit (*Oryctolagus cuniculus*),
- Cane Toad (*Rhinella marinus*)
- Pig (*Sus scrofa*).

Since the commencement of mining activities at SCM, control programs have been undertaken within the wider QNH as part of the routine management of the underlying properties.

2.3 Rehabilitation Areas and Relevant Activities

A Rehabilitation Area (RA) is defined in the PRC Plan Guideline as an area of land in the post-mining land use to which a rehabilitation milestone for the post-mining use relates. As mining progresses through a RA, sub-sections of land within the RA become available for rehabilitation at different times, which is detailed for each RA in the PRC Plan – Schedule. The RAs included in the PRC Plan Schedule for SCM are referred to throughout this PRC Plan.

The full extent of the planned LOM disturbance at SCM is shown in **Figure 17**. Only PMLU areas where disturbance has occurred or will occur, is mapped as a RA. Areas expected to remain undisturbed throughout the mine life are therefore not mapped as a RA.

The mining related disturbance areas which are to be rehabilitated to a stable condition have been allocated into eight (8) separate RAs, as detailed in **Table 19** and shown in **Figure 18**. The SCM RAs have been aligned such that each RA only comprises areas which share a common PMLU, rehabilitation methodology and rehabilitation milestones.

Table 19 – Rehabilitation Areas at SCM

Rehabilitation Area (RA)	Description	Relevant Activities	PMLU	Area (Ha)
RA1	Waste Rock Dumps	Waste rock dump areas including out of pit waste rock dumps, backfilled pit areas and associated haulage ramps and roads within the waste rock dump footprint.	Grazing pasture	235
RA2	Out of Pit Co-disposal	Existing out of pit co-disposal facility	Grassland Community	120.2
RA3	Surface Infrastructure	Built infrastructure areas, laydown areas, haul roads and water management infrastructure which will not be retained,	Grazing pasture	113.9
RA4	At-Grade Disturbance Areas	At-Grade disturbance activities	Grazing pasture	229.3
RA5	Two Mile Creek Diversion	Approved permanent watercourse diversion	Constructed Creek Diversion	65.5
RA6	Coral Creek Diversion	Approved permanent watercourse diversion	Constructed Creek Diversion	22.8
RA7	Retained Infrastructure	Haul roads/access tracks, infrastructure pads, water management infrastructure which will be retained in accordance with a landholder agreement	Retained Infrastructure	30.6
RA8	Existing Rehabilitation	Existing rehabilitation.	Grazing pasture	405.7

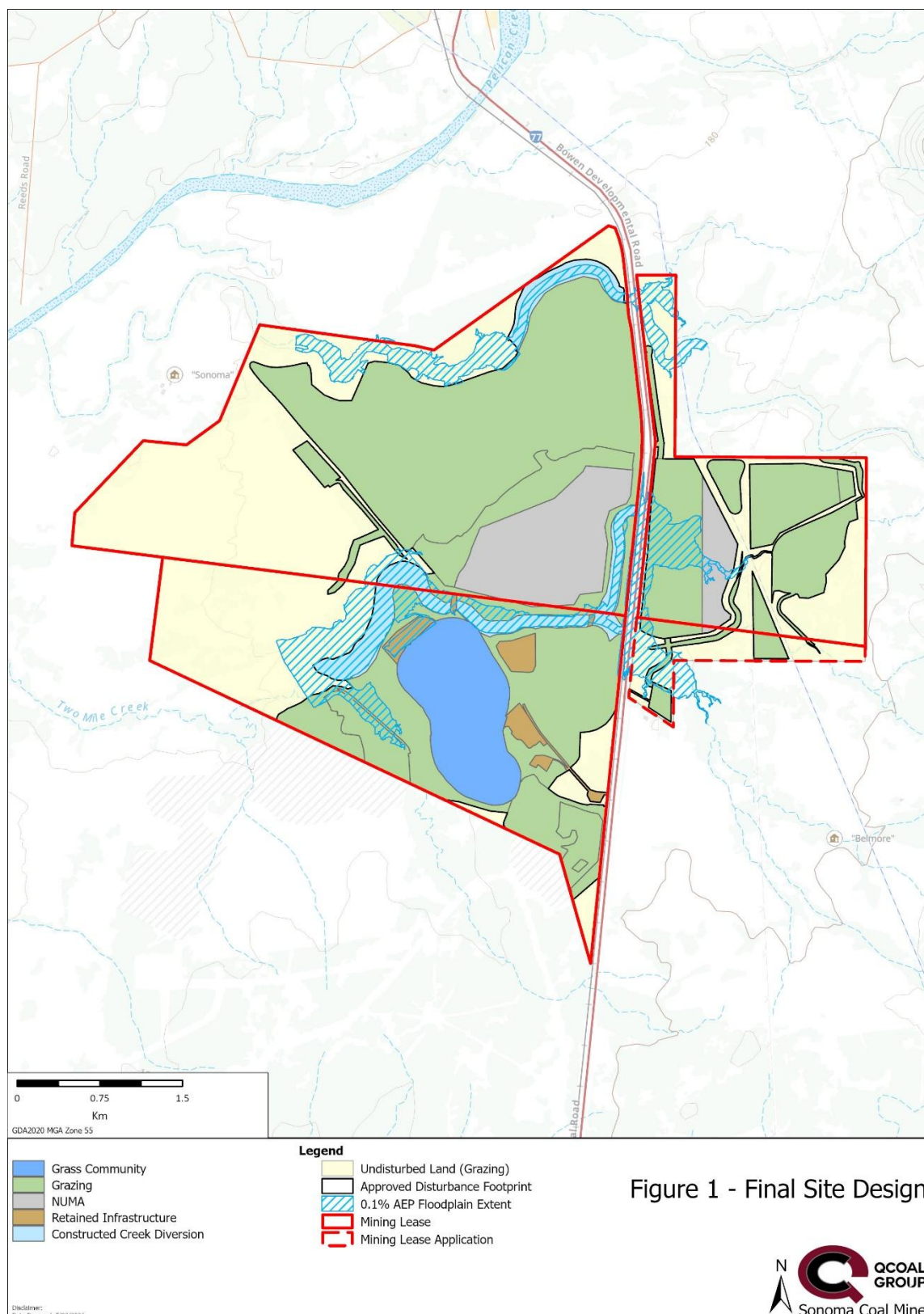


Figure 17 – SCM LOM Footprint

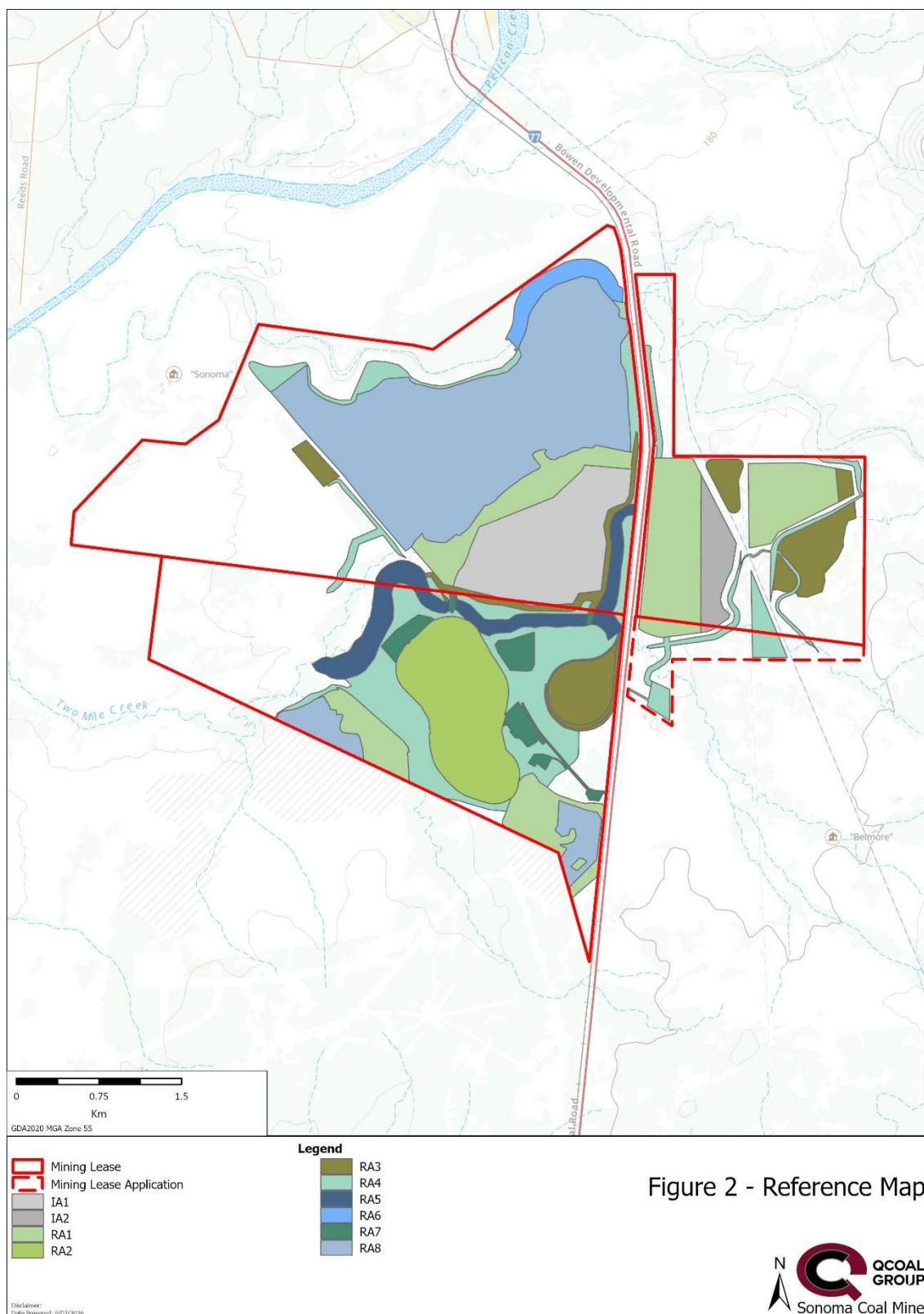


Figure 18 – SCM Rehabilitation and Improvement Areas

2.3.1 Rehabilitation Milestones

A rehabilitation milestone (RM) is defined in the PRC Plan Guideline as each significant event or step necessary to rehabilitate the land to a stable condition (section 112 of the EP Act).

The rehabilitation milestones (RM) included in the SCM PRC Plan Schedule are referred to throughout this PRC Plan and are detailed in **Table 20**.

Table 20 – Rehabilitation Milestones at SCM

Rehabilitation Milestones (RM)	
RM1	Infrastructure decommissioning and removal
RM2	Identification, remediation and removal of contaminated land
RM3	Landform development and reshaping
RM4	Installation of a cover system (RA2)
RM5	Surface preparation (top dressing, contour ripping, soil amelioration)
RM6	Revegetation
RM7	Achievement of surface requirement
RM8	Achievement of post-mining land use to a stable condition
RM9	Achievement of post-mining land use to a stable condition (RA5 and RA6)
RM10	Achievement of post-mining land use to a stable condition (RA7)
RM11	Achievement of post-mining land use water quality

2.3.2 Improvement Areas and management milestones

Table H1 of the SCM EA nominates the residual voids that are to be retained following the completion of mining. The SCM residual voids are designated non-use management areas (NUMAs) in accordance with section 112 of the EP Act.

The PRC Plan Guideline defines an area of land in the NUMA to which a management milestone for the NUMA relates as an improvement area (IA). Management milestones (MM) for a NUMA are defined in the PRC Plan Guideline as each significant event or step necessary to achieve best practice management of the area and to minimise risks to the environment. The IAs and MMs included in the SCM PRC Plan Schedule are referred to throughout this document.

The SCM IAs and associated relevant activities are detailed in **Table 21** and the management milestones (MMs) are detailed in **Table 22**.

Table 21 –Improvement Areas at SCM

Improvement Area (IA)	Relevant Activities	NUMA	Area (Ha)
IA1	Sonoma Main Pit Final Void, Pit walls (High wall and low wall of the final void above the maximum predicted water level at equilibrium), and set back area between crest of the highwall and low wall to the toe of the safety bund	Residual Void	120
IA2	Sonoma East Pit Void (High wall and low wall of the final void above the maximum predicted water level at equilibrium), and set back area between crest of the highwall and low wall to the toe of the safety bund	Residual Void	29

Table 22–Management Milestone at SCM

Management Milestones (MM)	
MM1	Achievement of structural stability
MM2	Achievement of surface requirements
MM3	Achievement of sufficient improvement

2.4 Existing Rehabilitation

SCM has commenced approximately 405Ha of rehabilitation between 2010 and 2025. The rehabilitation completed to date has been undertaken to achieve a safe, stable and non-polluting landform suitable for cattle grazing PMLU.

No progressive certification applications under the EP Act have been made for SCM rehabilitation areas.

3 Community Consultation

Section 126C(1)(c) of the EP Act requires the PRC plan include the following community consultation information:

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

The (then) DES information sheet “*Community Consultation for Progressive Rehabilitation and Closure Plan – ESR/20196/5101*” (the Consultation Guideline) provides more detail on identifying relevant parties and the nature of their interest, to enable relevant community consultation as required.

Following the approach outlined in the Consultation Guideline, QCS has identified the following members of the community who have a genuine interest in the rehabilitation and closure of SCM:

- Direct Interest - the underlying/adjoining landholders; and
- Land Use Interest - the overlapping/adjoining tenure holder.

The specific members of the community who have been identified as having a genuine interest in the rehabilitation and closure of SCM are listed in **Table 23**. It is noted that the list of identified community consultation members is subject to change in the event of a change in the landholdings, or tenure arrangements for the nominated parties.

Table 23 – Identified Community Consultation Members

Community Member	Interest Type	Interest Description
Mr Christopher Wallin	Direct – Underlying / Adjacent Landholder	Landholder - Lot 1 on SP190745
Mrs Amanda Rae Watts and Mr Shane Andrew Watts	Direct – Underlying / Adjacent Landholder	Landholder - Lot 25 on SP190745
Ms Yvonne Cox	Direct – Underlying / Adjacent Landholder	Landholder - Lot 4 on SP234989
Mr Christopher Wallin	Direct - Adjacent Landholder	Landholder - Lot A on AP2839 (Road Reserve) - Holder of Permit to Occupy
Whitsunday Regional Council	Direct - Adjacent Landholder	Landowner - Lot A on AP2839 (Road Reserve) - Entity in control of road/owner of road under <i>MR Act</i> (existing Compensation Deed in place) Landholder - Lot 26 on DK276 (Reserve) - Entity in control of aerodrome
Cows Coal Mine (Bowen River Coal Pty Ltd)	Land use – Adjacent Tenure Holder	Owner of adjoining coal mine (ML 10325)

3.1 Community Consultation Plan

A Community Consultation Plan (CCP) for the SCM PRC Plan is presented in **Table 24**. The purpose of the CCP is to provide a plan for QCS to engage with the identified relevant parties and enable those parties to provide input into the PRC Plan development (as well as any potential amendments) and be advised on progress of its subsequent implementation.

Table 24 – SCM PRC Plan Community Consultation Plan

Item	Details
Identified Community Members	The identified community members are those relevant parties which are: directly influenced by the rehabilitation of the mine; and having a demonstrable and legitimate genuine interest regarding: the land where the activities are occurring, the land adjacent to where the activities are occurring, the land/amenities surrounding where the activity will occur that are likely to be impacted by the activity (e.g. groundwater/drinking water users)

Item	Details
	within the surrounding area or a community located upstream or downstream of the activity). The relevant community members are identified in Table 23. For SCM a number of the identified community members with a relevant interest are associated with QCoal. Engagement and consultation regarding the PRC Plan with these entities as community members is assumed, is implicit and does not require specific documentation. The community members listed in Table 23 are subject to change in the event of a change in the landholdings or tenure arrangement. Where such a change occurs, and an additional community member is identified that is not associated with QCoal, consultation will be undertaken with the objective of enabling the identified community member to provide input into the PRC Plan development and subsequent implementation, as well as any potential amendments.
Consultation Objective and Approach – applicable to identified community member not associated with QCoal	The objective of the initial and ongoing communication with the identified community members will differ somewhat depending on the community member's specific interest in SCM, but is generally as follows: Outline the existing approved PMLU/NUMAs for SCM; Outline the progress of mining and rehabilitation activities at the time of consultation; Outline the proposed final landforms at the SCM; Outline the SCM PRCP schedule timeframes; Record, consider and respond to feedback on the SCM PMLU, final landform and PRCP Schedule. Given the advanced nature of the mining and rehabilitation activities at SCM, it will be communicated to the Community Member (as required) that following approval of the PRCP Schedule, limited opportunities are available to make significant changes to the approved PMLU, final landform and PRCP Schedule. Such consultation may include the following approaches as appropriate or requested by the member: engagement via telephone; engagement via face to face meetings; engagement via written contact; and/or existing QNH General Community Consultation (see Section 2.3) which is a minuted open community meeting held in Collinsville on a quarterly basis.
Frequency – applicable to identified community member not associated with QCoal	PRC Plan Development - To take place a minimum of 1 month prior to PRC Plan submission. PRC Plan Implementation - Every 5 years following initial PRC Schedule approval. PRC Plan Amendment - During preparation of PRC Plan / PRC Schedule amendments which have a material impact on the community member (as required). To take place a minimum of 1 month prior to PRC Plan amendment submission.

Item	Details
Information to be Provided – applicable to identified community member not associated with QCoal	PRC Plan Development - Information on PRC Plan – Rehabilitation Planning Part and PRC Plan - Schedule. PRC Plan Implementation - Update on project. PRC Plan Amendment - Presentation detailing PRC Plan – Rehabilitation Planning Part and PRC - Schedule, and proposed schedule of amendment.
Feedback Consideration – applicable to identified community member not associated with QCoal	PRC Plan Development – Feedback to be noted. A response to feedback including details of how it has been addressed will be provided to the relevant community member. PRC Plan Implementation - Feedback to be noted. A response to feedback including details of how it has been addressed will be provided to the relevant community member. PRC Plan Implementation - Feedback to be noted. A response to feedback including details of how it has been addressed will be provided to the relevant community member.
Consultation Records – applicable to identified community member not associated with QCoal	PRC Plan Development - Meeting records. Consultation to be included in PRC Plan Consultation Register. PRC Plan Implementation - Meeting records. Consultation to be included in PRCP Consultation Register. PRC Plan Amendment - Meeting records. Consultation to be included in PRCP Consultation Register.

3.2 PRC Plan Community Consultation Register

A PRC Plan Community Consultation Register has been developed to record consultation with identified community members undertaken during the development and implementation of this PRC Plan. The SCM PRC Plan Community Consultation Register is attached as **Appendix J**. The Register will be updated as required independent of this PRC Plan.

3.3 QNH General Community Consultation

A significant amount of community consultation has been undertaken at the QNH since the initial development of SCM in 2006 (as the first QNH mine). The various EIS and other approval processes for the QNH have included extensive community consultation as part of the Social Impact Assessments, which included engagement with nearby landowners, the wider community, relevant community groups and Local, State and Commonwealth governments.

As previously noted, SCM is operated as part of the integrated QNH operations. Mining pits and waste rock dumps (in-pit and out-of-pit) have progressed across the boundaries between the SCM, CCM and DCM, with shared infrastructure and a single mining contractor utilised by all four QNH mines.

Due to the integrated nature of the QNH operations (other than for the initial consultation during the approvals process for each mine) ongoing community consultation in relation to the QNH is typically undertaken for the QNH as a whole. While the wider community, including the Collinsville and Scottsville townships, are not considered to have a ‘genuine interest’ in the

rehabilitation and closure of SCM for the purposes of the PRCP (as described in the (then) DES Guideline), QCoal has a significant presence in the region and is therefore fully engaged in community matters.

Current ongoing community consultation for the QNH includes the following:

- Participation in the Collinsville Development and Industry Group (DIG) which was founded by QCoal in 2012 to facilitate local community and industry engagement. The DIG meets on a quarterly basis and membership is made up of representatives from local businesses, local and state government, and local services providers/industries. In addition to the quarterly DIG meeting, regular community forums organised by the DIG are also held which are open to all community members to attend. A standing item at the DIG meetings is the provision of an update on QNH activities. DIG minutes are taken by the Department of State Development, Infrastructure and Planning; and
- Attendance at ad-hoc community events/information sessions in Collinsville and other proximate population centres.

A separate Complaints Register is also maintained for the QNH, which records any issues raised by stakeholders regarding SCM, including in relation to progressive rehabilitation. To date no complaints relating to progressive rehabilitation have been received for SCM.

3.4 PMLU and NUMA Consistency with Outcomes of Consultation

Section 126C(1)(d) of the EP Act requires that a PRC Plan states the extent to which each post-mining land use (PMLU) and non-use management area (NUMA) is consistent with the outcomes of community consultation, and any strategies or plans for the land of a local government, the State or the Commonwealth.

The PMLU and NUMAs proposed for SCM are consistent with ongoing community consultation which commenced during the SCM EIS. The PMLUs and NUMAs are also detailed in the SCM Land Outcome Documents (LODs), which are SCM's EA as the primary LOD and the RMP as a subsidiary LOD. The PMLUs and NUMAs therefore have pre-existing approval not requiring further justification under the transitional PRCP provisions.

The PMLU and NUMAs proposed for the SCM are consistent with strategies and plans of local, State and Commonwealth governments as follows:

- **Local Government (Whitsunday Regional Council (WRC)) Plans and Strategies:**

The SCM area is subject to the WRC Planning Scheme, in which the underlying real property is zoned as 'rural'. The rural zoning is consistent with both the pre-mining grazing land-use and the adopted PMLU for SCM. Initial consultation was undertaken with WRC during the EIS process for SCM, and ongoing consultation occurs through community meetings, as well as specific consultation as required.

- Rural zoning under the WRC Planning Scheme does not preclude extractive industries, instead requiring that:

‘development for extractive industry... is appropriately designed, operated and managed to minimise significant nuisance and environmental impacts on surrounding premises’;

The WRC Planning Scheme does not preclude the retention of voids associated with extractive industries.

- It is noted that a significant number of existing third-party coal and other mines and quarries which also include NUMAs/residual voids are present within the WRC area (and are therefore subject to the WRC Planning Scheme).
- As such, the proposed SCM PMLU and NUMAs are considered to be consistent with the WRC Planning Scheme.

- **State Government Plans and Strategies:**

- The most relevant State Government ‘strategies/plans’ are the pieces of legislation which govern the mining industry, being the *Mineral Resources Act* 1989 (MR Act) and the *Environmental Protection Act* 1994 (EP Act).
- The SCM EIS process was undertaken to address the EIS Terms of Reference and was subject to consultation with relevant stakeholders including state government bodies and subsequent public notification.
- The SCM EIS Assessment Report was issued by the then-Environmental Protection Agency (EPA) in August 2006.
- The SCM MLs were subsequently granted under the MR Act, with the ML conditions not precluding the retention of voids/NUMAs following the completion of mining.
- The SCM EA was granted in March 2007 (current version dated 29 September 2022) and specifically nominates a general PMLU of grazing pasture (Condition H1), as well as permitting the retention of specific residual voids Table H1.
- As such, the proposed SCM PMLU and NUMAs are considered to be consistent with the relevant State Government legislation and policy governing the resources sector (considered to incorporate any relevant State Government plans and strategies).

- **Commonwealth Government Plans and Strategies:**

- No specific Commonwealth Government strategies or plans are relevant to the SCM site other than the overarching Environment Protection and Biodiversity Conservation Act (EPBC Act);

The SCM was referred to the (then) Department of Environment, Water, Heritage and the Arts in April 2005 under the EPBC Act. QCS was notified in June 2005

that the SCM was determined to be ‘not a controlled action’ requiring assessment under the EPBC Act.

- A subsequent EPBC referral was undertaken specifically in relation to impacts of Black Ironbox populations associated with the Coral Creek Diversion which is not directly relevant to the SCM PMLU/NUMAs.
- As such, the proposed SCM PMLU and NUMAs are considered to be consistent with the relevant Commonwealth Government legislation and policy governing the resources (considered to incorporate any relevant Commonwealth Government plans and strategies).

4 Post-mining Land Use

Section 126C(1)(d) of the EP Act requires the rehabilitation planning part of the PRC Plan to state the extent to which each post-mining land use for land identified in the PRC Plan 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

The *Progressive Rehabilitation and Closure Plan Guideline* (PRC Plan Guideline, DES 2024) notes that where a PMLU has been previously addressed in a land outcome document (LOD) and is able to be transitioned into the PRC Plan Schedule, the proponent is not required to complete the information requirements under section 126C(1)(j) of the EP Act in this section for those PMLUs.

As detailed in **Section 2.1.3** and **Table 4**, the PMLUs for the SCM final landforms have been transitioned from the SCM EA, which is the primary LOD for SCM, and the QNH RMP (also a LOD for SCM).

The PMLU's transitioned to this PRC Plan from the SCM LODs are:

- Grazing Pasture & grassland community
- Constructed creek diversions

As the QNH RMP is an approved LOD, SCM has transitioned the relevant RMP acceptance criteria, as per the legislative intent of the transitional provisions, to the final milestone criteria of achievement of grazing pasture, grassland community and constructed creek diversion PMLUs.

In order to achieve these acceptance criteria, a range of rehabilitation strategies have been developed to assist in the planning and execution of rehabilitation activities (see Section 5).

4.1 Grazing Pasture

Land to be rehabilitated to a grazing pasture PMLU at SCM is generally to be returned to land suitability Class 4 or Class 3 for beef cattle grazing, based on Table 2.2 of the Land Suitability Assessment Techniques guideline contained within the *Technical Guidelines for the Environment Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques (DME, 1995)*. The previously approved acceptance criteria for Class 4 beef cattle grazing land on the QNH (encompassing SCM) are presented in the QNH RMP and are replicated in **Table 25**.

Table 25 – QNH RMP Acceptance criteria – Class 4 Land Suitability for Beef Cattle Grazing

Parameter	Acceptance criteria
Plant Available Water Capacity (PAWC)	>50 mm
Nutrient Deficiency	≥4ppm bicarbonate P
Salinity	EC _{1:5} <1.2 mS/cm or Cl _{1:5} <1,500 ppm in the root zone (60 cm depth)
Rockiness	<100% (% coarse fragments at soil surface)
Soil pH	<10 and >4 as measured at any part of the root zone.
Exchangeable Sodium Percentage (ESP %)	<30% (0-10 cm depth)
Water erosion (a function of slope % and ESP %)	Mean Slope <15% on cracking clay soils Mean Slope <12% on sodic soils (ESP >15% within 500 mm of surface) rigid soils Mean Slope <45% on non-sodic (ESP <15% within 500 mm of surface) rigid soils
Grazing Criteria	≥70% of the productivity (or carrying capacity) of non-mined land in the lease area or, Carrying capacity within the range of values reported for the region, taken as 15 ha/head
Groundcover	Mean groundcover ≥50% or > than the reference site mean minus one standard deviation.
Grazing Trials	Undertaken following groundcover establishment to confirm carrying capacity.
Species Mix and Composition	Proportion of non-preferred species not increasing. Proportion class will not be more than one class* greater than the grazed reference sites. Proportion of declared plant pest species not increasing, and proportion class** will not be more than one class greater than the grazed reference sites.

* - Classes based on *State Rural Leasehold Land Strategy: Guidelines for determining land condition* prepared by DNRM (2013): Class 1 = 0%, Class 2 = 0-10%, Class 3 = 10-30%, Class 4 = >30% for declared plant pest (weed) species. Class 1 = >80%, Class 2 = 61-80%, Class3 = 10-60%, Class 4 = <10% for preferred species composition.

A direct comparison of the QNH RMP Acceptance Criteria against the complete DME (1995) Land Suitability Class 4 Criteria for Beef Cattle Grazing is shown in **Table 26** demonstrating the QNH RMP Acceptance Criteria are generally equivalent to or better than the DME (1995) criteria.

Table 26 – Comparison of SCM/QNH Acceptance Criteria Against DME (1995) Land Suitability Class 4 Criteria for Beef Cattle Grazing

Parameter	Technical Guidelines (DME 1995) Land Suitability Class 4 Criteria for Beef Cattle Grazing	QNH RMP Acceptance Criteria	Comment
Water Availability	PAWC50-75	>50 mm	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
Nutrient deficiency	Sands and loams at least 75 cm deep or overlying rock at shallow depth, with Bicarbonate P 5-10ppm, or Bicarbonate P ≤4 ppm	No criteria adopted in RMP* ≥4ppm adopted in RM3/4 criteria in V2 PRCP Schedule	*This parameter was not included in the QNH RMP but has been included in the Acceptance Criteria for the PRC Plan and Rehabilitation Milestones in the PRCP Schedule. The DME criteria effectively includes a range of 0-4ppm for bicarbonate P for the relevant soil profile (in this case soils overlying rock at shallow depth). A criteria of 4ppm has been adopted. Therefore, the adopted Acceptance Criteria are equivalent to or better than the DME Criteria.
Soil physical factors	No criteria for Class 4 Suitability for Beef Cattle Grazing	No criteria adopted	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
Salinity	Rootzone EC 0.9-1.2mS/cm or Rootzone Cl 900-1500ppm	EC _{1:5} <1.2 mS/cm or Cl _{1:5} <1,500 ppm in the root zone (60 cm depth)	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
Rockiness	>90% surface cobble and rock outcrop Note: Class 5 criteria: Rock outcrop and surface coarse fragments cover total area)	<100% (% coarse fragments at soil surface)	The Class 5 DME Criteria is total rock coverage (i.e. 100%), which effectively means the Class 4 DME criteria is 90-99.9%. The QNH acceptance criteria has adopted <100% as this is equivalent to the DME criteria but removes the lower limit from the criteria in the expectation that the application of topsoil will result in a significantly lower rockiness percentage in most areas. QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
Microrelief	No criteria for Class 4 Suitability for Beef Cattle Grazing	No criteria adopted	QNH RMP Acceptance Criteria are equivalent to DME Criteria
pH (1:5)	9.0-10.0 4.0-4.5	<10 and >4 as measured at any part of the root zone.	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
ESP (10cm)% Exchangeable Sodium Percentage	15-30	<30% (0-10 cm depth)	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria

Parameter	Technical Guidelines (DME 1995) Land Suitability Class 4 Criteria for Beef Cattle Grazing	QNH RMP Acceptance Criteria	Comment
Wetness	No criteria for Class 4 Suitability for Beef Cattle Grazing	No criteria adopted	QNH RMP Acceptance Criteria are equivalent to DME Criteria
Topography	Many deep gullies make cultivation for sowing pastures impractical, or Slopes >15% make cultivation along contours impractical	No criteria adopted	The DME criteria reflect limitations that are not relevant to rehabilitated mining final landforms – i.e. deep gullies are not present and slopes >15% do not prevent cultivation/sowing pastures which is effectively done via the placement of topsoil containing the natural seedbank.
Water Erosion	Slopes 6-12% on sodic rigid soils or Slopes 9-15% on cracking clays or Slopes 20-45% on non-sodic rigid soils	Mean Slope <15% on cracking clay soils Mean Slope <12% on sodic soils (ESP >15% within 500 mm of surface) rigid soils Mean Slope <45% on non-sodic (ESP <15% within 500 mm of surface) rigid soils	QNH RMP Acceptance Criteria are equivalent to or better than DME Criteria
Flooding	No criteria for Class 4 Suitability for Beef Cattle Grazing	No criteria adopted	QNH RMP Acceptance Criteria are equivalent to DME Criteria
Vegetation Regrowth (management limitation)	Eucalypt woodlands with wattle understorey or Broad-leaved tea tree woodlands	No criteria adopted	Regrowth in this context as a management limitation is not relevant to rehabilitated mining final landforms Not Applicable
Grazing Criteria	No equivalent criteria	≥70% of the productivity (or carrying capacity) of non-mined land in the lease area, or Carrying capacity within the range of values reported for the region, taken as 15 ha/head	QNH RMP Acceptance Criteria in addition to DME Criteria
Groundcover	No equivalent criteria	Mean groundcover ≥50% or > than the reference site mean minus one standard deviation.	QNH RMP Acceptance Criteria in addition to DME Criteria
Grazing Trials	No equivalent criteria	Undertaken following groundcover establishment to confirm carrying capacity.	QNH RMP Acceptance Criteria in addition to DME Criteria

Parameter	Technical Guidelines (DME 1995) Land Suitability Class 4 Criteria for Beef Cattle Grazing	QNH RMP Acceptance Criteria	Comment
Species Mix and Composition	No equivalent criteria	Proportion of non-preferred species not increasing. Proportion class will not be more than one class greater than the grazed reference sites. Proportion of declared plant pest species not increasing, and proportion class will not be more than one class greater than the grazed reference sites.	QNH RMP Acceptance Criteria in addition to DME Criteria

The LOD grazing pasture PMLU acceptance criteria have been incorporated into the SCM PRC Plan Schedule (RA1, RA3, RA4, RA8) and updated with consideration to best practice (were appropriate) and regulatory engagement in developing the milestone criteria.

4.1.1 Grassland community

Coarse and fine rejects from the SCM CHPP were deposited in an out-of-pit co-disposal area (CDA) between 2007-2021. The SCM CDA cells were assessed to be Regulated Structures under the Manual for assessing consequence categories and hydraulic performance of structures and were therefore designed and constructed in accordance with a Design Plan developed by a suitably qualified and experienced RPEQ.

Capping and buttressing of the CDA with waste rock commenced in 2021 as part of progressive rehabilitation. The final slopes of the buttressed CDA will align with the reshaped slopes of SCM waste rock dumps to ensure it is consistent with the surrounding grazing PMLU landform.

Deep rooted species are unsuitable for revegetating the CDA as their deep roots may physically penetrate the engineered cover system and create a preferential pathway for water infiltration, increasing seepage into the encapsulated tailings.

For rehabilitation areas that require a cover with shallow rooted species to manage risk, a grassland community PMLU is proposed. At SCM a grassland community PMLU is planned for the SCM out of pit CDA (RA2).

The grassland community PMLU is substantially similar to the cattle grazing PMLU with additional RMs included for the capping layer and the exclusion of tree species from the recommended seed mix.

4.2 Constructed Creek Diversions

The SCM EA and the QNH RMP recognise permanent creek diversions as an approved PMLU for SCM. The primary function of a permanent watercourse diversion is to provide a self-sustaining, stable and non-polluting waterway capable of conveying flow events. Revegetation strategies for creek diversions are specified within their approved design plans, as recognised by condition H2(h) of the SCM EA and the QNH RMP. There are currently two permanent creek diversions in place at SCM:

- Two Mile Creek diversion:
 - Design: Design of Two Mile Creek Diversion (BSM, 2012)
 - Construction completed in 2013
- Coral Creek diversion
 - Design: North Sonoma Creek Diversion Design Plan (Engeny, 2018)
 - Construction completed in 2018

Any future creek diversion works undertaken at SCM will be subject to the revegetation and rehabilitation requirements presented in their relevant design plans.

The approved permanent creek diversion PMLU and the relevant acceptance criteria from the LODs have been transitioned into the SCM PRC Plan Schedule. Two separate rehabilitation areas (RAs) for the existing SCM creek diversions have been included in the PRC Plan Schedule (RA5 Existing Two Mile Creek Diversion & RA6 Existing Coral Creek Diversion) and rehabilitation milestone criteria (RM9) reflecting the specific requirements for permanent creek diversions are also included.

4.3 Rehabilitation Milestones and completion criteria

The existing rehabilitation completion criteria for SCM are established and approved in the SCM EA and the QNH RMP (LODs). The proposed SCM PRC Plan Schedule Rehabilitation Milestone Criteria (the milestone criteria) have been transitioned from the QNH RMP and maintain the PMLUs and intent of the existing QNH RMP criteria.

Some criteria have been updated with consideration to the following:

- Application of SMART principles were possible.
- Consideration to the integrated nature of QNH operational sites, including contiguous final landforms.
- Consideration to best practice were appropriate.
- Regulatory engagement in developing the milestone criteria.

The proposed SCM PRC Plan Rehabilitation Milestone (RM) criteria are summarised in **Table 27** below.

Table 27 – Proposed SCM Rehabilitation Milestone Criteria

Milestone Reference	Rehabilitation Milestone	Milestone Criteria	
RM1	Infrastructure decommissioning and removal	1.1	With the exception of any infrastructure to remain as part of the post-mining land use (PMLU) or where infrastructure is agreed to be retained by the landholder as evidenced by a signed landholder agreement, the following are complete: (a) All services disconnected and removed. (b) All buildings and associated infrastructure dismantled and removed offsite. (c) All hardstand, concrete areas and roads (bitumen, blue metal, aggregate etc) removed. (d) All fencing and associated foundations not part of a PMLU removed. (e) All pipelines drained and removed. (f) All waste not authorised to be disposed of on-site under Environmental Authority EPML00707713 removed. (g) All drillholes, bores, sediment ponds and sumps decommissioned. (h) All machinery and equipment, not required for rehabilitation works removed from site. (i) All dams dewatered and desilted. (j) Watercourse crossings and culverts removed.
RM2	Identification, remediation and removal of contaminated land	2.1	Contaminated land investigation document completed in accordance with the Environmental Protection Act 1994, including a site investigation report, and, where required, a validation report and/or a draft site management plan.
		2.2	Contaminated water and sediment removed from dams.
		2.3	Contaminated and hazardous material either remediated in-situ or removed/transported to facility lawfully able to accept the material.
		2.4	A declaration from a SQP that no contamination remains.
RM3	Landform development and reshaping	3.1	All Rehabilitation Areas: Final landform design has been completed and approved by an AQP.
		3.2	Geotechnical assessment undertaken by an AQP prior to construction confirms that the landform design will achieve long-term stability, with a Factor of safety (FOS) ≥ 1.5 .
		3.3	All major earthworks completed to achieve final landform design.
		3.4	All landforms are shaped to be water shedding.
		3.5	For RA1: Batter slopes reshaped to maximum slopes of 20% (11.5°) or lower as recommended by an AQP
		3.6	For RA2: Batter slopes reshaped to maximum slopes of 20% (11.5°) or lower as recommended by an AQP.
		3.7	For RA2: Batter slopes reshaped to maximum slopes of 20% (11.5°) or lower as recommended by an AQP.
RM4	Installation of a cover system (RA2)	4.1	Detailed cover system design completed by an AQP, and includes a capping layer that has a minimum thickness of 3m and comprised of non-acid forming (NAF) material.
		4.2	The cover system has been installed as per design.

Milestone Reference	Rehabilitation Milestone	Milestone Criteria	
		43	RPEQ certifies the cover system is geotechnically stable and has achieved a FoS ≥ 1.5 .
RM5	Surface preparation (top dressing, contour ripping, soil amelioration)	5.1	Assessment of growth media characteristics and the development of an amelioration and physical treatment plan is completed by an AQP every 3 years.
		5.2	Ameliorant and physical treatments such as fertiliser, lime, gypsum and/or organic matter are applied as identified in RM5.1.
		5.3	Ameliorant and physical treatments such as fertiliser, lime, gypsum and/or organic matter are applied as identified in RM5.1.
		5.4	Deep ripping of compacted surfaces, to <400mm (or refusal*) into soil/subsoil profile along contour of slopes. *Note, 'or refusal' refers to the depth at which bedrock is intersected.
		5.5	Deep ripping of compacted surfaces, to <400mm (or refusal*) into soil/subsoil profile along contour of slopes. *Note, 'or refusal' refers to the depth at which bedrock is intersected.
		5.6	Prior to seeding testing of growth media confirms the values as specified in Appendix 1 – Soil Quality Criteria are achieved.
RM6	Revegetation	6.1	Seeding of placed growth media completed using a selection of the recommended species seed mix at the seeding rate as described in Appendix 2 – Species list and seeding rates.
		6.2	For RA1: The seed mix should comprise a minimum of 25% (by weight) native species, three 3P species and two shrub / tree species.
		6.3	For RA2: The seed mix should comprise a minimum of 25% (by weight) native species, excluding any trees.
		6.4	For RA3 and RA4: The seed mix should include a minimum of three 3P native species, and a nitrogen fixing legume.
		6.5	Stock exclusion fencing has been established to prevent stock from grazing newly seeded areas.
RM7	Achievement of surface requirements	7.1	Total weed presence is less than 10% of total vegetative groundcover.
		7.2	No evidence of erosion classified as 'moderate' or 'severe' as defined by Appendix 3 – Erosion classification framework is present.
		7.3	Where the AQP determines erosion will not stabilise, intervention measures and corrective actions must be undertaken to ensure RM7.2 is met.
		7.4	Seeded areas have >50% established and self-sustaining vegetative groundcover of species listed in Appendix 2 – Recommended species seed mix and seeding rate.
		7.5	For RA3 and RA4: Seeded areas have a minimum vegetation composition (per hectare averaged) of: - Three species of 3P native pasture species; and - Two native legumes.

Milestone Reference	Rehabilitation Milestone	Milestone Criteria	
RM8	Achievement of post-mining land use to a stable condition	7.6	For RA1 and RA8: Minimum vegetation composition (per hectare averaged) of: - Three species of 3P native pasture species; and - Two native shrub / tree species.
		7.7	For RA2: (a) Total percentage of ground cover (i.e. ground cover foliage, woody debris, organic litter and rock) is $\geq 70\%$. Assessment of RA2 landform by an AQP confirms landform continues to conform with cover and geotechnical design.
		8.1	Established and persistent vegetative groundcover $> 70\%$.
		8.2	Total weed presence comprise less than 5% of vegetative groundcover.
		8.3	No evidence of erosion classified as 'moderate' or 'severe' as defined by Appendix 3 - Erosion classification framework is present.
		8.4	Despite RM8.3 gullies are acceptable in the achievement of a stable landform provided they meet the following criteria as certified by an AQP: (a) does not exceed 1m in depth at any point; and (b) has not exposed environmentally problematic materials; and (c) the cause of the gully is known and has been resolved; and (d) has established and persistent vegetation cover and/or rock armouring at the head of the gully; and (e) is in a stabilised state, demonstrated by monitoring data over a 5 year period; and (f) does not provide a safety hazard within the context of the PMLU; and (g) does not impact the stability or performance of bench drains or stormwater chutes; and are isolated.
		8.5	The final landform is geotechnically stable and achieves a factor of safety ≥ 1.5 .
		8.6	Surface run-off leaving rehabilitation to the receiving environment is non-polluting and meets the contaminant limits below: (a) pH 6.5-9.0; (b) EC 800μS/cm or background +10%, whichever is greater; and (c) Turbidity 50NTU or background +10%, whichever is greater. Surface run-off which remains on the rehabilitated landform must meet livestock drinking water defined in ANZECC & ARM CANZ 2000.
		8.7	For RA3 and RA4: Land Suitability Class is 3 as per the Guidelines for Agricultural Land Evaluation in Queensland, 2015 or as per pre-mining conditions as certified by an AQP.
		8.8	For RA1 and RA8: Land Suitability Class is 4 or better as per the Guidelines for Agricultural Land Evaluation in Queensland, 2015 or consistent with the adjacent land use as certified by an AQP.

Milestone Reference	Rehabilitation Milestone	Milestone Criteria	
		8.9	For RA2: Monitoring of the cover system and encapsulated material confirms that: (a) the cover system is working in accordance with the AQP design; (b) no acid or saline seepage areas capable of causing environmental harm; and (c) no deep rooted species are present.
RM9	Achievement of post-mining land use to a stable condition (RA5 and RA6)	9.1	Diversions have been constructed and stabilised in accordance with the certified Design Plans: (a) Coral Creek Diversion Design Plan 2018; and (b) Two-Mile Creek Diversion Design Plan 2018.
		9.2	At least 50% of established and persistent tree and shrub species consistent with the seed mix in Appendix 4 – Creek Diversion Species Mix must be present within the diversion area*. *Note: Refers to upper, mid and lower banks of diversion alignment.
		9.3	No evidence of erosion classified as ‘moderate’ or ‘severe’ as defined by Appendix 3 - Erosion classification framework is present.
		9.4	No evidence of erosion classified as ‘moderate’ or ‘severe’ as defined by Appendix 3 - Erosion classification framework is present.
RM10	Achievement of post-mining land use to a stable	10.1	Infrastructure to be transitioned to a future landholder is deemed fit for purpose (verified by an AQP) and accepted, by signed agreement, with the future landholder.
		10.2	An AQP certifies that all infrastructure to be retained onsite is safe, stable and will not cause environmental harm.
		10.3	All dams, which are to remain as part of the PMLU or are to be retained as evidenced by a signed landholder agreement, comply with the following: (a) Safely accessible by humans and livestock; (b) All contaminated sediment has been removed; and Water storages monitored quarterly, water must be of a suitable quality for livestock ingestion and must not exceed the stock water guidelines (ANZECC 2000) at the end of each wet season, for a minimum of 5 consecutive years immediately prior to the milestone completion date.
RM11	Achievement of post-mining land use water quality	11.1	Surface water quality results monitored monthly during flow at, but not limited to, downstream locations specified in Appendix 5 – Surface water monitoring locations, must not exceed the limits in Appendix 6 – Surface water quality limits, for a minimum of five (5) consecutive years immediately prior to the milestone completion date.
		11.2	If the surface water quality exceeds criteria in RM11.1, the applicable upstream site must be compared to the downstream site result; and quality result measured at a downstream site must be equal to or less than the quality result measured at the applicable upstream site

Milestone Reference	Rehabilitation Milestone	Milestone Criteria	
		11.3	Where the surface water quality at the downstream site exceeds the upstream site result, an AQP must complete an assessment of the cause and risk of the rehabilitation not achieving a stable condition within the schedule timeframe and: (a) Where the likelihood of the rehabilitation not achieving a stable condition is low, then no further action is to be taken; or (b) Where the likelihood is greater than low to achieving a stable condition then an assessment of potential environmental harm by the AQP and their recommended rectification actions to rehabilitation activities must be determined and implemented.
		11.4	The assessment/s under RM11.3 must be completed and provided to the administering authority by 1 November each year.
		11.5	The five (5) year timeframe under RM11.1 is reset by a single occurrence of RM11.3(b).
		11.6	For a minimum of five (5) consecutive years groundwater quality must be monitored quarterly at, but not limited to, bores specified in Appendix 7 – Groundwater monitoring bores, for all quality characteristics listed in Appendix 8 – Groundwater quality limits.
		11.7	Groundwater quality results must not exceed the limits in Appendix 8 – Groundwater quality limits, for three (3) consecutive results, for a minimum of five (5) consecutive years immediately prior to the milestone completion date.

5 Non-Use Management Areas

Section 6.3.2 of the PRC Plan Guideline states, where a NUMA has already been identified in a LOD and is able to be transitioned into the PRCP schedule, the applicant is not required to:

- justify the proposed NUMA;
- provide evidence to support the justification of the NUMA;
- go through the Public Interest Evaluation process; and
- comply with the prohibition of voids located within a flood plain having to be rehabilitated to a stable condition;

Table H1 of the SCM EA nominates the residual voids that are to be retained following the completion of mining, with Condition H1 and H11 of the SCM EA outlining the residual void outcomes. The approved QNH RMP contains the following statements with regard to the PMLU for final voids at the QNH (s5.3):

- *As the residual voids on the QNH have degrading lake water quality, and are therefore unable to sustain a PMLU, they cannot be rehabilitated to a stable condition as per the EP Act. As per the definitions in section 112 of the EP Act, land that cannot be rehabilitated to a stable condition is considered a non-use management area (NUMA).*

- As the QNH mines transition into the Progressive Rehabilitation and Closure Plan (PRC Plan) framework, residual voids will be managed as NUMAs. The primary LOD for this land outcome will be the QNH RMP.

5.1 Nominated NUMAs

The current SCM LOM plan results in a number of voids (Sonoma B-Pit, Sonoma Q-Pit and Sonoma North) being backfilled with waste rock to a designed landform at or above the approximate natural ground level. The backfilled pits (B-Pit, Q-Pit and North Pit) will not result in final voids and their areas have been included in the grazing pasture PMLU.

The two approved SCM residual voids that are not able to be rehabilitated to a stable condition have been allocated to two separate Improvement Areas (IAs) in the SCM PRC Plan Schedule, as detailed in **Table 28** and as previously shown in **Figure 18**.

Table 28 – SCM Pits and Designated Improvement Areas

EA / RMP Residual Void Name	IA	Maximum Area (Ha)
Sonoma Main Pit	IA1	120
Sonoma East Pit	IA2	29
Total		149

SCM EA Table H1 prescribes the following maximum slopes for residual voids at SCM:

- High Walls: Top 10m - 45°, thereafter - 70°
- Low Walls: 17 to 37°

The maximum slopes for highwalls and low walls differs due to the fact that the highwall is an excavated face of in-situ material, while the low wall is dumped loose waste rock which settles at its natural angle of repose (typically a maximum of 37°).

The proposed SCM residual voids include a 10m setback from the crest of the highwall to a permanent safety bund and fence. For clarity, the area inside the fence (i.e. including the bund and setback) is considered to be part of the NUMA. The NUMAs as proposed include the setback and bund area, with sufficient area for access along the highwall outside the bund/fence available.

Table 12 of the QNH RMP includes further approved completion criteria relating to hydrogeological aspects and long-term void lake water level and water quality. The approved completion criteria from the SCM RMP have been transitioned to the PRC Plan Schedule.

5.2 Voids in Flood Plains

Coral Creek and Two Mile Creek (being the only relevant watercourses within SCM) have been diverted through permanent creek diversions constructed on the western side of the Bowen Development Road. The diversions have been designed and constructed in accordance with their approved Design Plans to convey 0.1% AEP flows without overtopping. The Sonoma Main Pit void, being the only void located on the western side of the Bowen Development Road corridor, is therefore located entirely outside the modelled 0.1% AEP floodplains for Two Mile Creek and Coral Creek.

The Sonoma East Pit void is located on the eastern side of the Bowen Development Road corridor. As shown in **Figure 12**, several tributaries of the upper Two Mile Creek catchment are located in the Sonoma East area. These tributaries are Stream Order 2/3 and therefore are not relevant watercourses requiring consideration. Irrespective of this, the Sonoma East void will be located outside the 0.1% AEP floodplain (refer to **Figure 13**).

As such, voids in flood plains are not a relevant consideration for the SCM PRC Plan.

5.3 NUMA Management milestones and completion criteria

The NUMA management milestone criteria have been transitioned from the SCM EA and QNH RMP LODs. Some milestone criteria have been updated with consideration to the following:

- Application of SMART principles were possible.
- Consideration to the integrated nature of QNH operational sites.
- Consideration to best practice were appropriate.
- Regulatory engagement in developing the milestone criteria.

The proposed SCM PRC Plan NUMA Management Milestone (MM) criteria are summarised in **Table 29**.

Table 29. Proposed SCM NUMA Management Milestone Criteria

Milestone Reference	Management Milestone	Milestone Criteria	
MM1	Achievement of structural stability	1.1	An RPEQ certifies the NUMA landform is constructed to the following design parameters: (a) High wall is competent rock battered to a maximum slope of 70°, with the top 10m having a maximum of 45° including a 1m bund. (b) Low wall is battered to a maximum slope of 17°- 35°. (c) Drainage and erosion controls established. (d) Highwall and low wall achieves a FoS ≥ 1.5 within the NUMA extent. (e) Final residual voids are not subject to inundation from floodwaters up to and including the 0.1% AEP. (f) Predictive modelling confirms that there is no risk of over topping
MM2	Achievement of surface requirements	2.1	Competent safety bund or equivalent landform in place to prevent access to the residual void, at the geotechnical set-back distance of a minimum of 15m

		2.2	Safety bund constructed around highwall, and low wall meets the following dimensions and requirements: (a) Height $\geq 2\text{m}$; and (b) Base width $\geq 4\text{m}$ wide.
		2.3	Appropriate seed mix as per Appendix 2 - Species list and seeding rates applied to the setback area between the crest of the high wall and low wall and the safety bund.
		2.4	Strand barbed wire fencing erected around the perimeter of the safety bund
		2.5	Warning signage to deter public access and warn of void related risks are designed in accordance with the Australian Standard AS1319-1994 and are erected as 100m intervals along the fence
MM3	Achievement of sufficient improvement	3.1	AQP certification that the area between the crest of the high wall and low wall and the safety bund, has $\geq 50\%$ vegetation cover.
		3.2	Certification from an RPEQ that the final NUMA landform complies with items below: (a) Erosion occurring within the NUMA landform will not adversely impact the stability of adjacent rehabilitation areas, or their ability to sustain their PMLU. (b) The water level and quality in the voids do not and will not cause environmental harm to the receiving environment, as demonstrated by groundwater level, quality monitoring and modelling. (c) An AQP demonstrates with water quality, water level and modelling data, that all the residual void/s in the Environmental authorities - EPML00707713*, EPML00337613**, and EPML00393013*** function collectively as groundwater sinks post-closure. (d) Voids retain flood immunity, supported by flood modelling re-run at end of life and calibrated against the final landform. (e) The residual voids will not present an unacceptable risk of environmental harm. note: * Sonoma Coal Mine **Jax Coal Mine ***Drake coal Mine

6 Rehabilitation Management Methodology

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

- For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.
- For each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.

6.1 General Rehabilitation Management

The rehabilitation methodology utilised at the SCM has been developed in accordance with the outcomes of various technical studies that have been undertaken since the development of the QNH mines commenced in 2006. Many of the technical studies have been undertaken for the QNH as an integrated operation, rather than a single mine in isolation. This approach is appropriate given the contiguous nature of the operation and the need to consider cumulative impacts.

The rehabilitation methodology outlined in the following sub-sections has been utilised in rehabilitation activities across the QNH since 2012, with monitoring indicating that rehabilitated areas are generally on a trajectory to achieving the nominated PMLUs.

6.2 Hydrogeology

The pre-mining hydrogeological regime for the SCM area is detailed in **Section 2.2.8**. As previously noted, there are no groundwater values present within SCM and surrounds, and minimal groundwater has been encountered during mining to date at SCM.

A number of groundwater studies have been undertaken during the development and operation of the QNH mines since 2006. A QNH-wide approach to groundwater assessment is appropriate given the contiguous geological units and the integrated nature of the QNH mining operations, the fact that pits span mining lease boundaries, and to facilitate a cumulative approach to potential impact assessment.

The QNH does not extract or undertake any injection activities in relation to groundwater. Impacts to groundwater from the QNH, once rehabilitated, can only occur through the following potential mechanisms:

- Permanent impacts to levels:
 - drawdown associated with voids acting as a groundwater sink,
- Permanent impacts to quality:
 - drawdown associated with voids acting as a groundwater sink having a resultant effect on quality under specific geochemical conditions;
 - infiltration into the surrounding groundwater of contaminated void water from voids acting as a groundwater source;
 - direct infiltration of contaminated surface water into groundwater (such as from dams or fuel depots);
 - direct infiltration of contaminated leachate from waste rock dumps or co-disposal facilities into the groundwater.

Waste rock at the SCM has been shown to be generally low risk (see **Section 6.4**) and is considered unlikely to generate poor quality runoff or leachate. During operations no evidence of poor-quality leachate has been observed from any of the QNH waste rock dumps. Regardless of any potential impact there are no notable groundwater EVs which can be negatively affected by the SCM final landforms.

6.2.1.1 Groundwater modelling

QNH final void numerical groundwater and water balance modelling assessments were undertaken to inform the QNH RMP development. That assessment comprised a final void assessment report that was included in the QNH RMP (Appendix A, *Residual Voids on the QCoal Northern Hub Mining Complex – Sonoma, Cows Drake and Jax Coal Mines* (QCoal, 2020)).

The groundwater model has been subsequently updated to incorporate changes to the LOM plans for SCM, DCM and JCM, and to support EA amendment applications for each of these sites in relation to disturbance maps and void tables. The updated modelling is reported in the QCoal Northern Hub Groundwater Modelling Report (AGE, 2023) which is included as **Appendix G**.

Previous technical studies undertaken to inform (AGE, 2023), included:

- *Jax Coal Mine Final Void Hydrology Study Main Pit* (Engeny, 2018)
- *Long Term Water Quality of Jax Coal Mine Residual Voids* (Engeny, 2018 Supplementary Memo)
- *Residual Void Hydrogeology Study QCoal Northern Hub Mines* (Engeny, 2020c); and
- *Report on QCoal Northern Hub Groundwater Model Update* (AGE, 2020)

AGE, 2023 reported that the updated 3D numerical groundwater model for the QNH complex utilised QCoal's detailed geological model from the extensive exploration activities undertaken within the QNH MLs and the surrounding EPCs which are held by QCoal subsidiaries. The model represents the weathered regolith and underlying Permian strata. Each key coal seam is represented as an individual model layer, as well as the interburden units that separate the coal seams. Most coal seams simulated are within the MCM, but the lower seam of the FCCM is also included. The base model layer represents the Exmoor Formation.

The current and predicted future groundwater levels at the QNH are driven by the proximity to the active/final voids at SCM, DCM and JCM (the CCM voids have been backfilled). Layer 1 in the model is representative of the water table, with some areas across the model domain layer 1 being fully unsaturated, in which case the predicted level resides in lower model layers. **Figure 19** shows the current extent of groundwater drawdown in layer 1 at the QNH, showing localised drawdown around the previous and current mining pits. **Figure 20** shows the predicted drawdown in layer 1 for the end of mining at the QNH (2051) with all pits dewatered. Due to the low permeability of the geology, predicted (and observed) impacts to the surrounding groundwater system remain local to the pits. The water levels in this figure become the starting point for the recovery simulation.

The recovery process was simulated by assuming recharge to the spoil and voids and factoring in evaporative losses from the void lakes. The level of recovery is controlled by the balance of water entering from rainfall derived recharge and groundwater inflow as inputs and the loss due to evaporation from the void lake.

Recharge rates into the void and into the in-pit spoil are higher than the undisturbed recharge rate calibrated for the model, which is conceptually expected as backfilled spoil has higher porosity and permeability than undisturbed material.

Presented in **Figure 21** is the predicted groundwater level at equilibrium, which shows the following results and conclusions:

- The extent of groundwater change within the QNH area is largest at equilibrium due to the continued dewatering offered by evaporation from void lakes that equilibrate below the pre mining water levels;
- The majority of residual voids showed hydraulic gradients flowing into each respective void (groundwater sinks);
- Several of the pits show results with a hydraulic gradient back into the surrounding geology (a net outflow) particularly where they have been completely backfilled or where the void footprint is small. Those pits are Sonoma East 2, Drake 3Q and Drake 3R:
 - A potential issue with such modelling outputs is the assumption that it indicates a migrating of water away from void. This assumption is not correct in the case of the QNH voids due to the proximity and influence of adjacent final voids. With this in mind, the predicted equilibrium water levels have been forensically interrogated to identify that all these potential sources are predicted to be intercepted by the larger and deeper voids (such as Drake 1, Drake 5 and Jax Main), and will not migrate away from the QNH.
- More broadly the model identifies some minor movement of water between some of the smaller voids towards adjacent larger voids, while all other voids remain as groundwater sinks. In summary, the QNH voids when assessed as complexes are all groundwater sinks and the QNH when assessed cumulatively is a groundwater sink with no migration away from the QNH. To illustrate this outcome groundwater flow directions have been added to

Figure 21.

Groundwater drawdown across the QNH is limited by the low permeability and poor connectivity of the coal measures, being the primary groundwater bearing unit. At the completion of mining at the QNH, there are 14 registered bores which are predicted to have a drawdown of 1m or more, all of which are mine monitoring bores in close proximity to the QNH mining activities, with 8 located within SCM. **Figure 22** shows the closest registered water supply bores to the QNH, along with the predicted groundwater drawdown at equilibrium. All water supply bores are located outside of the cone of depression and are therefore not expected to be impacted by final voids at the QNH.

As previously stated, there are no groundwater values which have the potential to be impacted by the modelled steady state drawdown extents of the final voids approved in the QNH.

Groundwater level data is routinely collected through the operational groundwater monitoring program and will continue to be used to refine and further calibrate the model for post-closure groundwater levels. SCM has committed to updating the groundwater model and associated long-term groundwater level predictions by December 2030, and to re-running the model every five years thereafter to ensure that potential impacts on groundwater are regularly assessed throughout the life of the mine.

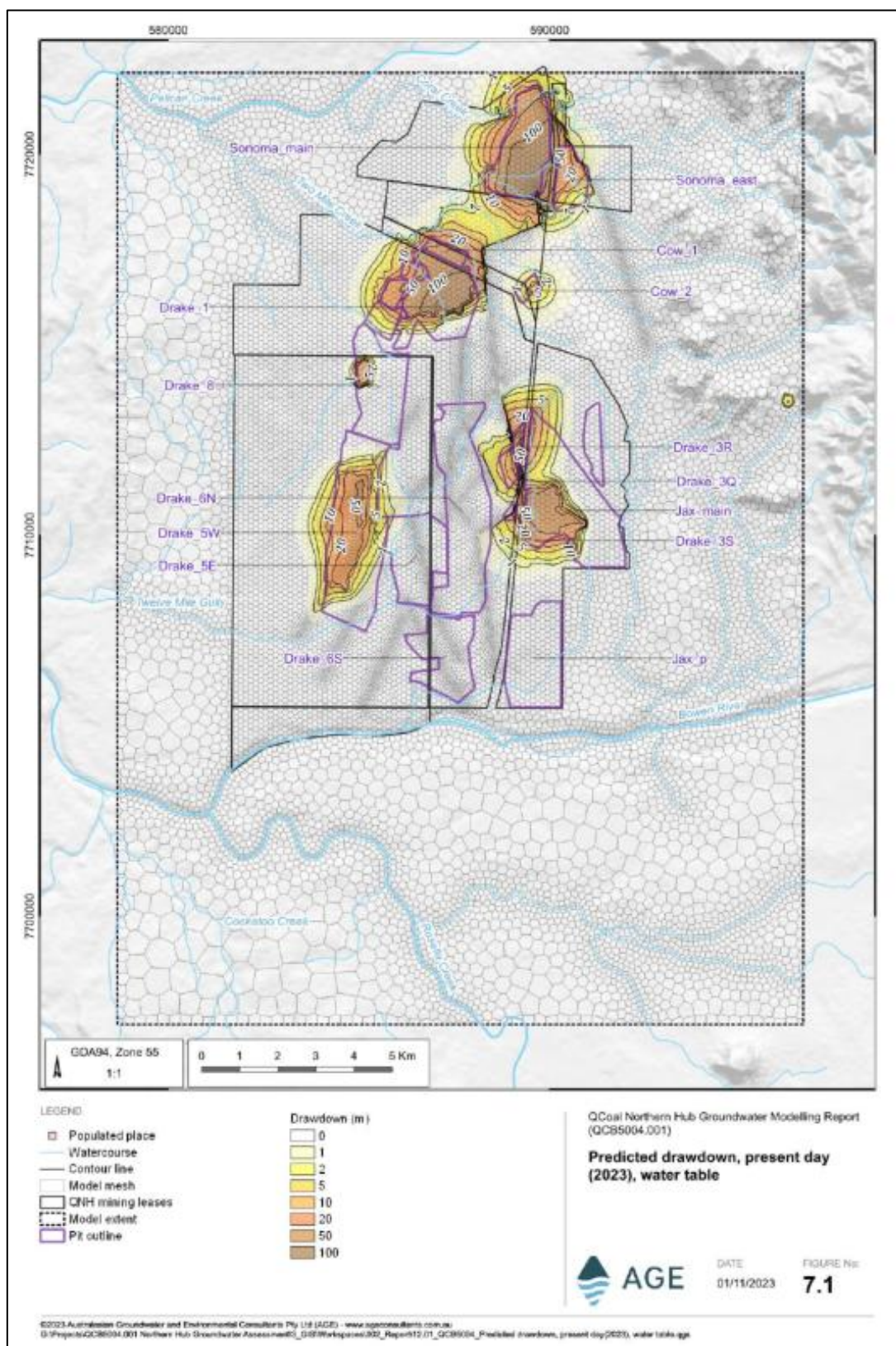


Figure 19 – Modelled existing water table drawdown (2023)

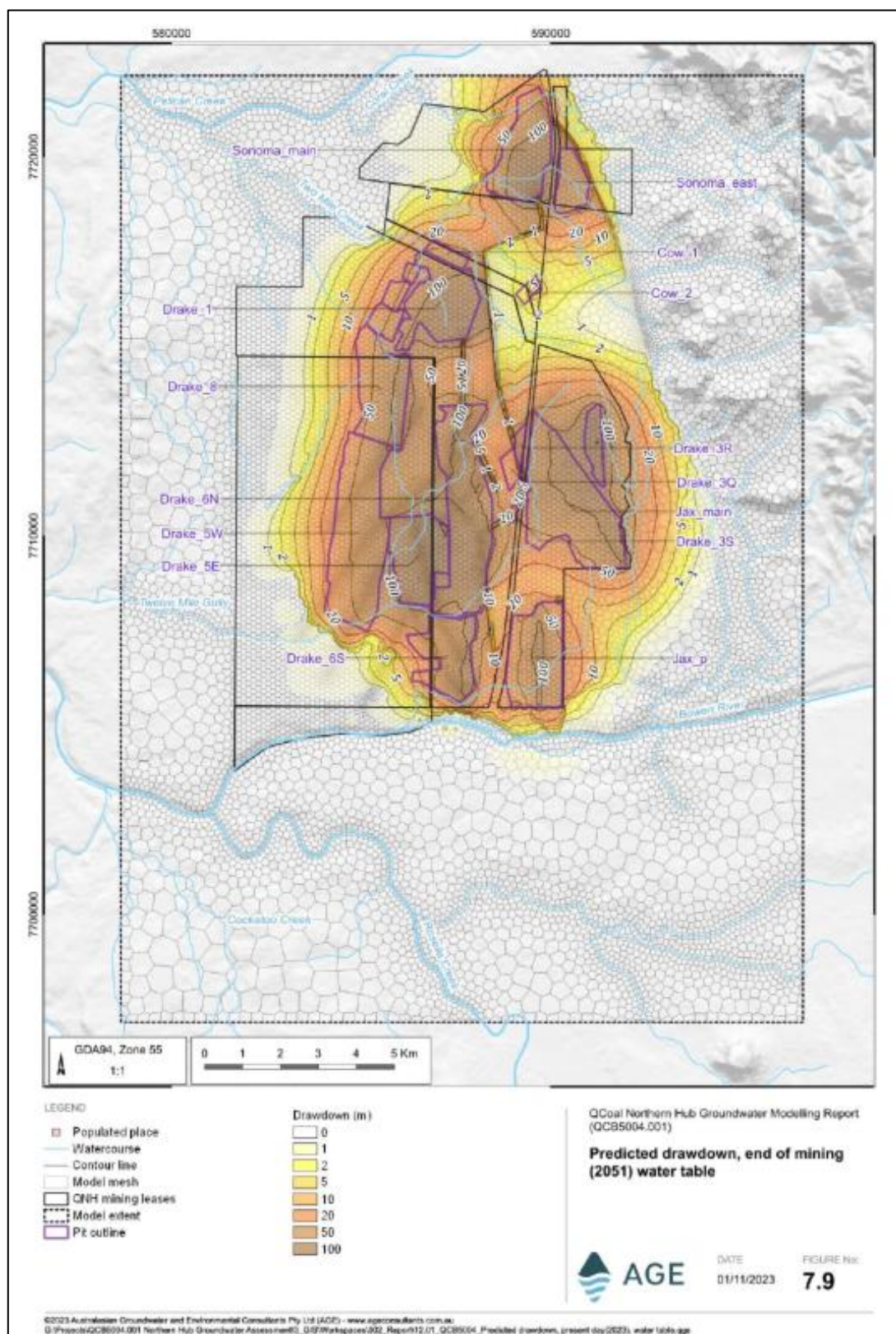


Figure 20 - Predicted Groundwater Table Drawdown at the End of Mining at the QNH (~2051)

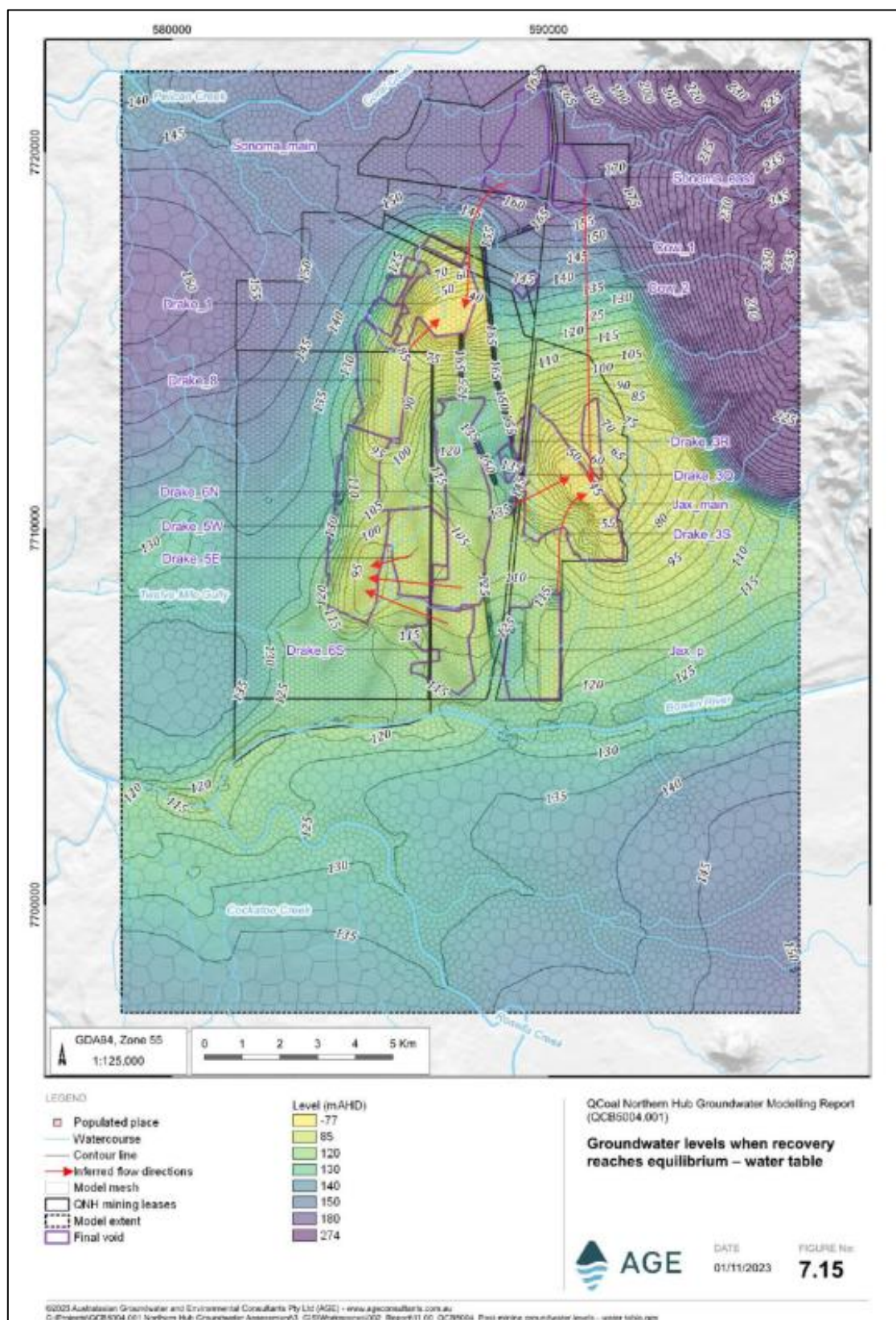


Figure 21 - Predicted Groundwater Table at Equilibrium

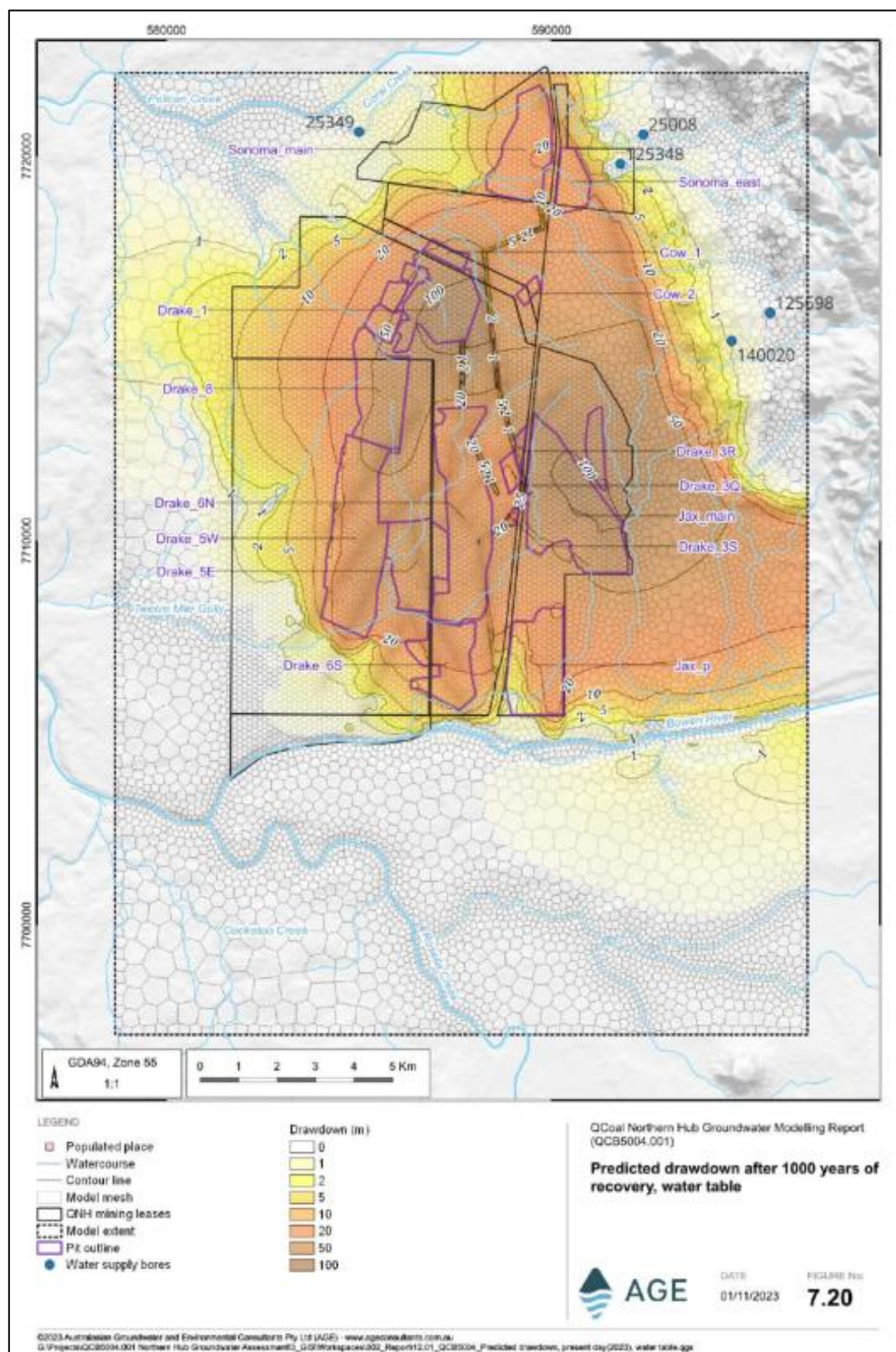


Figure 22 - Predicted Conservative Drawdown at Equilibrium and Registered Supply Bores

6.2.1.2 QNH Final Void Water Balance and Quality Modelling

The results of final void lake volume and level modelling for all QNH voids are presented as appended technical supporting documents to the QNH RMP. Specifically, QCoal (2020) detailed final void lake volume and level modelling (including sensitivity analysis) for all QNH voids. The results presented in QCoal (2020) included the following key information for each void:

- the simulation period:
 - 200 years for final voids at SCM and DCM;
 - 500 years for Jax Main Pit and Jax East Pit (presented for the first 100 years and the full 500 year simulation separately for both final voids)
- minimum, median and max levels and volumes presented for each day of the simulation period for all final voids;
- the observable oscillations are the normal concentration and dilution cycles associated with normal seasonal and climactic variations;
- the median, as used to define the equilibrium levels in the assessment;
- all results reported are from modelling of the “base case” which is the catchment extent provided by the LOM.

Void Lake Levels

No voids at the QNH are modelled to overtop at any time.

As stated in **Section 6.2.2.1** the QNH, when reviewed cumulatively, is a groundwater sink with no migration away from the QNH. Therefore, no migration of water from the voids into the surround groundwater aquifers is likely.

Void Lake Water Quality

Engeny (2020) concluded that the salinity of all residual voids modelled as part of the assessment is forecast to continue to increase over time due to the ongoing concentration resulting from evaporation with no significant outflow of salts from either net outflow, seepage or overflow. It should be noted that pits with net outflow were still shown to accumulate salts throughout the model duration. The reason for this occurrence is that predicted net outflow rates into the surrounding geology at all levels of rating curves for all pits, were significantly smaller in magnitude than flows associated with rainfall, runoff, and evaporation.

The results indicate significant variation in the EC of the voids as a result of differing pit storage curves and catchment sizes. However, all void lakes are forecast to exceed 10,000 $\mu\text{S}/\text{cm}$ after 200 years (with the exception of Jax Main Pit which is closer to 220 years), with some pits reaching 10,000 $\mu\text{S}/\text{cm}$ after 40 years. The overall water quality outcome is consistent for all void lakes (i.e. high levels of salinity that continue to increase over time). Ultimately, salts will continue to concentrate with the maximum concentration only limited by the solubility of the constituent salts

within the lake. This is conceptually the case for any comparable water body receiving inflow, which experiences evaporation as either the largest outflow, or at a rate exceeding all other outflows. As such, the water quality in all QNH voids is predicted to ultimately be unsuitable for any use.

As the residual voids on the QNH have degrading lake water quality, and are therefore unable to sustain a PMLU, they cannot be rehabilitated to a stable condition as defined in Section 111A of the EP Act. As per the definitions in Section 112 of the EP Act, land that cannot be rehabilitated to a stable condition is considered a NUMA. As such, the QNH RMP states that all residual voids at the QNH will be managed as NUMAs.

Summary

The results of the water balance model are summarised as follows:

- there are no groundwater values which have the potential to be impacted by the modelled steady state drawdown extents of the final voids at the QNH.
- the water quality in the voids will continue to degrade, as such the voids cannot be rehabilitated to a stable condition and they will be managed as NUMAs.
- the voids will continue to act as a sink and the void lake waters will not seep into the surrounding regional groundwater.
- no voids at the QNH will overtop.

Routine groundwater monitoring is undertaken across the QNH to identify fluctuations in groundwater level or quality in accordance with the EAs. To date, monitoring has shown the operations have not had a material effect on groundwater level or quality.

SCM has committed to updating the final void lake level model and associated long-term void lake level predictions by December 2030, and to re-running the model every five years thereafter to ensure that potential impacts on groundwater are regularly assessed throughout the life of the mine.

6.3 Flooding

As discussed in **Section 2.2.7.2** and **Section 5.2**, hydraulic modelling of Two Mile Creek and Coral Creek was undertaken during the design of the respective diversions to ensure the channels could convey the 0.1% AEP flood. None of the residual voids at SCM are located within the either of the respective 0.1% floodplains, therefore the PRC Plan only requires consideration of flooding as it relates to potential influences on the final landforms.

6.3.1 Two Mile Creek Flooding Impacts

Flood modelling undertaken for Two Mile Creek is outlined in Engeny (2020b), with the extent of the modelled existing 0.1% AEP Two Mile Creek floodplain within SCM shown in **Figure 13**. Within ML10326 and ML10325, the 0.1% AEP flood extent is confined to the Two Mile Creek diversion

channel. Within ML10327, the 0.1% AEP flood level extends outside the natural creek channel, however this is outside the LOM disturbance area for SCM.

Engeny (2020b) also modelled a baseline and an ultimate closure scenario which incorporate several mine plan and final landform options for the LOM and closure of SCM. With the application for ML700075 and the planned amalgamation of the Sonoma East Pits, the ultimate closure scenario is now the relevant scenario for the LOM and closure of SCM. This scenario incorporates several minor changes to the Two Mile Creek Diversion as follows:

- Completion of the CDA final landform toe (rehabilitated and stabilised waste rock buttressing which will extend slightly into the high-flow channel of the diversion);
- The removal of the existing rail loop crossings within the diversion alignment;
- Several permanent drainage diversions are implemented for the upstream tributaries (Stream Order 2) of Two Mile Creek around the Sonoma East Pit. These tributaries divert upstream flows around the Sonoma East area into Two Mile Creek, and also into Coral Creek; and
- The northern section of the existing Two Mile Creek diversion becomes redundant due to the upstream diversion of the Two Mile Creek tributaries and is mined out as part the final strip of the Sonoma Main Pit.

The 0.1% AEP flood extent for the closure scenario is shown in **Figure 23**. The modelling indicates that all flow events were contained within the Two Mile Creek diversion channel. The lack of significant areas of SCM final landforms within the Two Mile Creek 0.1% AEP flood extent mean that flood influence on SCM final landforms is negligible and flooding is not a significant consideration for the rehabilitation and closure of SCM.

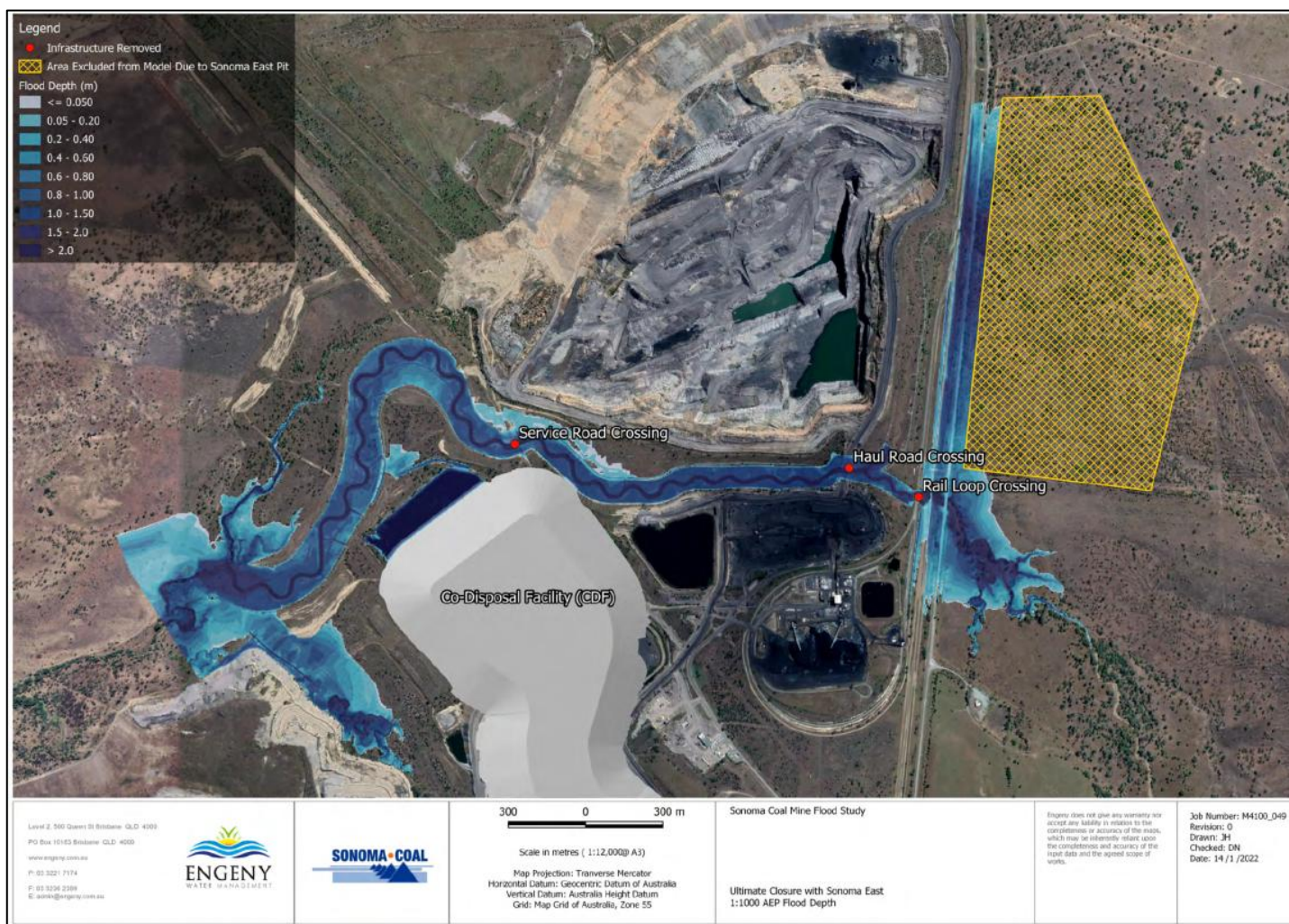


Figure 23 - SCM Two Mile Creek Ultimate Closure Scenario 0.1% AEP Flood Extent

6.3.2 Coral Creek Flooding Impacts

The extent of the modelled existing 0.1% AEP Coral Creek floodplain within SCM is shown in **Figure 14**, with the 0.1% AEP flood extent within ML10326 being confined to the Coral Creek diversion channel. Within ML10327, the 0.1% AEP flood extends outside the natural alignment of the creek but this is outside the LOM disturbance area for SCM.

The lack of significant areas of the SCM final landforms within the Coral Creek 0.1% AEP flood extent mean that flood influence on the SCM final landforms is negligible and flooding is not a significant consideration for the rehabilitation and closure of SCM.

6.4 Mine Waste Characterisation

Several geochemical investigations have been undertaken on the QNH sites and other adjoining third-party mines to provide a robust understanding of the nature of waste rock to be generated at the QNH mines (including SCM). Waste rock characterisation investigations/assessments that have been undertaken include, but are not limited to, the following:

- *Sonoma Coal Project – Overburden Assessment Report* (Parsons Brinckerhoff, 2006) – Included as **Appendix K**
- *Cows Coal Project – Waste Rock Report* (Tecsol, 2011)
- *Jax Coal Project – Waste Rock Report* (QCoal, 2011)
- *Geochemical Assessment of Mining Waste and Coal Reject Materials, Sonoma Coal Mine* (Terrenus, 2012)
- *Drake Coal Project EIS Waste Rock Characterisation Report*. (GHD, 2012)
- *Drake Coal Project SEIS Excavated Waste Characterisation Report* (GHD, 2013) – Included as **Appendix L**
- *Mining Waste and Coal Rejects Management Plan – Sonoma Coal Mine* (Terrenus, 2013)
- *Environmental Management Overview Strategy, Belmore Project - Pipeline Deposit* (Collinsville Coal Company, 1999). The Pipeline deposit was geologically contiguous to SCM, being a Q-seam deposit located on the eastern side of the Bowen Development Road within ML10250, directly opposite SCM Q-Pit.

The results of these investigations are summarised in the QNH RMP, and informed the development of the QNH Mine Waste Management Plan (QCoal, 2021) (MWMP), which is included as **Appendix M**.

Waste rock across the QNH has been found to be non-acid forming (NAF), with only one sample found in carbonaceous shale returning an Uncertain classification. Waste rock was also found to have a low potential for metal leaching and saline runoff. Therefore, the waste rock materials on site are generally classified as low risk for acid mine drainage (AMD).

6.4.1 SCM Waste Rock Characterisation

Previous waste rock characterisation studies for SCM and the adjacent and geologically contiguous former Belmore-Pipeline Coal Mine have shown that the waste rock is slightly alkaline and has a negligible potential for formation of AMD as follows:

- Waste rock was typically non-acid forming (NAF).
- Tertiary/Quaternary soils were generally slightly alkaline (pH between 7.8 and 8.6) and had low salinity (Electrical Conductivity (EC) of 200 $\mu\text{S}/\text{cm}$) to moderate salinity (EC of 675 $\mu\text{S}/\text{cm}$). A single sample returned moderately high salinity (EC of 924 $\mu\text{S}/\text{cm}$).
- Alluvial soils were found to have low to moderate salinity.
- Weathered Permian rocks were found to have similar salinity, sodicity and alkalinity characteristics to the overlying alluvial soils.
- Fresh Permian rocks had moderately high alkalinity levels and low to moderate salinity.

In addition to the above studies, a site specific investigation was undertaken within the DCM MLs (to the south of SCM) as part of the DCM EIS (GHD 2012). GHD 2012 is relevant to SCM as the DCM targets the adjacent and geologically contiguous MCM coal seams. GHD 2012 reported on testing that had been undertaken in 2008 to assess the geochemical characteristics for a wide range of lithologies from the DCM area, and the adjoining, geologically contiguous, JCM area. Results from this testing indicated:

- The acid-base accounting (ABA) analyses indicated that waste rock or spoil materials from the MCM for the Project area would be non-acid forming (NAF). Coal and other carbonaceous sediments (siltstone and mudstone) have a low potential for acid formation (PAF); however, the impacts of any PAF materials would be negated by the significantly higher neutralising capacity of other lithologies (e.g. quartzose sandstone) placed in the overburden dumps or spoil heaps. Carbonaceous sediments (siltstone and mudstone) which occur interbedded in the coal seams were potentially saline but were intended to be removed from site as a component of the ROM coal.
- Overburden materials from DCM and JCM areas recorded an average EC value of 281.1 $\mu\text{S}/\text{cm}$, which is within the low salinity range of 150 to 450 $\mu\text{S}/\text{cm}$ (DME, 1995b). In view of the stratigraphic similarities between mining operations in this region, specific requirements to manage salinity have not been required for overburden dumps in the JCM area, or elsewhere at the QNH mines.
- Total sulphate levels were found to be low. Together, the low sulphate and low EC values provide evidence to support the findings that the overburden materials are not saline.
- Waste rock/soil materials are more likely to disperse when calcium (Ca) / magnesium (Mg) ratios are less than 2 and exchangeable sodium percentages (ESP) are greater than 6%. The analyses confirmed the presence of high Ca/Mg ratios and low ESPs, and therefore significant dispersion of fine materials from overburden dumps is not expected to occur.

Further waste rock characterisation testing was undertaken within the DCM MLs for the DCM Supplementary EIS (DCM SEIS), as reported in GHD 2013. GHD 2013 is relevant to SCM as the investigation was undertaken in adjacent and contiguous MCM strata and is the most comprehensive geochemical investigation undertaken at QNH, building on the outcomes of the previous QNH investigations (including the SCM EIS investigation (Parsons Brinckerhoff, 2006)). Results from this additional testing indicated:

- All lithological waste groups, had high to very high mean pH1:5 results (DME 1995);
- All lithological waste groups, had low to very low mean EC1:5 results (DME 1995). Using the Anderson-Darling normality test, there was a 95% probability that meant EC1:5 for all 329 samples was less than 246 $\mu\text{S}/\text{cm}$; a low classification (DME 1995);
- All lithological waste groups had low to very low mean chloride results (DME 1995);
- All lithological waste groups were classified as non-acid forming (NAF) using data from 284 samples;
- All lithological waste groups, in addition to the tailings results, had no mean individual whole-rock metal value elevated above a geochemical abundance index using data from 292 samples;
- All lithological waste groups had some leachable metals from the 92 samples that were tested. The most commonly leached elements from the excavated waste were aluminium, arsenic, lead, zinc and selenium. Of these, only selenium returned a leachable concentration from various individual lithologies that exceeded the ANZECC stock watering guidelines. It was noted that the mean leachate pH value of the same 92 samples was 8.0, meaning that the elements of concern will be sparingly soluble and have limited environmental ecotoxicological risk; and
- Based on Exchangeable Sodium Percentage (ESP) results from 295 samples across the lithological waste groups; the carbonaceous material (the majority of which is removed from the site with the ROM coal) and mudstone showed a high dispersivity risk. The siltstone showed a medium dispersivity risk, while the sandstone and intrusive lithological waste groups showed low to medium dispersivity risk. The soil unit showed a low dispersivity risk. The mean Ca:Mg ratios for all lithological units, however, were found to be at levels which would preclude the excavated waste from being dispersive.

Potential environmental risks associated with mining waste (overburden) and coal rejects are mainly associated with AMD, the related mobilisation of metals, saline drainage and dispersion.

Waste rock generated at the QNH (including SCM) is relatively benign and is expected to generate moderately alkaline and low-to-moderately saline runoff and seepage, following surface exposure. As stated in the QNH MWMP, all rejects from the SCM CHPP are generally disposed of together in the SCM co-disposal facility, with some minor quantities of coarse reject disposed of in waste rock dumps (in-pit or out-of-pit). As noted in the GHD 2013 results above, several of the waste rock lithologies encountered at QNH are potentially moderately-highly dispersive based on the ESP, but less likely to be dispersive if the Ca:Mg ratios are also considered. It is important to note that over 67% of the waste rock generated at the QNH consists of the sandstone and intrusive lithological units which are low-medium dispersivity risk based on ESP alone, and also have high Ca:Mg ratios.

6.4.2 Coal Rejects Characterisation

Based on the analysis of 89 coal reject samples from the QNH by Terrenus (2013), and additional sampling and analysis undertaken by Terrenus, the following general observations can be made regarding the bulk coal reject material generated at the SCM CHPP and disposed of to the SCM CDA:

- Coal reject will generate alkaline, generally low-salinity run-off and seepage following surface exposure.
- Total sulfur concentration in coal rejects is generally low (median sulfur content of 0.21%); however, in approximately 5% of samples, sulfide concentrations were sufficient to generate acid. Sulfide-sulfur comprises between 14% and 99% of the total sulfur concentration of coal reject; however, for most coal reject material, sulfide-sulfur comprises about 50% of the total sulfur concentration.
- Conservatively, 90% of coal reject materials are expected to be NAF, with a third of these NAF samples classified as 'barren' with respect to sulfur concentration.
- Approximately 5% of coal reject materials are anticipated to be Potentially Acid Forming (PAF) and Potentially Acid Forming – Low Capacity (PAF-LC). Coal rejects are likely to have relatively low total sulphur concentrations (typically less than 1%), and therefore are regarded as low risk, with the main potential for environmental impact likely to be the generation of sulfate salts.
- Approximately 5% of coal reject materials are anticipated to be classified as Uncertain, with low sulphur concentrations, making these materials low risk.
- Total metal and metalloid concentrations in coal rejects are expected to be low, and below the applied health-based investigation levels for soils. However, there is potential for the concentrations of some metals (particularly Ba, Co, Cu, Mn, Ni, and V) to exceed the applied ecological investigation level. Some coal reject materials may produce leachate containing slightly elevated soluble Al, Se, and potentially As concentrations, as is common in Permian coal measures in the Bowen Basin.

6.4.3 Mine Waste Management

Waste rock at all QNH sites is managed in accordance with the QNH Mine Waste Management Plan (2021). Mining waste is grouped into four (4) categories as defined in **Table 30**.

Table 30 – Waste Rock Categories and Risk

Category	AMD Characterisation	Risk Classification	Material
Topsoil	NAF	Low	Soil (including sub-soil) to a nominal depth of 1 m below natural surface. Refer to Section 1.10 for characterisation of soil materials identified at the SCM.
Waste Rock – Category 1	NAF	Low	Waste Rock – Upper: Non-coal and non-carbonaceous material above the coal seams, and not within 1 m above or below ROM coal. Typically weathered or moderately weathered.
	NAF to PAF-LC	Low to Medium	Waste Rock – Lower: Non-coal and non-carbonaceous material below the upper seam, and not within 1 m above or below ROM coal. Typically fresh or slightly weathered.
Waste Rock – Category 2	PAF-LC	Medium	Carbonaceous waste rock and unsuitable coal: Carbonaceous material, material located within 1 m of ROM coal seams. Sub-economic coal, intruded coal or heat-affected coal.
Coal Rejects	NAF	Low	CHPP rejects (coarse and fine) as co-disposal slurry.

Strategies for each of the identified waste rock management categories are outlined in the following sub-sections.

6.4.3.1 Waste Rock - Category 1

The majority of waste rock excavated on the QNH is designated as Category 1, and is managed as follows:

- Materials are identified by a mine geologist and communicated to excavator and haul truck operators.
- Material is placed in overburden dumps (out-of-pit and/or in-pit).
- Materials may be used as site construction material, provided it meets geotechnical and engineering specifications.
- Materials may be used as a sub-soil cover material for rehabilitation of co-disposal facilities, ROM pads, and sediment dams at mine closure, prior to application of topsoil.
- Materials may potentially be incorporated into a final growth medium, should the geochemical and geophysical composition designate as suitable for such an application.
- Materials may be blended with Waste Rock – Category 2 during normal excavation, haulage and dumping.
- Where there is insufficient blending of Waste Rock - Category 2 with Waste Rock - Category 1, then Waste Rock – Category 1 should be used to encapsulate Waste Rock – Category 2.

6.4.3.2 Waste Rock - Category 2

A minimal proportion of excavated waste rock (by volume) is classified as Category 2. The material is managed as follows:

- Materials are identified by a mine geologist and communicated to excavator and haul truck operators.
- Materials will be blended with Waste Rock – Category 1 during normal excavation, haulage and dumping.
- Where there is insufficient blending of Waste Rock - Category 2 with Waste Rock - Category 1, then Waste Rock – Category 1 should be used to encapsulate Waste Rock – Category 2.
- Traffic compact material (where practical) prior to encapsulation (where required).

Due to the lack of trace elements within the waste rock lithological units, the risk of trace element (i.e. metalliferous) or saline drainage is considered minimal.

The inert nature of the waste rock lithologies has been further demonstrated by ongoing water quality monitoring of dams which receive run-off from active and rehabilitated waste rock dumps throughout the QNH. This monitoring program commenced in 2007 and will continue in accordance with EA requirements until surrender of the various QNH EAs. Results from monitoring undertaken to date does not indicate the occurrence of saline drainage or AMD. The demonstrated run-off water quality from waste rock stockpiles within and adjacent to SCM gives further confidence in the conclusions of the geochemical characterisation conducted on the waste rock material.

6.4.3.3 Coal Rejects Management

As previously noted, coal reject material was historically managed in an out-of-pit CDA (from 2007-2020), before transitioning to an in-pit CDA in the Sonoma Main Pit void. The in-pit CDA will continue to be utilised for the LOM of the QNH.

6.4.3.3.1 Out-of-Pit CDA

The CDA consists of four cells which were progressively developed over the life of the structure. CDA cells 1/2 were initially developed in 2007, followed by CDA cell 3 in 2014 and CDA cell 4 in 2015.

The CDA cells comprise an initial external clay starter embankment, from where the co-disposal material was deposited, with the CDA cannon moved as required to facilitate the deposition of coarse reject 'beaches' around the perimeter of the starter embankments. Decant structures within the cells enabled free water to report to the solution trenches and ultimately to the return water dam for reuse in the SCM CHPP. Successive lifts of the CDA cells were undertaken using segregated coarse rejects from the pumped co-disposal stream to build the walls for the next lift.

Deposition into the CDA1/2 cells ceased in 2017 while deposition into CDA3/4 cells ceased in 2021, when the Sonoma Main Pit void became available for in-pit co-disposal. Capping and

buttressing of the out-of-pit CDA cells has commenced, with CDA1/2 capping completed and CDA 3/4 commenced (refer to **Section 6.6.1** for further information).

CDA1/2 and CDA3/4 continue to be classed as regulated structures, and as such are subject to Schedule I of the SCM EA. This includes the requirement for annual inspections by a suitability qualified and experienced person (i.e. an RPEQ). Following completion of capping and buttressing of the CDA cells, the structure will be reassessed and it is expected it will no longer be considered to be a regulated structure.

6.4.3.3.2 In-Pit CDA

The in-pit CDA utilises the existing Sonoma Main Pit void for the ongoing deposition of reject materials. The co-disposal material is pumped to the south-western corner of the pit, where it is released at the top of the low wall through a 'cannon'. The deposited material gradually forms a coarse reject beach which extends from the cannon into the void water body (a mix of mainly co-disposal supernatant water with some minor contribution from any coal seam pit inflows and rainfall) in the deepest part of the void. The fine reject material settles in the water body, and decant water is pumped from the top of the water column for reuse in the CHPP and/or dust suppression.

No physical structures (decant walls, etc) are required for the in-pit CDA. Minimal ongoing management is required other than occasionally shifting the cannon to optimise the progressive evolution of the coarse reject beach, and raising the decant pump as the water level progressively rises

The final landform within the Sonoma Main Pit will consist of:

- the coarse reject 'beach' extending from the western low-wall;
- the northern low-wall;
- the southern and eastern high-walls; and
- the fine reject materials settled in the base of the void which is submerged by the void lake.

The in-pit co-disposal will not backfill fully the Sonoma Main Pit and therefore it will remain a residual void (and a NUMA) final landform.

6.5 Landform Design

The final landforms at SCM are designed to be consistent with the requirements for Class 4 suitability grazing land, and the surrounding topography of the land to the extent possible. Landform stability is typically achieved by achieving a desired slope length and angle, correct material selection and establishment of groundcover to improve erosion resistance.

The primary above-natural grade landforms resulting from the mining activities at SCM are the waste rock dumps and the out-of-pit CDA. Due to the CDA being capped and buttressed with waste rock (see **Section 6.6.1**), the PMLU and associated landform design considerations are much the same as for waste rock dumps. As discussed in **Section 4.1.1**, deep rooted species are not suitable for revegetation of the CDA and therefore a grassland community PMLU is proposed

for the CDA. The grassland community PMLU is substantially similar to the cattle grazing PMLU with additional criteria for the capping layer and exclusion of tree species from the recommended seed mix.

Final landforms (slope, height, size/footprint etc) for the waste rock dumps are designed taking into account the designed size/footprint, height, and operational slopes at the completion of operation of the dump. In this way the structure at the cessation of waste rock placement is as close as possible to the approved final landform design, which reduces the bulk earthwork requirements to achieve the desired final landform.

Landform design plans are produced commensurate with the operational requirements to ensure as much of the bulk earthworks can be undertaken during regular operation as is possible. The maximum final landform slopes for the various rehabilitation areas (RA) are detailed in **Section 4.3**.

The final landform design at SCM has been developed in consideration of the following constraints:

- Location of watercourses within SCM and the extent of the riparian zones and floodplains where present;
- Location of mapped remnant ecosystems;
- Size and location of the waste rock dumps and voids within SCM and adjoining QNH sites;
- Ongoing requirement for use of haul roads/ramps to support the wider QNH operations for the LOM; and
- Ongoing requirement for use of built infrastructure to support the wider QNH operations for the LOM.

Figure 24 shows the designed final landforms for the SCM mining areas in plan view with the design contours displayed.

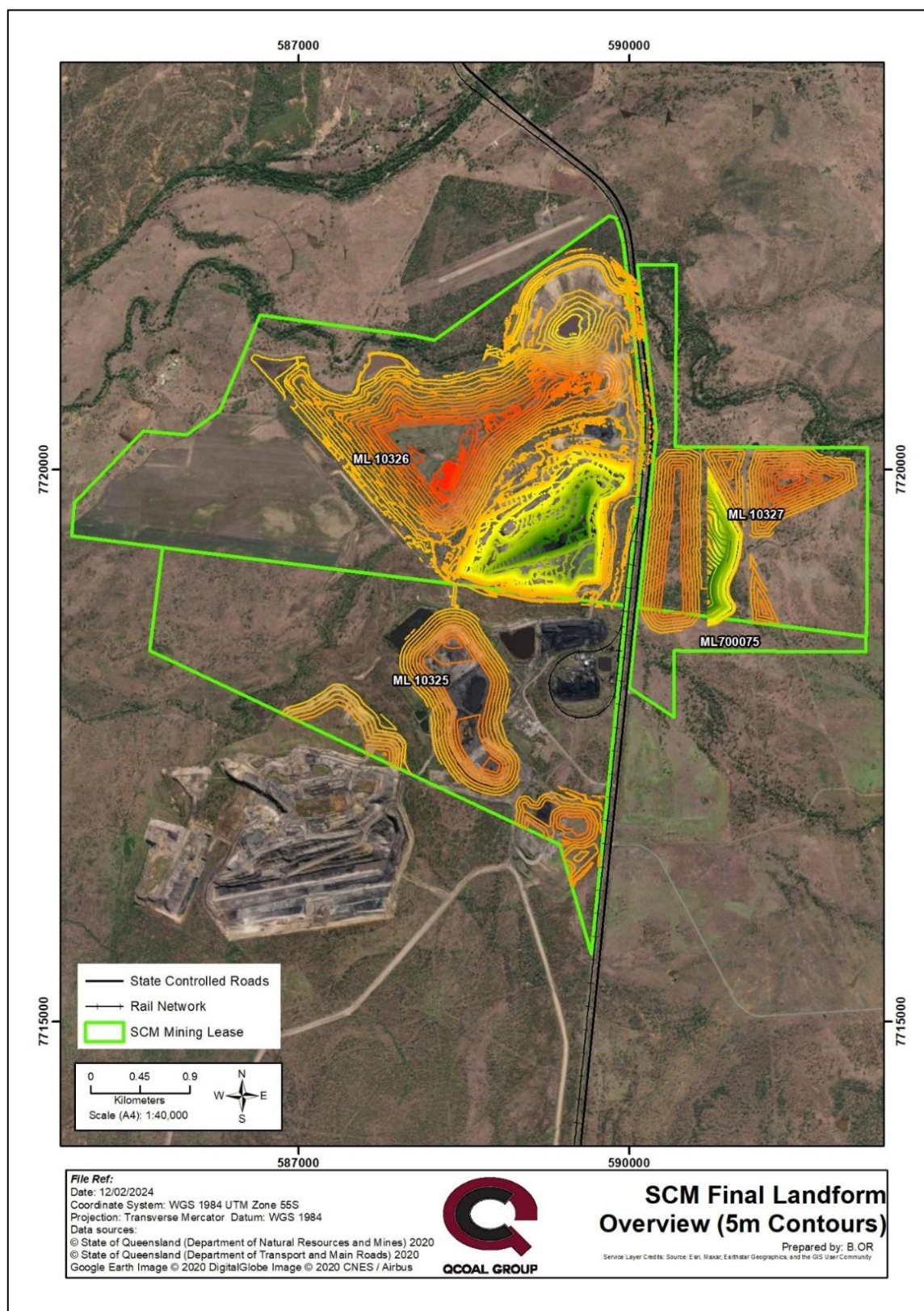


Figure 24 – SCM Final Landform Design

6.6 Capping Requirements

Waste rock generated at SCM and the wider QNH is relatively benign and expected to generate slightly alkaline and low-to-moderately saline runoff and seepage following surface exposure (**Section 6.4**). Accordingly, capping of waste rock emplacements has not been undertaken on rehabilitated landforms to date at the QNH and is not required or proposed for the completion of rehabilitation at SCM. Capping requirements for the out of pit CDA and the in pit CDA are detailed below.

6.6.1 Out-of-Pit CDA

The SCM out of pit CDA consists of four cells in which mixed coarse and fine reject material from the SCM CHPP was deposited between 2006 and 2020, at which time the Sonoma Main Pit became available for use as an in-pit CDA.

Co-disposal materials generated at the QNH are relatively benign and expected to generate slightly alkaline and low-to-moderately saline runoff and seepage following surface exposure Section 6.4). While the co-disposal material itself is benign, it is not suited to be utilised as a growing medium or substrate for rehabilitation for the following reasons:

- The rejects material itself is generally devoid of clays, silts, sands, nutrients and organic materials;
- Where left at surface, the co-disposal material absorbs significant heat from sunlight which may impact on the ability of vegetation to establish;
- While the coarse walls typically create a surface which dries/dewaters and is trafficable, in areas where a higher concentration of fines have been directed during operation (such as the central part of the CDAs), it will potentially result in soft, boggy areas;
- The design and operation of the CDA results in relatively steep perimeter batters formed of coarse reject material. The landform cannot be shaped to the design slope ($\leq 20\%$) using the cut and fill approach typically used on waste rock dump benches as the rejects walls are designed to remain as placed during operation. Instead, the outer batters need to be buttressed with waste rock which is then shaped as required.

As such, the SCM out-of pit CDA requires capping to be able to support the proposed grassland community PMLU.

Additionally, a capping layer reduces infiltration of rainfall into the out of pit CDA. Whilst quality of CDA seepage/leachate is relatively benign at SCM due to the coal rejects geochemistry continued dewatering is desirable for interim stability during rehabilitation works and to ensure seepage does not report to the surface of the wall buttressing.

The approach adopted for capping and rehabilitation of the out-of-pit CDA is outlined in the QNH RMP and is as follows:

- allow a period of drying/dewatering of completed cells;

- placement of Category 1 waste rock on the out of pit CDA surface to a minimum depth of 3m which constitutes:
 - the minimum depth for safe trafficability of mine haul trucks;
 - the minimum required to enable shaping of the top of the out of pit CDA for the purposes of drainage (prevent pooling of water on the top);
 - a conservative depth for the purposes of reducing the potential for oxidation;
 - a conservative depth for the purposes of restricting rainfall infiltration, and accelerating dewatering;
 - Provide a suitable substrate for revegetation and be constructed of non-dispersive material. Topsoil should be spread to a minimum of 0.1m above this.
- coarse reject walls (perimeter batters) of the out of pit CDA are then buttressed with Category 1 waste rock which is shaped to achieve the design slope.

At completion of the capping, the out of pit CDA will be encased in suitable waste rock material. The final landform will have topsoil applied and be revegetated to achieve the grassland community PMLU. Progressive rehabilitation of the out of pit CDA has commenced, with capping layer placement beginning in 2019. Buttressing of perimeter batters using Category 1 Waste Rock has also commenced.

The availability of the remainder of the out of pit CDA for the completion of capping and buttressing is dependent on the following:

- further drying of the out of pit CDA surface,
- seepage rates through the coarse rejects walls;
- the availability of suitable waste rock for capping from nearby pits; and
- the proximity of LOM QNH infrastructure, which impacts the ability to undertake buttressing of the out of pit CDA batters with waste rock, to achieve the required final landform slope and footprint.

Category 1 waste rock is sourced directly from mining operations in nearby pits (typically the Drake 1 Pit) and hauled to the out of pit CDA surface. Given a minimum of 40 million BCM of Category 1 waste rock is generated at the QNH annually, there is sufficient Category 1 waste rock available for capping.

6.6.2 In-Pit CDA

Management of coal rejects at SCM shifted from the out of pit CDA to in-pit co-disposal in the Sonoma Main Pit void in 2021. Following completion of reject deposition, the final landform within the Sonoma Main Pit will consist of:

- the coarse reject 'beach' extending from the western low-wall;
- the northern low-wall;
- the southern and eastern high-walls; and

- the fine reject materials settled in the base of the void which is submerged by the void lake.

The in-pit co-disposal will not completely backfill the Sonoma Main Pit and it will remain a residual void (and a NUMA) final landform.

As previously noted, the retained QNH voids are designated as NUMAs due to the modelled increase in salinity in the void lake over time, which will occur regardless of the presence of the co-disposed reject material. The rejects are placed fully saturated (co-disposal slurry) and as such with the presence of the void lake, the fine rejects are placed and remain submerged. As such, no capping or other treatment of the deposited in-pit co-disposal material is proposed.

6.6.3 Topsoil

Topsoil placement at SCM involves the application of previously salvaged topsoil to a minimum depth of 100 mm (as per the QNH RMP LOD), to act as a growth media for revegetation.

The surface layer within each RA requiring the application of topsoil consists of either a blend of the component waste rock lithologies (for RA1 and RA2) or select fill (which is a component of the waste rock) sourced from within SCM (for RA3). As confirmed by the waste rock characterization and rehabilitation monitoring at the QNH, waste rock is a suitable substrate for the topsoil (and demonstrably effective as subsoil for rehabilitation).

The QNH Topsoil Management Plan (QNH TMP) details the requirements for management of the topsoil resources at SCM. As previously discussed in **Section 2.2.9**, the primary soil units encountered at the SCM for the LOM are the following:

- Grey Uniform Clay (60%)
- Red Duplex Sandy Loam (25%)
- Brown Gradational Sandy Loam (15%)

The SCM soil units are suitable for stripping to varying depths for reuse in rehabilitation. During mine development activities on SCM, suitable topsoil from disturbance areas (i.e. infrastructure areas, pits, dumps, haul roads etc.) is progressively stripped in accordance with the QNH TMP and either placed into stockpiles or preferably placed directly onto areas being rehabilitated (if available). A topsoil register for the QNH is maintained to track topsoil quantities and locations against planned rehabilitation across the QNH.

The topsoil resources available within SCM are detailed in **Table 31**, with the available volumes sufficient to complete the rehabilitation of the site in accordance with the methodologies outlined in **Section 6.8**.

Table 31 – Topsoil Resources available within the SCM

# Stockpiles	Location	Predominant Land Unit in Stockpile	Haul Distance to Rehabilitation Area (m)	Volume (LCM)
26	Various Locations within SCM	All	<1000	1,930,316
Existing Stockpiles Subtotal				1,930,316
Approx. Future Topsoil Volumes Available to be Stripped	Sonoma East	All	-	517,100
SCM LOM Topsoil Inventory Total				2,447,416
SCM LOM Topsoil Requirement for Completion of Rehabilitation				605,122

The soil units salvaged from within SCM are suitable for use as a growing medium in rehabilitation at the site due to the following characteristics:

- The topsoils are non-sodic, neutral-slightly acidic, clays soils and sandy loam soils of moderate water holding capacity;
- The pre-mining land use for the majority of the areas from which these soil units have been stripped was improved pasture in the SCM area and, as a result, the stripped topsoil retains a significant seed bank of the preferred pasture species.

Based on the currently available topsoil volumes there will likely be a surplus of topsoil following the completion of rehabilitation at SCM. Any surplus topsoil at the SCM would be available for use in rehabilitation at other QNH sites as required.

6.7 Water Management

All water management infrastructure at SCM is constructed and operated as part of the wider QNH mine water infrastructure. The QNH Water Management Plan (WMP) details the operating philosophy for water management at the QNH and is updated periodically as mining progresses at the QNH. The WMP also incorporates the erosion and sediment control plan for the site.

6.7.1 Operational Water Management Infrastructure

Operational water management infrastructure at SCM consists of dams and drainage structures. All operational water management infrastructure within the Belmore West property will be retained by agreement with the landowner to support the PMLU. In addition, some water management structures, such as contour banks and drainage channels, are an integral part of the rehabilitated final landforms and will therefore be retained as part of the final landform.

It is noted that the Two Mile Creek and Coral Creek diversions are permanent diversions approved under the *Water Act* (previously) and *EP Act* (currently) and therefore do not require landowner approval to be retained.

6.7.1.1 Ongoing Water Management

Above ground waste rock dump final landforms have been designed to incorporate erosion and sediment controls to minimise erosion risk to the final landform. As previously noted, neither the topsoil or waste rock at SCM are dispersive which reduces the likelihood of significant erosion of the final landform occurring or the sedimentation of receiving waters.

The final landforms at SCM will have permanent drainage and erosion and sediment control (ESC) structures incorporated into their design (as required), with consideration to landform slope, slope length and the reporting catchment.

The ESC controls for the final landforms are designed and installed during rehabilitation establishment such that no ongoing management of surface water run-off (e.g. capture, storage or treatment) will be required following the completion of rehabilitation at SCM. Contour banks and other drainage channels within final landforms are intended to be retained as part of the final landform. The requirement for any repair works will be addressed on a case by case basis, including rectification and/or improvement of the structure.

To date, no persistent seepage has been observed from any rehabilitated landforms or other waste rock dumps at the QNH. Should any such seepage from waste rock dumps occur at the SCM, water quality monitoring will be undertaken to confirm the seepage does not constitute saline drainage or AMD, the occurrence of which has been deemed unlikely based on previous laboratory testing of waste rock.

6.8 Revegetation

As detailed in **Section 4**, the PMLU's transitioned to this PRC Plan from the SCM LODs are grazing pasture (including grassland community for the out of pit CDA) and permanent creek diversions. The revegetation objectives for the planned PMLUs have been adapted from the QNH RMP for inclusion as rehabilitation milestone (RM) criteria for revegetation in the PRC Plan Schedule:

- Grazing pasture & grassland community
 - Achieve >70% established vegetative groundcover of grazing pasture PMLU, using specified seed mixes;
 - Achieve total >70% groundcover (including vegetative cover, woody debris, organic litter and rock) of grassland community PMLU;
 - Weed presence comprises <5% of vegetative groundcover;
 - Land suitability Class 4 for Waste Rock Dumps (RA1) and existing rehabilitation (RA8);

- Land suitability Class 3 for Infrastructure areas (RA3) and at grade disturbance (RA4).
- Permanent creek diversions
 - Achieve >70% vegetative groundcover (excluding areas of rock armouring).
 - >50% of established and persistent tree and shrub species are consistent with the specified creek diversion species mix.

There are no revegetation objectives applicable to retained infrastructure (RA7) or planned NUMAs. The SCM EA does not require inclusion of species of conservation significance in rehabilitation planning for SCM.

6.8.1 Grazing pasture and grassland community revegetation

The growth media for cattle grazing and grassland community PMLUs will be pre-stripped topsoil, spread over rehabilitated landforms at a depth $\geq 150\text{mm}$, and ameliorated (if necessary) as recommended by an AQP to achieve defined soil quality criteria.

The recommended revegetation species for grazing pasture PMLU are based native and preferred pasture species that are perennial, productive and palatable (3P) grasses and legumes that have been observed in grazing paddocks nearby the QNH, or within undisturbed areas of the QNH.

Seed mix may vary with species seed availability, however the grazing pasture seed mix for waste rock dumps (RA1) should include at least 25% native grass species, three 3P grass species and two native tree/shrub species. For grassland community PMLU the seed mix should contain at least 25% native grass species and exclude tree species. The seed mix for infrastructure (RA3) areas and at grade disturbance areas (RA4) should include at least three 3P native species and two native legume species.

Seeding rates will be determined by an AQP. If possible, seed should be sourced from the Central Queensland region as locally adapted plants will be best suited to localised climate, soil and hydrological conditions. Any seed requiring storage prior to application is to be kept under controlled conditions to maximise seed viability.

Ideally seeding will be undertaken immediately prior to the onset of the wet season (i.e. December or January). This gives seed the best chance of striking and establishing, as soil moisture will be at its highest in the late wet season. Seeding is typically undertaken utilising an agricultural-class tractor and spreader.

The recommended revegetation species for grazing pasture and grassland community PMLUs are listed in **Table 32**.

Table 32 Recommended revegetation species for grazing pasture and grassland community PMLUs.

Scientific Name	Common Name
Preferred grazing species	
<i>Heteropogon contortus</i>	Black Speargrass
<i>Bothriochloa bladhii</i>	Forest Bluegrass
<i>Capillipedium spicigerum</i>	Scented tops
<i>Panicum effusum</i>	Hairy panic
<i>Megathyrsus maximus</i>	Green panic
<i>Ancistrachne uncinulata</i>	Hooky grass
<i>Urochloa foliosa</i>	Leafy panic
<i>Dichanthlum sericeum</i>	Queensland bluegrass
<i>Rhynchosia minima</i>	Rhynchosia
<i>Macroptilium lathyroides</i>	Phasey Bean
<i>Sorghum halepense</i>	Johnson Grass
Intermediate grazing species	
<i>Neptunia gracilis</i>	Native Sensitive Plant
<i>Panicum decompositum</i>	Native Millet
<i>Enteropogon acicularis</i>	Curly Windmill Grass
<i>Echinochloa esculenta</i>	Japanese Millet
<i>Chloris inflata</i>	Purple-top Rhodes Grass
Legumes	
<i>Chamaechaerista rotundifolia</i>	Wynn Cassia
<i>Macroptilium astropurpureum</i>	Siratro
<i>Stylosanthes humilis</i>	Stylo
<i>Stylosanthes scabra</i>	Seca Stylo
<i>Stylosanthes seabrana</i>	Caatinga Stylo
<i>Stylosanthes hamata</i>	Caribbean Stylo
<i>Desmanthus virgatus</i>	Desmanthus
<i>Clitoria ternatea</i>	Butterfly Pea
<i>Indigofera linnaei</i>	Nine-leaved Indigo
Trees	
<i>Eucalyptus tereticornis</i>	Queensland blue gum
<i>Eucalyptus melanophloia</i>	Silver-leaved ironbark
<i>Eucalyptus populnea</i>	Poplar box
<i>Casuarina cristata</i>	Belah
<i>Acacia harpophylla</i>	Brigalow

6.8.2 Permanent Creek Diversions

The existing permanent diversions of Two Mile Creek and Coral Creek have been previously revegetated in accordance with the approved Design Plans for the diversion works (**Section 4.2**). Monitoring of the existing permanent creek diversions will be ongoing to inform operational maintenance requirements.

The recommended revegetation species for the permanent creek diversion PMLU at SCM have been derived from species lists included in the approved Design Plans for the existing Two Mile Creek and Coral Creek diversion. The specific revegetation methodologies, timings and seeding rates for any future creek diversions undertaken at SCM will be specified by an AQP in the detailed Design Report for the proposed diversion, as approved in accordance with SCM EA requirements.

The recommended revegetation species for permanent creek diversion PMLUs are listed in **Table 33**.

Table 33 Recommended revegetation species for permanent creek diversion PMLU.

Scientific Name	Common Name
Grass / Ground Species	
<i>Echinochloa esculenta</i>	Japanese Millet
<i>Bothriochloa bladhii</i>	Forest Bluegrass
<i>Dichanthlum sericeum</i>	Queensland bluegrass
<i>Stylosanthes humilis</i>	Stylo
<i>Stylosanthes seabrana</i>	Caatinga Stylo
<i>Aristida personata</i>	Purple wiregrass
<i>Thellungia advena</i>	Coolabah grass
Shrubs / Small Trees	
<i>Alectryon oleifolius subsp. elongatus</i>	Western Rosewood
<i>Cassia brewsteri</i>	Leichhardt Bean
<i>Corymbia erythrophloia</i>	Variable-barked Bloodwood
<i>Erythrina vespertilio</i>	Bat's Wing Coral Tree
<i>Ficus opposita</i>	Sandpaper Fig
<i>Ficus racemosa</i>	Cluster Fig
<i>Lysiphyllum hookeri</i>	Pegunny
<i>Melaleuca bracteata</i>	Black Teatree
<i>Petalostigma pubescens</i>	Quinine Bush
<i>Vachellia bidwillii</i>	Corkwood Wattle
<i>Acacia salicina</i>	Sally Wattle

Scientific Name	Common Name
<i>Owenia acidula</i>	Emu apple
<i>Capparis lasiantha</i>	Split jack
<i>Lophostemon grandiflorus</i>	Northern swamp box
<i>Acacia bidwillii</i>	Corkwood wattle
Trees	
<i>Eucalyptus tereticornis</i>	Queensland blue gum
<i>Casuarina cunninghamii</i>	River Oak
<i>Corymbia clarksoniana</i>	Long-fruited Bloodwood
<i>Corymbia dallachiana</i>	Dallachy's Gum
<i>Atalaya hemiglauc</i>	Western whitewood
<i>Corymbia tessellaris</i>	Carbeen
<i>Eucalyptus brownii</i>	Reid River Box
<i>Eucalyptus crebra</i>	Narrow-leaved Red Ironbark
<i>Eucalyptus raveretiana</i>	Black Ironbox
<i>Lagunaria queenslandica</i>	Queensland Pyramid Tree
<i>Melaleuca fluviatilis</i>	River Teatree
<i>Melaleuca leucadendra</i>	Weeping Paperbark
<i>Melaleuca viminalis</i>	Weeping Bottlebrush
<i>Pleiogynium timorense</i>	Burdekin Plum

6.9 Void Closure Plan

For mine sites with voids, the PRC Plan is required to incorporate a void closure plan that addresses the listed criteria in the PRCP Guideline.

Voids at the SCM (and wider QNH) have been previously addressed by the report *Residual Voids on the QCoal Northern Hub Mining Complex* (QCoal 2020), which is attached to the QNH RMP (2020) and therefore forms part of the LOD. As such, QCoal (2020) is the current and approved void closure plan for the QNH.

Table 34 details the relevant section where each void closure plan requirement in the PRCP Guideline is addressed in QCoal (2020). There is also significant overlap between the void closure plan requirements and content in other Sections within this PRC Plan, as is also noted in **Table 34**.

Table 34 – QCoal 2020 Void Closure Plan Cross-Referencing to PRCP Guideline Void Closure Plan Requirements

Requirement	Sonoma Main Void IA1	Sonoma East Pit IA2
Options available for minimising final void area and volume	Waste rock from the Sonoma Main and Sonoma North Pits has been used to progressively backfill and minimise the footprint of the Sonoma Main Void. The Sonoma Main void will also be utilised as the QNH CDA for the remainder of the LOM of the QNH which will further reduce the volume of the final void.	Following completion of the initial Sonoma East Pit box cut (from which waste rock will report to the out-of-pit dumps) waste rock will be dumped in-pit behind the advancing face (i.e. progressive backfilling) which will limit the size of the final void.
	The Sonoma Main final void area represents ~42% of the LOM pit shell area	The Sonoma East Pit final void area represents ~34% of the LOM pit shell area
	The nominated final voids at the SCM total 149ha which aligns with the 149ha authorised in the SCM EA, which represents 40% of the overall SCM LOM pit shell area (i.e. the LOM mined area) of 370ha	
Proposed final dimensions of the void (depth*, length** and width**)	Depth: 146m Length: 1350m Width: 1350m	Depth: 110m Length: 1400m Width: 300m
	*Represents maximum depths. Note void depth is dependent on pit floor depth (i.e. bottom of lowest coal seam mined) and natural topography (where the measurement is taken from), therefore void depth can differ considerably in different parts of the void. **Represents maximum dimensions. Note the final void configurations are generally irregularly shaped Refer to Section 5.1 for final void configurations	
Pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events	Addressed in Sections 9.3.1, 9.3.2 and 9.3.3 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020) Also refer to Section 2.2.7.3 and Section 6.3 of this PRC Plan	

Proposed final slope angles of high wall, low wall and end walls of each final void	Addressed in Section 9.3.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020) As discussed in Section 4.3 of this PRC Plan, <i>Table– H1 - Residual Void Outcomes</i> in the SCM EA (as the primary LOD) prescribes the following maximum slopes for voids at the SCM: High Walls: Top 10m = 45°, thereafter = 70° (also applicable to end-walls as they are similarly competent material) Low Walls: 17-37°
Void hydrology, addressing the long-term water balance and water level in the voids, stratification connections to groundwater resources and potential for overflow	Addressed in Sections 7 and 8 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Groundwater modelling to determine whether the void is acting as a sink or a source for groundwater	Addressed in Section 8.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
A water balance study including an assessment of void surface and groundwater interactions such as:	Addressed in Section 7 and 8 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Groundwater lowering/reduction in hydraulic head (from new voids e.g. caves/karst systems)	Addressed in Section 8.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Cones of depression and associated impacts	Addressed in Section 8.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
The drainage and flooding behaviours of surface waters in the vicinity of the void	Addressed in Section 7.4 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
The potential extent of flooding and implications of interactions with the void	Addressed in Section 7.4 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020) Also refer to Section 2.2.7.3 and Section 6.3 of this PRC Plan

A conceptual model that incorporates all projected inflows, outflows, and recharge rates	Addressed in Section 7.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Water storage and long-term water balance	Addressed in Section 8.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Each of the major water fluxes into and out of the void	Addressed in Section 8.1 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
The sources of surface water within the mine catchment that are likely to influence the water quality in the void	Addressed in Section 7.4 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)
Predicted water quality in the long-term including potential stratification	Addressed in Section 8.2 of <i>Residual Voids on the QCoal Northern Hub Mining Complex</i> (QCoal 2020)

The QNH RMP details the actions to be undertaken for residual voids at the QNH. The 'improvement' actions for all residual voids at SCM include:

- The final landform is to be shaped and graded to be geotechnically stable. Re-profiling (including blasting of void walls) is generally not required as the operational slopes utilised at the SCM for high-walls and low-walls comply with the residual void slopes outlined in **Section 5.1**;
- Establish drainage and erosion controls (where required).
- Final slope (completion criteria) as per Section 5.5 of the QNH RMP (as reproduced in **Section 5.3** of this PRC Plan
- Signage, fencing, and/or safety bunds (specification based on DME (1995)) are placed as required to limit access to the voids, including:
 - Safety Bunds: A minimum 2m high, 4m wide earthen safety bund is in place around mining pits during mining operations at SCM. This bunding is retained for the residual voids;
 - Fencing - SCM residual voids are located on private property with no public access, with multiple existing fences and linear infrastructure located between public roads and the voids. A standard 5 strand barbed wire fence is to be constructed around the high-wall and end-walls of residual voids to prevent access by stock (primarily) and persons to these areas;
 - Signage – Standard 'Deep Excavation' warning signs are to be placed at 100m spacing along the high-wall/end-wall fencing.

7 Risk Assessment

Section 126C(1)(f) of the EP Act requires the PRC Plan to include the identification of risks to achieving a stable (as defined in the EP Act) condition for land with a designated PMLU, and any proposed management or mitigations to address those identified risks. The EP Act also requires the identification of risks for areas which are not proposed to achieve a PMLU (i.e. NUMAs).

To be considered stable rehabilitation must meet the following conditions:

- safe and structurally stable (i.e. geotechnical wall/slope stability); and
- there is no environmental harm being caused by anything on or in the land; and
- the land can sustain a post-mining land use (i.e. self-sustain a specified use for the landform after rehabilitation).

As described in **Section 4.3** and **Section 5.3**, completion criteria presented in the QNH RMP have been transitioned to the PRC Plan Schedule Rehabilitation Milestone criteria and Improvement Area Milestone criteria. Achievement of the milestone criteria demonstrates that either a stable PMLU landform has been achieved, or a NUMA has been sufficiently 'improved'. Accordingly, this

PRC Plan, has undertaken the required risk assessment by identifying and assessing risks to achieving completion of the milestones.

The QCoal risk assessment matrix (as shown in **Figure 25**) has been utilised in conducting the required risk assessment.

QCOAL GROUP		Risk Assessment Matrix				
Loss Type		Consequences				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
People Injury or Illness		Slight injury or health effects – First aid / minor medical treatment level	Minor injury or health effects – restricted work or minor lost workday case	Major injury or health effects – major lost workday case / permanent disability	Permanent total disabilities, single fatality	Multiple fatalities
Damage and Consequential Losses		Easily addressed or rectified by immediate corrective action. No loss of production. No Damage to equipment	Minor or superficial damage to equipment and/or facility. No loss of production	Moderate damage to equipment and/or facility. Loss of production < one week	Major damage to facility requiring significant corrective / preventative action. Loss of production < six months	Future operations at site seriously affected. Urgent corrective / remedial action. Loss of production > six months
Reputation, Community Regulatory Compliance		Slight impact – public awareness may exist but no public concern. Slight impact – Traditional Owner awareness may exist but no Traditional owner concern	Limited impact – some local public concern. Limited impact – some Traditional Owner concern	Considerable impact – regional public concern. Considerable impact – Traditional Owner concern	National impact – National public concern. Major impact – Traditional Owner Elders involved	International impact – International public concern. Major impact – Stop Work Direction from Traditional Owners
Environmental Impact		Environmental nuisance, no clean up, aesthetic impact only.	Minor clean up, no legal breach, minimal impact, minor non conformance	Major clean up, license breach, Business disruption at site level.	Local Ecosystem damage, Legal / Statutory breach	Regional Ecosystem damage, Major rehab failure, Mine closure
Financial / Commercial		<AUS \$10,000	AUS \$10,000 to \$100,000	AUS \$100,000 to \$1M	AUS \$1M to \$10M	>AUS \$10M

Likelihood		Risk Rating				
Almost Certain (A)	This event is expected to occur in most circumstances (once per month)	M (15)	H (10)	H (6)	E (2)	E (1)
Likely (B)	Will probably occur in most circumstances (once per year)	M (19)	M (14)	H (9)	E (4)	E (3)
Possible (C)	Might occur at some time (once per 10 years)	L (22)	M (18)	H (13)	H (8)	E (5)
Unlikely (D)	Could occur at some time (once per 100 years)	L (24)	L (21)	M (17)	H (12)	H (7)
Rare (E)	May occur only in exceptional circumstances (once per 1000 years)	L (25)	L (23)	M (20)	M (16)	H (11)

Figure 25 – QCoal Risk Assessment Matrix

7.1 Risk Treatment Options

Table 35 details the risks to the completion of the Rehabilitation Milestones (and achievement of stable landforms with the approved PMLU) at SCM, and the controls to be applied to manage, mitigate or reduce those impacts.

Table 35 – Risk Assessment

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
RM1: Infrastructure decommissioning and removal (RA1, RA2, RA3, RA4, RA5, RA6)												
Delays in RAs becoming available (infrastructure only becomes available for removal at end of mine life)	RM not completed in the required timeframes, non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH annual budget as required	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					PRCP progress meetings	Regular meeting to track progress against SCM PRCP Schedule	QNH Mining Manager QCoal Environmental Personnel					
					PRCP Schedule amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
Items of infrastructure not identified and removed	RM not completed in the required timeframes, non-compliance with PRCP Schedule	2	C	M	Decommissioning Plan (DMP) or equivalent to be in place	DMP will identify detailed scope of infrastructure removal works and sequence for removal	QNH Mining Manager			2	D	L

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Inadequate management of waste materials	Incorrect disposal of waste material onsite during infrastructure removal (e.g. disposal of fines from ROM pad, etc	2	C	M	Decommissioning Plan (DMP) or equivalent to be in place	DMP will identify detailed scope of infrastructure removal works, sequence for removal and waste management requirements	QNH Mining Manager			2	D	L
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager			2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager					
					PRCP progress meetings	Regular meeting to track progress against QNH PRCP Schedule	QNH Mining Manager QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM2: Identification, remediation and removal of contaminated land (RA1, RA2, RA3)												
Previously unidentified contaminated land	Remediation work required, delay to completion of RM	2	C	M	Bulk fuel and chemical storages are located in discrete areas at the SCM	Bulk fuel and chemical storages are located in fixed areas for the LOM (MIA, Sonoma East Laydown) with designated adjacent refuelling areas	QNH Mining Manager			2	D	L
					LOM bulk fuel and chemical storages are designed in accordance with relevant Australian Standards	Storages are designed with containment systems in the event of spillages	QNH Mining Manager					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Spill reporting processes and remedial actions during operations	Fuel and chemical spills are required to be contained, reported and cleaned up during operations. Records maintained in site incident reports	QNH Mining Manager					
					Stage 1 Contaminated Land Assessment to be undertaken	Contamination is most likely to occur on or adjacent to infrastructure (in particular fuel and chemical storages), refuelling areas, and park-up areas so these areas will be the primary focus	QCoal Environmental Personnel Contaminated Land Consultant					
					Specific remediation actions to be developed to address any identified contamination	Remediation actions will depend on extent, location and risk of identified contamination.	QCoal Environmental Personnel Contaminated Land Consultant					
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager			2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager					
					PRCP progress meetings	Regular meeting to track progress against QNH PRCP Schedule	QNH Mining Manager QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM3: Landform development and shaping (RA1, RA2, RA3)												
Delays in RAs becoming progressively available	RM not completed in the required timeframes, non-	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
	compliance with PRCP Schedule				Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager	Section 3 of the PRC Plan				
					PRCP progress meetings	Regular meeting to track progress against SCM PRCP Schedule	QNH Mining Manager QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
Landform design does not conform to acceptance criteria	Designed landform does not meet RM criteria	3	C	H	Completion of QA check for landform design	QA check of the landform design against the landform design criteria	QNH Technical Services Personnel			3	E	L
Designed ESC/drainage structures are inadequately sized/configured	Failure of drainage structures, erosion of final landform, RM not achieved	2	C	H	Completion of QA check for landform design	QA check of the landform design against the landform criteria	QNH Technical Services Personnel			2	E	L
Constructed landform does not conform to design	Constructed landform does not meet RM criteria	3	C	H	Completion of QA check for landform design	QA check of the constructed landform against the landform criteria.	QNH Technical Services Personnel			3	E	L
					'As Constructed' Survey'	The 'as constructed' survey of the completed landform is checked for compliance with the designed landform	QNH Technical Services Personnel					
Previously unidentified contaminated land	Remediation work required, delay to completion of RM	2	C	M	Bulk fuel and chemical storages are located in discrete areas at the SCM	Bulk fuel and chemical storages are located in fixed areas for the LOM (MIA, Sonoma East Laydown) with designated adjacent refuelling areas	QNH Mining Manager			2	C	L
					LOM bulk fuel and chemical storages are designed in accordance with relevant Australian Standards	Storages are designed with containment systems in the event of spillages	QNH Mining Manager					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Spill reporting processes and remedial actions during operations	Fuel and oil spills are required to be contained, reported and cleaned up during operations. Records maintained in site incident reports	QNH Mining Manager					
					Stage 1 Contaminated Land Assessment to be undertaken	Contamination is most likely to occur on or adjacent to haul road and park-up areas so these areas will be the main priority	Contaminated Land Consultant					
					Specific actions to be developed to address identified contamination	Remediation actions will depend on extent, location and risk of identified contamination.	QCoal Environmental Personnel Contaminated Land Consultant					
PRCP Schedule non-conformance / non-achievement of Milestone	Earthworks not completed, RM not completed in the required timeframes, non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager			2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule.	QNH Mining Manager					
					PRCP progress meetings	Regular meeting to track progress against QNH PRCP Schedule	QNH Technical Services Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM4: Installation of a cover system (RA2)												
Inadequate dewatering of CDA material prior to placement of capping material	Inability to apply capping material using in the preferred	3	C	H	Decant structures to be maintained in operational condition	Decant structures (in conjunction with surface drying) will continue to function after deposition ceases to dewater the CDA sufficiently to enable capping	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
	method/with the preferred equipment				CDA deposition methodology	Deposition methodology for final CDA lifts have ensured deposition of mixed CDA material to provide the firmest possible working surface	QNH Mining Manager	Section 3 of the PRC Plan				
					Capping to be undertaken by experienced personnel	Personnel experienced with capping/managing CDA materials will be utilised for the placement of the capping material	QNH Mining Manager					
Inadequate capping material depth placed	Inadequate capping material for rehabilitated landform to meet RM criteria, rework required	2	C	M	Waste rock from nearby QNH pits to be made available for capping as required	Adequate waste rock will be generated at the QNH mines to meet the required LOM capping needs for rehabilitation of the CDA	QNH Survey Personnel			2	D	L
					Spot-checks of capping material depth during placement	Survey/spot checks of applied capping material thickness within rehabilitation areas will be undertaken during spreading to ensure an adequate depth is respread.	QCoal Environmental Personnel QNH Survey Personnel					
PRCP Schedule non-conformance, non-achievement of Milestones	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager			2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM5: Surface Preparation (RA1, RA2, RA3, RA4)												

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Inadequate topsoil volumes available	Inadequate topsoil available for rehabilitated landform to meet RM criteria,	2	C	M	SCM topsoil inventory managed via QNH Topsoil Management Plan and Register	Adequate topsoil is currently available at the QNH for rehabilitation of all disturbed areas. Managing existing resources will minimise the likelihood of a deficit in the future.	QNH Survey Personnel	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Implementation of additional topsoil management measures if <10% surplus identified at the SCM at any point	If a topsoil deficit is identified, additional measures such as cartage of surplus topsoil from another QNH site will be considered	QCoal Environmental Personnel					
Inadequate topsoil volumes placed	Inadequate topsoil for rehabilitated landform to meet RM criteria, rework required	2	C	M	QNH topsoil inventory managed via Topsoil Management Plan and Register	Adequate topsoil is currently available at the QNH for rehabilitation of all disturbed areas. Managing existing resources will minimise the likelihood of a deficit in the future.	QNH Survey Personnel			2	D	L
					Spot-checks of depth during respreading	Random spot checks of applied topsoil thickness within rehabilitation areas will be undertaken during spreading to ensure an adequate depth is respread.	QCoal Environmental Personnel QNH Survey Personnel					
					Survey of topsoil stockpiles post-spreading and confirmation of total volume removed is within 20% of calculated required volume	Topsoil stockpile surveys are used to calculate the topsoil volume removed, which together with the spreading area, can be used to calculate an average spreading depth. Allowing a 20% variance allows for the swelling of the topsoil during rehandling.	QNH Survey Personnel					
Topsoil quality non-conformance with milestone criteria	Topsoil quality compromises rehabilitation establishment, milestone criteria unable to be achieved	2	C	M	Pre-disturbance topsoil assessments	The topsoil assessments undertaken to date indicate the topsoil available at the SCM is suitable for use in rehabilitation. The topsoil has been previously used successfully in rehabilitation at the QNH.	-			2	D	L
					Scheduled topsoil assessments in rehabilitation areas	Future topsoil assessments are expected to confirm the pre-disturbance assessment findings	Rehabilitation Monitoring Consultant					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Specific actions to be developed to address any identified topsoil issues	Remedial actions will depend on the location, extent and type of issue identified but may include amelioration, etc	QCoal Environmental Personnel Rehabilitation Monitoring Consultant					
Weed contamination from respread topsoil	Excessive growth of non-desired species within prepared areas	2	C	M	QNH Topsoil Management Plan incorporates weed management requirements for topsoil stockpiles	Management of weed establishment on topsoil stockpile reduces likelihood of establishment following respraying	QCoal Environmental Personnel Weed Control Contractor			2	D	L
Weed contamination -from vehicles / equipment	Excessive growth of non-desired species within prepared areas	2	C	M	Weed hygiene requirements outlined in QNH Weed Management Plan to be followed for all plant and equipment	Existing QNH weed hygiene requirements	QCoal Environmental Personnel Weed Control Contractor			2	D	L
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager			2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM6: Revegetation												
Inadequate strike, species diversity, groundcover	Revegetation does not meet ground cover requirements, acceptance	2	C	M	Revegetation works to be undertaken by experienced contractor(s) in accordance with QNH Rehabilitation Management Plan	Routine documented inspections will note any issues with ground cover establishment	QCoal Environmental Personnel	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
	criteria unable to be achieved				Ad-hoc and 6-monthly visual inspections following seeding	Routine documented inspections will note any issues with ground cover establishment	QCoal Environmental Personnel					
Poor establishment, die-off of first strike due to drought conditions	Revegetation does not meet ground cover requirements, acceptance criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections following topsoil spreading	Routine documented inspections will note any issues with ground cover establishment	QCoal Environmental Personnel			2	D	L
					Re-seeding (if required) to be undertaken before following wet season	Re-seeding requirements will depend on the location, extent and type of issue identified.	QCoal Environmental Personnel Seeding Contractor					
Failure of ESC structures due to lack of groundcover during establishment	Erosion of final landform, sedimentation of receiving waters, completion criteria unable to be achieved	2	C	M	Drainage/ESC to be designed for the no ground-cover scenario	Design for 'worst case' scenario, as ground cover establishes risk reduces	QNH Technical Services Personnel QCoal Environmental Personnel			2	D	L
					Ad-hoc and 6-monthly visual inspections includes drainage structures	Routine documented inspections will note any issues with constructed flow paths	QCoal Environmental Personnel					
					Noted issues to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for remedial actions as required					
Fire in rehabilitation areas	Reduction of groundcover, acceptance criteria unable to be achieved	2	C	M	Maintenance of on-lease and off-lease firebreaks	Existing disturbances act as fire breaks (e.g. SCM, CCM and DCM disturbed areas, haul roads, access tracks along toe of batters, Bowen Development Rd). Off-lease fire breaks have been put in place to the west by the landholder as a routine property management activity	Fire Break Maintenance Contractor			2	D	L
					Mine water carts available onsite 24/7 for firefighting if required	Mine water carts have a high water capacity and are equipped with cannons and spray bars to make them suitable for firefighting where required	-					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
PRCP Schedule non-conformance	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Annual rehabilitation monitoring to quantify progressive establishment of revegetation against the Milestone Criteria	Monitoring will be used to track the progress of ground cover establishment, project where revegetation is unlikely to meet the Milestone in the required timeframe and recommend remedial actions as required.	Rehabilitation Monitoring Consultant			2	D	L
RM7: Achievement of surface requirements (RA1, RA2, RA3, RA4, RA8)												
Inadequate vegetation cover, species diversity established	Rehabilitation does not meet ground cover requirements, acceptance criteria unable to be achieved	2	C	M	Annual rehabilitation monitoring to quantify progressive establishment of rehabilitation against the Milestone Criteria	Monitoring will be used to track the progress of ground cover establishment, project where rehabilitation unlikely to meet the Milestone in the required timeframe and recommend remedial actions as required.	Rehabilitation Monitoring Consultant	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Seeding (if required) to be undertaken before following wet season	Given the past success with relying on the natural seedbank in the topsoil, it is considered unlikely that the topsoil will require further seeding	QCoal Environmental Personnel Seeding Contractor					
Settlement of landform impacting flow paths	Installed drainage not functioning to design leading to erosion of final landform, completion criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections includes drainage structures	Routine documented inspections will note any issues with constructed flow paths	QCoal Environmental Personnel			2	D	L
					Noted issues to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for remedial actions as required					
Failure of ESC structures due to lack of groundcover during establishment	Erosion of final landform, sedimentation of receiving waters, completion criteria unable to be achieved	2	C	M	Drainage/ESC to be designed for the no ground-cover scenario	Design for 'worst case' scenario, as ground cover establishes risk reduces	QNH Technical Services Personnel QCoal Environmental Personnel			2	D	L
					Ad-hoc and 6-monthly visual inspections includes drainage structures	Routine documented inspections will note any issues with constructed flow paths	QCoal Environmental Personnel					
						QNH Environmental Actions Register is utilised to track and close-out	QCoal Environmental Personnel					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Noted issues to be included in QNH Environmental Actions Register	remedial actions in rehabilitated areas	Resources for remedial actions as required					
Weeds - proportion/increase/species of concern	Milestone criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections includes weed establishment	Generally, weed establishment is most likely to occur following topsoil placement when there is minimal ground cover present. Some establishment is expected, however declared/controlled weeds and weeds that may impact growth of preferred species (e.g. dense areas of weeds) will be monitored	QCoal Environmental Personnel			2	D	L
					Annual rehabilitation monitoring to identify weeds species present and trends/issues and recommend actions	The presence and spread of weeds within rehabilitation areas will be noted during rehabilitation monitoring	Rehabilitation Monitoring Consultant					
					Noted actions to be included in QNH Environmental Actions Register	QNH Environmental Action Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for remedial actions as required					
					Weed control program to be implemented	An ongoing weed control program is in place at the QNH	Weed Control Contractor					
Fire in rehabilitation areas	Reduction of groundcover, acceptance criteria unable to be achieved	2	C	M	Maintenance of on-lease and off-lease firebreaks	Existing disturbances act as fire breaks (e.g. SCM, CCM and DCM disturbed areas, haul roads, access tracks along toe of batters, Bowen Development Rd). Off-lease fire breaks have been put in place to the west by the landholder as a routine property management activity	Fire Break Maintenance Contractor			2	D	L
					Mine water carts available onsite 24/7 for firefighting if required	Mine water carts have a high water capacity and are equipped with cannons and spray bars to make them suitable for firefighting where required	QNH Mining Manager					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Ad-hoc and 6-monthly visual monitoring of fire-impacted areas to ensure reestablishment of pasture species is occurring and determine if reseeding is required	Fire impacted areas would be expected to re-establish from residual seed in the topsoil. Monitoring will determine if any intervention is required	QCoal Environmental Personnel					
Ground-disturbing pests - pigs, rabbits, etc.	Damage to rehabilitation/landform, RM criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections include noting any pest species present	Pests are not expected to a major issue based on rehabilitation monitoring to date, and the active pest control programs implemented by the surrounding land holders	QCoal Environmental Personnel			2	D	L
					Annual rehabilitation monitoring to identify evidence of pest species present and trends/issues and recommend actions	The presence of pest species within rehabilitation areas will be noted during rehabilitation monitoring	Rehabilitation Monitoring Consultant					
					Noted actions to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for remedial actions as required					
					Pest control program to be implemented	A pest control program will be implanted at the QNH if required	Pest Control Contractor					
Damage to rehabilitation from premature livestock grazing	Permanent reduction of ground cover, acceptance criteria unable to be achieved	2	C	M	Livestock to be excluded until <50% groundcover has been maintained for a minimum of 2 successive years, as measured by annual rehabilitation monitoring.	Sufficient time is required for pasture to become established and self-sustaining prior to the introduction of cattle onto rehabilitated areas.	QCoal Environmental Personnel			2	E	L
PRCP Schedule non-conformance	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Annual rehabilitation monitoring to quantify progressive establishment of grazing pasture against the Milestone Criteria	Monitoring will be used to track the progress of ground cover establishment, project where grazing pasture unlikely to meet the Milestone in the required timeframe and recommend remedial actions as required.	Rehabilitation Monitoring Consultant			2	D	L
RM8: Achievement of post-mining land use to a stable condition (RA1, RA2, RA3, RA4)												

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Settlement of landform impacting flow paths	Installed drainage not functioning to design leading to erosion of final landform, completion criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections includes drainage structures	Routine documented inspections will note any issues with constructed flow paths	QCoal Environmental Personnel	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Noted issues to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for any remedial actions					
Failure of ESC structures post-establishment	Erosion of final landform, completion criteria unable to be achieved	2	C	M	Drainage/ESC to be designed for the no ground-cover scenario	Design for 'worst case' scenario, as ground cover establishes risk reduces	QNH Technical Services Personnel QCoal Environmental Personnel			2	D	L
					Ad-hoc and 6-monthly visual inspections includes drainage structures	Routine documented inspections will note any issues with constructed flow paths	QCoal Environmental Personnel					
					Noted issues to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel Resources for any remedial actions					
Surface water contamination from unexpected waste rock material geochemical issue	Run-off/seepage to surface waters exceeds water quality requirements, completion criteria unable to be achieved	3	D	M	Previous geochemical testing programs	Geochemical testing and previous rehabilitation of waste rock dumps at the QNH indicates that issues with run-off/seepage to surface water from waste rock dumps are unlikely	QCoal Environmental Personnel			2	E	L
					Sampling at nominated locations in EA	Geochemical testing and previous rehabilitation of waste rock dumps at the QNH indicates that run-off/leachate issues from waste rock dumps are unlikely	QCoal Environmental Personnel					
					Specific actions to be developed to address identified geochemical issues	Remedial actions will depend on the location, extent and type of geochemical issue identified	QCoal Environmental Personnel Geochemical Consultants					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Weed establishment - proportion/ increase of non-preferred species/declared weeds	Acceptance criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections includes identifying weed establishment	Weed establishment is most likely to occur following topsoil placement when there is minimal ground cover present. Some establishment is expected, however declared weeds and weeds that may impact growth of pasture grasses (e.g. dense areas of weeds)	QCoal Environmental Personnel			2	D	L
					Annual rehabilitation monitoring to identify weeds species present and trends/issues and recommend actions	The presence and spread of weeds within rehabilitation areas will be noted during rehabilitation monitoring.	Rehabilitation Monitoring Consultant					
					Noted issues to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	QCoal Environmental Personnel					
					Weed control program to be implemented	An existing weed control program is in place at the QNH	Weed Control Contractor					
Fire in rehabilitation areas	Reduction of ground cover, acceptance criteria unable to be achieved	2	C	M	Maintenance of on-lease (and off-lease where land is held by QCoal) firebreaks.	Existing disturbances act as fire breaks (e.g. SCM, CCM and DCM disturbed areas, haul roads, access tracks along toe of batters, Bowen Development Rd). Off-lease fire breaks have been put in place to the west by the landholder as a routine property management activity.	Fire Break Maintenance Contractor			2	D	L
					Mine water carts available onsite 24/7 for firefighting if required.	Mine water carts have a large capacity and are equipped with cannons and spray bars to make them suitable for firefighting if required.	-					
Established rehabilitation die-off due to drought conditions	Reduction of ground cover, acceptance criteria unable to be achieved	2	C	M	Ad-hoc and 6-monthly visual inspections includes identification of die-off areas	Routine documented inspections will note any issues with pasture die-off in rehabilitated areas	QCoal Environmental Personnel			2	D	L
					Noted actions to be included in QNH Environmental Actions Register	QNH Environmental Actions Register is utilised to track and close-out remedial actions in rehabilitated areas	Rehabilitation Monitoring Consultant					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
					Remedial actions for pasture die-off areas to be implemented	Remedial actions will depend on the location and extent of pasture die-off identified	Weed Control Contractor					
PRCP Schedule non-conformance	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Annual Rehabilitation monitoring to quantify achievement of grazing pasture to stable condition against the Milestone Criteria	Monitoring will be used to track the progress of ground cover establishment, project where grazing pasture unlikely to meet the Milestone in the required timeframe and recommend remedial actions.	Rehabilitation Monitoring Consultant			2	D	L
RM9: Achievement of post mining land use to a stable condition (Permanent creek diversions - RA5, RA6)												
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
Non-compliance with approved Design Plan	Milestone Criteria not achieved	3	C	H	Annual Inspections of diversions during LOM by AQP (RPEQ)	The diversions have been constructed in accordance with the Design Plan Annual inspections will assess the ongoing performance and condition of the diversion against the requirements of the Design Plan	QCoal Environmental Personnel Suitably qualified person			2	D	L
RM10: Achievement of post-mining land use to a stable condition (Retained Infrastructure - RA7)												

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
RM11: Achievement of post mining land use water quality (RA1 - RA8)												
Surface water contamination from unexpected waste rock material geochemical issue	Run-off/seepage to surface waters exceeds water quality requirements, completion criteria unable to be achieved	3	D	M	Previous geochemical testing programs	Geochemical testing and previous rehabilitation of waste rock dumps at the QNH indicates that issues with run-off/seepage to surface water from waste rock dumps are unlikely	-			3	E	L
					Run-off sampling at nominated locations	Geochemical testing and previous rehabilitation of waste rock dumps at the QNH indicates that run-off/leachate issues from waste rock dumps are unlikely	QCoal Environmental Personnel					
					Specific actions to be developed to address identified geochemical issues	Remedial actions will depend on the location, extent and type of geochemical issue identified	QCoal Environmental Personnel Geochemical Consultants					

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Groundwater contamination from unexpected waste rock geochemical issue	Run-off/seepage to groundwater exceeds water quality requirements, completion criteria unable to be achieved	3	D	M	Previous geochemical testing programs	Geochemical testing and previous rehabilitation of waste rock dumps at the QNH indicates that issues with leachate to groundwater from waste rock dumps are unlikely	-			3	E	L
					Groundwater sampling at nominated locations	Ongoing groundwater monitoring program will identify trends that would indicate a geochemical issue	QCoal Environmental Personnel					
					Specific actions to be developed to address identified geochemical issues	Remedial actions will depend on the location, extent and type of geochemical issue identified	QCoal Environmental Personnel Geochemical Consultants					
MM1: Achievement of structural stability												
PRCP Schedule non-conformance, non-achievement of Milestone	Milestone timeframes not achieved, potential non-compliance with PRCP Schedule	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
Non-compliance with void area and slope criteria	Milestone Criteria not achieved	3	C	H	Survey of completed residual void	The SCM mining pits are developed in accordance with the slope criteria during LOM operations The maximum residual void areas form part of the design considerations during LOM planning for the SCM	QNH Technical Services Personnel QCoal Environmental Personnel			2	D	L

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
MM2: Achievement of Surface Requirements												
PRCP Schedule non-conformance, non-achievement of Milestone	PRCP Schedule non-conformance, non-achievement of Milestone	3	C	H	Inclusion of rehabilitation activities in QNH Annual Budget	All mining activity is driven by the budget and associated schedule, and rehabilitation activities are to be included in the budget to align with the PRCP Schedule	QNH Mining Manager	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L
					Inclusion of rehabilitation activities in QNH Mine Schedule/Forecast	Inclusion of rehabilitation activities in the schedule ensures that resources, personnel and equipment are available to undertake the required scope	QNH Mining Manager					
					QNH PRCP progress meetings	As required meetings to track progress against QNH PRCP Schedule	QNH Technical Services Personnel QCoal Environmental Personnel					
					PRCP Schedule Amendment	A PRCP Schedule amendment would only be undertaken where the schedule for land becoming available has slipped and there is no reasonable possibility of recovery	QCoal Environmental Personnel					
Non-compliance with approved milestone criteria	Milestone Criteria not achieved	2	C	M	Survey of completed residual void	The SCM mining pits are developed in accordance with the slope criteria during LOM operations The void bunding, fencing and signage requirements form part of the operational LOM planning for the SCM	QNH Mining Manager QCoal Environmental Personnel			2	D	L
MM3: Achievement of sufficient improvement												

Risk	Impact	Untreated Risk			Selected Control/ Treatment	Control/Treatment Justification	Resources Required	Performance Measures	Reporting and Monitoring	Residual Risk		
		Consequences	Likelihood	Risk Rating						Consequences	Likelihood	Risk Rating
Void does not achieve certification from AQPs in relation to environmental harm outside tenure boundary, that it is safe to humans and livestock and that the water level and quality will not cause environmental harm to the surrounding environment	Milestone Criteria not achieved	2	C	M	Early and ongoing engagement with AQPs to anticipate any certification issues	Modelling and monitoring undertaken to date indicates that the milestone criteria are achievable. Early engagement with the AQP will ensure that adequate data is available to enable certification	QCoal Environmental Personnel	Achievement of the PRCP Milestone Criteria as per Section 3 of the PRC Plan	Monitoring and reporting as outlined in Section 7 of the PRC Plan	2	D	L

7.2 Rehabilitation Trials

The SCM EA does not stipulate rehabilitation trials are required to be undertaken, and currently there are no rehabilitation trials planned at SCM.

Rehabilitation monitoring at the SCM commenced in 2012; and has been undertaken annually since that time with the monitoring program more recently being expanded to include rehabilitation at other QNH mines. The rehabilitation monitoring program provides data relating to actual completed rehabilitation at various locations across the QNH and SCM, including the effectiveness of the methodologies adopted in the QNH RMP and progress of rehabilitated areas towards meeting the completion criteria. As such rehabilitation monitoring negates the need for trials relating to rehabilitation methodology.

8 Monitoring and Maintenance

Following establishment of rehabilitation in an area, progress towards achieving the rehabilitation milestone criteria will be monitored. The ongoing monitoring activities will identify any maintenance that is required to be undertaken to enable the milestone criteria to be achieved.

8.1 Rehabilitation Monitoring

Monitoring of rehabilitation progress against completion criteria has been ongoing at the QNH since 2012 and has continued on an annual basis. Requirements, frequencies and methods of rehabilitation monitoring are detailed in QNH RMP and summarised in the following sections.

Monitoring of rehabilitation will continue at SCM until such time as the disturbed areas are certified and the EA surrendered.

8.1.1 Timing

Rehabilitation monitoring is undertaken annually following the wet season, or at an alternate frequency based on recommendations from a suitably qualified person. Monitoring of progressive rehabilitation areas will only commence after a minimum of one wet season has passed following completion of rehabilitation works. This will allow monitoring to better assess the performance of the growth media, seeding, rates of growth, groundcover, erosion, and other criteria.

Soil assessments at both monitoring and reference sites are undertaken approximately every five (5) years; however, a suitably qualified person may recommend an increase or decrease in the frequency of these assessments based on monitoring results.

8.1.2 Survey Intensity

Rehabilitation areas are broken into discrete management units to facilitate data management and planning for rehabilitation monitoring. Management unit delineation is based on the current and historic mining land use, proposed post mining land use, age of the rehabilitation and rehabilitation methodology.

Rehabilitation monitoring intensity will be determined by an appropriately qualified person with consideration to the PRCP Schedule requirements, proposed post mining land use and other relevant considerations.

8.1.3 Selection of Suitable Reference Sites

Reference sites are used as a non-mine affected point of comparison to assess performance of the rehabilitated areas with regard to groundcover, carrying capacity (productivity), weed proportion, and species mix and composition.

Monitoring reference sites are specifically selected to be appropriate analogues to the rehabilitated areas being monitored. The land use of the reference sites align with the intended PMLU of the rehabilitation area(s) being monitored. The location of suitable reference sites have been determined through monitoring and will continue to be monitored. However, reference site locations may be altered if required in response to the dynamic nature of ephemeral landscapes that are, and have historically been, used for cattle grazing. The location of reference sites may also be reviewed in the event of access restrictions or land use changes.

8.1.4 Monitoring Parameters

8.1.4.1 Land Suitability and Vegetation

Vegetation assessments are conducted using 50 m transects to confirm land suitability has been achieved. Sites have been chosen by the suitably qualified person undertaking the work and are landform dependent. Any photographs taken during vegetation assessment follow the methodology found in the *Pasture photo standards* (DPIF, 2003). The following parameters are measured:

- Species present in for each transect to determine species composition and proportion of preferred/non-preferred species.
- Groundcover within 1 m square quadrats and is averaged to assess compliance with the groundcover completion criteria. This measurement also includes characterisation of the groundcover (e.g. vegetation, woody debris, rock, etc.).
- Stock carrying capacity as head/Ha based on grass load.
- Vegetation structure.
- Species showing evidence of fruiting or flowering are to be noted.
- Prescribed weed species are to be noted.

Carrying capacity is calculated in accordance with advice from the (then) Queensland Department of Agriculture Fisheries and Forestry (NRA, 2015), as follows:

- One adult equivalent (450 kg beast) requires 2.2% of live body weight of dry biomass per day (3,650 kg per annum).
- A utilisation rate of 25% to 30% should be applied to prevent degradation.
- Therefore, one beast requires between 12,167 and 14,600 kg of dry biomass per annum.

The number of hectares required per beast is calculated by dividing the dry biomass required per annum by the measured mean pasture biomass (in kg/Ha) of each management unit. To determine the carrying capacity, the number of hectares per beast is then converted to head/Ha.

8.1.4.2 Soils

Soil monitoring is undertaken by excavating the soil profile to a depth of at least 1 m below ground surface, with samples typically collected at intervals of 10 cm. The following parameters are to be assessed:

- Plant Available Water Capacity (PAWC)
- Exchangeable Sodium Percentage (ESP)
- Soil Salinity (1:5)
- Soil pH (1:5)
- Water erosion, calculated as a function of slope % and ESP
- Rockiness

Laboratory analyses are undertaken by a laboratory that is NATA-accredited for the given parameter.

The following information is also gathered in accordance with the methods and categories in the *Australian Soil and Land Survey Field Handbook* (NCST, 2009):

- Slope
- Surface condition
- Depth of topsoil and other horizons
- Soil colour per horizon (as per the Munsell Soil Colour Charts)
- Soil structure per horizon
- Coarse fragment content at the soil surface and in each horizon
- Root depth
- Presence of waterlogging features
- Presence of free carbonate and other segregations.

8.1.4.3 Other

Other data collected during monitoring is as follows:

- Evidence of any slope failure or rock falls
- Evidence of any rill or gully erosion
- Evidence of pest animals
- Note any leachate observed originating from rehabilitated co-disposal facilities/waste rock dumps.

8.1.5 Reporting

Rehabilitation monitoring results are presented in a report summarising the findings from the data collected and progress towards meeting the relevant milestone criteria. The report also evaluates

progress of rehabilitation establishment and the suitability of the rehabilitated areas for certification. Rehabilitation monitoring reports also inform the continuous improvement of rehabilitation practices and rehabilitation maintenance requirements.

8.2 Rehabilitation and Improvement Area Milestone Tracking

The progress of rehabilitation works against the rehabilitation milestones will be monitored to ensure the timeframes in the PRC Plan - Schedule are achieved. **Table 36** details the monitoring, documentation and assurance activities to be undertaken for each rehabilitation milestone to document and track the timely completion of rehabilitation at SCM.

Table 36 – Rehabilitation Milestone Tracking

Milestone Reference	Monitoring	Records/ Documentation	Review and Assurance
RM1 - Infrastructure decommissioning and removal	Infrastructure survey to form basis of Decommissioning Plan Post-removal survey	Decommissioning Management Plan Decommissioning progress records	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM2 - Identification, remediation and removal of contaminated land	Phase 1 Contaminated Land Assessment for haul road drains (where present) and any other identified potentially contaminated areas Phase 2 Contaminated Land Assessment if required Validation sampling as required post-remediation	Stage 1 Contaminated Land Assessment, including remediation requirements Records of contaminated land remediation Validation sampling results Certification from SQP	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM3 - Landform development and reshaping	Survey/LiDAR of landform Analyse final landform against design and approval by AQP AQP verification of geotechnical stability Erosion and sediment controls verified by AQP	'As constructed' survey plan showing surveyed area contours, finished slope and conformance to designed landform and drainage for each sub-area GIS shapefile created for areas that have been shaped and contoured within QNH ArcGIS Rehabilitation map file	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM4 - Installation of a cover system (RA2)	Pre-capping survey Spot-checks of capping application thickness	As constructed' plan(s) showing capping layer, finished slopes conformance to design RPEQ certification that cover system is geotechnically stable and achieved required FOS.	Progress reporting against Milestone in Annual Return

Milestone Reference	Monitoring	Records/ Documentation	Review and Assurance
	Post-capping survey Analyse final landform against design and approval by AQP AQP verification of geotechnical stability	- GIS shapefile of capping spreading area to be updated within QNH ArcGIS Rehabilitation map file	3-Yearly PRCP Schedule Audits
RM5 - Surface preparation (top dressing, contour ripping, soil amelioration)	Assessment of growth media quality / suitability by AQP. Spot-checks of topsoil application (thickness, amelioration) Qualitative assessment of compaction and ripping recommendation	Growth media suitability report and amelioration plan (as required). GIS shapefile of topsoil spreading area to be updated within SCM ArcGIS Rehabilitation map file QNH Topsoil Register to be updated with respreading date and volume Records of compaction treatment and ripping works	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM6 - Revegetation	Monitoring of seed mix composition and application rates.	Records of seed purchase, seed certifications/declarations, seed mix compositions and seed application rates.	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM7 - Achievement of surface requirement	Scheduled and ad-hoc inspections of rehabilitation establishment to determine reseeding requirements Annual rehabilitation monitoring program for groundcover, species composition, weeds and erosion.	Ad hoc Rehab inspection records. Rehabilitation Monitoring reports detailing groundcover establishment, species composition, weed presence and erosion issues GIS shapefile of reseeding area to be updated within QNH ArcGIS Rehabilitation map file	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM8 - Achievement of post-mining land use to a stable condition	Annual rehabilitation monitoring program for groundcover, species composition, weeds, erosion and land suitability. AQP assessment of gully stability (as required)	Rehabilitation Monitoring reports detailing groundcover establishment, species composition, weed presence, erosion and land suitability. AQP report on gully stability.	Progress reporting against Milestone in Annual Return

Milestone Reference	Monitoring	Records/ Documentation	Review and Assurance
	AQP verification of landform geotechnical stability Surface water monitoring program. AQP confirmation that cover system (RA2) is functioning as designed.	Surface water monitoring data AQP reports on cover system function and landform geotechnical stability. GIS shapefile of reseeding area to be updated within QNH ArcGIS Rehabilitation map file	3-Yearly PRCP Schedule Audits
RM9 - Achievement of post-mining land use to a stable condition (RA5 and RA6)	Survey/LiDAR of diversion Analyse as built against design and approval by AQP Diversion inspection program	Approved Design Plans 'As constructed' survey plans and AQP verification of conformance with design. Diversion inspection reports detailing erosion, groundcover and species composition against required criteria.	Progress reporting against Milestone in Annual Return 3-Yearly PRCP Schedule Audits
RM10 - Achievement of post-mining land use to a stable condition (RA7)	AQP verification that retained infrastructure is safe, stable and non-polluting Water quality monitoring of retained water storages.	AQP report confirming retained infrastructure complies with milestone criteria. Written agreement with landholder accepting retained infrastructure. Water storage monitoring data.	3-Yearly PRCP Schedule Audits
RM11 - Achievement of post-mining land use water quality	Surface water monitoring program. Groundwater monitoring program	Surface water monitoring data Groundwater monitoring data Non-conformance assessment reports (if relevant)	3-Yearly PRCP Schedule Audits

8.3 Surface water monitoring

QNH maintains a comprehensive surface water monitoring program as part of the QNH environmental management system. The monitoring program has been developed and implemented ensure compliance with EA surface water monitoring requirements and to inform operational aspects of the sites water management systems.

The surface water monitoring program includes monitoring of:

- on-site water storages,
- monitoring of release water and receiving waters during controlled water releases;
- Ad hoc and event based monitoring as required;
- A Receiving Environment Monitoring Program (REMP).

All surface water monitoring is undertaken by suitably qualified and experienced persons in accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018).

The adequacy of the existing surface water monitoring program to assess the achievement of rehabilitation milestone criteria (pre and post closure) will be reviewed by an AQP by December 2030 (condition PRCP14). The review will assess the suitability of surface water monitoring locations and the water quality criteria required to achieve the desired PMLU outcomes.

8.4 Groundwater monitoring

The existing QNH groundwater monitoring program has been designed and implemented to monitor for potential unauthorised impacts to groundwater level or groundwater quality as a result of mining activities, while also achieving compliance with EA groundwater monitoring requirements. The existing QNH groundwater monitoring network comprises approximately 30 groundwater monitoring bores, 10 of which are included in the SCM EA.

All groundwater monitoring is undertaken by suitably qualified and experienced persons in accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018).

The adequacy of the existing groundwater monitoring program to assess the achievement of rehabilitation milestone criteria (pre and post closure) will be reviewed by an AQP by December 2030 (condition PRCP12). The review will assess the suitability of the groundwater monitoring network and the groundwater quality criteria required to achieve the desired PMLU outcomes.

8.5 Maintenance

Maintenance requirements for completed rehabilitation areas are identified during ongoing rehabilitation monitoring and during scheduled and ad-hoc inspections. Where maintenance issues are noted, they are assessed on a case by case basis to determine appropriate remedial actions.

Table 37 details examples of potential issues that may arise and possible remedial actions which would be considered should these occur.

Table 37 – Potential Issues and Remedial Action

Issue	Remedial Action
Seeding fails to germinate adequately, or groundcover dies following early establishment when.	Investigate topsoil quality, amelioration application (if relevant), seed quality and seed storage conditions. Reseed rehabilitated areas as required.
Rapid die-off of groundcover.	Investigate cause, and reseed rehabilitation as required.
Groundcover species are failing to thrive.	Investigate soil quality and amelioration sources and application.
Water logging – stem rot, fungal infection	Ensure that drainage features are installed correctly. Where additional drainage is required, instate drainage features. Reassess the use of fertiliser (if it had been applied)
Extensive exotic weed cover	Assess the requirement for additional weed management actions to aid preferred species establishment.
Erosion or Slippage in rehabilitation areas	Investigate for failures in drainage features and reinstate or add additional drainage as required. Repair rill erosion by ripping and re-contouring. Repair gully erosion by filling and recontouring.

Rehabilitation maintenance actions are recorded in the QNH Environmental Actions Register, where they are allocated to a responsible person, scheduled, and tracked through to completion.

Where appropriate, the outcomes/learnings from rehabilitation issues which require maintenance will be used to inform future rehabilitation programs, for example where a standard practice can be modified to prevent recurrence.

8.6 Weed Management

Invasive weeds can have serious implications for achievement of progressive rehabilitation completion criteria and achievement of PMLU outcomes. Rehabilitation milestone criteria for progressive rehabilitation at SCM requires vegetative groundcover of revegetated areas to be less than 5% weeds (Category 3 restricted invasive plant species and Weeds of National Significance).

Weed management practices at SCM are detailed in the *QNH Weed Management Plan*. Where weed control is required, a licenced and qualified professional undertakes herbicide treatment (including selection of appropriate herbicides and application) with a focus on priority weed species. Weed control is an ongoing process and will likely require repeated treatments.

Weed prevention is more effective and economical than weed treatment; therefore, efforts are made to prevent the spread of weeds into rehabilitation areas. These include:

- Limiting the area of soil disturbed at any one time to minimise exposure of bare ground.

- Using mulches and establish preferred groundcover as quickly as practicable
- Avoiding importing or using soils where their origins and seedbanks are unknown.
- Avoiding re-using weed infested topsoils if possible.
- Ensuring that any seed mixes used for rehabilitation are weed free
- Ensuring stockpiled topsoil material is weed-free prior to use.

Priority weed species for the QNH are listed in the QNH Rehabilitation Management Plan and reproduced in **Table 38**.

Table 38 - Significant Weeds identified

Family	Species	Common Name	Biosecurity QLD Declared (Class)	Whitsunday Regional Council Biosecurity Plan Class
Amaranthaceae	<i>Gomphrena celosioides</i>	Gromphrena Weed	No	No
Apocynaceae	<i>Cryptostegia grandiflora</i>	Rubber Vine	Yes (2)	Yes (2)
Asteraceae	<i>Parthenium hysterophorus</i>	Parthenium	Yes (2)	Yes (2), WoNS
Asteraceae	<i>Xanthium pungens</i>	Noogoora Burr	No	No
Cactaceae	<i>Eriocereus spp.</i>	Harrisia Cactus	Yes (2)	Yes (2)
Cactaceae	<i>Opuntia stricta</i>	Prickly Pear	Yes (2)	No
Mimosaceae	<i>Acacia farnesiana</i>	Prickly Mimosa	No	No
Mimosaceae	<i>Acacia nilotica</i>	Prickly Acacia	Yes (1)	Yes (2); WoNS
Papaveraceae	<i>Aremone ochraluca</i>	Prickly Poppy	No	No
Poaceae	<i>Cenchrus ciliaris</i>	Buffel Grass	No	No
Rhamnaceae	<i>Ziziphus mauritiana</i>	Chinee Apple	Yes (2)	Yes (2)

8.7 Rehabilitation Completion

Rehabilitation will be considered to have achieved post mining land use to a stable condition when the rehabilitation milestone criteria specified in the PRC Plan Schedule have been achieved and verified. Assessments and certifications that will be undertaken for SCM rehabilitation milestone criteria are outlined in **Table 39**. The timing of the assessments and certifications will be in accordance with the PRC Plan Schedule.

Table 39 – Assessments and Certifications

Task	Description
Contaminated Land Assessment	Requirement for a Phase 1 for all relevant sites, using ERC to inform the Phase 1. Phase 1 informs any required Phase 2, which in turn informs any remediation and verification. Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. Certification that any identified contaminated land has been managed appropriately and in accordance with the relevant administering authority guideline/s.
Geotechnical Assessment	Confirmation/Certification that the final landforms meet the design criteria and are therefore stable/geotechnically sound.

Task	Description
Geotechnical studies	Certification that the final landforms are stable/geotechnically sound, and there is a low risk of rock falls with serious environmental or safety consequences.
Surface and groundwater monitoring	Monitoring is to be undertaken to identify occurrence of any potential downstream impacts.
Soils Assessment	Monitoring of topsoil is to be undertaken in order to determine chemical, physical and biological properties remain appropriate for the proposed land use.
Final Rehabilitation Report	Report outlining compliance with conditions of the EA, achievement against completion criteria, the extent and success of the rehabilitation, ongoing environmental management and monitoring requirements, and residual risk.
Compliance Statement	Details compliance with EA conditions and confirms the accuracy of the Final Rehabilitation Report.

Once rehabilitation milestone criteria have been achieved to a satisfactory level and the performance verification has been completed, the final rehabilitation report will be provided to the administering authority. The final rehabilitation report outlines compliance with conditions of the SCM EA (the primary LOD) and the PRC Plan Schedule milestone criteria, the extent and success of the rehabilitation, any ongoing environmental management and monitoring requirements, as well as any residual risk. A compliance statement must also be provided with the final rehabilitation report, detailing compliance of the report against the various requirements of the EA and the PRC Plan Schedule.

Additionally, any land that has previously been on the Environmental Management Register (such as contaminated land) must be removed or have an appropriate Site Management Plan approved and in place.

Upon receipt of the final rehabilitation report, certification of the rehabilitation by the administering authority can proceed and allow for surrender of the site EA, at which time the PRCP Schedule will cease to have effect.

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Appendices

Appendix A - Sonoma PRC Plan Schedule

Appendix B - Sonoma Environmental Authority

Appendix C - QNH Rehabilitation Management Plan

Appendix D - Two Mile Creek Diversion Addendum Report for Final Landform (Engeny, 2022)

Appendix E - North Sonoma Creek Diversion Design Plan (Engeny 2018)

Appendix F - QCoal Northern Hub Groundwater Modelling Report (Australian Groundwater and Environmental Consultants 2023)

Appendix G - Sonoma Coal Project Land Resource Assessment Report (GSSE, 2005)

Appendix H - Drake Coal Project Soils and Land Suitability Assessment (GHD, 2012)

Appendix I - Sonoma PRC Plan Community Consultation Register

Appendix J - Sonoma Coal Project – Overburden Assessment Report (Parsons Brinckerhoff, 2006)

Appendix K - Drake Coal Project SEIS Excavated Waste Characterisation Report (GHD, 2013)

Appendix L - QNH Mine Waste Management Plan

Appendix A - Sonoma PRC Plan Schedule

PRCP Schedule

Environmental Protection Act 1994

P-PRCP-100716340 Sonoma Coal Mine

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

PRCP schedule: P-PRCP-100716340_V1

PRCP schedule holder(s)

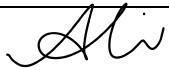
Name(s)	Registered address
QCoal Sonoma Pty Ltd	Level 15, 40 Creek Street BRISBANE CITY QLD 4000
CSC Sonoma Pty Ltd	Level 7, 300 Queen Street BRISBANE CITY QLD 4000
JS Sonoma Pty Ltd	Suite 3B, Level 33, 52 Martin Place SYDNEY NSW 2000
Watami (QLD) Pty Ltd	Level 2, 262 Adelaide Street BRISBANE CITY QLD 4000

Location details

Location(s)
ML10325, ML10326, ML10327, ML700075

Take effect

In accordance with section 202B of the *Environmental Protection Act 1994* (EP Act), the PRCP schedule has effect on the day the environmental authority for carrying out relevant activities on land to which the schedule relates takes effect. Pursuant to section 202C of the EP Act, a PRCP schedule continues in force until the environmental authority for the relevant activities to which the PRCP schedule relates is cancelled or surrendered, even if the resource tenure expires or is cancelled and even if the relevant environmental authority is suspended under Chapter 5, part 11 or 11A of the EP Act.



Signature

26 March 2026

Date

Alison Cummings

Department of the Environment, Tourism, Science and Innovation

Delegate of the administering authority

Environmental Protection Act 1994

Enquiries:

Business Centre (Coal)

PO Box 3028, Emerald QLD 4720

Phone: (07) 4987 9320

Email: CRMining@detsi.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

Pursuant to section 202E of the EP Act, if there is an inconsistency between an environmental authority and a PRCP schedule, the environmental authority prevails to the extent of the inconsistency.

Pursuant to section 285 of the EP Act:

- the holder of a PRCP schedule must commission an audit of the schedule by a rehabilitation auditor for the following periods (each an audit period) —
 - (a) the 3-year period starting on the day the schedule takes effect
 - (b) each 3-year period starting on the day after the previous audit period ended.
- the holder must, within 4 months after the end of each audit period, give the administering authority -
 - (a) the rehabilitation auditor's report (an audit report) about the audit that complies with section 286 of the EP Act, and
 - (b) a declaration for the audit report that complies with section 285 of the EP Act.

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

PRCP schedule

The PRCP schedule incorporates the following sections:

- Section A - Conditions of PRCP schedule
- Section B - Definitions
- Section C - Final site design and reference maps
- Section D - Post mining land uses
- Section E - Non-use management areas.
- Section F - Appendices

1 Section A - Conditions of PRCP schedule

Pursuant to section 206A of the EP Act:

- it is a condition of this PRCP schedule that, in carrying out a relevant activity under the schedule, the holder must comply with a requirement stated in the environmental authority relevant to carrying out the activity.
- it is a condition of this PRCP schedule that the holder must comply with the following matters stated in the schedule -
 - (a) each rehabilitation milestone and management milestone
 - (b) when each rehabilitation milestone and management milestone is to be achieved

There are no conditions beyond those contained in section 206A of the *Environmental Protection Act 1994* that apply to this PRCP schedule.

General conditions

PRCP	Condition
PRCP1	For each rehabilitation and improvement area, achieve the corresponding rehabilitation or management milestone criterion (milestone reference): (a) For the cumulative area available specified in this schedule; and (b) By the milestone completion date specified in this schedule.
PRCP2	Where land becomes 'available for rehabilitation' earlier than the date nominated in this schedule, the holder must: (a) Notify the administering authority in writing within thirty (30) days, or a longer timeframe as agreed with the administering authority of the land becoming 'available for rehabilitation'; and (b) Whether or not it considers that it would be reasonable and appropriate to apply to the administering authority to amend this schedule in a way that maximises the progressive rehabilitation of the land to a stable condition. Note: (a) Reference to "earlier than the nominated date in the schedule" means a date that is greater than 5 year prior to the date nominated in the schedule. (b) Assessment of land becoming available is undertaken nominally on an annual basis. (c) Rehabilitation of land size must be practicable and economical. (d) The dates by which milestones are to be completed is brought forward, to the extent it is reasonably practicable to do so, by the same amount of time as the commencement was brought forward.
PRCP3	Where an area achieves a rehabilitation or management milestone, the holder must continue to achieve the milestone criteria for that milestone until: (a) The next rehabilitation or management milestone is achieved; or (b) A progressive certification area has satisfied the provisions of section 318ZB(4) of the <i>EP Act</i>; or (c) Until a surrender is approved
PRCP4	The holder must maintain a risk register that identifies the risks to not achieving a stable condition for post-mining land uses, and how the risks are being managed or minimised. The risk register must be reviewed every three (3) years .

PRCP5	The holder must undertake monitoring and maintenance as described in this schedule and the rehabilitation planning part for the activity. Where there is any inconsistency between this schedule and the rehabilitation planning part the schedule criteria prevail to the extent of the inconsistency.
PRCP6	The holder must make and keep until the relevant milestone criteria has been met or progressive rehabilitation certification has been achieved, up to date records on: (a) Achievement and maintenance of achievement of each rehabilitation milestone criteria of this schedule. (b) Rehabilitation activities and the results of those activities (including but not limited to, actions taken, date, location, methods, data collected, QA/QC, photos, waste tracking and disposal records, appropriately qualified person (AQP) details and assumptions); (c) Maintenance of rehabilitation and the results of maintenance activities; (d) Monitoring of rehabilitation and the results of monitoring; (e) Details and results of rehabilitation trials; (f) Designs, drawings, specifications and any similar documents developed in accordance with good professional practice in relation to rehabilitation milestones or milestone criteria; and (g) Details of community consultation in the community consultation register relating to rehabilitation and closure activities.
PRCP7	Records made under PRCP 6 must be provided to the administering authority in the specified format within ten (10) business days or an alternative timeframe agreed to by the administering authority of a written request.
PRCP8	The holder must, by 31 December 2030, provide to the administering authority an AQP prepared cover design report for RA2 that includes: (a) Detailed engineering designs; (b) The depth and levels of tailings materials; and (c) Characteristics of the cover materials, that are proposed to be used including its quantity, quality, source location, and accessibility.
PRCP9	The holder must, by 31 December 2030 , provide to the administering authority an AQP prepared report that ensures that rejects and tailings material disposed of in-pit will remain completely submerged during various climatic conditions including drought.
PRCP10	The holder must, by 31 December 2030, provide to the administering authority a flood assessment that addresses the requirements of section 3.6.1 of the PRCP guideline and includes further detail and clarity regarding - (a) Flood depth and velocity for the 0.1%AEP for the final landform; (b) The influence of flooding on the final landform (including but not limited to overtopping risk for residual voids) and justify that this is a stable condition; (c) The future conditions of watercourses, including the geotechnical assessment against flood modelling velocities, the post mining flood model, and justify how this will form a stable condition; and (d) Mitigation measures to address the issues identified in the PRC planning part.
PRCP11	The holder must, by 31 December 2030 , provide to the administering authority up-to-date closure groundwater, residual void and water balance model/s (calibrated once data becomes available) which must be maintained with predictions rerun at least every five (5) years and within a year of any surrender application.

PRCP12	The holder must, by 31 December 2030, provide to the administering authority a report which: (a) Reviews the criteria / quality limits based on site-specific data for Appendix 8a – Groundwater Quality Limits; Appendix 8b – Bore specific Groundwater quality limits based on site-specific data and (b) Considers the requirements of the administering authority's, or its successor's, most recent edition of the Guideline: "Using monitoring data to assess groundwater quality and potential environmental impacts" (DES, 2021); and (c) Review the adequacy of the groundwater monitoring network for closure and propose suitable alluvial groundwater monitoring bores around the Sonoma east area and RA2.
PRCP13	The holder must, within three (3) months of finalising: (a) The updated modelling required by condition PRCP11; and (b) Groundwater quality review required by PRCP12; Seek to amend Appendix 7 – Groundwater monitoring bores, Appendix 8a – Groundwater quality limits and Appendix 8b – Bore specific Groundwater quality limits based on site-specific data of this PRCP schedule.
PRCP14	The holder must, by 31 December 2030, provide to the administering authority a report which: (a) Reviews the adequacy of the surface water quality monitoring locations identified in Appendix 4 - Surface water monitoring locations, for closure; and (b) Proposes suitable monitoring locations around Sonoma East area, with coordinates, and rationale for the proposed monitoring point(s).
PRCP15	Disturbance due to exploration and minor ancillary activities in areas not planned to be mined and not within a Rehabilitation Area in this Schedule must be rehabilitated in accordance with the provisions detailed in the '<i>Eligibility criteria and standard conditions for exploration and mineral development projects</i>' or its successor, with the exception that land must be rehabilitated to a stable condition which includes achieving the relevant post mining land use for the disturbance location as detailed in the Figure 1 - Final site design included in the PRCP schedule.

END OF CONDITIONS

2 Section B – Definitions

Activity (Environmental Protection Regulation)	includes that part, if any, of an activity relating to the following— (a) preparing a place for the activity before carrying out the activity; and (b) rehabilitating a place after it has been used for carrying out the activity.
Appropriately qualified person (AQP)	means a person who has professional qualifications, training, skills and 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.
Contaminants	can be a gas, liquid or solid; or an odour; or an organism (whether alive or dead), including a virus; or energy, including noise, heat, radioactivity and electromagnetic radiation; or a combination of contaminants.
Environmentally problematic material	means material that will negatively impact water quality and stability or vegetation growth.
Growth media	is defined as all soil and soil-like material that will support the final vegetation cover. This includes the topsoil and subsoil where these materials are applied independently. Where the topsoil is incorporated into the underlying subsoil/spoil, topsoil refers to the depth of incorporation and the remaining depth is regarded as subsoil. The total depth of growth media is nominally considered to be the effective plant root zone
Groundcover	means plants, plant litter, tree leaf litter, twigs, woody debris and rock mulch capable of protecting the soil surface from erosion.
Gully	A gully is a channel excavated by water; more than 0.3m deep.
Minor ancillary activities	Means activities that support the carrying of exploration, environmental monitoring and survey, and access* activities that may result in minor areas of disturbance. Note: *this does not include haul roads.
Potentially acid forming (PAF)	means material with either a Net Acid Producing Potential of greater than 5kg of H ₂ SO ₄ /tonne or a Net Acid Generation oxidation pH of less than 4.5 (pH unit).
Rill	A rill is a channel excavated by water; less than 0.3m deep.
Stable	in relation to land, means landform dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of environmental context, geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.
Stabilised	means one or both of the following conditions apply: no evidence of sediment movement; sides and/or floors of erosion form are revegetated (Australian Soil and Land Survey Field Handbook Fourth Edition).
Stable condition	see section 111A of the <i>Environmental Protection Act 1994</i> .
Suitably qualified and experienced person (SQP)	for performing a regulatory function under chapter 7, part 8 (Contaminated Land) of the EP Act or another function prescribed under a regulation, means a person who— (a) has qualifications and experience relevant to performing the function; and (b) if a regulation prescribes an organisation for this paragraph—is a member of the organisation.

Vegetative groundcover	Means plants, plant litter, tree leaf litter, twigs and woody debris capable of protecting the soil surface from erosion
Weeds	Weeds include: • Category 3 restricted invasive plant species, defined by the <i>Biosecurity Act 2014</i>; and • Weeds of National Significance, defined by Invasive Plants and Animals Committee 2016, Australian Weeds Strategy 2017 to 2027, Australian Government Department of Agriculture and Water Resources, Canberra.

3 Section C - Final site design and reference maps

Figure 1 – Final Site Design

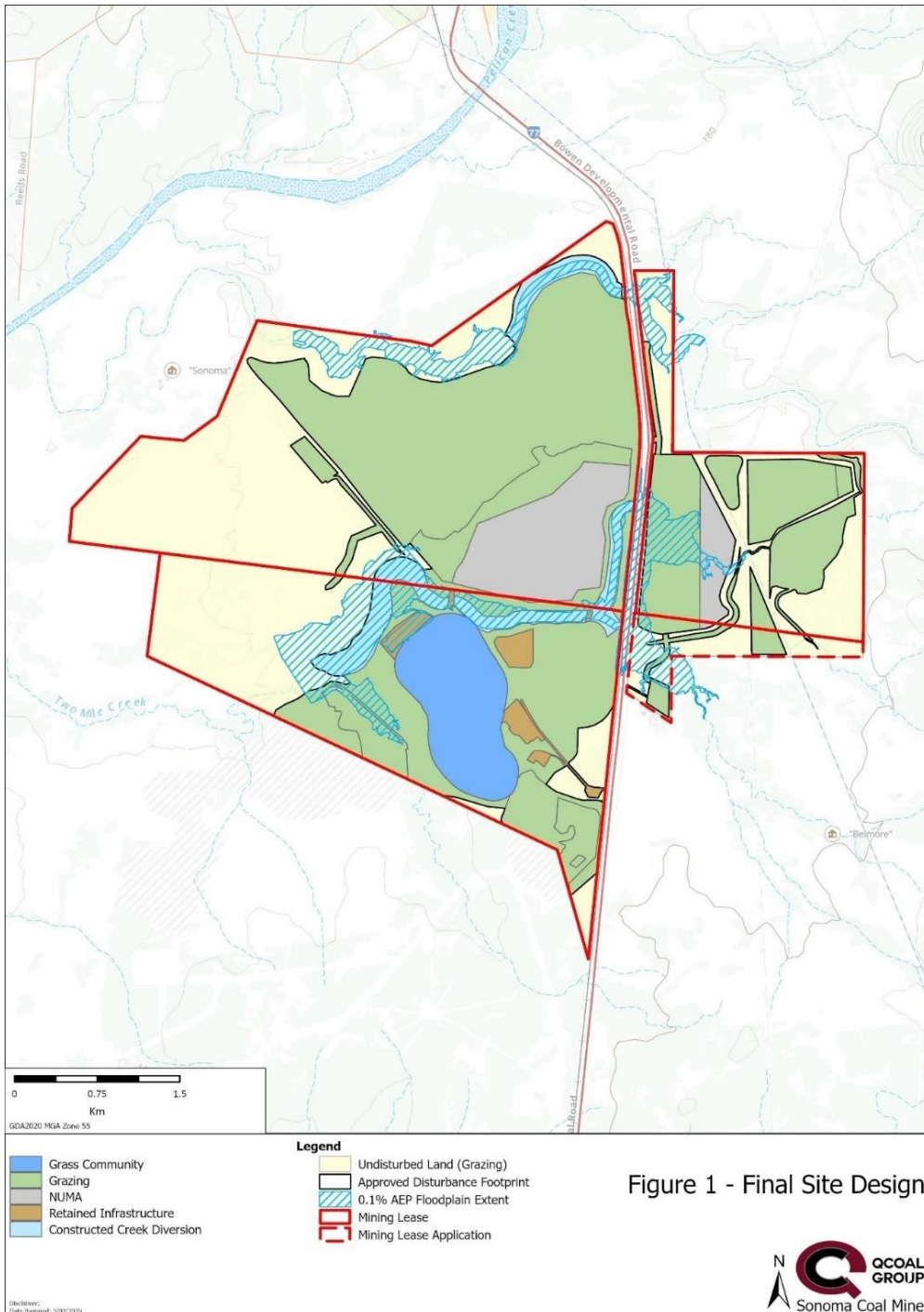
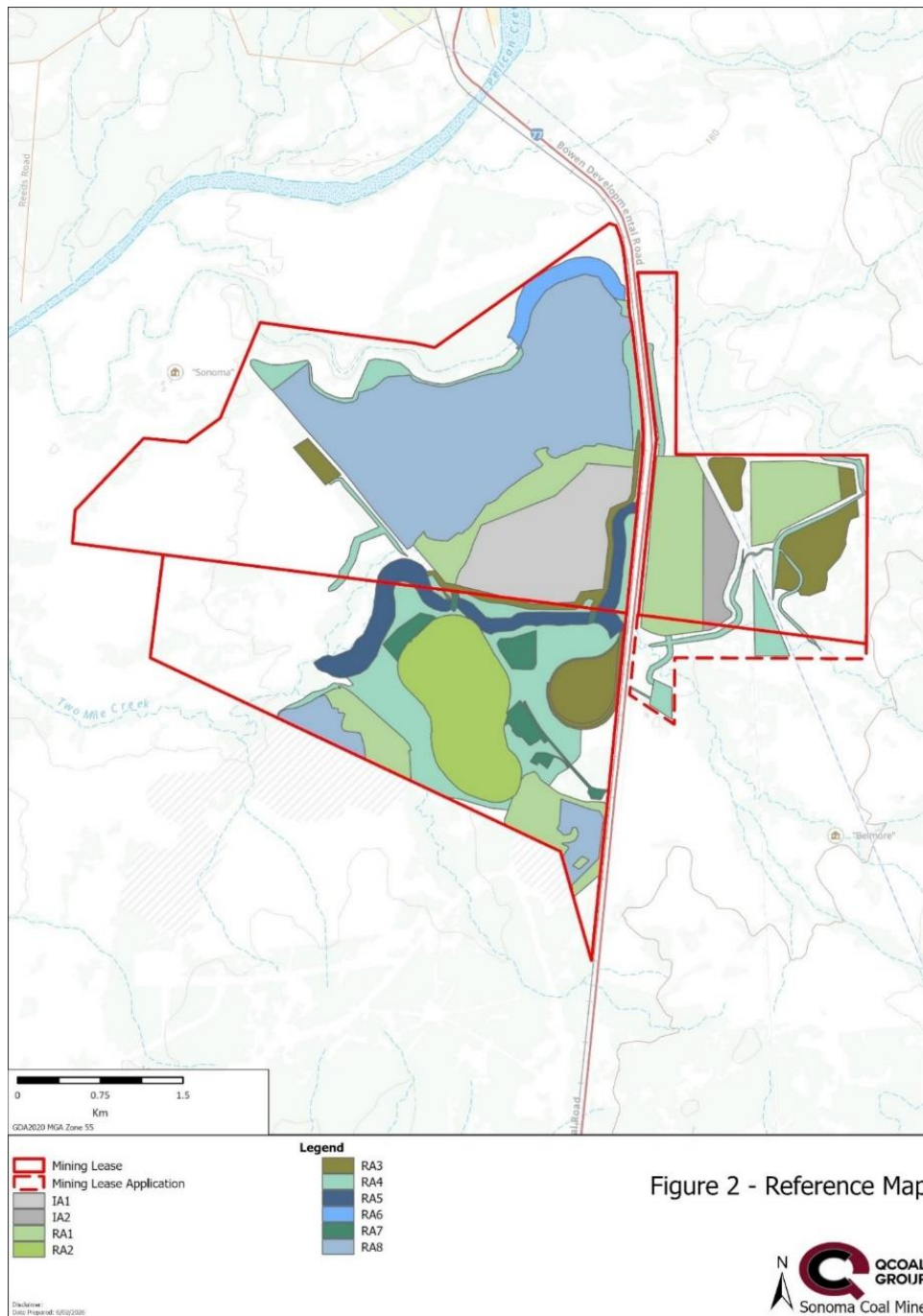


Figure 2 – Reference Map



4 Section D – Post mining land uses

Milestone reference	Milestone description	Rehabilitation Area								Improvement Area	
		RA1	RA2	RA3	RA4	RA5	RA6	RA7	RA8	IA1	IA2
		WRDs	CDA	Infrastruct ure	At-grade disturbance	Two-Mile Creek Diversion	Coral Creek Diversion	Retained Infrastructure	Existing rehab		
		Grazing	Grassland community	Grazing	Grazing	Constructed Creek Diversion	Constructed Creek Diversion	Retained infrastructure	Grazing		
Rehabilitation milestones											
RM1	Infrastructure decommissioning and removal										
RM2	Identification, remediation and removal of contaminated land										
RM3	Landform development and reshaping										
RM4	Installation of a cover system (RA2)										
RM5	Surface preparation (top dressing, contour ripping, soil amelioration)										
RM6	Revegetation										
RM7	Achievement of surface requirements										
RM8	Achievement of post-mining land use to a stable condition										
RM9	Achievement of post-mining land use to a stable condition (Creek Diversion)										

Milestone reference	Milestone description	Rehabilitation Area								Improvement Area	
		RA1	RA2	RA3	RA4	RA5	RA6	RA7	RA8	IA1	IA2
		WRDs	CDA	Infrastruct ure	At-grade disturbance	Two-Mile Creek Diversion	Coral Creek Diversion	Retained Infrastructure	Existing rehab		
		Grazing	Grassland community	Grazing	Grazing	Constructed Creek Diversion	Constructed Creek Diversion	Retained infrastructure	Grazing		
RM10	Achievement of post-mining land use to a stable condition (Retained Infrastructure)										
RM11	Achievement of post-mining land use water quality										
Management milestones											
MM1	Achievement of final landform design										
MM2	Achievement of safety requirements										
MM3	Achievement of sufficient improvement										

4.1 (RA1) Rehabilitation area 1

Post-mining land uses (PMLU)										
Rehabilitation area				RA1						
Relevant activities				Waste Rock Dumps						
Total rehabilitation area size (ha)				235.0						
Commencement of first milestone				10/12/2040						
PMLU				Grazing Pasture						
Date area is available	10/12/40	10/12/45	10/12/48	10/12/51	10/12/54	10/12/57				
Cumulative area available (ha)	139.6	139.6	139.6	139.6	139.6	235.0				
Milestone completed by	10/12/45	10/12/48	10/12/51	10/12/54	10/12/57	10/12/560	10/12/63	10/12/66	10/12/74	
Milestone Reference	Cumulative area achieved (ha)									
RM1	139.6					235.0				
RM2	139.6					235.0				
RM3	105.9	136.9				235.0				
RM5	105.9	136.9				235.0				
RM6	105.9	136.9				235.0				
RM7			79.8	139.6		139.6	235.0			
RM8				79.8	139.6	139.6	139.6	235.0		
RM11									235.0	

4.2 (RA2) Rehabilitation area 2

Post-mining land uses (PMLU)										
Rehabilitation area	RA2									
Relevant activities	Out-of-Pit Co-disposal Area									
Total rehabilitation area size (ha)	120.2									
Commencement of first milestone	10/12/2040									
PMLU	Grassland Community									
Date area is available	10/12/40	10/12/45	10/12/48	10/12/51						
Cumulative area available (ha)	41	44	66	120.2						
Milestone completed by	10/12/45	10/12/48	10/12/51	10/12/54	10/12/57	10/12/60	10/12/63	10/12/74		
Milestone Reference	Cumulative area achieved (ha)									
RM1	41			120.2						
RM2	41	44	66	120.2						
RM3	41	44	66	120.2						
RM4				66	120.2					
RM5					120.2					
RM6					66	120.2				
RM7					66	120.2				
RM8						66	120.2			
RM11								120.2		

4.3 (RA3) Rehabilitation area 3

Post-mining land uses (PMLU)										
Rehabilitation area			RA3							
Relevant activities			Surface Infrastructure (includes MIA, CHPP, coal stockpiles, rail loop, water storages)							
Total rehabilitation area size (ha)			113.9							
Commencement of first milestone			10/12/2046							
PMLU			Grazing Pasture							
Date area is available	10/12/46	10/12/48								
Cumulative area available (ha)	60	113.9								
Milestone completed by	10/12/48	10/12/49	10/12/50	10/12/52	10/12/54	10/12/74				
Milestone Reference	Cumulative area achieved (ha)									
RM1	60	113.9								
RM2	60	113.9								
RM3		113.9								
RM5			113.9							
RM6			113.9							
RM7				113.9						
RM8					113.9					
RM11						113.9				

4.5 (RA4) Rehabilitation area 4

Post-mining land uses (PMLU)										
Rehabilitation area				RA4						
Relevant activities				At-Grade Disturbance (includes areas at grade and areas of minor disturbance where there is limited removal of vegetation or topsoil)						
Total rehabilitation area size (ha)				229.3						
Commencement of first milestone				10/12/2046						
PMLU				Grazing Pasture						
Date area is available	10/12/46	10/12/48	10/12/50							
Cumulative area available (ha)	143.6	143.6	229.3							
Milestone completed by	10/12/48	10/12/50	10/12/52	10/12/74						
Milestone Reference	Cumulative area achieved (ha)									
RM1	143.6	229.3								
RM5	143.6	229.3								
RM6		143.6	229.3							
RM7		143.6	229.3							
RM8		143.6	229.3							
RM11				229.3						

4.7 (RA5) Rehabilitation area 5

Post-mining land uses (PMLU)										
Rehabilitation area				RA5						
Relevant activities				Existing Two-Mile Creek Diversion						
Total rehabilitation area size (ha)				65.5						
Commencement of first milestone				10/12/2050						
PMLU				Constructed Creek Diversion						
Date area is available	10/12/50									
Cumulative area available (ha)	65.5									
Milestone completed by	10/12/52	10/12/74								
Milestone Reference	Cumulative area achieved (ha)									
RM1	65.5									
RM9	65.5									
RM11		65.5								

4.8 (RA6) Rehabilitation area 6

Post-mining land uses (PMLU)										
Rehabilitation area				RA6						
Relevant activities				Existing Coral Creek Diversion						
Total rehabilitation area size (ha)				22.8						
Commencement of first milestone				10/12/2050						
PMLU				Constructed Creek Diversion						
Date area is available	10/12/50									
Cumulative area available (ha)	22.8									
Milestone completed by	10/12/52	10/12/74								
Milestone Reference	Cumulative area achieved (ha)									
RM1	22.8									
RM9	22.8									
RM11		22.8								

4.9 (RA7) Rehabilitation area 7

Post-mining land uses (PMLU)										
Rehabilitation area				RA7						
Relevant activities				Retained Infrastructure						
Total rehabilitation area size (ha)				30.6						
Commencement of first milestone				10/12/2064						
PMLU				Retained Infrastructure						
Date area is available	10/12/64									
Cumulative area available (ha)	30.6									
Milestone completed by	10/12/69	10/12/74								
Milestone Reference	Cumulative area achieved (ha)									
RM10	30.6									
RM11		30.6								

4.10 (RA8) Rehabilitation area 8

Post-mining land uses (PMLU)										
Rehabilitation area				RA8						
Relevant activities				Existing Rehabilitation						
Total rehabilitation area size (ha)				405.7						
Commencement of first milestone				10/12/2035						
PMLU				Grazing pasture						
Date area is available	10/12/2035	10/12/40								
Cumulative area available (ha)	287	405.7								
Milestone completed by	10/12/40	10/12/45	10/12/74							
Milestone Reference	Cumulative area achieved (ha)									
RM7	287	405.7								
RM8		405.7								
RM11			405.7							

4.11 Rehabilitation area milestones

Milestone reference	Rehabilitation milestone	Milestone criteria	
RM1	Infrastructure decommissioning and removal	1.1	With the exception of any infrastructure to remain as part of the post-mining land use (PMLU) or where infrastructure is agreed to be retained by the landholder as evidenced by a signed landholder agreement, the following are complete: (a) All services disconnected and removed. (b) All buildings and associated infrastructure dismantled and removed offsite. (c) All hardstand, concrete areas and roads (bitumen, blue metal, aggregate etc.) removed. (d) All fencing and associated foundations not part of a PMLU removed. (e) All pipelines drained and removed. (f) All waste not authorised to be disposed of on-site under Environmental Authority EPML00707713 removed. (g) All drillholes, bores, sediment ponds and sumps decommissioned. (h) All machinery and equipment, not required for rehabilitation works removed from site. (i) All dams dewatered and desilted. (j) Watercourse crossings and culverts removed.
RM2	Identification, remediation and removal of contaminated land	2.1	Contaminated land investigation document completed in accordance with the <i>Environmental Protection Act 1994</i> , including a site investigation report, and, where required, a validation report and/or a draft site management plan.
		2.2	Contaminated water and sediment removed from dams.
		2.3	Contaminated and hazardous material either remediated in-situ or removed/transported to facility lawfully able to accept the material.
		2.4	A declaration from a SQP that no contamination remains.
RM3		3.1	All Rehabilitation Areas: Final landform design has been completed and approved by an AQP.

Milestone reference	Rehabilitation milestone	Milestone criteria	
	Landform development and reshaping	3.2	Geotechnical assessment undertaken by an AQP prior to construction confirms that the landform design will achieve long-term stability, with a Factor of safety (FOS) ≥ 1.5 .
		3.3	All major earthworks completed to achieve final landform design.
		3.4	All landforms are shaped to be water shedding.
		3.5	For RA1: Batter slopes reshaped to maximum slopes of 20% (11.5°) or lower as recommended by an AQP.
		3.6	For RA2: Batter slopes reshaped to maximum slopes of 20% (11.5°) or lower as recommended by an AQP.
		3.7	For RA3 and RA4: (a) Landforms with the exception of the batter slopes of sediment dams and water management infrastructure are reshaped to a maximum slope of $\leq 15\%$. (b) All sediment dams and water management infrastructure, with the exception of those to be retained by landholder agreement, are dewatered, desilted, and reshaped to a maximum slope of $\leq 15\%$.
RM4	Installation of a cover system (RA2)	4.1	Detailed cover system design completed by an AQP, and includes a capping layer that has a minimum thickness of 3m and comprised of non-acid forming (NAF) material.
		4.2	The cover system has been installed as per design.
		4.3	Capping layer surface has slopes 0.5-2% to facilitate water shedding and minimise surface ponding.
		4.4	RPEQ certifies the cover system is geotechnically stable and has achieved a FoS ≥ 1.5 .
RM5	Surface preparation (top dressing,	5.1	Assessment of growth media characteristics and the development of an amelioration and physical treatment plan is completed by an AQP every 3 years .
		5.2	Ameliorant and physical treatments such as fertiliser, lime, gypsum and/or organic matter are applied as identified in RM5.1 .

Milestone reference	Rehabilitation milestone	Milestone criteria	
	contour ripping, soil amelioration)	5.3	Growth media suitability meets the key soil criteria specified in Appendix 1 – Soil Quality Criteria .
		5.4	Deep ripping of compacted surfaces, to <400mm (or refusal*) into soil/subsoil profile along contour of slopes. *Note, 'or refusal' refers to the depth at which bedrock is intersected.
		5.5	Growth media placement of a minimum of 150mm in areas where topsoil has previously been removed.
		5.6	Prior to seeding testing of growth media confirms the values as specified in Appendix 1 – Soil Quality Criteria are achieved.
RM6	Revegetation	6.1	Seeding of placed growth media completed using a selection of the recommended species seed mix at the seeding rate as described in Appendix 2 – Species list and seeding rates .
		6.2	For RA1: The seed mix should comprise a minimum of 25% (by weight) native species, three 3P species and two shrub / tree species.
		6.3	For RA2: The seed mix should comprise a minimum of 25% (by weight) native species, excluding any trees.
		6.4	For RA3 and RA4: The seed mix should include a minimum of three 3P native species, and a nitrogen fixing legume.
		6.5	Stock exclusion fencing has been established to prevent stock from grazing newly seeded areas.
RM7	Achievement of surface requirement	7.1	Total weed presence is less than 10% of total vegetative groundcover .
		7.2	No evidence of erosion classified as 'moderate' or 'severe' as defined by Appendix 3 – Erosion classification framework is present.
		7.3	Where the AQP determines erosion will not stabilise , intervention measures and corrective actions must be undertaken to ensure RM7.2 is met.
		7.4	Seeded areas have >50% established and self-sustaining vegetative groundcover of species consistent with Appendix 2 – Recommended species seed mix and seeding rate .

		7.5	For RA3 and RA4: Seeded areas have a minimum vegetation composition (per hectare averaged) of: • Three species of 3P native pasture species; and • Two native legumes.
		7.6	For RA1 and RA8: Minimum vegetation composition (per hectare averaged) of: • Three species of 3P native pasture species; and • Two native shrub / tree species.
		For RA2:	
		7.7	Total percentage of ground cover (i.e. ground cover foliage, woody debris, organic litter and rock) is $\geq 70\%$.
		7.8	Assessment of RA2 landform by an AQP confirms landform continues to conform with cover and geotechnical design.
RM8	Achievement of post-mining land use to a stable condition	8.1	Established and persistent vegetative groundcover $> 70\%$.
		8.2	Total weed presence comprise less than 5% of vegetative groundcover .
		8.3	No evidence of erosion classified as 'moderate' or 'severe' as defined by Appendix 3 - Erosion classification framework is present.
		8.4	Despite RM8.3 gullies are acceptable in the achievement of a stable landform provided they meet the following criteria as certified by an AQP: (a) does not exceed 1m in depth at any point; and (b) has not exposed environmentally problematic materials; and (c) the cause of the gully is known and has been resolved; and (d) has established and persistent vegetation cover and/or rock armouring at the head of the gully; and (e) is in a stabilised state, demonstrated by monitoring data over a 5 year period; and (f) does not provide a safety hazard within the context of the PMLU; and (g) does not impact the stability or performance of bench drains or stormwater chutes; and

			(h) are isolated.
		8.5	The final landform is geotechnically stable and achieves a factor of safety ≥ 1.5 .
		8.6	Surface run-off leaving rehabilitation to the receiving environment is non-polluting and meets the contaminant limits below: (a) pH 6.5-9.0; (b) EC 800 μ S/cm or background +10%, whichever is greater; and (c) Turbidity 50NTU or background +10%, whichever is greater. Surface run-off which remains on the rehabilitated landform must meet livestock drinking water defined in ANZECC & ARMCANZ 2000.
		8.7	For RA3 and RA4: Land Suitability Class is 3 as per the Guidelines for Agricultural Land Evaluation in Queensland, 2015 or as per pre-mining conditions as certified by an AQP.
		8.8	For RA1 and RA8: Land Suitability Class is 4 or better as per the Guidelines for Agricultural Land Evaluation in Queensland, 2015 or consistent with the adjacent land use as certified by an AQP.
		8.9	For RA2: Monitoring of the cover system and encapsulated material confirms that: (a) the cover system is working in accordance with the AQP design; (b) no acid or saline seepage areas capable of causing environmental harm; and (c) no deep rooted species are present.
RM9	Achievement of post-mining land use to a stable condition (RA5 and RA6)	9.1	Diversions have been constructed and stabilised in accordance with the certified Design Plans: (a) Coral Creek Diversion Design Plan 2018; and (b) Two-Mile Creek Diversion Design Plan 2018.
		9.2	At least 50% of established and persistent tree and shrub species consistent with the seed mix in Appendix 4 – Creek Diversion Species Mix must be present within the diversion area*. *Note: Refers to upper, mid and lower banks of diversion alignment.

		9.3	No evidence of erosion classified as 'moderate' or 'severe' as defined by Appendix 3 - Erosion classification framework is present.
		9.4	Vegetative groundcover (in the absence of rock or armouring at the surface) is $\geq 70\%$.
RM10	Achievement of post-mining land use to a stable condition (RA7)	10.1	Infrastructure to be transitioned to a future landholder is deemed fit for purpose (verified by an AQP) and accepted, by signed agreement, with the future landholder.
		10.2	An AQP certifies that all infrastructure to be retained onsite is safe, stable and will not cause environmental harm.
		10.3	All dams, which are to remain as part of the PMLU or are to be retained as evidenced by a signed landholder agreement, comply with the following: (a) Safely accessible by humans and livestock; (b) All contaminated sediment has been removed; and (c) Water storages monitored quarterly, water must be of a suitable quality for livestock ingestion and must not exceed the stock water guidelines (ANZECC 2000) at the end of each wet season, for a minimum of 5 consecutive years immediately prior to the milestone completion date.
RM11	Achievement of post-mining land use water quality	11.1	Surface water quality results monitored monthly during flow at, but not limited to, downstream locations specified in Appendix 5 – Surface water monitoring locations , must not exceed the limits in Appendix 6 – Surface water quality limits , for a minimum of 5 consecutive years immediately prior to the milestone completion date.
		11.2	If the surface water quality exceeds criteria in RM11.1 , the applicable upstream site must be compared to the downstream site result; and quality result measured at a downstream site must be equal to or less than the quality result measured at the applicable upstream site ¹ .
		11.3	Where the surface water quality at the downstream site exceeds the upstream site result, an AQP must complete an assessment of the cause and risk of the rehabilitation not achieving a stable condition within the schedule timeframe and: (a) Where the likelihood of the rehabilitation not achieving a stable condition is low, then no further action is to be taken; or (b) Where the likelihood is greater than low to achieving a stable condition then an assessment of potential environmental harm by the AQP and their recommended rectification actions to rehabilitation activities must be determined and implemented.

¹ For pH, the quality result measured at the downstream location must be within the prescribed range. However, where pH at the downstream location is greater-than (>) the highest limit in the range, the pH at the applicable upstream location must be greater-than or equal-to ($\geq$) the downstream location. Conversely, where pH at the downstream location is less than (<) the lowest limit in the range, the upstream pH at the applicable upstream location must be less-than or equal-to ($\leq$) the downstream location.

		11.4	The assessment/s under RM11.3 must be completed and provided to the administering authority by 1 November each year.
		11.5	The 5 year timeframe under RM11.1 is reset by a single occurrence of RM11.3(b) .
		11.6	For a minimum of 5 consecutive years groundwater quality must be monitored quarterly at, but not limited to, bores specified in Appendix 7 – Groundwater monitoring bores , for all quality characteristics listed in Appendix 8 – Groundwater quality limits .
		11.7	Groundwater quality results must not exceed the limits in Appendix 8 – Groundwater quality limits , for 3 consecutive results, for a minimum of 5 consecutive years immediately prior to the milestone completion date.

5 Section D – Non-use management areas

5.1 (IA1) Improvement area 1

Non-use management area (NUMA)										
Improvement area			IA1							
Relevant activities			Sonoma Main Pit Final Void, Pit walls (High wall and low wall of the final void above the maximum predicted water level at equilibrium), and set back area between crest of the highwall and low wall to the toe of the safety bund							
Total size (ha)			120							
Commencement of first milestone: MM1			10/12/2046							
NUMA			Residual Void							
Date area is available	10/12/46									
Cumulative area available (ha)	120									
Milestone completed by	10/12/56	10/12/66								
Milestone Reference	Cumulative area achieved (ha)									
MM1	120									
MM2	120									
MM3		120								

5.2 (IA2) Improvement area 2

Non-use management area (NUMA)										
Improvement area			IA2							
Relevant activities			Sonoma East Pit Void (High wall and low wall of the final void above the maximum predicted water level at equilibrium), and set back area between crest of the highwall and low wall to the toe of the safety bund							
Total size (ha)			29							
Commencement of first milestone: MM1			10/12/2046							
NUMA			Residual Void							
Date area is available	10/12/46									
Cumulative area available (ha)	29									
Milestone completed by	10/12/56	10/12/66								
Milestone Reference	Cumulative area achieved (ha)									
MM1	29									
MM2	29									
MM3		29								

5.3 Improvement area milestones

Milestone reference	Management milestone	Milestone criteria	
MM1	Achievement of structural stability	1.1	An RPEQ certifies the NUMA landform is constructed to the following design parameters: (a) High wall is competent rock battered to a maximum slope of 70°, with the top 10m having a maximum of 45° including a 1m bund. (b) Low wall is battered to a maximum slope of 17° - 37°. (c) Drainage and erosion controls established. (d) Highwall and low wall achieves a FoS ≥ 1.5 within the NUMA extent. (e) Final residual voids are not subject to inundation from floodwaters up to and including the 0.1% AEP. (f) Predictive modelling confirms that there is no risk of over topping.
MM2	Achievement of surface requirements	2.1	Competent safety bund or equivalent landform in place to prevent access to the residual void, at the geotechnical set-back distance of a minimum of 15m.
		2.2	Safety bund constructed around highwall, and low wall meets the following dimensions and requirements: (a) Height ≥2m; and (b) Base width ≥4m wide.
		2.3	Appropriate seed mix as per Appendix 2 - Species list and seeding rates applied to the setback area between the crest of the high wall and low wall and the safety bund.
		2.4	Strand barbed wire fencing erected around the perimeter of the safety bund.
		2.5	Warning signage to deter public access and warn of void related risks are designed in accordance with the Australian Standard AS1319-1994 and are erected as 100m intervals along the fence.
MM3		3.1	AQP certification that the area between the crest of the high wall and low wall and the safety bund, has ≥50% vegetation cover.

	Achievement of sufficient improvement	3.2	Certification from an RPEQ that the final NUMA landform complies with items below: (a) Erosion occurring within the NUMA landform will not adversely impact the stability of adjacent rehabilitation areas, or their ability to sustain their PMLU. (b) The water level and quality in the voids do not and will not cause environmental harm to the receiving environment, as demonstrated by groundwater level, quality monitoring and modelling. (c) An AQP demonstrates with water quality, water level and modelling data, that all the residual void/s in the Environmental authorities - EPML00707713*, EPML00337613**, and EPML00393013*** function collectively as groundwater sinks post-closure. (d) Voids retain flood immunity, supported by flood modelling re-run at end of life and calibrated against the final landform. (e) The residual voids will not present an unacceptable risk of environmental harm. note: * Sonoma Coal Mine ** Jax Coal Mine ***Drake coal Mine
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6 Section F - Appendices

6.1 Appendix 1- Soil Quality Criteria

Parameter	Criteria
pH	6.0 –9.0
Electrical Conductivity (saturated extract) (dS/cm)	<1.2
Nitrate (mg/kg)	As per AQP recommendation
Total Kjeldahl Nitrogen (mg/kg)	
Total Phosphorus (mg/kg)	
Exchangeable Sodium Percentage [ESP] (%)	<6
Total Organic Carbon (%)	As per AQP recommendation
Emerson aggregate class	>3

6.2 Appendix 2 - Species list and seeding rates.

Scientific Name	Common Name	Seeding rate (kg/ha)
Preferred grazing species		
<i>Heteropogon contortus</i>	Black Speargrass	As recommended by an AQP
<i>Bothriochloa bladhii</i>	Forest Bluegrass	
<i>Capillipedium spicigerum</i>	Scented tops	
<i>Panicum effusum</i>	Hairy panic	
<i>Megathyrsus maximus</i>	Green panic	
<i>Ancistrachne uncinulata</i>	Hooky grass	
<i>Urochloa foliosa</i>	Leafy panic	
<i>Dichanthlum sericeum</i>	Queensland bluegrass	
<i>Rhynchosia minima</i>	Rhynchosia	
<i>Macroptilium lathyroides</i>	Phasey Bean	
<i>Sorghum halepense</i>	Johnson Grass	
Intermediate grazing species		
<i>Neptunia gracilis</i>	Native Sensitive Plant	As recommended by an AQP
<i>Panicum decompositum</i>	Native Millet	
<i>Enteropogon acicularis</i>	Curly Windmill Grass	
<i>Echinochloa esculenta</i>	Japanese Millet	
<i>Chloris inflata</i>	Purple-top Rhodes Grass	
Legumes		
<i>Chamaechrista rotundifolia</i>	Wynn Cassia	As recommended by an AQP
<i>Macroptilium astropurpureum</i>	Siratro	
<i>Stylosanthes humilis</i>	Stylo	
<i>Stylosanthes scabra</i>	Seca Stylo	
<i>Stylosanthes seabrana</i>	Caatinga Stylo	
<i>Stylosanthes hamata</i>	Caribbean Stylo	
<i>Desmanthus virgatus</i>	Desmanthus	
<i>Clitoria ternatea</i>	Butterfly Pea	

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Scientific Name	Common Name	Seeding rate (kg/ha)
<i>Indigofera linnaei</i>	Nine-leaved Indigo	
Trees		
<i>Eucalyptus tereticornis</i>	Queensland blue gum	As recommended by an AQP
<i>Eucalyptus melanophloia</i>	Silver-leaved ironbark	
<i>Eucalyptus populnea</i>	Poplar box	
<i>Casuarina cristata</i>	Belah	
<i>Acacia harpophylla</i>	Brigalow	
Minimum total seeding rate		As recommended by an AQP

6.3 Appendix 3 - Erosion classification framework

Erosion classification ¹	Minor	Moderate	Severe
Sheet erosion	Indicators may include shallow soil deposits in downslope sediment traps (fence lines, farm dams). Often very difficult to assess as evidence may be lost with cultivation, pedoturbation or revegetation.	Indicators may include partial exposure of roots, moderate soil deposits in downslope sediment traps (fence lines, farm dams).	Indicators may include loss of surface horizons, exposure of subsoil horizons, pedestalling, root exposure, substantial soil deposits in downslope sediment traps (fence lines, farm dams).
Rill*	<15 rills per transect/100m	15-30 rills per transect/100m	>30 rills per transect/100m
Gully erosion	Absent	Absent	Present >0.3m deep Gullies are continuous or discontinuous and either tend to branch away from primary drainage lines and on to foot slopes, or have multiple branches within primary drainage lines.
Tunnel erosion	Absent	Absent	Present
Mass movement	Absent	Absent	Present

Erosion form definitions: NCST (2024) *Australian Soil and Land Survey Field Handbook, 3rd edition*. The National Committee on Soil and Terrain. CSIRO Publishing, Collingwood, Australia.

* Rill frequency assessed on the contour over entirety of rehabilitation area (not only features that intersect a monitoring transect).

6.4 Appendix 4 - Creek Diversion Species Mix

Scientific Name	Common Name	Seeding rate (kg/ha)
Grass / Ground Species		
Echinochloa esculenta	Japanese Millet	As recommended by an AQP
Bothriochloa bladhii	Forest Bluegrass	
Dichanthlum sericeum	Queensland bluegrass	
Stylosanthes humilis	Stylo	
Stylosanthes seabrana	Caatinga Stylo	
Aristida personata	Purple wiregrass	
Thellungia advena	Coolabah grass	
Shrubs / Small Trees		
Alectryon oleifolius subsp. elongatus	Western Rosewood	As recommended by an AQP
Cassia brewsteri	Leichhardt Bean	
Corymbia erythrophloia	Variable-barked Bloodwood	
Erythrina vespertilio	Bat's Wing Coral Tree	
Ficus opposita	Sandpaper Fig	
Ficus racemosa	Cluster Fig	
Lysiphyllum hookeri	Pegunny	
Melaleuca bracteata	Black Teatree	
Petalostigma pubescens	Quinine Bush	
Vachellia bidwillii	Corkwood Wattle	
Acacia salicina	Sally Wattle	
Owenia acidula	Emu apple	
Capparis lasiantha	Split jack	
Lophostemon grandiflorus	Northern swamp box	
Acacia bidwillii	Corkwood wattle	
Trees		
Eucalyptus tereticornis	Queensland blue gum	As recommended by an AQP
Casuarina cunninghamii	River Oak	

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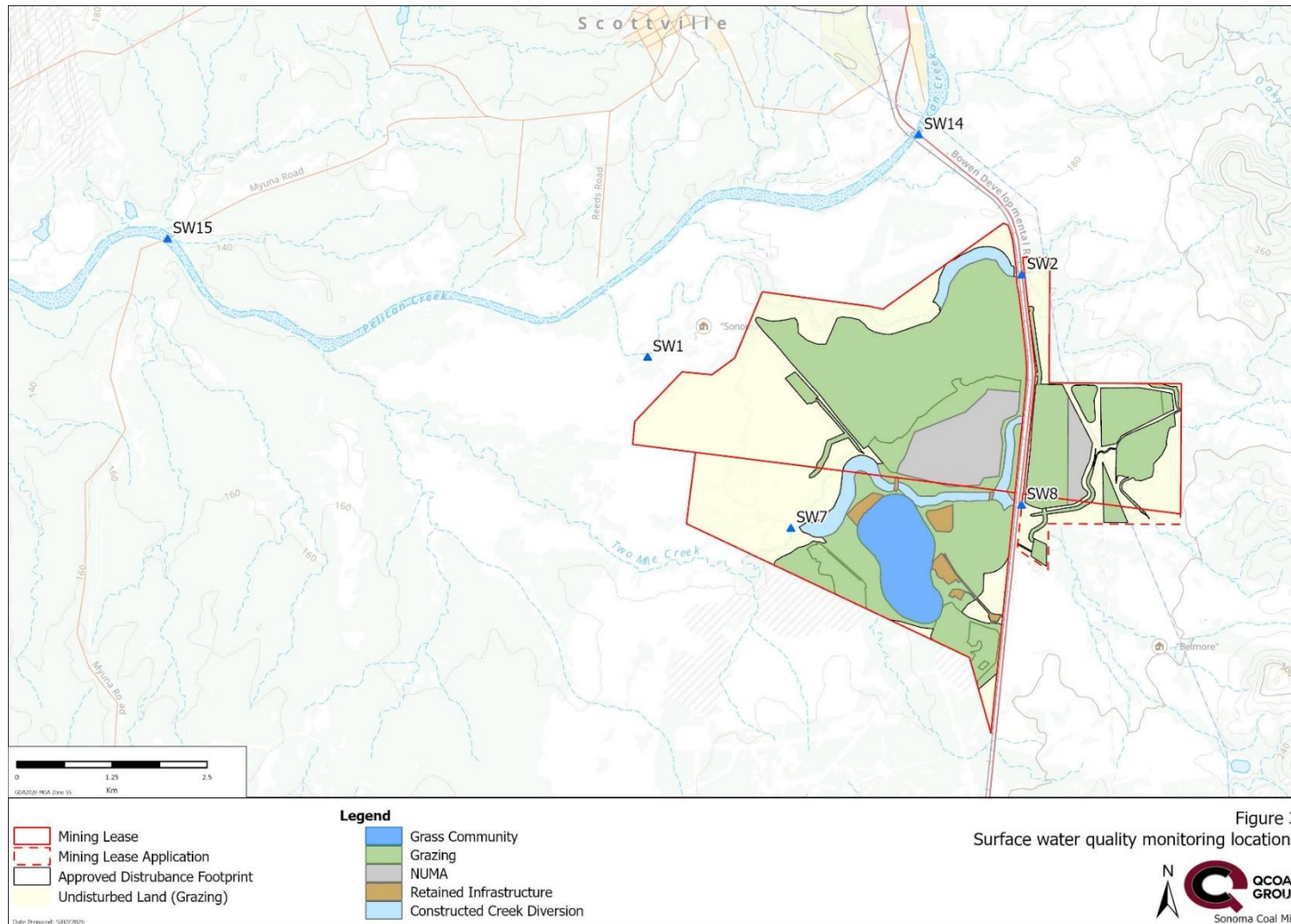
Scientific Name	Common Name	Seeding rate (kg/ha)
<i>Corymbia clarksoniana</i>	Long-fruited Bloodwood	
<i>Corymbia dallachiana</i>	Dallachy's Gum	
<i>Atalaya hemiglauca</i>	Western whitewood	
<i>Corymbia tessellaris</i>	Carbeen	
<i>Eucalyptus brownii</i>	Reid River Box	
<i>Eucalyptus crebra</i>	Narrow-leaved Red Ironbark	
<i>Eucalyptus raveretiana</i>	Black Ironbox	
<i>Lagunaria queenslandica</i>	Queensland Pyramid Tree	
<i>Melaleuca fluviatilis</i>	River Teatree	
<i>Melaleuca leucadendra</i>	Weeping Paperbark	
<i>Melaleuca viminalis</i>	Weeping Bottlebrush	
<i>Pleiogynium timorense</i>	Burdekin Plum	
Minimum total seeding rate		As recommended by an AQP

Note to Appendix 4, species derived from the North Sonoma Creek Diversion Design Plan 2018 and the Two-Mile Creek Diversion Design Plan 2018

6.5 Appendix 5 - Surface water monitoring locations

Monitoring Locations	Receiving waters location description	Latitude (decimal degree, GDA2020)	Longitude (decimal degree, GDA2020)
<i>Upstream monitoring locations</i>			
SW2	Coral Creek upstream	-20.602263	147.864223
SW14	Upstream of confluence of Coral and Pelican Creeks	-20.585721	147.851147
<i>Downstream monitoring locations</i>			
SW1	Coral Creek downstream	-20.612250	147.817112
SW7 (SW5)	Two Mile Creek downstream	-20.632465	147.835302
SW15 (PC1)	Downstream of confluence of Two Mile and Coral Creeks with Pelican Creek at upstream side of Myuna Road Crossing	-20.598503	147.756536

Figure 3 - Surface water quality monitoring locations



6.6 Appendix 6 - Surface water quality limits

Quality characteristic	Units	Limit	Comment on limit
pH	pH units	6.0 - 8.5	Site-specific
Electrical Conductivity	µS/cm	340	WQO
Total Suspended Solids	mg/L	10	WQO
Turbidity	NTU	18	Site-specific
Sulphate	mg/L	875	Site-specific
Nitrate	mg/L	0.5	Site-specific
Fluoride	mg/L	0.5	Site-specific
Aluminium - dissolved	µg/L	55	ANZG 2018
Antimony - dissolved	µg/L	9	ANZG 2018
Arsenic - dissolved	µg/L	13	ANZG 2018
Boron - dissolved	µg/L	82	Site-specific
Cadmium - dissolved	µg/L	0.2	ANZG 2018
Chromium - dissolved	µg/L	1	ANZG 2018
Cobalt - dissolved	µg/L	1.4	ANZG 2018
Copper - dissolved	µg/L	1.4	ANZG 2018
Iron - dissolved	µg/L	For interpretation purposes	
Lead - dissolved	µg/L	3.4	ANZG 2018
Manganese - dissolved	µg/L	133	Site-specific
Molybdenum - dissolved	µg/L	4	Site-specific
Nickel - dissolved	µg/L	11	ANZG 2018
Selenium - total	µg/L	5	ANZG 2018 - 99%
Uranium - dissolved	µg/L	0.5	ANZG 2018
Vanadium - dissolved	µg/L	6	ANZG 2018

Quality characteristic	Units	Limit	Comment on limit
Zinc - dissolved	µg/L	8	ANZG 2018
Total recoverable hydrocarbons (C6-C9)	µg/L	20	LOR of typical analytical method
Total recoverable hydrocarbons (C10-C36)	µg/L	100	LOR of typical analytical method
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	mg/L	For interpretation purposes only	
Hardness	mg/L	For interpretation purposes only	

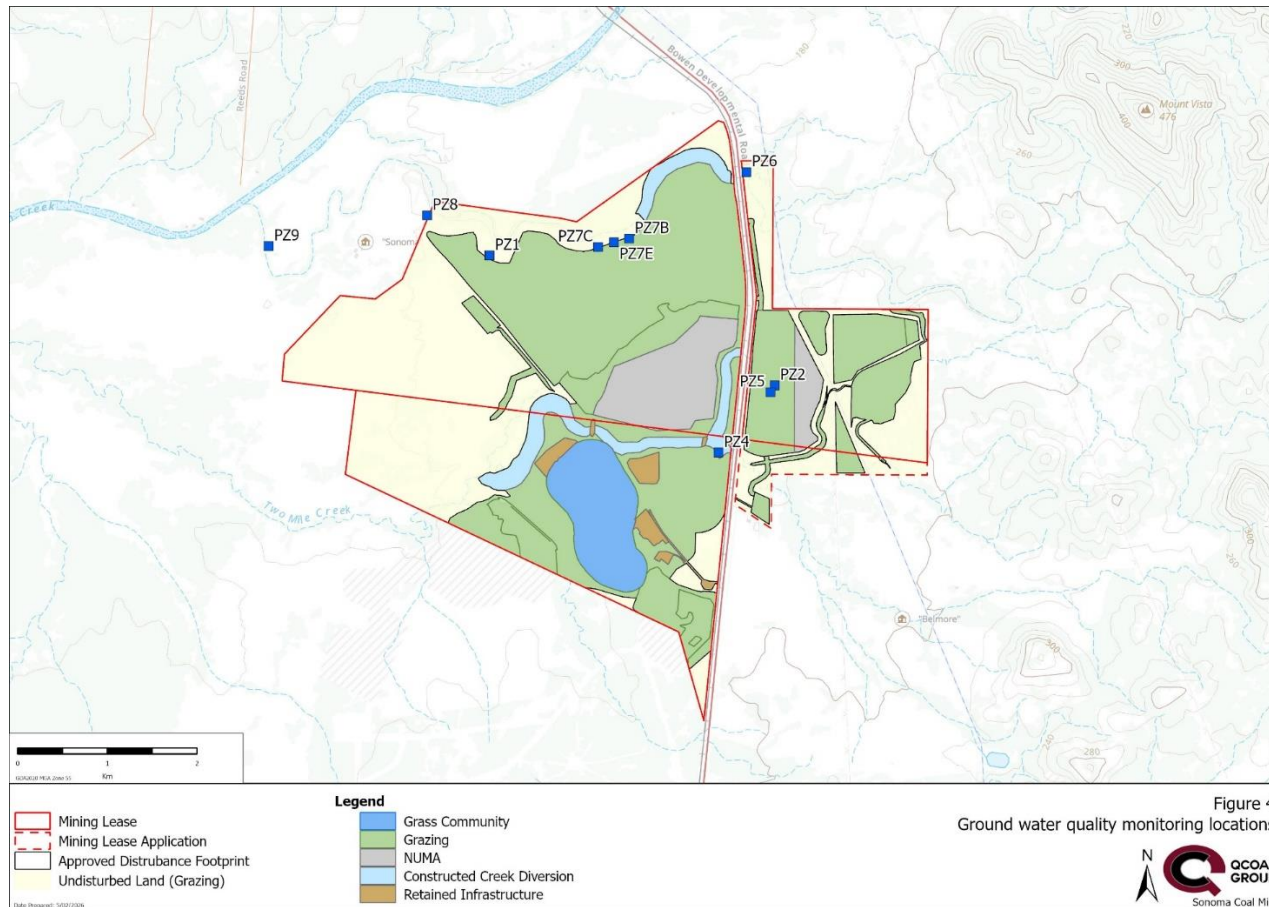
Notes:

- All metals and metalloids must be measured as 'dissolved' (from analysis of a filtered sample) and total (unfiltered).
- Limits for metals and metalloids apply to dissolved results.
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection) for all parameters except Selenium
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (99% protection) for Selenium
- WQO - Bogie River, Glenmore Creek, Little Bowen R, Pelican Creek, Rosella Creek sub-catchment fresh waters.
- Site-specific – 95th percentile of upstream data from BG1 (SW14), SW2, SW6 (SW8) from 2013.

6.7 Appendix 7 - Groundwater monitoring bores

Monitoring Bore	Hydrogeological Unit	Latitude (decimal degree, GDA2020)	Longitude (decimal degree, GDA2020)
PZ1	Alluvium	-20.609912	147.837415
PZ2	Alluvium	-20.621701	147.868977
PZ4	Moranbah Coal measures	-20.629651	147.862035
PZ5	Moranbah Coal measures	-20.622853	147.868034
PZ6	Alluvium	-20.601383	147.864880
PZ7B	Alluvium	-20.608149	147.852366
PZ7C	Alluvium	-20.609006	147.849031
PZ7E	Alluvium	-20.608528	147.850737
PZ8	Alluvium	-20.605915	147.830724
PZ9	Alluvium	-20.609094	147.813765

Figure 4 - Ground water quality monitoring locations



6.8 Appendix 8a - Groundwater quality limits

Quality characteristic	Units	Monitoring Bore	Limit*	Comment on limit
pH	pH units	All bores	6.0 – 8.5	Site-specific
Electrical conductivity	µS/cm	Alluvial bores	1,814	Site-specific
		Moranbah Coal measures	2,146	Site-specific
Sulfate	mg/L	Alluvial bores	144	Site-specific
		Moranbah Coal measures	32	Site-specific
Ammonia	mg/L	All bores	0.9	ANZG 2018
Nitrate	mg/L	All bores	2.6	ANZG 2018
Fluoride	mg/L	All bores	1.8	ANZG 2018
Aluminium - dissolved	µg/L	All bores	55	ANZG 2018
Antimony - dissolved	µg/L	All bores	9	ANZG 2018
Arsenic - dissolved	µg/L	All bores	13	ANZG 2018
Boron - dissolved	µg/L	All bores	370	ANZG 2018
Cadmium - dissolved	µg/L	All bores	0.2	ANZG 2018
Chromium - dissolved	µg/L	All bores	1	ANZG 2018
Cobalt - dissolved	µg/L	All bores	1.4	ANZG 2018
Copper - dissolved	µg/L	All bores	1.4	ANZG 2018
Iron - dissolved	µg/L	All bores	For interpretation purposes	
Lead - dissolved	µg/L	All bores	3.4	ANZG 2018
Manganese - dissolved	µg/L	All bores	1,900	ANZG 2018
Molybdenum - dissolved	µg/L	All bores	34	ANZG 2018
Nickel - dissolved	µg/L	All bores	11	ANZG 2018
Selenium - total	µg/L	All bores	5	ANZG 2018
Uranium - dissolved	µg/L	All bores	0.5	ANZG 2018
Vanadium - dissolved	µg/L	All bores	6	ANZG 2018

Quality characteristic	Units	Monitoring Bore	Limit*	Comment on limit
Zinc - dissolved	µg/L	All bores	8	ANZG 2018
Total recoverable hydrocarbons (C6-C9)	µg/L	All bores	20	LOR of typical analytical method
Total recoverable hydrocarbons (C10-C36)	µg/L	All bores	100	LOR of typical analytical method
Major ions Calcium, chloride, potassium, magnesium, sodium, bicarbonate, carbonate	mg/L	All bores	For interpretation purposes	
Hardness	mg/L	All bores	For interpretation purposes	
Water level	mAHD	All bores	For interpretation purposes	

Notes:

- All metals and metalloids must be measured as 'dissolved' (from analysis of filtered sample) and total (unfiltered).
- Limits for metals and metalloids apply to dissolved results.
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection) for all parameters except Selenium
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (99% protection) for Selenium
- * Unless bore-specific values are provided in table below.

Appendix 8b – Bore specific Groundwater quality limits based on site-specific data¹

Quality characteristic	Units	PZ1	PZ2	PZ6	PZ7B	PZ7C	PZ7E	PZ8	PZ9	PZ4	PZ5
		Alluvial								Moranbah Coal Measures	
Electrical conductivity	µS/cm	1,611	2,641	2,119	2,132	2,132	2,132	2,073	1,873	3,107	2,146
Sulfate	mg/L	44	15	62	144	144	144	53	55	248	32
Ammonia	mg/L		2.1					1.3	0.5	1.7	3.7
Boron - dissolved	µg/L	136	310	122				66	112	251	158
Copper - dissolved	µg/L	7.6						7.6			13
Zinc - dissolved	µg/L	60	88	60	66	66	66	48	35	56	80

Note:

¹for Table 8b where columns are blank, or a quality characteristic from **Table 8a - Groundwater quality limits** is not listed, the limits in **Table 8a - Groundwater quality limits** apply to these bores.

END OF PRCP SCHEDULE

Appendix B - Sonoma Environmental Authority

Permit

Environmental Protection Act 1994

Environmental authority EPML00707713

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

Environmental authority number: EPML00707713

Environmental authority takes effect on 29 November 2024

Environmental authority holder(s)

Name(s)	Registered address
QCoal Sonoma Pty Ltd	Level 15, 40 Creek Street BRISBANE CITY QLD 4000
CSC Sonoma Pty Ltd	Level 7, 300 Queen Street BRISBANE CITY QLD 4000
JS Sonoma Pty Ltd	Suite 3B, Level 33, 52 Martin Place SYDNEY NSW 2000
Watami (QLD) Pty Ltd	Level 2, 262 Adelaide Street BRISBANE CITY QLD 4000

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 13 - Mining black coal	ML10325, ML10326, ML10327, ML700075
Ancillary 08 - Chemical Storage 1 - Storing a total of 50t or more of chemicals of dangerous goods class 1 or class 2, division 2.3 under subsection (1)(a)	
Ancillary 08 - Chemical Storage 3 - Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	
Ancillary 31 - Mineral processing 2(b) - Processing, in a year, the following quantities of mineral products, other than coke - more than 100,000t	
Ancillary 60 - Waste disposal 2(e) - Operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(b) - more than 20,000t but not more than 50,000t	
Ancillary 62 - Resource recovery and transfer facility operation 1(c) - Operating a facility for receiving and sorting, dismantling, baling or temporarily storing category 2 regulated waste	
Ancillary 62 - Resource recovery and transfer facility operation 1(d) - Operating a facility for receiving and sorting, dismantling, baling or temporarily storing category 1 regulated waste	
Ancillary 63 - Sewage Treatment 1(a-i) - Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 to 100EP - if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	

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:

- (a) the presence of, or happening of an event involving, a hazardous contaminant on the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- (b) if the land is contaminated land – a change in the condition of the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- (c) a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the land (notice must be given within 20 business days).

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

Take effect

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

- (a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority – on the nominated day; or
- (b) if the authority states a day or an event for it to take effect – on the stated day or when the stated event happens; or
- (c) otherwise – on the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *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.

The anniversary day of this environmental authority is the same day each year as the effective date. The payment of the annual fee will be due each year on this day. An annual return will be due each year on 01 April.

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



Signature

29 November 2024

Date

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

Enquiries:

Business Centre Coal
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 Resources (to clear vegetation), and the Department of Agriculture and Fisheries (to clear marine plants or to obtain a quarry material allocation).

Conditions of environmental authority

The environmentally relevant activity(ies) conducted at the location as described above must be conducted in accordance with the following site-specific conditions of approval. This environmental authority consists of the following Schedules, Definitions and Figures:

Schedule A: General

Schedule B: Air

Schedule C: Waste Management

Schedule D: Noise and Vibration

Schedule E: Groundwater

Schedule F: Surface Water

Schedule G: Sewage Treatment

Schedule H: Land and Rehabilitation

Schedule I: Dams and Levees

Schedule J: Watercourse Diversions

Schedule K: Biodiversity

Definitions

Figures:

Figure 1 – Authorised disturbance area and groundwater monitoring locations

Figure 2 – Authorised mine domains as of June 2024

Figure 3 – Mine affected water release points, sources and receiving waters

Figure 4 (a) – Location of pre-mining Matters of State Environmental Significance (ML10327, ML700075)

Figure 4 (b) – Pre-mining potential habitat for Koala (ML10327, ML700075)

Figure 4 (c) – Pre-mining potential habitat for Squatter Pigeon (ML10327, ML700075)

Schedule A: General	
Condition number	Condition
A1	This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.
A2	No more than 6.5 Mtpa (million tonnes per annum) of ROM (run-of-mine) is to be extracted on site in a year.
A3	In carrying out the mining activity authorised by this environmental authority, disturbance of land on Figure 1 – Authorised disturbance area and groundwater monitoring locations : (a) may occur within the areas marked 'A', but only in accordance with condition A5 ; (b) must not occur in the areas marked 'B'; and (c) may occur in the areas marked 'C', but only in accordance with conditions A4 and A5 .
A4	Any disturbance within the areas marked 'C' on Figure 1 – Authorised disturbance area and groundwater monitoring locations is only authorised to the extent reasonably necessary for exploration activities, roads, fences, underground services, low-impact telecommunications facilities, electrical sub-stations, transmission grid works and supply network works, minor clean water diversions and drains, storage depots, similar minor infrastructure, and ancillary facilities for any of the above. The only water course diversions authorised under category 'C' are the existing Two Mile Creek and Coral Creek diversions.
A5	Any disturbance within the areas marked 'A' or 'C' on Figure 1 – Authorised disturbance area and groundwater monitoring locations must: (a) not impact adversely on areas marked 'B'; (b) not exceed 1,363ha in areas marked 'A'; and (c) substantial changes to the location of pits and out of pit waste rock dumps compared to the current mine layout as illustrated in Figure 2 – Authorised mine domains as of June 2024 must be discussed with the administering authority prior to making the changes. Note: A substantial change is where a proposed change to the location of pits and/or out of pit waste rock dumps could result in a change to the impacts on environmental values.

A6	Maintenance of plant and equipment The holder of this environmental authority must: (a) install all measures, plant, and equipment necessary to ensure compliance with the conditions of this environmental authority; (b) maintain such measures, plant, and equipment in a proper and efficient condition; (c) operate such measures, plant, and equipment in a proper and efficient manner; and (d) ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.
A7	Monitoring and sampling All monitoring and sampling required by conditions of this environmental authority must be carried out, interpreted, and recorded by an appropriately qualified person.
A8	Plans, reports, and programs Any plans, reports or programs required by a condition of this environmental authority must be developed and reviewed by an appropriately qualified person.
A9	Record Keeping Unless otherwise specified by a condition of this environmental authority, all monitoring records or reports required by this environmental authority must be kept for a period of not less than five (5) years.
A10	Upon request from the administering authority, copies of all records, plans and other documentation specifically required by the conditions of this environmental authority must be made available and provided to the administering authority within: (a) ten (10) business days; or (b) an alternative timeframe agreed between the administering authority and the environmental authority holder.
A11	Risk management The holder of this environmental authority must develop and implement a risk management system for mining activities which mirrors the content requirements of the Standard for Risk Management (ISO31000:2009), or the latest edition of an Australian Standard for risk management, to the extent relevant to the environmental management, prior to the commencement of mining activities.
A12	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 not in accordance, or reasonably expected to be not in accordance with, the conditions of this environmental authority.

A13	Within ten (10) business days following the initial notification of an emergency or incident, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following: (a) results and interpretation of any samples taken and analysed; (b) outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and (c) proposed actions to prevent a recurrence of the emergency or incident.
A14	Complaints The holder of this environmental authority must record all environmental complaints received about the mining activities including the following details: (a) name, address, and contact number for/of the complainant; (b) time and date of complaint; (c) reasons for the complaint; (d) investigations undertaken; (e) conclusions formed; (f) actions taken to resolve the complaint; (g) any abatement measures implemented; and (h) person responsible for resolving the complaint.
A15	As soon as reasonably practicable but no later than ten (10) business days after receiving a complaint under condition A14 (or a longer period agreed to in writing by the administering authority), an investigation must be undertaken: (a) the potential circumstances and actions on site that may have contributed to the basis of the complaint; and (b) reasonable and practicable measures that will be implemented to address the complaint.
A16	As soon as reasonably practicable but no later than ten (10) business days from the completion of the investigation into a complaint under condition A15 (or a longer period agreed to in writing by the administering authority), the reasonable and practicable measures identified in the investigation must be implemented.
A17	The outcome of the investigation carried out under condition A15, and the abatement measures implemented under condition A16 must be recorded.
A18	Third Party Reporting The holder of this environmental authority must: (a) every three (3) years, obtain from an appropriately qualified third party a report on compliance with the conditions of this environmental authority; and (b) provide each report to the administering authority within ninety (90) days of its completion.

A19	Where a condition of this environmental authority requires compliance with a standard, policy or guideline published externally to this environmental authority and the standard is amended or changed subsequent to the issue of this environmental authority, the holder of this environmental authority must: (a) comply with the amended or changed standard, policy, or guideline within two (2) years of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation, or where the amendment or change relates specifically to regulated structures referred to in Schedule I: Dams and Levees the time specified in that condition; and (b) until compliance with the amended or changed standard, policy or guideline is achieved, continue to remain in compliance with the corresponding provision that was current immediately prior to the relevant amendment or change.
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Schedule B: Air	
Condition number	Condition
B1	Dust nuisance The release of dust and/or particulate matter resulting from the mining activity must not cause an environmental nuisance at any sensitive or commercial place.
B2	When requested by the administering authority or as a result of a complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer), dust and particulate monitoring must be undertaken, and the results thereof notified to the administering authority within fourteen (14) days following completion of monitoring.
B3	Dust and particulate monitoring for condition B2 must be carried out in accordance with Table B1 – Monitoring locations, parameters, and methods and at a place or places relevant to the potentially affected dust sensitive place as agreed upon with the administering authority.
B4	Where monitoring identifies instances where a concentration specified in Table B2 – Air quality limits is exceeded at a sensitive or commercial place, the environmental authority holder must submit an investigation report to the administering authority within ten (10) business days that includes: (a) the air quality data at the monitoring location; (b) a description of meteorological conditions; (c) the air quality data upwind of the mining activities (if known); (d) the contribution of the Sonoma mining activities to the exceedance (if any); and (e) if the exceedance was caused by the mining activities, the immediate measures taken to reduce dust generated by the mining activities
B5	If the investigation under condition B4 indicates that the exceedance was caused by the mining activities, the environmental authority holder must submit to the administering authority an additional report within forty (40) business days following completion of monitoring, which includes: (a) further details as to the cause of the exceedance where available; (b) whether any environmental harm has occurred; (c) outline any actions required to mitigate environmental harm; and (d) additional measures to reduce dust generated by the mining activities.

B6	Monitoring locations The environmental authority holder must submit a report to the administering authority by 30 June 2025 or as otherwise agreed with the administering authority. The report must include: (a) assessment of the surrounding air-shed, sources and types of third-party dust and dust from the Sonoma mining activities, identification of potential sensitive receptors associated with mining activities on the Sonoma Mine including consideration of Collinsville and Scottsville; (b) suitable monitoring methods and locations applicable to the sources and types of dust identified from Sonoma Mine and the potential sensitive receptors associated with Sonoma Mine, to replace the TBC values in Table B1 – Monitoring locations, parameters, and methods; (c) confirmation that the monitoring methods and locations can determine if the Sonoma mining activities cause or substantially contributed to dust recorded at any downwind monitoring locations (including any PM10 locations if applicable); and (d) guidance as to the day-to-day planning of mining operations and implementation of both proactive and reactive mitigation measures to ensure compliance with the conditions of this environmental authority.
B7	Continuous monitoring Monitoring at the locations specified in Table B1 – Monitoring locations, parameters, and methods or as otherwise agreed with the administering authority must be implemented by 30 September 2025.
B8	Meteorological conditions must be monitored in accordance with and at locations specified in Table B1 – Monitoring locations, parameters, and methods.
B9	Submission of monitoring data All monitoring data collected at the locations specified in Table B1 – Monitoring locations, parameters, and methods or as otherwise agreed with the administering authority, must be submitted to administering authority upon request.
B10	The format and frequency of the data to submitted in accordance with condition B9, must be provided to the administering authority for acceptance by 30 June 2025.
B11	The environmental authority holder must implement the requirements of condition B9 by 30 September 2025.
B12	Dust Management Plan A Dust Management Plan must be developed and implemented for all stages of the authorised mining activities on the site by 30 September 2025.

B13	The Dust Management Plan must incorporate a program for continuous improvement for the management of dust and particulate matter resulting from the mining activities with respect to, but not limited to: (a) the collection of air quality and meteorological data using the monitoring methods described in Table B1 – Monitoring locations, parameters, and methods; (b) a system to identify adverse meteorological conditions likely to produce elevated levels of dust and/or other air quality parameters at the locations specified in Table B1 – Monitoring locations, parameters, and methods due to the mining activities; and (c) a Trigger Action Response Program (TARP).
B14	The Dust Management Plan required by condition B12 must be reviewed by 30 September each calendar year and any recommendations must be incorporated into the Dust Management Plan and implemented.
B15	Odour 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 sensitive or commercial place.
B16	If the administering authority receives a complaint related to odour nuisance, the environmental authority holder must address the complaint in accordance with conditions A15 and A16 of this environmental authority.

Table B1 – Monitoring locations, parameters, and methods

Monitoring Point	Latitude (decimal degree, GDA2020)	Longitude (decimal degree, GDA2020)	Monitoring Parameter	Monitoring Frequency	Monitoring Method
TBC	TBC	TBC	TBC	TBC	TBC
TBC	TBC	TBC	TBC	TBC	TBC
Sonoma Mine Infrastructure Area	-20.638422	147.855994	Weather (wind speed, wind direction, temperature rainfall)	Real time continuous	AS/NZS 3850.14:2014

Table B2 – Air quality limits

Monitoring Location	Parameter	Air Quality Limit	Monitoring Method
All applicable compliance locations as specified in Table B1 ; or as per condition B3	PM ₁₀	50µg/m ³ (24-hr avg)	AS/NZS 3580.9.6:2015 AS/NZS3580.9.7:2009 AS3580.9.8:2022 AS358.9.9:2017 AS/NZS35801.9.11:2022
	TSP	90µg/m ³	AS/NZS 3580.9.3:2015 <i>Any alternative method of monitoring TSP that may be permitted by the Air Quality Sampling Manual as published from time to time by the administering authority.</i>
	Dust deposition	120mg/m ² /day	AS/NZS3580.10.1:2003

Schedule C: Waste Management	
Condition number	Condition
C1	Burning Waste 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.
C2	The holder of this environmental authority may burn vegetation cleared in the course of carrying out extraction activities provided that the activity does not cause environmental harm at any sensitive place or commercial place.
C3	Tailings disposal Procedures for managing tailings disposal must be in place and should include: (a) containment of tailings; (b) the management of seepage and leachates both during operation and the foreseeable future; (c) the control of fugitive emissions to air; (d) a program of progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings; (e) maintaining records of the relative locations of any other waste stored within the tailings; (f) rehabilitation strategy; and (g) monitoring of rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of tailings, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.
C4	Storage and disposal of tyres Tyres must be stored and disposed of in accordance with the latest version of the Operational policy - <i>Disposal and storage of scrap tyres at mine sites</i> (ESR/2016/2380).
C5	The holder of the environmental authority must keep a record of the number and location of tyres disposed of in accordance with condition C4.
C6	Waste management Plan The holder of this environmental authority must develop, document, and implement a non-mineral waste management plan for all authorised activities.

C7	The waste management plan required under condition C6 must include: (a) a description of how waste is generated; (b) a program for reusing, recycling, or disposing of all wastes; (c) the waste management control strategies including: (i) the type of wastes; (ii) segregation of the wastes; (iii) storage of the wastes; (iv) transport of the wastes; (v) monitoring and reporting matters concerning the waste; (vi) emergency response planning; (vii) disposal, reused and recycling options; (d) the hazard characteristics of the wastes generated including disposal procedures for regulated wastes; (e) how the waste will be managed in accordance with the waste and resource management hierarchy, including a description of the types of waste that will be dealt with under each of the waste management practices in the waste management hierarchy (i.e. avoidance, reuse, recycling, energy recovery, disposal); (f) how the waste will be stored, handled, and transferred in a proper and effective manner; (g) procedures for identifying and implementing opportunities to minimise the amount of waste generated, promote efficiency in the use of resources and improve the waste management practices employed; (h) procedures for dealing with accidents, spills, and other incidents that may impact on waste management; (i) details of any management system employed, or planned to be employed, to deal with the waste; (j) indicators or other criteria on which the performance of the waste management practices will be assessed; (k) staff training and induction to the waste management program; (l) a system for regular review; and (m) identify responsible staff (positions) for implementing, managing, and reporting under the Waste Management Plan.
C8	The non-mineral waste management plan required under condition C6 must be regularly reviewed and updated at intervals of no greater than five (5) years.

C9	Regulated waste records must be kept for five (5) years, and must include the following information: (a) date of pickup of waste; (b) description of waste; (c) cross reference to relevant waste transport documentation; (d) quantity of waste; (e) origin of the waste; (f) destination of the waste; and (g) intended fate of the waste, for example, type of waste treatment, reprocessing, or disposal. Note: Records of documents maintained in compliance with a waste tracking system established under the <i>Environmental Protection Act 1994</i> or any other law for regulated waste will be deemed to satisfy this condition.
C10	Records of trade and regulated wastes or material leaving the mining lease for recycling or disposal, including the final destination and method of treatment, must be in accordance with the <i>Waste Reduction and Recycling Act 2011</i>.
C11	All regulated waste received at and removed from the site must be transported by a person who holds a current authority to transport such waste under the provisions of the <i>Environmental Protection Act 1994</i>.
C12	Except as otherwise provided by the conditions of this authority, all waste removed from the site must be taken to a facility that is lawfully allowed to accept such waste under the provisions of the <i>Environmental Protection Act 1994</i>.

Schedule D: Noise and Vibration	
Condition number	Condition
D1	Noise nuisance Noise resulting from the authorised mining activities must not cause an environmental nuisance at any sensitive or commercial place
D2	When requested by the administering authority, or as a result of a complaint noise monitoring must be undertaken and the results must be notified within ten (10) business days to the administering authority following completion of monitoring.
D3	Monitoring undertaken in accordance with condition D2 must be carried out at a place or places relevant to the potentially affected noise sensitive place as agreed upon with the administering authority.
D4	All noise monitoring which is conducted as per condition D2 must be undertaken in accordance with the following noise monitoring requirements: (a) all noise monitoring must be conducted in accordance with the administering authority's most recent version of the <i>Noise Measurement Manual</i> (ESR/2016/2195), the relevant Australian Standard and the <i>Environmental Protection Regulation 2019</i> (Chapter 5, Part 4).; (b) source noise levels must be expressed as component noise levels for the purposes of comparison with noise limits; (c) all noise measurements must be taken using an appropriate sound level meter as classified under AS IEC 61672; and (d) monitoring location(s) must be relevant to the matter(s) under investigation.
D5	If the administering authority request for noise monitoring is in relation to a complaint and results exceed the limits in Table D1 – Noise limits, then the environmental authority holder must: (a) address the complaint including the use of appropriate dispute resolution if required; and (b) implement noise abatement measures so that emissions of noise from the activity do not result in further environmental nuisance.
D6	Low Frequency Noise Noise emissions from the activity, when including substantial low frequency noise, must not cause an overall sound pressure level at a noise sensitive place exceeding 55 dB(Z). Note: Substantial low frequency noise means a noise emission that has an unbalanced frequency spectrum shown in a one-third octave band measurements, with a predominant component located within the frequency range 10 to 200 Hz.

D7	Blasting The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in Table D2 – Blasting noise limits to be exceeded at a sensitive place or commercial place. Peak particle velocity and/or air blast overpressure resulting from blasting must not cause an environmental nuisance at any sensitive or commercial place.
D8	The holder of this environmental authority must develop and implement a blast monitoring program to monitor compliance with Table D2 – Blasting noise limits for: (a) at least 50% of all blasts undertaken on this site in each month at the nearest and most affected sensitive place(s) or commercial place(s); and (b) all blasts conducted during any time period specified by the administering authority at the nearest and most affected sensitive place(s) or commercial place(s) or another such place to investigate an allegation of environmental nuisance caused by blasting.
D9	If the results of blast monitoring undertaken as per condition D7 exceed the limits in Table D2 – Blasting noise limits, then the environmental authority holder must investigate and report to the administering authority within ten (10) business days following completion of monitoring.

Table D1 – Noise limits

Noise level measured in dB(A)	Monday to Saturday			Sunday and Public Holidays		
	7am-6pm	6pm-10pm	10pm-7am	9am-6pm	6pm-10pm	10pm-9am
	Noise measured at a nuisance sensitive place					
LA _{eq adj,10}	Background Plus 5	Background Plus 5	Background Plus 0	Background Plus 5	Background Plus 5	Background Plus 0
LA _{1adj,10}	Background Plus 10	Background Plus 10	Background Plus 5	Background Plus 10	Background Plus 10	Background Plus 5
	Noise measured at a commercial place					
	LA _{eq adj,10}	Background Plus 10	Background Plus 10	Background Plus 5	Background Plus 10	Background Plus 10
	LA _{1adj,10}	Background Plus 15	Background Plus 15	Background Plus 10	Background Plus 15	Background Plus 10

Associated notes and requirements:

- (a) ‘Background’ means background noise level, measured in the absence of the noise under investigation, as **LA_{90,T}** being the A-weighted sound pressure level exceeded for ninety (90) per cent of the time period of 15 minutes, using Fast response.
- (b) “**LA_{eq adj,T}**” means the equivalent continuous A-weighted sound pressure level, adjusted for noise character, measured in the presence of the noise under investigation over a time period of 10 minutes, using Fast response.
- (c) “**LA_{1 adj,T}**” means the A-weighted sound pressure level, adjusted for noise character, measured in the presence of the noise under investigation and exceeded for one (1) per cent of the time period of 10 minutes, using Fast response.

Table D2 – Blasting noise limits

Blasting noise limits	Sensitive or commercial blasting noise limits place limits	
	Daytime 7am to 6pm	Evening/Night/Early Morning 6pm to 7am
Airblast overpressure	115 dB (Linear) Peak for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	No blasting is allowed during these times
Ground vibration peak particle velocity	5mm/second peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	No blasting is allowed during these times

Schedule E: Groundwater	
Condition number	Condition
E1	Contaminants must not be released directly or indirectly to groundwater.
E2	All groundwater sampling and monitoring methods must be in accordance with the latest version of the administering authority's <i>Monitoring and Sampling Manual 2018</i> , unless otherwise approved by the administering authority.
E3	Review of groundwater quality triggers By 30 September 2026, a report must be provided to the administering authority that reviews the continued suitability of groundwater quality trigger levels in Table E2 – Groundwater quality triggers based on data from at least eight (8) monitoring events.
E4	All groundwater quality monitoring data collected in accordance with the conditions of this environmental authority must be provided to the administering authority via WaTERS with each annual return.
E5	Groundwater quality Groundwater quality must be monitored: (a) at the locations specified in Table E1 – Groundwater monitoring locations and frequency and illustrated in Figure 1 – Authorised disturbance area and groundwater monitoring locations; (b) at the frequencies specified in Table E1 – Groundwater monitoring locations and frequency; and (c) for the quality characteristics listed in Table E2 – Groundwater quality triggers.
E6	If monitoring results from groundwater bores identified in Table E1 – Groundwater monitoring locations and frequency exceed any of the trigger levels stated in Table E2 – Groundwater quality triggers on three (3) consecutive monitoring occasions the environment authority holder must: (a) notify the administering authority via WaTERS within twenty-four (24) hours of receiving the results; and (b) complete an investigation under condition E7. Note: Where three (3) consecutive exceedances of a trigger level have occurred and are being investigated in accordance with E6(b) of this condition, no further reporting under E6(a) is required for subsequent trigger events for that quality characteristic during the investigation period.

E7	Exceedance investigation - Groundwater quality Where groundwater from bores identified in Table E1 – Groundwater monitoring locations and frequency exceeds any of the trigger levels specified in Table E2 – Groundwater quality triggers on three (3) consecutive sampling occasions, the holder of this environmental authority must: (a) complete an investigation to determine if the exceedance is the result of: (i) activities authorised under this environmental authority; or (ii) natural variation; or (iii) neighbouring land use resulting in groundwater impacts; and (b) submit a report to the administering authority within twenty-eight (28) days of receiving the results.
E8	If the investigation under condition E7 determines that the exceedance was the result of activities authorised under this environmental authority, then a further investigation must be completed, and a report must be submitted to the administering authority within fifty-six (56 days) after submission of the exceedance investigation report under condition E7. The investigation report must include: (a) the source, cause and extent of contamination and other investigation outcomes; and (b) must detail the appropriate mitigation and management measures (where applicable) undertaken, with evidence upon request to address any groundwater contamination and prevent recurrence of groundwater contamination.
E9	Groundwater Standing Water Level (SWL) Groundwater SWL must be monitored: (a) at the locations specified in Table E1 – Groundwater monitoring locations and frequency and illustrated in Figure 1 – Authorised disturbance area and groundwater monitoring locations; and (b) at the frequencies specified in Table E1 – Groundwater monitoring locations and frequency.
E10	The SWL in monitoring results from groundwater bores identified in Table E1 – Groundwater monitoring locations and frequency (with exception of dry bores) must be reviewed against the previous twelve (12) months of SWL monitoring data.

E11	Groundwater standing water level (SWL) When a bore listed in Table E1 – Groundwater monitoring locations and frequency (with the exception of dry bores) exceeds a fluctuation of two (2) meters per year, the holder of this environmental authority must: (a) notify the administering authority via WaTERS within twenty-four (24) hours of becoming aware; (b) complete an investigation into the cause of exceedance within ten (10) business days; and (c) if the investigation carried out under part (b) determines that the mining activities are a potential cause or contributor to the exceedance: (i) notify the administering authority within twenty-four (24) hours of making the determination; (ii) identify whether any actual environmental harm has occurred; and (iii) identify and implement mitigations to minimise the harm.
E12	Bore Specific SWL Thresholds By 4 April 2025, the environmental authority holder must provide to the administering authority a report: (a) proposing groundwater standing water level thresholds to replace all TBCs in Table E3 – Groundwater standing water level trigger threshold; (b) providing justification as to those proposed thresholds (such as modelling, monitoring data, risk assessments); and (c) providing a review of the continued suitability and/or monitoring value of Bore 7B, Bore 7C and Bore 7E listed in Table E1 – Groundwater monitoring locations and frequency.
E13	Groundwater Monitoring and Management Program A Groundwater Monitoring and Management Program (GMMP) must be developed, implemented, and maintained, including updates as required by reviews of the monitoring data, GMMP or model. The first version of the GMMP must be developed and implemented before 30 June 2025.

E14	The GMMP required by condition E13 must: (a) provide a hydrogeological conceptual model; (b) provide an analytical or numerical groundwater model including interaction or impact from groundwater on surface water; (c) identify all potential sources of contamination to groundwater from the activities; (d) identify all environmental values that may be impacted; (e) detail groundwater levels in all relevant hydrogeological units present across and adjacent to the site to confirm existing groundwater flow paths; (f) include details of a groundwater monitoring and data analysis program to: (i) detect any impacts to groundwater quality due to the activities authorised under this environmental authority; (ii) detect any changes to groundwater level due to the activities authorised under this environmental authority; and determine compliance with conditions E6, and E10; and (iii) determine trends in groundwater quality and level; (g) document groundwater management and monitoring methodologies undertaken for the duration of all the activities authorised under this environmental authority; (h) provide an appropriate quality assurance and quality control program; and (i) include a review process for the GMMP to identify improvements to the program that includes addressing any comments provided by the administering authority.
E15	Annual Groundwater Monitoring Report An Annual Groundwater Monitoring Report (AGMR) must be completed each year and submitted to the administering authority by 1 April each calendar year.
E16	The AGMR required by condition E15 must include: (a) all quality and SWL monitoring data of all groundwater bores listed within Table E1 – Groundwater monitoring locations and frequency, for the annual monitoring period; (b) an assessment of groundwater quality and SWL trends for all data from all groundwater bores listed in Table E1 – Groundwater monitoring locations and frequency; (c) an assessment of any impacts on groundwater quality and level due to the mining activities; (d) review of ongoing adequacy of the monitoring network and propose replacement bores (if required) where bores have been removed as part of mining activities; and (e) comparison with receiving environment surface water quality monitoring results to determine any interaction or impact from groundwater on surface water.
E17	Replacement bores If any groundwater monitoring bore listed in Table E1 – Groundwater monitoring locations and frequency, are scheduled to be decommissioned due to planned authorised activities, the holder must: (a) replace the bore (s) at least twelve (12) months prior to decommissioning; with groundwater monitoring bores that targets the same hydrogeological unit in a suitable location; and (b) the location of replacement bores be provided for inclusion in Table E1 – Groundwater monitoring locations and frequency.

E18	Within twenty-four (24) months after installation of replacement bores as per condition E17, the environmental authority holder must submit report to administering authority that includes: (a) groundwater quality triggers based on at least eight (8) monitoring events for inclusion in Table E2 – Groundwater quality triggers; and (b) groundwater level threshold for inclusion in Table E3 – Groundwater standing water level trigger threshold.
E19	Bore construction and maintenance and decommissioning The construction, maintenance, operation, and decommissioning of each groundwater monitoring bore (with the exception of bores installed prior to the EA commencement date) must be undertaken by an appropriately qualified person in a manner that: (a) prevents contaminants entering the groundwater; (b) ensures representative groundwater samples from the target hydrogeological unit/s including composite units where intended; and (c) does not alter the hydrogeological environment
E20	A bore report must be kept for each monitoring bore which includes: (a) a unique identification reference number and geographic coordinate location; (b) construction information including but not limited to the depth of bore, depth and length of casing, depth and length of screening and bore sealing details; (c) stratigraphy and target hydrogeological unit of the bore; (d) depth at which groundwater was intercepted; and (e) the final standing water level (SWL) after bore development.
E21	Bore 1 Trigger Values By 4 April 2025, the environmental authority holder must provide to the administering authority a report that: (a) provides a review of the potential sources of contamination, including Ammonia, Arsenic and Total dissolved solids, which have resulted in increased concentrations from 2021 within Bore 1; (b) proposes groundwater trigger values for Bore 1 in accordance with the methods in DES 2021¹; and (c) provides justification as to the proposed trigger values.

¹ DES (2021) Using monitoring data to assess groundwater quality and potential environmental impacts. Version 2. Department of Environment and Science (DES), Queensland Government, Brisbane.

Table E1 – Groundwater monitoring locations and frequency

Monitoring Point	Location GDA2020		Aquifer	Screen depth (m)	Surface RL (m) ²	Monitoring Frequency ¹
	Latitude	Longitude				
Bore 1	-20.609912	147.837415	Alluvium	22.0-25.0	163.339	Quarterly
Bore 2	-20.621701	147.868977	Alluvium	18.5-21.5	176.225	Quarterly
Bore 4	-20.629651	147.862035	Coal measures	66.0-72.0	175.328	Quarterly
Bore 5	-20.622853	147.868034	Coal measures	67.0-73.0	176.589	Quarterly
Bore 6	-20.601383	147.864880	Alluvium	22.0-25.0	170.575	Quarterly
Bore 7B	-20.608149	147.852366	Alluvium	3.7-6.7	166.728	Quarterly
Bore 7C	-20.609006	147.849031	Alluvium	5.0-8.0	163.487	Quarterly
Bore 7E	-20.608528	147.850737	Alluvium	3.1-6.1	166.893	Quarterly
Bore 8	-20.605915	147.830724	Alluvium	18.5-21.5	160.167	Quarterly
Bore 9	-20.609094	147.813765	Alluvium	23.9-26.9	153.199	Quarterly

¹Monitoring is not required where a bore has been removed as a direct result of the mining activity.

²RL must be calculated from the nearest 5cm from the top of the bore casing.

Table E2 – Groundwater quality triggers

Quality Parameter	Unit	Investigation Trigger Level for Bores									
		1	2	6	7B	7C	7E	8	9	4	5
		Alluvium								Coal measures	
pH	pH Units	6.0-8.5									
Electrical Conductivity	µS/cm	1611 ¹	2641 ¹	2119 ¹	2132 ²	2132 ²	2132 ²	2073 ¹	1873 ¹	3107 ¹	2146 ¹
Total Dissolved Solids	mg/L	1117 ¹	1082 ¹	1281 ¹	1034 ²	1034 ²	1034 ²	849 ¹	841 ¹	1814 ¹	1191 ¹
Sulfate	mg/L	44 ¹	15 ¹	62 ¹	144.2 ²	144.2 ²	144.2 ²	53 ¹	55 ¹	248 ¹	32 ¹
Hardness, Calcium, Chloride, Sodium, Potassium, Magnesium, Bicarbonate, Carbonate, Fluoride	mg/L	For interpretation purposes only									
Ammonia-N	mg/L	Condition E21	<2.1 ¹	<1 ¹	<1 ³	<1 ³	<1 ³	<1.3 ¹	<0.53 ¹	<1.7 ¹	<3.7 ¹
Nitrate-N	mg/L	<50 ³									
Nitrite-N	mg/L	<0.1 ³									
Aluminium (dissolved)	mg/L	0.055 ³									
Arsenic (dissolved)	mg/L	0.013 ³									
Boron (dissolved)	mg/L	0.136 ¹	0.310 ¹	0.122 ¹	0.370 ³	0.370 ³	0.370 ³	0.066 ¹	0.112 ¹	0.251 ¹	0.158 ¹
Cadmium (dissolved)	mg/L	0.0002 ³									
Chromium (dissolved)	mg/L	0.0033 ³									
Copper (dissolved)	mg/L	0.0076 ¹	0.005 ³	0.005 ³	0.005 ³	0.005 ³	0.005 ³	0.0076 ¹	0.005 ³	0.005 ³	0.013 ¹
Lead (dissolved)	mg/L	0.0034 ³									
Mercury (dissolved)	mg/L	0.0006 ³									
Molybdenum (dissolved)	mg/L	0.034 ³									
Nickel (dissolved)	mg/L	0.012 ¹	0.01 ¹	0.01 ¹	0.01 ²	0.01 ²	0.01 ²	0.01 ¹	0.01 ¹	0.01 ¹	0.01 ¹
Selenium (dissolved)	mg/L	0.01 ⁴									
Zinc (dissolved)	mg/L	0.06 ¹	0.088 ¹	0.06 ¹	0.066 ²	0.066 ²	0.066 ²	0.048 ¹	0.035 ¹	0.056 ¹	0.08 ¹
TRH (C6-C10)	µg/L	<20 ⁴									
TRH (C10-C40)	µg/L	<100 ⁴									

¹ Bore specific 95th percentile data 2018-2024

² Aquifer specific 95th percentile data 2018-2024

³ ANZG (2018) 95% aquatic ecosystem species protection value for slightly to moderately disturbed ecosystems or ANZECC-ARMCANZ 2000 guideline vol 3 (freshwater)

⁴ LOR- typical reporting limit for method stated. CMS- analytical method required to achieve LOR

Table E3 – Groundwater standing water level trigger threshold

Monitoring bore	Hydrogeological unit	Level trigger threshold (mAHD)
Bore 1	Alluvium	TBC
Bore 2	Alluvium	TBC
Bore 4	Coal measures	TBC
Bore 5	Coal measures	TBC
Bore 6	Alluvium	TBC
Bore 7B	Alluvium	TBC
Bore 7C	Alluvium	TBC
Bore 7E	Alluvium	TBC
Bore 8	Alluvium	TBC
Bore 9	Alluvium	TBC

Schedule F: Surface Water	
Condition number	Condition
F1	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.
F2	Contaminant release The release of mine affected water to waters must only occur from the release points specified in Table F1 – Mine affected water release points, sources and receiving waters and depicted in Figure 3 – Mine affected water release points, sources and receiving waters attached to this environmental authority.
F3	The release of mine affected water to waters from the release points must be monitored at the locations specified in Table F1- Mine affected water release points, sources and receiving waters for each quality characteristic and at the frequency specified in Table F2 – Mine affected water release limits and Table F3 – Release contaminant trigger investigation levels, potential contaminants. Note: The administering authority will take into consideration any extenuating circumstances prior to determining an appropriate enforcement response in the event condition F5 is contravened due to a temporary lack of safe or practical access. The administering authority expects the environmental authority holder to take all reasonable and practicable measures to maintain safe and practical access to designated monitoring locations.
F4	The release of mine affected water to waters in accordance with condition F2 must not exceed the release limits stated in Table F2 – Mine affected water release limits when measured at the monitoring points specified in Table F1 – Mine affected water release points, sources and receiving waters for each quality characteristic.
F5	Mine affected water release events The holder must ensure a 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 F4 – Mine affected water release during flow events.
F6	The release of mine affected water to waters in accordance with condition F2 must only take place during periods of natural flow in accordance with the receiving water flow criteria for discharge specified in Table F4 – Mine affected water release during flow events for the release point(s) specified in Table F1 – Mine affected water release points, sources and receiving waters .
F7	The daily quantity of mine affected water released from each release point must be measured and recorded at the monitoring points in Table F1 – Mine affected water release points, sources and receiving waters .

F8	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.
F9	Notification of release event The environmental authority holder must notify the administering authority via WaTERS as soon as practicable and no later than 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/time; (b) release point/s; (c) release rate; (d) release salinity and/or electrical conductivity; (e) receiving water/s including the natural flow rate; and (f) details regarding the compliance of the release with the conditions of Schedule F: Surface Water.
F10	The environmental authority holder must notify the administering authority via WaTERS as soon as practicable, and no later than twenty-four (24) hours after cessation of a release notified under condition F9. The cessation notification must include the following information: (a) release cessation date and time; (b) release point/s; (c) release rate; (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 this environmental authority. Note: Successive or intermittent releases from a Release Point occurring within twenty-four (24) 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 F9, F10 and F11, provided the relevant details of the release are included within the notification provided in accordance with conditions F9, F10 and F11.
F11	The environmental authority holder must within twenty-eight (28) days after cessation of a release event notified under condition F9 provide a report 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.

F12	Release trigger exceedance: If quality characteristics of the release exceed any of the trigger levels specified in Table F3 – Release contaminant trigger investigation levels, potential contaminants during a release event, the environmental authority holder must compare the downstream results in the receiving waters (Table F6 – Receiving water upstream background sites and downstream monitoring points) to the trigger values specified in Table F3 – 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 F3 – 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 (Table F6 – Receiving water upstream background sites and downstream monitoring points); 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, notify the administering authority via WaTERS within twenty-four (24) hours of receiving the result, and complete an investigation and provide a written report to the administering authority via WaTERS within twenty-eight (28) days of receiving the result, outlining: I. details of the investigations carried out; and II. whether the result is directly associated with mining activities, and, if so: 1. whether environmental harm has occurred, 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 F12(2)(b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.
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Table F1 – Mine Affected Water Release Points, Sources and Receiving Waters

Release Point (RP) ¹	Location (GDA2020)		Mine Affected Water Source and Location	Monitoring Point	Receiving waters description
	Latitude	Longitude			
RP1 (SW7)	-20.611277	147.833719	Sediment Dam 3	Spillway	Pelican Creek via Coral Creek
RP2 (SW8)	-20.630111	147.853545	Sediment Dam 5	Spillway	Pelican Creek via Two Mile Creek
RP3 (SW9)	-20.616874	147.837971	Sediment Dam 4	Spillway	Pelican Creek via Coral Creek
RP4 (SW10)	-20.629760	147.832408	Sediment Dam 13	Spillway	Pelican Creek via Two Mile Creek

Note: Where fixed release infrastructure is not currently installed portable pipes and pumps will be utilised.

F13	Notification of release event exceedance If the release limits defined in Table F2 – Mine affected water release limits are exceeded, the holder of the environmental authority must notify the administering authority within twenty-four (24) hours of receiving the results.
F14	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 which (if any) part of this volume was non-compliant; (d) the total duration of the release and which (if any) part of this period was non-compliant; (e) all water quality monitoring results (including all laboratory analyses); (f) identification of any environmental harm as a result of the non-compliance; (g) all calculations; and (h) any other matters pertinent to the water release event.
F15	Receiving environment monitoring and contaminant trigger levels The quality of the receiving waters must be monitored at the locations specified in Table F6 – Receiving water upstream background sites and downstream monitoring points and Figure 3 – Mine affected water release points, sources and receiving waters for each quality characteristic and at the monitoring frequency stated in Table F5 – Receiving waters contaminant trigger levels.
F16	If quality characteristics of the receiving water at the downstream monitoring points exceed any of the trigger levels specified in Table F5 – 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) if the result is less than the upstream monitoring data, then no action is to be taken; or (b) if the result is greater than the upstream monitoring data, notify the administering authority via WaTERS within twenty-four (24) hours of receiving the result, and complete an investigation and provide a written report to the administering authority via WaTERS within twenty-eight (28) days of receiving the result, outlining (i) details of the investigations carried out; and (ii) whether the result is directly associated with the release, and, if so: I. whether environmental harm has occurred; and II. actions taken to prevent environmental harm. Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with condition F16(2) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.

Table F2 – Mine Affected Water Release Limits

Quality Parameter	Release Limit	Monitoring frequency	Comment
Electrical conductivity (µS/cm)	Release limits specified in Table F4	Daily during release (the first sample must be taken within 2 hours of commencement of release)	-
pH (pH Unit)	6.5 (minimum) 9.0 (maximum)	Daily during release (the first sample must be taken within 2 hours of commencement of release)	-
Turbidity ¹ (NTU)	300	At commencement and prior to cessation of release (at a minimum) and weekly during a release	Turbidity is required to assess ecosystem impacts and can provide instantaneous results.

¹The determination of suitability for release of water should be informed by monitoring undertaken prior to release.

Table F3 – Release contaminant trigger investigation levels, potential contaminants

Quality Parameter	Unit	Trigger Levels	Comment on Trigger Level	Monitoring Frequency
Aluminium	mg/L	0.082	80 th percentile of background	Commencement of release and thereafter weekly during release
Arsenic	mg/L	0.013	For aquatic ecosystem protection, based on SMD guideline	
Cadmium	mg/L	0.0002	For aquatic ecosystem protection, based on SMD guideline	
Chromium	mg/L	0.001	For aquatic ecosystem protection, based on SMD guideline	
Copper	mg/L	0.002	For aquatic ecosystem protection, based on LOR for ICPMS	
Iron	mg/L	0.3	For aquatic ecosystem protection, based on low reliability guideline	
Lead	mg/L	0.004	For aquatic ecosystem protection, based on SMD guideline	
Mercury	mg/L	0.02	For ecosystem protection based on LOR for CVFIMS	
Nickel	mg/L	0.011	For aquatic ecosystem protection, based on SMD guideline	
Zinc	mg/L	0.008	For aquatic ecosystem protection, based on SMD guideline	
Boron	mg/L	0.37	For aquatic ecosystem protection, based on SMD guideline	
Cobalt	mg/L	0.09	For aquatic ecosystem protection, based on low reliability guideline	
Manganese	mg/L	1.9	For aquatic ecosystem protection, based on SMD guideline	
Molybdenum	mg/L	0.034	For aquatic ecosystem protection, based on low reliability guideline	
Selenium	mg/L	0.01	For aquatic ecosystem protection, based on LOR for ICPMS	
Silver	mg/L	0.001	For aquatic ecosystem protection, based on LOR for ICPMS	
Uranium	mg/L	0.001	For aquatic ecosystem protection, based on LOR for ICPMS	
Vanadium	mg/L	0.01	For aquatic ecosystem protection, based on LOR for ICPMS	
Ammonia	mg/L	0.9	For aquatic ecosystem protection, based on SMD guideline	
Nitrate	mg/L	1.1	For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN	
Petroleum hydrocarbons (C6-C9)	µg/L	20	For aquatic ecosystem protection, based on LOR	
Petroleum hydrocarbons (C10-C36)	µg/L	100	For aquatic ecosystem protection, based on LOR	

Quality Parameter	Unit	Trigger Levels	Comment on Trigger Level	Monitoring Frequency
Fluoride (total)	mg/L	2.0	Protection of livestock and short-term irrigation guideline	
Sodium	mg/L	180	Based on Australian Drinking Water Guidelines	
Suspended Solids	mg/L	150	Based on receiving water reference data from Drake Coal Mine	
Sulfate (SO ₄ ²⁻)	mg/L	250	Drinking water environmental values from NHMRC 2006 guidelines or ANZECC	

Note:

- (a) Trigger levels for metal/metalloids apply if dissolved results exceed trigger.
- (b) SMD – slightly moderately disturbed level of protection, guideline refers ANZECC & ARMCANZ (2000)
- (c) LOR – typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LO

F17	Receiving Environment Monitoring Program (REMP) The environmental authority holder must develop and implement a 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 Coral Creek, Two Mile Creek, and Pelican Creek, and connected or surrounding waterways within 10km 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.
F18	A REMP Design Document that addresses the requirements of conditions F17 and F19 must be prepared and made available to the administering authority upon request.

F19	The REMP must address (but not necessarily be limited to) the following: (a) description of potentially affected receiving waters including key communities and background water quality characteristics based on accurate and reliable monitoring data that takes into consideration any temporal variation (e.g. seasonality); (b) description of applicable environmental values and water quality objectives to be achieved (i.e. as scheduled pursuant to the Environmental Protection (Water) Policy 2009); (c) any relevant reports prepared by other governmental or professional research organisations that relate to the receiving environment within which the REMP is proposed; (d) water quality targets within the receiving environment to be achieved, and clarification of contaminant concentrations or levels indicating adverse environmental impacts during the REMP; (e) monitoring for any potential adverse environmental impacts caused by the release; (f) monitoring of stream flow and hydrology; (g) monitoring of toxicants should consider the indicators specified in Table F3 – Release contaminant trigger investigation levels, potential contaminants to assess the extent of the compliance of concentrations with water quality objectives and/or the ANZECC and ARMCANZ 2000 guidelines for slightly to moderately disturbed ecosystems; (h) monitoring of physico-chemical parameters as a minimum those specified in Table F2 – Mine affected water release limits (in addition to dissolved oxygen saturation and temperature); (i) monitoring biological indicators (for macroinvertebrates in accordance with the AusRivas methodology) and metals/metalloids in sediments (in accordance with ANZECC and ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.1 Guidance on Sampling of Bottom Sediments) for permanent, semi- permanent water holes and water storages; (j) the locations of monitoring points (including the locations specified in Table F6 – Receiving water upstream background sites and downstream monitoring points which are background and downstream impacted sites for each release point); (k) the frequency or scheduling of sampling and analysis sufficient to determine water quality objectives and to derive site specific reference values within two (2) years (depending on wet season flows) in accordance with the Queensland Water Quality Guidelines 2006. For ephemeral streams, this should include periods of flow irrespective of mine or other discharges; (l) specify sampling and analysis methods and quality assurance and control; (m) any historical datasets to be relied upon; (n) description of the statistical basis on which conclusions are drawn; and (o) any spatial and temporal controls to exclude potential confounding factors.
F20	For each year that REMP monitoring is undertaken, a REMP report must be prepared by 31 October and submitted to the administering authority on request.
F21	The REMP report required by condition F20 must include: (a) an assessment of long-term upstream water quality; (b) an assessment of the long-term condition or state of surface waters, (c) recommendations for further investigation or actions; (d) recommendations for changes or improvements to the monitoring program; (e) potential changes to management of the authorised activity to minimise impacts; (f) all monitoring results; and (g) a description of all conclusions formed.

F22	Where no REMP monitoring is undertaken in any given year (1 November to 31 October), a summary report of the findings of REMP must be prepared and submitted to the administering authority upon request, including the following information: (a) introduction, including an explanation as to why no REMP monitoring was undertaken; (b) rainfall data; and (c) watercourse flow data.
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Table F4 – Mine affected water release during flow events

Receiving water/stream	Release Point (RP)	Gauging Station	Gauging Station Latitude	Gauging Station Longitude	Receiving Water Flow Recording Frequency	Receiving Water Flow Criteria for discharge (m³/s)	Maximum Release Rate (for all combined RP flows)	Electrical Conductivity Release Limits
Pelican Creek (via Coral and Two Mile Creek)	RP1 SW7 (SD3)	Gauging Station 1	-20.585721	147.851138	Continuous (minimum daily)	Medium flow (low) more than 1.5 m³/s	0.5 m³/s	Electrical conductivity 1,200 µS/cm
	RP 2 SW8 (SD5)							
	RP3 SW9 (SD4)					Medium Flow (high) more than 5 m³/s	5 m³/s	Electrical conductivity 2,000 µS/cm
	RP4 SW10 (SD13)							

Table F5 – Receiving waters contaminant trigger levels

Quality Characteristic	Trigger Level	Monitoring Frequency
Ph	6.5 – 8.5	Daily during the release
Electrical Conductivity (µS/cm)	1,000	
Total suspended solids (mg/L)	110	
Sulfate (SO ₄ ²⁻) (mg/L)	250	

F23	Water re-use 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 consent of the third party).
F24	If the responsibility of the water contaminated by mining activities (the water) is given or transferred to another person in accordance with condition F23, then: (a) the responsibility of the water must only be given or transferred in accordance with a written agreement (the third party agreement); and (b) include in the third party agreement a commitment from the person utilising the water to use water in such a way as to prevent environmental harm or public health incidences and specifically make the persons aware of the General Environmental Duty (GED) under section 319 of the <i>Environmental Protection Act 1994</i>, environmental sustainability of the water disposal and protection of environmental values of waters.
F25	Annual Water Monitoring Data Submission The following information must be recorded in relation to all mine affected surface water release monitoring required under the conditions of this environmental authority and submitted to the administering authority via WaTERS with each annual return: (a) the date on which the sample was taken; (b) the time at which the sample was taken; (c) the monitoring point at which the sample was taken; (d) the measured or estimated daily quantity of mine affected water released from all release points; (e) the release flow rate at the time of sampling for each release point; and (f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority.
F26	Water Management Plan A Water Management Plan must be developed and implemented for all stages of mining activities.

F27	The Water Management Plan must: (a) provide for effective water management of actual and potential environmental impacts resulting from water management associated with the mining activities carried out under this environmental authority; and (b) be developed in accordance with the administering authority's most recent version of the guideline for 'Preparation of water management plans for mining activities' (EM324) or any updates that become available from time to time and must include at least the following components: (i) a study of the source on contaminants; (ii) a water balance model for the site; (iii) a map showing the water management system for the site; (iv) measures to manage, reduce and prevent saline drainage; (v) measures to manage, reduce and prevent acid rock drainage; and (vi) contingency procedures for incidents and emergencies.
F28	On an annual basis the Water Management Plan must either be: (a) updated and re-issued in accordance with the requirements of conditions F26 and F27(with the update commencing by 30 November each calendar year; or (b) reviewed for continued suitability (review to commence by 30 November each calendar year). The review must be documented and include: (i) a statement that the review has been undertaken by an appropriately qualified person; (ii) an assessment of the plan against the requirements under F26 and F27, including identify where updates are required; (iii) identification of any actual or potential environmental impacts which are not effectively managed by the Water Management Plan; (iv) make recommendations to ensure actual or potential environmental impacts are effectively managed (if required); and (v) provide details and timelines to implement the recommendations (if required).
F29	Stormwater and water sediment controls An Erosion and Sediment Control (ESC) Plan must be developed and implemented for all stages of the mining activities.

F30	The ESC Plan must: (a) demonstrate how erosion and sediment control measures detailed in the plan adequately minimise the release of sediment to receiving waters; (b) assess the size and characteristics of all catchment areas; (c) assessment of relevant properties of soil; (d) specify minimum design criteria for erosion and sediment control structures to achieve the management intent of receiving waters; (e) locations and descriptions of major erosion and sediment control measures (sediment dams and related drainage management); and (f) an audit schedule to ensure erosion and sediment control measures are maintained.
F31	On an annual basis the ESC Plan must either be: (a) updated and re-issued in accordance with the requirements of conditions F29 and F30 (with the update commencing by 30 November each calendar year); or (b) reviewed for continued suitability (review to commence by 30 November each calendar year) with the review to include: (i) a statement that the review has been undertaken by an appropriately qualified person; (ii) an assessment of the plan against the requirements under condition F29 and identify where updates are required; (iii) identification of any actual or potential environmental impacts which are not effectively managed by the Erosion Sediment Control Plan; (iv) make recommendations to ensure actual or potential environmental impacts are effectively managed (if required); and (v) provide details and timelines to implement the recommendations (if required).
F32	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 F29; and (b) water management infrastructure that is installed and operated, in accordance with a water management plan that complies with condition F26, for the purpose of ensuring water does not become mine affected water.

Table F6 – Receiving water upstream background sites and downstream monitoring points

Monitoring Points	Receiving Waters Location Description	Latitude	Longitude
Upstream Background Monitoring Points			
SW2	Coral Creek 3,330 metres upstream of release point SW7 and 3,170 metres upstream of release point SW9	-20.602263	147.864223
SW6	Two Mile Creek 1,140 metres upstream of release point SW8	-20.629549	147.864357
BG1	Upstream of confluence of Coral and Pelican Creeks	-20.585721	147.851147
Downstream Monitoring Points			
SW1	Coral Creek 2,065 metres downstream of release point SW7 and 2,800 metres downstream of release point SW9	-20.612250	147.817112
SW5	Two Mile Creek 4,280 metres downstream of release point SW8	-20.632465	147.835302
PC1	Downstream of confluence of Two Mile and Coral Creeks with Pelican Creek at upstream side of Myuna Road Crossing	-20.598503	147.756536

Note: The data from background monitoring points must not be used where they are affected by releases from other mines.

Schedule G: Sewage Treatment	
Condition number	Condition
G1	Contaminants generated by sewage treatment activities must not be released to waters.
G2	Treated sewage effluent may only be released to land in accordance with the conditions of this approval at the following locations: (a) within the nominated area(s) identified in Figure 3 – Mine- Affected water release points, sources and receiving waters (irrigation areas); (b) haul roads and areas of mining activity for the purpose of dust suppression; (c) re-use in coal processing; (d) secondary water storage; and (e) firefighting.
G3	The release of treated sewage effluent to the nominated irrigation area identified in condition G4 , must be monitored for each quality characteristic and at the frequency specified in Table G1 – Contaminants release limits to land .
G4	The release of treated sewage effluent to the nominated irrigation area identified in condition G4 , must not exceed the release limits stated in Table G1 – Contaminants release limits to land .
G5	Irrigation with treated effluent must be carried out in a manner such that: (a) vegetation is not damaged; (b) there is no surface ponding of effluent; and (c) there is no run-off of effluent.
G6	If irrigation areas are accessible to employees or the general public, prominent signage must be provided advising that effluent is present, and care should be taken to avoid consuming or otherwise coming into unprotected contact with the effluent.
G7	The daily volume of treated effluent used for irrigation must be measured and records kept of the volumes of effluent released.
G8	When circumstances prevent the irrigation or beneficial reuse of treated sewage effluent such as during or following rain events, waters must be directed to a wet weather storage or alternative measures must be taken to store/lawfully dispose of effluent.
G9	A minimum area of one (1) ha of land, excluding any necessary buffer zones, must be utilised for the irrigation of treated sewage effluent.
G10	Treated sewage effluent must only be supplied to another person or organisation that has a written plan detailing how the user of the treated sewage effluent will comply with their general environmental duty under section 319 of the Act whilst using the treated sewage effluent. Note: The supply of treated wastewater for re-use is regulated under <i>the Water Supply (Safety and Reliability) Act 2008</i>.

Table G1 – Contaminant release limits to land

Contaminant	Unit	Release limit	Limit type	Monitoring Frequency
5-day Biochemical oxygen demand (BOD)	mg/L	20	Maximum	Monthly
Total suspended solids	mg/L	30	Maximum	Monthly
Nitrogen	mg/L	30	Maximum	Monthly
Phosphorus	mg/L	15	Maximum	Monthly
E-coli	Organisms/100ml	1,000	Maximum	Monthly
pH	pH units	6.0 – 9.0.	Range	Monthly

Schedule H: Land and Rehabilitation	
Condition number	Condition
H1	Land disturbed by the activity must be rehabilitated to achieve the following rehabilitation goals: (a) safe to humans and wildlife; (b) structurally stable; (c) non-polluting; and (d) self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids.
H2	A Rehabilitation Management Plan for the authorised activities must be implemented and must include: (a) rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas; (b) detailed rehabilitation methods for each disturbed area; (c) rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives; (d) final completion criteria that will achieve the rehabilitation goals and objectives; (e) details of appropriate monitoring and maintenance of rehabilitation; (f) identification of three (3) reference sites to be used to develop rehabilitation success criteria for each disturbance domain; (g) a description of monitoring of reference sites inclusive of statistical design; (h) for rehabilitation of watercourse diversions, details of the required methods of rehabilitation stated in the relevant approved Design Plans; and (i) a description of progressive rehabilitation planning.
H3	All areas significantly disturbed by mining activities must be rehabilitated in accordance with the Rehabilitation Management Plan to achieve the final completion criteria.
H4	The environmental authority holder must notify the administering authority of any changes to the Rehabilitation Management Plan and submit the updated document to the administering authority.
H5	Mining waste management A waste rock and spoil disposal plan must be developed, implemented, and include, where relevant, at least: (a) effective characterisation of the waste rock and spoil to predict under the proposed placement and disposal strategy the quality of runoff and seepage generated concerning potentially environmentally significant effects including salinity, acidity, alkalinity, and dissolved metals, metalloids, and non-metallic inorganic substances; and (b) a program of progressive sampling and characterisation to identify dispersive and non-dispersive spoil and the salinity, acid and alkali producing potential and metal concentrations of waste rock; and (c) a materials balance and disposal plan demonstrating how potentially acid forming and acid forming waste rock will be selectively placed and/or encapsulated to minimise the potential generation of acid mine drainage; and (d) where relevant, a sampling program to verify encapsulation and/or placement of potentially

	acid-forming and acid-forming waste rock; and (e) how often the performance of the plan will be assessed; and (f) the indicators or other criteria on which the performance of the plan will be assessed; and (g) rehabilitation strategy; and (h) identification of areas proposed to contain tailings; and (i) monitoring or rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of the placed materials, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.
H6	Contaminated Land Before applying for surrender of a mining lease, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the mining lease which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use.
H7	Before applying for progressive rehabilitation certification for an area, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the area the subject of the application which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use under the approved Rehabilitation Management Plan as per condition H2.
H8	The holder of the environmental authority must not directly or indirectly release hazardous contaminants to land.
H9	Chemicals and flammable or combustible liquids All flammable and combustible liquids must be contained within an on-site containment system and controlled in a manner that prevents environmental harm and maintained in accordance with the current edition of <i>AS 1940 – Storage and Handling of Flammable and Combustible Liquids</i>.
H10	All chemicals and flammable or combustible liquids stored on site that have the potential to cause environmental harm must be stored in or serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to waters or land. Where no relevant Australian standard exists store such materials within an effective on-site containment system, the environmental authority holder must, at a minimum, minimise the potential for contamination of land and waters by diverting stormwater around contaminated areas and facilities used for the storage of chemicals and flammable or combustible liquids.
H11	Residual void outcome Residual voids must comply with the following outcomes: (a) residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifers, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority; (b) residual voids must comply with Table H1 – Residual void outcomes; and (c) at the completion of decommissioning and rehabilitation, all residual voids must

	demonstrably have the appropriate level of flood protection from nearby watercourses as approved by the administering authority, such that the protection is sustainable for the foreseeable future.
H12	All reasonable and practical measures must be taken to minimise the size of the void remaining after mining activities cease.
H13	Weed Management A weed management plan must be developed and implemented for this site outlining: (a) areas of control priority and the methods used to determine such areas; (b) strategies to promote dense grass growth (which out-competes weeds) through reduced disturbance; (c) monitoring methodologies that document the spread of weeds and any new outbreaks; (d) methods for the control of weeds. These methods should include best practice management; (e) stringent wash-down and inspection procedures for both machinery involved in clearing/construction activities and those operating outside of designated roads during mine operation; and (f) promotion of the awareness of weed management issues at the site.
H14	Exploration Land subject to exploration activities previously approved under EPC586 that subsequently became ML10325, ML10326, ML10327 and ML700075 must be rehabilitated in accordance with the <i>Eligibility criteria and standard conditions for exploration and mineral development projects (Version 2)</i>..
H15	Land subject to exploration activities carried out on ML10325, ML10326, ML10327 and ML700075 subsequent to the grant of the relevant mining lease, must be rehabilitated in accordance with the <i>Eligibility criteria and standard conditions for exploration and mineral development projects (Version 2)</i> .

Table H1 – Residual Void Outcomes

Residual Void	Void Maximum Surface Area	Location*		Void wall – competent rock max slope (percent)	Void wall – incompetent rock max slope (percent)
		Latitude	Longitude		
Sonoma Main Pit	120 ha	-20.622821°	147.858642°	High wall – Maximum slope of 70° with the top 10m having a maximum of 45° including a 1m bund	Low wall – 17°-37°
Sonoma East Pit	29 ha	-20.62324°	147.87028°		
Sonoma Q-Pit	n/a – backfilled				
Sonoma B-Pit	n/a – backfilled				

* Location based on approximate centre point of residual void

Schedule I: Dams and Levees	
Condition number	Condition
I1	Consequence Category The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)</i> 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.
I2	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.
I3	Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)</i> .
I4	Design and Construction of a Regulated Structure 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 <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)</i>.
I5	Construction of a regulated structure is prohibited unless: (a) the holder has submitted a consequence category assessment report and certification to the administering authority; and (b) certification of the design plan and operating procedures (except where the structure does not require operating procedures such as for levees) has been certified by a suitably qualified and experienced person for compliance with the relevant condition of this authority.
I6	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 <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)</i> and must be recorded in the Register of Regulated Structures.

17	Regulated structures must: (a) be designed and constructed in accordance with and conform to the requirements of the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures</i> (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 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. (c) for dams associated with a failure to contain; have the floor and sides of the dam designed and constructed to prevent or minimise the passage of the wetting front and any entrained contaminants through either the floor or sides of the dam during the operational life of the dam and for any period of decommissioning and rehabilitation of the dam.
18	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.
19	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 conditions 14 to 16; (b) a set of 'as constructed' drawings and specifications; (c) certification of those 'as constructed drawings and specifications' in accordance with condition 18; (d) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the Design Storage Allowance (DSA) volume across the system, a copy of the certified system design plan; (e) the requirements of this authority relating to the construction of the regulated structure have been met; (f) the holder has entered the details required under this authority, into a Register of Regulated Structures; and (g) there is a current operational plan for the regulated structure (except where the structure does not require operating procedures such as for levees).
110	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.

I11	Mandatory Reporting Level Conditions I12 to I15 inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.
I12	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.
I13	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.
I14	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.
I15	The holder must record any changes to the MRL in the Register of Regulated Structures.
I16	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.
I17	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 DSA volume for the dam (or network of linked containment systems).
I18	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.
I19	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.
I20	Annual Inspection Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

I21	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. Regulated structures must be assessed: (a) against the most recent hazard assessment report and design plan (or system design plan); (b) against recommendations contained in previous annual inspections reports; (c) against recognised dam safety deficiency indicators; (d) for changes in circumstances potentially leading to a change in hazard category; (e) for conformance with the conditions of this authority; (f) for conformance with the 'as constructed' drawings; (g) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year of accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems); and (h) for evidence of conformance with the current operational plan.
I22	The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)</i>.
I23	The environmental authority holder must: (a) within twenty (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.
I24	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.
I25	Register of Regulated Structures A Register of Regulated Structures must be established and maintained by the holder for each regulated dam.
I26	The holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated dam is submitted to the administering authority.

I27	The holder must make a final entry of the required information in the Register of Regulated Structures once compliance with conditions I9 and I10 has been achieved.
I28	The holder must ensure that the information contained in the Register of Regulated Structures is current and complete on any given day.
I29	All entries in the Register of Regulated Structures must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.
I30	The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Structures, in the electronic format required by the administering authority.

Schedule J: Watercourse Diversions	
Condition number	Condition
J1	Permanent watercourse diversions Permanent watercourse diversions, or the re-establishment of a pre-existing watercourse where a temporary watercourse diversion is being replaced, 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.
J2	Temporary watercourse diversions Temporary watercourse diversions must be designed and constructed to: (a) maintain the pre-existing hydrologic characteristics of surface water systems for the area in which the watercourse diversion is located; (b) maintain the hydraulic characteristics of the watercourse diversion that are equivalent to other local watercourses and are suitable for the area in which the diversion is located. Where structures that require ongoing maintenance are used, they must not compromise the equilibrium and performance of the temporary watercourse diversion and adjoining watercourses; (c) maintain sediment transport and water quality regimes that minimise any impacts to upstream and downstream water quality, geomorphology, or vegetation; and (d) maintain equilibrium and functionality at all substrate conditions at the location of the diversion.
J3	Design plan – All diversion For all watercourse diversions other than for Two Mile Creek and Coral Creek a Design Plan certified by a Registered Professional Engineer of Queensland that achieves condition J1 for permanent watercourse diversions and condition J2 for temporary watercourse diversions must be submitted to the administering authority for approval at least ten (10) business days before commencing construction of the diversion.
J4	Watercourse diversion authorised by this environmental authority must be rehabilitated in accordance with the approved Rehabilitation Management Plan (as per condition H2)

J5	Construction and operation – All diversions A certified set of ‘as constructed’ drawings and specification must be submitted to the administering authority within sixty (60) business days from the completion of construction of the temporary or permanent watercourse diversion, or re-establishment of the pre-existing watercourse. These drawings and specifications must state: (a) that the ‘as constructed’ drawings and specifications meet the original intent of the approved Design Plan for the watercourse diversion; and (b) construction of the watercourse diversion is in accordance with the approved Design Plan
J6	Register – All diversions The details of watercourse diversions planned and constructed under an environmental authority must be accurately recorded on the Register of Regulated Structures kept by the holder of the authority. An electronic copy must be provided to the administering authority on request.
J7	The holder of this authority is required to monitor the performance of all diversions by way of a performance report prepared for each diversion by a registered professional engineer (RPEQ) at the following times: (a) April of each year; and (b) at any time when poor performance and/or potential failure of the diversion are observed. Note: Monitoring of the works must include recommendations as per ACARP Project C9068 “Monitoring and Evaluation Program for Bowen Basin River Diversions”. Two (2) hard copies and an electronic copy shall be furnished to the Chief Executive by 30 June each year.
J8	The performance report must detail the following: (a) the performance of the diversion by way of comparison with the relevant approved Design Plans, specifications, and monitoring/maintenance strategies therein; (b) surveys to identify and quantify any changes to the channel bed and permanent corridor width subjected to settlement; (c) detail any remedial works to be undertaken including a timetable for completion of proposed works; and (d) any recommendations on measures to be taken to ensure the physical integrity of the works.
J9	The holder of this authority must maintain to the satisfaction of the administering authority the diversion in accordance with the conditions of this environmental authority. Where the operation of the diversion channel in the opinion of the administering authority has demonstrated that acceptable channel stability cannot be achieved the administering authority may direct the holder to take whatever approved measure and modifications are considered necessary by the administering authority for the protection and proper maintenance of the inference.

Schedule K: Biodiversity	
Condition number	Condition
K1	Impacts to State Environmental Matters Significant residual impacts to prescribed environmental matters are limited to those impacts specified in Table K1 – Significant residual impacts to prescribed environmental matters and for Matters of State Environmental Significance, as illustrated in the Figure 4 (a) – Location of pre-mining Matters of State Environmental Significance (ML10327, ML700075), Figure 4 (b) – Pre-mining potential habitat for Koala (ML10327, ML700075) and Figure 4 (c) – Pre-mining potential habitat for Squatter Pigeon (ML10327, ML700075).
K2	If prescribed environmental matters not listed in Table K1 – Significant residual impacts to prescribed environmental matters are impacted by mining activities, a report must be produced by an appropriately qualified person detailing whether the impact constitutes a significant residual impact to the matter.
K3	Any offsets to prescribed environmental matters must be delivered in accordance with the <i>Environmental Offsets Act 2014</i> and Queensland Environmental Offsets Policy (EPP/2015/1658), as amended from time to time.
K4	Staged Impacts The significant residual impacts to a prescribed environmental matter listed in Table K1 – Significant residual impacts to prescribed environmental matters may be carried out in stages. An environmental offset can be delivered for each stage of the impacts to prescribed environmental matters.
K5	Prior to the commencement of each stage, a report completed by an appropriately qualified person, that includes an analysis of the following must be provided to the administering authority: (a) for the forthcoming stage – the estimated significant residual impacts to each prescribed environmental matter; and (b) for the previous stage, if applicable – the actual significant residual impacts to each prescribed environmental matter, to date.
K6	The report required by condition K5 must be approved by the administering authority before a notice of election for the forthcoming stage, if applicable, is lodged with the administering authority.
K7	A notice of election for the staged environmental offset referred to in condition K6, must be provided to the administering authority no less than three (3) months before the proposed commencement of that stage, unless a lesser timeframe has been agreed to by the administering authority.

Table K1: Significant residual impacts to prescribed environmental matters

Prescribed Environmental Matters	Location of impact	Maximum Extent of Impact	State Environmental Offset Required
RE 11.3.30 (Intersecting watercourse)	ML700075 and ML10327	0.4 ha	Y
RE 11.3.25 (Intersecting watercourse)		2.1 ha	Y
RE 11.3.7/11.3.31 (Intersecting watercourse)		1.5 ha	Y
RE 11.3.25		11.3 ha	Y
RE 11.3.25a		14.6 ha	Y
RE 11.3.27f		11.9 ha	Y
RE 11.3.31		21.9 ha	Y
RE 11.3.4		6.4 ha	Y
RE 11.3.7		54.9 ha	Y
RE 11.9.10		6.0 ha	Y
Squatter Pigeon (Southern) (<i>Geophaps scripta scripta</i>)*		197.5 ha	Y
Koala (<i>Phascolarctos cinereus</i>)*		264.5 ha	Y

*This matter is to be managed in accordance with State offset requirements and may be amended upon finalisation of referral under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

END OF CONDITIONS

Definitions

Key terms and/or phrases used in this document are defined in this section. Where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

Acid mine 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.

Adversely means in a way that results in a material change in condition within Category 'B' areas such that there is a harmful or unfavourable impact to a specific receptor or environmental value.

Affected person is someone whose drinking water can potentially be impacted as a result of discharges from a dam, or their life can be put at risk due to dwellings or workplaces being in the path of a dam break flood.

Airblast overpressure means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dBL).

Annual exceedance probability or AEP the probability that at least one event in excess of a particular magnitude will occur in any given year.

Annual inspection report means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan):

- (a) against recommendations contained in previous annual inspections reports;
- (b) against recognised dam safety deficiency indicators;
- (c) for changes in circumstances potentially leading to a change in consequence category;
- (d) for conformance with the conditions of this authority;
- (e) for conformance with the 'as constructed' drawings;
- (f) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year of accumulated sediment, state of the containment barrier and the level of liquids in the **dam** (or network of linked containment systems); and
- (g) for evidence of conformance with the current operational plan.

Appropriately qualified person means a person who has professional qualifications, training, skills, or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods, or literature.

Approved design plans are defined as:

- (a) design of Two Mile Creek Diversion, Brisbane Stormwater Management Pty Ltd, 30 March 2012
- (b) design of Two Mile Creek Diversion Addendum Report, Brisbane Stormwater Management Pty Ltd, 17 September 2012
- (c) Two Mile Creek Diversion Addendum Report for Temporary Crossing (Engeny, Dec 2020)
- (d) Two Mile Creek Diversion Addendum Report for Final Landform (Engeny, Feb 2022)
- (e) design of Coral Creek Diversion, Brisbane Stormwater Management Pty Ltd, May 2011

- (f) design of Coral Creek Diversion Addendum Report, Brisbane Stormwater Management Pty Ltd, November 2011
- (g) North Sonoma Creek Diversion Design Plan, Engeny Water Management Pty Ltd, May 2018

Assessed or assessment by a suitably qualified and experienced person in relation to a consequence assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all the following aspects are addressed and are sufficient to allow an independent audit of the assessment:

- (a) exactly what has been assessed and the precise nature of that determination;
- (b) the relevant legislative, regulatory, and technical criteria on which the assessment has been based;
- (c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and
- (d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.

Associated works in relation to a dam, means:

- (a) operations of any kind and all things constructed, erected, or installed for that dam; and
- (b) any land used for those operations.

Authority means an environmental authority or a development approval.

Background, with reference to the **Schedule F: Surface Water** means the average of samples taken prior to the commencement of mining from the same waterway that the current sample has been taken.

Blasting means the use of explosive materials to fracture:

- (a) rock, coal and other minerals for later recovery; or
- (b) structural components or other items to facilitate removal from a site or for reuse.

Certification, certifying or certified by an appropriately qualified and experienced person in relation to a design plan or an annual report regarding dams/structures, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit at any time:

- (a) exactly what is being certified and the precise nature of that certification;
- (b) the relevant legislative, regulatory, and technical criteria on which the certification has been based;
- (c) the relevant data and facts on which the certification has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and
- (d) the reasoning on which the certification has been based using the relevant data and facts, and the relevant criteria.

Certification means assessment and approval must be undertaken by a suitably qualified and experienced person in relation to any assessment or documentation required by this Manual, including design plans, 'as constructed' drawings and specifications, construction, operation, or an annual report regarding regulated structures, undertaken in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQS (ID: 1.4 (2A)).

Certifying, certify or certified have a corresponding meaning as 'certification'.

Chemical means:

- (a) an agricultural chemical product or veterinary chemical product within the meaning of the *Agricultural and Veterinary Chemicals Code Act 1994* (Commonwealth);
- (b) a dangerous good under the Australian Code for the Transport of Dangerous Goods by Road and Rail approved by the Australian Transport Council;
- (c) a lead hazardous substance within the meaning of the *Workplace Health and Safety Regulation 1997*;
- (d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or
- (e) any substance used as, or intended for use as:
 - (i) a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product;
 - (ii) a surface active agent, including, for example, soap or related detergent;
 - (iii) a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide;
 - (iv) a fertiliser for agricultural, horticultural, or garden use;
 - (v) a substance used for, or intended for use for mineral processing or treatment of metal, pulp and paper, textile, timber, water, or wastewater; or
 - (vi) manufacture of plastic or synthetic rubber.

Commercial place means a workplace used as an office or for business or commercial purposes, which is not part of the mining activity and does not include employees' accommodation or public roads.

Consequence in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting, or controlling flowable substances.

Consequence category means a category, either low, significant, or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Construction or **constructed** in relation to a regulated structure includes building a new regulated structure and lifting or otherwise modifying an existing regulated structure, but does not include investigations and testing necessary for the purpose of preparing a design plan.

Dam means a land-based structure or a void that contains, diverts, or controls flowable substances, and includes any substances that are thereby contained, diverted, or controlled by that land-based structure or void and **associated works**.

Dam crest volume means the volume of material (liquids and/or solids) that could be within the walls of a dam at any time when the upper level of that material is at the crest level of that dam. That is, the instantaneous maximum volume within the walls, without regard to flows entering or leaving (for example, via spillway).

Design plan is a document setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.

Design storage allowance or **DSA** means an available volume, estimated in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an **annual exceedance probability** (AEP) specified in that Manual.

Designer for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

Disturbance of land includes:

- (a) compacting, removing, covering, exposing, or stockpiling of earth;
- (b) removal or destruction of vegetation or topsoil or both to an extent where the land has been made susceptible to erosion;
- (c) carrying out mining within a watercourse, waterway, wetland, or lake;
- (d) the submersion of areas by tailings or hazardous contaminant storage and dam/structure walls;
- (e) temporary infrastructure, including any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be removed after the mining activity has ceased; or
- (f) releasing of contaminants into the soil, or underlying geological strata.

However, the following areas are not included when calculating areas of 'disturbance':

- (a) areas off lease (e.g. roads or tracks which provide access to the mining lease);
- (b) areas previously disturbed which have achieved the rehabilitation outcomes;
- (c) by agreement with the administering authority, areas previously disturbed which have not achieved the rehabilitation objective(s) due to circumstances beyond the control of the mine operator (such as climatic conditions);
- (d) areas under permanent infrastructure. Permanent infrastructure includes any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be left by agreement with the landowner; or
- (e) disturbance that pre-existed the grant of the tenure.

Effluent treated waste water released from sewage treatment plants.

Emergency action plan means documentation forming part of the operational plan held by the holder or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam owners to annually update contact information.

Existing structure means a structure that prior to 18 September 2014 meets any or both of the following, a structure:

- (a) with a design that is in accordance with the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* and that is considerably in progress;
- (b) that is under considerable construction or that is constructed.

Extreme storm storage – means a storm storage allowance determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

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.

Hazard category means a category, either low significant or high, into which a dam is assessed as a result of the application of tables and other criteria in '*Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*'.

Holder means:

- (a) where this document is an environmental authority, any person who is the holder of, or is acting under, that environmental authority; or
- (b) where this document is a development approval, any person who is the registered operator for that development approval.

Hydraulic performance means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Infrastructure means water storage dams, levees, roads and tracks, buildings and other structures built for the purpose of the mining activity.

Land in **Schedule H – Land and rehabilitation** of this document means land excluding waters and the atmosphere, that is, the term has a different meaning from the term as defined in the *Environmental Protection Act 1994*. For the purposes of the *Acts Interpretation Act 1954*, it is expressly noted that the term '**land**' in this environmental authority relates to physical land and not to interests in land.

Land use means the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

Leachate means a liquid that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed, or disposed of at the operational land which contains soluble, suspended, or miscible contaminants likely to have been derived from the said material.

Levee means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of **water** or **flowable substances** at any other times.

Low consequence dam means any dam that is not a high or significant consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

m means metres.

Mandatory reporting level or **MRL** means a warning and reporting level determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/933)* published by the administering authority.

Manual means the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

Measures includes any measures to prevent or minimise environmental impacts of the mining activity such as bunds, silt fences, diversion drains, capping, and containment systems.

Mine affected water:

(a) means the following types of water:

- (i) pit water, tailings dam water, processing plant water;
- (ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity;
- (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:
 - I. areas that are been capped and have monitoring data demonstrating hazardous material adequately contained with the site;
 - II. 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.

Mineral waste means waste materials resulting from the extraction and processing of coal including overburden, inter-burden, waste rock, tailings, and rejects.

Mining waste means waste rock, spoil, overburden and interburden.

Modification or modifying (see definition of **construction**).

Natural flow means the flow of water through waters caused by nature.

Non polluting means having no adverse impacts upon the receiving environment.

Operational plan includes:

- (a) normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA);

- (b) contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

Peak particle velocity (ppv) means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mm/s).

Permanent watercourse diversion is a man-made structure that incorporates the geomorphologic, hydraulic, hydrologic, and ecological components of a local watercourse and is designed, constructed, operated, and maintained according to an engineering standard that ultimately achieves a self-sustaining watercourse able to function without features or characteristics that rely on ongoing maintenance or that impose a financial or other burden on the proponent, government, or the community.

Protected area means – a protected area under the *Nature Conservation Act 1992*; or

- (a) a marine park under the *Marine Parks Act 1992*; or
- (b) a World Heritage Area.

Register of regulated structure includes:

- (a) date of entry in the register;
- (b) name of the structure, its purpose, and intended/actual contents;
- (c) the consequence category of the dam as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635);
- (d) dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;
- (e) name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;
- (f) for the regulated dam, other than in relation to any levees –
 - (i) the dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;
 - (ii) coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area
 - (iii) dam crest volume (megalitres);
 - (iv) spillway crest level (metres AHD).
 - (v) maximum operating level (metres AHD);
 - (vi) storage rating table of stored volume versus level (metres AHD);
 - (vii) design storage allowance (megalitres) and associated level of the dam (metres AHD);
 - (viii) mandatory reporting level (metres AHD);
- (g) the design plan title and reference relevant to the dam;
- (h) the date construction was certified as compliant with the design plan;
- (i) the name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;
- (j) details of the composition and construction of any liner;
- (k) the system for the detection of any leakage through the floor and sides of the dam;
- (l) dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;
- (m) dates when recommendations and actions arising from the annual inspection were provided to the administering authority;

- (n) dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.

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 of this environmental authority.

The term does not include land that is specified in Authorised Activities of this environmental authority.

Receiving waters means the waters into which this environmental authority authorises releases of mine affected water.

Regulated structure means any structure in the significant or high consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority. A regulated structure does not include:

- (a) a fabricated or manufactured tank or container, designed and constructed to an Australian Standard that deals with strength and structural integrity of that tank or container;
- (b) a sump or earthen pit used to store residual drilling material and drilling fluid only for the duration of drilling and well completion activities; and
- (c) a flare pit.

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 meaning the mining activities carried out at the mining tenements detailed in **Figure 1 – Authorised disturbance area and groundwater monitoring locations** of this environmental authority.

Residual drilling material means waste drilling materials including muds and cuttings or cement returns from well holes and which have been left behind after the drilling fluids are pumped out.

RL means reduced level, relative to mean sea level as distinct from depths to water.

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.

Sensitive place means:

- (a) a dwelling, residential allotment, mobile home or caravan park, residential marina, or other residential premises; or
- (b) a motel, hotel, or hostel; or
- (c) an educational institution; or
- (d) a medical centre or hospital; or
- (e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 1992* or a World Heritage Area; or
- (f) a public park or gardens.

Note: The definition of 'sensitive place' and 'commercial place' is based on Schedule 1 of *EPP Noise*. That is, a sensitive place is inside or outside on a dwelling, library & educational institution, childcare or kindergarten, school or playground, hospital, surgery or other medical institution, commercial & retail activity, protected area or an area identified under a conservation plan under *Nature Conservation Act 1992* as a critical habitat or an area of major interest, marine park under *Marine Parks Act 2004*, park or garden that is outside of the mining lease and open to the public for the use other than for sport or organised entertainment. A commercial place is inside or outside a commercial or retail activity.

A mining camp (i.e., accommodation and ancillary facilities for mine employees or contractors or both, associated with the mine the subject of the environmental authority) is not a sensitive place for that mine or mining project, whether or not the mining camp is located within a mining tenement that is part of the mining project the subject of the environmental authority. For example, the mining camp might be located on neighbouring land owned or leased by the same company as one of the holders of the environmental authority for the mining project, or a related company. Accommodation for mine employees or contractors is a sensitive place if the land is held by a mining company or related company, and if occupation is restricted to the employees, contractors and their families for the particular mine or mines which are held by the same company or a related company.

For example, a township (occupied by the mine employees, contractors and their families for multiple mines that are held by different companies) would be a sensitive place, even if part or all of the township is constructed on land owned by one or more of the companies.

Spillway means a weir, channel, conduit, tunnel, gate, or other structure designed to permit discharges from the dam, normally under flood conditions or in anticipation of flood conditions.

Structure means dam or levee.

Suitably qualified and experienced person in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience:

- (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.

SWL means standing water level.

System design plan means a plan that manages an integrated containment system that shares the required DSA and/or ESS volume across the integrated containment system.

Temporary watercourse diversion is a man-made structure that may incorporate geomorphologic, hydraulic, hydrologic, and ecological components of a local watercourse and is designed, constructed, operated, and maintained according to an engineering standard that ensures the diversion does not compromise the equilibrium and performance of the diversion and adjoin watercourses. A temporary diversion is replaced by a permanent diversion, or the re-establishment of the pre-existing watercourse, within the timeframe specified in the design plan.

The Act means the *Environmental Protection Act 1994*.

µS/cm means micro siemens per centimetre.

Void means any constructed, open excavation in the ground.

Watercourse has the same meaning given in the *Water Act 2000*.

Water quality means the chemical, physical and biological condition of water.

Waters includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined natural or artificial watercourse, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), storm water channel, storm water drain, and groundwater and any part thereof.

WaTERS means the Queensland Government's WaTERS database system.

Wet season means the time of year, covering one or more conditions, when most of the average annual rainfall in a region occurs. For the purposes of DSA determination this time of year is deemed to extend from 1 November in one year to 31 May in the following year inclusive.

Figures:

Figure 1 – Authorised disturbance area and groundwater monitoring locations

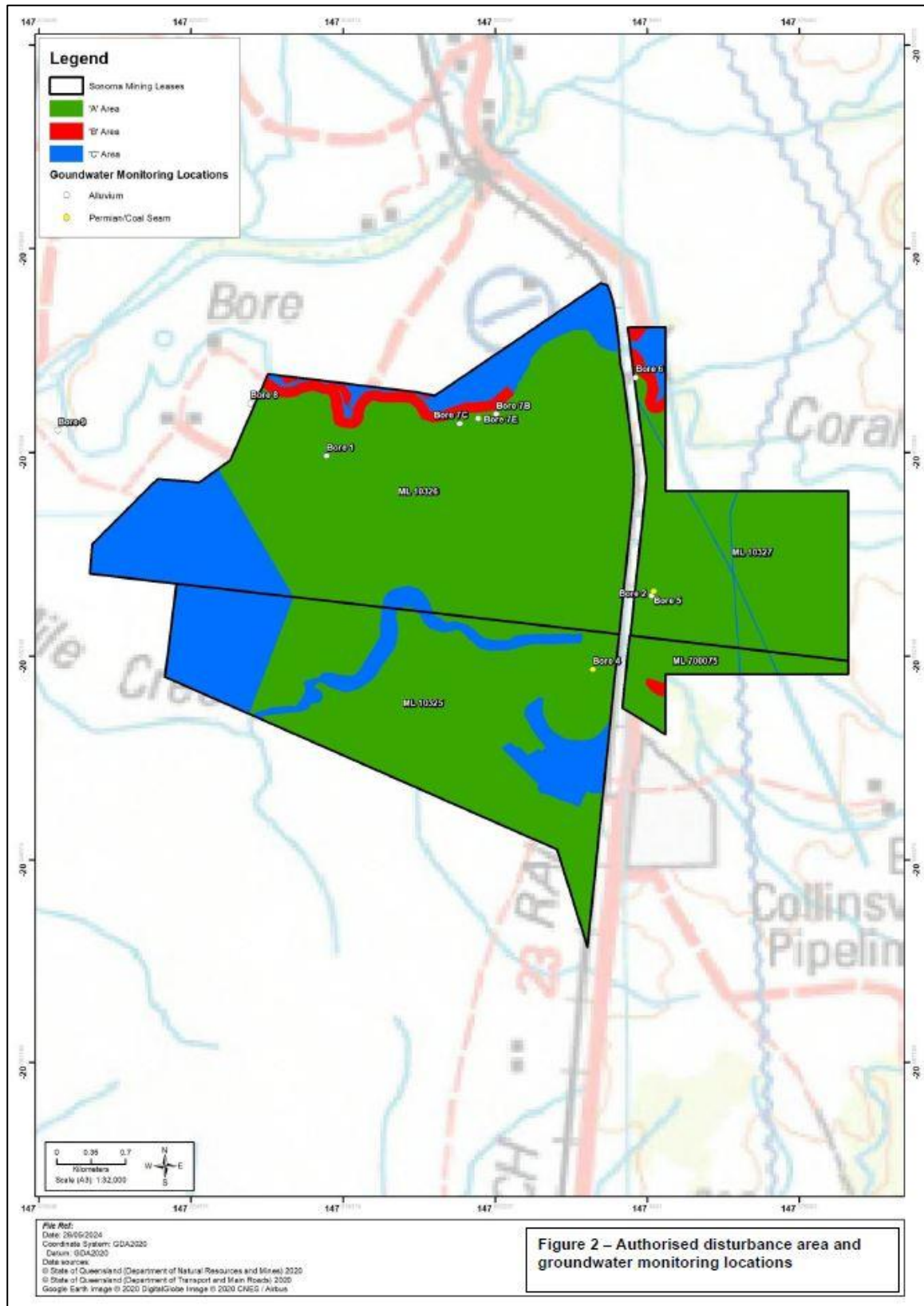


Figure 2 – Authorised mine domains as of June 2024

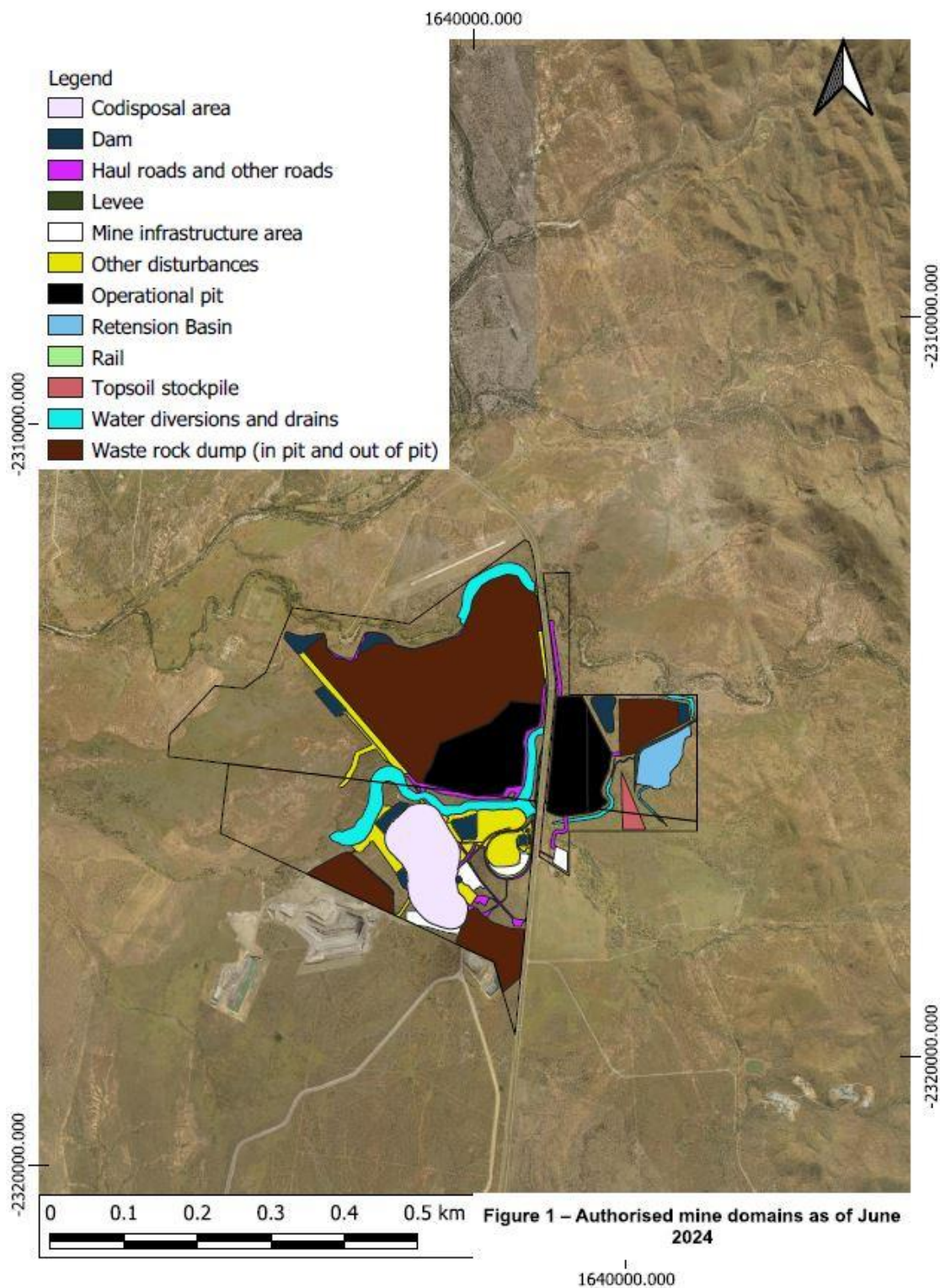


Figure 3 – Mine affected water release points, sources and receiving waters

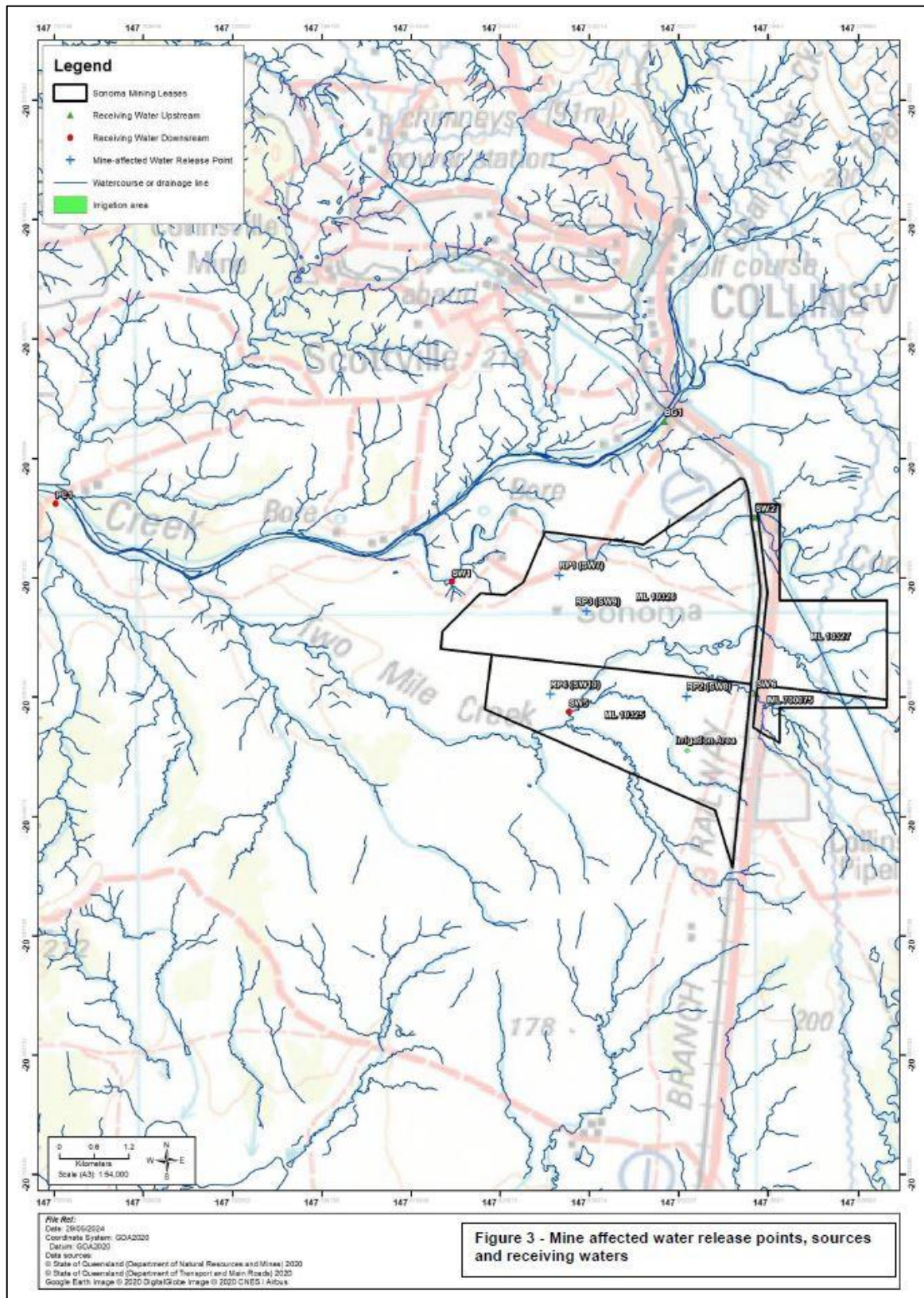


Figure 4 (a) – Location of Pre-mining Matters of State Environmental Significance (ML10327, ML700075)

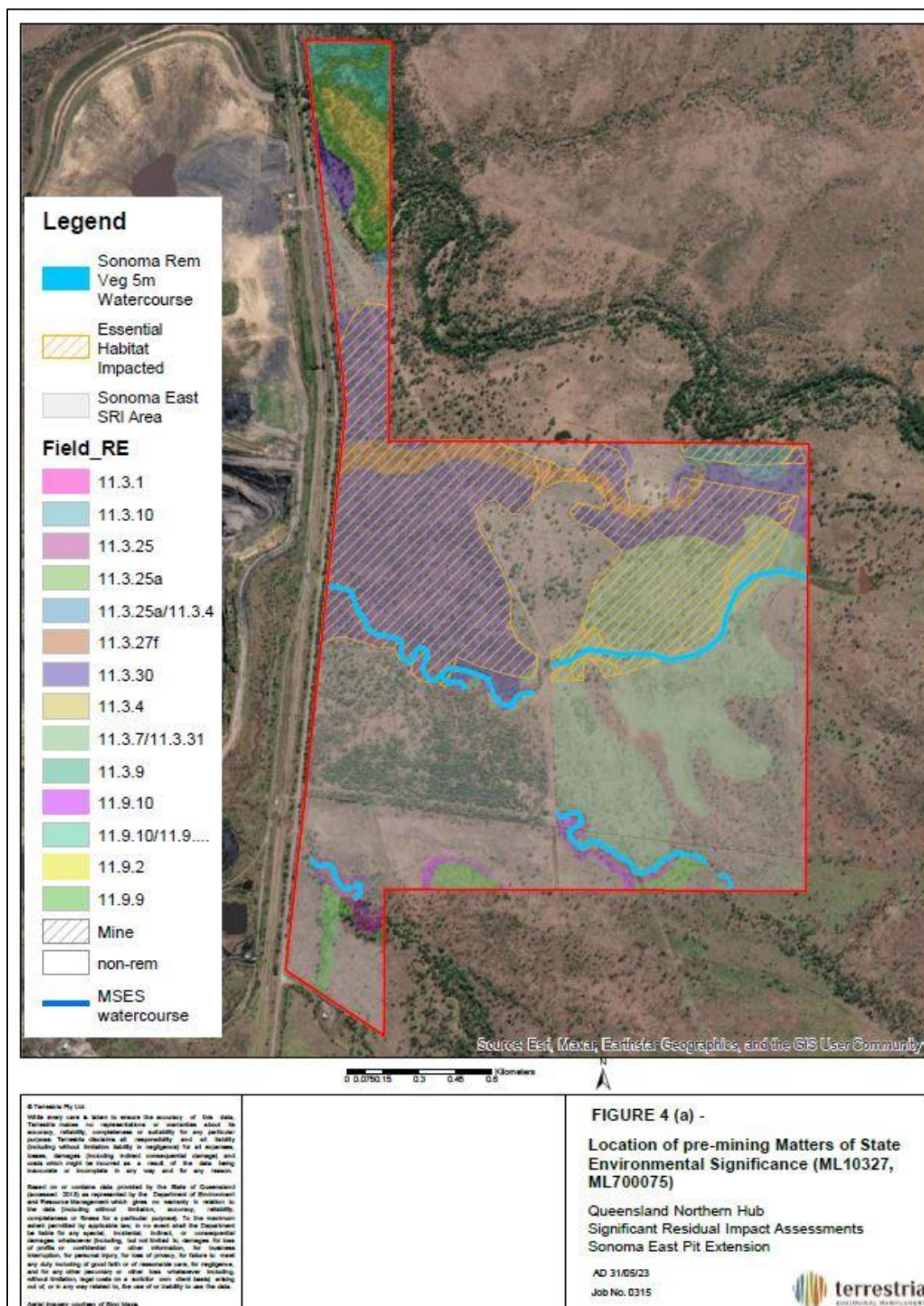


Figure 4 (b) – Pre-mining potential habitat for Koala (ML10327, ML700075)

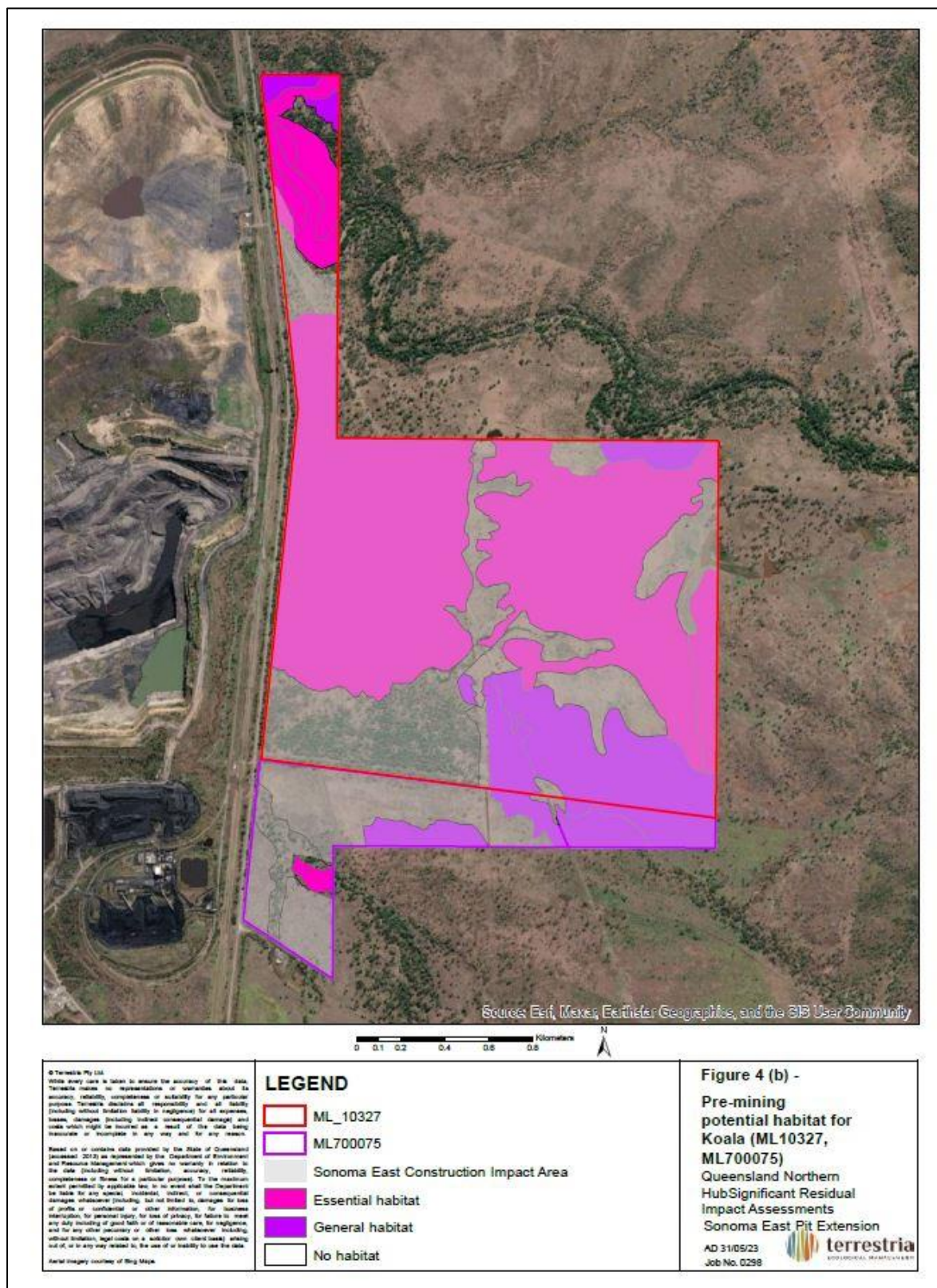
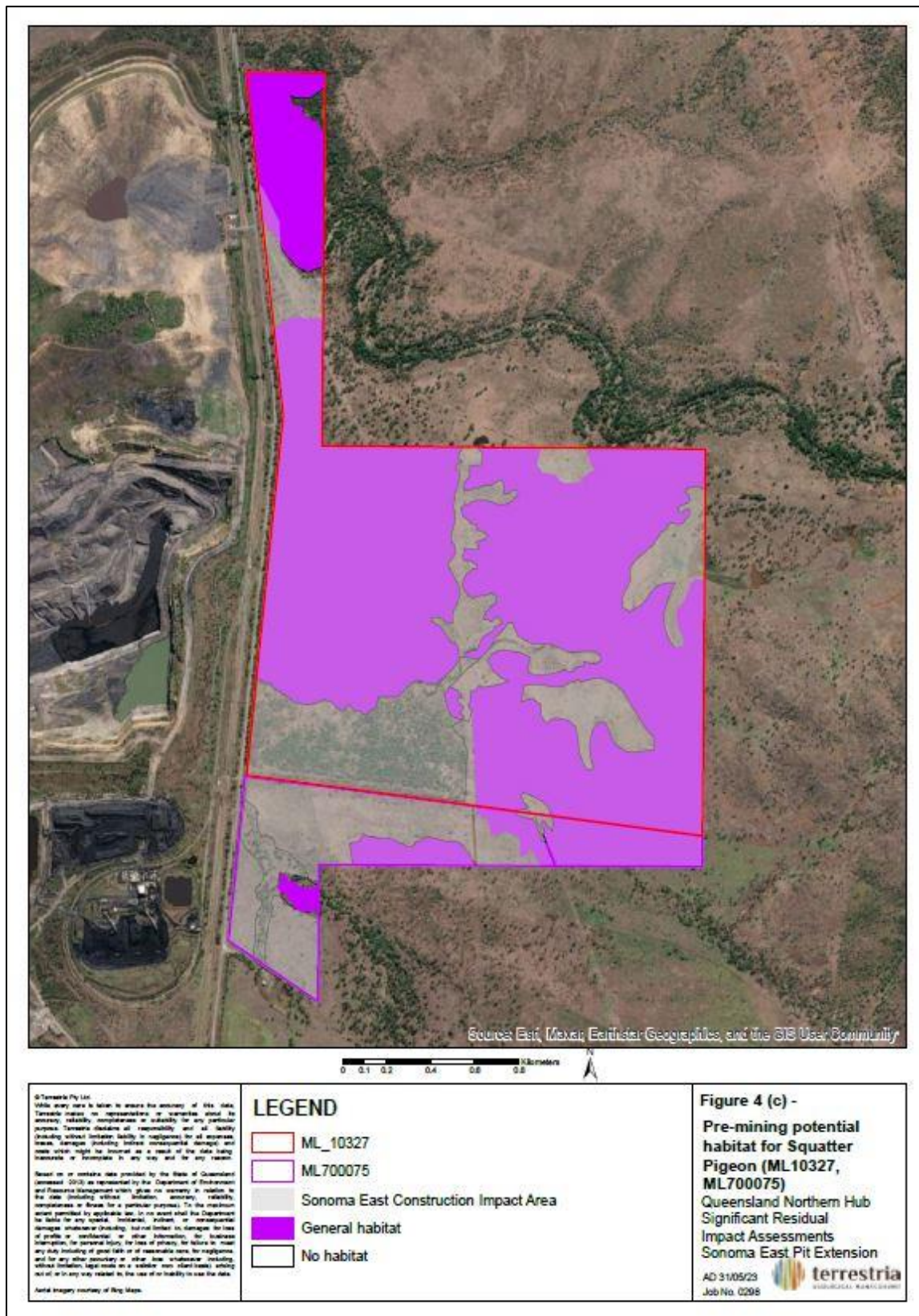


Figure 4 (c) – Pre-mining potential habitat for Squatter Pigeon (ML10327, ML700075)



END OF ENVIRONMENTAL AUTHORITY

Appendix C - QNH Rehabilitation Management Plan

QCoal Northern Hub

Rehabilitation Management Plan



Submitter information	
Report type	Rehabilitation Management Plan
Author(s)	Environment – QCoal Group
Address	Level 15, 40 Creek Street, Brisbane Qld 4000 PO Box 10630, Adelaide Street, Brisbane Qld 4000
Project(s)	Sonoma Coal Mine Cows Coal Mine Drake Coal Mine Jax Coal Mine
Date of report	June 2020

Revision summary		
Author	Version	Date
R. Pane	Draft 1	24 April 2020
R. Pane	Revision 1	3 June 2020

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1 Introduction

QCoal Pty Ltd (QCoal) manages four (4) adjacent open cut coal mines located approximately six (6) km south of the town of Collinsville in Central Queensland. The four mines are Sonoma Coal Mine (SCM), Cows Coal Mine (CCM), Drake Coal Mine (DCM), and Jax Coal Mine (JCM), with pits, dumps, haul roads and water management infrastructure spanning the boundaries of the various mining leases (MLs). Each mine has its own approval, being an environmental authority (EA); however, as with physical infrastructure, operational and environmental management and resources are integrated across the four mines.

The mines that make up the QNH are directly adjacent to one another on the western side of Bowen Development Road and the parallel Newlands rail line, with the exception of JCM, which is on the eastern side (see **Figure 1**).

Accordingly, these four (4) mines are collectively managed and operated as a single multi-pit operation, which is referred to as the QCoal Northern Hub (QNH).

1.1 Rehabilitation Management Plan Objectives

Presented in **Section 2.5** are the details of the four (4) QNH EAs. Condition H3 of all four (4) site EAs requires the development of an RMP, due for submission by **24 April 2020**. As such, this QNH Rehabilitation Management Plan (QNH RMP) has been developed to:

- Satisfy the EA conditions within each of the four (4) QNH mines which require an RMP;
- Present a consistent approach to rehabilitation across the QNH, which will:
 - Improve final landform planning and design (especially for landforms that cross EA boundaries),
 - Maximise efficiency in undertaking rehabilitation activities, and
 - Allow for assessment of rehabilitation success on a whole-of-operation basis.

This QNH RMP will supersede any existing rehabilitation management plan applicable to any of the QNH mines.

In preparing the QNH RMP, reference has been made to previous QNH investigations and reports, as well as regulatory documents which provide direction on rehabilitation (e.g. requirements, methods, or outcomes), including, but not limited to, the following:

- Relevant conditions of site EAs.
- Commitments made by individual sites in other statutory documentation.
- *Design of Two Mile Creek Diversion* (BSM, 2012)
- *North Sonoma Creek Diversion Design Plan* (Engeny, 2018)
- *Investigation into Residual Void Sonoma Coal Mine* (QCoal, 2016)
- *Residual Voids on the QCoal Northern Hub Mining Complex* (QCoal, 2020)

- *Rehabilitation requirements for mining projects* (EHP, 2014)¹.
- *Groundwater Monitoring and Management Plan – Drake Coal Pty Ltd – Drake Coal Project* (QCoal, 2014)
- *Northern Hub Groundwater Assessment* (AGE, 2018)
- *Northern Hub Groundwater Assessment* (AGE, 2020)
- *Residual Void Hydrology Study QCoal Northern Hub Mines June 2020* (Engeny, 2020)
- *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995).

The QNH RMP presents the rehabilitation strategies and objectives for closure to achieve agreed post-mine land uses (PMLUs). Rehabilitation strategies have been developed for all relevant areas of disturbance (domains) across the QNH. These strategies have been developed to ensure the requirements of the four (4) QNH EAs have been satisfied.

A monitoring and reporting framework has been developed to demonstrate achievement of the relevant rehabilitation completion criteria.

¹ This guideline describes the policy framework and assessment process for determining the acceptability of rehabilitation outcomes and strategies. It provides EA holders with a clear structure for the development of objectives and targets that should be presented in approvals and mine management documents such as PoOs and rehabilitation plans.

2 Project Overview

2.1 Location

The QNH is located approximately 6 km south of the town of Collinsville, and 78 km southwest of the regional centre of Bowen (see **Figure 1**). Access to all four QNH sites is by the state-controlled Bowen Development Road.

2.2 Ownership

The QNH sites have ownership makeups as follows:

- SCM is a joint venture between QCoal Sonoma Pty Ltd, JS Sonoma Pty Ltd, CSC Sonoma Pty Ltd and Watami (Qld) Pty Ltd.
- DCM is owned by Northern Hub (Drake) Pty Ltd and Drake Coal Pty Ltd.
- CCM is owned by Bowen River Coal Pty Ltd.
- JCM is owned by Jax Coal Pty Ltd.

QCoal Sonoma Pty Ltd, Northern Hub (Drake) Pty Ltd, Drake Coal Pty Ltd, Bowen River Coal Pty Ltd and Jax Coal Pty Ltd, are wholly or majority owned subsidiaries of QCoal Pty Ltd. The owner and Managing Director of QCoal Pty Ltd is Mr Christopher Wallin.

2.3 Mining Tenures

The ML tenure details for the QNH mines are provided in **Table 1**, **Table 2**, **Table 3** and **Table 4**.

Table 1 – SCM Mining Lease Details

Details	ML10325	ML10326	ML10327
Permit Type	Mining Lease	Mining Lease	Mining Lease
Permit Status	Granted	Granted	Granted
Permit Sub-Status	None	None	None
Lodgment Date	21/11/2005	21/11/2005	21/11/2005
Grant Date	12/4/2007	13/09/2007	13/09/2007
Expiry Date	30/04/2037	30/09/2037	30/09/2037
Authorised Holder Name	QCoal Sonoma Pty Ltd	QCoal Sonoma Pty Ltd	QCoal Sonoma Pty Ltd
Area	716.7 ha	1,063 ha	360.4 ha
Permit ID	108618	108619	108620
Native Title Category	Exclusive Land	Exclusive Land	Exclusive Land

Table 2 – CCM Mining Lease Details

Details	ML10345
Permit Type	Mining Lease
Permit Status	Granted
Permit Sub-Status	None
Lodgment Date	11/04/2009
Grant Date	16/08/2012
Expiry Date	31/08/2027
Authorised Holder Name	Bowen River Coal Pty Ltd
Area	210.5 ha
Permit ID	108636
Native Title Category	Exclusive Land

Table 3 – DCM Mining Lease Details

Details	ML10349	ML10350	ML10351
Permit Type	Mining Lease	Mining Lease	Mining Lease
Permit Status	Granted	Granted	Granted
Permit Sub-Status	None	None	None
Lodgment Date	21/04/2010	21/04/2010	21/04/2010
Grant Date	2/11/2014	2/11/2014	2/11/2014
Expiry Date	29/02/2044	29/02/2044	29/02/2044
Authorised Holder Name	Northern Hub (Drake) Pty Ltd	Northern Hub (Drake) Pty Ltd	Northern Hub (Drake) Pty Ltd
Area	3,982 ha	4,805 ha	427.9
Permit ID	108640	108641	108642
Native Title Category	Right To Negotiate Agreement	Right to Negotiate Agreement	Right to Negotiate Agreement

Table 4 – JCM Mining Lease Details

Details	ML10346
Permit Type	Mining Lease
Permit Status	Granted
Permit Sub-Status	None
Lodgment Date	11/12/2009
Grant Date	20/12/2013
Expiry Date	31/12/2034
Authorised Holder Name	Jax Coal Pty Ltd
Area	1,943 hectares
Permit ID	108637
Native Title Category	Right to Negotiate Agreement

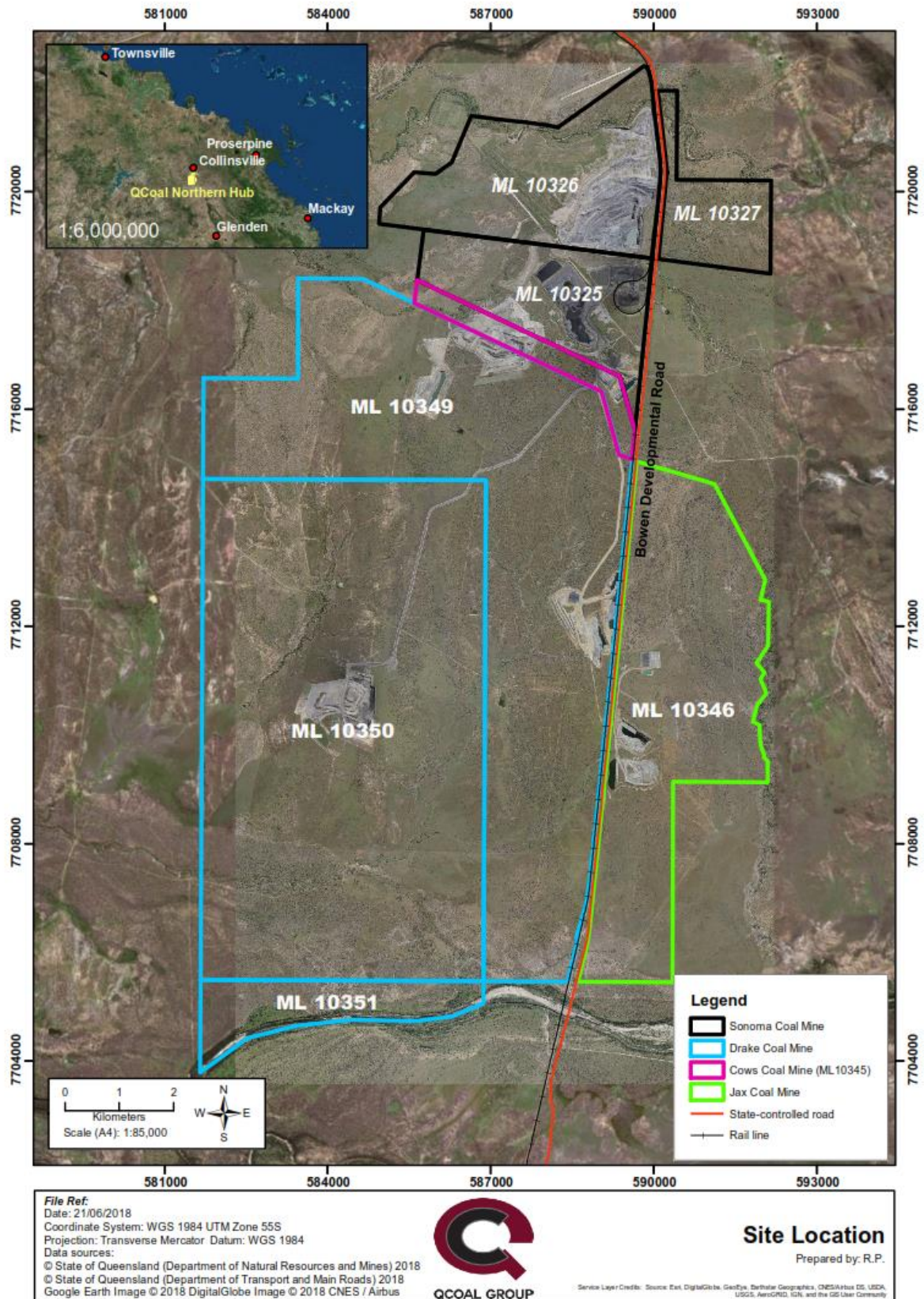


Figure 1 – QCoal Northern Hub Location

2.4 Underlying Landholders

The QNH spans eight (8) MLs, as described in **Section 2.3**. The MLs are located on land with several landholders, as summarised below and presented in **Figure 2**:

- **SCM:**
 - ML10325: The land underlying ML10325 is owned by Mr Christopher Wallin.
 - ML 10326: The land underlying ML10326 is “Sonoma” station, which is privately owned by a third party, apart from the land underlying the SCM rail spur, which is owned by Mr Christopher Wallin.
 - ML10327: The land underlying ML10327 is “Sonoma” station, which is privately owned by a third party.
- **CCM:**
 - ML10345: the land underlying ML10345 is a historic stock route which is no longer declared for that purpose. The land is held under a permit to occupy by Mr Christopher Wallin.
- **DCM:**
 - ML10349, ML10350, and ML10351: The land underlying these MLs is “Birralelee” station, owned by Mr Christopher Wallin.
- **JCM:**
 - ML10346: The land underlying ML10346 is “Birralelee” station, owned by Mr Christopher Wallin.

2.5 Environmental Authorities

EA numbers and primary holders for the QNH mines are provided in **Table 5**.

Table 5 – QCoal Northern Hub Environmental Authorities

Mine	MLs	EA Number	Grant	Primary EA Holder	Current version
SCM	ML10325, ML10326, ML10327	EPML00707713	13/9/2007	QCoal Sonoma Pty Ltd	6/03/2020
CCM	ML10345	EPML00334613	16/8/2012	Bowen River Coal Pty Ltd	9/03/2020
DCM	ML10349, ML10350, ML10351	EPML00393013	2/11/2014	Northern Hub (Drake) Pty Ltd	6/03/2020
JCM	ML10346	EPML00337613	20/12/2013	Jax Coal Pty Ltd	14/04/2020

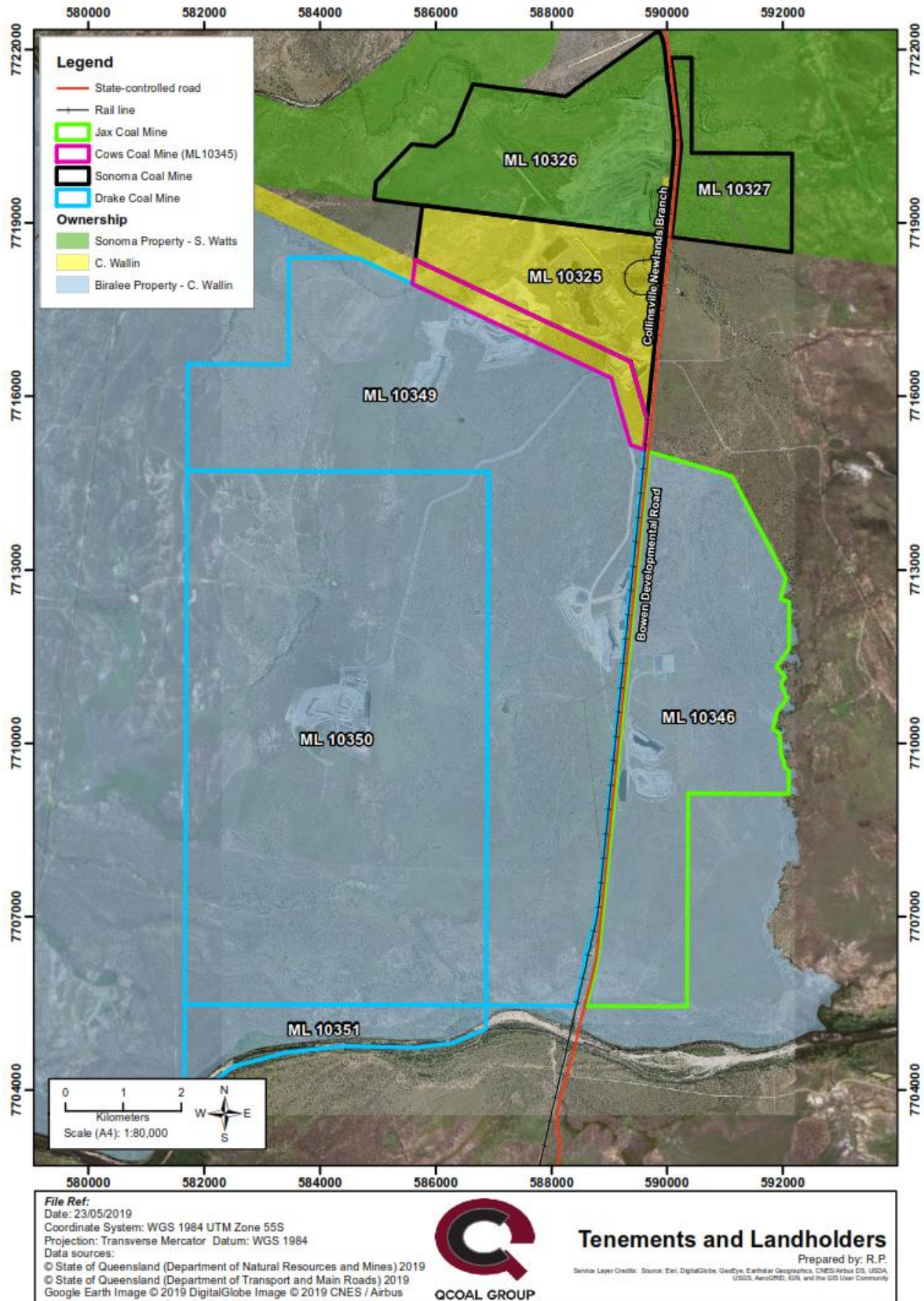


Figure 2 – Tenements and Underlying Landholders

2.6 Activities and Mining Methods

Mining operations on the QNH involve extraction of Run of Mine (ROM) coal using conventional drill and blast, and excavator and truck methodology. ROM coal is then processed and shipped as product coal (coking and thermal).

Topsoil stripped ahead of mine-related activities is either stockpiled for later use in rehabilitation or placed directly on areas already prepared for rehabilitation works. Waste rock materials are placed in either out-of-pit dumps or in-pit dumps.

The QNH mines share water management infrastructure, haul roads, equipment, resources, and other infrastructure. ROM coal from all four QNH mines is sent to the Coal Handling and Processing Plant (CHPP) and train load-out facility located on the SCM. Processed coal is transported to Abbot Point Coal Terminal for shipment to customers.

Coal rejects material generated during processing at the CHPP are placed into co-disposal facilities located on the SCM.

3 Environmental Values

3.1 Climate

The region is characterised by distinct wet and dry seasons, with the majority of rainfall occurring during the summer months, along with higher temperatures and evaporation rates. Average monthly temperature, rainfall and evaporation statistics, as collected at the Bureau of Meteorology's (BoM) Collinsville Post Office Station (no. 033013) are presented in **Figure 3**.

The average annual rainfall for the QNH is 701.6 mm and the average annual evaporation is 1,861.5 mm (BoM, 2019). As such, the region is subject to net annual evaporation, and is dry for much of the year. Predominant winds are south-easterly for the majority of the year.

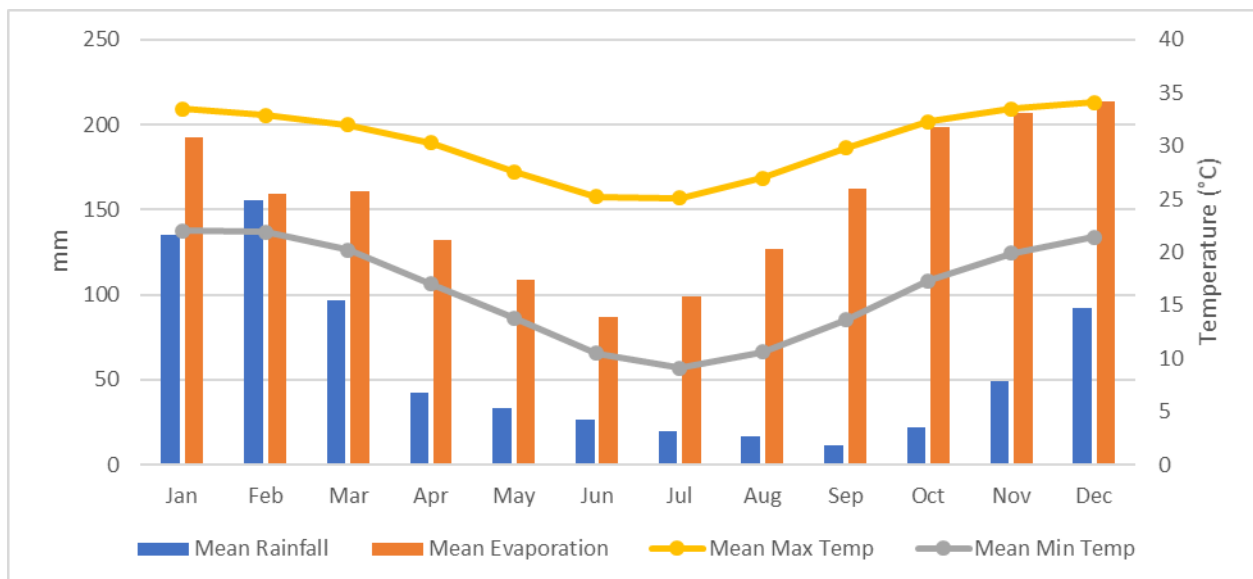


Figure 3 – QCoal Northern Hub Climate Averages

3.2 Topography

The QNH is situated in a flat-to-undulating landscape between the Bowen River (which curves to the south and west of the QNH), Pelican Creek to the north, and the northern sections of the Clarke Ranges to the east. Pre-mining topography in the region was described by GSSE (2005) as alluvial plains and terraces bordering Coral Creek in the north and the Bowen River in the south, and plains and low hills bordered by Two Mile Creek in the middle of the area. Pre-mining elevations ranged from 200 mAHD in the east to 160 mAHD in the west. Undisturbed areas of the QNH MLs typically have a slope of less than 10%.

3.3 Land Use and Suitability

Land suitability classification is assessed based on the *Guidelines for Agricultural Land Evaluation in Queensland* (DSITI & DNRM, 2015). The majority of the land on which the QNH MLs are held has been historically cleared for grazing activities; however, there are scattered areas of remnant vegetation. Current land use in the region is predominantly low intensity grazing on native and improved pastures, with other land uses including coal mining (including exploration), quarrying, and power generation (coal-fired and solar).

Previous land suitability assessments undertaken during the SCM and DCM EIS processes noted that:

- Large areas of the QNH were cleared historically for grazing;
- Logging and ringbarking have been undertaken historically in riparian zones, and mixed woodlands have been thinned, with understories removed to facilitate grazing;
- Soils and landforms are generally suitable for cattle grazing.
- Ongoing pastoral activities by landholders across the QNH MLs and the surrounding region have included agistment/grazing, clearing, regrowth and weed control, and control of feral animals (dogs, pigs, etc.).

The land underlying the SCM, and, by extension, the CCM was characterised as Class 2 for beef cattle grazing prior to the commencement of operations, and it has been concluded that the land was typically not suited to cultivation due to limitations of slope, soil, erosion and climate (GSSE, 2005).

The land underlying the DCM was assessed during the DCM EIS process and typically found to be Class 3 suitability for beef cattle grazing, with limitations to its suitability for broad acre cropping, typically due to water availability, workability, erosion and dissected topography (GHD, 2012).

The *State Rural Leasehold Land Strategy* (NRM, 2013) provides a framework for the management of leasehold land used for agricultural or pastoral pursuits, with a focus on managing land condition and sustaining productive use of leased land. Although mining activities are outside this land use, the rehabilitation strategies and post-mine land use targets for mined land must consider the impacts of rehabilitation on the condition of surrounding pastoral land and any obligations as a lessee.

The *Land Act 1994* obliges leaseholders to take all reasonable actions to:

- Maintain pastures dominated by perennial and productive species
- Maintain native grasslands free of encroachment
- Protect riparian vegetation
- Manage declared pests
- Avoid causing or contributing to salinity that reduces the productivity of leased land, or causes damage to surrounding land
- Conserve soil, water resources, and biodiversity.

3.4 Soils and Geology

The DCM EIS (GHD, 2012) describes the soil profile and geology of the land underlying the DCM and the broader QNH area and has been used to inform this section.

The QNH is located in the northern Bowen Basin. The regional geology documented by the 1:250,000 Geological Series (Bowen, Sheet SF55-3) indicates the QNH is underlain by the Later Permian Blackwater Group consisting of lithic sandstone, siltstone, shale, conglomerate, dolomite and tuff, and minor coal. This is surrounded and underlain by the Early to Late Permian Bienheim Sub-group described as a succession of siltstone, sandstone, coquinite, and limestone.

Overburden and reject materials generated by the QNH are likely to be relatively benign and are expected to generate slightly alkaline and low-to-moderately saline runoff and seepage following surface exposure (see **Section 3.5**).

The majority of the soil and subsoil materials tested were characterised as sodic and alkaline, which is typical of the region. Sodic soils are typically observed at 0.3 m below surface soils. The topsoil horizon depth varies between 0.2m and 1.0m in depth.

3.5 Mine Waste Characteristics

The geochemical characteristics of mine waste materials inform their placement during operations. Materials that have potential geochemical risks are to be encapsulated within materials categorised as lower risk. A number of geochemical investigations have been undertaken on the QNH, including, but not limited to, the following:

- *Sonoma Coal Project – Overburden Assessment Report* (Parsons Brinckerhoff, 2006)
- *Drake Coal Mine EIS – Chapter 7 Mining Waste* (2012)
- *Geochemical Assessment of Mining Waste and Coal Reject Materials, Sonoma Coal Mine* (Terrenus, 2012)
- *Mining Waste and Coal Rejects Management Plan – Sonoma Coal Mine* (Terrenus, 2013)

The findings of these assessments have provided an understanding of the nature of mining waste on the QNH, as detailed in the following sub-sections.

3.5.1 Mine Waste Risk Categories

Based on the geochemical analysis of spoils and coal rejects, a *Mining Waste and Coal Reject Management Plan* (Terrenus, 2013), was developed for the SCM. This plan establishes spoil categories for management of waste rock materials across the QNH. These categories have been visualised in **Figure 4**.

- **Topsoil and subsoil (low risk).** Topsoil (and subsoil) to nominal depth of 1 m below natural surface. Three types of topsoil are defined: Grey uniform clay, brown gradational sandy loam and red duplex sandy loam. Of these types, grey uniform clay is the most prevalent within the existing and future disturbance areas of the mine. This material is defined as Non-Acid Forming (NAF).

- **Category 1 (low risk).** Includes non-coal and non-carbonaceous material above C Seam, not including topsoil/sub-soil, and not within 1 m above and below ROM coal. Typically weathered or moderately weathered. This material is defined as NAF.
- **Category 2 (low to medium risk).** Includes non-coal and non-carbonaceous material below C Seam and not within 1 m above and below ROM coal. Generally fresh or slightly weathered and is defined as material with some capacity to generate Acid and Metalliferous Drainage (AMD). This material is classified as Potentially Acid Forming – Low Capacity (PAF-LC).
- **Category 3 (medium risk).** Includes coal and carbonaceous material, including material within 1 m above and below ROM coal seams, sub-economic coal, intruded coal and heat-affected coal. This material is defined as having some capacity to generate AMD, and is classified as PAF-LC.

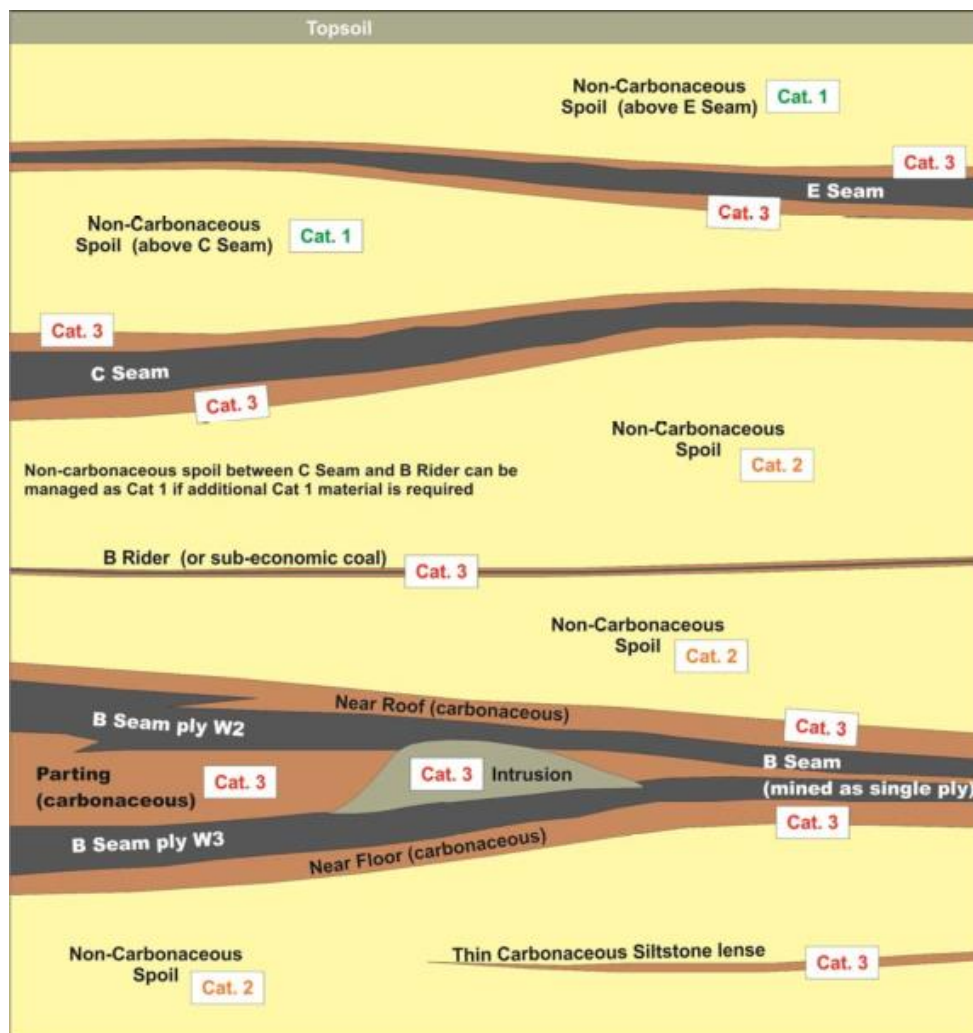


Figure 4 – Conceptual Representation of Spoil Categories (Terrenus, 2013)

3.5.2 QNH Waste Rock Characterisation

A summary of the findings of PB (2006) has been presented below:

- Waste rock was typically non-acid forming (NAF); however, rocks within 5m of coal seams should not be concentrated near the surface of waste rock dumps.
- Tertiary/Quaternary soils were generally slightly alkaline (pH between 7.8 and 8.6) and had low salinity (electrical conductivity (EC1:5) of 200 $\mu\text{S}/\text{cm}$) to moderate salinity (EC1:5 of 675 $\mu\text{S}/\text{cm}$). A single sample returned moderately high salinity (EC1:5 of 924 $\mu\text{S}/\text{cm}$).
- Alluvial soils were found to have low to moderate salinity.
- Weathered Permian rocks were found to have similar salinity, sodicity and alkalinity characteristics to the overlying alluvial soils. This material is considered suitable for capping.
- Fresh Permian rocks had moderately high alkalinity levels and low-to-moderate salinity. This material is considered unsuitable for capping.

A summary of the Terrenus (2013) waste rock findings is presented below:

- Spoil is likely to generate alkaline, low-salinity runoff and seepage following surface exposure.
- The total sulphur concentration of spoil is generally very low, and almost negligible. The majority of spoil materials are classified as NAF, with most spoil further classified as 'barren' (i.e. <0.1% sulphur) with respect to sulfuret content.
- Total metal and metalloid concentrations in spoils are low.
- There is potential for spoil to produce leachate containing slightly elevated soluble molybdenum and selenium concentrations, which is common for materials from the Moranbah Coal Measures.
- Spoil materials are expected to be moderately to highly sodic; however, they are not expected to be dispersive in their current condition. Following weathering or exposure, dispersion may occur.
- Waste rock at the QNH is anticipated to be mostly low risk.

3.5.3 Coal Rejects

Findings of the Terrenus (2013) investigation into the properties of coal rejects likely to be generated at the QNH are summarised below:

- Coal rejects are expected to generate low salinity, neutral to alkaline pH run-off and seepage following surface exposure.
- The total sulphur and sulphide concentrations are generally low. Fine rejects generally have higher sulphur and sulphide concentrations compared to coarse rejects.
- The coal reject materials as a whole are expected to have little capacity to generate acid.
- Total metal and metalloid concentrations are generally low.
- Some coal reject materials *may* produce leachate containing slightly elevated concentrations of soluble elements (particularly aluminium and arsenic).

3.6 Flora

The QNH is located in the northern section of the Brigalow Belt Bioregion. A desktop analysis of flora was undertaken as part of the Drake EIS (GHD, 2012), and a targeted survey was undertaken by GHD in April 2010, identifying 192 plant species from 50 families.

In the northern section of the QNH, the Coral Creek Riparian Management Zone has been established to protect a population of Black ironbox (*Eucalyptus raveretiana*), which is listed in the *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) as vulnerable.

3.7 Weeds

Weeds identified during surveys at the QNH (formerly covered by exploration permit EPC586) have been provided in **Table 6** below (TECSol, 2011). The *QCoal Northern Hub Weed Management Plan* has been developed as per the relevant conditions within the QNH EAs; however, general weed management practices on the QNH are also addressed in **Section 7.3.3** of this document.

Weed species are classified at the state level by the *Land Protection (Pest and Stock Route Management) Act 2002*, and regionally by the *Whitsunday Regional Council Biosecurity Plan 2016-2020* (WRC, 2016).

Table 6 – Significant Weeds identified on EPC 586 (TECSol, 2011)

Family	Species	Common Name	Biosecurity QLD Declared (Class)	Whitsunday Regional Council Biosecurity Plan Class
Amaranthaceae	<i>Gomphrena celosioides</i>	Gromphrena Weed	No	No
Apocynaceae	<i>Cryptostegia grandiflora</i>	Rubber Vine	Yes (2)	Yes (2)
Asteraceae	<i>Parthenium hysterophorus</i>	Parthenium	Yes (2)	Yes (2), WoNS
Asteraceae	<i>Xanthium pungens</i>	Noogoora Burr	No	No
Cactaceae	<i>Eriocereus spp.</i>	Harrisia Cactus	Yes (2)	Yes (2)
Cactaceae	<i>Opuntia stricta</i>	Prickly Pear	Yes (2)	No
Mimosaceae	<i>Acacia farnesiana</i>	Prickly Mimosa	No	No
Mimosaceae	<i>Acacia nilotica</i>	Prickly Acacia	Yes (1)	Yes (2); WoNS
Papaveraceae	<i>Aremone ochraluca</i>	Prickly Poppy	No	No
Poaceae	<i>Cenchrus ciliaris</i>	Buffel Grass	No	No
Rhamnaceae	<i>Ziziphus mauritiana</i>	Chinee Apple	Yes (2)	Yes (2)

3.8 Surface Water

A detailed description and general characterisation of the receiving waters of the QNH can be found in the *QCoal Northern Hub Receiving Environment Monitoring Program* (REMP) (Freshwater Ecology, 2016) and the current version of the *QNH Water Management Plan* (WMP) (Engeny, 2020). The REMP outlines the requirements for ongoing collection of baseline monitoring results, including water quality and macroinvertebrate surveys within the

watercourses surrounding the QNH. The WMP outlines the requirements for water quality monitoring within watercourses, creeks and drainage channels in and surrounding the QNH, and describes the catchments, water storage and movement infrastructure on the sites. The WMP is updated annually to reflect changes in water management across the site and contains the Erosion and Sediment Control Plan for the QNH sites.

The QNH is located within the Bowen Broken Bogie Basin, in the upper reaches of the broader Burdekin River catchment. The QNH MLs extend over two sub-catchments, namely the Bowen River sub-catchment and the Pelican Creek sub-catchment. There are twenty-five (25) release points in the various site EAs; however, many of these have not been established and are not currently being used.

Apart from the Bowen River, the majority of waterways in the region are highly ephemeral, with flow typically only associated with significant regional rainfall events.

Two Mile Creek, which previously flowed through the middle of the SCM, was diverted in 2012 to allow for ongoing mining activities in the southern extent of the Sonoma Main Pit. Coral Creek, north of SCM, was diverted in 2018 to allow for the extraction of coal from Sonoma North Pit, the northern extension of the Sonoma Main Pit.

Priority actions for sub-catchments have been defined in the *Burdekin Water Quality Improvement Plan 2016* for both the Bowen River and Pelican Creek sub-catchments. These include the management of grazing, mining, industry, and other infrastructure, and they have been addressed as part of the management of rehabilitation activities.

The defined environmental values (EVs) for both the Bowen River and Pelican Creek are based on the *Environment Protection Policy (Water and Wetlands)* (DES). These EVs have their own associated set of water quality monitoring criteria based on the ANZECC (Australian and New Zealand Environment and Conservation Council) *Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000); however, the sites have prescribed monitoring parameters.

Bowen River EVs

- Aquatic Ecosystems
- Irrigation
- Farm Supply
- Stock Watering
- Human Consumer
- Primary, Secondary and Visual Recreation
- Drinking Water
- Industrial Use
- Cultural and Spiritual Values

Pelican Creek EVs

- Aquatic Ecosystems
- Irrigation
- Farm Supply
- Stock Watering
- Human Consumer
- Secondary and Visual Recreation
- Drinking Water
- Industrial Use
- Cultural and Spiritual Values

Routine surface water monitoring is undertaken to satisfy conditions of the four (4) QNH EAs and the REMP. Material impacts to water quality or aquatic ecology have not been identified in association with QNH activities to date. Final landforms are not anticipated to impact adjacent surface water EVs once the rehabilitation criteria are achieved.

3.9 Groundwater

Numerous groundwater studies have been undertaken across the QNH, including *Groundwater Monitoring and Management Plan – Drake Coal Pty Ltd – Drake Coal Project* (QCoal, October 2014), *Northern Hub Groundwater Assessment* (AGE, 2018) and *Northern Hub Groundwater Assessment* (AGE, 2020).

Findings of these studies indicate the following:

- Groundwater values:
 - There are no known groundwater springs or seeps in the QNH area.
 - Stygofauna have not been identified in the area.
 - Groundwater Dependent Ecosystems (GDEs) are not considered likely to exist in the QNH area.
 - Based on searches of registered licensed groundwater bores and a landholder bore survey, groundwater use (including, but not limited to pastoral, irrigation, mining, stock, domestic, and town water) is not considered a groundwater value across or in the immediate vicinity of the QNH.
 - The quality of groundwater is generally described as marginal, with typically poorer quality groundwater encountered within coal-bearing strata.
- Hydrogeological regime (see **Appendix A** for further detail)
 - Groundwater has been found to be present intermittently within alluvial strata and within the Permian coal measures.
 - There is limited connectivity between surface water, alluvium and the Permian coal measures (as evidenced by hydrograph data and major ion chemistry)
 - No significant interactions are expected between ephemeral creeks or the Bowen River and the Permian Coal measures.
 - Some direct interaction between the Bowen River and groundwater within the immediate alluvial banks is likely and would be associated with flooding/receding cycles.

Impact on groundwater from the QNH, once rehabilitated, can only occur through two mechanisms: 1) direct infiltration of contaminated runoff or leachate into groundwater, and/or 2) drawdown associated with voids reducing groundwater levels, which can have a secondary effect on quality under specific geochemical conditions.

Waste rock (including reject material) has been shown to be generally low risk (see **Section 3.5**) and is considered unlikely to generate poor quality runoff or leachate. Rehabilitation (includes capping for co-disposal facilities) and revegetation further reduces leachate and runoff risks.

Drawdown of water associated with the QNH voids is specifically addressed in the *Investigation into Residual Void Sonoma Coal Mine* (QCoal, 2020) report (see **Appendix A**), supported by Engeny, 2020 and AGE, 2020, which determined that the QNH voids will either remain perpetual groundwater sinks or groundwater sources which do not feed surrounding aquifers, but rather the other QNH void sinks, and, therefore, no migration of water from the voids into the surround groundwater aquifers is likely.

Based on the nature of regional groundwater characteristics, and its current level of use, the QNH is assumed to have minimal impact on groundwater values following rehabilitation.

Routine groundwater monitoring is undertaken across the QNH to identify fluctuations in water level or quality. To date, monitoring has shown the operations have not had a materially effect on groundwater level or quality. Accordingly, final landforms are not anticipated to affect the surrounding regional groundwater levels or EVs.

4 Environmental Authority Rehabilitation Conditions

The QNH EAs are the primary approval documents that stipulate rehabilitation requirements. The conditions related to rehabilitation in each of the four (4) QNH EAs are identical, apart from void outcomes. As such, the rehabilitation conditions for all four (4) QNH mines are presented in **Table 7** and the rehabilitation requirements for the QNH final voids (as detailed in **Table H1** of each of the EAs) has been summarised as **Table 8**.

Table 7 – QNH EA Rehabilitation Conditions

Condition	Condition Wording
H1	All areas significantly disturbed by mining activities must be rehabilitated to achieve the following rehabilitation goals: a) safe to humans and wildlife; b) stable; c) non-polluting; and d) self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids
H2	Rehabilitation must commence progressively in accordance with the Plan of Operations.
H3	A Rehabilitation Plan must be developed by 24 April 2020 by a suitably qualified person and submitted for approval prior to implementing.
H4	Within 20 business days of the receipt of comments from the administering authority, the updated Rehabilitation Plan must be submitted to the department for approval.
H5	The Rehabilitation Plan must include: a) Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas; b) Detailed rehabilitation methods for each disturbed area; c) Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives; d) Final completion criteria that will achieve the rehabilitation goals and objectives; e) Details of appropriate monitoring and maintenance of rehabilitation; f) Identify 3 reference sites to be used to develop rehabilitation success criteria for each disturbance domain; and g) Include a description of monitoring of reference sites inclusive of statistical design. h) For rehabilitation of watercourse diversion, details of the required methods of rehabilitation stated in the relevant approved Design Plans
H6	All areas significantly disturbed by mining activities must be rehabilitated in accordance with the Rehabilitation Plan to achieve the final completion criteria.
H7	The environmental authority holder must notify the administering authority of any changes to the Rehabilitation Plan and submit the updated document to the administering authority.
H10	Contaminated Land Before applying for surrender of a mining lease, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the mining lease which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use.
H11	Before applying for progressive rehabilitation certification for an area, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the area the subject of the application which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use under the approved Rehabilitation Plan as per Condition H3 .

H15	Residual void outcome Residual voids must comply with the following outcomes: a) Residual voids must not cause any serious environmental harm to land, surface waters or any recognized groundwater aquifers, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority; b) Residual voids must comply with Table H1 – Residual void outcomes; and c) At the completion of decommissioning and rehabilitation, all residual voids must demonstrably have the appropriate level of flood protection from nearby watercourses as approved by the administering authority, such that the protection is sustainable for the foreseeable future.
H16	All reasonable and practical measure must be taken to minimize the size of the void remaining after mining activities cease.
H18	Exploration Land subject to exploration activities previously approved under EPC586 that subsequently became... (QCoal Comment: relevant site-specific MLs) must be rehabilitated in accordance with the <i>Code of Environmental Compliance for Exploration and Mineral Development Projects</i> .
H19	Land subject to exploration activities carried out on... (QCoal Comment: relevant site-specific MLs) subsequent to the grant of the relevant mining lease, must be rehabilitated in accordance with the <i>Code of Environmental Compliance for Exploration and Mineral Development Projects</i> .

Table 8 – EA Table H1 Summary

Site	Residual Void	Void Area	Void Outcome	Maximum Slope
Sonoma Coal Mine	Sonoma Main Pit	120 ha	Unspecified in SCM EA Table H1	High wall – 70° with top 10m max 45° including a 1m bund
	Sonoma East Pit 1	14 ha		
	Sonoma East Pit 2	15 ha		
	Sonoma Q-Pit	n/a backfilled		n/a backfilled
	Sonoma B-Pit	n/a backfilled		n/a backfilled
Drake Coal Mine	Drake Pit 5	59 ha	Unspecified in DCM EA Table H1	High Wall – 65° Low wall – 45°
	Drake Pit 1	258 ha		
	Drake Pit 2			
	Drake Pit 2 Expansion			
	Central Pit 3	50 ha		
	Central Pit 4	16 ha		
	East Pit 1	14 ha		
	Drake Pit 3-Q	61 ha		
	Drake Pit 3-R			
Jax Coal Mine	Jax Main Pit	70 ha	Residual void unable to sustain a post-mining land use	High wall – 60°
	Jax East Pit	27 ha		Low wall – 32°
Cows Coal Mine	B Seam Pit	Backfilled	Unspecified in CCM EA Table H1-	N/A
	Q Seam Pit	Backfilled	Unspecified in CCM EA Table H1-	

5 Rehabilitation Objectives and Targets

5.1 Domains of Disturbance

Disturbance by mining activities at the QNH has been split into eight (8) domains, each with individual rehabilitation requirements, as detailed in **Table 9**.

Table 9 – Rehabilitation Domains

Domain	Description	Applicable Mine
1	Residual voids	SCM, DCM, JCM
2	Overburden dumps	SCM, CCM, DCM, JCM
3	Mine Infrastructure	SCM, DCM, JCM
4a	Co-disposal dams	SCM
4b	In-Pit Co-disposal	SCM
5	ROM and product stockpiles	SCM, DCM, JCM
6	Haul roads and access tracks	SCM, CCM, DCM, JCM
7	Sediment dams and water management infrastructure	SCM, DCM, JCM
8	Creek diversions	SCM

5.2 Rehabilitation Goals

Broad rehabilitation goals for the QNH sites are defined in **Condition H1** of the QNH EAs. These rehabilitation goals generally align with the rehabilitation goals summarised in the *Rehabilitation Requirements for Mining Projects* (EHP, 2014), and are as follows:

- Safe to humans and wildlife
- Stable
- Non-polluting
- Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids.

EHP (2014) also includes a range of suggested strategies to aid in achieving the rehabilitation goals, which have informed the development of the rehabilitation strategies presented in this RMP (see **Section 7**).

5.3 Agreed Post-Mining Land Use

The post-mining land use is agreed between the mining company and the administering authority. Generally, the agreed post-mining land use considers both the historical use(s) of the land underlying the operations and the current use(s) of the land surrounding the operations.

Post-mining land use in the context of the Progressive Rehabilitation and Closure Plan (PRC Plan) for transitional sites is determined by Land Outcome Documents (LODs), as defined in the EP Act as follows:

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

- (a) an environmental authority for a resource activity on the land;
- (b) a document made under a condition of an environmental authority mentioned in paragraph (a), if—
 - (i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and
 - (ii) the document was received by the administering authority before the assent date; and
 - (iii) the administering authority has not, within 20 business days after the assent date, given notice to the holder of the environmental authority that the document is insufficient in a material particular relevant to a matter mentioned in subparagraph (i); and
 - (iv) before the assent date, the document had not been superseded;
- (c) a document made under a condition of an environmental authority mentioned in paragraph (a), if—
 - (i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and
 - (ii) the environmental authority requires the document to be given to the administering authority on a stated day that is on or after the assent date, or does not state a day when the document must be given; and
 - (iii) the document is received by the administering authority within 3 years after the assent date; and
 - (iv) the administering authority does not, within 20 business days after receiving the document, give the holder of the environmental authority notice that the document is insufficient in a material particular relevant to a matter mentioned in subparagraph (i);
- (d) a report evaluating a EIS under the State Development and Public Works Organisation Act 1971, section 34D;
- (e) an EIS assessment report;
- (f) a written agreement between the holder of an environmental authority mentioned in paragraph (a) and the State that is in force on the assent date.

Post mining land use by domain and the relevant LOD to that post-mining land use has been presented in **Table 10**.

Table 10 – Post Mining Land Use by Domain

Domain	Sonoma Coal Mine		Drake Coal Mine		Jax Coal Mine		Cows Coal Mine	
	PMLU	LOD	PMLU	LOD	PMLU	LOD	PMLU	LOD
Residual voids	Residual void unable to sustain a post-mining land use.	QNH RMP	Residual void unable to sustain a post-mining land use.	QNH RMP	Residual void unable to sustain a post-mining land use.	QNH RMP and EA	-	-
Overburden Dumps	Grazing pasture	EA	Grazing pasture	EA	Grazing pasture	EA	Grazing pasture	EA
Mine Infrastructure	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	-	-
Co-disposal dams	Grazing pasture	EA	-	-	-	-	-	-
In-pit co-disposal	Part of the Sonoma Main Pit Void complex	-	-	-	-	-	-	-
ROM and product stockpiles	Grazing pasture	EA	Grazing Pasture	EA	Grazing Pasture	EA	-	-
Haul Roads and Access tracks	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA
Sediment dams and water management infrastructure	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	Grazing pasture or retained*	EA	-	-
Creek diversions	Grazing Pasture and Permanent Watercourse	EA and Diversion Design Documents	-	-	-	-	-	-

* These domains may be retained by the landholder only in the presence of written agreement

The agreed post-mining land use for all QNH mines, as per **Condition H1** in each of the QNH EAs (considered in the legislation as the highest Land Outcome Document), is self-sustaining grazing pasture for all domains with the exception of residual voids, creek diversions, and any infrastructure retained by the landholder (such as dams, hardstand areas, buildings, haul roads/access tracks, etc.) which will have a post-mining land use specific to the landholder.

When mine pits are backfilled, no residual void remains, and those areas no longer classified as Domain 1 (residual voids). Areas of backfilled pit (i.e. in-pit waste rock dumps) are classified as Domain 2 (overburden dump), and sediment control structures constructed within areas of backfilled pit are captured by Domain 7 (sediment dams and water management infrastructure). The PMLU for these landforms is identified in the relevant sections of **Table 10** above.

The residual voids permitted on the QNH are stated in the QNH EA's (presented in **Table 8**). The JCM EA stipulates a void outcome for the JCM voids as "Residual unable to sustain a post mining land use"; however, the DCM and SCM EAs do not stipulate a post-mining land use. As the DCM and SCM voids are not sources of groundwater to surrounding aquifers, and have perpetually degrading void lake water quality, they are also considered to be unable to sustain a post-mining land use (see **Appendix A**).

For rehabilitation to have been considered successful, the land must be returned to a "stable condition" as defined in Section 111A of the EP Act:

111A Meaning of stable condition

*Land is in a **stable condition** if –*

- (a) the land is safe and structurally stable; and*
- (b) there is no environmental harm being caused by anything on or in the land; and*
- (c) the land can sustain a post-mining land use.*

As the residual voids on the QNH have degrading lake water quality, and are therefore unable to sustain a PMLU, they cannot be rehabilitated to a stable condition as per the EP Act. As per the definitions in section 112 of the EP Act, land that cannot be rehabilitated to a stable condition is considered a non-use management area (NUMA):

non-use management area means an area of land the subject of a PRC plan that can not be rehabilitated to a stable condition after all relevant activities for the PRC plan carried out on the land have ended.

As the QNH mines transition into to the Progressive Rehabilitation and Closure Plan (PRC Plan) framework, residual voids will be managed as NUMAs. The primary LOD for this land outcome will be the QNH RMP; however, for JCM, these void outcomes are presented in the EA (see **Appendix A** for further detail).

5.3.1 Requirements for Grazing Pasture

QNH land to be rehabilitated to a grazing post mining land-use is to be returned to Class 4 suitability or better, based on the *Guidelines for Agricultural Land Evaluation in Queensland* (DSITI & DNRM, 2015). The acceptance criteria for Class 4 land are presented in **Table 11**.

Table 11 – Acceptance criteria – Class 4 Land Suitability

Parameter	Acceptance criteria
Plant Available Water Capacity (PAWC)	>50 mm
Salinity	EC _{1.5} <1.2 mS/cm or Cl _{1.5} <1,500 ppm in the root zone (60 cm depth)
Rockiness	<100% (% coarse fragments at soil surface)
Soil pH	<10 and >4 as measured at any part of the root zone.
Exchangeable Sodium Percentage (ESP %)	<30% (0-10 cm depth)
Water erosion (a function of slope % and ESP %)	Mean Slope <15% on cracking clay soils Mean Slope <12% on sodic soils (ESP >15% within 500 mm of surface) rigid soils Mean Slope <45% on non-sodic (ESP <15% within 500 mm of surface) rigid soils
Grazing Criteria	≥70% of the productivity (or carrying capacity) of non-mined land in the lease area or, Carrying capacity within the range of values reported for the region, taken as 15 ha/head
Groundcover	Mean groundcover ≥50% or > than the reference site mean minus one standard deviation.
Grazing Trials	Undertaken following groundcover establishment to confirm carrying capacity.
Species Mix and Composition	Proportion of non-preferred species not increasing Proportion class will not be more than one class* greater than the grazed reference sites. Proportion of declared plant pest species not increasing, and proportion class* will not be more than one class greater than the grazed reference sites.

* - Classes based on *State Rural Leasehold Land Strategy: Guidelines for determining land condition* prepared by DNRM (2013): Class 1 = 0%, Class 2 = 0-10%, Class 3 = 10-30%, Class 4 = >30% for declared plant pest (weed) species. Class 1 = >80%, Class 2 = 61-80%, Class 3 = 10-60%, Class 4 = <10% for preferred species composition.

In order to achieve these acceptance criteria, a range of rehabilitation strategies have been developed for site personnel to assist in the planning and execution of rehabilitation activities (see **Section 7**).

5.4 Landform Design

The design of rehabilitated landforms (other than voids or infrastructure retained by the landholder) is to be consistent with Class 4 suitability grazing, and the surrounding topography of the land. The rehabilitation process may include shaping of the landform to the designed slope, encouraging groundcover and any required works for drainage, and erosion control. Scheduling of works is discussed in **Section 7.4**.

Landform stability is typically achieved by achieving a desired slope length and angle, correct material selection and establishment of groundcover to improve erosion resistance. Mining operational requirements, particularly for waste rock dumps and co-disposal facilities, inform the size (footprint), height, and operational slopes, and other parameters related to the final landform. These operational requirements consider the need to leave domains in a state that

minimises the bulk earthwork requirements to achieve the desired landform design (i.e. geotechnical stability as a function of slope design) once they are released from operational use. Landform design plans are produced commensurate with the operational requirements to ensure as much of the bulk earthworks can be undertaken during regular operation as is possible. Slope ranges are detailed in **Table 12**.

5.5 Completion Criteria

Completion criteria for rehabilitation of the QNH mine domains have been developed to enable measurable/quantifiable criteria, which once achieved demonstrate that rehabilitation is complete and that the rehabilitated final landforms are (1) safe to humans and wildlife, (2) stable, (3) non-polluting, and (4) able to self-sustain the agreed post-mining land use. The criteria have been presented in **Table 12**.

Table 12 – QCoal Northern Hub Rehabilitation Completion Criteria

Domain	Objective	Completion Criteria	Performance Verification																
Domain 1 - Residual Voids	Safe to humans and wildlife	Access to the high wall will be restricted by bunds and/or fencing. Appropriate remediation of slope failures or rock falls.	Photographic evidence of bunding/fencing. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.																
	Stable	Maximum slope: <table border="1"><thead><tr><th>Site</th><th>EA reference</th><th>Highwall / Competent Rock</th><th>Low wall / Incompetent Rock</th></tr></thead><tbody><tr><td>SCM</td><td>Table H1</td><td>Top 10m = 45° Thereafter = 70°</td><td>17° to 37°</td></tr><tr><td>DCM</td><td>Table H1</td><td>65°</td><td>45°</td></tr><tr><td>JCM</td><td>Table H1</td><td>60°</td><td>45°</td></tr></tbody></table> Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	Site	EA reference	Highwall / Competent Rock	Low wall / Incompetent Rock	SCM	Table H1	Top 10m = 45° Thereafter = 70°	17° to 37°	DCM	Table H1	65°	45°	JCM	Table H1	60°	45°	Slope measurements retained with rehabilitation documentation. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Site	EA reference	Highwall / Competent Rock	Low wall / Incompetent Rock															
	SCM	Table H1	Top 10m = 45° Thereafter = 70°	17° to 37°															
	DCM	Table H1	65°	45°															
JCM	Table H1	60°	45°																
Non-polluting	Hydrogeological assessment completed. Void water balance completed and confirms 'no overtopping' in final design. Void water quality will not diminish the EVs of the surrounding groundwater.	Hydrogeology and water balance report. Groundwater monitoring/modelling shows no risk to local aquifer EVs.																	
Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Not applicable to residual voids that are groundwater sinks, which are classified as "Residual void unable to sustain a post mining land use". See Appendix A .	Not applicable to residual voids that are groundwater sinks. See Appendix A .																	
Domain 2 - Overburden dumps	Safe to humans and wildlife	Appropriate remediation of slope failures or rock falls.	If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.																

Domain	Objective	Completion Criteria	Performance Verification
	Stable	The nominated maximum slope on dumps is 20% (11.5°), unless otherwise advised by an RPEQ. Mean groundcover ≥50%, or > the reference site mean minus one standard deviation. Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Spoil is to be dumped in accordance with the <i>QNH Mining Waste and Coal Rejects Management Plan</i> (Terrenus, 2013). Run-off or seepage water is not to diminish the EVs of the receiving environment including surrounding groundwater.	<i>Mining Waste and Coal Rejects Management Plan</i> (Terrenus, 2013) to be retained with rehabilitation documentation. As-built/survey information to be retained with rehabilitation documentation. REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 3 - Mine Infrastructure including CHPP, Train Load out facility and rail loop.	Safe to humans and wildlife	Hazardous material is identified and managed Only infrastructure remaining on-site is as per an agreement with the landholder and the State. Appropriate remediation of slope failures or rock falls	Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. All unwanted infrastructure is removed. Evidence of agreement is held with rehabilitation documentation. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.
	Stable	For all infrastructure on the QNH the adopted maximum slope completion criteria will be 20% (11.5°), unless otherwise advised by an RPEQ. Mean groundcover ≥50%, or > the reference site mean minus one standard deviation. Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Hazardous material is identified and managed. Run-off or seepage water is not to diminish the EVs of the receiving environment and local aquifers.	REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 4a - Co-disposal	Safe to humans and wildlife	Appropriate remediation of slope failures or rock falls.	If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.

Domain	Objective	Completion Criteria	Performance Verification
dams (out-of-pit)	Stable	For all co-disposal facilities on the QNH the adopted slope completion criteria will be 11.5°, unless otherwise advised by an RPEQ. Mean groundcover ≥50%, or > the reference site mean minus one standard deviation. Appropriate remediation of rill and gully erosion.	Approved Site Management Plan is in place. Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Hazardous material is identified and managed. Run-off or seepage water is not to diminish the EVs of the receiving environment and local aquifers.	Remediation of potentially contaminated areas is verified. REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 4b - Co-disposal dams (in-pit)	Safe to humans and wildlife	Pit access is restricted as part of Void rehabilitation actions; therefore, no further action is required to make the in-pit co-disposal safe.	Residual void acceptance criteria met.
	Stable	As there are no batters associated with the in-pit co-disposal, there is no risk of slope failures or rock falls. The in-pit co-disposal is to be capped with appropriate waste material.	Residual void acceptance criteria met.
	Non-polluting	The in-pit co-disposal makes up a part of the SCM Main Pit complex, which is a groundwater sink, and will not have any impacts on groundwater or surface water EVs.	Residual void acceptance criteria met.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	As the in-pit co-disposal becomes part of the residual void floor, and the Sonoma Main Pit is a groundwater sink, there will be no PMLU, and the in-pit co-disposal will make up part of the void NUMA.	N/A
Domain 5 - ROM and Product stockpile areas	Safe to humans and wildlife	Hazardous material is identified and managed. Appropriate remediation of slope failures or rock falls.	Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.

Domain	Objective	Completion Criteria	Performance Verification
	Stable	For all ROM/Product Stockpiles on the QNH the adopted slope completion criteria will be 11.5° (20%), unless otherwise advised by an RPEQ. Mean groundcover ≥50%, or > the reference site mean minus one standard deviation. Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Hazardous material is identified and managed. Run-off or seepage water is not to diminish the EVs of the receiving environment and local aquifers.	REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 6 - Haul roads and tracks not being retained for post-mining use	Safe to humans and wildlife	Appropriate remediation of slope failures or rock falls.	If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.
	Stable	Agreement from landholder regarding infrastructure allowed to remain on site For all roads and tracks not being retained the adopted slope completion criteria will be 11.5° (20%), unless otherwise advised by an RPEQ. Mean groundcover ≥50%, or > the reference site mean minus one standard deviation. Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	Evidence of landholder agreement. As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Run-off or seepage water is not to diminish the EVs of the receiving environment and local aquifers.	REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Ongoing pasture management measures documented in the PMCP. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 7 - Sediment dams and other water	Safe to humans and wildlife	Appropriate remediation of slope failures or rock falls.	If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure.

Domain	Objective	Completion Criteria	Performance Verification
management infrastructure not retained for post-mining use	Stable	Agreement from landholder regarding infrastructure allowed to remain on site For all dams and water management infrastructure on the QNH the adopted slope completion criteria will be advised by an RPEQ. Mean groundcover $\geq 50\%$, or $>$ the reference site mean minus one standard deviation. Appropriate remediation of slope failures or rock falls. Appropriate remediation of rill and gully erosion.	Evidence of landholder agreement Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If slope failure has occurred, it is rectified and ongoing design accounts for the previous failure. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Hazardous material is identified and managed Run-off or seepage water is not to diminish the EVs of the receiving environment and local aquifers.	REMP reporting during operations. Post-closure surface and groundwater quality monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	Class 4 land suitability and light cattle grazing target (see Section 5.3)	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Ongoing pasture management measures documented in the PMCP. Rehabilitation monitoring reports verify species mix and community composition standards are met.
Domain 8 - Creek diversions	Safe to humans and wildlife	RPEQ designed and certified	As-built drawings and ongoing monitoring show no safety issues.
	Stable	Total ground cover on the creek banks is sufficient to minimize erosion (70% protective foliage cover in the absence of rock or armouring at the surface) Maximum bank slope: $\leq 25\%$ (<i>Design of Two Mile Creek Diversion</i> (BSM, 2012) and <i>North Sonoma Creek Diversion Design Plan</i> (Engeny, 2018)) RPEQ designed and certified Revegetation works completed using the species lists found in the relevant design documents Appropriate remediation of rill and gully erosion.	As-built/survey information retained with rehabilitation documentation. Rehabilitation monitoring reports to verify groundcover. If rill or gully erosion is identified, it is rectified, and additional erosion controls implemented as appropriate.
	Non-polluting	Creek diversions do not impact the EVs of the receiving environment and local aquifers.	REMP reporting during operations. Post-closure surface and groundwater monitoring reports.
	Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids	At least 50% of tree and shrub species located in analogue areas are growing in the diversion area. Abundance of tree species are at least 80% of analogue species abundance. Plant cover is stable or increasing. Class 4 land suitability and light cattle grazing target (see Section 5.3) for at least 60% of the land area. Index of Diversion Condition (IDC) score of the diversion is consistent with the creek control reaches.	Rehabilitation monitoring reports verify soil/land suitability standards are met. Rehabilitation monitoring reports verify productivity standards are met. Ongoing pasture management measures documented in the PMCP. Rehabilitation monitoring reports verify species mix and community composition standards are met. Annual monitoring reports show that diversion reaches score equally or better than reference reaches based on the methodology of IDA, 2001. <i>Monitoring and evaluation program for Bowen Basin river diversion</i>, ID&A Pty Ltd. Australian Coal association Research Program C9068 (IDA 2001).

6 Required Assessments and Certifications

In order to determine the efficacy of rehabilitation and compliance with various EA conditions, the tasks presented in **Table 13** are to be undertaken by an Appropriately Qualified Person (AQP) (as defined in the QNH EAs) relevant to each task.

Table 13 – Assessments, Designs, and Certifications

Task	Description	Timing
Contaminated Land Assessment	Requirement for a Phase 1 for all sites, using ERC to inform the Phase 1. Phase 1 informs any required Phase 2, which in turn informs any remediation and verification. Remediation of identified contaminated areas is verified and/or approved Site Management Plan is in place. Certification that any identified contaminated land has been managed appropriately and in accordance with the relevant administering authority guideline/s.	Prior to rehabilitation of relevant areas (e.g. MIAs, Infrastructure areas, CHPPs etc.).
Geotechnical studies	Certification that the final landforms are stable/geotechnically sound, and there is a low risk of rock falls with serious environmental or safety consequences.	Following completion of all rehabilitation works with associated geotechnical or rock-fall related risks.
Surface and groundwater monitoring	Monitoring is to be undertaken to identify occurrence of any downstream impacts.	During rehabilitation works and following completion of works until rehabilitation is certified.
Capping material assessment	Assessment of suitable materials and depth for capping of co-disposal facilities	As part of capping of the co-disposal facilities
Soils Assessment	Monitoring of topsoil is to be undertaken in order to determine chemical, physical and biological properties remain appropriate for the proposed land use.	Following completion of rehabilitation works and 5-yearly until certification of rehabilitation completion.
Final Rehabilitation Report	Report outlining compliance with conditions of the EA, achievement against completion criteria, the extent and success of the rehabilitation, ongoing environmental management and monitoring requirements, and residual risk.	Following completion of rehabilitation works, to be submitted in order to discharge Financial Assurance.
Compliance Statement	Details compliance with EA conditions and confirms the accuracy of the Final Rehabilitation Report.	To be submitted with the Final Rehabilitation Report.
Diversion Monitoring Reports	A report on monitoring of diversion stretches to assess Index of Diversion Condition (IDC) and process towards revegetation goals.	Annually during operations. The requirement to continue following relinquishment will be assessed based on operational monitoring.

7 Rehabilitation Strategies

Strategies for undertaking rehabilitation to achieve the completion criteria provided in **Section 5.5** are provided in the following sections, with the general objective to achieve a post-mining land suitability of Class 4 for grazing.

7.1 Mining Domains

7.1.1 Residual Voids (Domain 1)

The design of operational mining pits is such that they are generally geotechnically stable and meet slope requirements prior to being released for rehabilitation works. A number of pits on the QNH have been and will be backfilled during normal mining operations; however, the majority of pits will not be backfilled and will remain as final voids.

It is critical to note that although residual voids on the QNH are unable to sustain a PMLU, this does not remove the requirement for them to be safe, structurally stable and non-polluting.

The rehabilitation process for residual voids is as follows:

- The final landform is to be shaped and graded to be geotechnically stable. Re-profiling (including blasting of void walls) may be required.
- Establish drainage and erosion controls.
- Final slope (completion criteria) as per **Section 5.5**.
- Signage, fencing, and/or safety bunds (specification based on DME (1995)) are to be placed as required to limit access to the void lakes for people, stock and fauna.

QNH voids are to have the following characteristics based on a final hydrogeological assessment:

- Acceptable (low) risk of overtopping.
- Isolated from surface water flows (non-flushing).
- Void water is unlikely to impact the EVs of any surrounding groundwater.
- Voids are to have no intended or planned access for livestock or any other uses.

7.1.2 Overburden Dumps (Domain 2)

Waste Rock Management

The waste rock categories and characteristics for the QNH are detailed in **Section 3.5**. Placement of waste rock in overburden dumps is to be undertaken in accordance with the current version of the *QCoal Northern Hub Mine Waste Management Plan*.

Waste Rock Dump Landforms

The general strategy to be followed when rehabilitating waste rock dumps is as follows:

- Shape and grade the final landform to be geotechnically stable. Final slope completion criteria as per **Section 5.5**.
- Rip surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls through ripping, profiling and/or construction of control structures.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to any required seeding.
- Seed with an appropriate species mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

Note that waste rock dumps are typically designed to be geotechnically stable and safe during the operation of the mine, which minimises the need for major stabilisation works during rehabilitation.

Topsoil Stockpiles

During routine mine operations, topsoil will be stripped, typically to a depth of 300 mm, and either used immediately on rehabilitation works (stripped and then placed) or stockpiled separately for use in future rehabilitation. These stockpiles will be tracked, inventoried and seeded where required to minimise erosion.

Topsoil will be recovered from stockpiles and spread during rehabilitation works, with depth of spreading based on the nature/condition of the surface on which the topsoil is spread.

Areas where topsoil was previously stockpiled will be rehabilitated once the stockpiled topsoil has been recovered for use, with the following methodology:

- Recover topsoil for use in rehabilitation elsewhere, leaving a minimum of 100 mm of topsoil.
- Establish drainage and erosion controls as required.
- Rip/scarify any compacted topsoil material.
- Final slope completion criteria as per **Section 5.5**.
- Scarify the surface immediately prior to any required seeding.
- Seed with an appropriate seed mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

7.1.3 Mine Infrastructure (Domain 3)

Constructed infrastructure is typically to be removed from site when the infrastructure areas are decommissioned and demolished. This includes, but is not limited to, demountable offices, CHPPs, sewage treatment systems, etc. However, any infrastructure (or components of infrastructure) considered beneficial to the subsequent landholder or the final land use, may be retained upon formal agreement. Examples of constructed infrastructure that could be retained include hardstand areas, concrete pads, shipping containers, sheds, workshops, tanks, etc.

A contaminated land assessment (see **Section 6**) is to be undertaken to determine the requirement for any remediation activities prior to the commencement of rehabilitation activities.

Below are rehabilitation strategies for infrastructure areas where infrastructure is not to be retained, and assumes that physical structures including foundations and concrete slabs have been removed:

- Contaminated land assessment completed as per **Section 6**.
- Final slope completion criteria as per **Section 5.5**.
- Rip compacted surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls as required.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to seeding
- Seed with an appropriate seed mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

7.1.4 Co-disposal Facilities (Domain 4)

Out-of-Pit

The general strategy for decommissioning and rehabilitating out-of-pit co-disposal facilities on the QNH involves capping of the facility followed by rehabilitation activities. The top and upper slopes would be capped first (reducing ongoing infiltration) in order to allow the co-disposal to drain residual leachate prior to capping the lower slopes and shaping.

The capping materials for co-disposal dams should consider the following elements:

- *Trafficability* – If the dams are not suitable for direct vehicle access at the time of decommissioning, a layer of stable material is required to allow heavy vehicles to access the dams safely when undertaking rehabilitation works (nominal thickness of 0.5-1m).
- *Impeding infiltration* – To reduce the infiltration of surface water into the body of the co-disposal and reduce capillary rise should that be identified as a likely issue (nominal thickness of 0.5 – 1 m).

- *Growth* – Provide a suitable substrate for revegetation and be constructed of non-dispersive material with a nominal thickness of 0.5 – 1 m. Topsoil should be spread to a minimum of 0.1m above this.

The geochemical and geotechnical properties required for capping material, as well as the depth and any compaction requirements are to be determined by an SQP (see **Section 6**), and, where necessary, materials on-site that can be used in this application should be stockpiled for this use during normal operations. Shaping and capping is necessary to reduce rainwater infiltration into the body of the co-disposal, which reduces minimises the phreatic surface within the decommissioned co-disposal facilities and reduces the potential for leaching of water from the body of the co-disposal through the rehabilitated slopes

Monitoring of shaped slopes is required to determine whether seepage is reporting through the capping material, which can a) affect geotechnical stability, and b) in the case of acidic leachate, pose a potential environmental risk. Therefore, geotechnical stability should be assessed to identify any slippage risks, and with regard to the potential for acid leachate, the rejects material is non-acid forming (see **Section 3.5**).

Rehabilitation works for co-disposal facilities following capping are as follows:

- Final slope completion criteria as per **Section 5.5**.
- Establish drainage and erosion controls.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to seeding (if seeding is required).
- Seed with an appropriate seed mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

In-Pit

Currently, one in-pit co-disposal facility is proposed on the QNH, being the SCM Main Pit in-pit co-disposal. Similar to out-of-pit co-disposal facilities, the general strategy for decommissioning and rehabilitation in-pit co-disposal facilities on the QNH involves capping of the facility followed by rehabilitation activities; however, as there are no outer batters associated with the in-pit facility, only the top needs to be capped. As this facility is completely within the Sonoma Main Pit void, and will ultimately be inundated, no further rehabilitation actions are required, and the in-pit co-disposal will make up part of the Sonoma Main Pit residual void.

7.1.5 ROM and Product Stockpile Areas (Domain 5)

Rehabilitation of ROM and product stockpile areas is similar to other infrastructure areas and is subject to the contaminated land assessment outcomes discussed in **Section 6**.

A contaminated land assessment (see **Section 6**) is to be undertaken to determine the requirement for any remediation activities prior to the commencement of rehabilitation activities.

Rehabilitation works are as follows:

- Final slope completion criteria as per **Section 5.5**.
- Rip surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls as required.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to seeding (if seeding is required).
- Seed with an appropriate species mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

7.1.6 Haul Roads and Tracks (Domain 6)

Constructed haul roads, access roads and tracks (including paved and dirt roads) are typically rehabilitated; however, any roads or tracks which are considered beneficial to the underlying landholder or the final land use may be retained upon formal agreement. Haul roads used for moving coal are subject to contaminated land investigations and potential associated remediation works.

A contaminated land assessment (see **Section 6**) is to be undertaken to determine the requirement for any remediation activities prior to the commencement of rehabilitation activities. As haul roads are routinely graded, it is considered likely that the only areas of potential contamination are the haul road drains, and therefore only these areas require assessment.

The rehabilitation strategy for haul roads and tracks below only applies in instances where they are not being retained, and assumes that physical components such as pavement and culverts etc., have been lifted and removed:

- Final slope completion criteria as per **Section 5.5**.
- Rip surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls as required.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to seeding (if seeding is required).
- Seed with an appropriate species mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

7.1.7 Water Management Infrastructure (Domain 7)

Sediment Dams

Dams (mine affected, sediment affected, or raw water) can be decommissioned, demolished and rehabilitated; however, any dams considered beneficial to the underlying landholder, or

would be necessary or beneficial to the final land use, may be retained based on formal agreement with the landholder.

For mine-affected sediment dams (i.e. those dams that have come into contact with coal) or dams which have contained other contaminated water (such as hydrocarbons), a contaminated land assessment is to be undertaken to determine the requirement for any remediation (see **Section 6**) prior to the commencement of rehabilitation activities.

For those dams being retained, some minor rehabilitation works may be required prior to hand-over to the landholder. As such, the rehabilitation strategy has been split into two categories: (1) retained or (2) demolished then rehabilitated. The rehabilitation strategy assumes that dams are dry (or drained) prior to commencing rehabilitation works, as inflows will be restricted to rainfall once production ceases, and water from dams will be used for dust suppression during rehabilitation works.

Dams retained:

- Sediment within drained mine affected dams are subject to a contaminated land assessment (as per **Section 6**), and any contaminated material removed is to be encapsulated within a waste rock dump. This does not apply to sediment affected or raw water dams.
- Embankments, dam walls and spillways should be repaired where required (i.e. where rill erosion is observed). Following any repairs:
 - Apply topsoil to a minimum depth of 100 mm.
 - Scarify the surface immediately prior seeding (if seeding is required)..
 - Seed with an appropriate species mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
 - Control weeds and pest animals.
 - Exclude livestock during establishment of groundcover.

Dams demolished and rehabilitated:

- Sediment within drained mine affected dams are subject to a contaminated land assessment (as per **Section 6**), and any contaminated material removed is to be encapsulated within a waste rock dump. This does not apply to sediment affected or raw water dams.
- Final slope completion criteria as per **Section 5.5**.
- The final landform must not retain water.
- Rip surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior to seeding (if seeding is required).
- Seed with an appropriate species mix (see **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

Levees and Drains

Levees and drains are in place on a mine site to manage surface water runoff and, in the specific case of a co-disposal facility, the decant water cycle. More specifically, they are in place to manage surface water runoff from mine-affected areas, sediment-affected areas, and unaffected areas (clean run-off) in a controlled/designed manner. This avoids adverse impacts on pits/dumps/roads/dams or any other infrastructure. Accordingly, the decision whether a drain or levee is retained post-closure (and therefore the level of rehabilitation required for that drain or levee) depends on a number of factors including:

- What infrastructure the landholder is retaining. If the landholder requests that infrastructure be retained, then any drain or levee associated with that infrastructure should also be retained to ensure its ongoing functionality and safety.
- The specific design of rehabilitated final landforms. For example, during operation, waste rock dumps have drains to collect and manage runoff, so the post-closure design of drainage must consider:
 - whether the runoff from a rehabilitated waste rock dump would flow down the slopes to the toe and then onto the surrounding land without control (thereby carving its own flow path ultimately into a local watercourse); or
 - whether the drain should be retained to control the runoff post-closure along a designated flow path into a designated watercourse.
- How the removal of some drains or levees might affect the hydraulic functionality of those that are retained.

In addition, any drains or levees not associated with retained infrastructure, but which are considered directly beneficial to the subsequent landholder or would be directly necessary/beneficial to the final land use, may be retained upon formal agreement.

For drains or levees being retained, some minor rehabilitation works may be required prior to hand-over to the landholder. As such, the below rehabilitation strategy is separated into those being retained and those being demolished and rehabilitated.

Drains or levees retained:

- Mine affected drains (co-disposal decant, ROM/Product pad drains, etc.): Sediment within mine-affected drains is subject to a contaminated land assessment (as per **Section 6**), with any contaminated material removed encapsulated within a waste rock dump. This does not apply to sediment affected or un-affected drains/levees.
- All drains: where required, remove sediment build-up and/or reeds to ensure hydraulic functionality.
- Drain or levee walls should be repaired where required (e.g. where rill erosion is observed).
- Drain beds should be repaired where required (e.g. where scouring is observed)
- Following any required repair works:
 - Apply topsoil to external drain batters and levee walls to a minimum depth of 100 mm and where required.
 - Scarify the surface immediately prior seeding (if seeding is required).

- Seed with an appropriate species mix (see **Section 0.0.0**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

Drains or levees being demolished:

- Mine affected drains (co-disposal decant, ROM/Product pad drains, etc.): Sediment within mine-affected drains is subject to a contaminated land assessment (as per **Section 6**), with any contaminated material removed encapsulated within a waste rock dump. This does not apply to sediment affected or un-affected drains/levees.
- Drains backfilled.
- Drain walls and levees graded to final slope (completion criteria) as per **Section 5.5**.
- Rip surface material on the contour at a spacing of 1 m to between 0.5 and 1.0 metres as required.
- Establish drainage and erosion controls.
- Apply topsoil to a minimum depth of 100 mm.
- Scarify the surface immediately prior seeding (if seeding is required).
- Seed with an appropriate species mix (See **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

7.1.8 Creek Diversions (Domain 8)

Creek diversions are to be permanent landforms following mine closure. Rehabilitation works (particularly along the banks) may be required to achieve the requirements of the diversion design (i.e. stable, non-polluting and ecologically functional).

As at the time of this RMP, there are two creek diversions as follows:

- Two Mile Creek diversion:
 - Design: Design of Two Mile Creek Diversion (BSM, 2012)
 - Construction completed in 2013
- Coral Creek diversion
 - Design: North Sonoma Creek Diversion Design Plan (Engeny, 2018)
 - Construction completed in 2018

Any other creek diversion works undertaken on the QNH will be subject to the revegetation and rehabilitation requirements presented in their relevant design plans.

Diversions become non-polluting and able to sustain their agreed post-mining land use through appropriate design, material selection, construction methods and revegetation. Low-flow channels in both diversions are designed with rock lining and therefore, revegetation within the low flow channel is not required. Any imported or native rock material should be geochemically inert to ensure that no pollution to the surrounding environment occurs. Revegetation of benches above the low flow channel or on the upper banks is required, as they are not rock lined. Revegetation strategies vary between creek diversions, as the nature of the flow regime and vegetation diversity/abundance are specific to each creek.

Two Mile Creek Diversion Revegetation

Construction of the Two Mile Creek Diversion was completed in 2013. The natural seedbank present in the topsoil spread has continued to support a self-sustaining population of groundcover species (such as grasses), shrubs, and small and large trees. The requirement for future revegetation works is assessed during annual creek diversion inspections (see **Section 6**).

Coral Creek Diversion Revegetation

Construction of the Coral Creek Diversion was completed in 2018. After construction activities were completed, the bench above the low flow channel and adjacent batters of the diversion were hydromulched with a seed mix comprising grasses, shrubs and trees as per Engeny, 2018. The requirement for potential future revegetation works is assessed during annual creek diversion inspections (see **Section 6**).

7.2 Supporting Activities

7.2.1 Exploration

Exploration activities undertaken on the granted mining leases are not considered a mining domain, and they do not represent a significant area of disturbance. Exploration areas generally comprise an access track, a small cleared drill pad (e.g. 50m by 50m), a sump, drill cuttings and the drill hole. Disturbance associated with exploration is to be rehabilitated as follows:

- Boreholes are to be backfilled with cuttings, sealed and capped.
- Shape and grade the drill pads to match the grade of the surrounding area.
- If required, rip any compacted surface material to between 0.5 and 1.0 metres.
- Establish drainage and erosion controls as required.
- Any stripped topsoil is to be replaced to a minimum depth of 100 mm.
- Scarify the surface immediately prior seeding (if seeding is required).
- Seed with an appropriate species mix (See **Section 7.3.2**) where natural seedbanks have been identified as unsuitable.
- Control weeds and pest animals.
- Exclude livestock during establishment of groundcover.

Under the relevant conditions of the QNH EAs, lands previous subject to exploration under Exploration Permit Coal (EPC) 586 are to be rehabilitated in general accordance with Conditions B24 to B31 of ESR/2016/1985 *Eligibility criteria and standard conditions for exploration and mineral development projects – Version 2* (EHP, 2016). The rehabilitation status of legacy boreholes will be assessed on a case by case to prioritise a program of rehabilitation based on environmental risk.

The conditions of the Code also apply to any additional exploration activities undertaken on the now granted mining leases. These criteria have been extracted and presented in **Table 14**.

Table 14 – Rehabilitation Conditions for Exploration

Condition	Description
B24	In Riverine Areas, the holder of the environmental authority must complete the Rehabilitation Processes on all areas disturbed by mining activities, apart from those areas currently being utilised for mining activities, as soon as practical and prior to the onset of the wet season
B25	For all other areas on the mining tenement, the holder of the environmental authority must complete the rehabilitation processes on all areas disturbed by mining activities, apart from those areas currently being utilised for mining activities, as soon as practical and at least within six months of the completion of works in those areas.
B26	The holder of the environmental authority must backfill all excavations, drill holes or sampling sites as soon as practical following the completion of exploration activities.
B27	Condition B26 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.
B28	The holder of the environmental authority must rehabilitate areas disturbed by mining activities to a stable landform similar to that of surrounding undisturbed areas.
B29	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 disturbed areas.
B30	For any Mine Infrastructure to remain after all mining activities have ceased, the holder of the environmental authority must obtain the written agreement of the land owner stating they will take over responsibility for that infrastructure.
B31	The holder of the environmental authority must complete rehabilitation of disturbed areas to the satisfaction of the administering authority.

7.3 General Rehabilitation Strategies

7.3.1 Establishing Drainage and Erosion Controls

Final landform surfaces are to be contoured, and the final drainage features installed, along with permanent sediment control structures.

The most effective way to control surface flow in rehabilitated areas is to construct contour furrows or contour banks at regular intervals down the slope, effectively dividing a long slope into a series of short slopes. As slope angle increases, these banks or furrows must be spaced closer together. Contour banks are typically the preferred erosion control option for relevant domains (e.g. waste rock dumps, out-of-pit co-disposal facilities, etc.). Construction plant required to establish contour banks is a small dozer (civil scale) with a multi-tined, rear-mounted ripper and a front angle-and-tilt blade.

7.3.2 Establishing Vegetation

Establishment of vegetation is required to ensure a stable and productive landform following rehabilitation activities. Vegetation is to be established by either a reliance on a viable seedbank existing within previously stripped and stockpiled topsoil, or direct seeded if the seedbank found to not be viable.

Natural Seedbank

The stripped and stockpiled topsoils on the QNH have shown to be laden with viable seed, and minimising the maximum height of stockpiles ensures that the seedbank remains viable until it is respread on rehabilitated areas. The natural seedbank contains a representative

diversity of the dominant grass, shrub and tree species present on the land prior to disturbance and is therefore inherently suitable for the rehabilitated use.

To ensure the greatest potential for rehabilitation success when using the existing seedbank in the topsoil, the subsoils are ripped to between 0.5 and 1 metres immediately prior to spreading topsoil (see the **Soil Preparation** subsection for further detail). This breaks up any potential soil compaction and allows the roots of newly sprouted plants to penetrate the subsoils more readily.

Direct Seeding

Where topsoil stockpiles have been observed to have unsuitable seedbanks from previous rehabilitation works, or where the topsoil seedbank has failed to produce an appropriate level of groundcover or species mix, direct seeding may be required.

Sourcing Seed and Suitable Species

Seed can be purchased from a commercial supplier or collected from the local area. Collection of seed may only take place where the collector has the relevant permission and/or permits for the area from which they are collecting. Any seeds requiring storage prior to planting should be maintained in cool, dry conditions and protected from insects.

Based on surrounding pasture, native grass and pasture species composition should be considered, but not necessarily be limited to, the list of species in **Table 15**. These species have been observed in paddocks either surrounding the QNH, or within undisturbed areas of the QNH, and will help facilitate the final land use of cattle grazing. Other suitable improved pasture and native grass species may also be used in seeding mixes.

Table 15 – Suitable Grass Species

Species Name	Common Name
Preferred grazing species	
<i>Urochloa mosambicensis</i>	Sabi Grass
<i>Cenchrus ciliaris</i>	Buffel Grass
<i>Heteropogon contortus</i>	Black Speargrass
<i>Dichanthium sp.</i>	Bluegrass
<i>Rhynchosia minima</i>	Rhynchosia
<i>Macroptilium lathyroides</i>	Phasey Bean
<i>Clitoria ternatea</i>	Butterfly Pea
<i>Sorghum halepense</i>	Johnson Grass
Intermediate grazing species	
<i>Neptunia gracilis</i>	Native Sensitive Plant
<i>Chloris inflata</i>	Purple-top Rhodes Grass
Legumes	
<i>Chamaecrista rotundifolia</i>	Wynn Cassia
<i>Macroptilium astropurpureum</i>	Siratro
<i>Stylosanthes humilis</i>	Stylo
<i>Stylosanthes scabra</i>	Seca Stylo

Soil preparation

Where compaction of subsoil has occurred, such as in infrastructure areas, roads, and other heavily trafficked areas, the surface will need to be ripped to between 0.5 and 1 metres prior to topsoiling and seeding. This will break up the compaction and allow vegetation to establish more easily. In order to prevent degradation of soils with high clay content, ripping should be undertaken after a dry period. In areas where compaction has not been identified, scarification could still be undertaken on a case-by-case basis to assist in establishing a soil bed.

The need for fertilisation will be informally assessed prior to the commencement of rehabilitation, or following any failed rehabilitation, where the cause of the failure is assessed as being due to poor nutrient loading. Typically, a low phosphate fertiliser at a nominal application rate of up to 250 kg per hectare is appropriate. Care should be taken when using fertilisers to minimise runoff into drainage channels. Fertilisers can also promote weed growth.

Seed Application

Seeding, where required, should ideally be undertaken immediately prior to the onset of the wet season (i.e. December or January). This gives seeds the best chance of taking hold, as soil moisture will be at its highest in the late wet season.

Establishment period

Regardless of reliance on the seedbank or direct seeding, the establishment period for species can vary, so progress should be regularly monitored following spreading of topsoil or any seeding undertaken. Monitoring typically commences one month from spreading of topsoil (reliance on seedbank) or from application of seed (direct seeding), in order to assess germination. Reseeding may be required if germination does not occur; however, it should not be undertaken outside of the wet season unless suitably wet weather is forecast.

Weed management may be required during the establishment period (see **Section 7.3.3**).

7.3.3 Weed Control and Pest Management

Weeds

Weeds that pose the highest risk to sustaining cattle grazing productivity are those that limit stocking rate, are toxic to animals and/or may potentially outcompete pasture grasses. These include, but are not limited to Parthenium, Lantana, Chinee Apple, and Prickly Mimosa. As light cattle grazing is the agreed post-mining land use, the control of these weeds should be prioritised. See **Section 3.7** for a complete list of expected weed species.

Weed management is to be undertaken as per the *Thiess Weed Management Plan QCoal Northern Hub* (Thiess, 2016), the *Sonoma Coral Creek Weed Management Plan* (NRA, 2013), and any other relevant QNH weed management document, or any updates thereof.

Where weed control is required, a licenced and qualified professional should undertake herbicide treatment (including selection of appropriate herbicides and application) with a focus on priority weed species (see **Section 3.7**). Weed control is an ongoing process and will likely require repeated treatments.

Weed prevention is more effective and economical than weed treatment; therefore, efforts should be made to prevent the spread of weeds into rehabilitation areas. These include:

- Limiting the area of soil disturbed at any one time to minimise exposure of bare ground.
- Use mulches and establish preferred groundcover as quickly as practicable
- Avoid importing or using soils where their origins and seedbanks are unknown.
- Avoid re-using weed infested topsoils if possible
- Ensure that any seed mixes used for rehabilitation are weed free
- Ensure stockpiled topsoil material is weed-free prior to use.

Pest Animals

Pest animals considered relevant to rehabilitation efforts at the QNH include feral pigs, rabbits, and goats. During rehabilitation activities, active pest management should be undertaken where impacts are observed during routine monitoring of rehabilitation works. Methods of control should consider how the QNH manages pest species during active mining operation, as well as how the underlying landholder manages pest species in the area.

7.4 Scheduling of Rehabilitation

Rehabilitation activities undertaken during active mining is referred to as progressive rehabilitation.

During mining activities, works on sections of disturbed land may be completed to a point where there is no further potential operational use for that section of disturbed land. The domain is then considered available to be rehabilitated. The most common example is sections of a waste rock dump face which have received their final dumping sequence and therefore have no further operational use. Rehabilitation can then be undertaken on that face in isolation, without having to rehabilitate the entire dump at the time.

By undertaking progressive rehabilitation, the actual amount of rehabilitation required at the completion of mining is minimised. Progressive rehabilitation is scheduled considering the following factors:

- Progressive rehabilitation is to be undertaken in line with the relevant PRCPs for each QNH mine as they are approved;
- The potential for future operational use of the area;
- The progressive rehabilitation is not to conflict with mining/production priorities;
- Required plant must not be currently needed for mining/production operations.
- Opportunities to minimise double handling of topsoil, such as applying topsoil stripped directly to areas of rehabilitation is preferred. This also prevents degradation of the natural seedbank during stockpiling.

Additionally, there is an economic benefit to completing progressive rehabilitation as soon as practicable. This includes a reduction in Estimated Rehabilitation Cost (ERC) held, and reduced area requiring erosion control and dust suppression during operations. As such, while there are currently no requirements to achieve a target rate of rehabilitation (such as timeframes, areas, or outcomes) in the absence of established PRCPs, QNH will undertake progressive rehabilitation when areas and schedules become available to do so.

8 Monitoring, Maintenance and Reporting

8.1 Monitoring

8.1.1 Timing

General rehabilitation monitoring is to be undertaken annually following the wet season, or at a suitable frequency based on recommendations from the SQP undertaking the monitoring.

Soil assessments at both monitoring and reference sites (to allow comparison) are to be undertaken five (5) yearly; however, an SQP may recommend an increase or decrease in the frequency of these assessments.

Monitoring of progressive rehabilitation areas will only commence after at least one wet season has passed following completion of rehabilitation works. This will allow monitoring to better assess the performance of the seedbank, rates of growth, areas of erosion, and other issues.

8.1.2 Survey Intensity

A 1:15,000 monitoring scale (or approximately one (1) observation per nine (9) hectares) is to be used initially, as this allows for a detailed assessment of the land (McKenzie *et al.* 2008). This may be scaled up or down upon review, depending on the level of detail required as per the recommendations of an SQP.

Rehabilitation areas are to be broken into discrete management units to facilitate data management and planning for rehabilitation monitoring. Management units should be delineated based on the age of the rehabilitation, waste type, and rehabilitation methodology.

8.1.3 Reference Sites

Reference sites are used as a non-mine affected point of comparison to assess performance of the rehabilitated areas with regard to groundcover, carrying capacity (productivity), weed proportion, and species mix and composition.

Monitoring reference sites are to be chosen to be appropriate analogues to the areas being monitored and on-the-ground assessments are required to select the most appropriate locations. The land use of the reference site should align with the intended post-mining land use of the rehabilitation area(s) being monitored. The location of reference sites are to be determined during monitoring works and can be altered based on the dynamic nature of ephemeral landscapes that are, and have historically been, used for cattle grazing. The location of reference sites may also change based on landholder access restrictions.

Current reference sites used for monitoring of progressive rehabilitation on the QNH are presented in **Table 16**. The location or number locations may change based on the recommendations of an SQP undertaking the monitoring.

Table 16 – QNH Rehabilitation Reference Sites

Reference Site	Start		End	
	Latitude	Longitude	Latitude	Longitude
V19	-20.6168	147.8346	-20.6164	147.8346
V20	-20.6187	147.8352	-20.6182	147.8351
V21	-20.6143	147.8323	-20.6139	147.8324
V33	-20.6157	147.8336	-20.6153	147.8335

8.1.4 Parameters

Soils

Where soil monitoring is undertaken, profiles will be excavated to a depth of at least 1 m below the soil surface, with samples collected at intervals of 10 cm, except where an SQP recommends that sampling be undertaken to a different depth or at different intervals. The following parameters are to be assessed:

- Plant Available Water Capacity (PAWC)
- Exchangeable Sodium Percentage (ESP)
- Soil Salinity (1:5)
- Soil pH (1:5)
- Water erosion, calculated as a function of slope % and ESP
- Rockiness

Analysis is to be undertaken by a laboratory that is NATA-accredited for the given parameter.

The following information should also be gathered in accordance with the methods and categories in the *Australian Soil and Land Survey Field Handbook* (NCST, 2009):

- Slope
- Surface condition
- Depth of topsoil and other horizons
- Soil colour per horizon (as per the Munsell Soil Colour Charts)
- Soil structure per horizon
- Coarse fragment content at the soil surface and in each horizon
- Root depth
- Presence of waterlogging features
- Presence of free carbonate and other segregations.

Land Suitability and Vegetation

Vegetation assessments are to be conducted using 50 m transects to confirm land suitability has been achieved. Sites will be chosen through a random selection process by the SQP undertaking the work and is landform dependent. Any photographs taken during vegetation assessment are to follow the methodology found in the *Pasture photo standards* (DPIF, 2003). The following parameters are to be measured:

- Species list for each transect to determine species composition and proportion of preferred species
- Groundcover to be measured within 1 m square quadrats and the average will be used to assess compliance with the groundcover completion criteria (see **Section 5.5**). This measurement is also to include characterisation of the groundcover (e.g. vegetation, woody debris, rock, etc.).
- Stock carrying capacity as head/ha based on grass load.
- Vegetation structure.
- Species showing evidence of fruiting or flowering are to be noted.
- Prescribed weed species are to be noted.

Carrying capacity is to be calculated as per advice from Bob Shepard, Principal Extension Officer, Queensland Department of Agriculture Fisheries and Forestry (NRA, 2015), as follows:

- One adult equivalent (450 kg beast) requires 2.2% of live body weight of dry biomass per day (3,650 kg per annum).
- A utilisation rate of 25% to 30% should be applied to prevent degradation.
- Therefore, one beast requires between 12,167 and 14,600 kg of dry biomass per annum.

The number of hectares required per beast is to be calculated by dividing the dry biomass required per annum by the measured mean pasture biomass (in kg/ha) of each management unit. To determine the carrying capacity, the number of hectares per beast is then converted to head/ha.

Other

Other data to be collected during monitoring is as follows:

- Evidence of any slope failure or rock falls
- Evidence of any rill or gully erosion
- Evidence of pest animals
- Note any leachate observed originating from rehabilitated co-disposal facilities.

8.1.5 Creek Diversions

Diversions are present on the SCM and require specific administering authority approval based on RPEQ designs. Those designs include requirements for rehabilitation of the landform as part of construction activities.

In addition, the designs require annual monitoring and reporting (by an RPEQ) of diversion stretches as per **Condition J7** of the SCM EA. The monitoring and reporting program includes annual assessment of the progress of the rehabilitation of the diversion. As such, diversion rehabilitation monitoring is separate from other rehabilitation monitoring works and is subject to the approved diversion design.

8.2 Reporting

Following annual monitoring (or any other frequency as proposed by an SQP), a report is to be prepared providing a summary of data collected and an update on the progress towards meeting completion criteria. These reports do not need to be submitted to the administering authority; however, they should be retained and reviewed internally to determine the readiness of the rehabilitated domains for certification. Monitoring reports are also to be used to identify the need to amend rehabilitation practices, or the RMP itself, prior to future works.

A separate report related to creek diversions is also to be generated by an RPEQ annually and must be submitted to the administering authority.

8.3 Rehabilitation Maintenance and Potential Issues

Ongoing monitoring of progressive rehabilitation will inform any required maintenance and identify any issues requiring corrective action. Potential issues, which could occur following rehabilitation, have been identified and include, but are not limited to, those presented in **Table 17**.

Table 17 – Potential Issues and Remedial Action

Issue	Remedial Action
Seedbank fails to germinate or groundcover dies following early establishment when using the seedbank present in topsoil.	Investigate topsoil quality. Considering supplementary seeding of future rehabilitation using this topsoil. Reseed rehabilitated areas as required.
Rapid die-off of groundcover.	Investigate cause, and reseed rehabilitation as required.
Groundcover species are failing to thrive.	Investigate soil quality, consider the suitability of applying fertilisers
Water stress – wilting foliage, heavy insect damage, die back.	Apply water to the rehabilitation area until signs of stress have been alleviated.
Water logging – stem rot, fungal infection	Ensure that drainage features are installed correctly. Where additional drainage is required, instate drainage features. Cease, or cut back, any watering regime being undertaken. Reassess the use of fertiliser (if it had been applied)
Extensive exotic weed cover	Assess the viability of undertaking additional weed management actions in order to ensure that the groundcover seedbank can undertake secondary succession.
No germination or die-off of direct seeding	Assess the seed being used and consider reseeding with a different stock. Assess soil quality and consider the requirement for fertilisation.
Erosion or Slippage in rehabilitation areas	Investigate for failures in drainage features and reinstate or add additional drainage as required. Repair rill erosion by ripping and re-contouring. Repair gully erosion by filling and recontouring.

8.4 Rehabilitation Completion

Rehabilitation is considered functionally complete once the completion criteria set out in **Section 5.5** have been achieved, and the associated performance verification works have been undertaken.

Once completion criteria have been met to a satisfactory level and the performance verification has been completed, a final rehabilitation report (see **Section 6**) must be provided to the administering authority. The final rehabilitation report outlines compliance with conditions of the EA and completion criteria, the extent and success of the rehabilitation, any ongoing environmental management and monitoring requirements, and any residual risk. A compliance statement drafted by a third party must also be provided with the final rehabilitation report, detailing compliance of the report against the requirements of the EA, as well as the accuracy of the report itself.

Additionally, any land that has previously been on the environmental management register (such as contaminated land) must be removed or have an appropriate Site Management Plan approved and in place (see **Section 6**).

Upon receipt of the final rehabilitation report, the administering authority can certify the rehabilitation and subsequent allow for the surrender of the site EAs.

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Appendix A Residual Voids on the QCoal Northern Hub Mining Complex



Residual Voids on the QCoal Northern Hub Mining Complex

Sonoma, Cows, Drake and Jax Coal Mines



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Submitter information	
Report type	Investigation to inform Rehabilitation Management Plan
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Project	Sonoma Coal Mine Cows Coal Mine Drake Coal Mine Jax Coal Mine
Date of report	27 April 2020

Revision summary		
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QCoal	1	27 April 2020

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1 Introduction

QCoal Pty Ltd (QCoal) manages four (4) adjacent open cut coal mines located between six (6) and fifteen (15) km south of the town of Collinsville in Central Queensland. The four mines are Sonoma Coal Mine (SCM), Cows Coal Mine (CCM), Drake Coal Mine (DCM) and Jax Coal Mine (JCM). Mining pits, waste rock dumps, roads and water management infrastructure span mining lease (ML) boundaries. As such the four (4) mines are collectively managed and operated as a single multi-pit operation referred to as the QCoal Northern Hub (QNH). Each mine has its own environmental authority (EA), however, operational and environmental management and resources are integrated across the four mines.

1.1 Ownership

The QNH sites have ownership makeups as follows:

- SCM is owned by the Sonoma Coal Joint Venture (SCJV) in which QCoal Sonoma Pty Ltd is the majority interest holder;
- DCM is owned by Northern Hub (Drake) Pty Ltd and Drake Coal Pty Ltd;
- CCM is owned by Bowen River Coal Pty Ltd; and
- JCM is owned by Jax Coal Pty Ltd.

QCoal Sonoma Pty Ltd, Northern Hub (Drake) Pty Ltd, Drake Coal Pty Ltd, Bowen River Coal Pty Ltd and Jax Coal Pty Ltd, are wholly or majority owned subsidiaries of QCoal Pty Ltd. The owner and Managing Director of QCoal Pty Ltd is Mr Christopher Wallin.

1.2 Environmental authorities

EA numbers and primary holders for the QNH mines are provided in **Table 1**.

Table 1 – QNH EAs

Mine	MLs	EA Number	Grant	Primary EA Holder	Current version
SCM	ML10325, ML10326, ML10327	EPML00707713	13/9/2007	QCoal Sonoma Pty Ltd	6/3/2020
CCM	ML10345	EPML00334613	16/8/2012	Bowen River Coal Pty Ltd	9/3/2020
DCM	ML10349, ML10350, ML10351	EPML00393013	2/11/2014	Northern Hub (Drake) Pty Ltd	6/3/2020
JCM	ML10346	EPML00337613	20/12/2013	Jax Coal Pty Ltd	14/4/2020

1.3 Objectives

The SCM, DCM and JCM include final voids as part of their rehabilitated final landforms, while the CCM does not have approved voids (pits having previously been backfilled). The voids are approved by the Department of Environment and Science (DES) within the respective EAs. Specifically, the EAs provide the required rehabilitated landform design criteria for each void, being size (area), location and wall angles (high-wall and low-wall). The other consideration for final void rehabilitation is the approved void outcome (whether or not a final void can sustain a post mining land use and if so what type).

The JCM EA stipulates a post-mining land use (PMLU) of “residual void unable to sustain a post mining land use”, while the DCM and SCM EAs do not provide a PMLU for residual voids. Void outcomes are discussed in detail within the relevant sections of this document.

A key objective of this investigation is to determine appropriate void outcomes for the voids on the SCM and the DCM for inclusion in the respective EAs. This objective allows for the DCM and SCM EAs to align and be consistent with the JCM EA, which:

- allows for constancy in regulation of voids across the QNH;
- allows for catchment-wide cumulative consideration of all final voids collectively on the QNH rather than on a site by site basis; and
- informs the “*QCoal Northern Hub Rehabilitation Management Plan*” – April 2020 (QNH RMP) which is a single plan addressing rehabilitation of all four (4) QNH mines (including voids) cumulatively rather than in isolation.

1.4 Methodology

To achieve the above objective, this investigation addresses the following:

- Location and size of all voids on the QNH;
- Surrounding land uses (pre and post mining);
- Geology of the QNH;
- Hydrogeological and hydrological modelling of voids to determine interaction with surrounding groundwater, potential for overtopping and void water quality;
- Based on the above modelling, determine whether any DCM or SCM voids can sustain a PMLU and, if so, what that PMLU should be, and confirm the appropriateness of the approved PMLU for the JCM residual voids as “residual voids unable to sustain a post mining land use”; and
- Demonstrate that for each void, regardless of void outcome, the final landform will be safe, structurally stable, and will not cause environmental harm, including assessment of relevant surrounding values (human and environmental) and the suitability of the approved final landform wall angles for each void.

1.5 Previously submitted void studies

This investigation relies upon previously completed waste rock, rehabilitation, geochemical, geotechnical, hydrological and hydrogeological assessments undertaken across the QNH, which are referenced in the relevant sections. Two previous void studies have been completed on the QNH and submitted to DES, the conclusions of which are referenced in the relevant sections:

- “*Investigation into Residual Void Sonoma Coal Mine – QCoal January 2016*” (submitted to DES 29 January 2016), which included the technical study “*Sonoma Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2015*” (Engeny 2015a); and
- “*Investigation into Residual Void Jax Coal Mine – QCoal October 2018*” (submitted to DES 12 October 2018), which included the technical study “*Jax Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2018*” (Engeny 2018) and “*Long Term Water Quality of Jax Coal Mine Residual Voids - 2 April 2019*” ((Engeny (2018) Supplementary Memo).

1.6 Technical studies for this assessment

QCoal engaged technical consultants to undertake specific studies for this assessment as follows:

- Engeny had previously undertaken a specific final void study for the Jax Main Pit and Jax East Pit final voids “*JCM Final Void Hydrology Study Main Pit – Engeny Water Management 2018*” (Engeny 2018) which was appended to “*Investigation into Residual Void Jax Coal Mine – QCoal October 2018*” (submitted to DES 12 October 2018). Engeny (2018) is relied upon for the Jax Main Pit and Jax East Pit final voids and is appended to this assessment as **Appendix A**.
 - o A supplementary memo was prepared by Engeny “*Long Term Water Quality of Jax Coal Mine Residual Voids - 2 April 2019*”, to present an extended prediction length for water quality beyond what was presented in Engeny (2018) The results of this memo were provided to DES in person (Emerald Coal Hub) on 4 April 2019. The memo is referred to as “Engeny (2018) Supplementary Memo” and has been included in Appendix A of this assessment for completeness.
- Engeny Water Management Pty Ltd (Engeny) was engaged to undertake water balance modelling of the remaining QNH final voids, which is reported in “*Residual Void Hydrology Study QCoal Northern Hub Mines April 2020*”, Engeny (2020). Engeny (2020) is appended as **Appendix B** to this assessment.
- The key objectives of both Engeny (2018) and Engeny (2020) void modelling included:
 - o model the equilibrated (steady state) water level in QNH final voids, allowing an assessment of interaction with surrounding groundwater and the potential for overtopping into surface waterways; and
 - o determine the rate of change and make predictions on the water quality within final voids.
- Australasian Groundwater and Environmental Consultants Pty LTD (AGE) was engaged to undertake hydrogeological modelling of the QNH final voids. A specific report title was not available for reference at the time of submission of this assessment; however, the results of the AGE study are referred to in this assessment as AGE (2020) and outputs have been inserted into this assessment in the relevant sections.

2 Description of QNH

2.1 Location

The QNH is between six (6) and fifteen (15) km south of the town of Collinsville in Central Queensland. Access to all four QNH sites is by the state-controlled Bowen Development Road. The location of the QNH (SCM, CCM, DCM and JCM) is presented in **Figure 1**, which also presents the four (4) individual QNH mines.

The mines that make up the QNH are directly adjacent to one another on the western side of Bowen Development Road and the parallel Newlands rail line, apart from JCM, which is on the eastern side.

2.2 Mining tenures

The ML tenures for the QNH mines are provided in **Table 2**, for each respective mine.

Table 2 – QNH MLs

Details	Sonoma			Cows	Jax	Drake		
Lease	ML10325	ML10326	ML10327	ML10345	ML10346	ML10349	ML10350	ML10351
Status	Granted	Granted	Granted	Granted	Granted	Granted	Granted	Granted
Lodgment	21/11/2005	21/11/2005	21/11/2005	11/04/2009	11/12/2009	21/04/2010	21/04/2010	21/04/2010
Grant	12/4/2007	13/09/2007	13/09/2007	16/08/2012	20/12/2013	2/11/2014	2/11/2014	2/11/2014
Expiry	30/04/2037	30/09/2037	30/09/2037	31/08/2027	31/12/2034	29/02/2044	29/02/2044	29/02/2044
Holder	QCoal Sonoma Pty Ltd	QCoal Sonoma Pty Ltd	QCoal Sonoma Pty Ltd	Bowen River Coal Pty Ltd	Jax Coal Pty Ltd	Northern Hub (Drake) Pty Ltd	Northern Hub (Drake) Pty Ltd	Northern Hub (Drake) Pty Ltd
Area (ha)	716.7	1,063	360.4	210.5	1,943	3,982	4,805	427.9
Permit ID	108618	108619	108620	108636	108637	108640	108641	108642
Native Title	Exclusive Land	Exclusive Land	Exclusive Land	Exclusive Land	Right to Negotiate Agreement	Right to Negotiate Agreement	Right to Negotiate Agreement	Right to Negotiate Agreement

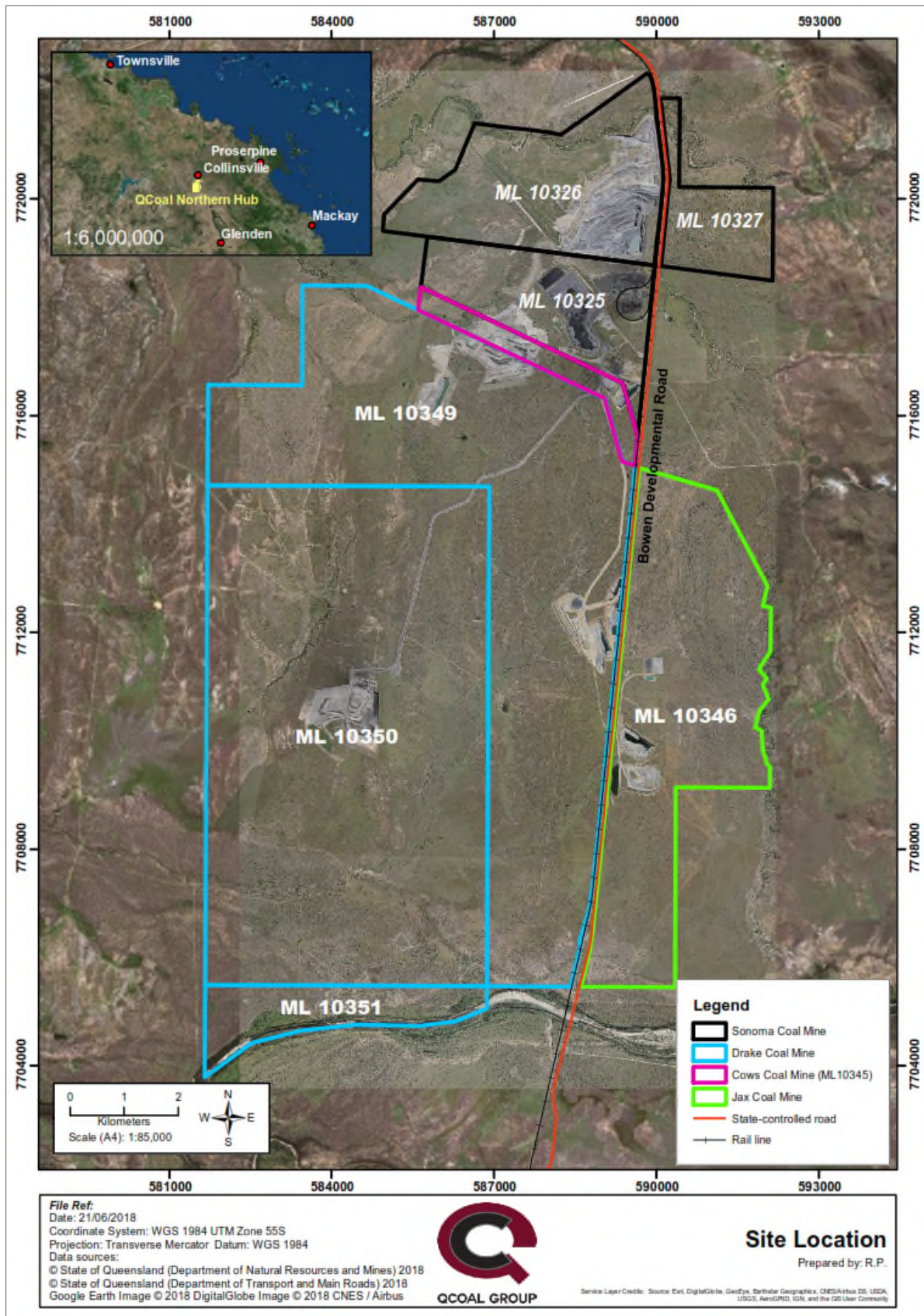


Figure 1 – QNH location and MLs

2.3 Underlying landholders

The QNH spans eight (8) MLs (see **Table 2**) located on land with several landholders, as summarised below and presented in **Figure 2**:

- **SCM:**
 - o ML10325: The land underlying ML10325 is owned by Mr Christopher Wallin.
 - o ML 10326: The land underlying ML10326 is “Sonoma” station, which is privately owned by a third party, with the exception of the land underlying the SCM rail spur and loop, which is owned by Mr Christopher Wallin.
 - o ML10327: The land underlying ML10327 is “Sonoma” station, which is privately owned by a third party.
- **CCM:**
 - o ML10345: the land underlying ML10345 is a historic stock route which is no longer declared for that purpose. The land is held under a permit to occupy by Mr Christopher Wallin.
- **DCM:**
 - o ML10349, ML10350, and ML10351: The land underlying these MLS is “Birralee” station, owned by Mr Christopher Wallin.
- **JCM:**
 - o ML10346: The land underlying ML10346 is “Birralee” station, owned by Mr Christopher Wallin.

2.4 Mining methods

Mining operations on the QNH involve extraction of Run of Mine (ROM) coal with conventional advancing highwall (mining face) open cut mining methods, utilising drill and blast, and, excavator and truck. As the high wall of an active pit progresses forwards (following the coal seam) to allow continued mining, dumping of waste rock occurs at the low wall (rear of the pit) behind the mining areas, progressively backfilling the pit.

ROM coal is hauled from active pits on the QNH (i.e. all the four QNH mines) to the SCM for processing and shipping. Processing is undertaken at the SCM Coal Handling and Processing Plant (CHPP) after which the product coal is loaded onto trains at the SCM train load-out facility located for transport to Abbot Point Coal Terminal. Coal rejects materials generated during processing at the CHPP are placed into a co-disposal facility located on the SCM.

Topsoil stripped ahead of mine-related activities is either stockpiled for later use in rehabilitation or placed directly on areas already shaped and prepared for rehabilitation works. Waste rock materials are placed in either out-of-pit dumps or in-pit dumps.

The QNH mines share water management infrastructure, haul roads, equipment, resources, and other infrastructure.

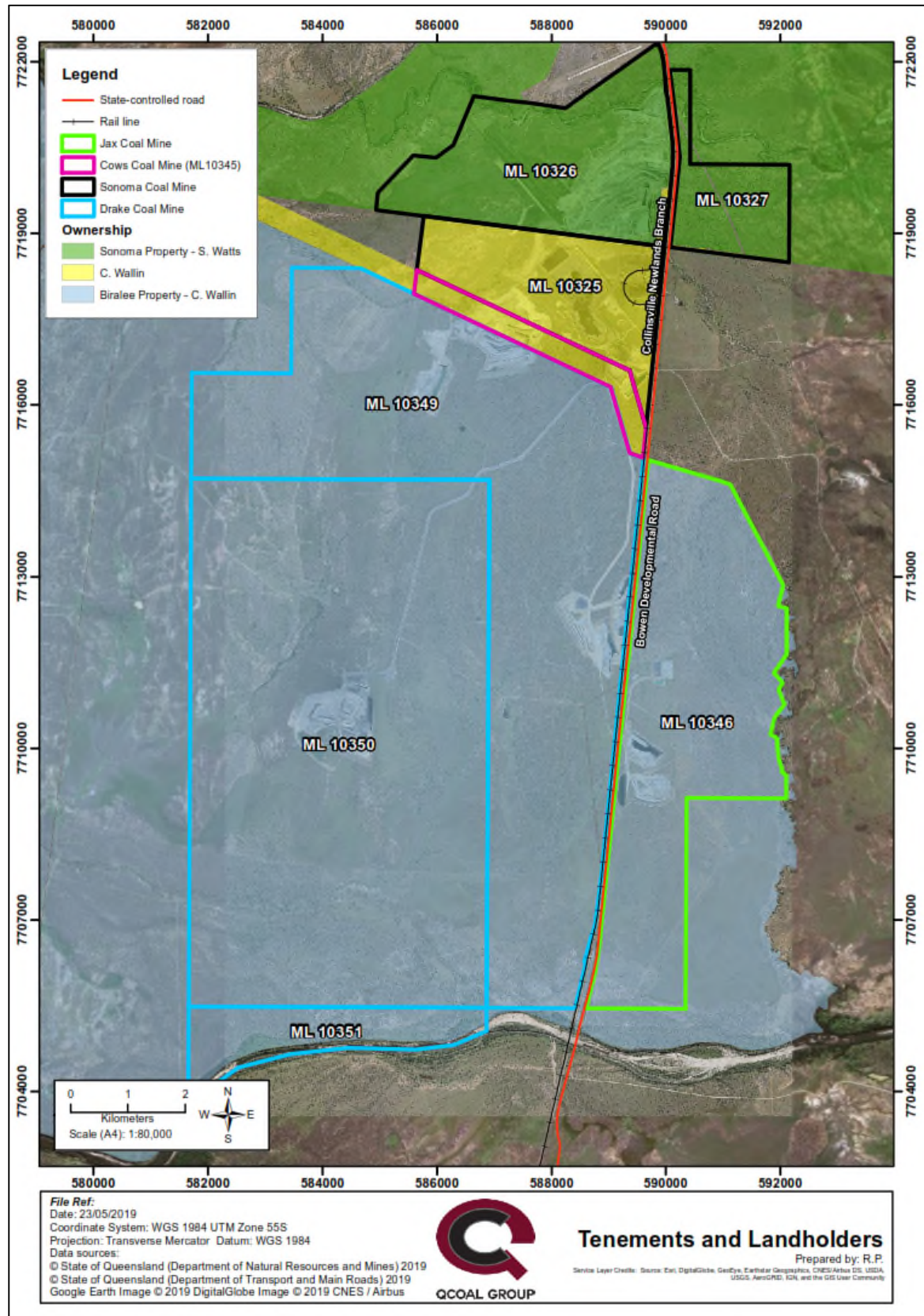


Figure 2 – QNH underlying landholders

3 Regional and Local Geology

A geological understanding of the QNH is required for both the groundwater model (**Section 6**) and water balance model (**Section 7**).

The QNH is located in the northern Bowen Basin, where active subsidence and deposition during the Permo-Triassic was centred within an extensional terrain known as the Taroom Trough. This deposition centre was situated marginal to the Collinsville Shelf in the west, which typically behaved as a stable platform throughout. The deformed Taroom Trough of the north Bowen Basin is defined by the Nebo Synclinorium, where contained sediments and volcanics of the western two-thirds dip gently toward the major synclinal axis in the east. Post-depositional compression has resulted in a fold-and-thrust style of deformation, particularly on the eastern side of the basin where sediments along this margin tend to dip steeply westward.

The QNH is underlain by the late Permian Blackwater Group consisting of lithic sandstone, siltstone, shale, conglomerate, dolomite and tuff and minor coal. This is surrounded and underlain by the low to upper Permian Blenheim Subgroup described as a succession of siltstone, sandstone, conquite and limestone (i.e. the Blackwater Group is an outlier surrounded by the Blenheim Subgroups). The Collinsville Coal Measures underlie the Blenheim Group.

Regionally, the stratigraphic sequence is summarised as follows: the Permo-Triassic sediments of the Bowen Basin are overlain by a veneer of unconsolidated Quaternary alluvium and colluvium, poorly consolidated Tertiary sediments and, in places, remnants of Tertiary basalt flows. The stratigraphy comprises basal Lizzie Creek Volcanics and overlying marine Back Creek Group, non-marine Blackwater Group, and Tertiary sediments of the Sutor Formation.

QNH geology is presented in **Figure 3**, in which the coal measures targeted by the QNH (the Fort Cooper and the Moranbah Coal Measures) are highlighted.

Geological detail in the QNH area is intermittently obscured by alluvium and gravel, especially adjacent to creeks and watercourses. This recent (Cainozoic) cover comprises unconsolidated fine to very coarse-grained sand, along with occasional irregularly interbedded silt, clay and gravel lenses. The most persistent gravel bed occurs at the base of the unit and generally comprises markedly rounded pebble to cobble-sized clasts of predominantly andesitic to basaltic composition set in a silt to clay-rich matrix. Generally the alluvial unit is a thin veneer but becomes thicker along rivers and watercourses in the region.

An example of typical QNH surficial strata is presented in **Figure 4**, which is a photo of the south-eastern wall of the current Jax Main Pit showing the surficial geological strata, in particular a thin veneer of alluvial material.

The QNH is well understood to comprise a consistent, contiguous geology and hydrogeology across the four mines. As such, geological, geochemical, and geotechnical findings are applicable across the QNH. Specific operational examples of geological continuity include (see **Figure 5**):

- the Drake 3 Pit complex and the Jax Main Pit complex target the same coal seams, with consistent overburden characteristics; and
- the SCM, CCM and DCM Q-Pit and B-Pit complexes target the same coal seams, with consistent overburden characteristics.

CENOZOIC	REWAN GROUP	QUATERNARY SEDIMENTS BASALT AND VOLCANICS SUTTOR FORMATION
		ARCADIA FORMATION SAGITTARIUS SANDSTONE
TRIASSIC		
LATE PERMIAN	BLACKWATER GROUP	RANGAL COAL MEASURES
		FORT COOPER COAL MEASURES
		MORANBAH COAL MEASURES
EARLY PERMIAN	BACK CREEK GROUP	EXMOOR FORMATION
		BLENHEIM FORMATION
		COLLINSVILLE COAL MEASURES
		GEBBIE FORMATION
LATE CARBONIFEROUS		TIVERTON FORMATION
		LIZZIE CREEK VOLCANICS
		BULGONUNNA VOLCANICS

Figure 3 – Geological conceptualisation



Figure 4 – Example of surficial strata Jax Main Pit

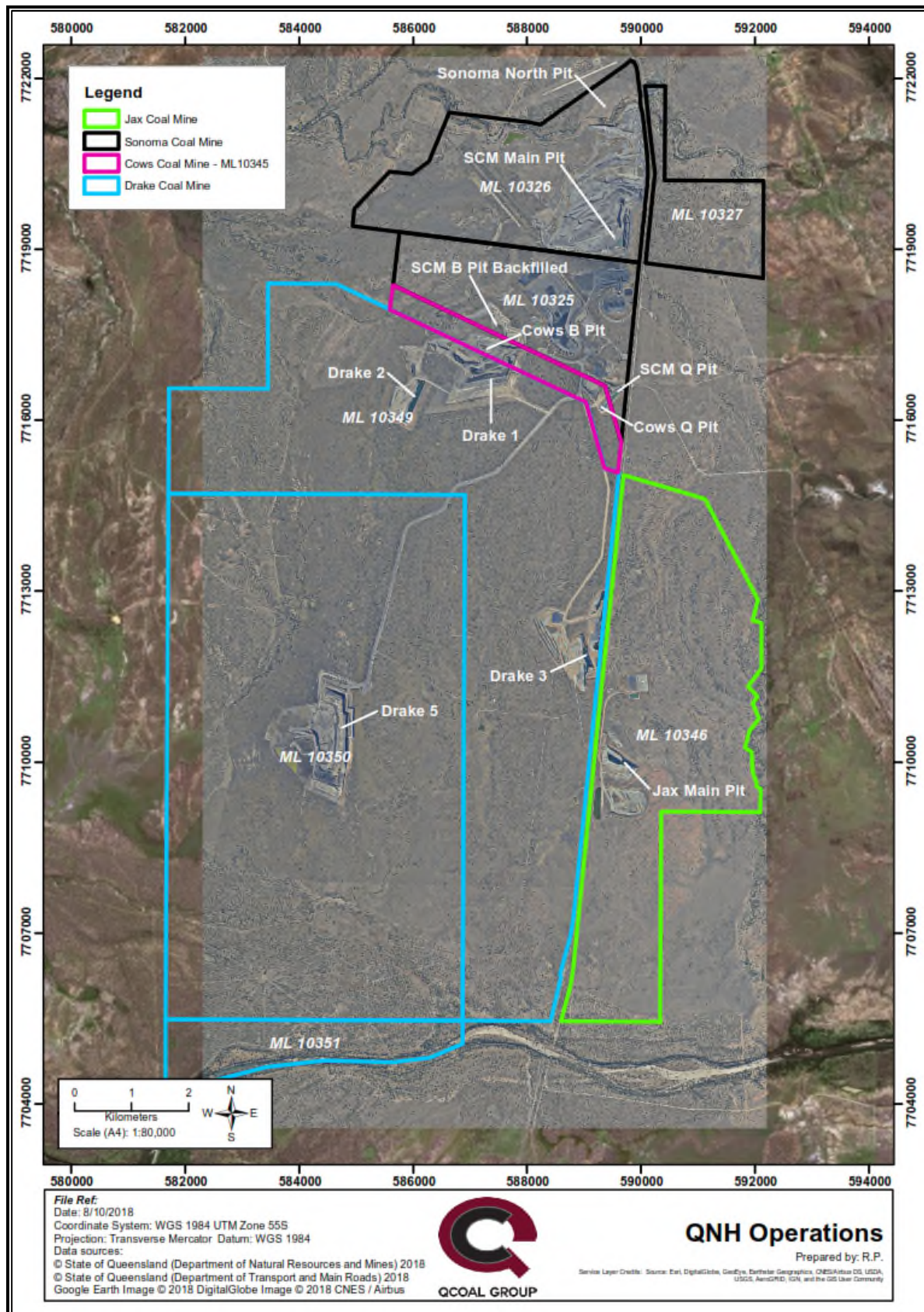


Figure 5 – QNH Operations

4 Regional and Local Groundwater

4.1 Groundwater studies

The hydrogeology across the QNH is well understood with numerous hydrological and hydrogeological studies previously completed for individual mines within the QNH (including specific void modelling for the JCM and SCM) and the QNH cumulatively. The relevant studies are listed below chronologically, and all documents have previously been submitted to DES:

- “Sonoma Coal Environmental Impact Statement – November 2005” (SCM EIS)
- “Drake Coal Project Environmental Impact Statement – March 2012” (DCM EIS)
- “Groundwater Monitoring and Management Plan – Drake Coal Project” (QCoal (2014))
- “Drake Coal Project Groundwater Model – Australasian Groundwater and Environmental Consultants Pty Ltd 2015” (AGE (2015))
- “Sonoma Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2015” (Engeny (2015a))
- “Stygofauna Survey for the Drake Coal Mine Project (July 2016) – Freshwater Ecology Pty Ltd 2016” (Freshwater Ecology (2016))
- “QCoal Northern Hub Water Management Plan – Engeny Water Management 2017” (Engeny (2017))
- “QCoal Northern Hub Water Management Plan – Engeny Water Management 2018” (Engeny (2018))
- “Northern Hub Groundwater Assessment – Australasian Groundwater and Environmental Consultants Pty Ltd 2018” (AGE (2018))
- “JCM Final Void Hydrology Study Main Pit – Engeny Water Management 2018” (Engeny (2018a))
- “QCoal Northern Hub Water Management Plan – Engeny Water Management 2019” (Engeny (2019))

4.2 Groundwater values (resources)

The actual groundwater values (the ways in which groundwater is relied upon by natural hydrological or ecological processes, or by humans) across the QNH area form the basis for any assessment of potential groundwater impact. A detailed review of the potential groundwater values surrounding the QNH was undertaken as part of QCoal (2014), which identified four main potential values that groundwater may have in that area:

- 1) connection to surface water as a source of baseflow for surface waterways, including the consideration of inter-aquifer hydraulic connectivity;
- 2) source water for springs, wetlands or groundwater dependent ecosystems (GDEs);
- 3) stygofauna habitat requirement; and/or
- 4) human groundwater users (irrigation, livestock, domestic, or industrial water supply).

4.2.1 Groundwater - surface water (baseflow) and inter-aquifer connectivity

As part of the DCM EIS and SCM EIS baseline studies, interaction between groundwater and surface water was considered, as well as any potential interaction between various identified groundwater-bearing units. Of particular note were the assessments of the potential for connection to exist between:

- between the groundwater underlying the QNH and the Bowen River (the only surface water body with permanent flow in the vicinity of the QNH);
- between the groundwater underlying the QNH and Twelve Mile Gully drainage channel in the central QNH area; and
- between the groundwater underlying the QNH and the Two Mile Creek/Coral Creek/Pelican Creek drainage channels in the northern QNH areas.

QCoal (2014) summarised the findings of the above in consideration of the geology of the area (further detailed in AGE (2015)), operational pit groundwater inflow data, and, importantly, ongoing groundwater monitoring of bores across the QNH since 2007.

DCM EIS, SCM EIS and QCoal (2014) concluded that there is limited connectivity between alluvium (where present) and the underlying Permian coal measures across the QNH. This observation is considered consistent with the expected low permeability of the majority of the coal measure's strata. In addition, the major ion chemistry results indicate a difference between groundwater sampled from the coal measures and surface water samples, further suggesting limited interaction between groundwater and surface water.

The groundwater level hydrographs, groundwater quality data, and expected permeabilities of the Permian coal measure aquitards suggest limited interaction between the alluvium and the underlying coal measures. Given that the Bowen River flows through strata of alluvial material, the DCM EIS concludes that there is limited connection between the coal measures and the Bowen River. Due to the observed and recorded highly ephemeral nature of Twelve Mile Gully, Two Mile Creek, Coral Creek and Pelican Creek (the channels for all of which run east west across the QNH), any alluvial deposits associated with these watercourses are well understood to be dry except as a result of rainfall, and therefore not fed by groundwater baseflow. No significant interaction between groundwater and surface water is therefore anticipated along these minor watercourses.

With specific regard to the Bowen River, AGE (2015) reports on numerical modelling of the Bowen River which was undertaken specifically for DCM approval purposes (as reported in QCoal (2014)). AGE (2015) concludes in the presentation of numerical modelling results, that drawdown extents would reach the Bowen River; however, as a result of the lack of direct hydraulic connection between groundwater and the Bowen River, the DCM voids would not have any direct interaction with baseflow in the Bowen River.

AGE (2018) builds on the modelling undertaken in AGE (2015), with updates to the QNH layout and final void locations, in addition to updated modelling software. The updates to the numerical modelling in AGE (2018) result in the cumulative QNH drawdown having a smaller southern extent than was previously modelled, mainly due to a change in the layout of the DCM. Results from AGE (2018) confirmed a lack notable surface water – groundwater connectivity in the QNH area and therefore a limited potential for changes in QNH groundwater to impact on surface water. The maximum extent of final void driven drawdown in AGE (2018) was >3 kilometres from the Bowen River, in both the coal measures and the alluvial modelling layers.

AGE (2020) was completed as a cumulative groundwater modelling study for final voids in the QNH for the specific purpose of informing this final void assessment. AGE (2020) included updated numerical modelling of steady state drawdown extents associated with the final voids on the QNH. Results and drawdown extents of AGE (2020) are presented in **Section 6**.

Conceptually, the above studies conclude that surface water channels across the QNH are losing-disconnected streams (see **Figure 6**) with no notable interconnection between the watercourses and the groundwater system.

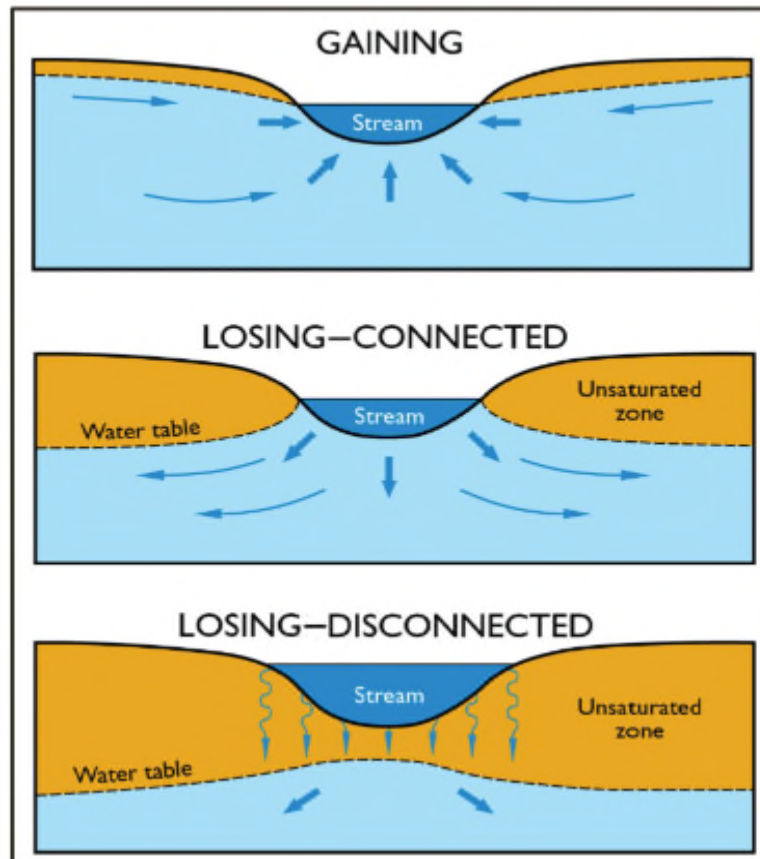


Figure 6 – Groundwater to surface water connectivity (NSW Government 2010)

As such, surface water in the vicinity of the QNH is not reliant on groundwater for baseflow; however, AGE (2018) does states there is potential for some surficial alluvial groundwater interaction with the Bowen River directly along the incised banks of the river channel. Such interaction is stated as being associated with periods of flooding in the river saturating the banks, which would then seep back into the channel after flood waters recede as opposed to any hydraulic connection to groundwater.

As such, surface water baseflow as a value for QNH groundwater is not considered further in this investigation other than in presentation of groundwater and water balance modelling results in **Section 6** and **Section 7** respectively.

4.2.2 Springs, wetlands and GDE

As part of the DCM EIS and SCM EIS baseline studies, a review of potential springs, swamps, wetlands and GDEs in the surrounding area was undertaken. Numerous environmental surveys, investigations and studies have been undertaken during ongoing QNH operations, including numerous receiving environment monitoring programs (REMPs) which specifically focus on aquatic ecology, groundwater reviews such as QCoal (2014) and stygofauna assessments such as Freshwater Ecology (2016). As a result of those EIS's, operational site observations and environmental studies, it is concluded that

- there are no notable groundwater springs or seeps in the QNH area;
- there are no notable wetlands in the QNH area; and
- GDEs are unlikely to exist in the vicinity of the QNH.

As such, springs, wetlands and GDEs are not considered groundwater values for the QNH and are therefore not considered further for impact assessment or associated mitigation.

4.2.3 Stygofauna

As part of the DCM EIS baseline survey assessments, a stygofauna pilot survey was undertaken in May 2011 (GHD (2011)) in accordance with *Guideline No. 54a: Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (the stygofauna guideline). The DCM EIS stygofauna pilot survey sampling was undertaken in ten (10) bores at varying depths across QNH area (predominantly across the DCM and JCM). Stygofauna were not recorded in any of the samples obtained during the pilot survey; however, it is noted that low abundances of terrestrial invertebrates including Diptera adults and Coleoptera larvae were recovered from some samples (these are typical of ingress from surface environments and are not obligate subterranean forms, i.e. are not stygofauna). As such, the DCM EIS determined that the absence of stygofauna from the sampled bores indicates a low likelihood of stygofauna occurrence in the groundwater across the area, and, as such, stygofauna was not identified as a QNH groundwater value in the DCM EIS.

Subsequently, a second stygofauna study was undertaken in July 2016 (Freshwater Ecology (2016)) at three DCM bores located along the Bowen River to focus on alluvial sequences in the QNH, which were identified by the Queensland Government Department of Natural Resources Mines and Energy (DNRME) as potential stygofauna habitat. The alluvial groundwater bores along the Bowen River were recorded as dry and as such the alluvial material along the Bowen River in the vicinity of the QNH is not a notable stygofauna habitat.

As per **Section 3**, the QNH spans a consistent contiguous geology and hydrogeology with consistent overburden characteristics. As such, stygofauna results from the DCM EIS and the Bowen River alluvium study are representative of the entire QNH. Accordingly, stygofauna is not a groundwater value on the QNH in the Permian groundwater or the Bowen River alluvium, and, as such, stygofauna is not considered further for impact assessment or associated mitigations.

4.2.4 Human groundwater use

Groundwater resource management in Queensland involves the identification of Groundwater Management Units (GMU) within heavily utilised areas and Unincorporated Areas (UA) where use and/or monitoring data is limited. GMUs are defined by the extent of aquifer systems while UAs are established by dividing the remaining area in Queensland based on geological region boundaries (ANRA (2007)). The QNH is located within the Bowen UA, which covers an area of 153,800 km². Average groundwater resource usage in the Bowen UA is estimated to be 14,900 ML/yr compared to an estimated sustainable yield of 260,000 ML/yr (National Land and Water Resources Audit, 2001).

The current low levels of groundwater use within the Bowen UA, may conservatively be considered to include pastoral, irrigation, mining, stock and domestic, and town water. The quality of the groundwater is generally described as marginal, with poorer quality groundwater typically encountered within coal bearing strata. According to the National Land and Water Resources Audit 2001, there are no priority issues for groundwater management within the Bowen UA and the current level of extraction within the Bowen UA is considered sustainable, given the relatively low level of groundwater utilisation.

As part of the previous hydrogeological investigations across the QNH (including the *“Investigation into Residual Void Sonoma Coal Mine – QCoal January 2016”* and *“Investigation into Residual Void Jax Coal Mine – QCoal October 2018”*), the Queensland Government Groundwater Database (GWDB) has been accessed and searched numerous times. The GWDB is a publicly available database of registered groundwater bores, administered by the Queensland Government Department of Natural Resources Mines and Energy (DNRME) via an online geospatial interface “The Queensland Globe”. An updated search was undertaken in April 2020, the results of which are presented in **Figure 7**, which shows the raw GWDB data (as at 20 April 2020), for a search radius of approximately 10km from the external QNH ML boundaries.

For comparison, presented in **Figure 8** is the figure from the 2016 Sonoma Final Void assessment, in which the raw DNMRE GWDB data was reviewed and identified as either supply or other use. Between 2016 and the preparation of this investigation, no new registered supply bores have been installed within the respective search radius.

Of the over 50 registered bores within the area on **Figure 8**, only four (4) are identified as a potential water supply bores:

- RN25008 – located ~2.5 km north-east from the SCM East Pits 1 and 2 and Main Pit residual final voids;
- RN125696 – located ~8.5 km east-north-east from the JCM Main Pit residual voids and ~9 km from the SCM East Pit 1 and 2 residual voids;
- RN125698 – located ~6 km south-east from the SCM East Pits 1 and 2 final voids, ~7.5 km east of the DCM Drake 1 Pit final void and ~8 km north-east of the JCM Main Pit final void; and
- RN140020 – located ~6 km south-east from the SCM East Pit final voids and ~6.5 km north-east from the JCM Main Pit void.

This indicates that landholder groundwater use (including irrigation, livestock watering and domestic use) is not considered a groundwater value across or in the immediate vicinity of the QNH site. As such, groundwater use is not considered further for impact assessment or associated mitigation.

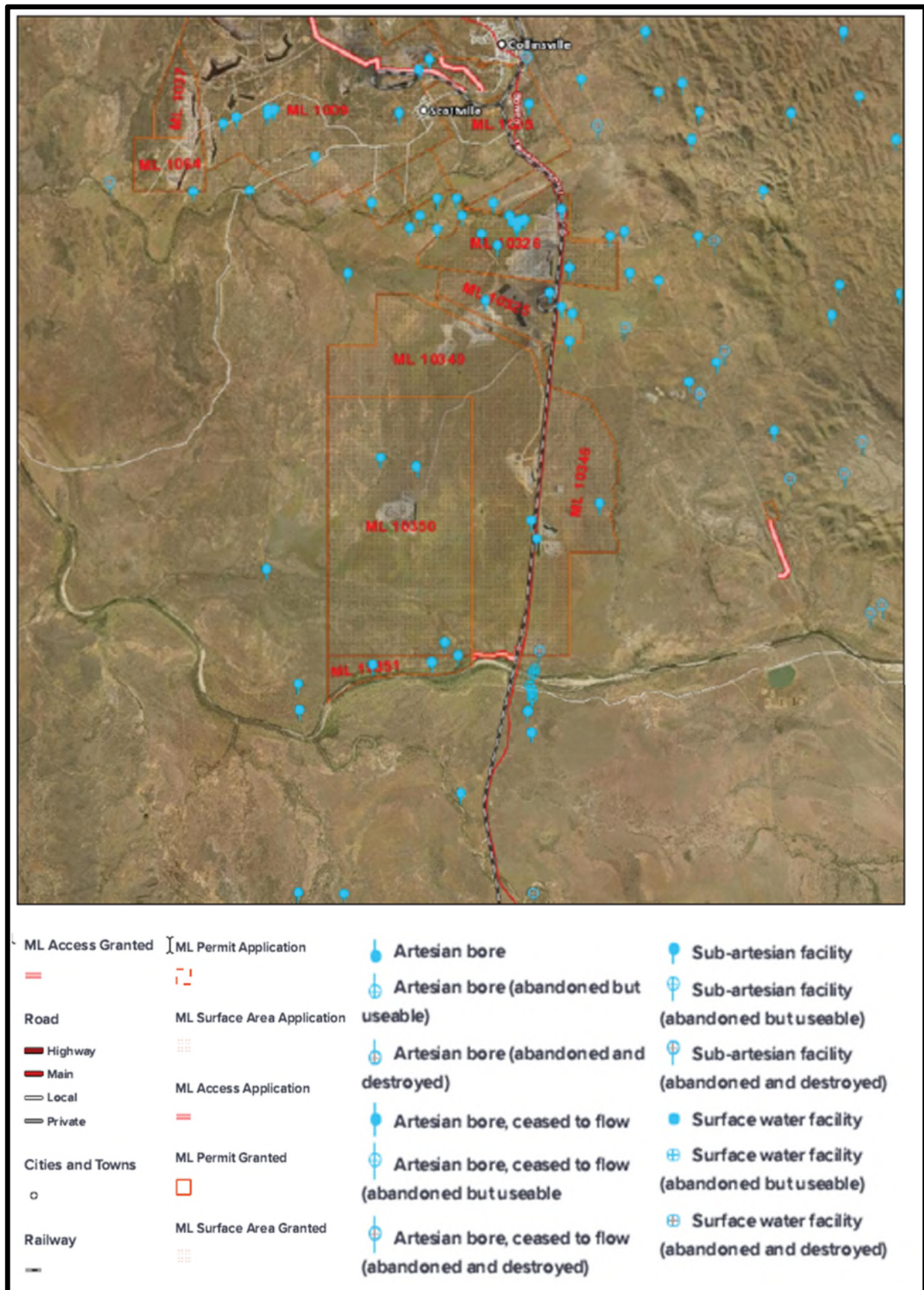


Figure 7 – DNRME GWDB April 2020 (no scale)

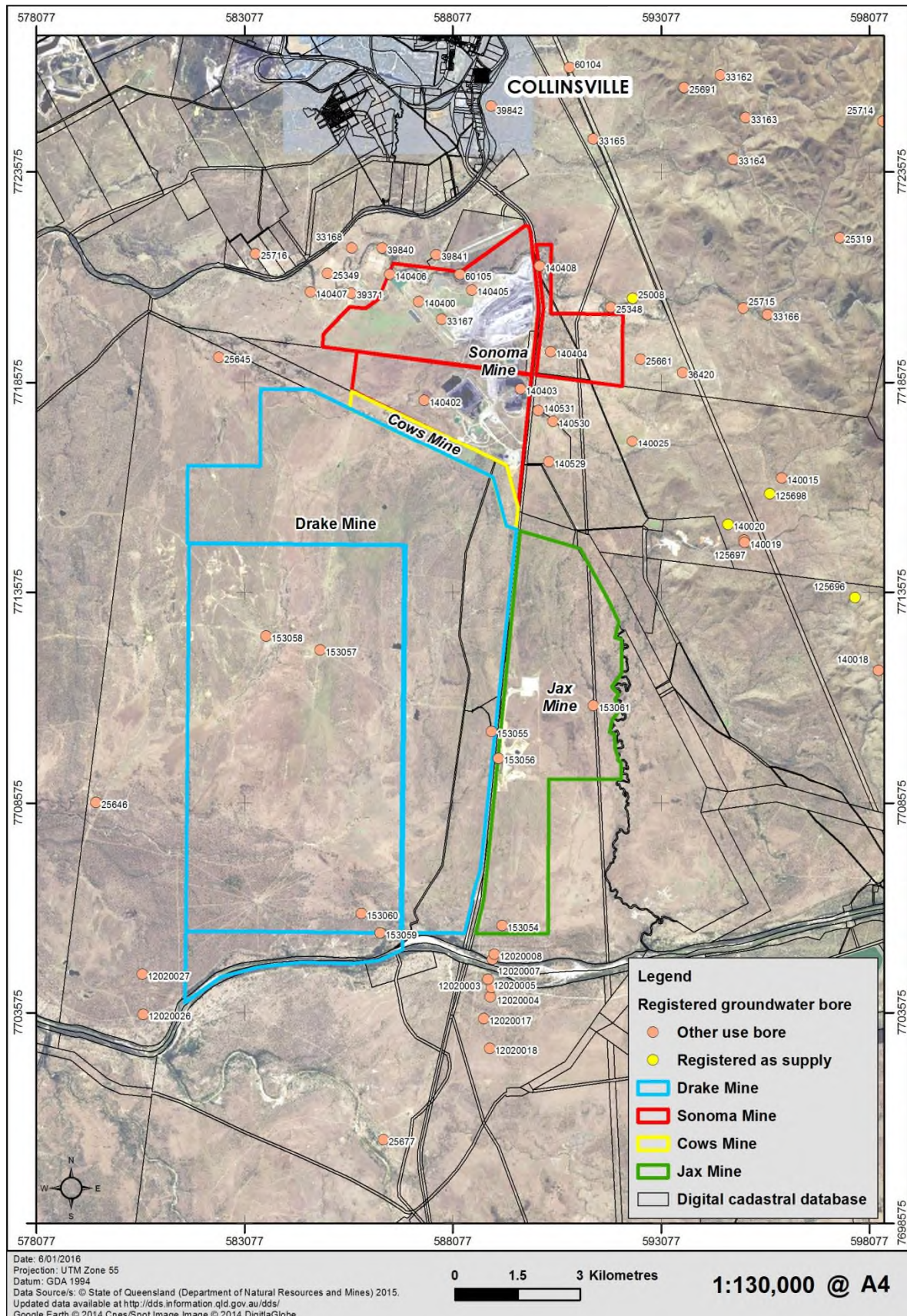


Figure 8 – DNRME GWDB figure from 2016 Sonoma Final Void Investigation

4.2.5 Summary

The four potential groundwater values of the northern QNH are listed in **Section 4.2** and discussed respectively in **Section 4.2.1** to **Section 4.2.4**. A summary of those findings is as follows:

- surface water in the vicinity of the QNH is not reliant on groundwater for baseflow and, as such, is not considered a groundwater value;
- springs, wetlands and GDEs are not considered a groundwater value for the QNH;
- stygofauna is not considered a groundwater value for the QNH; and
- groundwater use (conservatively including pastoral, irrigation, stock and domestic supply) is not considered a groundwater value across the QNH (CCM and SCM).

It has been concluded through a range of previously completed studies listed in **Section 4.1**, as well as operational environmental monitoring data (specifically groundwater monitoring), that groundwater in the QNH area has minimal value. Therefore, any changes in groundwater associated with drawdown resulting from the presence of the QNH final voids will not have notable impacts.

However, as a conservative measure, this investigation includes a modelling assessment of the potential level changes which may occur to the surrounding groundwater (e.g. modelled drawdown curve), and an associated void lake water balance (level and quality). The modelling assessments quantify the potential changes to groundwater resulting from QNH final voids.

5 QNH Final Voids

5.1 Definitions

With the advancing highwall – progressive backfilling method of open cut mining adopted at the QNH, a pit remains when mining of the highwall ceases and the waste rock recovered as part of active mining is no longer available to continue advancing the low wall (progressive backfilling). Such pits are then available to support ongoing mining related activities such as bulk water storage, in-pit rejects disposal or as a designated location for waste rock to be dumped from adjacent mining pits.

Assuming the residual pit was not backfilled by in-pit rejects disposal or waste rock from adjacent mining, the void that remains is then considered the final void, which requires rehabilitation to the final landform (shape, size, slopes etc) as discussed in **Section 9**.

5.2 Authorised final voids, locations and catchments

On the QNH, there are 14 approved final voids, which are located on the SCM, DCM and JCM, with pits on the CCM having been backfilled with waste rock from adjacent mining operations on the DCM.

The SCM, DCM and JCM EAs contain conditions relating to the size, location, slopes and post-mining land use of authorised final voids (Table H1 in each EA). It is noted that the approved size of selected final voids in the DCM EA is a cumulative total area across multiple final voids in close proximity (a “complex” of pits).

Presented in **Table 3** are the approved final voids, the operational complexes to which they belong, the approved size, void outcome and wall slopes. Also shown in **Table 3** is the status of the pit for each approved residual void, with seven of the 14 approved voids having commenced mining and the remainder yet to be developed as pits.

For the final void and the associated rehabilitated waste rock dump details required by the modelling (such as layouts, geometry, storage curves, depths, heights and precise locations), the current “life-of-mine planning” (LOMP) was used in combination with actual operational progression and observations for those pits and dumps which have commenced. For pits and dumps which have yet to commence the final void details were informed by the LOMP and by operations in adjacent pits. It is noted that the LOMP is updated and changes frequently during the life of a mine and, as such, for pits or dumps planned for commencement years into the future, the specific planning is likely to change.

Additionally, it is noted that:

- the DCM final voids “Central 3” and “Central 4”, as named in the DCM EA, are referred to in this assessment as “Drake Pit 4 North” and Drake Pit 4 South” respectively due to changes in naming conventions; and
- specific assessment of East Pit 1 (Drake) has been excluded from this assessment at this time due to its proximity to Drake 1 Pit (its hydrological processes would be dominated by Drake Pit 1 and East Pit 1 may potentially be amalgamated into Drake Pit 1 at a later date).

The locations of the final voids modelled as part of this assessment are presented in **Figure 9** along with the assumed areas of rehabilitated waste rock dumps from which runoff reports to the respective voids (the catchments). Catchment definition is required to quantify rainfall runoff inflow into a void as part of water balance modelling.

Table 3 – QNH approved final voids (as per SCM, DCM and JCM EAs)

Site	QNH Operational Complex	Approved Void Name	Approved Void Area	Approved Void Outcome	Pit status	Approved High Wall Slope	Approved Low Wall Slope
Jax	Jax	Jax Main Pit	70 ha	Residual void unable to sustain a post mining land use	Commenced	High wall – 60°	Low wall – 32°
		Jax East Pit	27 ha	Residual void unable to sustain a post mining land use	Planned		
Sonoma	Sonoma	Sonoma Main Pit	120 ha	<i>Not specified in EA</i>	Commenced	High wall – Maximum slope of 70° with the top 10m having a maximum of 45° including a 1m bund	Low wall – 17°-37°
		Sonoma East Pit 1	14 ha	<i>Not specified in EA</i>	Planned		
		Sonoma East Pit 2	15 ha	<i>Not specified in EA</i>	Planned		
Drake	Drake 5	Drake Pit 5	59 ha	<i>Not specified in EA</i>	Commenced	High wall – 65°	Low wall – 45°
	Drake 1-2	Drake Pit 1	258 ha	<i>Not specified in EA</i>	Commenced		
		Drake Pit 2		<i>Not specified in EA</i>	Commenced		
		Drake Pit 2 Expansion		<i>Not specified in EA</i>	Planned		
		East Pit 1	14 ha	<i>Not specified in EA</i>	Planned		
	Drake 3-4	Central Pit 3 (Drake Pit 4 North)	50 ha	<i>Not specified in EA</i>	Planned		
		Central Pit 4 (Drake Pit 4 South)	16 ha	<i>Not specified in EA</i>	Planned		
		Drake Pit 3-Q	61 ha	<i>Not specified in EA</i>	Commenced		
		Drake Pit 3-R		<i>Not specified in EA</i>	Commenced		

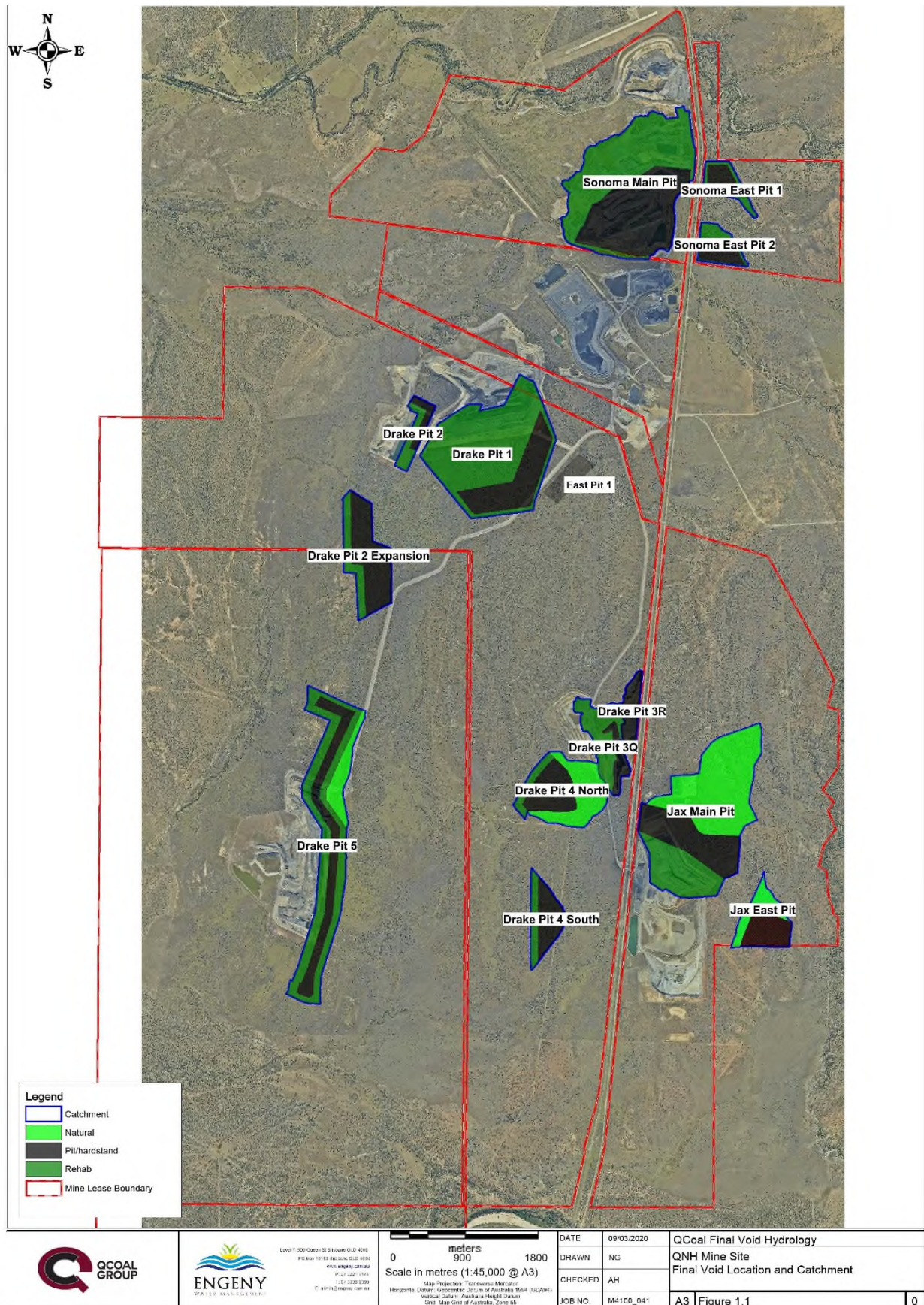


Figure 9 – QNH final void locations and catchments (adapted from Engeny (2020))

5.3 Final void storage curves

The storage curves of the final voids (i.e. the relationship between level, area and volume within a void) are a key input for the water balance and numerical groundwater modelling, and are derived from the geometry of the final voids.

Storage curves for the Jax Main Pit and Jax East Pit final voids are described and plotted in detail in Engeny (2108), provided as **Appendix A** to this assessment. Storage curves for all other QNH voids are described and plotted in detail in Engeny (2020), provided as **Appendix B** to this assessment.

The final void volumes extracted from the storage curves for all QNH voids are presented in **Table 4**.

Table 4 – Void capacity to crest (ML)

Void	Capacity to crest (ML)
Jax Main Pit	32,000 Engeny (2018)
Jax East Pit	11,000 Engeny (2018)
Sonoma Main Pit	45,151 Engeny (2020)
Sonoma East Pit 1	1,788 Engeny (2020)
Sonoma East Pit 2	2,009 Engeny (2020)
Drake Pit 5	13,996 Engeny (2020)
Drake Pit 1	18,323 Engeny (2020)
Drake Pit 2	1,711 Engeny (2020)
Drake Pit 2 Expansion	15,824 Engeny (2020)
East Pit 1	refer Section 5.2 .
Central Pit 3 (Drake Pit 4 North)	6,160 Engeny (2020)
Central Pit 4 (Drake Pit 4 South)	3,708 Engeny (2020)
Drake Pit 3-Q	2,326 Engeny (2020)
Drake Pit 3-R	1,254 Engeny (2020)

6 Groundwater Model (hydrogeology)

6.1 Model Development

AGE (2020) is a numerical groundwater modelling scope, the results of which have been inserted into this assessment.

A 3D numerical groundwater model was developed that covers the QNH mining leases. The model represents the weathered regolith and underlying Permian strata. Each key coal seam is represented as an individual model layer, as well as the interburden units that separate the coal seams. Most coal seams simulated are within the Moranbah Coal Measures, but also include the lower seam of the Fort Cooper Coal Measures. The base model layer represents the Exmoor Formation.

The modelling uses the unstructured version of the industry standard MODFLOW model (MODFLOW-USG). MODFLOW-USG uses a control volume finite difference scheme to represent the groundwater flow equation. The model is transient and simulates pre mining water levels through a steady state timestep, followed by transient annual timesteps representing both historical and future mining. The model has been calibrated against historical groundwater monitoring data. The model also simulates recovery of the groundwater system post mining, where hydraulic properties are changed within the pits to represent spoil emplacement and final voids.

The open cut mining at QNH is represented in the model using the Drain package. The drains are applied to each model layer within the mined out areas and groundwater is removed to create the desaturated conditions within the open cut pits. This drawdown then propagates away from the pits as water from the surrounding groundwater system flows through the ground towards the pits due to the gradients created by the desaturated conditions. The coal seam (and model layer) that the pit floor is in varies across the site due to the basin shape and accessibility of seams in different areas.

The mining is conservatively represented in the model by maintaining the dewatering (leaving the drain boundary on) once mining has started. This is done also to simplify the model setup, with all pits changed to spoil / void properties at the same time. This means that for pits such as Drake 3Q and 3R, which have completed mining and recovered, they continue to be dewatered in the model until all other pits have completed mining.

6.2 Groundwater level predictions

Presented in **Figure 10**, is the predicted water level in layer 1 for the end of mining with all pits dewatered. This prediction is representative of the water table, with some areas across the model domain layer 1 being fully unsaturated, in which case the predicted level resides in lower model layers. Predicted water levels in lower layers reflect these contours, though any sharp changes in level in higher levels tend to be gradually muted with depth. Due to the low permeability of the geology, predicted (and observed) impacts to the surrounding groundwater system remain local to the pits. The water levels in this figure become the starting point for the recovery simulation.

The recovery process is simulated by assuming recharge to the spoil and voids, factoring in evaporative losses to the void lakes. The level of recovery is controlled by the balance of water coming in from rainfall derived recharge and groundwater inflow as inputs and the loss due to evaporation from the void lake.

Recharge rates into the void and into the in-pit spoil are much higher than the undisturbed recharge rate calibrated for the model, which is conceptually expected as backfilled spoil has higher porosity and permeability than undisturbed material.

Presented in **Figure 11** is the predicted groundwater in layer 1 at year 10 after end of mining, and presented in **Figure 12** is the predicted groundwater in layer 1 at equilibrium, which show the following:

- the extent of groundwater change is largest at equilibrium due to the continued dewatering offered by evaporation from void lakes that equilibrate below the pre mining water levels;
- some of the pits have been predicted to have a hydraulic gradient back into the surrounding geology (a net outflow) particularly where they have been completely backfilled or where the void footprint is small. Those pits are Drake 3Q, Drake 3R and Sonoma East 2:
 - o A potential issue with such modelling outputs is the assumption that it indicates a migrating of water away from void. This assumption is not correct in the case of the QNH voids due to the proximity and influence of adjacent final voids. With this in mind, the predicted equilibrium water levels have been forensically interrogated to identify that all these potential sources are predicted to be intercepted by the larger and deeper voids (such as Drake 1, Drake 5, Sonoma East 1, and Jax 1), and will not migrate away from the site.
 - o More broadly the model identifies some minor movement of water between some of the smaller voids towards adjacent voids, while all other voids remain as groundwater sinks. In summary, the QNH voids when assessed as complexes are all groundwater sinks and the QNH when assessed cumulatively is a groundwater sink with no migration away from the QNH. To illustrate this outcome groundwater flow directions have been added to **Figure 12**.

Presented in **Figure 13** is the predicted groundwater in layer 1 at equilibrium with the bores registered as supply bores (**Section 4.2.4**). All bores are located outside of the extent of the cone of depression.

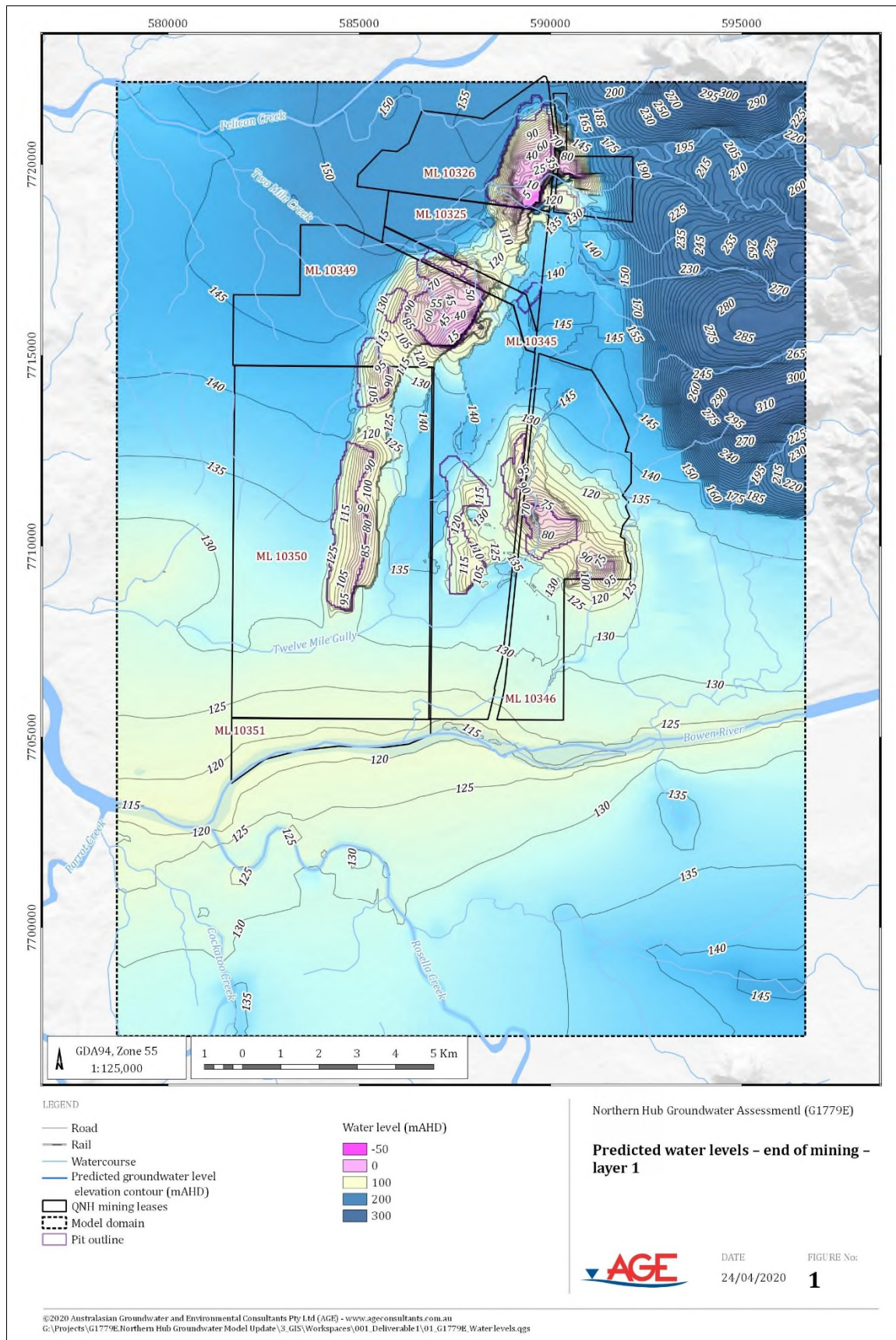


Figure 10 – Predicted groundwater levels end of mining – model layer 1

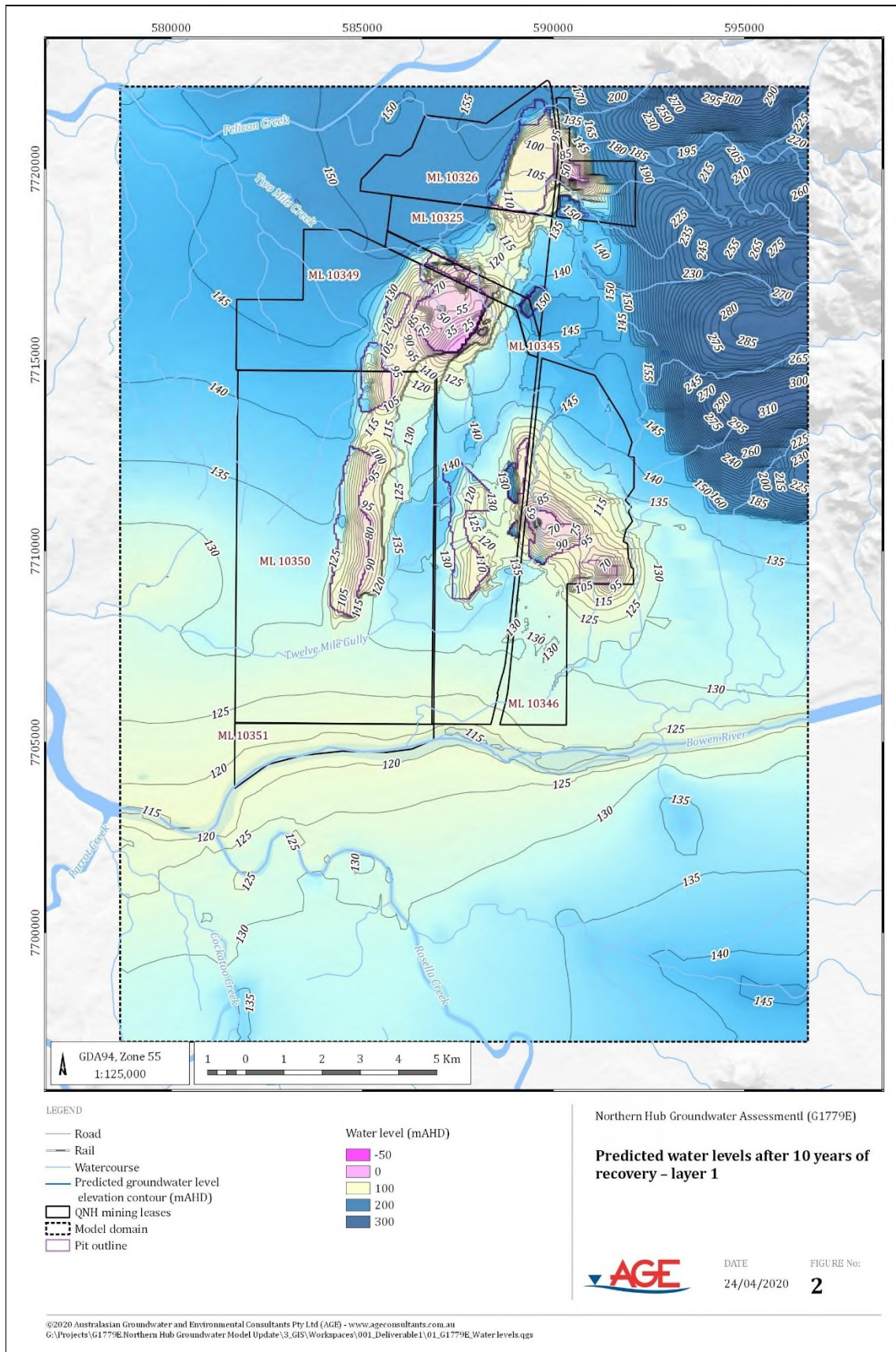


Figure 11 – Predicted groundwater levels year 10 after mining – model layer 1

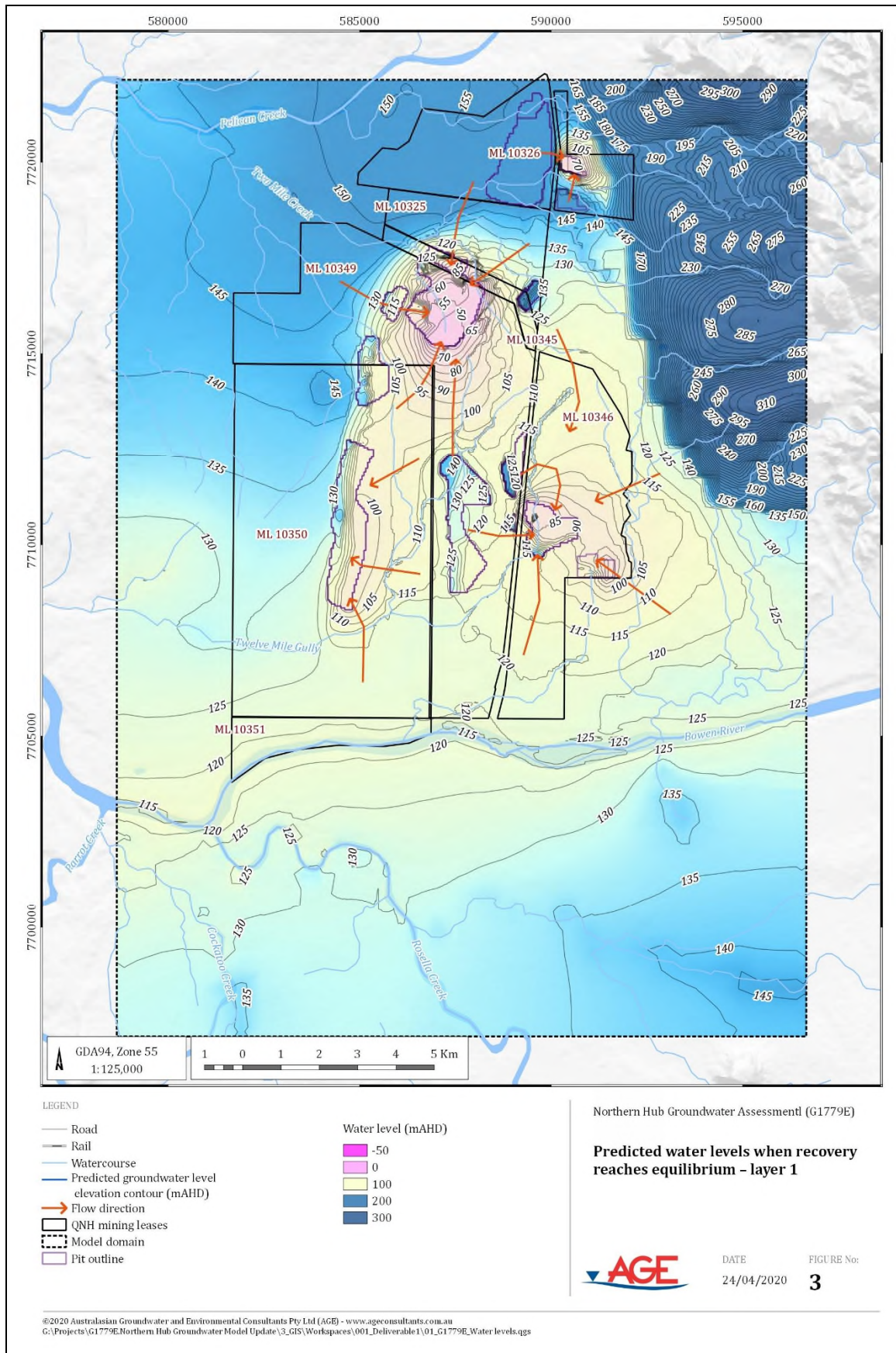


Figure 12 – Predicted groundwater levels equilibrium – model layer 1

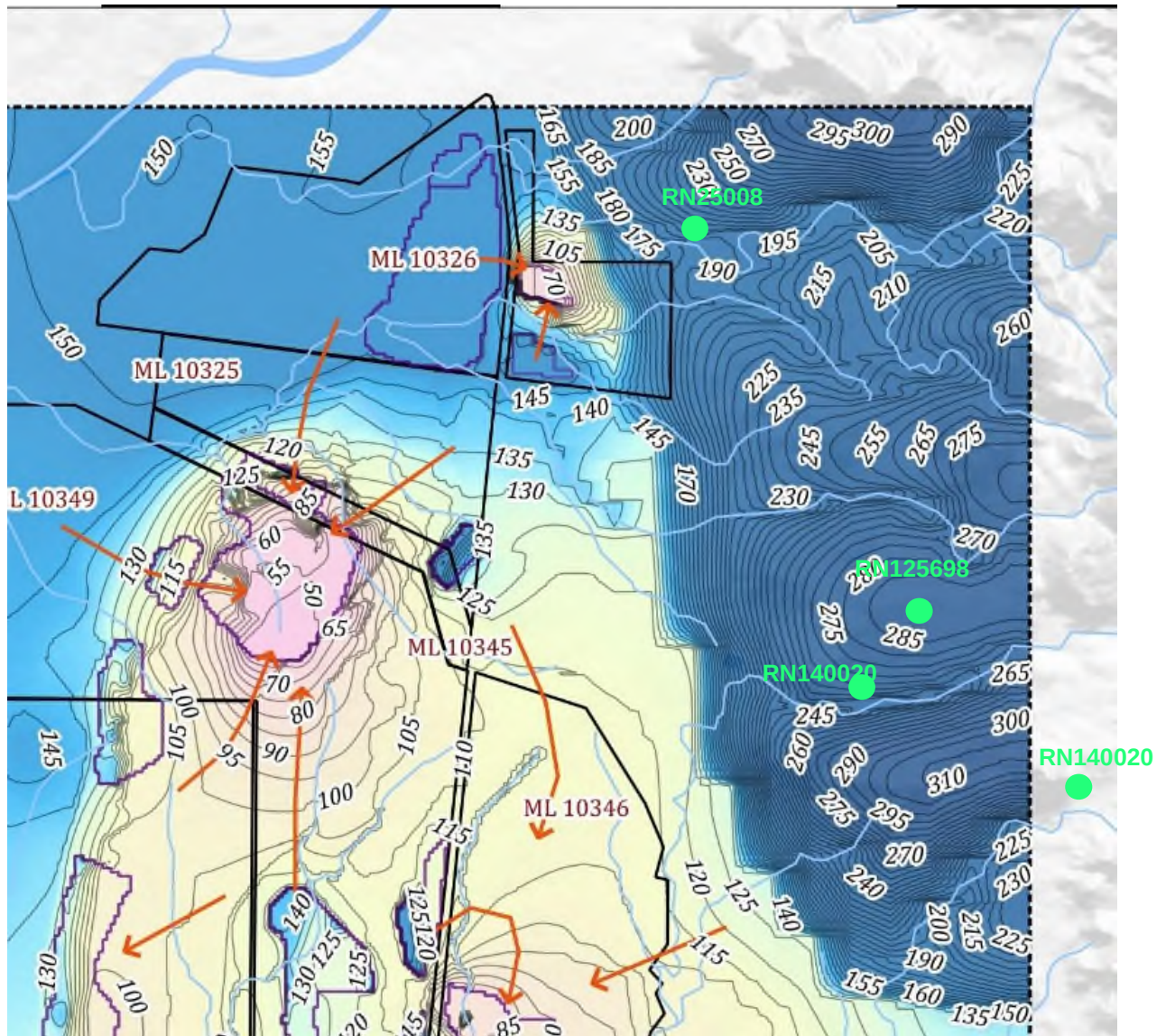


Figure 13 – Predicted groundwater levels equilibrium layer 1 and registered supply bores

7 Water Balance Model Inputs

7.1 Conceptual void hydrology

The water balance of the QNH final voids will be governed by the following water inflows and outflows:

- Inflows:
 - Surface runoff inflows from rehabilitated spoil areas that drain to the void.
 - Surface runoff inflows from the walls and ramps of the void.
 - Inflows from incident rainfall on the void lake.
 - Groundwater inflows to the void (nominally where void lake level is lower than regional groundwater).
- Continuous outflows:
 - Outflows due to evaporation losses from the surface area of the void lake.
- Hypothetical outflows (conditional on void lake level):
 - Seepage outflows from the void lake – potential to flow into an adjacent groundwater sink void or into the unsaturated low-wall waste rock dump or into the local groundwater system if not contained by the cumulative cone-of-depression surrounding the QNH voids.
 - Discharges to surface water (conditional on maximum void lake levels relative to crest height).

7.2 Groundwater recovery curves

Numerical groundwater modelling of the design residual voids was undertaken by AGE (2018) for Jax Main Pit and Jax East Pit, and by AGE (2020) for all other QNH voids, to predict groundwater recovery after the cessation of mining. From those modelling studies a rating curve of groundwater inflow versus pit water level for each residual void was developed which is required for the water balance modelling of the final voids.

Groundwater recovery curves for the Jax Main Pit and Jax East Pit final voids are described and plotted in detail in Engeny (2108), provided as **Appendix A** to this assessment. Groundwater recovery curves for all other QNH voids are described and plotted in detail in Engeny (2020), provided as **Appendix B** to this assessment.

It is noted that the range of the groundwater recovery curves is limited by the water levels simulated in the groundwater model. Where required, the final value of the groundwater recovery curves have been conservatively extrapolated for the remainder of the adopted void storage curve values.

Negative flows shown in the groundwater recovery curve figures indicate the elevation of water level within the lake is generating a hydraulic gradient out of the void lake, at which point a net outflow from the void lake can potentially occur. **Any modelled outflows from a void lake resulting from these portions of the groundwater recovery curves need to be interpreted with care and may not necessarily indicate flows to the surrounding regional groundwater system.** It is understood that the adopted groundwater recovery curves are impacted by the following processes:

- Interaction between residual void lakes located in close proximity, such as hydraulic gradients between void lakes resulting in flow from one void lake to another, which **is not considered flow into the surrounding regional groundwater** (e.g. as has been identified between Sonoma East 1 and Sonoma East 2 and between Drake 3Q and Drake 3R). It is noted that the modelled flow rates in these situations are generally of very small magnitude.
- Outflows from the void lakes into the surrounding spoil material. **The groundwater recovery curves make no distinction between outflows from the void lake into the low-wall backfill material, outflows into an adjacent void or outflows into the regional groundwater system.** As such, a modelled outflow as determined by the model may be associated with the saturation period of the low-wall waste rock until such time as steady state equilibrium is reached. This primarily occurs during the initial recovery period when the spoil material is first becoming saturated.

The interaction between the residual void lake and surrounding regional groundwater (be it net inflow or outflow) considers a range of indicators including:

- Base of Weathering – the threshold between highly weathered material and less permeable hard rock. The base of weathering provides an indication of areas where seepage from a void lake into the surrounding geology might occur if lake levels are forecast to exceed this threshold. Again, such seepage is not immediately representative of a groundwater source into regional groundwater.
- Regional Groundwater Level – when the regional groundwater level exceeds the forecast void lake level then there is a hydraulic gradient into the void and the void is considered to act as a groundwater sink. Alternatively, a void lake level that is forecast to be above the regional groundwater level may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow), but, again, a net outflow is not immediately representative of a groundwater source into regional groundwater.
- Net Zero Flow Level – This level is extracted from the groundwater recovery curves and provides an indication of the direction of water fluxes to the void lake. **As previously stated, outflows resulting from these recovery curves need to be interpreted with care as they may represent movement from one void (a net outflow) to an adjacent void which is a groundwater sink (a net inflow), thus containing void water from both voids (considered as movement within a groundwater sink system), or movement of water into unsaturated low wall spoil material, as opposed to an actual flow into the regional groundwater system.**

A summary of indicator levels for each QNH final void is summarised in **Table 5**.

Table 5 – Base of weathering and regional groundwater levels

Mine Site	Residual Void	Base of Weathering (mAHD)	Pre- mining Regional Groundwater Level (mAHD)	Net Zero Flow Level (mAHD)
Jax	Jax Main Pit	149.78	140	
	Jax East Pit	146.72	140	
Sonoma	Sonoma Main Pit	153.02	155.67	8.23
	Sonoma East Pit 1	155.80	156.30	Inflows at all levels
	Sonoma East Pit 2	156.92	155.53	Outflows at all levels
Drake	Drake Pit 5	144.39	137.42	Inflows at all levels
	Drake Pit 1	169.07	146.57	Inflows at all levels
	Drake Pit 2	153.4	147.23	100.11
	Drake Pit 2 Expansion	163.99	144.24	Inflows at all levels
	East Pit 1	refer Section 5.2.		
	Central 3 (Drake Pit 4 North)	126.96	139.50	Inflows at all levels
	Central 4 (Drake Pit 4 South)	146.72	136.71	Inflows at all levels
	Drake Pit 3Q	161.28	142.55	Inflows at all levels
	Drake Pit 3R	156.72	141.78	83.15

7.3 Rainfall and evaporation data

Engeny (2020) provides detail on the climate data used for the water balance model. Long-term daily rainfall data at the QNH was obtained from the SILO climate database facility hosted by DES. SILO includes both Patched Point Data and Data Drill. The Data Drill utilises grids of data interpolated from point observations by the Bureau of Meteorology to provide climate statistics for a specified location. Patched Point Data is only available at selected rainfall stations and utilises grids of data to 'patch' any data gaps in the climate record at that site. A SILO Patched Point Data climate series was obtained for the nearby Collinsville Post Office (33013) covering the period January 1889 to September 2019. A composite data set was obtained by merging the SILO data with SCM site rainfall to obtain a continuous record from January 1889 to September 2019 (130 years of data).

The largest single day rainfall event measured as 348.7 mm (08/04/1940) and the largest seven day total measured as 454 mm (02/02/1991 – 08/02/1991),

Corrections to the lake evaporation rates were applied in the residual void water balance model to reflect the reduction to the freshwater evaporation rate that occurs for a saline water body. Morton's method for adjusting evaporation rates has been adopted as presented in Hydrological Recipes: Estimation Technique in Australian Hydrology (1996). The method predicts a relatively small evaporation correction for salinity of approximately 1% reduction per 10,000 mg/L total dissolved solids (TDS) for TDS values up to 50,000 mg/L (i.e. 5% reduction for 50,000 mg/L TDS).

7.4 Runoff rates and quality

Engeny (2020) provides detail on the assumed rates and quality of runoff used for the water balance model. Catchment runoff has been simulated using the Australian Water Balance Model (AWBM). The model represents the catchment using three conceptual surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the baseflow store if there is a baseflow component to the stream flow. AWBM parameters were adopted from the existing QNH operational water balance model (as for “*Water Management Plan QNH Mines*” (Engeny, 2019)). These parameters are as summarised in **Table 6**.

Table 6 – Adopted AWDM Runoff Parameters

Parameter	Natural	Hardstand & Pits	Rehabilitated Spoil
C1 (mm)	23.0	5.0	10.0
C2 (mm)	125.0	20.0	120.0
C3 (mm)	180.0	40.0	180.0
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
3	0.433	0.433	0.433
BFI	0.05	0.00	0.35
Kb	0.87	0.60	0.60

For the assessment of final voids, a single indicator parameter is adopted by the water balance modelling to predict dilution and concentration cycles in the void lake. Salinity is the industry standard indicator parameter. Salinity of runoff generated in the water balance is determined based on land use type. Surface water runoff total dissolved solids (TDS) characteristics have previously been calibrated for certain land use types as documented in “*Water Management Plan QNH Mines*” (Engeny, 2019). These runoff TDS characteristics have been adopted for the modelling of the QNH voids and are summarised in **Table 7**.

Table 7 – Adopted runoff quality

Source	Salinity (mg/L)
Pit wall runoff	1300 (1,931 μ S/cm EC)
Rehabilitated Spoil runoff	700 (1,040 μ S/cm EC)
Natural catchment runoff	700 (1,040 μ S/cm EC)
Direct rainfall	5 mg/L, based on latitude and distance from the coast (DNR, 1997)

7.5 Assumed groundwater quality

Monitoring of groundwater quality across a number of monitoring bores at QNH is undertaken on a quarterly basis. For the assessment of final voids, a single indicator parameter is adopted by the water balance modelling to predict dilution and concentration cycles in the void lake. Salinity is the industry standard indicator parameter.

The groundwater quality data has previously been assessed as part of the “*Sonoma Coal Mine Final Void Hydrology Study Main Pit 2015*” (Engeny, 2015) and “*Cows Coal Mine Final Void Hydrology Study Q Pit and B Pit 2017*” (Engeny 2017). Both studies determined a representative groundwater inflow quality of 2,000 $\mu\text{S}/\text{cm}$.

A consistent quality was adopted for the Jax Main Pit and Jax East Pit final voids as described in Engeny (2108), provided as **Appendix A**, and for all other QNH voids as described in Engeny (2020), provided as **Appendix B**.

8 Water Balance Model Results

8.1 Final void lake levels

The final void lake volume and level modelling (including sensitivity analysis) for the Jax Main Pit and Jax East Pit final voids, is described and plotted in detail in Engeny (2108), which has been provided as **Appendix A**. The final void lake volume and level modelling for all other QNH final voids is described and plotted in detail in Engeny (2020), provided as **Appendix B**.

Results have been extracted from the above, and are presented in **Figure 14 - Figure 26**, with the following key information presented:

- the simulation period:
 - o 500 years for Jax Main Pit and Jax East Pit (presented for the first 100 years and the full 500 year simulation separately for both final voids)
 - o 200 years for all other QNH final voids
- minimum, median and max levels and volumes are presented for each day of the simulation period for all final voids;
- the observable oscillations are the drying/filling cycles associated with normal seasonal and climactic variations;
- the median has been used to define the equilibrium levels in this assessment;
- the crest/spill level, regional groundwater level and base of weathering assumed in the model is also presented on each figure for each final void:
 - o the additional information for Jax Main Pit and Jax East Pit is presented as an un-scaled schematic
 - o all other QNH final voids have this information presented as plotted data
- all results reported in this assessment are from modelling of the “base case” which is the catchment extent provided by the LOMP, except for Central 3 (Drake Pit 4 North), where an opportunity to refine the catchment boundary was identified during the modelling (referred to as the mitigated case). For ease of interpretation only the Central Pit 3 (Drake Pit 4 North) mitigated case is included within the body of this assessment; however, Engeny (2020) includes both the base and mitigated cases.

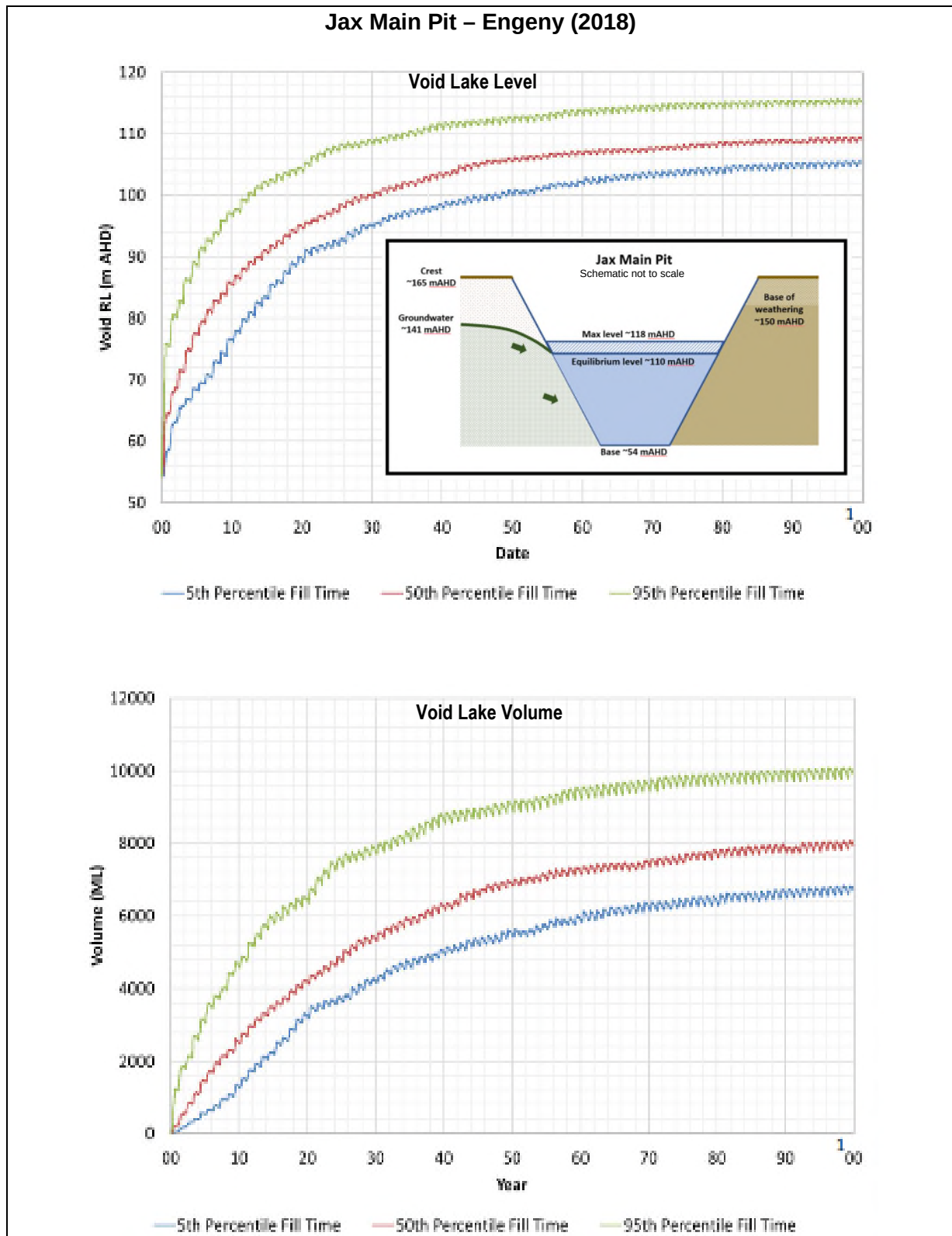


Figure 14 – Jax Main Pit final void water volume and level (base case)

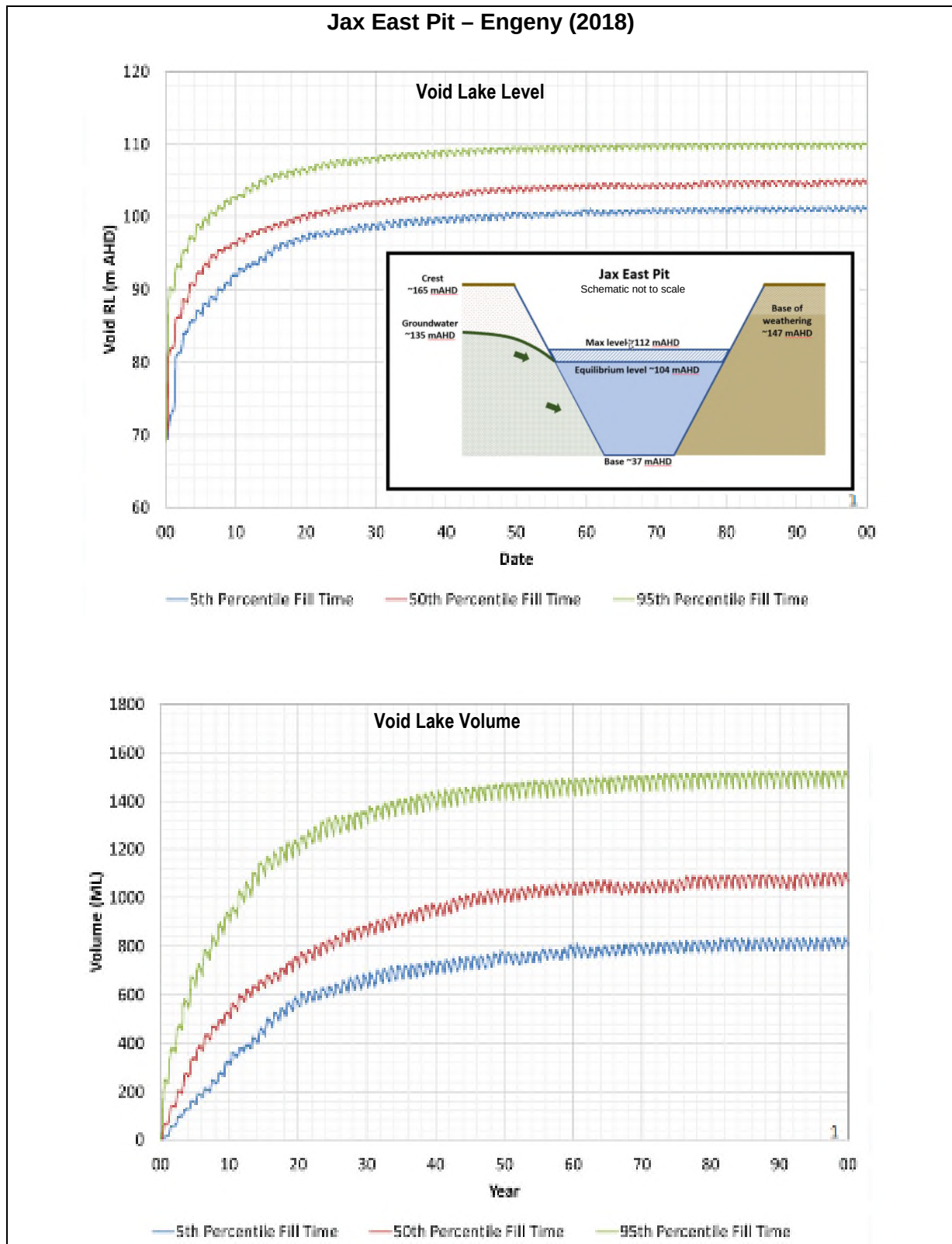


Figure 15 – Jax East Pit final void water volume and level (base case)

Sonoma Main Pit – Engeny (2020)

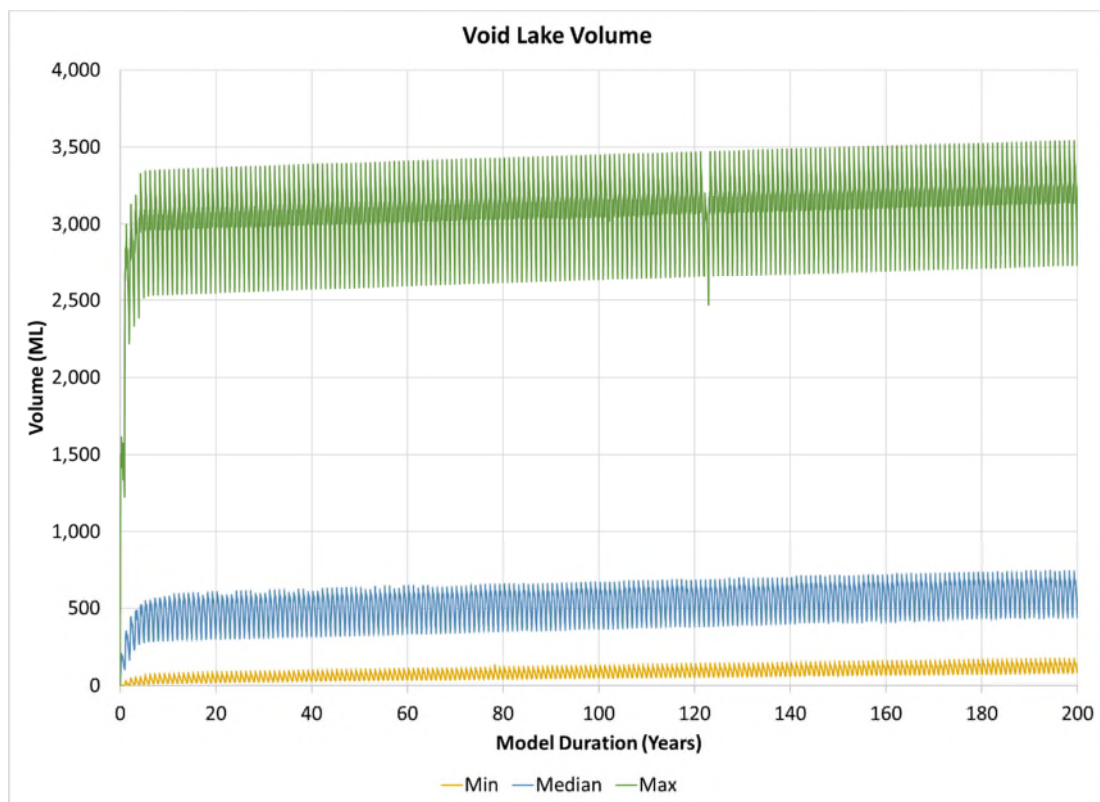
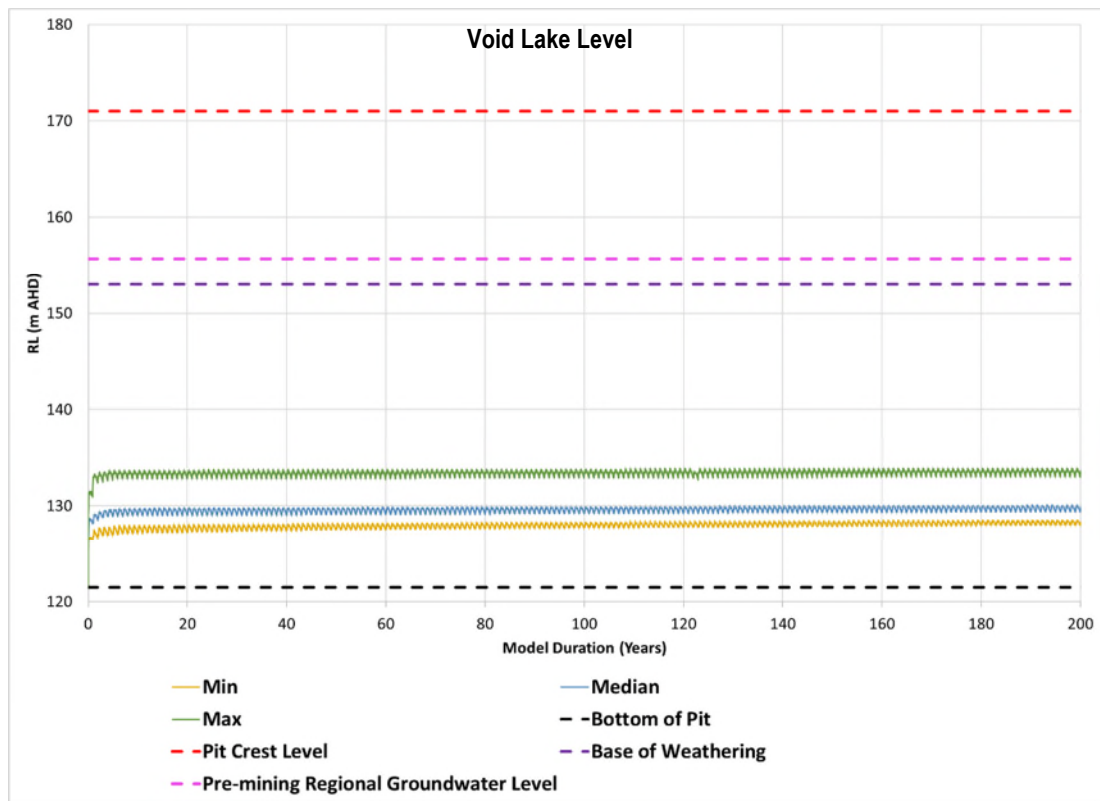


Figure 16 – Sonoma Main Pit final void water volume and level (base case)

Sonoma East Pit 1 – Engeny (2020)

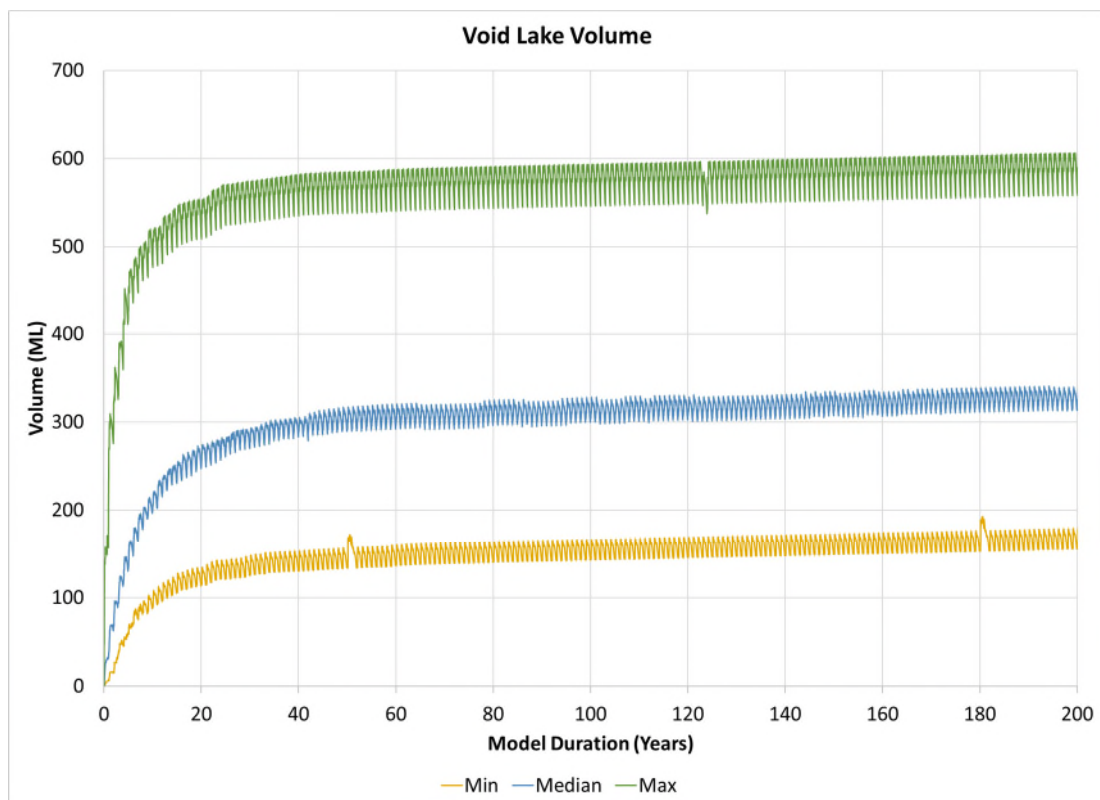
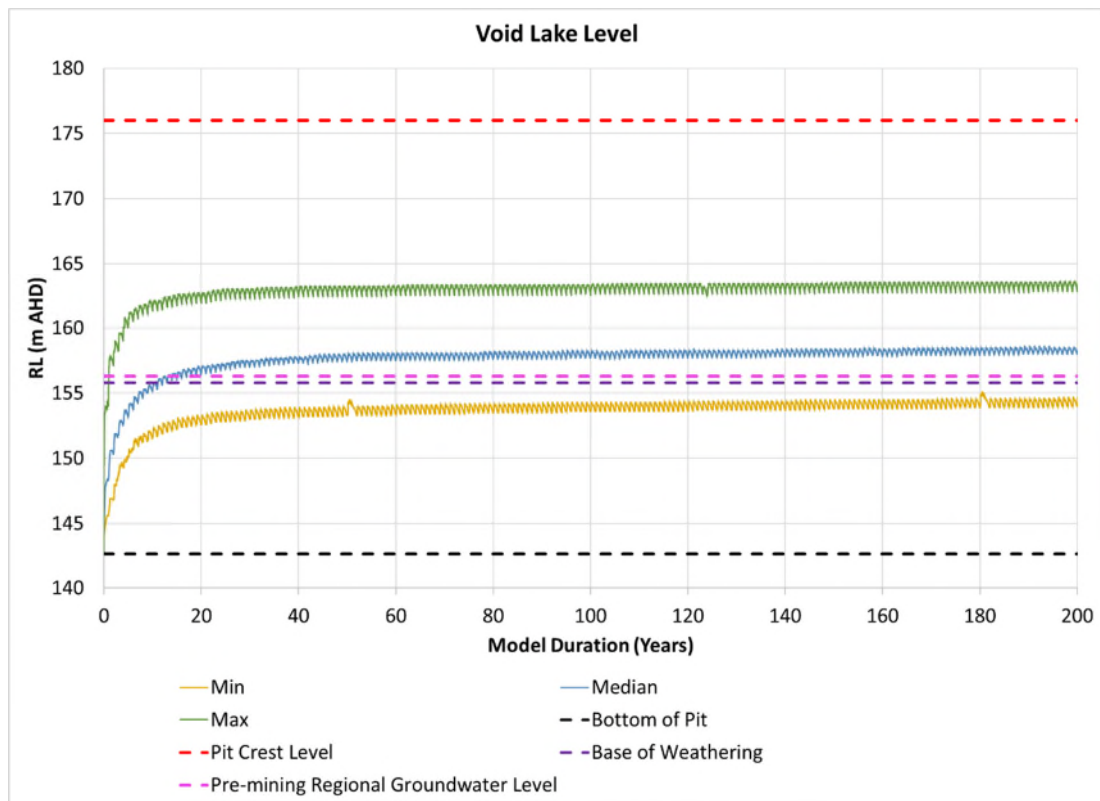


Figure 17 – Sonoma East Pit 1 final void water volume and level (base case)

Sonoma East Pit 2 – Engeny (2020)

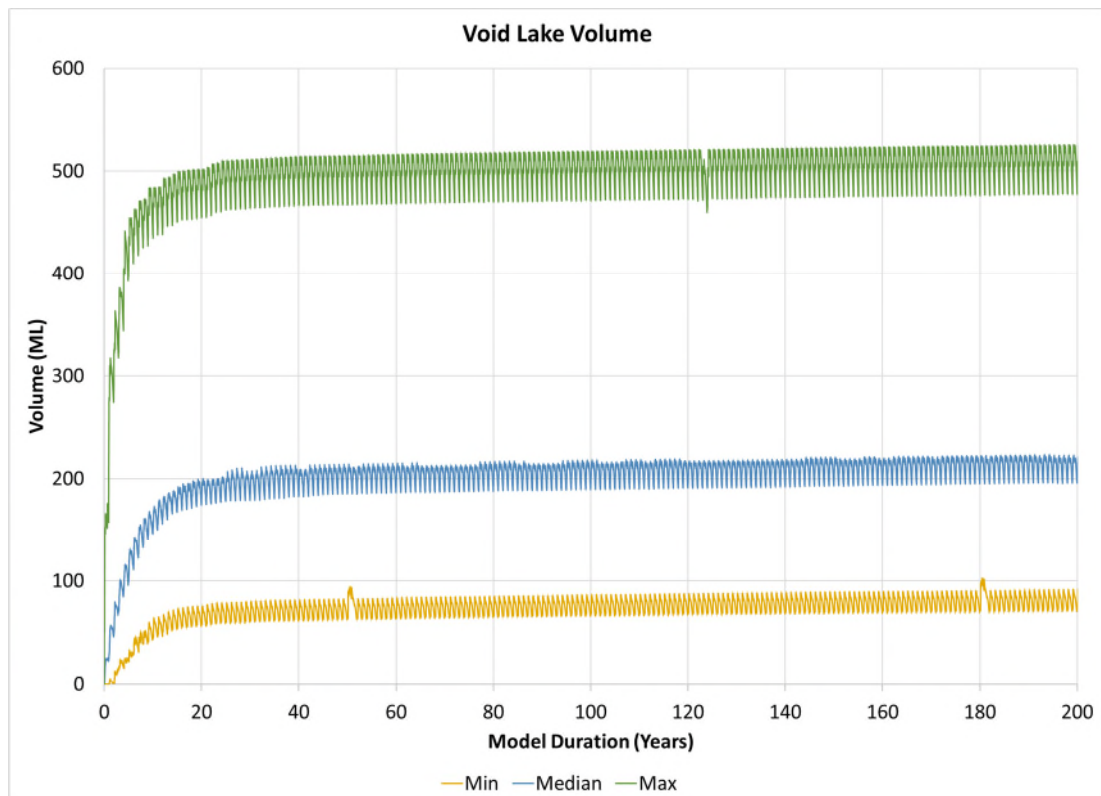
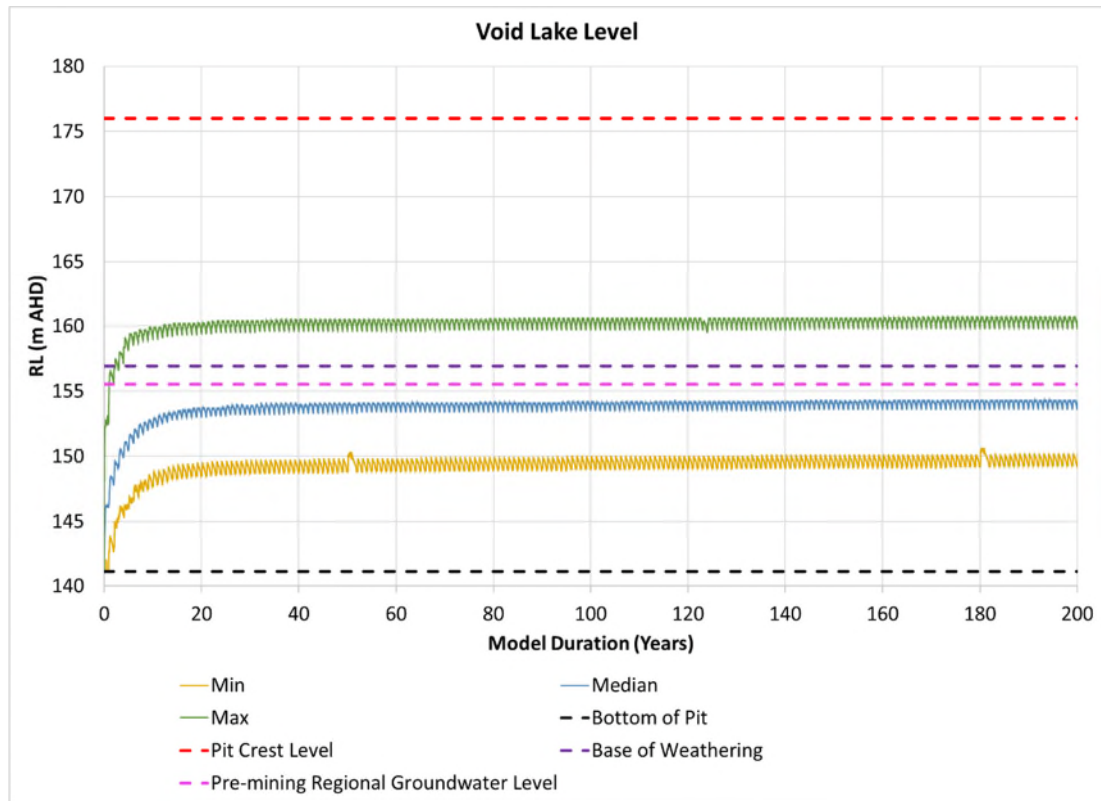


Figure 18 – Sonoma East Pit 2 final void water volume and level (base case)

Drake 5 Pit – Engeny (2020)

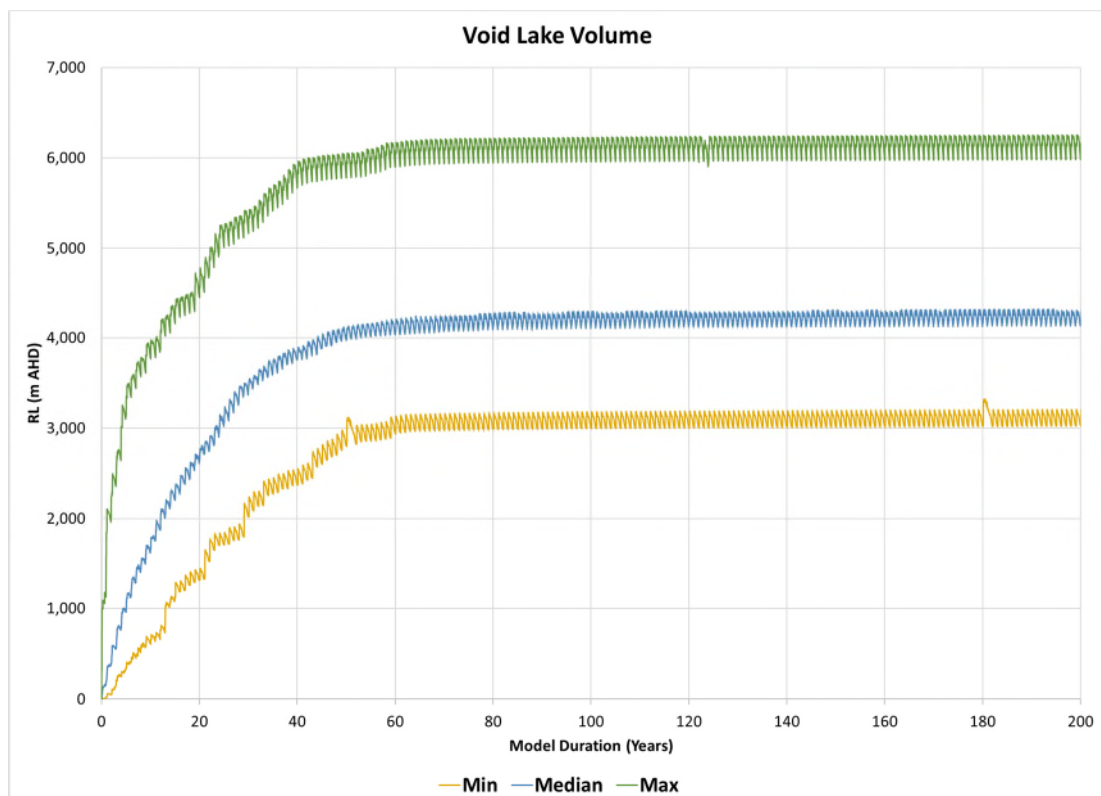
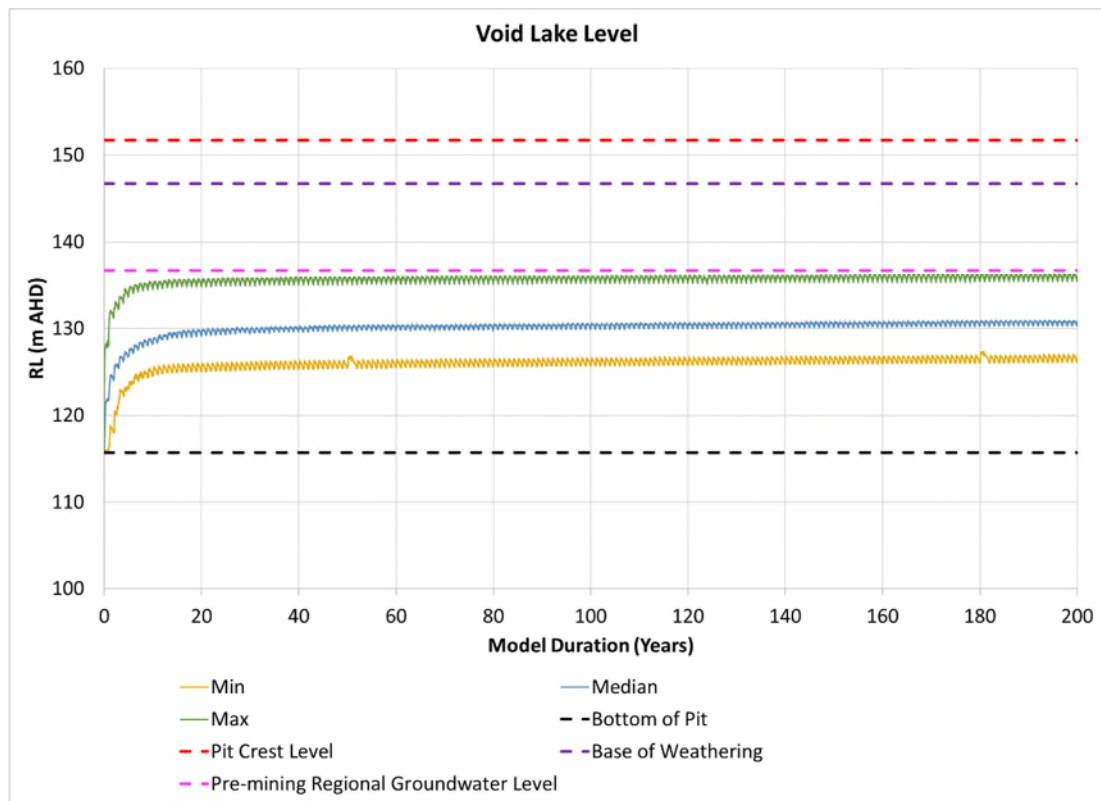


Figure 19 – Drake Pit 5 final void water volume and level (base case)

Drake 1 Pit – Engeny (2020)

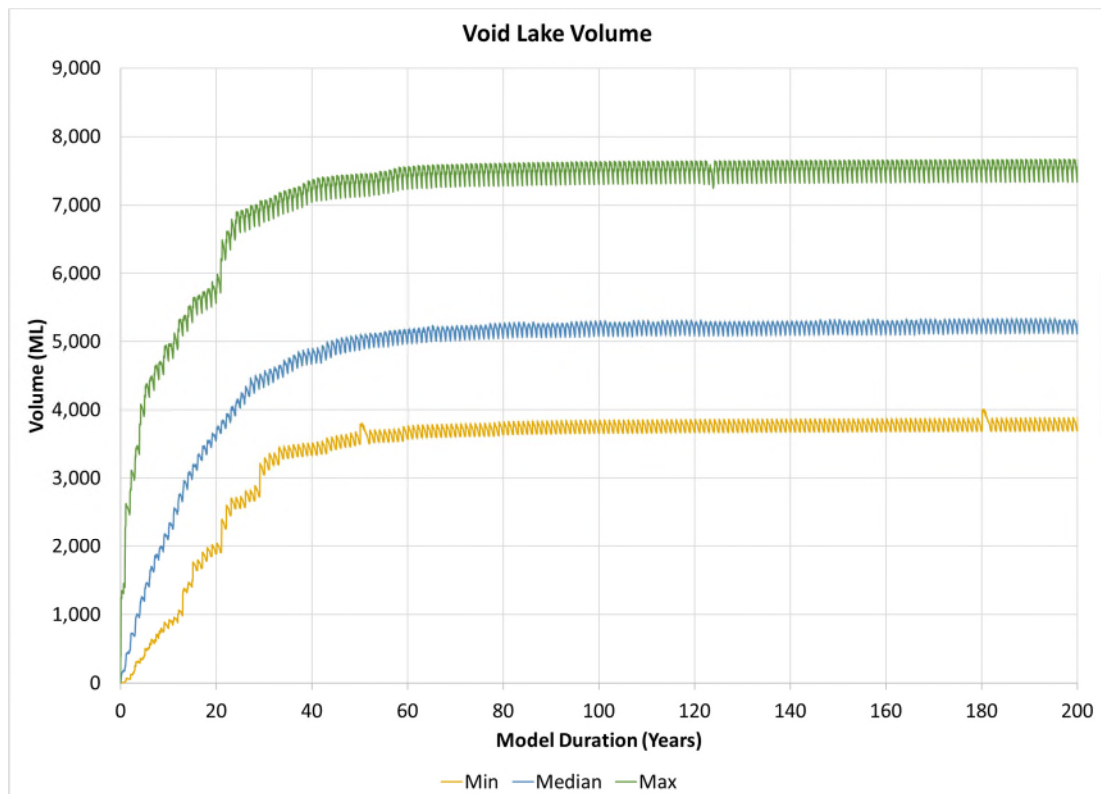
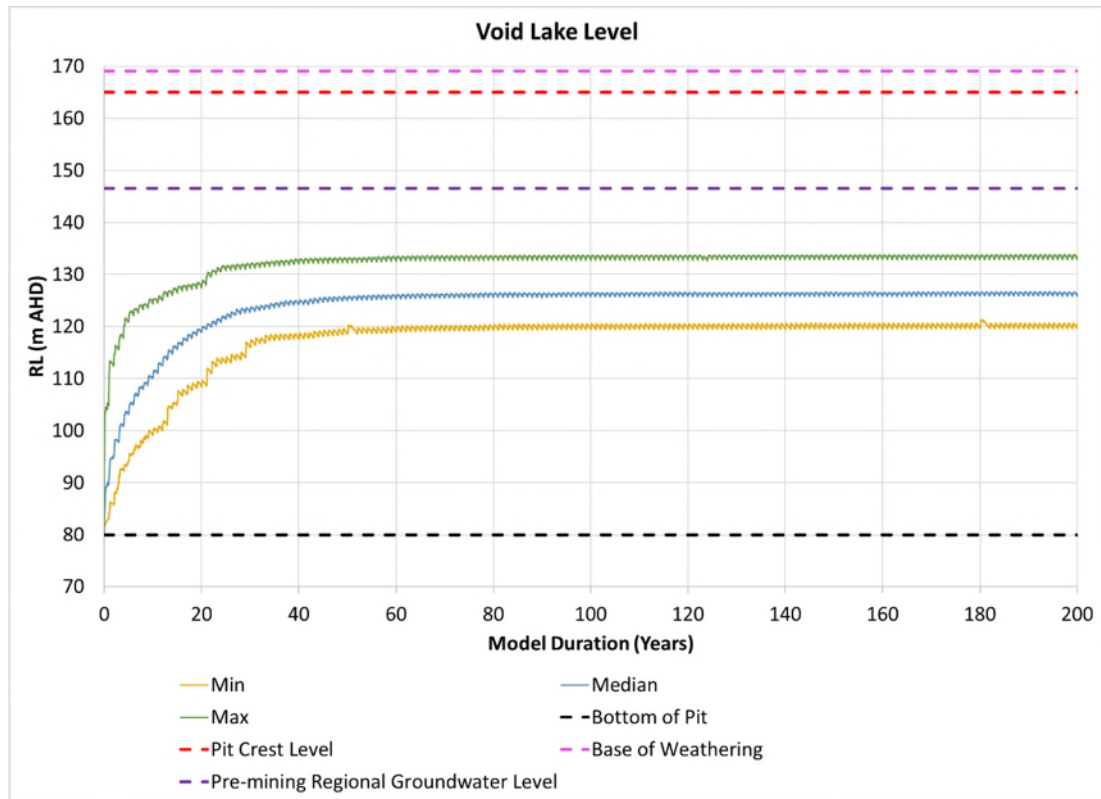


Figure 20 – Drake Pit 1 final void water volume and level (base case)

Drake Pit 2 – Engeny (2020)

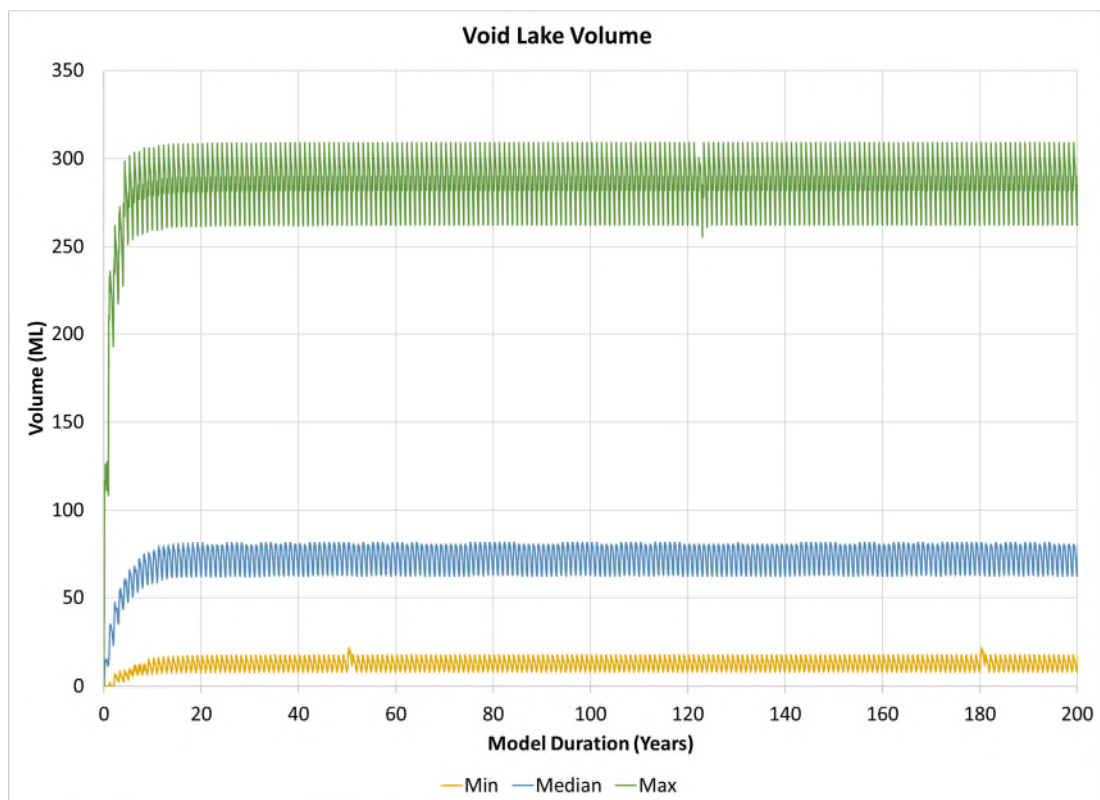
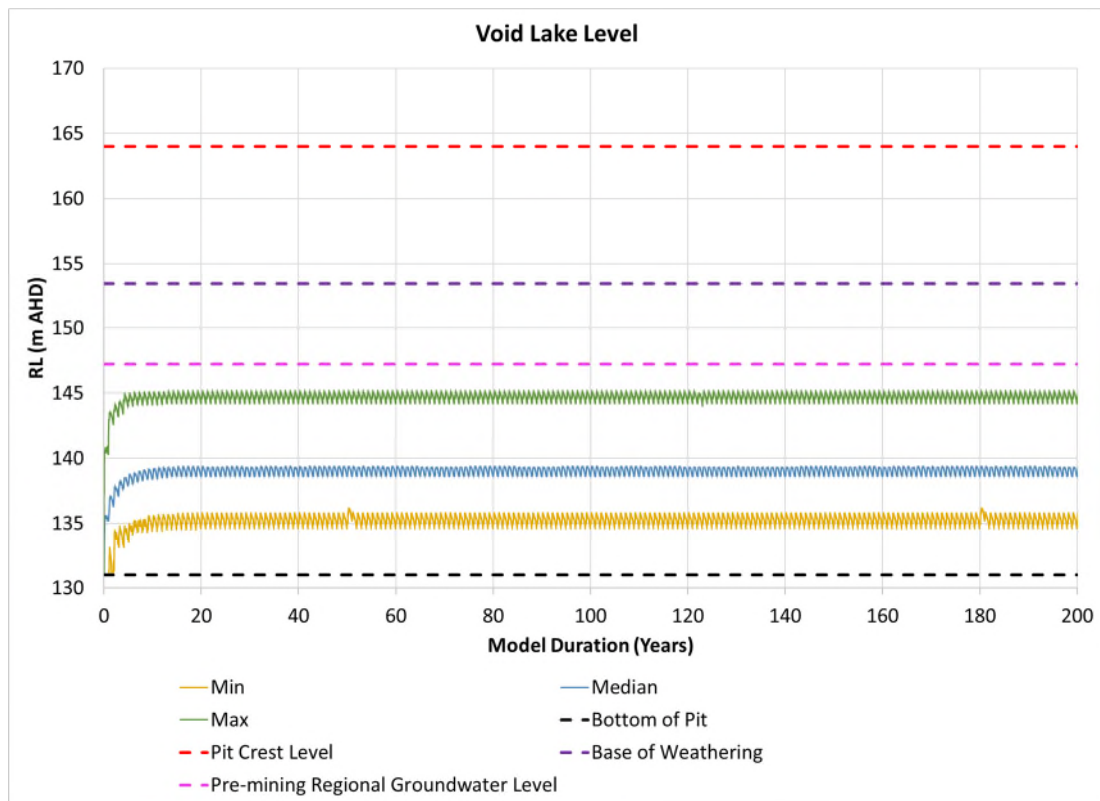


Figure 21 – Drake Pit 2 final void water volume and level (base case)

Drake Pit 2 Expansion – Engeny (2020)

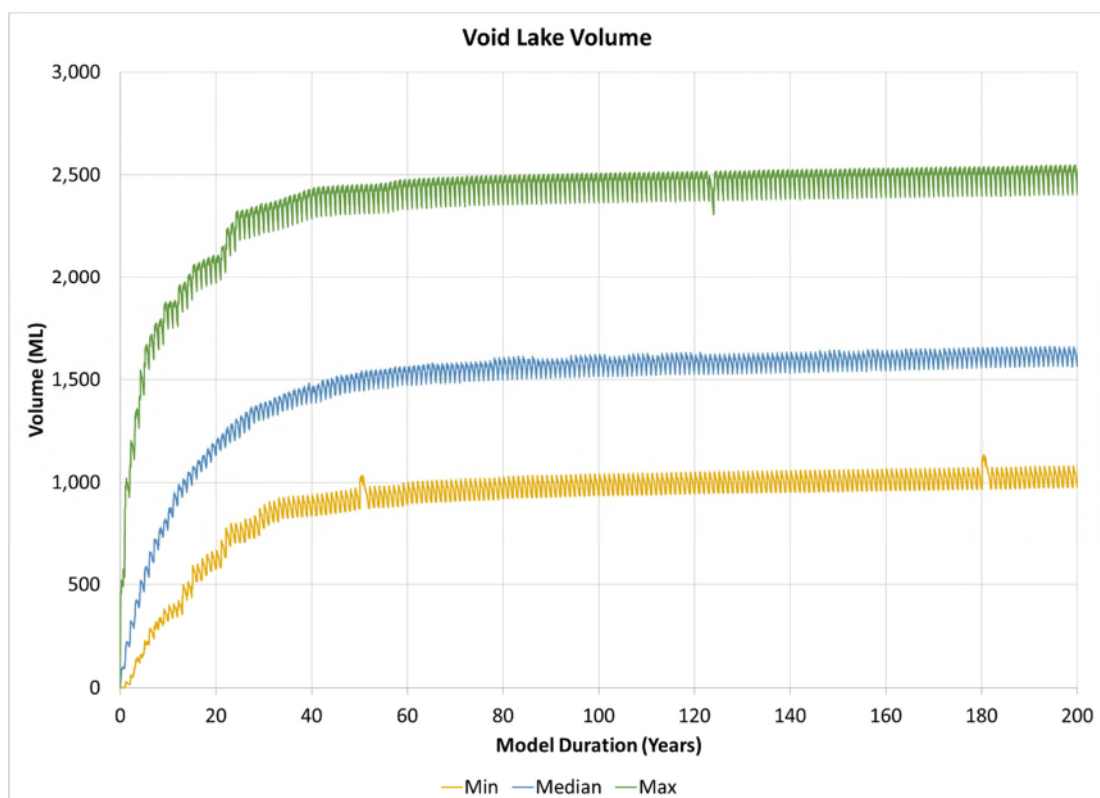
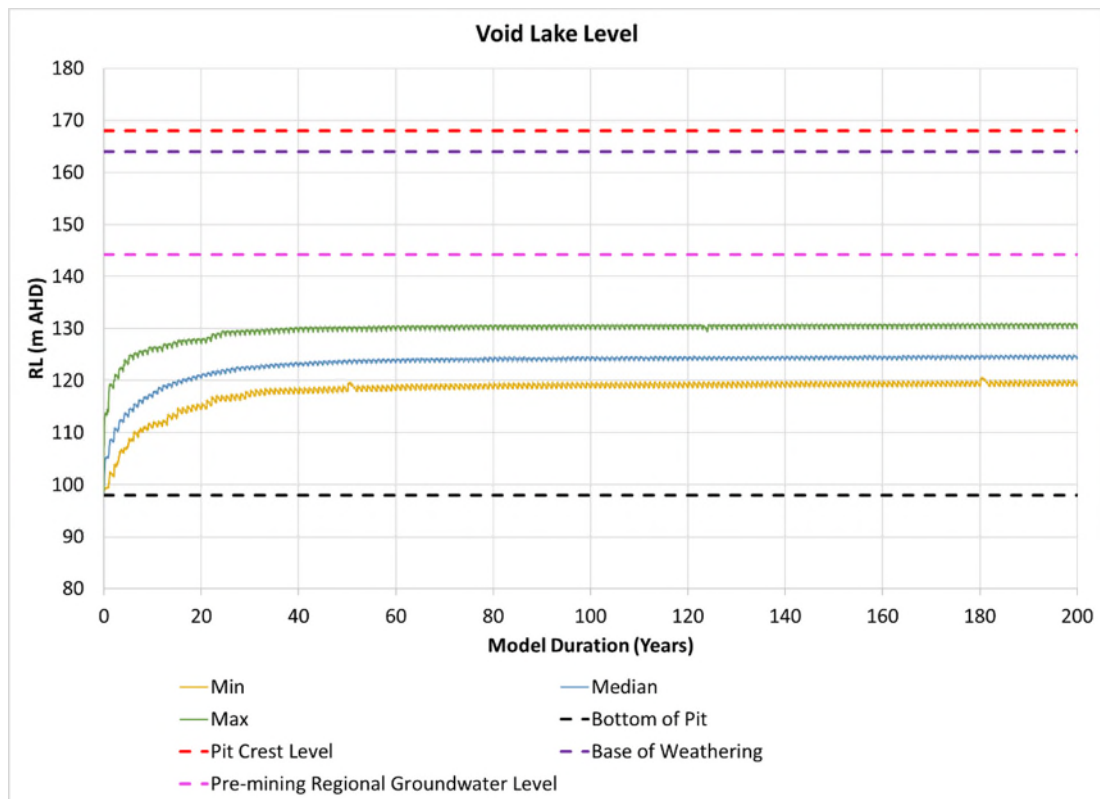


Figure 22 – Drake Pit 2 Expansion final void water volume and level (base case)

Central 3 (Drake Pit 4 North) Mitigated Case – Engeny (2020)

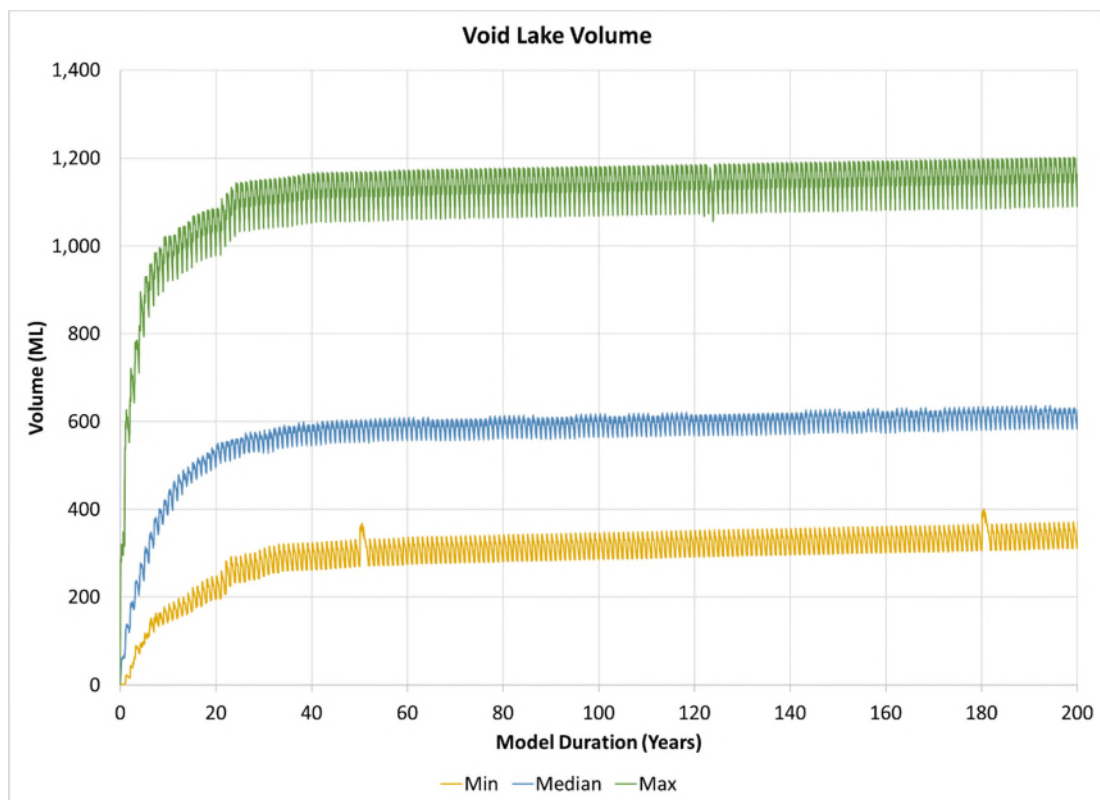
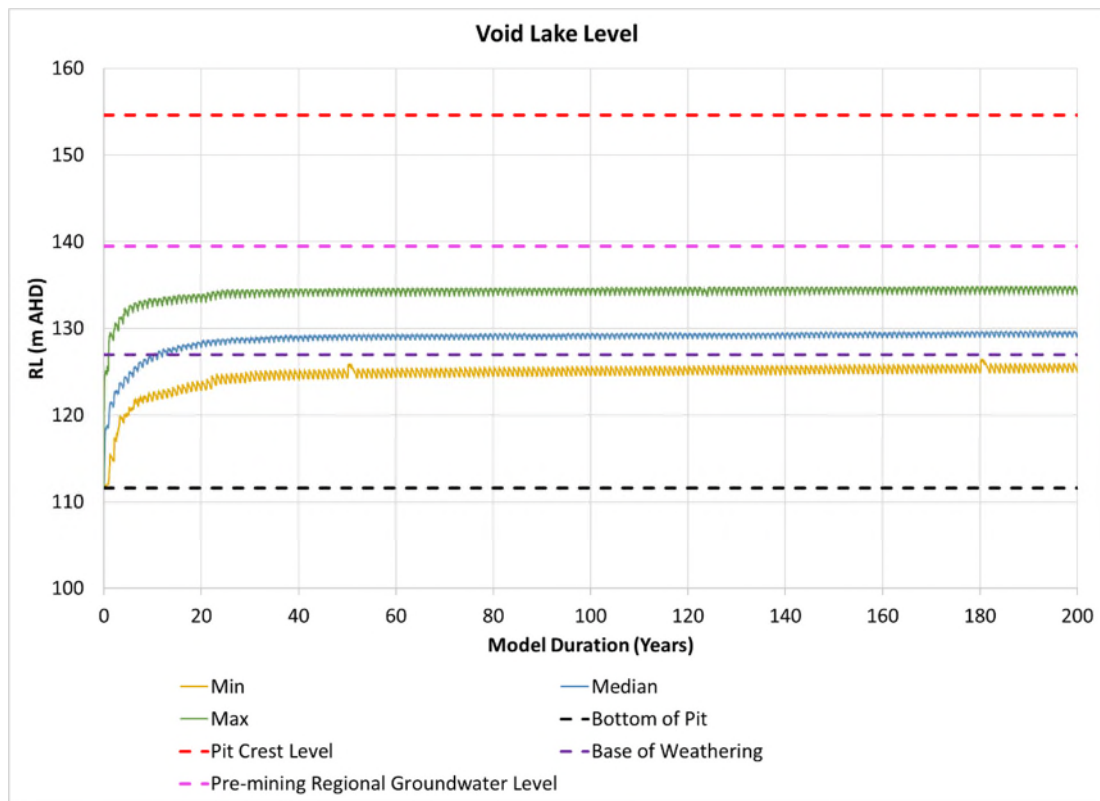


Figure 23 – Central 3 (Drake Pit 4 North) final void water volume and level (mitigated case)

Central 4 (Drake Pit 4 South) – Engeny (2020)

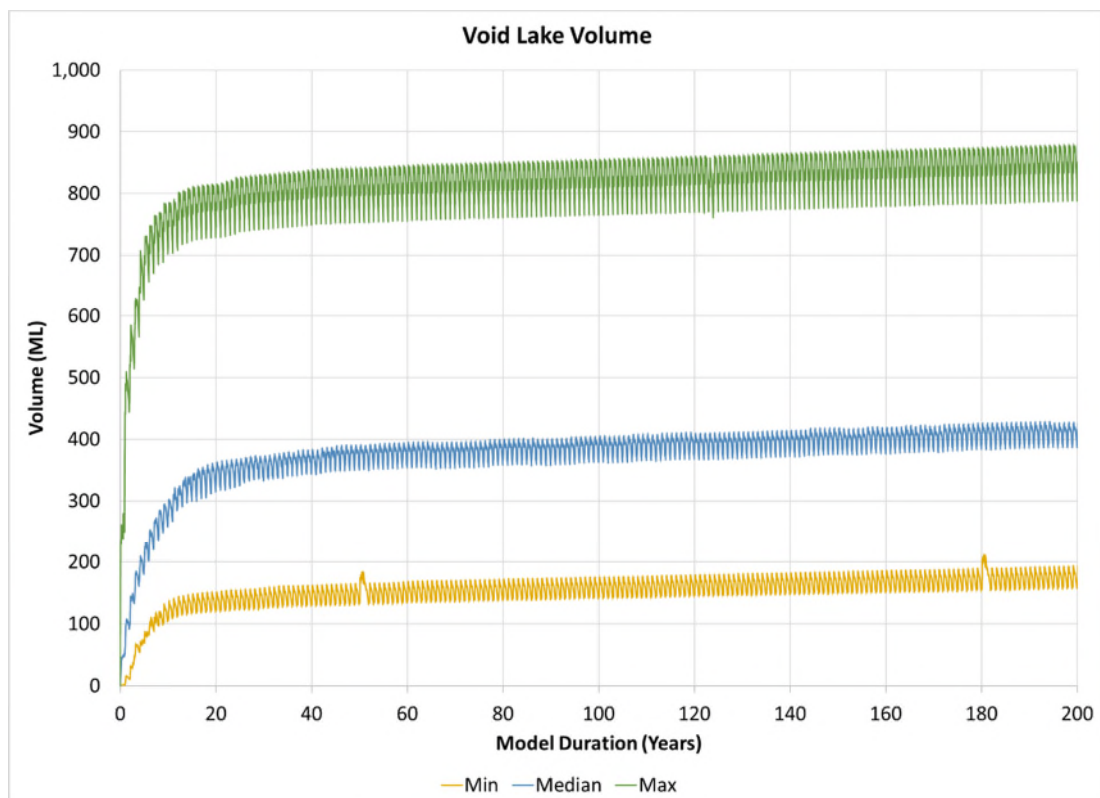
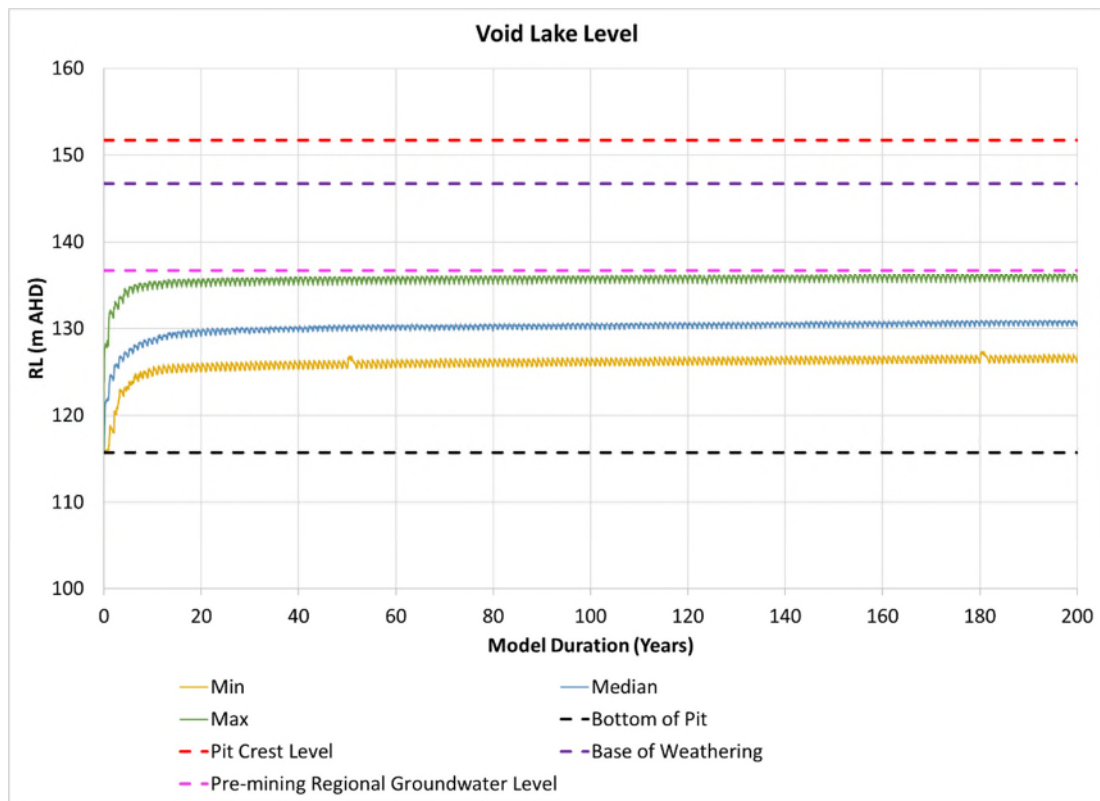


Figure 24 – Central 4 (Drake Pit 4 South) final void water volume and level (base case)

Drake 3Q Pit – Engeny (2020)

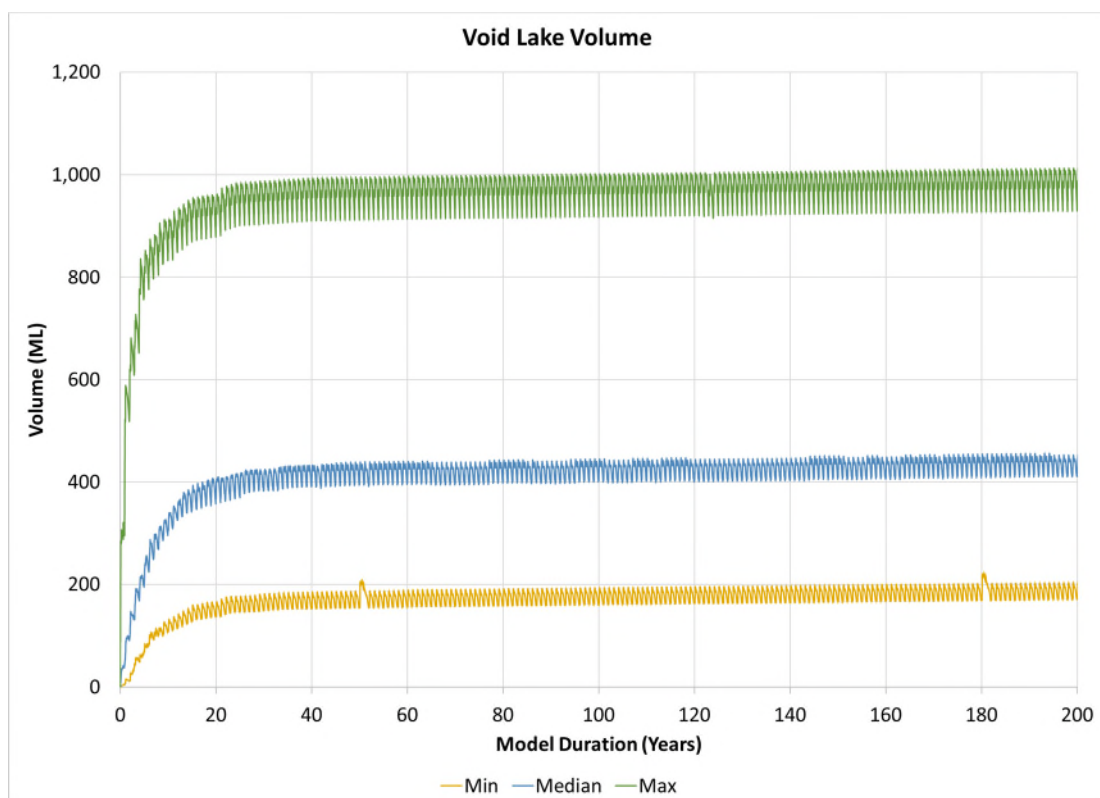
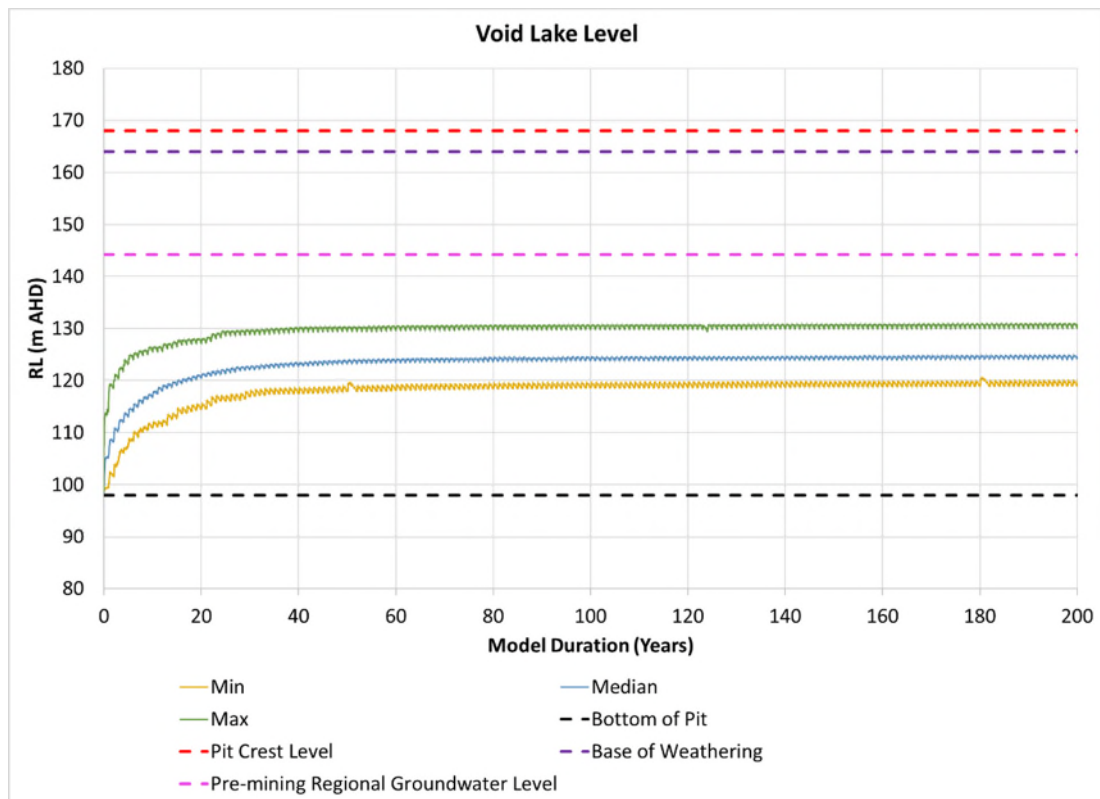


Figure 25 – Drake 3Q Pit final void water volume and level (base case)

Drake 3R Pit – Engeny (2020)

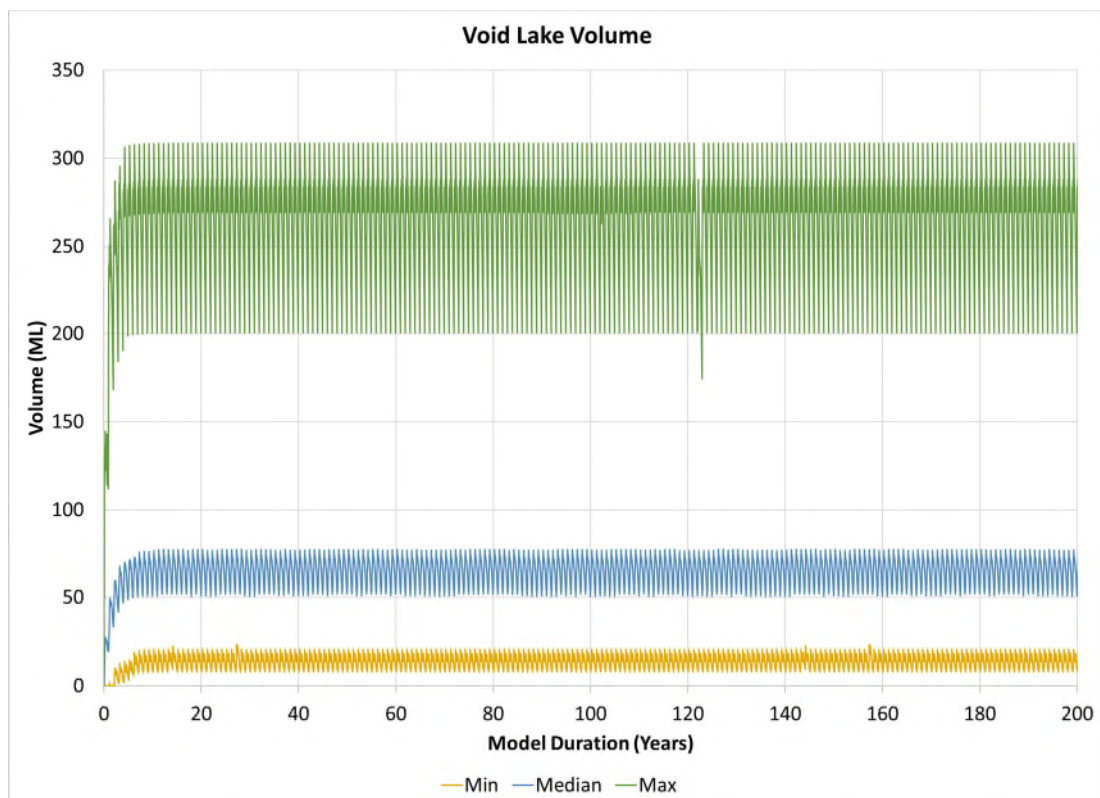
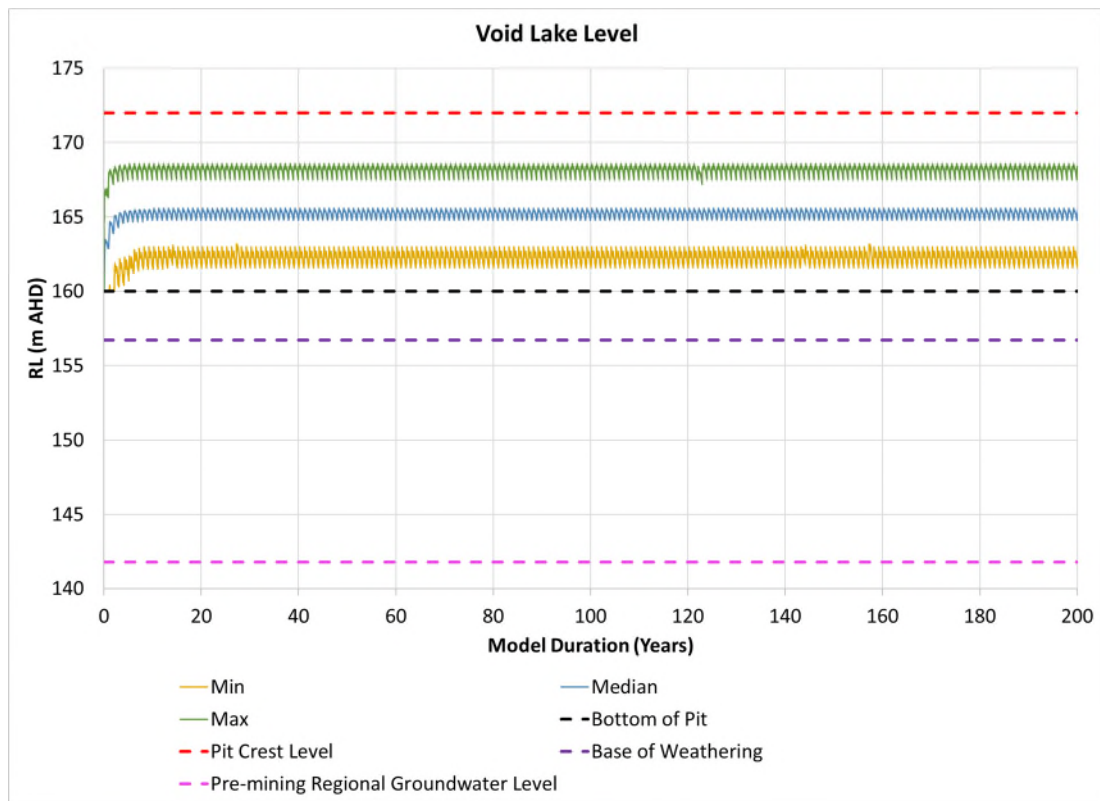


Figure 26 – Drake 3R Pit final void water volume and level (base case)

The time for the void lakes to reach their equilibrium levels varies based on the ratio of catchment area to void volume. The shortest filling time is seen to be Sonoma Main Pit (5 years) while the longest is Jax Main Pit (80 years). A summary of the results for level is provided for each final void (adapted from Engeny (2020)):

- Jax Main Pit – Using the catchment layout for the LOMP (the base case) the void lake equilibrium level (110 m AHD) and maximum void lake level (118 m AHD) are 30.8-30 m and 22.8-22 m below the pre-mining regional groundwater level (140.8-140 m AHD) respectively. Therefore, the residual void is forecast to act as a sink as per Engeny (2018).
 - o For comparison, a potential mitigated scenario was also modelled for a reduced catchment. The mitigated void lake equilibrium level (98 m AHD) and maximum void lake level (105 m AHD) are 42.8-42 m below and 35.8-35 m below the pre-mining regional groundwater level (140.8-140 m AHD) respectively.
- Jax East Pit – The void lake equilibrium level (104 m AHD) and maximum void lake level (112 m AHD) are 31.2-23.2 m and 36-28 m below the pre-mining regional groundwater level (135.2-140 m AHD) respectively. Therefore, the residual void is forecast to act as a sink. Therefore, the residual void is forecast to act as a sink as per Engeny (2018).
 - o For comparison, a potential mitigated scenario was also modelled for a reduced catchment. The mitigated void lake equilibrium level (103 m AHD) and maximum void lake level (110 m AHD) are 32.2-25.2 m below and 37-30 m below the pre-mining regional groundwater level (135.2-140 m AHD) respectively.
- Sonoma Main Pit - The void lake equilibrium level (130 m AHD) and maximum void lake level (134 m AHD) are 25.7 m and 21.7 m below the pre-mining regional groundwater level (155.67 m AHD) respectively. These outcomes are based on the design landform surface at year 20. It is expected the final co-disposal surface will be as much as 20m higher than this level. The conservative addition of a further 20 vertical metres of rejects material can be expected to result in an equilibrium level of 150 m AHD and a maximum level of 154 m AHD which remain below the regional groundwater level.
 - o As such, the Sonoma Main Pit is expected to act as a groundwater sink; however, as it will be subject to in-pit co-disposal of rejects, it will behave differently to the other voids modelled and further consideration is recommended in the detailed mine planning for this void based on the in-pit co-disposal plan.
 - o In addition, due the placement of rejects material within the void, the Sonoma Main Pit residual void geometry included a large predominantly flat surface. The void is forecast to behave as an evaporation pan and therefore periodically dries out to very minimal volumes.
- Sonoma East Pit 1 - The void lake equilibrium level (158 m AHD) and maximum void lake level (164 m AHD) are 1.7 m and 7.7 m above the pre-mining regional groundwater level (156.30 m AHD) respectively. The residual void is forecast to have ongoing net outflows to the local geology.
 - o The Sonoma East Pit 1 void lake level is forecast to result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, as concluded during the numerical groundwater modelling (**Section 6.2**) any outflow from this void will be intercepted by the larger and

deeper voids. In the case of Sonoma Main Pit, Sonoma East Pit 1 and Sonoma East Pit, the numerical groundwater modelling concludes that groundwater in this complex of pits is fully contained with some amount of inter void movement, predicted to be minor considering the small differential in height of 1.7m.

- Sonoma East Pit 2 - The void lake equilibrium level (154 m AHD) and maximum void lake level (161 m AHD) are 1.5 m below and 5.5 m above the pre-mining regional groundwater level (155.53m AHD) respectively. The residual void is forecast to have ongoing net outflows to the local geology or regional groundwater.
 - o The Sonoma East Pit 2 void lake level is forecast to result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, as concluded during the numerical groundwater modelling (**Section 6.2**) any outflow from this void will be intercepted by the larger and deeper voids. In the case of Sonoma Main Pit, Sonoma East Pit 1 and Sonoma East Pit, the numerical groundwater modelling concludes that groundwater in this complex of pits is fully contained with some amount of inter void movement, predicted to be minor considering the small differential in height of 1.5m.
- Drake Pit 5 - The void lake equilibrium level (111 m AHD) and maximum void lake level (119 m AHD) are 26.4 m and 18.4 m below the pre-mining regional groundwater level (137.42 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Drake Pit 1 - The void lake equilibrium level (126 m AHD) and maximum void lake level (134 m AHD) are 20.6 m and 12.6 m below the pre-mining regional groundwater level (146.57 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Drake Pit 2 - The void lake equilibrium level (139 m AHD) and maximum void lake level (145 m AHD) are 8.2 m and 2 m below the pre-mining regional groundwater level (147.23 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Drake Pit 2 Expansion - The void lake equilibrium level (124 m AHD) and maximum void lake level (131 m AHD) are 20.2 m and 13.2 m below the pre-mining regional groundwater level (144.24 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Central 3 (Drake Pit 4 North) – The LOMP is not optimised to consider catchment reduction or completed to a level of detail sufficient to consider specific drainage solutions. As such, a review of catchment reduction options was undertaken which resulted in reduced catchment reporting to the Central 3 (Drake 4 North) final void, which is referred to as the mitigated case and has been assumed as the preferred catchment layout for this void. The mitigated void lake equilibrium level (125 m AHD) and maximum void lake level (130 m AHD) are 14.5 m below and 9.5 m below the pre-mining regional groundwater level (139.50 m AHD) respectively. Therefore, based on the primary indicator of void lake and groundwater interaction, the mitigated residual void is forecast to act as a sink.
- Central 4 (Drake Pit 4 South) - The void lake equilibrium level (131 m AHD) and maximum void lake level (136 m AHD) are 5.7 m and 0.7 m below the pre-mining regional groundwater level (136.71 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.

- Drake Pit 3Q - The void lake equilibrium level (150 m AHD) and maximum void lake level (157 m AHD) are 7.5 m and 14.5 m above the pre-mining regional groundwater level (142.55 m AHD) respectively. Therefore, the residual void is forecast to have ongoing net outflows to the local geology or regional groundwater.
 - o The Drake Pit 3Q void lake level is forecast to result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, as concluded during the numerical groundwater modelling (**Section 6.2**) any outflow from this void will be intercepted by the larger and deeper voids (in the case of Drake 3Q primarily to Jax Main Pit which is a groundwater sink) and will not migrate away from the site.
- Drake Pit 3R - The void lake equilibrium level (165 m AHD) and maximum void lake level (169 m AHD) are 23.2 m and 27.2 m above the pre-mining regional groundwater level (141.78 m AHD) respectively. Therefore, the residual void is forecast to have ongoing net outflows to the local geology or regional groundwater
 - o The Drake Pit 3R void lake level is forecast to result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, as concluded during the numerical groundwater modelling (**Section 6.2**) any outflow from this void will be intercepted by the larger and deeper voids (in the case of Drake 3R primarily to Jax Main Pit which is a groundwater sink) and will not migrate away from the site.

8.2 Final void lake quality

The final void lake water quality modelling (including sensitivity analysis) for the Jax Main Pit and Jax East Pit final voids, is described and plotted in detail in Engeny (2108) and the Engeny (2018) Supplementary Memo, provided as **Appendix A**.

The final void lake water quality modelling for all other QNH final voids is described and plotted in detail in Engeny (2020), provided as **Appendix B**.

Results extracted from the above are presented in **Figure 28-**

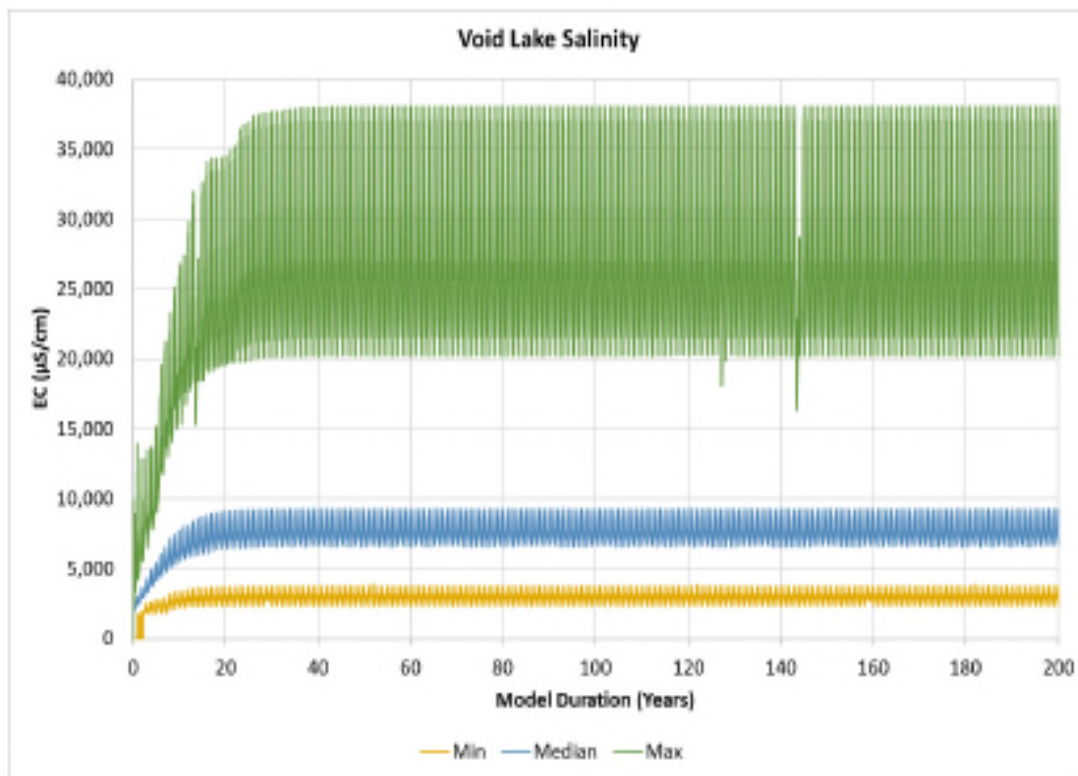


Figure 42, with the following key information presented:

- the simulation period:
 - o 500 years for Jax Main Pit and Jax East Pit (presented for the first 100 years and the full 500 year simulation separately for both final voids)
 - o 200 years for all other QNH final voids
- minimum, median and max levels and volumes are presented for each day of the simulation period for all final voids;
- the observable oscillations are the normal concentration and dilution cycles associated with normal seasonal and climactic variations;
- the median has been used to define the equilibrium levels in this assessment;
- all results reported in this assessment are from modelling of the “base case” which is the catchment extent provided by the LOMP, except for Central 3 (Drake Pit 4 North), where an opportunity to refine the catchment boundary was identified during the modelling (referred to as the mitigated case). For ease of interpretation only the Central Pit 3 (Drake Pit 4 North) mitigated case is included within the body of this assessment; however Engeny (2020) includes both the base and mitigated cases.

Engeny (2020) concludes that the salinity of all residual voids modelled as part of this assessment is forecast to continue to increase over time due to the ongoing concentration resulting from evaporation with no significant outflow of salts from either net outflow, seepage or overflow. **It should be noted that pits with net outflow (Section 8.1) were still shown to accumulate salts throughout the model duration.** The reason for this occurrence is that predicted net outflow rates into the surrounding geology at all levels of

rating curves for all pits (**Section 7.2**) were significantly smaller in magnitude than flows associated with rainfall, runoff, and evaporation.

The results indicate significant variation in the EC of the voids as a result of differing pit storage curves and catchment sizes. However, all void lakes are forecast to exceed 10,000 $\mu\text{S}/\text{cm}$ after 200 years (with the exception of Jax Main Pit which is closer to 220 years), with some pits reaching 10,000 $\mu\text{S}/\text{cm}$ after 40 years. The overall water quality outcome is consistent for all void lakes (i.e. high levels of salinity that continue to increase over time). Ultimately, salts will continue to concentrate with the maximum concentration only limited by the solubility of the constituent salts within the lake. This is conceptually the case for any comparable water body receiving inflow, which experiences evaporation as either the only outflow, or at a rate exceeding all other outflows. As such, the water quality in all QNH voids is predicted to ultimately be unsuitable for any use.

As a comparison, typical guidelines for livestock water quality are presented in **Figure 27**, (note the values are in mg/L for TDS).

Livestock	Total dissolved solids (mg/L)		
	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 a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually
Beef cattle	0–4000	4000–5000	5000–10 000
Dairy cattle	0–2500	2500–4000	4000–7000
Sheep	0–5000	5000–10 000	10 000–13 000 ^a
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

a From ANZECC (1992), adapted to incorporate more recent information
b Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production

Figure 27 – Livestock water quality guidelines

Additionally, “*Draft Environmental Values and Water Quality Guidelines for Burdekin Basin and fresh estuarine waters*” (Department of Science, Information Technology and Innovation March 2017) identified a guideline EC for aquatic ecosystems in the Pelican Creek sub-catchment of 1,800 $\mu\text{S}/\text{cm}$.

The water quality forecast for the Sonoma Main Pit residual void exhibits characteristics not evident in other residual voids modelled at QNH in that modelled salinity at 200 years is an order of magnitude higher than any other modelled void. The proposed residual void for Sonoma Main Pit has a large, relatively flat surface produced by the co-disposal of tailings and rejects within the pit. Therefore, any ponding within Sonoma Main Pit is subject to very large evaporation surface areas. The modelled void behaviour is conceptually similar to an evaporation pan, or, as is naturally present in the QNH areas, an ephemeral creek with senescing pools that dry out in the dry season. In those situations, the void lake volume decreases during drying periods, and the remaining water becomes highly saline as the void does not have any mechanisms (net outflow to groundwater or spills) for salt mass reduction.

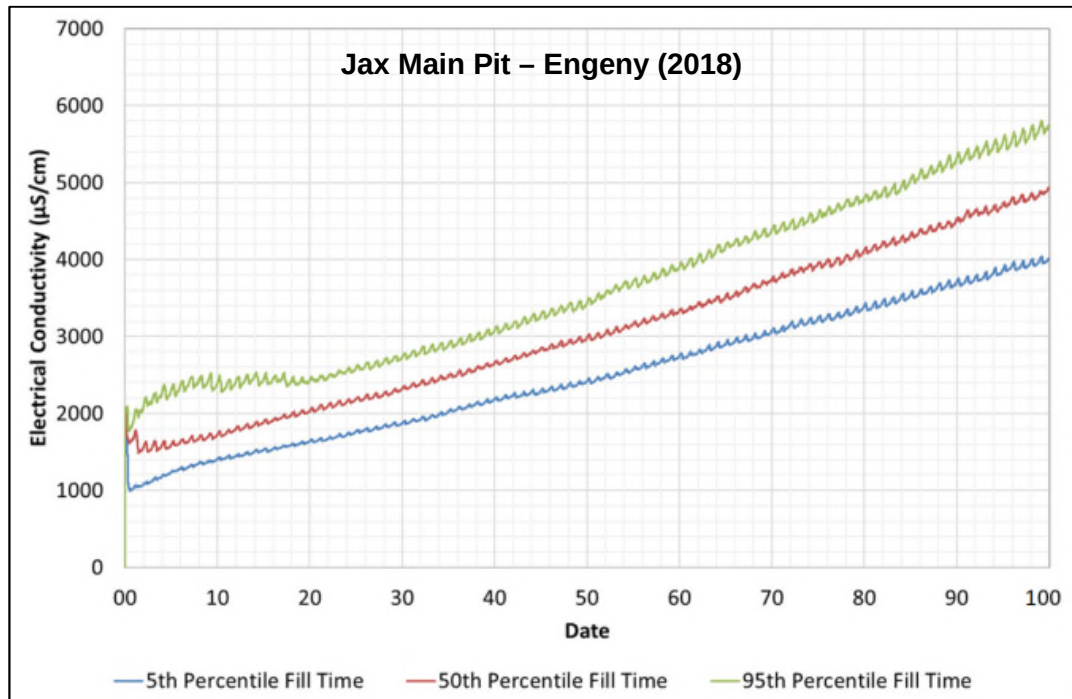


Figure 28 – Jax Main Pit final void lake EC modelling (base case)- 100 years

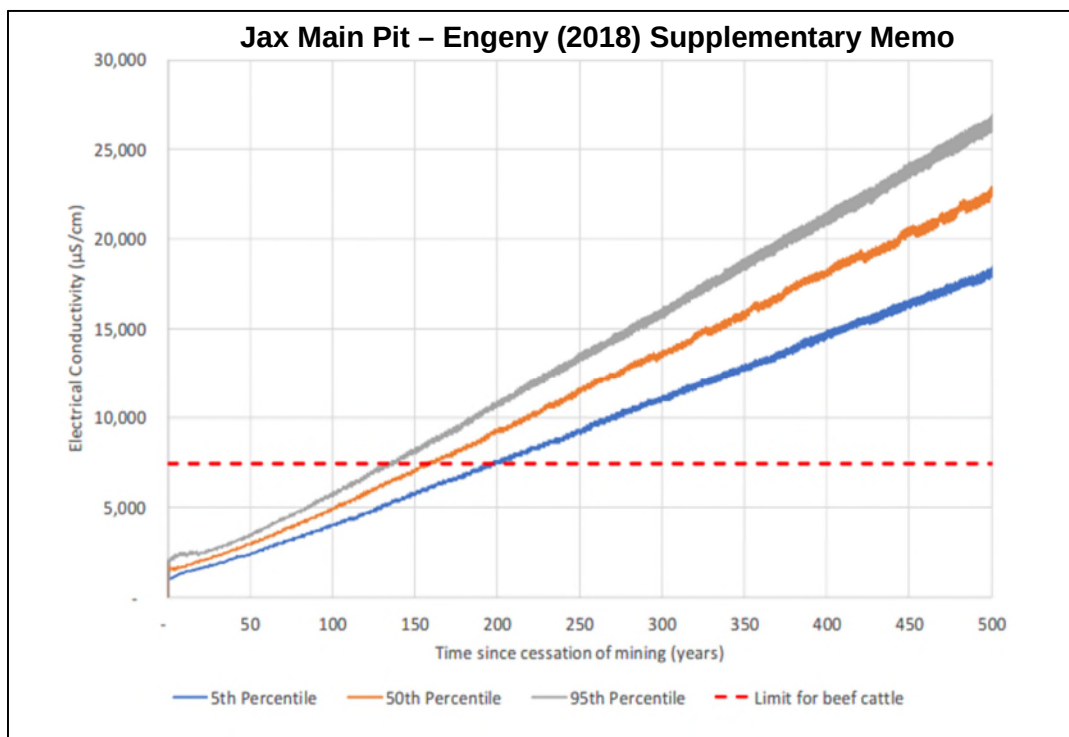


Figure 29 – Jax Main Pit final void lake EC modelling (base case) -500 years

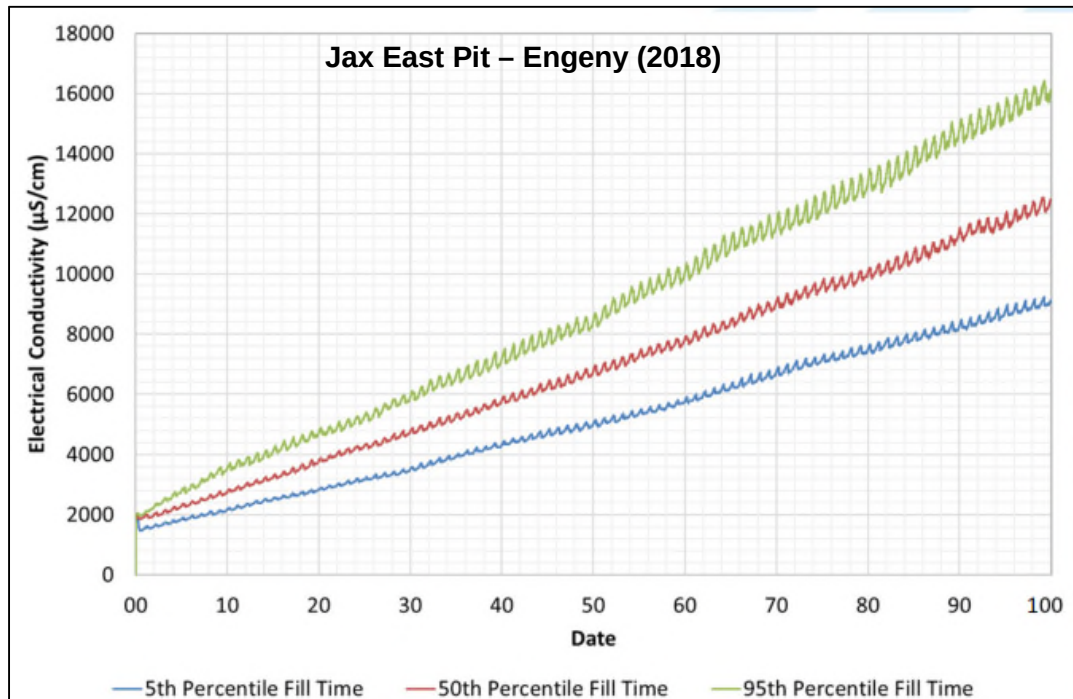


Figure 30 – Jax East Pit final void lake EC modelling (base case) – 100 years

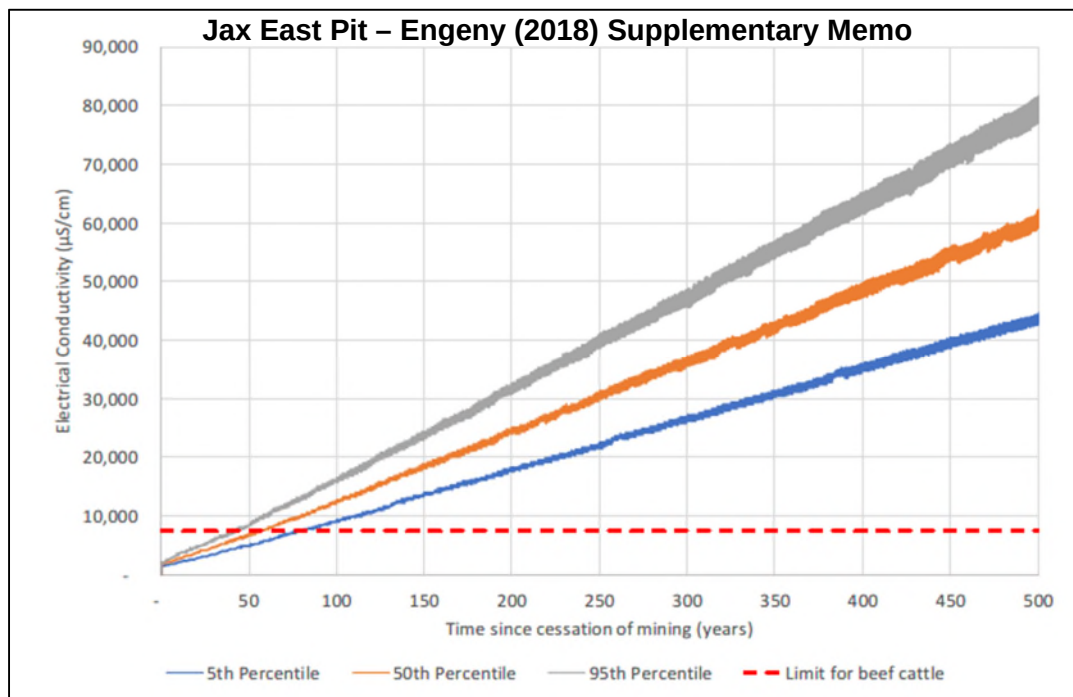


Figure 31 – Jax East Pit final void lake EC modelling (base case) – 500 years

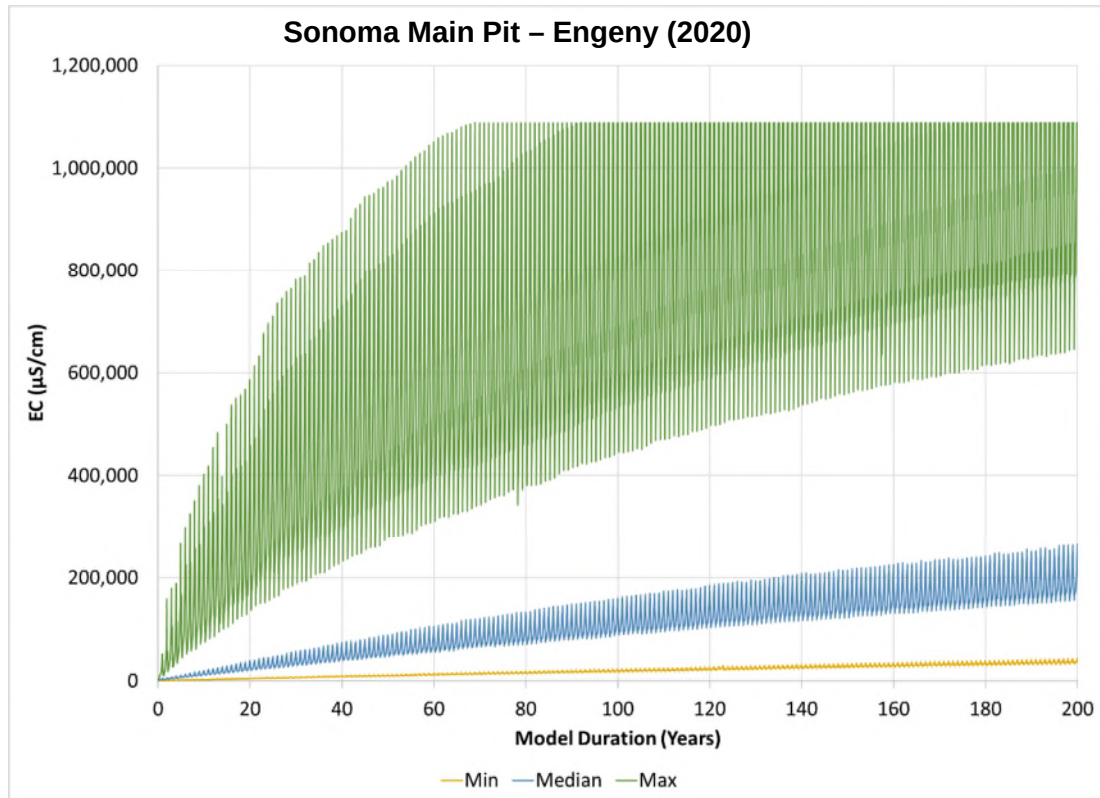


Figure 32 – Sonoma Main Pit final void lake EC modelling (base case)

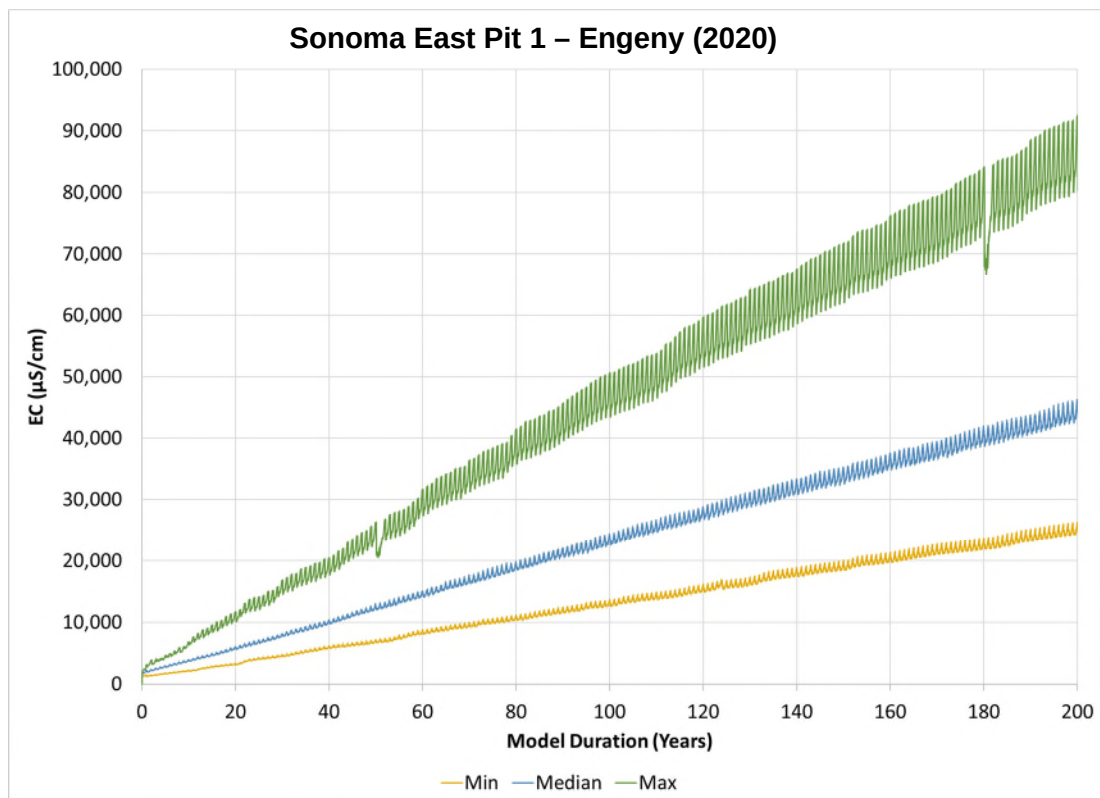


Figure 33 – Sonoma East Pit 1 Pit final void lake EC modelling (base case)

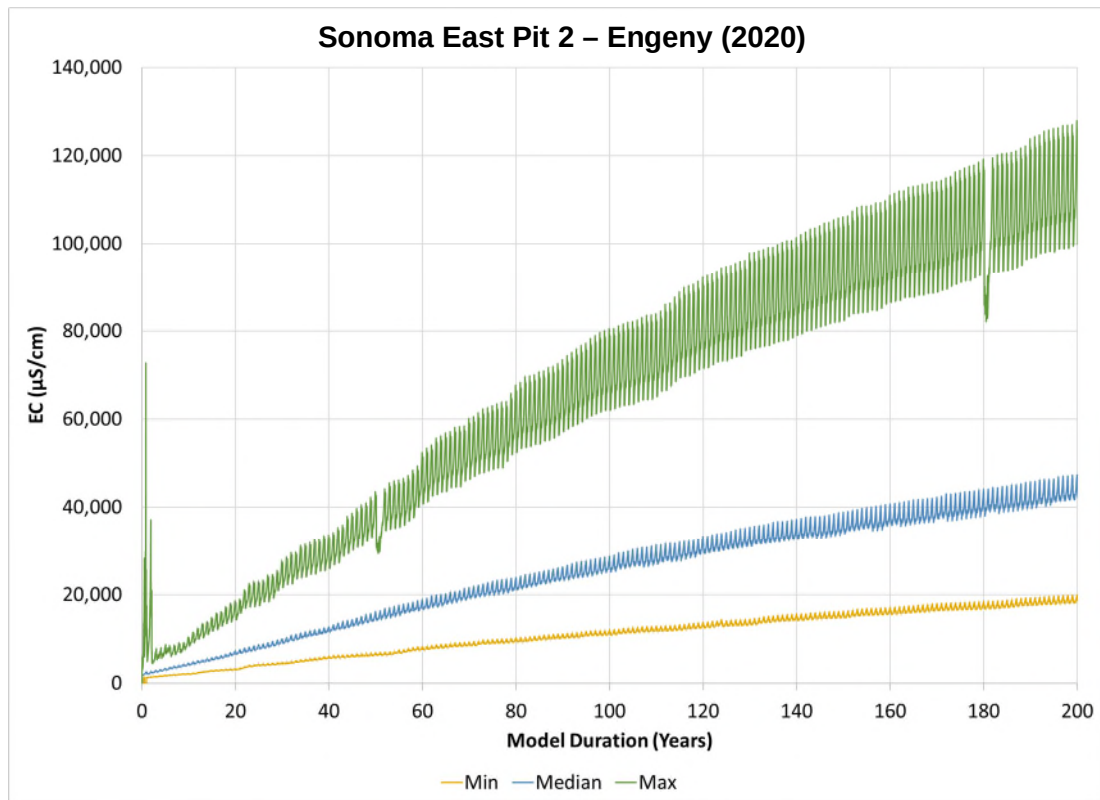


Figure 34 – Sonoma East Pit 2 final void lake EC modelling (base case)

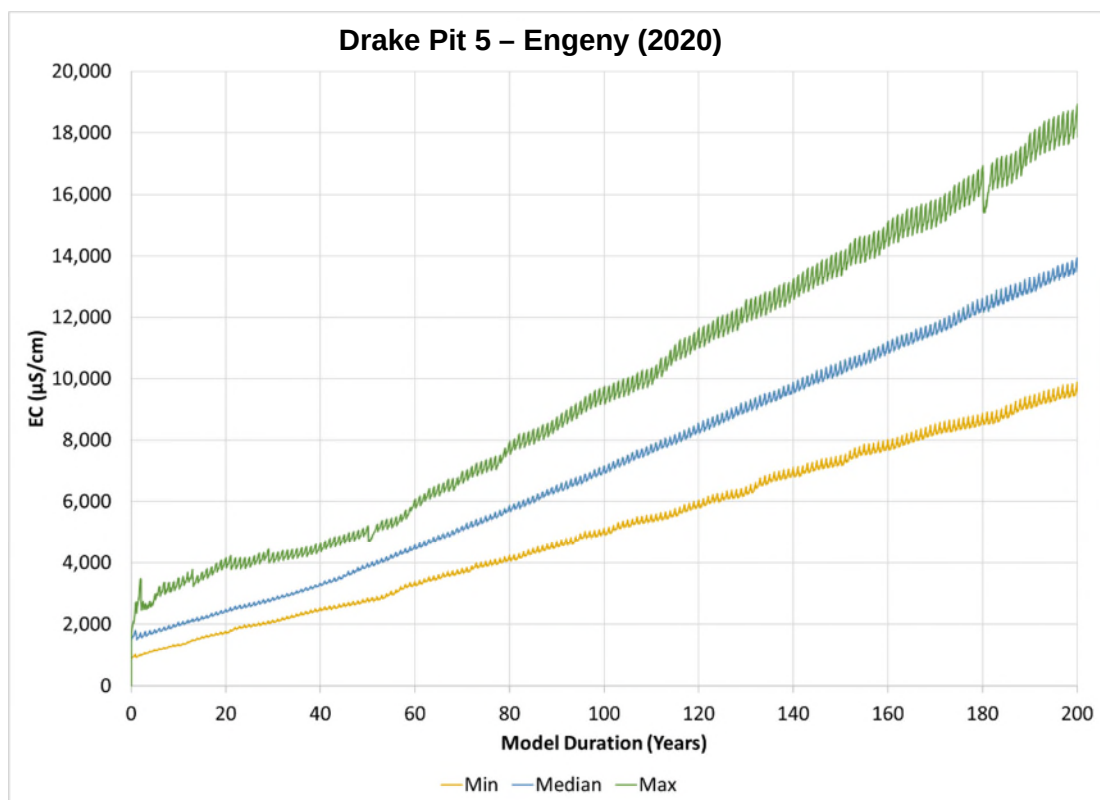


Figure 35 – Drake Pit 5 Pit final void lake EC modelling (base case)

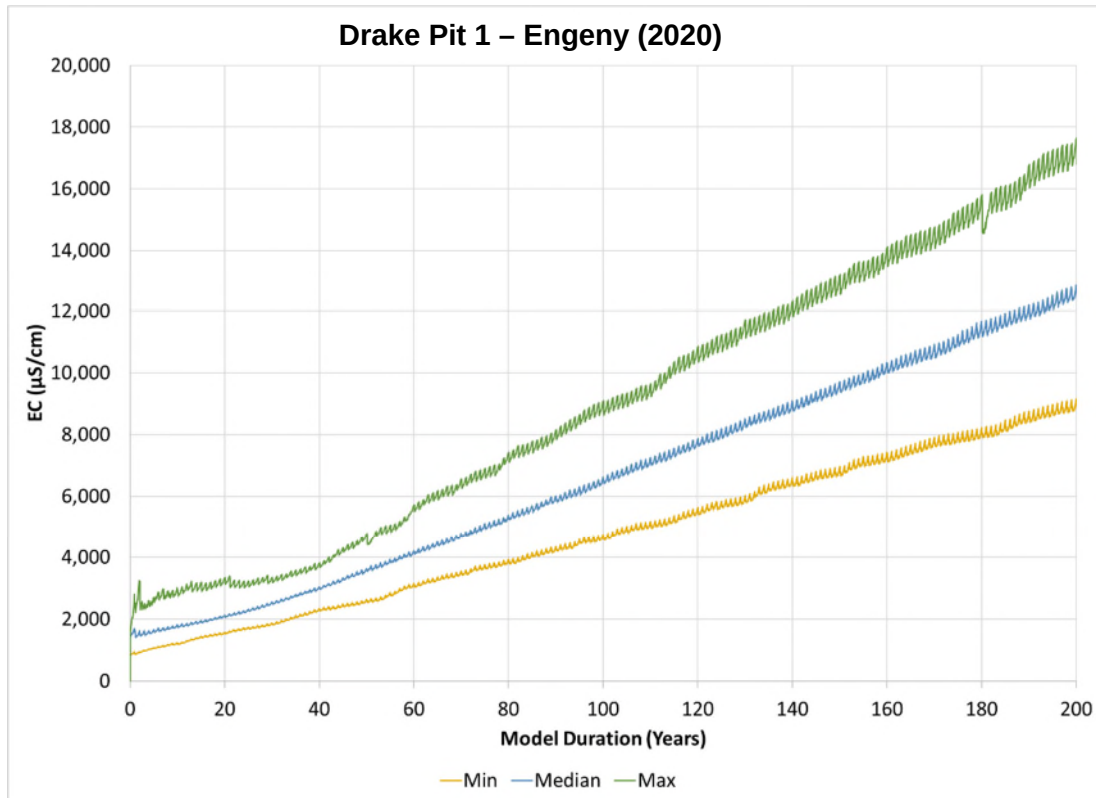


Figure 36 – Drake Pit 1 final void lake EC modelling (base case)

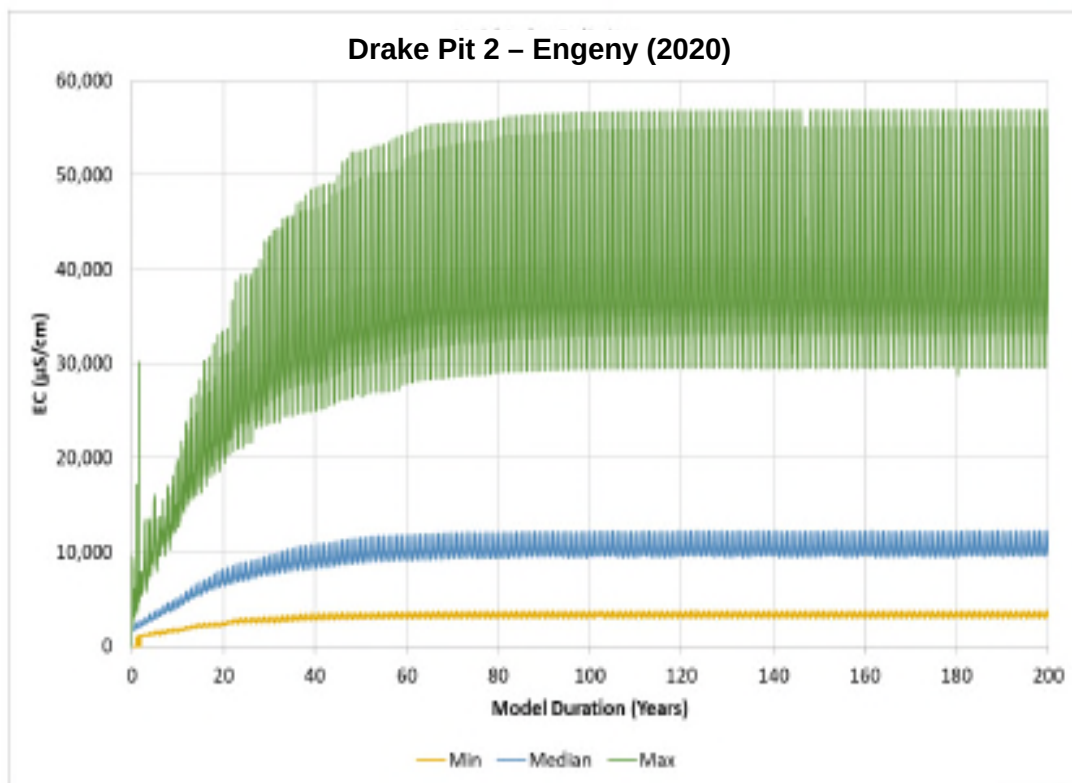


Figure 37 – Drake Pit 2 final void lake EC modelling (base case)

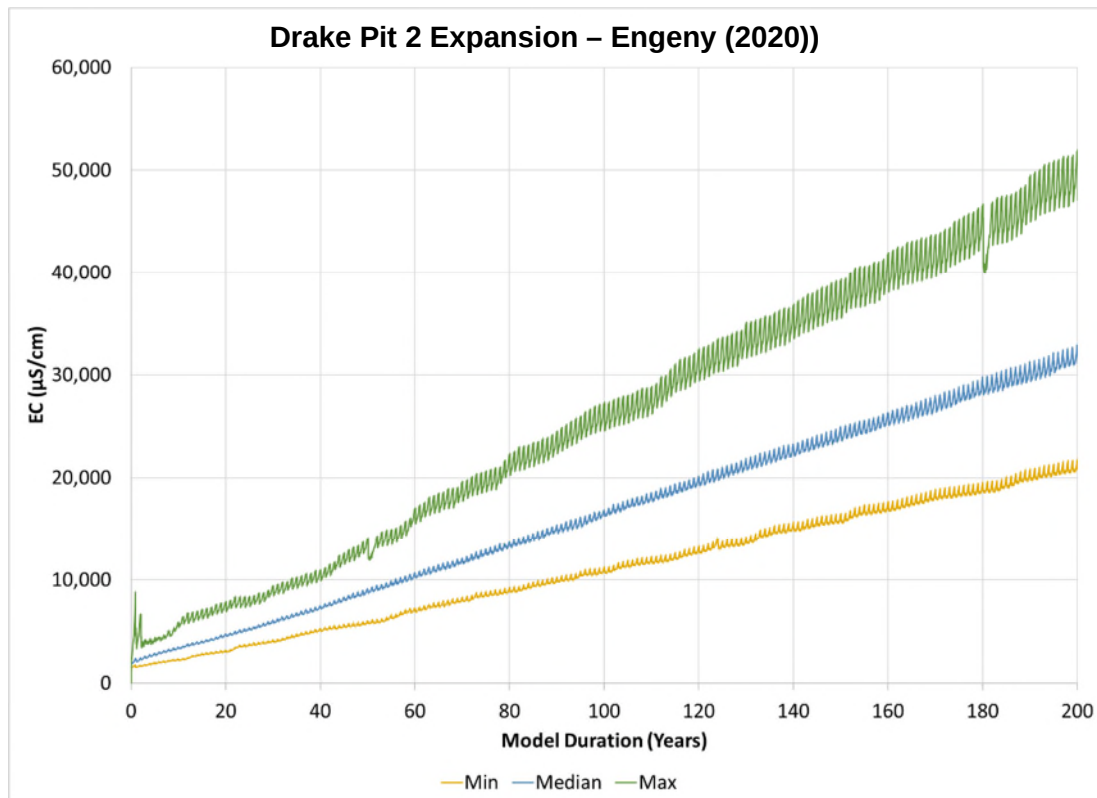


Figure 38 – Drake Pit 2 Expansion final void lake EC modelling (base case)

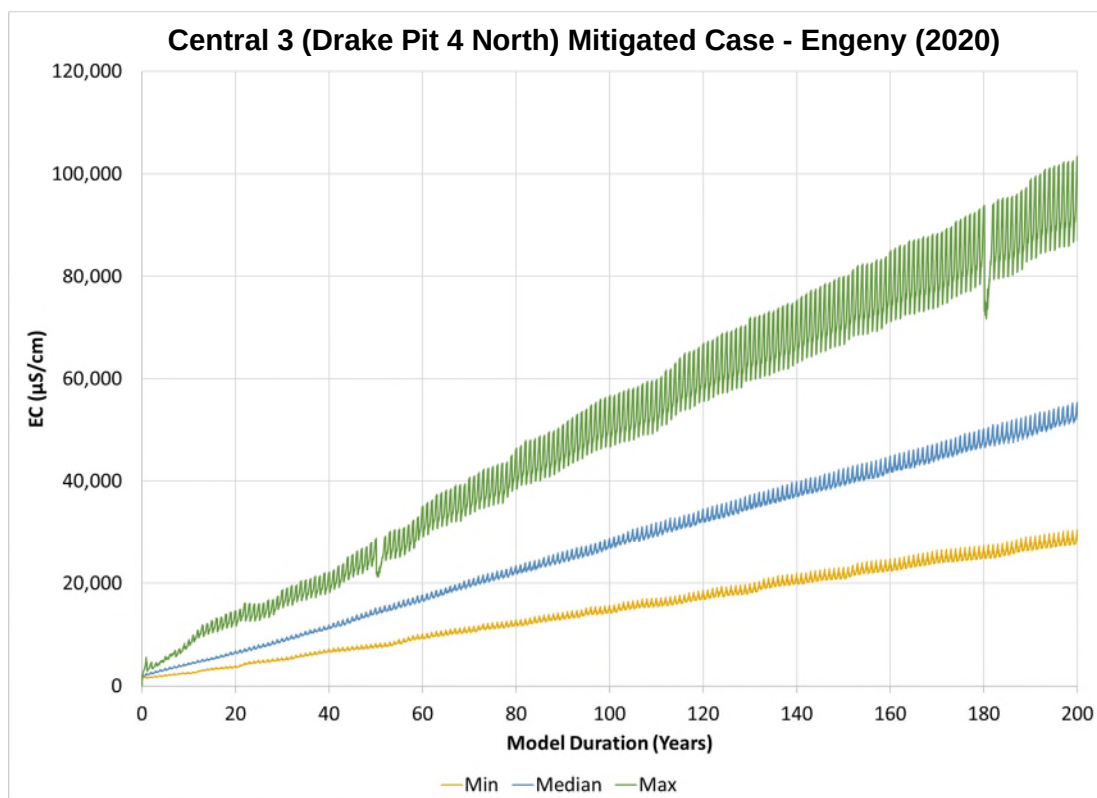


Figure 39 – Central 3 (Drake Pit 4 North) final void lake EC modelling (mitigated case)

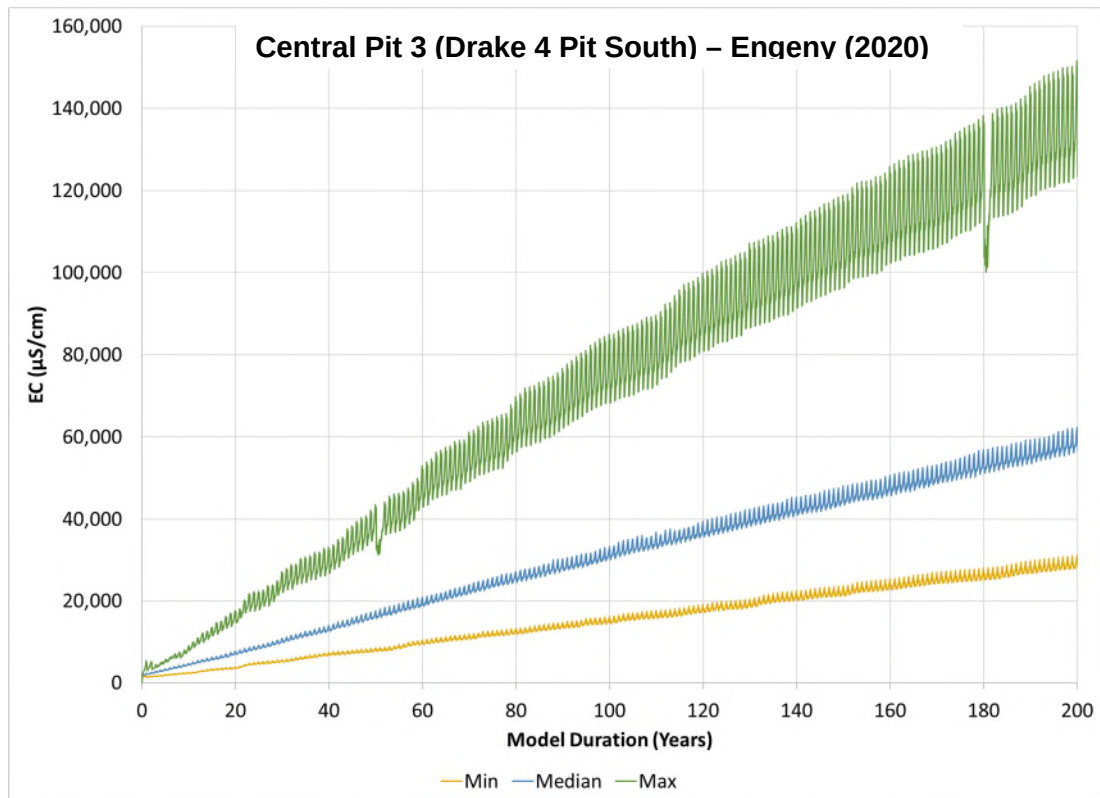


Figure 40 – Central 3 (Drake 4 Pit South) final void lake EC modelling (base case)

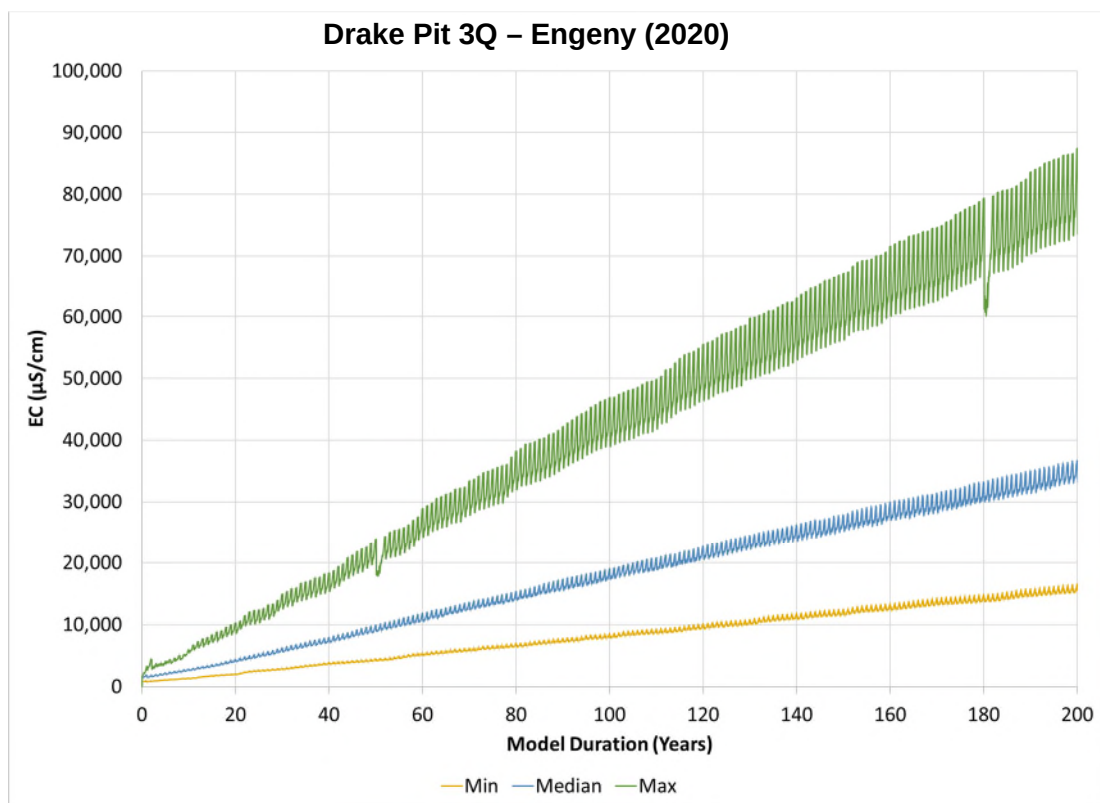


Figure 41 – Drake Pit 3Q final void lake EC modelling (base case)

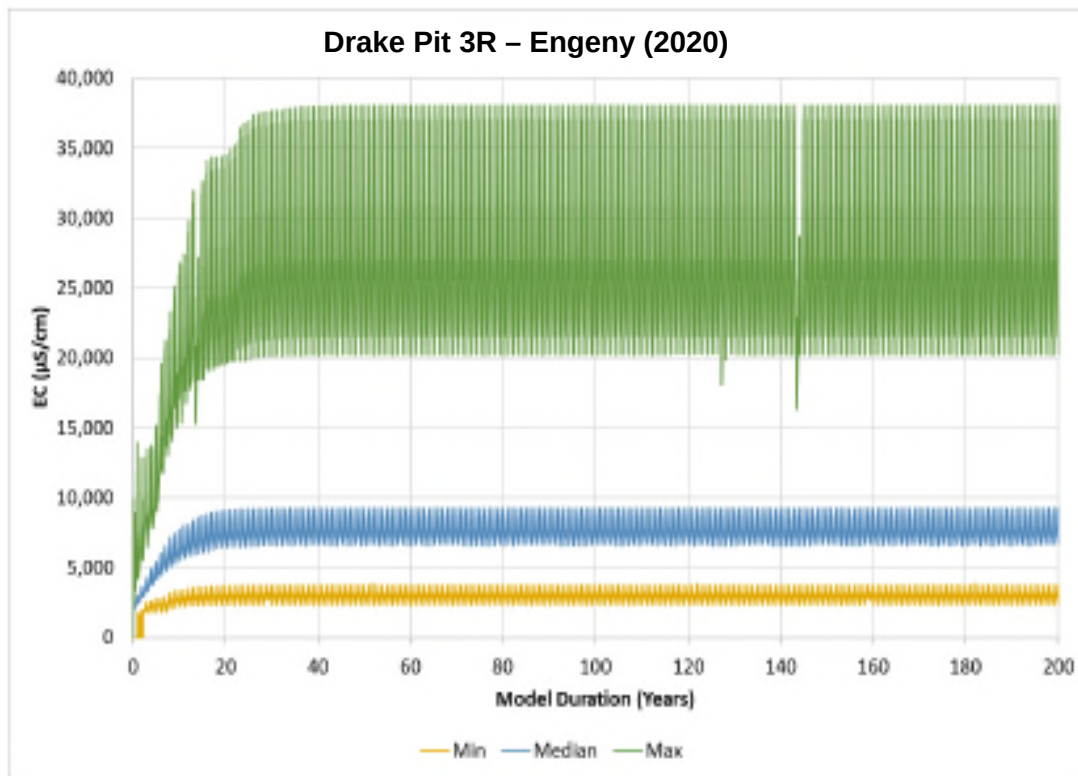


Figure 42 – Drake Pit 3R final void lake EC modelling (base case)

9 Rehabilitation

Since the commencement of operations in the QNH several rehabilitation plans have been implemented and subsequently superseded as the QNH has expanded and rehabilitation conditions within the various QNH EAs have been amended. This section should be read in conjunction with the QNH RMP. Land disturbed by mining and ancillary activities on the QNH is grouped into rehabilitation domains based on areas which require similar rehabilitation requirements and/or levels of environmental risks. Residual voids are referred to as Domain 1 in the QNH RMP. This investigation only considers the rehabilitation of final voids and therefore does not address any other rehabilitation domain.

9.1 Rehabilitation goals

Broad rehabilitation goals for the QNH are defined in **Condition H1** of the QNH EAs., which generally align with the rehabilitation goals summarised in the *Rehabilitation Requirements for Mining Projects* (EHP, 2014). The **Condition H1** rehabilitation goals in all QNH EAs are:

- Safe to humans and wildlife;
- Stable (referring specifically and only to geotechnical stability);
- Non-polluting; and
- Self-sustaining for the post-mining land use of grazing pasture, with the exception of residual voids.

This definition of “stable” for rehabilitated landforms is distinct from the from the definition of “stable condition” in the Environmental Protection Act 1994 (EP Act) Section 111A (applicable to mines under EAs). Section 111A of the EP Act defines a final landform as being in “stable condition” only if it meets all the following conditions:

- safe and structurally stable (i.e. geotechnical wall stability); and
- there is no environmental harm being caused by anything on or in the land; and
- the land can sustain a post-mining land use (i.e. self-sustain a specified use for the landform after rehabilitation).

As such, where a landform does not meet all three of the requirements under Section 111A of the EP Act, it is not considered to be in “stable condition” as per the EP Act definition.

Rehabilitation of final landforms, including voids on the QNH, is therefore undertaken to achieve one of two scenarios:

- rehabilitated to a “stable condition” as per Section 111A of EP Act; or
- rehabilitated to a condition which does not satisfy all the requirements to be considered in “stable condition” as per Section 111A of the EP Act (i.e. the final landform is unable to meet all of the criteria to be considered in “stable condition”):
 - o Section 112 of the EP Act defines such landforms as “non-use management areas” (NUMAs) – specifically defining a NUMA as an area of land the subject of a Progressive Rehabilitation and Closure plan (PRC Plan) that cannot be rehabilitated to a “stable condition” after all relevant activities for the PRCP carried out on the land have ended.
 - o until such time as the SCM, DCM and JCM transition into the PRC Plan framework, any final landforms which are determined not to be in “stable

condition” under Section 111A will be managed as NUMAs whilst not definitionally be referred to as NUMAs – once transitioned into the PRC Plan framework any such landforms will then also be definitionally referred to as NUMAs.

- o **it is noted that as per Condition H1 of the QNH EAs, all rehabilitated landforms (including those managed as NUMAs) must be safe, structurally stable and not cause any environmental harm – otherwise it is a non-compliance with the EA.** As such, where a final landform (including a void) is not considered to be in “stable condition” and is therefore managed as a NUMA, it is due only to the inability of the landform to sustain a post-mining land-use.

9.2 Void outcomes

As stated in **Section 8.2**, the water quality modelling results for final void lake water in all QNH final voids modelled as part of this assessment indicated that the water quality will continue to degrade over time, with solubility being the ultimate limiting factor. The reason for the degradation, as detailed in **Section 8.2**, is that:

- for the voids determined to be groundwater sinks in **Section 8.1**, (namely Jax Main Pit, Jax East Pit, Sonoma Main Pit, Drake Pit 5, Drake Pit 1, Drake Pit 2, Drake Pit 2 Expansion, Central Pit 3 (Drake Pit 4 North), Central Pit 4 (Drake Pit 4 South)), evaporation is the only water loss, and, as such, evaporative concentration of salts from the various inflows occurs over time; and
- for the voids determined to have a mathematical net outflow (**Section 8.1**) into an adjacent final void (**Section 6.2**) in (namely Sonoma East Pit 1, Sonoma East Pit 2, Drake Pit 3-Q and Drake Pit 3-R), the rate of net outflow into the QNH cone of depression was notably less than the evaporation rate and as such evaporative concentration of salts from the various inflows occurs over time.

As further stated in **Section 8.2**, due the degradation of quality over time, resulting from the net evaporative climate of the region, the water quality in all QNH voids will become unsuitable for any human use, agricultural or livestock use, as drinking water or designated habitat for native fauna. The time it takes for quality to reach the levels where it is unsuitable (which differ depending on the acceptable limits for each use) varies between pits; however, in all pits the quality is modelled to continue to degrade beyond acceptable limits for all potential uses identified.

In consideration of those results, it is concluded that none of the QNH final voids can self-sustain a designated post-mining land use, as all potential uses are contingent on having an acceptable level of quality for that use, none of which can be met over time.

As discussed in **Section 9.1**, where a final void is demonstrably unable to sustain a post-mining land use, it does not satisfy the requirement to be considered in “stable condition” under the definition of Section 111A of the EP Act. Accordingly, the QNH final voids modelled in this assessment are recommended to have a void outcome of “residual void unable to sustain a post mining land use”.

The Jax Main Pit and Jax East Pit voids already have this void outcome conditioned in the JCM EA, which is consistent with the findings of this assessment and the findings of “*Investigation into Residual Void Jax Coal Mine – QCoal October 2018*” (submitted to DES 12 October 2018), which included the technical study “*Jax Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2018*” (Engeny 2018).

It is also noted that these findings are consistent with the void outcomes previously identified for Sonoma Main Pit in *“Investigation into Residual Void Sonoma Coal Mine – QCoal January 2016”* (submitted to DES 29 January 2016), which included the technical study *“Sonoma Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2015”* (Engeny 2015a).

As also stated in **Section 8.1**, final voids with an outcome of “unable to self-sustain a post mining land use”, are required to be rehabilitated to be safe and geotechnically stable condition, and to not cause environmental harm as per conditions of the QNH EAs.

9.3 Safe and structurally stable

9.3.1 Slope designs

As stated in **Section 3**, the QNH comprises a consistent contiguous geology, soils profile and hydrogeology across the four mines. Geotechnical understanding of the QNH pit high-walls and low-walls is based on geotechnical studies undertaken for the SCM (being the first of the QNH mines). The SCM slope designs were derived from the geotechnical study *“QCoal Sonoma Project Initial Geotechnical Assessment”* undertaken by Sherwood Geotechnical and Research Services (Simmons 2006). Simmons (2006) provided the following summary (detailed therein) for the slope design:

- Alluvium: 37° overall
- Weathered coal measures rock: 45° overall
- Fresh coal measures rock: 70° overall separated by benches to suit drilling and high wall ramp/road requirements
- Benching: a minimum 10m bench at the base of alluvium or weathered coal measures (i.e. top of "hard" digging)
- Excavated faces in-pit spoil: 37° overall, 45° to max height of 15m above floor
- Dumped spoil (alluvium and coal measures): rill angle 37°, max. height of rill slope 30m normally, separated by benches to suit operational requirements
- Ex-pit dump toe setback to pit crest: not less than 20m under any conditions until in-pit spoil dump has been developed.

The above slope design targets were further investigated by consultant GHD in *“Sonoma Mine Management Residual Void Outcome of Sonoma Mine July 2010”* (GHD 2010), which provided acceptance criteria for slope rehabilitation to meet the recommended design.

The slope requirements for final voids are conditioned in the QNH EAs, as discussed in **Section 5.2**, and are presented again in **Table 8**.

The QNH EAs conditions for slopes on the low and high-walls in voids are informed by the aforementioned geotechnical assessments.

Table 8 – QNH EA void slope criteria

Site	QNH Operational Complex	Void Name	Approved High Wall Slope	Approved Low Wall Slope
Jax	Jax	Jax Main Pit	High wall – 60°	Low wall – 32°
		Jax East Pit		
Sonoma	Sonoma	Sonoma Main Pit	High wall – Maximum slope of 70° with the top 10m having a maximum of 45° including a 1m bund	Low wall – 17°-37°
		Sonoma East Pit 1		
		Sonoma East Pit 2		
Drake	Drake 5	Drake Pit 5	High wall – 65°	Low wall – 45°
	Drake 1-2	Drake Pit 1		
		Drake Pit 2		
		Drake Pit 2 Expansion		
		East Pit 1		
	Drake 3-4	Central Pit 3 (Drake Pit 4 North)		
		Central Pit 4 (Drake Pit 4 South)		
		Drake Pit 3-Q		
		Drake Pit 3-R		

Further to the above, quarterly geotechnical inspections across the QNH operational pits have been undertaken by GeoTek Solutions (GeoTek) under the supervision of an RPEQ, with reports submitted after each inspection. The objective of those inspections and reports is to monitor, assess and provide ongoing operational recommendations on the geotechnical stability of the major landforms across the QNH, including slopes, drainage, loose materials etc. Inspections provide actual geotechnical observations of active pits in the same material which will comprise final void walls and which are therefore directly applicable to likely final void conditions. A list of the RPEQ geotechnical quarterly inspection reports for the last five years are listed as follows:

- Geotechnical Inspection of QCNH, 21-22 Apr 2015 (GeoTek Solutions 26/4/15);
- Geotechnical Inspection of QCNH, 23-24 Aug 2015 (GeoTek Solutions 29/4/15);
- Geotechnical Inspection of QCNH, 10-13 Nov 2015 (GeoTek Solutions 21/11/15);
- Geotechnical Inspection of QCNH, 15-17 Feb 2016 (GeoTek Solutions 28/2/16);
- Geotechnical Inspection of QCNH, 8-10 Nov 2016 (GeoTek Solutions 3/12/16);
- Geotechnical Inspection of QCNH, 13-15 Feb 2017 (GeoTek Solutions 16/2/17);
- Geotechnical Inspection of QCNH, 22-24 May 2017 (GeoTek Solutions 26/6/17);
- Geotechnical Inspection of QCNH, 14-16 Aug 2017 (GeoTek Solutions 20/8/17);
- Geotechnical Inspection of QCNH, 13-14 Nov 2017 (GeoTek Solutions 4/12/17);
- Geotechnical Inspection of QCNH, 2-3 Mar 2018 (GeoTek Solutions 9/3/18); and
- Geotechnical Inspection of QCNH, 8-9 Aug 2018 (GeoTek Solutions 27/8/18).
- Geotechnical Inspection of QCNH, 30 Nov-1 Dec 2018 (GeoTek Solutions 22/12/18);
- Geotechnical Inspection of QCNH, 5-6 Apr 2019 (GeoTek Solutions 11/6/19);
- Geotechnical Inspection of QCNH, 3-4 Oct 2019 (GeoTek Solutions 28/11/19); and
- Geotechnical Inspection of QCNH, 10-11 Jan 2020 (GeoTek Solutions 23/3/2020).

These inspections directly inform the geotechnical condition of walls in all pits, refer to original design slopes recommended in Simmons (2006), and inform ongoing and regular assessment of the suitability of final void approved design slopes.

As such, and in addition to regular geotechnical inspections, GeoTek Solutions has periodically undertaken assessment of, and made specific recommendations relating to, the wall design slopes across the QNH. These periodic assessments are undertaken as pits develop and walls become exposed and available for actual geotechnical observation. For example, the report “Compilation of Current Pit Slope Design Recommendations Ver 5 30/08/16” (GeoTeck Solutions 30/8/16). was undertaken on pit slope designs for all QNH pits and determined that no notable changes were required to the existing approved design slopes.

Subsequent and future inspections may make recommendations based on updated and new observations. If such recommendations make suggestions that a revision to the approved EA final void design slopes for a specific EA is required (i.e. the maximum slope is recommended to be reduced), then EA amendments would be made accordingly.

QNH final void detailed designs will be subject to RPEQ review.

9.3.2 Erosion and weathering

This section addresses the potential erosion and weathering of the void walls. Specific geochemical studies completed for the SCM are directly applicable to the broader QNH (as per **Section 3**), and it is noted that the JCM ML was approved by the Queensland Government, relying on SCM waste rock investigations being directly applicable to the JCM. Key geochemical studies are listed below:

- “*Sonoma Coal Project – Overburden assessment report May 2006*”, (Parsons Brinkerhoff 2006).
- “*Geochemical Assessment of Mining Waste and Coal Reject Materials Sonoma Coal Mine – Dec 2012*” (Terrenus 2012)
- “*Mining waste and coal reject management plan Ver 1: Jan 2013*” (Terrenus 2013)

Parsons Brinkerhoff (2006) described the tertiary/quaternary material in the SCM and CCM areas, making a determination that the materials were consistent from the SCM into the CCM, indicating continuity of the soils and geology from north to south (as per **Section 3**). Parsons Brinkerhoff (2006) made the following comments on tertiary/quaternary material:

- slightly alkaline (pH 7.8 – 8.6);
- low to moderate salinity/EC (EC 200 – 700 ms/cm);
- ESP <15% (<5% is non-dispersive);
- Emerson class results of 4-6 (5-6 is considered non-dispersive);
- dispersivity index 2-6% (<30% is non-dispersive); and
- suitable for capping.

Terrenus (2012) and (2013) provide geochemical comment for the SCM factoring in operational pit data and pit wall observations. Of note are the findings relating to dispersion of the wall material (reported as overburden and interburden). Soil dispersion is the loss of cohesion and the breaking down of soil structures into soil particles, making spoils susceptible to erosion or loss of geotechnical competence.

The following relevant conclusions have been extracted from Terrenus (2012) and (2013) regarding the potential for erosion of the overburden and interburden of the SCM as applicable to the QNH:

- Terrenus (2013) stated that Permian spoil is generally moderately sodic, however it is not expected to be significantly dispersive or prone to significant soil erosion. Alluvial spoil was noted as generally having lower sodicity.
- Terrenus (2012) stated that weathered and un-weathered Permian overburden and interburden is expected to be moderately sodic, but is not expected to be dispersive or prone to significant soil erosion, based on:
 - in-pit and drill core spoil samples of weathered and unweathered Permian overburden and interburden;
 - exchangeable sodium percentage (ESP) tests which are an indirect measure of the potential for dispersion - ESP results indicated moderate sodicity with no notable difference between weathered and unweathered overburden; and
 - Emerson Class tests which are a direct measure of soil dispersion - Emerson Class results (class No. 8 on a scale of 1-8 for all samples tested) indicated that the overburden and interburden soils are non-slaking, non-swelling and non-dispersive.

Therefore, pit walls on the QNH, which comprise an upper layer of surficial tertiary/quaternary material underlain by weathered and unweathered Permian material, are considered to be potentially sodic but unlikely to be dispersive. The risk of erosion on the QNH final void walls is considered to be more likely associated with normal weathering of material, or hydraulic or gully erosion, which requires mitigation in drainage designs.

9.3.3 Significant hydrological events

As detailed in **Section 7.3**, the water balance model used climate data from 1889 to September 2019 (a 130 year period) measured in the QNH area (Collinsville). The largest single day rainfall event measured as 348.7 mm (08/04/1940) and the largest seven day total measured as 454 mm (02/02/1991 – 08/02/1991), as such the adoption of this climate data factors in actual measured significant hydrological events. Specific consideration of these events as they relate to geotechnical stability of the JCM and SCM final voids was considered in the previous void assessment and modelling reports:

- *“Investigation into Residual Void Jax Coal Mine – QCoal October 2018”* (submitted to DES 12 October 2018), which included the technical study *“Jax Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2018”* (Engeny 2018); and
- *“Investigation into Residual Void Sonoma Coal Mine – QCoal January 2016”* (submitted to DES 29 January 2016), which included the technical study *“Sonoma Coal Mine Final Void Hydrology Study Main Pit – Engeny Water Management 2015”* (Engeny 2015a).

The other aspect of significant rainfall events potentially affecting pit wall stability is associated with infiltration of rain water into the walls from the surface down, saturating the material behind the wall surface, reducing the geotechnical competency of the wall material. The geotechnical inspections listed in **Section 9.3.1**, include assessment of drainage and saturation of wall materials. As such the final detailed landform designs associated with the QNH final void closures (which will include drainage requirements above the highwall to prevent pooling and saturation) will be well informed by geotechnical highwall observations made on the QNH operational pits.

9.3.4 Revegetation

Revegetation considerations for the QNH final voids are only applicable to the sections of the low-walls between the void lake level and the upper sections of the low-wall where the rehabilitation domain transitions from final void to waste rock dump. This is because there is no practical revegetation activities which could be undertaken on the high-wall or the void lake itself (as it is a water body).

As stated in **Section 9.2**, the recommended void outcome for all QNH final voids is “Residual void unable to sustain a post-mining-land-use”, with the Jax Main Pit and Jax East Pit voids already having that outcome as a rehabilitation condition in Table H1 of the JCM EA. Revegetation of the applicable sections of the low walls on the QNH final voids is not intended to be utilised habitat or grazing, but is for the purpose of slope stabilisation and erosion protection. As such, a primary metric of successful rehabilitation will be the capability of the void to support establishment, survival and propagation of suitable vegetation species to stabilise slopes and reduce erosion.

QCoal (2018) provides guidance on establishing vegetation in rehabilitated areas, including a list of preferred native and pasture species for revegetation, and should be referred to accordingly. Additional detailed information is provided in the QNH RMP

Indirect/incidental establishment of grasses is anticipated to occur on the final void low-walls based on observed and monitored progressive rehabilitation of areas of rehabilitated waste rock dump on the QNH mines

It is important to note that grass and shrub cover has been well established on rehabilitated areas of the QNH for several years, which is a clear demonstration of the suitability of the QNH waste rock and re-spread topsoil to support vegetation. In addition, it is noted that this revegetated area was not actively seeded as part of rehabilitation works, but was revegetated by seedbank within the material and the indirect/incidental processes described above.

9.4 Potential for environmental harm

This section considers the potential for the final voids on the QNH to directly or indirectly cause environmental harm once they have been rehabilitated to achieve the approved final landform design criteria (**Section 9.5**) and void outcomes (**Section 9.2**).

The potential for environmental harm to occur exists where there is an environmental or human value which could experience long-term negative impact beyond the normal range of natural variations.

9.4.1 Groundwater levels

As presented in **Section 4.2**, the following are not considered values of groundwater in the QNH:

- inter-aquifer connectivity;
- springs wetlands of GDEs;
- stygofauna; or
- human groundwater use.

In specific consideration of potential impacts to surface water baseflow, conceptually for there to be any impact to baseflow associated with a QNH final void, two conditions would need to be satisfied simultaneously:

- a surface water body needs to have demonstrated baseflow which is (at least partly) fed by a hydraulic connection to the underlying groundwater; and
- the extent of a cone of depression would need to intercept that same underlying groundwater causing a reduction in level.

As stated in **Section 4.2**, Pelican Creek, Coral Creek, Two Mile Creek and Twelve Mile Creek are ephemeral, and are considered to be losing-disconnected systems with no notable hydraulic connection to groundwater. As such, despite the prediction of a cone-of-depression in the vicinity of Coral Creek, Two Mile Creek and Twelve Mile Creek, no potential impact is considered likely.

As also stated in **Section 4.2**, the Bowen River does experience a baseflow; however, previous studies have determined that no hydraulic connection exists with the underlying groundwater. The modelling results from groundwater modelling presented in **Section 6.2** (and previously in AGE (2015)), indicate that cones-of-depression do not extend to the Bowen River. As such, the Bowen River is not expected to experience any impact to baseflow as a result of the QNH final voids.

9.4.2 Non-polluting

The mechanisms by which pollution (that is the release of a contaminant to the environment **outside of the natural range of concentrations**) could occur as the result of the presence of the QNH voids, are:

- void lake water of a degraded quality (as discussed in **Section 8.2**) migrating into the **regional** groundwater system; or
- void lake water of a degraded quality (as discussed in **Section 8.2**) spilling over the pit crest and into surrounding drainage channels flowing into the Bowen River.

The potential for void lake water to migrate to the regional groundwater is addressed in **Section 6.2 and Section 8.1**, which collectively describe that:

- Modelling predictions indicate that all final voids on the QNH are predicted to be groundwater sinks with a net inflow, except for Drake Pit 3Q, Drake Pit 3R, Sonoma East 2 and Sonoma East 1 (in the water balance model), where the modelling returned a mathematical net outflow;
- **Section 6.2** determines that in all such cases any such net outflow is intercepted by an adjacent groundwater sink final void on the QNH, that QNH voids when assessed as complexes are all groundwater sinks and that QNH when assessed cumulatively is a groundwater sink with no migration away from the QNH
- As such, the modelling results indicate that no water from the QNH final void lakes is predicted to migrate outside of the cumulative cone of depression, with nine of the 14 final voids predicted to not experience any outflow at all. The mechanisms by which pollution of the regional groundwater might occur are not predicted by the modelling.

The potential for void lake water to spill over void crests is addressed for every QNH final void in **Section 8.1**, where water balance modelling results indicated that no QNH final void maximum water level height was above the final landform crest elevation. This modelling was in consideration of all possible inflows including natural catchment and disturbed catchment runoff, direct rainfall and pit inflows (no flood ingress was identified as potentially occurring on any QNH final void as a result of location and landform design)

9.5 Rehabilitation completion criteria

The void outcome for all QNH voids has been recommended as “residual void unable to sustain a post-mining-land use” (with the Jax Main Pit and Jax East Pit voids already having this outcome as a condition in the JCM EA). As such, rehabilitation of the QNH final voids is required to achieve the following goals:

- Safe to humans and wildlife;
- Structurally and geotechnically stable; and
- Non-polluting with no environmental harm being caused by anything on or in the land.

In order to demonstrate that a rehabilitated final void has achieved the rehabilitation goals, objectives for each goal have been identified along with completion criteria to be applied to each objective. Completion criteria are the specific quantifiable metrics by which the status, progress and ultimately completion of a rehabilitation objective can be demonstrated. The completion criteria comprise an indicator and a target value for the indicator. Once the rehabilitation criteria are achieved, the final void can be said to have been rehabilitated to the required condition.

Table 9 provides a summary of the rehabilitation goals, objectives and completion criteria recommended for the QNH final voids.

Table 9 – QNH voids rehabilitation goals, indicators and completion criteria

Goal	Rehabilitation objective	Completion Criteria	
		Indicator	Target to be achieved
Safe to humans and wildlife	Safety risk to people, fauna and livestock is managed	- Access to high walls minimised	Bunds present, stable and self-sustaining. Fencing around high walls present.
Structurally and geotechnically stable	Void walls are geotechnically stable	- Slope of high wall and low wall; - No evidence of cracking/collapse; - No evidence of significant erosion	- high wall slope: $\leq 173\%$ (60°) - low wall slope: $\leq 86\%$ (32°) - RPEQ monitoring of void walls - Drainage design and completion to prevent scouring or gully erosion - RPEQ sign-off of drainage design - RPEQ inspection of completed slopes
Non-polluting with no environmental harm being caused by anything on or in the land.	Void water does not present a risk of impacting on the surface water environmental values (overtopping)	Results from water balance model determining overtopping risk.	Model results predict low risk of overtopping including consideration of significant hydrological events.
	Void water does not present a risk of impacting on the groundwater environmental values of the local aquifer/s (seepage into groundwater)	Results from water balance model and numerical groundwater model	Model results predict a low risk of void lake water migrating into the regional groundwater system Specific model findings may be that voids are individually groundwater sinks or (if there is a mathematical outflow) are located within a cone of depression associated with an adjacent pit such that there is a net groundwater inflow into the QNH.
	Void drawdown does not present a risk of impacting on the groundwater values of the local aquifer/s	Surrounding groundwater level	Model results provide a maximum drawdown extent inside of which there are either no groundwater values which can be impacted, or if groundwater values are identified the drawdown extent, the risk of impact is determined to be low.

10 Conclusions

There are 14 approved QNH final voids, three on the SCM, two on the JCM and nine on the DCM. At cessation of active operation, dewatering will cease and the natural hydrological/hydrogeological process will commence the formation of void lakes.

The groundwater in the QNH area has no notable value as baseflow in surrounding surface water features, as stygofauna habitat, or as source water for springs, wetlands or GDEs. In addition, there is limited human use of groundwater in the vicinity of the QNH.

A numerical hydrogeological model and a numerical water balance model were developed for the QNH final voids to predict an equilibrium state after completion of rehabilitation. The results indicated an equilibrated state where:

- Groundwater drawdown cones-of-depression will occur surrounding the void complexes, as expected, with the extent of drawdown not shown to intercept the Bowen River or any surrounding potential supply bores.
- Void water is fully contained within the QNH final void complexes:
 - o void water from Drake 3Q Pit and Drake 3R flows into the Jax Main Pit.
 - o void water in the Sonoma Main Pit, Sonoma East Pit 1 and Sonoma East Pit 2 voids may experience localised flow between voids dependent on the final level of in-pit rejects disposal within Sonoma Main Pit.
 - o all other individual QNH final voids are groundwater sinks predicted not to experience any net outflow.
 - o the QNH voids when assessed as complexes are all groundwater sinks, and the QNH when assessed cumulatively is a groundwater sink. As such, there is no scenario which results in migration of QNH void water out of the cumulative cones of depression.
- No scenario was predicted where any void lake water level will reach spill/crest elevation.

The salinity of all residual voids modelled is forecast to continue to increase over time due to the ongoing concentration resulting from evaporation in conjunction with no significant outflow of salts from either net outflows seepage or overflows. **It should be noted that pits with net outflow were still shown to accumulate salts throughout the model duration.** The reason for this occurrence is that predicted net outflow rates into the surrounding geology, at all levels of rating curves, for all pits, were significantly smaller in magnitude than flows associated with rainfall, runoff, and evaporation. The results indicate significant variation in the EC of the different voids; however, all void lakes are forecast to exceed 10,000 $\mu\text{S}/\text{cm}$ after 200 years (with the exception of Jax Main Pit which is closer to 220 years), with some pits reaching 10,000 $\mu\text{S}/\text{cm}$ after 40 years. Ultimately, salts will continue to concentrate with the maximum concentration only limited by solubility of the constituent salts within the lake. This is conceptually the case for any comparable water body receiving inflow, which experiences evaporation as either the only outflow, or at a rate exceeding all other outflows. As such, the water in the QNH voids is predicted to be unsuitable for any use and be contained within the QNH voids for all modelled scenarios. In consideration of those results, it is concluded that none of the QNH final voids can self-sustain a designated post-mining land use, as all potential uses are contingent on having an acceptable level of quality for that use, none of which can be met over time.

The specific slope design criteria for the QNH final void walls is conditioned in the respective EAs. The origin of those slopes was the initial geotechnical assessment for the SCM followed by specific subsequent geotechnical studies which informed the slopes designs adopted in the EAs. Since commencement of operation, QNH pit walls have been subject to RPEQ geotechnical inspections, including specific reviews of the design slopes for pit walls. None of the findings in the RPEQ geotechnical assessments indicate that the final void slopes proposed in the QH EAs are unsuitable, provided contributing factors are addressed (such as drainage), and a final RPEQ design of final voids is undertaken to consider the specific materials exposed in the final high walls. As such, provided an RPEQ final design is undertaken which includes full drainage design, there is no impediment to achieving a geotechnically stable final landform.

There have been several studies previously completed into the geochemistry of the QNH including which included comment on sodicity and dispersion. The materials comprising QNH final void walls are not considered especially dispersive, and, as such, erosion and weathering risk is considered more likely to be associated with hydraulic erosion (gully, erosion, tunnel erosion and scouring), which is to be addressed in drainage designs. In additional saturation of walls (leading to a risk of failure) is also to be addressed in final drainage designs.

Revegetation of the applicable sections of the low walls on the QNH final voids is not intended to be utilised for habitat or grazing but is for the purpose of slope stabilisation and erosion protection. QCoal (2018) provides guidance on establishing vegetation in rehabilitated areas, including a list of preferred native and pasture species for revegetation, and should be referred to accordingly. Additional detailed information is provided in the QNH RMP. Indirect/incidental establishment of grasses is anticipated to occur on the final void low-walls based on observed and monitored progressive rehabilitation of areas of waste rock dump on the QNH mines. It is important to note that grass and shrub cover has been well established on rehabilitated areas of the QNH for several years, which is a clear demonstration of the suitability of the QNH waste rock and re-spread topsoil to support vegetation.

Accordingly, all QNH final voids modelled in this assessment are determined not to be in “stable condition” as defined in Section 111A of the EP Act, and are recommended to have a void outcome of “residual void unable to sustain a post mining land use”. Until such time as the SCM, DCM and JCM transition into the PRC Plan framework, any final landforms which are determined not to be in “stable condition” under Section 111A will be managed as NUMAs whilst not definitionally be referred to as NUMAs. Once transitioned into the PRC Plan framework any such landforms will then also be definitionally referred to as NUMAs.

The Jax Main Pit and Jax East Pit voids already have this void outcome conditioned in the JCM EA, which is consistent with the findings of this assessment and *“Investigation into Residual Void Jax Coal Mine – QCoal October 2018”* (submitted to DES 12 October 2018).

These findings are also consistent with the void outcomes previously identified for Sonoma Main Pit in *“Investigation into Residual Void Sonoma Coal Mine – QCoal January 2016”* (submitted to DES 29 January 2016).

Final voids with an outcome of “unable to self-sustain a post mining land use”, are required to be rehabilitated to be safe and geotechnically stable condition, and to not cause environmental harm as per conditions of the QNH EAs.

10.1 Recommendations

The following recommendations are made based on this investigation:

- 1) The goals for all QNH residual voids are that they should be safe, geotechnically stable and not cause any environmental harm or carry any additional level of risk, beyond what is inherent to the existence of the void itself. The nominated completion criteria reflect this objective.
- 2) All QNH residual voids have been found to be unable to sustain a PMLU as a result of degrading water quality. This is reflected in the JCM EA for the JCM voids. The SCM and DCM EAs should be amended to also reflect this finding.
- 3) From the cessation of pit dewatering until the completion of rehabilitation activities:
 - a) undertake a monthly survey or measurement of water level in the main pit final voids;
 - b) undertake quarterly water quality monitoring of final void water;
 - c) undertake a monthly inspection of the pit walls by a geotechnical engineer/mining engineer/pit geologist for any visual signs of weakening, slipping, failure or gully/tunnel erosion
 - o if required, the inspection may make recommendations for remedial actions
 - o if required, the inspection may make recommendations for further pit wall stability studies.
- 4) Prior to final rehabilitation, engage a third party RPEQ engineer to undertake a final assessment and design of the high wall and low wall, in consideration of the completion criteria in the EA. Such a design should be informed by the prior quarterly RPEQ operational inspections and data.
 - a) Any recommendations made by the RPEQ should be factored into rehabilitation works.

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Sonoma Mine Management Residual Void Outcome Sonoma Mine July 2010 (GHD 2010).

Stygofauna Survey for the Drake Coal Mine Project (July 2016) – Freshwater Ecology Pty Ltd 2016 (Freshwater Ecology 2016)

APPENDIX A

**Jax Coal Mine Final Void Hydrology Study Main Pit – Engeny Water
Management 2018 (Engeny 2018)**

and

**Long Term Water Quality of Jax Coal Mine Residual Voids - 2 April 2019
(Engeny (2018) Supplementary Memo)**



JAX COAL PTY LTD

JCM Final Void Hydrology Study

Jax Main Pit and Jax East Pit



November 2018

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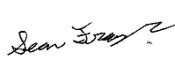
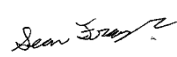
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1. INTRODUCTION

The Jax Coal Mine (JCM) is located approximately 8 km south of Collinsville within the Bowen Basin. Sonoma Coal Mine (SCM), Drake Coal Mine (DCM) and Cow Coal Mine (CCM) are located to the north and west of JCM. These four mines are owned and operated by subsidiaries of QCoal Pty Ltd (QCoal) and are collectively referred to as the QCoal Northern Hub (QNH).

There is currently one open cut mining pit within the JCM mining lease (ML10346), JCM Main Pit. JCM East Pit is a planned open cut mining pit, which has not yet commenced. The site layout is illustrated in Figure 1.1.

The JCM is authorised to operate under Environmental Authority (EA) EPML00337613 dated 5th September 2017. The EA specifies the following requirements for final voids:

- **Condition F9 Residual Void Outcome**

Residual voids must comply with the following outcomes:

- a) *Residual voids must not cause any serious environmental harm to land, surface waters or any recognised 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.*
- b) *residual voids must comply with Table F1: Residual void design.*
- c) *with the exception of the residual void (Jax Pit 1) referred to in Table F1, all voids must be backfilled.*

- **Condition F10**

Complete an investigation into residual voids and submit a report to the administering authority for review and approval. The report must propose acceptance criteria to meet the landform design criteria stipulated in the Rehabilitation Management Plan and Table F1: Residual void design by 31 July 2018.

QCoal has commissioned Engeny Water Management (Engeny) to undertake a void hydrology study of the proposed JCM voids, to inform the assessment report required under **Condition F10**. This void hydrology study has been prepared under the direct supervision of Sean Frazer (RPEQ No. 21211).

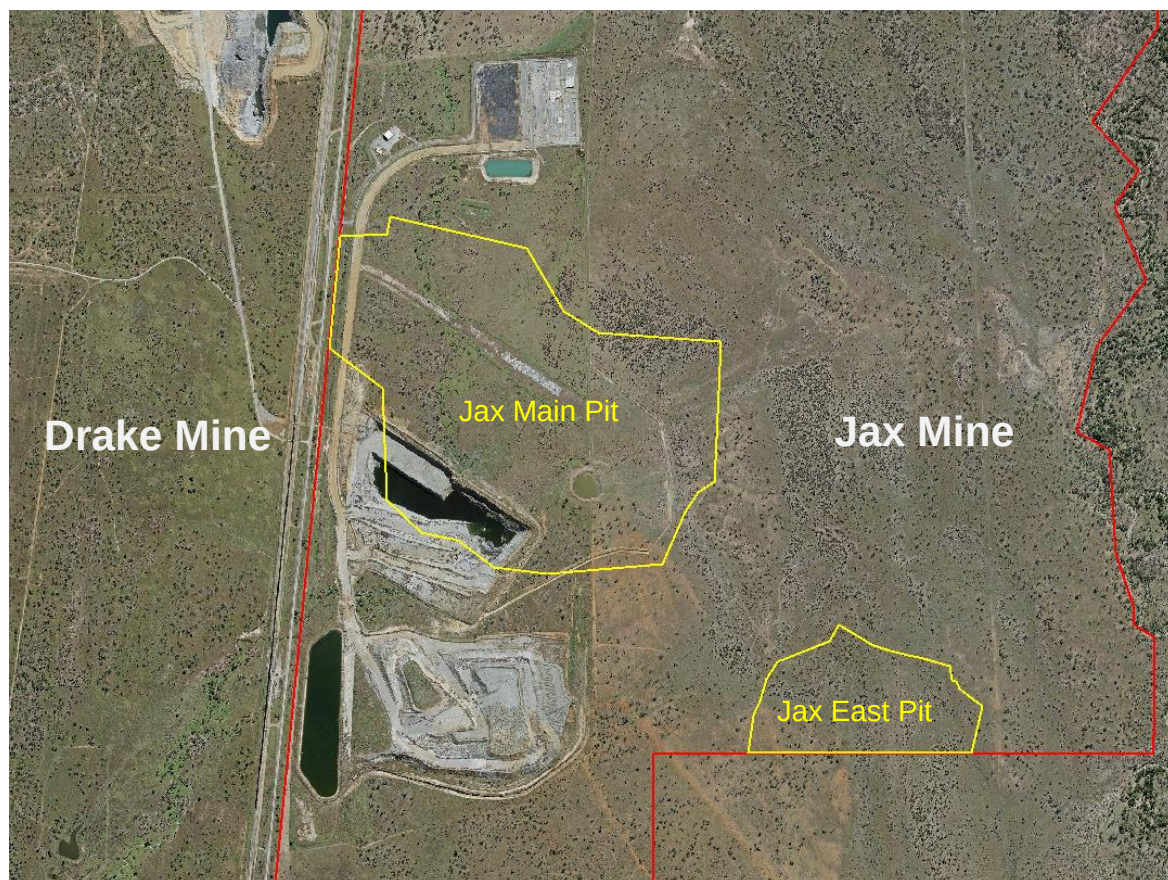


Figure 1.1 JCM Site Layout

2. DATA REVIEW

2.1 Previous Studies

A number of previous studies have been referred to for this assessment including:

- *Water Management Plan 2017 QCNH Mines* (Engeny, December 2017).
- *SCM Final Void Hydrology Study Main Pit* (Engeny, November 2015).
- *CCM Final Void Hydrology Study Q Pit and B Pit* (Engeny, April 2017).
- *Drake Coal Project Groundwater Model* (AGE, January 2015).

2.1.1 Water Balance Model

Engeny has previously developed a water balance model of the QNH mines (including JCM) in the GoldSim software. The development of the model, input parameters and calibration are detailed in *Water Management Plan Northern Hub Mines* (Engeny, Dec 2017). The existing model has been adopted as a basis for this final void hydrology study.

2.2 Final Void Landform

The purpose of this study is to conservatively inform the overall report required as per Condition F10; therefore, a final void scenario has been assumed which has both Jax pits retained as final voids. As such the final landforms for the JCM voids (including storage curves) have been determined based upon the latest mine planning designs supplied by QCoal. Catchment areas for the base case have been estimated from the mine plans and existing survey while a sensitivity analysis has been undertaken with potential catchment variations. The actual final landforms on the JCM are not considered likely to differ from the final landforms modelled in this report to a degree which would negate the findings of this study.

2.2.1 Storage Curve

The assumed final landform storage curves are presented in Figure 2.1 and Figure 2.2. The Jax Main Pit and Jax East Pit voids are estimated to have a storage capacity of 32 GL and 11 GL respectively. The storage curves have been adopted as a reasonable estimate of the final pit void storage characteristics.

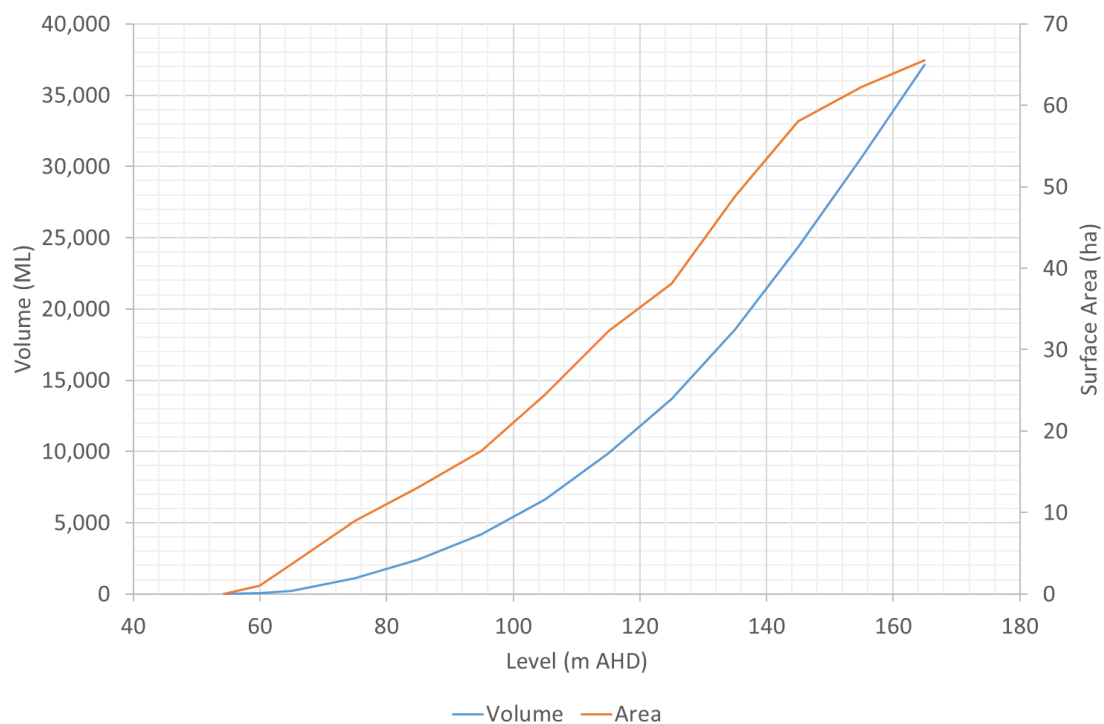


Figure 2.1 Jax Main Pit Storage Curve

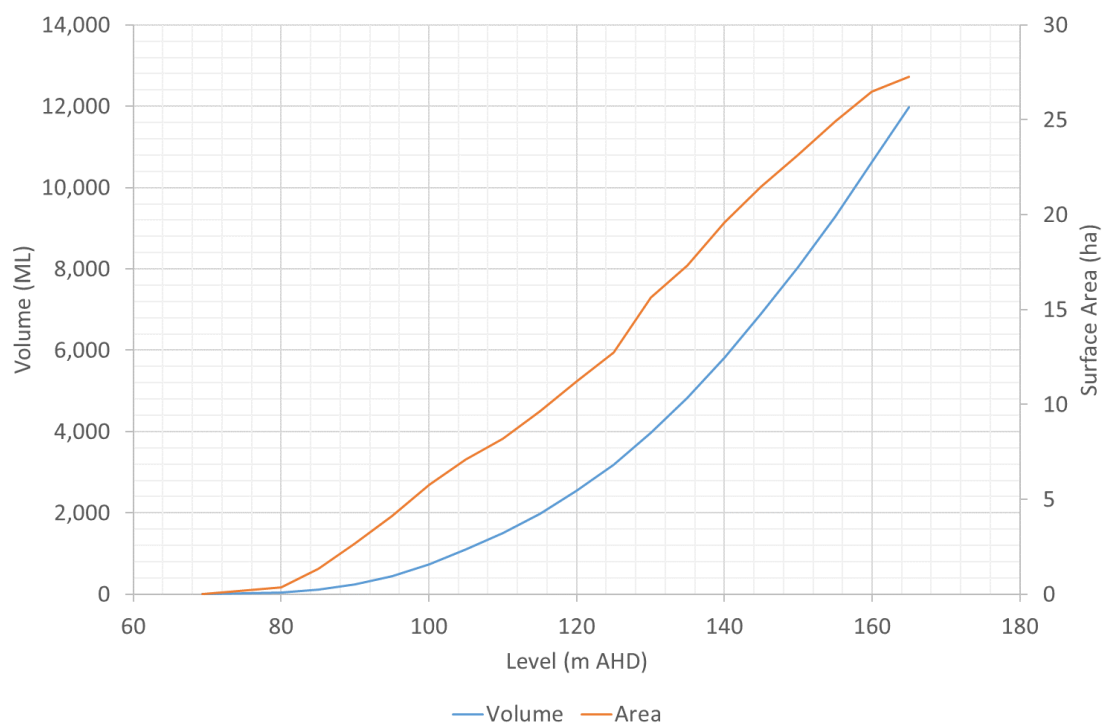


Figure 2.2 Jax East Pit Storage Curve

2.2.2 Contributing Catchment

In addition to the LiDAR data, aerial photography from July 2018 and mine plans have been used to model the final landform catchments. It has been assumed that all out-of-pit spoil areas will be rehabilitated following the cessation of mining.

The adopted final void catchments for JCM pits are presented in Figure 2.3 and Figure 2.4 for the Base Case Scenario. These catchments have been determined from current topography and final void designs. Review of the topography indicates that the natural catchment to the east of Jax Main Pit can be readily diverted away from the void and it was therefore considered reasonable to exclude this area from the Base Case catchment (refer to pink shaded region in Figure 2.3).

Both final voids have additional upslope natural catchments that would require more substantial drainage infrastructure to divert. The impact of diverting this additional catchment has been assessed by undertaking a sensitivity assessment presented in the Reduced Catchment Scenario. The contributing catchments for this scenario are presented in Figure 2.5 and Figure 2.6 and represent the minimum contributing catchment, which will minimise the void lake level.

A summary of the contributing catchment areas for the two scenarios is provided in Table 2.1.

Table 2.1 Contributing Catchment and Landuse

Pit	Scenario	Area (ha)			
		Pit	Rehab	Natural	Total
Jax Main Pit	Base case	69.4	59.8	134.3	263.5
Jax Main Pit	Reduced catchment	69.4	59.8	14.1	143.3
Jax East Pit	Base case	28.3	-	20.3	48.6
Jax East Pit	Reduced catchment	28.3	-	12.9	41.2

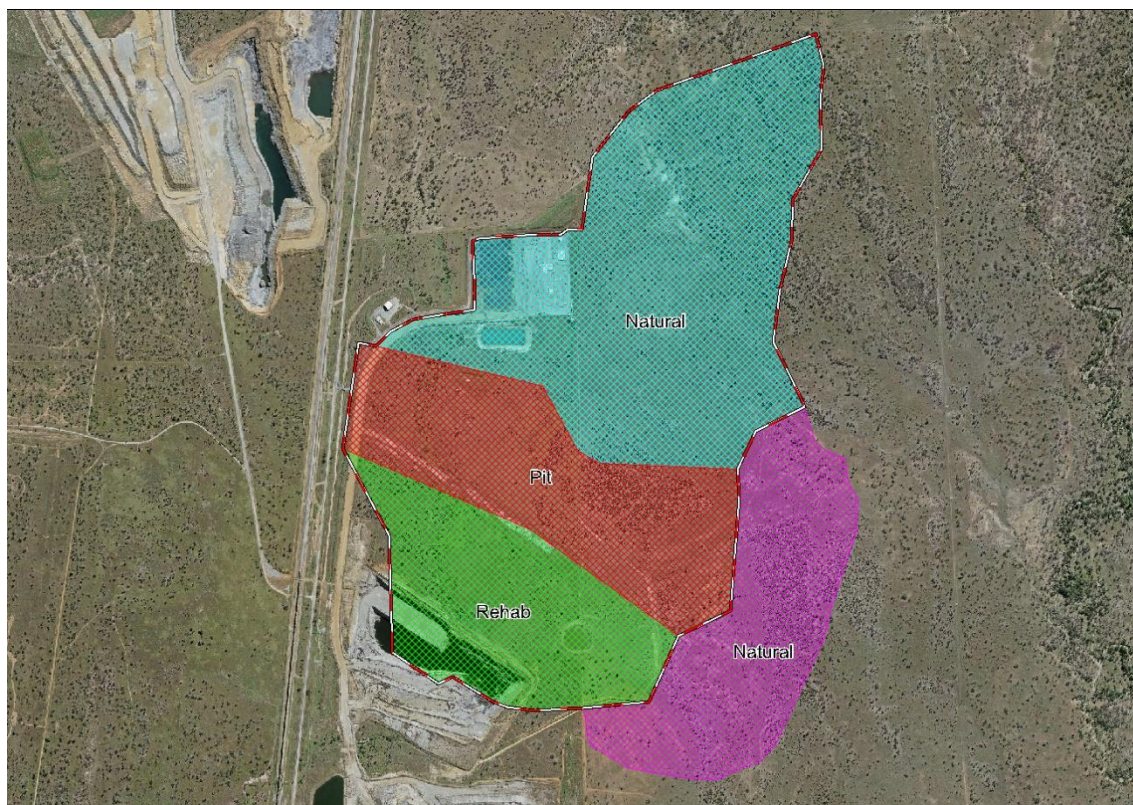


Figure 2.3 Jax Main Pit Catchment (Base Case)

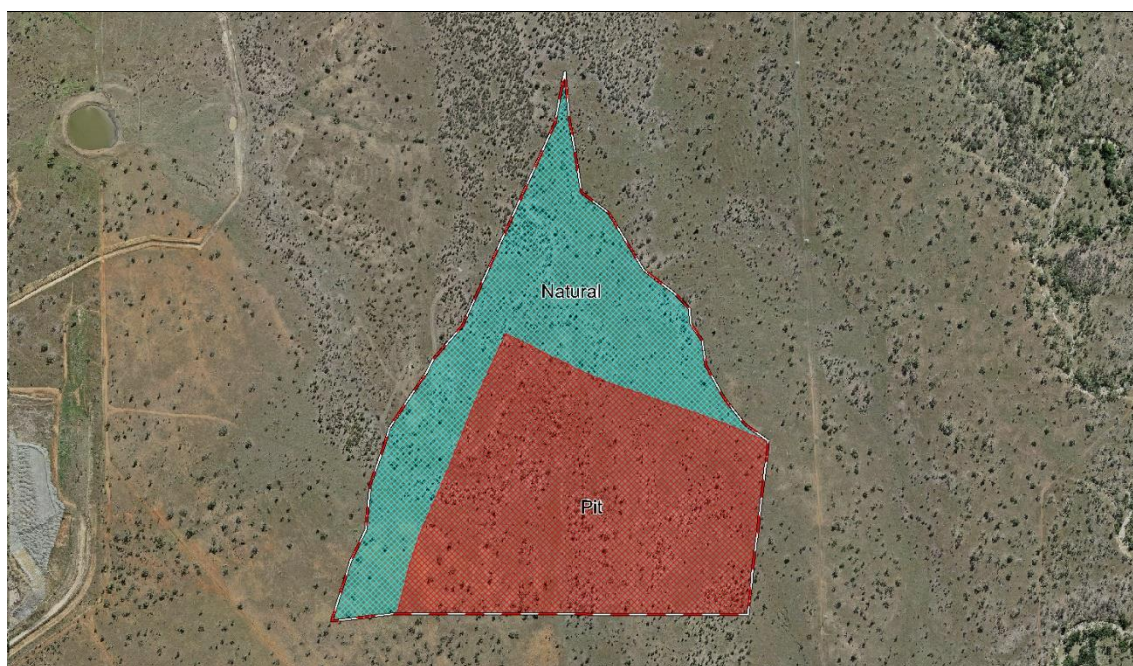


Figure 2.4 Jax East Pit Catchment (Base Case)

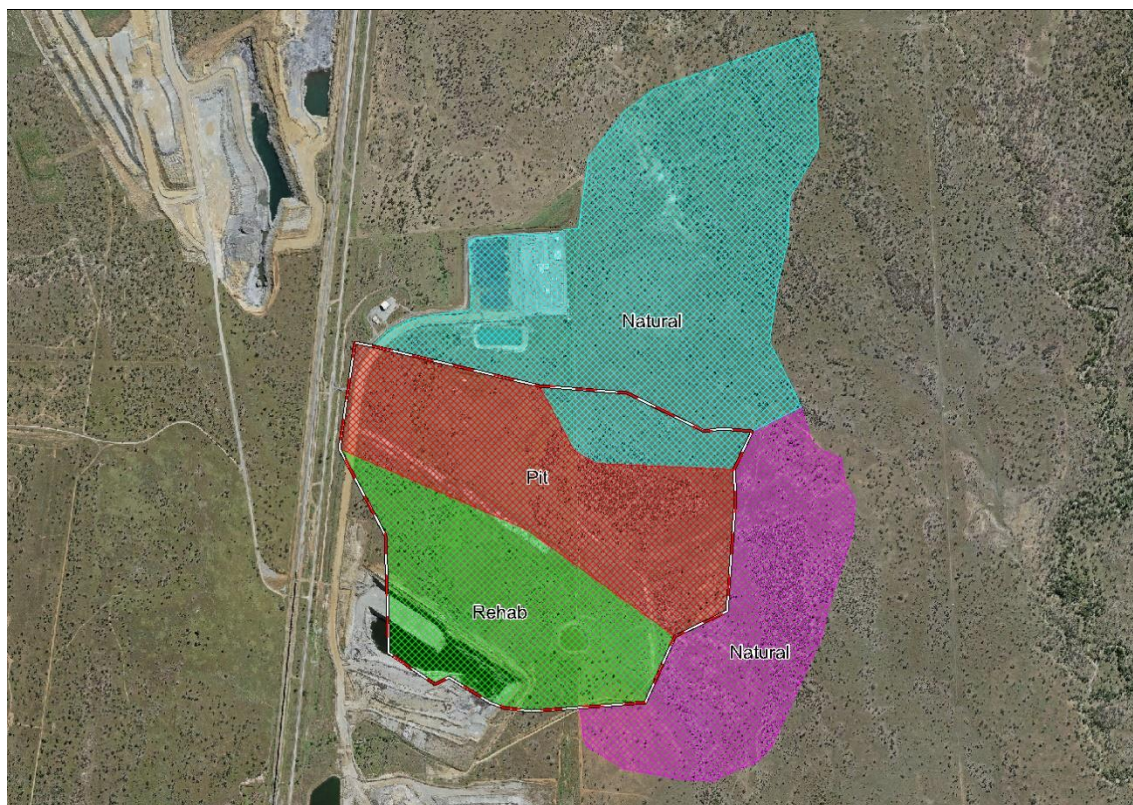


Figure 2.5 Jax Main Pit Catchment (Reduced Catchment Scenario)

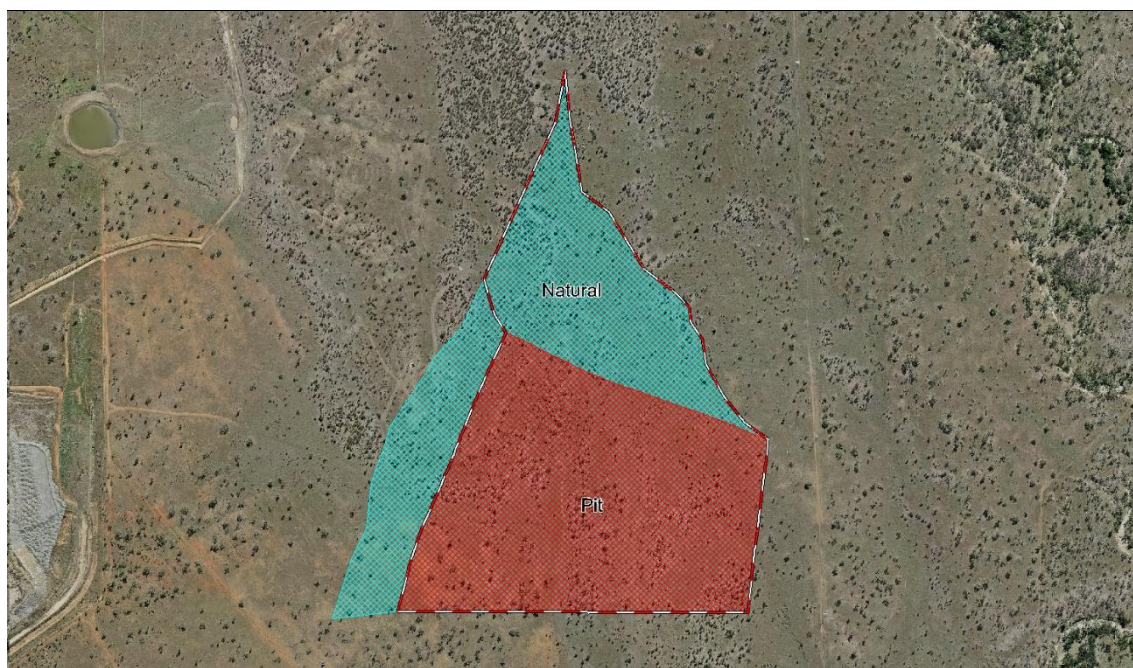


Figure 2.6 Jax East Pit Catchment (Reduced Catchment Scenario)

2.3 Connections to Groundwater

The regional groundwater system in the vicinity of the JCM has been described in a number of previous studies, the most recent of which is the Drake Coal Project Groundwater Model (AGE, 2015) which informed a broader groundwater assessment inclusive of the JCM, in the Drake Coal Mine Groundwater Monitoring and Management Plan (QCoal, 2014).

Numerical groundwater modelling of the design final voids was undertaken by AGE in September 2018 to predict groundwater inflow in the Jax Pit voids. From the model, a rating curve of groundwater inflow vs pit water level for the two Jax Voids was developed. The modelling included both a combined assessment (assuming the water level in each void is the same) as well as Jax Main Pit and East Pit in isolation. The groundwater inflow relationship for the base case scenario is based on the combined pits model. A sensitivity analysis was undertaken using the rating curves derived for each pit in isolation.

The AGE assessment (Sep 2018) identified the following key findings:

- The pre-mining regional groundwater levels in the vicinity of Jax Pits is approximately 140 m AHD. As shown in Figure 2.7, the zero flow level (i.e. the level at which there is no net inflow or outflow from the pit lake to groundwater) is 143 m AHD for Main Pit and 131 m AHD for East Pit.
- The base of weathering around Jax Main Pit varies from approximately 140 m AHD in the south west of the pit to around 160 m AHD in the north east of the pit.
- The base of weathering at Jax East Pit ranges from 143 m AHD to 154 m AHD across the pit footprint.
- The numerical model indicate that the pre-mining regional water table is coincident with the base of weathering.

The base case relationship between water level and groundwater inflows for both Jax Main Pit and Jax East Pit are presented in Figure 2.7. Negative flows shown in the figure indicate a net outflow from the pit into the surrounding groundwater system. In theory, this would occur in the situation where the water level in the pit is higher than the groundwater level surrounding the pit. It is noted that these hypothetical net outflow rates are likely to be artificially high due to the application of an “infinite sink” as a boundary condition on the groundwater model.

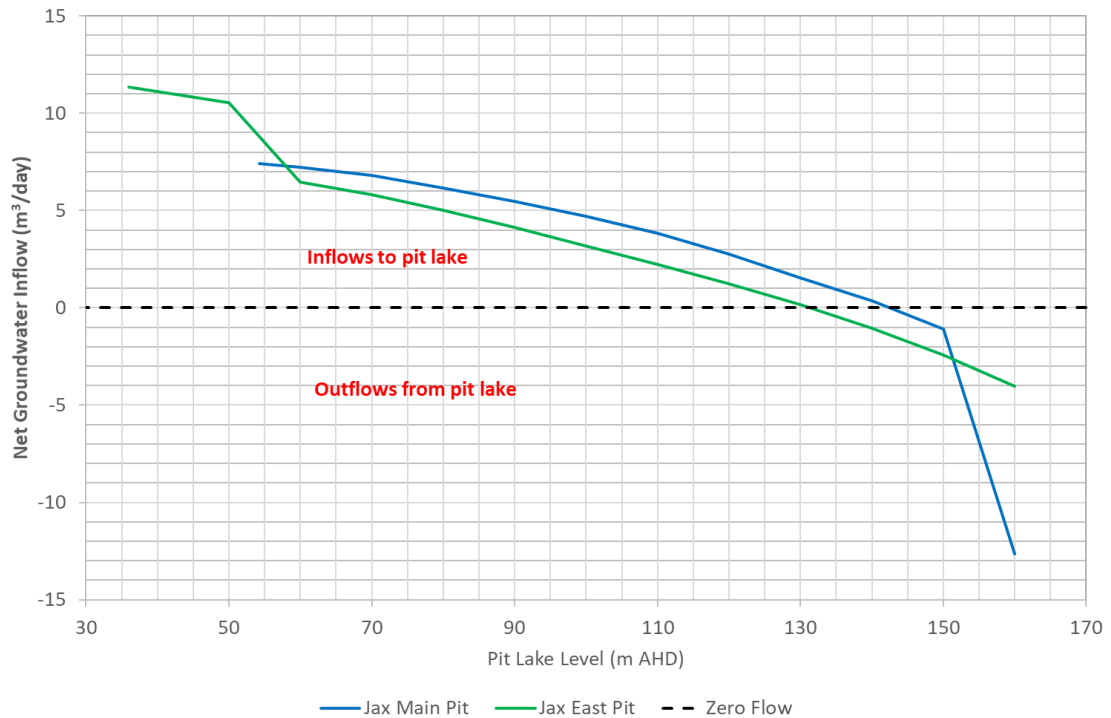


Figure 2.7 Pit Lake Level vs Groundwater Inflow Relationship for JCM Pits

2.4 Water Quality

Electrical conductivity (EC) and Total Dissolved Solids (TDS) are key indicators of water quality and can be simulated within the existing water balance model. The model directly simulates TDS using a salt mass balance and converts to EC via a constant conversion factor ($1 \text{ mg/L TDS} = 1.49 \text{ } \mu\text{S/cm EC}$). Water quality inputs to the water balance model have been reviewed and are summarised in the following sections.

2.4.1 Groundwater

Monitoring of groundwater quality across a number of monitoring bores at QNH is undertaken on a quarterly basis. The groundwater quality data has previously been assessed as part of the *SCM Final Void Hydrology Study Main Pit* (Engeny, 2015) and *CCM Final Void Hydrology Study Q Pit and B Pit* (Engeny 2017). Both studies determined a representative groundwater inflow quality of $2,000 \text{ } \mu\text{S/cm}$. A consistent quality has been adopted for the JCM Void Assessment, which is considered suitable to model the rate of change resulting from hydrological processes within the pit voids. The impact of a higher groundwater inflow EC has been assessed via a sensitivity analysis (as presented in Section 3.4).

2.4.2 Surface Water

Surface water runoff TDS characteristics have previously been calibrated for a number of land use types as documented in *Water Management Plan Northern Hub Mines* (Engeny, Dec 2017). These runoff TDS characteristics have been adopted for the modelling of both JCM voids in this void hydrology study and are summarised in Table 2.2.

Table 2.2 Runoff TDS

Landuse Type	TDS (mg/L)
Pit	1,300
Rehabilitated Spoil	Varies with runoff depth: $547 \times (\text{Rainfall Excess})^{-0.19}$ max 700 mg/L

2.4.3 Potential for Stratification

Due to the depths of the final void lakes and the likely thermal gradients, the lakes are considered to have a potential for stratification. This is likely to occur on a seasonal cycle with stratification in the warmer summer months followed by mixing in the cooler winter months or under climatic conditions that would promote the turnover of the void lake stratification (e.g. strong winds).

3. WATER BALANCE MODEL ASSESSMENT

3.1 Final Void Inflows and Outflows

The water balance of the final void will be governed by the following water inflows and outflows:

- Inflows:
 - Surface runoff inflows from rehabilitated spoil areas that drain to the void.
 - Surface runoff inflows from the walls and ramps of the void.
 - Inflows from incident rainfall on the void lake.
 - Groundwater inflows to the void (if the void lake level is lower than the regional groundwater level).
- Continuous Outflows:
 - Outflows due to evaporation losses from the surface area of the void lake.
- Potential Outflows (conditional on void lake level):
 - Seepage outflows from the void lake to groundwater (if the void lake level is higher than the regional groundwater level).
 - Discharges to surface water (only if the void fills to its' spill level).

3.2 Modelled Scenarios

A number of scenarios have been simulated using the water balance model in order to assess the hydrological behaviour of the final voids. The scenarios assessed are presented in Table 3.1. Scenario 1 (i.e. the Base Case) has adopted the best available estimates of model inputs, while Scenarios 2 to 8 provide a sensitivity analysis of uncertainties in key adopted input parameters.

The model has been simulated for a period of 100 years. The historical climate record (as detailed in the Water Management Plan (Engeny, 2017)) has been utilised to assess 124 potential realisations of the void behaviour under different climate sequences.

Table 3.1 Water Balance Model Scenarios

ID	Scenario	Description
1	Base	Jax Main Pit: Pit shell = 69.4 ha; Rehab spoil = 59.8 ha, Natural = 134.3 ha Jax East Pit: Pit shell = 28.3 ha; Natural = 20.3 ha

ID	Scenario	Description
2	Reduced catchment sensitivity	Jax Main Pit: Pit shell = 69.4 ha; Rehab spoil = 59.8 ha, Natural = 14.1 ha Jax East Pit: Pit shell = 28.3 ha; Natural = 12.9 ha
3	Groundwater inflow sensitivity	Base with 50% increase in groundwater rates (both inflow and outflows)
4	Regional groundwater level sensitivity	Groundwater inflow relationship shifted up by 5m (i.e. higher inflows at the same void lake level)
5	Groundwater TDS sensitivity	Base with EC of groundwater inflows increased to 15,000 $\mu\text{S/cm}$
6	Reduced evaporation sensitivity	Base with 30% reduced lake evaporation due to reduced wind, increased shading and increased salinity
7	Isolated Groundwater Inflow	Base model with groundwater rates associated with each pit in isolation
8 ¹	Increased catchment sensitivity	Base with natural catchment at the east of Jax Main Pit Jax Main Pit: Pit shell = 69.4 ha; Rehab spoil = 59.8 ha, Natural = 194.6 ha

Note 1: Assessed increased catchment sensitivity for Jax Main Pit only

3.3 Base Case Results

3.3.1 Void Lake Volume

The predicted future void lake volume over time in Jax Main Pit and Jax East Pit are presented in Figure 3.1 and Figure 3.2 respectively. The range of forecast void lake behaviour is illustrated, including:

- A high void lake level (95th Percentile).
- A median void lake level (50th Percentile).
- A low void lake level (5th Percentile).

The results indicate that the void lake levels will rise steadily over the first decades following the cessation of mining. Although the void lake levels are forecast to fluctuate over time as a result of the prevailing climate conditions, an equilibrium volume of approximately 8 GL and 1 GL is forecast for Jax Main Pit and East Pit respectively.

The time required for the void lakes to reach their equilibrium volume is presented in Table 3.2 and ranges from approximately 70 to 90 years for Jax Main Pit to 40 to 50 years for Jax East Pit.

The equilibrium volumes correspond to void lake levels of approximately 110 m AHD (Jax Main Pit) and 104 m AHD (Jax East Pit). These levels are 47 m to 58 m below the level at which the void lakes would spill to the receiving waterways. No overtopping of the void lakes to the receiving environment is forecast to occur.

The modelled Jax Main Pit equilibrium level (110 m AHD) is 30 m below the pre-mining regional groundwater level (140 m AHD) and 33 m below the zero flow level (143 m AHD). The Jax Main Pit final void is therefore forecast to operate as a sink, with a groundwater inflow of 3.9 m³/day (i.e. 1.4 ML/year) and no flow from the void to groundwater expected to occur.

The modelled Jax East Pit equilibrium level (104 m AHD) is 36 m below the pre-mining regional groundwater level (140 m AHD) and 27 m below the zero flow level (131 m AHD). The Jax East Pit final void is therefore forecast to operate as a sink, with a groundwater inflow of 2.7 m³/day (i.e. 1.0 ML/year) and no flow from the void to groundwater expected to occur.

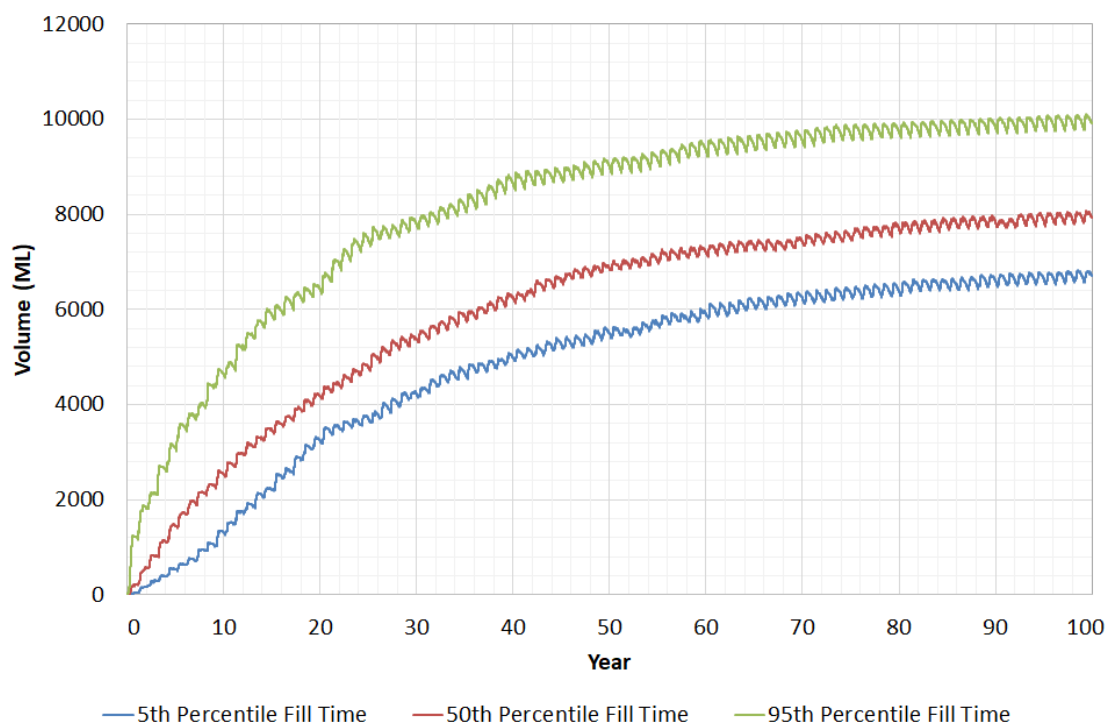


Figure 3.1 Forecast Jax Main Pit Void Lake Volume (Base Case)

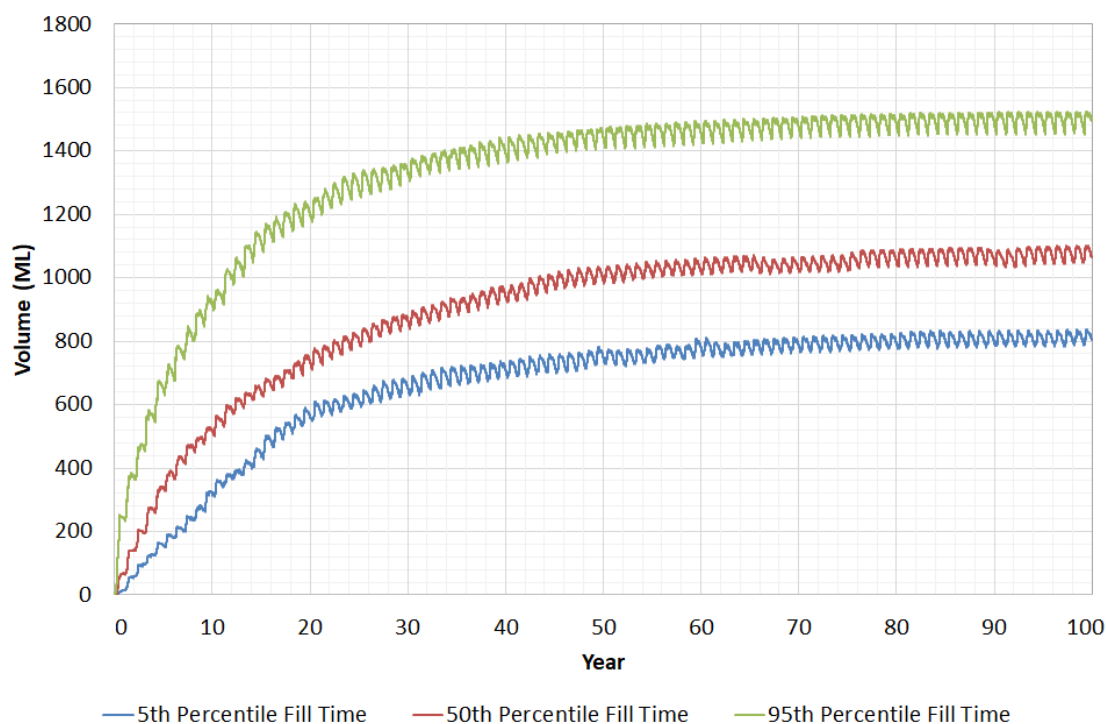


Figure 3.2 Forecast Jax East Pit Void Lake Volume (Base Case)

Table 3.2 Forecast Time for Void Lake to Fill to Equilibrium Level

Percentile	Filling Time (Years)	
	Jax Main Pit	Jax East Pit
95	90	50
50	80	45
5	70	40

The average annual inflows and outflows to the final voids following the initial filling to the equilibrium void level are presented in Table 3.3. The results indicate that:

- Groundwater inflows are a negligible component of the void lake water balance.
- Direct rainfall on the lake surface is approximately 35% smaller than the catchment runoff.
- Evaporation is the only significant water loss from the lake.

Table 3.3 Average Void Water Balance at Equilibrium

Inflow / Outflow		Average Annual Volume (ML/yr)	
		Jax Main Pit	Jax East Pit
Inflow	Rainfall on Void Lake	209	52
	Surface Runoff	328	79
	Groundwater Inflow	1.4	1.0
Outflow	Evaporation	522	131
	Groundwater Outflow	0	0

3.3.2 Water Quality

The void lake EC for the base case scenario was modelled and is presented in Figure 3.3 (Jax Main Pit) and Figure 3.4 (Jax East Pit).

The salinity of the final void lakes is predicted to increase over time. This is a result of evaporation being the only significant outflow from the lakes, which results in an ongoing concentration of salts. Modelling indicates that salts will continue to concentrate with a generally linear trend at an average rate of approximately 30 – 100 $\mu\text{S}/\text{cm}$ per year. Ultimately the maximum EC will be limited by solubility, which will vary with temperature both seasonally and with depth throughout the void lake water column.

It is noted that the invert levels of drainage paths in the vicinity of Jax Final Voids are significantly higher than equilibrium lake levels. Consequently, surface water quality in the drainage paths is not expected to be impacted by the void lakes.

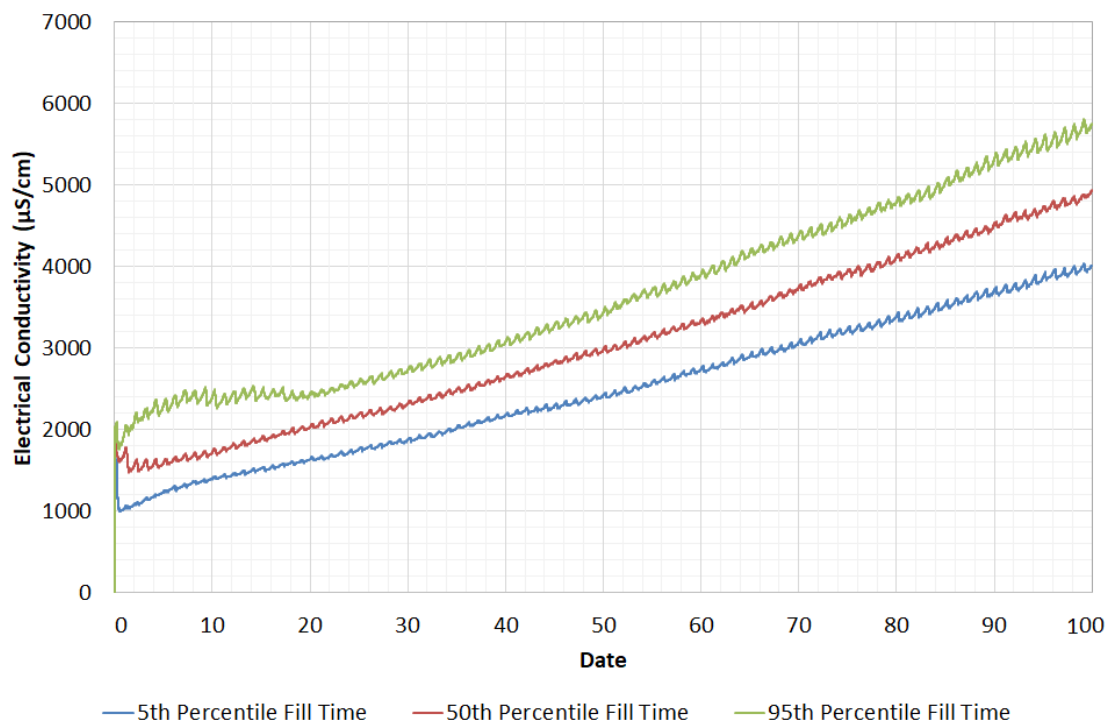


Figure 3.3 Forecast Jax Main Pit Void Lake EC (Base Case)

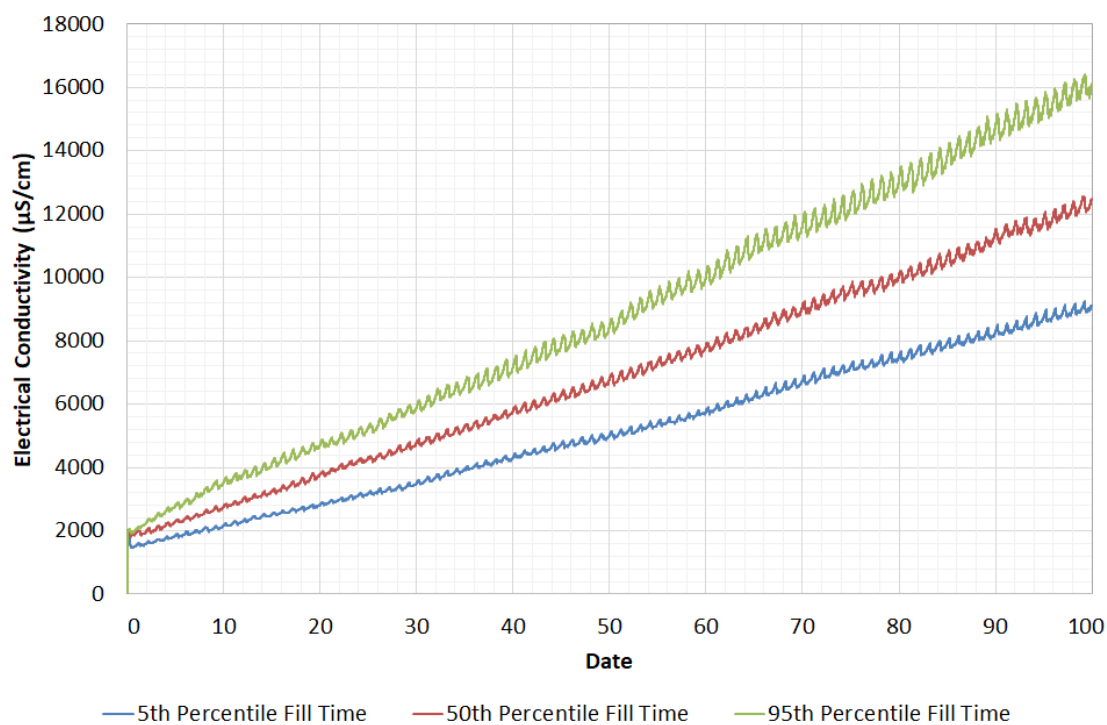


Figure 3.4 Forecast Jax East Pit Void Lake EC (Base Case)

3.4 Sensitivity Results

3.4.1 Void Lake Volume

The median forecast void lake volumes for the range of sensitivity analysis scenarios summarised in Table 3.1 are presented in Figure 3.5 and Figure 3.6 for Jax Main Pit and Jax East Pit respectively. Results indicate:

- Changes to the groundwater inflow rates and regional groundwater level (Scenario 3 and 4) are seen to have minimal impact on the void filling times and equilibrium void lake volumes.
- Scenario 7 uses the alternative groundwater inflow vs pit water level curve developed by AGE for the case of either Jax Main Pit or Jax East Pit in isolation (i.e. a one final void scenario). This scenario indicates that the void lake behaviour does not change significantly based on there being only one final void instead of two.
- Reducing the out-of-pit catchment (Scenario 2) results in lower equilibrium volumes due to the smaller catchment.
- The greatest variation is a result of reduced evaporation (Scenario 6), which results in increased filling rates and higher equilibrium levels.
 - The equilibrium level in Jax Main Pit of 133 m AHD (17 GL) is 7 m lower than to the pre-mining regional water table (140 m AHD) and 10 m lower than the zero flow level (143 m AHD). The void is forecast to remain a minor groundwater sink of 1.4 m³/day (i.e. 0.5 ML/yr).
 - The equilibrium level in Jax East Pit of 121 m AHD (17 GL) is 29 m lower than to the pre-mining regional water table (140 m AHD) and 10 m lower than the zero flow level (131 m AHD). The void is forecast to remain a minor groundwater sink of 1.2 m³/day (i.e. 0.4 ML/yr).
- Inclusion of the natural catchment in the east of Jax Main Pit (Scenario 8) results in a slightly higher equilibrium volume due to the increased catchment. This impact is less than the Scenario 6 sensitivity.

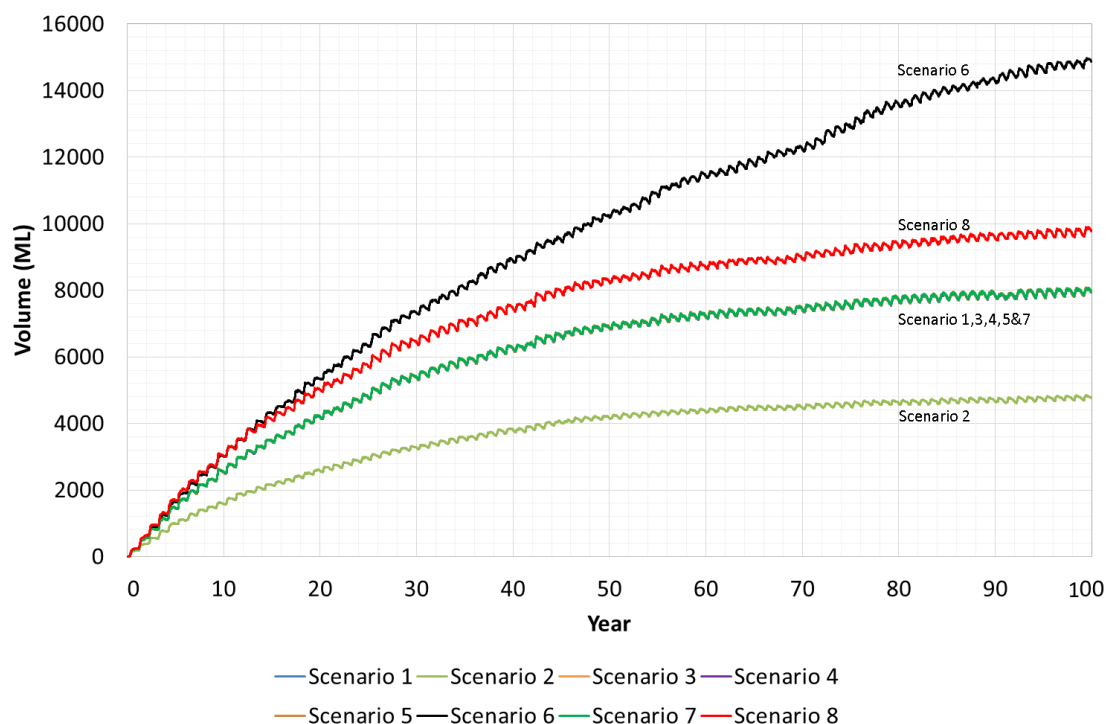


Figure 3.5 Forecast Jax Main Pit Void Lake Median Volume (Sensitivity)

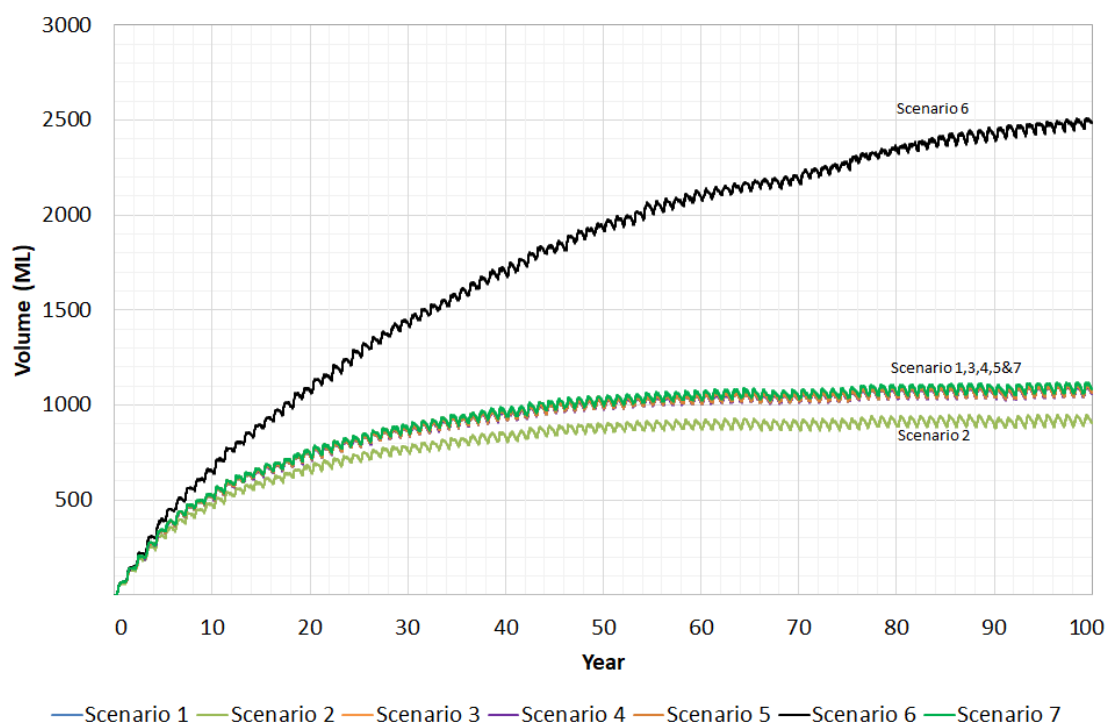


Figure 3.6 Forecast Jax East Pit Void Lake Median Volume (Sensitivity)

3.4.2 Water Quality

The median forecast void lake EC for the range of scenarios summarised in Table 3.1 are presented in Figure 3.7 and Figure 3.8 for Jax Main Pit and Jax East Pit respectively, for the period up to volumetric equilibrium for each void. Results indicate:

- Changes to the groundwater inflow rates, regional groundwater level and isolated pit groundwater inflow rate (Scenario 3, 4 and 7) are seen to have minimal impact on the long-term void lake salinity.
- Reducing the out-of-pit catchment (Scenario 2) results in the salinity of the void lakes increasing more quickly, although this difference in quality is minor. This is a result of the comparative reduction in rehabilitated catchment area, which produces 'clean' runoff to dilute void lake EC.
- By contrast, increasing the natural catchment to the east of Jax Main Pit (Scenario 8) is forecast to result in a slower increase in the concentration of salts in the void lake.
- Increasing the groundwater EC is found to result in a very minor increase in the rate of increase of overall void lake EC (Scenario 5). This is due to groundwater being a negligible component of the void lake water balance.
- Reducing evaporation (Scenario 6) is forecast to result in a slower increase in the concentration of salts in the void lake. However, as for the Base Case, maximum EC will be governed by the salt solubility limit rather than the evaporation rate.

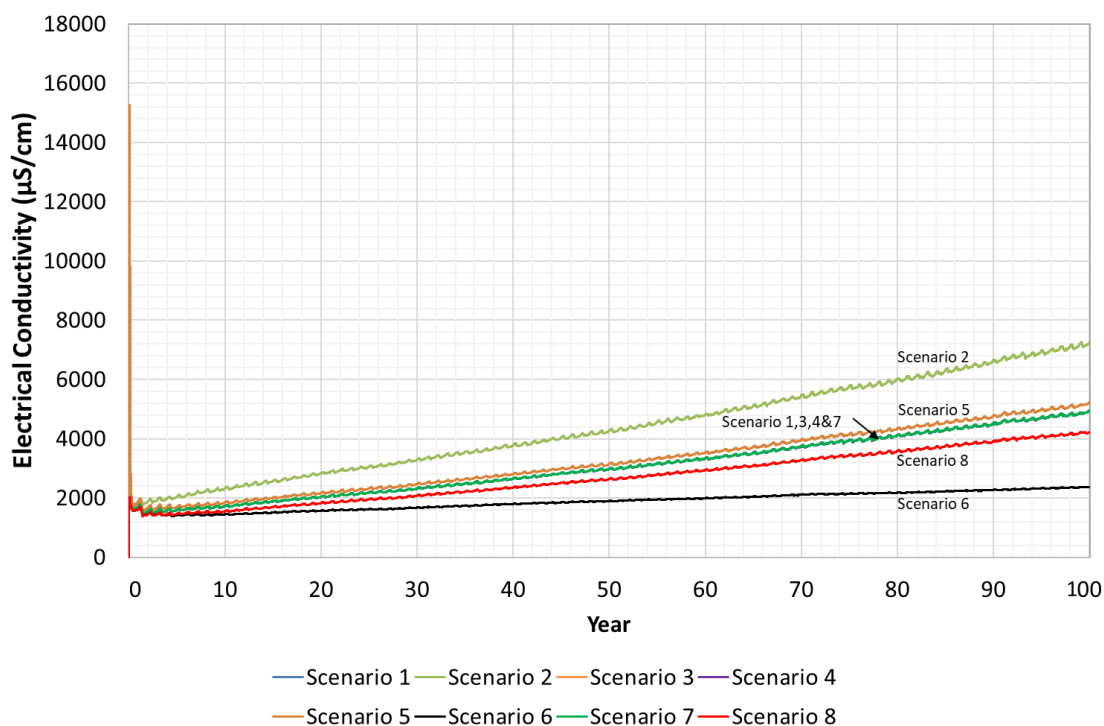


Figure 3.7 Forecast Jax Main Pit Void Lake Median EC (Sensitivity)

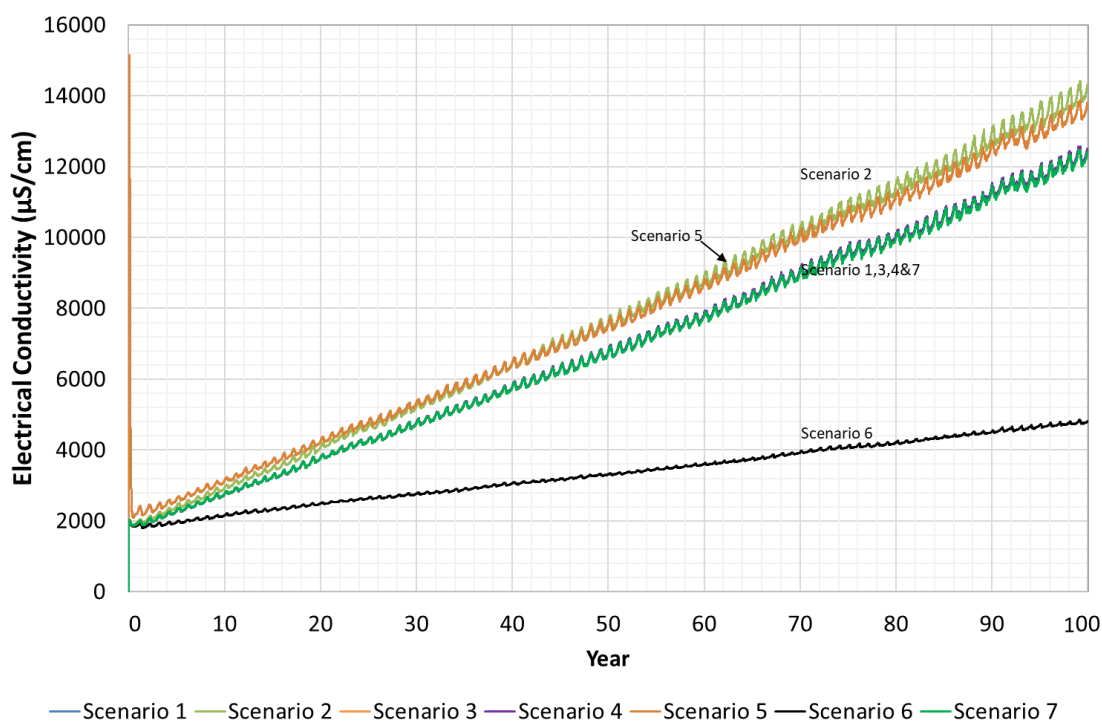


Figure 3.8 Forecast Jax East Pit Void Lake Median EC (Sensitivity)

4. CONCLUSIONS

The key findings from the study are:

- The final void lakes are forecast to fill to equilibrium levels of:
 - Approximately 110 m AHD in Jax Main Pit within a period of approximately 70 to 90 years following cessation of dewatering activities in Jax Main Pit.
 - Approximately 104 m AHD in Jax East Pit within a period of approximately 40 to 50 years following cessation of dewatering activities in Jax East Pit.
 - These levels are approximately 47 m to 58 m below the level at which the void lakes would spill to the receiving waterways. No overtopping of the void lakes to the receiving environment is forecast to occur.
- The pre-mining groundwater level in the vicinity of Jax Main Pit is substantially higher (30 m) than the forecast void lake equilibrium level. Accordingly, the Jax Main Pit final void is expected to remain a sink to groundwater flows, with no reverse flow from the void to groundwater expected to occur.
- The pre-mining groundwater level in the vicinity of Jax East Pit is substantially higher (36 m) than the forecast void lake equilibrium level. Accordingly, the Jax East Pit final void is expected to remain a sink to groundwater flows, with no reverse flow from the void to groundwater expected to occur.
- Due to the future depth of the void lakes and the likely thermal gradient, the lakes are considered to have a high potential for stratification. This is likely to occur on a seasonal cycle with stratification in the warmer summer months followed by mixing in the cooler winter months or under climatic conditions that would promote the turnover of the void lake stratification (e.g. strong winds).
- The salinity of the void lakes is forecast to increase over time as evaporation results in on-going concentration of salts.
 - The void lake EC of both Jax Main Pit and Jax East Pit is forecast to increase at an average rate of approximately 30-100 $\mu\text{S}/\text{cm}$ per year. The maximum EC will ultimately be governed by the salt solubility limit.
 - The water in the Jax void lakes is not expected to impact surface water quality in the adjacent drainage features due to the significant difference in elevation between the equilibrium lake level and the surface drainage channels.

5. QUALIFICATIONS

- a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
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2 April 2019

QCoal Services Pty Ltd
Level 15, 40 Creek Street
Brisbane QLD 4000

Attention: Julian Dobos

Dear Julian,

RE: LONG TERM WATER QUALITY OF JAX COAL MINE RESIDUAL VOIDS

As per our conversation on Monday 25 March 2019, I understand that you require confirmation of the long term water quality in the planned residual void lakes at the Jax Coal Mine (JCM). This is to inform the post-mining land use.

Previous Study

Engeny Water Management (Engeny) previously prepared the *JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit* (Engeny, Nov 2018). That study utilised a GoldSim water balance model of the planned residual voids to forecast the long term hydrology of the void lakes including equilibrium volumes and water quality trends. Water quality was represented as electrical conductivity (EC) by undertaking a salt mass balance coupled with the water balance to estimate Total Dissolved Solids (TDS) and utilising a conversion factor ($1 \mu\text{S/cm EC} = 0.67 \text{ mg/L TDS}$).

The study presented results for a 100 year simulation after cessation of mining, which was long enough to achieve an equilibrium volume in the void lakes. However, the EC was continuing to rise linearly over time. This increase is due to the lack of any significant outflows from the voids (i.e. water leaves the voids through evaporation, but there is no associated transport of salt). Consequently, the concentration of TDS and associated EC continues to increase over time, ultimately governed by the solubility limit.

Review of Livestock Drinking Water Quality

Guidance on drinking water quality limits for livestock is provided in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, Oct 2000). Tolerance of livestock to TDS in drinking water is summarised in Table 1. The livestock of interest in the locality of JCM is beef cattle, which experiences a loss of production and decline in animal condition for TDS values exceeding 5,000 mg/L (approximately 7,460 $\mu\text{S/cm EC}$).

Table 1 Tolerance of livestock to TDS in drinking water (ANZECC & ARMCANZ, Oct 2000)

Livestock	Total dissolved solids (mg/L)		
	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 a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually
Beef cattle	0–4000	4000–5000	5000–10 000
Dairy cattle	0–2500	2500–4000	4000–7000
Sheep	0–5000	5000–10 000	10 000–13 000 ^b
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

a From ANZECC (1992), adapted to incorporate more recent information

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

Long Term Water Quality

The previous water balance model has been extended to simulate a period of 500 years after cessation of mining. The forecast water quality trends in the Jax Main Pit and Jax East Pit void lakes over this horizon are presented in Figure 1 and Figure 2 respectively.

The results indicate that the previous water quality trends continue over the longer simulation period. The time to exceed the threshold for loss of production in beef cattle is summarised in Table 1 and shown to be within 80 years and 200 years for Jax East Pit and Jax Main Pit respectively. The average rate of increase in EC over the simulation is summarised in Table 3.

Table 2 Time to exceed the threshold for loss of production in beef cattle (years)

Pit Void	5 th Percentile	50 th Percentile	95 th Percentile
Jax Main Pit	196	157	133
Jax East Pit	78	55	40

Table 3 Rate of increase in EC (µS/cm/year)

Pit Void	5 th Percentile	50 th Percentile	95 th Percentile
Jax Main Pit	34	42	50
Jax East Pit	84	119	157

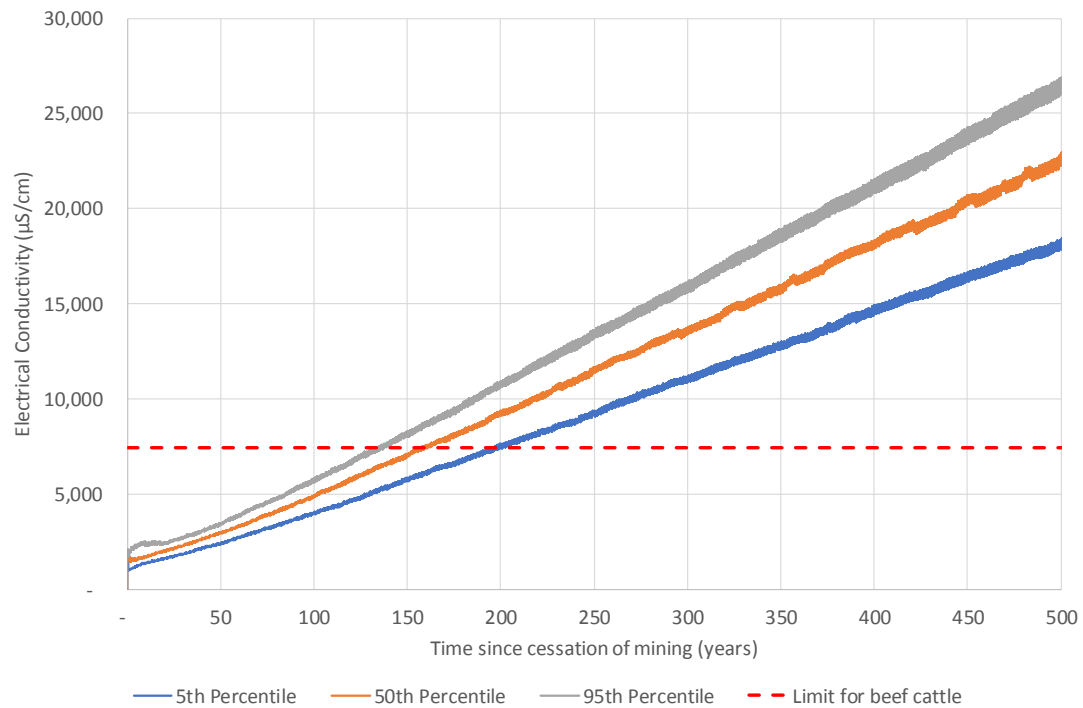


Figure 1 Jax Main Pit void lake EC forecast

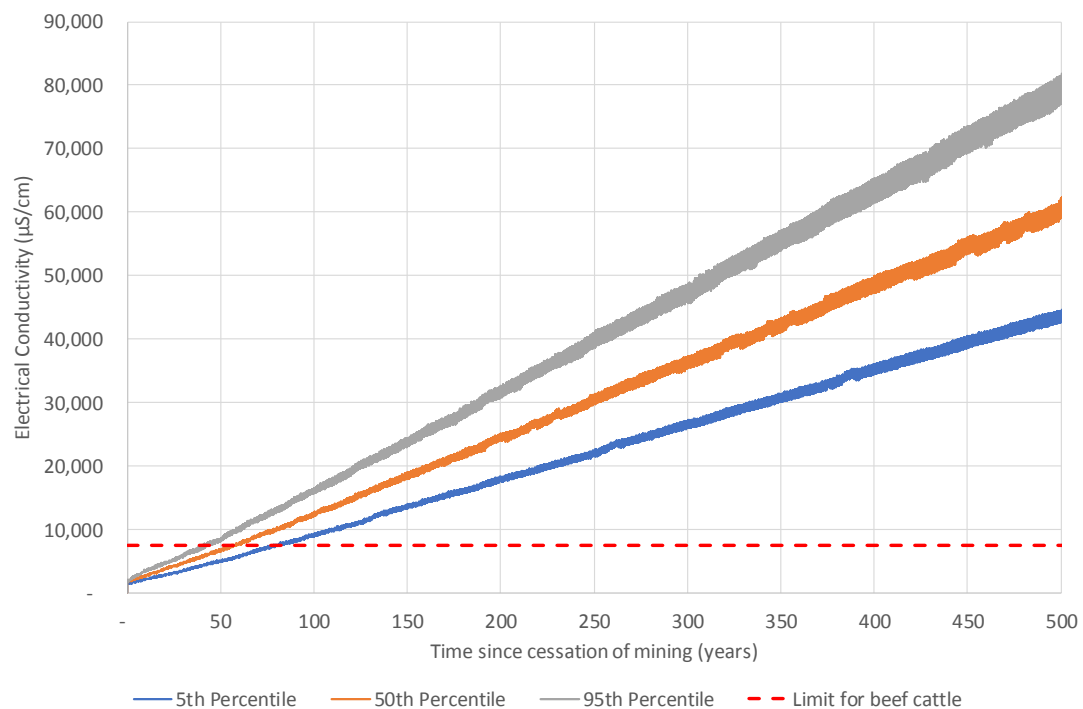
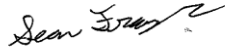


Figure 2 Jax East Pit void lake EC forecast

Please don't hesitate to contact the undersigned if you have any questions or would like to discuss further.

Yours faithfully



Sean Frazer
Principal Engineer (CPEng, RPEQ)
Associate

APPENDIX B

Residual Void Hydrology Study QCoal Northern Hub Mines April 2020 (Engeny ((2020))

QCOAL SERVICES PTY LTD

Residual Void Hydrology Study

QCoal Northern Hub Mines



April 2020

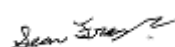
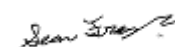
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M4100_041 RESIDUAL VOID HYDROLOGY STUDY						
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REV	DESCRIPTION	AUTHOR	REVIEWER	PROJECT MANAGER	APPROVER (PD)	DATE
Rev 0	Client Issue	Nutan Gothwal	Sean Frazer	Alice Hines	Sean Frazer	27 March 2020
Rev 1	Client Issue	Nutan Gothwal	Sean Frazer	Alice Hines	Sean Frazer	22 April 2020
Rev 2	Client Issue	Nutan Gothwal	Sean Frazer	Alice Hines	Sean Frazer	24 April 2020
Signatures						

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1. INTRODUCTION

Sonoma Coal Mine (SCM), Cows Coal Mine (CCM), Drake Coal Mine (DCM) and Jax Coal Mine (JCM) are four independent but co-located mining operations owned and operated by subsidiaries of QCoal Pty Ltd (QCoal) and are collectively referred to as the QCoal Northern Hub (QNH). The QNH is located south of Collinsville within the Bowen Basin.

Environmental Authorities (EAs) have been issued for each independent mine by the Department of Environment and Science (DES) under the Environmental Protection Act 1994. The EAs associated with the QNH are summarised in Table 1.1. SCM, CCM, DCM and JCM are each authorised to operate under their respective EA.

Table 1.1 Summary of QNH Environmental Authorities

Site	EA Permit Number	EA Date	EA Holder	Locations
SCM	EPML00707713	03/10/2019	Watami (Qld) Pty Ltd JS Sonoma Pty Ltd CSC Sonoma Pty Ltd QCoal Sonoma Pty Ltd	ML10325 ML10326 ML10327
CCM	EPML00334613	03/10/2019	Bowen River Coal Pty Ltd	ML10345
DCM	EPML00393013	03/10/2019	Northern Hub (Drake) Pty Ltd Drake Coal Pty Ltd	ML10349 ML10350 ML10351
JCM	EPML00337613	2020	Jax Coal Pty Ltd	ML10346

QCoal has commissioned Engeny Water Management (Engeny) to undertake a void hydrology study of existing and proposed QNH residual voids. Previous void assessments have been undertaken by Engeny for the QNH as described in Section 2.1.

2. DATA REVIEW

2.1 Previous Studies

Previous studies referred to for this assessment include:

- Water Management Plan 2019/2020 QNH Mines (Engeny, February 2020).
- Drake Coal Project: Environmental Impact Statement (GHD, 2012)
- SCM Final Void Hydrology Study Main Pit (Engeny, November 2015).
- CCM Final Void Hydrology Study Q Pit and B Pit (Engeny, April 2017).
- *JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit (Engeny, November 2018)* – this assessment and the conclusions therein remain applicable as there is no change to the proposed final landform.

2.2 Approved Residual Voids

The EAs for SCM, DCM, CCM and JCM stipulate the approved voids, their size and required wall slopes for each of the specific sites (i.e. Table H1 in each EA), which has been summarised in Table 2.1.

It is noted that not all of the voids may eventuate and/or some approved voids stated as discrete pits in the EA are operationally part of broader complexes comprising multiple in close proximity where the void area is cumulative (this is especially the case for the DCM), as shown in Table 2.1 and detailed further in Section 2.3.

Table 2.1 EA Table H1 for SCM, CCM, DCM and JCM

Residual Void	Void Area	Maximum Slope
Sonoma Coal Mine – EPML00707713		
Sonoma Main Pit	120 ha	High wall – maximum slope of 70° with the top 10m having a maximum slop of 45° including a 1m bund Low wall – 17° – 37°
Sonoma East Pit 1	14 ha	
Sonoma East Pit 2	15 ha	
Sonoma Q-Pit	N/A backfilled	N/A backfilled

Residual Void	Void Area	Maximum Slope
Sonoma B-Pit	N/A backfilled	N/A backfilled
Cows Coal Mine – EPML00334613		
B Seam Pit	Backfilled	N/A
Q Seam Pit	Backfilled	N/A
Drake Coal Mine – EPML00393013		
Drake Pit 5	59 ha	High wall – 65° Low wall – 45°
Drake Pit 1	258 ha	
Drake Pit 2		
Drake Pit 2 Expansion		
Central Pit 3	50 ha	
Central Pit 4	16 ha	
East Pit 1	14 ha	
Drake Pit 3-Q	61 ha	
Drake Pit 3-R		
Jax Coal Mine - EPML00337613		
Jax Main Pit ¹	70 ha	High wall – 60° Low wall – 32°
Jax East Pit ¹	27 ha	

Note 1: Post mining land use of Aquatic Ecosystems

2.3 Voids Modelled for this Assessment

There are currently seven existing open cut mining pits across QNH. There are an additional six open cut pits planned at this time (subject to operational and economically driven changes) which have not yet commenced (i.e. Sonoma East Pit 1, Sonoma East Pit 2, Jax East Pit, Drake Pit 2 Expansion, Drake Pit 4 North and Drake Pit 4 South).

It is clearly noted that as mine planning is subject to change driven by economic factors locally and internationally (notably coal price and demand), the presence of voids as well as their size or shape, is subject to change. As such within the level of design information available, Engeny has undertaken to conservatively assess the layout of final voids provided by QCoal, such that should minor changes to a void or pit complex occur over the life of QNH, this assessment can still be relied upon to inform impact assessments provided key hydrological modelling parameters (e.g. catchment and pit geometry) are maintained (see Section 5.1).

Additionally, the nomenclature for QNH pits and residual voids has changed from approvals through to operation as a result of changes to mine planning.

As such the key document sets used to define the residual void locations and extents were:

- Environmental Impact Statements (EIS) for DCM;
- Later Development Plans (LDP) for SCM, DCM and JCM;
- EAs for SCM, CCM, JCM and DCM; and
- QCoal Life of Mine Planning (LOMP) for SCM, CCM, JCM and DCM

A summary of the residual voids modelled in this assessment, including the various nomenclatures, areas and operational status is provided in Table 2.2, which shows that:

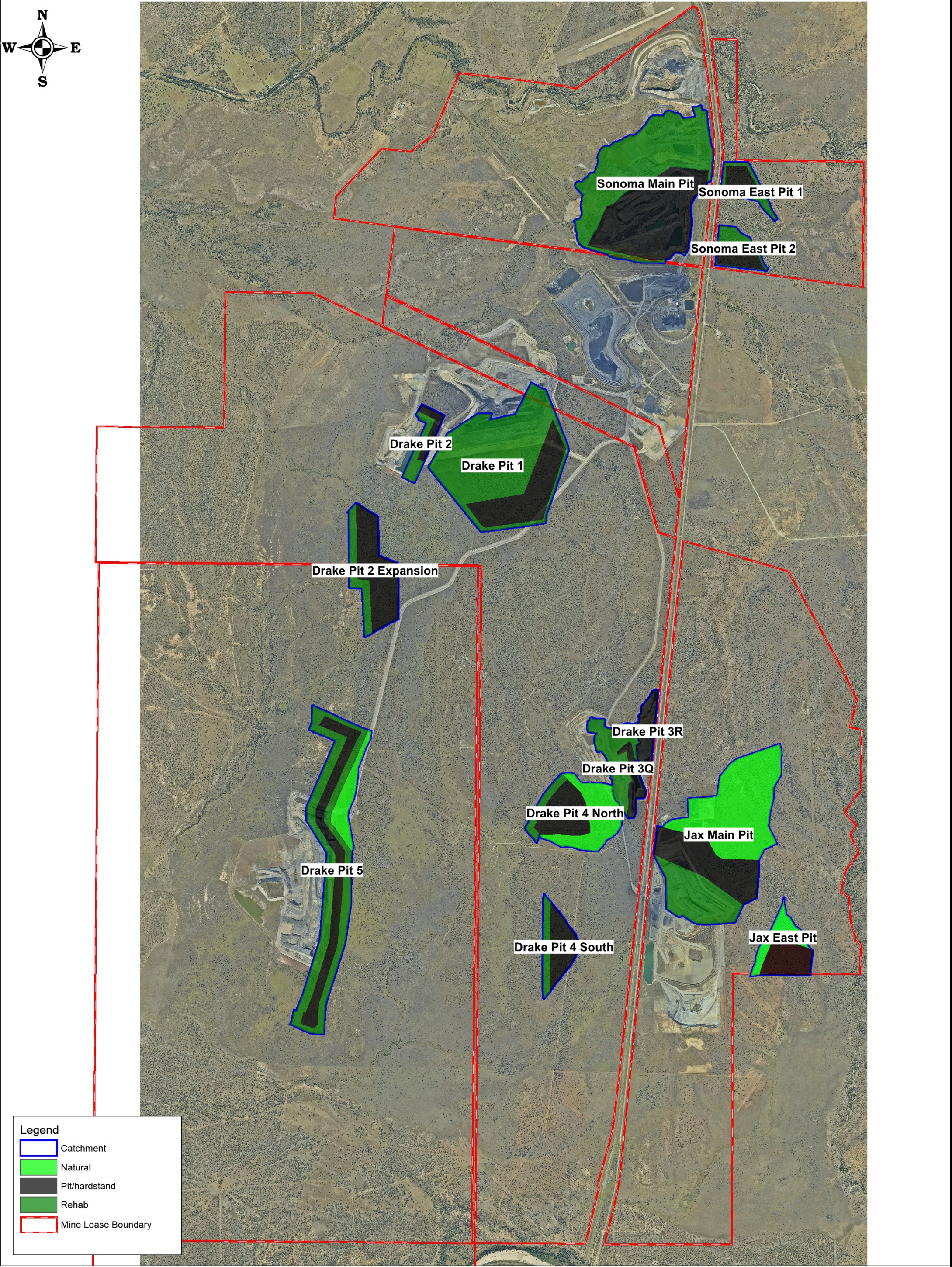
- DCM Central 3 is Drake Pit 4 North;
- DCM Central 4 is Drake Pit 4 South; and
- DCM East Pit 1 void as approved in the EA has not been modelled as a discrete void for the purposes of this assessment as it was considered that any potential development of East Pit 1 would be more likely as a small extension or satellite pit of Drake 1 Pit.

A site layout is presented in Figure 2.1 and identifies the locations of the proposed residual voids modelled in this assessment.

Table 2.2 Summary of Modelled QNH Residual Voids

Mine Site	Report ID	EIS ID	EA ID	Approved Residual Void Surface Area	Modelled Residual Void Surface Area	Current Status
SCM	Sonoma East Pit 1	Sonoma East Pit Complex	Sonoma East Pit 1	14 ha	14 ha	Planned
	Sonoma East Pit 2		Sonoma East Pit 2	15 ha	15 ha	Planned
	Sonoma Main Pit	Sonoma Main Pit	Sonoma Main Pit	120 ha	139 ha	Commenced
DCM	Drake Pit 1	West 2	Drake Pit 1	258 ha	64 ha	Commenced
	Drake Pit 2		Drake Pit 2		9 ha	Commenced
	Drake Pit 2 Expansion		Drake Pit 2 Expansion		60 ha	Planned
	Drake Pit 3Q	East 3	Drake Pit 3Q	61 ha	14 ha	Commenced
	Drake Pit 3R		Drake Pit 3R		21 ha	Commenced
	Drake Pit 4 North	Central 3	Central 3	66 ha	38 ha	Planned
	Drake Pit 4 South	Central 4	Central 4		28 ha	Planned
	Drake Pit 5	West 1	Drake Pit 5	59 ha	59 ha	Commenced
JCM	Jax Main Pit	N/A	Jax Main Pit	70 ha	69 ha	Commenced

Mine Site	Report ID	EIS ID	EA ID	Approved Residual Void Surface Area	Modelled Residual Void Surface Area	Current Status
	Jax Pit East	N/A	Jax East Pit	27 ha	28 ha	Planned



2.4 Residual Void Requirements and Outcomes

The EAs for SCM, DCM, CCM and JCM also stipulate general rehabilitation requirements and outcomes for voids (stated as Condition H13 in each EA):

- Condition H13 Residual Void Outcome (all QNH EAs)

Residual Voids must comply with the following outcomes:

- a) Residual voids must not cause any serious environmental harm to land, surface waters or any recognised 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;*
- b) residual voids must comply with Table H1: Residual void outcomes;*
- c) At the completion of decommissioning and rehabilitation, all voids must demonstrably have the appropriate level of flood protection from nearby watercourses as approved by the administering authority, such that the protection is sustainable for the foreseeable future.*

The JCM EA also includes some more specific detail regarding the outcomes for the two approved voids (stated in JCM EA Table H1), which the SCM, DCM and CCM EAs do not. The JCM EA Table H1 includes the following void outcome statement:

- Table H1 JCM EA

Void Outcomes for Jax Main Pit and Jax East Pit: Residual Void unable to sustain a Post Mining Land Use.

2.5 Mine Planning and Residual Void Concepts

The residual void locations and extents for current and proposed pits were determined based on the following documents:

- DCM EIS (2012).
- LOMP – outlines the mining operations and extent of disturbance within existing as well as proposed mining pits for the remainder of the mine life. This was used to determine the geographical location of the residual voids.
- LDP – a 5-year plan (FY20 to FY24) developed by QCoal which was used to determine the direction of mining progression within the disturbed extent.
- EAs – for each respective mine site. Approved residual void surface areas for each residual void were used as a guide to delineate void surface area at natural ground level.

An overview of the conceptual final landform for residual voids at each mine site is provided in the following sections.

2.5.1 SCM Residual Voids

- Sonoma Main Pit is located centrally within the SCM ML. Design final landforms including in-pit co-disposal have been provided by QCoal (August 2019) for two final scenarios. Option 1 involved in-pit co-disposal with a rejects embankment and Option 2 involved in-pit co-disposal without rejects embankment. Option 2 (refer Figure 2.2) has been assumed for this assessment. Both options remain under review by QCoal at the time of this assessment. Results presented in this document are for Option 2. It is noted that the landform provided to Engeny was for year 20 of in-pit co-disposal deposition and it is understood that the ultimate final landform of rejects deposition is estimated to be an additional 20m higher. Forecast void lake water levels determined in this assessment need to be translated up by a similar amount but remain representative of the final higher final landform surface.
- Sonoma North Pit is located in the north-east of the SCM ML. QCoal propose to backfill this pit and it will therefore will not remain as a residual void post-mine closure.
- Sonoma East Pit 1 and Sonoma East Pit 2 are planned for commencement within the next five years. It is not proposed to backfill either pit and therefore both are expected to remain as residual voids.

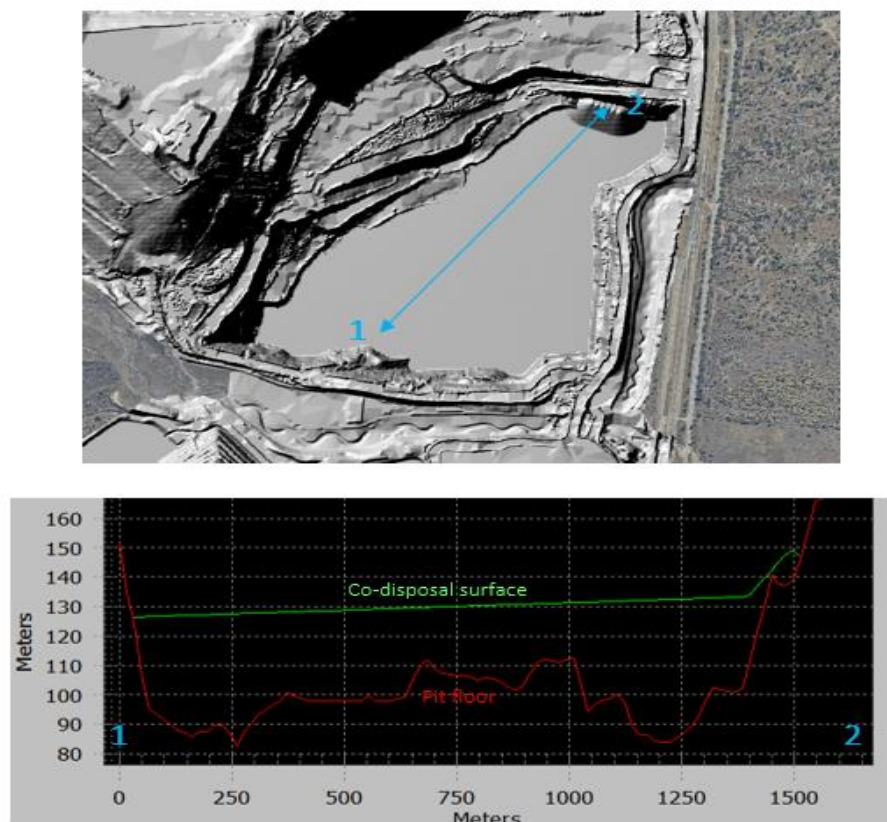


Figure 2.2 Year 20 Proposed Sonoma Main Pit Residual Void Landform (Option 2)

2.5.2 CCM Residual Voids

- Q Pit was in the south-east corner of the SCM/CCM mines and spanned the SCM and CCM MLs. Q Pit has been fully backfilled. A small sediment dam (Q Pit Sediment Dam) has since been constructed on the SCM ML portion of the backfilled void.
- B Pit operation (referred to as the Cows Pit in various other documents) spans the SCM and CCM MLs, and transitions into the Drake 1 Pit to the south on the DCM ML. B Pit void on the SCM and CCM MLs has been backfilled.

There are no residual voids proposed on the CCM mine lease.

2.5.3 DCM Residual Voids

- Drake Pit 1 void is located at the northern extent of the DCM abutting the CCM ML boundary and is the southern progression from B Pit into the north of DCM.
- Drake Pit 2 is immediately to the west of Drake 1 Pit.
- Drake Pit 2 Expansion is a proposed residual void to the south-west of Drake 1.
- Drake Pit 3R is located on the eastern boundary of the mine lease approximately 5 km south of Q Pit.
- Drake Pit 3Q is located on the eastern boundary of the mine lease immediately south of Drake 3 R Pit.
- Drake Pit 4 North and Drake Pit 4 South are two additional proposed residual voids within DCM.
- Drake Pit 5 is located in the south- western portion of DCM.
- East Pit 1 remains an approved void but as describe in Section 2.3 is likely to be amalgamated as part of the broader Drake Pit 1, Drake Pit 2 and Drake Pit 2 Expansion complex.

It is not currently planned to backfill any of the DCM pits and therefore all above mentioned DCM pits will remain as residual voids. It is noted that a new pit called Drake Pit 3Q South is included in the DCM life of mine plan, however it has not been included in the residual void hydrology assessment. As advised by QCoal, there is not sufficient planning data to inform an assessment of Drake 3Q South Pit at this time. It may be assessed at a future date when planning has further progressed.

2.5.4 JCM Residual Voids

- The JCM Main Pit void is located centrally within the JCM mine lease. QCoal is not planning to backfill the JCM Main Pit and it is planned to remain as a residual void.

- Jax East Pit has not yet commenced, and the timing of mining commencement has not yet been confirmed. It is planned to remain as a residual void.

A residual void hydrology assessment for Jax Coal Mine was previously undertaken (Engeny, November 2018). The proposed final landform has not changed since that study was undertaken. Minor changes to groundwater levels and recovery curves were reported in the updated groundwater assessment (AGE, 2020) however these changes were not material to residual void outcomes. Consequently, the previous Jax pits void assessment outcomes remain suitable and have not been updated.

2.6 Storage Characteristics

It has been assumed that existing storage curves of operational pits at their current layout is suitable to represent pit geometry of their respective residual voids. Storage curves for pits which have not yet commenced were estimated based on the geometry of existing pits of similar size. The process for adapting storage curves to new locations involved the following steps:

- Comparison of approved residual void areas to the surface area (at crest level) of existing pit voids to identify an appropriate pit to represent the future residual void storage characteristics.
- Transpose the adopted storage curve vertically such that the crest level corresponds to the natural ground level at the location of the planned residual void.

The assumed final landform storage curves of existing and proposed residual voids along with their respective storage capacities are summarised in Table 2.3. Plots of adopted storage curves are provided in Appendix A. Storage curves for any final void planning or assessment are an area of uncertainty as actual final storage curves will not be possible to determine until mining has been completed, and any low-wall/high-wall rehabilitation requirements have also been completed. The adopted curves are the best available estimate of the residual void storage characteristics based on currently available mine planning information and are considered suitable for the purposes of this assessment.

Table 2.3 Assumed Residual Void Storage Curves

Residual Void	Adopted Storage Curve	Storage Capacity (ML)
Sonoma Main Pit	In-pit co-disposal without reject wall (Design)	45,151
Sonoma East Pit 2	Jax Pit (survey 2013)	2,009
Sonoma East Pit 1	Jax Pit (survey 2013)	1,788
Drake Pit 1	Drake Pit 1 (survey 2019)	18,323

Residual Void	Adopted Storage Curve	Storage Capacity (ML)
Drake Pit 2	Drake Pit 2 (survey 2019)	1,711
Drake Pit 2 Expansion	Drake Pit 1 (survey 2019)	15,824
Drake Pit 3Q	Drake Pit 3Q (survey 2019)	2,326
Drake Pit 3R	Drake Pit 3R (survey 2019)	1,254
Drake Pit 4 North	Jax Pit (survey 2019)	6,160
Drake Pit 4 South	Jax Pit (survey 2019)	3,708
Drake Pit 5	Drake Pit 1 (survey 2019)	13,996

2.7 Catchment Delineation

The contributing catchment to each residual void has been determined using the following data:

- Drone survey dated August 2019.
- LOMP polygons (supplied by QCoal 11/10/2019).
- EA conditions determining maximum residual void footprints (refer Table 2.1).
- Site wide aerial survey dated July 2014.
- Aerial photography dated June 2019.

It has been assumed that all out-of-pit spoil areas will be rehabilitated following the cessation of mining. The adopted catchments for QNH residual voids are presented in Figure 2.1. Based on the final landform criteria defined in the site EAs (refer Table 2.1) and the anticipated maximum landform heights (LOMP), it is estimated that approximately a 100 m width of the low wall batter will drain to the residual void while all remaining rehabilitated catchment will be diverted by grading the dump away from the void.

Where diversion of upslope natural catchment can be achieved with minor drainage works (i.e. shallow drains and bunds) it has been assumed that these works would be incorporated into the final landform. Where more significant infrastructure would be required to divert upslope catchment, it has been conservatively assumed to report to the residual void in the base case scenario with an optimised catchment scenario discussed in Section 2.7.1.

A summary of the contributing catchment areas for the base scenarios is provided in Table 2.4

Table 2.4 Contributing Catchment Area for Residual Voids (Base Case)

Mine Site	Residual Void	Catchment Area (ha)
SCM	Sonoma East Pit 1	25
	Sonoma East Pit 2	27
	Sonoma Main Pit	280
DCM	Drake Pit 1	240
	Drake Pit 2	22
	Drake Pit 2 Expansion	80
	Drake Pit 3Q	55
	Drake Pit 3R	21
	Drake Pit 4 North	97
	Drake Pit 4 South	42
	Drake Pit 5	191
JCM	Jax Main Pit	264
	Jax East Pit	49

2.7.1 Optimisation of Catchment

Catchment area is one of the key driving variables for residual void hydrology outcomes. Void catchment area was investigated as a driver in the equilibrium lake level, which informs a voids potential for seepage into the regional groundwater. For example, the conceptual Drake Pit 4 North residual void was identified during this assessment as a void where sections of the upslope catchment defined in the LOMP could be diverted around the void as an alternative to directing it into the void, thereby reducing the void lake level. The diversion concept is illustrated in Figure 2.3 and involves an excavated drain along the north-eastern side of Drake Pit 4 North to divert approximately 48 ha of undisturbed catchment.

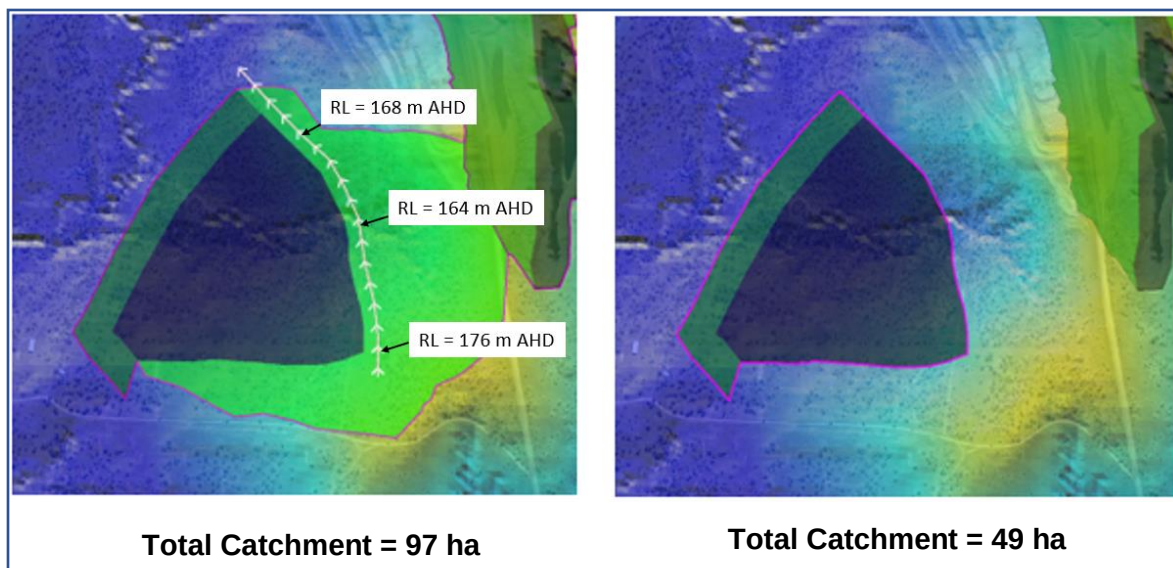


Figure 2.3 Drake Pit 4 North diversion concept (left) and mitigated catchment (right)

3. GROUNDWATER CONTRIBUTION

3.1 Groundwater Quantity and Interaction

Numerical groundwater modelling of the design residual voids was undertaken by AGE (March 2020) to predict groundwater recovery after the cessation of mining. From the model, a rating curve of groundwater inflow versus pit water level for each residual void was developed (Refer to Appendix B). It is noted that the range of the groundwater recovery curves is limited by the water levels simulated in the groundwater model. Where required, the final value of the groundwater recovery curves have been conservatively maintained for the remainder of the adopted void storage curves.

Negative flows shown in the groundwater recovery curve figures indicate the elevation of water level within the lake at which point a net outflow from the void lake can potentially occur. **Any modelled outflows from a void lake resulting from these portions of the groundwater recovery curves need to be interpreted with care and may not necessarily indicate flows to the surrounding regional groundwater system.** In particular, through discussion with AGE, it is understood that the adopted groundwater recovery curves are impacted by the following processes:

- Interaction between residual void lakes located in close proximity such as hydraulic gradients between void lakes resulting in flow from one void lake to another **which is not considered to be flow into the surrounding regional groundwater** (e.g. between Sonoma East 1 and Sonoma East 2 and between Drake 3Q and Drake 3R). It is noted that the modelled flow rates in these situations are generally of very small magnitude.
- Outflows from the void lakes into the surrounding spoil material. The numerical model makes no distinction between outflows from the void lake into the low-wall backfill waste rock material and outflows into the regional groundwater system. As such a modelled outflow as determined by the model may be associated with the saturation period of the low-wall waste rock until such time as steady state equilibrium is reached. This primarily occurs during the initial recovery period when the spoil material is first becoming saturated.

The interaction between the residual void lake and surrounding regional groundwater (be it net inflow or outflow) considers a range of indicators including:

- Base of Weathering – the threshold between highly weathered material and less permeable hard rock. The Base of Weathering provides an indication of areas where seepage from a void lake into the surrounding geology might occur if lake levels are forecast to exceed this threshold. Again such seepage is not immediately representative of a groundwater source into regional groundwater.
- Regional Groundwater Level – when the regional groundwater level exceeds the forecast void lake level then there is a hydraulic gradient into the void and the void is considered to act as a groundwater sink. Alternatively, a void lake level that is forecast

to be above the regional groundwater level may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, localised outflow from a source pit has the potential to be captured by a down-gradient pit acting as a global sink in which case would not be representative of a source to the regional groundwater. This process can be identified through hydrogeological modelling.

- **Net Zero Flow Level** – This level has been extracted from the groundwater recovery curves described in Section 3.1 and provides an indication of the direction of water fluxes to the void lake. As previously stated, outflows resulting from these recovery curves need to be interpreted with care as they may represent movement from one void (an net outflow) to an adjacent void which is a groundwater sink (a net inflow) thus containing void water from both voids (considered as movement within a groundwater sink system), or movement of water into unsaturated low wall spoil material, as opposed to an actual flow into the regional groundwater system.

AGE (2020) has provided a summary of these indicator levels for each of the residual voids as summarised in Table 3.1.

Table 3.1 Base of Weathering and Regional Groundwater Levels

Mine Site	Residual Void	Base of Weathering (mAHD)	Pre- mining Regional Groundwater Level (mAHD)	Net Zero Flow Level (mAHD)
SCM	Sonoma East Pit 1	155.80	156.30	Inflows at all levels
	Sonoma East Pit 2	156.92	155.53	Outflows at all levels
	Sonoma Main Pit	153.02	155.67	8.23
DCM	Drake Pit 1	169.07	146.57	Inflows at all levels
	Drake Pit 2	153.4	147.23	100.11
	Drake Pit 2 Expansion	163.99	144.24	Inflows at all levels
	Drake Pit 3Q	161.28	142.55	Inflows at all levels
	Drake Pit 3R	156.72	141.78	83.15
	Drake Pit 4 North	126.96	139.50	Inflows at all levels
	Drake Pit 4 South	146.72	136.71	Inflows at all levels
	Drake Pit 5	144.39	137.42	Inflows at all levels

3.2 Groundwater Quality

Monitoring of groundwater quality across a number of monitoring bores at QNH is undertaken on a quarterly basis. The groundwater quality data has previously been assessed as part of the *SCM Final Void Hydrology Study Main Pit* (Engeny, 2015) and *CCM Final Void Hydrology Study Q Pit and B Pit* (Engeny 2017). Both studies determined a representative groundwater inflow quality of 2,000 $\mu\text{S}/\text{cm}$. A consistent quality was been adopted for the *JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit* (Engeny, November 2018) is considered suitable for the purposes of this assessment.

4. WATER BALANCE MODEL DEVELOPMENT

4.1 Overview

Engeny has previously developed a water balance model of the QNH mines using the GoldSim software. The development of the model, input parameters and calibration are detailed in *Water Management Plan QNH Mines* (Engeny, 2020). The existing model has been adopted as a basis for this assessment.

4.2 Residual Void Inflows and Outflows

The water balance of the residual voids will be governed by the following water inflows and outflows:

- Inflows:
 - Surface runoff inflows from rehabilitated spoil areas that drain to the void.
 - Surface runoff inflows from the walls and ramps of the void.
 - Inflows from incident rainfall on the void lake.
 - Groundwater inflows to the void (if the void lake level is lower than the regional groundwater level) (refer to Section 3).
- Continuous Outflows:
 - Outflows due to evaporation losses from the surface area of the void lake.
- Potential Outflows (conditional on void lake level):
 - Seepage outflows from the void lake – either to an adjacent groundwater sink void, into the unsaturated low-wall waste rock dump or into the regional groundwater (if the void lake level is higher than the regional groundwater level).
 - Discharges to surface water (only if the void fills to spill level).

4.2.1 Runoff Generation

Catchment runoff has been simulated using the Australian Water Balance Model (AWBM). The model represents the catchment using three conceptual surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the baseflow store if there is a baseflow component to the stream flow.

AWBM parameters were adopted from the existing QNH operational water balance model (as for *Water Management Plan QNH Mines* (Engeny, 2020)). These parameters are as summarised in Table 4.1.

Table 4.1 Adopted AWBM Runoff Parameters

Parameter	Natural	Hardstand & Pits	Rehabilitated Spoil
C1 (mm)	23.0	5.0	10.0
C2 (mm)	125.0	20.0	120.0
C3 (mm)	180.0	40.0	180.0
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
A3	0.433	0.433	0.433
BFI	0.05	0.00	0.35
Kb	0.87	0.60	0.60
Ks	0.30	0.10	0.10
Average Soil Store (mm)	135	27	131
Average Annual Runoff Coefficient	14%	36%	16%

4.2.2 Climate Data

Long-term daily rainfall data at the QNH was obtained from the SILO climate database facility hosted by the Queensland Department of Environment and Science (DES). SILO includes both Patched Point Data and Data Drill. The Data Drill utilises grids of data interpolated from point observations by the Bureau of Meteorology to provide climate statistics for a specified location. Patched Point Data is only available at selected rainfall stations and utilises grids of data to 'patch' any data gaps in the climate record at that site.

A SILO Patched Point Data climate series was obtained for the nearby Collinsville Post Office (33013) covering the period January 1889 to September 2019. A composite data set was obtained by merging the SILO data with SCM site rainfall to obtain a continuous record from January 1889 to September 2019 (130 years of data).

Table 4.2 Residual void Hydrology Assessment Climate Data

Month	Mean Rainfall (mm)	Mean Morton's Lake Evaporation (mm)	Mean Evapotranspiration (mm)
January	156	198	195
February	144	170	162
March	99	171	164
April	37	139	133
May	31	110	107
June	32	89	89
July	20	100	100
August	17	127	127
September	15	158	162
October	24	196	199
November	55	205	207
December	98	214	212
Total	727	1875	1857

Corrections to the lake evaporation rates were applied in the residual void water balance model to reflect the reduction to the freshwater evaporation rate that occurs for a saline water body. Morton's method for adjusting evaporation rates has been adopted as presented in *Hydrological Recipes: Estimation Technique in Australian Hydrology (1996)* as follows:

- Evaporation reduction factor = $1 / [1 + \text{TDS (mg/L)} / 10^6]$

This equation predicts a relatively small evaporation correction for salinity of approximately 1% reduction per 10,000 mg/L total dissolved solids (TDS) for TDS values up to 50,000 mg/L (i.e. 5% reduction for 50,000 mg/L TDS).

4.3 Water Quality

4.3.1 Salinity EC Conversion

Electrical conductivity (EC) and Total Dissolved Solids (TDS) are key indicators of water quality and can be simulated within the residual voids water balance model. The model directly simulates TDS using a salt mass balance and converts to EC via a constant conversion factor (1 mg/L TDS = 1.49 μ S/cm EC) (ANZECC & ARMCANZ, 2000). Water quality inputs to the water balance model have been reviewed and are summarised in the following sections.

4.3.2 Rainfall Dependent Salt Mass Inputs

Salinity of runoff generated in the water balance is determined based on land use type. Surface water runoff TDS characteristics have previously been calibrated for certain land use types as documented in *Water Management Plan QNH Mines* (Engeny, 2020). These runoff TDS characteristics have been adopted for the modelling of all voids in this void hydrology study and are summarised in Table 4.3.

Table 4.3 Water Source TDS Concentration (mg/L)

Source	Salinity (mg/L)
Pit wall runoff	1300 (1,931 μ S/cm EC)
Rehabilitated Spoil runoff	700 (1,040 μ S/cm EC)
Natural catchment runoff	700 (1,040 μ S/cm EC)
Direct rainfall	5 mg/L, based on latitude and distance from the coast (DNR, 1997)

4.3.3 Potential for Stratification

Due to the depths of the residual void lakes and the likely thermal gradients, the lakes are considered to have a potential for stratification which is a well understood hydrological occurrence. This is likely to occur on a seasonal cycle with stratification in the warmer summer months followed by mixing in the cooler winter months or under climatic conditions that would promote the turnover of the void lake stratification (e.g. strong winds).

For the purpose of the model, runoff entering the residual voids was assumed to be fully mixed with the existing stored water. This does not account for the potential stratification of water quality within voids. Assuming complete mixing of the void lake contents will provide an average salinity in the void lake over the simulation period and is considered suitable for the purposes of this assessment.

4.4 Model Assumptions

The following key assumptions were applied in the water balance modelling:

- Water outflows associated with the saturation of the spoil in the backfilled voids (typically during first filling conditions) are indirectly captured in the groundwater recovery curves and as such not explicitly represented in the water balance model. The model results are indicative of void lake behaviour after the backfill material becomes saturated.
- All residual voids were assumed empty at the start of simulation.
- The void lakes are fully mixed (i.e. no stratification). Water quality results indicate the average salt concentration of the entire void lake.
- The salinity of runoff from rehabilitated spoil was assumed to be consistent with undisturbed natural runoff.
- Storage curves and catchment areas have been inferred from the best available mine planning information. Adopted storage curves are assumed to be representative of proposed residual voids.
- All spoil stockpiles, backfilled areas and regraded pit walls were assumed to have the runoff quantity and quality characteristics of rehabilitated spoil.

5. MODEL RESULTS

The residual void hydrology water balance model was simulated for a period of 200 years. The historical climate data set has been used to assess 130 potential realisations of the void lake behaviour under different climate sequences. The residual void hydrology assessment was completed for two scenarios as described below:

- Base Case Scenario - The base case has been adopted using catchment delineation methodology described in Section 2.7 and Table 2.4.
- Mitigated Case Scenario - The mitigated scenario has been modelled where there is an opportunity to reduce the catchment area reporting to the residual voids beyond what was provided in the LOMP designs – which are not intended to be to such a detailed level of drainage design (Refer to Section 2.7.1).

Forecast void lake performance indicators are defined in section 5.1 while an example of typical void lake behaviour is provided in section 5.2. Detailed model output plots are provided in Appendix C and Appendix D. A discussion of the key outcomes of the assessment is provided in Section 5.3.1 and Section 5.3.2.

5.1 Void Lake Performance Indicators

The key indicators of the hydrological behaviour of the void lakes for this assessment include:

- Void lake equilibrium level - The equilibrium level is defined as the forecast median level (50th percentile) after the rapid filling period. This is considered to be the level at which the void lake is most likely to sit with periodic fluctuations above and below. Equilibrium level is relatively stable in the long term following the initial rapid filling period.
- Void lake equilibrium volume – The equilibrium volume is defined as the volume corresponding to equilibrium level.
- Void lake maximum level – The maximum level is defined as the highest void lake level forecast during the simulation.
- Void lake filling time – The void filling time is defined as the initial period of filling of the void after cessation of mining until the lake reaches its equilibrium volume.
- Poned area at equilibrium – Equilibrium level is determined by the balance between lake inflows (primarily catchment runoff) and outflows (primarily evaporation). The evaporation is governed by the ponded area of the lake based on the adopted storage curve. The ponded area at equilibrium has been reported to inform the suitability of the forecast results following more detailed refinement of the mine plan (i.e. the results presented are applicable when the contributing catchment, equilibrium level and ponded area at equilibrium are maintained), allowing for potential changes to void designs as per Section 2.3.

- Void lake water quality (EC) 200 years after cessation of operations – Void lake salinity has been reported at the end of the simulation to indicate the general trend of EC over time. The concentration of salts is forecast to increase beyond simulation period as there are negligible outflows of the salts from the residual voids.
- Residual void outcome - The void equilibrium and maximum level results have been compared with the groundwater interaction indicator levels (refer Section 3.1) to determine whether the void is likely to act as a groundwater 'sink' or a 'source'.
 - Sink - A groundwater 'sink' refers to a void which has modelled equilibrium and/or maximum levels lower than the regional groundwater level. The hydraulic gradient generated by this change in levels would result in groundwater ingress to the pit. It has been identified where lake levels are in close proximity to the regional groundwater level (within 2 m) or above the base of weathering as these outcomes may be impacted by uncertainties in model inputs.
 - Source - A groundwater 'source' refers to a void which has a net outflow of water from the void lake into the surrounding geology (generally identified by a water level above the regional groundwater level) where such outflow is not into the low-wall backfill material. In these cases, the hydraulic gradient would result in water within the pit seeping into groundwater systems.

A summary of the key void lake hydrology performance indicators are provided in Table 5.1 for the base case and mitigated catchment scenarios respectively.

5.2 Typical Void Lake Forecast Behaviour

An example of the void lake hydrology assessment results is provided in Figure 5.1 for level and Figure 5.2 for quality, for a typical residual void (i.e. Drake Pit 1).

Figure 5.1 presents the following key results for void lake water level:

- Minimum value on each day of the simulation period.
- Median (i.e. 50th percentile) value on each day of the simulation period. The median is indicative of the most likely value at any point in time (i.e. half the results are higher and half the results are lower) and has been used to define the equilibrium level.
- Maximum value on each day of the simulation period.

The information provided on Figure 5.1 provides the results of Drake 1 Pit void as an example of the typical behaviour of the void lake levels. The graph also features the key levels such as pit floor and pit crest level indicating the total depth of the pit and providing context for the void lake depth. The base of weathering level and pre-mining regional groundwater level (defined in Section 3.1) are also presented to assess the potential pit behaviour. The pre-mining regional groundwater level is a key level compared against the maximum pit lake level to demonstrate if the residual void will act as a "sink" or a "source", whereas, the base

of weathering level is used a secondary indicator to determine seepage through weathered material. Such a scenario can be when maximum void lake level is below pre-mining regional groundwater level but above the base of weathering level.

Key features illustrated on Figure 5.1 include:

- Void lake level will steadily rise over initial years following the cessation of mining (approximately 40 years in this example).
- The void lake levels are forecast to fluctuate over time as a result of prevailing climate conditions. The lake level fluctuates around an equilibrium level, which has been defined as the median lake level (approximately 126 m AHD in this example). The minimum and maximum forecast levels indicate the potential range of fluctuation in lake levels over time (120 m AHD to 134 m AHD in this example).
- The depth of the forecast lake levels relative to the groundwater interaction levels. In this example, the maximum void lake level (134 m AHD) is 12.6 m below the pre-mining regional groundwater level (146.6 m AHD) and 35.1 m below the base of weathering level (169.1 m AHD). This example residual void is therefore forecast to behave as a groundwater sink.

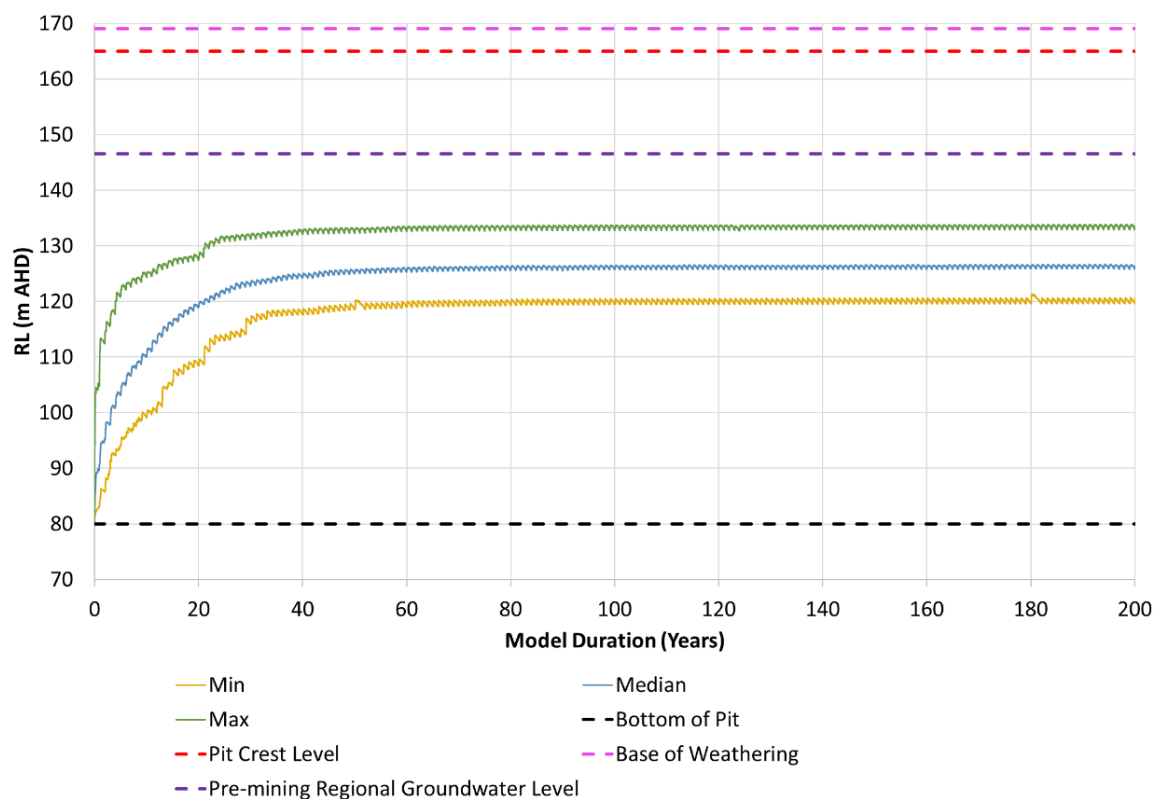


Figure 5.1 Example Void Lake Level Forecast

Figure 5.2 provides the results of water quality modelling for the Drake 1 Pit as an example of typical water quality behaviour of the void lakes. Key features illustrated include:

- The void lake salinity (EC) increases over the simulation period. This is a result of evaporation being the only significant outflow from the void lakes, which results in ongoing concentration of salts. In this example, the equilibrium void lake EC (i.e. the median value) at the end of simulation period is approximately 12,900 $\mu\text{S/cm}$.
- The forecast indicates an ongoing linearly increasing trend in void lake salinity. In this example, the equilibrium void lake EC is continuing to increase at a rate of approximately 130 $\mu\text{S/cm}$ per year. **Ultimately salts will continue to concentrate with the maximum EC limited by solubility of the constituent salts within the lake – this is conceptually the case for any comparable water body which experiences an inflow where evaporation is the only outflow and occurs at a rate exceeding the inflow.**

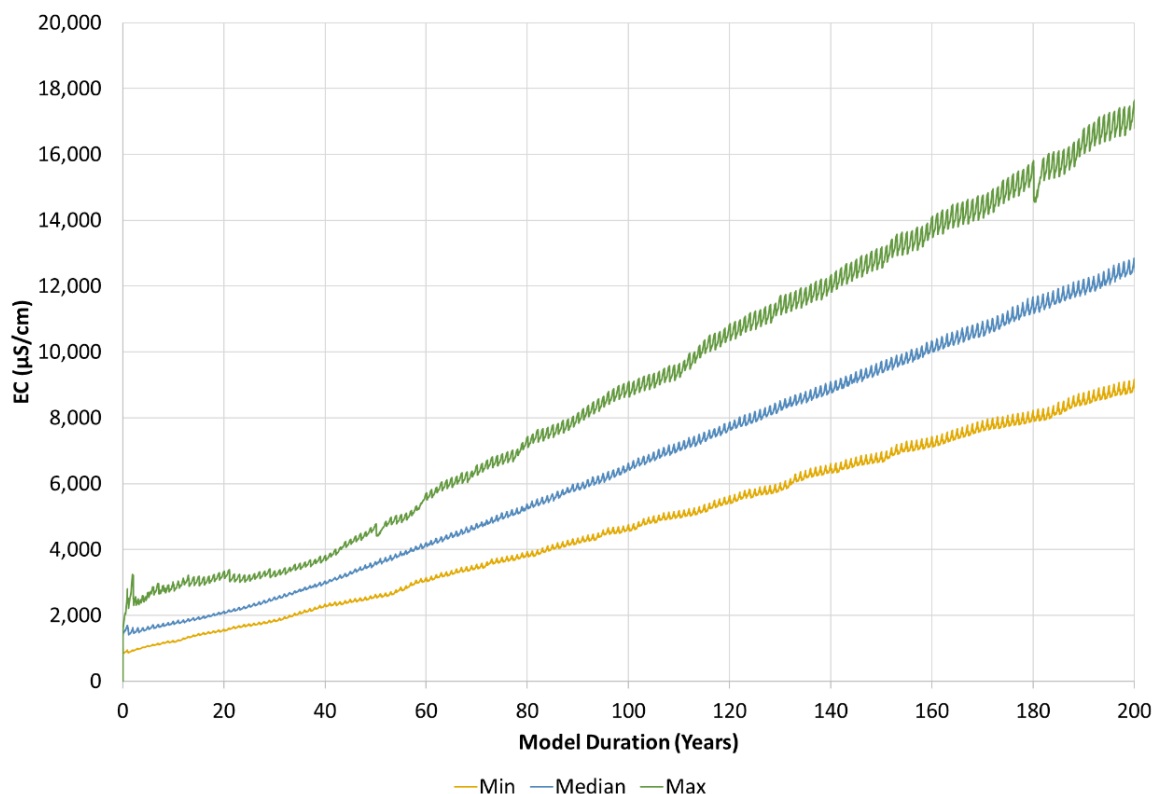


Figure 5.2 Example Void Lake Salinity (EC) Forecast

5.3 Modelling Results

The key model outputs for all QNH modelled voids are summarised in Table 5.1 for level and quality. A graphical representation of the forecast void lake level, volume and salinity for all QNH modelled voids are provided in Appendix C for base cases and Appendix D for mitigated cases.

Table 5.1 Residual Void Lake Results Summary (Base Case and Mitigated Case for Selected Voids)

Residual void	Catchment Area (ha)	Void Equilibrium Water Level (m AHD)	Maximum Water Level (m AHD)	Void Spill Elevation (m AHD)	Pre-mining Groundwater Level (m AHD)	Base of Weathering Level (m AHD)	Void Equilibrium Volume (ML)	Ponded area at Equilibrium (ha)	Void Equilibrium EC at 200 years (µS/cm)	Rate of Increase in EC (µS/cm/year)	Initial Void Filling Period (Years)
Sonoma East Pit 1 (Base Case)	25	158	164	176	156.30	155.80	322	4.6	46,352	493	20
Sonoma East Pit 2 (Base Case)	27	154	161	176	155.53	156.92	214	3.8	47,635	380	20
Sonoma Main Pit (Base Case)	280	150 ¹	154 ¹	171	155.67	153.02	587	49.2	266,030	1,787	5
Drake Pit 1 (Base Case)	240	126	134	165	146.57	169.07	5,245	27.3	12,896	130	40
Drake Pit 2 (Base Case)	22	139	145	164	147.23	153.40	74	2.3	12,282	15	10
Drake Pit 2 Expansion (Base Case)	80	124	131	168	144.24	163.99	1,601	13.0	33,008	310	30
Drake Pit 3Q (Base Case)	55	150	157	172	142.55	161.28	434	3.6	36,812	334	15
Drake Pit 3R (Base Case)	21	165	169	172	141.78	156.72	66	2.4	9,284	9	5
Drake Pit 4 North (Base Case)	97	133	140	155	139.50	127.96	961	11.7	37,665	394	20

Residual void	Catchment Area (ha)	Void Equilibrium Water Level (m AHD)	Maximum Water Level (m AHD)	Void Spill Elevation (m AHD)	Pre-mining Groundwater Level (m AHD)	Base of Weathering Level (m AHD)	Void Equilibrium Volume (ML)	Ponded area at Equilibrium (ha)	Void Equilibrium EC at 200 years (µS/cm)	Rate of Increase in EC (µS/cm/year)	Initial Void Filling Period (Years)
Drake Pit 4 North (Mitigated Case)	49	125	130				608	6.1	55,775	594	20
Drake Pit 4 South (Base Case)	42	131	136	152	136.71	146.72	401	6.6	62,509	606	20
Drake Pit 5 (Base Case)	191	111	119	138	137.42	144.39	4,237	21.6	14,007	140	60
Jax Main Pit 4 (Base Case)	264	110	118	165	140.8 ² /140 ³	149.78	7,999	28.4	4,940	30-100	80
Jax Main Pit 4 (Mitigated Case)	143	98	105				4,794	19.4	7,271	60	80
Jax East Pit 4 (Base Case)	47	104	112	165	135.2 ² /140 ³	146.72	1,086	6.9	12,547	30-100	80
Jax East Pit 4 (Mitigated Case)	41	103	110				923	6.6	14,415	130	45

Note 1: Levels have been shifted up 20m to represent additional 20m of co-disposal deposition

Note 2: Level as provided by AGE (2020)

Note 3: Level used in previous assessment (Engeny, 2018)

Note 4: JCM Final Void Hydrology Study (Engeny 2018)

Legend

	Void lake level is below the pre-mining regional groundwater level and base of weathering
	Void lake level is above pre-mining regional groundwater level

5.3.1 Levels

The key level findings for each residual void are summarised as follows:

- Sonoma East Pit 1 - The void lake equilibrium level (158 m AHD) and maximum void lake level (164 m AHD) are 1.7 m and 7.7 m above the pre-mining regional groundwater level (156.30 m AHD) respectively. The residual void is forecast to have ongoing net outflows to the local geology or regional groundwater.
 - The Sonoma East Pit 1 void lake level is forecast to be above the regional groundwater level and therefore may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, localised outflow from Sonoma East Pit 1 has the potential to be captured by a down-gradient pit acting as a global sink (for example, Sonoma Main Pit) and would therefore not be representative of a source to the regional groundwater. This process can be identified through hydrogeological modelling.
- Sonoma East Pit 2 - The void lake equilibrium level (154 m AHD) and maximum void lake level (161 m AHD) are 1.5 m below and 5.5 m above the pre-mining regional groundwater level (155.53m AHD) respectively. The residual void is forecast to have ongoing net outflows to the local geology or regional groundwater.
 - The Sonoma East Pit 2 void lake level is forecast to be above the regional groundwater level and therefore may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, localised outflow from Sonoma East Pit 2 has the potential to be captured by a down-gradient pit acting as a global sink (for example, Sonoma Main Pit) and would therefore not be representative of a source to the regional groundwater. This process can be identified through hydrogeological modelling.
- Sonoma Main Pit - The void lake equilibrium level (130 m AHD) and maximum void lake level (134 m AHD) are 25.7 m and 21.7 m below the pre-mining regional groundwater level (155.67 m AHD) respectively. These outcomes are based on the design landform surface at year 20. It is expected the final co-disposal surface will be as much as 20m higher than this level. The conservative addition of a further 20 vertical metres of rejects material can be expected to result in an equilibrium level of 150 m AHD and a maximum level of 154 m AHD which remain below the regional groundwater level.
 - As such the Sonoma Main Pit is expected to act as a groundwater sink; however as it will be subject to in-pit co-disposal of rejects it will behave differently to the other voids modelled and further consideration is recommended in the detailed mine planning for this void based on the in-pit co-disposal plan.
 - In addition, due the placement of rejects material within the void, the Sonoma Main Pit residual void geometry included a large predominantly flat surface. The void is forecast to behave as an evaporation pan and therefore periodically dries out to very minimal volumes.

- Drake Pit 1 - The void lake equilibrium level (126 m AHD) and maximum void lake level (134 m AHD) are 20.6 m and 12.6 m below the pre-mining regional groundwater level (146.57 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Drake Pit 2 - The void lake equilibrium level (139 m AHD) and maximum void lake level (145 m AHD) are 8.2 m and 2 m below the pre-mining regional groundwater level (147.23 m AHD) respectively. The residual void is forecast to act as a sink.
- Drake Pit 2 Expansion - The void lake equilibrium level (124 m AHD) and maximum void lake level (131 m AHD) are 20.2 m and 13.2 m below the pre-mining regional groundwater level (144.24 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Drake Pit 3Q - The void lake equilibrium level (150 m AHD) and maximum void lake level (157 m AHD) are 7.5 m and 14.5 m above the pre-mining regional groundwater level (142.55 m AHD) respectively. Therefore, the residual void is forecast to have ongoing net outflows to the local geology or regional groundwater.
 - The Drake Pit 3Q void lake level is forecast to be above the regional groundwater level and therefore may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, localised outflow from Drake Pit 3Q has the potential to be captured by a down-gradient pit acting as a global sink (for example, Jax Main Pit) and would therefore not be representative of a source to the regional groundwater. This process can be identified through hydrogeological modelling.
- Drake Pit 3R - The void lake equilibrium level (165 m AHD) and maximum void lake level (169 m AHD) are 23.2 m and 27.2 m above the pre-mining regional groundwater level (141.78 m AHD) respectively. Therefore, the residual void is forecast to have ongoing net outflows to the local geology or regional groundwater
 - The Drake Pit 3R void lake level is forecast to be above the regional groundwater level and therefore may result in a hydraulic gradient out of the void into the surrounding geology (a net outflow). However, localised outflow from Drake Pit 3R has the potential to be captured by a down-gradient pit acting as a global sink (for example, Jax Main Pit) and would therefore not be representative of a source to the regional groundwater. This process can be identified through hydrogeological modelling.
- Drake Pit 4 North – Using the catchment layout from the LOMP (the base case), the void lake equilibrium level (133 m AHD) and maximum void lake level (140 m AHD) are 6.5 m below and 0.5 m above the pre-mining regional groundwater level (139.50 m AHD) respectively. The equilibrium and maximum void lake level sit above the base of weathering (127.96 m AHD) which has been used as a secondary indicator for potential seepage out of the void lake. As such the base case modelling results indicate that this void may alternate between periods of net outflow and periods of acting as a sink, as the lake levels fluctuate over time.

- As discussed in Section 2.7.1 and Section 5, the LOMP is not optimised to consider catchment reduction or completed to a level of detail sufficient to consider specific drainage solutions. Accordingly, a review of catchment reduction options was undertaken which resulted in reduced catchment reporting the Drake 4 North Void (referred to as the mitigated option). The catchment mitigation is discussed in Section 2.7.1.
- The key outcomes for the mitigated case are summarised in Table 5.1. The mitigated void lake equilibrium level (125 m AHD) and maximum void lake level (130 m AHD) are 14.5 m below and 9.5 m below the pre-mining regional groundwater level (139.50 m AHD) respectively. Therefore, based on the primary indicator of void lake and groundwater interaction, the mitigated residual void is forecast to act as a sink.
- Drake Pit 4 South - The void lake equilibrium level (131 m AHD) and maximum void lake level (136 m AHD) are 5.7 m and 0.7 m below the pre-mining regional groundwater level (136.71 m AHD) respectively. The residual void is forecast to act as a sink.
- Drake Pit 5 - The void lake equilibrium level (111 m AHD) and maximum void lake level (119 m AHD) are 26.4 m and 18.4 m below the pre-mining regional groundwater level (137.42 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- Jax Main Pit – Using the catchment layout for the LOMP (the base case) the void lake equilibrium level (110 m AHD) and maximum void lake level (118 m AHD) are 30.8-30 m and 22.8-22 m below the pre-mining regional groundwater level (140.8-140 m AHD) respectively. Therefore, the residual void is forecast to act as a sink.
- As a measure of comparison a potential mitigated scenario was also modelled for a reduced catchment. The key outcomes for the mitigated case are also summarised in Table 5.1.. The mitigated void lake equilibrium level (98 m AHD) and maximum void lake level (105 m AHD) are 42.8-42 m below and 35.8-35 m below the pre-mining regional groundwater level (140.8-140 m AHD) respectively.
- Conclusions as per JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit (Engeny, November 2018).
- Jax East Pit – The void lake equilibrium level (104 m AHD) and maximum void lake level (112 m AHD) are 31.2-23.2 m and 36-28 m below the pre-mining regional groundwater level (135.2-140 m AHD) respectively. Therefore, the residual void is forecast to act as a sink. Conclusions as per *JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit (Engeny, November 2018)*.
- As a measure of comparison a potential mitigated scenario was also modelled for a reduced catchment. The key outcomes for the mitigated case are also summarised in Table 5.1. The mitigated void lake equilibrium level (103 m AHD) and maximum void lake level (110 m AHD) are 32.2-25.2 m below and 37-30 m below the pre-mining regional groundwater level (135.2-140 m AHD) respectively.
- Conclusions as per JCM Final Void Hydrology Study Jax Main Pit and Jax East Pit (Engeny, November 2018).

5.3.2 Quality

The salinity of all residual voids modelled as part of this assessment is forecast to continue to increase over time due to the ongoing concentration resulting from evaporation with no significant outflow of salts from either net outflows seepage or overflows. It should be noted that pits with net outflow to the regional groundwater were still shown to accumulate salts throughout the model duration (refer Appendix C). The flow rates to groundwater at all levels of rating curves for all pits (refer Appendix B) were significantly smaller in magnitude than flows associated with rainfall, runoff, and evaporation. This resulted in accumulation of salt in net outflow pits despite salt losses through groundwater mechanisms.

The results presented in Table 5.1 indicate significant variation in the EC of the different voids as a result of differing rates of concentration. However, all void lakes are forecast to exceed 10,000 $\mu\text{S}/\text{cm}$ after 200 years (with the exception of Jax Main Pit). The overall water quality outcome is consistent for all void lakes (i.e. high levels of salinity that continue to increase over time).

The water quality forecast for the Sonoma Main Pit residual void exhibits characteristics not evident in other residual voids modelled at QNH in that modelled salinity at 200 years is an order of magnitude higher than any other modelled void. The proposed residual void for Sonoma Main Pit has a large, relatively flat surface produced by the co-disposal of tailings and rejects within the pit. Therefore, any ponding within Sonoma Main Pit is subject to very large evaporation surface areas. The void behaves much like an evaporation pan, with the volume of water within the void regularly reaching very low quantities. During drying periods, the remaining water in the void becomes highly saline as the void does not have any mechanisms (net outflow to groundwater or spills) for salt mass reduction.

The time for the void lakes to reach their equilibrium levels varies based on the ratio of catchment area to void volume. The shortest filling time is seen to be Sonoma Main Pit (5 years) while the longest is Jax Main Pit (80 years).

5.3.3 Ongoing Reliability of Results

It has been necessary to make a number of assumptions associated with the LOMP, which itself is expected to change as the QNH progresses (as discussed in Section 2.3). The accuracy of the results presented is inherently dependent upon the input data and assumptions. In particular, the relationship between contributing catchment area, equilibrium level relative to regional groundwater levels and ponded area at equilibrium level determines the residual void modelling results (i.e. sink or net outflow).

As noted previously in Section 2.3, Engeny has undertaken to conservatively assess the layout of final voids provided by QCoal, such that should minor changes to a void or pit complex occur over the life of QNH, this assessment can still be relied upon to inform impact assessments provided key hydrological modelling parameters are maintained (see Section 5.1).

6. UNCERTAINTY ASSESSMENT

The outcomes of numerical models are inherently dependent upon the quality of the inputs in addition to the modelling process itself. A qualitative uncertainty assessment has been completed on key input data that impacts the outcomes of the residual void lake hydrology and is presented in Table 6.1. Each data input has been assigned a quality rating based on confidence in the data, and whether the data is measured or estimated:

- High – measured data with a high level of confidence.
- Medium – measured data with a low level of confidence or estimated from data with a high level of confidence.
- Low – Estimated from data with a low level of confidence, or incomplete measured data.

Data inputs with a 'Low' quality rating and a 'High' impact rating are the greatest sources of uncertainty in the assessment. As seen in Table 6.1, the data input items with this **Low/High** combination are the pit geometry of residual voids that are yet-to-commence which is to be expected of any mining operation and the pre-mining regional groundwater level.

Table 6.1 Uncertainty Assessment – Residual Void Hydrology

Input	Primary Data Source	Data Quality Rating	Impact on Residual Void Results
130 years of climate data	SILO climate database facility hosted by Science Division of DES.	High	High
Catchment areas for storages	Based on mine plan polygons, survey dated 2014 and August 2019 provided by QCoal	High	High
Pit geometry: storage curves and maximum storage capacities for residual voids of existing pits	Based on existing pit geometry and survey dated August 2019 or design surfaces (e.g. SCM Main Pit). Residual void inferred to be similar to existing geometry.	Medium	High
Pit geometry: storage curves and maximum storage capacities for residual voids that are yet-to-commence	Based on comparison with existing pit geometry and void surface area	Low	High
Pre-mining regional groundwater level	Supplied by AGE from monitoring and numerical modelling	Low	High

Input	Primary Data Source	Data Quality Rating	Impact on Residual Void Results
Location of residual voids	Based on mine plan polygons provided by QCoal	Medium	Medium
Base of Weathering	Supplied by AGE from exploration data	Medium	Medium
Groundwater recovery curves	Supplied by AGE from numerical modelling	Low - Medium	Low

Pit geometry is critical for identifying the equilibrium level (i.e. the level at which the evaporative outflow from the ponded surface area balances the catchment inflows). The depth at which the equilibrium level and associated ponded area occur in relation to the regional groundwater level determines whether the residual void is expected to act as a sink or a source. However, it is understood that the final void geometry for an open cut coal mine pit which has yet to commence will always be an estimate, due to the changes which occur during the life of pit, in the economic which govern the pit activities (Section 2.3). As such the uncertainty level in this parameter is a normal expectation in void modelling of this kind.

The pre-mining regional groundwater level, as described in sections 3 and 5, is the primary reference level for determining whether a pit is a sink or source. The uncertainty associated with this input originates from the model and has been quantified with input from AGE.

The results of this assessment are considered suitable for determining overall final void hydrology outcomes (i.e. whether a void is a groundwater sink) for the purposes of assessing potential environmental impacts associated with the presence of the final voids.

All model outputs are improved with more accurate inputs and should further modelling of voids be required, additional refining of the inputs would assist in improving the model.

7. CONCLUSIONS

The residual void assessment has demonstrated the following key outcomes:

- None of the void lakes assessed were modelled to overtop to the receiving environment in any climate scenarios.
- The salinity of the residual void lakes is forecast to increase over time as evaporation results in on-going concentration of salts. Water quality in all voids is expected to continue to worsen beyond the 200 year modelled time frame with solubility being the limit on increasing salinity.
- Four (4) residual voids were forecast to have ongoing net outflows to surrounding geology:
 - Sonoma East Pit 1
 - Sonoma East Pit 2
 - Drake Pit 3Q
 - Drake Pit 3R
- Nine (9) residual voids were forecast to act as groundwater sinks:
 - Sonoma Main Pit
 - Drake Pit 1
 - Drake Pit 2
 - Drake Pit 2 Expansion
 - Drake Pit 4 North (mitigated scenario)
 - Drake Pit 4 South
 - Drake Pit 5
 - Jax Main Pit
 - Jax East Pit
- Key areas of uncertainty were identified to be the pit geometry for voids which have not yet commenced as well as with the reported regional groundwater levels.

The residual void forecast outcome in ascending order of depth below regional groundwater are presented in Table 7.1.

Table 7.1 Residual Void Forecast Outcome

Residual void	Modelling outcome	Maximum lake level comparison to pre-mining groundwater level
Jax Main Pit	Sink	35.8 m below pre-mining GW Level
Jax East Pit	Sink	25.2 m below pre-mining GW Level

Residual void	Modelling outcome	Maximum lake level comparison to pre-mining groundwater level
Drake Pit 5	Sink	18.4 m below pre-mining GW Level
Drake Pit 2 Expansion	Sink	13.4 m below pre-mining GW Level
Drake Pit 1	Sink	12.6 m below pre-mining GW Level
Drake Pit 4 North (mitigated)	Sink	9.5 m below pre-mining GW Level
Drake Pit 2	Sink	2 m below pre-mining GW Level
Sonoma Main Pit	Sink	1.7m below pre-mining GW Level
Drake Pit 4 South	Sink	0.7 m below pre-mining GW Level
Sonoma East Pit 2	Net outflow	5.4 m above pre-mining GW Level
Sonoma East Pit 1	Net outflow	7.7 m above pre-mining GW Level
Drake Pit 3Q	Net outflow	14.4 m above pre-mining GW Level
Drake Pit 3R	Net outflow	27.2 m above pre-mining GW Level

8. QUALIFICATIONS

- a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
- b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.
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 - (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.
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- g. This report does not provide legal advice.

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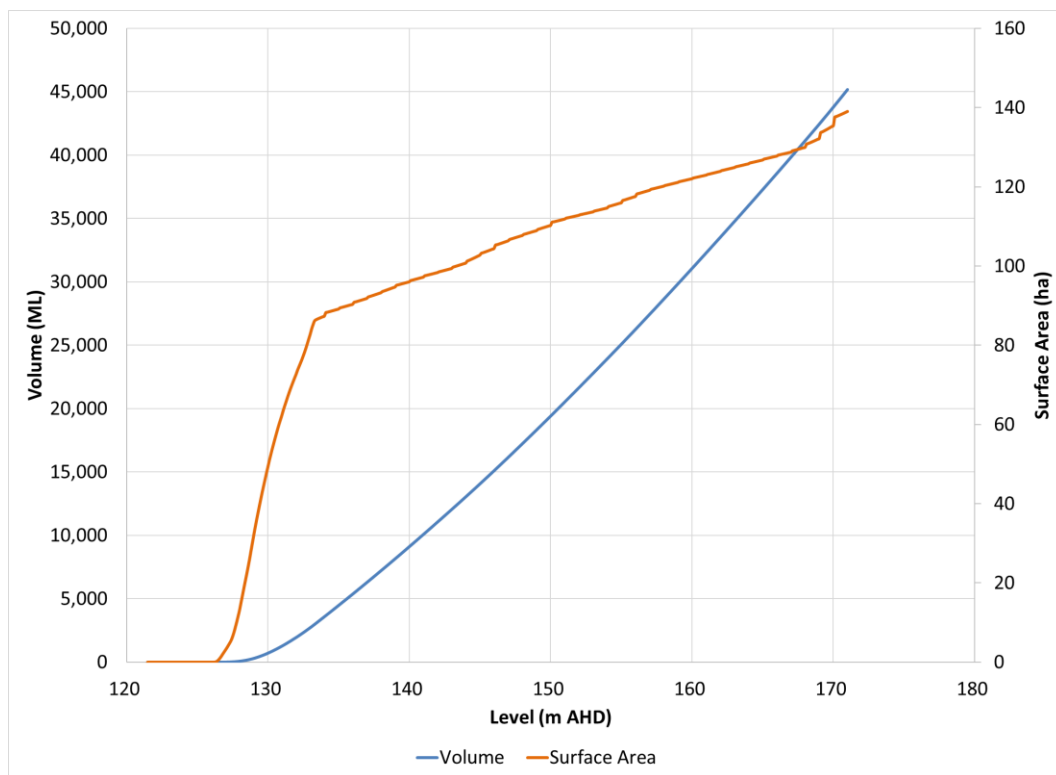
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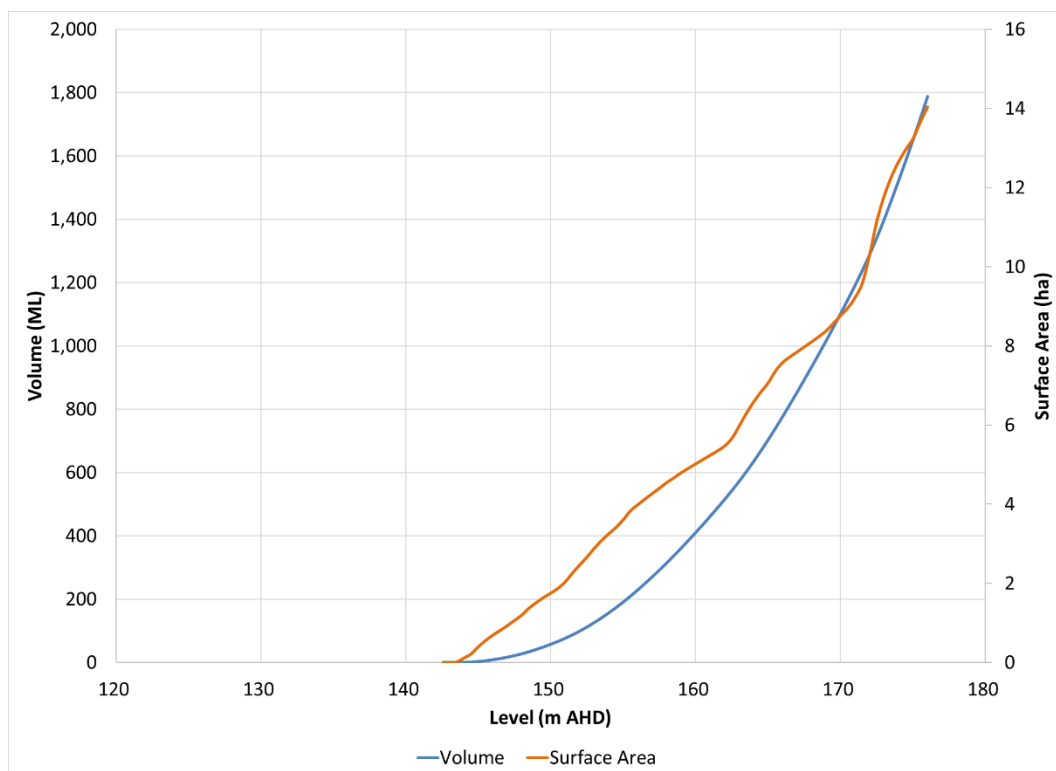
Appendix A

Residual Void Storage Curves

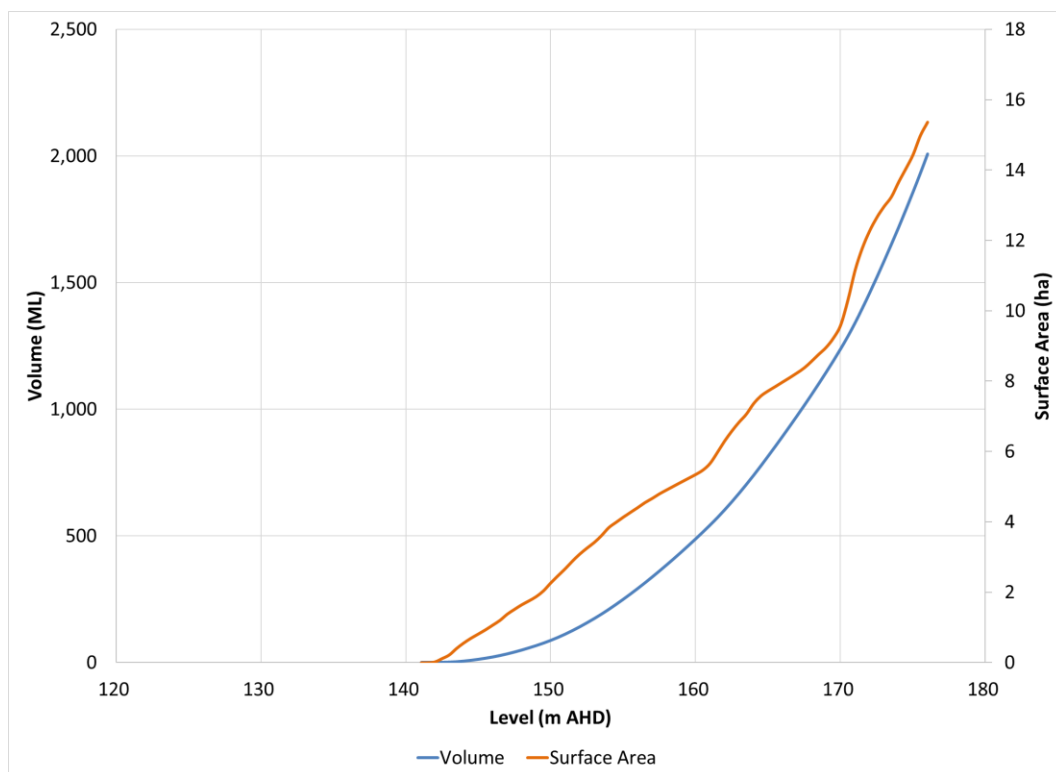
Sonoma Main Pit



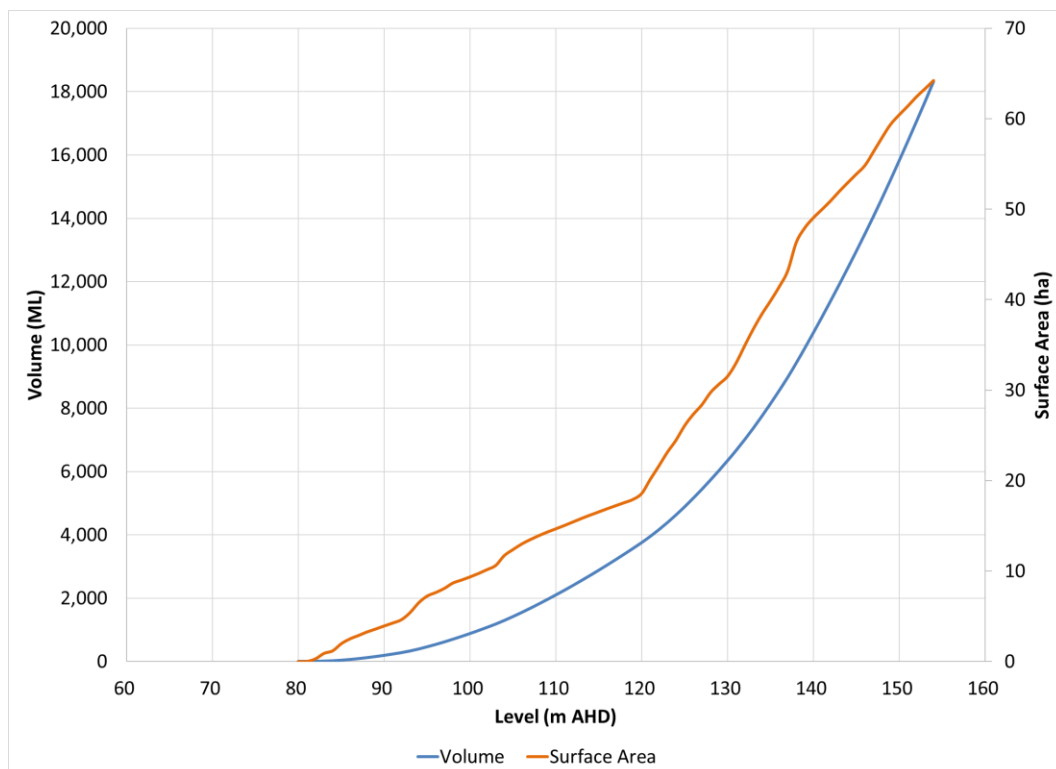
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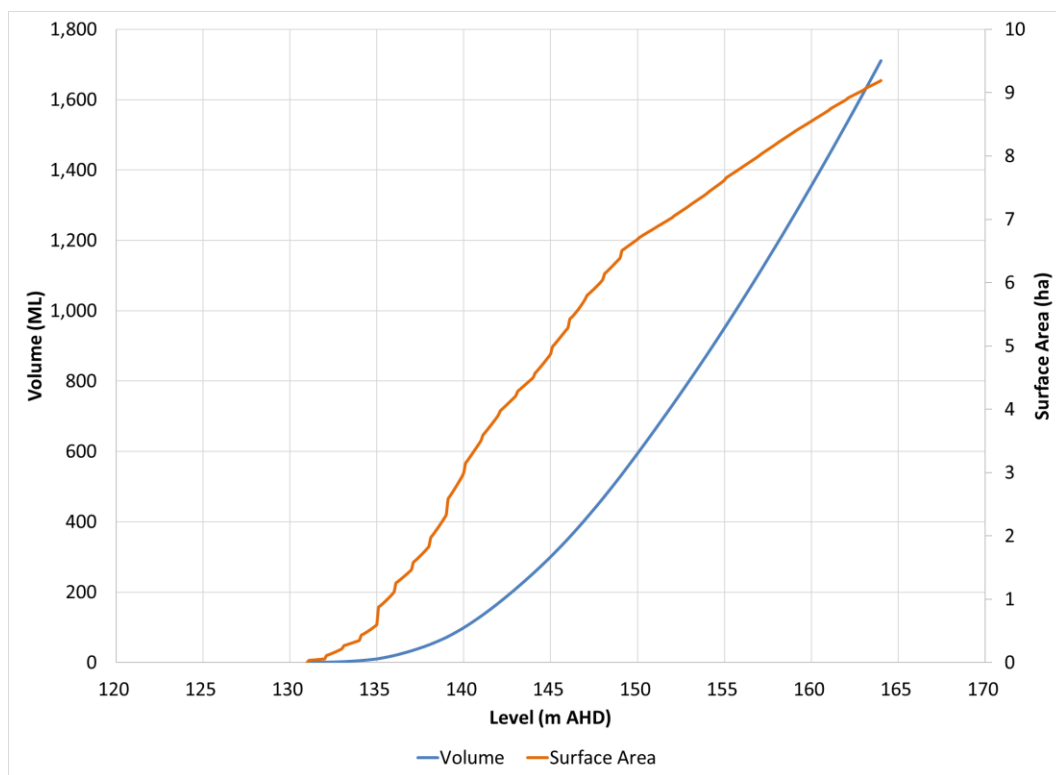
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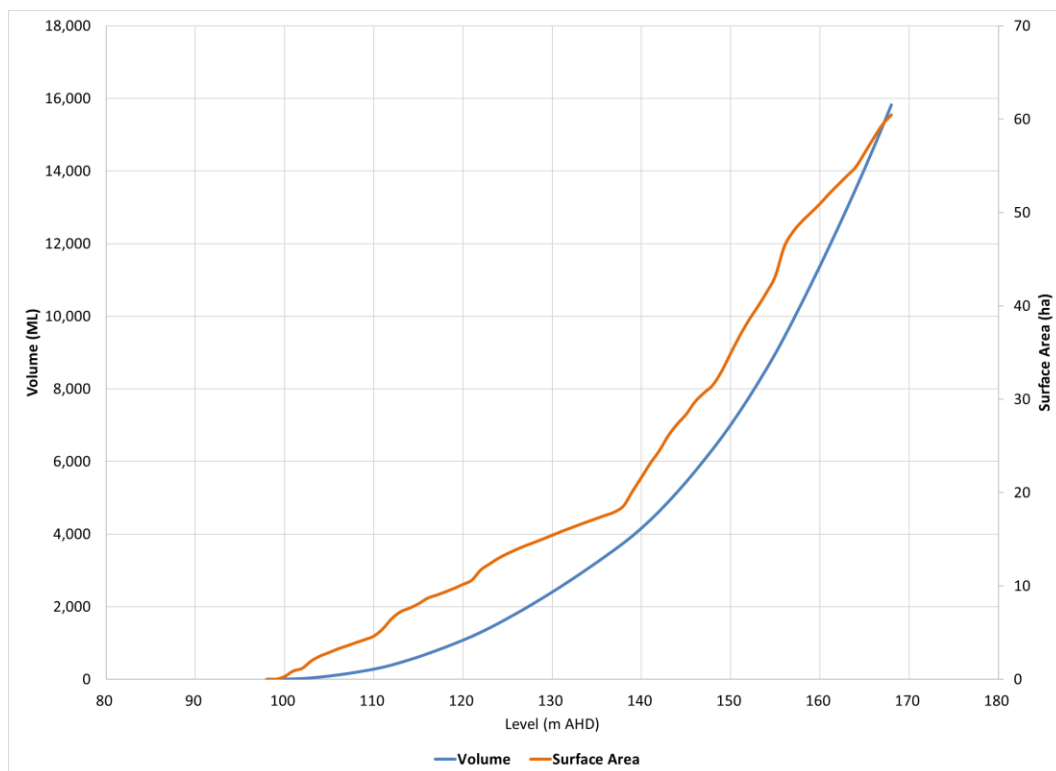
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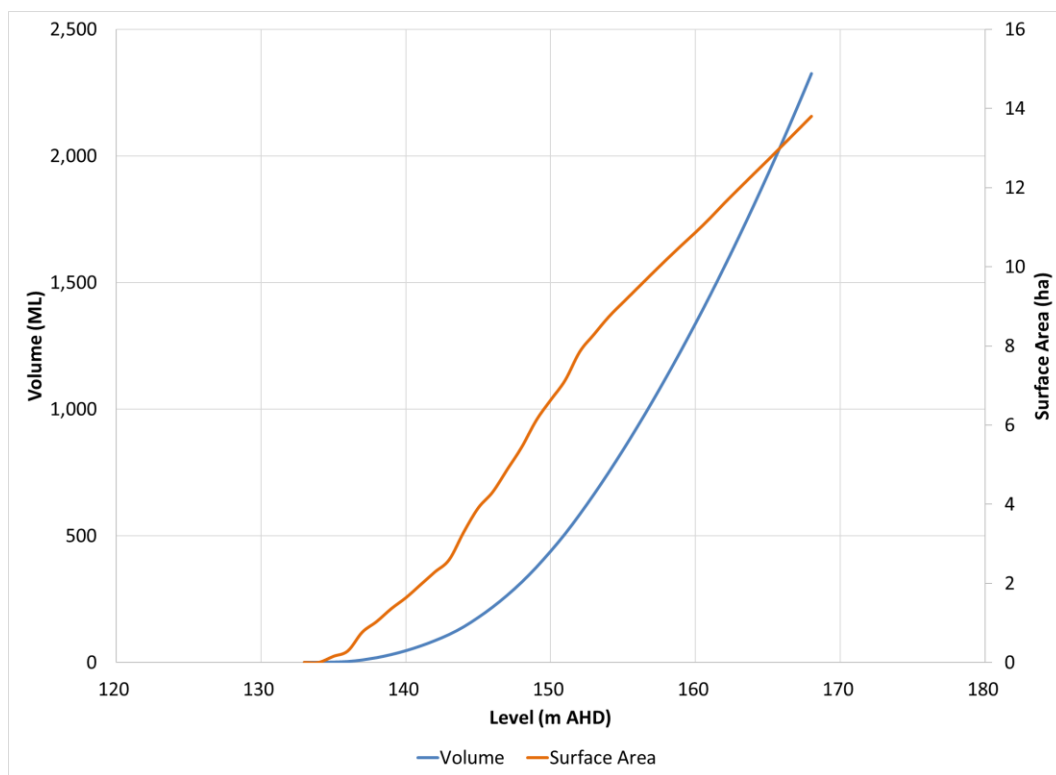
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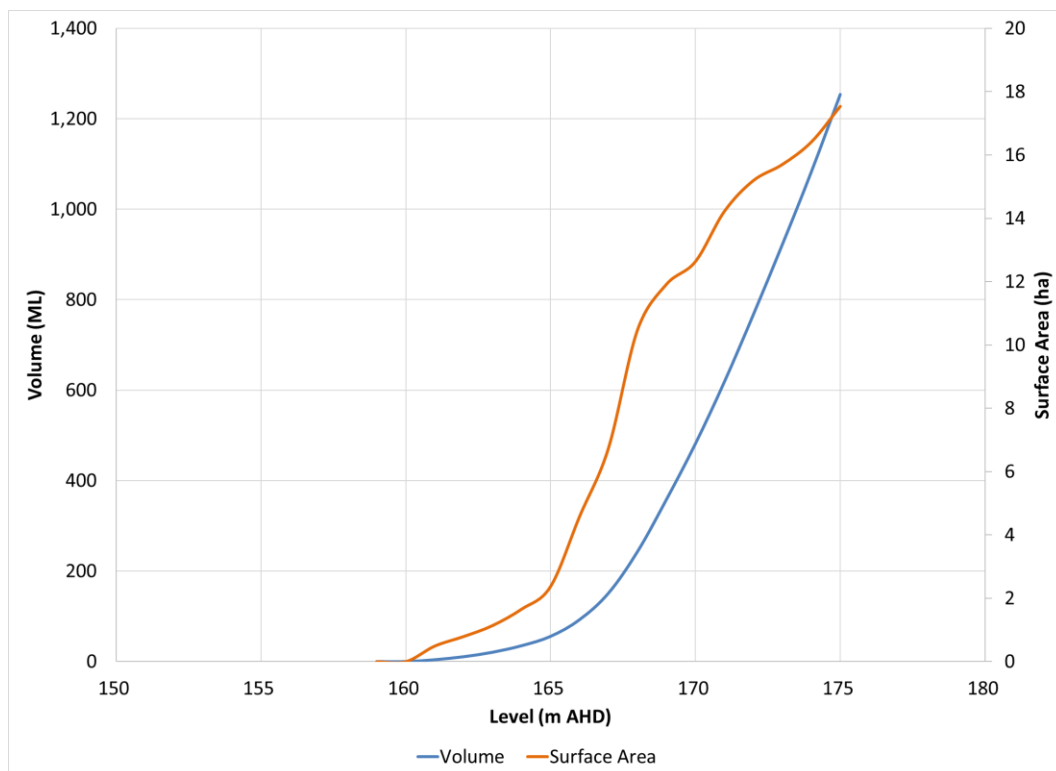
Drake Pit 2 Expansion



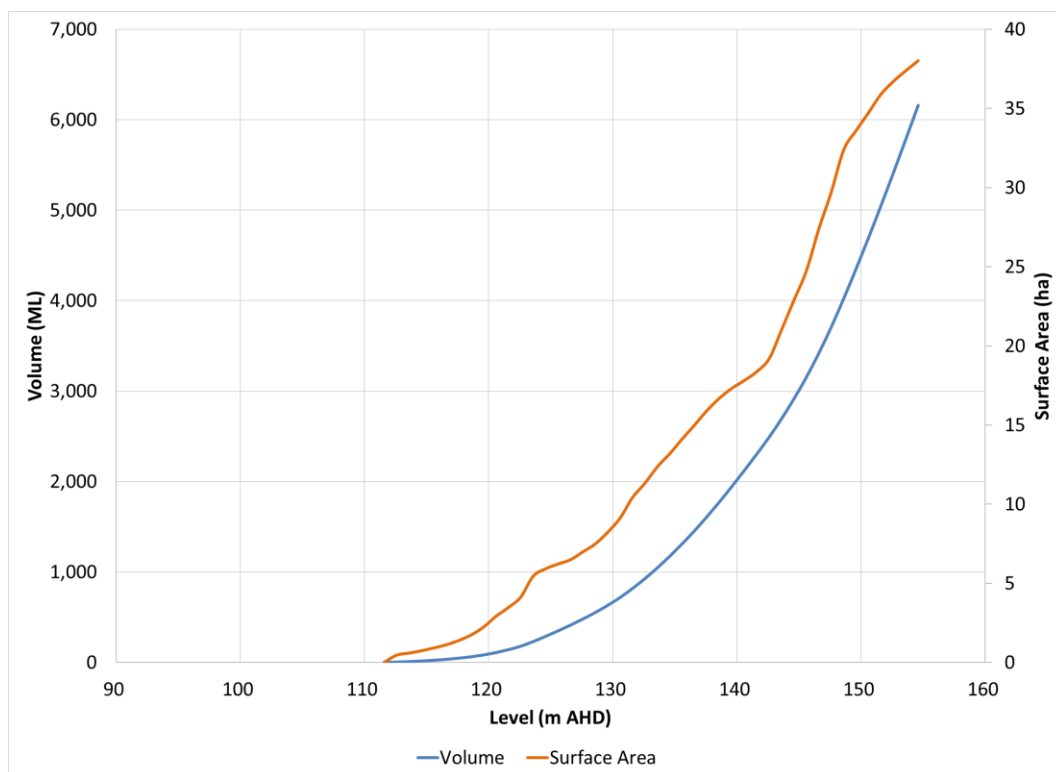
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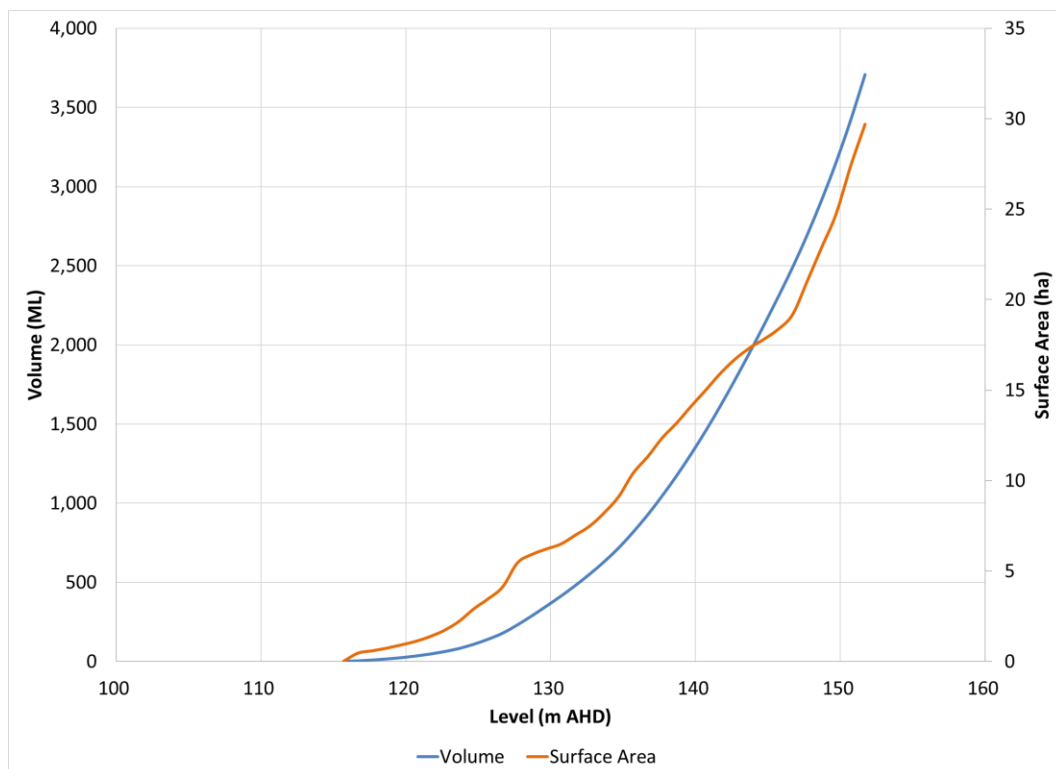
Drake Pit 3R



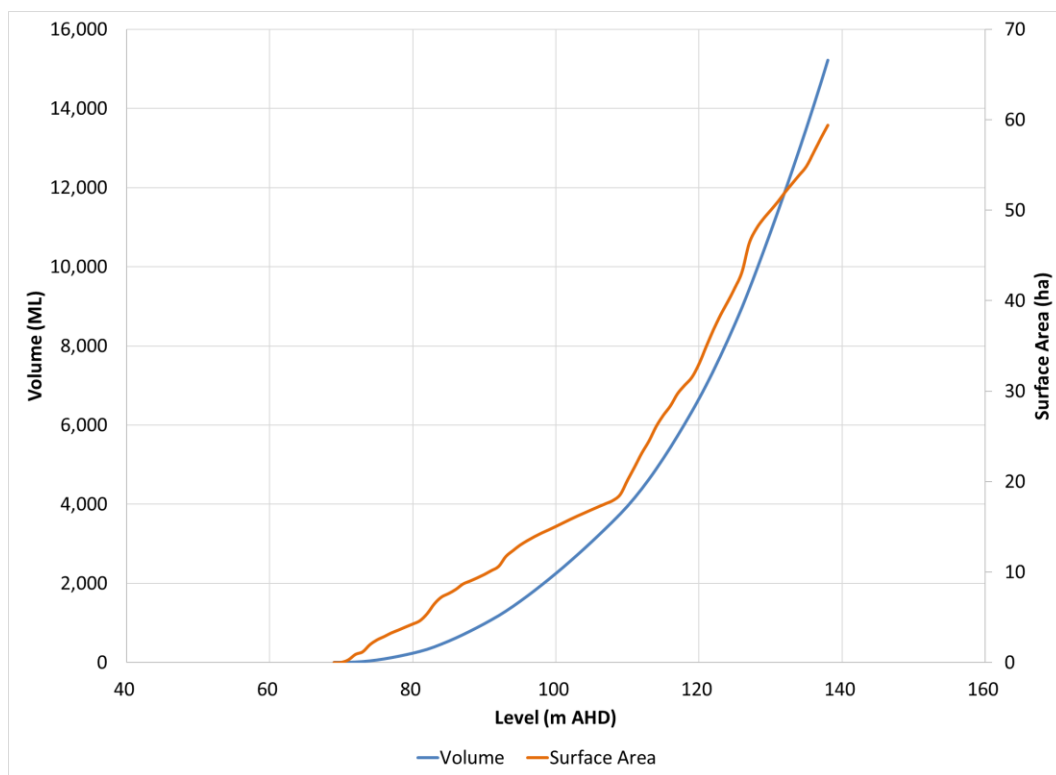
Drake Pit 4 North



Drake Pit 4 South



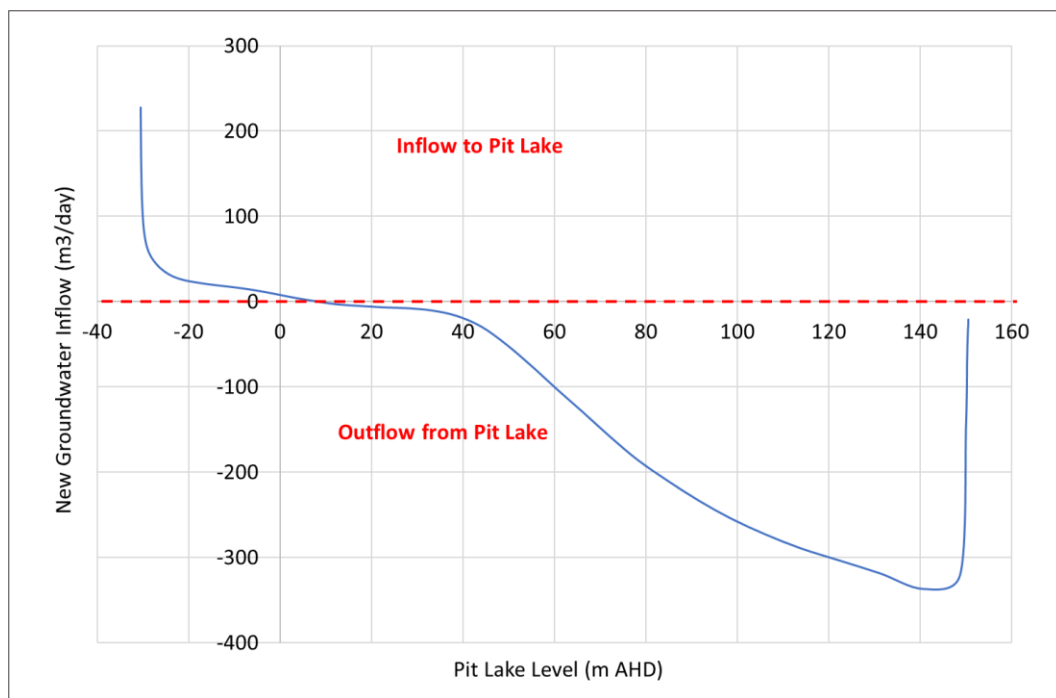
Drake Pit 5



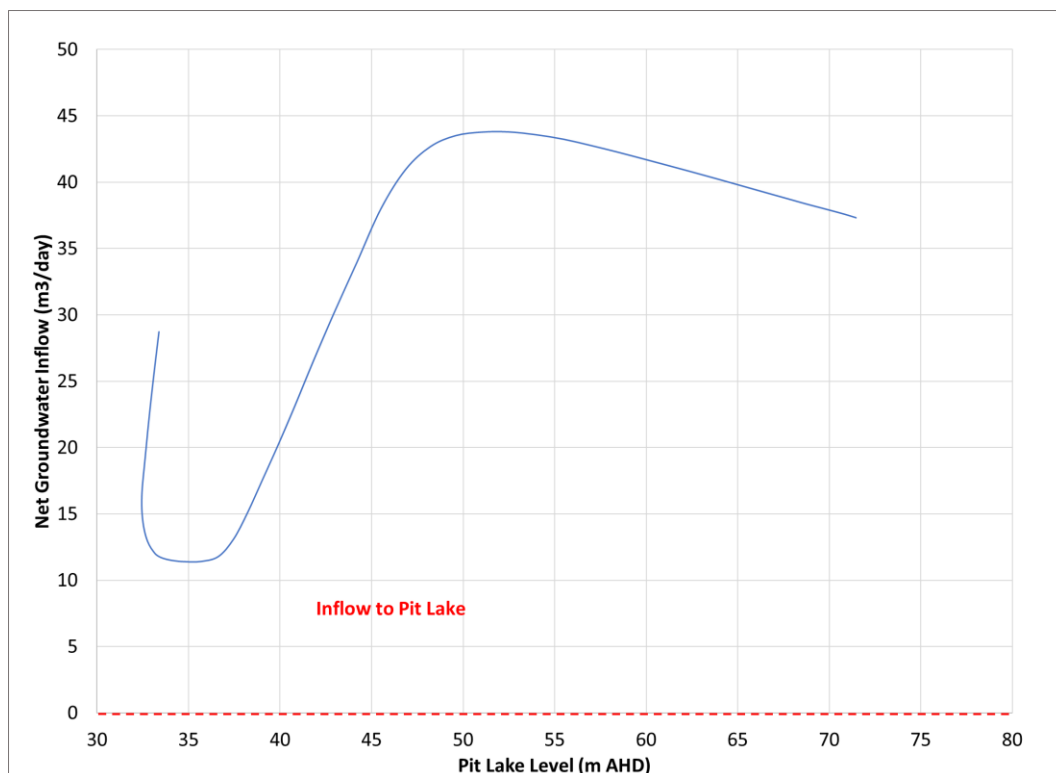
Appendix B

Groundwater Recovery Curves

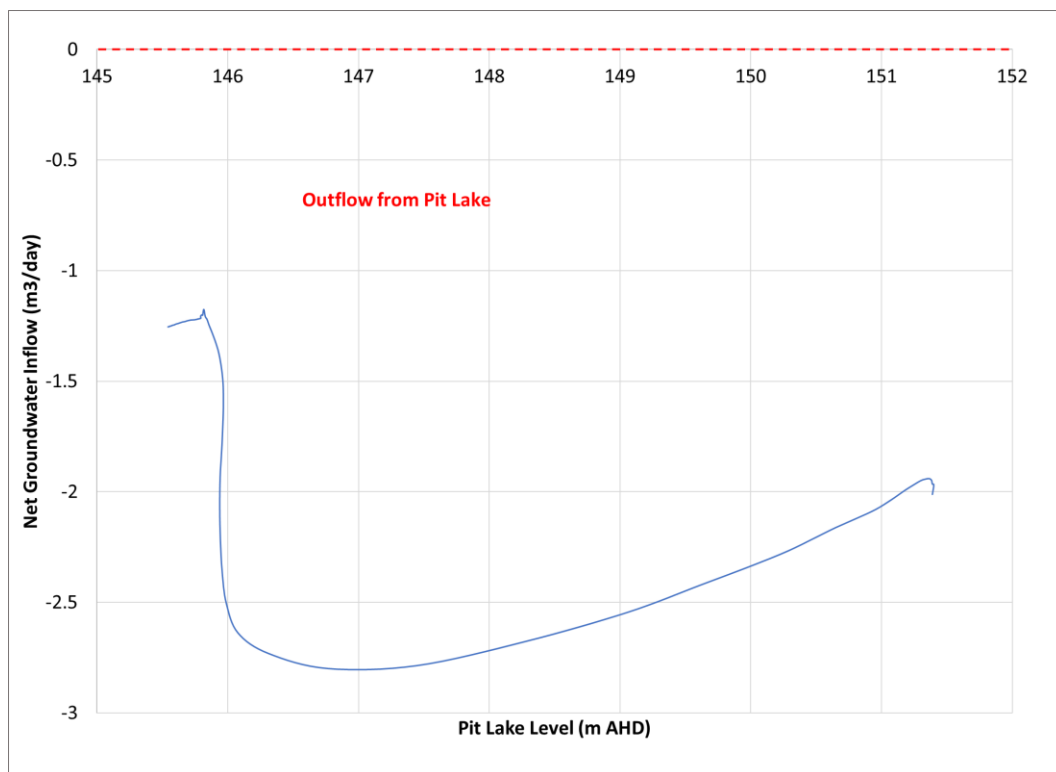
Sonoma Main Pit



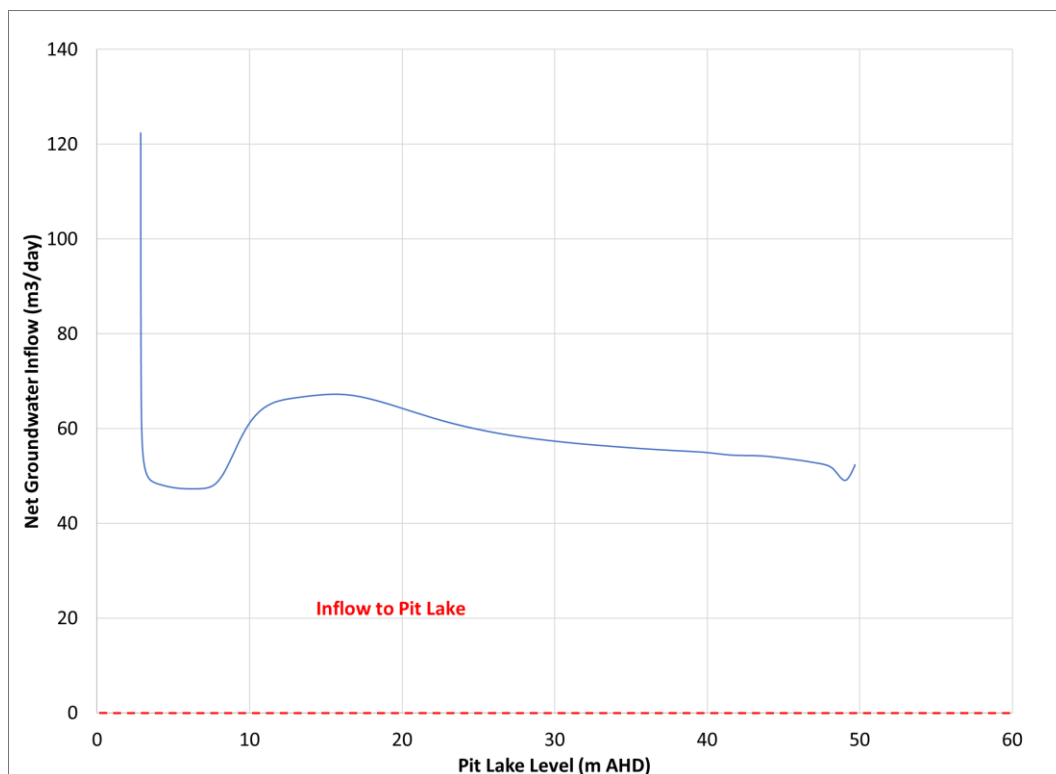
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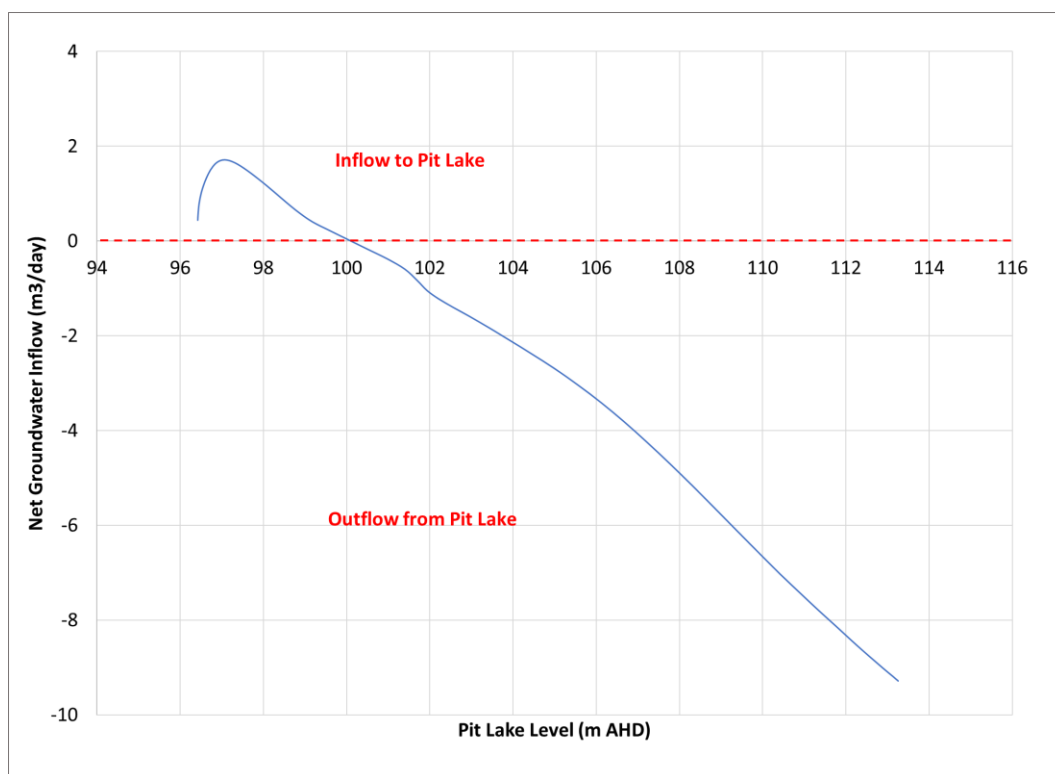
Sonoma East Pit 2



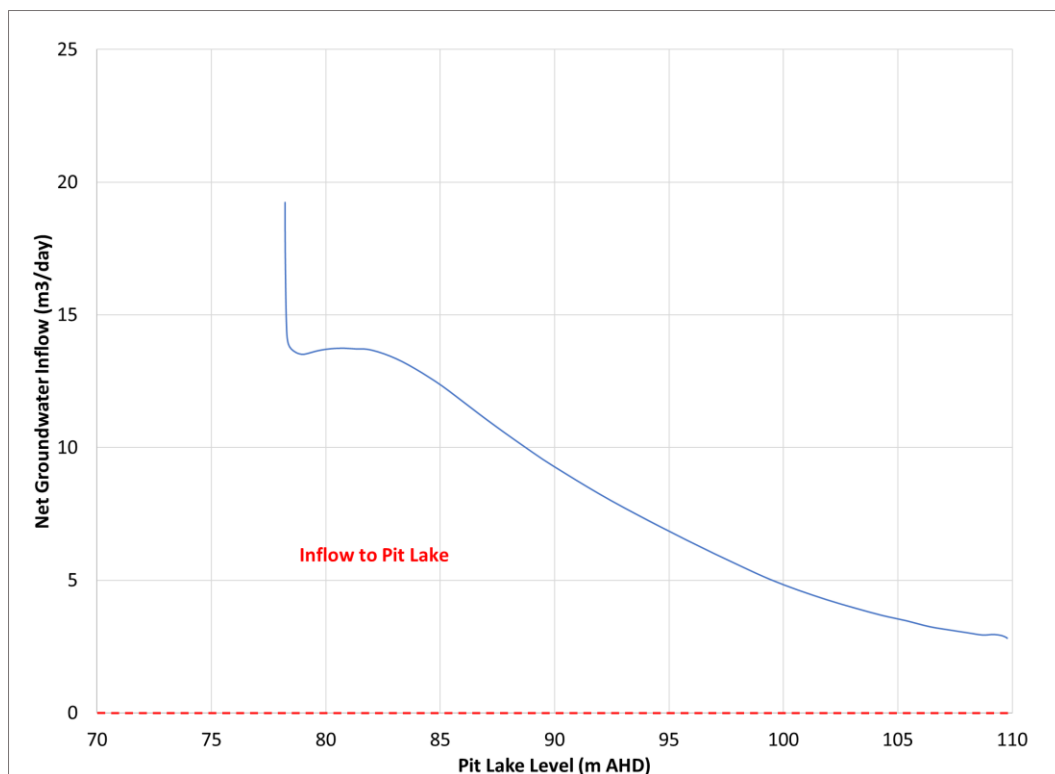
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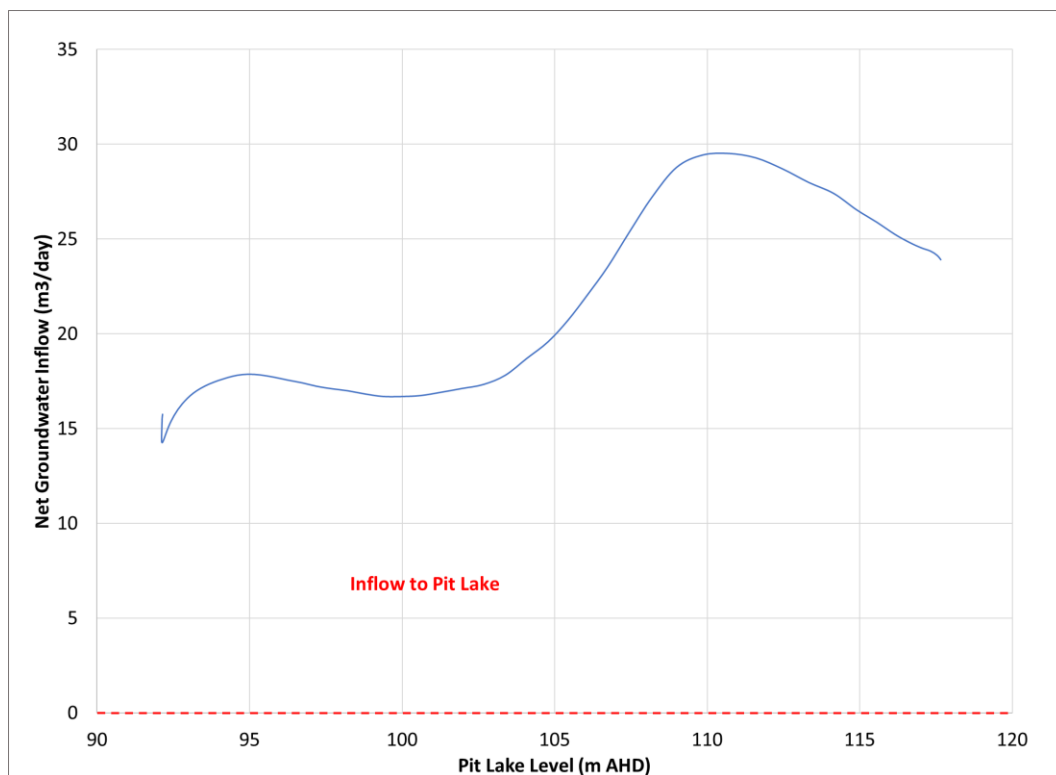
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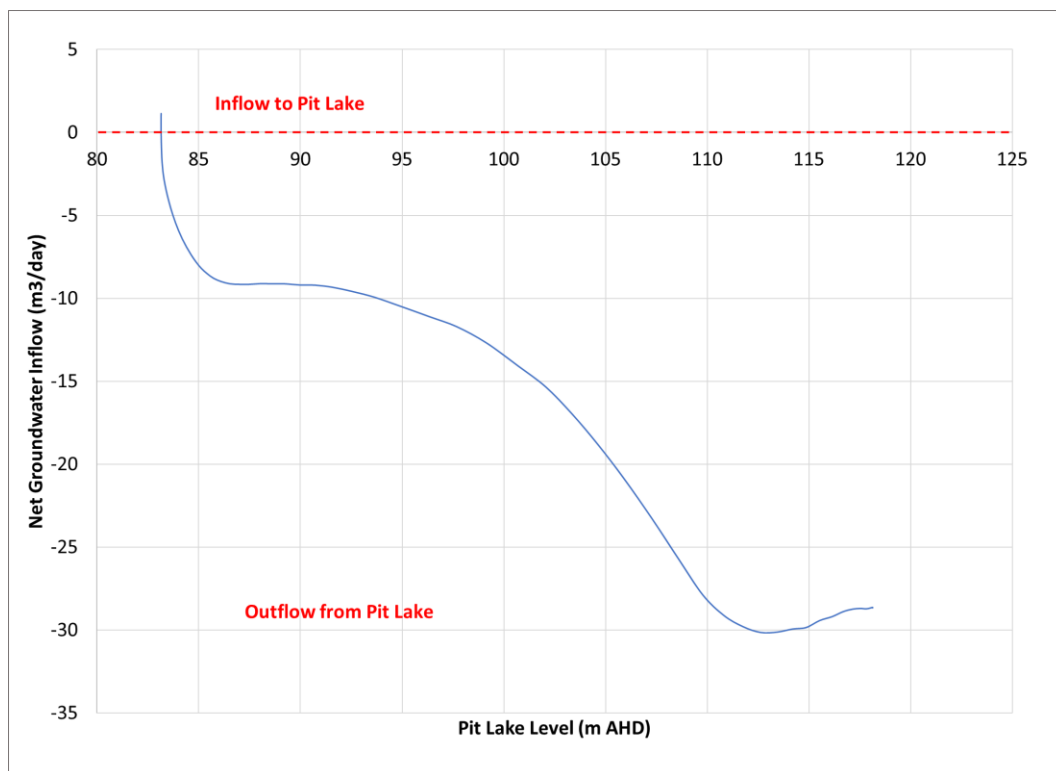
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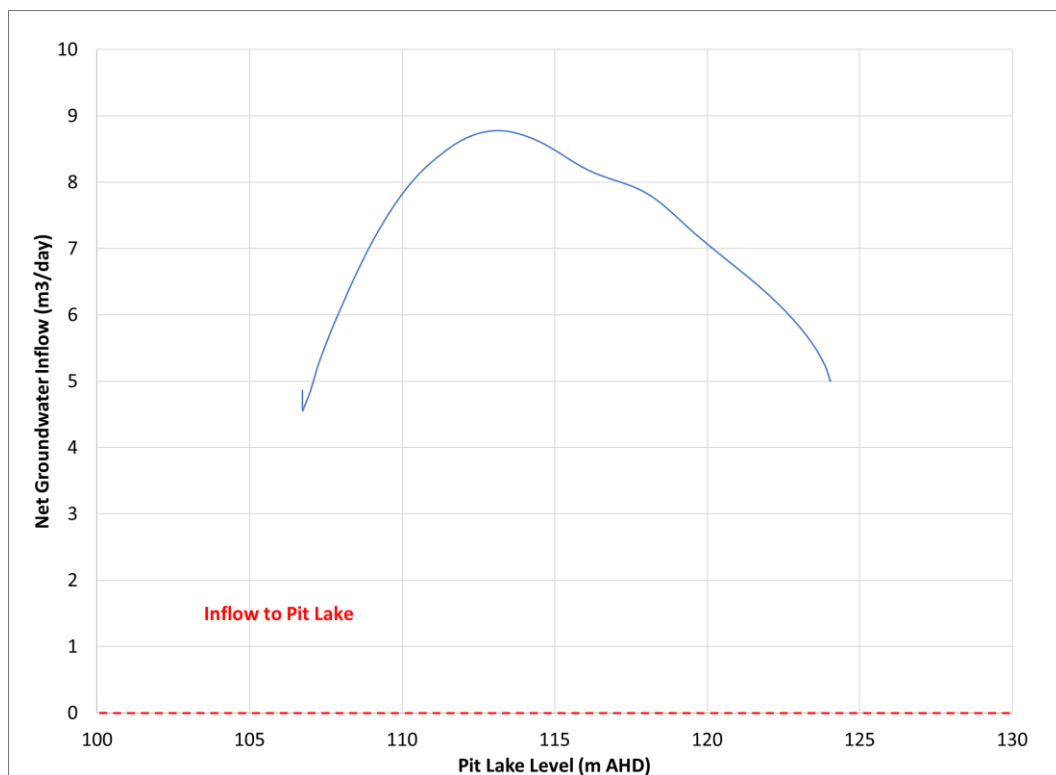
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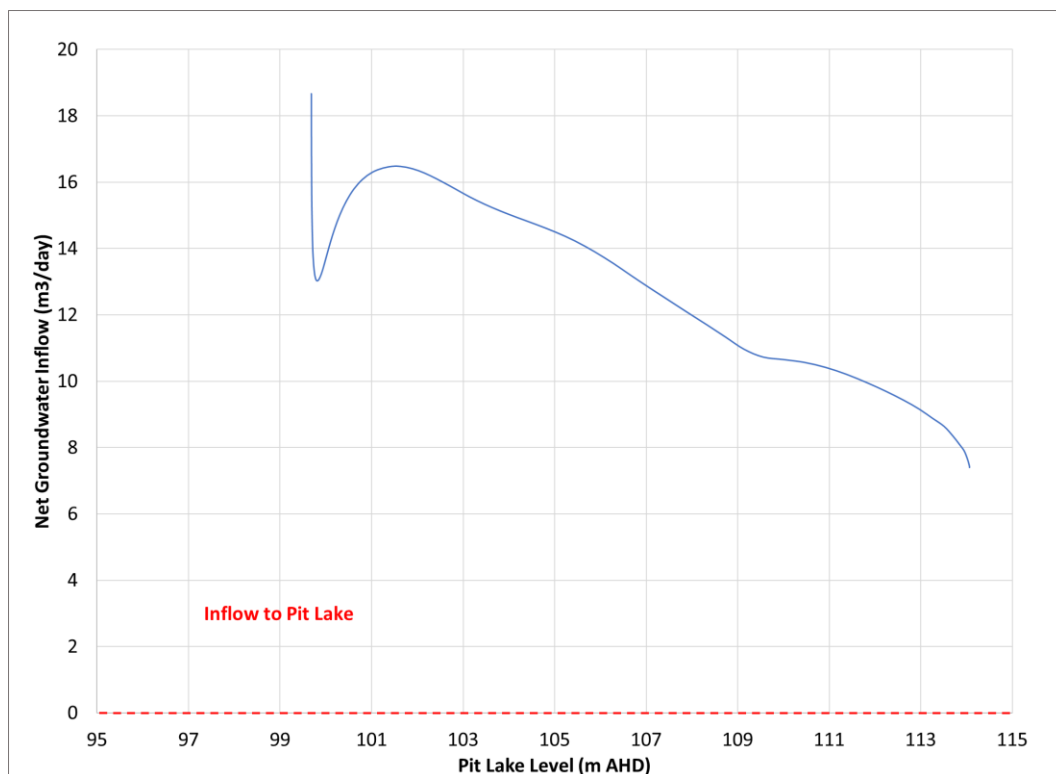
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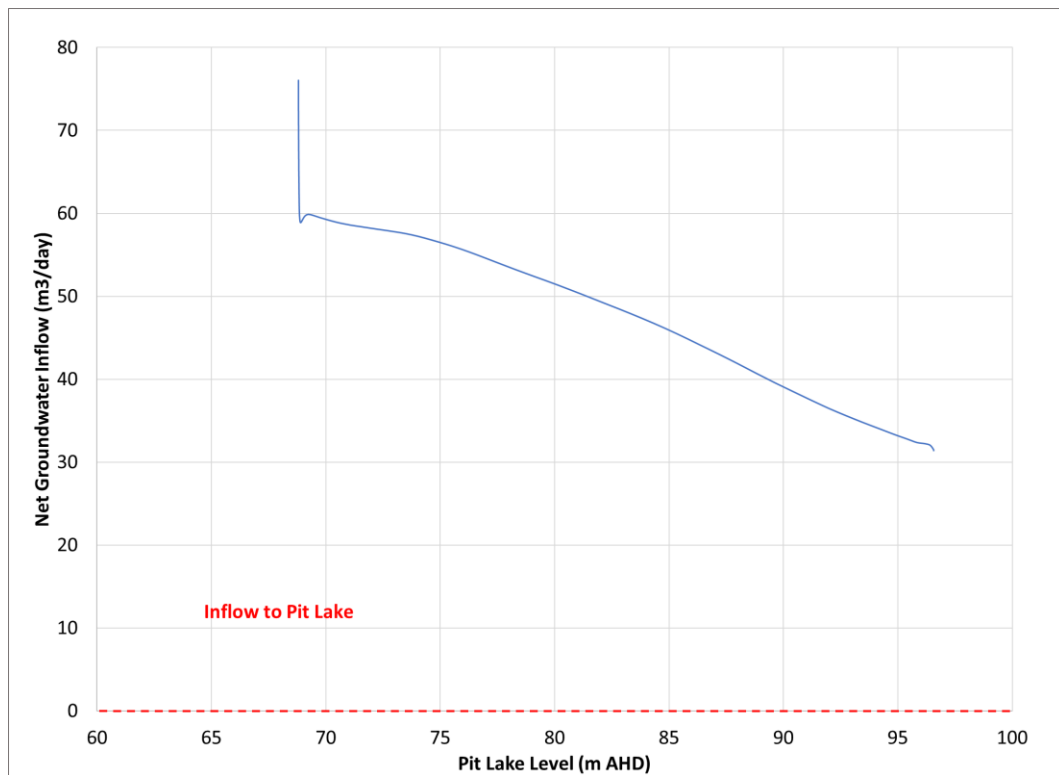
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Drake Pit 4 South



Drake Pit 5

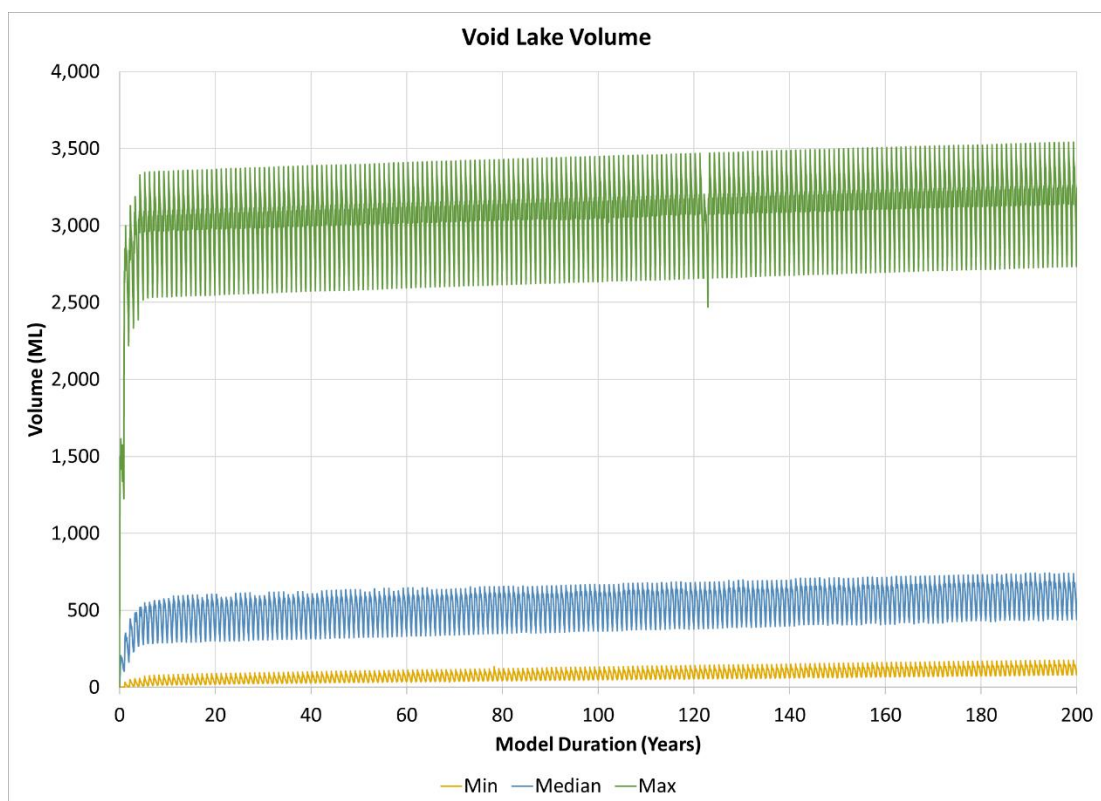
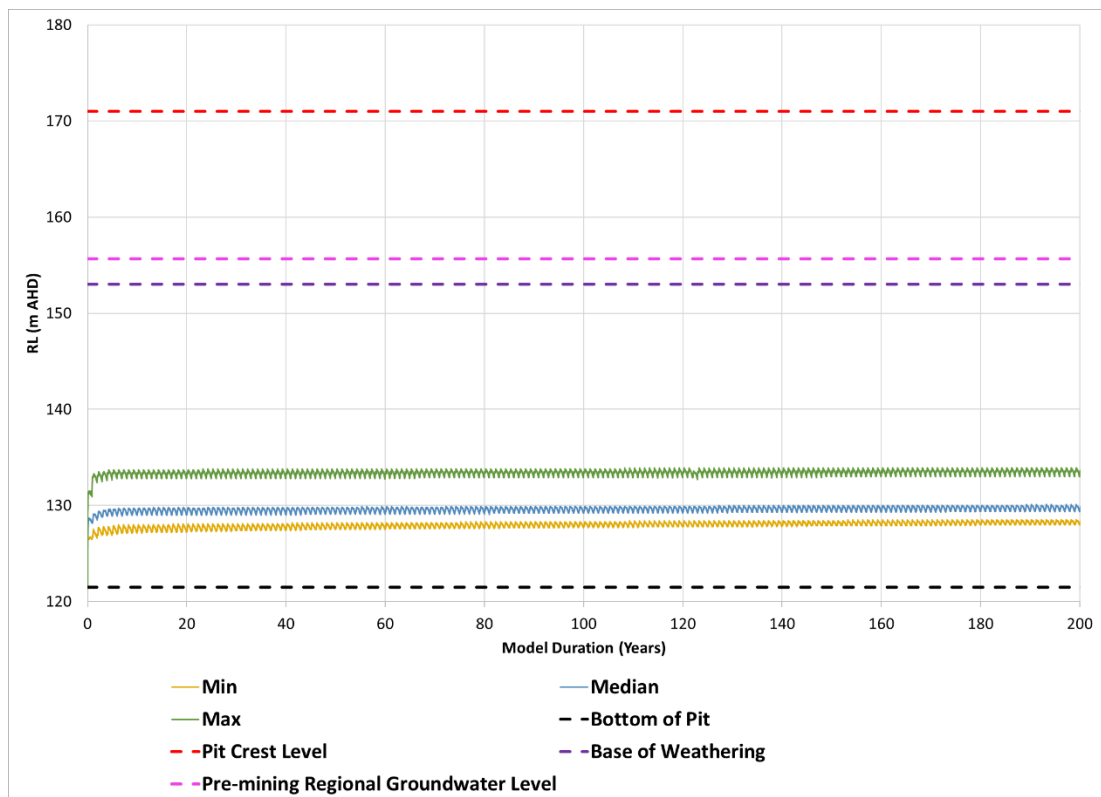


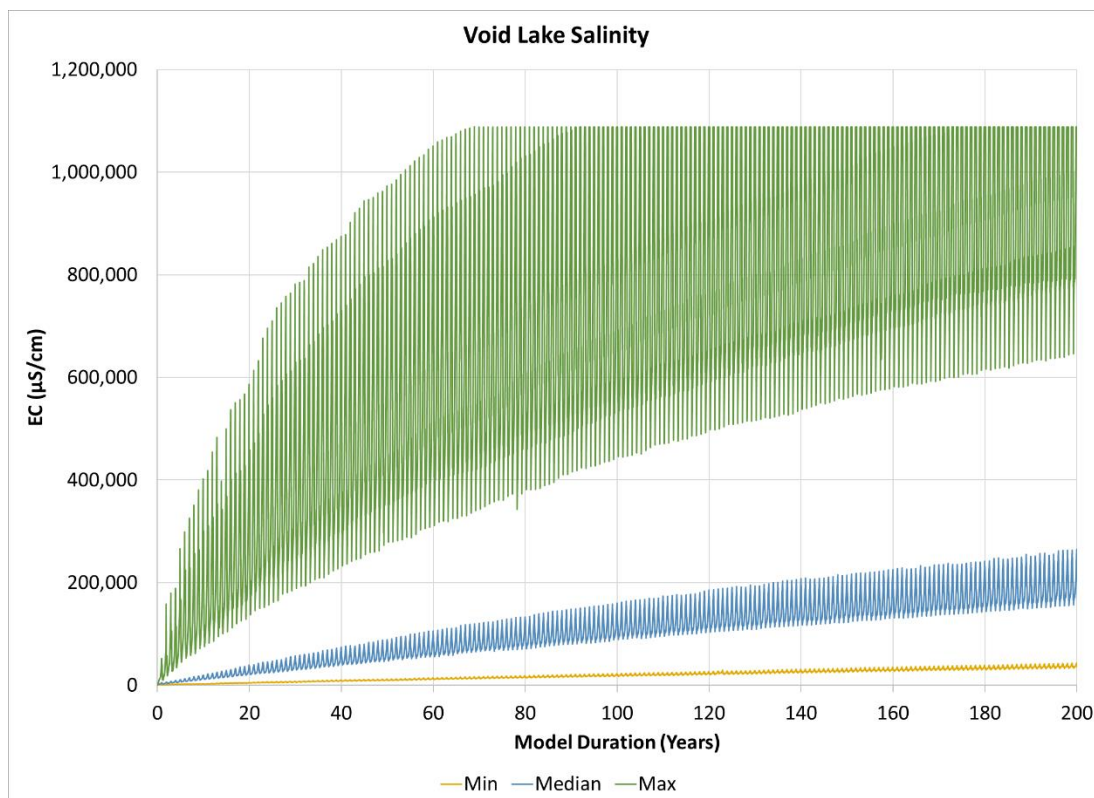
Appendix C

Void Hydrology Model Results

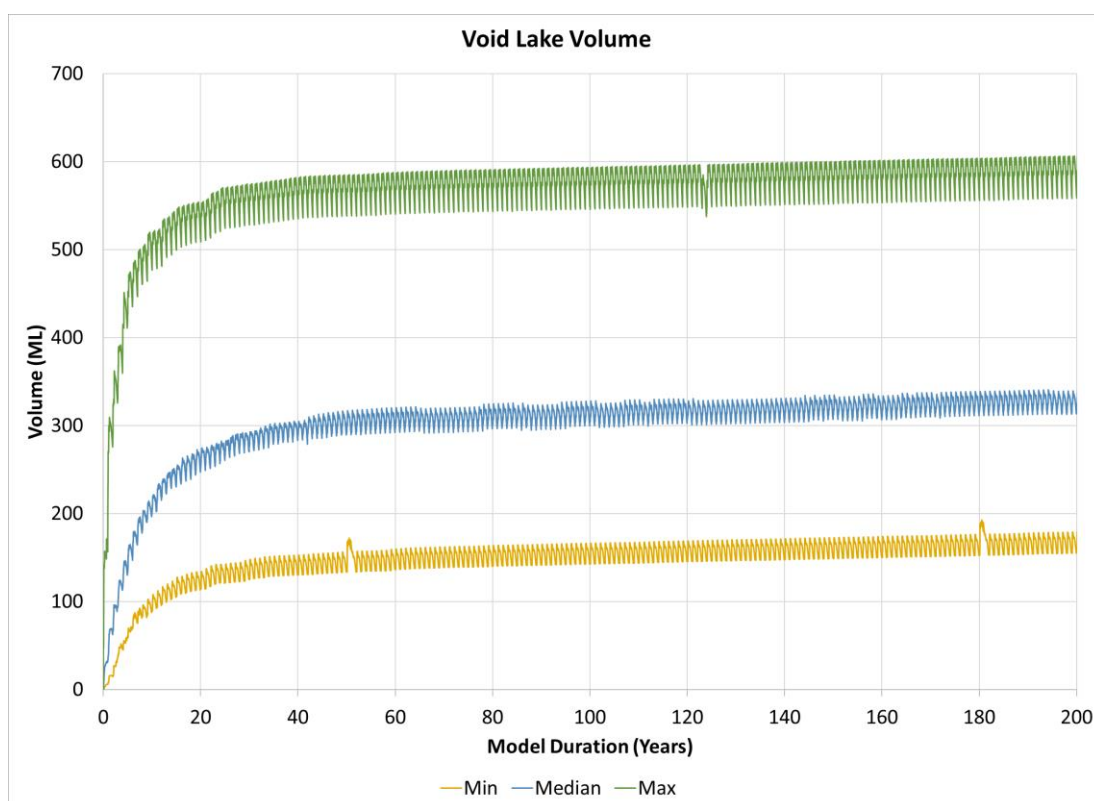
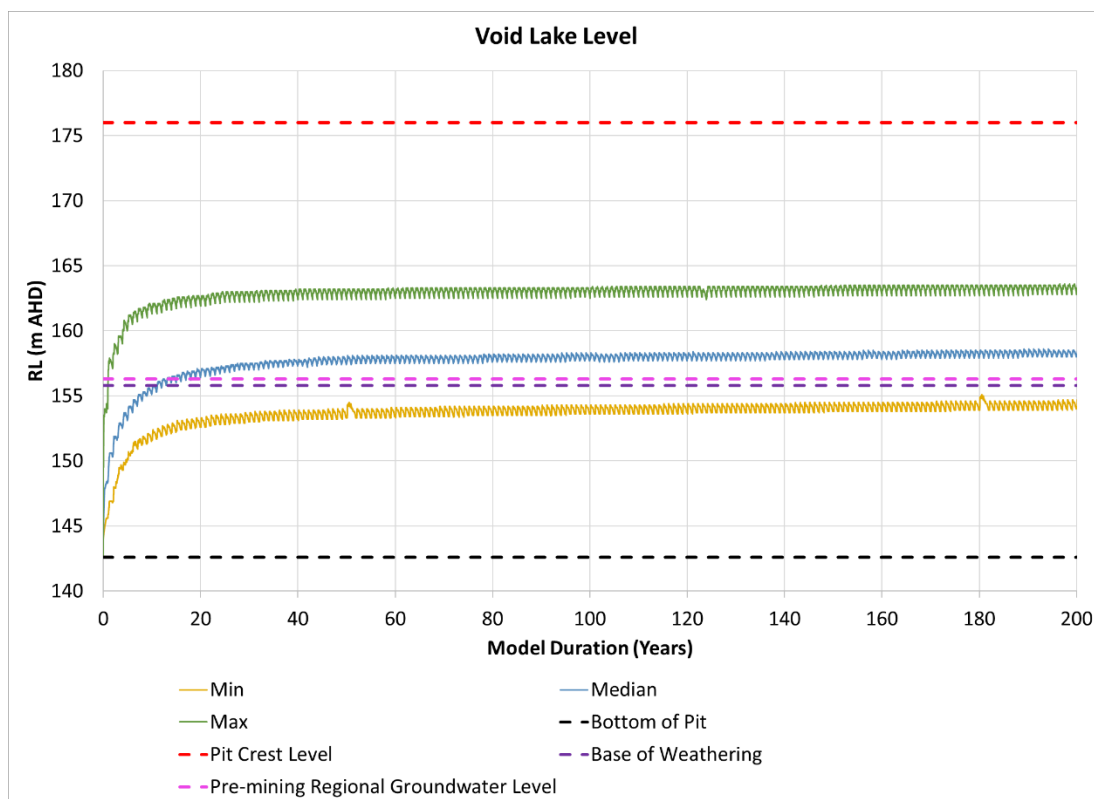
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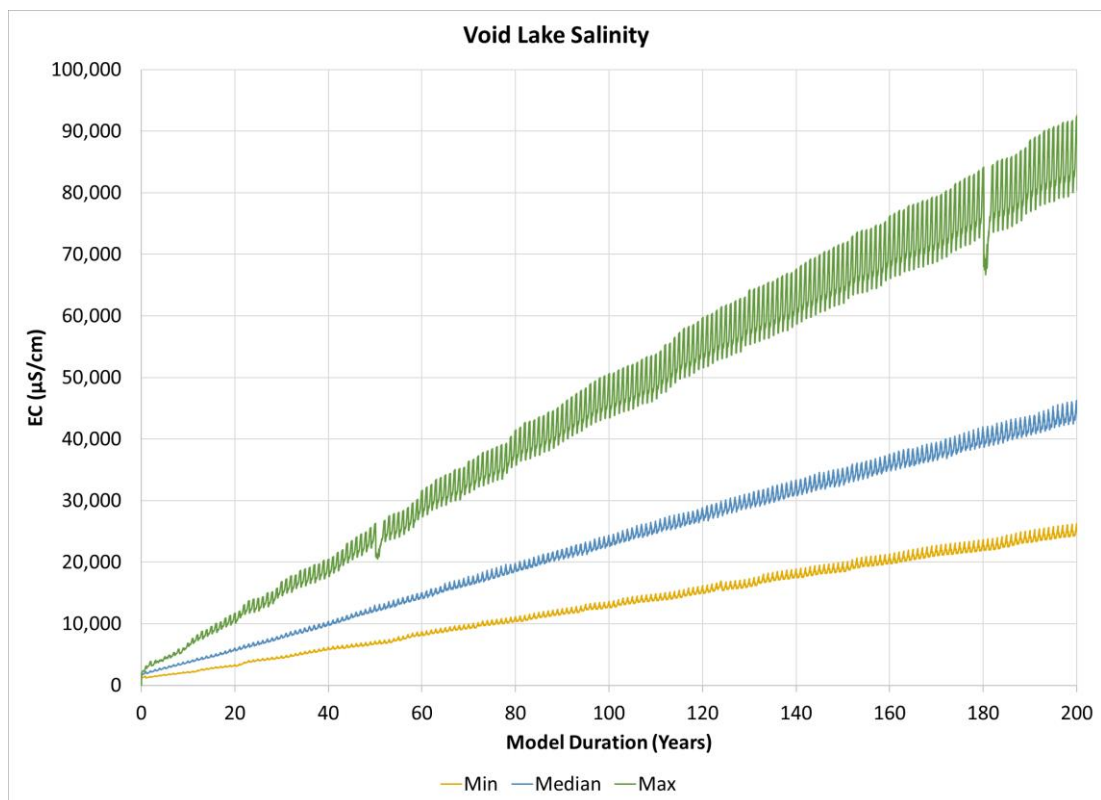
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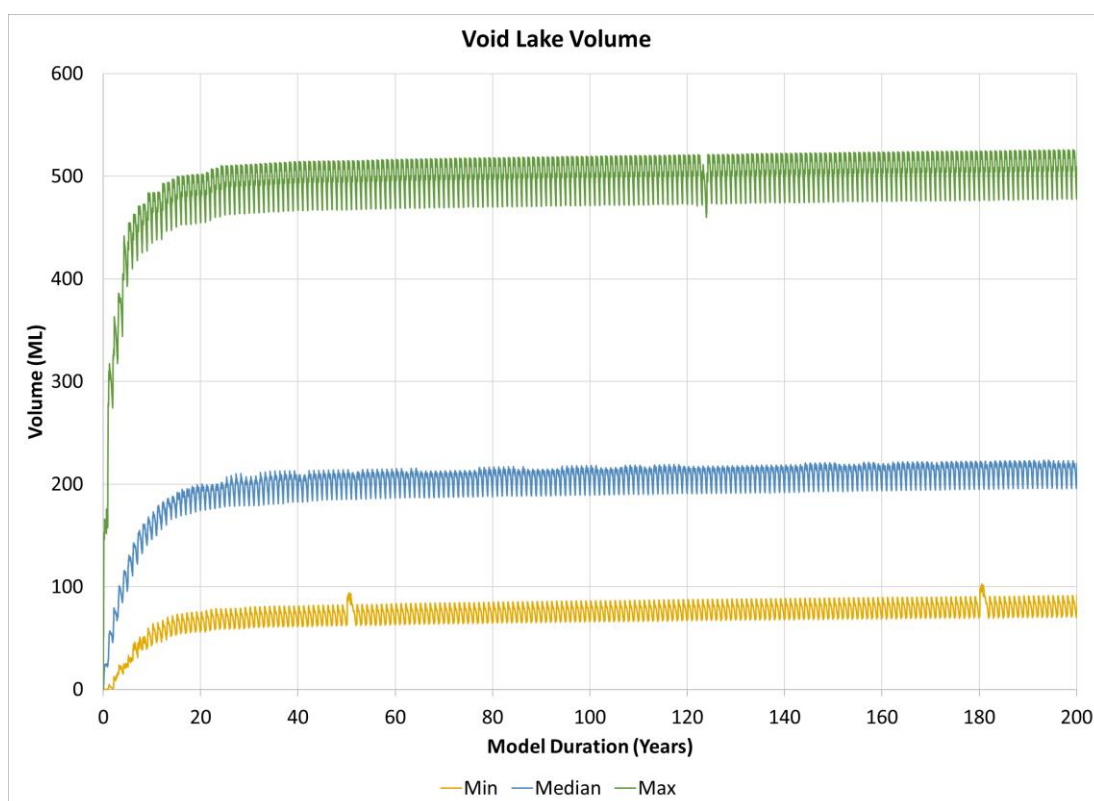
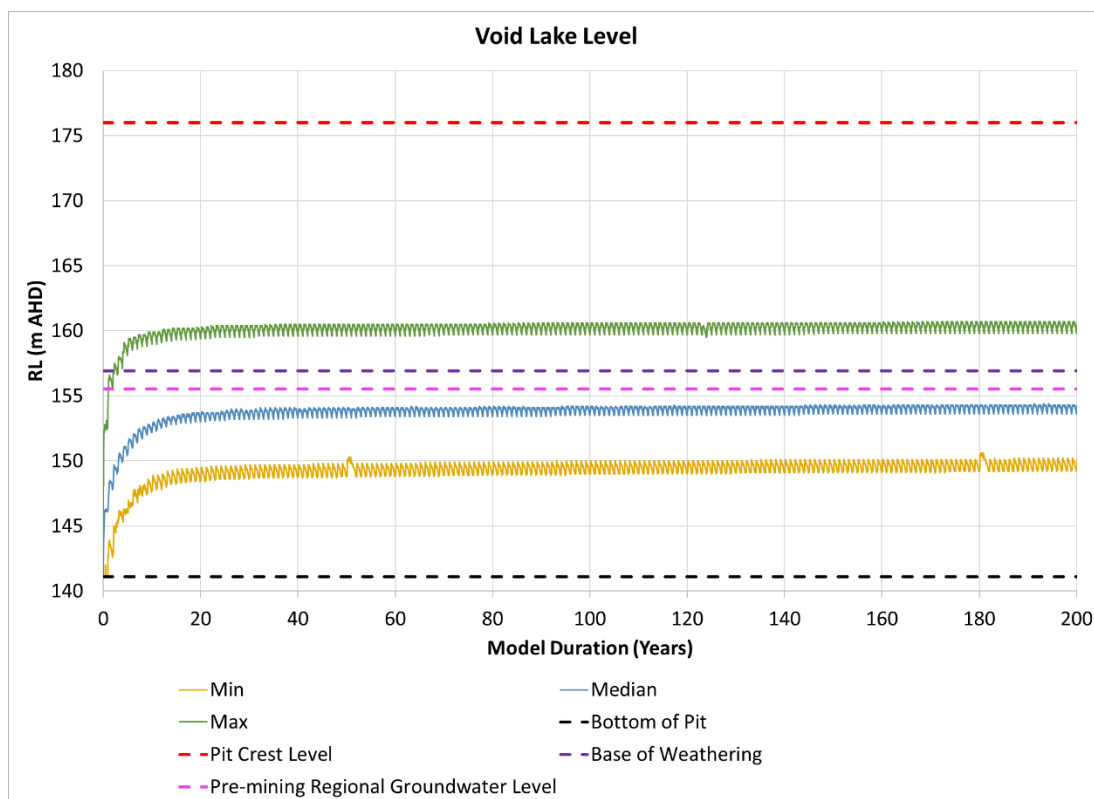


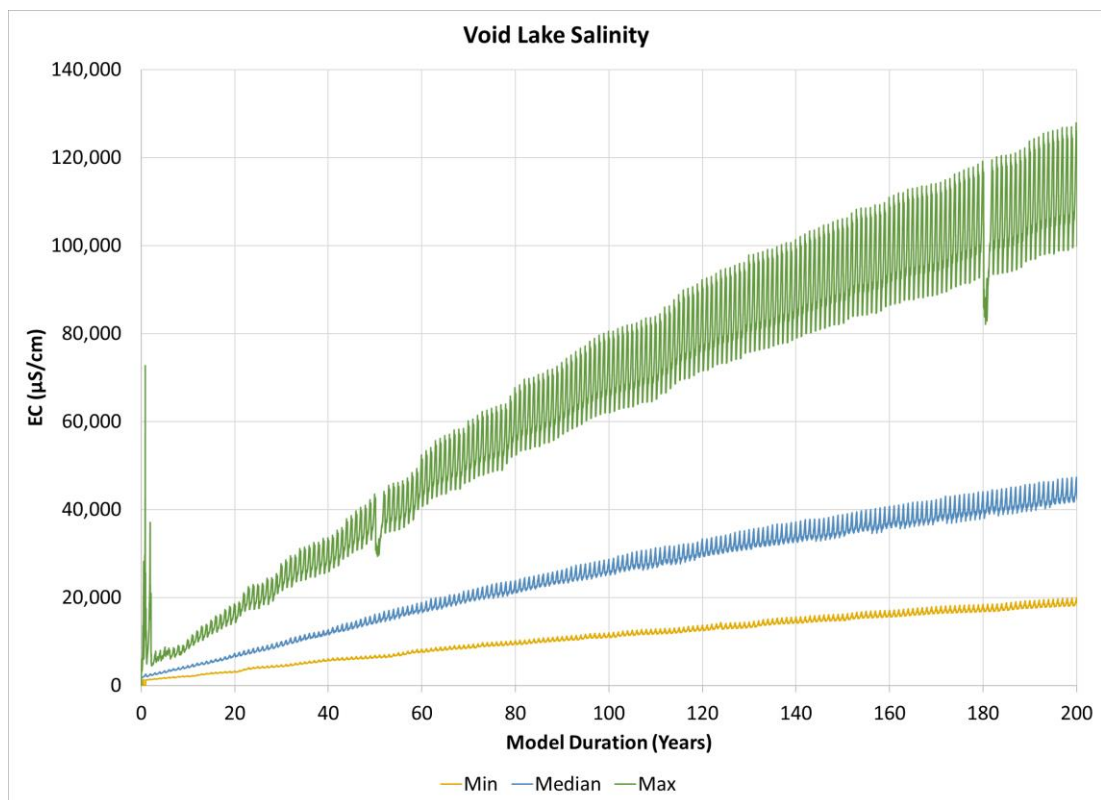
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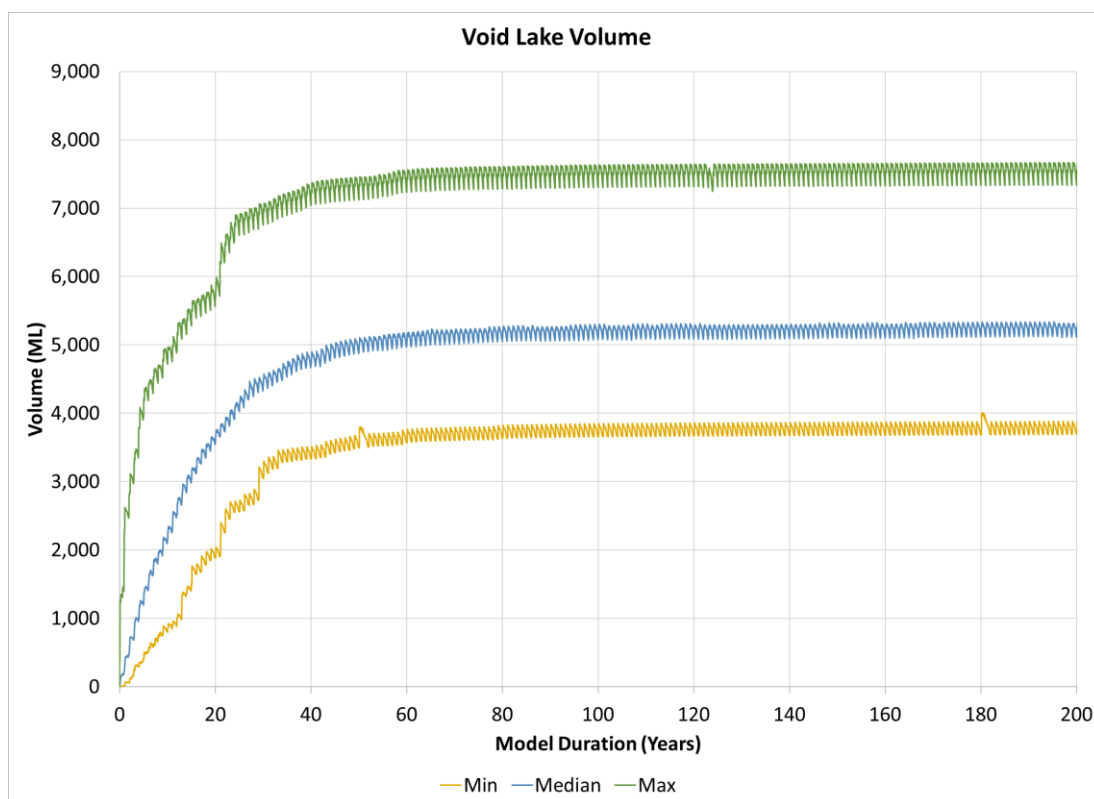
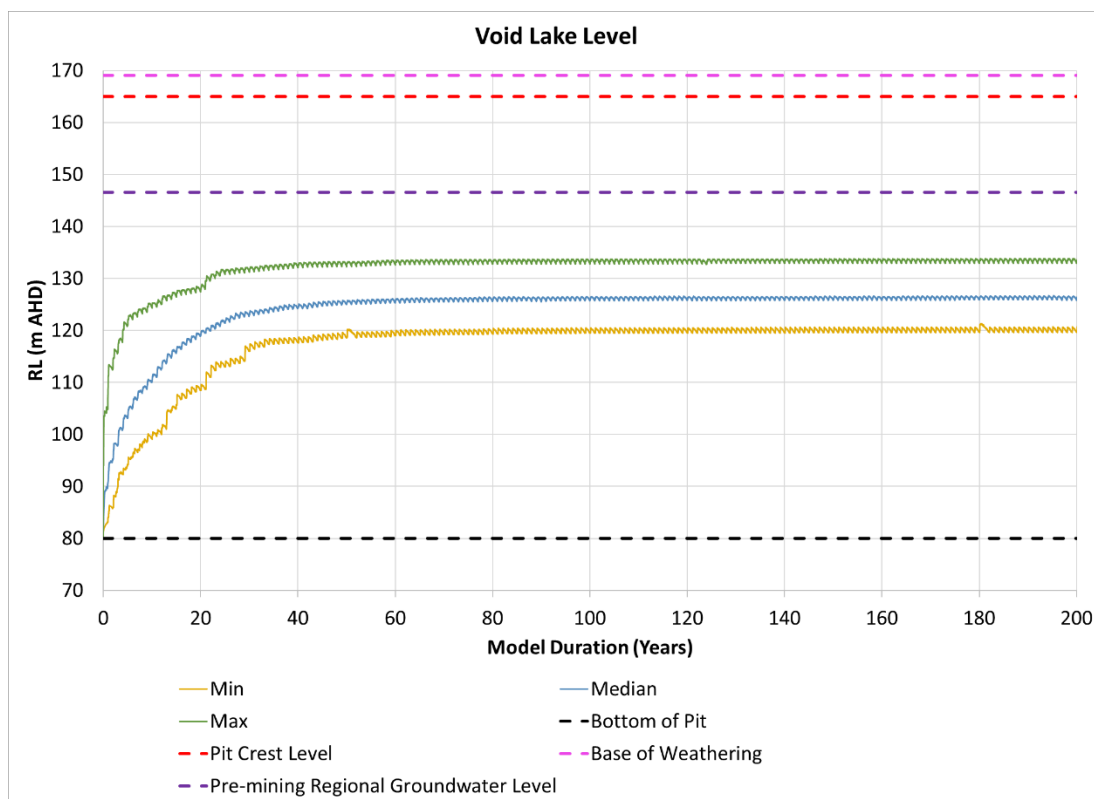


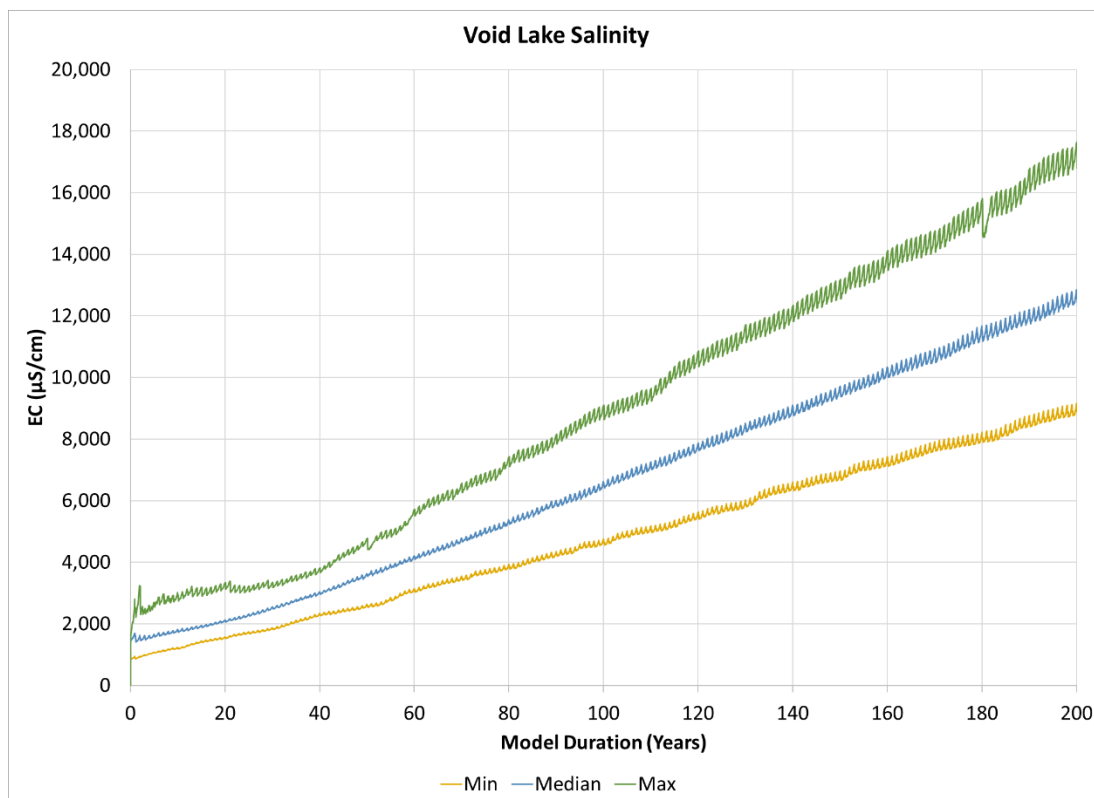
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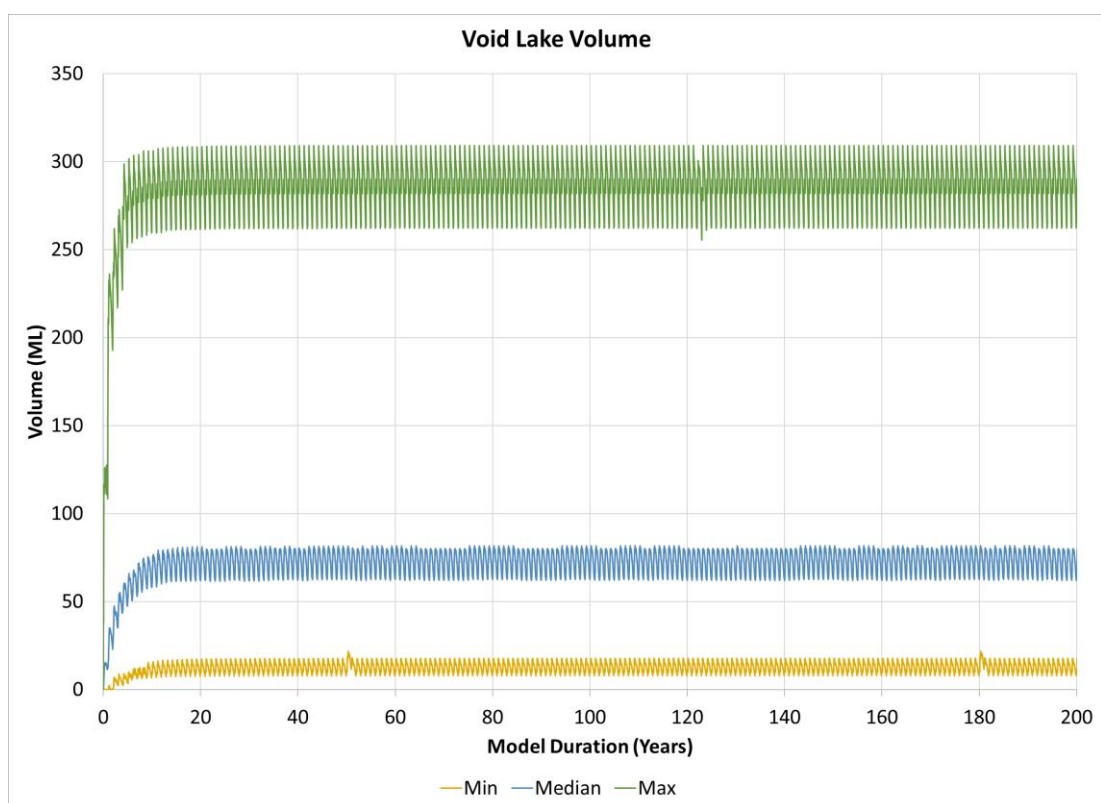
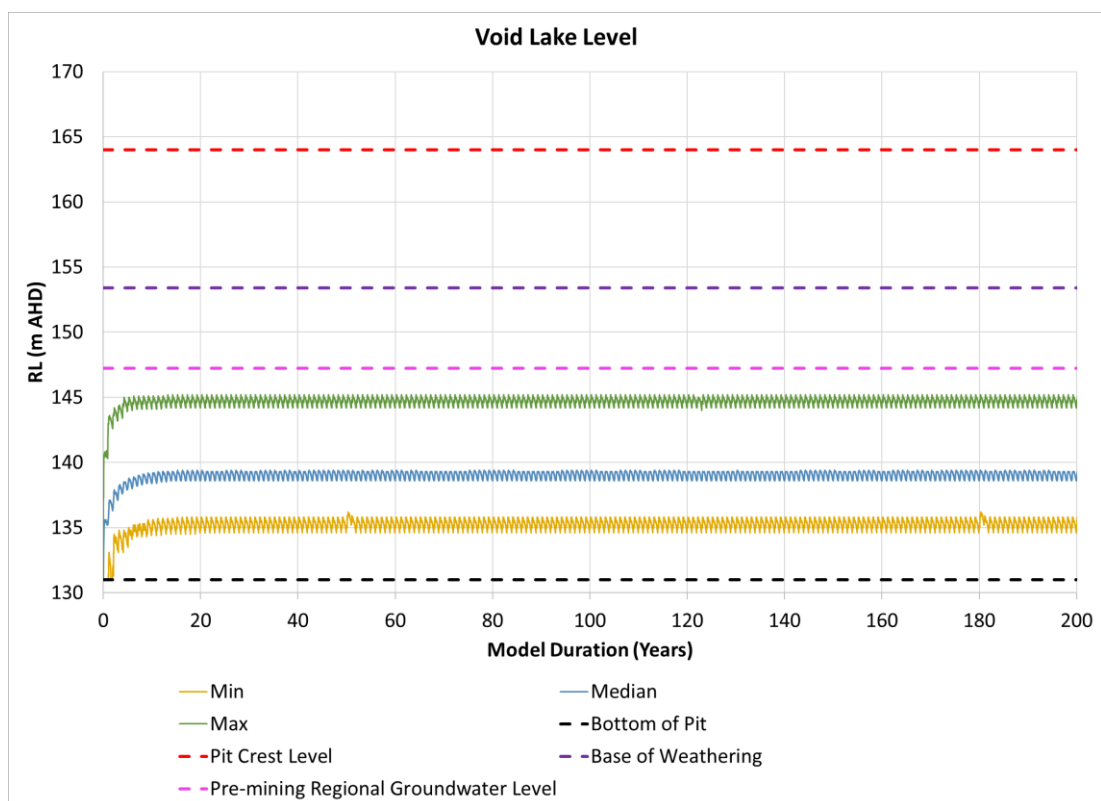


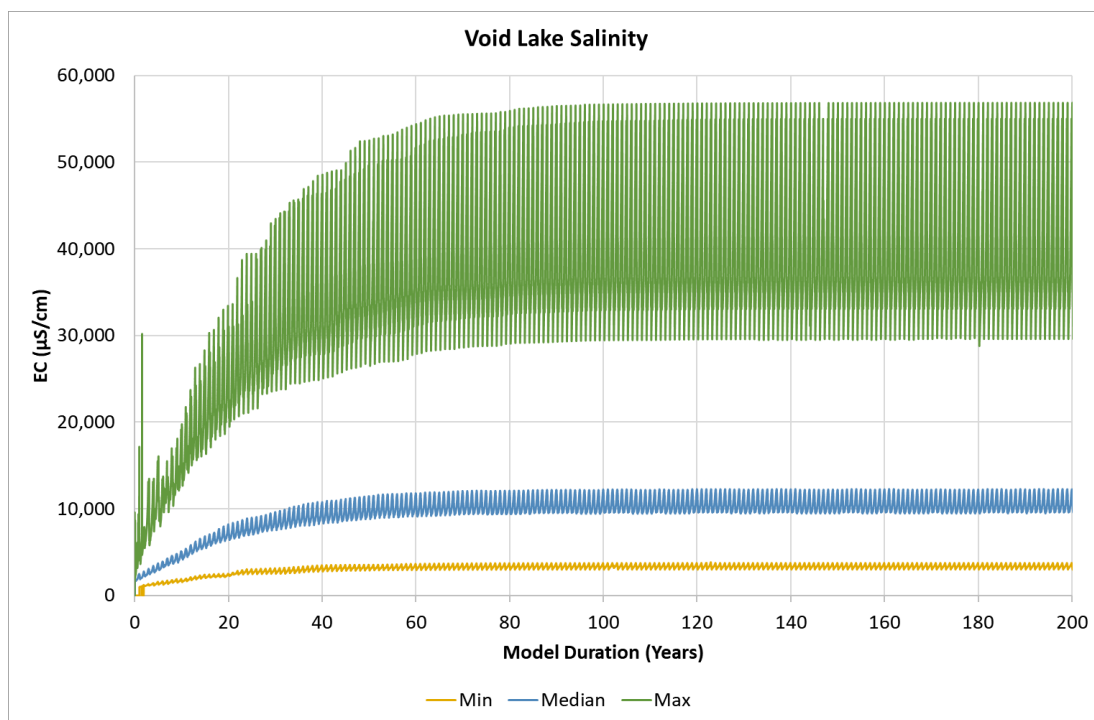
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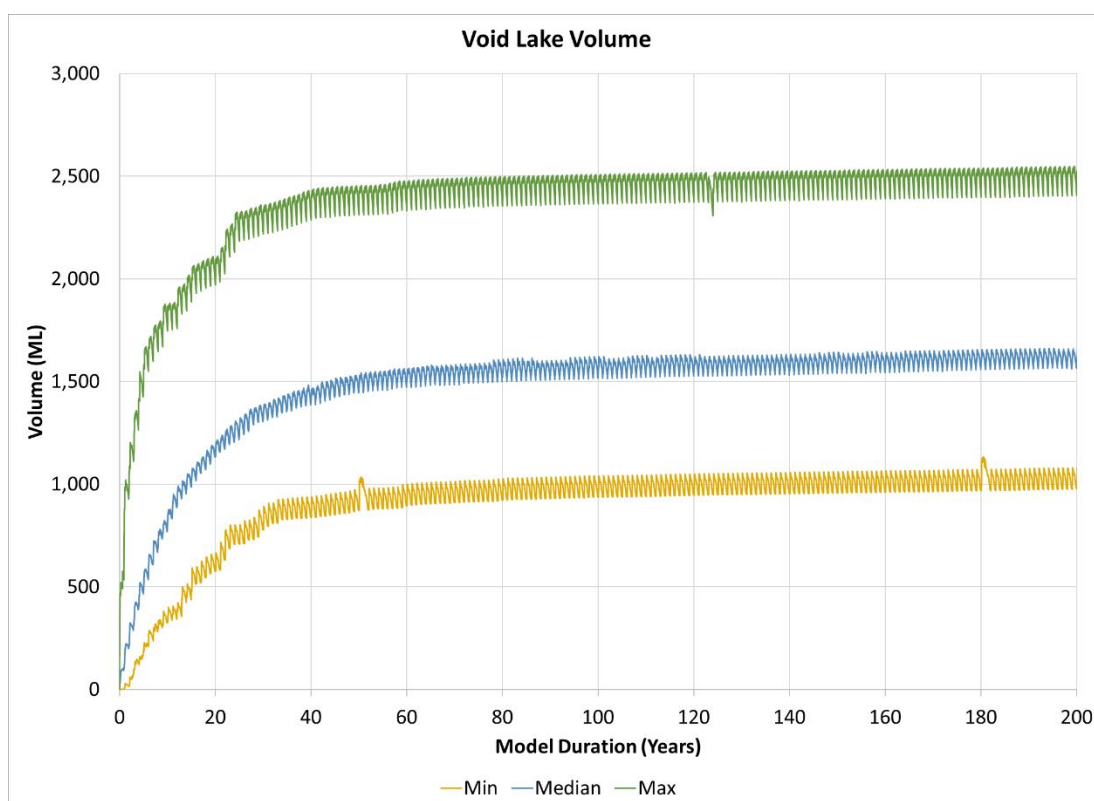
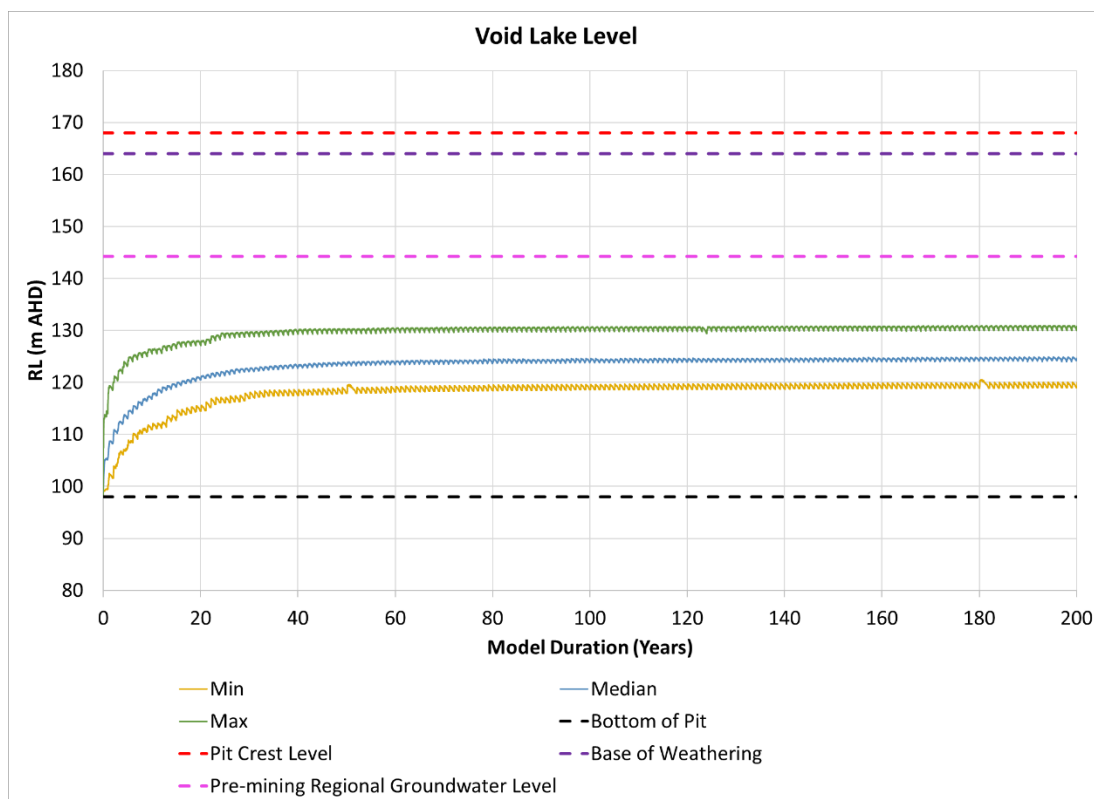


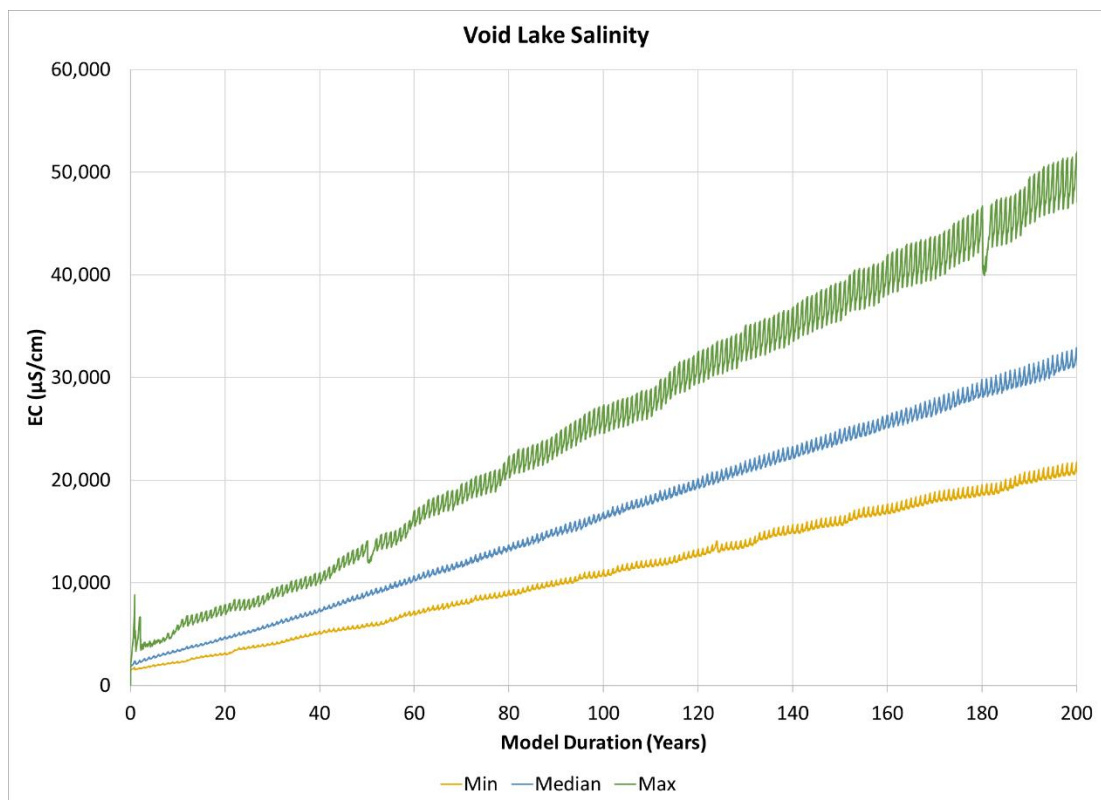
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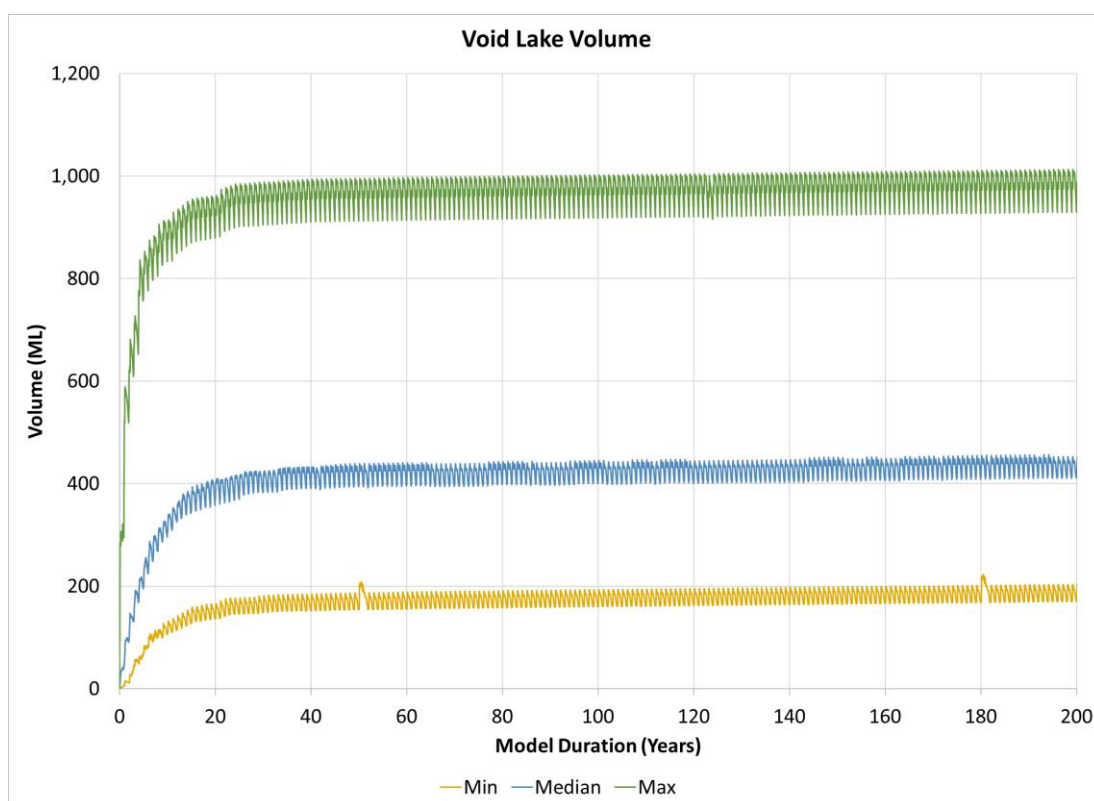
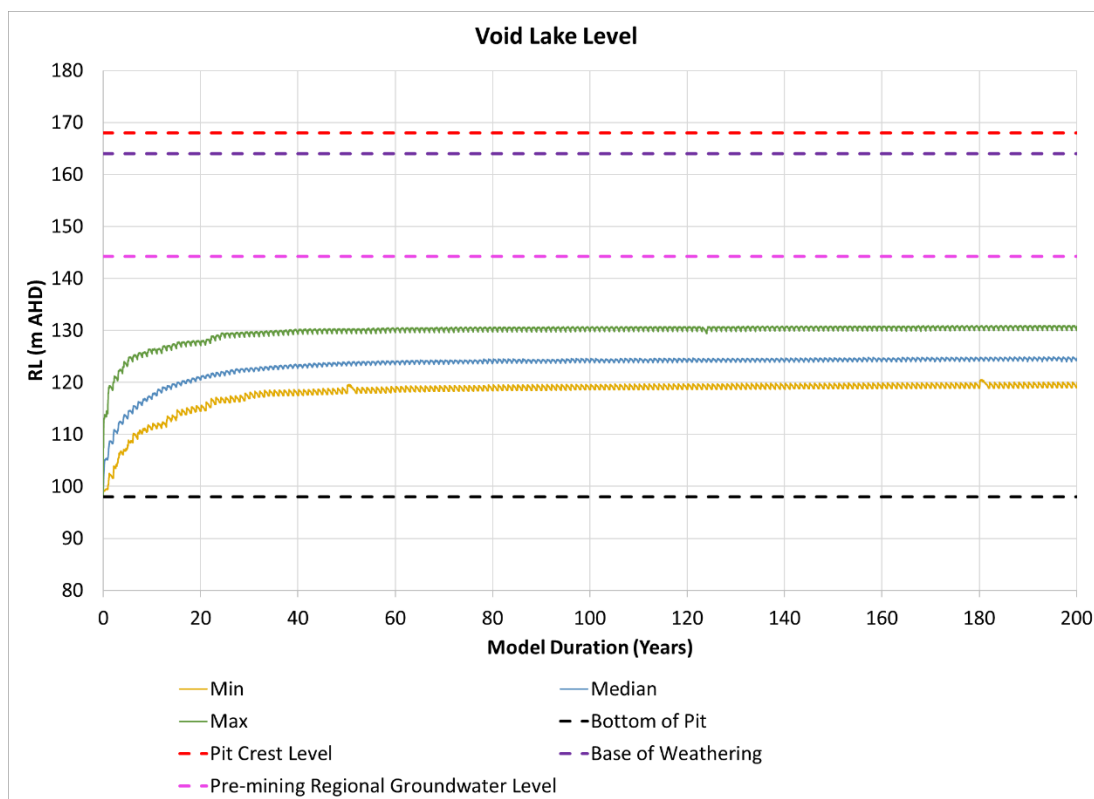


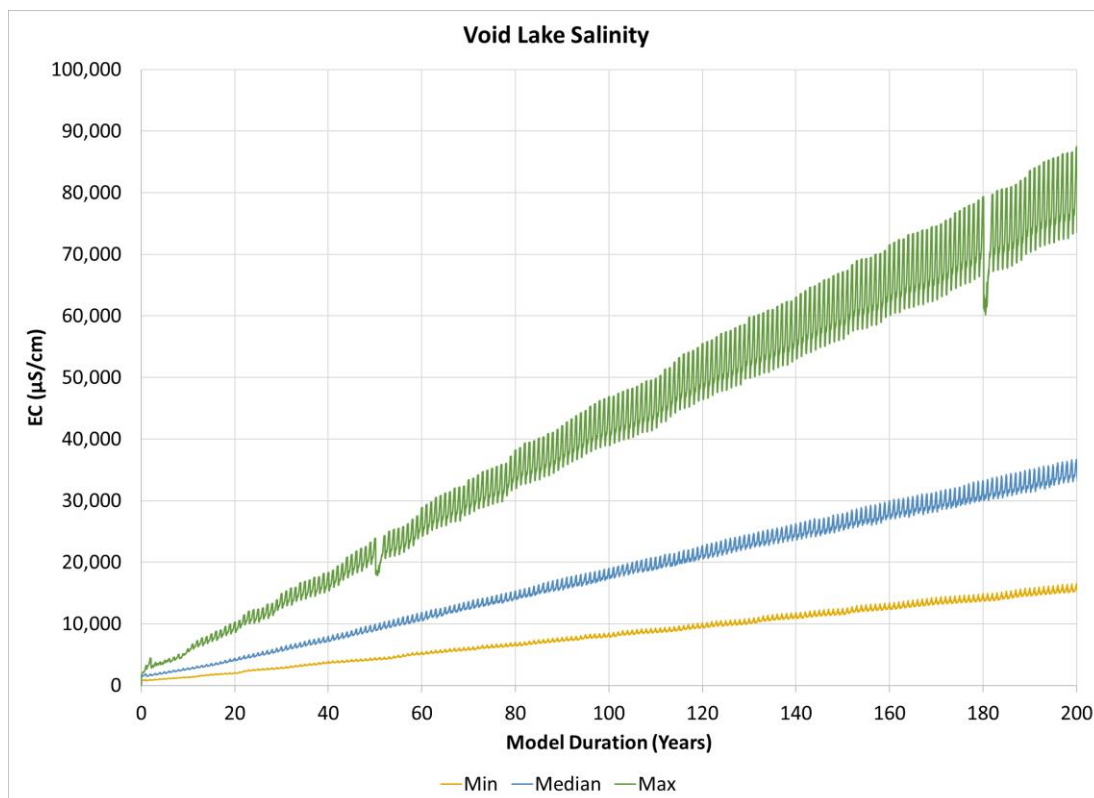
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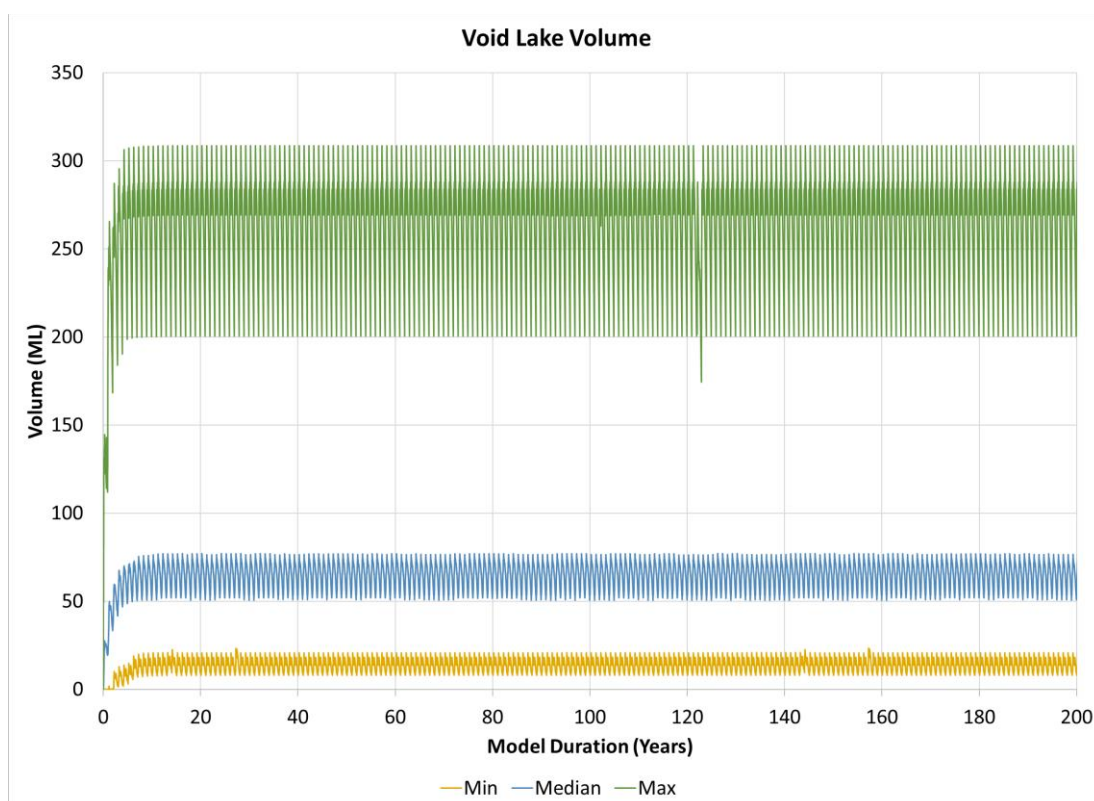
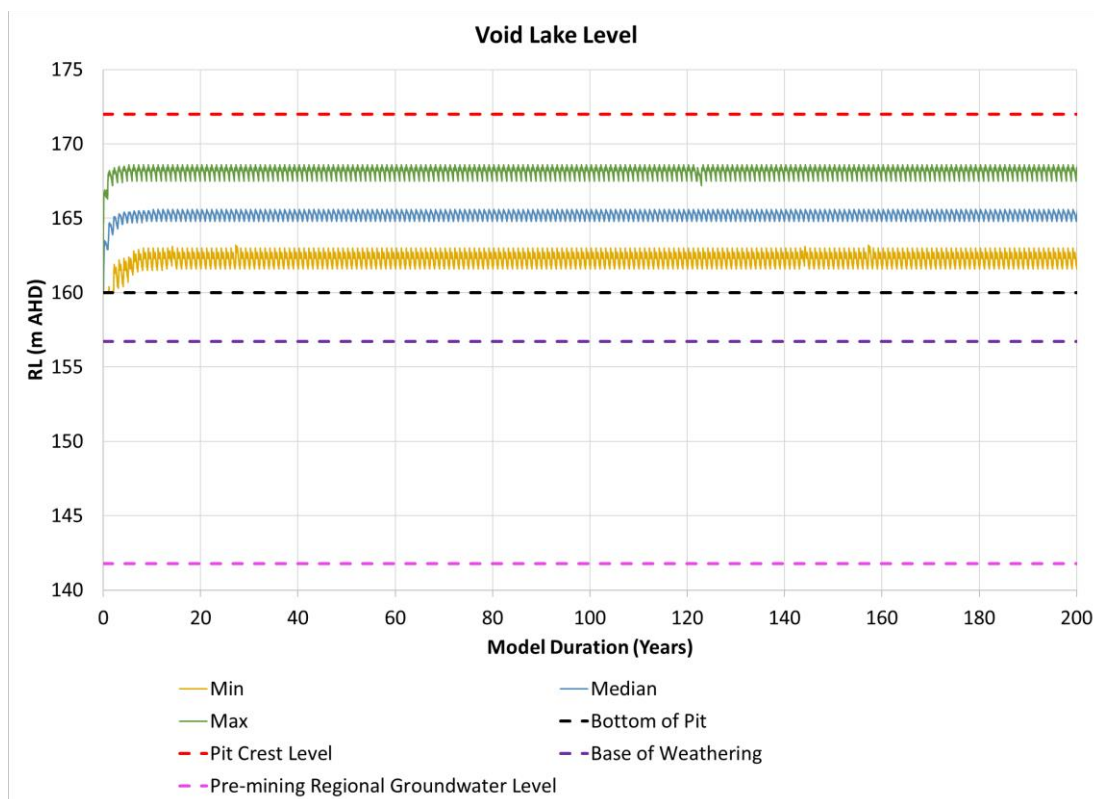


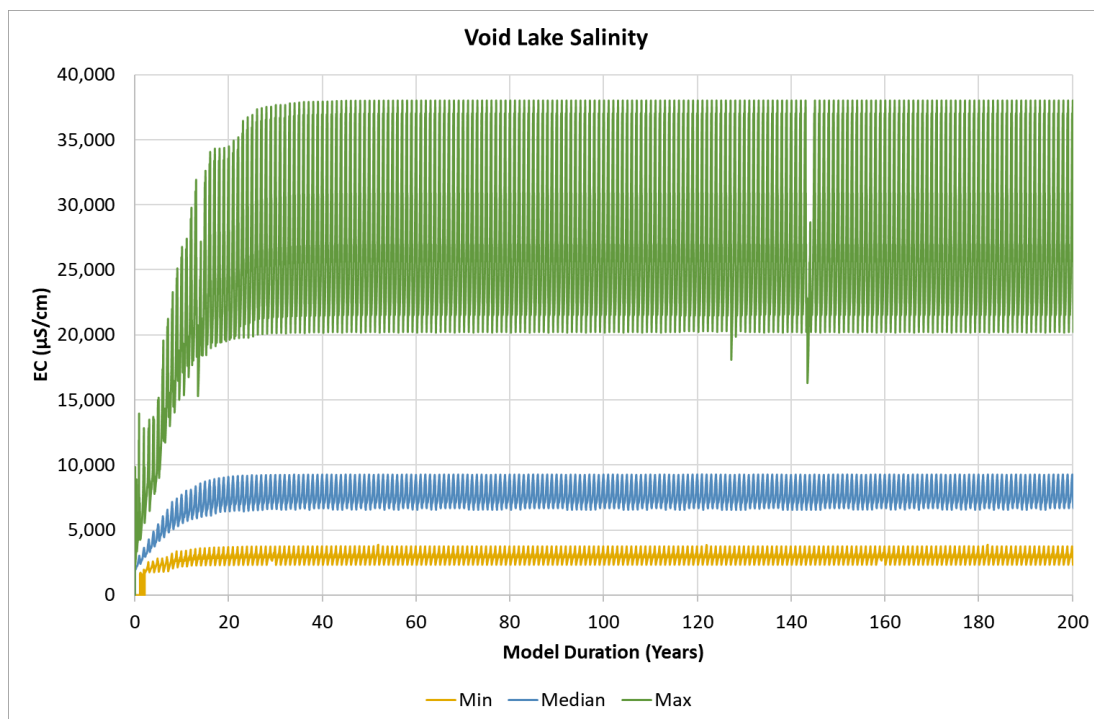
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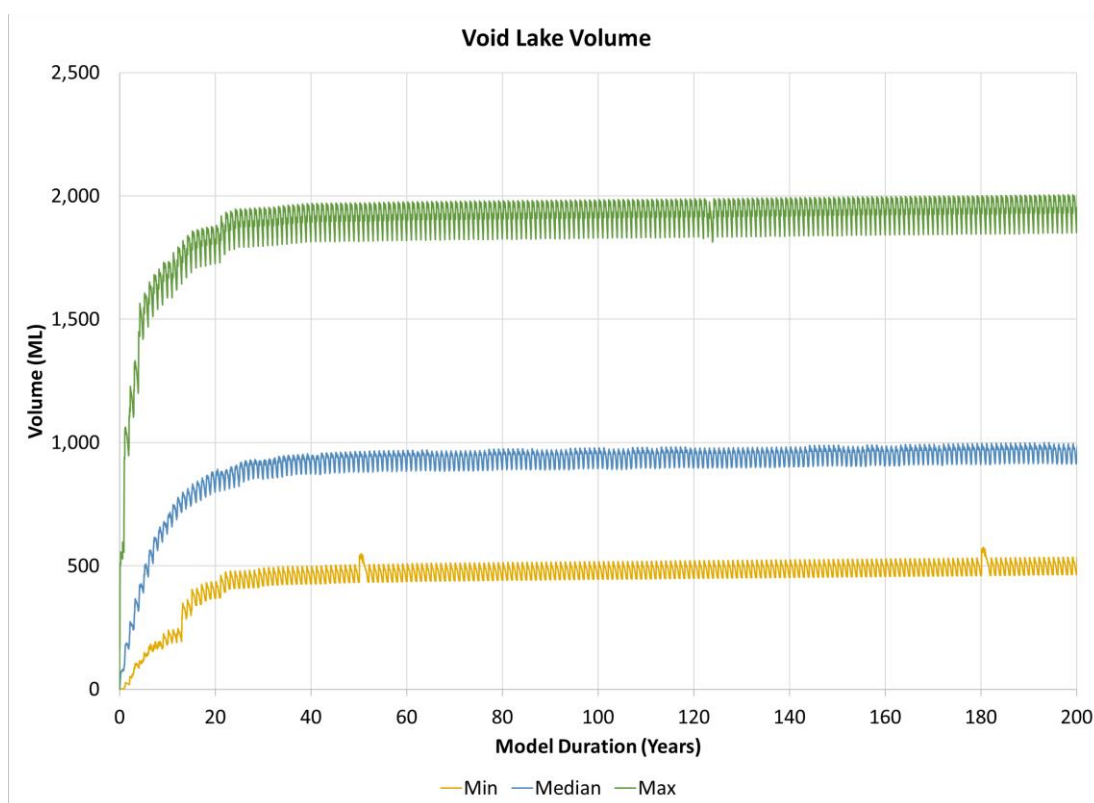
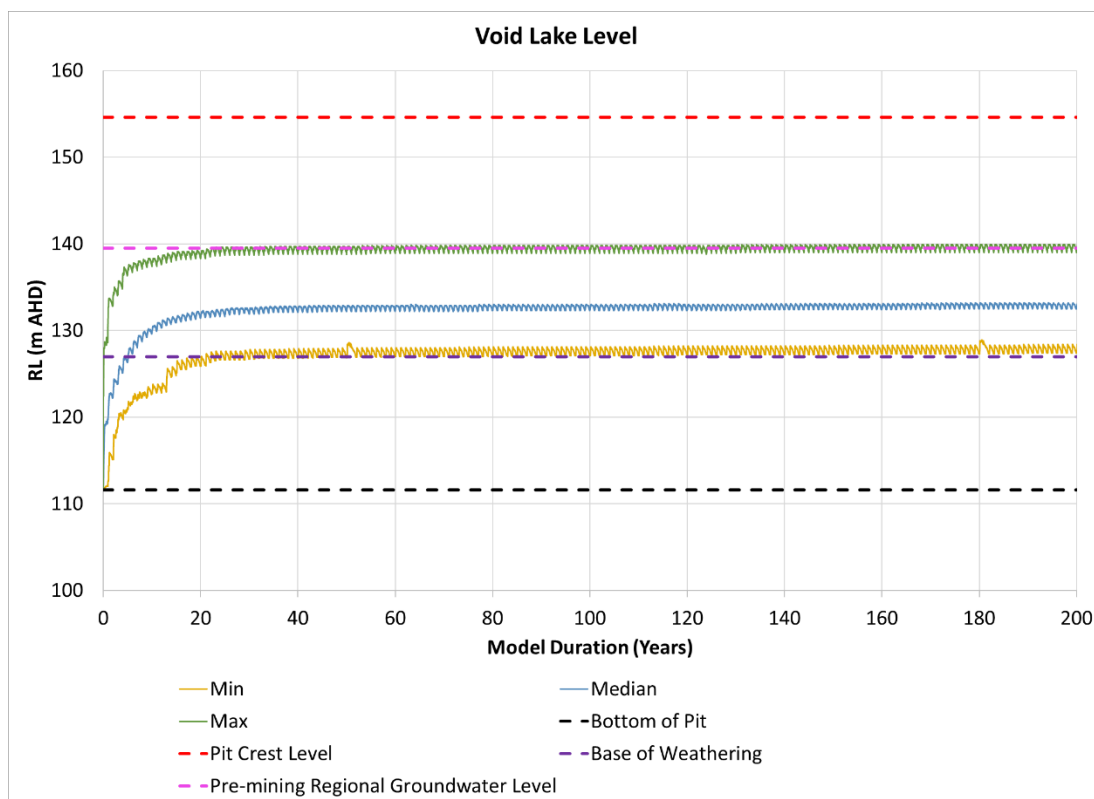


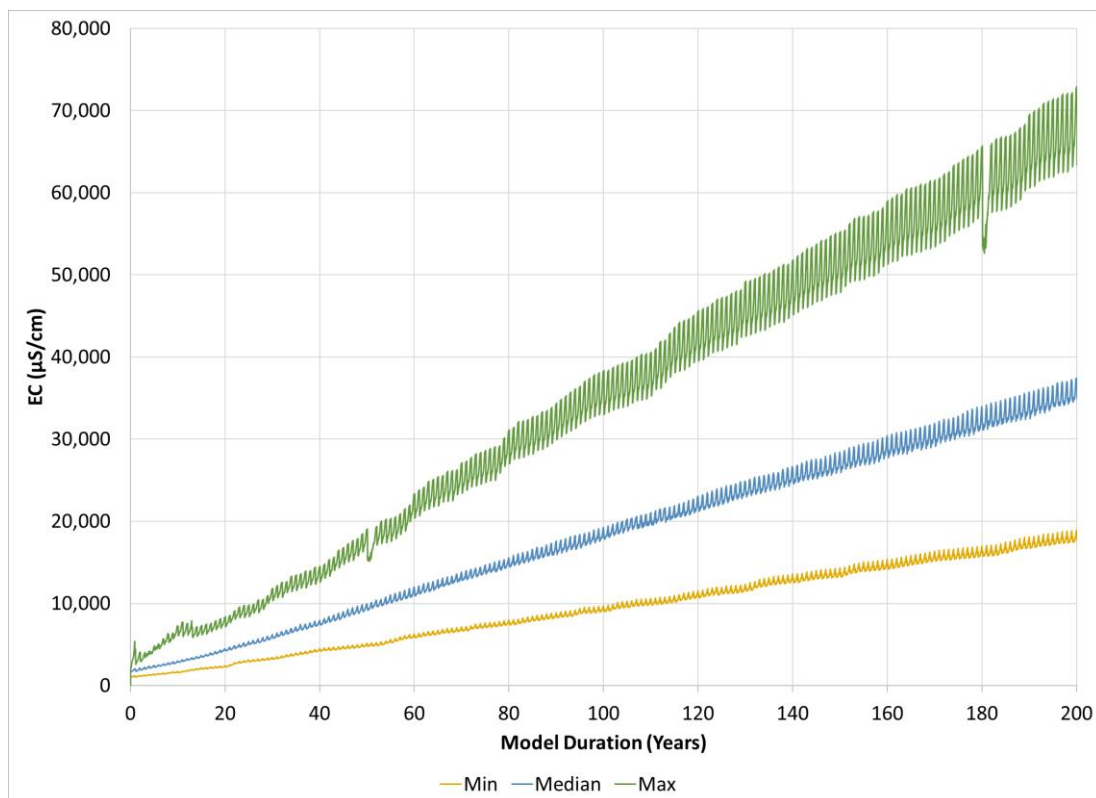
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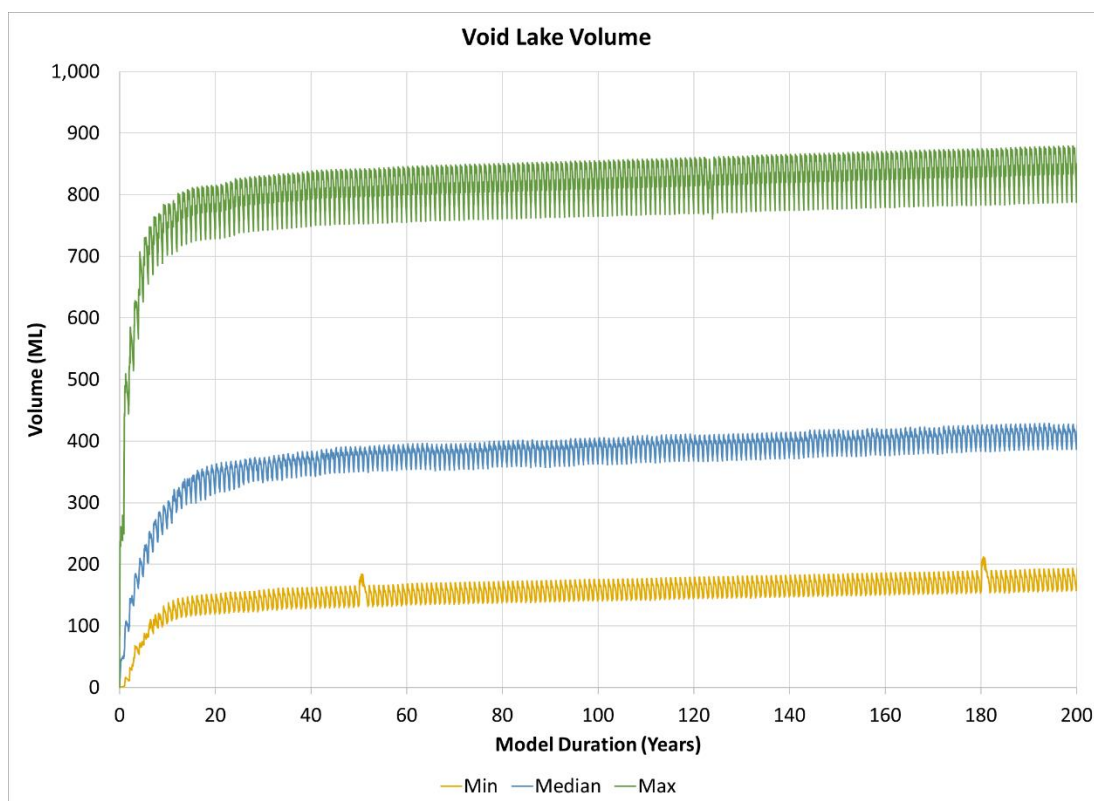
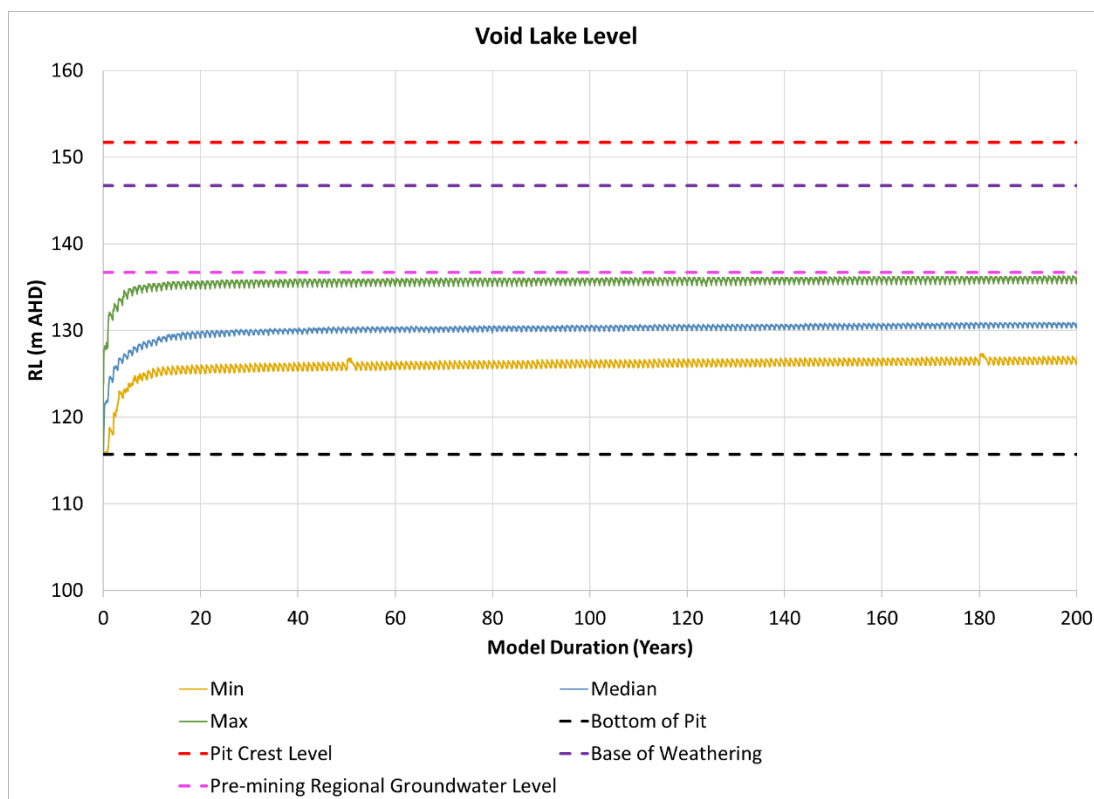


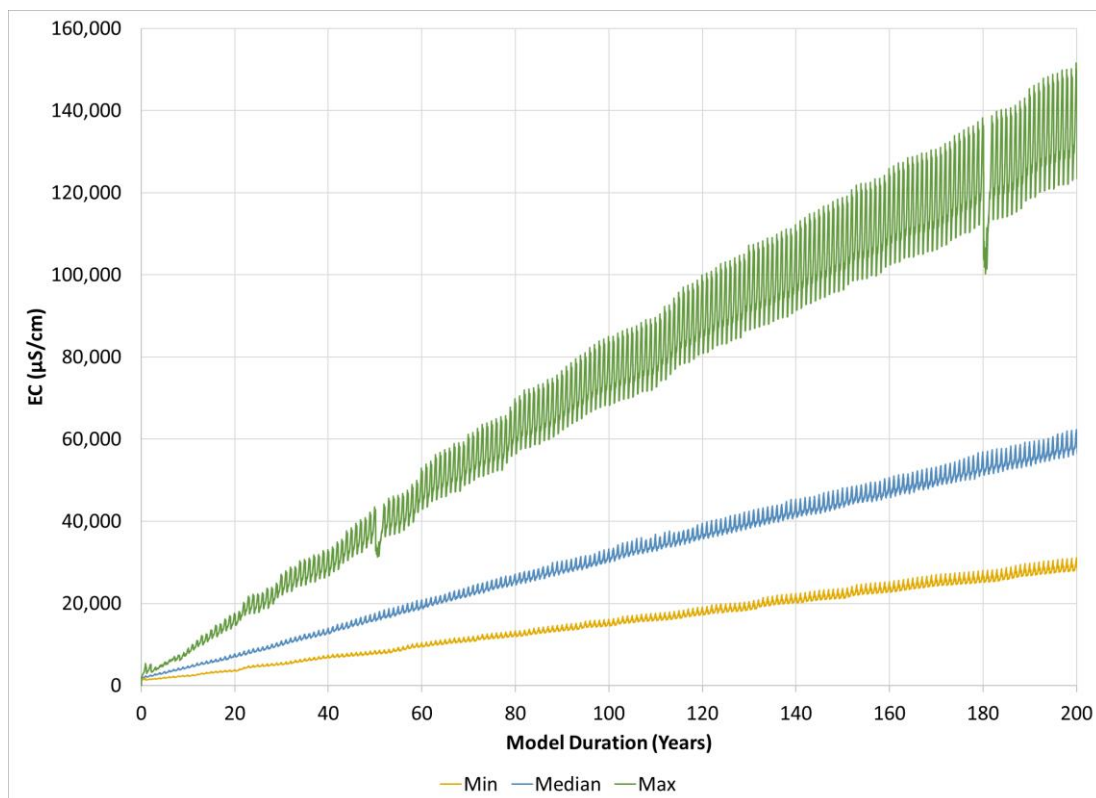
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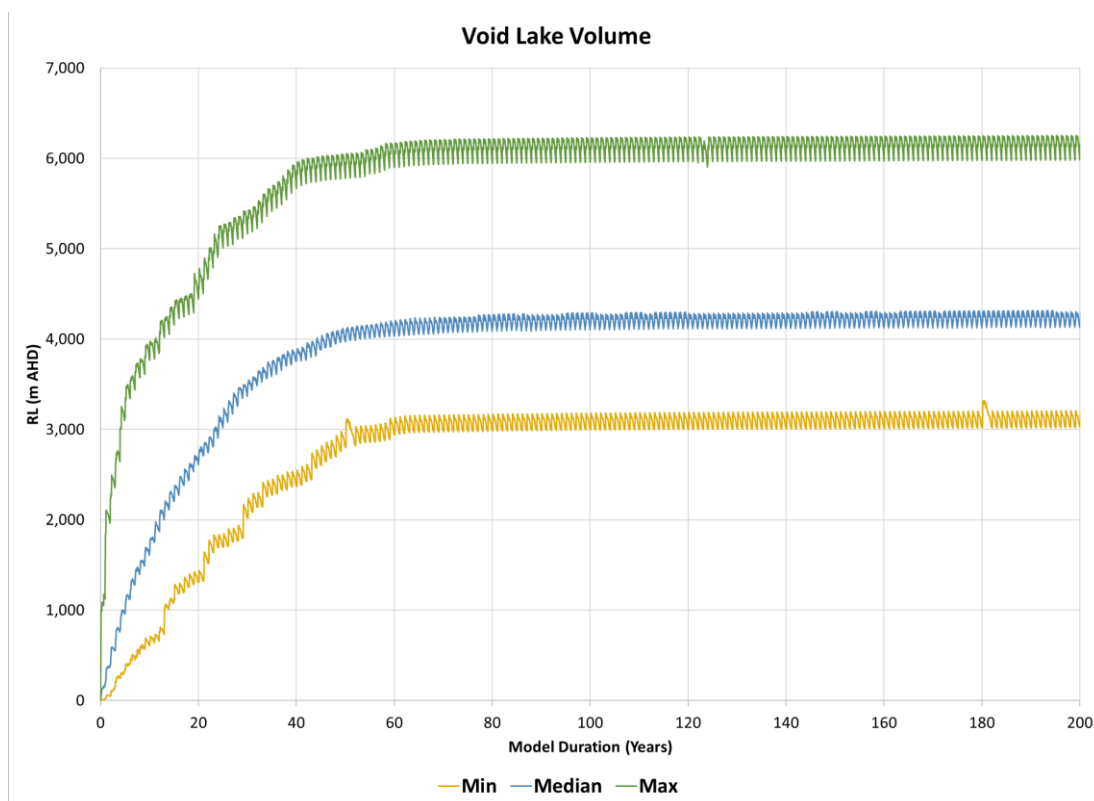
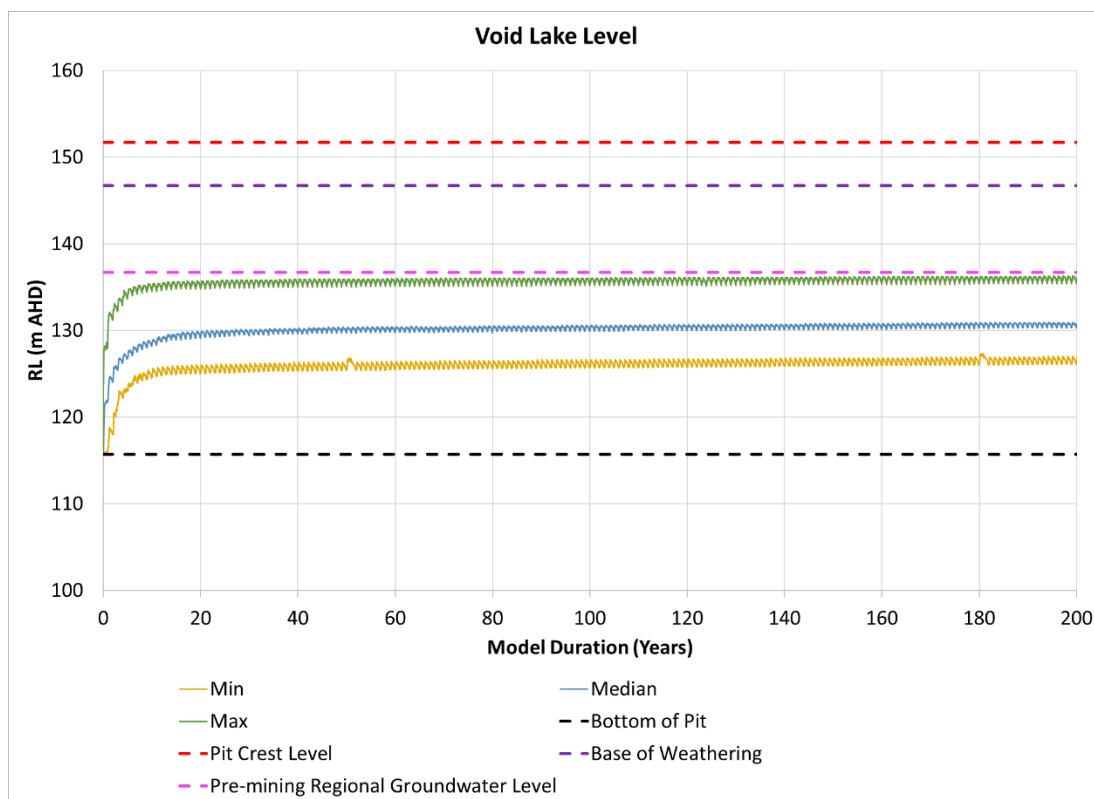


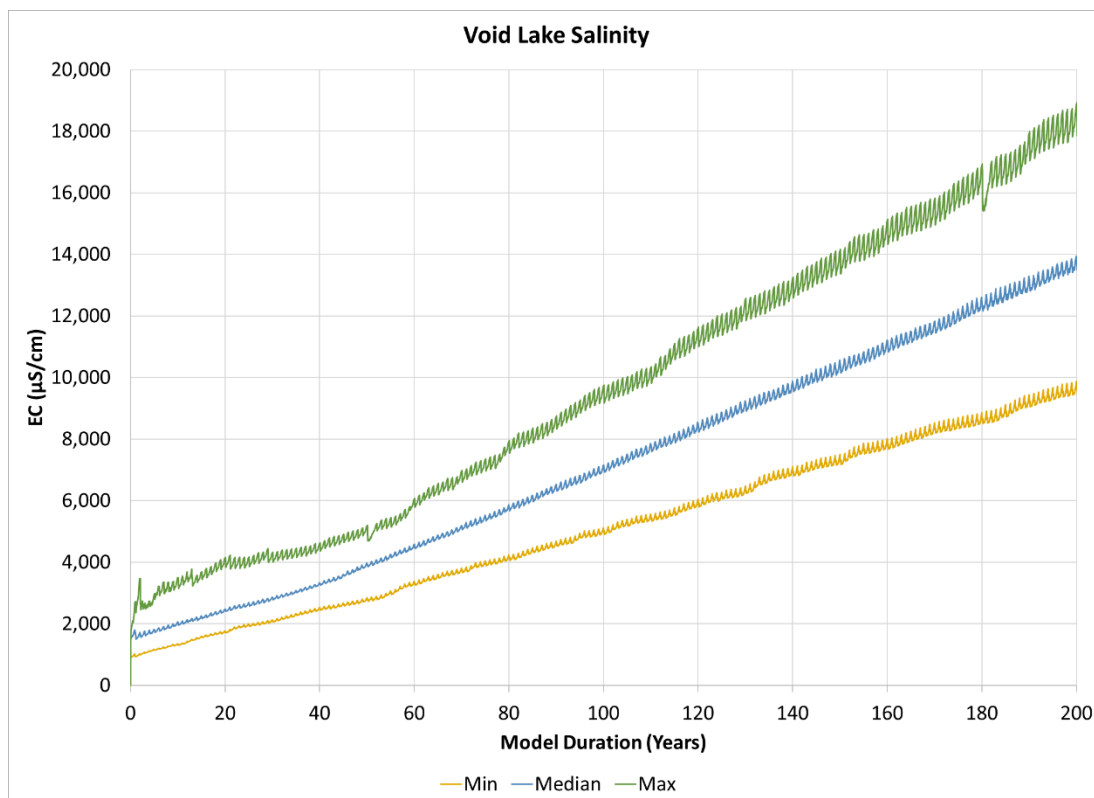
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Drake Pit 5



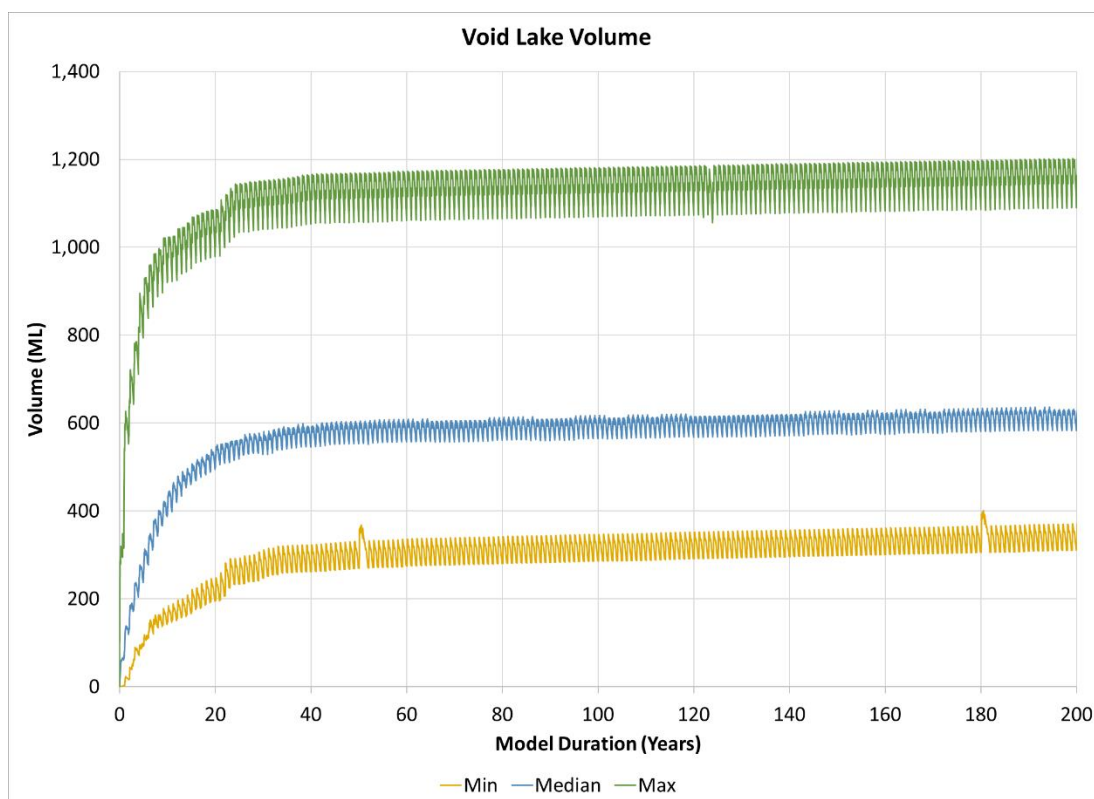
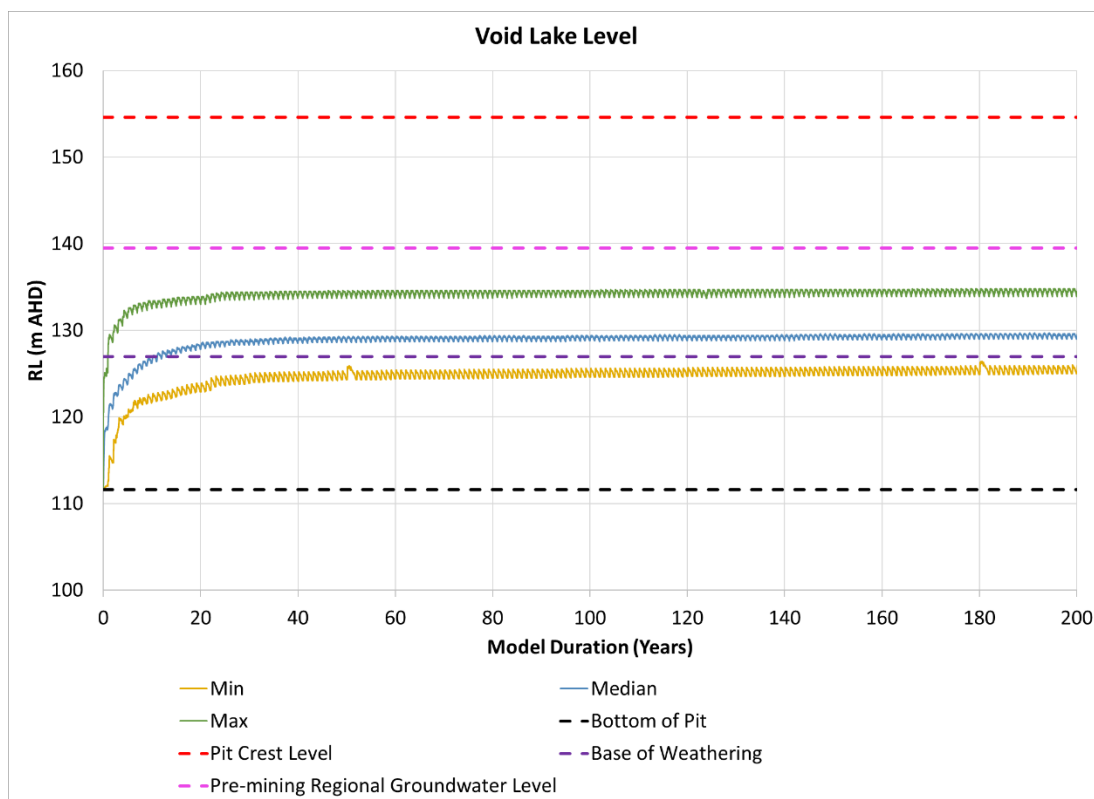


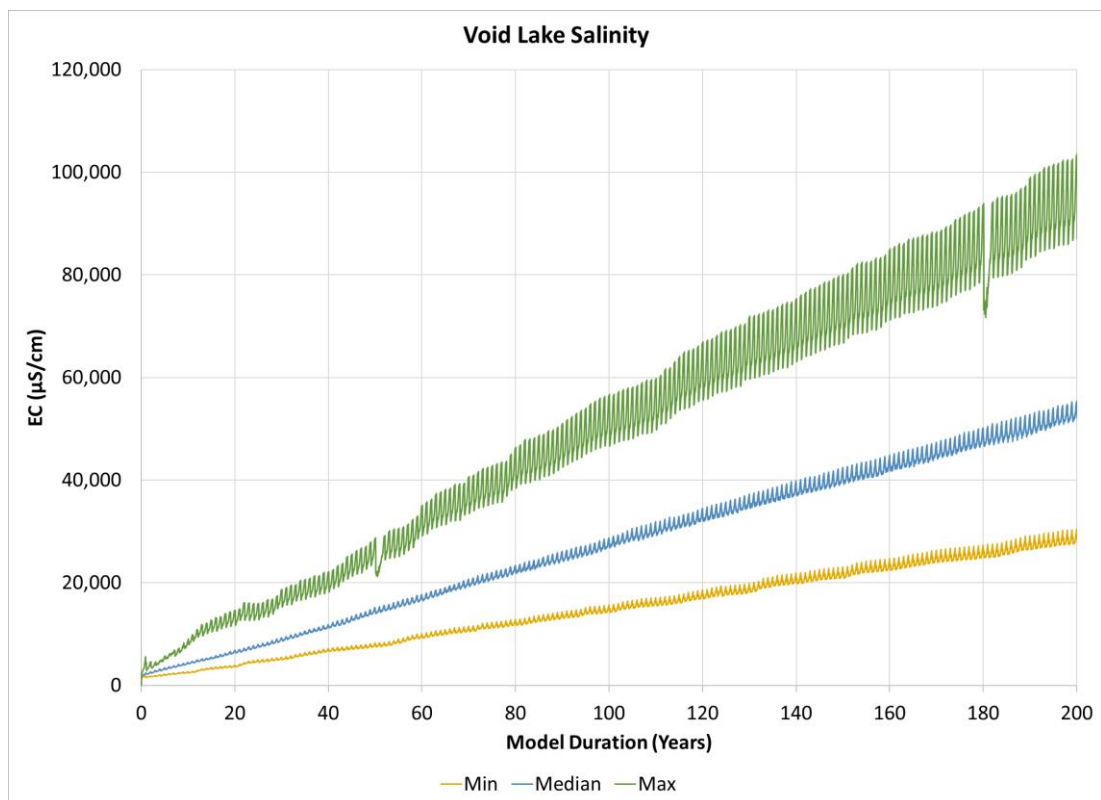
Appendix D

Void Hydrology Model Results

Mitigated Scenario

Drake Pit 4 North





Appendix D - Two Mile Creek Diversion Addendum Report for Final Landform (Engeny, 2022)



Sonoma Mine Management Pty Ltd

Two Mile Creek Diversion

Addendum Report for Final Landform

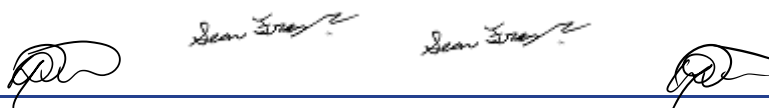
1 February 2022

M4100_049-REP-003-1

Job no. and Project Name: M4100_049 TMC Flood Model
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	3/12/2021	Final Issue	D. Niven	S. Frazer	S. Frazer	D. Niven
1	1/02/2022	Final Issue	D. Niven	S. Frazer	S. Frazer	D. Niven

Signatures



DISCLAIMER

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1 INTRODUCTION

Sonoma Mine Management Pty Ltd (SMM) engaged Engeny Water Management (Engeny) to investigate various options relating to mine operations and closure planning of the Sonoma Coal Mine (SCM), which is part of the QCoal Northern Hub mining complex (QNH). Engeny has previously undertaken a flood study of the Two Mile Creek (TMC) catchment within the SCM operating area (Engeny, Feb 2021). The purpose of the flood study was to determine the flooding behaviour associated with TMC and to investigate the closure aspects relating to:

- Capping geometry of the Co-disposal Facility (CDF) and potential encroachment on the TMC flood plain.
- Main Pit flood protection requirements.

It is noted that the original design and approval of the TMC Diversion included specific elements associated with Closure or Final Landform conditions. An updated Design Plan for the Final Landform conditions of the TMC Diversion is required due to refinements to the flood model since the original design (including assessment against the latest guidelines and industry standards) and changes to mine planning. Engeny has prepared this Design Plan to capture key aspects of closure planning and the final landform that relate to compliance of the TMC Diversion with the objectives defined in the Environmental Authority (EA) conditions for Watercourse Diversions. The scope of the Design Plan is limited to closure and final landform aspects that influence the objectives of the diversion (i.e. primarily geometry of the CDF and pit flood protection landforms). This Design Plan excludes detailed engineering design of these broader landforms including geotechnical stability and capping designs. Further detailed design of these elements (where required) will be undertaken by SMM prior to construction.

1.1 BACKGROUND

A certified diversion design for TMC, which is a defined watercourse under the *Water Act 2000*, was previously prepared by BSM Pty Ltd as documented in:

- Design of Two Mile Creek Diversion (BSM, March 2012) and
- Design of Two Mile Creek Diversion Addendum Report (BSM, Sept 2012).

A water licence under the *Water Act 2000* (Licence Number 607257 dated 13/10/2012) was granted to QCoal Sonoma Pty Ltd, to construct the diversion in accordance with the certified design.

Since granting of Licence Number 607257, the *Water Act 2000* was amended to provide an exemption from the requirement to gain approval under the *Water Act 2000* for diversions associated with resource activities, which are assessed and conditioned under an environmental authority (EA). Mining proponents may seek approval under this streamlined approach under the *Environmental Protection Act 1994* (*EP Act 1994*) as part of their application for the EA.

The approval for the construction of the TMC Diversion (including conditions and referenced certified designs), was transferred from the *Water Act 2000* licence, into the SCM EA EPML00707713 (take effect date 13/10/2021), which is administered under the *EP Act 1994*. Accordingly, Water Licence Number 607257 was surrendered by Qcoal Sonoma Pty Ltd.

Condition J5 of the diversion approval (the EA) regarding construction and operation of diversions, requires certification that the diversion is constructed in accordance with, and meets the original intent of, the approved Design Plan. The approved Design Plans associated with TMC are defined in the EA as *Design of Two Mile Creek Diversion (BSM, March 2012)* and *Design of Two Mile Creek Diversion Addendum Report (BSM, Sept 2012)*.

Mining of Sonoma Main Pit at SCM has recently reached its current economic limit. In addition, the existing CDF at SCM has reached its design capacity. Consequently, SMM have transitioned to an in-pit CDF using the Main Pit void. This required the co-disposal pipe to cross the diversion of TMC. A certified crossing design was prepared by Engeny as documented in 'Two Mile Creek Diversion Addendum report for Temporary Crossing' dated 21 December 2020 (ref M4100_049-REP-002). SMM have further commenced closure activities for the CDF including encapsulation within spoil material.

It is understood that SMM will seek an amendment to the EA to include the following additional reports as approved Design Plans:

- *Two Mile Creek Diversion Addendum Report for Temporary Crossing (Engeny, Dec 2020)* and
- *Two Mile Creek Diversion Addendum Report for Final Landform (Engeny, TBC)* – i.e. this report.

1.2 PURPOSE OF THE DOCUMENT

This report is an addendum of the previous Design Plans (BSM, March 2012, BSM, Sept 2012 and Engeny 2020) to update the final closure profiles and has been prepared in accordance with the requirements of the '*Guideline: Works that interfere with water in a watercourse – watercourse diversions*' (DNRM, 2014) (the Guideline). The design approach has been to minimise changes from the previously approved design and minimise the extent of required works and potential impacts to the existing diversion. The assessments and findings of the previously licensed Design Plans (BSM, Mar 2012 and BSM, Sept 2012) are considered to remain the overarching Design Plan for the entirety of the diversion, with this addendum providing an update for the closure case where appropriate. It is noted that the temporary crossing previously documented by Engeny will be removed prior to closure along with other operational crossings (i.e. haul road crossing and rail loop crossing).

The objective of the report is to demonstrate that the updated closure case continues to satisfy the outcomes identified in the EA and the Guideline for permanent watercourse diversions. The design has been certified in accordance with DNRM requirements by Daniel Niven (Principal Engineer, RPEQ No. 12581). A copy of the certification statement is included in Appendix A. The basis of design and drawings are included in Appendix B and C, respectively.

As noted above, this Design Plan excludes detailed engineering design or certification of the broader landforms including geotechnical stability and capping designs. Further detailed design of these elements (where required) will be undertaken by SMM prior to construction.

2 BASIS OF DESIGN

As previously noted, the design approach has been to minimise changes from the previously approved design and minimise the extent of required works and potential impacts to the existing diversion. The assessments and findings of the previously licensed Design Plans (BSM, Mar 2012, BSM, Sept 2012 and Engeny 2020) are considered to remain the overarching Design Plan for the entirety of the diversion, with this addendum providing an update for the closure case where appropriate.

The basis of design has been largely determined by SMM requirements and is summarised in detail in Appendix C. A summary of the diversion design guidelines that have been referred to in the development of this addendum to the design plan is provided below. However, it is noted, that the overarching design approach has been to minimise changes from the existing approved design plan and assess diversion streamflow stability criteria against changes from existing conditions rather in preference to guideline thresholds.

2.1 EXISTING DIVERSION CONDITION

Annual performance monitoring inspections of the diversion have been undertaken by SMM since construction (Engeny 2014-2021). These monitoring reports indicate that:

- The diversion is generally considered to be in good condition and performing as per the design intent.
- From a geomorphic perspective, the diversion reach is in better condition than the upstream and downstream control reaches.
- The riparian vegetation condition of the diversion reach is limited due to the lack of diversity in plant type and relatively short establishment period since construction; however, vegetation establishment and diversity appears to be continuing to improve. Existing ground covers are performing the function of providing the stability as other species continue to establish in the future.

Based on these findings, the existing diversion appears to be trending towards achieving the objectives defined in Condition J1 of the EA for Permanent Watercourse Diversions. Consequently, as noted above the overarching design approach has been to minimise changes from the existing approved design plan and existing diversion.

2.2 DESIGN GUIDELINES

There are currently two recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity — watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).

Both the DNRME and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions. Details of the guidelines that have been used to inform this addendum to the design plan are summarised below.

2.2.1 DNRME Guideline

The diversion design outcome requirements are nominated by DNRME for permanent watercourse diversions and have been used to inform the addendum to the design plan:

- 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 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 on 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.

Design Criteria

DNRM recommend the following design criteria in development of permanent watercourse diversions, and these have been considered in development of the addendum to the design plan:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRM Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 2.1 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.
- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Flow velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential however stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

Table 2.1: DNRM 2019 Hydraulic Design Criteria

Design Flow Event	Stream Power (W/m ²)	Velocity (m/s)	Shear Stress (N/m ²)
2-year ARI (no vegetation)	<35	<1.0	<40
2-year ARI (vegetated)	<60	<1.5	<40
50-year ARI	<150	<2.5	<80

Note 1: DNRM values are taken from ACARP 2002. It is noted that the value reported in DNRM 2014 appears to be incorrect.

2.2.2 ACARP Guideline

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, including an analogous approach (where channel dimensions are selected from a reference reach), a hydraulic geometry approach (where dimensions are determined from regression relationships), and an analytical approach (where equations are used to calculate continuity, hydraulic resistance, and sediment transport, with channel characteristics determined from field inspection of a reference reach).

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be representative of stable watercourses within the Bowen Basin and are summarised in Table 2.2.

Table 2.2: ACARP 2014 Alluvial Channel Design Parameters

Stream Type	Sediment Transport Group	Stream Power 2 yr. ARI (W/m ²)	Stream Power 50 yr. ARI (W/m ²)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock Controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 2.3.

Table 2.3: ACARP 2014 Recommended Vegetation Shear Stress Thresholds

Vegetation Type	Design Shear Stress (N/m ²)
Buffel grass	40
Structurally diverse suite of established native vegetation	120

The long-term performance of the diversion under both operating and closure scenarios is also recommended to be assessed. The scenarios and recommended performance objectives are included in Table 2.4.

Table 2.4: ACARP 2014 Threshold Design Events

Consequence of channel scour	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 open cut pit	1:1000 AEP	Probable Maximum Flood

3 HYDROLOGIC AND HYDRAULIC ASSESSMENT

The hydrology and hydraulics of the TMC Diversion have been previously assessed, as documented in Engeny's *Sonoma Mine Flood Study Diversion and Closure Investigation* dated December 2020 (ref M4100_049-REP-001-0). The previous assessments have been updated as part of this Design Plan where required to address the design changes and are summarised in the following sections.

3.1 HYDROLOGIC ASSESSMENT

Design event simulations for the existing case were undertaken using the hydrologic model for Two Mile Creek for the 1:2, 1:10, 1:20, 1:50, 1:100, 1:1000 AEP and PMF events. Storm durations modelled ranged from the 1-hour to the 48-hour duration. A summary of the peak design flows along the channel at the CDF location can be seen in Table 3.1 below.

Table 3.1: Predicted Design Flood Flows

Design Event	Peak Flow (m ³ /s)	Critical Duration (min)	Critical Storm
1:2 AEP	49	540	4
1:10 AEP	129	360	5
1:20 AEP	164	360	10
1:50 AEP	206	360	8
1:100 AEP	243	360	4
1:1000 AEP	333	360	GSDM
PMF	1586	360	GSDM

3.2 HYDRAULIC ASSESSMENT

The TUFLOW hydraulic modelling package was utilised for the hydraulic assessment of the SCM. The TUFLOW modelling software is used extensively throughout Australia for flood studies. Three (3) separate scenarios have been developed to assess flooding behaviour. A summary of each scenario can be seen below:

- Existing Scenario: This assumed the existing features prior to the construction of the temporary crossing. Key elements included in the topography include:
 - Rail loop crossing
 - Haul Road crossing, which assumed the removal of safety bunding, which would be expected to wash away in large overtopping flood events.
 - Service Road crossing.
 - The co-disposal pipeline crossing, which was constructed in 2021 was excluded from the topography.
- Baseline Closure Scenario: This scenario assumed the closure of the SCM and hence the
 - decommissioning and removal of the
 - co-disposal pipeline crossing,
 - rail loop,
 - haul road and service road including the associated culverts and
 - the extension of the CDF landform to its currently proposed final rehabilitation profile and extent (refer Figure 3.1). The flood assessment of this option assumes the following profile for the CDF:

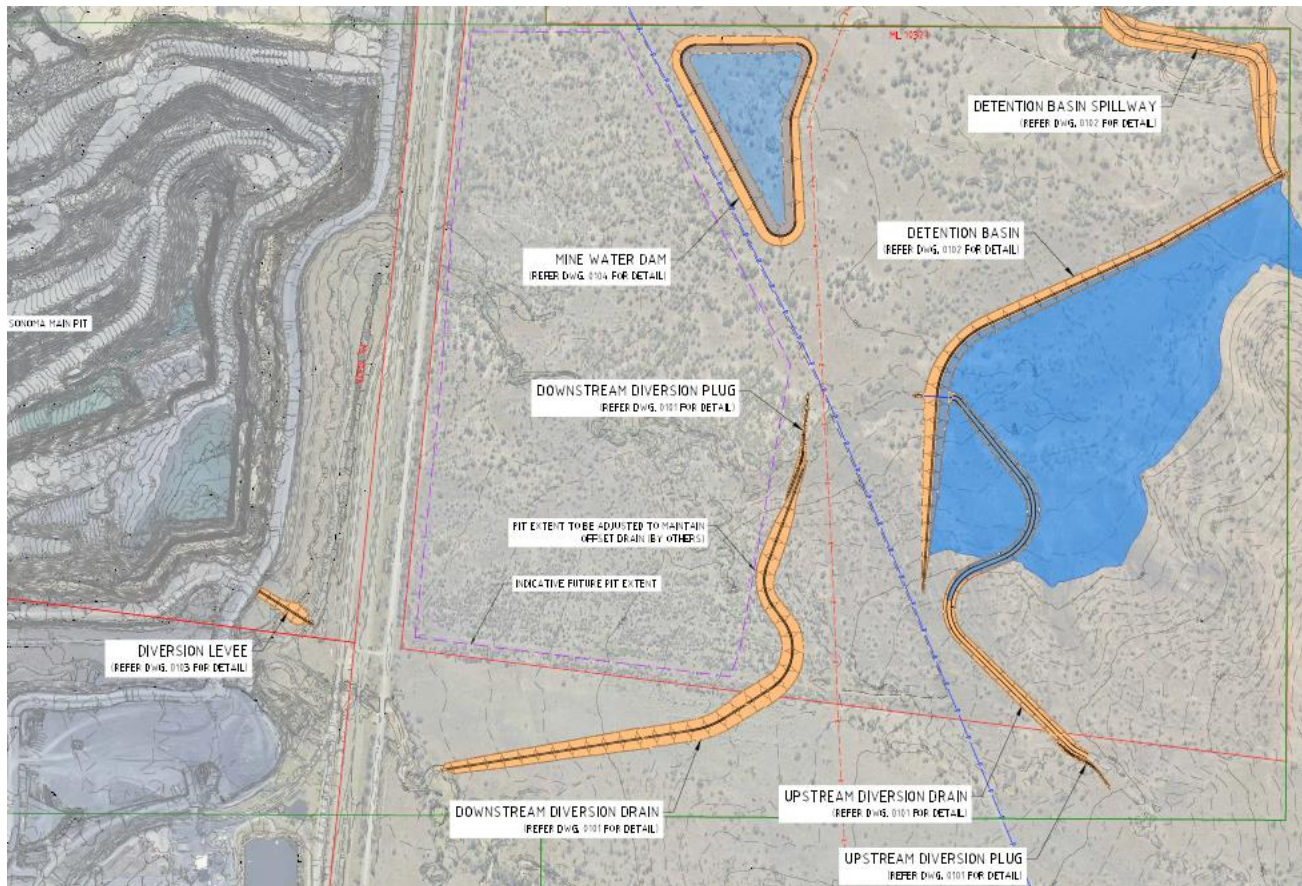
- Maximum elevation of RL 205.0 m.
 - Side batter slope of 1V:5H.
 - Top width of 520m.
- Ultimate Closure with Sonoma East Scenario: This scenario adopts the Baseline Closure scenario and includes the proposed Sonoma East Mine Development and associated creek diversion and flood protection levees (refer Figure 3.2).

The existing scenario was assessed for the 1:2 AEP, 1:20 AEP, 1:50 AEP, 1:100 AEP, 1:1000 AEP and PMF events. The closure scenarios considered the 1:1000 AEP and PMF events, but do not provide any information to inform the consideration of the embankment design. The more frequent AEP events were not considered as the proposed works will not reduce flood peaks and therefore expected to reduce potential for scour/erosion. The lower flows from the Sonoma East Scenario has been included only to assess the ultimate profile requirements. It is anticipated if these works proceed additional assessment will be undertaken on the more frequent AEP events.

Figure 3.1: Baseline Closure Scenario Infrastructure Locations with CDF Footprint



Figure 3.2: Ultimate Closure with Sonoma East Scenario Concept Infrastructure Locations



For the Baseline Closure and Ultimate Closure with Sonoma East scenarios described above, additional sensitivity simulations have been undertaken. The purpose of including these sensitivity scenarios was to confirm the design level for the final landform design including:

- **Glass Wall:** This approach assumes levee crests are raised to achieve flood immunity. This approach allows the levee design crest level to be readily extracted should levee upgrades be required.
- **Increased Vegetation:** This assumes that the TMC Diversion continues to establish vegetation over time with a resulting increase in hydraulic roughness, which would be expected to result in increased flood levels.

3.3 MODEL FINDINGS

Flood mapping for the 1:1,000 AEP and PMF events are provided in Appendix D, E and F for the Existing, Baseline Closure, and Ultimate Closure with Sonoma East Scenarios, respectively. Flood level reporting points are illustrated in Figure 3.3.

Figure 3.3: Reporting Locations



Key observations of the results are summarised below:

3.3.1 Existing Scenario

- The Sonoma Main Pit is immune up to and including the 1:1,000 AEP flood event for the Existing Scenario, although flow into the pit is forecast for the PMF design event.

3.3.2 Baseline Closure Scenario

- The CDF design has only a minor encroachment upon the existing flood plain of TMC. There would be opportunity to further reduce this encroachment through minor adjustments to the design of the landform.
- While events exceeding the 1:10 AEP event reach the toe of the batter of the CDF footprint, there is negligible impact on flood levels for events up to and including the 1:1,000 AEP.
- Some localised flood level increases were observed in the PMF event (up to 60mm), although this impact was restricted to the immediate vicinity of the CDF (i.e., between reporting points D20 and D14 shown in Figure 3.3). This localised impact had little influence on the overall flood extent and did not compromise the existing immunity of the adjacent roads or pits.
- Removal of the Haul Road in the Baseline Closure Scenario results in significant flood level reductions upstream of the Haul Road of up to 2m.
- The Sonoma Main Pit is identified to be immune for the 1:1,000 AEP event for Baseline Closure and predicted to experience flood ingress during the PMF event, based on the existing haul road configuration. Landform adjustments to achieve PMF event immunity are detailed in Section 5 and the design drawings provided in Appendix B.
- The increased vegetation density sensitivity assessment generally produces increases to flood levels for Baseline Closure of up to 550mm. Although it is noted that increases to flood levels begin to decrease towards the lower end of the diversion.

A summary of the predicted flood levels for the 1:1,000 AEP and PMF events are presented in Table 3.2 for the Baseline Closure Scenario at the reporting points presented in Figure 3.3.

Table 3.2: Predicted Flood Levels – Baseline Closure Scenario

Reporting Point Location	1:1000 WSL (m AHD)	PMF WSL (m AHD)	“Glass Wall” PMF WSL (m AHD)	“Increased Vegetation” PMF WSL (m AHD)
D02	163.525	164.672	164.672	164.802
D06	165.755	166.844	166.844	167.057
D14	167.897	169.832	169.833	170.196
D20	169.73	171.793	171.793	172.025
D26	172.554	175.147	175.148	175.707
D28	173.206	175.855	175.856	176.388
D42	173.487	176.172	176.173	176.72
D50a	173.467	176.265	176.249	176.793

3.3.3 Ultimate Closure with Sonoma East Scenario

- Changes to the catchments upstream of the Rail Loop due to the potential Sonoma East Pit development are generally forecast to result in reductions of flood level relative to the Baseline Closure Scenario throughout the existing diversion. Reductions are generally within 0.5m and 0.7m for the 1:1,000 AEP and PMF events respectively.
- The Sonoma Main Pit is identified to be 1:1,000 AEP and PMF design event immune in the Ultimate Closure with Sonoma East Scenario.
- Increased vegetation density produces greater flood levels throughout the existing diversion, up to 550mm.

A summary of the predicted flood levels for the 1:1,000 AEP and PMF events are presented in Table 3.3 for the Ultimate Closure with Sonoma East Scenario at the reporting points presented in Figure 3.3.

It is noted that this scenario is only included to review the final profile of the proposed final landforms for protection of the pit. It is anticipated a more detailed assessment of the diversion stability will be completed if the Sonoma East works proceed.

Table 3.3: Predicted Flood Levels – Ultimate Closure with Sonoma East Scenario

Reporting Point Location	1:1000 WSL (m AHD)	PMF WSL (m AHD)	“Glass Wall” PMF WSL (m AHD)	“Increased Vegetation” PMF WSL (m AHD)
D02	163.084	164.41	164.41	164.567
D06	165.321	166.495	166.495	166.678
D14	167.405	169.1	169.1	169.461
D20	169.225	171.008	171.008	171.229
D26	171.922	174.197	174.197	174.686
D28	172.532	174.704	174.705	175.241
D42				
D50a	173.072	175.351	175.351	175.825

4 MORPHOLOGICAL ASSESSMENT

The Morphological Assessment of the previously licensed design is presented in Chapter 5 of Design of Two Mile Creek Diversion (BSM, 2011). Specialist advice and certification of the assessment was provided by A. Markham (Director, Hydrobiology (Qld) Pty Ltd).

The proposed closure works do not encroach within the 1:2 nor 1:50 AEP flood extents, hence the previously certified assessment is considered to remain unchanged. It is noted that in the event that the Sonoma East mine proceeds it is anticipated a detailed assessment of the changes on the morphologic behaviour will be undertaken.

Consequently, the proposed works are considered to meet the requirements of Item D within Condition J1 of the EA to *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.*

5 DESIGN ELEMENTS

The detailed design drawings for the closure case geometry of the CDF and Main Pit flood protection landform are included in Appendix B for reference. The key design elements relating to the waterway diversion are detailed below.

5.1 CDF CAPPING

The design considered the following key geometry profile:

- Maximum elevation of RL 205.0 m.
- Side batter slope of 1V:5H.
- Top width of 520m.

Based on the findings presented in Section 3, it is concluded that the proposed capping geometry has a negligible impact on flood levels within the constraints described above. Reshaping of the CDF in accordance with the original design plan (BSM 2012) is therefore not required provided the capping is maintained within the geometry adopted for the flood model. The footprint of the adopted capped landform for both closure scenarios is shown in Figure 3.1.

It is noted that in the Baseline Closure scenario, the toe of the capped CDF landform is expected to be exposed to some flow for events that exceed the 1:10 AEP design flood. The maximum velocities forecast in the vicinity of the CDF batter are approximately 2 m/s in the 1:1000 AEP and PMF. It is recommended that appropriate surface treatment (e.g. vegetation establishment and/or dumped rock scour protection) is provided as part of the detailed design to manage potential scour. Alternatively, there is opportunity to optimise the design landform to further reduce encroachment on the TMC flood plain.

5.2 MAIN PIT FLOOD PROTECTION

The following design considerations are noted for the flood protection requirements of the Main Pit residual void:

- Operational mining pits typically required 1:1,000 AEP flood protection as specified for a significant consequence category levee in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933).
- The approved design plans for the TMC Diversion (BSM 2012) include upgrades to the diversion at closure to achieve flood immunity for the Probable Maximum Flood (PMF) event.

In addition, where structures are required to achieve flood immunity it is generally understood that the preference of the regulator is that these structures are bulked out to achieve a “landform” as opposed to a narrower engineered structure. This avoids the need for ongoing maintenance of structures beyond closure. In the context of a flood protection levee, a “landform” is generally understood to have a minimum 50 m wide crest.

To inform SMM's closure planning, the extent of earthworks required to achieve a landform levee (assuming 50m wide crest) with PMF flood protection has been assessed and captured in the design drawings provided in Appendix B. This has been determined for the increased vegetation scenario in TMC to provide a worst-case estimate.

Figure 5.1 below shows the alignment and location of two areas of earthworks required to achieve a PMF landform levee, with Figure 5.2 indicating the typical section. A summary of the works required for the PMF landform levee is provided in Table 5.1.

Table 5.1: PMF Landform Design Parameters

Landform	Crest Level (m AHD)	Length (m)	Fill Volume Required (m ³)
Landform 1	RL 178.1m	650	40,440
Landform 2	RL 176.8m	160	

Figure 5.1: Landform Alignment to achieve PMF Immunity for Baseline Closure Scenario

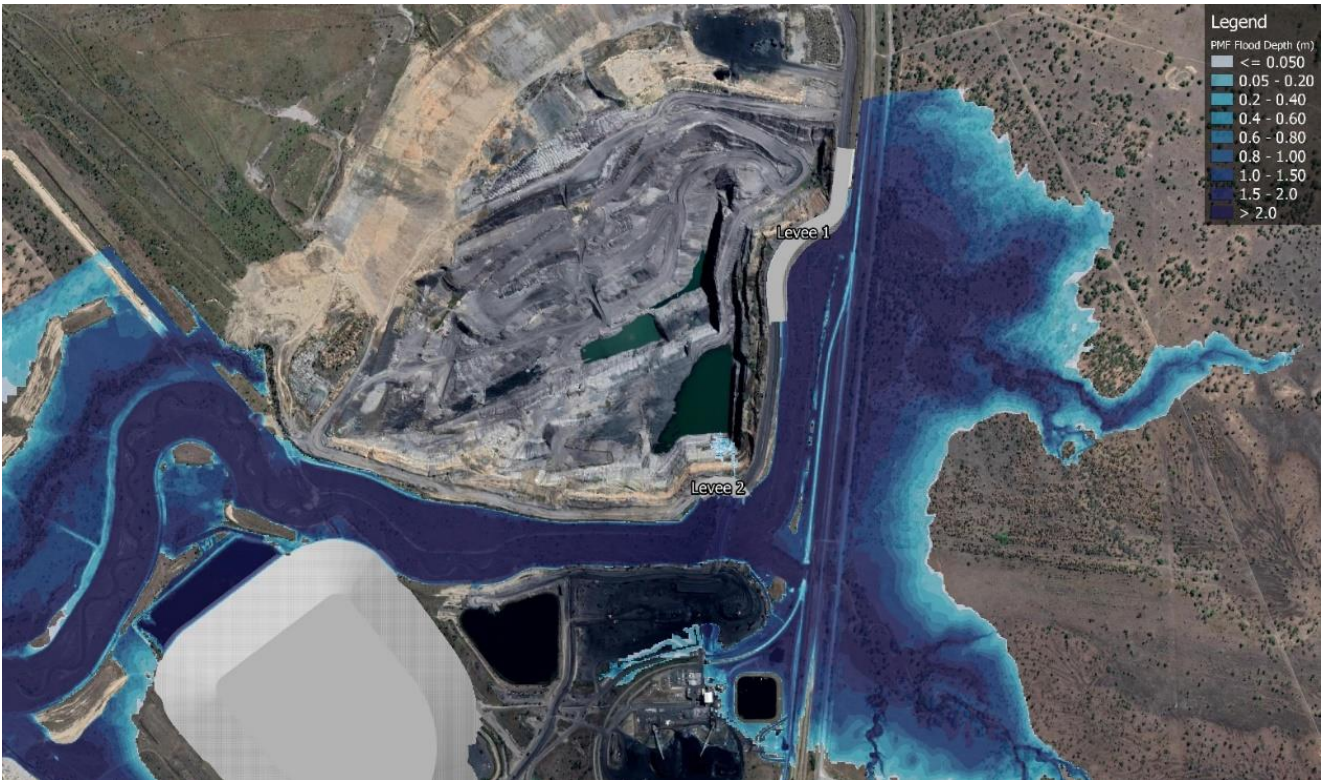
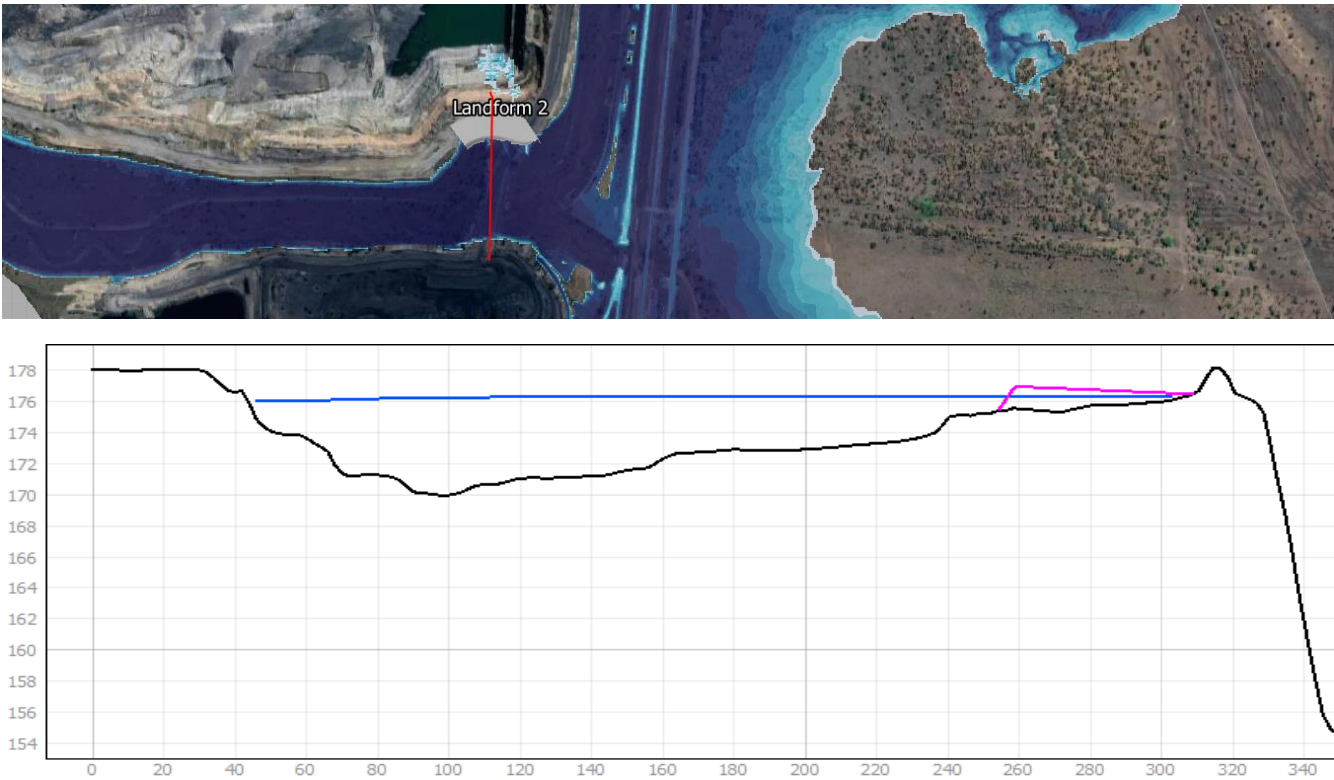


Figure 5.2: Landform 2 Typical Section



6 CONSTRUCTION

Any construction works in a watercourse are subject to the risk of experiencing a flood flow in the creek during the construction period; however, this risk is increased during the wet season. It will be necessary for SMM to prepare a detailed construction plan including schedule, sequencing and Erosion and Sediment Controls Plan (ESCP) to manage this risk. Regular monitoring of weather conditions and rainfall forecasts are expected to form a key component of the construction plan.

This plan will be provided prior to implementing the closure works.

7 REVEGETATION PLAN

The Revegetation Plan for the previously licensed design is presented in Chapter 7 of Design of TMC Diversion (BSM, 2012). Specialist advice and certification of the plan was provided by M.C. Evans (Director, Esys Consulting Pty Ltd). Due to the limited disturbance footprint and proposed surface treatments, it is not anticipated that significant revegetation will be required as part of the works. Placement of topsoil and seeding of localised areas of disturbance is recommended to promote establishment of vegetation. The original design plan (BSM, 2012) remains consistent and unchanged for the localised revegetation works associated with implementation of the closure landforms described in this Design Plan.

8 PERFORMANCE MONITORING

SMM undertakes routine monitoring of the performance of the TMC Diversion in accordance with the requirements of Condition J7 of the EA. The monitoring program was developed by Engeny in the first year following construction of the diversion and is contained within the annual inspection reports. The latest version of the monitoring program is presented in Two Mile Creek Diversion Operations Monitoring 2021 (Engeny, June 2021).

The existing monitoring program is suitable for ongoing use as part of this Design Plan.

9 QUALIFICATIONS

- a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
- b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.
- c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:
 - i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
 - ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.
- d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.
- e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.
- f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.
- g) This Report does not provide legal advice.

10 REFERENCES

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- ACARP (2001) Monitoring and Evaluation Program for Bowen Basin River Diversions. ACARP Project C9068, prepared by ID&A.
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Engeny (2019). Two Mile Creek Diversion Operations Monitoring 2021 – Sonoma Coal Mine. Engeny Water Management. June 2021.

Engeny, (2021) Sonoma Mine Flood Study Diversion and Closure Investigation

Engeny, (2020) Two Mile Creek Diversion Addendum report for Temporary Crossing

Keller, R.J. (2003). Guideline for the Design of Rock Chutes using CHUTE. CRC for Catchment Hydrology. September 2003.

Appendix A:

Statement of Certification

FORM OF CERTIFICATION

DESIGN PLAN FOR TWO MILE CREEK DIVERSION – FINAL LANDFORM – SONOMA COAL MINE

Name of Registered Professional Engineer providing certification:

Daniel Norman Niven

Address of Registered Professional Engineer providing certification:

Level 2/500 Queen Street, Brisbane QLD 4000

Statement of relevant experience

I hereby state that I am a Registered Professional Engineer of Queensland and meet the requirements of the definition of 'suitably qualified and experienced person' for watercourse diversions as stated in the model conditions for watercourse diversions (141126 EM944).

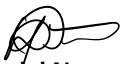
Statement of certification

I hereby certify that the detailed design plan titled *Two Mile Creek Diversion Addendum Report for Final Landform* and dated 1 February 2022:

- Relates to watercourse diversion of Two Mile Creek between the upstream limit (590,073E, 7,719,708N) and downstream limit (587,227E, 7,718,359N).
- Includes all relevant material relied on by me including information provided by the previously approved design plans prepared by Brisbane Stormwater Management (*Design of Two Mile Creek Diversion* dated 30th March 2012 and *Design of Two Mile Creek Diversion Addendum Report* dated 24th September 2012).
- Is in accordance with all relevant conditions of Environmental Authority EPML00707713 including the requirement of Condition J3 for a Design Plan that achieves Condition J1 for permanent watercourse diversions.

I Daniel Norman Niven, declare that the information and opinions provided as part of this certification is true to the best of my knowledge and belief. I acknowledge that it is an offence under section 480 of the *Environmental Protection Act 1994* to give the administering authority a document containing information that I know is false, misleading or incomplete in a material particular.

Signed:



Daniel Norman Niven, RPEQ No. 12581

Appendix B:

Basis of Design

Project Basis of Design

Date 13/01/2022
Job No.: M4100_049
 TMC Flood Model
Project: Final Landform Assessment

Revision B
Project Manager: SF
Project Director: DN

Client: Sonoma Coal
Client Contact: Julian Dobos

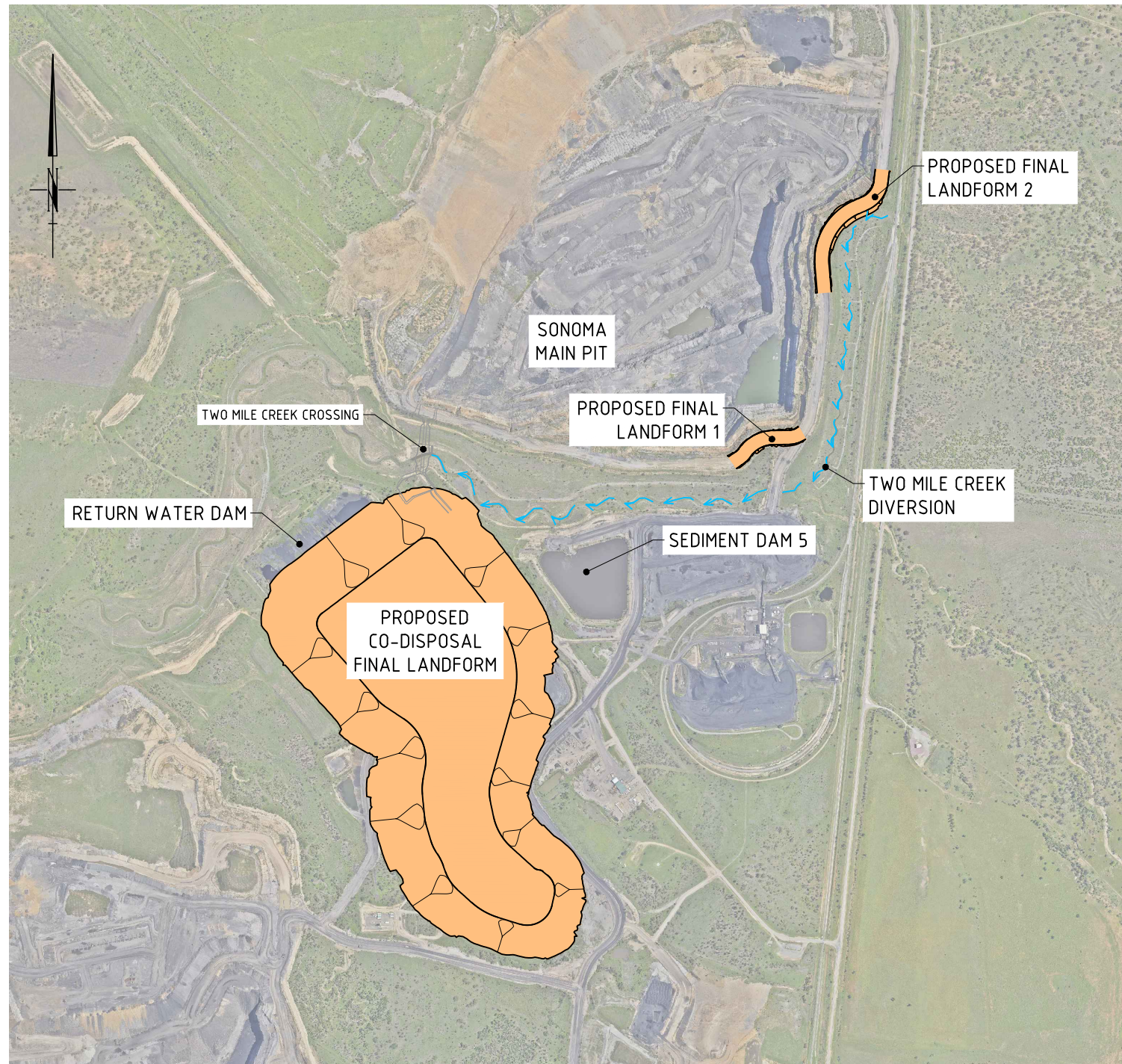


Item No.	Assumption	Reference
1.0	General Information	
1.1	Main Mine Pit Final Void embankment to achieve PMF immunity	Engeny / QCoal
1.2	Only light traffic on embankment, assuming mine closure	QCoal
1.3	All works to comply to Environmental Authority EPML00707713	Engeny / QCoal
1.4	All works to comply to <i>Guideline: Works that interfere with water in a watercourse for a resource activity—watercourse diversions authorised under the Water Act 2000</i> OSW/2019/4599 Version 2.00 05/02/2019	Engeny / QCoal
1.5	All works to comply to <i>Criteria for Functioning River Landscape Units in Mining and Post Mining Landscapes</i> ACARP Project C20017 Published 01/03/2014	Engeny / QCoal
2.0	Embankment Typical Section	
2.1	50m top of crest width (to allow achieve significant landform)	QCoal
2.2	1:3 batter to existing ground levels	Engeny / QCoal
2.3	Embankment foundation excavated at least 1m into existing surface, or to a depth of a solid foundation	Engeny
2.4	Detailed capping and civil / geotechnical design to be completed at detailed design	Engeny
3.0	Co-Disposal Final Landform	
3.1	Peak Capping Level of 205mAHD	Engeny / QCoal
3.2	1:5 batter to existing ground levels	Engeny / QCoal
3.3	Optimise extent of Capping into the floodplain to minimise flood impacts	QCoal
3.4	Detailed capping and civil / geotechnical design to be completed at detailed design	Engeny

Appendix C:

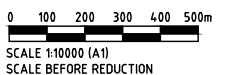
Design Drawings

TWO MILE CREEK DIVERSION FINAL LANDFORM



LOCALITY PLAN
SCALE 1:10000 m

DRAWING INDEX	
M4100-049-DWG-1001	LOCALITY PLAN & DRAWING INDEX
M4100-049-DWG-1002	GENERAL NOTES & LEGEND
M4100-049-DWG-1100	KEY PLAN
M4100-049-DWG-1101	CO-DISPOSAL FINAL LANDFORM PLAN & SECTION
M4100-049-DWG-1102	LANDFORM 1 PLAN & SECTION
M4100-049-DWG-1103	LANDFORM 2 PLAN & SECTION
M4100-049-DWG-1201	LONGITUDINAL SECTIONS - LANDFORM 1 AND LANDFORM 2



THIS DRAWING IS CONFIDENTIAL AND SHALL ONLY BE USED BY ENGNEY'S CLIENT FOR WHICH IT WAS PREPARED

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NOT FOR CONSTRUCTION

Ph. 07 3221 7174 Level 2 500 Queen St Brisbane QLD www.engeny.com.au	DESIGNED	MT	CHECKED	DN
	DRAWN	LC	CHECKED	MT
	PM APPD.	SF	PD APPD.	DN
	RPEQ	D.NIVEN	RPEQ No.	12581

SONOMA MINE MANAGEMENT PTY LTD

TWO MILE CREEK DIVERSION FINAL LANDFORM
LOCALITY PLAN & DRAWING INDEX

ORIGINAL SIZE
A1

DWG NO.
M4100-049-DWG-1001

0

1. CONCEPT DESIGN DETAIL ONLY TO PROVIDE SUPPORT FOR APPROVED DIVERSION WORKS UNDER EA EPML00707713. CAPPING AND GEOTECHNICAL DESIGN OF LANDFORM BY OTHERS.
2. ALL DIMENSIONS ARE IN METRES (m) UNLESS NOTED OTHERWISE. ALL ELEVATIONS ARE IN METRES (m). ALL CO-ORDINATES ARE IN METRES (m).
3. VERTICAL DATUM IS AUSTRALIAN HEIGHT DATUM (A.H.D.)
4. HORIZONTAL DATUM IS IN ACCORDANCE WITH MGA94 MGA ZONE 55.
5. THE COMPANY'S REPRESENTATIVE SHALL ESTABLISH SURVEY BASELINES AND BENCHMARKS. PRIOR TO THE COMMENCEMENT OF WORK THE CONTRACTOR SHALL VERIFY THE EXISTING SURVEY LEVELS AND AGREE WITH THE PRINCIPAL ANY VARIATION FROM THE LEVELS SHOWN ON THE DRAWINGS.
6. ALL WORKMANSHIP AND MATERIALS SHALL BE IN ACCORDANCE WITH RELEVANT SAA CODES, BY-LAWS AND ORDINANCES OF RELEVANT STATUTORY AUTHORITIES.
7. SECTION NUMBERS REFER TO THE LAST FOUR NUMBERS OF THE DRAWING NUMBER. IE. REFER DRAWING 0201
8. SETTING OUT DIMENSIONS SHOWN ON THE DRAWINGS SHALL BE VERIFIED BY THE SITE CONTRACTOR. REFER ANY DISCREPANCY TO THE COMPANY'S REPRESENTATIVE BEFORE PROCEEDING WITH WORK.
9. ALL REINFORCEMENT, CONCRETE, CONCRETE MATERIALS AND CONSTRUCTION TO BE IN ACCORDANCE WITH AS3600.
10. REFER ALL DISCREPANCIES TO THE COMPANY'S REPRESENTATIVE BEFORE PROCEEDING WITH THE WORKS.
11. AS CONSTRUCTED BASED ON LIDAR SURVEY DATED JUNE 2021. SUPPLIED BY THE PRINCIPAL. ENGNEY WATER MANAGEMENT TAKES NO RESPONSIBILITY FOR INACCURACIES ASSOCIATED WITH THE PRINCIPAL SUPPLIED LIDAR SURVEY AND DISCREPANCIES WITH EXISTING GROUND LEVELS.
12. EXISTING SERVICE LOCATIONS ARE INDICATIVE ONLY.
13. LOCATION OF ALL EXISTING SERVICES TO BE CONFIRMED PRIOR TO CONSTRUCTION AND TREATMENT APPROVED BY COMPANY'S REPRESENTATIVE.

1. STRIP THE CONSTRUCTION AREA OF ALL GRASS, SHRUBS, RUBBISH, DELETERIOUS MATERIAL, UNSUITABLE TOPSOIL AND ALL UNCONTROLLED FILL MATERIAL AS NOMINATED BY THE ENGINEER. DISPOSE OF ALL SUCH MATERIAL OFF SITE.
2. TOPSOIL AND UNCONTROLLED FILL APPROVED BY THE ENGINEER FOR REUSE, IS TO BE STOCKPILED ON SITE AS DIRECTED BY THE ENGINEER.
3. BULK EARTHWORKS IS TO BE CARRIED OUT IN ACCORDANCE WITH THE EARTHWORKS SPECIFICATION BY A N.A.T.A. REGISTERED GEOTECHNICAL TESTING AUTHORITY OR AS APPROVED BY THE PRINCIPAL AT THE CONTRACTORS COST. THE CONTRACTOR SHALL PROVIDE DETAILS OF ALL TESTING TO THE ENGINEER PROGRESSIVELY THROUGH THE WORKS AND NOTIFY THE ENGINEER OF ANY NON-CONFORMANCES. ALL NON CONFORMING WORK IS TO BE RECTIFIED AS DIRECTED BY THE ENGINEER.
4. PRIOR TO FILL OPERATIONS AND IN THE PRESENCE OF THE ENGINEER, PROOF ROLL THE FILL AREA SUBGRADE. REMOVE SOFT AND OR COMPRESSIBLE ZONES AND REPLACE WITH SELECT SITE MATERIAL COMPACTED TO A DENSITY CONSISTENT WITH THAT PRESCRIBED FOR PROPOSED FILLING ABOVE.
5. INSITU CLAYEY MATERIAL WON FROM PROPOSED EXCAVATIONS SHOULD BE SUITABLE FOR REUSE AS FILL MATERIAL APART FROM ANY OVERSIZE MATERIAL. SUITABLE MATERIALS FOR FILLING SHOULD HAVE A MAXIMUM PARTICLE SIZE NOT EXCEEDING 75mm. OVERSIZE MATERIAL IS TO BE EITHER CRUSHED TO A PARTICLE SIZE $\leq 75\text{mm}$ FOR REUSE AS FILL MATERIAL OR DISPOSED OF OFF SITE.
6. PLACE GENERAL FILL IN LAYERS OF LOOSE THICKNESS APPROPRIATE TO THE TYPE OF COMPACTION EQUIPMENT BEING USED AND NOT GREATER THAN 250mm. COMPACT EACH FILLING LAYER TO THE 98% STANDARD MAXIMUM DRY DENSITY SPECIFIED. THE MOISTURE CONTENT OF FILL MATERIAL SHOULD BE MAINTAINED WITHIN THE RANGE OF -2% TO +2% OF THE OPTIMUM MOISTURE CONTENT.
7. EARTHWORKS PROFILES ARE TO BE TRANSITIONED UNIFORMLY BETWEEN PRESCRIBED SLOPES.
8. FOLLOWING COMPLETION OF BULK EARTHWORKS OPERATIONS THE CONTRACTOR IS TO NOTIFY THE ENGINEER. THE FINISHED SURFACE IS TO BE PROOF ROLLED IN THE PRESENCE OF THE ENGINEER PRIOR TO TOPSOILING.
9. IT IS THE CONTRACTORS RESPONSIBILITY TO PROTECT THE SITE AND SURROUNDING AREAS FROM DAMAGE RESULTING FROM STORMWATER RUNOFF. TEMPORARY DIVERSION DRAINS AND OR OTHER DRAINAGE CONTROL DEVICES ARE TO BE IMPLEMENTED BY THE CONTRACTOR DURING CONSTRUCTION TO MINIMISE THE EFFECTS OF WEATHER. NO EXTENSIONS OF TIME WILL BE GRANTED SHOULD DAMAGE TO THE WORKS AND SURROUNDING AREAS RESULT FROM THE CONTRACTOR'S NEGLIGENCE IN NOT PROVIDING ADEQUATE PROTECTION.
10. IMPORTED STRUCTURAL FILL MATERIAL IF ORDERED, SHALL BE LOW PLASTICITY COHESIVE GRAVEL FILL HAVING THE FOLLOWING CHARACTERISTICS

CBR	5% MIN
PLASTICITY INDEX	15% MAX
% PASSING 75mm SIEVE	100%
% PASSING 37.5mm SIEVE	85-100%
% PASSING 0.075 SIEVE	25-85% MIN
LIQUID LIMIT	45% MAX
SHRINK/SWELL INDEX	1% MAX
11. EXCESS SPOIL MATERIAL GENERATED DURING CONSTRUCTION IS TO BE REMOVED FROM THE SITE BY THE CONTRACTOR.
12. ALL FILL MATERIAL PLACED ON THE SITE COMPRISING ONLY NATURAL EARTH AND ROCK IS TO BE FREE OF CONTAMINANTS (AS DEFINED BY SECTION 11 OF THE ENVIRONMENTAL PROTECTION ACT 1994), NOXIOUS, HAZARDOUS, DELETERIOUS AND ORGANIC MATERIALS. SUITABLE FILL MATERIAL IS DEEMED TO COMPLY WITH THE REQUIREMENTS OF CLAUSE 4.3, AS3798, GUIDELINES ON EARTHWORKS FOR COMMERCIAL AND RESIDENTIAL DEVELOPMENTS.
13. ALL EXPOSED SURFACES APART FROM SWALE DRAINS ARE TO BE GRASS SEEDDED AS A SEDIMENT AND EROSION CONTROL MEASURE.

-THE FOLLOWING GEOMETRIC TOLERANCES MUST ALSO COMPLY (AND TAKE PRECEDENCE OVER BMA STANDARD TOLERANCES):

- -30 TO +0mm (SUBGRADE OR TOP OF SUBGRADE FILL EMBANKMENT)
- -15 TO +25mm (SUB-BASE)
- -15 TO +25mm (BASE)
- -0 TO +25mm (LEEVE CREST OR LEEVE CREST ACCESS ROAD)

- -12 TO +12mm (SUBGRADE)
- -10 TO +10mm (SUB-BASE)
- -10 TO +10mm (BASE)

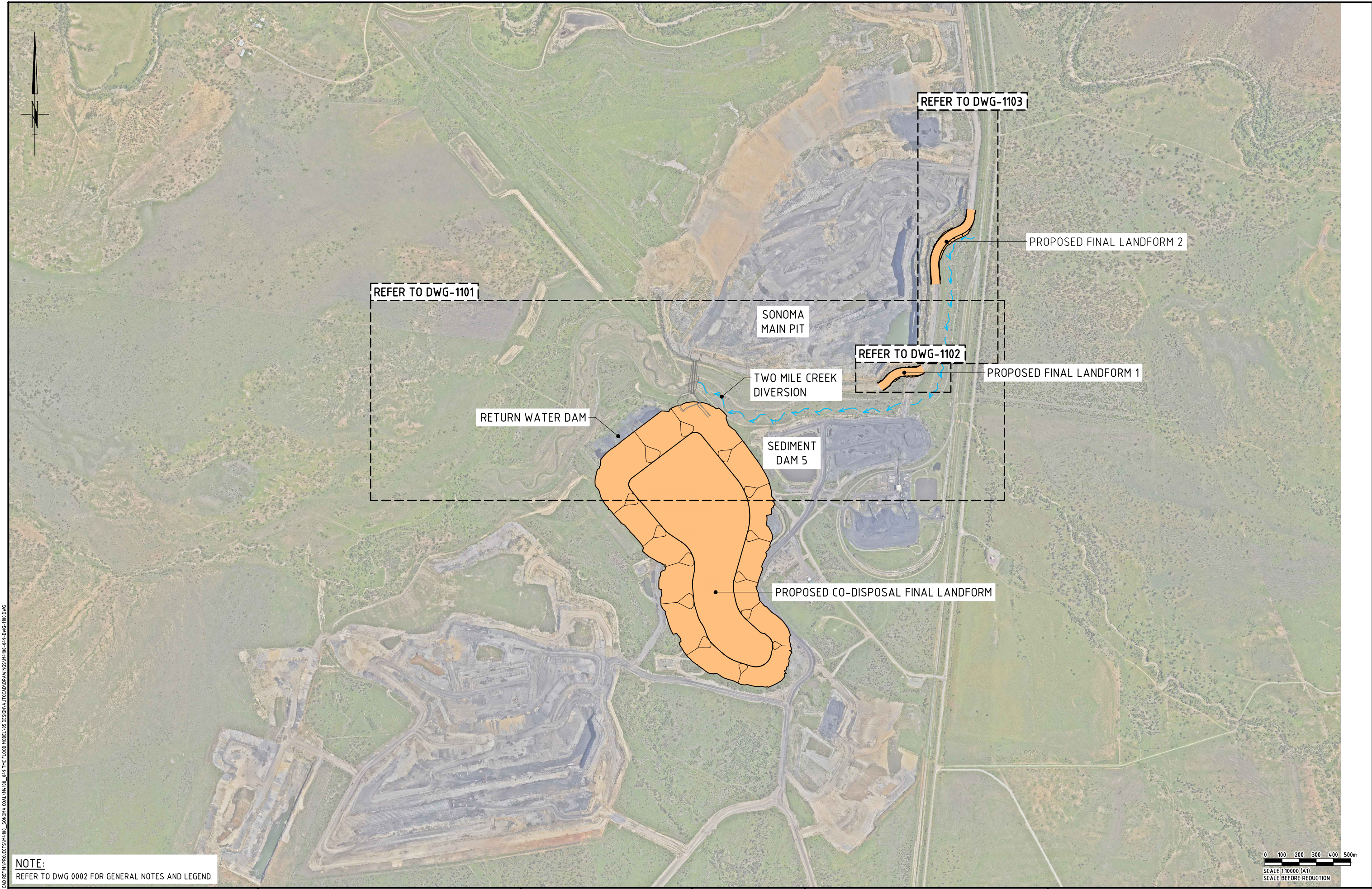
- -0.5% TO +0.5% (SUBGRADE)
- -0.2% TO +0.2% (SUB-BASE)
- -0.2% TO +0.2% (BASE)
- -0.5% TO +0.5% LEVEE CREST OR LEVEE CREST ACCESS ROAD

- -50 TO +50mm

→ → → — EXISTING WATERCOURSE
 PROPOSED DESIGN EXTENT

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PM APPD.		SF		PD APPD.		DN		RPEQ		D.NIVEN		RPEQ No.		12581																											
														ORIGINAL SIZE A1		DWG NO. M4100-049-DWG-1002				REV. 0																					

AST MODIFIED:11/18/2021 4:29 PM
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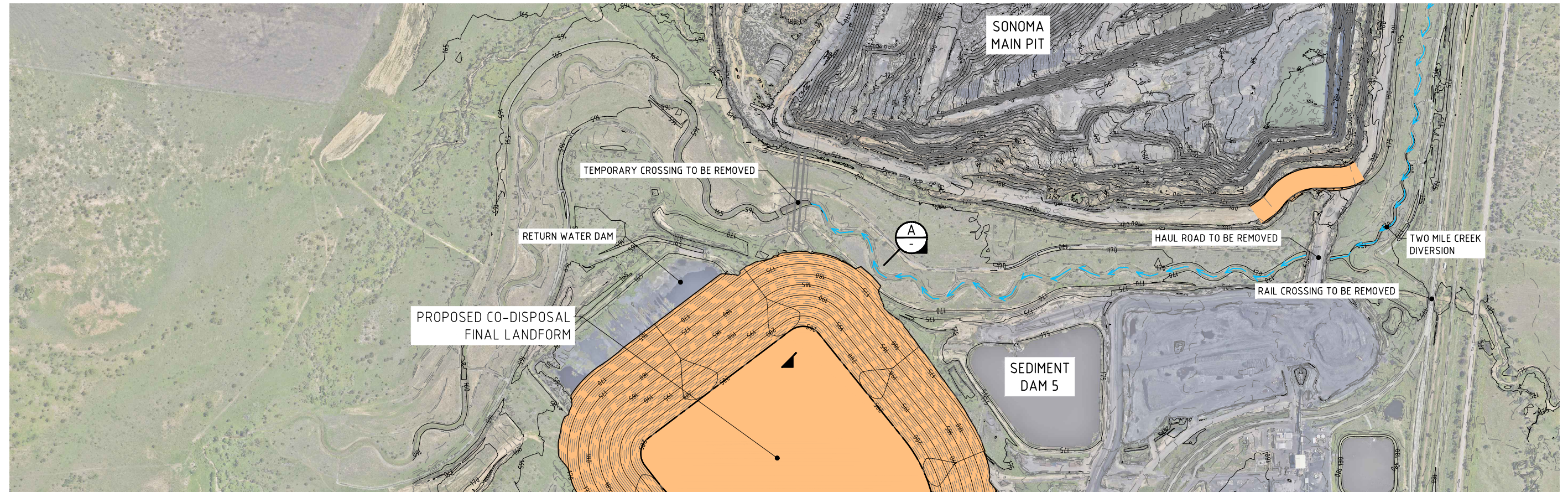
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REFER TO DWG 0002 FOR GENERAL NOTES AND LEGEND.

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REV	BY	DATE	REVISION DESCRIPTION	PM APPD	REFERENCE DOCUMENTS	

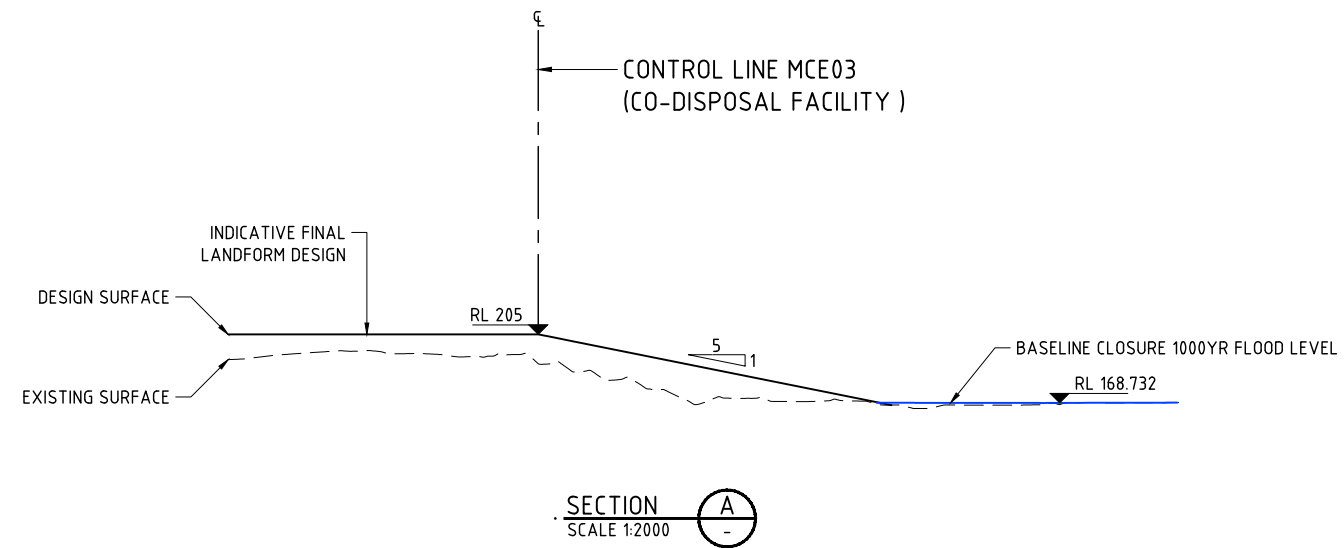


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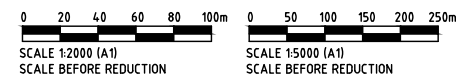
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TWO MILE CREEK DIVERSION FINAL LANDFORM KEY PLAN		
ORIGINAL SIZE	DWG NO.	REV.
A1	M4100-049-DWG-1100	0



DETAIL PLAN - CO-DISPOSAL FINAL LANDFORM
SCALE 1:5000



NOTE:
REFER TO DWG 0002 FOR GENERAL NOTES AND LEGEND.

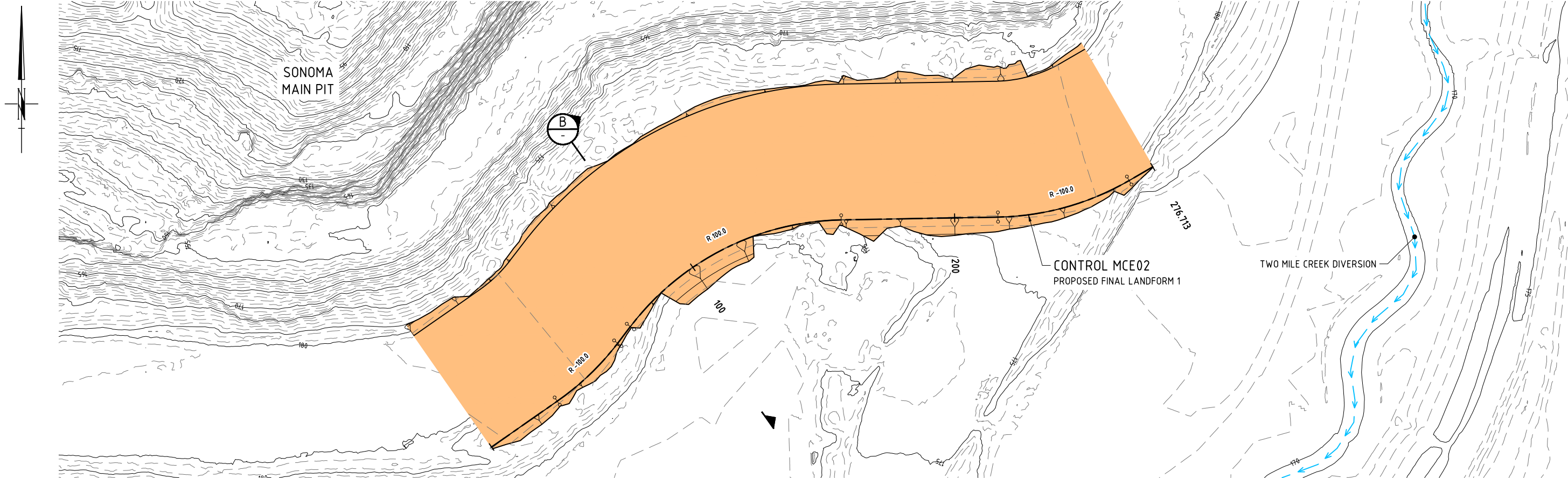


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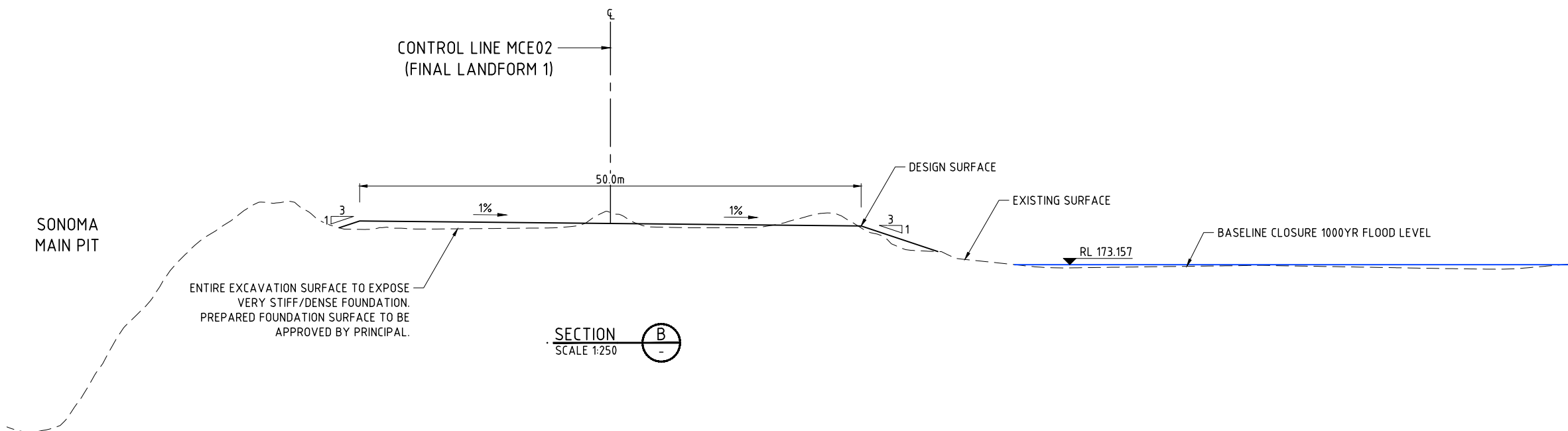


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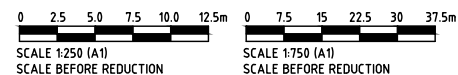
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TWO MILE CREEK DIVERSION FINAL LANDFORM CO-DISPOSAL FINAL LANDFORM PLAN & SECTION			
ORIGINAL SIZE A1	DWG NO. M4100-049-DWG-1101	REV. 0	



DETAIL PLAN - FINAL LANDFORM 1
SCALE 1:750



NOTE:
REFER TO DWG 0002 FOR GENERAL NOTES AND LEGEND.

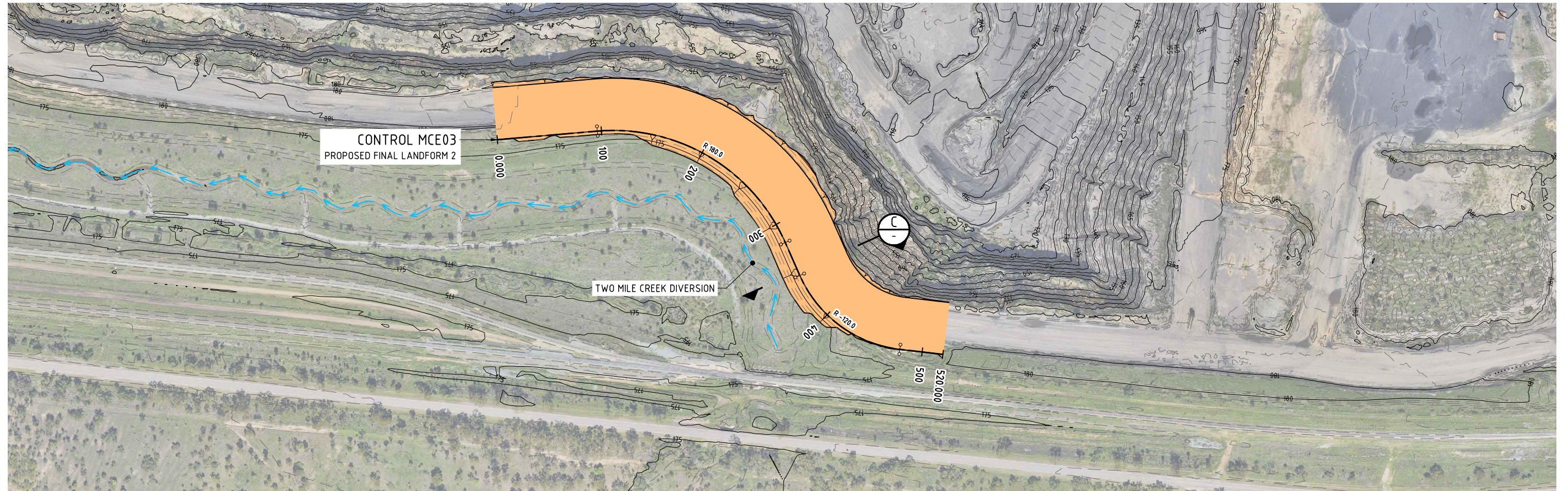


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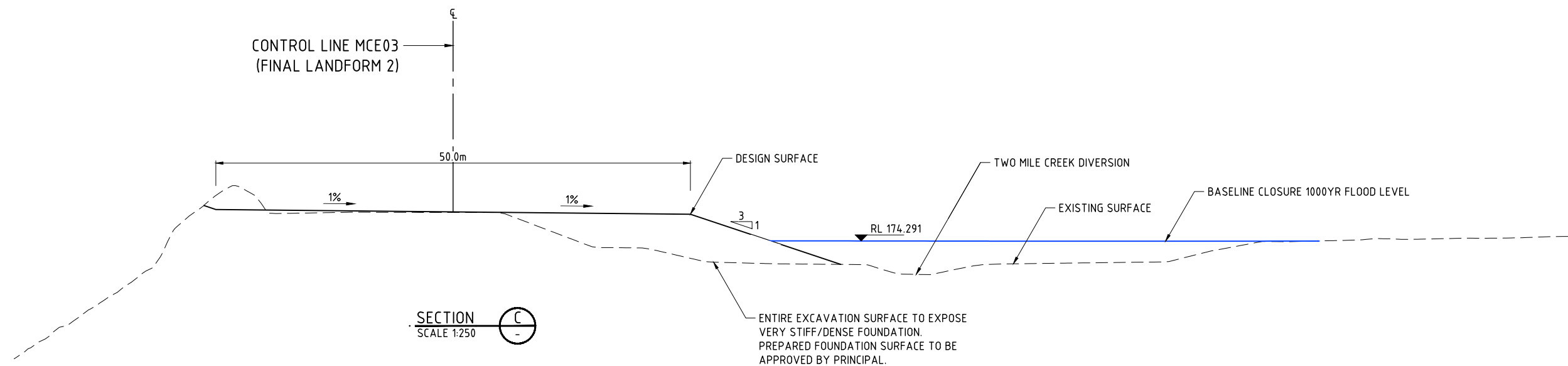


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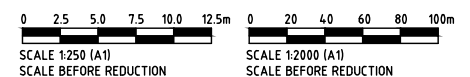
SONOMA MINE MANAGEMENT PTY LTD			
TWO MILE CREEK DIVERSION FINAL LANDFORM LANDFORM 1 PLAN & SECTION			
ORIGINAL SIZE	DWG NO.	REV.	
A1	M4100-049-DWG-1102	0	



DETAIL PLAN - FINAL LANDFORM 2
SCALE 1:2000



NOTE:
REFER TO DWG 0002 FOR GENERAL NOTES AND LEGEND.



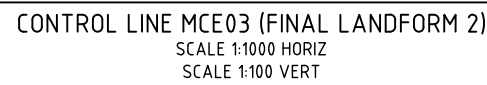
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SONOMA MINE MANAGEMENT PTY LTD			
TWO MILE CREEK DIVERSION FINAL LANDFORM LANDFORM 2 PLAN & SECTION			
ORIGINAL SIZE	DWG NO.		REV.
A1	M4100-049-DWG-1103		0

NOTE:
REFER TO DWG 0002 FOR GENERAL NOTES AND LEGEND.



0 1 2 3 4 5m

SCALE 1:100 (A1)
SCALE BEFORE REDUCTION

0 10 20 30 40 50m

SCALE 1:1000 (A1)
SCALE BEFORE REDUCTION



SONOMA • COAL



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TWO MILE CREEK DIVERSION FINAL LANDFORM LONGITUDINAL SECTIONS LANDFORM 1 AND LANDFORM 2		
ORIGINAL SIZE A1	DWG NO. M4100-049-DWG-1201	REV. 0

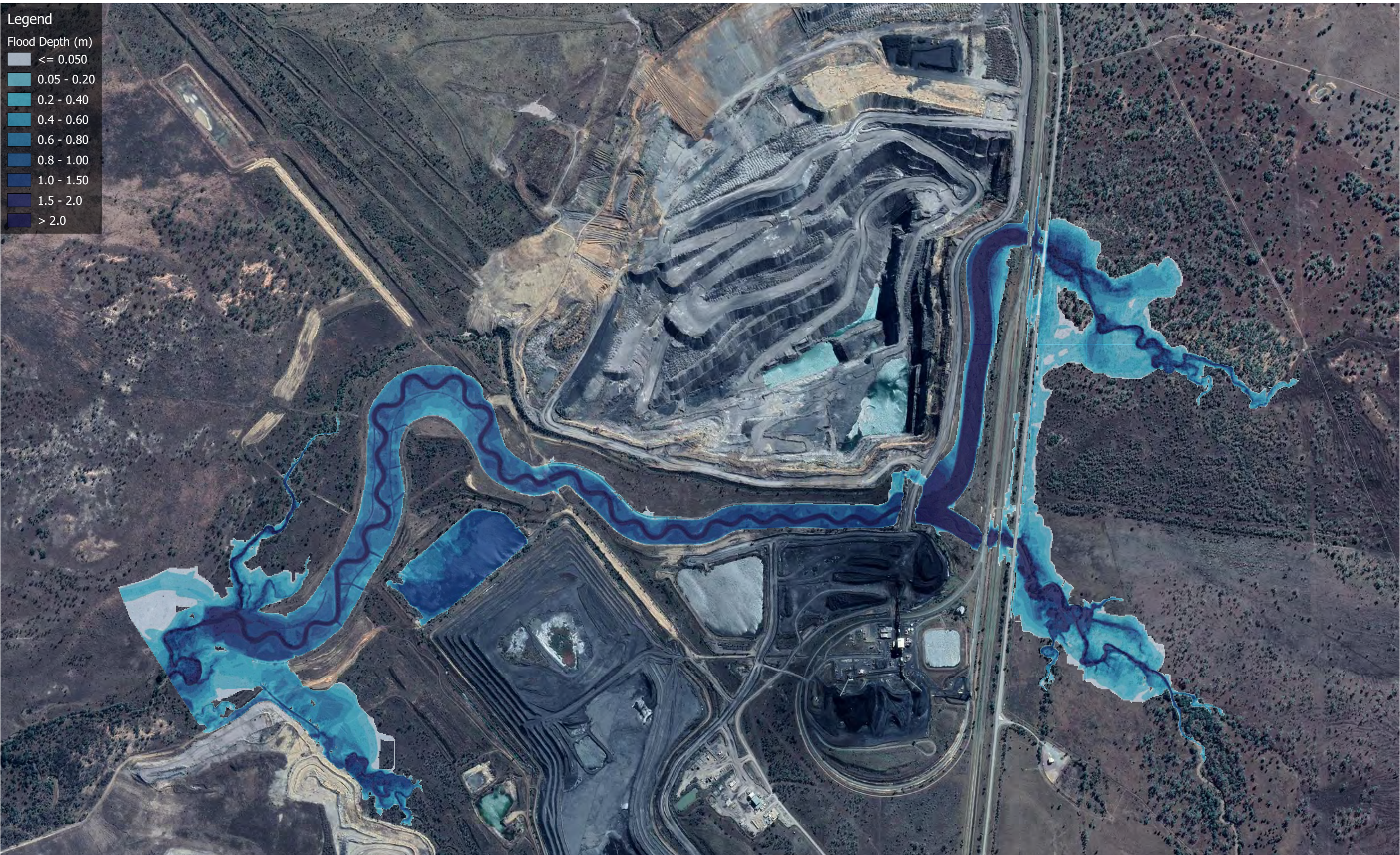
Appendix D:

Flood Outputs – Existing Scenario

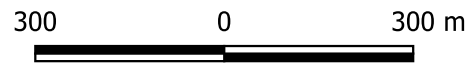
Legend

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:20 AEP Flood Depth

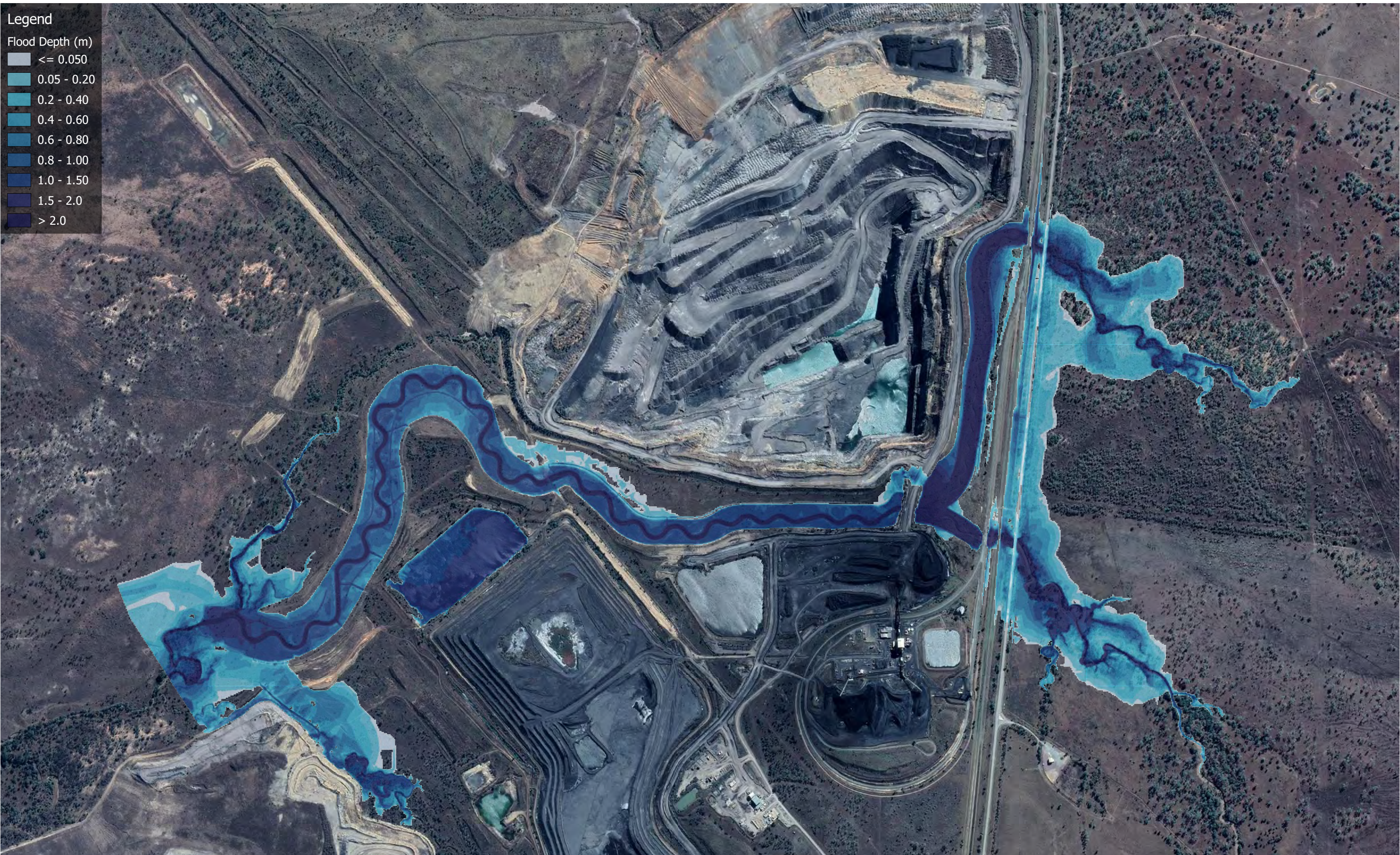
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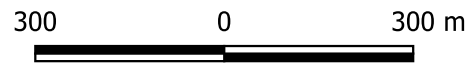
Legend

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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Scale in metres (1:12,000@ A3)

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Sonoma Coal Mine Flood Study

Existing Scenario
1:50 AEP Flood Depth

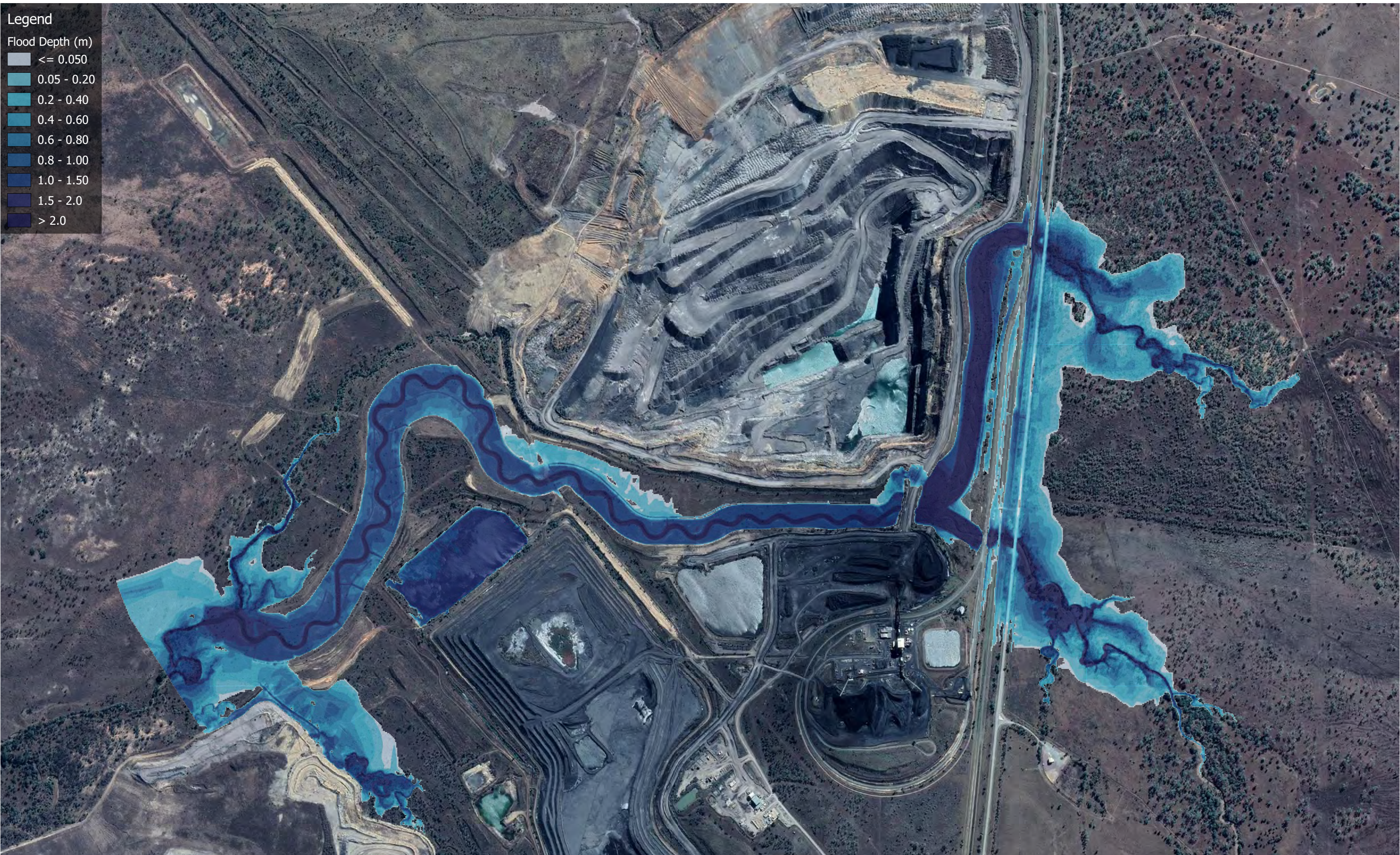
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Date: 6 /8 /2020

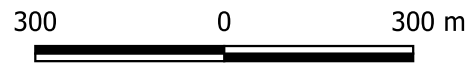
Legend

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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Scale in metres (1:12,000@ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:100 AEP Flood Depth

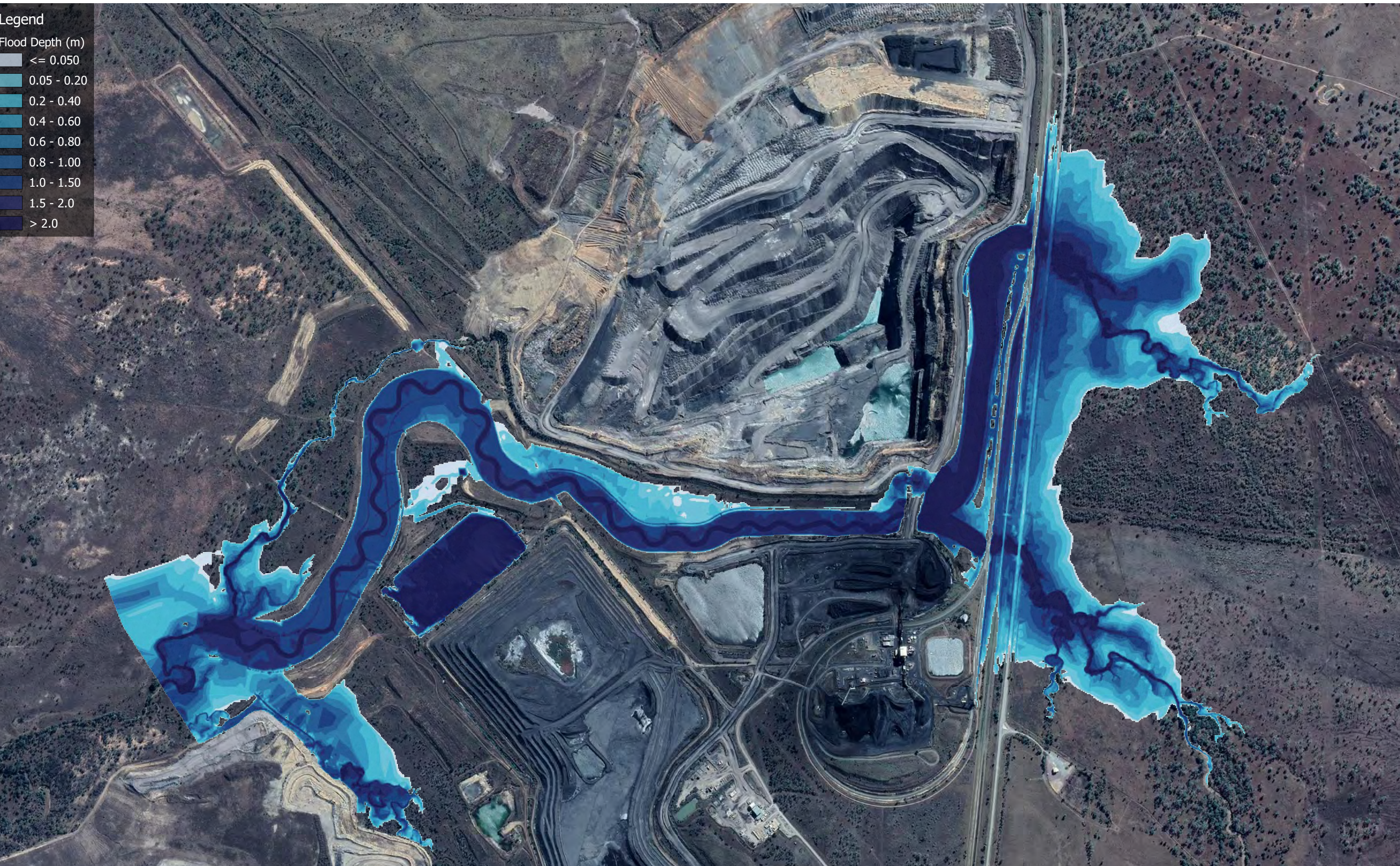
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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 6 /8 /2020

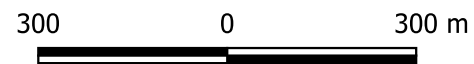
Legend

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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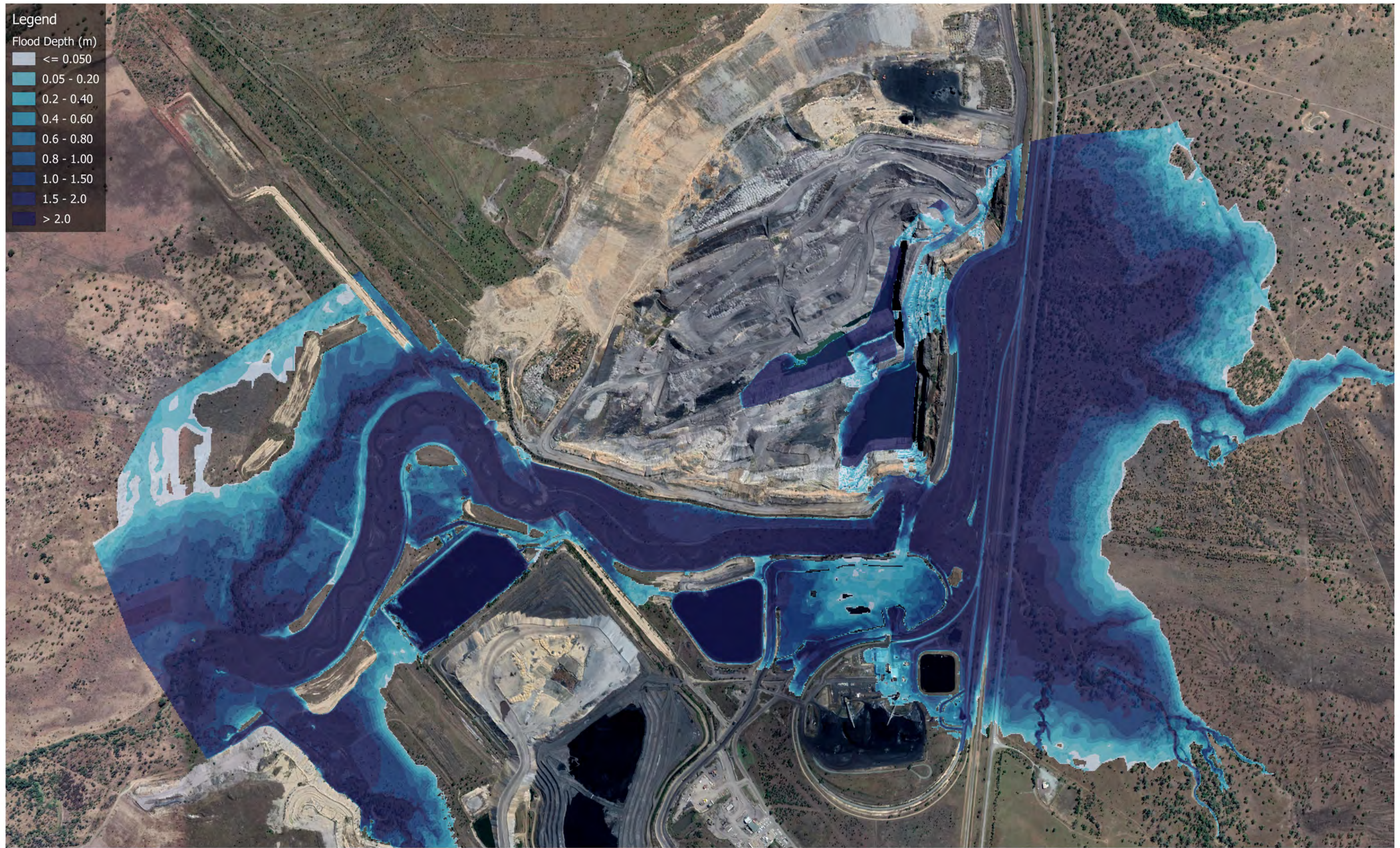
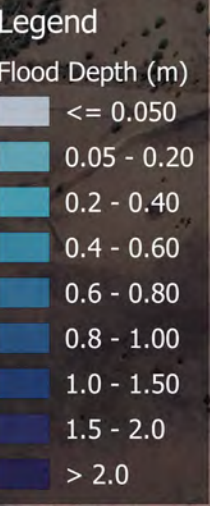
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Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

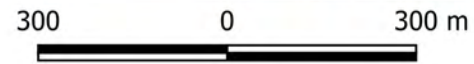
Existing Scenario
1:1000 AEP Flood Depth

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Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
PMF Flood Depth

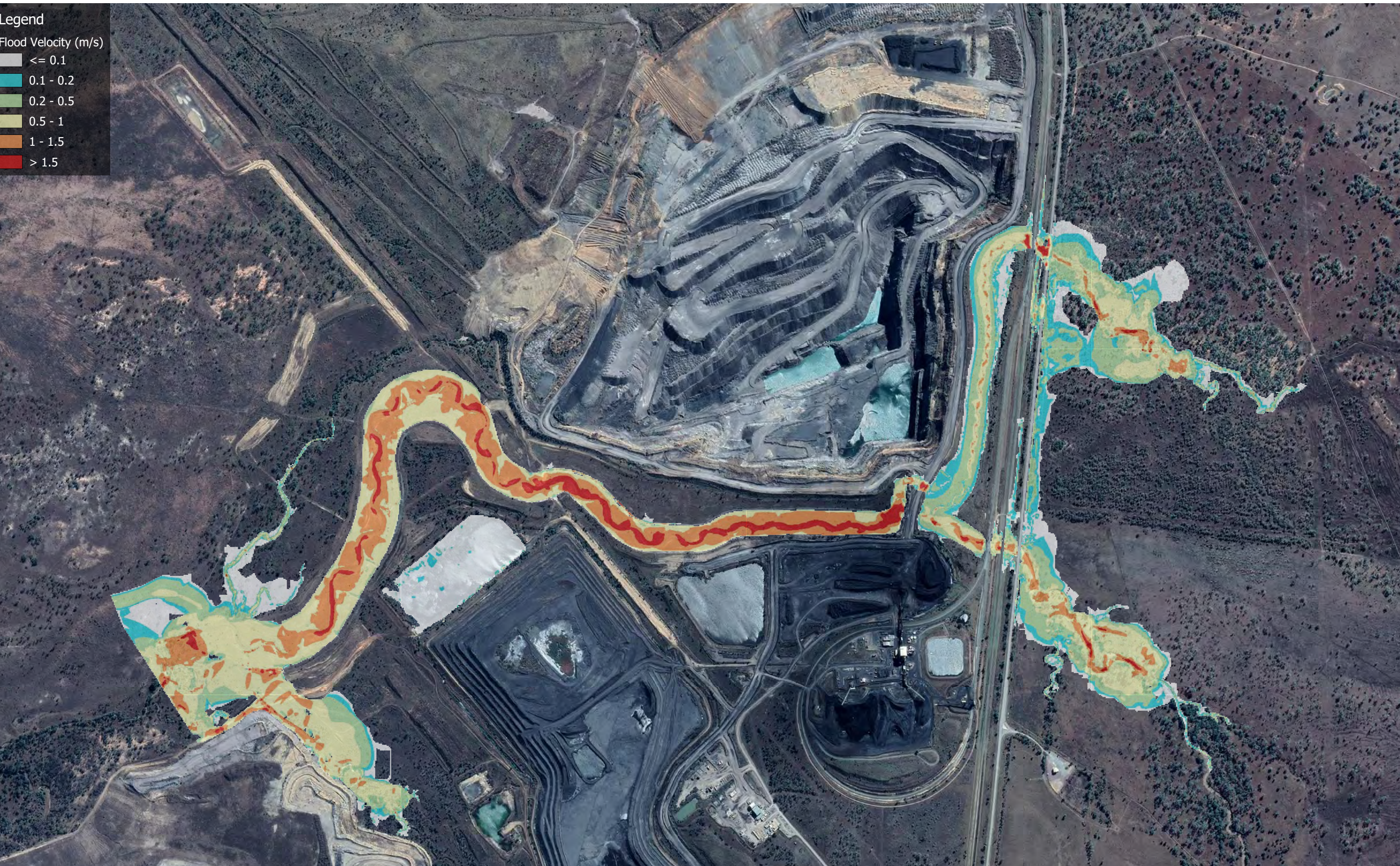
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Drawn: JH
Checked: DN
Date: 14 /1 /2022

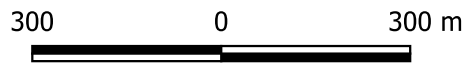
Legend

Flood Velocity (m/s)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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Scale in metres (1:12,000@ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:20 AEP Flood Velocity

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Date: 6 /8 /2020

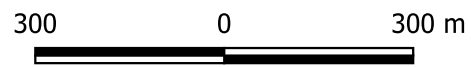
Legend

Flood Velocity (m/s)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:50 AEP Flood Velocity

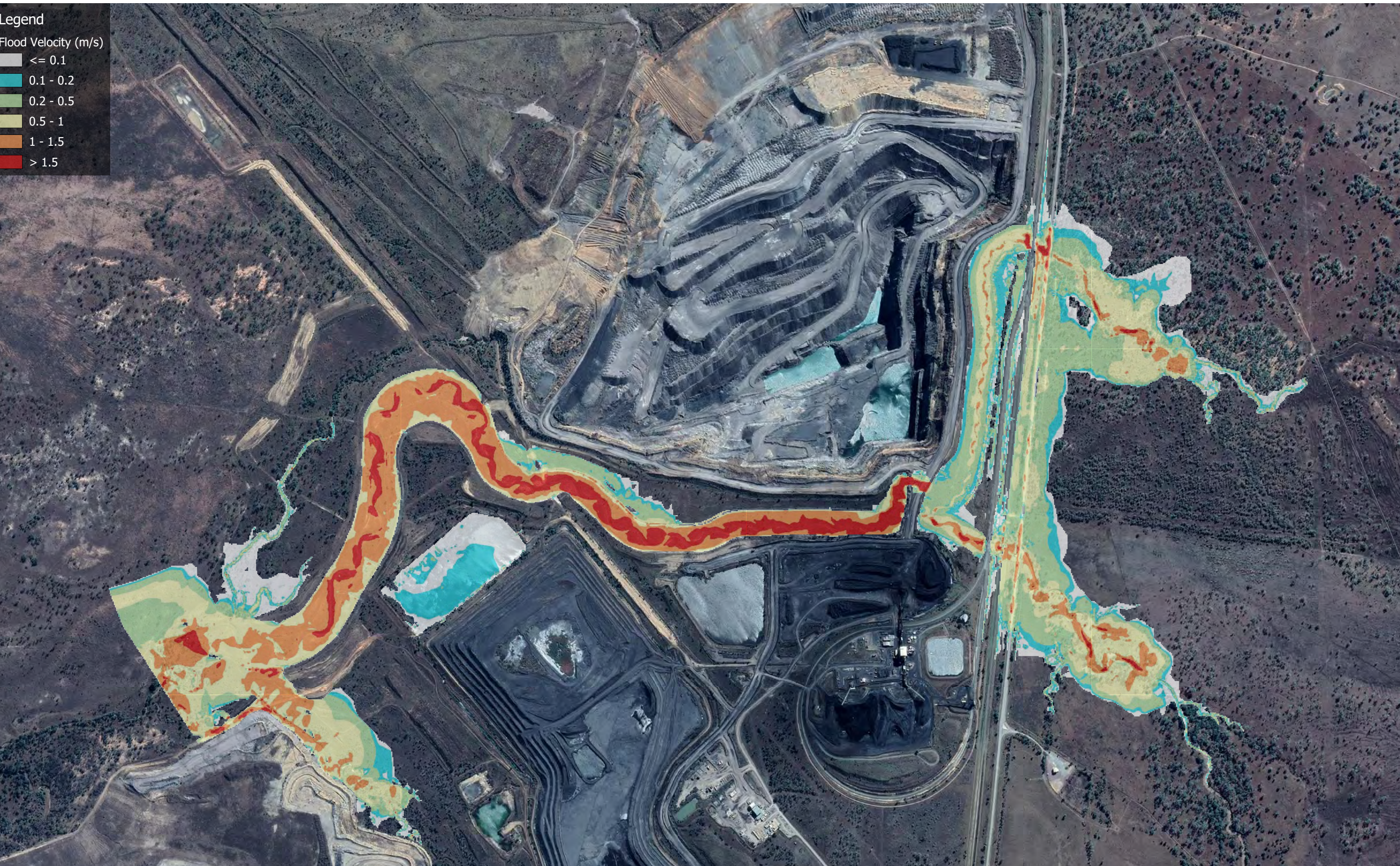
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Drawn: JH
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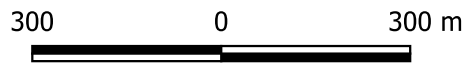
Legend

Flood Velocity (m/s)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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Scale in metres (1:12,000@ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:100 AEP Flood Velocity

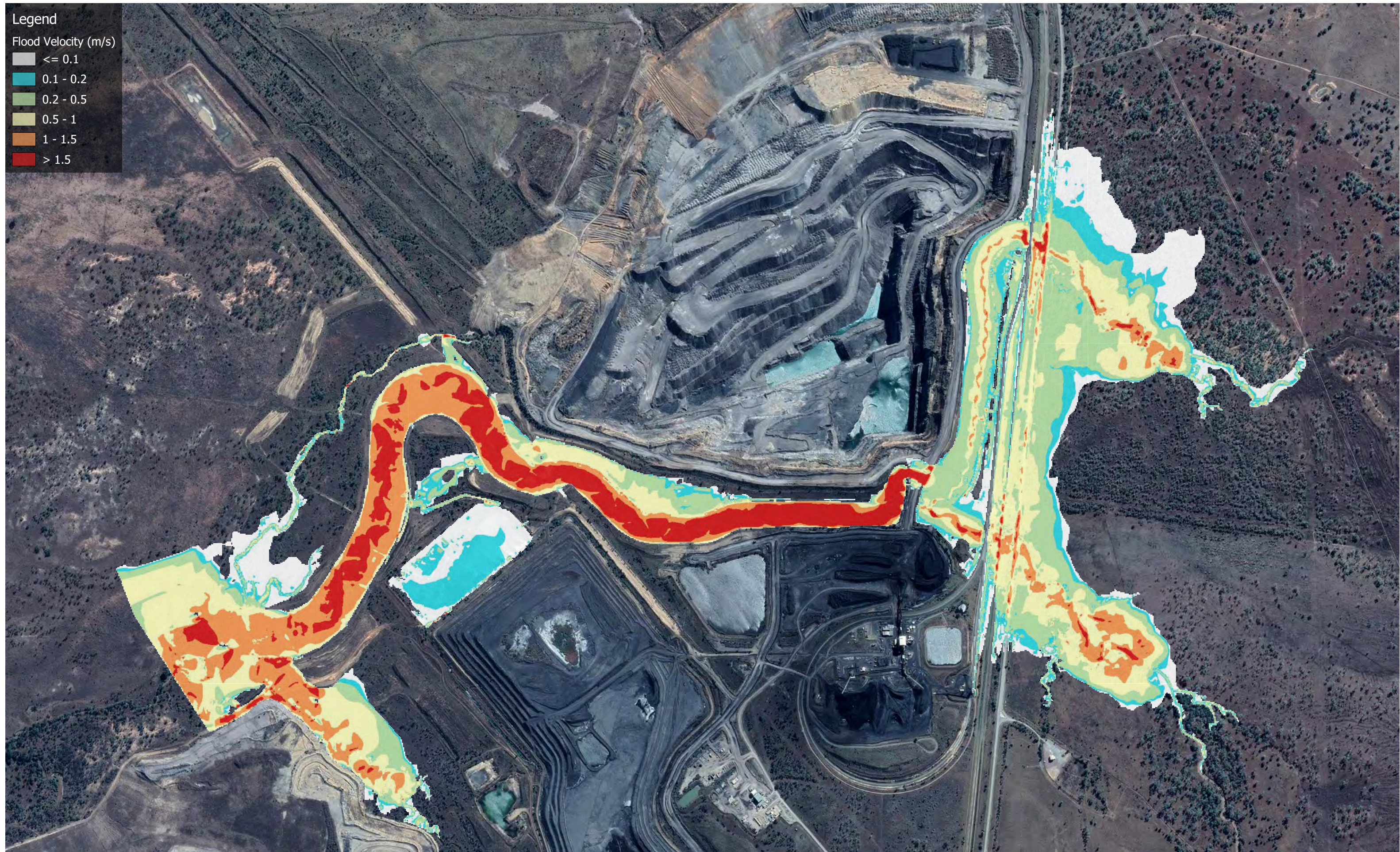
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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 6 /8 /2020

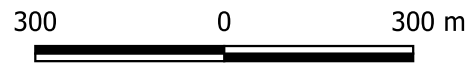
Legend

Flood Velocity (m/s)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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Scale in metres (1:12,000@ A3)

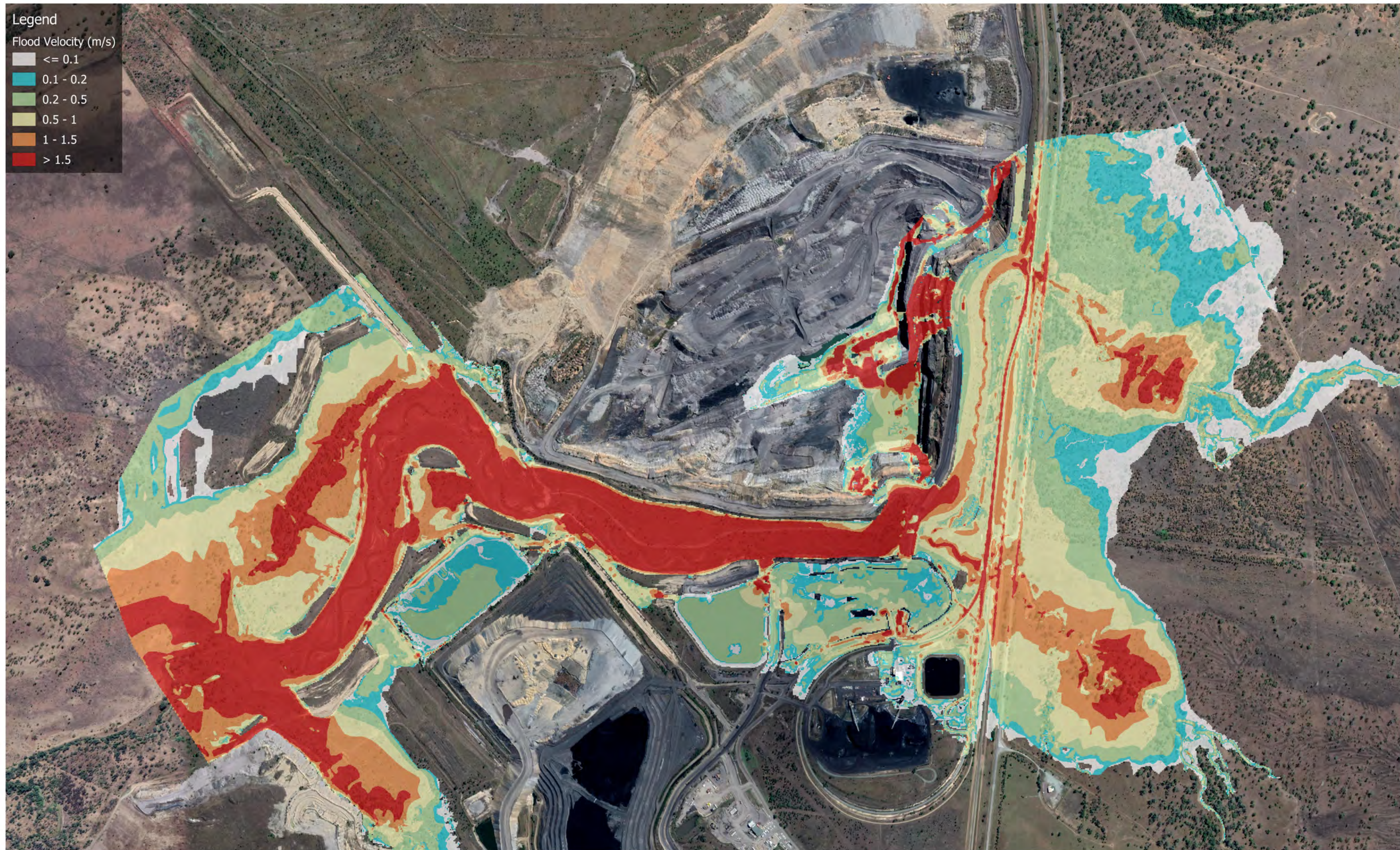
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:1000 AEP Flood Velocity

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.

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Revision: 0
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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
PMF Flood Velocity

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Revision: 0
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Checked: DN
Date: 14 /1 /2022

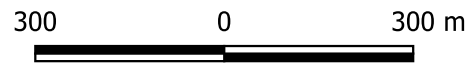
Legend

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 170



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Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:20 AEP Flood Level

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Checked: DN
Date: 6 /8 /2020

Legend

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 170



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:50 AEP Flood Level

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Revision: 0
Drawn: JH
Checked: DN
Date: 6 /8 /2020

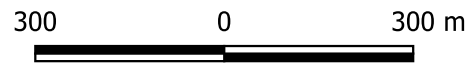
Legend

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 170



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Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Existing Scenario
1:100 AEP Flood Level

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Revision: 0
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Date: 6 /8 /2020

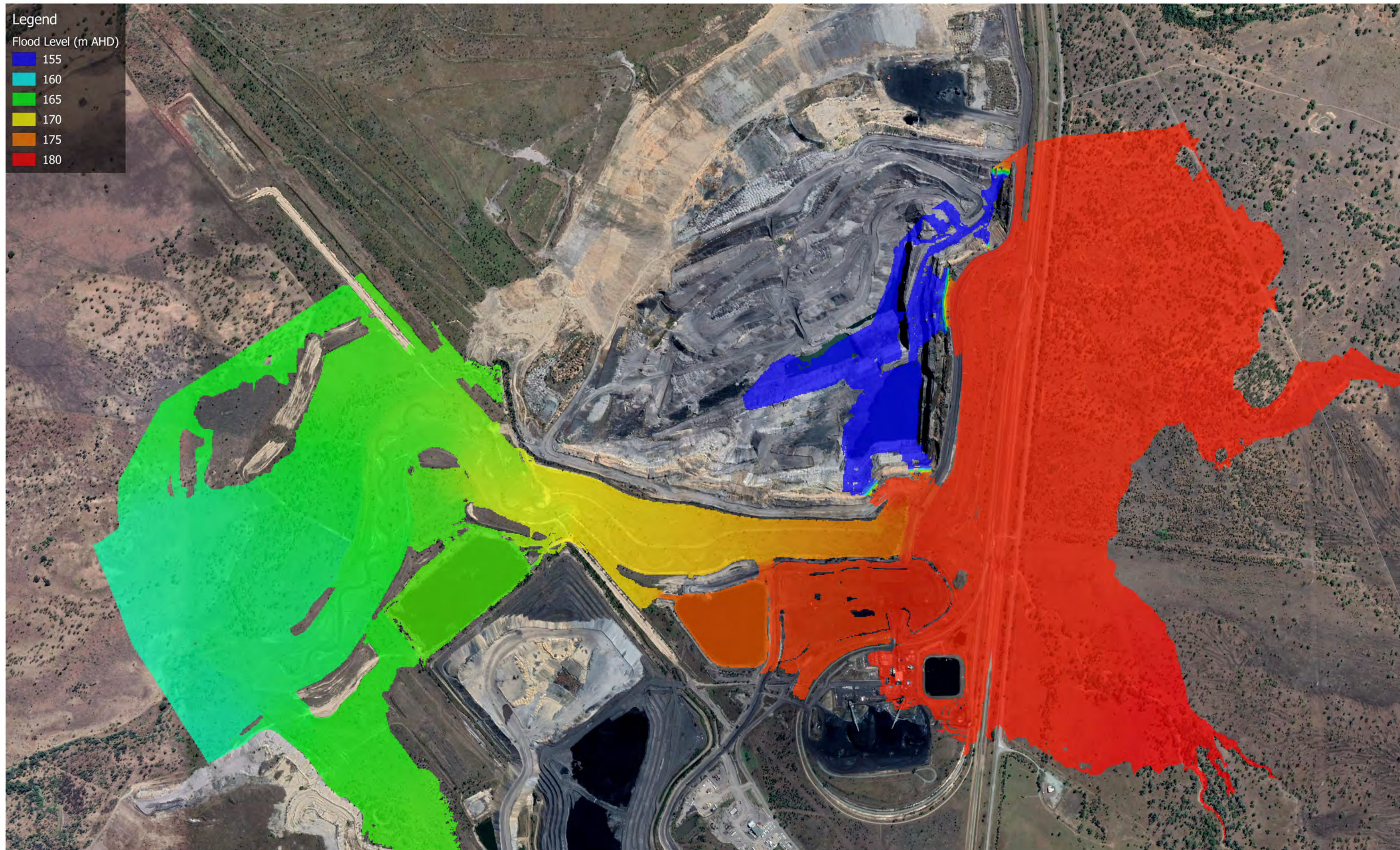


Legend

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 170

Level 2, 500 Queen St Brisbane QLD 4000 PO Box 10183 Brisbane QLD 4000 www.engeny.com.au P: 03 3221 7174 F: 03 3236 2399 E: admin@engeny.com.au 		300 0 300 m  Scale in metres (1:12,000@ A3) Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Vertical Datum: Australia Height Datum Grid: Map Grid of Australia, Zone 55	Sonoma Coal Mine Flood Study Existing Scenario 1:1000 AEP Flood Level	Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.	Job Number: M4100_049 Revision: 0 Drawn: JH Checked: DN Date: 6 /8 /2020
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Legend

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 180

Level 2, 500 Queen St Brisbane QLD 4000 PO Box 10183 Brisbane QLD 4000 www.engeny.com.au P: 03 3221 7174 F: 03 3236 2399 E: admin@engeny.com.au  ENGENY WATER MANAGEMENT	 SONOMA COAL	300 0 300 m Scale in metres (1:12,000@ A3) Map Projection: Tranverse Mercator Horizontal Datum: Geocentric Datum of Australia Vertical Datum: Australia Height Datum Grid: Map Grid of Australia, Zone 55	Sonoma Coal Mine Flood Study Existing Scenario PMF Flood Level	Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.	Job Number: M4100_049 Revision: 0 Drawn: JH Checked: DN Date: 14 /1 /2022
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Appendix E:

Flood Outputs – Baseline Closure Scenario

Legend

● Infrastructure Removed

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
1:1000 AEP Flood Depth

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

● Infrastructure Removed

Flood Depth (m)

<= 0.050

0.05 - 0.20

0.2 - 0.40

0.4 - 0.60

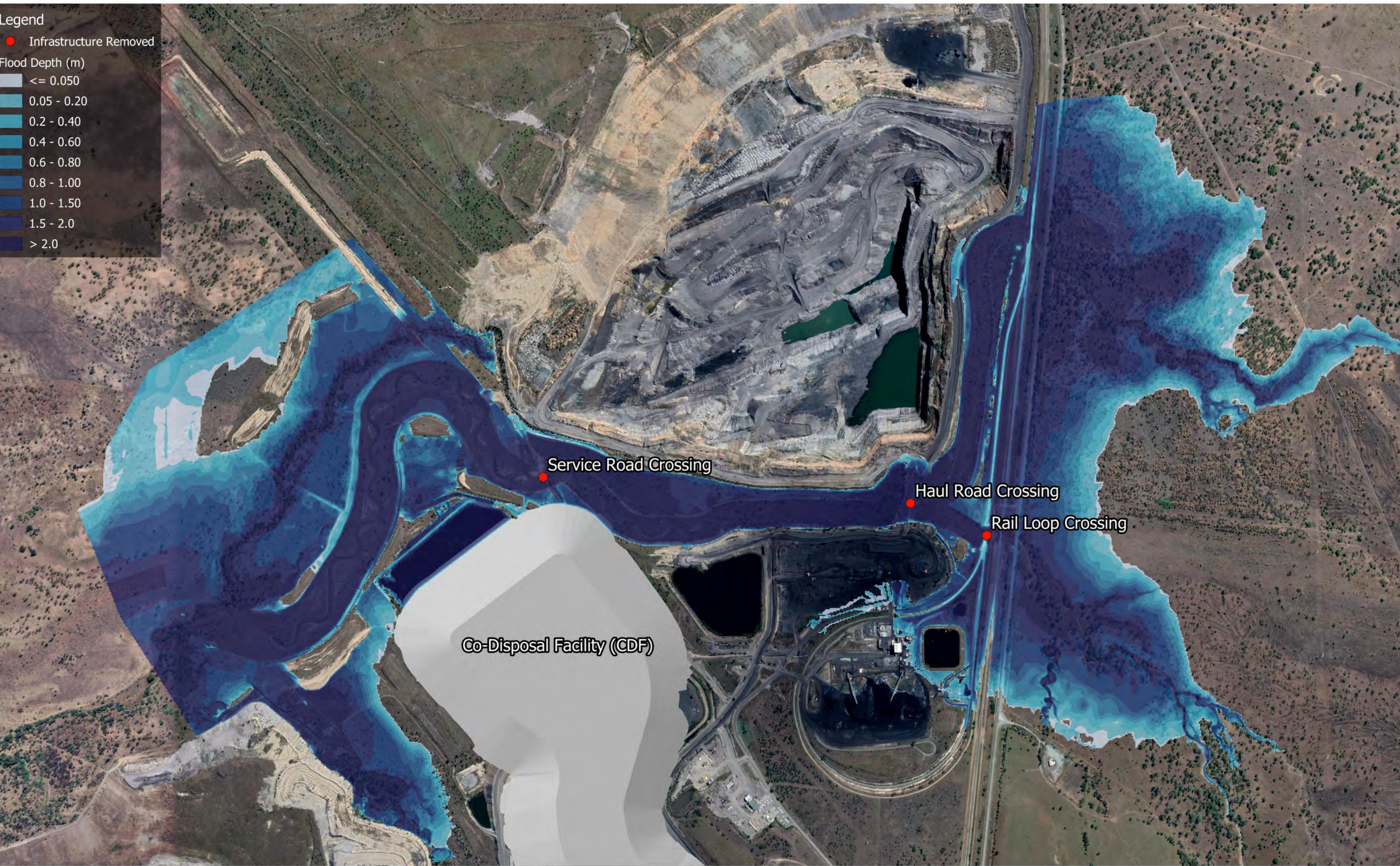
0.6 - 0.80

0.8 - 1.00

1.0 - 1.50

1.5 - 2.0

> 2.0



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300 0 300 m
Scale in metres (1:12,000@ A3)
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
PMF Flood Depth

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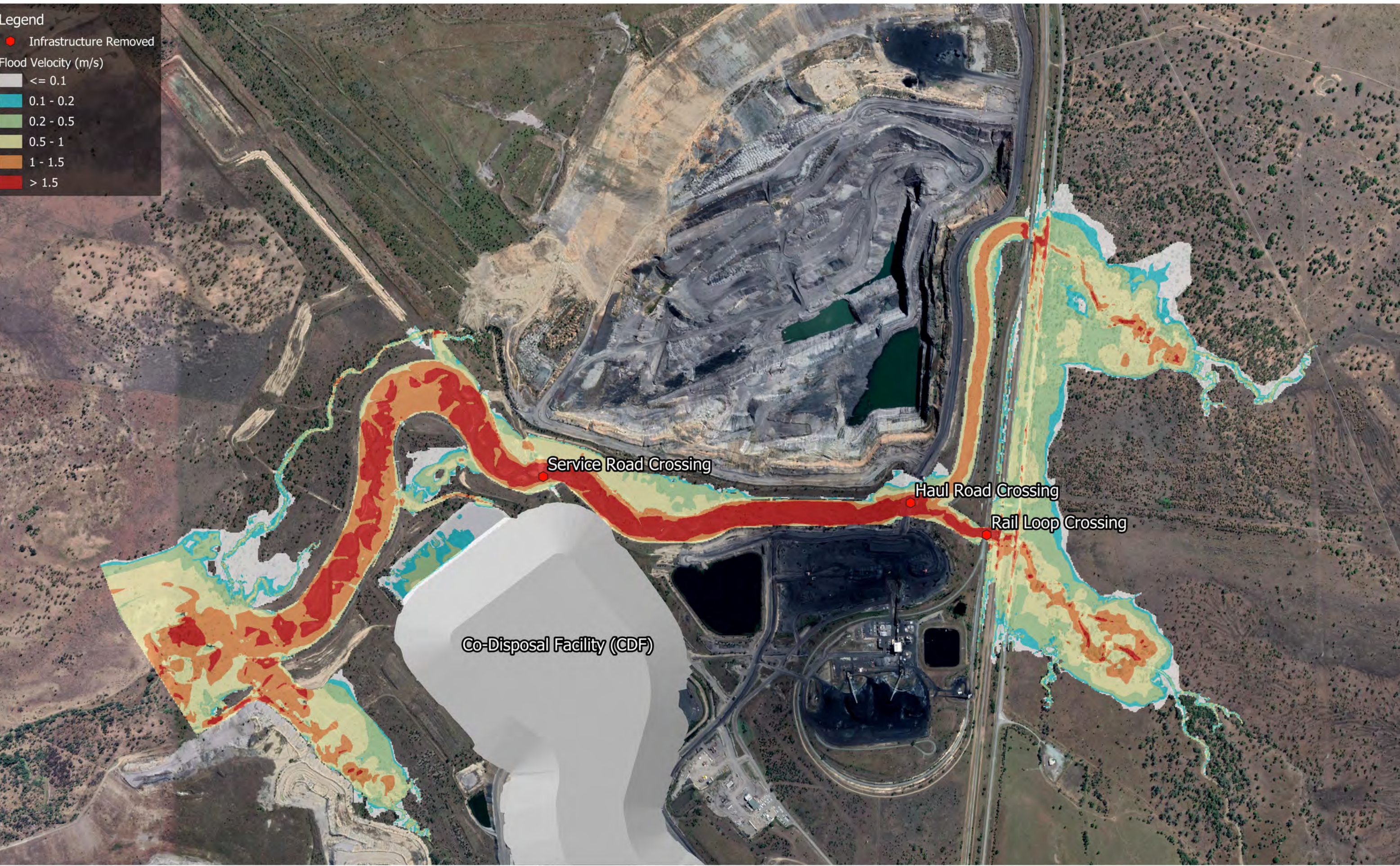
Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

● Infrastructure Removed

Flood Velocity (m/s)

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
1:1000 AEP Flood Velocity

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

● Infrastructure Removed

Flood Velocity (m/s)

<= 0.1

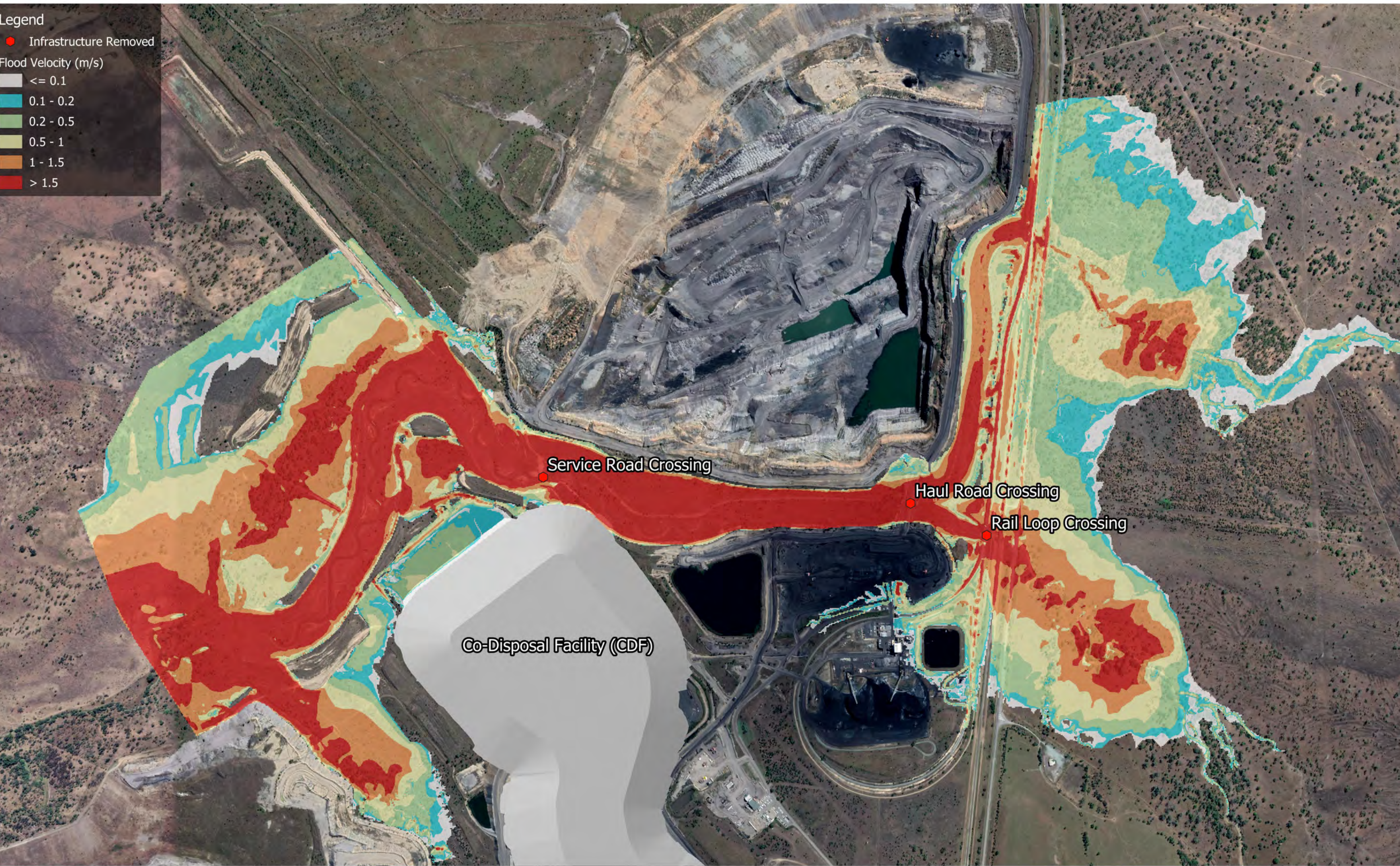
0.1 - 0.2

0.2 - 0.5

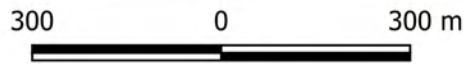
0.5 - 1

1 - 1.5

> 1.5



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Scale in metres (1:12,000@ A3)
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
PMF Flood Velocity

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.

Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

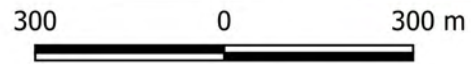
● Infrastructure Removed

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 180



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Scale in metres (1:12,000@ A3)

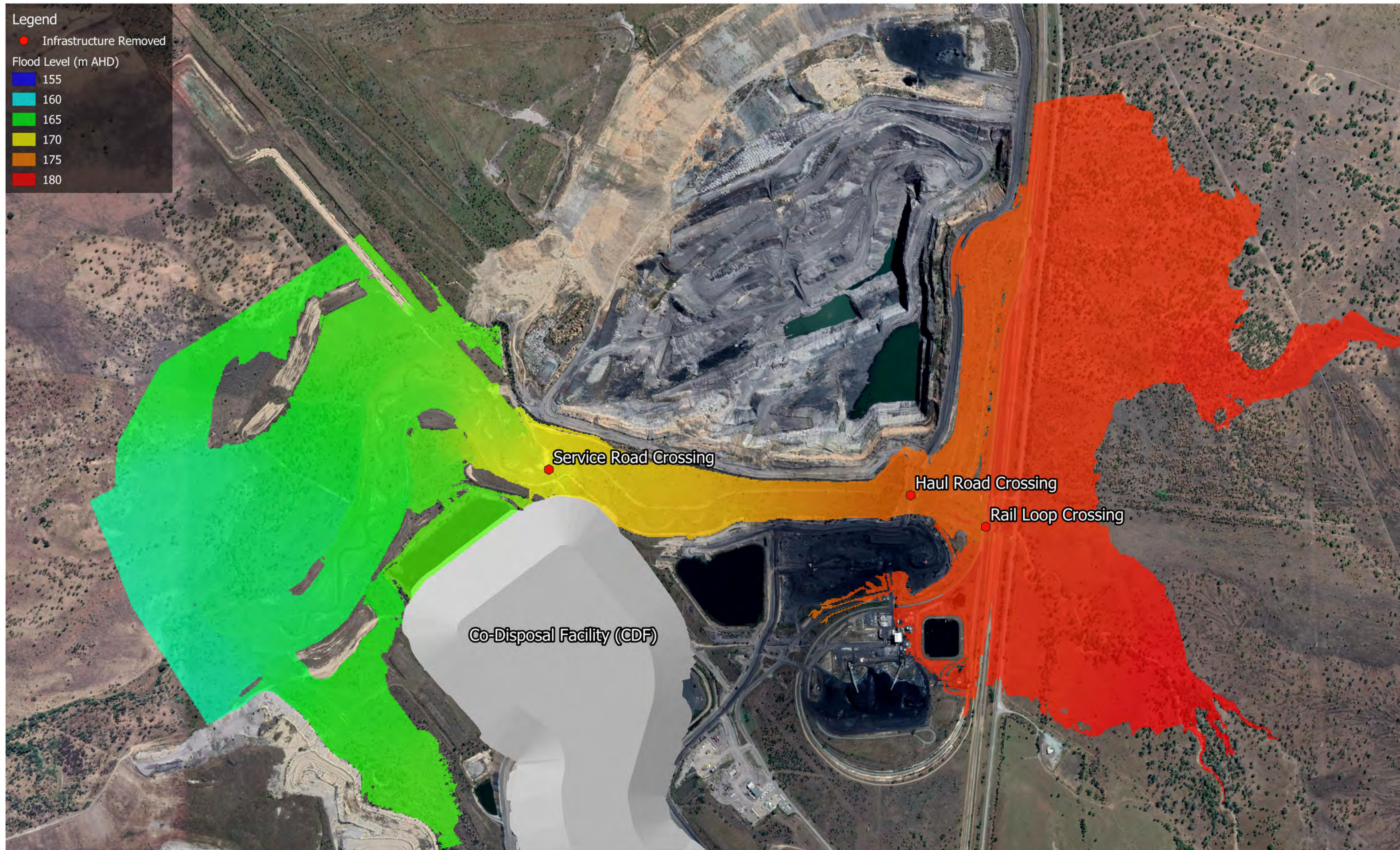
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
1:1000 AEP Flood Level

Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the maps, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works.

Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022



Legend

● Infrastructure Removed

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 180

Service Road Crossing

Haul Road Crossing

Rail Loop Crossing

Co-Disposal Facility (CDF)

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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Baseline Closure Scenario
PMF Flood Level

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Appendix F:

Flood Outputs – Ultimate Closure with Sonoma East Scenario

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Depth (m)

- <= 0.050
- 0.05 - 0.20
- 0.2 - 0.40
- 0.4 - 0.60
- 0.6 - 0.80
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
1:1000 AEP Flood Depth

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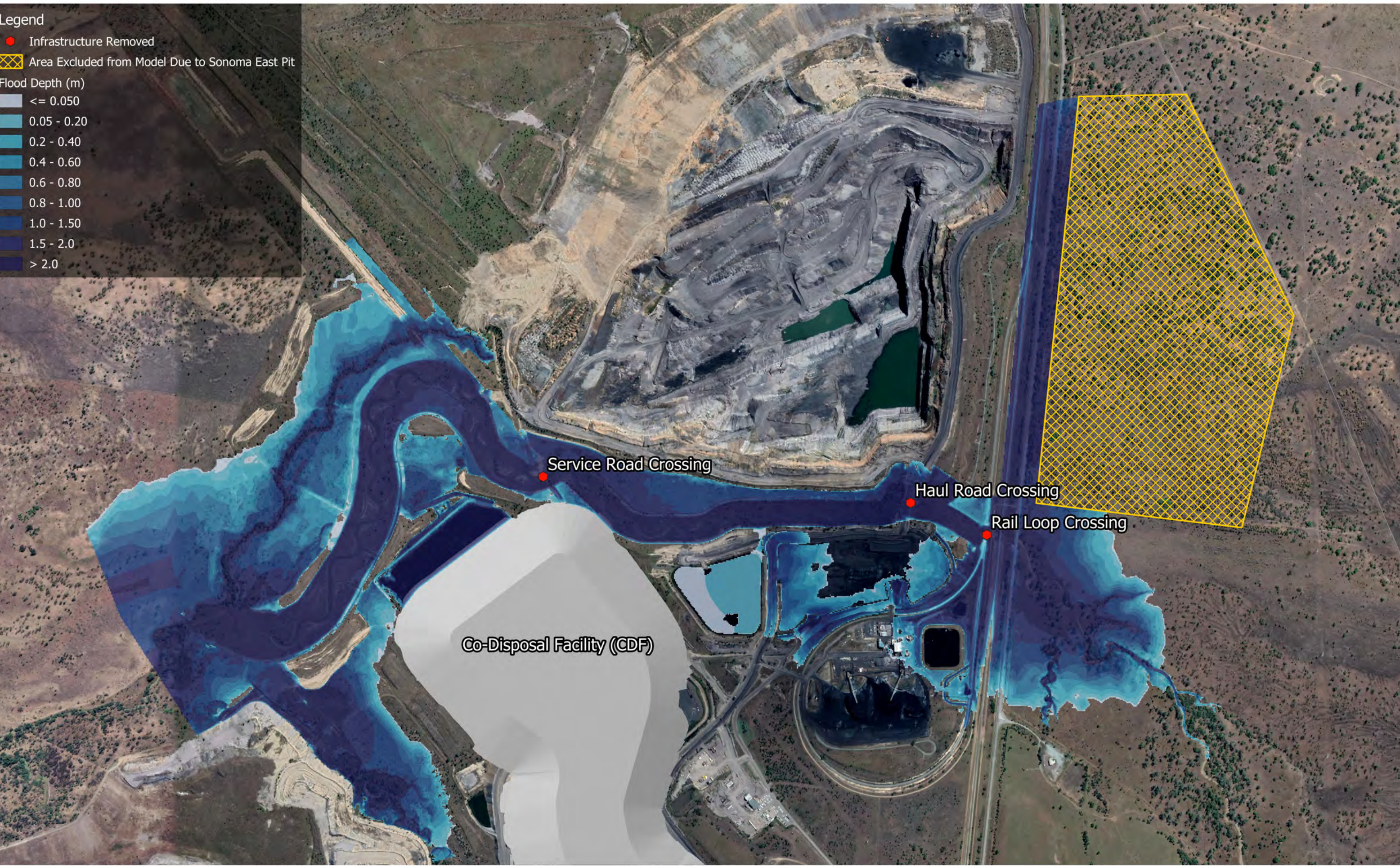
Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Depth (m)

≤ 0.050
0.05 - 0.20
0.2 - 0.40
0.4 - 0.60
0.6 - 0.80
0.8 - 1.00
1.0 - 1.50
1.5 - 2.0
> 2.0



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
PMF Flood Depth

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Velocity (m/s)

- ≤ 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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Scale in metres (1:12,000@ A3)
Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
1:1000 AEP Flood Velocity

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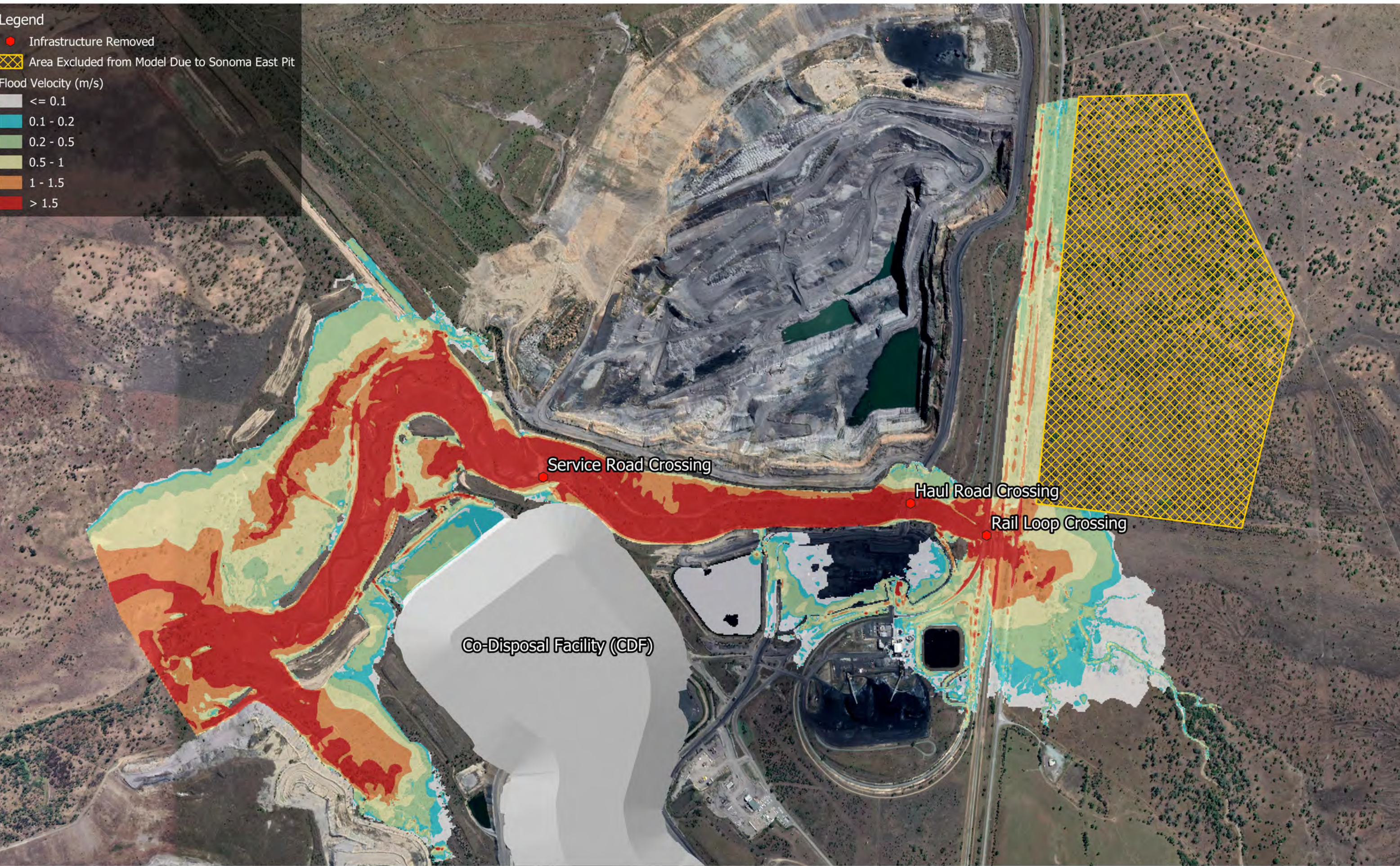
Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Velocity (m/s)

- ≤ 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
PMF Flood Velocity

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 180



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
1:1000 AEP Flood Level

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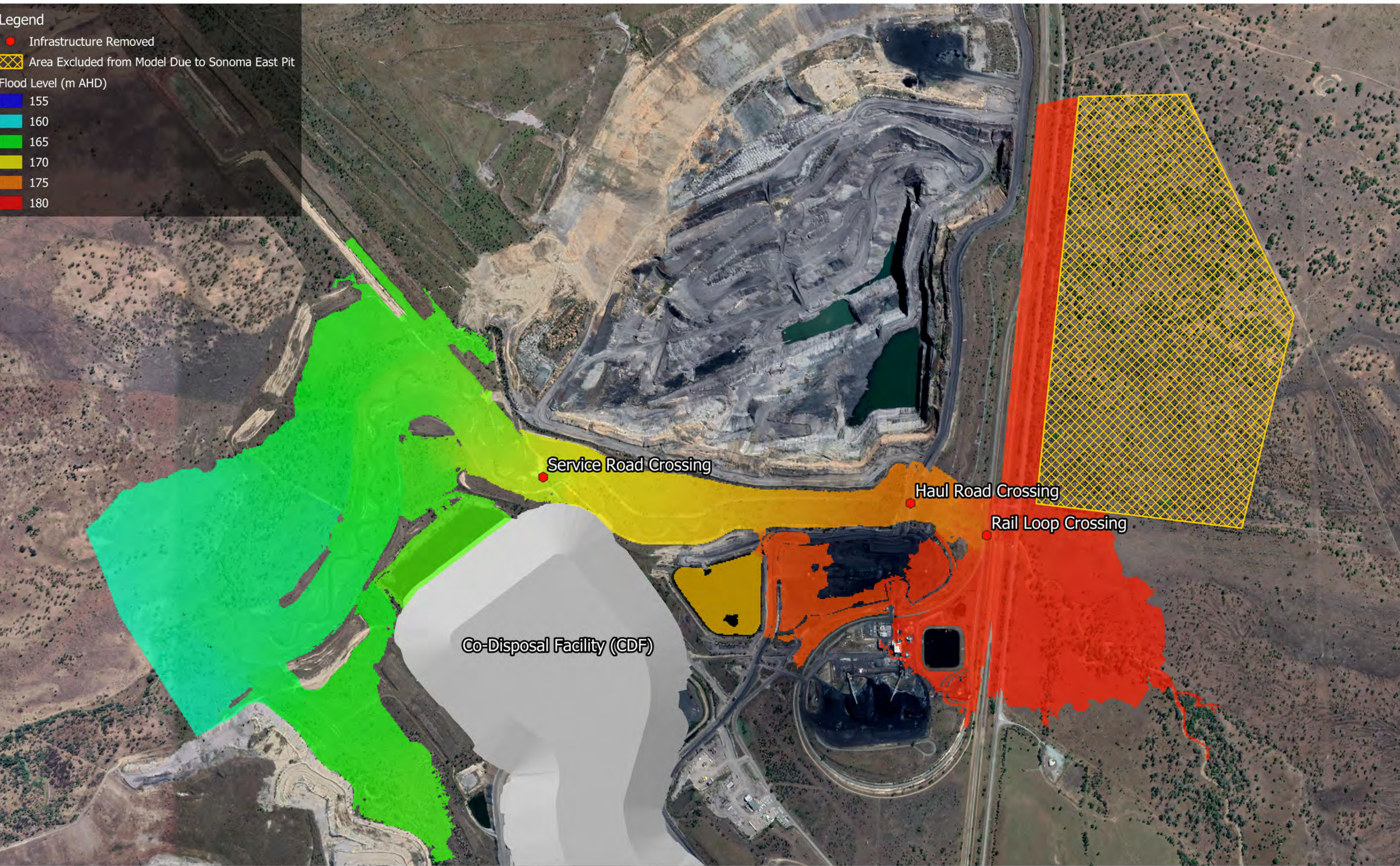
Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022

Legend

- Infrastructure Removed
- ▨ Area Excluded from Model Due to Sonoma East Pit

Flood Level (m AHD)

- 155
- 160
- 165
- 170
- 175
- 180



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300 0 300 m

Scale in metres (1:12,000@ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Sonoma Coal Mine Flood Study

Ultimate Closure with Sonoma East
PMF Flood Level

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Job Number: M4100_049
Revision: 0
Drawn: JH
Checked: DN
Date: 14 /1 /2022



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Appendix E - North Sonoma Creek Diversion Design Plan (Engeny 2018)



Sonoma Mine Management Pty Ltd

North Sonoma Creek Diversion

Design Plan



May 2018

M4100_027

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M4100_027 North Sonoma Creek Diversion Design Report					
\\EGIBRAPP02\management\$\Projects\M4100_Sonoma Coal\M4100_027 Coral Ck Diversion Design\07 Deliv\Docs\Report\Revs\North Sonoma Creek Diversion Design Report_Rev0.docx					
REV	DESCRIPTION	AUTHOR	REVIEWER	APPROVED BY	DATE
Rev 0	Client Issue Final	Sean Frazer	Andrew Vitale	Andrew Vitale	11 May 2018
Signatures					
					

EXECUTIVE SUMMARY

The Sonoma Coal Mine (SCM) is part of the QCoal Northern Hub (QCNH) and is located approximately 10 km south of Collinsville in central Queensland. The mine is operated by Sonoma Mine Management Pty Ltd (SMM). Mining of North Sonoma Pit at SCM is planned to occur within the current Plan of Operations period. North Sonoma Pit is the northern extension of Main Pit and requires the diversion of Coral Creek, which is a defined watercourse under the *Water Act 2000*. The watercourse diversion is referred to as the North Sonoma Creek Diversion (previous nomenclature has referred to the diversion as the “Coral Creek Diversion”).

A diversion design for Coral Creek was previously prepared and certified by BSM Pty Ltd as documented in Design of Coral Creek Diversion (BSM, May 2011) and Design of Coral Creek Diversion Addendum Report (BSM, Nov 2011). A water licence under the *Water Act 2000* (Licence Number 607384 dated 3/12/2012) was granted to QCoal Sonoma Pty Ltd, to construct the diversion in accordance with the certified design.

The Queensland Government approval for the construction of the North Sonoma Creek Diversion (including approval conditions and referenced certified designs), was subsequently transferred from the *Water Act 2000* licence, into the SCM Environmental Authority (EA) EPML00707713 (take effect date 14/9/2017), which is administered under the *Environmental Protection Act 1994 (EP Act 1994)*. Accordingly, Water Licence Number 607384 was surrendered by QCoal Sonoma Pty Ltd (notice dated 6/12/2017).

The certified designs referenced in the diversion approval (the EA), allow for updates or addendums. Since the completion of the original approved certified designs in 2011, design improvements have been identified that have the potential to reduce the capital cost and extent of disturbance, without materially affecting the functionality of the previously approved certified design. Engeny has been engaged to prepare and certify an updated Design Plan for the North Sonoma Creek Diversion (the Design Plan). The Design Plan has been prepared with the goal of achieving a state of dynamic equilibrium with no long-term maintenance requirements once vegetation is established.

The Design Plan has been prepared to comply with the objectives defined in Condition I1 of the EA and the relevant Guideline: Works that interfere with water in a watercourse – watercourse diversion (DNRM, 2014). These objectives are presented below along with a summary of how they have been addressed.

- Outcome 1 – The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
 - The diversion cross section has been designed to replicate the shape of the existing waterway while incorporating riffles which are designed to provide habitat variability and the opportunity for remnant pools to persist following flow events (refer Section 6 of this Design Plan). The revegetation strategy aims to restore and

maintain ecological function and bank stability (refer Section 10 of this Design Plan).

- Outcome 2 – The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
 - The diversion does not adversely impact the hydrological or hydrogeological systems within the Coral Creek catchment (refer Section 5 of this Design Plan).
- 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.
 - Model results indicated that flow characteristics (velocity, bed shear stress, stream power) for the diversion are high relative to guideline values (DNRM 2014, ACARP 2014) but very close to the actual existing natural flow conditions within Coral Creek. The diversion will fractionally decrease upstream flood levels at the Bowen Developmental Road Bridge with a minor improvement to trafficability. The downstream flood characteristics (i.e. peak flow rates, flood levels and flow velocities) are practically unaffected by the diversion (refer Section 5 of this Design Plan).
- 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.
 - Due to the close agreement between existing and diverted flow characteristics (velocity, bed shear stress, stream power) the morphological processes will be well replicated in the diversion (refer Section 5 of this Design Plan).
- Outcome 5 - The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.
 - The diversion has been designed for the expected substrate conditions to be encountered and no ancillary structures are proposed to maintain diversion functionality (refer Section 7 of this Design Plan).

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1. INTRODUCTION

Sonoma Mine Management Pty Ltd engaged Engeny Water Management (Engeny) to prepare a Design Plan for the North Sonoma Creek Diversion at the Sonoma Coal Mine (SCM) which is part of the QCoal Northern Hub mining complex (QNH).

1.1 Background and Purpose of Document

Mining of North Sonoma Pit at SCM is planned to occur within the current Plan of Operations (PoOps) period. North Sonoma Pit is the northern extension of Main Pit and requires the diversion of Coral Creek, which is a defined watercourse under the *Water Act 2000*. A certified diversion design for Coral Creek was previously prepared by BSM Pty Ltd as documented in:

- Design of Coral Creek Diversion (BSM, May 2011) and
- Design of Coral Creek Diversion Addendum Report (BSM, Nov 2011).

A water licence under the *Water Act 2000* (Licence Number 607384 dated 3/12/2012) was granted to QCoal Sonoma Pty Ltd, to construct the diversion in accordance with the certified design.

Since granting of Licence Number 607384, the *Water Act 2000* was amended to provide an exemption from the requirement to gain approval under the *Water Act 2000* for diversions associated with resource activities, which are assessed and conditioned under an environmental authority (EA). Mining proponents may seek approval under this streamlined approach under the *Environmental Protection Act 1994* (*EP Act 1994*) as part of their application for the EA.

The approval for the construction of the North Sonoma Creek Diversion (including conditions and referenced certified designs), was transferred from the *Water Act 2000* licence, into the SCM EA EPML00707713 (take effect date 14/9/2017), which is administered under the *EP Act 1994*. Accordingly, Water Licence Number 607384 was surrendered by QCoal Sonoma Pty Ltd (notice dated 6/12/2017).

Since the completion of the original approved certified designs in 2011, design improvements have been identified that have the potential to reduce the capital cost and extent of disturbance, without materially affecting the functionality of the previously approved certified design.

Condition I5 of the diversion approval (the EA) regarding construction and operation of diversions, requires certification that the diversion is constructed in accordance with, and meets the original intent of, the approved Design Plan. The approved Design Plans are defined in the EA as *Design of Coral Creek Diversion (BSM, May 2011)* and *Design of Coral Creek Diversion Addendum Report (BSM, Nov 2011)*, or *Updates/addendums*

thereof which have been prepared by an RPEQ in accordance with Guideline: Works that interfere with water in a watercourse – watercourse diversion (DNRM, 2014).

This report is an update of the previous Design Plans (BSM, May 2011 and BSM, Nov 2011) to incorporate design improvements and has been prepared in accordance with the requirements of the Guideline: Works that interfere with water in a watercourse – watercourse diversions (DNRM, 2014) (the Guideline). The design approach has been to minimise changes from the previously approved design and is further detailed in Section 2 of this Design Plan. This includes maintaining the horizontal and vertical alignment of the diversion and limiting cross section changes to the upper channel (i.e. >1:100 AEP flood levels). The assessments and findings of the previously licensed Design Plans (BSM, May 2011 and BSM, Nov 2011) have been maintained where appropriate.

The objective of the report is to demonstrate the watercourse diversion design process and satisfaction of the outcomes identified in the EA and the Guideline. The design has been certified in accordance with DNRM requirements by Dr Andrew Vitale (Principal Engineer, RPEQ No. 9341). A copy of the certification statement is included in Appendix A. The design drawings are included in Appendix C.

2. DESIGN BASIS

As previously noted, the design approach has been to minimise changes from the previously licensed design. This has included maintaining the horizontal and vertical alignment of the diversion and limiting cross section changes to the upper channel (i.e. >1:100 AEP flood levels). Consequently, there is no change to the hydraulic behaviour of the diversion channel for more frequent events, including the flood events used to assess the geomorphic and sediment transport characteristics of the diversion (i.e. the 2 year Average Recurrence Interval (ARI) and 50 year ARI events) in the DNRM and ACARP guidelines.

QCoal intends to construct the diversion in the 2018 dry season and open the diversion to flow prior to the start of the 2018-19 wet season. The duration of mining in the North Sonoma Pit is expected to be short (i.e. 1-2 years). The North Sonoma Pit will be back-filled within a period of several years following completion of mining.

2.1 Design Changes

The major design changes from the previously approved diversion design are presented in the design drawings included in Appendix C and summarised as follows:

- **Steepening of upper channel batters:** This change will impact flood behaviour for events exceeding the 1:100 AEP event (events smaller than the 1:100 AEP flood remain unaffected) including increased depths and velocities. The impacts of this change are summarised in Section 5 (of this Design Plan). This change significantly reduces the footprint of the diversion and the extent of disturbance.
- **Remove bench drains and minor chutes:** Due to silting, bench drains are unlikely to be an effective long-term drainage feature of the diversion. Steepening of the upper channel batters has significantly reduced the footprint of the diversion and the length of the upper batter slopes. This in turn has reduced the need for the bench drains and minor chutes.
- **Remove rock lining of perimeter drains:** Design flow velocities in the perimeter drain are low (less than 1.5 m/s). Grass cover is considered to be a suitable surface treatment for erosion protection of the perimeter drains.
- **Lower crest of diversion plugs:** The diversion plug crest was previously set 300 mm above the 1:25,000 AEP flood level. The Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933) requires that regulated levees are designed for the 1:1,000 AEP flood plus freeboard. This change does not impact the hydraulics of the diversion channel but does increase the risk of flooding the pit and damage to the diversion plugs, if a flood exceeding the 1:1,000 AEP occurs prior to backfilling of the pit (very low likelihood given the short period between the diversion construction and the backfilling of the North Sonoma Pit)

- **Reduced extent of clay-liner seepage controls:** The previous design included clay lining of any high permeability alluvial strata exposed in the southern batter slope to militate against potential seepage into the pit. The previous design assumptions include a high level of conservatism and have been refined as described in Section 8 of this Design Plan. It is expected that only a small extent of clay-liner seepage control will be required. This change does not impact the hydraulic behaviour of the diversion channel.
- **Simplified zoning of diversion plugs:** The geotechnical design of the diversion plugs has been simplified and is described in Section 9 of this Design Plan. This change does not impact the hydraulic behaviour of the diversion channel.
- **Amendments to the revegetation strategy:** The revegetation strategy has been simplified to reduce the number of planting zones and refine the species list based upon the latest inspections of the Coral Creek area. The revegetation strategy is detailed in Section 10 of this Design IPan.

2.2 Design Guidelines

There are currently two recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRM and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse – watercourse diversions (DNRM, 2014).
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).

Both the DNRM and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions. Details of the guidelines that have been used to design the North Sonoma Creek Diversion are summarised below.

2.2.1 DNRM Guideline

The diversion design outcome requirements are nominated by DNRM for permanent watercourse diversions and have been used to develop the design for North Sonoma Creek Diversion:

- 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 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 on 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.

Design Criteria

DNRM recommend the following design criteria in development of permanent watercourse diversions and these have been considered in development of the North Sonoma Creek Diversion:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRM Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 2.1 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.

- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Flow velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential however stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

Table 2.1 DNRM 2014 Hydraulic Design Criteria

Design Flow Event	Stream Power (W/m ²)	Velocity (m/s)	Shear Stress (N/m ²)
2-year ARI (no vegetation)	<35	<1.0	<40
2-year ARI (vegetated)	<60	<1.5	<40
50-year ARI	<150	<2.5	<80 ¹

Note 1: DNRM values are taken from ACARP 2002. It is noted that the value reported in DNRM 2014 appears to be incorrect.

2.2.2 ACARP Guideline

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, including an analogous approach (where channel dimensions are selected from a reference reach), a hydraulic geometry approach (where dimensions are determined from regression relationships), and an analytical approach (where equations are used to calculate continuity, hydraulic resistance, and sediment transport, with channel characteristics determined from field inspection of a reference reach).

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be representative of stable watercourses within the Bowen Basin and are summarised in Table 2.2.

Table 2.2 ACARP 2014 Alluvial Channel Design Parameters

Stream Type	Sediment Transport Group	Stream Power 2 yr. ARI (W/m ²)	Stream Power 50 yr. ARI (W/m ²)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 2.3.

Table 2.3 ACARP 2014 Recommended Vegetation Shear Stress Thresholds

Vegetation Type	Design Shear Stress (N/m ²)
Buffel grass	40
Structurally diverse suite of established native vegetation	120

The long-term performance of the diversion under both operating and closure scenarios is also recommended to be assessed. The scenarios and recommended performance objectives are included in Table 2.4.

Table 2.4 ACARP 2014 Threshold Design Events

Consequence of channel scour	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 open cut pit	1:1000 AEP	Probable Maximum Flood

2.3 Diversion Plugs and Flood Levees

The North Sonoma Creek Diversion requires two plugs across the existing creek alignment at the upstream and downstream end of the diversion. The plugs will act as flood protection levees for the North Sonoma Pit and direct creek flows into the diversion. As determined by the hydraulic assessment (refer Section 5 of this Design Plan), no other flood protection levees are required along the remainder of the diversion alignment.

A consequence category assessment (CCA) has been undertaken for the plugs in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures ESR/2016/1933 Version 5.00 (DEHP, Mar 2016) (the Manual) and Condition G1 of the EA. The CCA and resulting design criteria are summarised in Section 3 of this Design Plan.

3. CONSEQUENCE CATEGORY ASSESSMENT

3.1 Methodology

The consequence category of the upstream and downstream diversion plugs was assessed in accordance with the Manual and Condition G1 of the EA.

The Manual requires the assessment of the consequences of the following failure event scenarios:

- 'Failure to Contain – seepage' – spills or releases to ground and/or groundwater via seepage from the floor and/or sides of the structure.
- 'Failure to Contain – overtopping' – spills or releases from the structure that result from loss of containment due to overtopping of the structure.
- 'Dam Break' – collapse of the structure due to any possible cause.

For each failure event scenario, the consequences need to be assessed for the following categories of harm:

- Harm to humans.
- General environmental harm.
- General economic loss or property damage.

The consequence category for each type of harm is assigned based on the severity of harm as defined in Table 3.1 (Table 1 of The Manual).

Table 3.1 Consequence Category Assessment Criteria (Table 1 of the Manual)

Environmental Harm	Consequence Category		
	High	Significant	Low
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected¹. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected¹. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam	Location such that people are not routinely present in the failure path and loss of life is not expected¹. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.

Environmental Harm	Consequence Category		
	High	Significant	Low
		break' scenario.	
	Location such that contamination of waters (surface and/or groundwater ²) used for human consumption could result in the health of 20 or more people being affected ³ .	Location such that contamination of waters (surface and/or groundwater ²) used for human consumption could result in the health of 10 or more people but less than 20 people being affected ³ .	Location such that contamination of waters (surface and/or groundwater ²) used for human consumption could result in the health of less than 10 people being affected ³ .
General Environmental Harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects⁴ on Significant Values are likely; and c) The adverse effects⁴ are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$50,000,000; or ii) Remediation of damage is likely to take 3 years or more; or iii) permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 5 km².	Location such that contaminants may be released so that adverse effects⁴ (that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects⁴ would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$10,000,000 but less than \$50,000,000; or ii) Remediation of damage is likely to take more than 6 months but less than 3 years; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 1 km² but less than 5 km². or b) Would be likely to be caused to environmental	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects⁴.

Environmental Harm	Consequence Category		
	High	Significant	Low
		values classed as slightly or moderately disturbed waters ⁵ , wetland of general ecological significance ⁶ , riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects ⁴ are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$20,000,000; or ii) Remediation of damage is likely to take more than 1 year; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 2 km ² .	
General economic loss or property damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$10 million or greater in rehabilitation, compensation, repair or rectification costs ⁷ .	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$1 million and greater but less than \$10 million in rehabilitation, compensation, repair or rectification costs ⁷ .	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than \$1 million in rehabilitation, compensation, repair or rectification costs ⁷ .

1. 'People routinely present in the failure path' could be considered to be people who occupy buildings or other places of occupation that lie within the failure impact zone. For the purposes of this Manual, this should refer to people other than site personnel engaged by the resource operation and located on the tenements and tenure associated with the resource operation; for other ERAs, it would be the 'premises referred to in the authority'. It should be noted that while this is appropriate for the assessment of consequence categories in accordance with this Manual, adherence to the requirements of this Manual does not limit, amend or change in any way, any other requirements to be complied with under relevant health and safety acts or legislation that requires the safety of site personnel to be considered.

2. When considering potential impacts on groundwater, it is not envisaged that a full hydrogeological assessment will be required in all cases. Any consideration of potential impacts on groundwater systems should consider the water quality of the potential receiving aquifer as well as the quality of fluid stored in the regulated dam. Existing groundwater drawdown in areas surrounding resource operations (e.g. drawdown as a result of mine pit or underground mine dewatering) can also be considered when assessing the consequence of dam seepage on groundwater systems.

3. 'An adverse effect on human health means a physiological effect on human health and does not include an impact on the quality of downstream water that merely negatively affects taste and which is unlikely to cause persons to become physically ill.

4. Adverse effects includes chronic and acute effects where an acute effect is on living organism/s which results in severe symptoms that develop rapidly, and a chronic effect is an adverse effect on a living organism/s which develops slowly. In some instances, it may be necessary to carry out or reference existing ecological/toxicological studies to assess the impacts of contaminants on living organisms.

5. See Water EPP for definitions.

6. Wetland of general ecological significance' means a wetland shown on a map of referable wetland as a 'general ecologically significant wetland' or 'wetland of other environmental value'.

7. This does not include the holder's own mine or gas production, on-site industrial or commercial assets, the holder's workers' accommodation, agricultural facilities on the holder's land such as a farm shed or farm dam or infrastructure solely for servicing the holder.

The consequence category will determine whether the structure is a regulated structure. A structure is only a regulated structure where the consequence category for the structure is 'significant' or 'high'. The overall consequence category of a structure is the highest consequence category determined for any of the categories of harm and failure event scenarios.

3.2 Description of Receiving Environment

The receiving environment for water structures at SCM is described in detail in the site-wide CCA report (Engeny, Jan 2015). The receiving waterways are Coral Creek, Pelican Creek, the Bowen River and the Burdekin River downstream of Lake Dalrymple.

Matters of state environmental significance (MSES) are located along Coral Creek, Pelican Creek and the Bowen River downstream of SCM and are mainly associated with regional ecosystems classified as 'of concern' under the *Vegetation Management Act 1999*.

For the purposes of the State Planning Policy (SPP) biodiversity state interest, Matters of National Environmental Significance (MNES) are those natural matters given statutory protection under *Commonwealth's Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Birralea – Pelican Creek wetland is a nationally important wetland located along the Bowen River approximately 35 km downstream of SCM. However, the Pelican Creek confluence with the Bowen River is the northern (downstream) extent of this wetland and consequently only a small section of the Birralea – Pelican Creek wetland has the potential to receive discharged water from SCM.

The Burdekin-Bowen Junction and Blue Valley Weir Aggregation is another nationally important wetland located at the confluence of the Bowen River and Burdekin River and is located more than 30 km downstream of the Pelican Creek confluence with the Bowen River (more than 65 km downstream of the SCM).

There are several farm buildings and other dwellings located along the receiving waterways. The closest dwelling is located adjacent to Coral Creek approximately 4 km downstream of the North Sonoma Diversion with another seven dwellings located along Pelican Creek up to approximately 20 km from the mine lease area.

There are no third-party assets of significant value along the receiving waterways downstream of SCM.

3.3 Consequence Category Assessment

The consequence category of the diversion plugs was assessed in accordance with Version 5.00 of the Manual. The consequence category assessment is documented in Appendix B. The consequence categories are summarised in Table 3.2.

Certification of the consequence category assessment by the suitably qualified and experience person who performed the assessment is provided in Appendix A.

The diversion plugs been assessed as Significant consequence category structures and are regulated structures.

Table 3.2 Consequence Categories Assessed for Diversion Plugs

Failure Event Scenario	Upstream Plug	Downstream Plug
Failure to contain - seepage	Low	Low
Failure to contain - overtopping	Low	Low
Dam break	Significant	Significant
Overall Consequence Category	Significant	Significant

3.4 Performance Criteria

Based on the results of the consequence category assessment, hydraulic performance criteria for the design of the diversion plugs have been adopted in accordance with the Manual. The hydraulic performance criteria are provided in Table 3.3

Table 3.3 Hydraulic Performance Criteria Requirements

Performance Criteria	Upstream and Downstream Diversion Plugs
Seepage containment and detection	Not required for levees
Wet season containment (DSA)	Not required for levees
Storm event containment (ESS/MRL)	Not required for levees
Spillway capacity	Not required for levees
Flood ingress prevention	1:1000 AEP for levees determined to be regulated structures

4. GEOTECHNICAL INVESTIGATION

4.1 General

Two geotechnical investigations were undertaken within the proposed area of the North Sonoma Creek Diversion in 2010 by both Cardno Ullman & Nolan Geotechnic (Cardno UNG 2010) and Golder Associates Pty Ltd (Golder 2011c).

4.1.1 Cardno Investigation

The Cardno UNG investigation completed in March and April 2010 comprised the following:

- Drilling and Sampling of four (4) boreholes.
 - BH1 to BH4 along the concept North Sonoma Creek Diversion alignment.
 - Standard Penetrometer testing (SPT), undertaken at selected intervals at BH1 only – this was due to the conditions encountered in the other boreholes (Cardno UNG, 2010).
 - Sampling of representative materials and laboratory testing of samples.

Borehole logs and laboratory test certificates from the Cardno investigation can be found in the report *Proposed Coral Creek Diversion Report on Geotechnical Investigation* (Cardno UNG, 2010).

4.1.2 Golder Investigation

The Golder investigation completed in September 2010 comprised the following:

- Drilling of thirteen (13) boreholes and associated installation of piezometers.
 - SO-BH01 to SO-BH12a within the proposed North Sonoma Creek Diversion vicinity.
 - SPT's, undertaken at regular depth intervals for the length of each borehole.
 - Sampling of representative materials and laboratory testing of samples.
- Excavation of eight (8) tests pits.
 - SO-TP01 to SO-TP08 within the proposed North Sonoma Creek Diversion vicinity.
 - Test Pits were excavated using a 35t excavator with a blade bucket to depths of up to 5 m.
 - Sampling of representative materials and laboratory testing of samples.
- In situ constant head permeability testing.

Borehole and test pit logs and laboratory test certificates from the Golder investigation can be found in the report *Coral Creek Diversion Levees and Clay Liner Design Report* (Golder, 2011).

4.2 Results

4.2.1 Subsurface Conditions

General

The general subsurface profile encountered within the vicinity of the North Sonoma Creek Diversion is typically comprised of clay, sandy clay, silty or clayey sand, clayey gravel and cobbles / boulders overlying extremely to slightly weathered sedimentary rock ranging in strength from extremely low to high strength. Weathered rock types encountered beneath the soil sediments included sandstone, siltstone, mudstone, carbonaceous mudstone and siltstone, coal and intrusions of volcanic origin (Golder, 2011).

Diversion Plugs

The subsurface conditions under the proposed diversion plug foundations generally consisted of silty / clayey sand and cobble/boulder mixtures; underlain by sand or sandy gravel, clay and extremely weathered rock grading to competent rock with depth. Rock types encountered below the diversion plugs include coal, siltstone, carbonaceous siltstone and microdiorite intrusions (Golder, 2011).

4.2.2 Standard Penetrometer Testing (SPT)

SPT test results suggest the residual soils across the North Sonoma Creek Diversion area have a consistency ranging from stiff to hard for the cohesive soils and loose to very dense for non-cohesive materials. The consistency of the soil profile was generally observed to increase with depth.

4.2.3 Laboratory Testing

Table 4.1 summarises the laboratory test results from the Cardno UNG and Golder geotechnical investigations undertaken in 2010. Plots of the particle size distributions and plasticity results for the borrow materials are also included in Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4.

Laboratory testing indicates the residual soils within the North Sonoma Creek Diversion area are CLAY to Clayey GRAVEL with a fines component ranging from low to high plasticity CLAY.

The results of the investigations indicate that material within the North Sonoma Creek Diversion excavation will typically be suitable for use as Zone 1 and Zone 3 fill. The majority of tested samples were found to be suitable for use as Zone 1 'clay' fill while only two samples were found to be suitable for use in the coarser Zone 3 fill. A relatively small

amount of laboratory testing was undertaken during the geotechnical investigations, however, and no laboratory testing was undertaken on samples from the weathered rock profile. Due to the large cut quantities involved compared to the relatively small fill quantities the risk of not winning sufficient quantities of suitable fill material from the diversion excavations is considered low.

Table 4.1 Summary of Laboratory Test Results

Test Pit ID	Material Description	Depth (m)	Field Moisture Content (%)	Moisture Density Relationship		Atterberg Limits					Particle Size Distribution (% passing)								Emerson Class (Distilled Water)		
																	37.5 (mm)	19 (mm)		9.5 (mm)	4.75 (mm)
Cardno UNG Investigations																					
BH1	Silty CLAY	0.1 - 0.4				44	24	20	14										4		
BH1	Silty SAND	1.4 – 1.5									100	100	99	97	89	75	50				
BH2	Clayey SAND	1.7 – 4.0				40	20	20	9										4		
BH3	Silty CLAY	0.7 – 1.6				61	25	36	17										4		
BH3	Silty CLAY	3.0 – 4.1				52	24	28	16	1163	100	100	99	97	94	75	50		4		
BH3	Silty CLAY	4.1 – 4.8									100	100	100	100	100	86	64				
Sample A	Clayey SAND										95	86	80	76	73	52	33				
Sample B	Clayey SAND										100	96	92	87	82	61	44				
Sample C	Clayey SILT										100	100	100	100	100	94	75				
Golder Investigations																					
SO-TP01	Clayey SAND	0.8 – 1.2	20.4			45	17	28	15	1876	100	100	99	95	87	67	72		4		
SO-TP02	CLAY	0.8 – 1.0	20.7	1.6	23.5	65	19	46	21	3818	100	100	100	100	98	83	69		4		
SO-TP03	Clayey SAND	4.2 – 4.4	13.6			40	19	21	11	1701	100	99	97	96	94	81	44		3		
SO-TP04	Clayey GRAVEL	1.3 – 1.5	12.3	1.7	17.0						72	60	60	58	56	44	32		4		
SO-BH07	Sandy CLAY	2.5 – 3.0	10.8			34	18	16	8	1552	100	100	100	100	100	97	65		4		
SO-BH08	Sandy CLAY	5.5 – 6.0	9.4			67	18	49	18	4067	100	100	97	93	90	83	51		1		
SO-BH10	Silty SAND	1.0 – 1.5	6.4			24	20	4	3	332	100	100	100	100	100	83	28		4		
SO-BH12	Clayey SAND	1.0 – 1.5	7.4			25	18	7	4	602	100	100	100	99	98	86	39		5		

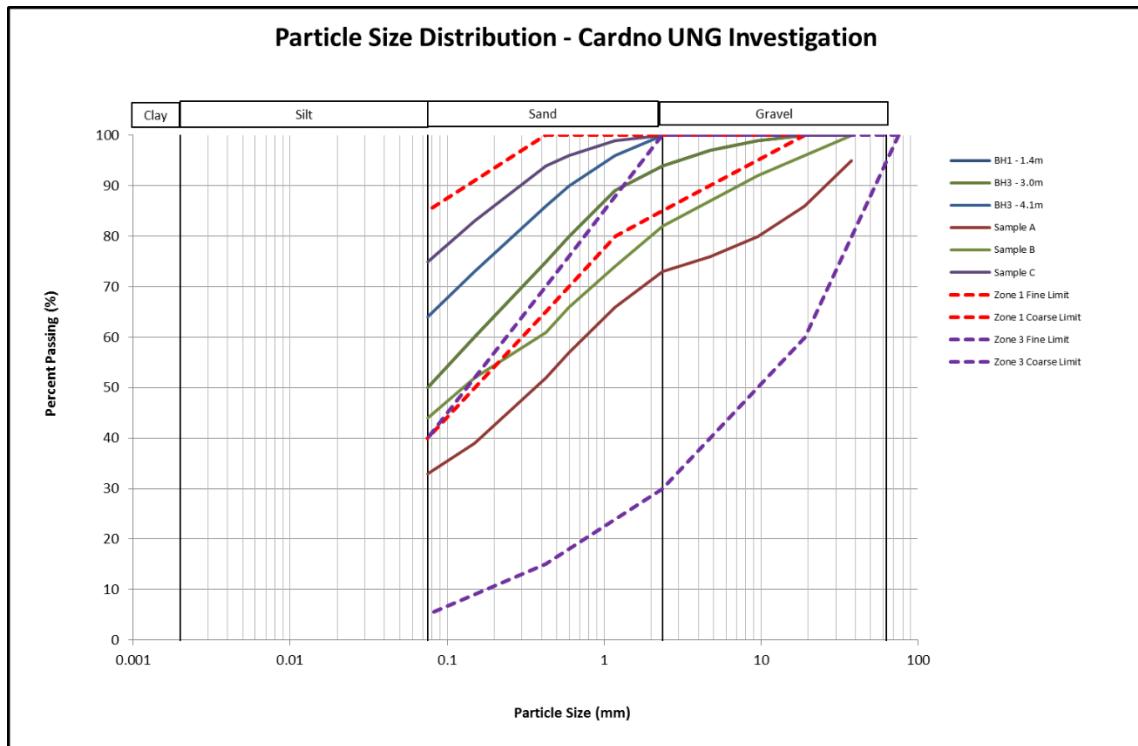


Figure 4.1 Cardno UNG Investigation Particle Size Distribution

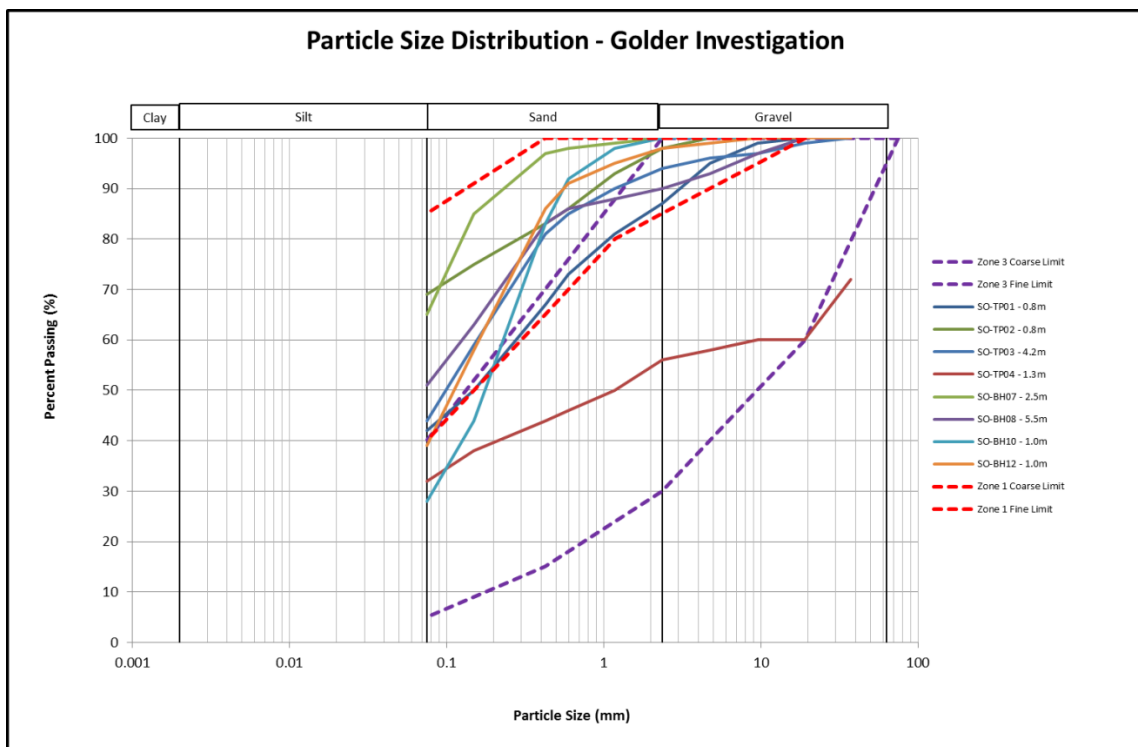


Figure 4.2 Golder Investigation Particle Size Distribution

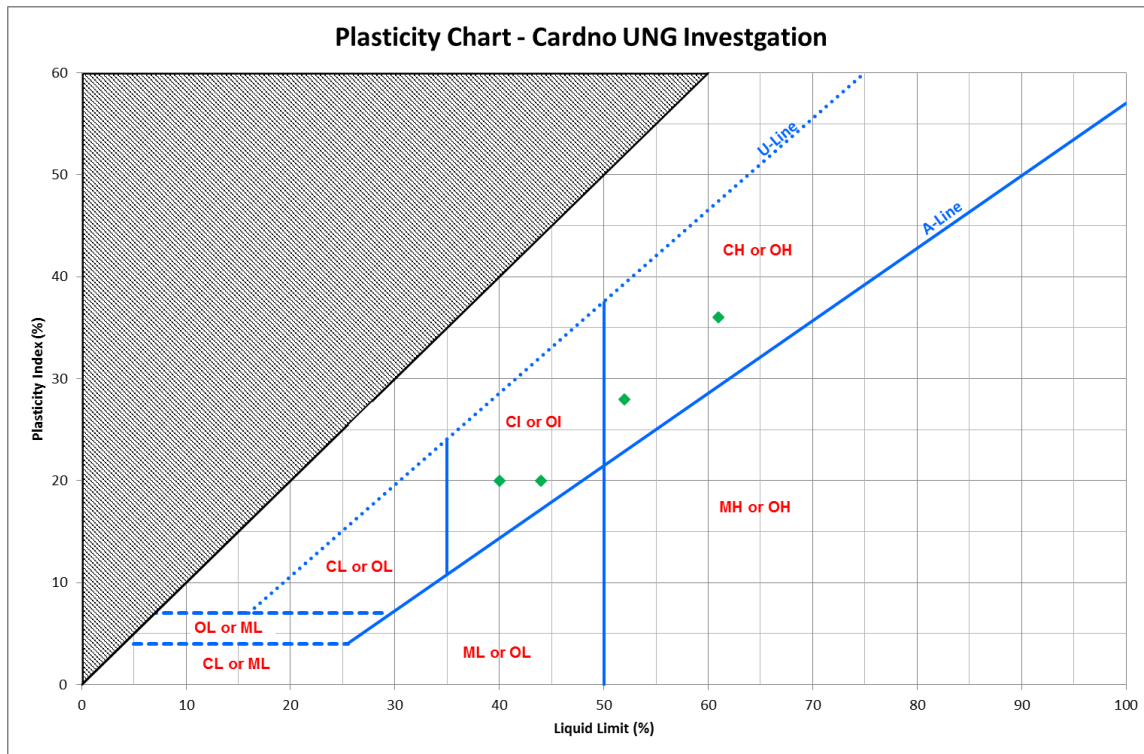


Figure 4.3 Cardno UNG Investigation Atterberg Limits

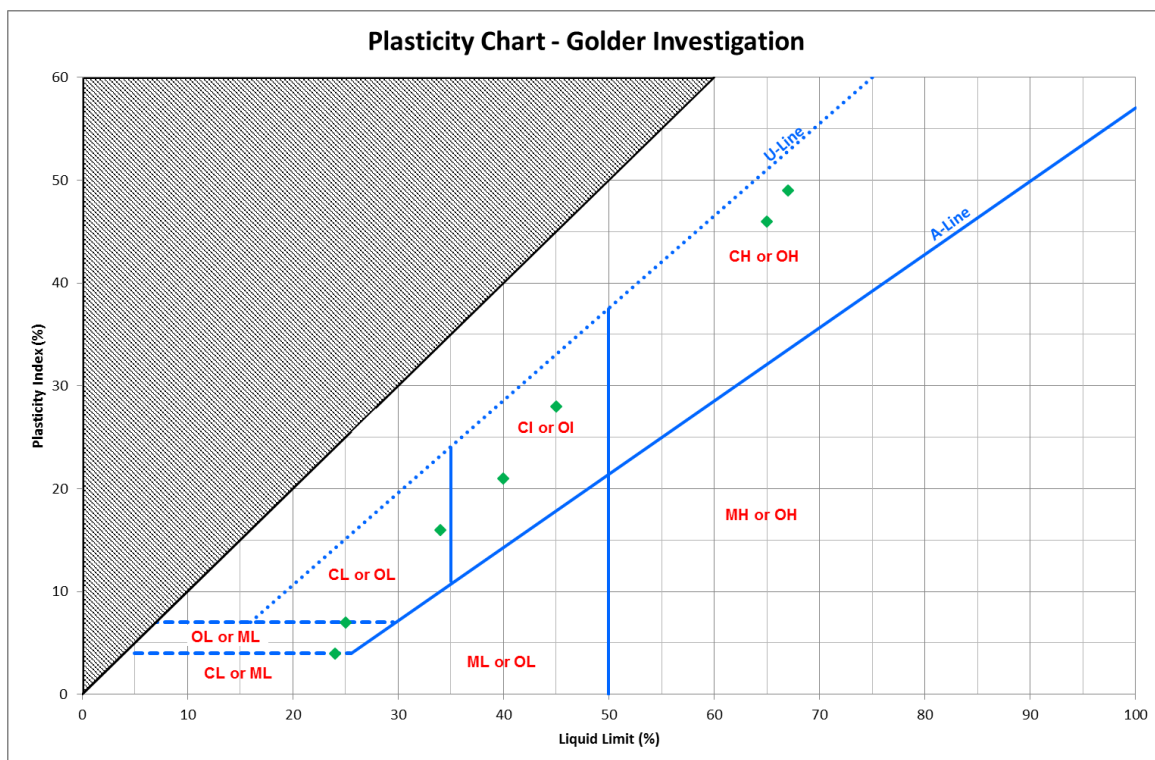


Figure 4.4 Golder Investigation Atterberg Limits

5. HYDROLOGIC AND HYDRAULIC ASSESSMENT

The hydrology and hydraulics of the North Sonoma Creek Diversion have been previously assessed, as documented in Design of Coral Creek Diversion (BSM, 2011). The previous assessments have been updated as part of this Design Plan where required to address the design changes and are summarised in the following sections.

5.1 Hydrology

5.1.1 Design Rainfall

Design rainfall estimates were derived by BSM in accordance with industry standard techniques including Australian Rainfall and Runoff (The Institution of Engineers Australia, 1987, 1999), the Queensland CRC-FORGE project (DNRM, 2005) and the Bureau of Meteorology (2003, 2005). Design rainfalls for the 2 year ARI were determined from ARR (1987,1999) while other events up to and including the 1:1,000 AEP were adopted from CRC-FORGE (DNRM, 2005).

Temporal patterns for events up to the 1:100 AEP were adopted from ARR (1987, 1999) while Probable Maximum Precipitation (PMP) temporal patterns (BOM 2003, 2005) were adopted for larger events.

5.1.2 Design Flow Estimates

The contributing catchment area upstream of the diversion is 107 km². A RORB hydrologic model of the upstream catchment was developed by Gilbert & Sutherland (2011) and calibrated to design flow estimates up to the 1:100 AEP derived in accordance with ACARP (2001) guidelines for creek diversions. The modelled flow estimates were found to match well for larger events with some overestimation for more frequent events (i.e. 2 year and 5 year ARI).

The calibrated RORB model was used to derive design flood hydrographs for the range of events up to the Probable Maximum Flood (PMF). Storm durations ranging from 6 hours to 24 hours were simulated. The critical duration for the 2 year ARI event was found to be the 18 hour event while the critical duration for other flood magnitudes was the 12 hour duration event. The design flood estimates are summarised in Table 5.1.

Table 5.1 Design Flow Estimates

Annual Exceedance Probability (AEP)	Peak Design Flow (m ³ /s) - ACARP	Peak Design Flow (m ³ /s) - RORB
PMF	N/A	2,871
1:1,000	N/A	940

Annual Exceedance Probability (AEP)	Peak Design Flow (m ³ /s) - ACARP	Peak Design Flow (m ³ /s) - RORB
1:100	549	549
1:50	441	453
1:20	314	360
1:10	277	288
1:5	190	237
1:2	80	129

5.2 Previous Hydraulic Assessment

5.2.1 Hydraulic Model

The previous assessment utilised hydraulic modelling undertaken by Water Technology (2011) using a Sobek two-dimensional hydraulic model originally developed by Gilbert & Sutherland. The model utilised a 5 m digital elevation model (DEM) derived from LiDAR survey. The model extended approximately 1 km upstream of the diversion and 5 km downstream of the diversion.

Manning's 'n' roughness values of 0.045 were adopted for the open channel areas and 0.060 on the bank and overbank areas. The roughness value of 0.045 was adopted for the diversion channel in the base case while a reduced roughness of 0.035 was assessed for the "no vegetation" scenario.

A constant tailwater level of 148.4 m AHD was adopted as the downstream boundary condition. The downstream boundary was located a sufficient distance downstream that it would not impact results within the diversion.

5.2.2 Hydrologic and Hydraulic Impacts

Detailed flood modelling results are provided by Water Technology (2011). The diversion channel was found to achieve a reasonably close match to the flow parameters for the existing creek reach to be diverted (i.e. velocity, bed shear stress, stream power) while having negligible adverse impact on flow rates, flow velocities and flood levels upstream and downstream of the diversion.

A summary of the previous findings is provided below.

Upstream Impacts

- The diversion will fractionally decrease flood levels at the Bowen Developmental Road Bridge for events in the range of 1:10 to 1:20 AEP. This will provide a minor improvement to trafficability of this bridge.
- Impacts on flow velocity at both the road and rail bridges are negligible (less than 0.1 m/s change in flow velocity).

Adjoining Impacts

- The nearest adjoining property is the Collinsville airport located to the north of the mine lease. The 1:100 AEP flood extent within the diversion will be approximately 65 m from the lease boundary. Consequently, the diversion will not impact flood susceptibility of that property.
- Given that the diversion channel in this vicinity will be excavated into the underlying sandstones and siltstones to a significant depth, any future migration of the diversion channel via morphological processes is expected to be an extremely slow process. Consequently, the diversion does not pose a threat to the airport.

Downstream Impacts

- The downstream flood characteristics (i.e. peak flow rates, flood levels and flow velocities) are practically unaffected by the diversion.
- The diversion will not intersect the underlying groundwater aquifer (as per GHD, 2010) and is proportionately small relative to the broader Coral Creek catchment. Consequently, the diversion is not expected to have any significant impact on the downstream low-flow or baseflow regimes.

Probable Maximum Flood

- As the North Sonoma Pit will be backfilled within a relatively short timeframe (i.e. several years following completion of mining), the pit does not require protection from the Probable Maximum Flood (PMF) event¹.

5.3 Updated Hydraulic Assessment

As previously noted, the design approach has been to minimise changes from the previously licensed design. This has included maintaining the horizontal and vertical alignment of the diversion and limiting cross section changes to the upper channel (i.e. above the 1:100 AEP flood levels). Consequently, there is no change to the hydraulic behaviour of the diversion channel for more frequent events, including the flood events

¹ Agreed by the former Department of Environment and Resource Management (DERM) at a meeting on 1st July 2010 (BSM, 2011).

used to assess the geomorphic and sediment transport characteristics of the diversion (i.e. the 2 year ARI and 50 year ARI events) in the DNRM and ACARP guidelines.

Steepening of the upper channel batters will impact flood behaviour for events exceeding the 1:100 AEP event. A hydraulic assessment has been undertaken for the 1:1,000 AEP event to determine the impact of this design modification.

5.3.1 Hydraulic Model Development

A hydraulic model of Coral Creek including the diversion reach has been developed in the TUFLOW software. The model extends approximately 1.4 km upstream of the diversion and 2.7 km downstream of the diversion. A 4 m model cell size has been adopted utilising a Digital Terrain Model (DTM) developed by AAM from aerial photography captured in July 2014.

Manning's 'n' roughness values were maintained as per the previous assessment (i.e. 0.045 for the open channel areas including the diversion and 0.060 on the bank and overbank areas). The "no vegetation" scenario was determined to be unnecessary for the very rare events being considered (i.e. 1:1,000 AEP).

The design flow hydrograph for the 1:1,000 AEP event determined from the RORB model (Gilbert & Sutherland 2011) has been applied as the upstream inflow boundary. A normal depth downstream boundary condition has been adopted. The boundary has been located a sufficient distance downstream of the diversion to prevent impacting results in the area of interest. The upstream road and rail bridges have been represented as layered flow constrictions.

5.3.2 Hydraulic Impact Assessment

Two scenarios have been simulated: the previously licensed design and the proposed updated design. This allows the magnitude of flood behaviour (i.e. depth and velocity) of the proposed updated design to be assessed as well as determining the incremental impact of the design modification. Flood events less than or equal to the 1:100 AEP are not impacted by the design modification and as such do not require updated simulations.

The incremental impact (proposed updated design compared to previously licensed design) of the design modification along the diversion and upstream and downstream reaches is plotted in section view (Figure 5.1 and Figure 5.2 for depth and velocity respectively) and plan view (Figure 5.3 and Figure 5.4 for depth and velocity respectively). The absolute depth and velocity for the updated design is presented in Figure 5.5 and Figure 5.6.

Model results indicate that the change of cross section shape will have a minor impact on flood levels in the 1:1,000 AEP event. Flood levels will be generally slightly higher upstream of the diversion and for most of the diversion reach compared to the previously licensed diversion design; with the impacts at the road and rail bridge being approximately 150 mm and 200 mm respectively. These impacts are even smaller relative to existing

flood levels for the 1:1,000 AEP event (130 mm and 180 mm respectively) and are considered acceptable. The design change will have negligible impact on flood levels downstream of the diversion.

The design change will result in a decrease in flow velocities at the upstream road and rail bridges of approximately 0.2 m/s. This reduced velocity will result in a corresponding reduction in the risk of scour at the bridges. The design change will result in a trend towards gradually increased velocities along the diversion (negligible change at the upstream end to 0.2 m/s increase at the downstream end) but with essentially no change within a short distance downstream of the diversion.

Localised velocity reductions are evident at the location of the rock chutes. This is likely due to the chutes not being included in the previous hydraulic model.

The minor increase in flood levels upstream of the diversion corresponds to a small increase to the area of inundation in the 1:1,000 AEP flood event (i.e. generally less than one model cell width). This change will not result in any material increase to the flood risk of third party assets or public infrastructure.

The proposed modification to the diversion design above the 1:100 AEP flood level will not result in any significant impact to flood behaviour for more rare events.

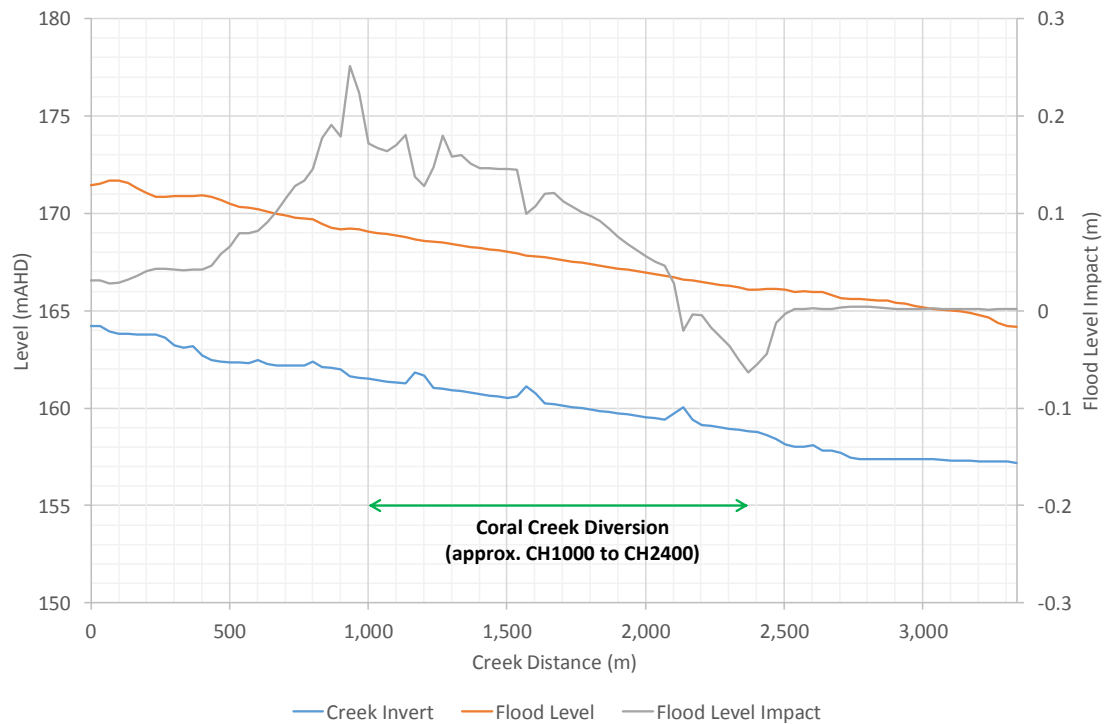
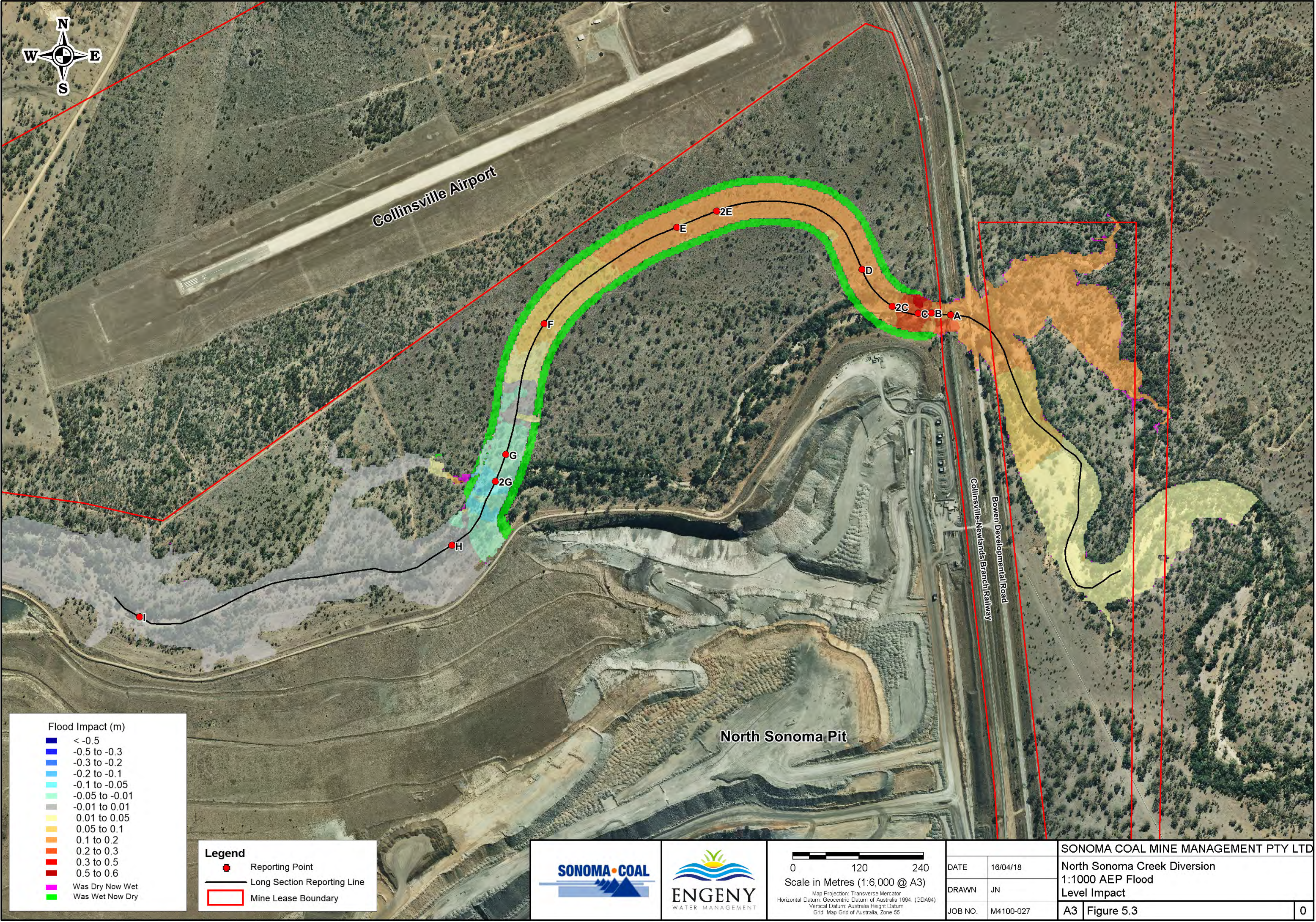
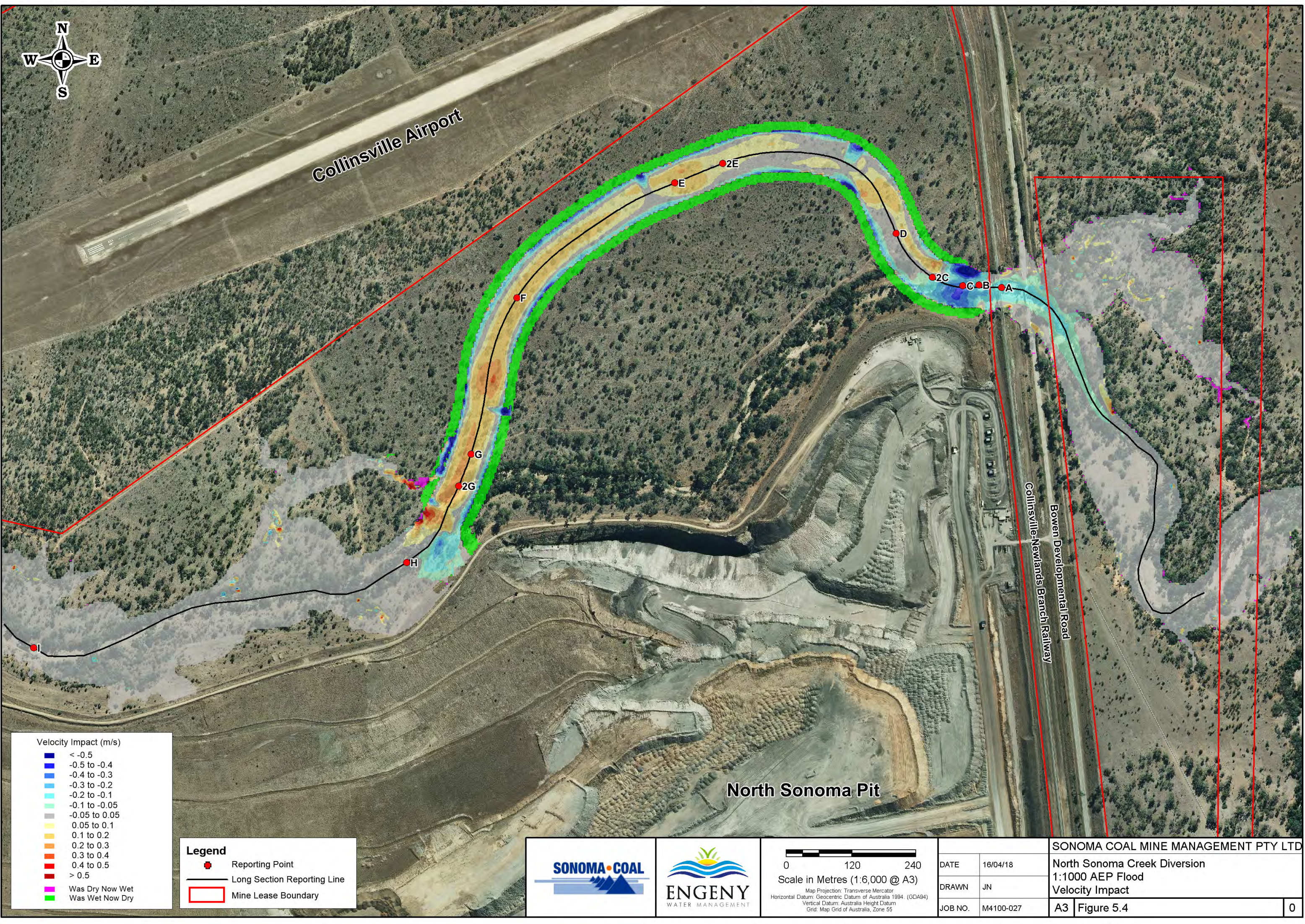


Figure 5.1 Incremental 1:1,000 AEP Flood Level Impact – Long Section



Figure 5.2 Incremental 1:1,000 AEP Flood Velocity Impact – Long Section





Velocity Impact (m/s)

- < -0.5
- 0.5 to -0.4
- 0.4 to -0.3
- 0.3 to -0.2
- 0.2 to -0.1
- 0.1 to -0.05
- 0.05 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5

Was Dry Now Wet
Was Wet Now Dry

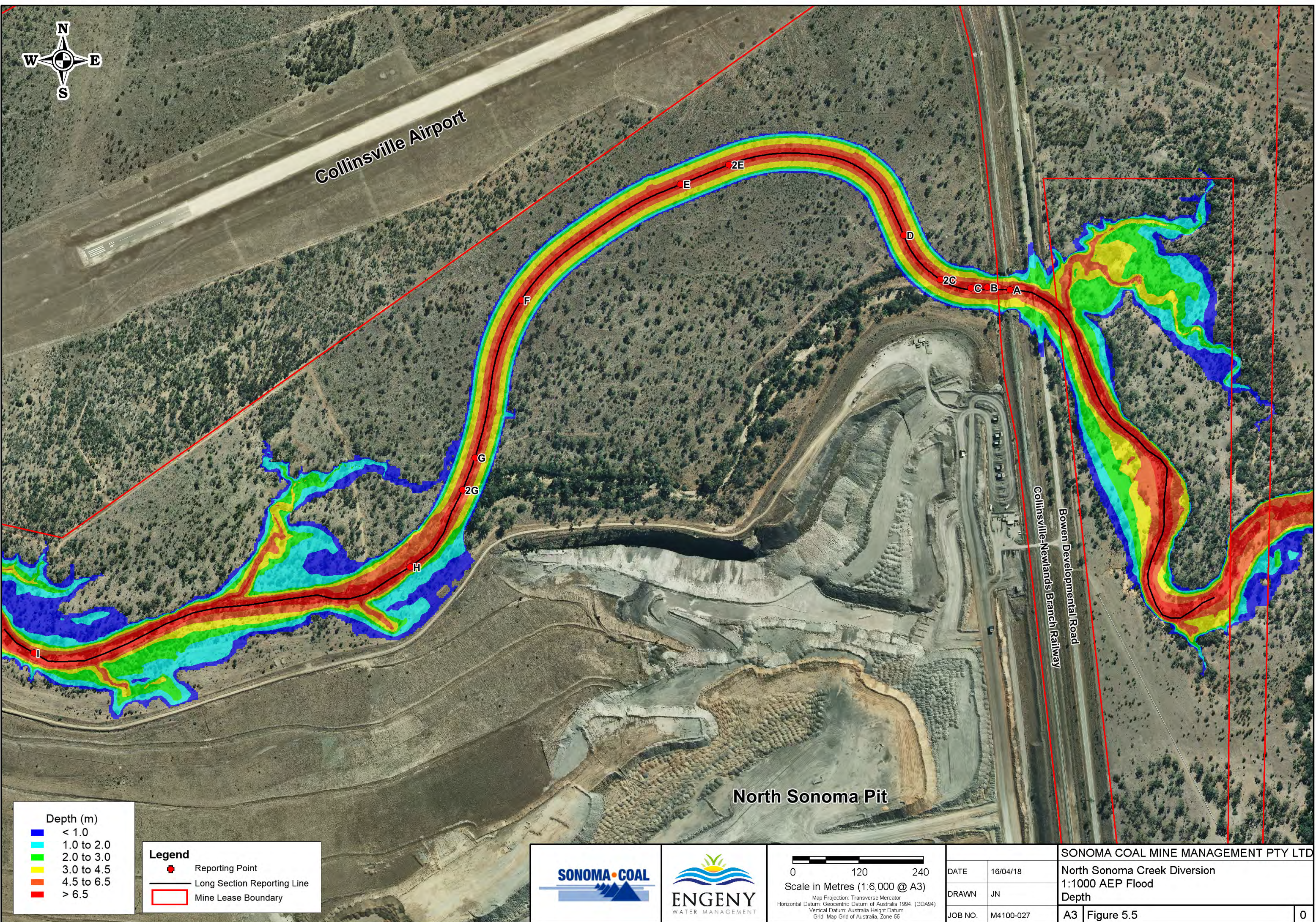
Legend

- Reporting Point
- Long Section Reporting Line
- Mine Lease Boundary



0 120 240
Scale in Metres (1:6,000 @ A3)
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

DATE		16/04/18	SONOMA COAL MINE MANAGEMENT PTY LTD North Sonoma Creek Diversion 1:1000 AEP Flood Velocity Impact	
DRAWN		JN		
JOB NO.		M4100-027		
A3		Figure 5.4	0	



Collinsville Airport

Bowen Developmental Road
Collinsville-Newlands Branch Railway

North Sonoma Pit

Depth (m)

Blue	< 1.0
Cyan	1.0 to 2.0
Green	2.0 to 3.0
Yellow	3.0 to 4.5
Orange	4.5 to 6.5
Red	> 6.5

Legend

	Reporting Point
	Long Section Reporting Line
	Mine Lease Boundary

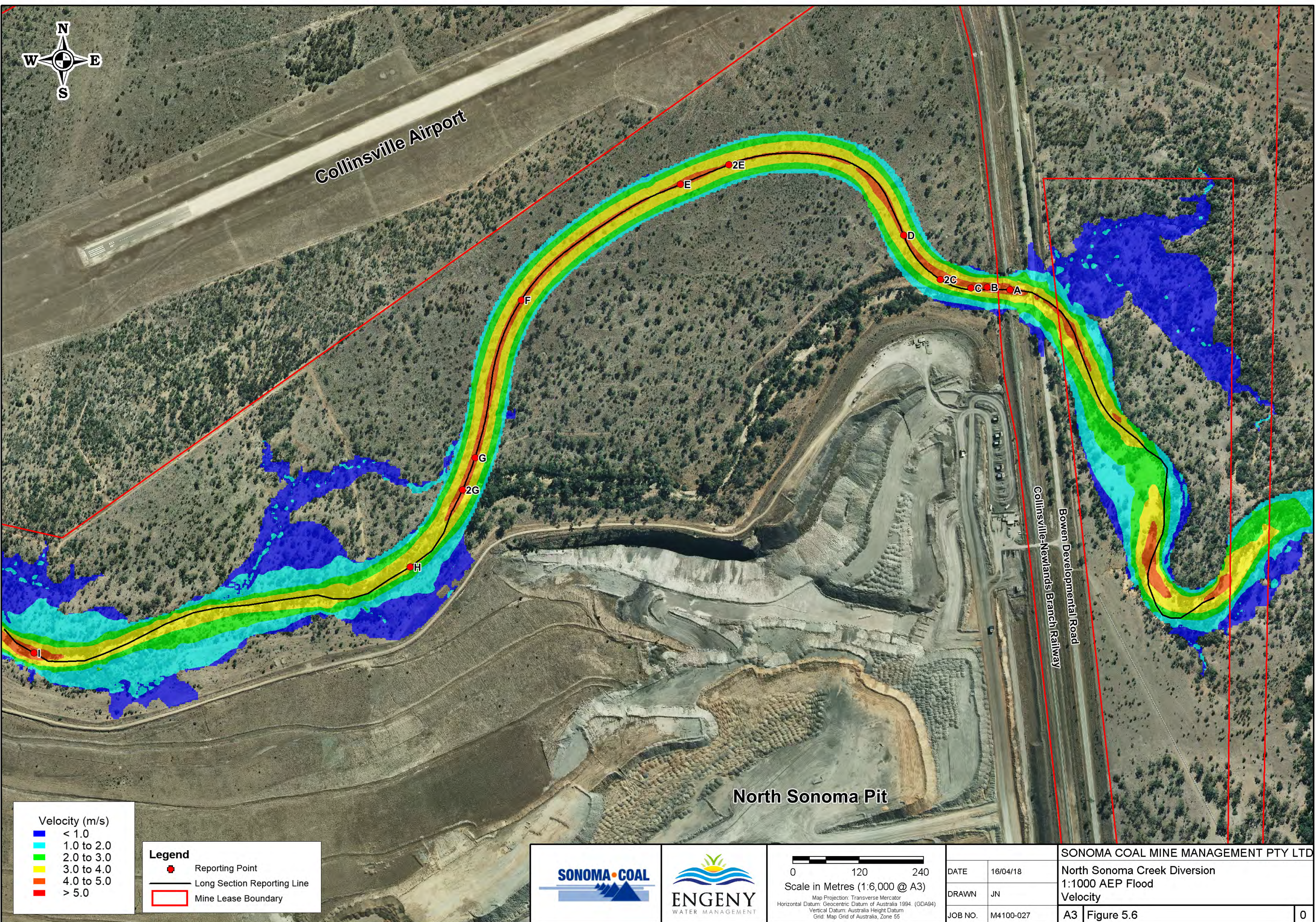


0 120 240
Scale in Metres (1:6,000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

DATE	16/04/18
DRAWN	JN
JOB NO.	M4100-027

SONOMA COAL MINE MANAGEMENT PTY LTD		
North Sonoma Creek Diversion		
1:1000 AEP Flood Depth		
A3	Figure 5.5	0



Collinsville Airport

North Sonoma Pit

Bowen Developmental Road
Collinsville-Newlands Branch Railway

Velocity (m/s)

- < 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- > 5.0

Legend

- Reporting Point
- Long Section Reporting Line
- Mine Lease Boundary

0 120 240

Scale in Metres (1:6,000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

DATE	16/04/18	SONOMA COAL MINE MANAGEMENT PTY LTD	
DRAWN	JN	North Sonoma Creek Diversion	
JOB NO.	M4100-027	1:1000 AEP Flood Velocity	
		A3	Figure 5.6
			0

6. MORPHOLOGICAL ASSESSMENT

The Morphological Assessment of the previously licensed design is presented in Chapter 4 of Design of Coral Creek Diversion (BSM, 2011). Specialist advice and certification of the assessment was provided by A. Markham (Director, Hydrobiology (Qld) Pty Ltd).

The previous assessment has been reviewed. The following sections provide a summary of key extracts from BSM (2011) with revisions relevant to the updated design where required.

6.1 Geomorphology of the Existing Waterway

The morphology of streams of the Bowen Basin is generally varied and complex, with streams exhibiting a variety of erosion and deposition features, of both contemporary and historic origin. Two broad groups of fluvial landforms are currently observed: Incised and Complex. Coral Creek corresponds most closely to the Incised channel type, which comprises incised, single-threaded channels with a meandering form.

Fluvial processes are generally driven by larger and more infrequent floods. These events can change channel form through the erosion, transport and subsequent deposition of sediment. Depositional features including benches and mid channel deposits are often observed. Other features typical of regional streams can include erodible banks, high sediment loads and a large amount of flood-derived timber debris within the channel.

Coral Creek is an ephemeral creek which flows mostly in direct response to rainfall events but is also likely to experience some residual flow following particularly wet periods, where rainfall saturates the alluvial material within the creek banks, which seeps back into the creek sub-surface following cessation of surface flow. The existing channel consists of an incised/confined flood channel with a minor network of near channel flow paths. Large medial and side bars (i.e. “riffles”) exist in the flood channel at a spacing of roughly 100 to 150 m. The presence of these features indicates sediment bedload movement and temporary deposition processes within the incised channel. Limited scouring of the bed and re-deposition would be likely to occur under moderate to high flows. Other morphological features include temporary benches, pools and rock outcrops.

Field inspection indicated that bank material and condition are variable with residual soil overlying strata containing intermittent rock outcropping. Bed material is spatially variable, consisting of sand and gravel size fractions. The planform of the channel is gently meandering.

6.2 Morphology of the Diversion Channel

The key features identified in the morphological assessment of the existing creek have been incorporated in the design of the diversion channel in accordance with ACARP (2001) and NRW (2008). The key objectives of the design are to (NRW, 2008).

- Maintain channel capacity
- Maintain channel length
- Replicate existing watercourse features
- Manage out of channel (floodplain) flows
- Assess erosion and stability, and
- Ensure integrity of upstream and downstream reaches and transition zones

These objectives have been achieved by:

- The cross section of the designed channel is symmetrical and includes a low-flow channel with a base width of 8.2 m, a depth of 3.7 m and channel side slopes of 1V:4H, set below a bench width of 5.5 m. This is consistent with the existing channel cross section form. The flow capacity of the low flow channel is the 2 year ARI design discharge.
- The planform encompasses a single broad meander bend of variable curvature. The length and longitudinal gradient of the existing creek and diversion are summarised in Table 6.1 below. The diversion reach is slightly flatter than the existing creek due to the increased length (approximately 20%).
- The design incorporates 3 riffle features (i.e. medial bars), which are designed to provide habitat variability and the opportunity for remnant pools to persist following flow events. Each riffle is 100 m long and occupies the width of the low flow channel to a depth of 750 mm. Capping of the riffle structure is provided by screened cobbles from the existing creek bed to better represent the existing bar surface.

Table 6.1 Comparison of Design and Existing Channel Gradient

Item	Existing	Design
Length (m)	1,248	1,503
Slope (m/m)	0.0023	0.0019

6.3 Verification of Hydraulic Performance

The hydraulic performance of the diversion was previously assessed for flow velocity, bed shear stress and stream power. Industry guidelines for watercourse diversions have been reissued over time with newer versions released since the original Design of Coral Creek Diversion (BSM, 2011). The recent evolution of the guidelines is summarised as follows:

- The previous assessment utilised the NRW (2008) guidelines, which were derived from ACARP (2001).
- NRW (2008) was updated as DERM (2011) with no change to guideline hydraulic parameters.
- DNRM (2014) adopted guidelines values from ACARP (2002) which are summarised in Section 2.2.1 of this report.
- ACARP (2014) developed revised design parameters, with variation provided for different channel types (i.e. alluvial or bedrock controlled). These are summarised in Section 2.2.2 of this report.

Hydraulic model results indicated that the flow characteristics (velocity, bed shear stress and stream power) in the existing Coral Creek for both the 2 year ARI and 50 year ARI events are generally high relative to other streams in the region and exceed the guideline values. It was determined that this was due to the combined effect of the incised nature of the stream and the lack of floodplain conveyance capacity. For this reason, the emphasis for design has been to ensure that flow characteristics for the diversion design replicate the flow characteristics of the existing creek.

Key aspects of the geomorphology of the diversion design are presented in the following sections.

6.3.1 Diversion Reach

Previous model results indicated that flow characteristics (velocity, bed shear stress and stream power) for the diversion are high relative to guideline values but very close to the actual existing natural flow conditions. Results for the diversion are marginally less than the existing natural channel due to the flatter grade of the diversion. The relatively high velocity results indicate that while bars and bench features may be expected to deposit following flow events, they are likely to be transient in nature and will be moved through the reach with subsequent flows. It was concluded that due to the close agreement between existing and design flow characteristics the morphological processes will be well replicated in the diversion.

6.3.2 Upstream and Downstream Reaches

Model results also indicated minimal change to flow characteristics in the upstream and downstream reach. Therefore, no changes to morphological processes in the downstream waterways (including the Birralelee-Pelican Creek Wetland Aggregation) are expected.

6.3.3 Durability of In-situ Rock

Further work was presented in Design of Coral Creek Diversion Addendum Report to address queries raised regarding the durability of in-situ rock. Key findings of that assessment are summarised below.

Flow velocities in the diversion channel for the unvegetated scenario were found to be approximately 10 % higher than the vegetated scenario. However, it was noted that this does not signify a major departure from the frequencies at which the resulting velocities would have occurred over the exposed rock in the existing channel.

Advice from geotechnical consultants, Golder Associates (2011b), indicated that the drill core recovered showed no indication that the newly exposed rock in the diversion would be any more susceptible to erosion than the rock that is currently exposed in the existing creek reach. The exposed rock is therefore generally expected to be adequately durable. The diversion design includes provision for the stabilisation of sections of exposed rocks that are assessed by the inspecting engineer as unlikely to withstand the expected flow velocities.

7. DIVERSION DESIGN

7.1 Cross Section Shape

The original design of the diversion (BSM, 2011) was focussed on determining a cross section that mimics the typical cross section shape of the existing Coral Creek channel and floodplain. By maintaining a similar cross section shape, the flow characteristics (i.e. velocity, bed shear stress and stream power) within the diversion can be maintained at similar values to the existing channel and changes to the flood and sediment transport regime upstream and downstream are minimised.

The updated design has maintained the same cross section shape up to the 1:100 AEP flood level and adopted a steeper batter slope (1V:4H) above this level. Hydraulic modelling indicates that this change does not result in any significant impact to flood behaviour for more rare events. Cross section geometry is summarised in Table 7.1.

Table 7.1 Cross section geometry

Parameter	Value
Low flow channel base width	8.2 m
Low flow channel batter	1V:4H
Low flow channel top width	37.8 m
Bench width	5.5 m
Bench cross fall	3%
High flow channel batter	1V:4H

7.2 Horizontal Alignment and Longitudinal Grade

The horizontal alignment and longitudinal gradient of the diversion has been maintained as per the previously licensed design. As summarised in Section 6.2 of this Design Plan, the planform encompasses a single broad meander bend of variable curvature. The length of the diversion is 1,503 m with a longitudinal gradient of 0.19%. The diversion is slightly flatter than the existing creek due to the increased length (approximately 20%).

7.3 Geomorphology and Habitat Features

The geomorphology and habitat features of the diversion are detailed further in other sections of this Design Plan. In summary:

- **Stability – refer Section 4:** Much of the length of the diversion channel will be excavated into the underlying sandstones and siltstones to a significant depth. It is expected that any future migration of the diversion channel due to erosion, would be an extremely slow morphological process. The remainder of the low flow channel and diversion plugs will be rock armoured to provide stability (refer Section 7.5).
- **Riffles – refer Section 6:** The design incorporates 3 riffle features (i.e. medial bars), which are designed to provide habitat variability and the opportunity for remnant pools to persist following flow events. Each riffle is 100 m long and occupies the width of the low flow channel to a depth of 750 mm. Capping of the riffle structure is provided by screened cobbles from the existing creek bed to better represent the existing bar surface.
- **Revegetation – refer Section 10:** The revegetation strategy aims to restore and maintain ecological function and bank stability. Root systems from trees and shrubs provide much of the erosion resistance for channel widening from the shear stresses of flowing water, while groundcover species protect the soil surface from splash erosion and overland flows during rainfall events.

7.4 Diversion Plugs and Clay Liner

The previous diversion plugs and clay liner (seepage control) design was undertaken by Golders (2011a). The geotechnical assessment and design of the plugs has been revised and is documented in Section 8 and Section 9 of this Design Plan. The geometry of the diversion plugs has been updated to match the revised diversion channel profile while the crest level has been lowered to provide 1:1,000 AEP flood immunity as determined from the hydraulic assessment (refer Section 5.3 of this Design Plan).

Additional seepage analyses have been undertaken (Section 9 of this Design Plan) and have confirmed that there is no need for extensive clay lining of the southern excavation batter of the diversion (intended to prevent seepage flows from the diversion into the North Sonoma Pit during flood events and corresponding potential instability of the North Sonoma Pit highwall). The diversion design includes the provision for localised clay lining of any high permeability zones identified along the southern excavation batter of the diversion (to be identified during construction by the inspecting engineer).

7.5 Scour Protection

Dumped rock protection is proposed for the bed and banks of the low-flow channel, from the upstream and downstream ends of the diversion to the point at which competent insitu rock is encountered along the diversion reach. This will provide stability for flow events up to the 2 year ARI event.

In addition, dumped rock protection will be provided on both the upstream and downstream diversion plugs up to crest level. Dumped rock protection on the plugs is required on the upstream batter (i.e. the batter exposed to flow in Coral Creek) only and is

not required on the downstream batter (i.e. the batter on the pit side of the diversion plugs). Rock sizing has been undertaken in accordance with the methods laid out in Creeks & Catchments (2011) for highly turbulent flow in low-gradient channels.

The depth-average design flow velocity of 3.0 m/s has been adopted as the maximum simulated velocity in the diversion channel for the 1:100 AEP flood event. This design standard has been adopted to provide an acceptable level of risk to the plugs prior to backfilling of the North Sonoma Pit.

7.6 Vegetation Establishment

QCoal intends to construct the diversion in the 2018 dry season and open the diversion to flow prior to the start of the 2018-19 wet season. ACARP (2014) provides a cumulative exceedance assessment for the vegetation establishment phase of diversions, which is reproduced in Table 7.2 below. ACARP (2014) further provides a proposed minimum design performance standard for vegetation establishment phase of being resilient to a 10 year ARI event at opening and a 50 year ARI event after 10 years.

The adopted strategy to achieve vegetation establishment includes:

- the low flow channel of the diversion will be entirely within in-situ rock or dumped rock which will provide initial stability for flow events up to the 2 year ARI event (refer Section 7.5).
- Vegetation to be seeded will include cover crops and non-invasive grass species for early establishment. The application of seed will be facilitated through a hydro-mulch application and watering will be undertaken (if required subject to rainfall) to ensure grass cover is established prior to the wet season (refer Section 10).
- Vegetation to be seeded will further include native grasses, shrubs and trees for long term erosion protection of the upper channel batters (refer Section 10).

Table 7.2 Cumulative Exceedance Assessment for the Vegetation Establishment Phase (ACARP 2014)

System Resilience		Likely Outcome	
Flood event that diversion is resilient to at opening	Flood event that diversion is resilient to after 10 years	Likelihood of threshold exceedance over 10 year period (e.g. stripping of vegetation/ scour)	Likelihood of not being exceeded over 10 year period (i.e. likelihood of successful vegetation establishment)
1 year ARI	20 year ARI	88%	12%
10 year ARI	20 year ARI	50%	50%

System Resilience		Likely Outcome	
Flood event that diversion is resilient to at opening	Flood event that diversion is resilient to after 10 years	Likelihood of threshold exceedance over 10 year period (e.g. stripping of vegetation/ scour)	Likelihood of not being exceeded over 10 year period (i.e. likelihood of successful vegetation establishment)
1 year ARI	50 year ARI	77%	23%
10 year ARI ¹	50 year ARI ¹	35%	65%
20 year ARI	100 year ARI	19%	81%

Note 1: Proposed minimum design performance standard for vegetation establishment phase in diversions

7.7 Lateral Drainage

The occurrence of concentrated flow down the diversion batters may result in ongoing rilling erosion above the level of insitu rock, particularly prior to the establishment of grass cover. A perimeter drain has been designed to convey local catchment runoff from upslope areas to the north and west of the diversion to designated inflow locations. These concentrated inflows will be conveyed down the diversion batter via two rock lined chutes.

A small residual catchment on the south bank of the diversion drains via an existing drainage path that will intersect the diversion approximately 100 m upstream of the downstream plug. A third rock lined chute is required at this location. It is noted that this residual catchment will reduce in the short term as the North Sonoma Pit progresses; however, the catchment is expected to be reinstated following backfilling of the pit. The chute sizing will need to be reassessed as part of the final landform design to ensure it can convey runoff from its ultimate contributing catchment area.

The perimeter drain has been sized to convey the 1:100 AEP run-off from the upslope catchment with 300 mm of freeboard. No surface treatment for erosion protection is expected to be required to manage the low flow velocities (less than 1.5 m/s for the 1:100 AEP event).

Rock chutes have been designed in accordance with the CHUTE program (Keller 2003) provided as part of the eWater Toolkit (<https://toolkit.ewater.org.au/Default.aspx>). CHUTE is a hydraulic design program for the design of rock chute structures used for stabilising river and stream beds. Chute widths have been sized to maintain consistent rock sizing to the low-flow channel and diversion plugs for ease of construction.

8. GEOTECHNICAL ASSESSMENT

8.1 Diversion Excavation Conditions

An assessment of excavation conditions within the proposed creek diversion alignment was undertaken based on Point Load Index (PLI) and defect spacing data presented in the 2010 geotechnical investigations. The assessment was based on the relationship developed by Pettifer and Fookes (1994) which relates PLI and defect spacing to excavation conditions. The assessment chart used to assess excavation conditions is presented below in Figure 8.1.

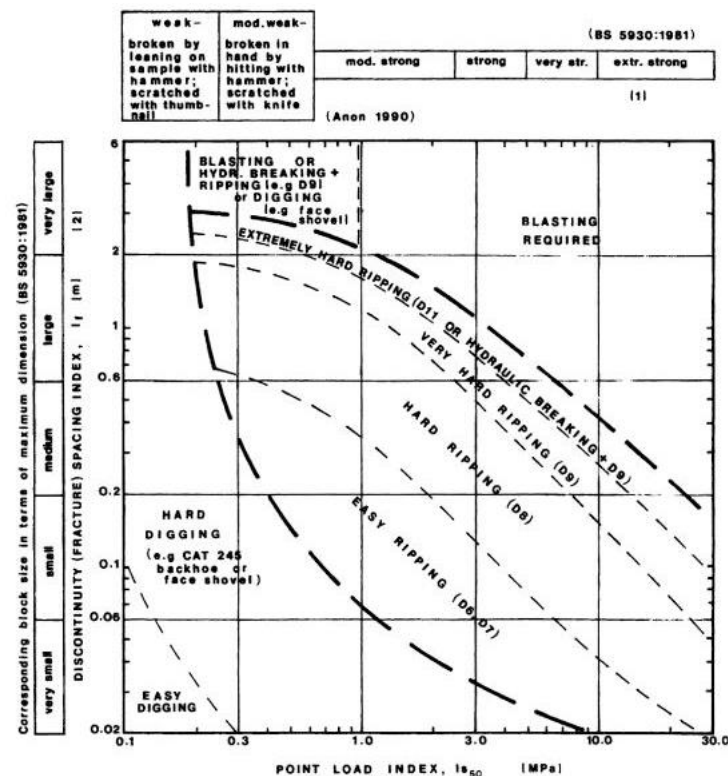


Figure 8.1 Excavation Conditions Assessment Chart (Pettifer and Fookes, 1994)

Based on the available investigation data the assessment suggests that the following typical excavation conditions will be encountered within the creek diversion alignment:

- Residual Soil – Easy to Hard Digging
- Weathered Rock – Hard Digging to Very Hard Ripping

8.2 Foundations Conditions for Diversion Plugs

8.2.1 General Foundation

Nominal general foundation stripping depths of 1.5 m and 1.0 m are anticipated for the upstream and downstream diversion plug footprints respectively. The geotechnical investigation results (test pit / bore logs) indicate this is typically the stripping depths required to found the embankments on stiff / dense material. Actual foundation stripping depths will need to be verified and approved by the Engineer during construction.

8.2.2 Key Trench

The borehole logs indicate that high permeability layers are likely present within the subsurface profile below the proposed diversion plugs and as a result the low permeability Zone 1 key trench should be extended 0.5m into low to moderate permeability residual soil or weathered rock foundations. The foundation materials encountered during the geotechnical investigations suggest a typical key trench depth below existing surface of 3.0 m to 3.5 m will be required to cut off highly permeable alluvial sands and gravels. Actual key trench depths will need to be verified and approved by the Engineer during construction.

8.3 Construction Material

8.3.1 Material Suitability

The suitability of available construction materials in the nominated borrow area (diversion channel excavation) has been assessed from borehole and test pit logs and laboratory test results. The specified Zone 1 and Zone 3 plug embankment fill material properties have been developed to allow incorporation of a significant proportion of the materials which will be excavated from the diversion channel. Due to the large quantity of excavation involved in the diversion construction and relatively small fill quantities, there is expected to be sufficient quantities of suitable fill material available from within the diversion excavation area.

8.3.2 Material Zone Properties

The diversion plug embankments will be constructed of:

- Zone 1 Fill comprised of Gravelly CLAY to CLAY soil with the following properties:
 - Low permeability: 40-85% fines content (% passing 0.075 mm sieve) and plotting above the "A-Line";
 - Low to moderate reactivity: Weighted Plasticity Index < 3200;
 - No highly dispersive materials: Emerson Crumb Class Number ≥ 2 .

- Zone 3 fill comprised of Clayey GRAVEL to Sandy CLAY or weathered rock with the following properties:
 - Moderate permeability: 10-40% fines content (% passing 0.075 mm sieve) and plotting above the “A-Line”;
 - Low reactivity: Weighted Plasticity Index < 2200;
 - No highly dispersive materials: Emerson Crumb Class Number ≥ 2.

The Zone 1 fill shall be compacted to a density ratio of at least 98% of standard maximum dry density (SMDD) with a moisture content range of Optimum Moisture Content (OMC) - 2% to +2%. The compacted thickness of each layer shall not exceed 250 mm.

The Zone 3 fill shall be compacted to a density ratio of at least 96% of standard maximum dry density (SMDD) with a moisture content range of Optimum Moisture Content (OMC) - 2% to +2%. The compacted thickness of each layer shall not exceed 250 mm.

8.3.3 Borrow Locations

The proposed construction material borrow locations are summarised below in Table 8.1.

Table 8.1 Construction Material Borrow Locations

Material	Proposed Borrow Material Locations
Zone 1 Fill	Gravelly CLAY to CLAY residual soil won from the North Sonoma Creek Diversion excavations.
Zone 3 Fill	Clayey GRAVEL to Sandy CLAY residual soil or weathered rock won from the North Sonoma Creek Diversion excavations.

9. GEOTECHNICAL DESIGN

9.1 General

Geotechnical analyses were undertaken for expected critical sections of the upstream and downstream diversion plug embankments.

Finite element seepage analysis was undertaken using SEEP/W 2018 software (version 9.0.2.15352) developed by GEO-SLOPE International. Seepage analysis was undertaken to predict the location of the phreatic surface under transient flood conditions.

Limit equilibrium slope stability analysis was undertaken using SLOPE/W 2018 software (version 9.0.2.15352) developed by GEO-SLOPE International. All slip failure surfaces and factors of safety (FoS) were computed using the Morgenstern-Price method.

The geotechnical slope stability was assessed under steady state (no flood) and transient flooding conditions representing the assumed existing groundwater conditions and the predicted changes to the groundwater profile / phreatic surface due to the rise and fall of the 1:1,000 AEP design flood event.

The embankment stability was assessed under both drained and undrained conditions, for the transient analyses. Embankment and foundation materials were modelled using effective strength parameters for the drained analysis and total stress parameters for the undrained analysis where appropriate.

9.2 Representative Sections

Two representative sections were selected for stability analyses (one section for each of the proposed diversion plug embankments). The alignment of the sections are shown in Figure 9.1, with the sections presented in Figure 9.2 and Figure 9.3. Sections were taken at the maximum height along the alignment of each diversion plug.

Surface levels were determined from the latest LiDAR survey data and design levels, while foundation levels and subsurface profiles were based on surrounding geotechnical investigations.

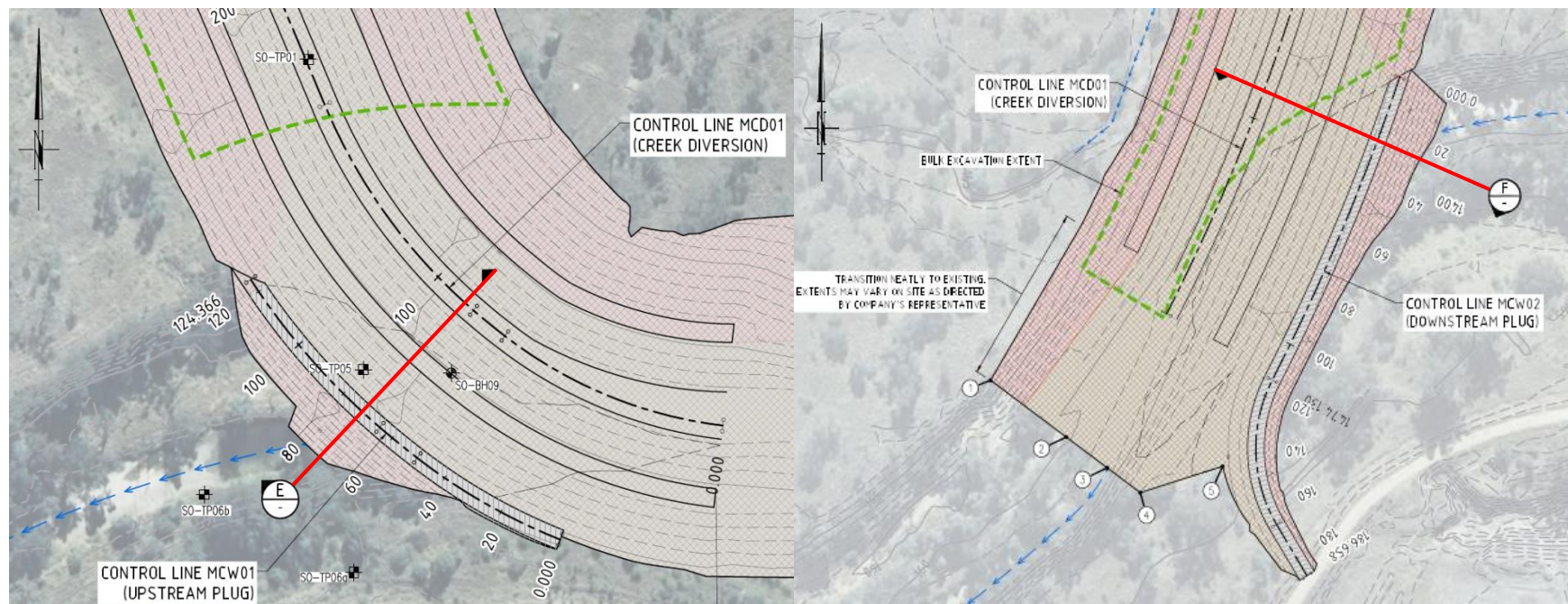


Figure 9.1 Upstream and downstream diversion plug representative sections.

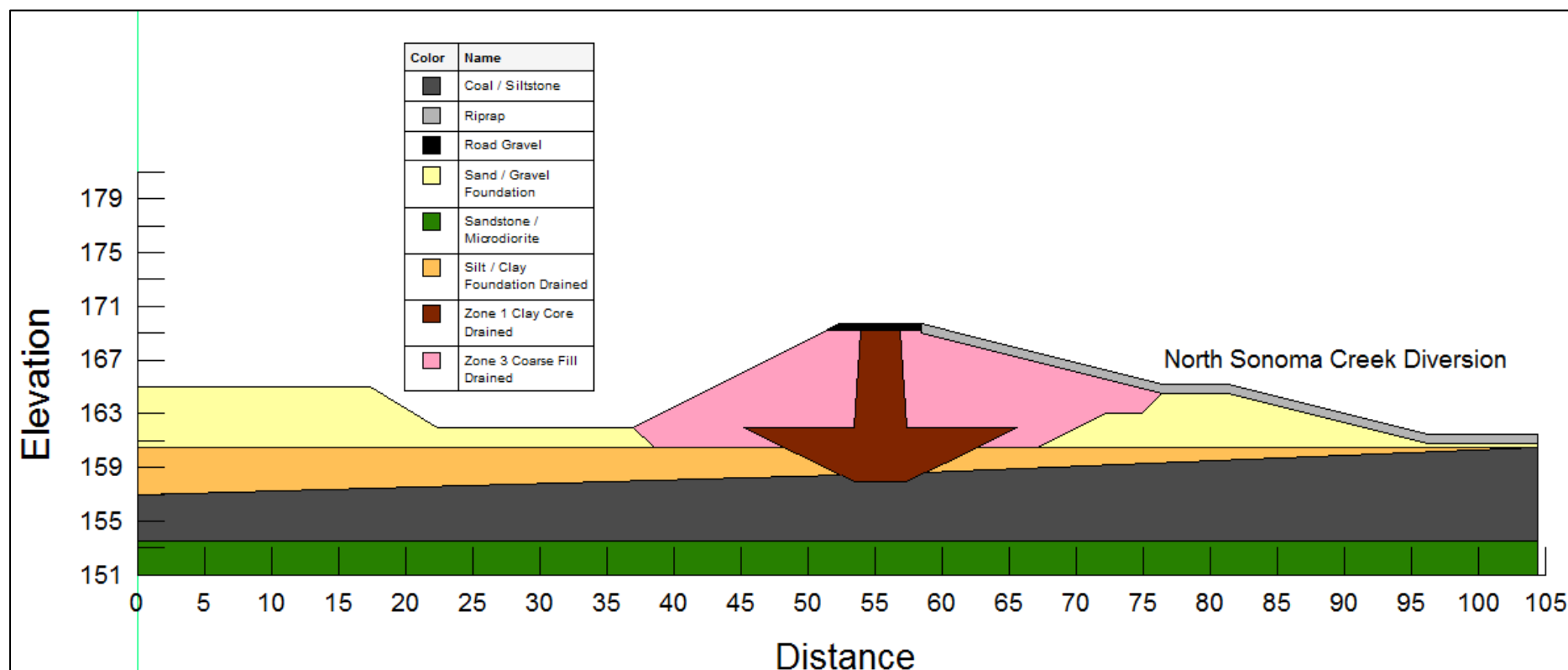


Figure 9.2 Section A – Upstream Diversion Plug Typical Section

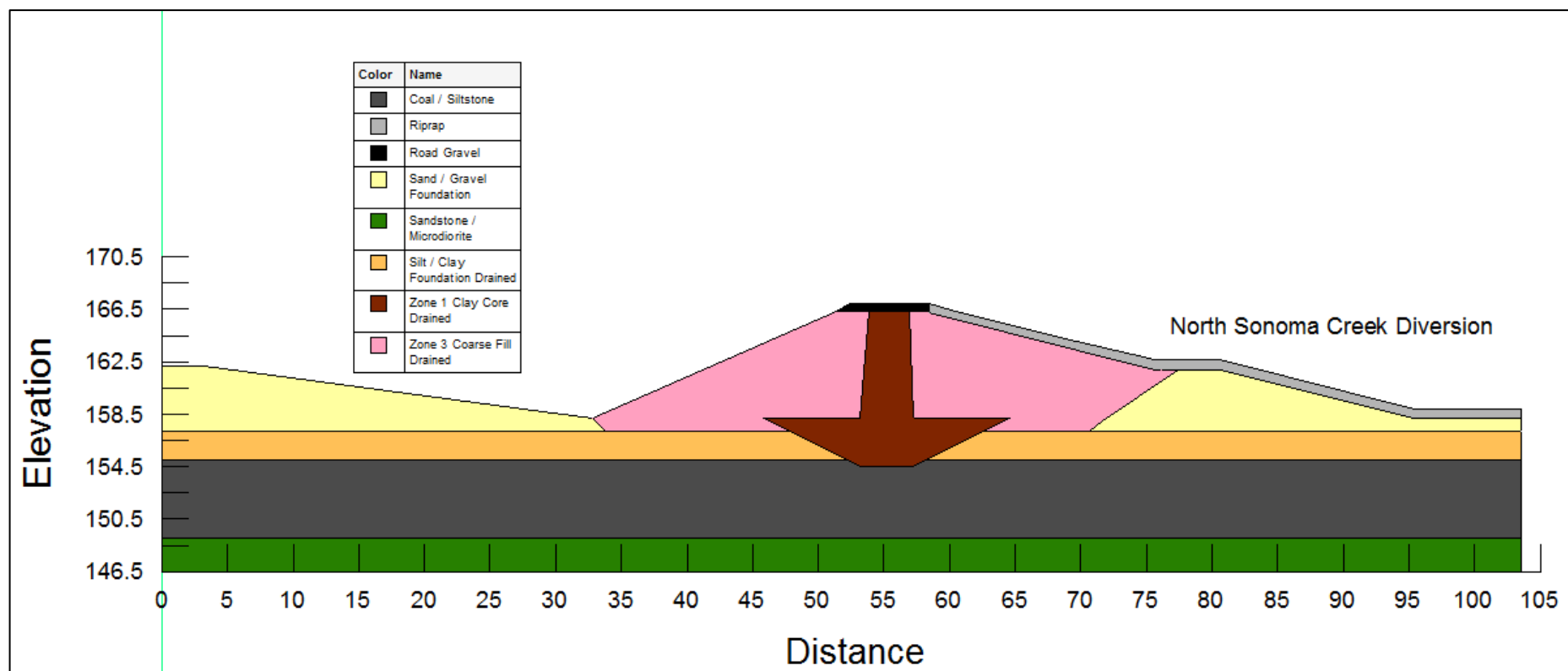


Figure 9.3 Section B – Downstream Diversion Plug Typical Section

9.3 Minimum Factors of Safety

Table 9.1 outlines the minimum acceptable factors of safety (FoS) against embankment instability adopted for the design based on ANCOLD guidelines (2012) and Fells (2005).

Table 9.1 Minimum Acceptable Factors of Safety

Condition	Minimum FoS
End of construction	1.3
Transient Flood Conditions – Rapid Drawdown	1.3
Post-Seismic	1.1

9.4 Material Parameters

The design parameters adopted for the embankment materials and upper residual and alluvial soils are based on the most recent geotechnical investigation data (refer to Section 4 of this Design Plan) and past experience with similar materials.

The design parameters adopted for each material type are summarised below in Table 9.2.

Table 9.2 Design Material Parameters

Material	Unit Weight γ (kN/m ³)	Undrained Shear Strength C_u (kPa)	Effective Cohesion (Drained Strength) c' (kPa)	Effective Friction Angle (Drained Strength) ϕ' (°)	Permeability $k_{h,sat}$ (m/s)	Permeability k_v / k_h
Zone 1 Fill	19	50	2	27	1×10^{-9}	0.1
Zone 3 Fill	19	50	2	30	1×10^{-8}	0.2
Riprap	24	-	0	40	1×10^{-3}	1.0
Road Gravel	20	-	2	35	5×10^{-7}	0.5
Sand / Gravel Foundation	18	-	0	30	1×10^{-5}	1.0
Silt / Clay Foundation	19	50	2	26	1×10^{-7}	0.2

Material	Unit Weight γ (kN/m ³)	Undrained Shear Strength C_u (kPa)	Effective Cohesion (Drained Strength) c' (kPa)	Effective Friction Angle (Drained Strength) ϕ' (°)	Permeability $k_{h,sat}$ (m/s)	Permeability k_v / k_h
Coal / Siltstone	19	-	20	30	5×10^{-7}	0.2
Sandstone / Microdiorite	Bedrock (Impenetrable)				5×10^{-7}	0.2

9.5 End of Construction Stability

The end of construction analysis assesses the embankment stability during and immediately after construction. This condition assesses the short-term behaviour of the soils and considers the impact on stability from the development of excess pore water pressures as a result of the embankment and construction loading. For the end of construction analysis, the following assumptions were made:

- Groundwater level conservatively assumed to be at the base of the embankment;
- A material excess pore water pressure coefficient (R_u) of 0.3 was adopted to approximate the development of excess pore water pressures within the embankment and clay foundation soils during construction; and
- A 15 kPa surcharge loading on the embankment crest was included to allow for anticipated construction equipment loading.

The results of the end of construction analysis are summarised below in Table 9.3 and selected output are included in Appendix D. The limit equilibrium FoS are presented for the critical non-circular failure surfaces in accordance with the recommendations of the ANCOLD (2012) guidelines.

Table 9.3 End of Construction Stability Analysis Results

Section	Upstream Slope FoS	Downstream Slope FoS
Section A – Upstream Diversion Plug	2.51	1.40
Section B – Downstream Diversion Plug	2.52	1.44

The SLOPE/W results suggest that the diversion plug embankments will provide a FoS which exceeds the minimum required FoS of 1.30 for end of construction conditions.

9.6 Post-Seismic Stability

Post seismic stability analyses were conducted to assess embankment stability following a Maximum Design Earthquake (MDE) seismic event. Given that the embankments will be founded on stiff, cohesive foundations it is not anticipated that the foundations would be susceptible to seismic induced liquefaction.

The strength of embankment and foundation materials was reduced by 20 % to account for potential strain weakening of the materials during earthquake loading, such that:

$$c^* = 0.8 \times (c' \text{ or } c_u)$$

$$\phi^* = \tan^{-1} (0.8 \times \tan \phi')$$

Groundwater and phreatic conditions were assumed to be the same as those used for the end of construction stability analysis. Total stress parameters were adopted for cohesive materials and effective stress parameters were adopted for non-cohesive, granular materials.

No surcharge loading (for vehicle traffic) was included in the post seismic stability analysis.

The results of the post seismic analysis are summarised below in Table 9.4 and selected outputs are included in Appendix D. The limit equilibrium factors of safety are presented for the critical non-circular failure surfaces in accordance with the recommendations of the ANCOLD (2012) guidelines.

Table 9.4 Post Seismic Stability Analysis Results

Section	Upstream Slope FoS	Downstream Slope FoS
Section A – Upstream Diversion Plug	2.01	1.15
Section B – Downstream Diversion Plug	2.01	1.25

The SLOPE/W results suggest that the diversion plugs will provide a FoS which exceeds the minimum required FoS of 1.1 for post seismic conditions.

9.7 Transient Seepage Stability

The 1:1,000 AEP design flood was simulated in SEEP/W with a transient seepage analysis. The transient seepage analysis was based on a water level versus time relationship (boundary condition) which was developed to represent the rise and fall of the predicted 1:1,000 AEP design flood.

The seepage analysis simulated the pore water pressure conditions within the diversion plug embankments and foundations for a number of time steps. The pore water pressure

conditions were imported into SLOPE/W and the slope stability at each time step was analysed to provide a relationship between FoS and time.

The following assumptions were made in this analysis:

- Hydraulic conductivity functions adopted for each material type were based on relevant sample functions provided in SEEP/W
- The volumetric water content function adopted for each embankment zone was based on relevant sample functions provided in SEEP/W
- The flood height time relationship was adopted from the results of the hydraulic modelling of the North Sonoma Creek Diversion for the 1:1,000 AEP critical storm duration. The adopted flood height-time relationship for the upstream and downstream diversion plugs are shown in Figure 9.4 and Figure 9.5 respectively.

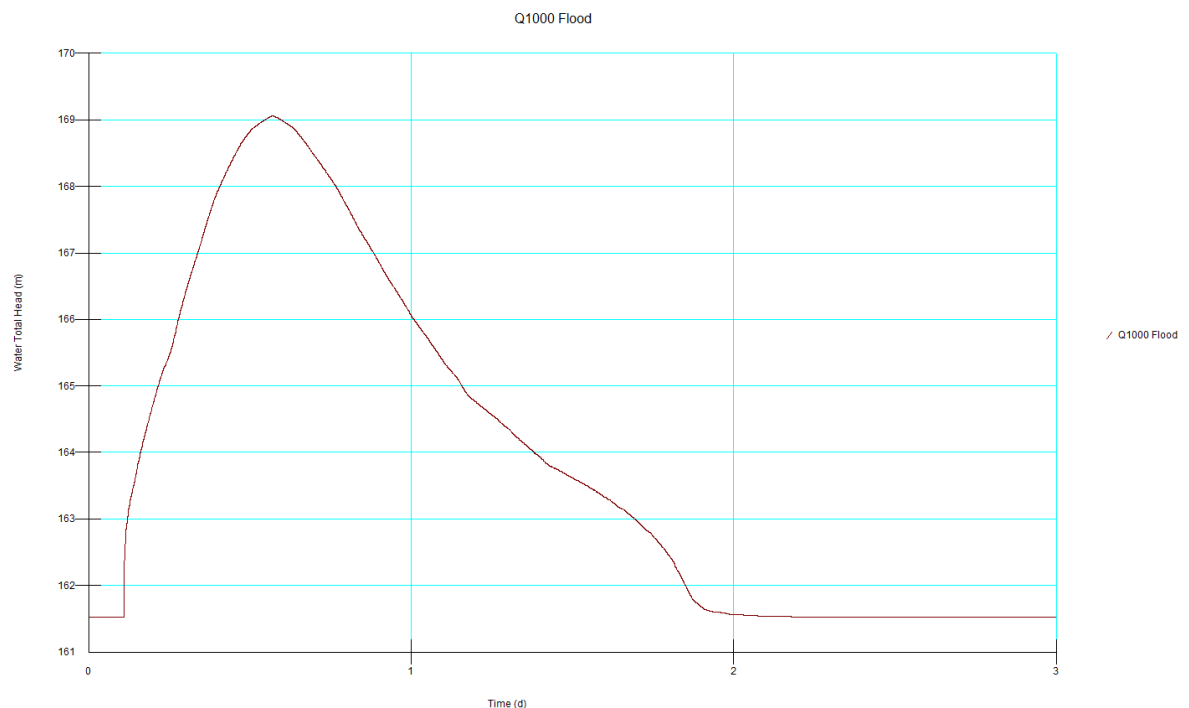


Figure 9.4 1:1,000 AEP Flood Height-Time Relationship Upstream Diversion Plug

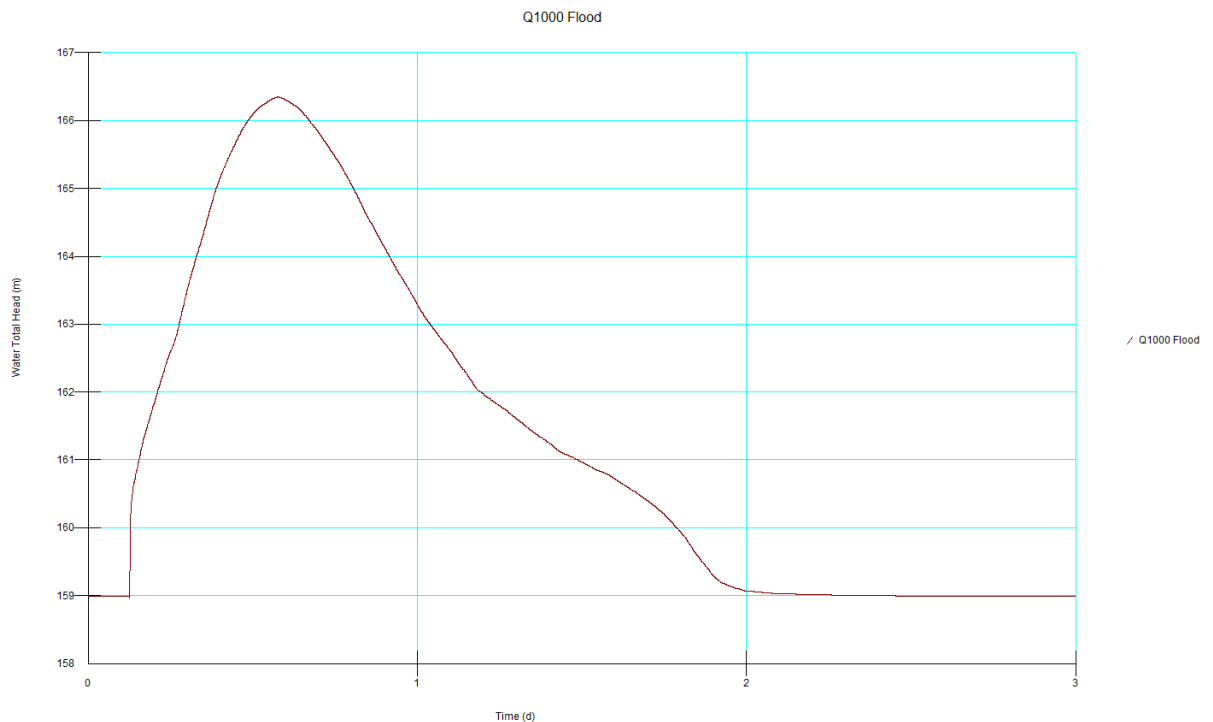


Figure 9.5 1:1,000 AEP Flood Height-Time Relationship Downstream Diversion Plug

The results of the stability analysis are summarised below in Table 9.5 and selected outputs are included in Appendix D. The limit equilibrium FoS are presented for the critical non-circular (optimised) failure surfaces in line with ANCOLD recommendations.

Results are presented for the following potential slope instability locations:

- Diversion plug upstream batter slopes – failure of the upstream batter slopes under rapid drawdown conditions as the flood waters recede.
- Diversion plug downstream batter slopes – failure of the downstream batter slope of the diversion plugs during the flood event.

Table 9.5 Transient Stability Analysis Results

Section	Drained FoS	Undrained FoS
Section A – Upstream Diversion Plug		
Upstream Slope Stability	1.97	2.03
Downstream Slope Stability	1.43	1.96
Section B – Downstream Diversion Plug		

Section	Drained FoS	Undrained FoS
Upstream Slope Stability	2.04	2.02
Downstream Slope Stability	1.57	1.97

The outcomes of the stability analysis are summarised below:

- Both the upstream and downstream diversion plugs will provide a FoS against embankment instability in excess of the minimum acceptable FoS of 1.30 during the design flood event.
- Only the upstream portion of the levee embankment shoulder has time to saturate due to the short duration of the design flood event and the low to moderate permeability of the embankment materials. As such, the design flood event has minimal impact on the pore pressure conditions within the levee embankment. The FoS against instability is largely dictated by the strength of the embankment and foundation materials and the embankment geometry.

9.8 Diversion Channel Seepage Assessment

A seepage analysis of a typical section of the diversion channel was conducted using SEEP/W to simulate pore water pressure conditions within the in situ material located between the creek diversion and the future North Sonoma Pit highwall. The objective of the assessment was to determine whether a flood event in the diversion channel would result in seepage exiting through high permeability sand / gravel lenses into the Sonoma Pit through the highwall.

The assessment involved the simulation of the 1:1,000 AEP design flood together with a sensitivity analysis of the permeability of possible in situ sand / gravel lenses. Results from the assessment are shown in Table 9.6.

Table 9.6 Seepage Analysis Results

Permeability of Sand / Gravel layer $k_{h,sat}$ (m/s)	Pit Crest Offset from the 1:1,000 AEP flood level	Wetting Front Advancement (m)	Distance between Wetting Front and Pit Crest
1×10^{-3}	60m	30m	30m
1×10^{-4}	60m	14m	46m
1×10^{-5}	60m	<1m	~60m

The results suggest that even for a very high permeability in situ lense (1×10^{-3} m/s), associated with clean gravel / cobbles, seepage would not be expected to exit through the highwall during the design 1:1,000 AEP flood event.

Notwithstanding the results of the analysis, provision for construction of a low permeability Zone 1 liner at high permeability in situ zones has been included in the diversion channel design to control the following risks:

- Seepage of clean water into the pit including increased seepage rates
- Development of elevated pore water pressures in the highwall and associated highwall stability impacts

The presence of high permeability zones requiring lining will need to be verified by the Engineer during construction

The risk of pit highwall instability is considered low based on the results of this assessment and the plan to backfill the pit shortly after the completion of mining.

10. REVEGETATION PLAN

The Revegetation Plan for the previously licensed design is presented in Chapter 6 of Design of Coral Creek Diversion (BSM, 2011). Specialist advice and certification of the plan was provided by M.C. Evans (Director, Esys Consulting Pty Ltd).

The previous plan has been reviewed and updated to reflect the revised design and construction strategy. In particular, QCoal intends to construct the diversion in the 2018 dry season and open the diversion to flow prior to the 2018-19 wet season. As described in Section 7.6 of this Design Plan, the low flow channel of the diversion will be entirely within in-situ rock or dumped rock which will provide initial stability for flow events up to the 2 year ARI event. The updated revegetation plan detailed below will provide longer term stability for larger flood events.

Specialist advice has been provided for the update of the diversion revegetation strategy by Chris Hansen (Director/Principal Ecologist, Ecological Survey & Management).

10.1 Revegetation Goals and Performance Criteria

Rehabilitation of the North Sonoma Creek Diversion is required to maintain environmental values in the long-term, along and downstream of the diversion. The environmental objectives are dependent on the relevant environmental values to be protected both during and after the construction of the diversion.

The EPA guideline Rehabilitation requirements for mining projects (EPA, 2008) describe a pathway for determining acceptable rehabilitation objectives, indicators and completion criteria. The objectives are considered in reference to four environmental goals. These four goals correspond to those defined under Condition F1 of the EA, which are:

- Safe to humans and wildlife.
- Stable.
- Non-polluting.
- Self-sustaining for the post-mining land use of grazing pasture.

Condition I4 of the EA requires that the North Sonoma Creek Diversion be rehabilitated in accordance with the approved Rehabilitation Plan as per Condition F5 of the EA, which details what must be addressed within the Rehabilitation Plan. Condition F3 of the EA stipulates that a revised Rehabilitation Plan must be submitted to the administering authority (to account for the North Sonoma Creek Diversion). As such, the North Sonoma Creek Diversion rehabilitation requirements will be addressed in the revised Rehabilitation Plan.

The existing Sonoma Coal Mine Rehabilitation Plan December 2015 (NRA, 2016) identifies the post-mine land use for disturbed areas as 'low intensity grazing' (i.e. Class 4 land as defined in the EA at the time). It is proposed that the North Sonoma Creek Diversion post-mine land use will be a self-sustaining community suitable for native habitat, which includes a riparian zone grading into low intensity grazing. This land use is also defined for the existing Two Mile Creek Diversion at the SCM.

10.2 Revegetation Approach

Three revegetation planting zones have been proposed as illustrated in Figure 10.1 and summarised in Table 10.1.

Table 10.1 Nominal section widths of planting zones

Planting Zones		Width of Planting Zone
Riverine Woodland	Planting Zone 1 (including shelf)	Entire bench and any portion of the low-flow batter that is not overlying in-situ rock
Ecotane Gradation from Riverine Woodland to Eucalypt Woodland	Planting Zone 2	Lower 20 m beyond bench
		Upper Edge of Lower Zone to top of batter
Diversion Plugs	Planting Zone 3	Downstream batter of diversion plugs

Note: Discretion to be utilised where batter lengths only marginally exceed the prescribed interval. In these instances, extend the mix from the previous interval to the edge of batter.

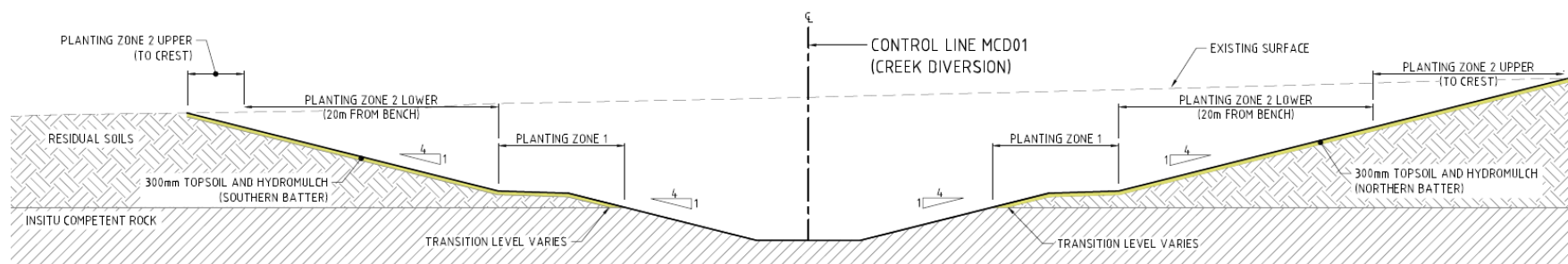


Figure 10.1 Typical Cross-Section of the Diversion together with Revegetation Zones

10.3 Revegetation Strategy

The rationale of the re-vegetation strategy is to achieve similar vegetative cover and function to the existing stream. The approach is based on the establishment and maintenance of fringing riparian woodland on the bench above the low flow channel and adjacent batters, grading into mixed eucalypt woodland communities on the upper batters.

The establishment of native vegetation is not only essential for the restoration and maintenance of ecological function but also 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, while groundcover species protect the soil surface from splash erosion and overland flows during rainfall events.

Vegetation to be seeded will include cover crops and non-invasive grass species for short and medium-term erosion protection and native grasses, shrubs and trees for long term erosion protection. The application of seed will be facilitated through a hydro-mulch application, which also provide initial soil surface protection, introduce micro-biota and minimise the loss of soil moisture. Rainfall is the best form of watering and seed germination due to the secondary climatic effects following rain. Revegetation areas will be monitored in the months following construction and watered if required to promote establishment of grass cover prior to the commencement of the wet season (as per Section 7.6).

Revegetation works will include a combination of native grass, shrub and tree species that are representative of regional ecosystems (REs) within the stream section to be diverted, as well as within and adjacent to the upstream and downstream reaches. The proposed planting palette for the fringing riparian woodland is representative of RE 11.3.25, while the mixed eucalypt woodland communities on the upper batters will be representative of REs 11.3.7, 11.3.9, 11.3.10 and potentially RE 11.9.9.

The strategy for Planting Zone 3 on the downstream batters of the diversion plugs is to use grass seed only (refer Section 10.3.2 of this Design Plan) and excludes tree and shrub species (refer Section 10.3.1 of this Design Plan). This approach of targeting groundcover only is to stabilise the batter while preventing the establishment of large root systems that could compromise the diversion embankment.

All soils, particularly top-soil, will be assessed as required by a soil scientist and/or agronomist to determine whether ameliorants are required - either in-situ, manufactured on site or imported, to allow vegetation to establish and persist.

The approach of not applying topsoil to areas of in-situ competent rock and areas of rock-armouring, has been proposed to minimise the risk of topsoil loss given that the diversion will be opened to stream flows within a short timeframe after construction. It is anticipated that these areas will receive and retain aggraded substrates from high flow events and over time be colonised by seed dispersed from up-stream reaches as well as established

vegetation on adjacent batters. This process has been directly observed in the rock armouring of the nearby Two Mile Creek diversion at SCM.

Further detail on topsoil management, seed collection, vegetation establishment and weed management is provided in Sonoma Coal Mine Rehabilitation Plan December 2015 (NRA, 2016), which is due to be updated as per the EA (refer Section 10.1 of this Design Plan). Additional management plans have been put in place in accordance with the approval conditions under the EPBC Act including Sonoma Coal Mine Coral Creek Weed Management Plan (NRA, 2013) and Sonoma Coal Mine Coral Creek Riparian Zone Management Plan (NRA, 2014).

10.3.1 Woody Vegetation Establishment

The previous proposed seed mix has been revised based on recent inspections of Coral Creek by Ecological Survey & Management. The mix has been rationalised to focus on species endemic to the local area and is summarised in Table 10.2. An application rate of 5 kg/ha is recommended.

As noted above, Planting Zone 3 on the downstream batters of the diversion plugs utilises grass seed only.

Table 10.2 Revegetation Species Palette (native woody vegetation seed mix)

Species		Percentage Composition of Re-vegetation Mix			
Botanical Name	Common Name	Planting Zone 1 (including shelf)	Riverine Woodland	Ecotane Gradation from Riverine Woodland to Eucalypt Woodland	
			Lower	Middle	Upper
Large Trees					
Casuarina cunninghamii	River Oak	10			
Corymbia clarksoniana	Long-fruited Bloodwood		20	10	5
Corymbia dallachiana	Dallachy's Gum		5	10	15
Corymbia tessellaris	Carbeen	10	25	15	5
Eucalyptus brownii	Reid River Box			10	15
Eucalyptus crebra	Narrow-leaved Red Ironbark			5	20
Eucalyptus raveretiana	Black Ironbox	20			
Eucalyptus tereticornis subsp. tereticornis	Queensland Blue Gum	20	20	10	
Lagunaria queenslandica	Queensland Pyramid Tree	##			
Melaleuca fluviatilis	River Teatree	##			
Melaleuca leucadendra	Weeping Paperbark	##			
Melaleuca viminalis	Weeping Bottlebrush	##			
Pleiogynium timorense	Burdekin Plum	1			
Shrubs/Small Trees					
Acacia excelsa subsp. excelsa				5	5
Acacia salicina	Sally Wattle	10	20	15	10

Species		Percentage Composition of Re-vegetation Mix			
Botanical Name	Common Name	Riverine Woodland	Ecotane Gradation from Riverine Woodland to Eucalypt Woodland		
		Planting Zone 1 (including shelf)	Planting Zone 2		
			Lower	Middle	Upper
Alectryon oleifolius subsp. elongatus	Western Rosewood	3			
Cassia brewsteri	Leichhardt Bean	3	10	10	5
Corymbia erythrophloia	Variable-barked Bloodwood				10
Erythrina vespertilio	Bat's Wing Coral Tree			2	
Ficus opposita	Sandpaper Fig	7			
Ficus racemosa	Cluster Fig	1			
Lysiphyllum hookeri	Pegunny	10			
Melaleuca bracteata	Black Teatree	5			
Petalostigma pubescens	Quinine Bush			3	5
Vachellia bidwillii	Corkwood Wattle			5	5
Total		100	100	100	100

Note: those species denoted with a ## are common components of riparian woodland within the section of Coral Creek to be diverted. However, these species grow within the channel and immediate toe of the low flow batter. Their inclusion on the batters is likely to fail. It is anticipated that these species will colonise aggraded soil within the channel and low flow batters over time.

10.3.2 Grass Establishment

It is proposed that the hydromulch application includes a sterile cover crop species (Japanese Millet) as well as perennial species that will provide adequate, stoloniferous cover. The recommended seed mix is provided in Table 10.3.

Table 10.3 Revegetation Species Palette (grass seed mix)

Species		Composition of Re-vegetation Mix (kg/ha)
Botanical Name	Common Name	All Planting Zones
* <i>Echinochloa esculenta</i>	Japanese Millet (cover crop)	10 (cover crop)
* <i>Cynodon dactylon</i>	Couch Grass	5
* <i>Chloris gayana</i>	Reclamer Rhodes Grass#	nil (or 5)
<i>Bothriochloa bladhii</i> subsp. <i>bladhii</i>	Forest Bluegrass	1
* <i>Bothriochloa pertusa</i>	Indian Bluegrass	5
<i>Dichanthium fecundum</i>	Curly Bluegrass	1
<i>Dichanthium sericeum</i>	Queensland Bluegrass	1
* <i>Stylosanthes hamata</i>	Verano Stylo	1
* <i>Stylosanthes scabra</i>	Seca Stylo	1

*Note: * indicates species is either exotic or a naturalized exotic flora species.*

Note: # Reclamer Rhodes Grass is a robust grass that can exceed 1 m in height. As such, it has the potential to dominate a rehabilitation area to the detriment of germinating woody vegetation. This species may also enhance the risk of loss attributed to fire. However, this species is strongly stoloniferous.

11. CONSTRUCTION

11.1 Construction Strategy

The construction of the North Sonoma Creek Diversion will be completed in two stages. Stage 1 will be a Bulk Excavation Phase to be completed by the existing mining contractor using mining equipment. Stage 2 will be the Creek Diversion Phase to be completed by a civil contractor following completion of Stage 1. The scope of work for the two stages is detailed in Technical Specification North Sonoma Creek Diversion – Stage 2 Works (Engeny, 2018) and is summarised below.

- Stage 1 (Bulk Excavation Phase)
 - Clearing and grubbing of the Bulk Excavation area as defined in the Design Drawings (refer Appendix C of this Design Plan).
 - Topsoil stripping of the Bulk Excavation area, including stockpiling of stripped topsoil.
 - Bulk excavation of the diversion channel, including removal and stockpiling / spoiling of material where required. The bulk excavation includes the downstream natural bank but excludes the upstream natural bank, which will provide flood protection to the diversion during construction.
 - Possible sediment control option: A portion of the downstream natural bank (e.g. the final one or two vertical metres) may be retained until the diversion construction is complete, at the direction of the Company's Representative. This would act as an erosion and sediment control structure for the diversion construction area and would be removed as part of the commissioning of the diversion.
- Stage 2 (Creek Diversion Phase)
 - Clearing and grubbing of the remaining works area.
 - Topsoil stripping of the remaining works area, including stockpiling of stripped topsoil.
 - Final trim / detailed excavation of North Sonoma Creek Diversion (MCD01 on design drawings included in Appendix C), including removal and spoiling of unsuitable or excess material.
 - Excavation of a perimeter drain (MCD03 on design drawings included in Appendix C), including the removal and spoiling of unsuitable or excess material.
 - Supply and installation of erosion protection works including rock lining of the diversion channel and rock chute erosion protection.
 - Diversion plug foundation stripping, including removal and spoiling of unsuitable or excess material.
 - Diversion plug key trench excavation, including removal and spoiling of unsuitable or excess material.
 - Incorporation of suitable fill materials which conform to the requirements of the specification including proving borrow sources (through investigation and further soil testing if required).

- Diversion plug fill material placement including borrowing (won from stockpiles or excavations), moisture conditioning, haulage, placement and compaction to the designated standards for the upstream and downstream diversion plugs (MCW01 & MCW02).
- Topsoiling and revegetation in accordance with the proposed revegetation strategy.

11.2 Construction Sequencing

QCoal intends to construct the diversion in the 2018 dry season and the use of mining equipment for Stage 1 (Bulk Excavation) will result in a short construction timeframe. Consequently, the risk of experiencing a flood flow in the creek during construction is minimised. The following construction sequence has been proposed to minimise the residual risk of flood impacts during construction.

- Stage 1 (Bulk Excavation Phase) will leave the upstream creek bank in place to act as a temporary plug providing flood protection to the diversion works. The downstream creek bank will be excavated as any flow would be back water only with low velocity and low scour potential.
- Stage 2 (Creek Diversion Phase):
 - Excavate perimeter drains and undertake final trim of diversion
 - Install dumped rock and chutes
 - Excavate in-situ ground at upstream end of diversion not excavated in Stage 1 (i.e. open diversion to stream flow)
 - Construct upstream plug, then downstream plug
 - Finalise upstream transition (existing creek to diversion) and downstream transition (diversion to existing creek)
 - Topsoil placement and revegetation

12. FUTURE WORKS AND CLOSURE

The duration of mining in the North Sonoma Pit is expected to be short (i.e. 1 to 2 years). The North Sonoma Pit will be back-filled within a period of several years following completion of mining. The landform of the back-filled pit will be shaped such that it is free draining and the diversion plugs will cease to be required for flood protection of the pit.

The North Sonoma Creek Diversion will be a permanent diversion. Following vegetation establishment and back-filling of the pit, no further construction activities or maintenance of structures (e.g. diversion plugs) are expected to be required for the diversion prior to or after mine closure. The stability and establishment of the diversion will be monitored after construction in accordance with Condition I7 of the EA and the monitoring plan provided in Section 13 of this Design Plan.

It is noted that the sizing of the downstream rock chute on the south bank of the diversion will need to be reassessed as part of the final landform design to ensure it can convey runoff from its ultimate contributing catchment area following backfilling of the North Sonoma Pit.

13. PERFORMANCE MONITORING

Operations performance monitoring of the North Sonoma Creek Diversion will be undertaken after construction to assess whether the diversion is meeting the required performance outcomes. The main aims of the operations monitoring program will be to:

- Identify the magnitude of flow events through the diversion after construction.
- Assess the establishment of vegetation in the diversion.
- Assess any impacts to the natural reaches of Coral Creek, upstream and downstream of the diversion.
- Assess the degree to which the diversion is tracking towards achieving the long-term performance outcomes for the diversion.
- Provide early identification of remedial actions and management strategies to improve the trajectory of the diversion towards meeting the long-term performance outcomes.

The operations monitoring program for the diversion has been developed with reference to the ACARP guidelines for Monitoring and Evaluation Program for Bowen Basin River Diversions (ACARP, 2001) and conditions I7 and I8 of the EA.

The diversion monitoring will be undertaken annually by a Registered Professional Engineer of Queensland (RPEQ) in accordance with condition I7 of the EA and will involve the following activities:

1. Review of flow event monitoring data
 - Review of site rainfall gauging data to assess the magnitude of rainfall events in the period since the last monitoring activity.
 - Review of surveyed flood levels within the diversion (e.g. flood debris marks) relative to design event flood levels determined from hydraulic modelling of the diversion to assess the magnitude of significant stream flow events in the period since the last monitoring activity.
2. Fixed point photographs
 - Collection of a photographic record at fixed monitoring points in the diversion reach, upstream reach (1 km reach upstream of the Bowen Developmental Road) and downstream reach (1 km reach downstream of the downstream end of the North Sonoma Creek Diversion).
 - The photographic record will be collected during the month of April each year.
 - The fixed monitoring points will include four monitoring points in each of the diversion reach, upstream reach and downstream reach. The fixed monitoring points will be the same as the monitoring points used for the Index of Diversion Condition (IDC) assessments.

- The fixed monitoring points will be determined and located (pegs to be installed at the top of the creek bank at the monitoring points) following completion of the diversion construction and prior to the first operations monitoring activity. Where practical, these may be located to align with existing environmental monitoring locations.
 - The fixed point photographs will include the following photographs:
 - Photo looking upstream from the monitoring point peg.
 - Photo looking downstream from the monitoring point peg.
 - Photo looking cross-stream from the monitoring point peg (i.e. toward the opposite creek bank).
 - Photo looking away from the monitoring point peg (i.e. away from the creek bank).
 - Photo looking upstream from the creek bed.
 - Photo looking downstream from the creek bed.
 - Fixed point photos are to be compared (side by side) with the same fixed point photo from the last monitoring activity.
3. Aerial imagery assessment
- Assessment of recent aerial imagery (satellite imagery or aerial photography) where available, to identify any lateral migration of the creek channel or changes to riparian vegetation density (diversion reach or upstream and downstream reaches) since the last monitoring activity.
4. IDC assessments for the diversion as described in Appendix C of the ACARP guidelines for Monitoring and Evaluation Program for Bowen Basin River Diversions (ACARP, 2001)
- Visual inspection of the diversion reach, and upstream and downstream reaches to undertake the IDC assessments during the month of April each year.
 - Assessment of Geomorphic Index and Riparian Index at the fixed point monitoring stations in the diversion, upstream and downstream reaches (same locations as the fixed point photograph locations).
 - Determination of reach-averaged Geomorphic Index, Riparian Index and overall IDC scores for the diversion, upstream and downstream reaches.
 - Compare the Geomorphic Index, Riparian Index and overall IDC score for the diversion reach to assess the condition of the diversion reach relative to the upstream and downstream reaches.
 - Compare the Geomorphic Index, Riparian Index and overall IDC scores for the diversion, upstream and downstream reaches against the corresponding scores from previous monitoring activities to assess any changes to the condition of the diversion, upstream and downstream reaches.
5. Maintenance and damage assessment
- Walkover and visual inspection of the entire diversion reach during the month of April each year to identify any damage to the diversion since the last monitoring activity.

- Identification of any maintenance or remedial actions required to ensure the physical integrity of the diversion or to improve the performance of the diversion.

An annual operations performance monitoring report for the diversion should be prepared by the RPEQ that performed the annual monitoring. The annual performance monitoring report should include as a minimum:

- A summary of the data collected during the monitoring activities.
- A summary of the condition and performance of the diversion.
- Recommended maintenance or remedial actions required to ensure the physical integrity of the diversion or to improve the performance of the diversion.
- A proposed timetable for completion of the recommended maintenance or remedial actions.

In accordance with condition 17 of the EA, the annual performance monitoring report should be submitted to the EA administering authority by 30 June each year.

In addition to the routine annual operations monitoring, the following additional diversion monitoring activities as recommended by ACARP (ACARP, 2001) will be performed less frequently, the results of which will be included in the annual performance monitoring report for those years where such additional monitoring activities have been undertaken:

1. Cross-section survey (to be performed every five years or in years following the occurrence of a flow event larger than the 10 year ARI event in the diversion. Refer to Table 13.1 for peak flow and flood depth of 10 year ARI event)
 - Cross-section survey of the creek channel up to the top of the channel banks at each of the fixed point monitoring stations in the diversion, upstream and downstream reaches. The survey could be a ground survey or an aerial survey.
 - Comparison of the surveyed cross-sections against the corresponding surveyed cross-sections from previous monitoring activities to identify any geomorphic changes to the creek channel (i.e. channel migration, widening, deepening or aggradation, etc.) in the diversion, upstream and downstream reaches.
2. Riparian vegetation assessment (to be performed every five years)
 - Assessment of the species, abundance and diversity of riparian vegetation in the diversion reach.

The plugs at the upstream and downstream ends of the diversion have been classified as regulated structures (Section 3 of this Design Plan). An annual inspection of these structures will need to be undertaken in accordance with conditions G22 to G25 of the EA:

- Condition G22: Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

- Condition G23: 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.
- Condition G24: 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).
- Condition G25: The holder must: (a) within 20 business days of receipt of the annual inspection report, provide to the administering authority: (i) the recommendations section of the annual inspection report; and (ii) if applicable, any actions being taken in response to those recommendations; and (b) if, following receipt of the recommendations and (if applicable) actions, the administering authority requests a full copy of the annual inspection report from the holder, provide this to the administering authority within 10 business days of receipt of the request.

The annual inspection of the North Sonoma Creek Diversion plug structures will be performed as part of the annual inspection of all regulated structures at the Sonoma Coal Mine (the annual inspection typically occurs in October prior to the start of the wet season) and not as part of the annual operations performance monitoring report for the diversion.

Additional monitoring of Coral Creek is required under management plans that have been put in place in accordance with the approval conditions under the EPBC Act, including Sonoma Coal Mine Coral Creek Weed Management Plan (NRA, 2013) and Sonoma Coal Mine Coral Creek Riparian Zone Management Plan (NRA, 2014).

- Weed monitoring should be undertaken on an annual basis for the duration of site management (NRA, 2013).
- To report on the health of the Black Ironbox population and to more accurately determine positive and negative influences of the diversion, an assessment of the population will be undertaken immediately prior to the diversion and then again a minimum of one year after completion of the diversion (NRA, 2014).

A summary of the monitoring requirements for the North Sonoma Creek Diversion is provided in Table 13.1.

Table 13.1 Monitoring requirements for North Sonoma Creek Diversion

Monitoring Activity	Monitoring Frequency
Review of flow event monitoring data	Annually (prior to 30 June)

Monitoring Activity	Monitoring Frequency
Fixed point photographs	Annually (in April)
Aerial imagery assessment	Annually (prior to 30 June)
Index of Diversion Condition (IDC) assessments	Annually (in April)
Maintenance and damage assessment	Annually (in April)
Cross-section survey	Five yearly or following a wet season in which a 10 year ARI flow event ¹ occurs in the diversion (in April)
Riparian vegetation assessment	Five yearly (in April)
Annual regulated structure inspection of upstream and downstream diversion plugs	Annually (typically prior to start of wet season)
Annual weed monitoring	Annually
Assessment of Black Ironbox population	Immediately prior to the diversion and a minimum of one year after completion of the diversion

Note 1: The 10 year ARI peak design flow is 288 m³/s (refer Table 5.1) and the associated flood depth in the diversion reach is 5.0 m (BSM, 2011)

14. QUALIFICATIONS

- a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.
- b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.
- c. Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:
 - (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
 - (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.
- d. Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.
- e. This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.
- f. If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.
- g. This report does not provide legal advice.

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APPENDIX A

Statement of Certification

11 May 2018

Form of Certification

Design Plan for North Sonoma Creek Diversion – Sonoma Coal Mine

Name of Registered Professional Engineer providing certification:

Andrew Michael Vitale

Address of Registered Professional Engineer providing certification:

Level 7/500 Queen Street, Brisbane QLD 4000

Statement of relevant experience

I hereby state that I am a Registered Professional Engineer of Queensland and meet the requirements of the definition of 'suitably qualified and experienced person' for watercourse diversions as stated in the model conditions for watercourse diversions (141126 EM944).

Statement of certification

I hereby certify that the detailed design plan titled *North Sonoma Creek Diversion Design Report* and dated 11 May 2018:

- Relates to watercourse diversion of Coral Creek between the upstream limit (589,941E, 7,721,650N) and downstream limit (588,966E, 7,721,232N).
- Includes all relevant material relied on by me including information provided by other persons with relevant expertise including Chris Hansen (Director/Principal Ecologist, Ecological Survey & Management) and the previously approved design plans prepared by Brisbane Stormwater Management (*Design of Coral Creek Diversion* dated 9 May 2011 and *Design of Coral Creek Diversion Addendum Report* dated 18 November 2011).
- Is in accordance with all relevant conditions of Environmental Authority EPML00707713 including the requirement of Condition I3 for a Design Plan that achieves Condition I1 for permanent watercourse diversions.

In addition, I certify that

- The consequence category assessment prepared for the Upstream Plug and Downstream Plug structures associated with the diversion presented in *North Sonoma Creek Diversion Design Report* dated 11 May 2018 has been prepared in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures published by the administering authority (ESR/2016/1933) and Condition G1 of Environmental Authority EPML00707713.
- The design of the plugs has been prepared in accordance with good engineering practice and the design is also consistent with the standards required for structures of the assessed consequence category as set out in the Manual published by the administering authority.
- Provided the plug structures are constructed or modified (in consultation with the designer) in the manner specified and the facility is operated and maintained as recommended, the structure is capable of delivering the performance stated in the report *North Sonoma Creek Diversion Design Report* dated 11 May 2018 so as to be compliant with relevant conditions of the environmental authority.

I Andrew Michael Vitale, declare that the information and opinions provided as part of this certification is true to the best of my knowledge and belief. I acknowledge that it is an offence under

section 480 of the *Environmental Protection Act 1994* to give the administering authority a document containing information that I know is false, misleading or incomplete in a material particular.

Signed:



Andrew Michael Vitale, RPEQ No. 9341

APPENDIX B

Consequence Category Assessment

Storage Consequence Category Assessment

Site: Sonoma Coal Mine
 Structure Name: Upstream Diversion Plug

Storage Details	
Current Levee Function	Flood protection for North Sonoma Pit from Coral Creek
Type of Levee Construction	Compacted earth embankment with clay key
Storage Capacity	N/A - not a storage
Maximum Embankment Height	7.8 m
Catchment Area	Coral Creek catchment to location of diversion plug is 107 km ²
Water Quality	N/A - not a storage
Receiving Waterways: Overtopping	North Sonoma Pit
Receiving Waterways: Dam Break	North Sonoma Pit

Scenario	Category of Harm	Detail	Consequence Category	Scenario Consequence Category
Failure to Contain - Seepage	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	Assessment of failure to contain - seepage scenario is not required for levees	N/A	N/A
Failure to Contain - Overtopping	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	The diversion plug has been designed to provide flood protection for the pit up to the 1:1,000 AEP flood event. Flood water overtopping the levee in larger events would be contained within the North Sonoma Pit and managed within the mine water management system. A flood event that would casue the pit to fill and discharge to Coral Creek would result in significant dilution of any discharge in the downstream waterway. Overtopping of the diversion plug is not expected to result in Harm to Humans, General Environmental Harm or General Economic Loss or Property Damage that would exceed the threshods specified for the Low Consequence Category in Table 1 of the Manual.	Low	Low
Dam Break	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	Section 2.3.1 of the Manual states: Where a levee is designed to prevent ingress of non-mine affected flood water into an operational area, or catchment of a containment system, the suitably qualified and experienced person conducting and certifying the assessment and construction would declare that the levee is a regulated structure where the flood modelling shows that the pit would be encroached by a flood event with a probability more likely than or equal to 1:1000 AEP. The diversion plug is deemed to be a regulated structure for dam break.	Significant	Significant

Overall Consequence Category Assessment	Significant
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Storage Consequence Category Assessment

Site: Sonoma Coal Mine
Structure Name: Downstream Diversion Plug

Storage Details	
Current Levee Function	Flood protection for North Sonoma Pit from Coral Creek
Type of Levee Construction	Compacted earth embankment with clay key
Storage Capacity	N/A - not a storage
Maximum Embankment Height	7.8 m
Catchment Area	Coral Creek catchment to location of diversion plug is 107 km ²
Water Quality	N/A - not a storage
Receiving Waterways: Overtopping	North Sonoma Pit
Receiving Waterways: Dam Break	North Sonoma Pit

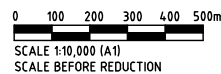
Scenario	Category of Harm	Detail	Consequence Category	Scenario Consequence Category
Failure to Contain - Seepage	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	Assessment of failure to contain - seepage scenario is not required for levees	N/A	N/A
Failure to Contain - Overtopping	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	The diversion plug has been designed to provide flood protection for the pit up to the 1:1,000 AEP flood event. Flood water overtopping the levee in larger events would be contained within the North Sonoma Pit and managed within the mine water management system. A flood event that would casue the pit to fill and discharge to Coral Creek would result in significant dilution of any discharge in the downstream waterway. Overtopping of the diversion plug is not expected to result in Harm to Humans, General Environmental Harm or General Economic Loss or Property Damage that would exceed the threshods specified for the Low Consequence Category in Table 1 of the Manual.	Low	Low
Dam Break	Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage	Section 2.3.1 of the Manual states: Where a levee is designed to prevent ingress of non-mine affected flood water into an operational area, or catchment of a containment system, the suitably qualified and experienced person conducting and certifying the assessment and construction would declare that the levee is a regulated structure where the flood modelling shows that the pit would be encroached by a flood event with a probability more likely than or equal to 1:1000 AEP. The diversion plug is deemed to be a regulated structure for dam break.	Significant	Significant

Overall Consequence Category Assessment	Significant
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APPENDIX C

Design Drawings

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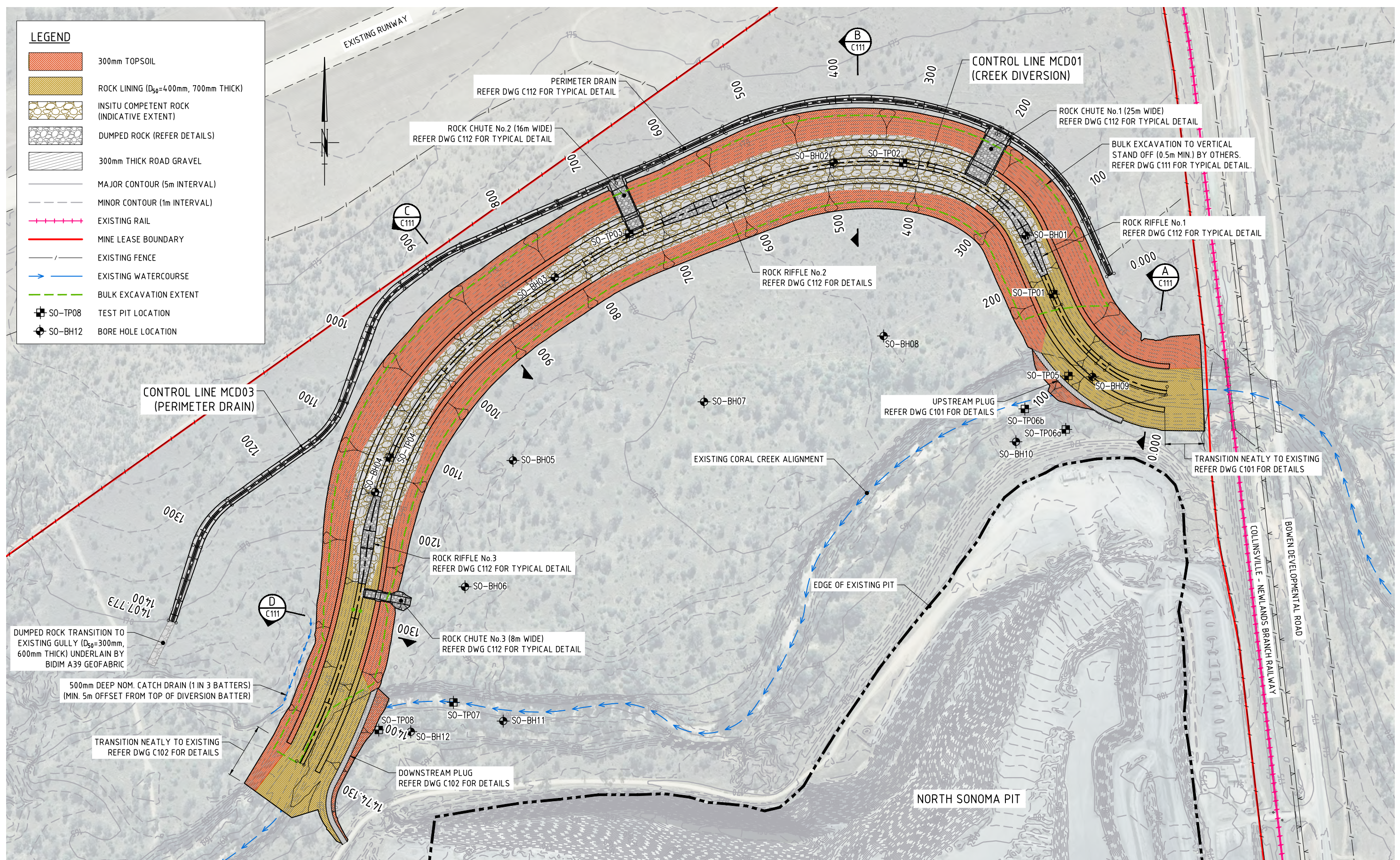
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SONOMA • COAL



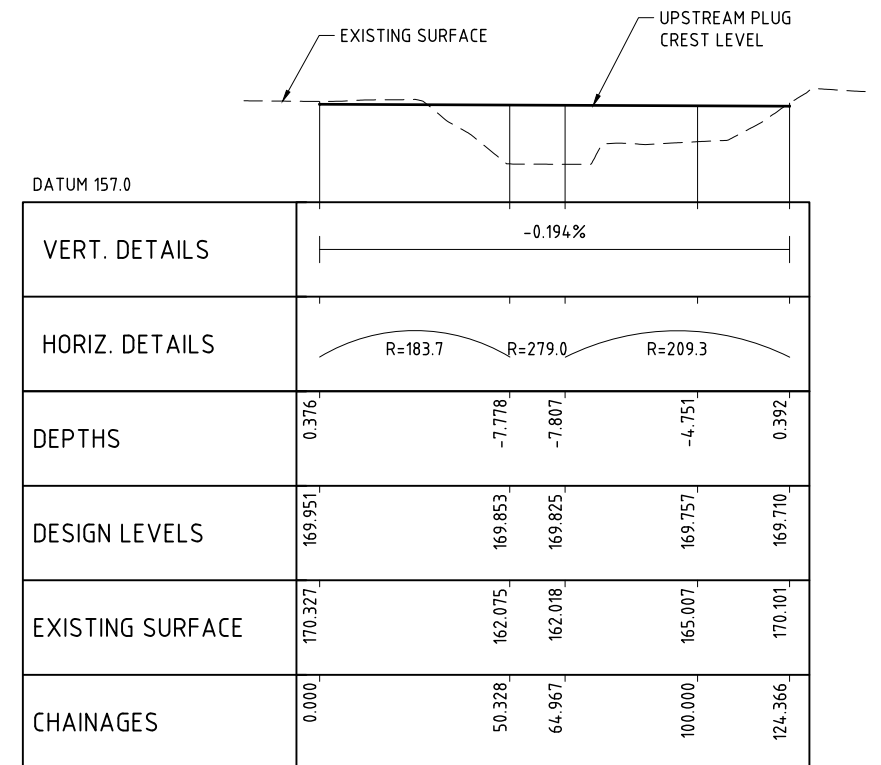
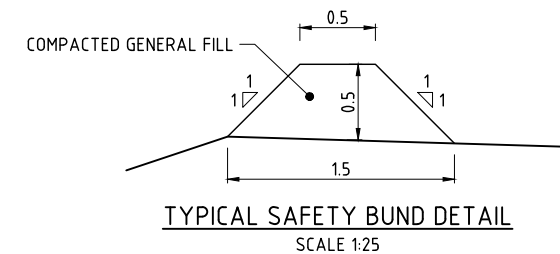
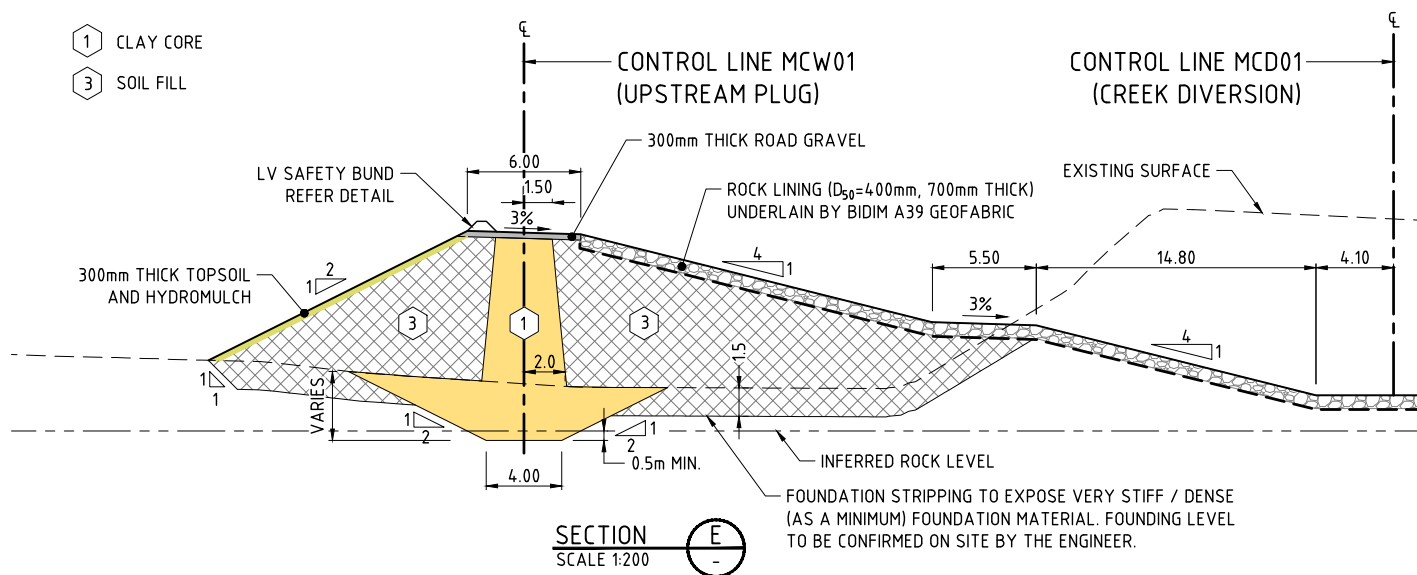
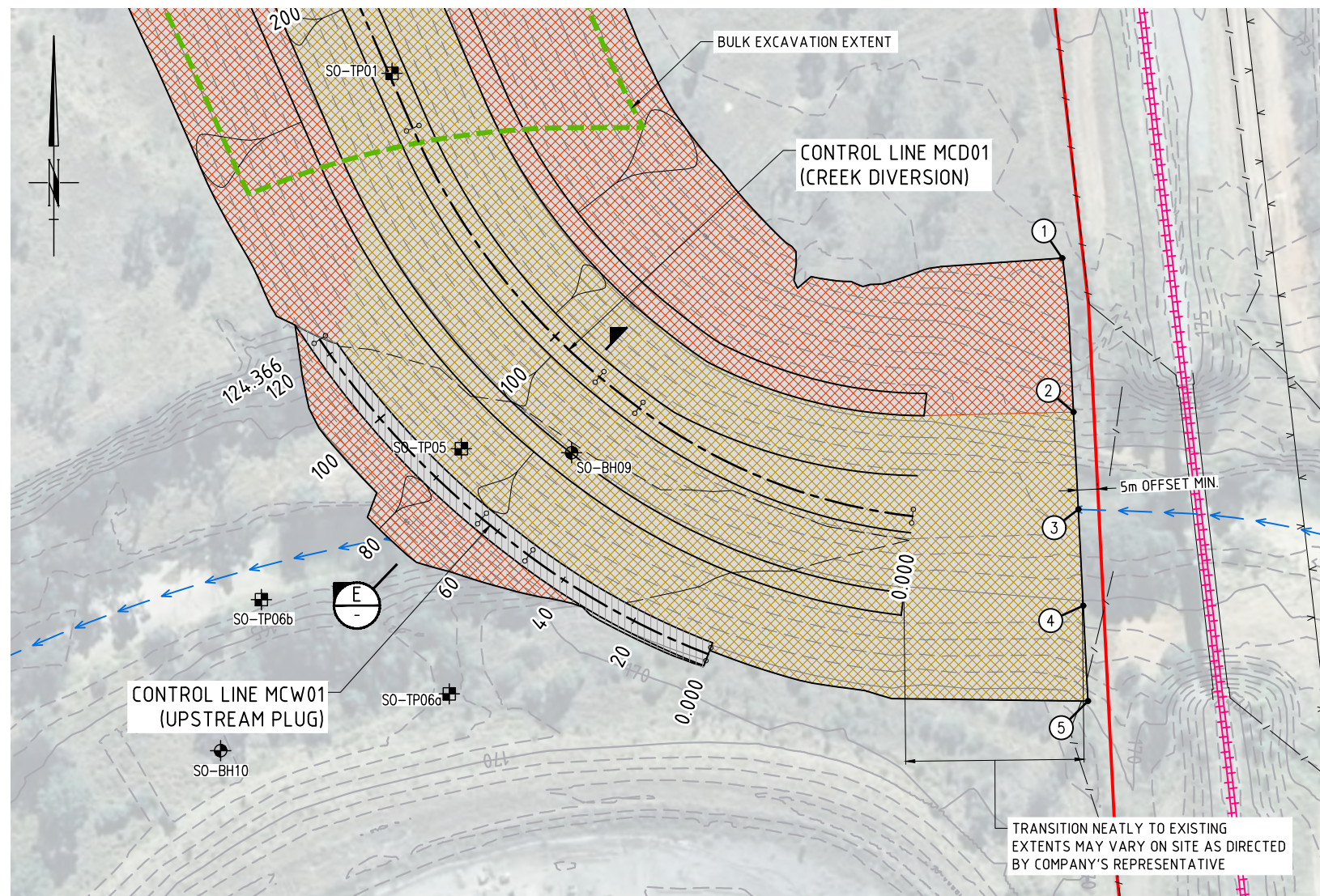
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NORTH SONOMA CREEK DIVERSION COVER SHEET, LOCALITY PLAN & GENERAL NOTES			
Original Size	A1	Dwg No.	M4100-027-C001
		Rev.	0



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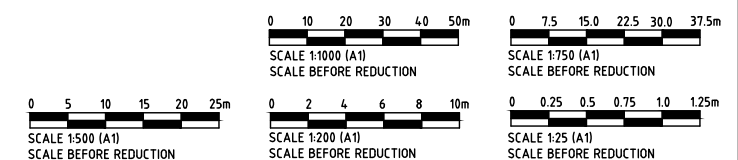
Ph. 07 3221 7174
Fax. 07 3236 2399
Level 7
500 Queen St
Brisbane QLD
PO Box 10183
Brisbane QLD 4000
www.engeny.com.au



SETOUT POINTS

POINT No.	COORDINATES		
	EASTING	NORTHING	LEVEL
1	589977.696	7721713.362	EXISTING
2	589980.468	7721675.624	EXISTING
3	589981.663	7721651.776	EXISTING
4	589982.844	7721628.184	EXISTING
5	589984.016	7721604.793	EXISTING

CONTROL LINE MCW01 (UPSTREAM PLUG)					
PT	CHAINAGE	EASTING	NORTHING	HEIGHT	RAD/SPIRAL
IP 1	0.000	589890.992	7721616.296	169.951	
	20.000	589872.744	7721624.459	169.912	
IP 2	25.164	589867.349	7721625.364	169.902	R = 183.734
	40.000	589855.492	7721634.556	169.873	
CC	50.328	589847.040	7721640.489	169.853	
IP 3	57.648	589841.168	7721644.862	169.839	R = 278.991
	60.000	589839.384	7721646.400	169.835	
CC	64.967	589835.534	7721649.538	169.825	
	80.000	589824.319	7721659.544	169.796	
IP 4	94.667	589812.523	7721668.631	169.767	R = 209.327
	100.000	589810.567	7721674.055	169.757	
	120.000	589798.261	7721689.811	169.718	
IP 5	124.366	589795.779	7721693.403	169.710	



NOTE:

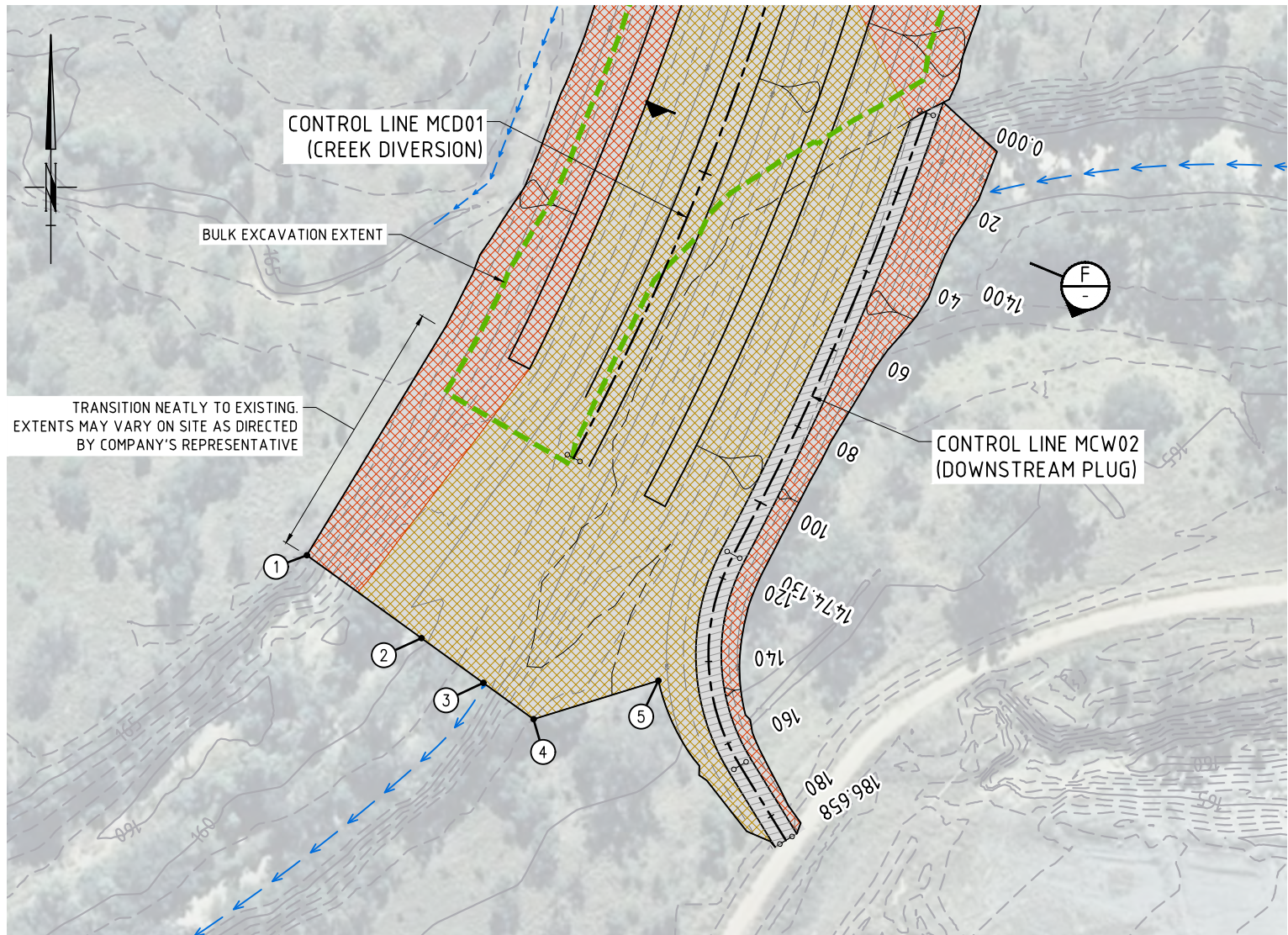
1. THE CONTRACTOR SHALL MAINTAIN AND PROGRESSIVELY RAISE SAFETY BUNDS ON THE DOWNSTREAM EDGE OF THE WORKS.

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					-	NORTH SONOMA CREEK DIVERSION-STAGE 2 WORKS
					-	NORTH SONOMA CREEK DIVERSION DESIGN REPORT
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No.	BY	DATE	REVISION	APPD	REFERENCE DOCUMENTS	

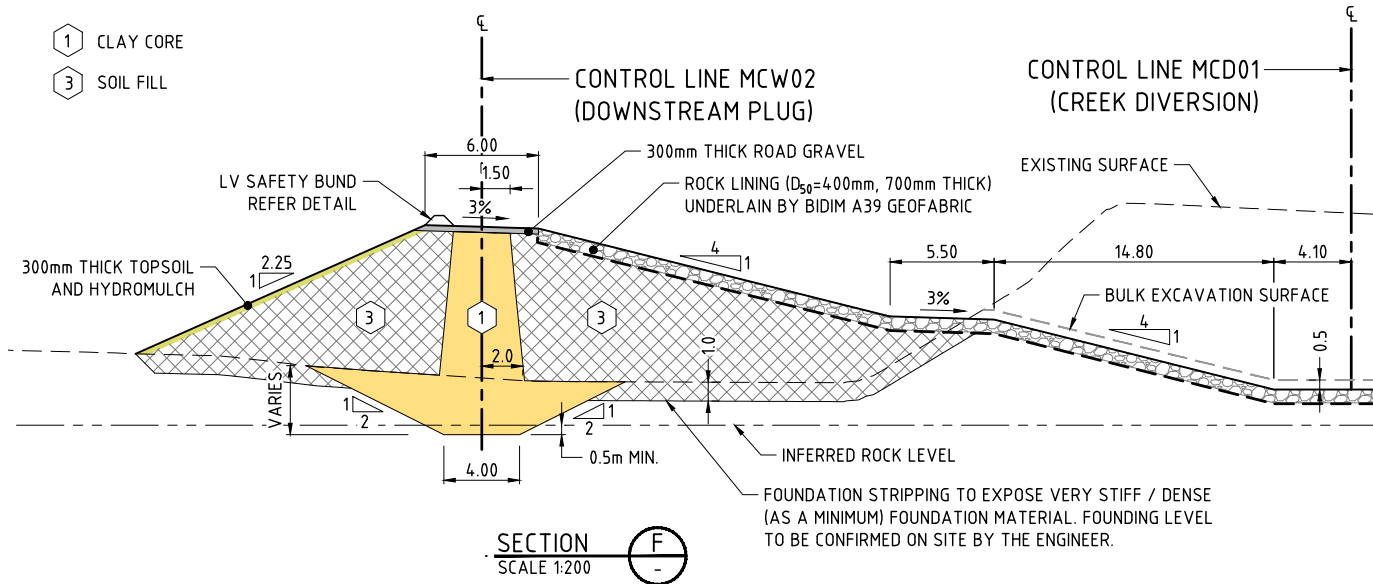


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DRAWN	SA	CHECKED	MT
APPROVED	AV	DATE	16.04.18
RPEQ	AV	RPEQ No.	9341

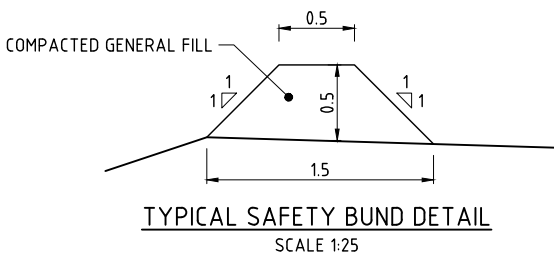
SONOMA MINE MANAGEMENT PTY LTD			
NORTH SONOMA CREEK DIVERSION UPSTREAM TRANSITION & PLUG			
Original Size	A1	Dwg No.	M4100-027-C101
		Rev.	0



DOWNSTREAM PLUG - DETAIL PLAN
SCALE 1:750



SECTION
SCALE 1:200



TYPICAL SAFETY BUND DETAIL
SCALE 1:25

	EXISTING SURFACE	DOWNSTREAM PLUG CREST LEVEL
DATUM 154.0		
VERT. DETAILS	-0.194%	
HORIZ. DETAILS	R=732.3 R=-50.0 L=20.693	
DEPTHS	0.151	-2.704 -2.691 -1.406 1.164
DESIGN LEVELS	167.085	166.891 166.864 166.763 166.723
EXISTING SURFACE	167.237	164.187 164.174 165.358 167.887
CHAINAGES	0.000	100.000 113.883 165.965 186.658

CONTROL LINE MCW02 (DOWNSTREAM PLUG)

SCALE 1:1000 HORZ.
SCALE 1:500 VERT.

SETOUT POINTS

POINT No.	COORDINATES		
	EASTING	NORTHING	LEVEL
1	588903.221	7721208.699	EXISTING
2	588930.285	7721189.145	EXISTING
3	588944.893	7721178.590	EXISTING
4	588956.736	7721170.032	EXISTING
5	588986.176	7721179.113	EXISTING

CONTROL LINE MCW02 (DOWNSTREAM PLUG)					
PT	CHAINAGE	EASTING	NORTHING	HEIGHT	RAD/SPIRAL
IP 1	0.000	589049.446	7721313.042	167.085	
	20.000	589042.628	7721294.241	167.047	
	40.000	589035.300	7721275.632	167.008	
IP 2	56.942	589030.730	7721259.143	166.975	R = 732.310
	60.000	589027.466	7721257.231	166.969	
	80.000	589019.133	7721239.051	166.930	
	100.000	589010.306	7721221.105	166.891	
CC	113.883	589003.892	7721208.792	166.864	
	120.000	589001.352	7721203.232	166.853	
IP 3	139.924	588990.401	7721183.480	166.814	R = -50.000
	140.000	588998.042	7721183.642	166.814	
	160.000	589002.622	7721164.311	166.775	
CT	165.965	589005.440	7721159.057	166.763	
	180.000	589012.799	7721147.106	166.736	
	186.658	589016.290	7721141.437	166.723	

NOTE:
1. THE CONTRACTOR SHALL MAINTAIN AND PROGRESSIVELY RAISE SAFETY BUNDS ON THE DOWNSTREAM EDGE OF THE WORKS.

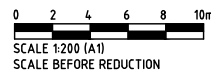
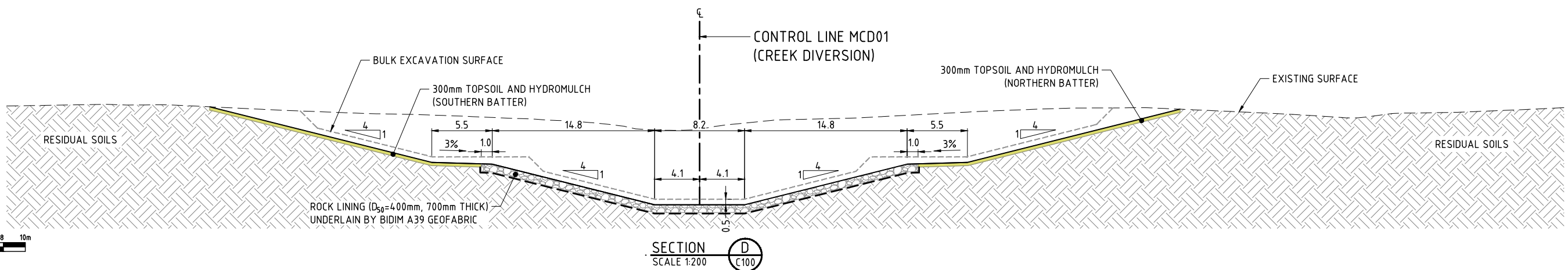
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SONOMA MINE MANAGEMENT PTY LTD			
NORTH SONOMA CREEK DIVERSION DOWNSTREAM TRANSITION & PLUG			
Original Size	Orig No.		Rev.
A1	M4100-027-C102		0

1. BULK EXCAVATION TO VERTICAL STAND OFF (0.5m MIN. ABOVE DESIGN LEVEL) BY OTHERS.



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						-	NORTH SONOMA CREEK DIVERSION-STAGE 2 WORKS
						-	NORTH SONOMA CREEK DIVERSION DESGIN REPORT
0	MT	16.04.18	ISSUED FOR CONSTRUCTION			SF	DOC. NUMBER
No.	BY	DATE	REVISION			APPD	DOCUMENT TITLE
							REFERENCE DOCUMENTS



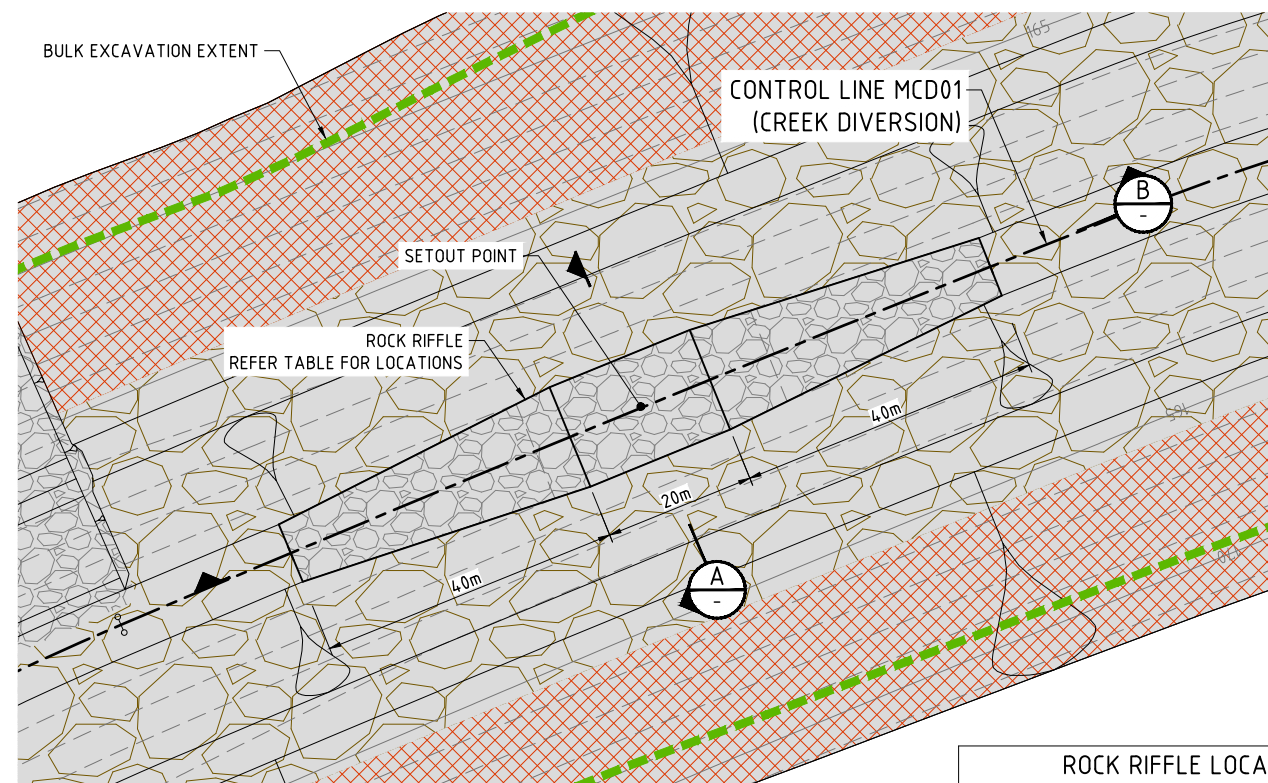
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RPEQ	AV	RPEQ No.	9341

SONOMA MINE MANAGEMENT PTY LTD
NORTH SONOMA CREEK DIVERSION
TYPICAL SECTIONS & DETAILS
SHEET 1 OF 2

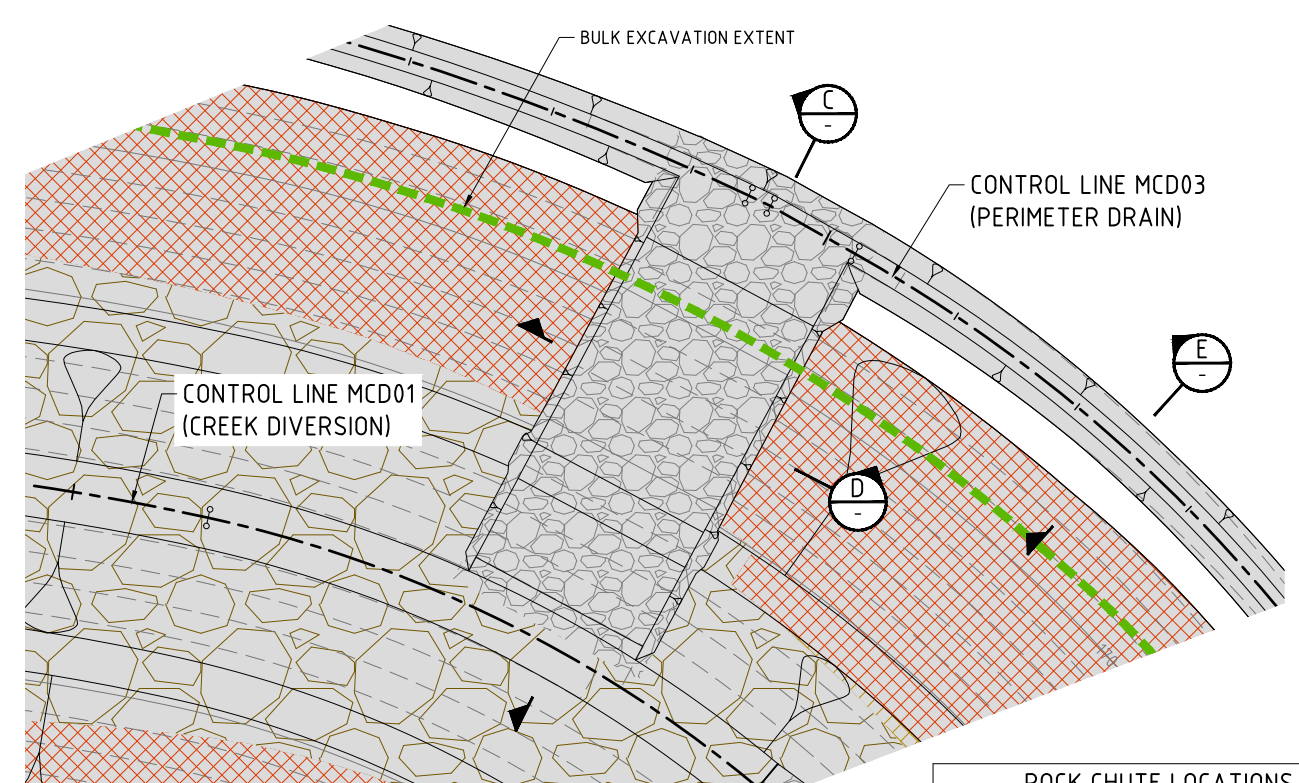
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A1	M4100-027-C111

Rev
0



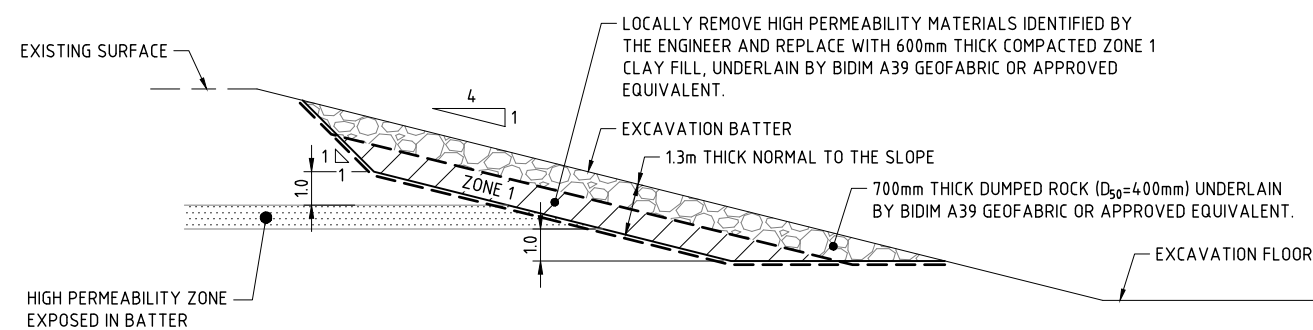
ROCK RIFFLE TYPICAL DETAIL
SCALE 1:500

ROCK RIFFLE LOCATIONS	
RIFFLE NO.	CHAINAGE ON CONTROL LINE MCD01
1	250
2	650
3	1210

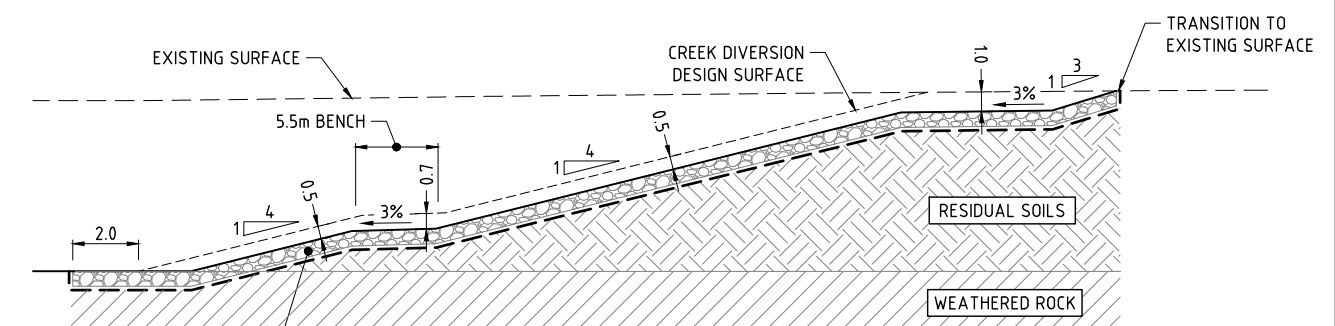
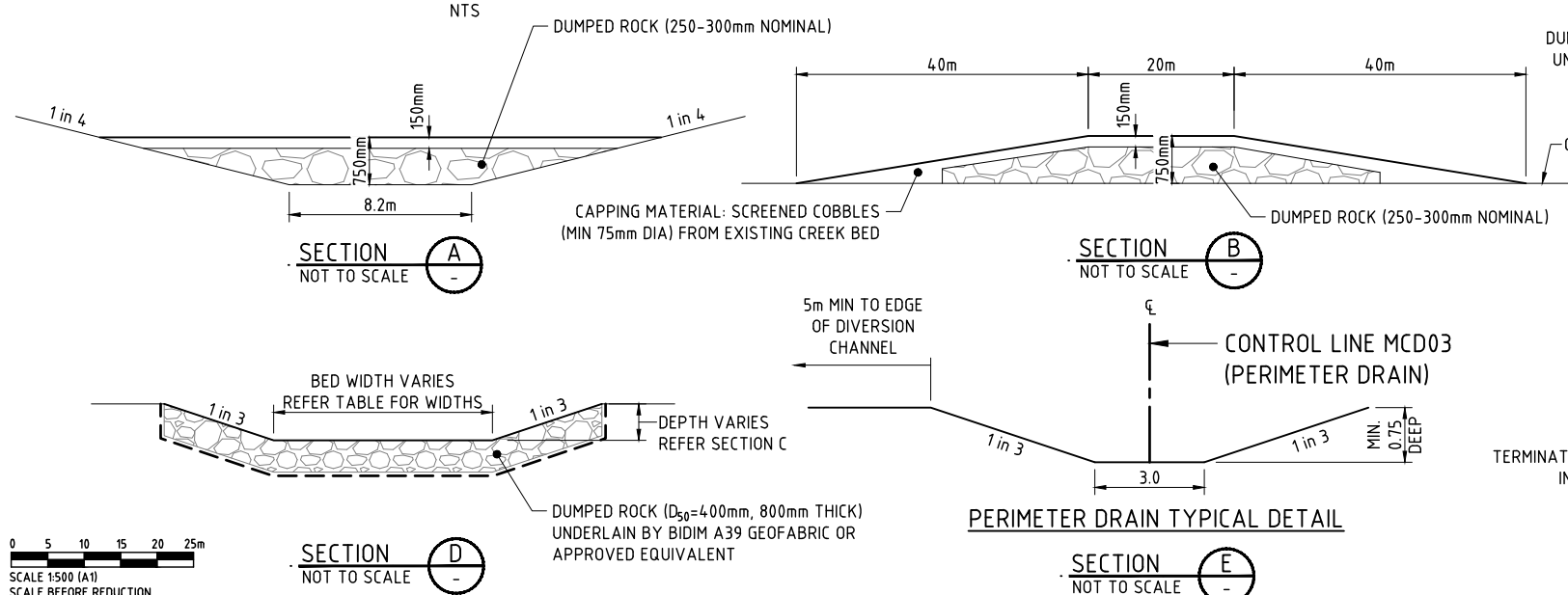


ROCK CHUTE & PERIMETER DRAIN TYPICAL DETAIL
SCALE 1:500

ROCK CHUTE LOCATIONS			
CHUTE NO.	CHAINAGE ON CONTROL LINE MCD01	WIDTH	BANK
1	335	25	NORTH
2	730	16	NORTH
3	1270	8	SOUTH

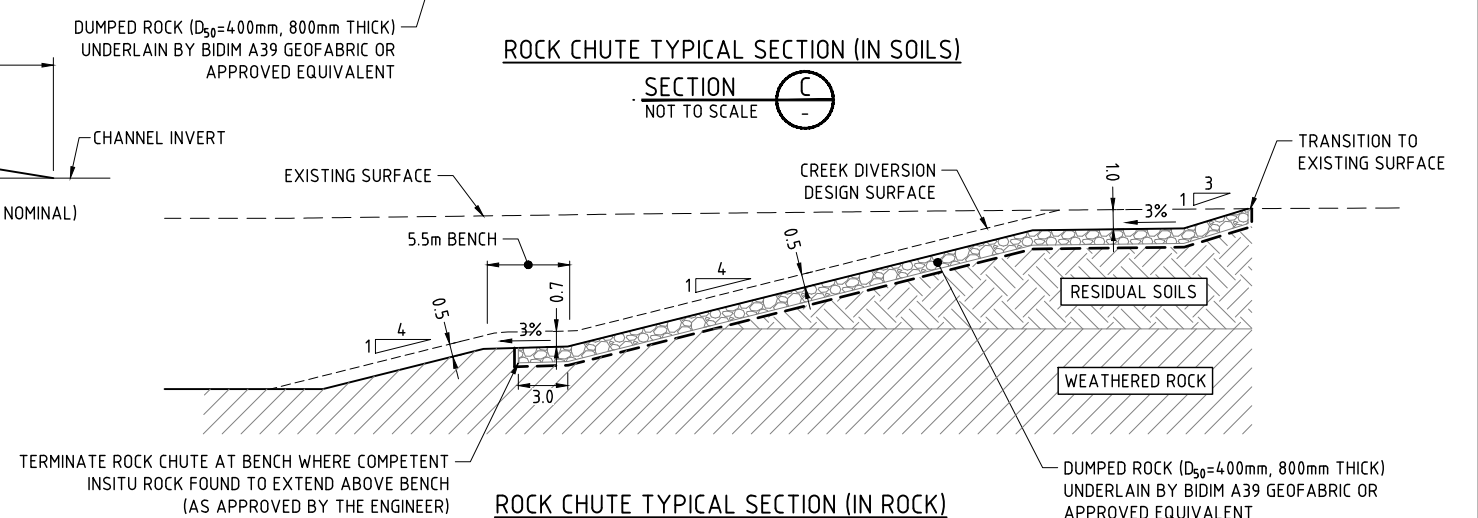


TYPICAL CLAY LINING DETAIL - EXCAVATION BATTER
NTS



ROCK CHUTE TYPICAL SECTION (IN SOILS)

SECTION C
NOT TO SCALE



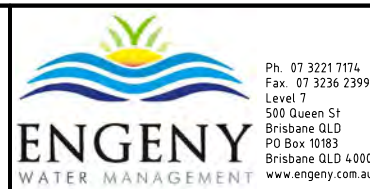
ROCK CHUTE TYPICAL SECTION (IN ROCK)

SECTION C
NOT TO SCALE

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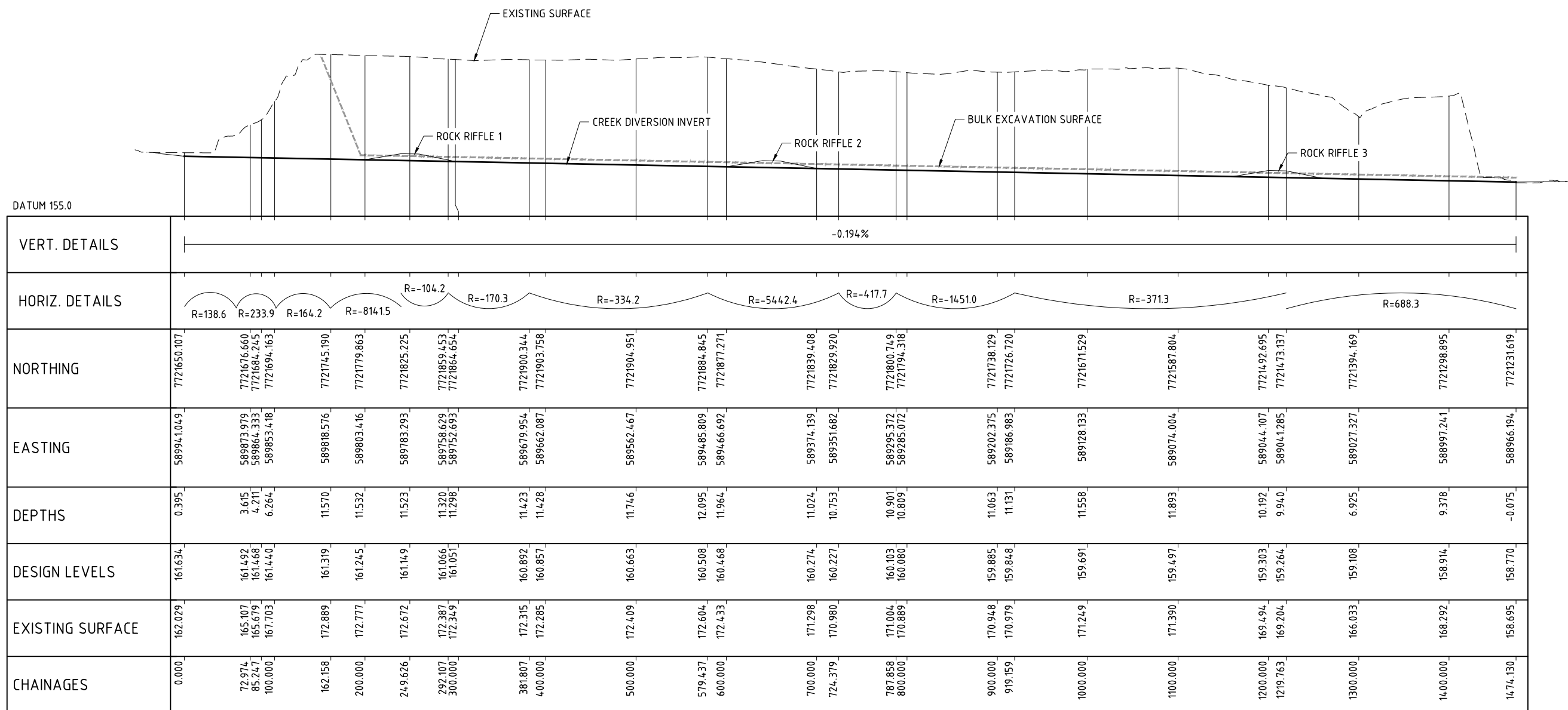
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-	NORTH SONOMA CREEK DIVERSION DESIGN REPORT
APPD	REFERENCE DOCUMENTS

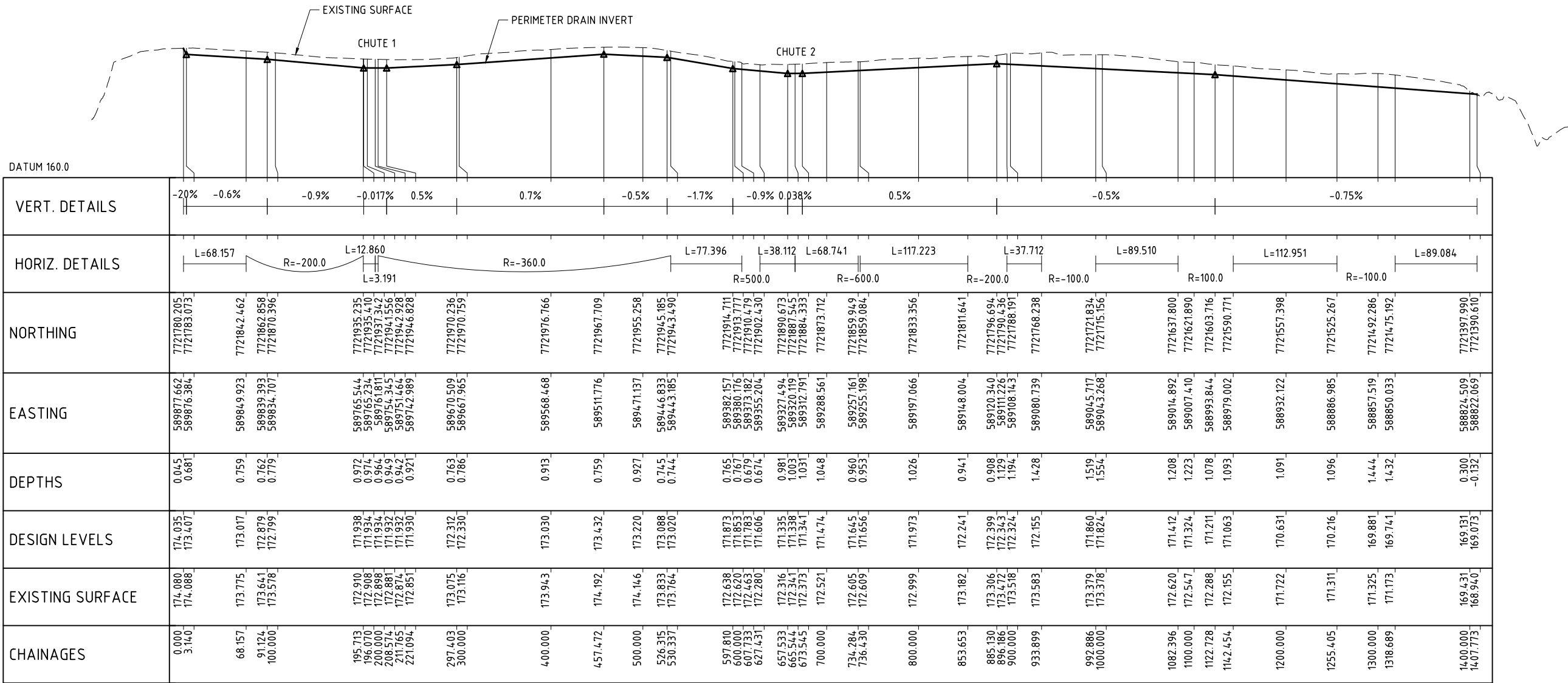


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DRAWN	SA	CHECKED	MT
APPROVED	AV	DATE	16.04.18
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SONOMA MINE MANAGEMENT PTY LTD	
NORTH SONOMA CREEK DIVERSION TYPICAL SECTIONS & DETAILS SHEET 2 OF 2	
Original Size A1	Rev. 0

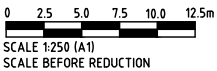
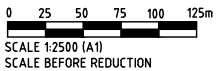
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CONTROL LINE MCD03 (PERIMETER DRAIN)

SCALE 1:2500 HORIZ.
SCALE 1:250 VERT.



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No.	BY	DATE	REVISION	APPD	REFERENCE DOCUMENTS	

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-	NORTH SONOMA CREEK DIVERSION DESGIN REPORT	



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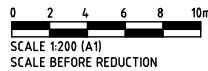
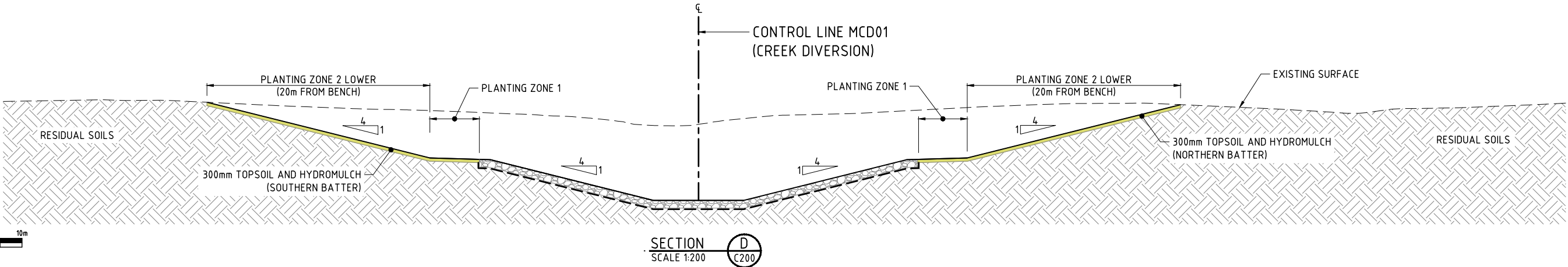
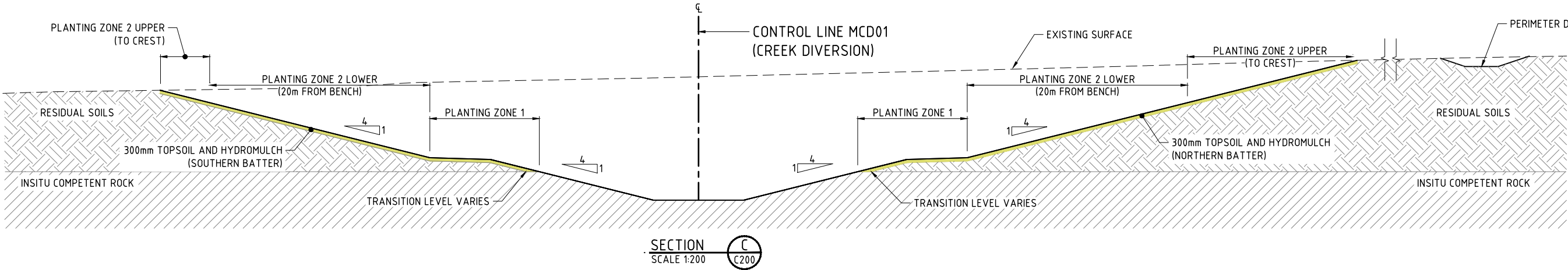
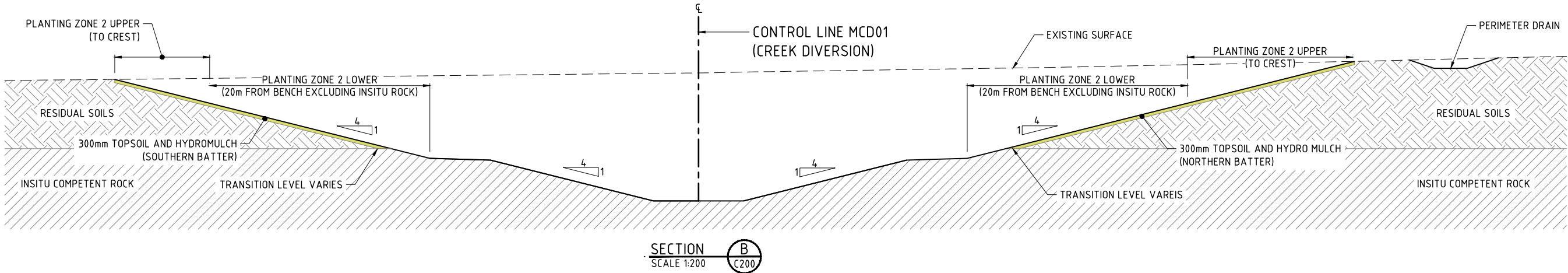
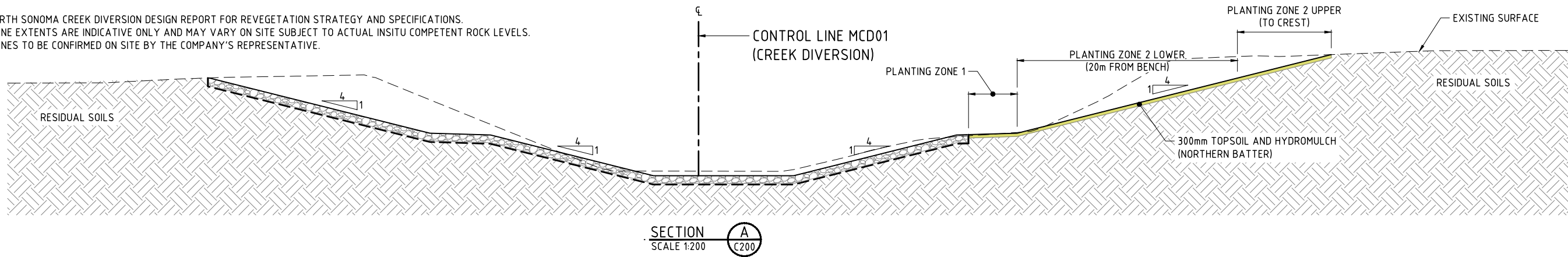
SONOMA MINE MANAGEMENT PTY LTD

NORTH SONOMA CREEK DIVERSION
LONGITUDINAL SECTIONS
SHEET 2 OF 2

Original Size	A1	Orig No.	M4100-027-C122	Rev.	0
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NOTE:

1. REFER TO NORTH SONOMA CREEK DIVERSION DESIGN REPORT FOR REVEGETATION STRATEGY AND SPECIFICATIONS.
2. PLANTING ZONE EXTENTS ARE INDICATIVE ONLY AND MAY VARY ON SITE SUBJECT TO ACTUAL INSITU COMPETENT ROCK LEVELS.
PLANTING ZONES TO BE CONFIRMED ON SITE BY THE COMPANY'S REPRESENTATIVE.



CAD REF: H:\PROJECTS\H4100_SONOMA_COAL\H4100_027_CORAL_CK_DIVERSION\DESIGN\AUTOCAD\DRAWINGS\H4100-027-C200.DWG
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-	NORTH SONOMA CREEK DIVERSION DESGIN REPORT
APPD	REFERENCE DOCUMENTS



Status FOR CONSTRUCTION			
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DRAWN	SA	CHECKED	MT
APPROVED	AV	DATE	16.04.18
RPEQ	AV	RPEQ No.	9341

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NORTH SONOMA CREEK DIVERSION REVEGETATION TYPICAL SECTIONS & DETAILS	
Original Size A1	Orig No. M4100-027-C210
Rev. 0	

APPENDIX D

Geotechnical Analysis Output

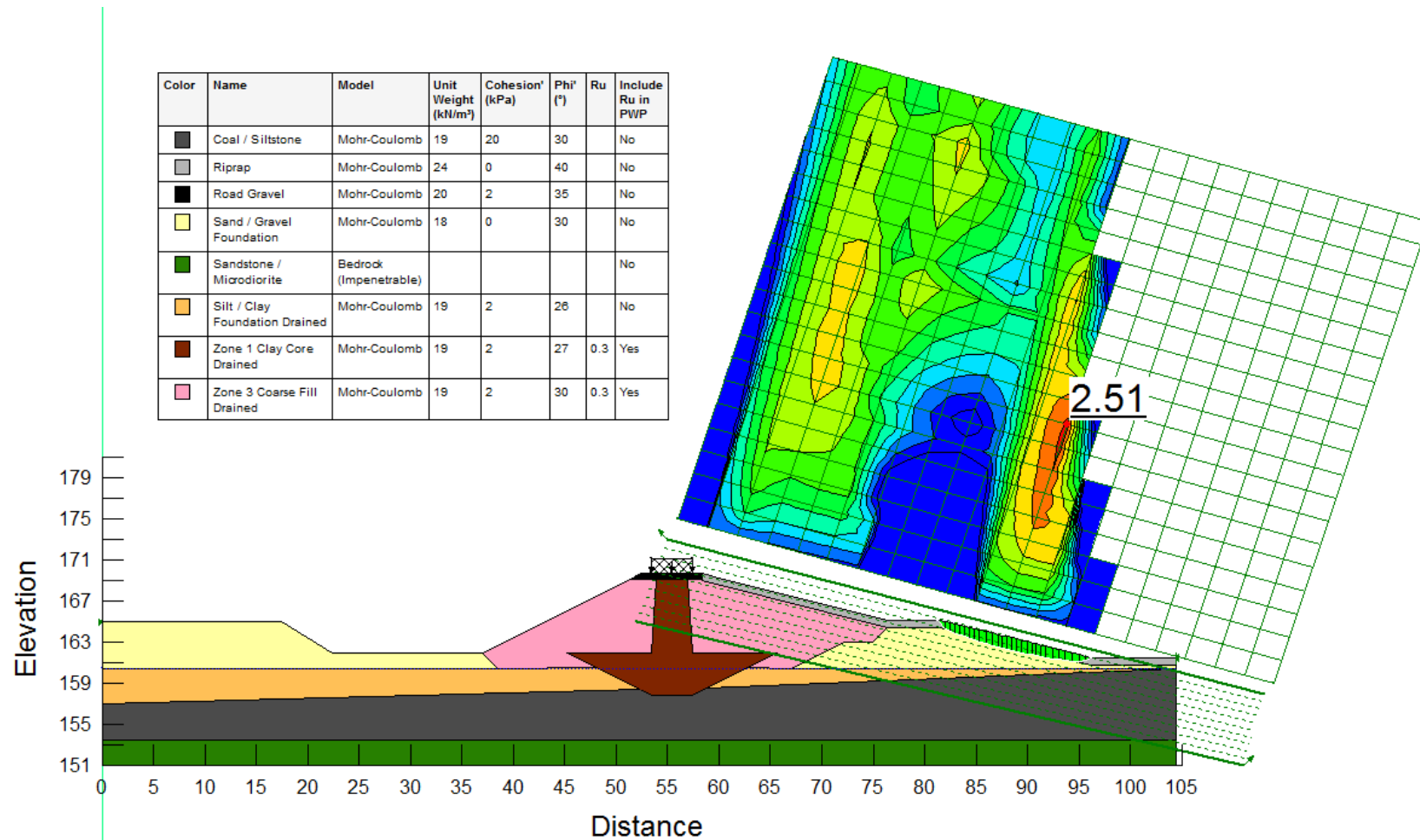


Figure 15.1 Section A – Upstream Drainage Plug Upstream Stability

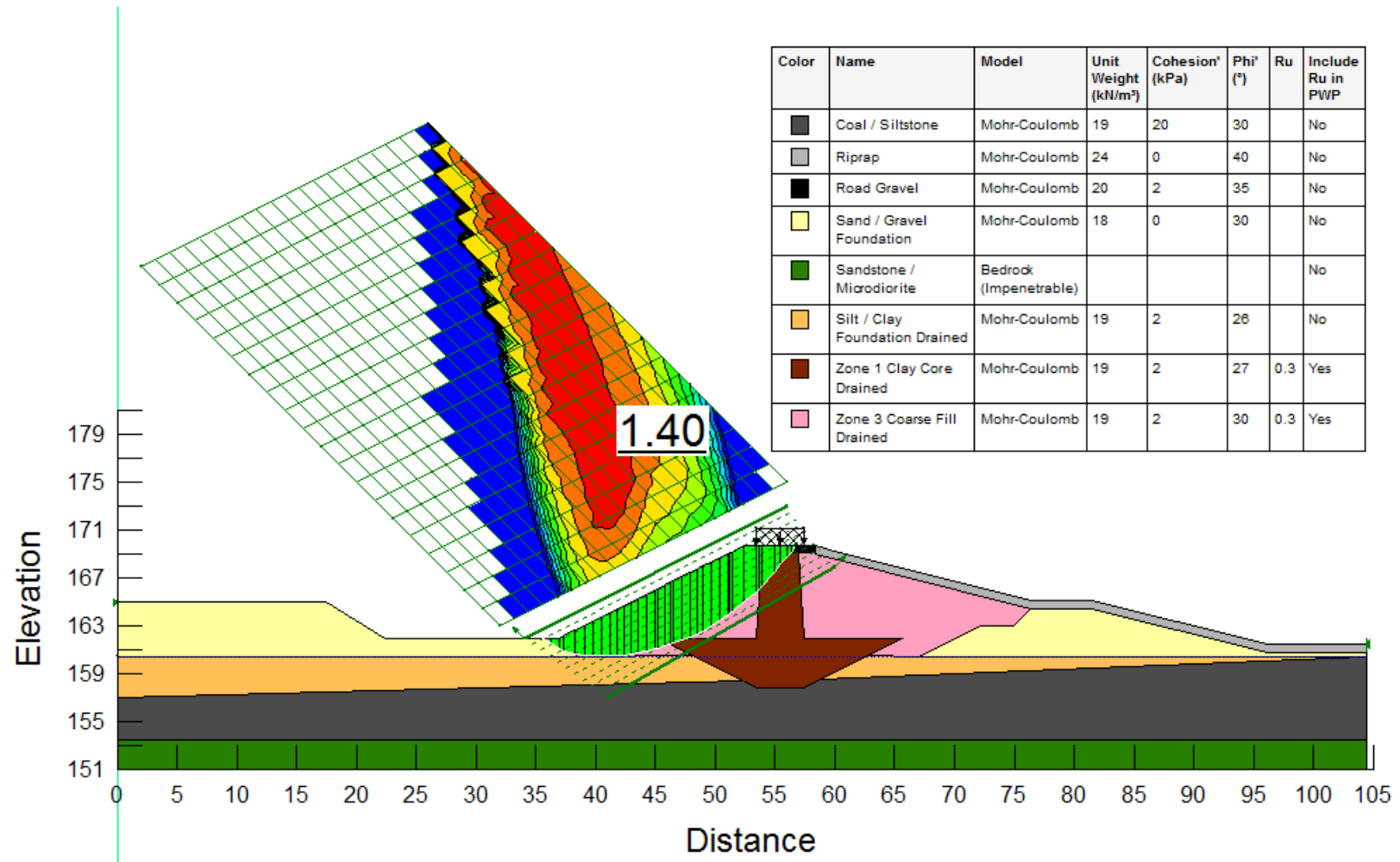


Figure 15.2 Section A – Upstream Drainage Plug Downstream Stability

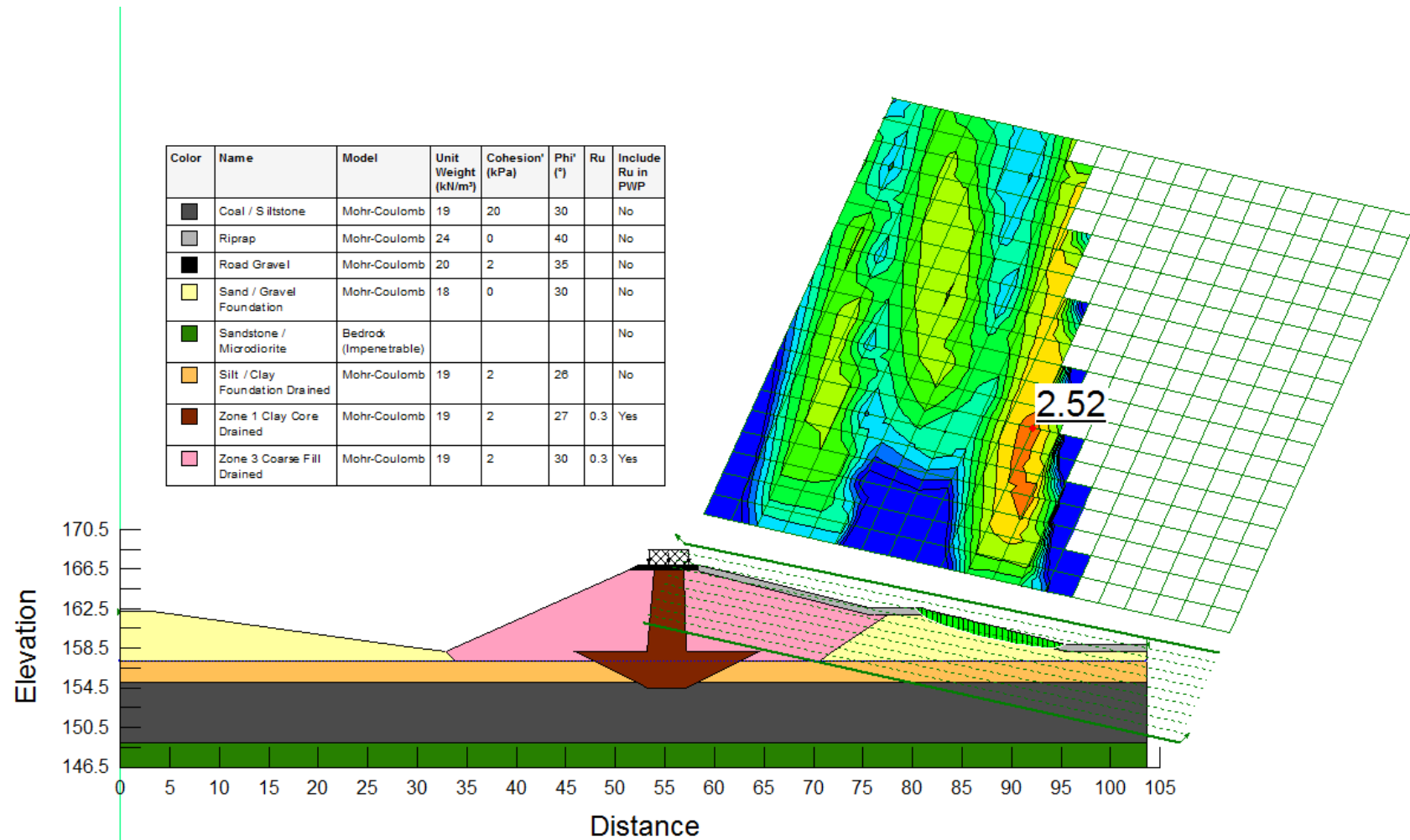


Figure 15.3 Section B – Downstream Drainage Plug Upstream Stability

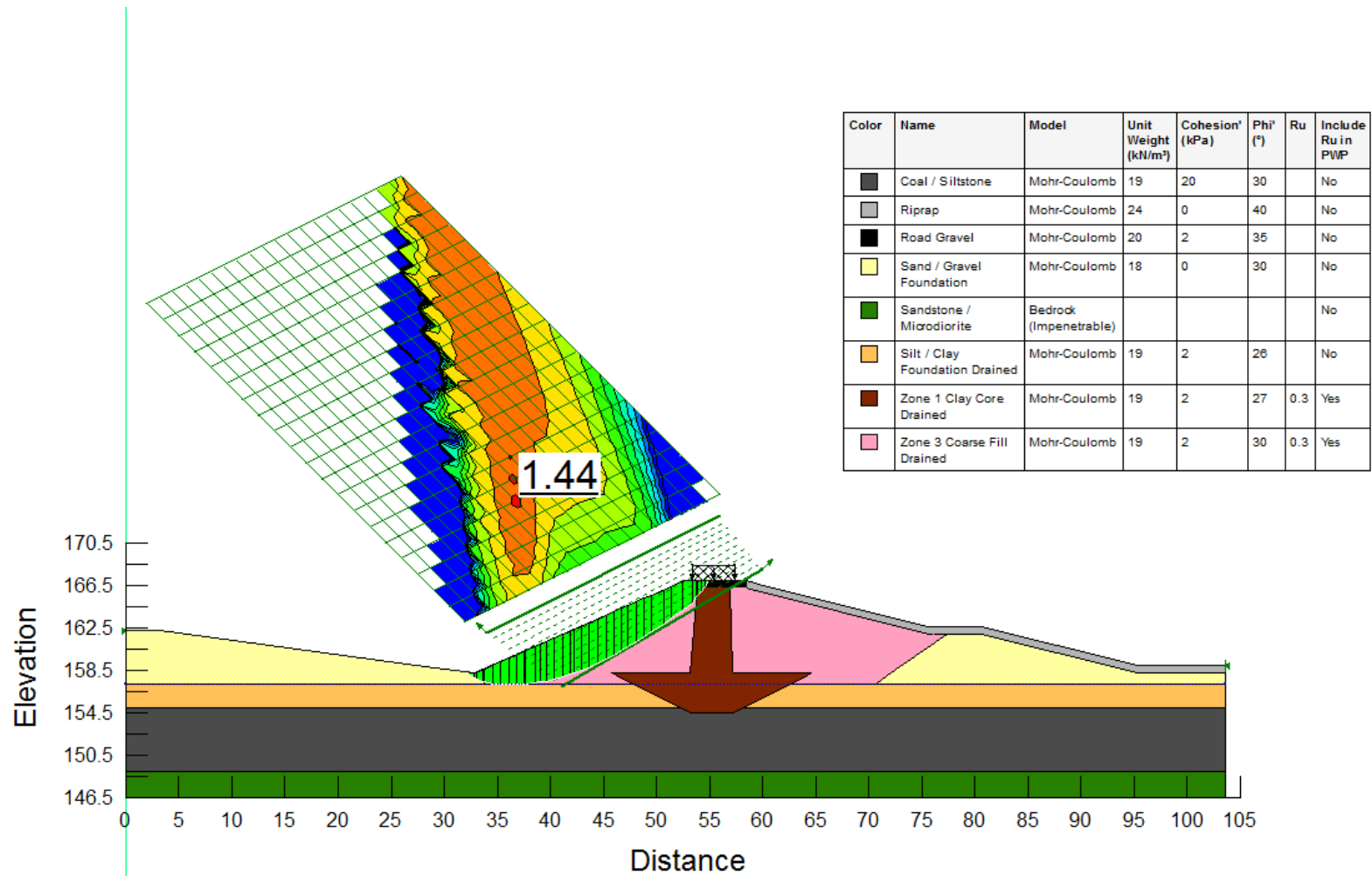


Figure 15.4 Section B – Downstream Drainage Plug Downstream Stability

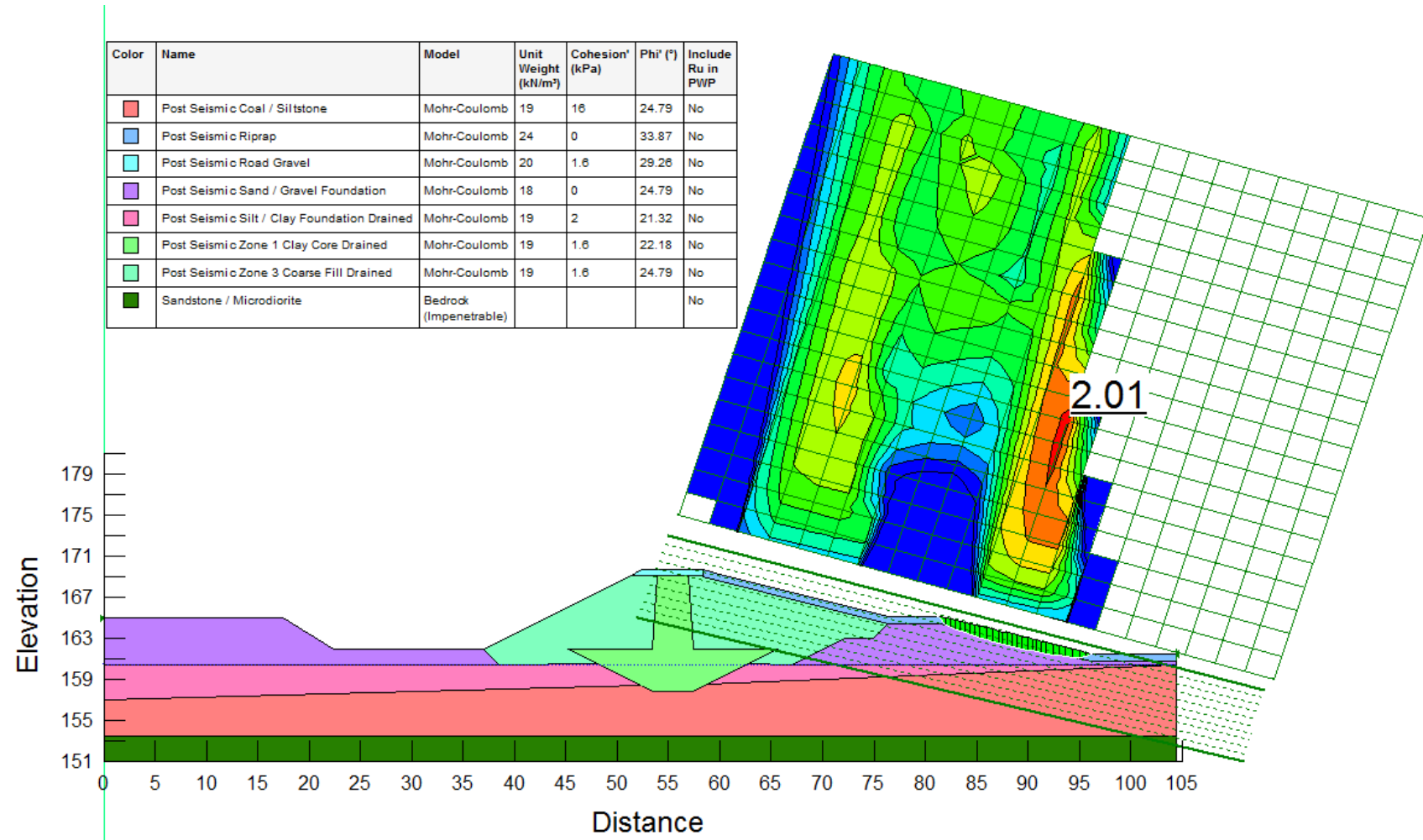


Figure 15.5 Section A – Upstream Drainage Plug Post Seismic Upstream Stability

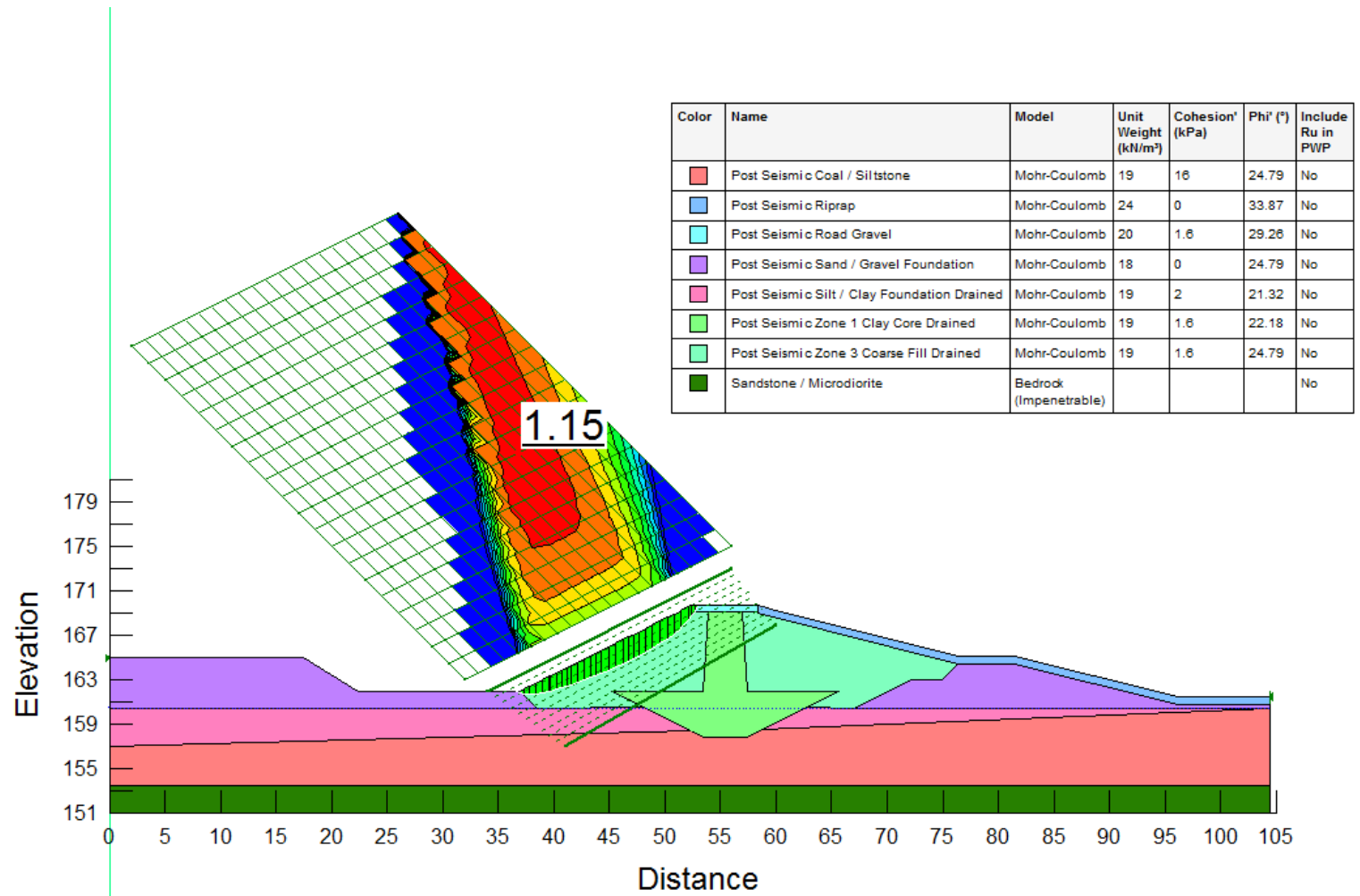


Figure 15.6 Section A – Upstream Drainage Plug Post Seismic Downstream Stability

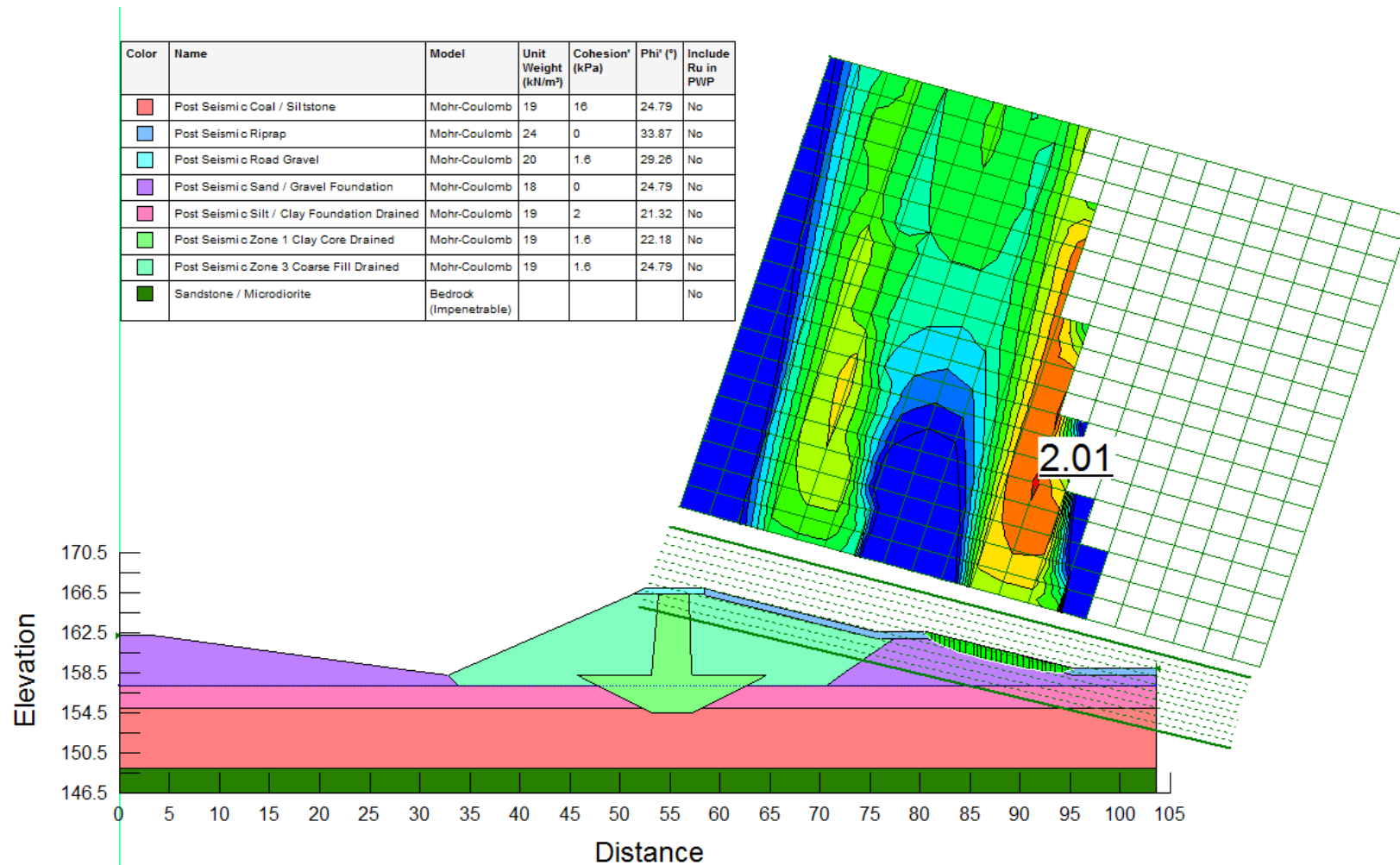


Figure 15.7 Section B – Downstream Drainage Plug Post Seismic Upstream Stability

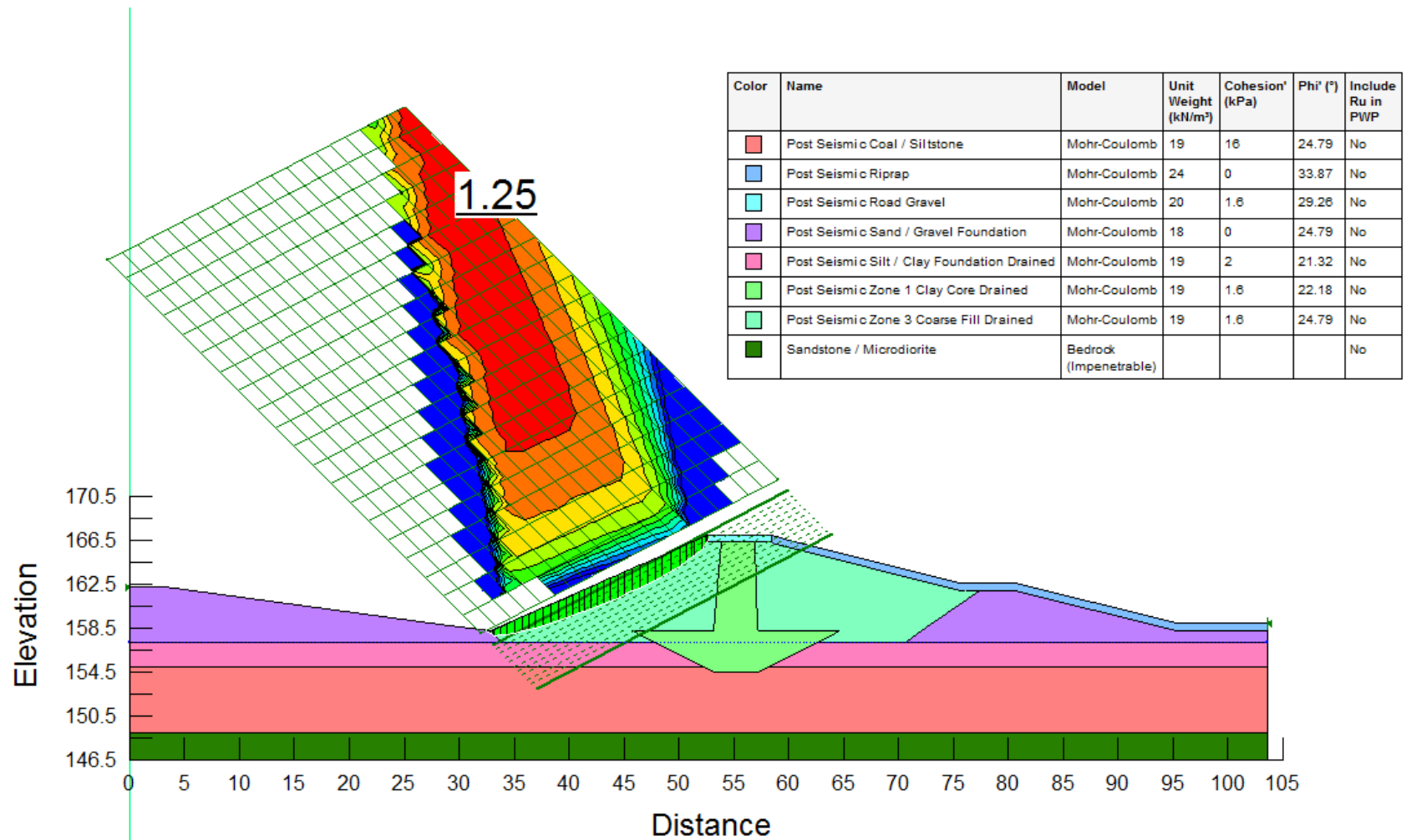


Figure 15.8 Section B – Downstream Drainage Plug Post Seismic Downstream Stability

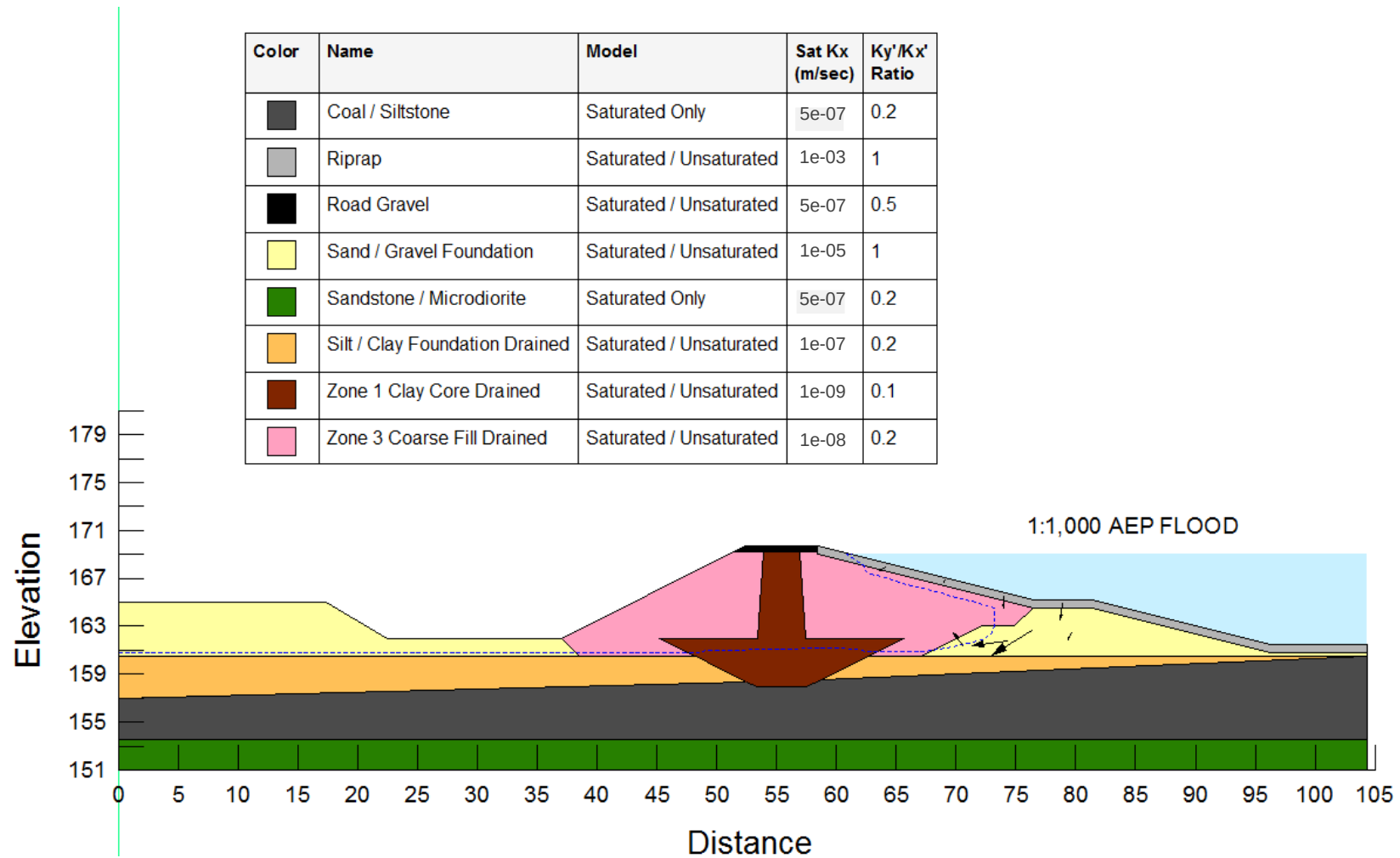


Figure 15.9 Section A – Upstream Drainage Plug 1:1,000 AEP Max Flood Level

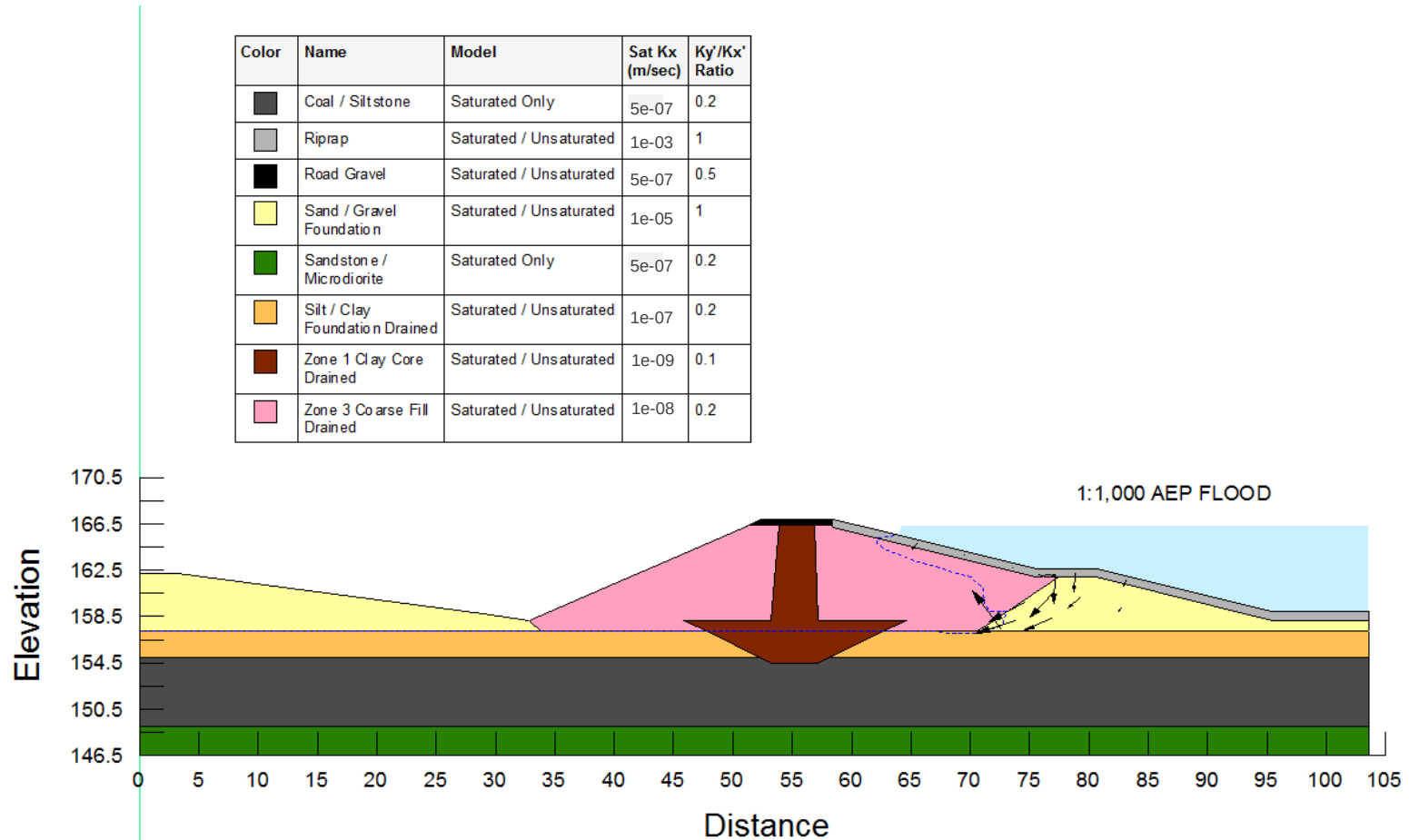


Figure 15.10 Section B – Downstream Drainage Plug 1:1,000 AEP Max Flood Level

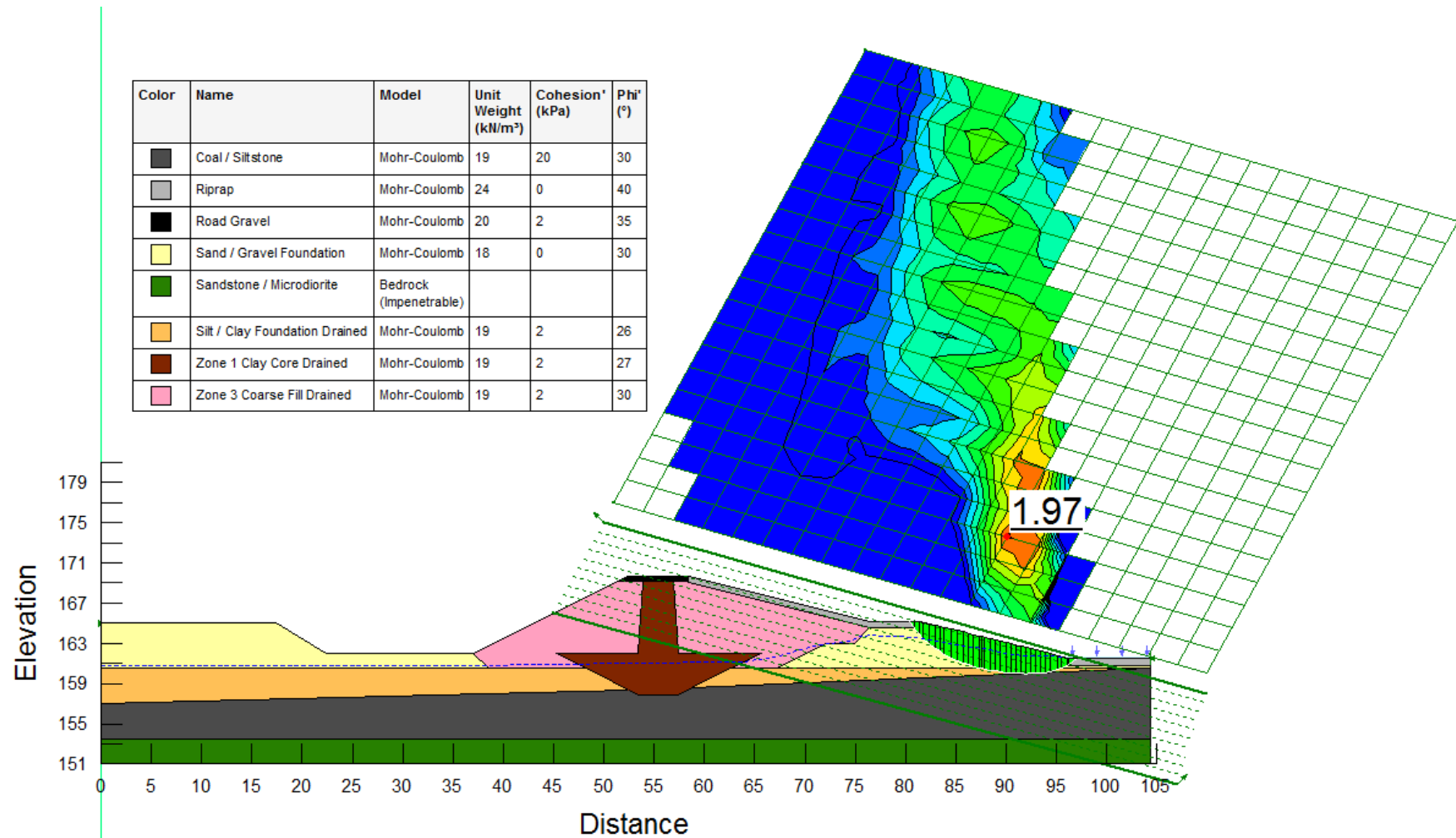


Figure 15.11 Section A – Upstream Drainage Plug (Drained) Upstream Rapid Drawdown Critical Time Step

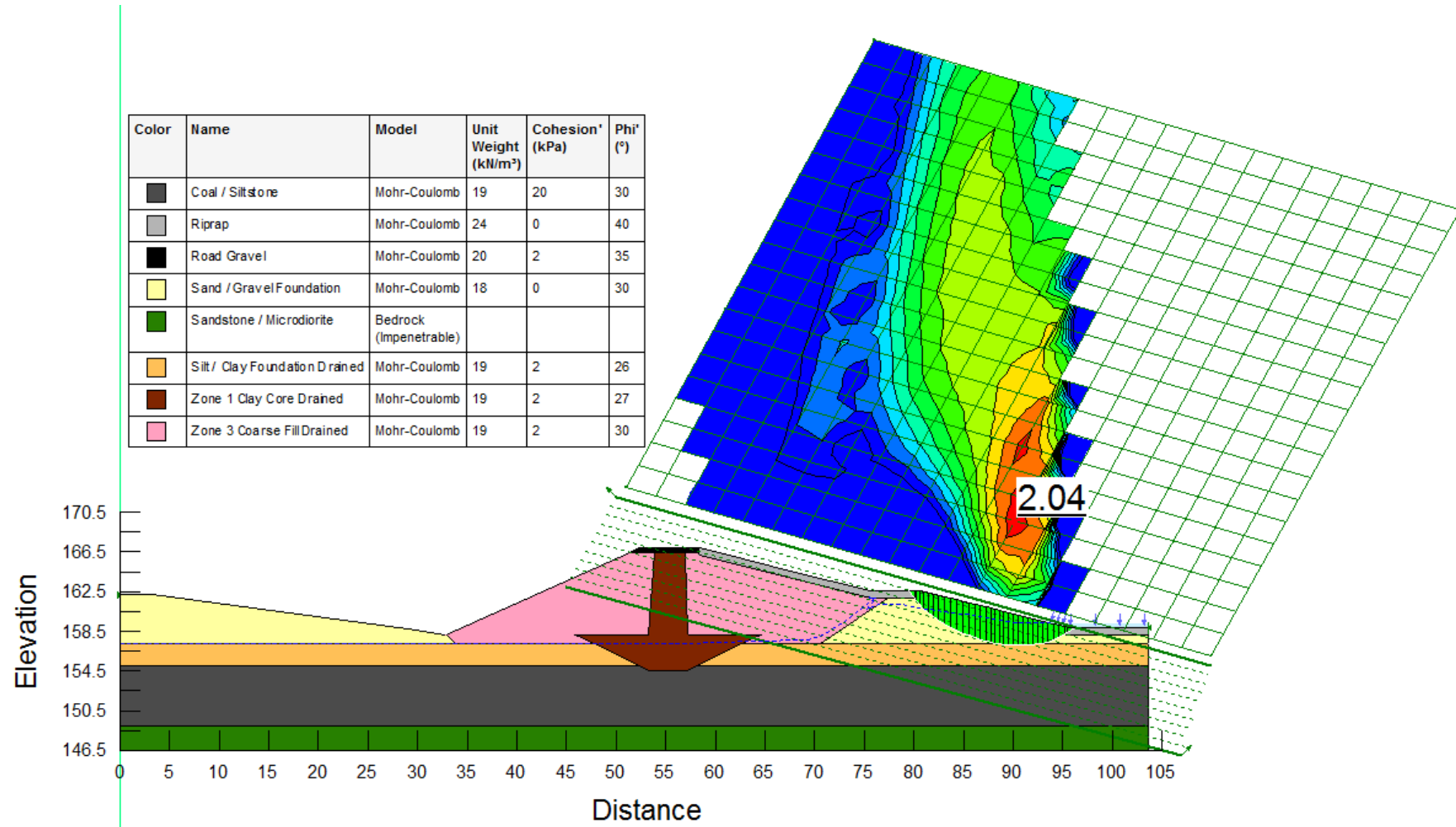


Figure 15.12 Section B – Downstream Drainage Plug (Drained) Upstream Rapid Drawdown Critical Time Step

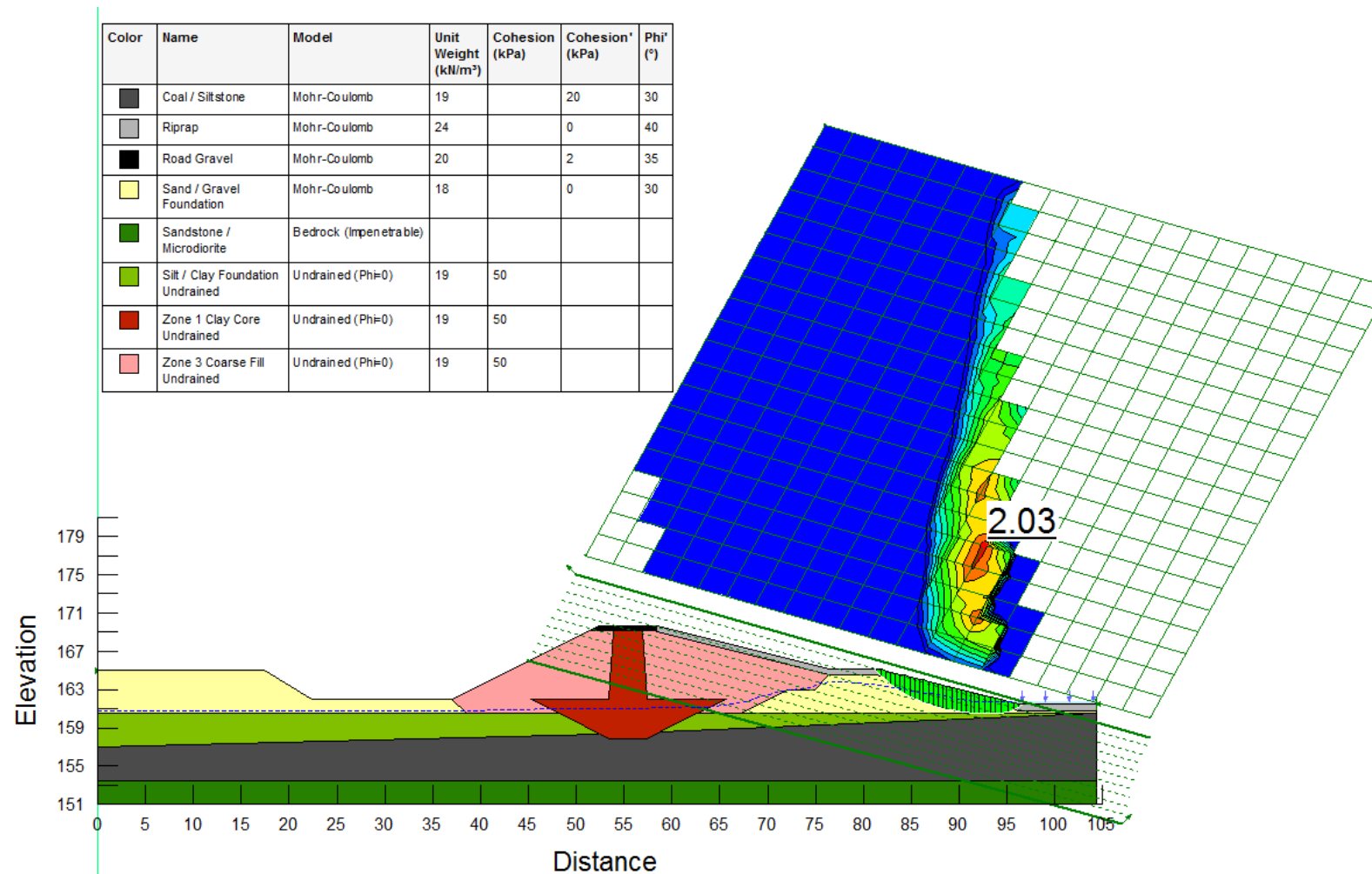


Figure 15.13 Section A – Upstream Drainage Plug (Undrained) Upstream Rapid Drawdown Critical Time Step

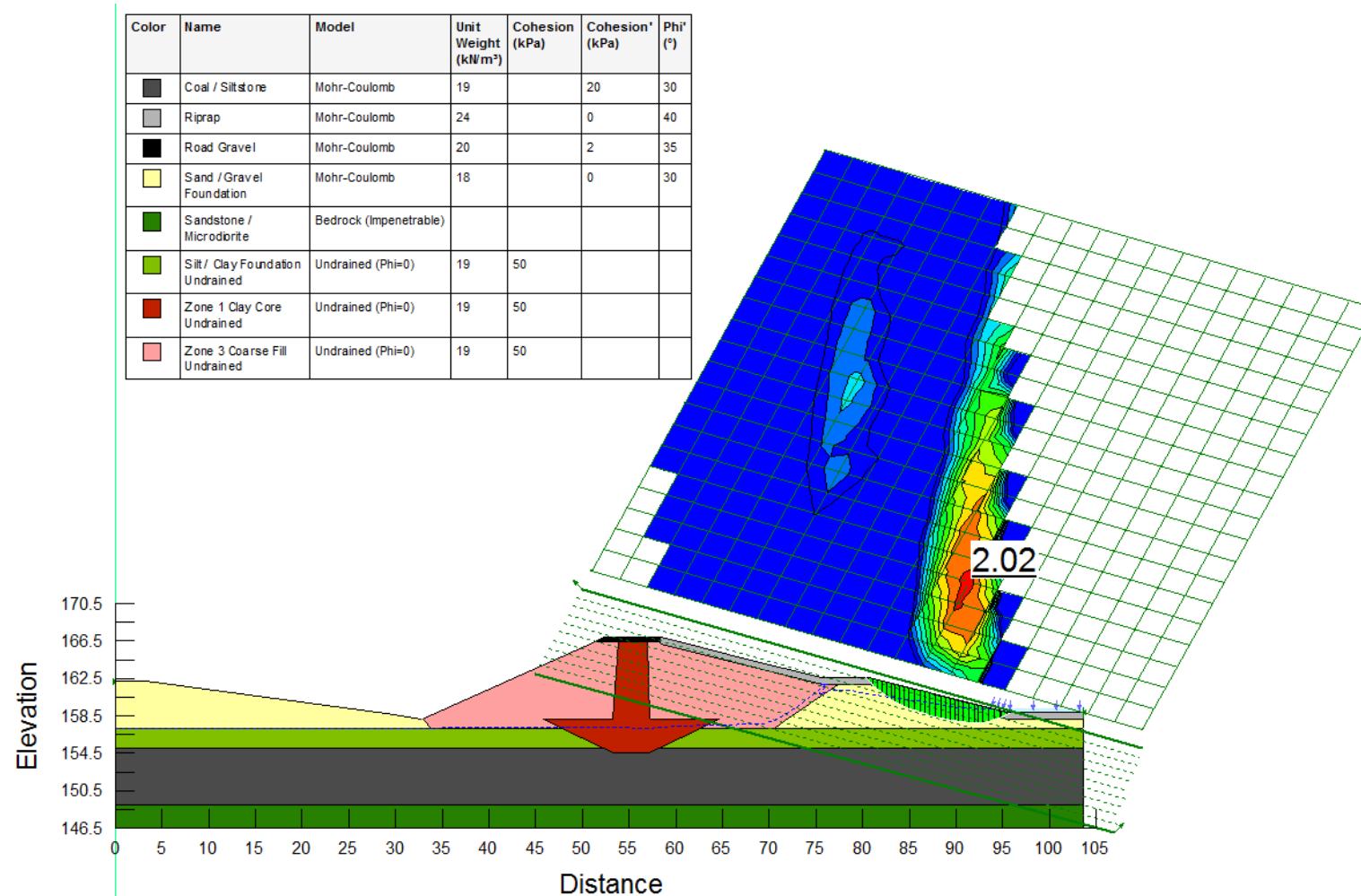


Figure 15.14 Section B- Downstream Drainage Plug (Undrained) Upstream Rapid Drawdown Critical Time Step

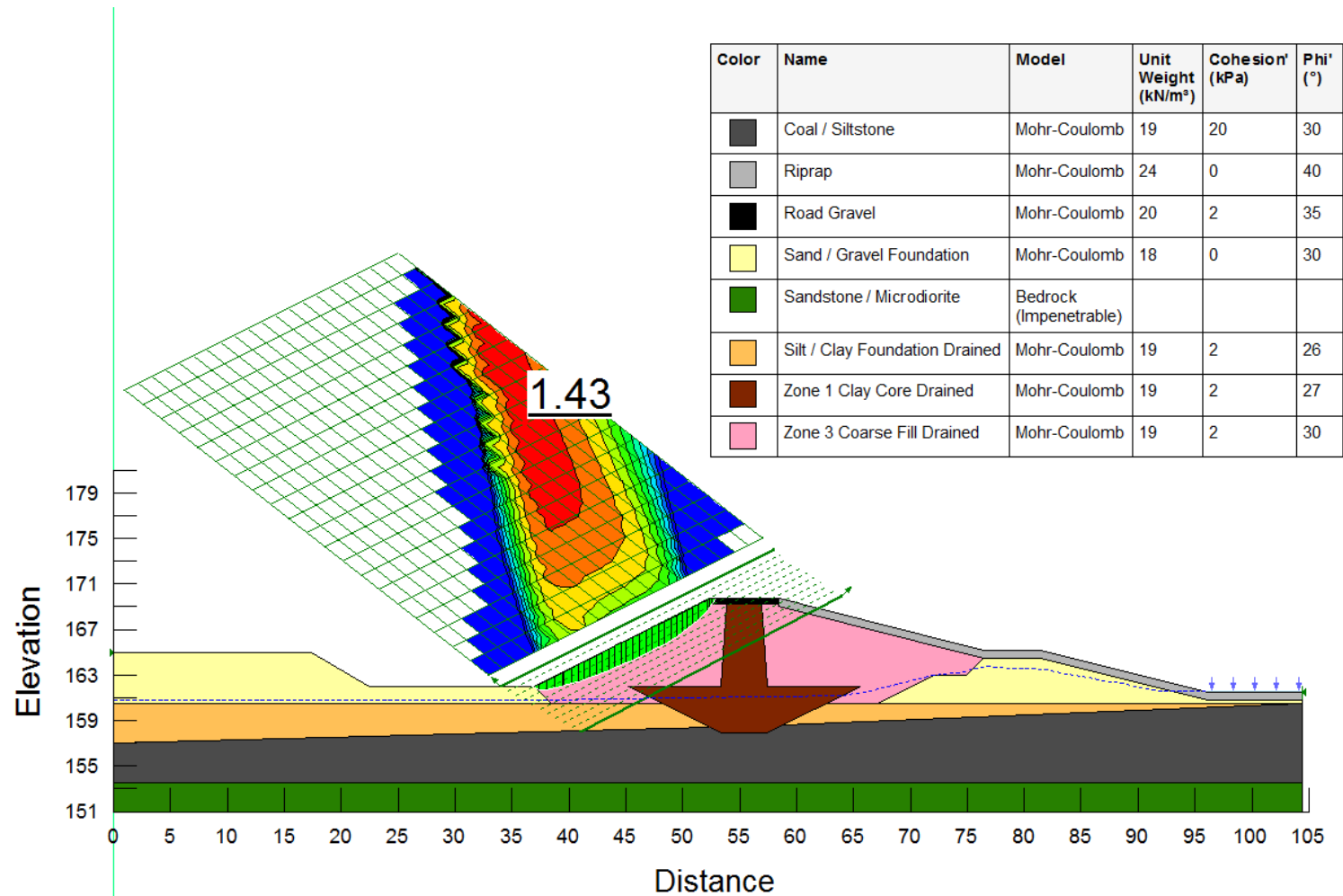


Figure 15.15 Section A – Upstream Drainage Plug (Drained) Downstream Rapid Drawdown Critical Time Step

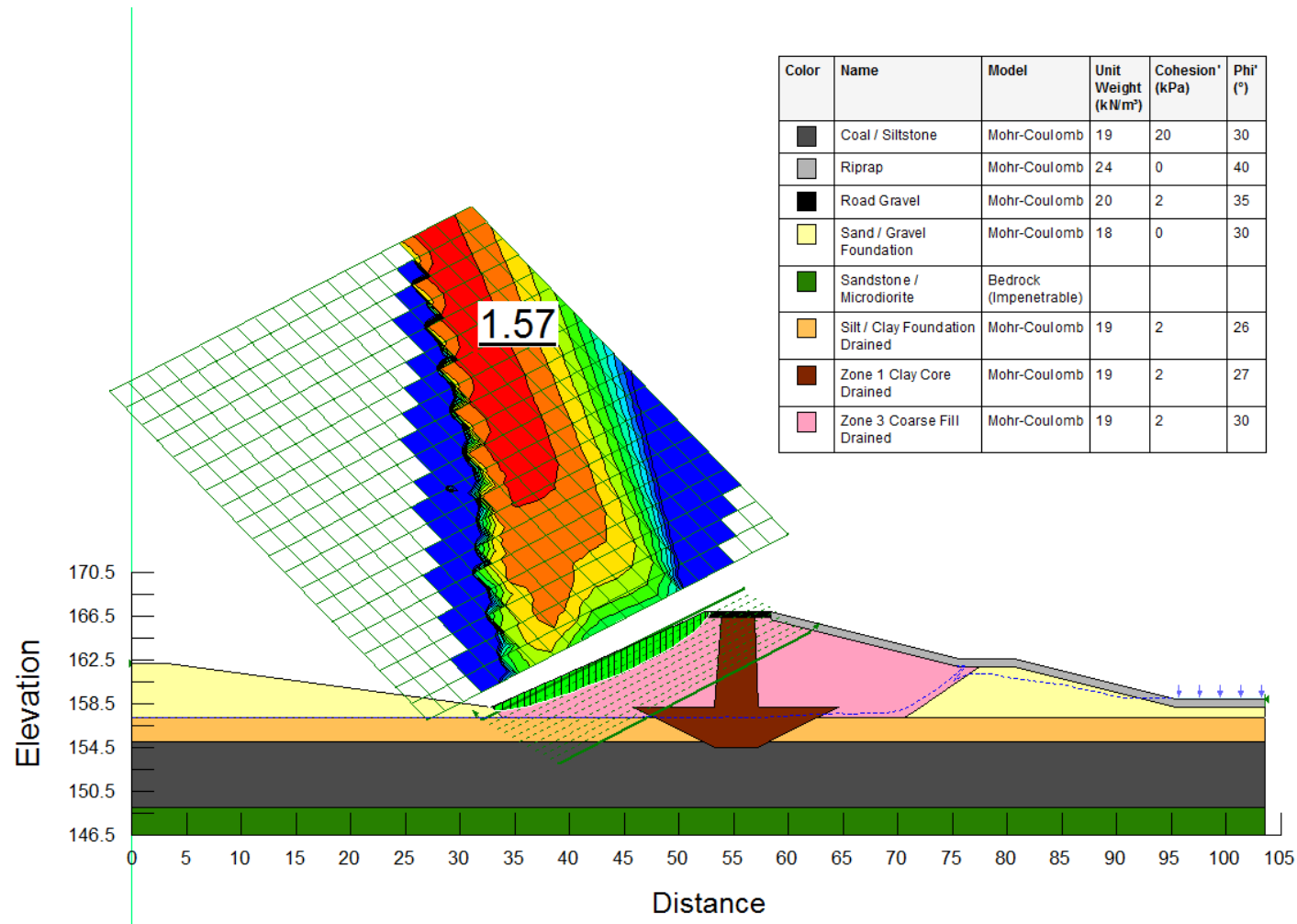


Figure 15.16 Section B – Downstream Drainage Plug (Drained) Downstream Rapid Drawdown Critical Time Step

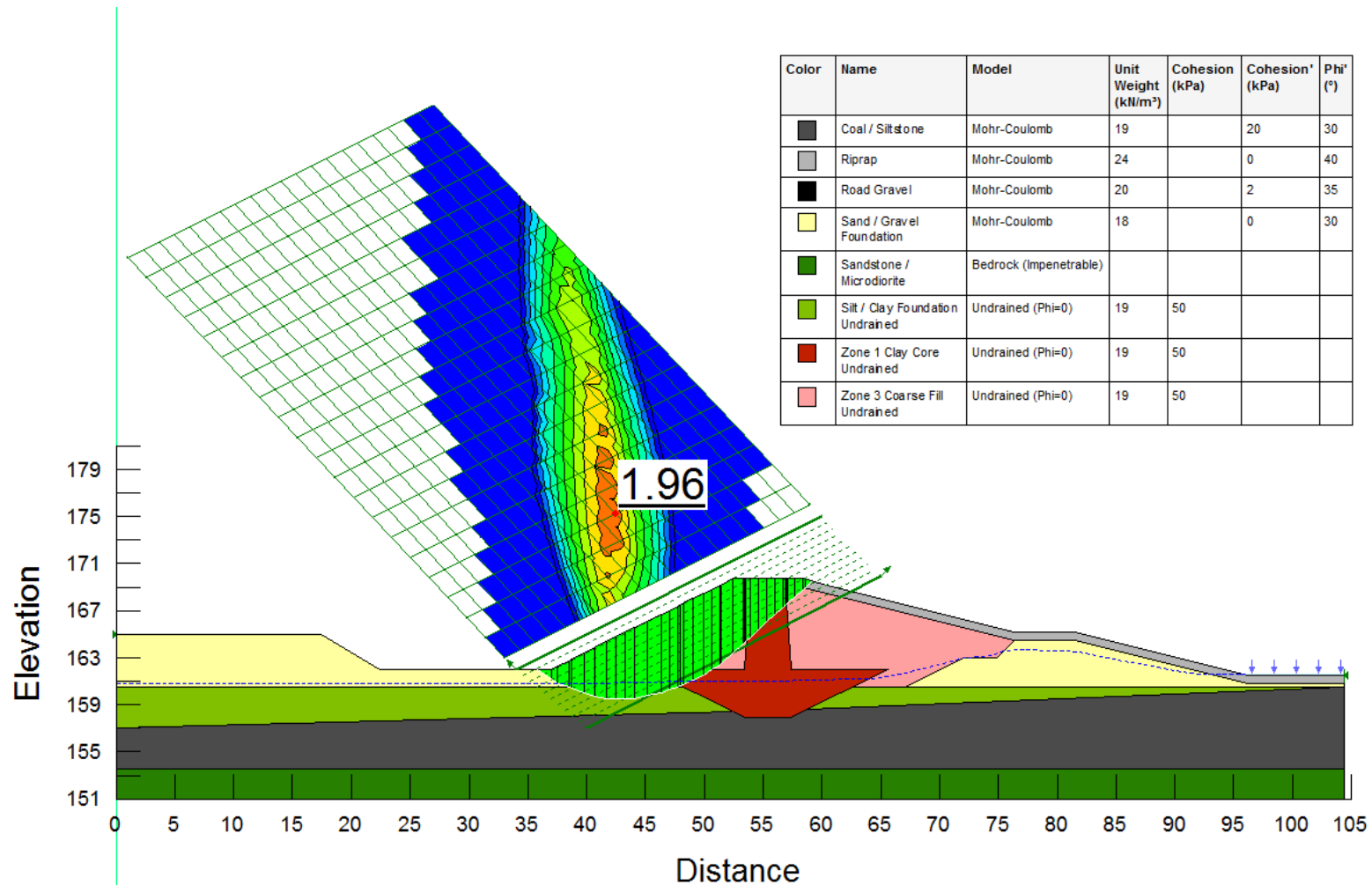


Figure 15.17 Section A – Upstream Drainage Plug (Undrained) Downstream Rapid Drawdown Critical Time Step

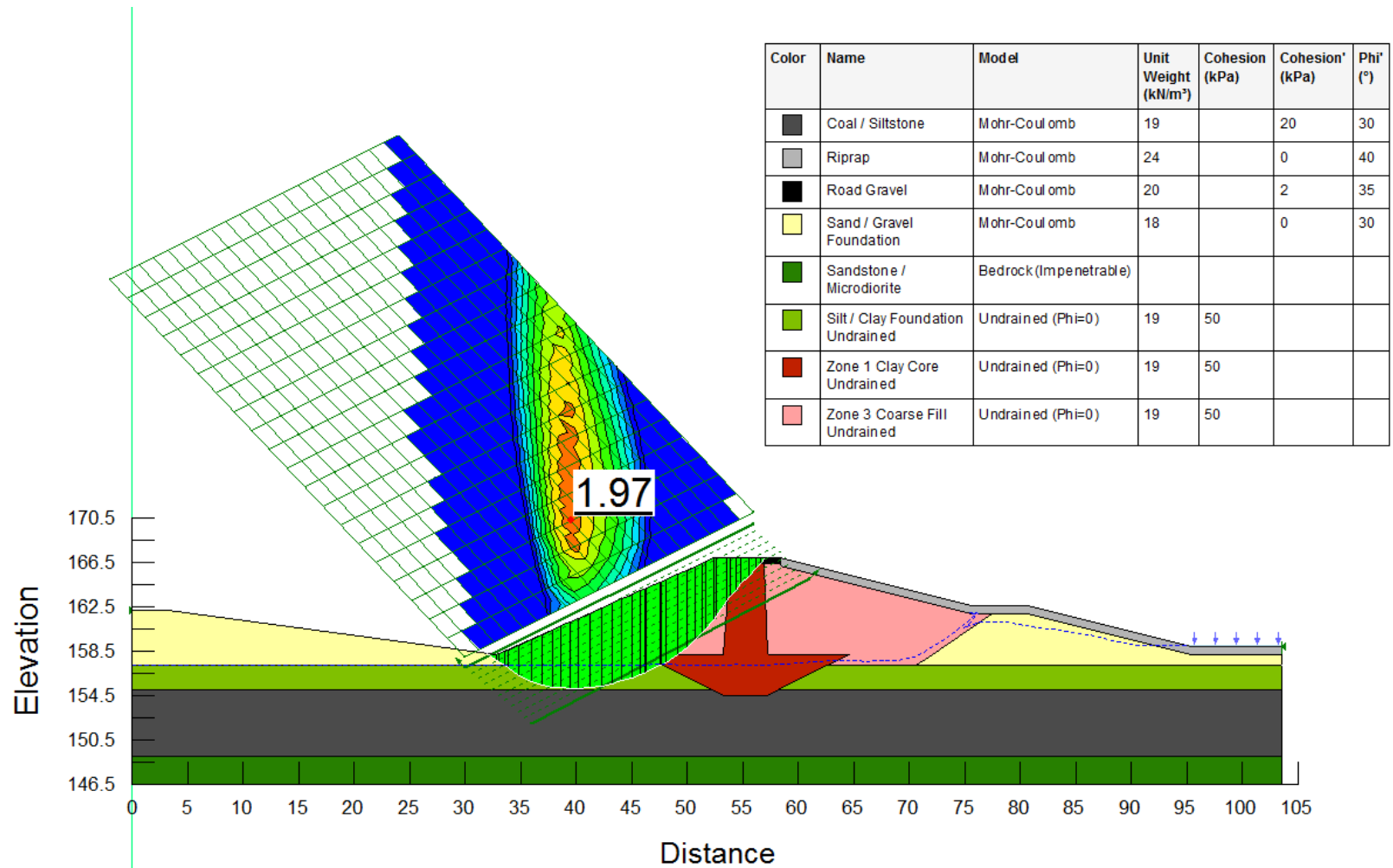


Figure 15.18 Section B – Downstream Drainage Plug (Undrained) Downstream Rapid Drawdown Critical Time Step

Appendix F - QCoal Northern Hub Groundwater Modelling Report (Australian Groundwater and Environmental Consultants 2023)



Australasian
Groundwater
& Environmental
Consultants

Report on

QCoal Northern Hub Groundwater Modelling Report

Prepared for
QCoal Services Pty Ltd

Project No. QCB5004.001
November 2023

ageconsultants.com.au

ABN 64 080 238 642

Document details and history



Document details

Project number	QCB5004.001
Document title	QCoal Northern Hub Groundwater Modelling Report
File name	QCB5004.001 QNH Groundwater Modelling Report_v02.01.docx

Document status and review

Edition	Comments	Author	Authorised by	Date
v01.01	Draft	AL/XL/TC	JT/AD	19/10/2023
V02.01	Addressing comments from Qcoal	AL/XL/TC	AD/AL	6/11/2023

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Townsville
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West End QLD 4810
t: (07) 4413 2020

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QCoal Northern Hub

Groundwater Modelling Report

1 Introduction

1.1 Project description

QCoal Group (QCoal) manages and operates four adjacent open cut coal mines located between six and 18 kilometres south of Collinsville, in central Queensland. The four coal mines are named Sonoma (SCM), Cows (CCM), Drake (DCM) and Jax (JCM). These mines form the 'Qcoal Northern Hub' (QNH) and are operated as a single multiple-pit operation (the Project). The opencut mining areas are located on mining leases ML 10325, ML 10326, ML 10327, ML 10345, ML 10345, ML 10346, ML 10349, ML 10350, and ML 10351. Figure 1.1 shows the extent of the QNH mining leases and proximity to the nearest town of Collinsville.

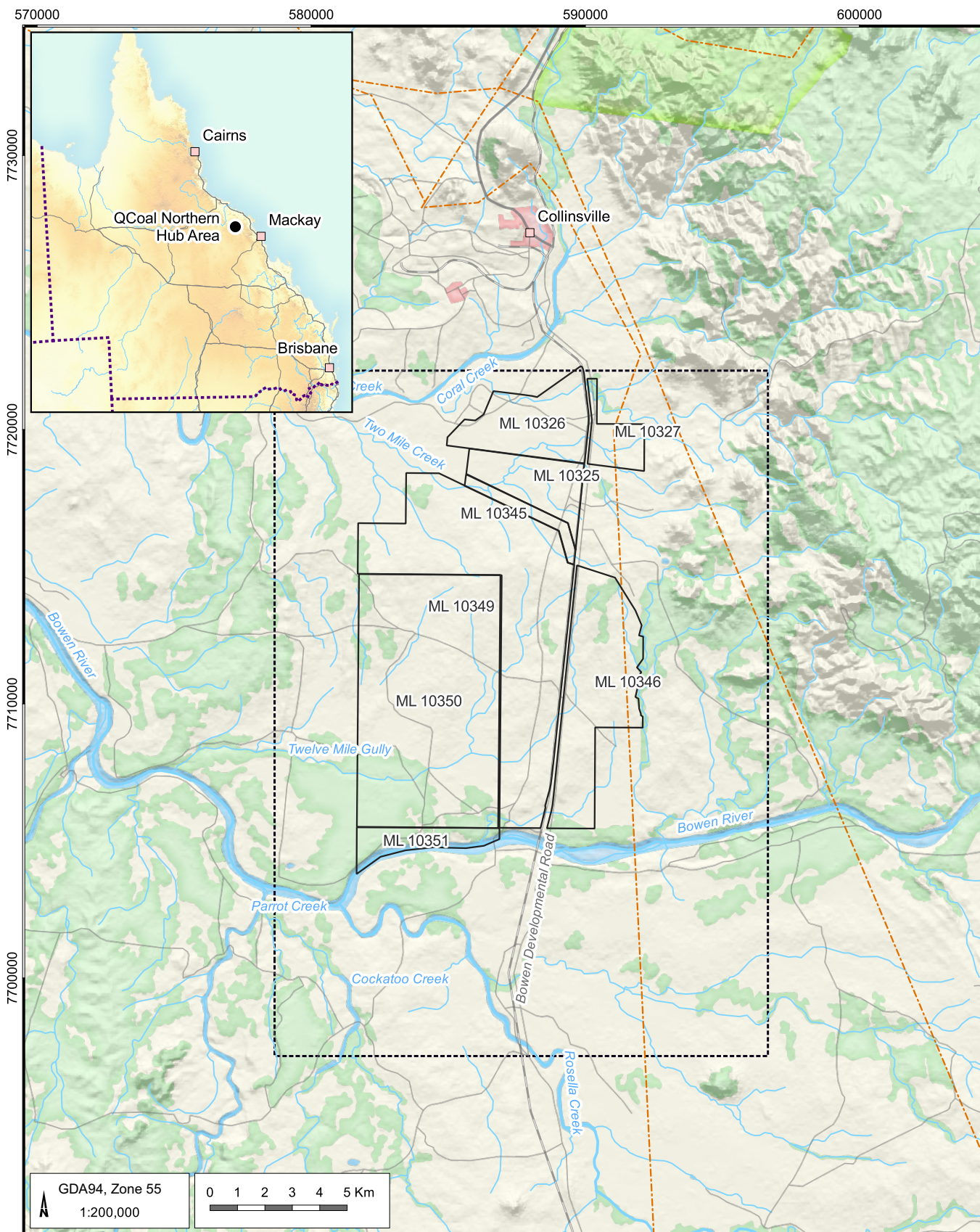
QCoal is currently planning to change the approved location of future pits and associated voids within QNH. This will require approval from the Queensland Government and amendment to the Environmental Authority (EA). QCoal engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to update the previous groundwater numerical model to represent changes in the historical and future mine plans for the Northern Hub mines.

1.2 Objectives and scope of work

The objective of the groundwater assessment is to evaluate the types of impacts, and the magnitude of environmental risk to the groundwater regime posed by the proposed changes to mining at the QNH to assist the regulatory decision-making process. The updated numerical model also assists operational management by providing estimates of groundwater inflows to each pit for use in the site water budget.

To achieve this objective the scope of work included the following key stages:

- Stage 1 – Data collation and review. Available groundwater monitoring data were reviewed to observe potential mining activities and climatic influence.
- Stage 2 – Model verification. Numerical model predictions were reviewed to determine how accurately they replicated the observed drawdown impacts of the mining.
- Stage 3 – Model re-construction and calibration. The numerical model was rebuilt and recalibrated using the Unstructured Grid Version of MODFLOW (MODFLOW-USG).
- Stage 4 – Impact assessment. The numerical model was run to provide predictions of impacts due to changes to the mine plans and final voids.
- Stage 5 – Reporting. This report provides the results of the work undertaken for the tasks listed above.



LEGEND

- | | |
|--|---|
| ■ Populated place | --- State borders |
| ● Site location | QNH mining leases |
| — Road | Built up area |
| — Rail | Reserve |
| — Watercourse | Vegetation |
| --- Powerline | Model extent |

QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Project location



DATE
13/10/2023

FIGURE No:
1.1

2 Site setting

2.1 Existing and proposed mining

Mining at QNH started in 2008 at Sonoma mine. Mine timing progression extended from 2033 to 2051 since the last approval. Changes to the mine plans are described in the following sections for all four mine areas (Sonoma, Cows, Drake and Jax) and illustrated in Figure 2.1. The current site layout is provided in Figure 2.2 and the end of mining is provided in Figure 2.3. Mine progression is discussed further in Section 6.3.5.4. From the shallowest to the deepest, the mined coal seams in the four mine sites are Q seam, P seam, E seam, and B seam.

2.1.1 Sonoma mine

Sonoma mine comprises three pits: North, Main and East pits:

- Mining at North and Main pits was completed in 2018. North pit was recently rehabilitated, and a residual void will remain at the Main pit at the end of QNH mining.
- Sonoma east pit design has been modified and is now proposed as a single pit. It will be developed between 2033 and 2035 with a residual void within the eastern part of the footprint.

2.1.2 Cows mine

Cows mine pits were completed between 2013 and 2014:

- B pit (Cows_1) has been expanded and become amalgamated into the Drake 1, which was converted into a Dump pit.
- The Q pit (Cows_2) was rehabilitated.

2.1.3 Drake mine

The layout of the updated Drake mine plan (as shown in Figure 2.1) has varied from the previously proposed footprint based on further data collection and extension of the end of mining from 2033 to 2051. Drake mine comprises the development of nine pits:

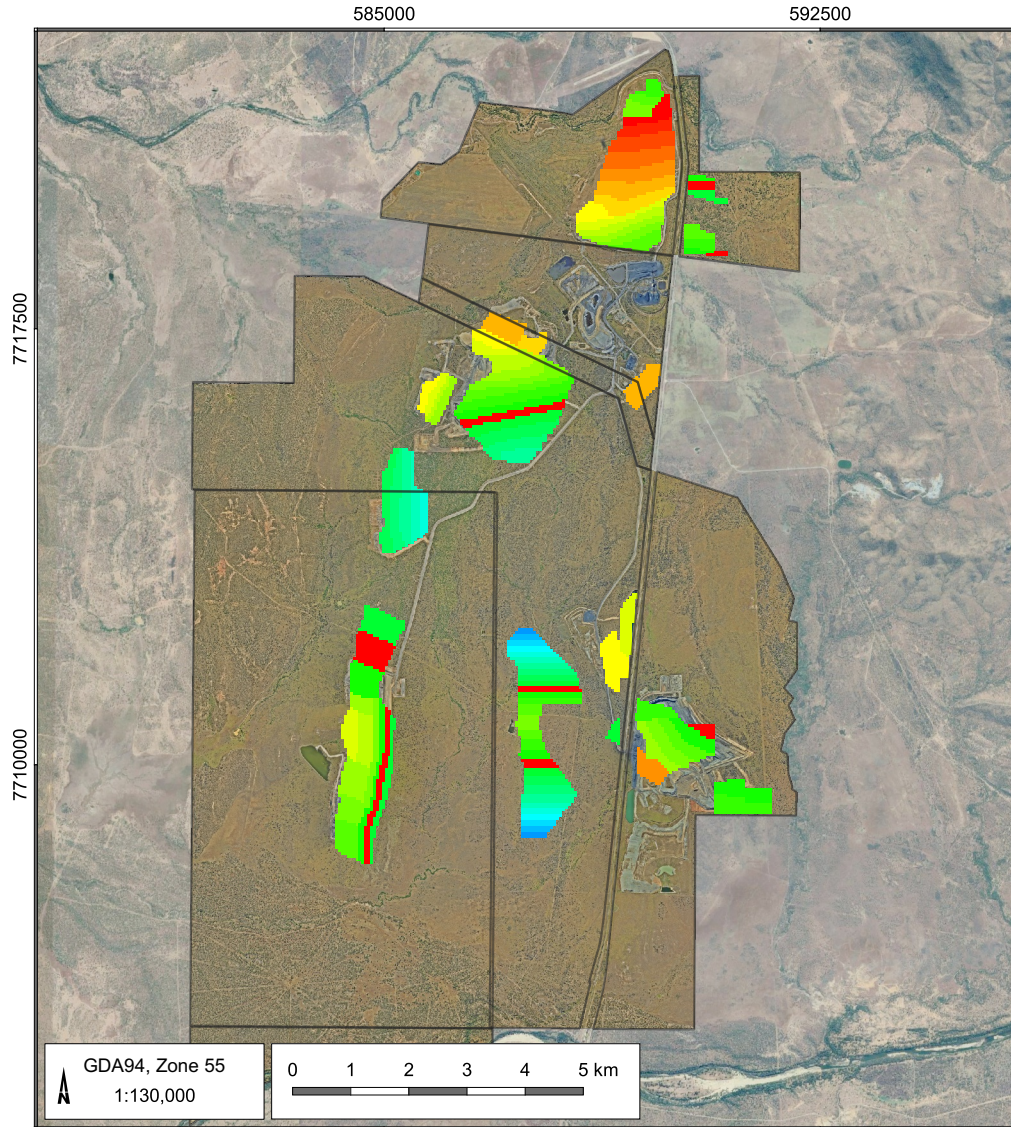
- Drake 3Q and 3R were mined in 2015 and 2016 respectively.
- Drake pits 1, 2, 5 and 8 are currently operating. The proposed extension of Drake 1, 8, 5W, 5E and 6N pits will connect them.
- The proposed pit 6S is planned to be mined between 2043 and 2049 and will be located south of Drake 6N, down to 550 m from the Bowen River.
- A pit south of Drake 3Q is planned to be developed between 2050.
- Figure 2.3 shows a total of seven residual voids at the end of mining on Drake mine.

2.1.4 Jax mine

The Jax mine has been in care and maintenance after the initial development of the Jax 1 Pit in 2012. The updated design of Jax mine comprises the development of four pits instead of two in the previous numerical model (AGE, 2020):

- The main mining re-started in 2018 and is planned to be completed by 2032.
- A second pit is planned to be developed adjacent to the main pit from 2034 to 2046.
- A third pit, north of the main pit, will be mined between 2024 and 2035.
- A new pit, Jax P, is proposed to be developed in the south corner of the Mining Lease 10346. The south part of Jax P pit will be approximately 800 metres from the Bowen River and will be developed between 2030 and 2040.
- Most of the pits will be backfilled and a residual void will remain at Jax Main and Jax P (Figure 2.3).

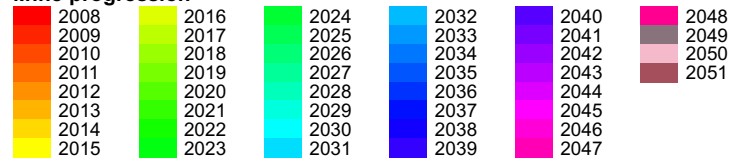
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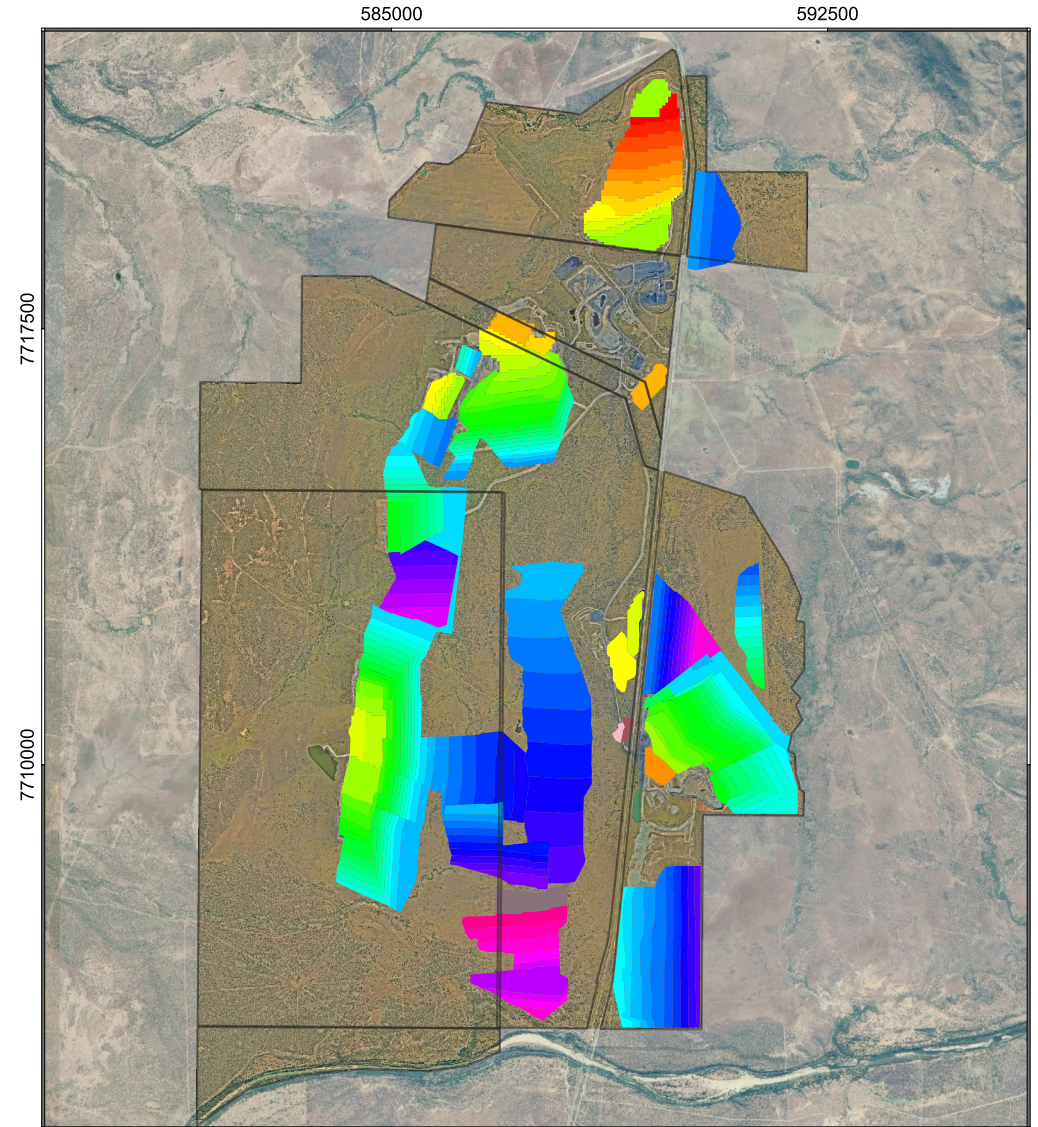
LEGEND

QNH mining leases

Mine progression



Proposed

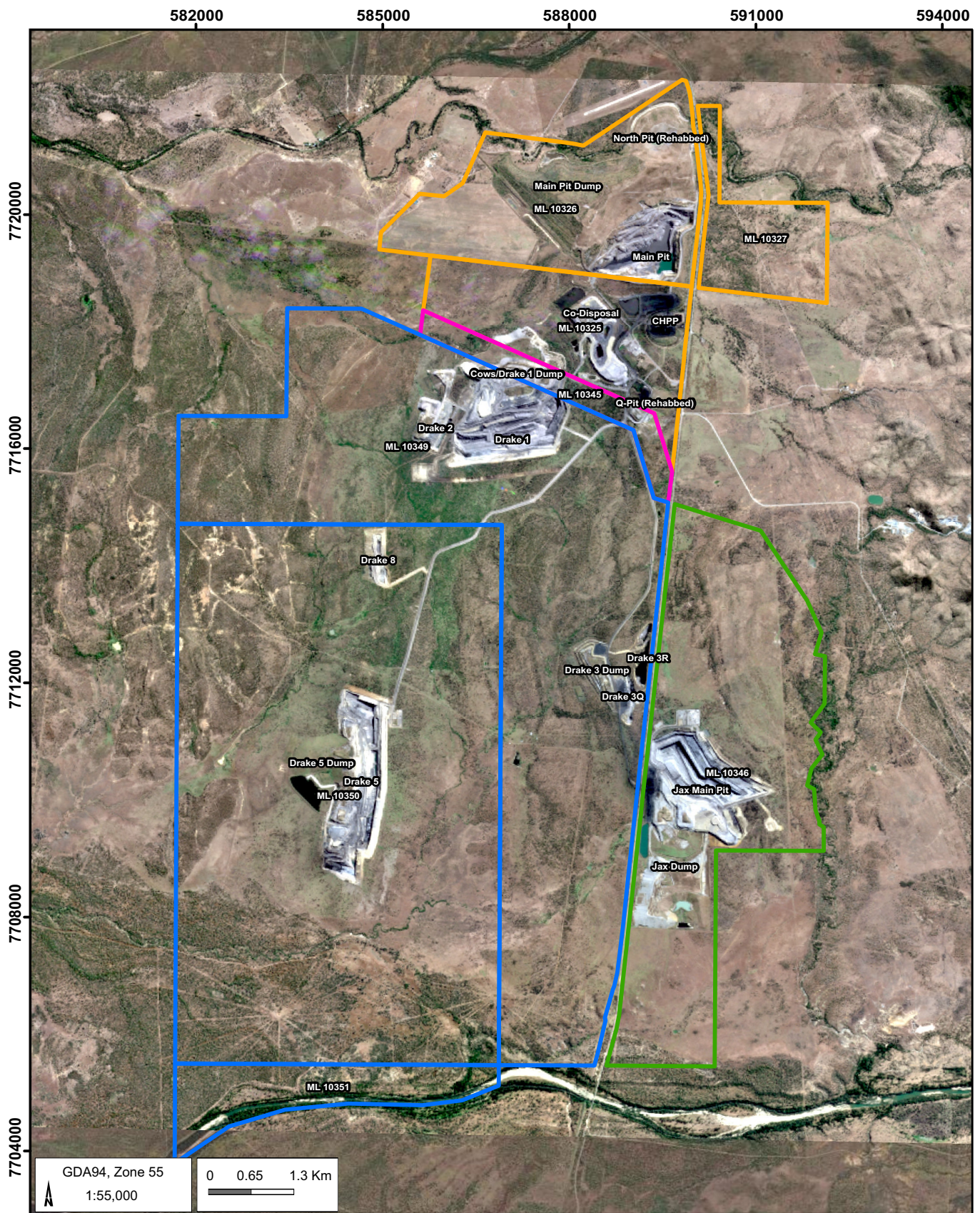


QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

**QNH approved and proposed mine
development**

DATE
23/10/2023

FIGURE No:
2.1



LEGEND

- Cows Coal Mine
- Jax Coal Mine
- Drake Coal Mine
- Sonoma Coal Mine

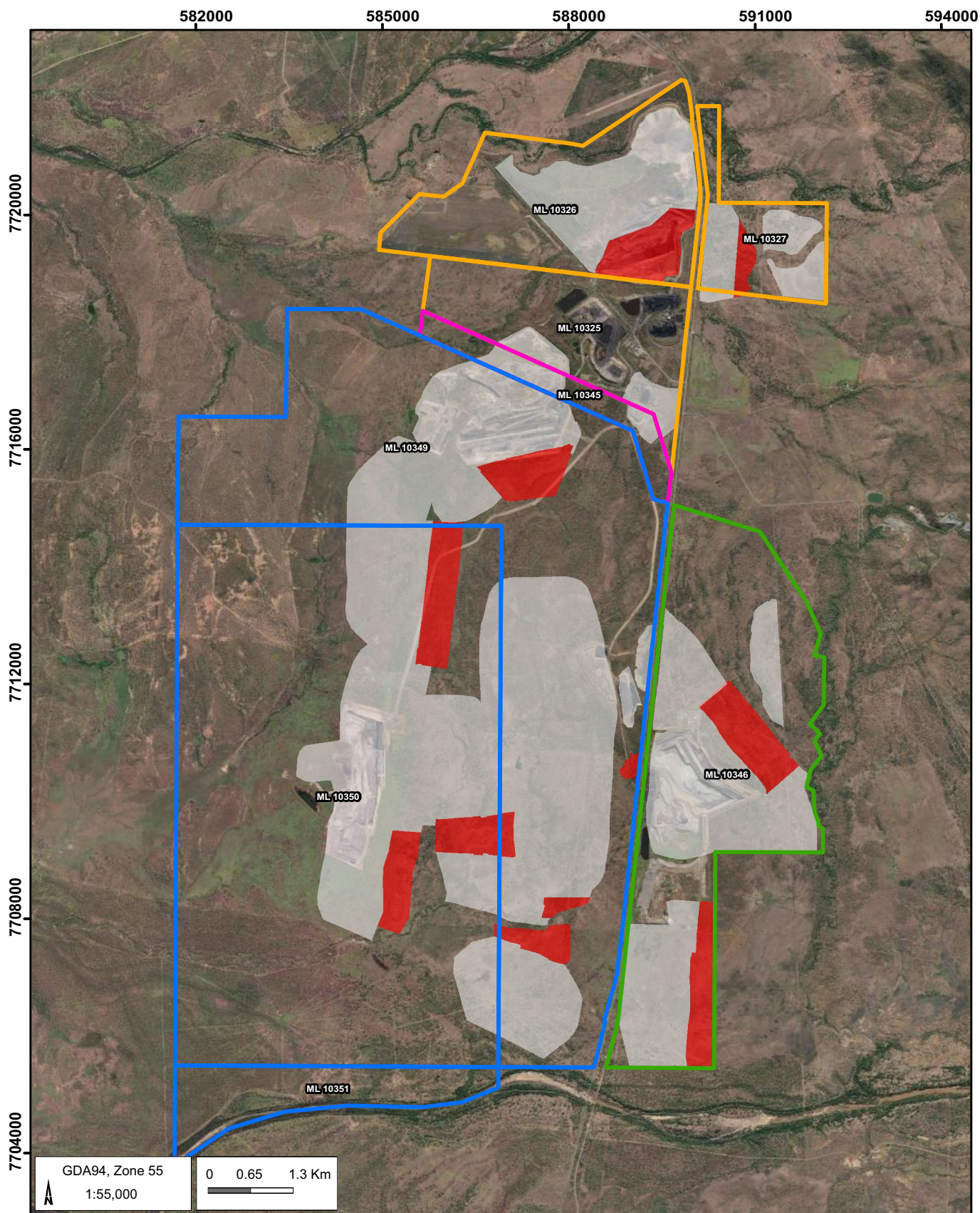
Qcoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Qcoal Northern Hub 2023 – layout



DATE
10/10/2023

FIGURE No:
2.2



LEGEND

- Cows Coal Mine
- Jax Coal Mine
- Drake Coal Mine
- Sonoma Coal Mine
- Backfilled pits
- Residual Void

Qcoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Qcoal Northern Hub – Layout EOM



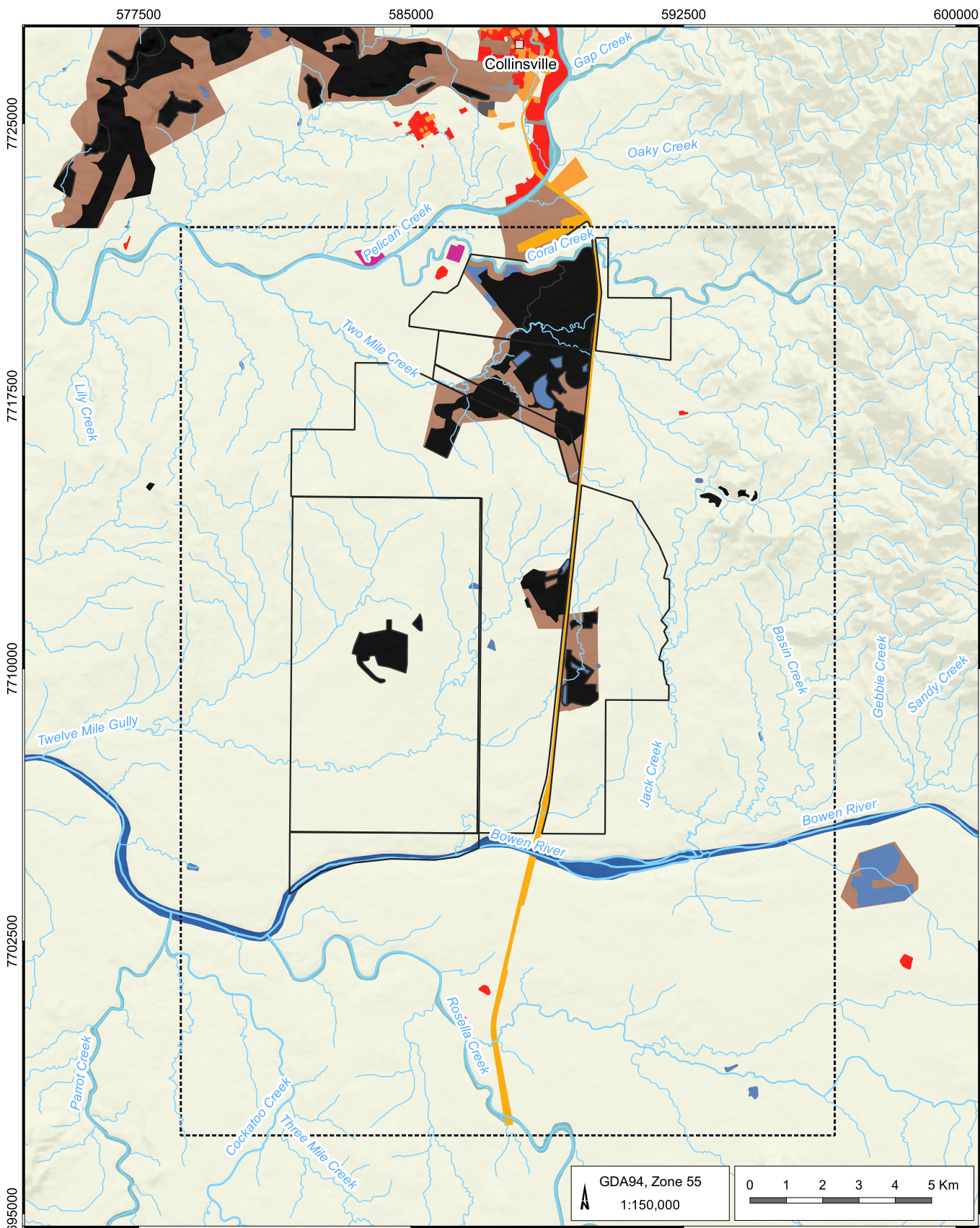
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10/10/2023

FIGURE No:
2.3

2.2 Land use

Figure 2.4 shows the Australian Land Use and Management (ALUM) Classification in the region. Outside the mining areas, the predominant land use in the region is beef cattle grazing. Small areas of irrigated agriculture are situated along Pelican Creek to the north-west of Sonoma mine.

The Bowen Development Road and Newlands-Abbot Point railway line corridor pass through the Northern Hub project area in a north-south alignment. The Collinsville township is approximately 5 km north of the Project's northern boundary. The Collinsville mine is also located to the north of QNH, across Pelican Creek.



LEGEND

- Populated place
- Watercourse
- QNH mining leases
- Model extent

- Land use**
- Grazing native vegetation
 - Irrigated cropping
 - Marsh/wetland
 - Mining
 - Other minimal use
 - Reservoir/dam
 - Residential and farm infrastructure
 - River
 - Transport and communication

QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Land use



DATE
13/10/2023

FIGURE No:
2.4

2.3 Climate

The Collinsville region has a semi-arid to tropical climate with high variability in rainfall, temperature and evaporation. The area experiences a warm humid summer and a relatively dry winter, and can experience drought, floods, heatwaves and frosts. The annual average rainfall recorded at Collinsville Post Office (1939-2023) is 704.1 mm. The Collinsville Post Office (Station No. 033013) is located about 10 km to the north of the Project at an elevation of 196 m AHD. Over 65% of the mean annual rainfall occurs in the wet season months between December and March from thunderstorms and tropical lows associated with cyclones.

Table 2.1 presents average evaporation rates recorded at the Collinsville Post Office for the period 1967 to 2023, together with the above-mentioned rainfall data. Evaporation exceeds annual rainfall in all months of the year.

Table 2.1 Mean rainfall and evaporation (mm) from 1967 to 2023; Collinsville Post Office – Stn 033013

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Mean rainfall (mm)	135.4	153.8	95.3	42.8	33.3	26.4	20.6	16.6	11.5	22	50.2	93.2	704.1
Mean evaporation (mm)	192.2	161	161.2	132	108.5	87	99.2	127.1	162	201.5	207	213.9	1853.6
Evaporation minus rainfall (mm)	56.8	7.2	65.9	89.2	75.2	60.6	78.6	110.5	150.5	179.5	156.8	120.7	1149.5

Note: data is rounded to one decimal place.

Rainfall data has been recorded at the Sonoma site since September 2014. Table 2.2 compares the recorded mean rainfall at Sonoma station and the interpolated rainfall from the Scientific Information for Landowners (SILO) database for the same location. Average annual rainfall from the Sonoma station and the SILO database are similar. The mean rainfall recorded at the Collinsville Post Office station is higher than the mean rainfall recorded at Sonoma since 2014.

Table 2.2 Mean rainfall at Sonoma from site data and SILO database (2014 to 2023).

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sonoma station Mean rainfall (mm)	105.3	86.8	63.5	20.6	45.6	27.3	26.4	7.3	5.6	22.4	47.0	65.8	523.6
SILO Mean rainfall (mm)	118.5	92.4	74.7	34.4	44.4	25.1	29.0	6.3	9.6	28.2	46.7	75.9	585.3

Figure 2.5 presents the Cumulative Rainfall Departure (CRD) (also commonly referred to as the rainfall residual mass) for the Sonoma site and from the SILO database between 2000 (pre-mining) and 2023 (current). The CRD graphically presents long-term trends in rainfall, with a rising slope indicating above average rainfall, and a falling slope indicating below average.

Figure 2.5 illustrates that QNH experienced a period of below average rainfall from 2001 to 2007, a period now known as the 'Millennium Drought'. Rainfall was above average between 2007 and 2012 and resulted in significant flooding in central Queensland. This was followed by the period from 2013 to 2021 when below average rainfall resulted in some drought conditions occurring. Rainfall since 2022 has commonly been above average as indicated by the rising trend in the CRD.

Groundwater levels in shallow aquifer systems can be commonly related to the CRD, with water levels falling in dry periods and rising in response to above average rainfall. The recent climate records suggest groundwater levels would have risen since 2022 in response to above average rainfall.

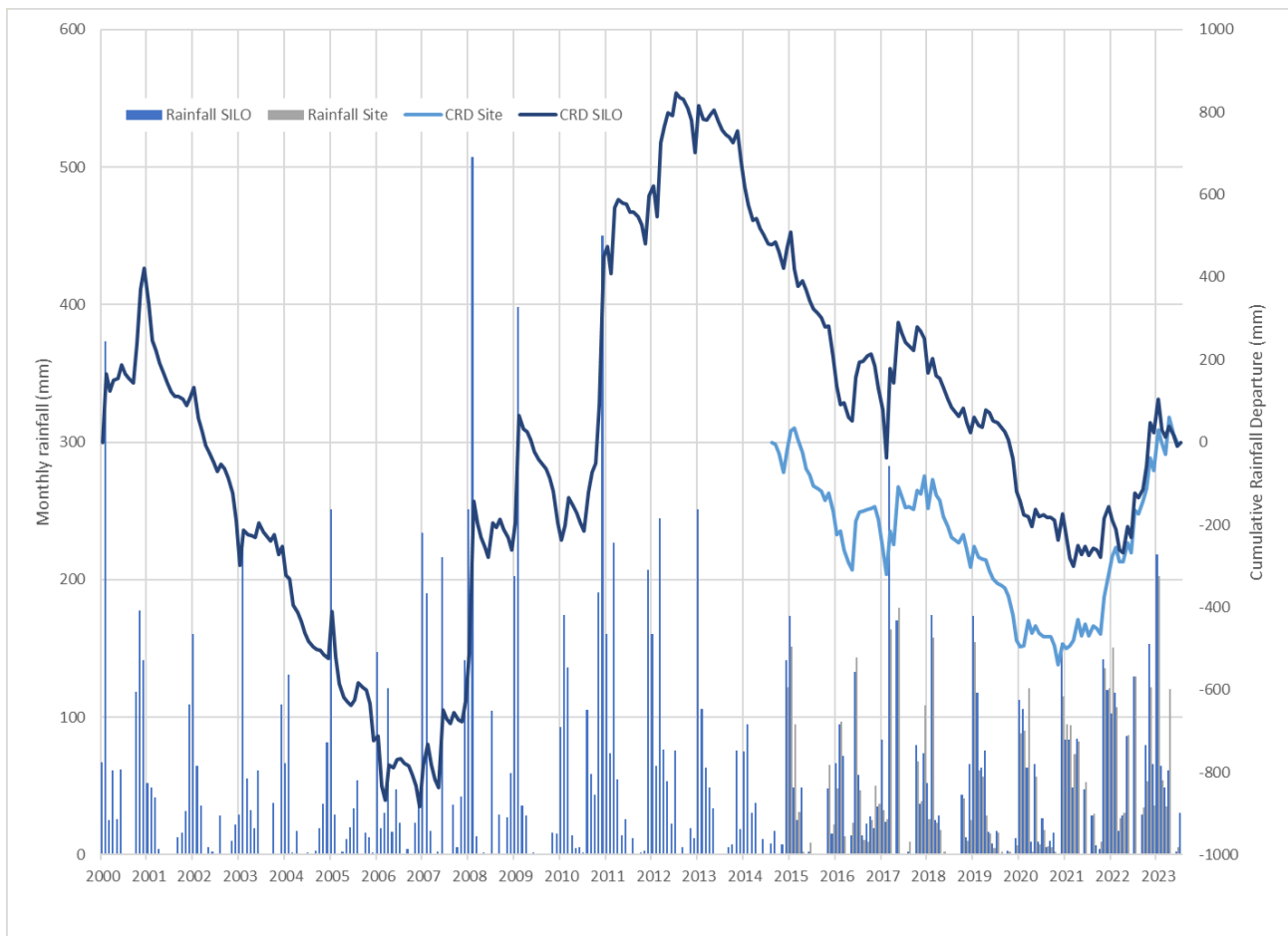
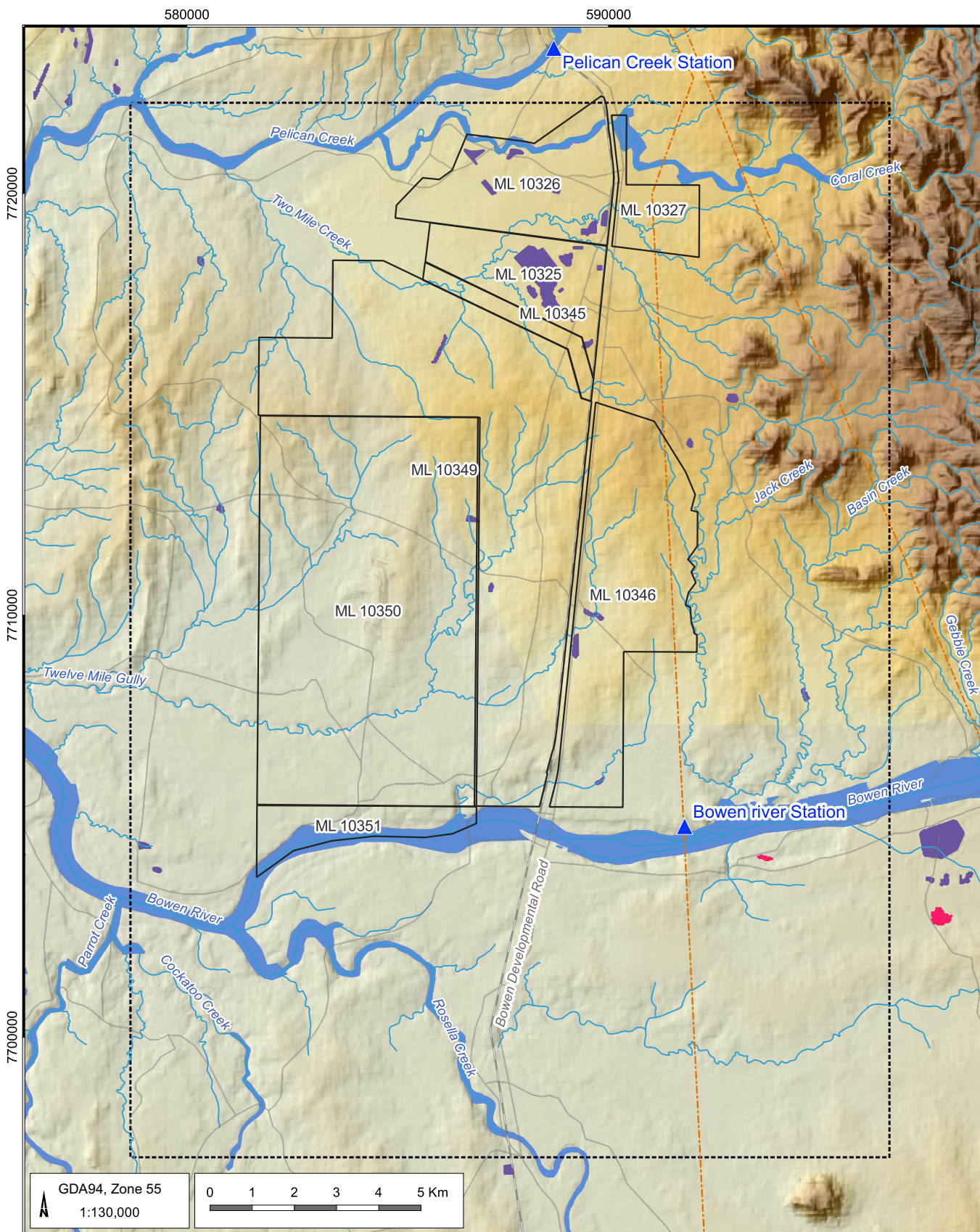


Figure 2.5 Annual Rainfall and Cumulative Rainfall Departure from the site and SILO up to February 2023.

2.4 Topography

Flat to slightly undulating plains characterise the southern portion of the QNH site, with minor hills in the north-east and north-west. The elevation of the site varies from 130 m to 200 m Australian Height Datum (AHD). The slope is typically $\leq 3\%$ over much of the site with steeper slopes of up to 10% associated with hills in the northeast (Figure 2.6).



LEGEND

- ▲ River gauging station
- Road
- Rail
- Watercourse
- - - Powerline
- Lacustrine
- Palustrine
- Riverine
- QNH mining leases
- Model extent

Elevation (mAHD)

- 40
- 100
- 150
- 200
- 300
- 600

QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Topography and drainage



DATE
13/10/2023

FIGURE No:
2.6

2.5 Drainage

Figure 2.6 shows the drainage lines and catchments of the QNH region. The QNH site is bound to the north by Pelican Creek and to the south by the Bowen River. QNH is located within the Bowen River Catchment (a sub-catchment of the Burdekin River catchment), which originates in Eungella National Park and flows in a north-west direction to join the Burdekin River upstream of the Blue Valley Weir. The catchment area of the Bowen River is approximately 9,530 km², while the Burdekin River catchment area is approximately 130,000 km².

Two minor creeks drain the QNH site; Twelve Mile Gully (an upper tributary of the Bowen River) and Two Mile Creek, a tributary of Pelican Creek which also flows into the Bowen River, 27 km west of Collinsville (Figure 2.6). The majority of the site (70.5 km²) drains in a south-west direction into the Twelve Mile Gully catchment, while the northern most portion of the site (18 km²) drains in a north-west direction into the Two Mile Creek catchment. Twelve Mile Gully and Two Mile Creek are both ephemeral and only flow during, and shortly after, heavy rainfall. In contrast, the Bowen River is perennial due to a combination of catchment runoff and releases from the Eungella Dam that maintain flow in the river.

Figure 2.7 shows a hydrograph of Bowen River water level elevation since July 2007. QNH installed a flow gauge at Pelican Creek and has recorded flow events since December 2016. Figure 2.8 and Figure 2.9 show the recorded flow rates at Bowen River (station no. 120209B) and Pelican Creek.

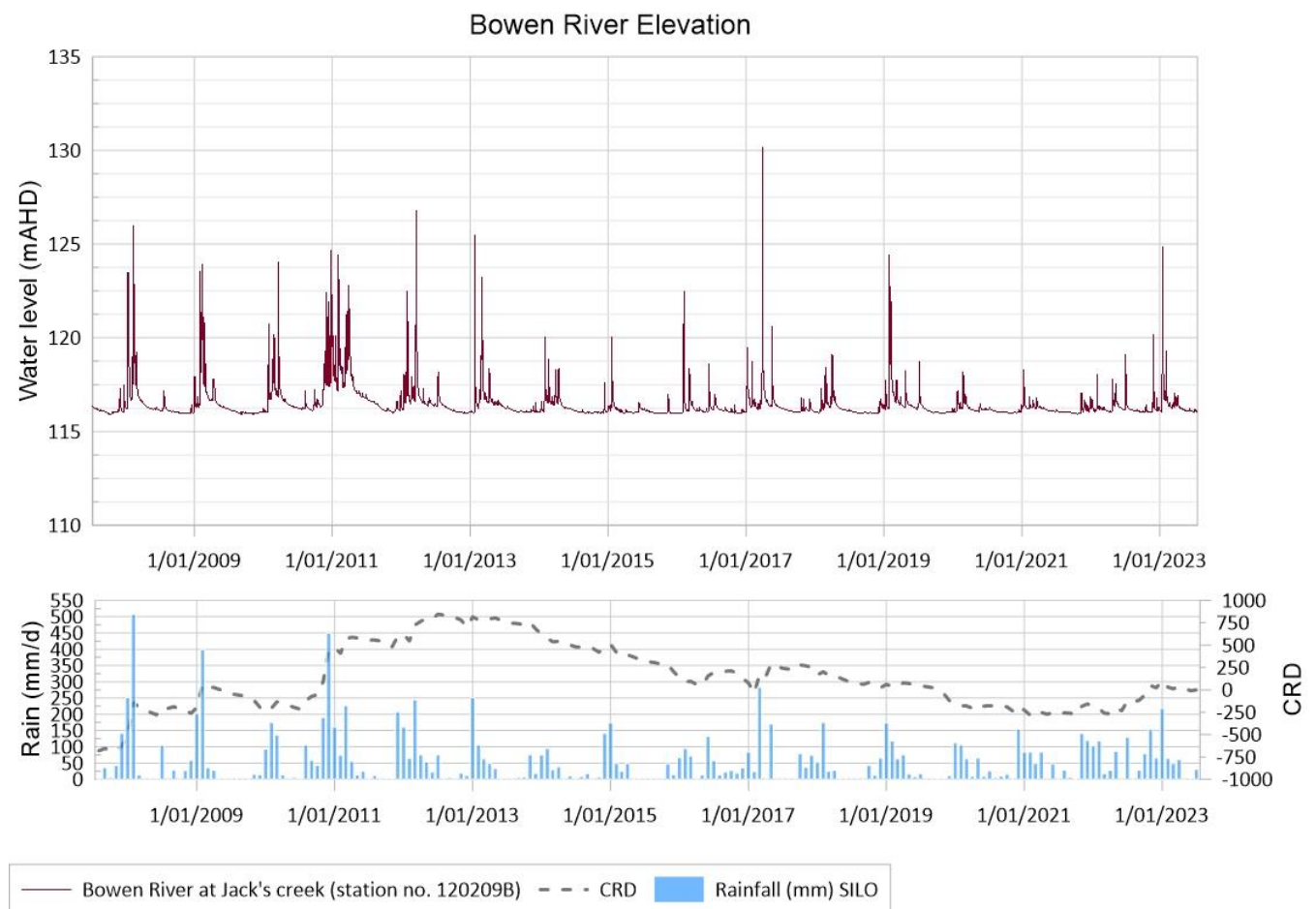


Figure 2.7 Bowen River elevation and SILO CRD since July 2007

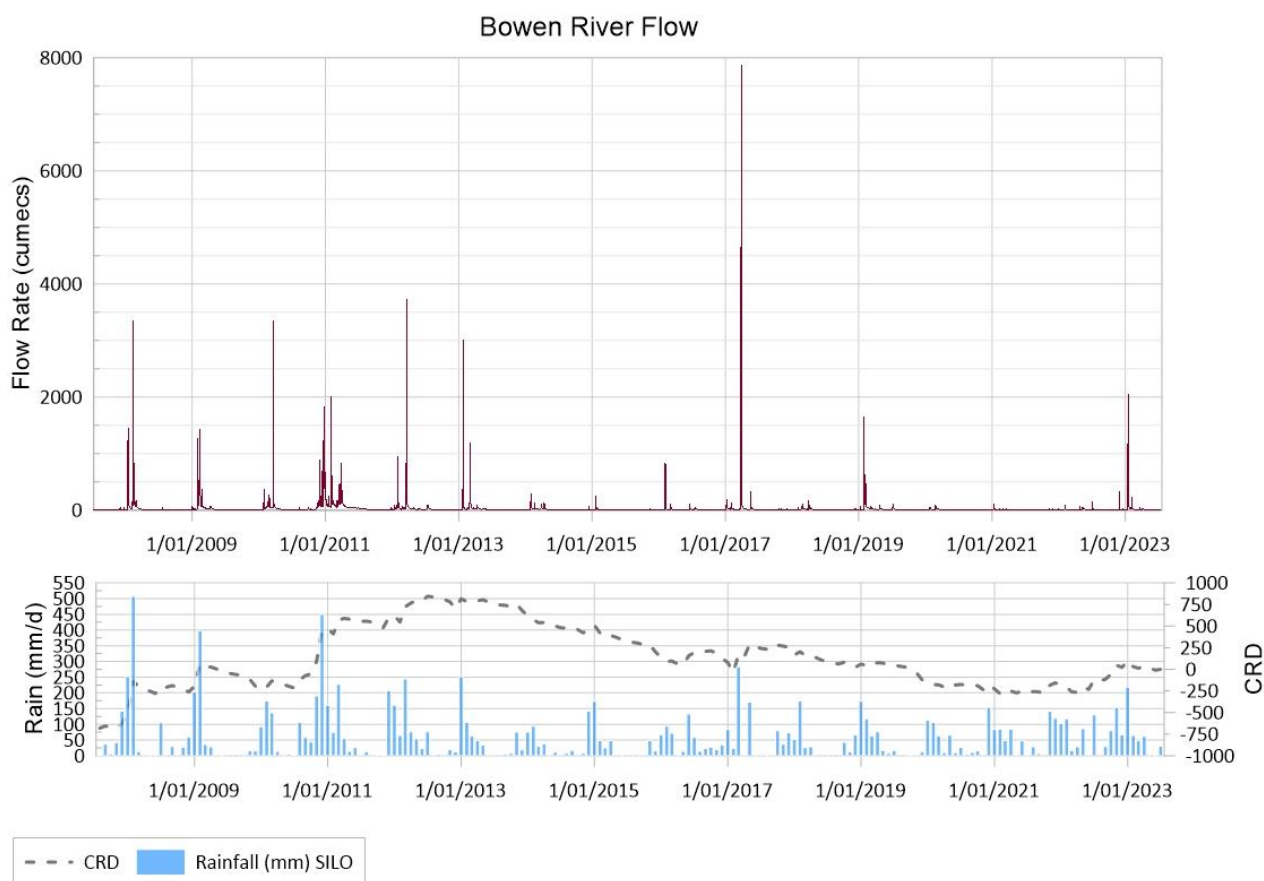


Figure 2.8 Bowen River flow rate since July 2007

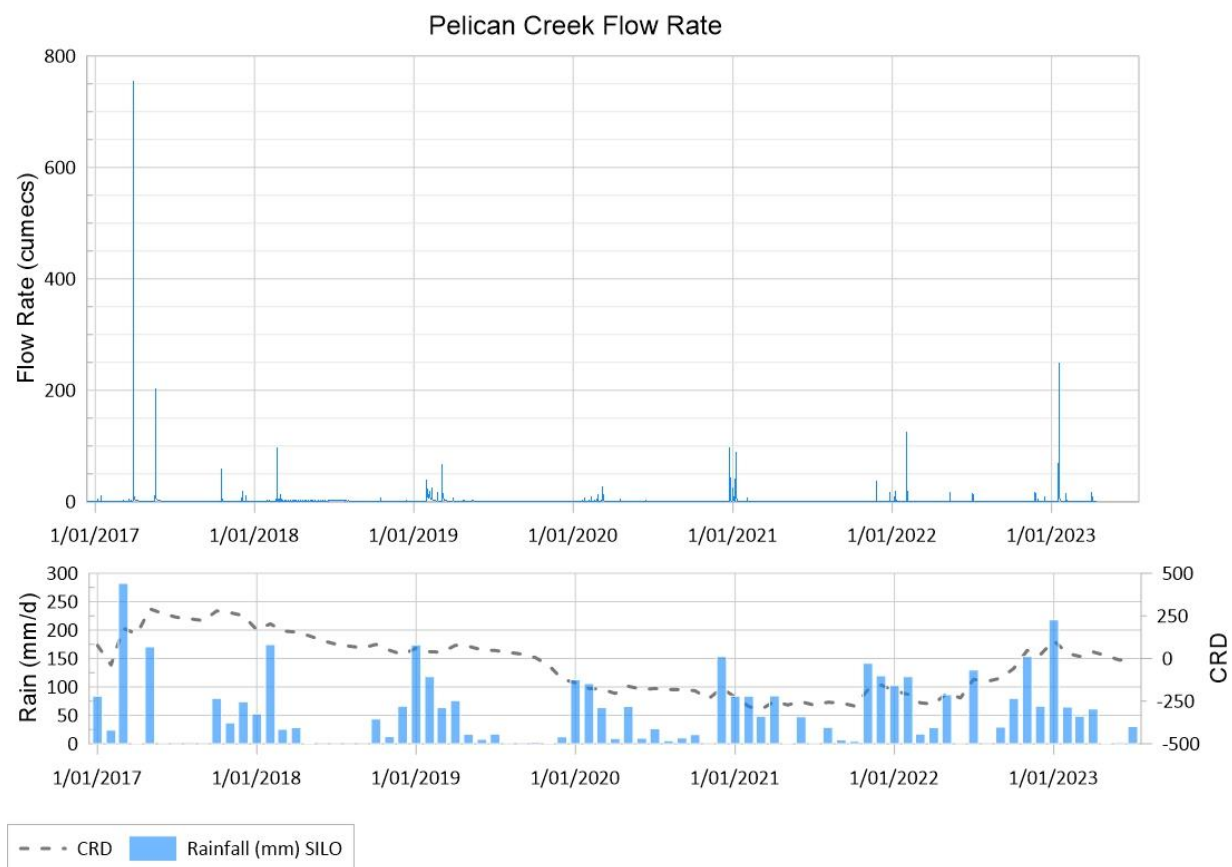


Figure 2.9 Pelican Creek flow rate since December 2016

3 Environmental value and receptors

Potential environmental receptors surrounding the Northern Hub mines have been identified and summarised below and shown in Figure 3.1 and Figure 3.2. The main environmental receptors are associated with the surface waters of the surrounding creeks and their tributaries.

3.1 Matters of state environmental significance

Matters of State Environmental Significance (MSES) are a component of the biodiversity state interest that is defined under the State Planning Policy (SPP) and the Environmental Offsets Regulation 2014 (Offset Regulation). MSES includes specific environmental values that are protected under Queensland legislation. The MSES generally occur along the local watercourses and around wetland areas. Several areas of regulated vegetation are present inside the Northern Hub mining leases and within a 5 km buffer of the site (Figure 3.1). A review of mapped MSES sites available on Queensland Globe has identified the following:

- Regulated vegetation (Category B) – Regional ecosystems considered endangered, and of concern. The areas occur along the Bowen River and Twelve Mile Gully flood plains and within Drake mine.
- Regulated vegetation (Category C) – Regional ecosystems considered endangered, and of concern. A stand of Category C vegetation occurs along the Twelve Mile Gully.
- Regulated vegetation (Category R) – Riverine areas. Riverine areas occur along drainage channels in the north of the site.

3.2 Surface water and wetlands

The Directory of Important Wetlands in Australia (DIWA)¹ identifies nationally important wetlands, and the flora and fauna species that depend on them. There is one DIWA wetland located approximately 15 km downstream of the QNH site on the Bowen River. The wetland is called Birralee-Pelican Creek and is located along a section of the Bowen River, between Twelve Mile Gully and Pelican Creek (Figure 3.1). There are no natural lacustrine waterbodies mapped between Drake mine and Jax mine. All existing water bodies are dams or ponds for livestock watering.

3.3 Protected areas

The closest protected area is the Sonoma State Forest located approximately 10 km north of QNH. Given the distance from the QNH, the state forest is not considered an environmental receptor.

3.4 Groundwater dependent ecosystems

Groundwater-dependent ecosystems (GDEs) rely on the availability of groundwater, on either a permanent or intermittent basis, to meet the requirements that sustain plant and animal communities, ecological processes and ecosystem function.

The location and extent of potential GDEs are indicated on the GDE Atlas produced by the Bureau of Meteorology (BOM). The GDE atlas indicates that moderate to high potential terrestrial GDEs occur in stands along the Bowen River, Twelve Mile Gully, Pelican Creek, and Coral Creek (Figure 3.2). The GDE Atlas also indicates there is a high potential for aquatic GDEs to occur in Bowen River, Twelve Mile Gully, and Pelican Creek. Although GDEs were mapped on the QNH by the atlas produced by the BOM, none were identified by a site-specific assessment previously undertaken.

¹ <https://www.dcceew.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands>.

3.5 Groundwater users

A review of the Queensland groundwater database of registered bores was undertaken to assess the current use of groundwater in the area. The database indicates five water supply bores within the model extent for QNH.

Table 3.1 summarises the number of existing registered bores (per facility role) within the QNH numerical model area. A total of 55 existing registered bores are within the model extent (Figure 3.2). Most of the registered bores were installed for mine or sub-artesian monitoring purposes. Registered water supply bores details at QNH are provided in Table 3.2.

Table 3.1 Existing registered groundwater bores within QNH model extent.

Bore Types	Number in Use
Water Supply	5
Sub-Artesian Monitoring	12
Mine Monitoring	13
Water Resources Investigation	9
Unknown	16
Total	55

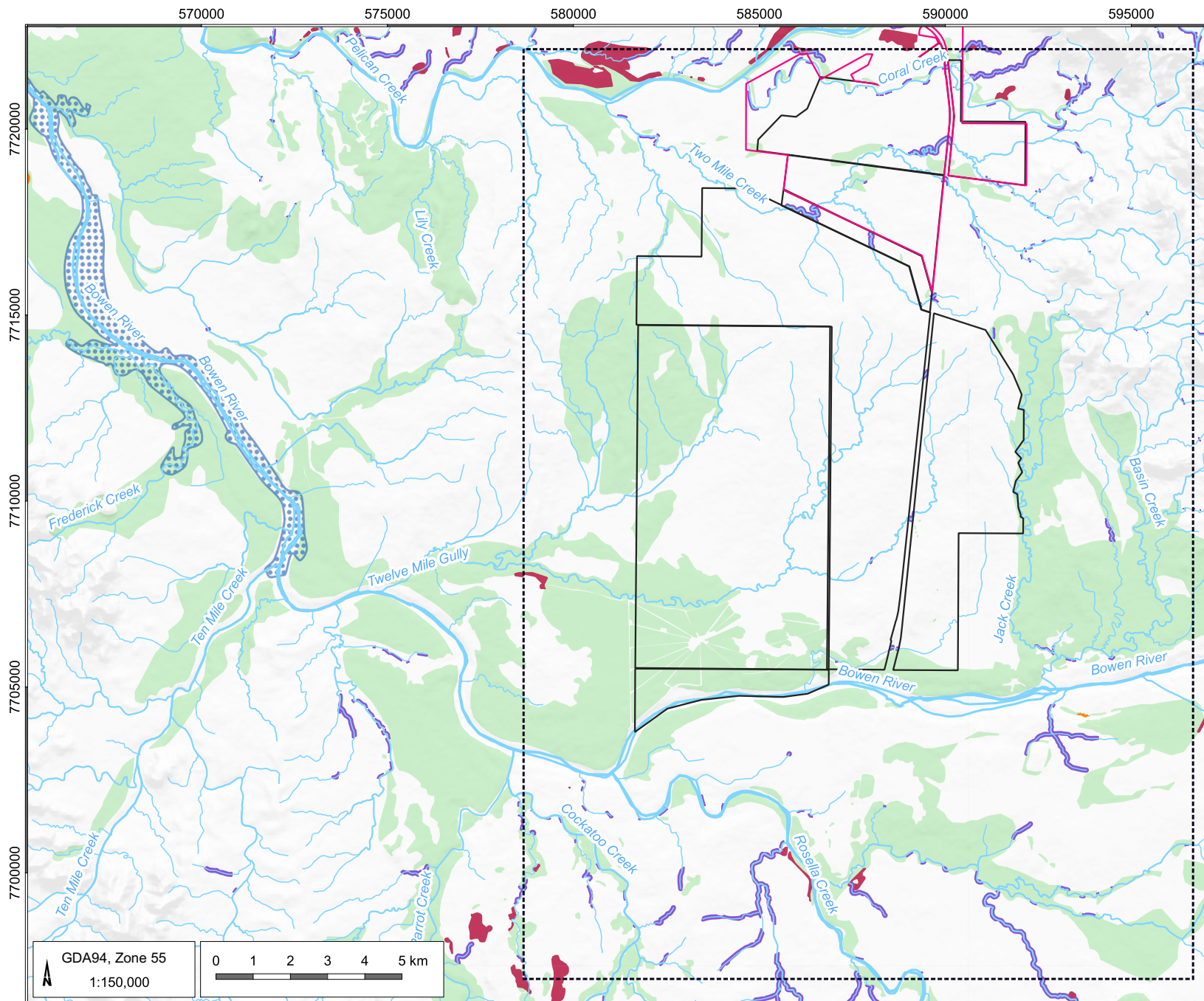
Table 3.2 Registered water supply bore details

RN	Easting*	Northing*	Year drilled	Formation	Top Screen (mbgl)	Bottom Screen (mbgl)	SWL (mbgl)	Yield (L/s)
25008	592391	7720564	1966	NA	0	18.3	-12.2	NA
125348	591794	7719800	1966	NA	15	33	NA	NA
25349	585005	7720630	1966	NA	0	18.3	NA	NA
125698	595687	7715912	2005	Sandstone	30	37	-25.0	5.6
140020	594690	7715181	2006	Sandstone	12	18	-8.30	0.74

Notes: *Coordinate system: GDA94.
mbgl: meters below ground level.
SWL: Standing Water Level.
NA: Not Available.

3.1 Cultural and spiritual values

The Northern Hub mining leases are located within the cultural heritage boundaries of the Birriah People. The mining leases are covered under the cultural heritage management plan (CHMP) number CLH000473 for the QCoal Sonoma Coal Project (Figure 3.1 and Figure 3.2).



LEGEND

- Watercourse
- QNH mining leases
- Model extent
- Cultural Heritage Management
- Plan boundary (CLH000473)
- Directory of Important Wetlands in Australia (DIWA)

MSES

- High ecological significance wetlands
- Regulated vegetation category B endangered
- Regulated vegetation category C endangered
- Regulated vegetation category R GBR riverine

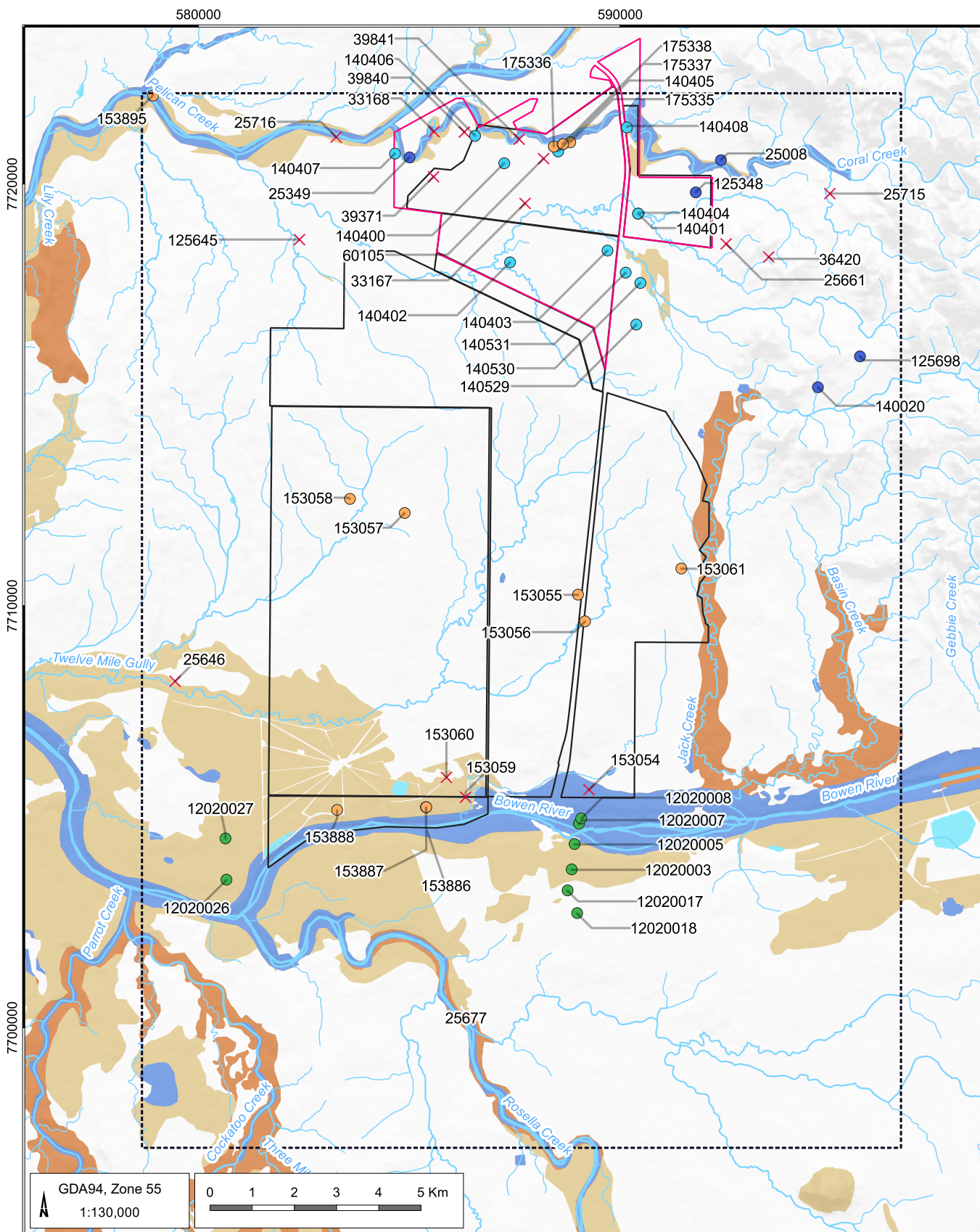
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

MSES and receptors

DATE
13/10/2023

FIGURE No:
3.1





LEGEND

Registered bores

- Water
- Mine monitoring
- Sub-Artesian Monitoring
- Water supply
- × Unknown

Watercourse

QNH mining leases

Model extent

Cultural Heritage Management

Plan boundary (CLH000473)

Aquatic

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment

Terrestrial

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment

QCoal Northern Hub Groundwater Modelling Report
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Groundwater dependent ecosystems and receptors



DATE
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FIGURE No:
3.2

4 Geology

4.1 Stratigraphy

The Project area is located on the northern tip of the north-south trending Bowen Basin. The Bowen Basin is an Early Permian to Middle Triassic geological unit extending over 600 km through central Queensland from Collinsville in the north, to Rolleston in the south.

The underlying geology comprises the basal Lizzie Creek Volcanics, overlying marine (Back Creek Group) and Upper Permian freshwater sediments (Blackwater Group). The marine sedimentary rocks of the Back Creek Group are subdivided into the Collinsville Coal Measures and the laterally equivalent Gebbie Formation, Blenheim Formation and Exmoor Formation. The Blackwater Group comprises the Moranbah and Fort Cooper Coal Measures. A blanket of unconsolidated Quaternary alluvium covers the coal measures along the main drainage lines. Table 4.1 summarises the main stratigraphic units present in the region, with Figure 4.2 showing the surface geology of the area and Figure 4.3 showing the Bowen basin geology.

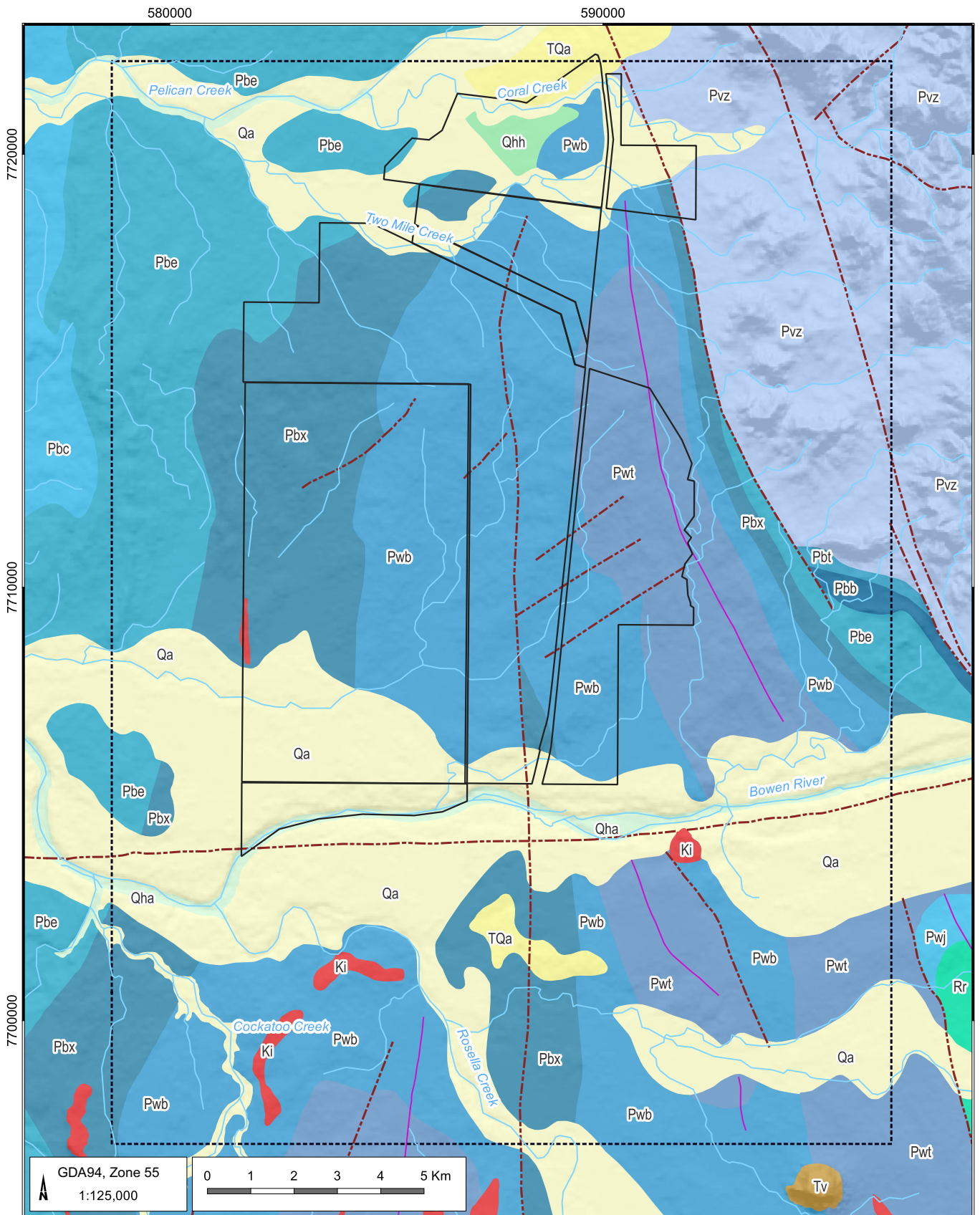
Table 4.1 Generalised stratigraphy of the Collinsville area

Age	Group	Formation	Description
Cainozoic		Quaternary alluvium	Unconsolidated clay, silt, sand and gravel
Permian	Black-water group	Fort Cooper Coal Measures	Sandstone, conglomerate, mudstone, carbonaceous shale, coal, cherty tuff
		Moranbah Coal Measures	Cross-bedded lithic sandstone and siltstone, mudstone, coal, with fossil logs
	Back Creek Group	Exmoor Formation	Sandstone, siltstone, mudstone, rare fossils
		Collinsville Coal Measures/ Gebbie Formation	Quartzose sandstone, conglomerate, siltstone, coal (mined at Collinsville mine)
		Blenheim subgroup	Micaceous siltstone, pebbly in places, labile sandstone, quartzose lithic sandstone, coquinite, limestone
Carboniferous/ Permian		Lizzie Creek Volcanics	Basaltic, andesitic rhyolitic to dacitic lavas, volcaniclastic rocks, local siltstone, shale and conglomerate

QNH main economic target seams are within the Moranbah Coal Measures. The mining complex will also intercept the shallower R and S seams of the Fort Cooper Coal Measures which overlie the Moranbah Coal Measures. The coal seams are relatively clean and contain only minor tuffaceous and mudstone bands. Figure 4.1 summarises the nomenclature for the coal seams and the various plys that occur in the area.

STRATIGRAPHY and COAL SEAMS at DRAKE			
FORT COOPER COAL MEASURES	S seam	S1 seam S2 seam	
	R seam	R1 seam R2 seam	outcrops along eastern boundary
MORANBAH COAL MEASURES	Q seam	Q1 seam Q2 seam Q3 seam	mined at JAX and Sonoma
	P seam	P1 seam P2 seam P TUFF P3 seam	
	E seam	E1 seam E2 seam E3 seam	mined at Sonoma
	D seam		thin seam, no resources
	C seam	C seam CL seam	mined at Sonoma previously called BR seam
	B seam	B1 seam B2 seam B3 seam B4 seam B5 seam B6 seam	mined at Sonoma
EXMOOR FORMATION	A seam	A1 seam A2 seam	high ash, no resources

Figure 4.1 Coal seam nomenclature in QNH



LEGEND

Anthropocene (Qhh)	Gebbie Formation (Pbb)
Helocene (Qha)	Tiverton Formation (Pbt)
Quaternary (Qa)	Collinsville Coal Measures (Pbc)
Late tertiary (TQa)	Blenheim Formation (Pbe)
Early tertiary (Tv)	Lizzie Creek Volcanic Group (Pvz)
Cretaceous (Ki)	
Rewan Group (Rr)	Watercourse
Rangal Coal Measures (Pwj)	Fault
Fort Cooper Coal Measures (Pwt)	Fold
Moranbah Coal Measures (Pwb)	QNH mining leases
Exmoor Formation (Pbx)	Model extent

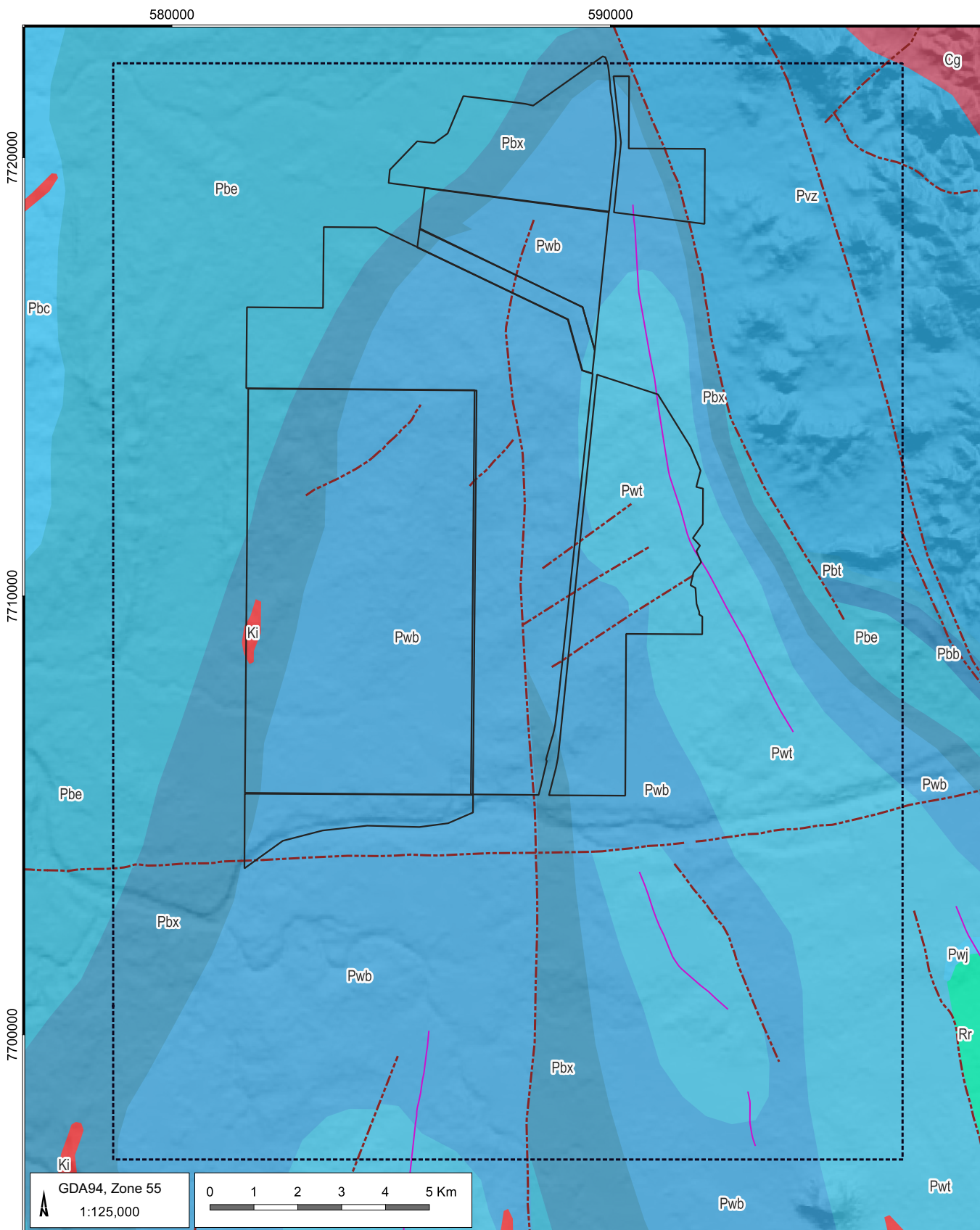
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Surface geology



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FIGURE No:
4.2



LEGEND

Bowen Basin Geology

- Carboniferous (Cg)
- Cretaceous (Ki)
- Rewan Group (Rr)
- Rangal Coal Measures (Pwj)
- Fort Cooper Coal Measures (Pwt)
- Moranbah Coal Measures (Pwb)
- Exmoor Formation (Pbx)
- Gebbie Formation (Pbb)
- Tiverton Formation (Pbt)
- Collinsville Coal Measures (Pbc)
- Blenheim Formation (Pbe)
- Lizzie Creek Volcanic Group (Pvz)

- Watercourse
- Fault
- Fold
- QNH mining leases
- Model extent

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Bowen basin geology



AGE

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FIGURE No:
4.3

4.2 Structural geology

QNH is located within a synclinal basin. The axis of the syncline runs through the eastern area of QNH with the mining largely located on the western limb of the syncline as shown in Figure 4.2 and Figure 4.3. A north south oriented regional thrust fault traverses Cows and Drake mines, with an upward displacement on the eastern side of the fault. A series of thrust faults also displace and offset the coal seams through QNH. The displacements are in the order of 20 m to 40 m.

5 Hydrogeology

5.1 Hydrostratigraphy

Two geological units have the potential to form aquifers within the region:

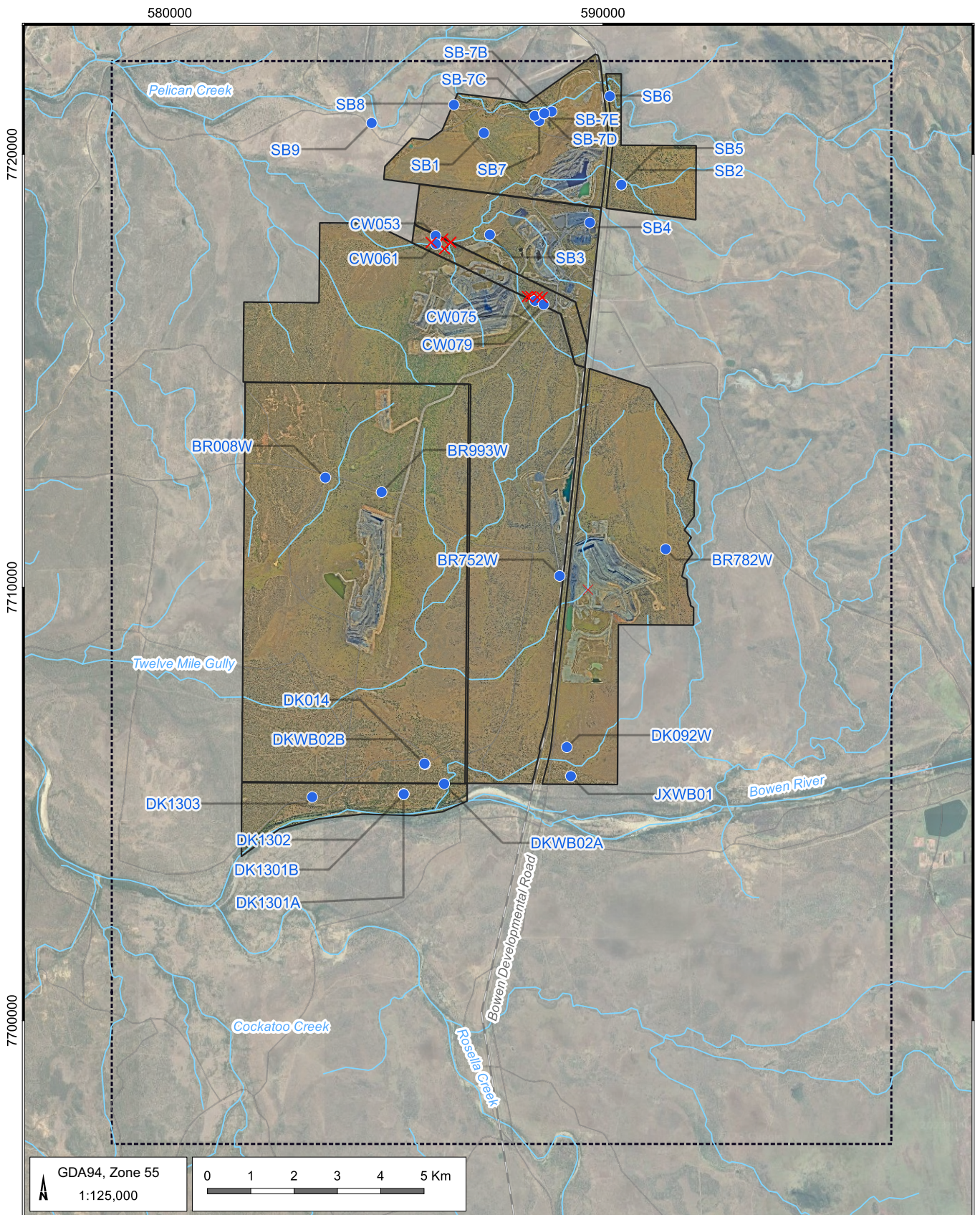
- Cainozoic alluvial sediments that form a sporadic shallow unconfined aquifer where sufficiently thick; and
- deeper confined Permian coal seams.

Quaternary alluvium occurs intermittently within the flood plains of Pelican Creek and the Bowen River and comprises finer silts and clays overlying coarser sands and gravels at the base of the unit. At Sonoma, the alluvium is only sporadically saturated in areas where the alluvial material is thicker and below the water table.

It is generally accepted that in the Bowen Basin coal seams have a higher permeability than the inter-burden and therefore comprise the main water bearing beds. The review of the resource exploration data for the Sonoma and Drake deposits indicates that the inter-burden is typically comprised of fine-grained sandstone, siltstone and mudstone that are of low primary porosity.

5.2 Groundwater monitoring bores

Figure 5.1 shows the location of the existing groundwater monitoring bores network throughout QNH. A total of 30 monitoring bores are used to measure groundwater level and quality in the Project area. Hydrographs are provided and discussed in Section 5.3.



LEGEND

Monitoring bores location
 ● Existing
 ✕ Destroyed

— Watercourse
 — Road
 — Rail
 □ QNH mining leases
 □ Model extent

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Groundwater monitoring bores



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FIGURE No:
5.1

5.3 Groundwater levels

QCoal commenced monitoring groundwater levels at the QNH in 2007 as part of the coal exploration program. Figure 5.2 to Figure 5.5 show the groundwater levels and CRD recorded from each mining area over time.

5.3.1 Sonoma mine

Figure 5.2 shows groundwater levels recorded at Sonoma mine over time. Monitoring bores SB04 and SB05 are screened within coal seam, with the remaining SB1, SB2, SB3, SB6, SB7, SB7B/C/D/E, SB8 and SB9 monitoring alluvium. Figure 5.3 shows groundwater levels respond to prevailing climatic conditions rising in response to above average rainfall periods that occurred from 2009 to 2012, and 2022 to 2023, and declining during periods of below average rainfall when deep drainage and recharge is limited due to low rainfall and soil moisture levels. No significant impact from mining is evident within the alluvial aquifer system.

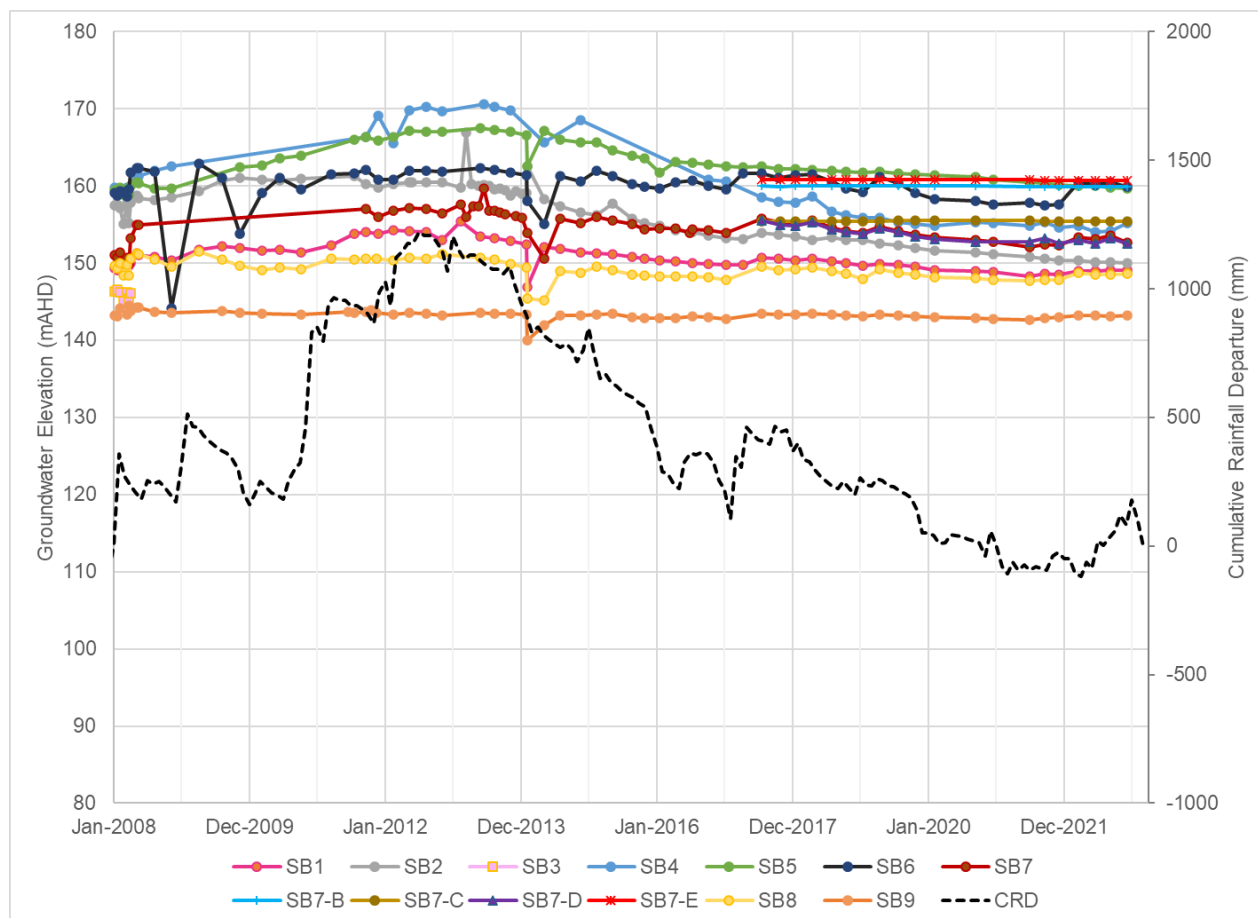


Figure 5.2 Groundwater levels and rainfall – Sonoma Mine

5.3.2 Cows mine

Figure 5.3 shows the groundwater levels recorded in monitoring bores situated at Cows mine. Groundwater levels were measured after the monitoring bores were installed in CW053 and CW061 in 2010, with routine monitoring commencing in 2015. The groundwater levels in these bores show variability that appears correlated with climatic conditions, with rising water levels in response to periods of above average rainfall in 2009-2012 and 2022-2023. No impact on groundwater levels due to mining activities is obvious within the recorded data.

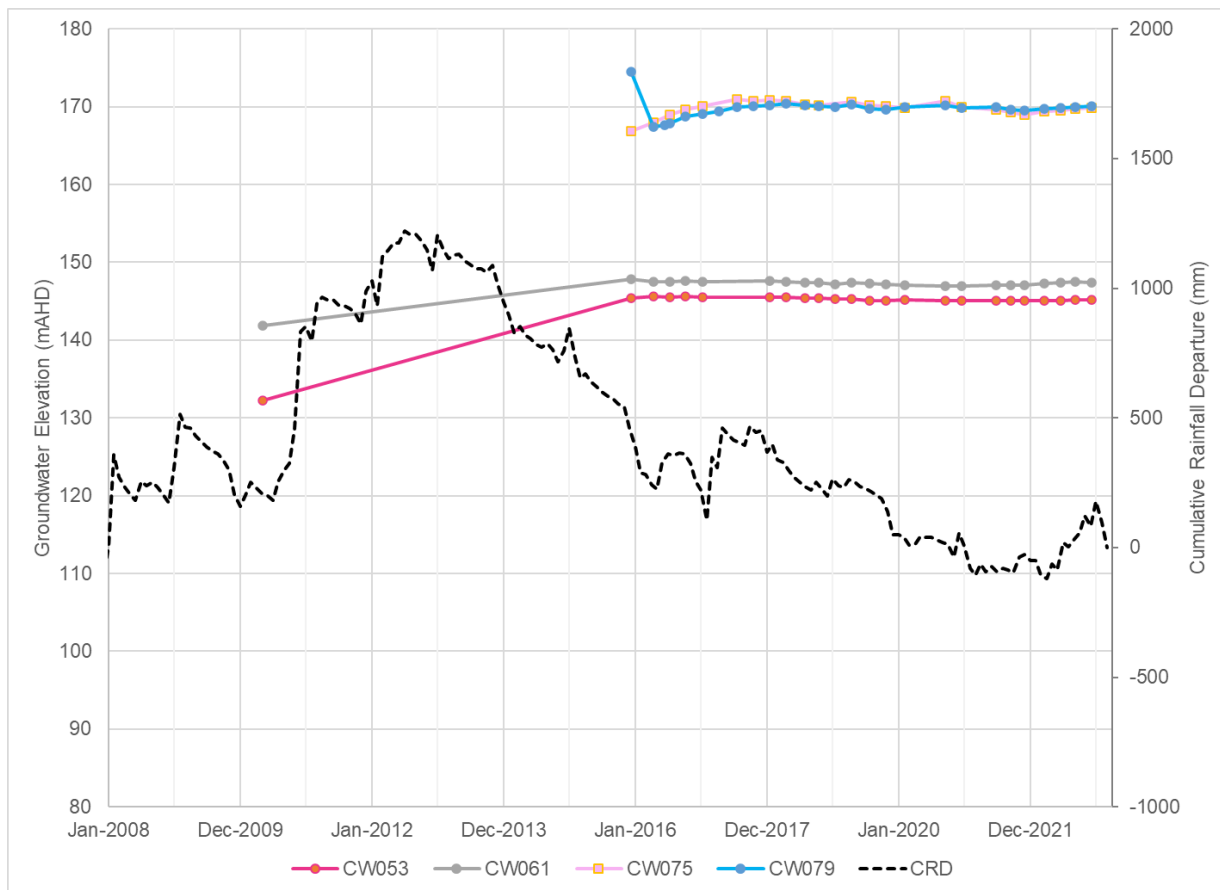


Figure 5.3 Groundwater levels and rainfall – Cows Mine

5.3.3 Drake mine

Figure 5.4 shows the groundwater levels recorded in monitoring bores installed at the Drake mine. The hydrographs indicate:

- Monitoring bores DK1301B, DKWB02B and DK1303 are dry.
- Monitoring bore BR584 only have two measurements from 2010 that recorded minor fluctuation (± 0.1 m).
- Bore BR993W was monitored from 2012 and shows little groundwater level fluctuation until mid-2019. From 2019 to 2023 the groundwater level decreased one metre whilst mining was occurring north of Drake 5.
- Monitoring bores DK014 and DK1301A are located near the Bowen River, a couple of kilometres away from Drake 5 mine pit. Groundwater levels in these monitoring bores have recorded a steady decline in groundwater levels since 2012 which coincides with a long period of generally below average rainfall.
- Water levels recorded in bore BR008W are anomalous, showing a continual rising trend since 2009. This bore monitors the Exmoor formation, and it is considered likely that the very slow recovery of this bore post construction is due to it being within a zone of extremely low permeability.
- Monitoring bore DKWB02A was dry from 2017 to 2020. Groundwater levels were recorded from late 2021, following average rainfall, with fluctuations showing since showing a relationship with climate.

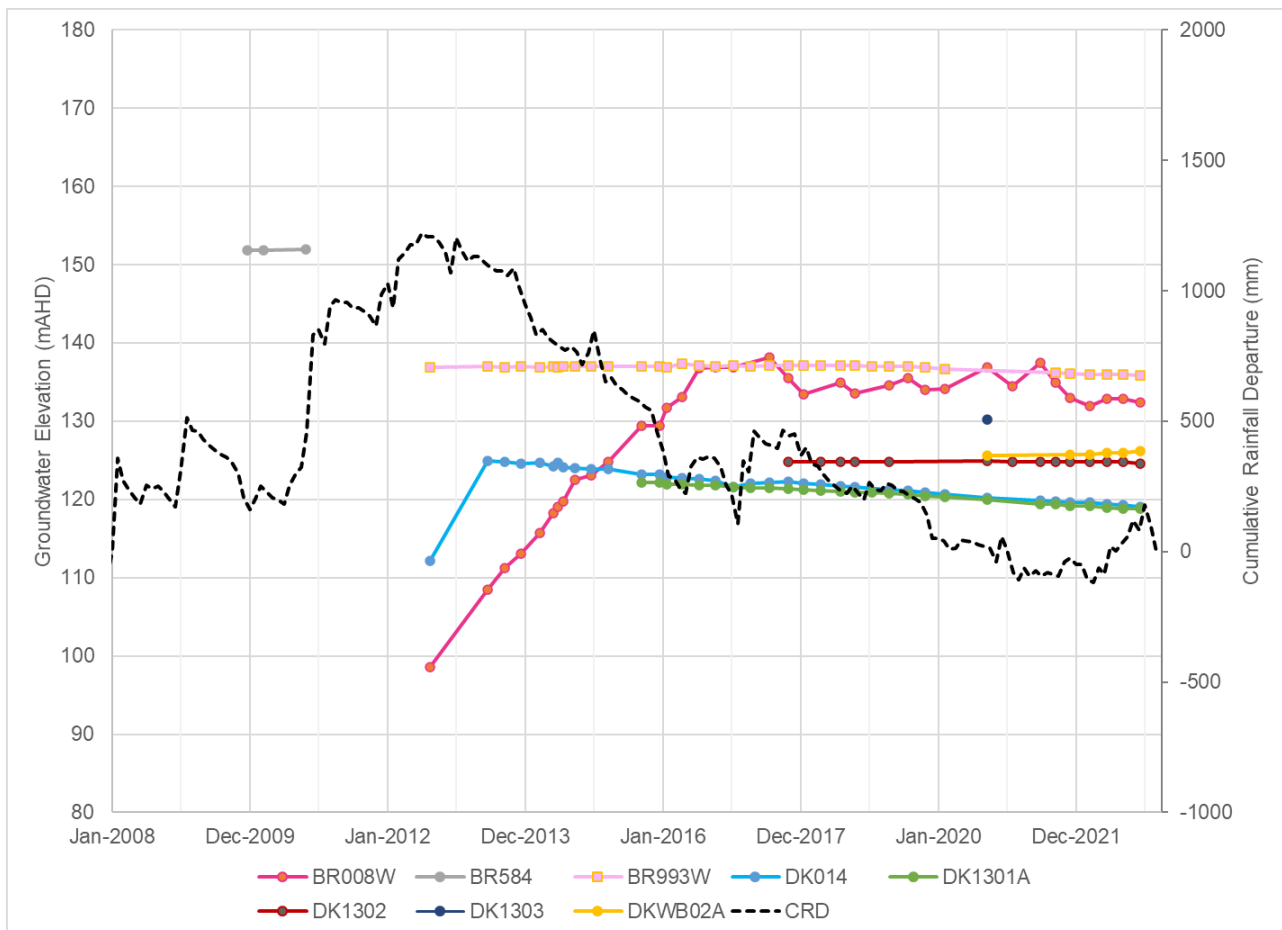


Figure 5.4 Groundwater levels and rainfall – Drake Mine

5.3.4 Jax mine

Figure 5.5 shows the historical groundwater levels at Jax mine. The hydrographs indicate that:

- Bore BR752W has recorded a general decline in water levels since 2009. This bore is near the Jax pit and may be responding to ongoing passive evaporative pit dewatering depressurising the groundwater system.
- Bores DK092W and BR782W have recorded similar groundwater level trends related to climatic conditions with no obvious declines attributable to mining.

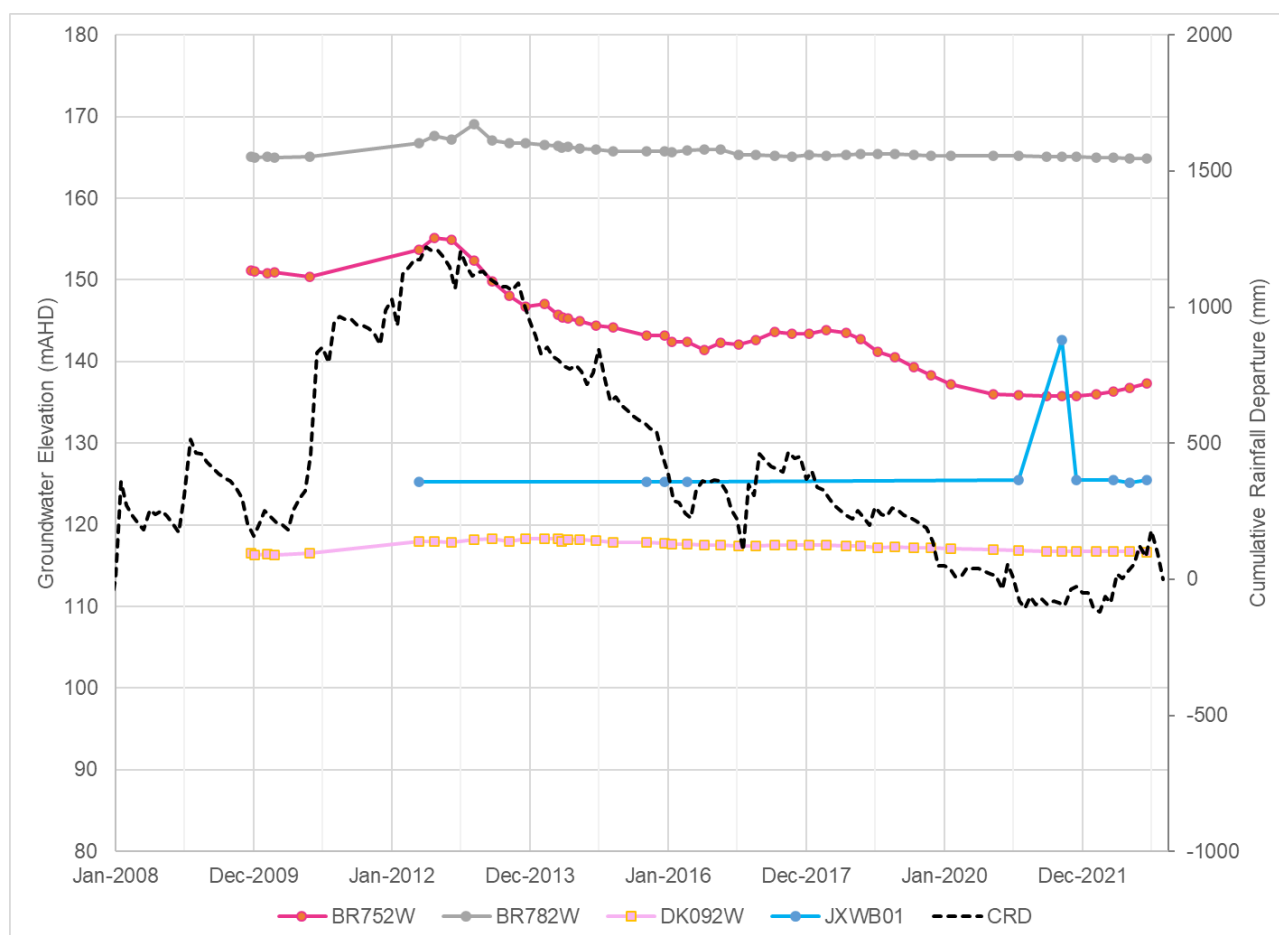


Figure 5.5 Groundwater levels and rainfall – Jax Mine

5.4 Hydraulic properties

There was no further hydraulic testing undertaken between the 2020 modelling report (AGE, 2020) and this current model update. Estimated hydraulic properties are based on falling head tests by Geoaxiom in 2010, observations of seepages in the mine pits over a site visit and AGE experiences of Bowen Basin hydrogeology.

Geoaxiom (2010) measured hydraulic conductivity in four bores at the project site using falling head tests. These tested zones were within the upper coal seams and intrusive sills of the Moranbah coal measures for bores DK092W, BR752W, and BR993W, and within sandstone and sandy siltstone for bore BR782W. The estimated hydraulic conductivity ranged from 0.1 m/day to 0.7 m/day. Geoaxiom concluded the tested zones form semi-pervious poor aquifers. These estimates are considered an upper bound to the Permian due to the shallow depth. Hydraulic conductivity is known to decline with depth in coal as increasing overburden pressure closes up the fractures or cleats in the coal seam reducing permeability.

No data was obtained for the alluvium and the weathered zone; however, the alluvium is expected to have a higher permeability than the measured coal seams due to its unconsolidated and more porous nature.

The hydraulic conductivity of the weathered zone is expected to be highly variable depending on clay and silt content and fracture networks, but it is not considered to form an aquifer.

The interburden units between the coal seams typically have a lower hydraulic conductivity than the coal seams, and thus act as confining layers for the coal seams. Observations at the Sonoma mine indicate these units are particularly dry and tight and are indicative of a hydraulic conductivity several orders of magnitude lower than the coal seams.

5.5 Surface water interaction

Conceptually the shallow groundwater system towards the southern end of the project area is likely to be in connection with the Bowen River. This connection provides the logical mechanism for recharge to these adjacent aquifers. Generally, the Bowen River is considered a gaining stream (water draining from the aquifer to the river); however, during high flow periods and flood events, the gradients are likely to be temporarily reversed with water seeping through the riverbank into the adjacent aquifer.

Groundwater discharge is unlikely to occur in the surface drainage lines across the site due to the groundwater levels lower than the drainage beds.

5.6 Recharge

Recharge to the aquifers in the study areas occurs through rainfall infiltration and potentially through flooding of the Bowen River. The rate of infiltration recharge is expected to be very low given the clayey nature of the unsaturated zone and the high evaporation rate in the region. There is very limited groundwater extraction occurring within the study area, and the primary discharge of groundwater to surface drainages is baseflow. The discharge would also occur through evapotranspiration when water tables are within reach of vegetation root zones.

There is only sparse groundwater abstraction from private bores for stock from the area surrounding QNH; which is further evidenced by the EIS (GHD 2012) identifying the targeted Moranbah Coal Measures as generally having low yields of less than 0.1 Litres per second (L/s), with a maximum yield recorded of 5 L/s.

6 Numerical model development

6.1 Model Objectives

The model is being developed to provide predicted groundwater level behaviour in response to the Northern Hub complex of coal mining activities. More specifically, the model is developed to predict the following:

- Inflow to mine pits over the life of mine.
- Groundwater drawdown / depressurisation resulting from the pit dewatering.
- Post mining groundwater conditions resulting from the changed conditions due to mining.
- Environmental impact.
- Pre-mining groundwater levels and post mining recovery hydrographs in the proposed voids (for water balance modelling).

6.2 Modelling approach

To better assess the groundwater flow regime and potential groundwater impacts from the Northern Hub mines, a numerical groundwater model has been constructed according to the updated geological stratigraphic data. Compared to the previous structured grid model, this reconstructed model adopted an unstructured grid (USG), which allows us to achieve improved accuracy and efficiency in simulating complex phenomena and irregular geometries. The flexibility of the unstructured grid enables a more precise representation of real-world scenarios, facilitating an improved understanding and analysis of groundwater flow. Additionally, the adaptability of the unstructured grid allows for targeted mesh refinement in critical areas, such as the mine pit, reducing computational costs while maintaining high-resolution results.

Once the model was constructed and calibrated against up-to-date observed groundwater levels, the calibrated model was used to assess the impact of the updated future mine progression.

6.3 Model construction

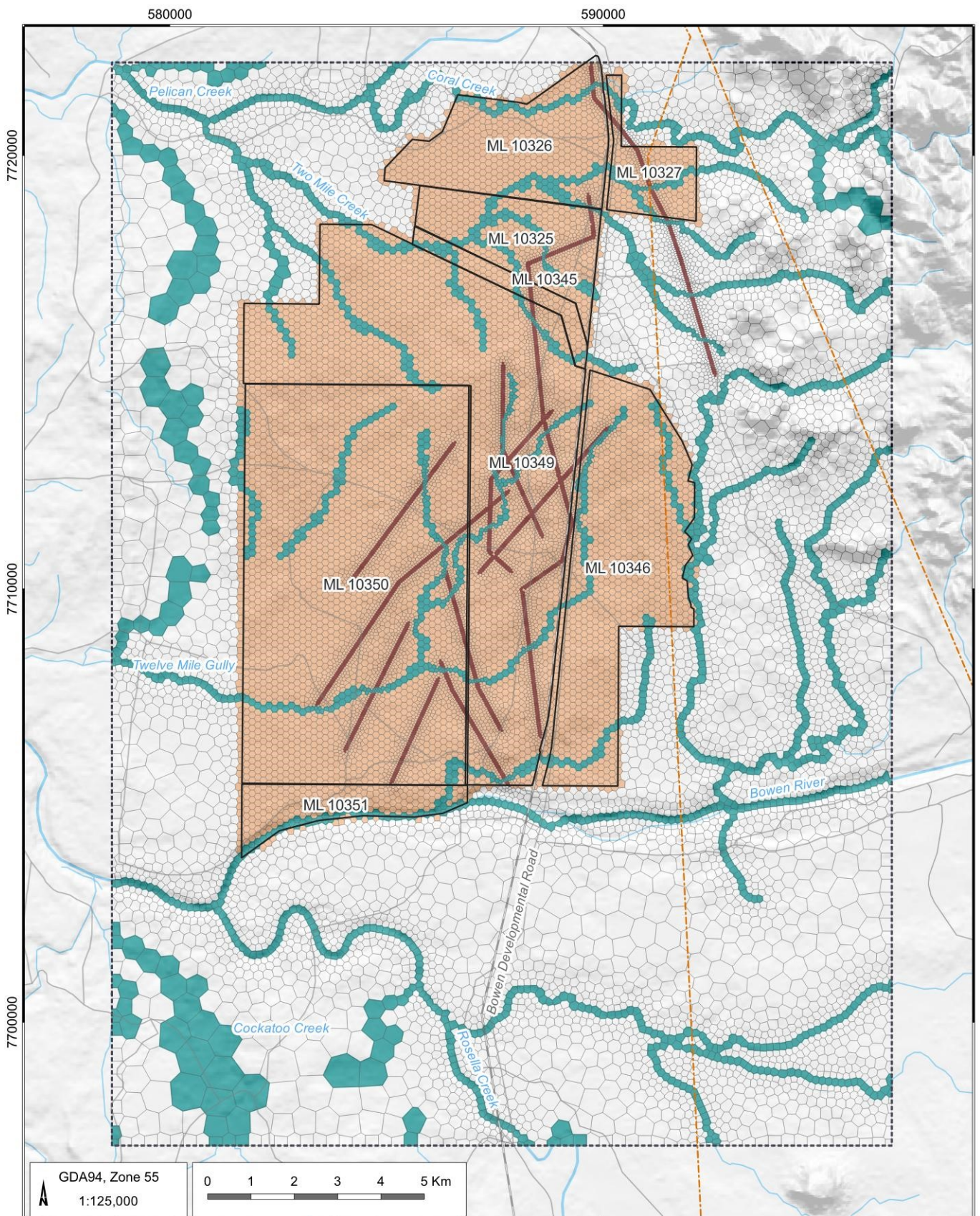
A 3D numerical groundwater flow model was developed using the Unstructured Grid Version of MODFLOW (MODFLOW-USG) to predict the impacts of the approved and amended coal mining activities. Details of the model development are provided in the sections which follow.

6.3.1 Model extent and mesh

The model extent, mesh and boundary conditions are presented in Figure 6.1. The extent of the model remained the same as the previous model. The northwest corner of the grid is located at 575987.2 mE and 7722266.5 mN (MGA 94, Zone 55). The model grid adopts similar overall dimensions to the previous model and is 18 km wide (E-W) and 25 km long (N-S). The model maintains a consistent layering approach, similar to the previous model, with the vertical dimension discretised into 14 layers, totalling 163,789 cells. This mesh was generated using a Voronoi-based gridding method implemented with AlgoMesh (HydroAlgorithmics, 2020), resulting in a significant reduction in cell count compared to the previous model. The previous model utilised structured discretisation, which generated 60140 cells per layer and a total of 841960 cells.

As shown in Figure 6.1 relatively small cells have been defined within and around the mine leases area, the Bowen River and its tributaries, the alluvium associated with the rivers, and the faults. The following Voronoi cell dimensions were adopted for key detail areas of the model domain:

- cells covering the mine leases and the surrounding area, approximately 150 m × 150 m;
- cells representing main rivers and the surrounding alluvium area, approximately 150 m × 150 m; and
- cells representing faults and the surrounding area, approximately 50 m × 50 m.



LEGEND

- Road
- Rail
- Watercourse
- Powerline
- Model mesh
- QNH mining leases
- Model extent
- Area of refinement to simulate mine dewatering
- Area of refinement to simulate faults
- Area of refinement to simulate rivers

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Model extent and boundary conditions



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FIGURE No:
6.1

6.3.2 Time discretisation

QCoal commenced monitoring groundwater levels at the project site in 2007 as part of the coal exploration program. Accordingly, a steady state simulation was initially simulated to obtain a pre-development groundwater condition in 2007. From this point, the transient historical model simulation commences in September 2007 and adopts monthly stress periods until June 2023. Observations of groundwater levels collected over this same historical period were used to calibrate the transient groundwater model.

The predictive part of each simulation, used for impact assessment purposes, simulates mine development representing a period from July 2023 until the end of mining (2051). Stress period length through the predictive phase is mostly yearly (365 days). For the post-mining recovery, the stress period gradually increases from one year to 300 years. The combined historical and predictive mining simulation spans from the year 2007 to 2051, while post-mining simulation extends from the year 2052 to 4284, altogether comprising a total of 240 stress periods.

6.3.3 Model layers

QCoal has created a detailed geological model of the region using exploration drilling data from Sonoma, Drake and Havilah. It contains the numerous coal seams and plies that occur at the project site. Numerical groundwater flow models cannot practically represent this level of geological detail as separate layers. QCoal therefore simplified the geological model at AGE's request by amalgamating key seams and numerous plies into larger layers. This allowed the groundwater model to represent the true thickness of the coal seams with fewer individual layers to ensure the computation time was manageable.

The model grouped geological units with similar hydraulic properties into single layers. Where the geological unit was not present across the entire model domain, the layer thickness was reduced and 'wrapped' under the above layer, adopting the properties of the overlying layer. The model represented the main hydrostratigraphic units as 14 layers (Table 6.1).

Table 6.1 Geological layers in the model

Layer	Lithology
1	Alluvium and weathered zone;
2	Weathered zone (down to the base of weathering);
3	Fort Cooper Coal Measures;
4	Interburden;
5	Coal seam (Q seam);
6	Interburden;
7	Coal seam (P seam);
8	Interburden;
9	Coal seam (E seam);
10	Interburden;
11	Coal seam (C seam);
12	Interburden;
13	Coal seam (B seam); and
14	Exmoor Formation.

6.3.4 Solver settings

The groundwater flow equations represented in MODFLOW-USG are solved by the unstructured preconditioned conjugate gradient (PCGU) solver with the preconditioned bi-conjugate gradient stabilised (BCGS) linear acceleration method, which is handled using the sparse matrix solver (SMS) package. The head change criterion (HCLOSE) and head change criterion for convergence (HICLOSE) were set to 0.001 m and 0.0001 m respectively.

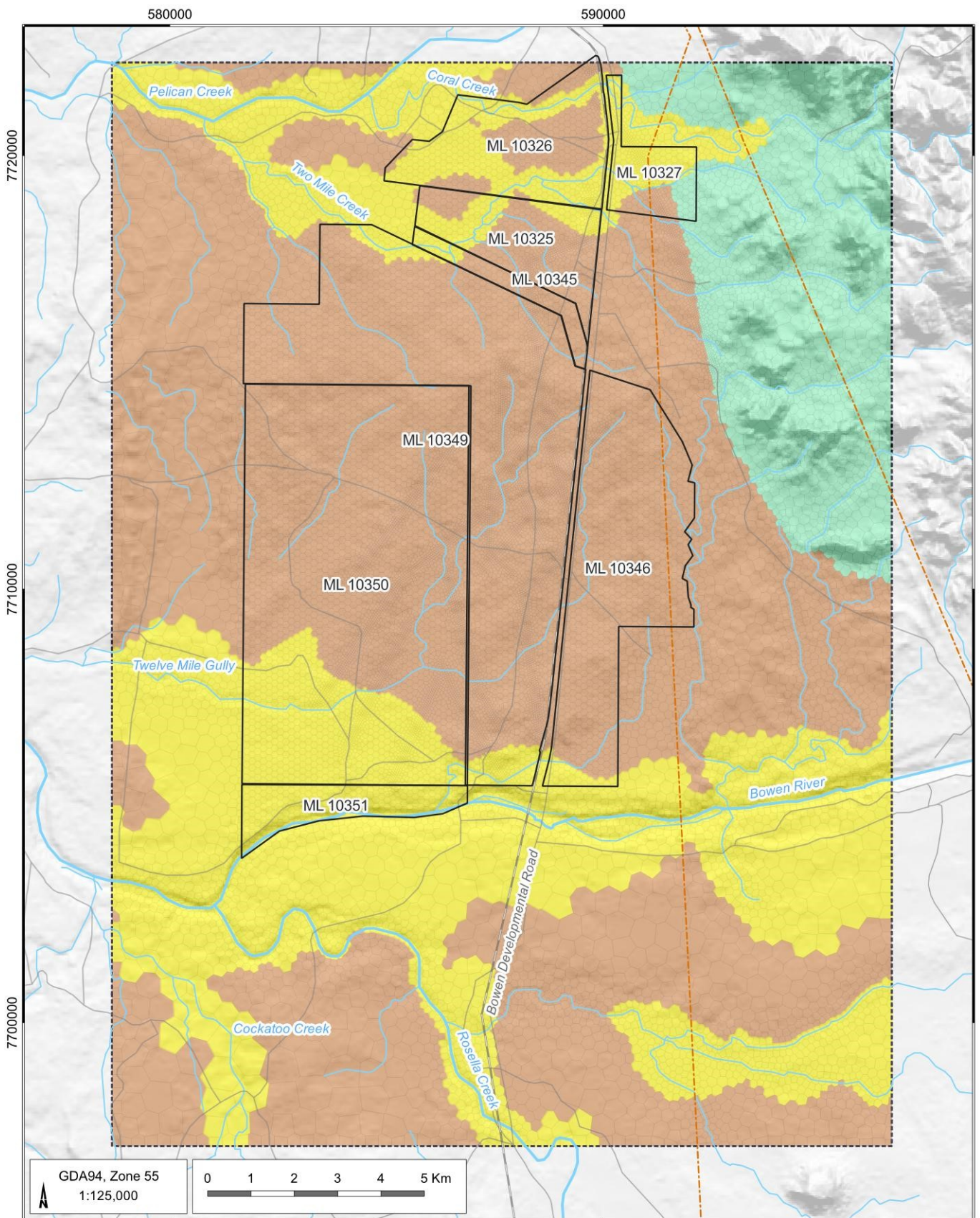
6.3.5 Boundary conditions

6.3.5.1 External model domain

The external model domain was assigned with no flow boundaries. While it is likely the alluvial systems continue beyond the model domain, this assumption was the most conservative as it prevents the alluvium from acting as an infinite source or sink of water. Apart from the southern boundary, the Moranbah Coal Measures were completely contained within the model domain. The southern boundary was located far enough away that the coal seams are deep and not impacted directly by mining at Northern Hub complex.

6.3.5.2 Recharge

Recharge to the aquifer system was distributed across the model domain according to the inferred surface geology. As shown by Figure 6.2, the model domain was zoned into three areas: one where alluvium was situated near rivers, another being a volcanic zone located on the northeast side of the domain, and the remaining area designated as regolith. The recharge rates were estimated as a proportion of the average annual rainfall for each geology zone. The model assumed the recharge to the alluvium was significantly higher than through the regolith and volcanic areas due to the greater permeability of the alluvial soils. The adopted recharge rate is a deep drainage value, and therefore it accounts for all other losses of incident rainfall including water intercepted by vegetation and evaporated, transpiration and runoff. The recharge varied in the transient calibration monthly, with the predictive model using an annual average recharge rate.



LEGEND

- Populated place
- Road
- Rail
- Watercourse
- Powerline
- Model mesh
- QNH mining leases
- Model extent

- Model recharge zone**
- Alluvium
 - Regolith
 - Volcanics

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Model recharge zone



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FIGURE No:
6.2

6.3.5.3 Surface drainage

The river package simulated the river and creek drainages in the region. The bed of the major river cells was set at 1.5 m below the LIDAR digital elevation data along the river alignment. The model represented all rivers and drainage lines, other than the Bowen River, as drains where only flow of water from the aquifer to the stream could occur.

A catchment divide occurs through the centre of the project area that splits the site into a north or south catchment. Surface drainage in the northern catchment flows towards Pelican Creek, while runoff to the south flows to the Bowen River.

The water level in the Bowen River varied uniformly along the cells representing the river. The Bowen River water level for the transient simulation was varied monthly based on average daily water level records from the gauging station for the corresponding month.

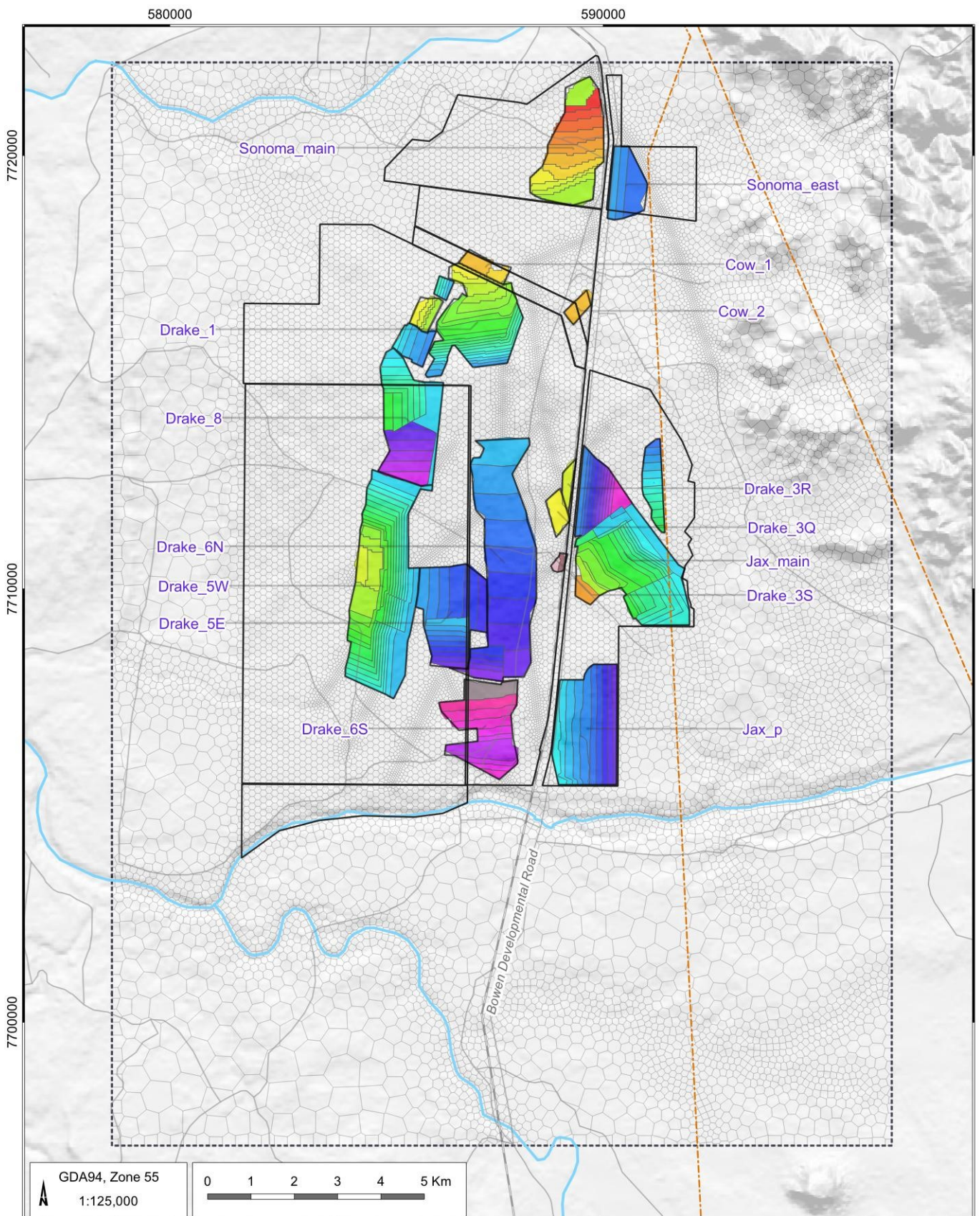
6.3.5.4 Mining progression and dewatering

The gradual mine dewatering activities at the site over the period from 2008 to 2051 (Figure 6.3) have been simulated using the MODFLOW-USG Drain (DRN) package. Overall, the drain package removes groundwater from the model when the groundwater level in the model cell is above the defined drain elevation. When the head is below the defined drain elevation, the drain becomes inactive. The lowest elevation of weathering levels and the lowest layer of mining for each void are shown in Table 6.2.

A relatively high drain conductance value of 100 m²/day was assigned to each cell representing dewatering. This ensures that each cell is fully desaturated and that inflow to the pit is primarily related to the estimated permeability of the surrounding strata, without being artificially constrained by the modelled drain conductance term.

Table 6.2 Lowest weathering levels and mining layers for each pit

Pit	Lowest elevation of the base of weathering (mAHD)	Lowest layer of dewatering
Cow_1	146.34	B seam (layer 13)
Cow_2	165.25	Q seam (layer 5)
Drake_1	126.67	B seam (layer 13)
Drake_3S	144.30	P seam (layer 7)
Drake_3Q	128.19	Q seam (layer 5)
Drake_3R	120.90	Q seam (layer 5)
Drake_5W	112.72	B seam (layer 13)
Drake_5E	116.11	B seam (layer 13)
Drake_6N	117.47	E seam (layer 9)
Drake_6S	114.14	E seam (layer 9)
Drake_8	132.42	B seam (layer 13)
Jax_main	135.28	Q seam (layer 5)
Jax_p	104.18	P seam (layer 7)
Sonoma_main	72.61	B seam (layer 13)
Sonoma_east	151.77	E seam (layer 9)



LEGEND

- Populated place
- Road
- Rail
- Watercourse
- Powerline
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Mine progression

2008	2019	2030	2041
2009	2020	2031	2042
2010	2021	2032	2043
2011	2022	2033	2044
2012	2023	2034	2045
2013	2024	2035	2046
2014	2025	2036	2047
2015	2026	2037	2048
2016	2027	2038	2049
2017	2028	2039	2050
2018	2029	2040	2051

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Proposed mine pit location and progression



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FIGURE No:
6.3

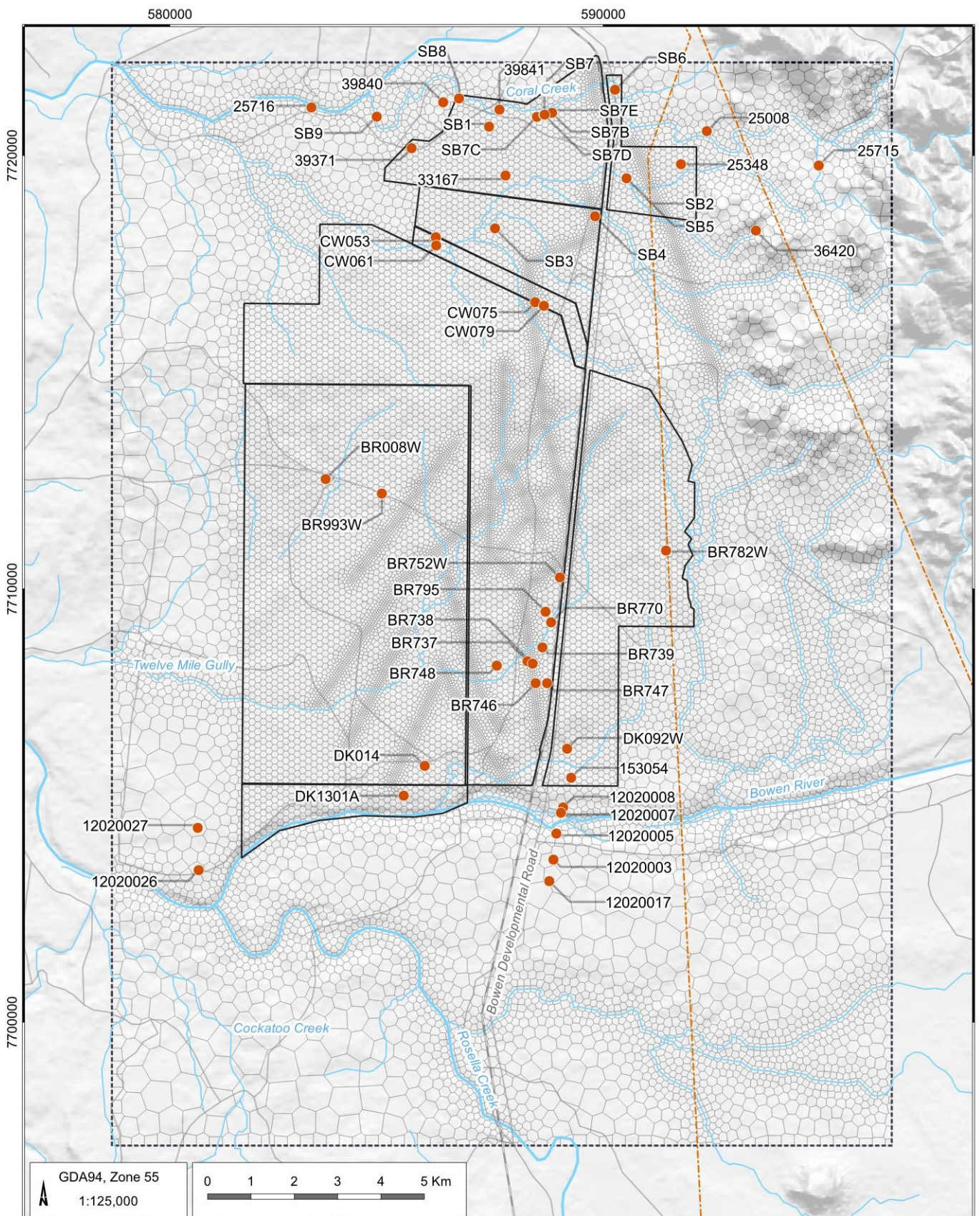
6.4 Model calibration

Once constructed, there are still many aspects of the groundwater regime, such as aquifer parameters, that are not fully understood across the model domain. These parameters that affect groundwater flow can be trained, or calibrated such that the model predicted water levels better match the corresponding observed groundwater levels collected in the area covered by the model domain. Calibration can be done through manual changes to model inputs, or through an automated process using specific software (PEST) to automate the changes and assess the model matching from the change. Observed groundwater levels were used as the calibration targets and the distribution of the monitoring bores where these levels were collected is shown in Figure 6.4.

Observation data used for the calibration statistics were updated to include the new observations from both existing and new observation bores constructed since the last modelling exercise (AGE 2020). The steady state observation dataset remained unchanged and consisted of water levels measured in both monitoring and exploration bores at the project site and surrounding region.

Pre-mining water levels represented by data *circa* September 2007 when Sonoma started mining, were sourced from baseline measurements at Sonoma and from the Queensland Government groundwater database. The groundwater database generally only contained a standing water level at the time of drilling the bore for the private bores, which in most cases significantly predated the relevant period of 2007. This was considered a valid approach as exiting bore measurements indicate limited variability with time; therefore, any observations before mining at Sonoma could be considered representative.

Bore measurement data across the Drake mining area were also used for steady state targets, as it was considered unaffected by the existing neighbouring mines. Some of the Drake bores are dry. These bores were flagged, and the model output was checked to confirm the predicted water level was below the base of the bore.



LEGEND

- Registered/monitoring bore
- Populated place
- Road
- Rail
- Watercourse
- Powerline
- Model mesh
- QNH mining leases
- Model extent

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Registered and monitoring groundwater bores used for model calibration



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FIGURE No:
6.4

The calibration process itself was managed using specialised automated parameterisation software (PEST_HP, Watermark Numerical Computing, 2023) by varying the following modelled parameters as necessary to match the observed data:

- Horizontal hydraulic conductivity, Kh.
- Vertical anisotropy, i.e. the ratio between horizontal and vertical hydraulic conductivity Kh:Kv.
- Specific yield, Sy.
- Specific storage, Ss.
- Recharge rates.
- Riverbed conductance for Bowen River and other branches.

To ensure that the calibration is not dominated by data relating to the monitoring bores for which detailed logger data are available, a simple observation weighting strategy was adopted for the initial zonal based calibration whereby bore specific weights were applied to each groundwater level observation using the following formula:

$$\text{Weight of datapoint} = 1/\sqrt{\text{(number of points for that site)}}.$$

6.4.1 Calibration parameters

A zonal based calibration was undertaken whereby single hydraulic parameter values were assigned to each model lithology and different recharge factors were defined and calibrated based on the outcrop geology. Calibrated geological layer hydraulic parameter values are presented in Table 6.3. The bed sediment vertical hydraulic conductivity of the two river segments is shown in Table 6.4. Calibrated recharge factors are shown in Table 6.5.

Table 6.3 Calibrated geological layer hydraulic parameters

Geo zone	Model layer	Lithology	Horizontal hydraulic conductivity, Kh (m/d)	Kv:Kh ratio	Specific yield	Specific storage (m ⁻¹)
1	1	Weathered cover	1.17×10^{-2}	7.95×10^{-2}	1×10^{-4}	3×10^{-5}
2	1 ~ 14	Volcanics	1.5×10^{-6}	0.14	9.63×10^{-4}	6.15×10^{-7}
3	1	Alluvium	10	2.03×10^{-3}	0.2	3×10^{-5}
4	3, 4, 6, 8, 10, 12, 14	Interburden	1×10^{-3}	1	9.91×10^{-4}	3×10^{-5}
5	5, 7, 9, 11, 13	Coal seam	1×10^{-2}	1	3×10^{-2}	1×10^{-4}
6	2	Weathered zone	1.5×10^{-3}	0.26	1.24×10^{-5}	2×10^{-7}
7	3 ~ 14	Faults_1	1.87×10^{-2}	1.16	1.66×10^{-4}	2×10^{-7}
8	3 ~ 14	Faults_2	2.51×10^{-6}	0.1	2.27×10^{-4}	3×10^{-5}
9	3 ~ 14	Faults_3	3.3×10^{-5}	1.26	3.06×10^{-4}	3×10^{-5}

The Kh:Kh ratio for the coal seams and the interburden calibrated to a value of 1, meaning that from a model perspective there is no anisotropy between vertical and horizontal flow in these units. The three fault zones show a variety of interactions as well, with zones 1 and 3 calibrating to values that have a higher vertical connection. In comparison to the previous model, shallow unconsolidated layers have higher conductivity and storage in this updated model.

Table 6.4 Calibrated river hydraulic parameters

Parameter	Model layer	Zone name	Hydraulic conductivity (m/d)
River, zone 1	1	Bowen river	9.68×10^{-2}
River, zone 2	1	Others	1.13×10^{-2}

Table 6.5 Calibrated recharge

Parameter	Model layer	Lithology	Rainfall recharge	
			% of annual rainfall	mm/year
Recharge, zone 1	1	Weathered cover	4.27×10^{-2}	0.29
Recharge, zone 2	1	Volcanics	4.61×10^{-4}	0.003
Recharge, zone 3	1	Alluvium	0.165	1.13

6.4.2 Steady state calibration

A comparison of observed and simulated steady state groundwater levels resulting from the calibration is presented in Figure 6.5.

The measured water levels and the model predicted water levels are generally well correlated. Areas of mismatch in the scatter diagram below are points away from the 1:1 diagonal line and are due to:

- the heterogeneity of the in-situ material that cannot be represented with uniform model parameters; and
- the variability in the baseline observation data that has been compiled from various time periods and may not truly reflect the long-term pre-mining water levels.

An objective method to evaluate the calibration of the model is to examine the statistical parameters that describe the match between model predicted and observed groundwater levels. The root mean square (RMS) below is considered the best measure of error, if errors are normally distributed.

$$RMS = [1/n \sum (h_o - h_m)_i^2]^{0.5}$$

Where n is number of measurements, h_o is observed water level and h_m is simulated water level. The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head loss in the system is small, the errors are only a small part of the overall model response (Anderson and Woessner, 1992). The error based on the population of observations is estimated as follows:

$$Scaled\ RMS = \left[\frac{RMS}{range} \times 100 \right] \%$$

The RMS error, which is a statistic similar to standard deviation, is a measure of the variability in the observed versus simulated water level records. The model reported an RMS error calculated for the calibrated steady state model of 7.35 m. The ratio of RMS to the total head change across the calibration points (113.32 m) indicated a Scaled RMS of 7.5%, indicating a close and satisfactory match between observed and predicted water levels.

Figure 6.6 shows the predicted pre-mining steady state water levels. The heads reflect the groundwater flow regime before the commencement of any mining within the model domain and indicate a general flow of groundwater towards the south with the water table largely following the surface topography. The major rivers act as groundwater discharge areas in the model.

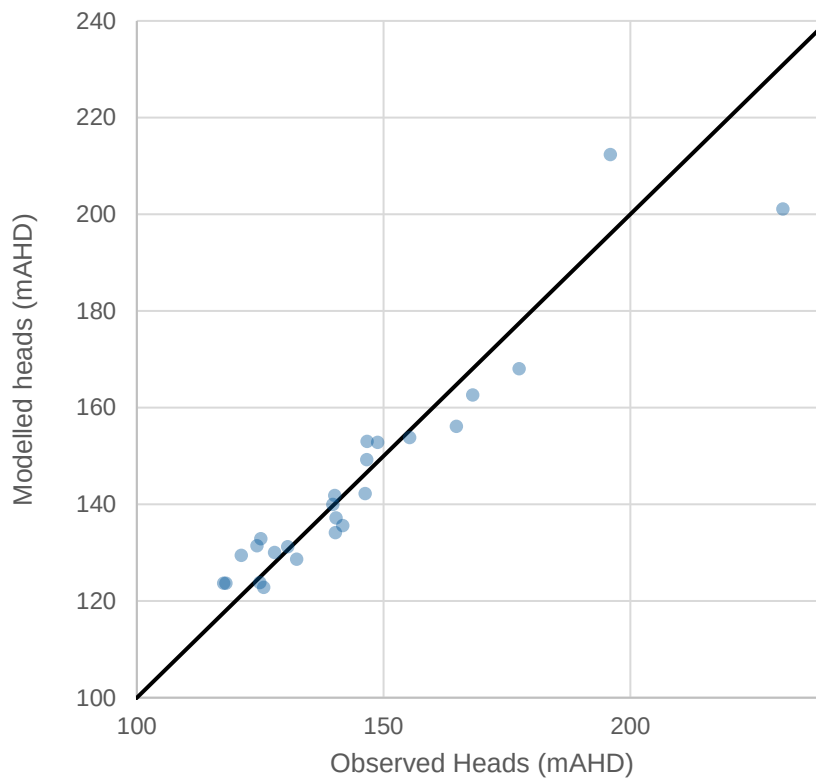


Figure 6.5 Steady state scatter diagram

The steady state model water budget is shown below in Table 6.6.

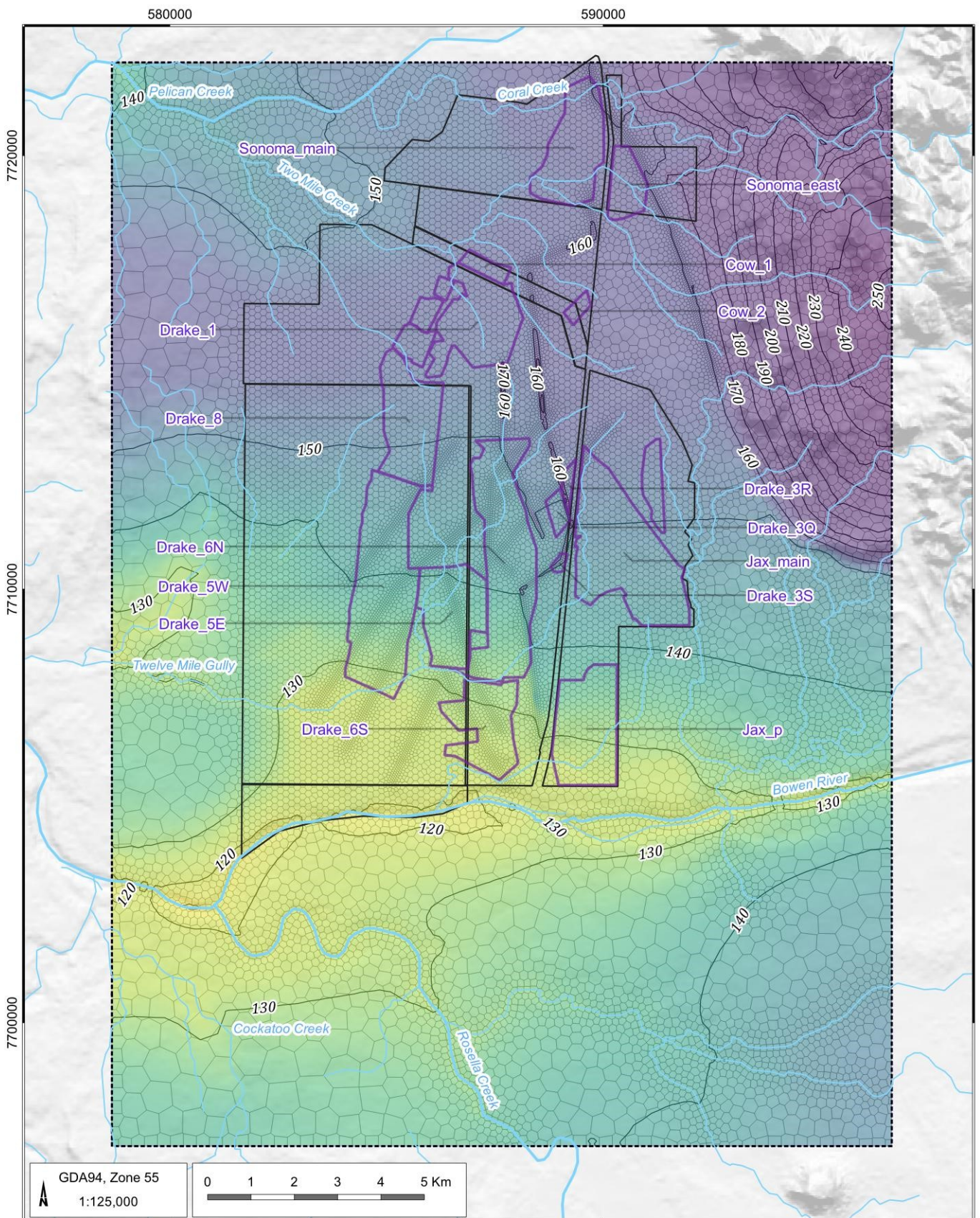
Table 6.6 Water budget – steady state model water budgets (ML/day)

Parameter	Input	Output
Rainfall recharge	0.46	-
River leakage	8.69	-
River baseflow	-	9.15
TOTALS	9.15	9.15

The net discharge from the model is calculated by subtracting river baseflow from river leakage (8.69 ML/day – 9.15 ML/day = -0.46 ML/day). This net value shows the difference between the volume of water going into the groundwater system from the river cells (leakage) and water leaving the groundwater system through the river cells (baseflow) across the whole model domain (net positive value = net leakage, net negative value = net baseflow). The water budget is higher than in the previous model, which could be due to increased calibrated recharge rates and hydraulic conductivity in the alluvium and weathered cover.

Under steady state conditions, the model predicts the Bowen River has a baseflow of 9.15 ML/day, with leakage of 8.69 ML/day, indicating a net baseflow of 0.46 ML/day. The average daily flow in the Bowen River measured at the Jacks Creek Weir is 1797 ML/day; therefore, the model estimates that under steady state conditions baseflow represents a very small portion of the average daily flow (about 0.01%), in the Bowen River. This suggests that in the absence of the releases from the Eungella Dam the Bowen River at the project site would likely be dry.

It should be noted the model has ‘no flow’ boundaries at its extents and is therefore set up conservatively as a ‘bucket’. This approach is considered appropriate based on the limited recharge occurring and the influence of the basin shape and faulting on the target coal measures. There may be flow of groundwater beyond the boundaries of the model, however it is likely to be limited in volume, and therefore has been assumed zero.



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Levels (mAH)

- 109
- 120
- 130
- 140
- 150
- 160
- 170
- 180
- 190
- 200
- 210
- 220
- 230
- 240
- 250
- 260

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Pre-mining groundwater levels - water table



DATE
01/11/2023

FIGURE No:
6.6

6.4.3 Transient calibration

Transient model calibration was also carried out. The scatter diagram below (Figure 6.7) compares the predicted and measured groundwater levels.

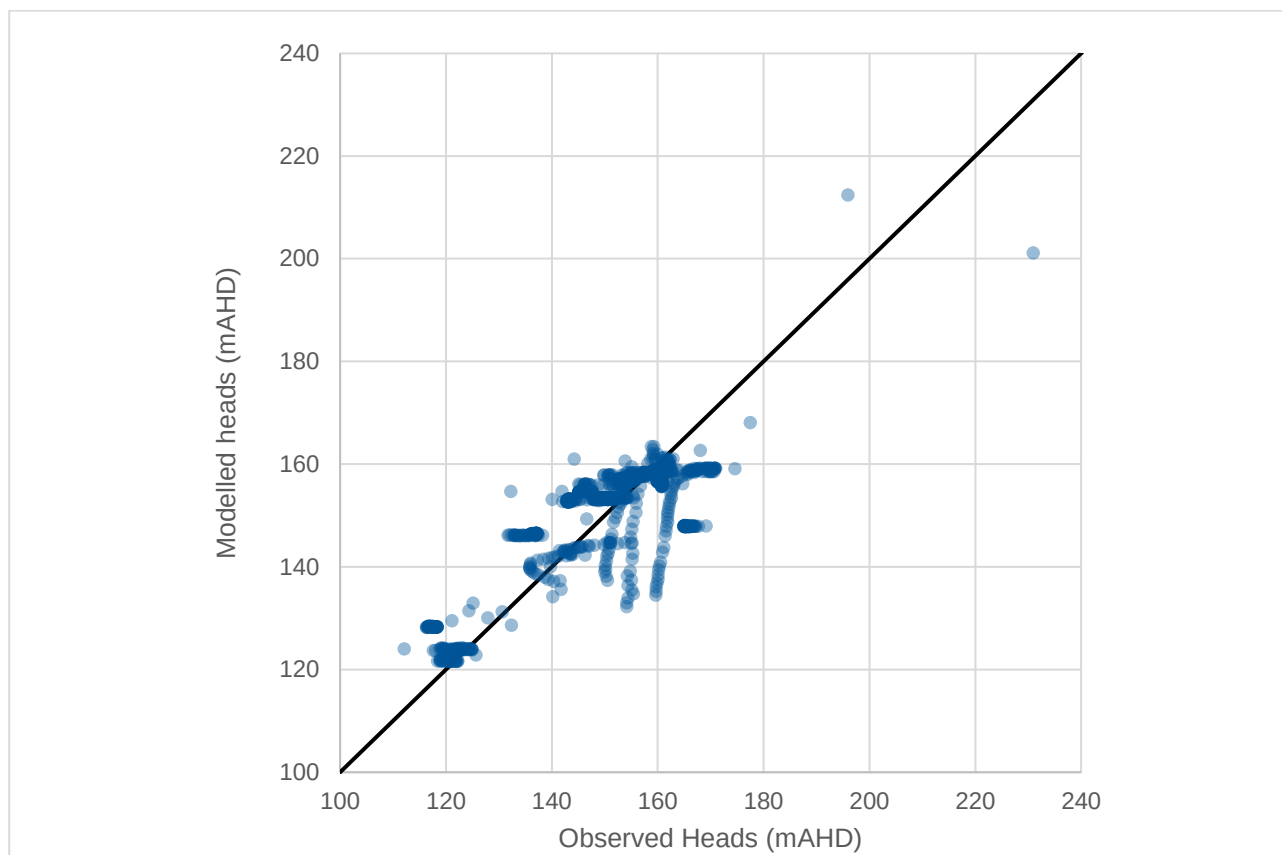


Figure 6.7 Transient scatter diagram

The RMS error, calculated for the calibrated transient model is 7.05 m. The ratio of RMS to the total head change across the calibration points (118.78 m) indicated a Scaled RMS of 6.8%.

The scattergram shows the transient calibration's limited ability to match transient water level behaviour as a series of straight lines not aligned with the 1:1 diagonal line. Because of the low recharge rates coming from the steady state calibration, the predicted water levels do generally not respond to recharge events. The transient calibration resulted in the storage values calibrating towards the lower bounds assigned in order to maximise water level fluctuations. The vertical lines under the line of perfect fit indicate that the modelled heads are varying, while the observed heads are comparably static. This indicates that the model is likely predicting impacts to areas that are not showing any impacts at present. This could be due to the model's propensity to create connections within the model which results from necessary simplifications in areas of model setup, such as model layering.

Appendix A contains the measured and the model predicted water level hydrographs for the monitoring bores used in the transient calibration. Some of the transient water level data contains anomalies, such as the continually rising BR008W, and this data whilst included within Appendix A for completeness, was not utilised in the calibration.

Many hydrographs show an initial mismatch from the start of the simulation. This is generally because the water level information for most transient bores was not available in the steady state simulation.

The predicted water levels show almost no response to climate variability. This is not the case for all the field observations where some bores have risen following high rainfall and floods. The limited response in the model is caused by the very low calibrated recharge rate and the fact the model does not account for antecedent conditions such as the wetting of the soil profile in prior events.

Most important though is the matching of trends where mine impacts are apparent. The predicted decline in SB4, SB5 and SB6 show this match, particularly with the more recent observation data. Not many of the observation bores are showing mine related impacts at present time, despite their locations. The fact that impacts have remained close to the open cut pits is most likely indicative of the tightness of the geological strata across the QNH area.

6.4.4 Model confidence classification

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 (i.e. Class 3 has the highest level of confidence). Several factors are considered in determining the model confidence level as shown in Table 6.7.

The model is currently considered a Class 2 based on the criteria it meets. The Class 2 confidence level is suitable for predicting groundwater responses to arbitrary changes in applied stress or hydrological conditions and the evaluation and management of potentially high-risk impacts.

Table 6.7 Model classification – model performance indicators

Class	Data	Calibration	Prediction	Quantitative Indicators
1 (Simple)	× Not much × Sparse coverage × No metered usage × Low resolution × Poor aquifer geometry	× Not possible × Large error statistic × Inadequate data spread × Targets incompatible with model purpose.	× Timeframe >> Calibration × Long stress periods × Poor/no validation × Transient prediction but steady-state calibration	× Timeframe > 10x × Stresses < 5x × Mass balance > 1% (or one-off 5%) × Properties < > field values × No review by Hydro/Modeller
2 (Impact Assessment)	× Some ✓ Ok coverage ~ Some usage data/ low volumes × Baseflow estimates. Some K & S measurements ✓ Some high resolution topographic DEM &/or some aquifer geometry	✓ Partial performance ✓ Some long term trends are wrong. × Short term record. ✓ Weak seasonal match. ✓ No use of targets compatible with model purpose (heads & fluxes)	× Timeframe > Calibration × Long stress periods ✓ Ok validation ✓ Transient calibration and prediction ✓ New stresses not in calibration	× Time frame = 3-10x ✓ Stresses = 2-5x ✓ Mass balance <1% ✓ Some properties < > field values. Review by Hydrogeologist × Some coarse discretisation in key areas of the grid or at key times
3 (Complex Simulator)	~ Lots, with good coverage. ~ Good, metered usage info. ✓ Local climate data ~ Kh, Kv & Sy measurements from a range of tests ✓ High resolution DEM in all areas. ✓ Good aquifer geometry.	✓ Good performance stats ✓ Most long term trends matched ✓ Most seasonal matches ok. ✓ Present day data targets ✓ Head & Flux targets used to constrain calibration	✓ Timeframe ~ calibration ✓ Similar stress periods × Good validation ✓ Calibration & prediction consistent (transient or steady state). ✓ Similar stresses to those in calibration.	✓ Timeframe < 3x ✓ Stresses < 2x ✓ Mass balance < 0.5% ~ Properties ~field measurements ✓ No coarse discretisation in key areas (grid or time) ✓ Review by experienced Modeller

7 Model predictions

7.1 Mine plan and progression, staged timing and stress periods

Mining at QNH has been assumed to commence in 2007 with the Main Pit of Sonoma Mine. Mining progression is shown in Figure 6.3. For the purposes of predictive modelling, mining has been assumed to occur over a 43.3-year period from late 2007 through to the end of 2051.

The mining process, or more specifically the dewatering due to mining, was simulated using the MODFLOW-USG drain package. Drain boundary conditions were assigned to dewater model cells that were within the extent of the mining pit shell. A nominally high conductance term was applied to ensure the model cell was completely desaturated within the pit shell.

As with the previous model, to provide a conservative estimate of potential inflows, the pits remained open and draining throughout the model simulation once active.

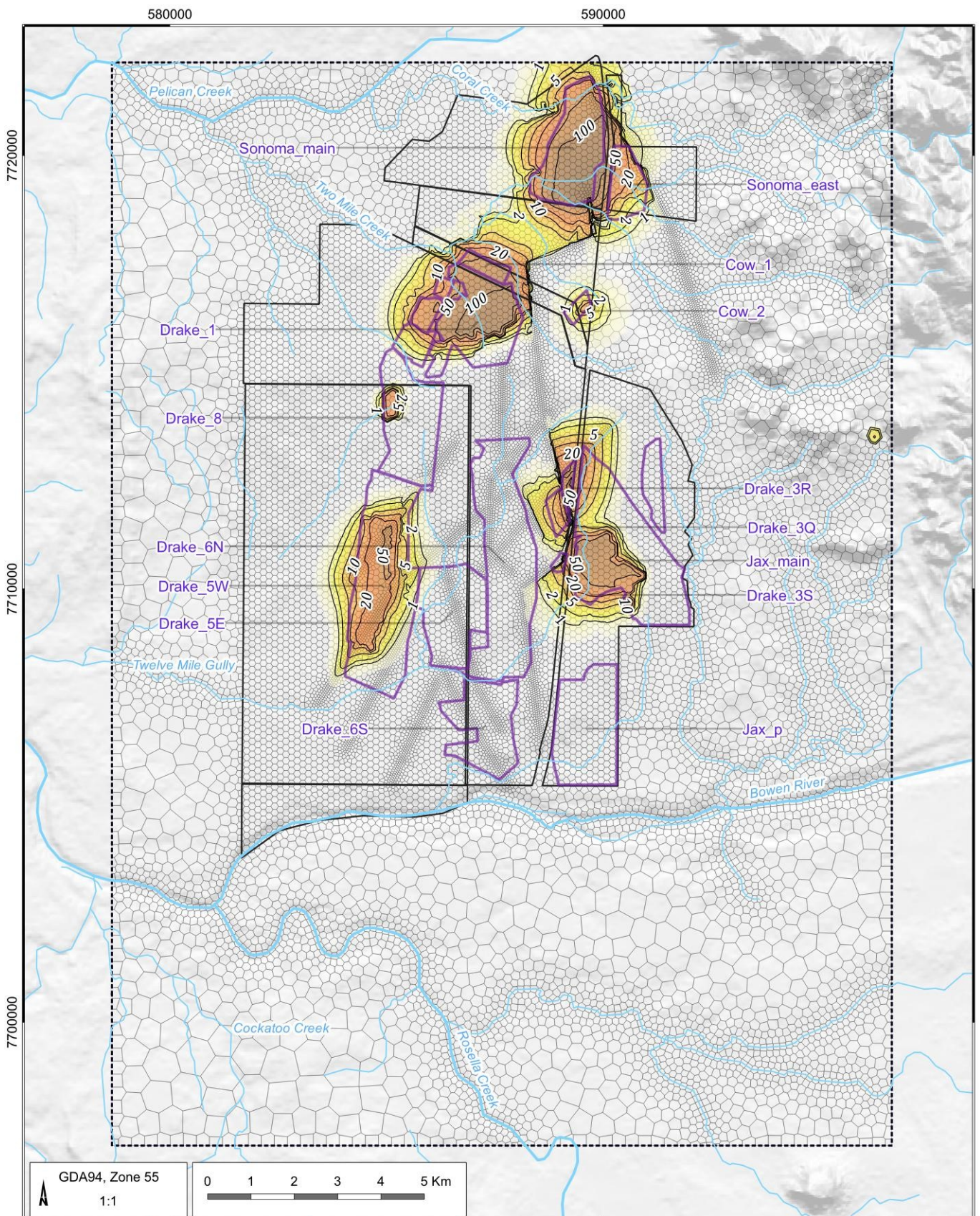
The time discretisation for the predictive period was based on stress periods of one year. This means that all boundary conditions remain constant for the period of a year, such as the locations and elevations of drain cells representing the mining. Within these stress periods, the model simulation time was divided into time steps where the groundwater flow equations were solved. The number of time steps within each stress period varied based on the difficulty of the numerical solution, but generally varied from 1 to 6 days.

7.2 Drawdown extent

The drawdown predicted by the model was calculated by running two paired simulations. The first simulated all the dewatering from mining occurring, and the second assumed no mining occurs at any of the QNH mines. The drawdown is then the difference at any particular time step between these two simulations.

The drawdown produced and presented here is cumulative across the four QNH mining areas. Predicted drawdown is presented for a number of specific times from the present day (mid-2023) through to the end of mining (2051). These specific times are the present day (mid of 2023), 5 years (end of 2028), 10 years (end of 2033), 20 years (end of 2043), and then finally the end of mining (2051).

The drawdown can be seen in Figure 7.1 to Figure 7.10 representing the predicted drawdown in the water table and Layer 13 of the model. The water table can appear in the weathered zone, shallow alluvium, and the upper sections of the Permian strata depending on location in the model, while Layer 13 is predominantly the B seam which is the lowest of the target seams for mining. Not all pits mine the B seam, and given the tightness of the interburden, there is little indication of dewatering in these shallower pits. The figures show the predicted 1 m drawdown contour as the outer contour.



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

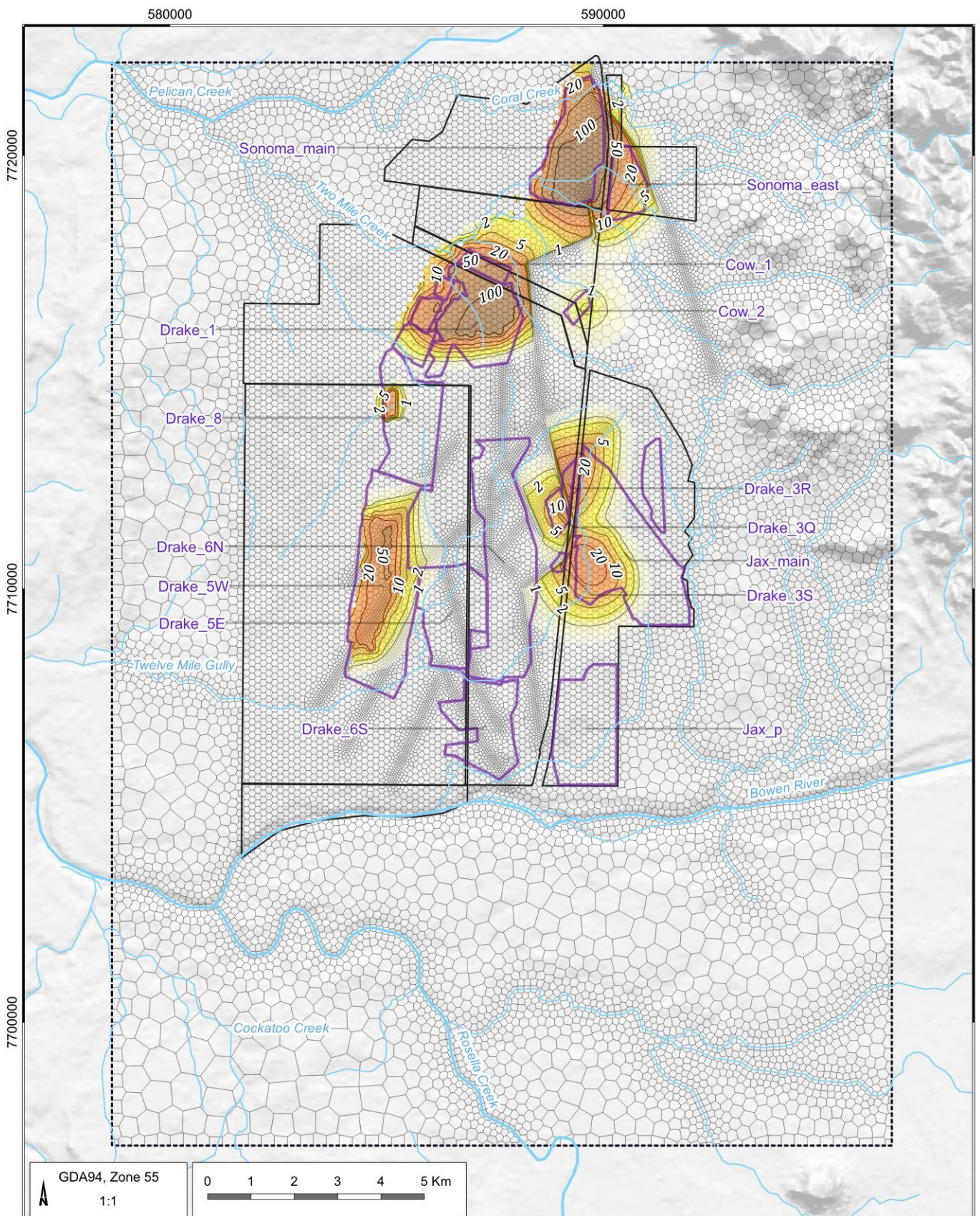
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Predicted drawdown, present day (2023), water table



DATE
01/11/2023

FIGURE No:
7.1



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

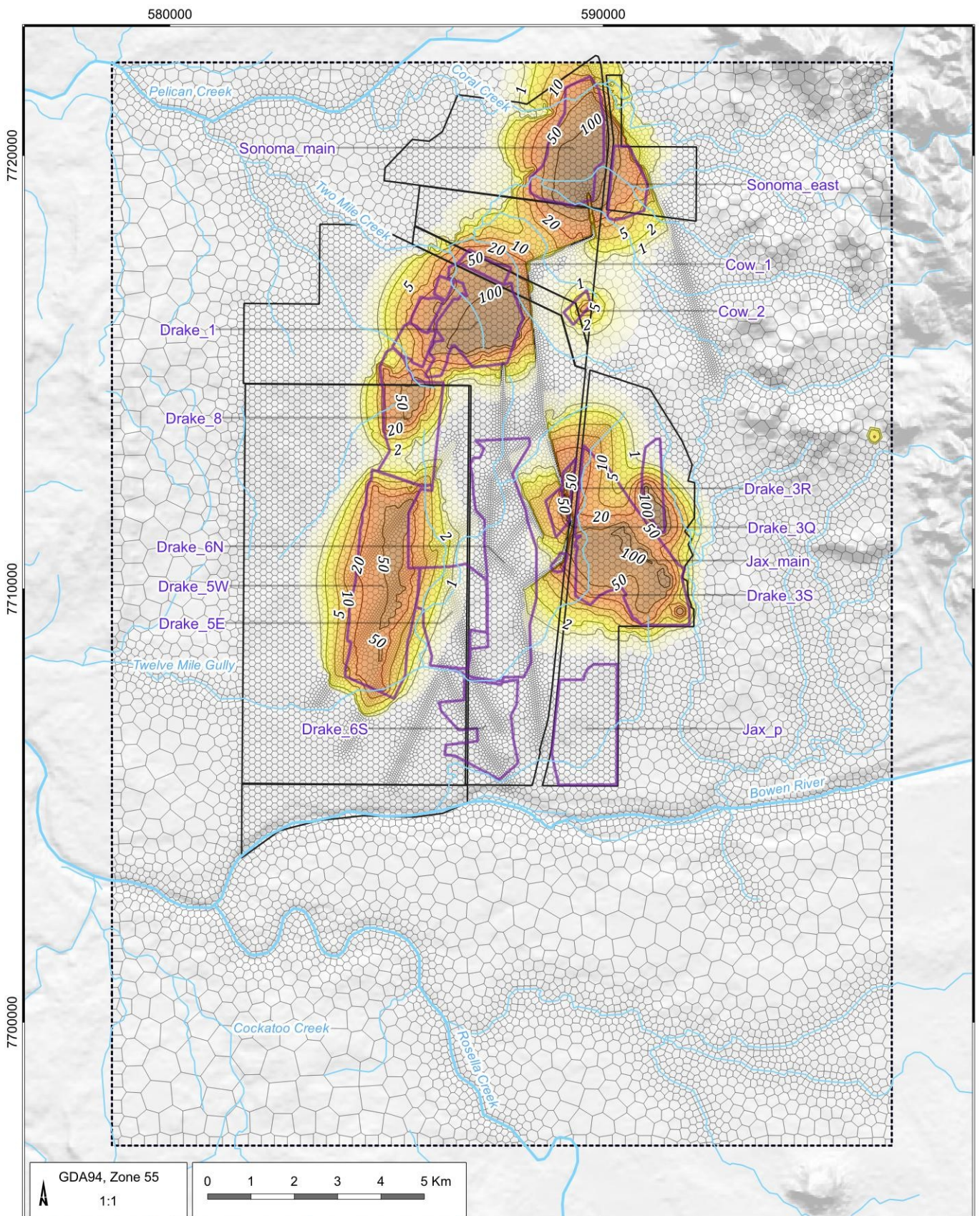
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Predicted drawdown, present day (2023), Layer 13



DATE
01/11/2023

FIGURE No:
7.2



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

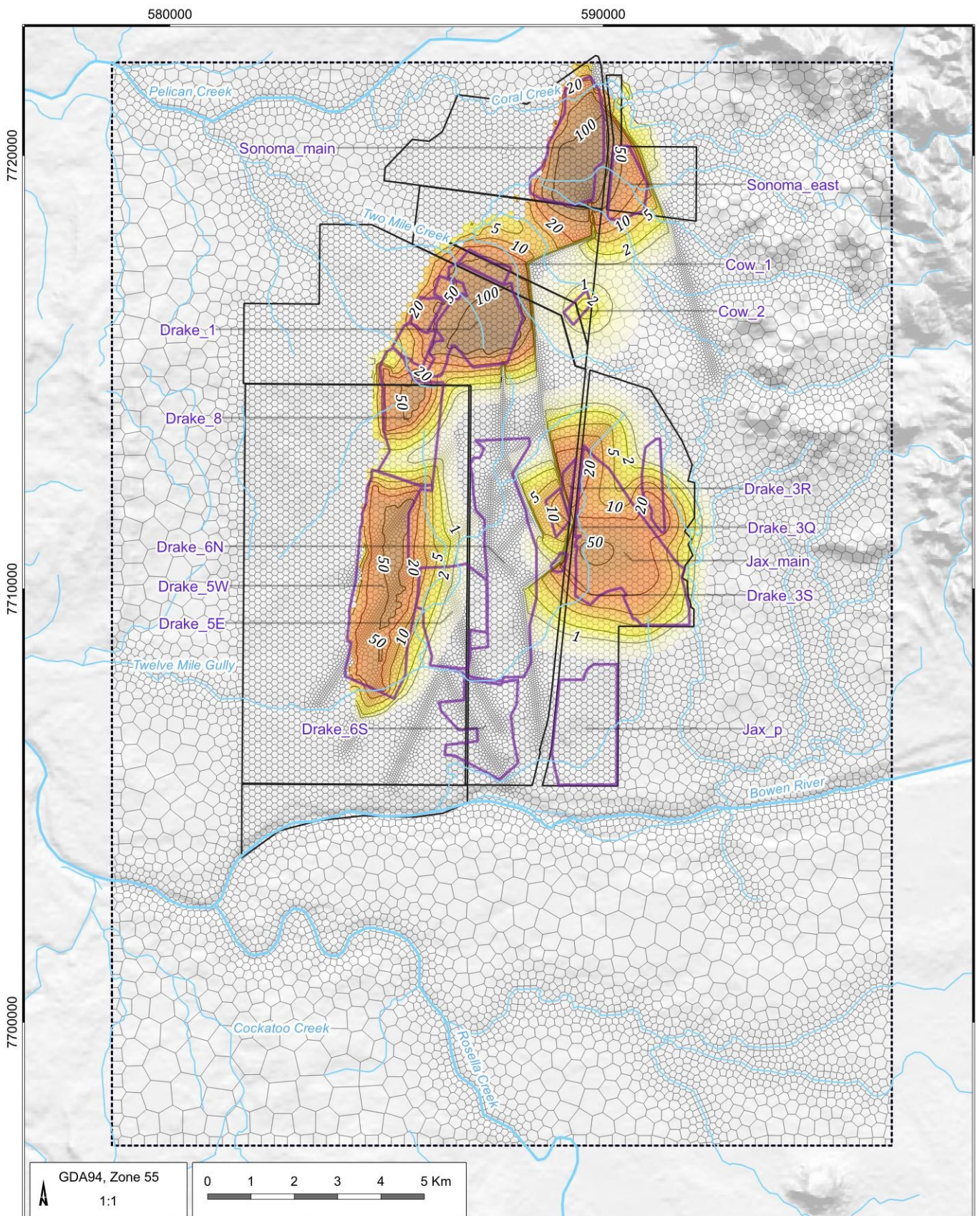
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(QCB5004.001)

Predicted drawdown, 5 years (2028), water table



DATE
01/11/2023

FIGURE No:
7.3



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

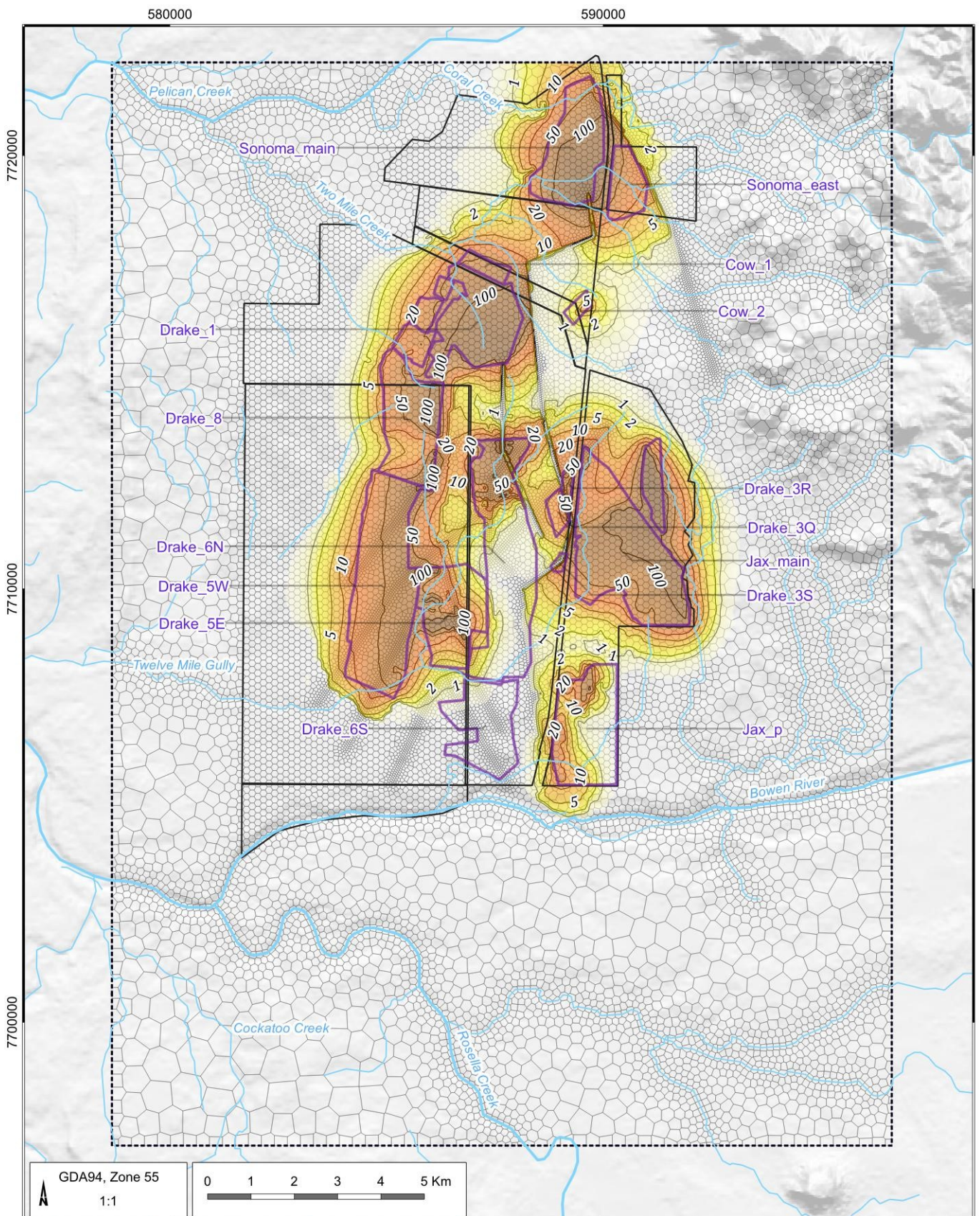
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(QCB5004.001)

Predicted drawdown, 5 years (2028) Layer 13



DATE
01/11/2023

FIGURE No:
7.4



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

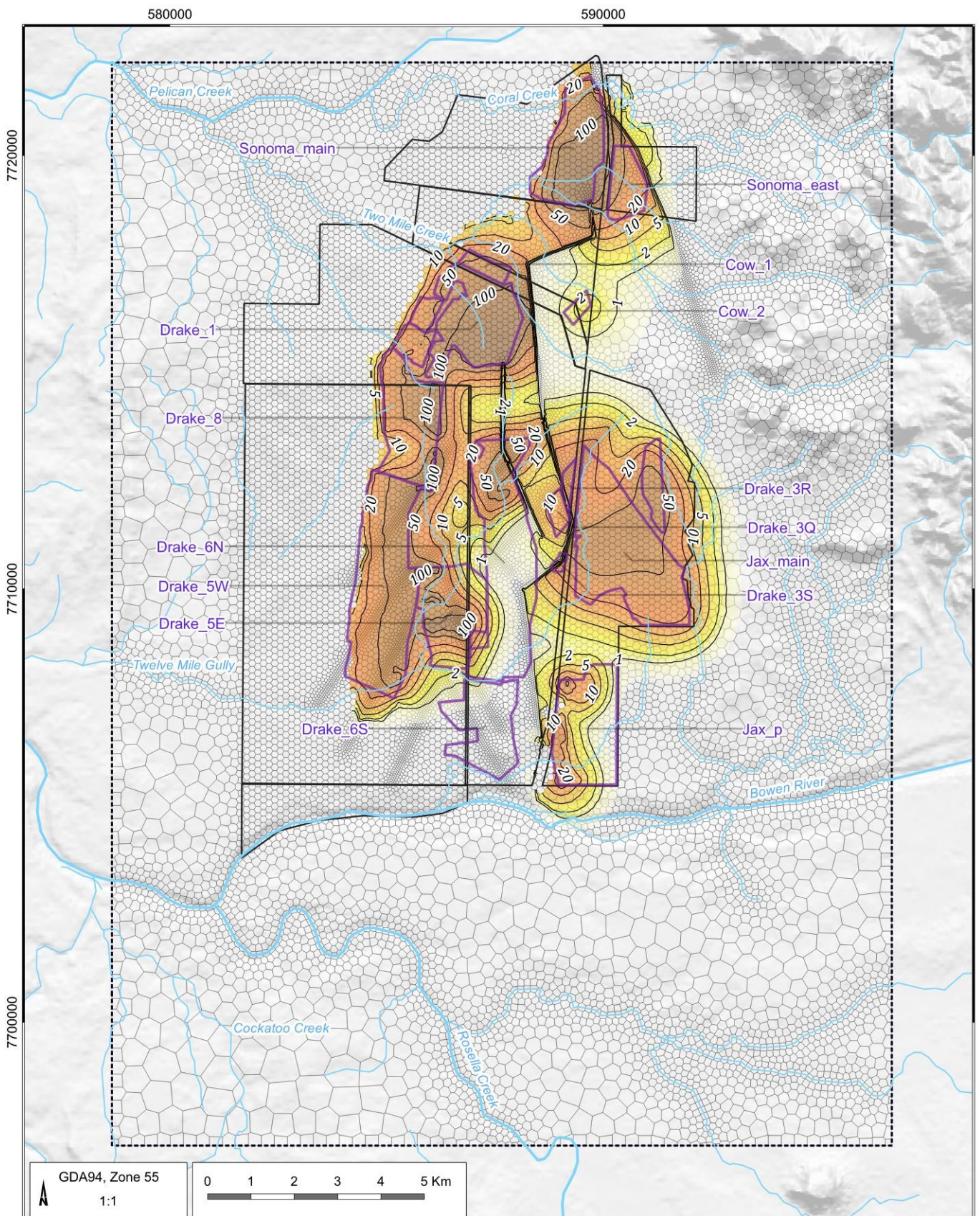
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(QCB5004.001)

Predicted drawdown, 10 years (2033) water table



DATE
01/11/2023

FIGURE No:
7.5



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

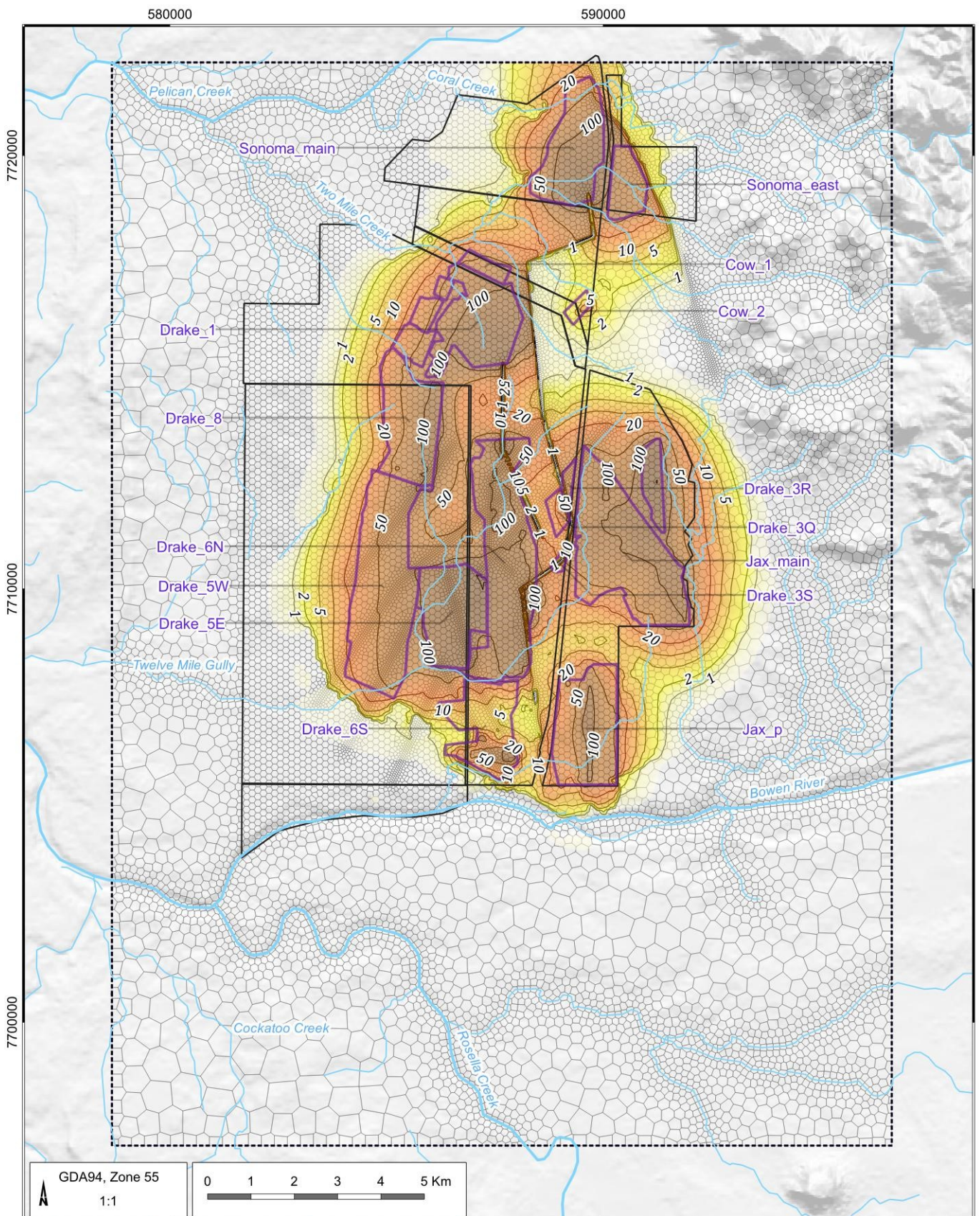
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Predicted drawdown, 10 years (2033) Layer 13



DATE
01/11/2023

FIGURE No:
7.6



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

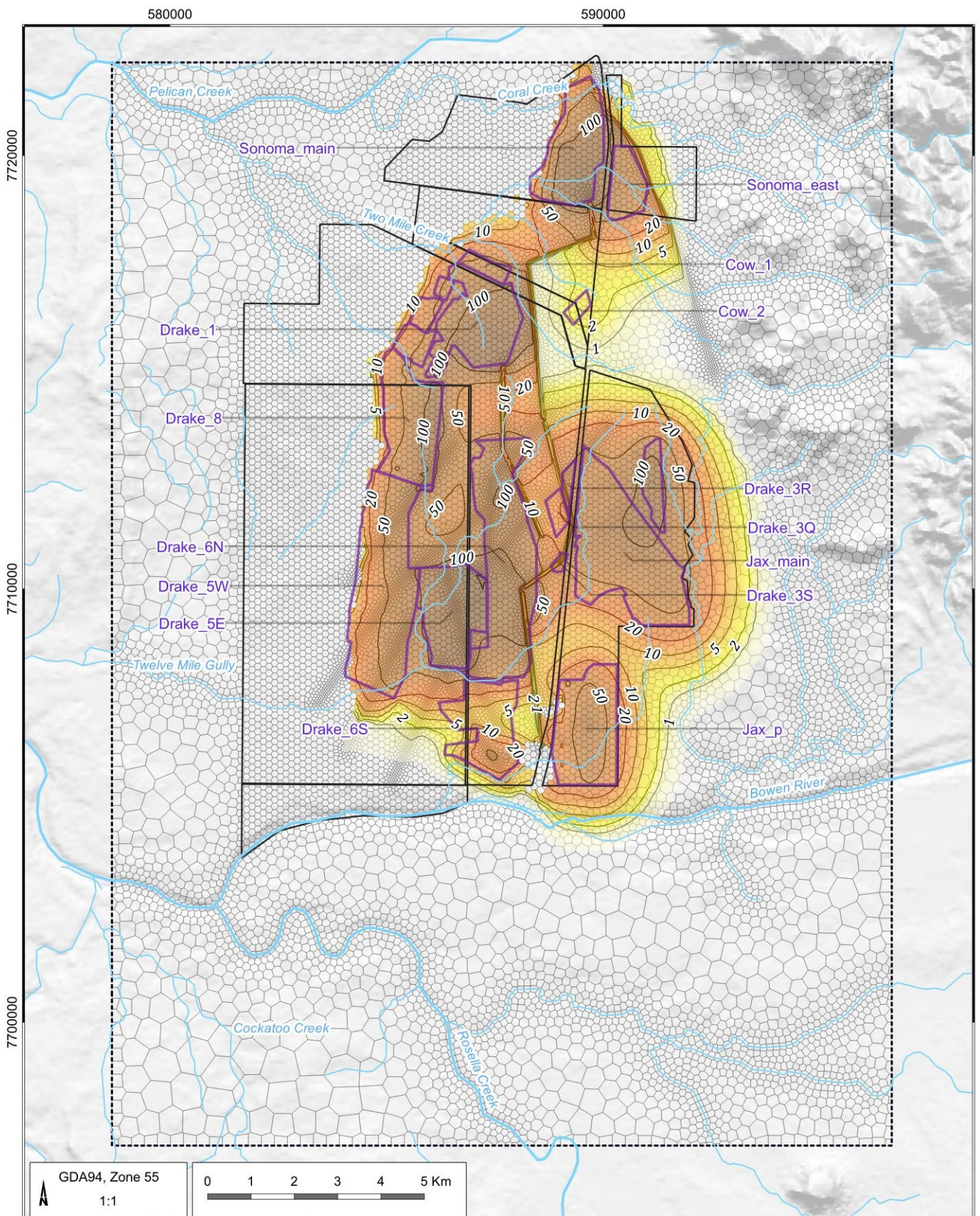
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Predicted drawdown, 20 years (2043) water table



DATE
01/11/2023

FIGURE No:
7.7



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

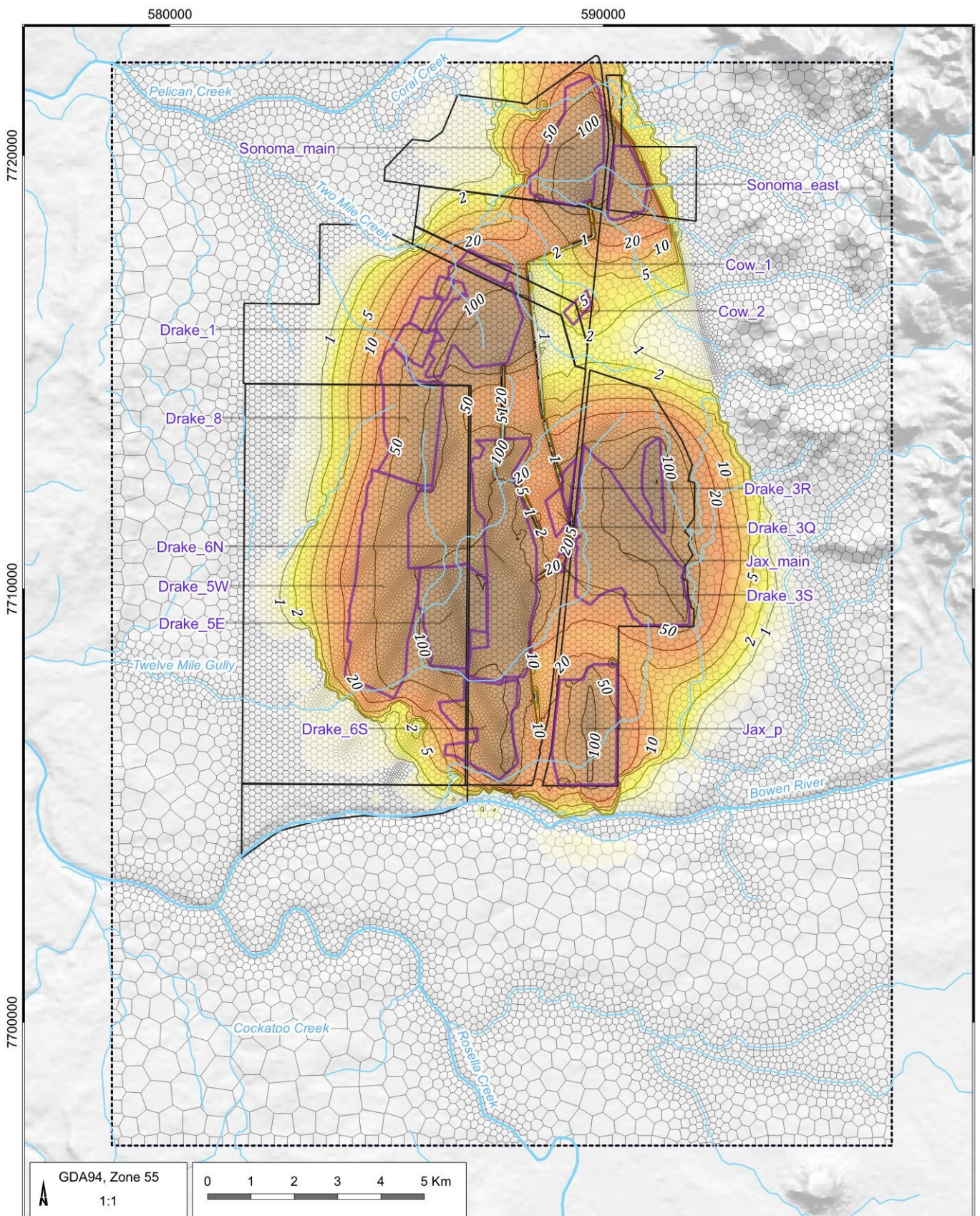
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Predicted drawdown, 20 years (2043) Layer 13



DATE
01/11/2023

FIGURE No:
7.8



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

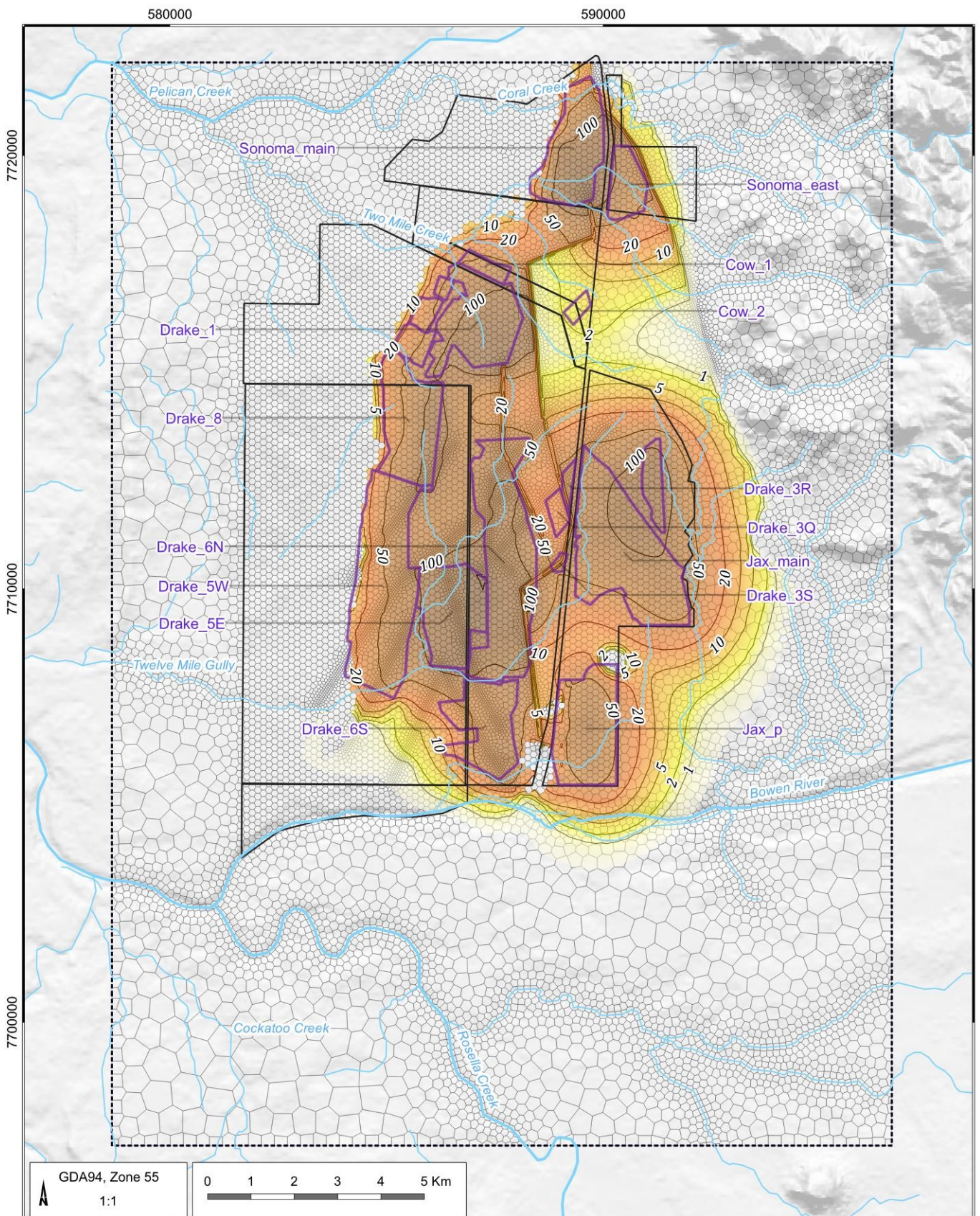
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Predicted drawdown, end of mining (2051) water table



DATE
01/11/2023

FIGURE No:
7.9



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline

Drawdown (m)

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

QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Predicted drawdown, end of mining (2051) Layer 13



DATE
01/11/2023

FIGURE No:
7.10

7.3 Pit inflows

The model also provides estimates of groundwater seepage to the open cut pits. The pit seepage rates for the proposed QNH pits are presented below in Table 7.1. Sonoma Main pit provides the largest predicted daily inflow, peaking at 1680.47 ML in 2018. This is the largest pit inflow predicted as it has the largest operating footprint.

The predicted pit inflows presented below have not been adjusted for evaporation losses. The low predicted rates would in most cases experience some evaporative loss at the pit face before arriving at a pit sump; however, event-based pit inflows (from large rainfall events) would require storage and subsequent pumping from an in pit sump.

Table 7.1 Predicted annual pit inflow (ML)

Year	Cows	Drake 1	Drake 3S	Drake 5E	Drake 5W	Drake 6N	Drake 6S	Drake 8	Sonoma main	Sonoma East	Jax main	Jax P	Drake 3Q	Drake 3R	Total
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.73	0.00	0.00	0.00	0.00	0.00	44.73
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	319.95	0.00	0.00	0.00	0.00	0.00	319.95
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	381.33	0.00	0.00	0.00	0.00	0.00	381.33
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	498.21	0.00	0.00	0.00	0.00	0.00	498.21
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	836.27	0.00	19.09	0.00	0.00	0.00	855.36
2013	106.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1108.67	0.00	34.84	0.00	0.00	0.00	1250.32
2014	334.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1219.47	0.00	35.36	0.00	0.00	0.00	1589.76
2015	419.12	146.45	0.00	0.00	0.00	0.00	0.00	0.00	1421.51	0.00	23.94	0.00	3.90	1.24	2016.16
2016	172.80	257.93	0.00	0.00	3.41	0.00	0.00	0.00	1400.44	0.00	22.19	0.00	15.64	10.05	1882.45
2017	103.96	333.54	0.00	0.00	38.31	0.00	0.00	0.00	1065.94	0.00	21.25	0.00	28.79	50.93	1642.71
2018	85.76	591.40	0.00	0.00	174.25	0.00	0.00	0.00	1680.47	0.00	38.20	0.00	13.35	110.58	2694.01
2019	74.56	640.70	0.00	0.00	188.01	0.00	0.00	0.00	1585.48	0.00	77.39	0.00	9.63	122.87	2698.64
2020	65.97	861.91	0.00	0.00	200.42	0.00	0.00	0.00	1145.95	0.00	118.94	0.00	8.92	92.98	2495.09
2021	58.04	1043.72	0.00	0.00	242.44	0.00	0.00	0.00	665.24	0.00	185.54	0.00	8.50	82.79	2286.27
2022	52.40	1046.52	0.00	0.00	341.81	0.00	0.00	0.00	506.48	0.00	256.57	0.00	8.18	76.25	2288.22
2023	48.13	1249.85	0.00	0.00	501.62	0.00	0.00	157.81	437.84	0.00	449.83	0.00	7.94	71.62	2924.64
2024	22.44	507.20	0.00	0.00	192.14	0.00	0.00	85.84	197.64	0.00	219.84	0.00	3.89	34.11	1263.10
2025	42.19	617.42	0.00	0.00	412.48	0.00	0.00	175.00	365.54	0.00	564.02	0.00	7.63	65.51	2249.79
2026	39.90	742.15	0.00	0.00	455.54	0.00	0.00	193.09	343.01	0.00	613.73	0.00	7.49	63.13	2458.05
2027	37.90	602.19	0.00	0.00	573.63	0.00	0.00	325.32	324.84	0.00	776.23	0.00	7.37	61.03	2708.49
2028	36.14	795.08	0.00	0.00	788.98	0.00	0.00	292.49	309.47	0.00	846.07	0.00	7.25	59.12	3134.57
2029	34.57	690.58	0.00	0.00	640.90	0.00	0.00	319.03	296.66	0.00	883.03	0.00	7.14	57.36	2929.27
2030	33.16	682.91	0.00	0.00	873.35	0.00	0.00	253.45	285.73	0.00	1083.48	450.54	7.04	55.70	3725.35
2031	31.89	611.06	0.00	0.00	853.44	0.00	0.00	674.47	275.74	0.00	1260.99	451.08	6.94	54.13	4219.75

Year	Cows	Drake 1	Drake 3S	Drake 5E	Drake 5W	Drake 6N	Drake 6S	Drake 8	Sonoma main	Sonoma East	Jax main	Jax P	Drake 3Q	Drake 3R	Total
2032	30.73	654.20	0.00	454.52	1082.20	448.86	0.00	865.50	266.80	0.00	1287.73	694.45	6.85	52.62	5844.44
2033	29.67	686.93	0.00	719.98	899.90	717.53	0.00	534.62	259.04	0.00	1201.71	503.72	6.77	51.12	5610.99
2034	28.69	615.12	0.00	1008.53	655.48	825.57	0.00	634.04	252.16	6.29	1292.80	849.75	6.69	39.74	6214.87
2035	27.78	504.12	0.00	1127.45	435.63	1116.28	0.00	361.45	245.52	164.08	1164.12	1424.48	6.63	32.51	6610.06
2036	26.94	414.70	0.00	1231.92	272.20	1342.66	0.00	294.17	238.63	334.02	1136.77	1094.87	6.57	27.09	6420.54
2037	26.16	326.36	0.00	1597.46	213.76	1477.66	0.00	256.94	231.44	393.19	1116.72	1088.63	6.51	23.05	6757.86
2038	25.43	266.57	0.00	1488.76	185.82	1689.32	0.00	228.38	224.50	254.43	991.95	691.27	6.44	19.75	6072.60
2039	24.74	240.87	0.00	1518.86	165.06	1736.73	0.00	216.79	218.05	119.48	1005.20	658.84	6.37	16.95	5927.94
2040	24.10	221.93	0.00	1200.47	148.94	1710.79	0.00	252.11	211.89	101.02	880.44	637.25	6.28	14.55	5409.77
2041	23.49	206.16	0.00	810.89	135.98	1724.60	0.00	327.58	206.08	88.85	911.34	685.61	6.19	12.49	5139.25
2042	22.91	193.23	0.00	597.62	125.17	1075.95	0.00	431.21	200.90	79.79	817.76	698.54	6.10	10.84	4260.03
2043	22.36	182.47	0.00	497.91	116.12	834.41	540.75	413.50	196.03	72.53	794.20	592.25	5.99	9.54	4278.06
2044	21.83	173.30	0.00	407.18	107.64	559.20	735.32	402.25	191.31	66.65	757.16	552.33	5.88	8.48	3988.53
2045	21.33	165.41	0.00	361.41	99.59	460.51	824.48	207.11	186.85	61.62	719.98	523.26	5.76	7.51	3644.82
2046	20.85	158.04	0.00	328.01	92.32	405.24	1070.44	135.35	182.75	57.14	711.18	500.39	5.64	6.58	3673.95
2047	20.39	151.50	0.00	302.62	86.10	362.19	755.26	114.09	178.93	53.20	669.65	481.47	5.51	5.85	3186.78
2048	19.95	145.58	0.00	282.19	81.15	328.24	606.72	102.07	175.35	49.96	625.05	465.80	5.38	5.36	2892.79
2049	19.53	140.08	0.00	264.44	76.78	296.33	883.36	95.29	171.96	47.20	607.70	451.92	5.24	4.99	3064.81
2050	19.12	135.01	0.00	248.78	72.86	267.69	694.23	90.10	168.76	44.70	566.47	439.61	5.11	4.64	2757.07
2051	18.72	130.39	0.53	235.02	69.31	241.04	587.69	85.86	165.68	42.43	544.26	428.58	4.97	4.29	2558.76
2052	18.33	126.22	0.07	223.00	66.07	217.14	349.21	82.17	162.76	40.45	525.05	418.69	4.83	3.95	2237.95
2053	23.53	130.54	0.01	254.60	64.63	266.83	427.01	69.01	765.38	105.73	519.86	458.32	4.88	3.70	3094.03

7.4 Environmental impacts

Environmental values and receptors identified in the numerical model extent are described in Section 3. Predicted environmental impacts on Bowen River baseflow and water users are described below.

7.4.1 Bowen River baseflow

With the mining of the pits Jax_P and Drake_6S, the drawdown extent propagates to Bowen River due to their proximity, as shown in Figure 7.7 to Figure 7.10. The predicted peak reduction is around 0.44 ML/day baseflow during and after the mining period of Jax_P and Drake_6S (Year 2030 - 2049). This baseflow reduction is higher than that of the previous model (0.005 ML/day), which did not account for the mining plans of Jax_P and Drake_6S. However, this increased peak reduction would be still indiscernible in Bowen River that has a daily average flow measured at the Jacks Creek Weir of 1797 ML/day. The change in baseflow recovered over time and back to -0.02 ML/day upon reaching equilibrium.

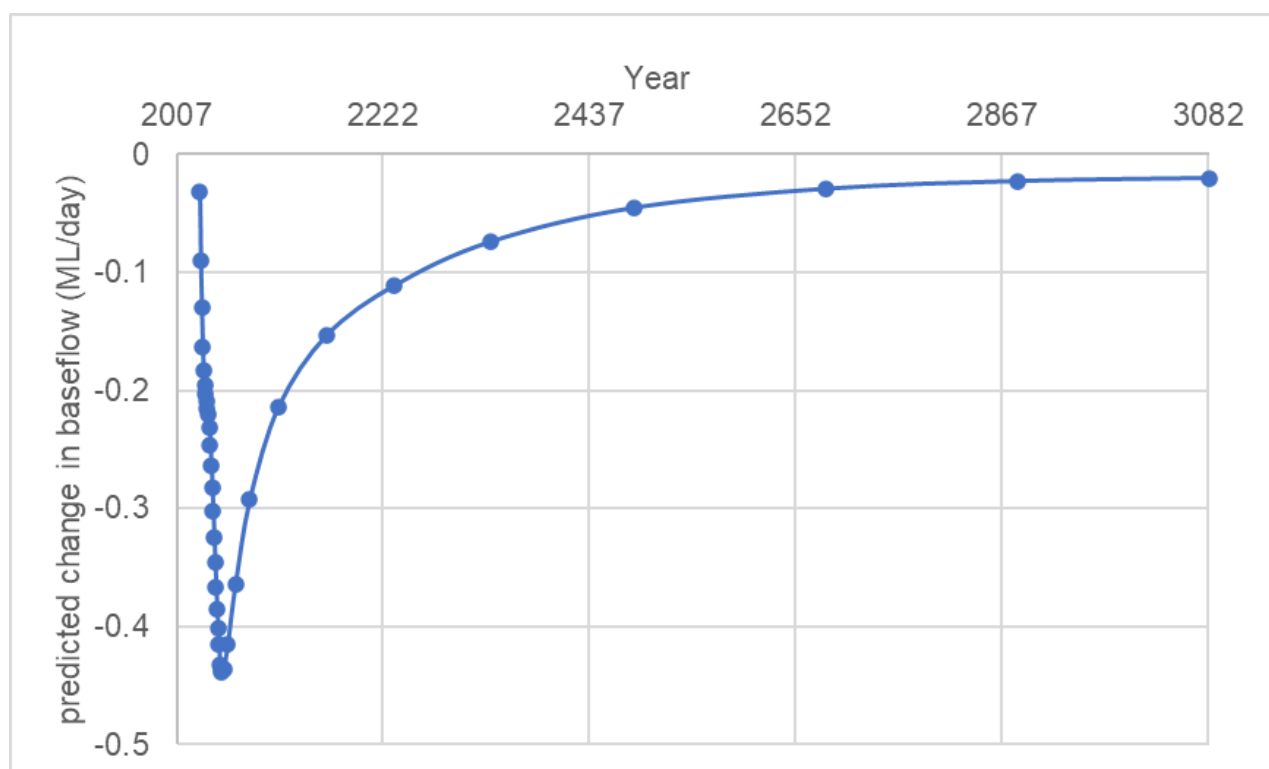


Figure 7.11 Predicted Bowen River baseflow variation (ML/day)

7.4.2 Water users

The predicted drawdown of water supply bores is shown in Figure 7.12. The impact of mining on registered water supply bores is relatively limited for the future 1000 years. Bore 125348 experiences a maximum drawdown of -1.6 meters, which is expected to gradually recover to approximately 0.7 m upon reaching equilibrium.

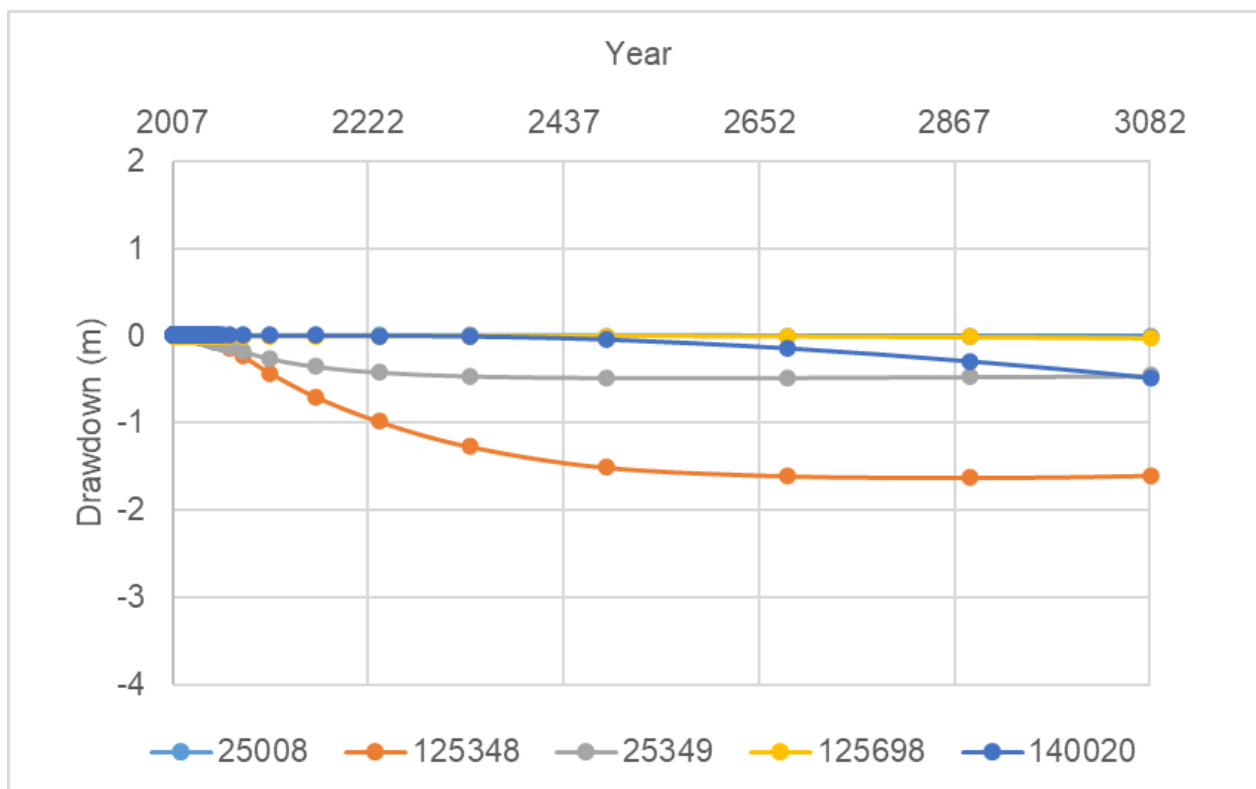


Figure 7.12 Predicted drawdown of water supply bores (m)

7.5 Post mining recovery

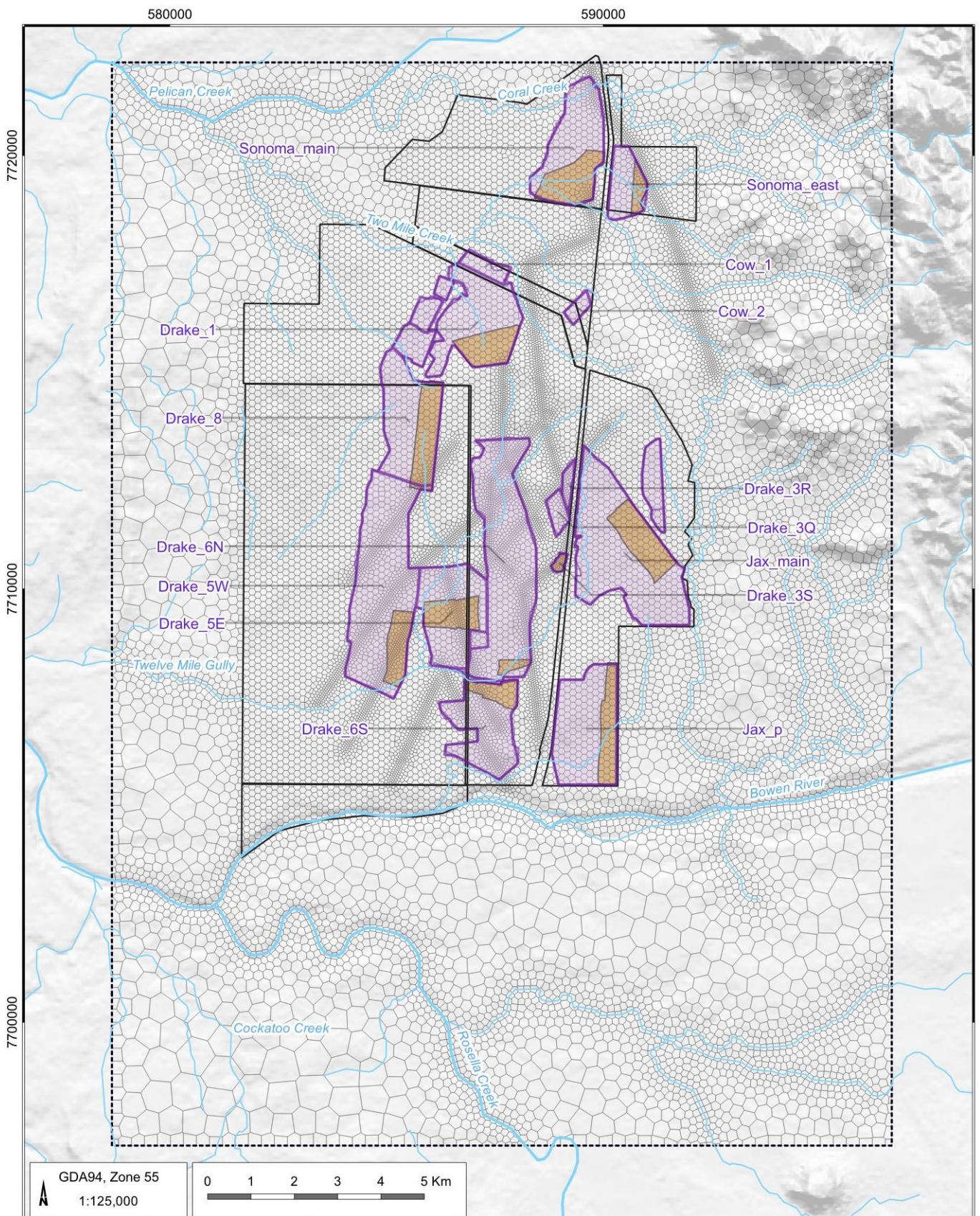
Figure 7.14 shows the predicted water level at the end of mining with all pits dewatered. It's worth noting that in various locations within the model domain, layer 1 is not fully saturated, and, as a result, the projected water level is situated within lower model layers. Predicted water levels in lower layers echo these contours though any sharp changes become gradually muted with depth. Due to the low permeability of the geology, predicted (and observed) impacts on the surrounding groundwater system remain local to the pits, as shown in Figure 7.14. The water levels in this figure become the starting point for the recovery simulation. The recovery is simulated in the pits by assuming recharge to the spoil and voids, and by applying evaporative losses to the void lakes (Figure 7.13). The level of recovery is controlled by the balance of water coming in from rainfall derived recharge, the loss due to evaporation from the void lake, and groundwater inflow or outflow based on interaction with other voids. Recharge to the void and spoil are much higher than the undisturbed recharge rate calibrated for the model. The seepage connections between different pits at the end of mining are indicated by red arrows in Figure 7.14.

Figure 7.15 shows the recovered groundwater level at equilibrium. Equilibrium in the recovery is predicted to occur around 1000 years post mining. However, this is a prediction made where only long-term average recharge is applied to the void. This tends to extend the recovery period because the evaporation has more influence on the water level at these average rates. In reality, it will be the large rainfall events that will create the water level rises for the filling of the voids, so it is expected that this timing is an overestimate. The extent of groundwater drawdown is largest at equilibrium due to the continued dewatering offered by evaporation from void lakes that equilibrate below the pre mining water levels. Some of the pits have been predicted to become sources of groundwater across the site, particularly where they have been completely backfilled or where the void footprint is small. The concern with this occurrence is that water may migrate away from the site. An analysis of the predicted equilibrium water levels indicates that these potential sources will likely be contained by the larger and deeper voids within the Northern Hub complex, such as Drake 1, Drake 5, and Jax main, as indicated by the red arrows in Figure 7.15, and will not migrate away from the site.

The predicted drawdown in the water table and layer 13 after 60 years, 300 years, and 1000 years of recovery are shown in Figure 7.16 to Figure 7.21. The maximum drawdown is located near the final voids, and the range of the drawdown expands with time.

Water level and inflow relationships for all the voids are presented in Figure 7.22. These have been derived from the transient recovery simulation where all the voids start desaturated at the end of mining (2051). Many of these “inflow – water level” relationships do not conform to the typical response where inflows are initially high, but then reduce with increased water levels in the voids. This is mostly due to the interaction between connected void areas. Each void recovers at a different rate, dependent on the geometry (depth and aperture) of the void. Other influences on these recovery rates include the adjacent groundwater conditions driven by how long the dewatering has been operating, as well as how quickly the void water level recovers. On this last point, there may be outflows predicted from the void if the water level in the lower parts of the void gets ahead of the surrounding groundwater re-pressurisation and the void becomes a temporary source. Where voids are predicted to remain sinks, we do not have predictions of spill points where the void changes from a sink to a source.

Groundwater recovery curves from Year 2051 for each void is shown in Figure 7.23. The water level rises gradually over time, with most of the void level stabilizing around the 1000 years post mining.



LEGEND

- Watercourse
- Model mesh
- QNH mining leases
- model_extent
- Pit outline
- Spoil
- Final voids

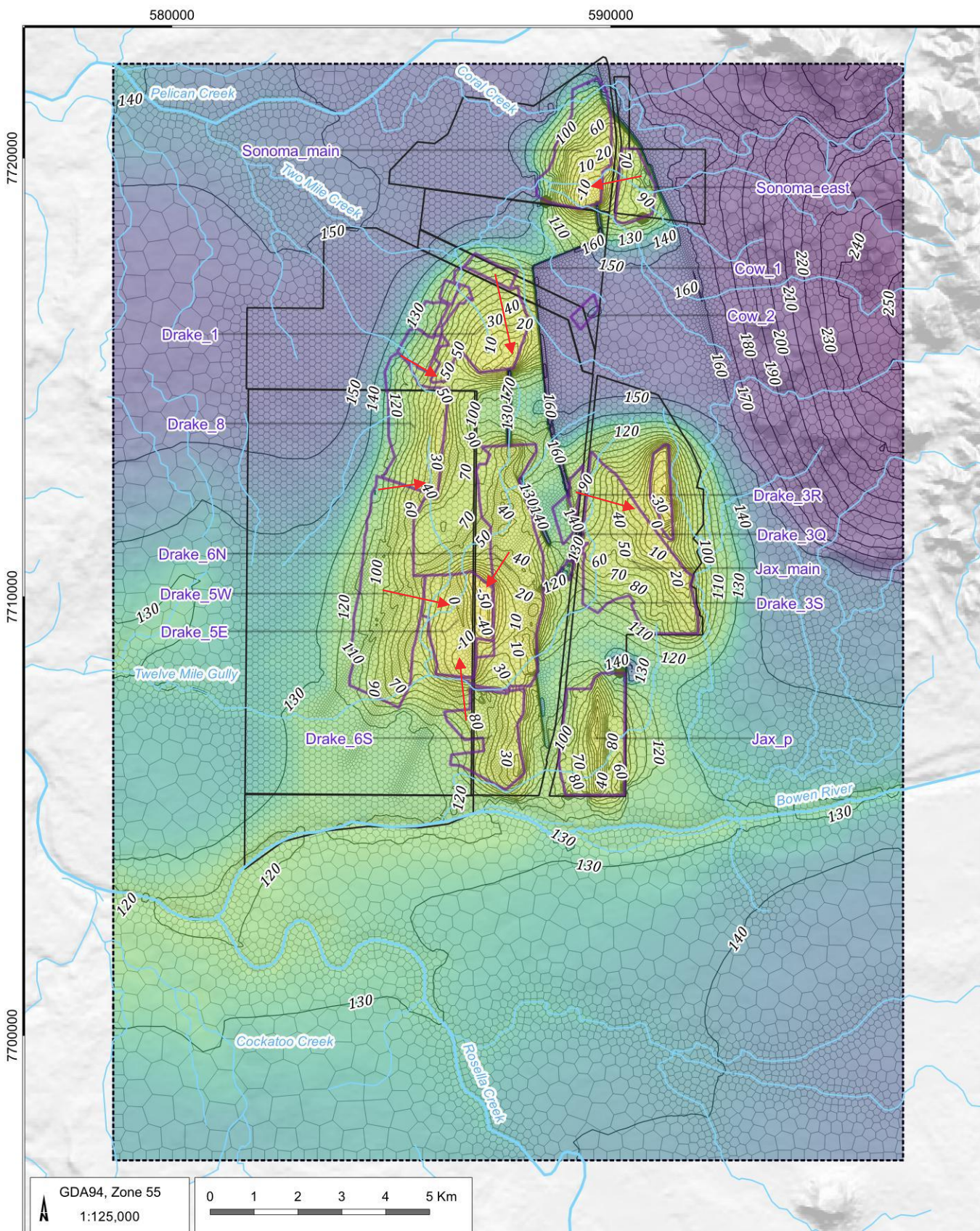
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Area of spoil and voids during recovery



DATE
17/10/2023

FIGURE No:
7.13



LEGEND

- Populated place
- Watercourse
- Contour line
- Inferred flow directions
- Model mesh
- QNH mining leases
- Model extent
- Final void

Level (mAHD)

- 77
- 85
- 120
- 130
- 140
- 150
- 180
- 274

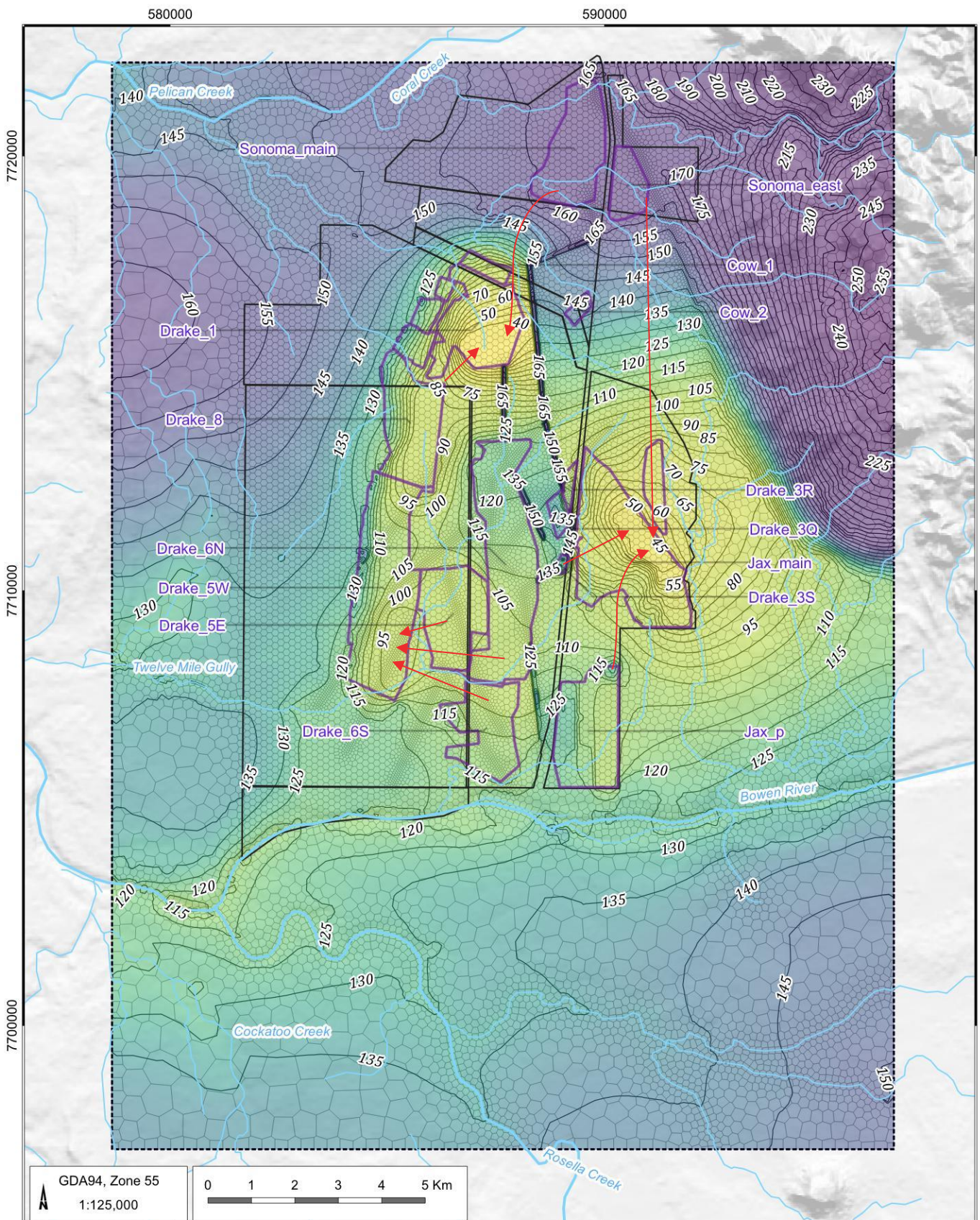
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

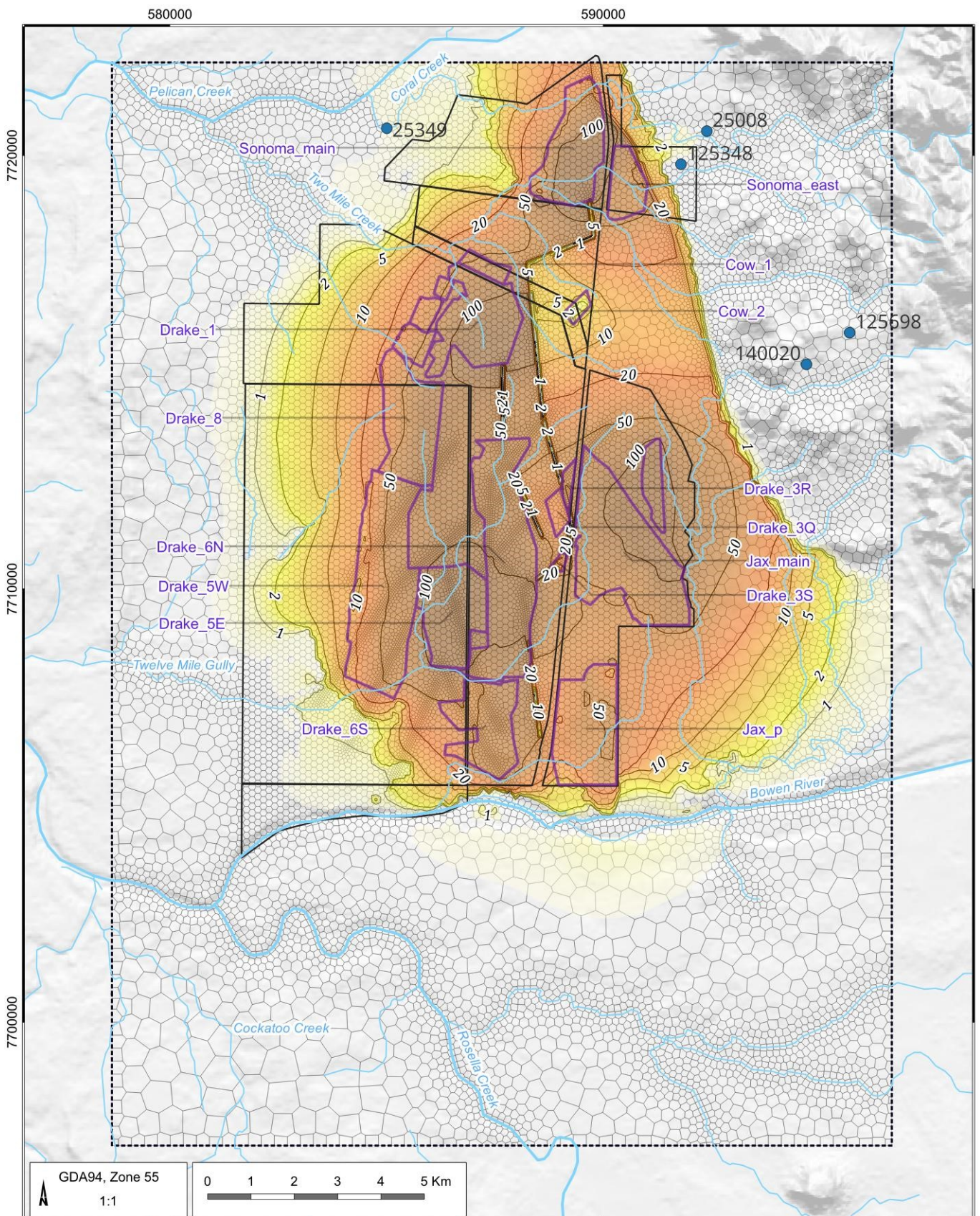
Groundwater levels at the end of mining (2051) – water table



DATE
01/11/2023

FIGURE No:
7.14





LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

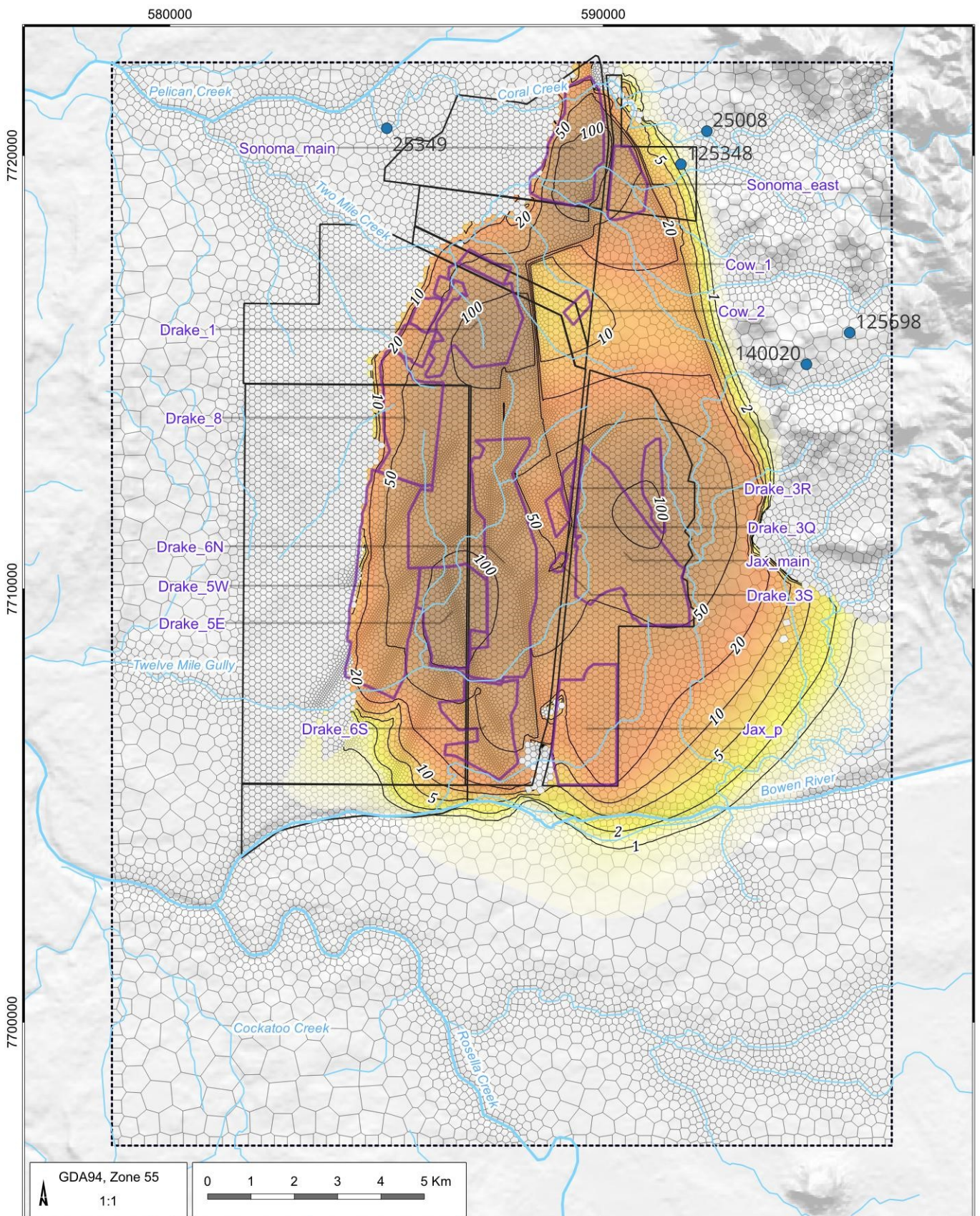
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

**Predicted drawdown after 60 years of
recovery, water table**



DATE
01/11/2023

FIGURE No:
7.16



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

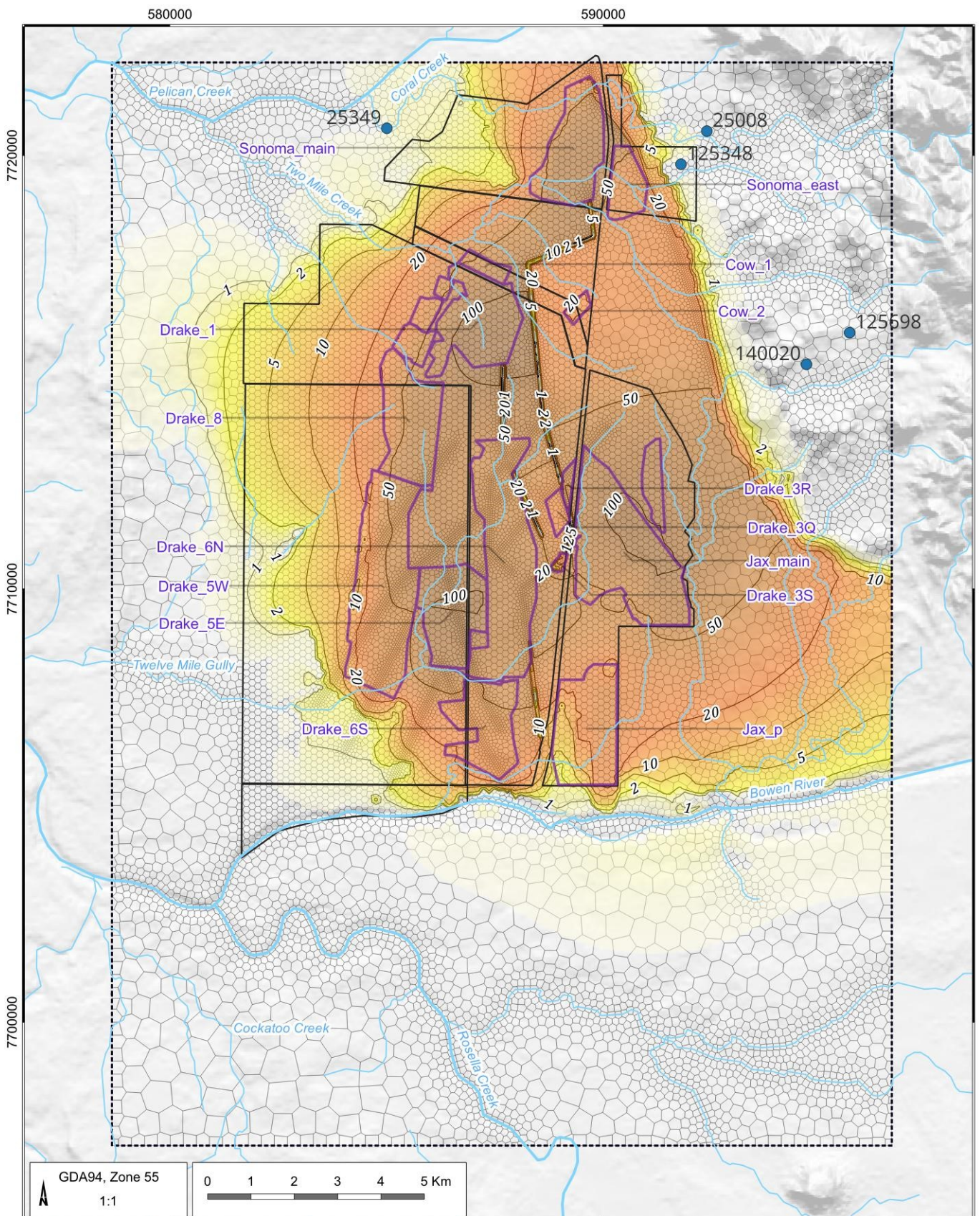
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Predicted drawdown after 60 years of recovery, Layer 13



DATE
01/11/2023

FIGURE No:
7.17



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

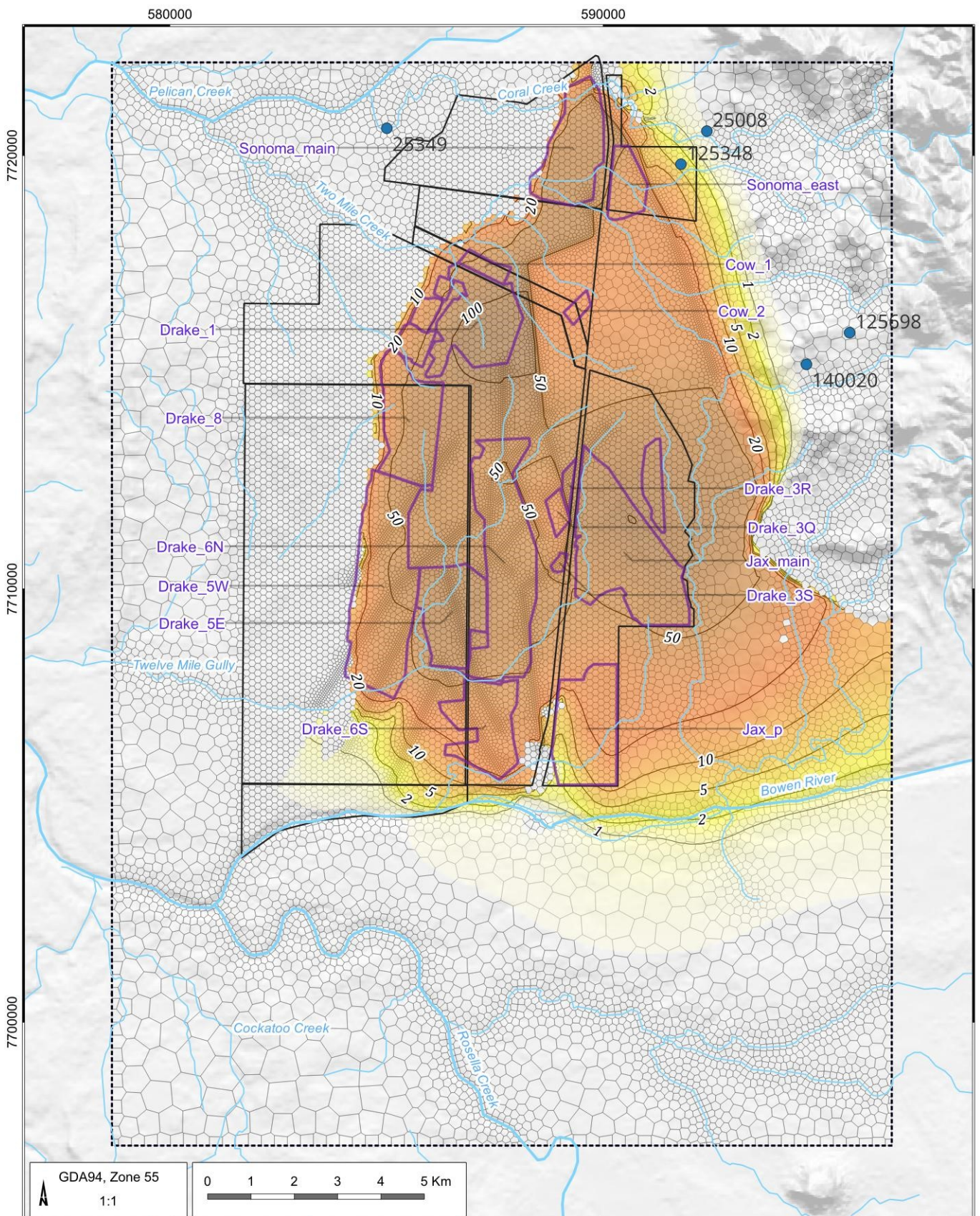
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

**Predicted drawdown after 300 years of
recovery, water table**



DATE
01/11/2023

FIGURE No:
7.18



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

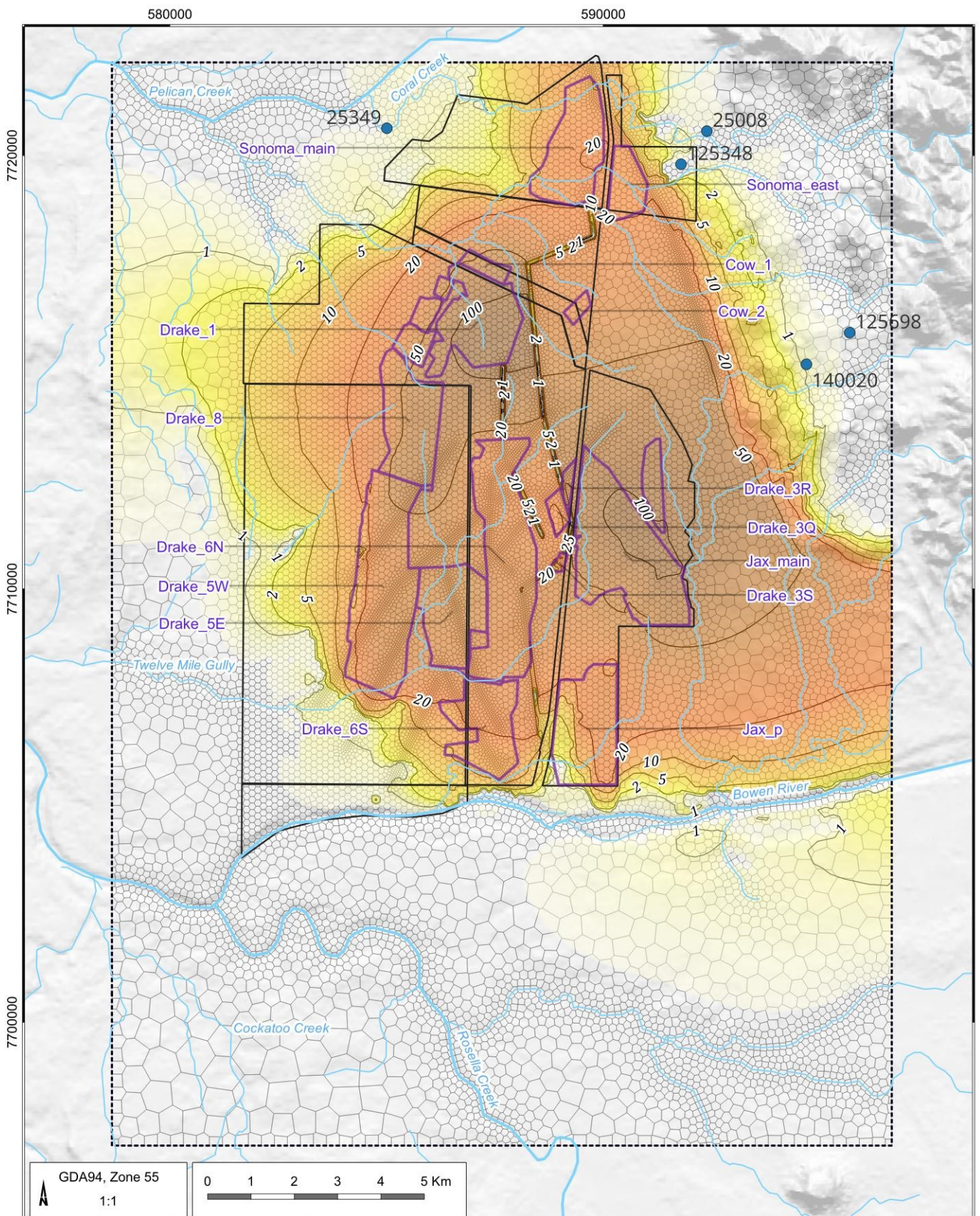
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Predicted drawdown after 300 years of recovery, Layer 13



DATE
01/11/2023

FIGURE No:
7.19



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

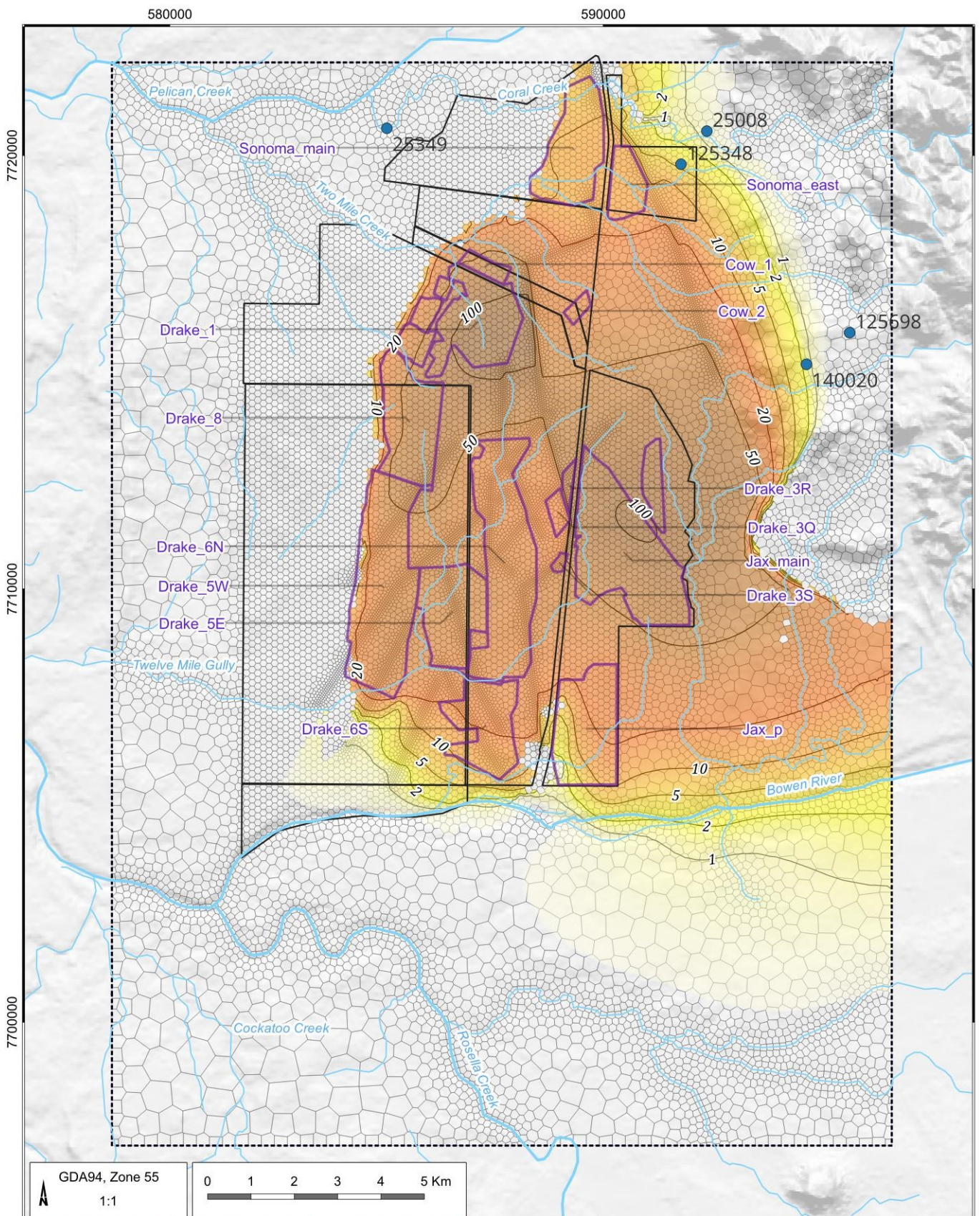
QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

**Predicted drawdown after 1000 years of
recovery, water table**



DATE
01/11/2023

FIGURE No:
7.20



LEGEND

- Populated place
- Watercourse
- Contour line
- Model mesh
- QNH mining leases
- Model extent
- Pit outline
- Water supply bores

Drawdown (m)

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

QCoal Northern Hub Groundwater Modelling Report
(QCB5004.001)

Predicted drawdown after 1000 years of recovery, Layer 13



DATE
01/11/2023

FIGURE No:
7.21

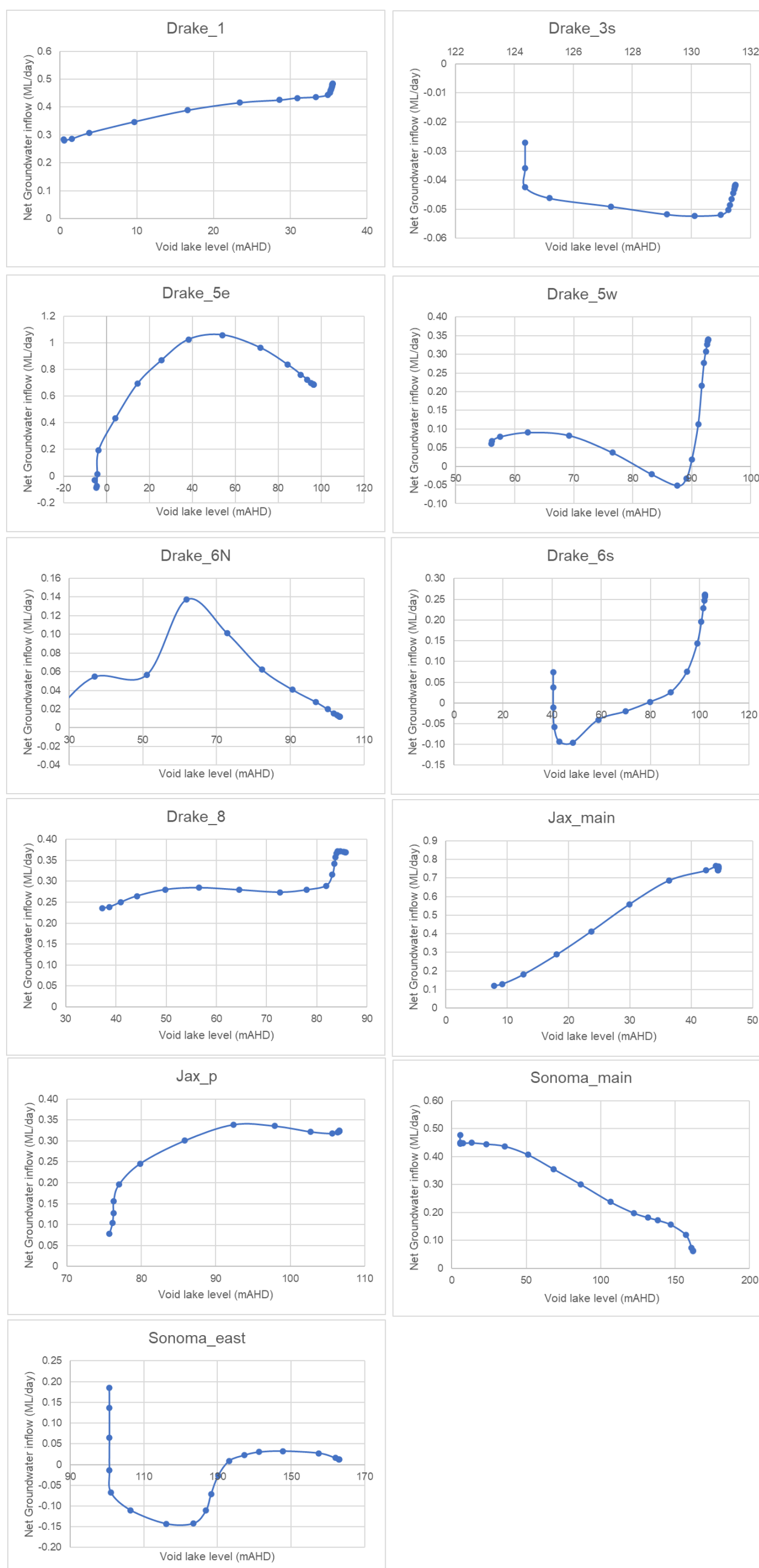


Figure 7.22 Groundwater recovery curves for final void (RL vs Flow, positive flow means inflow to pit lake)

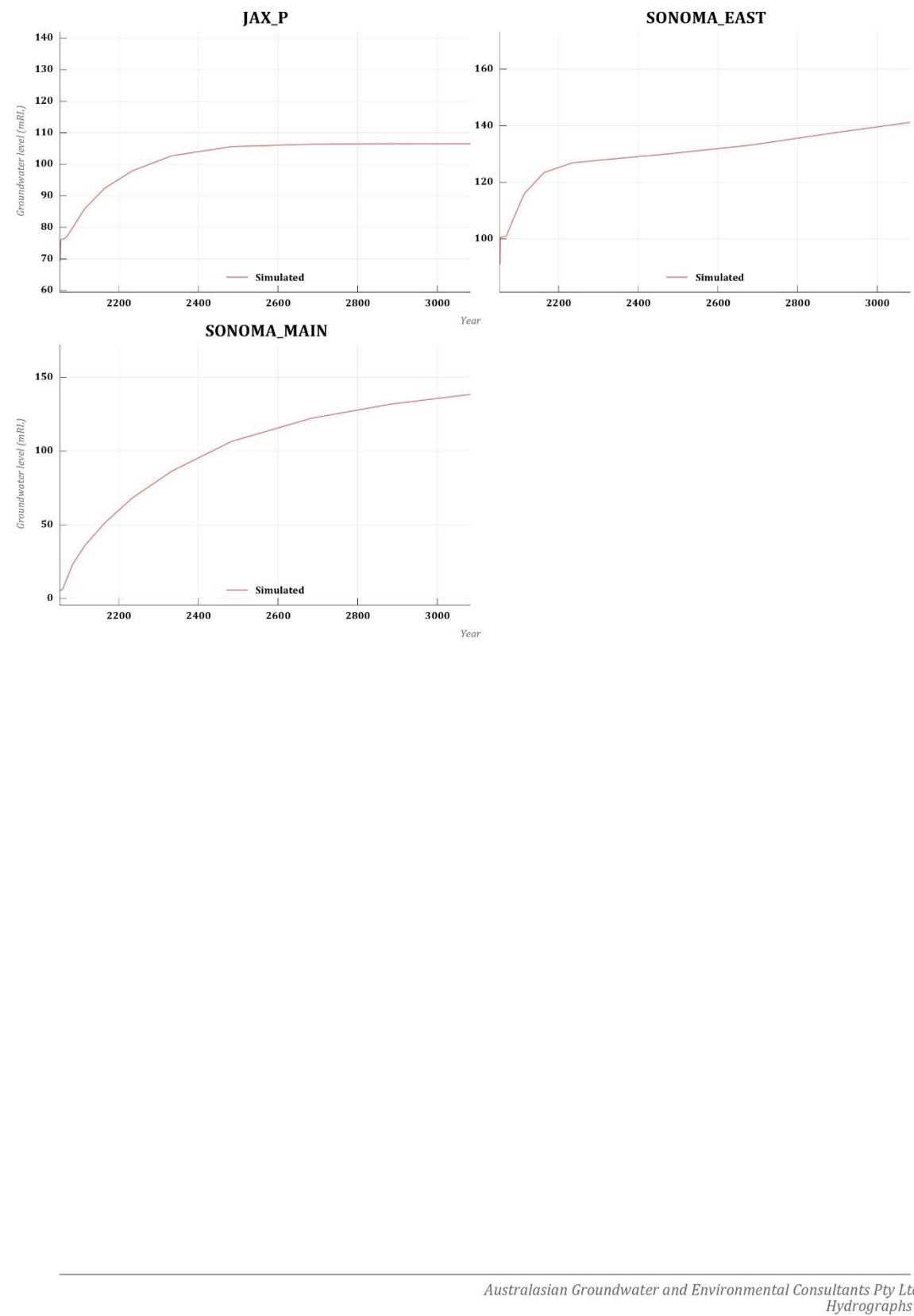
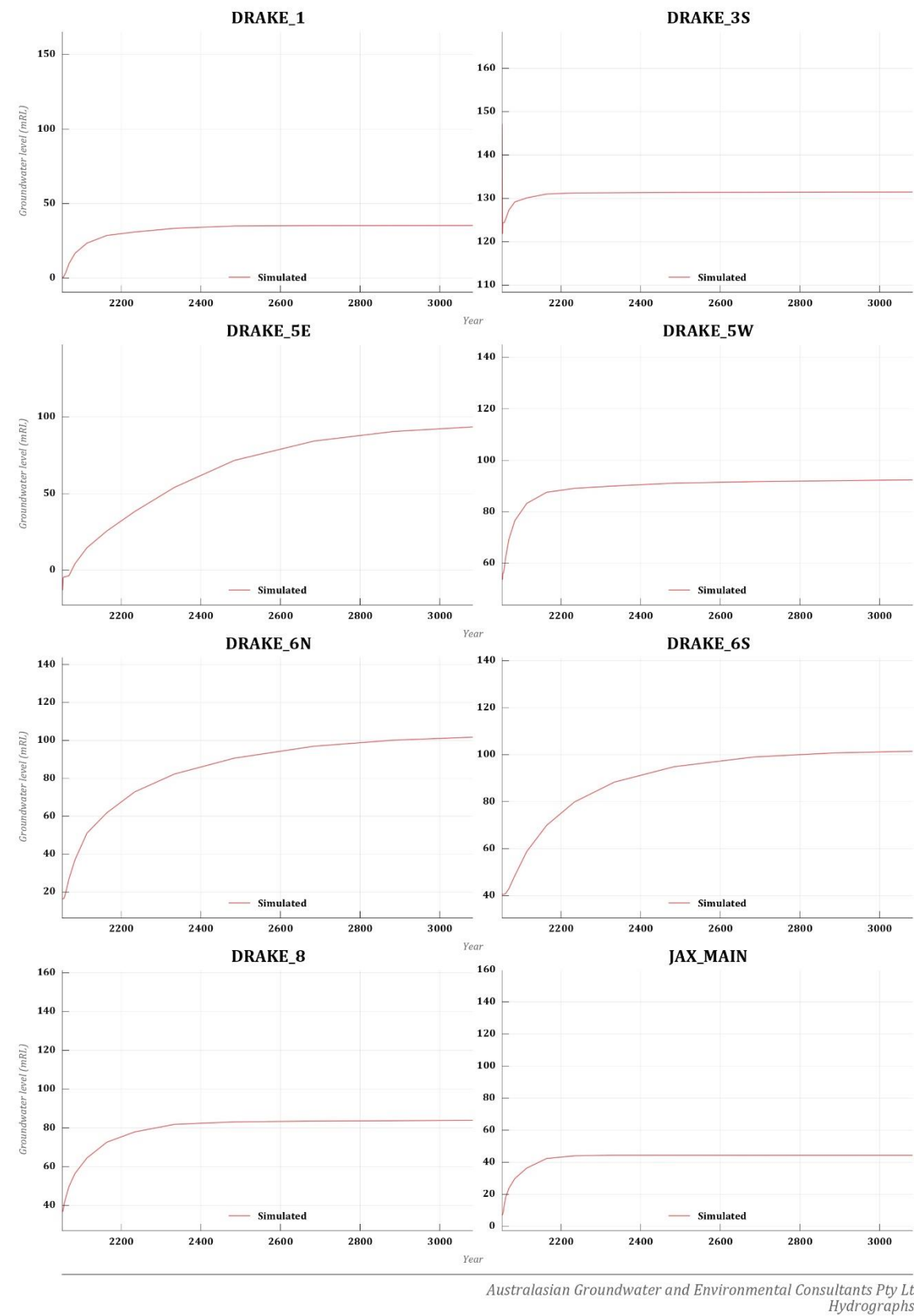


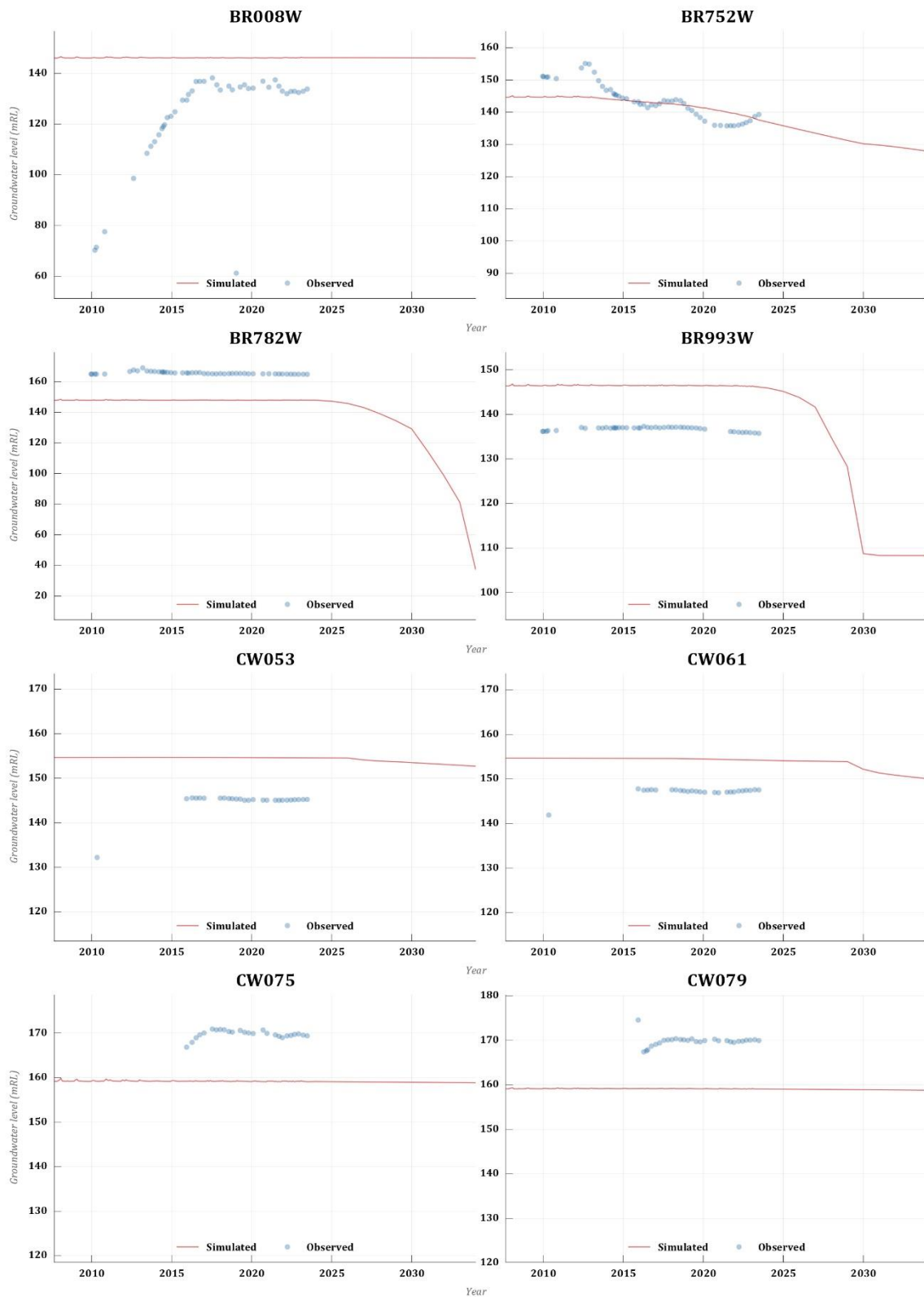
Figure 7.23 Groundwater recovery curves for final void (year 2052 to 3082)

8 References

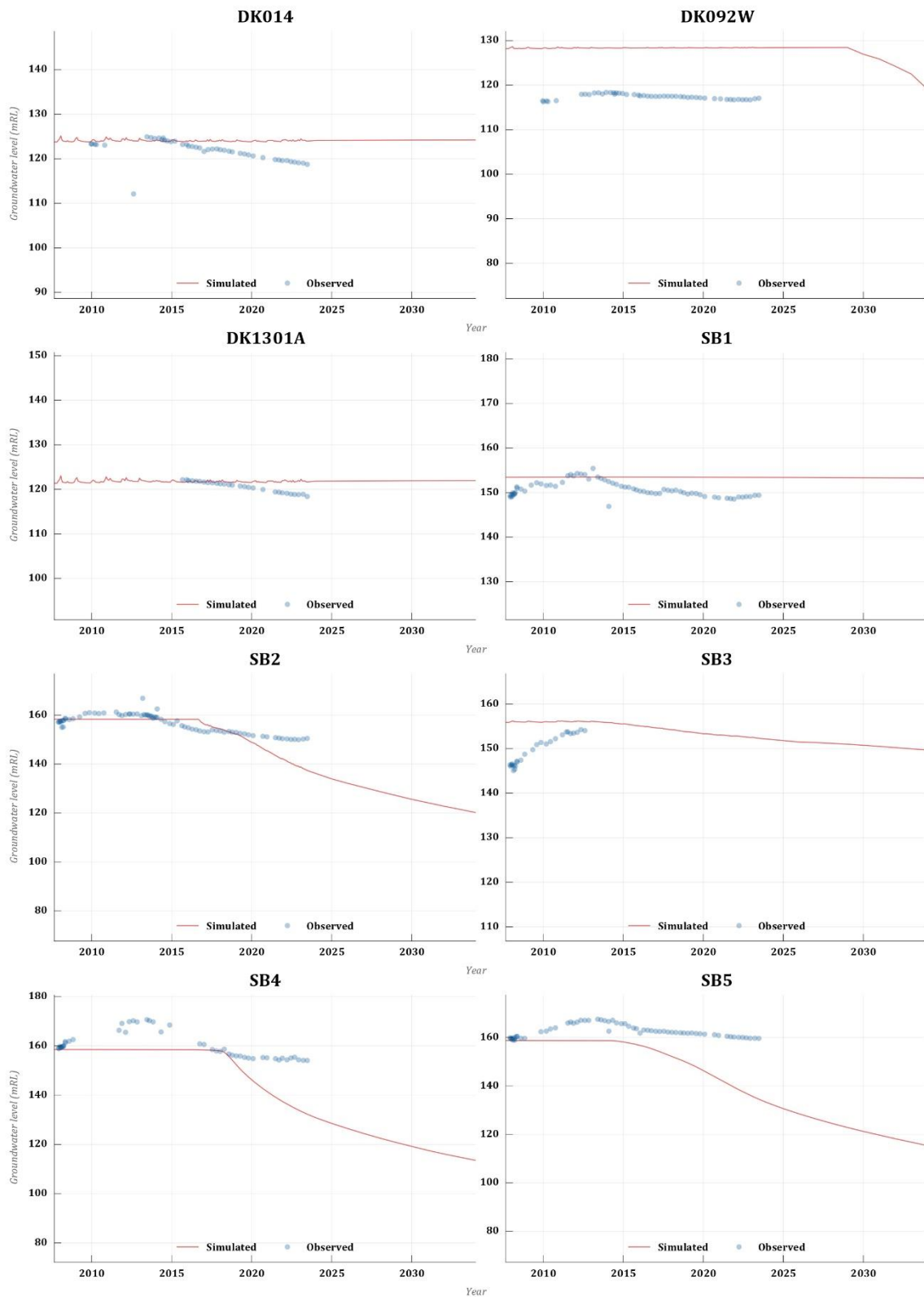
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Appendix A

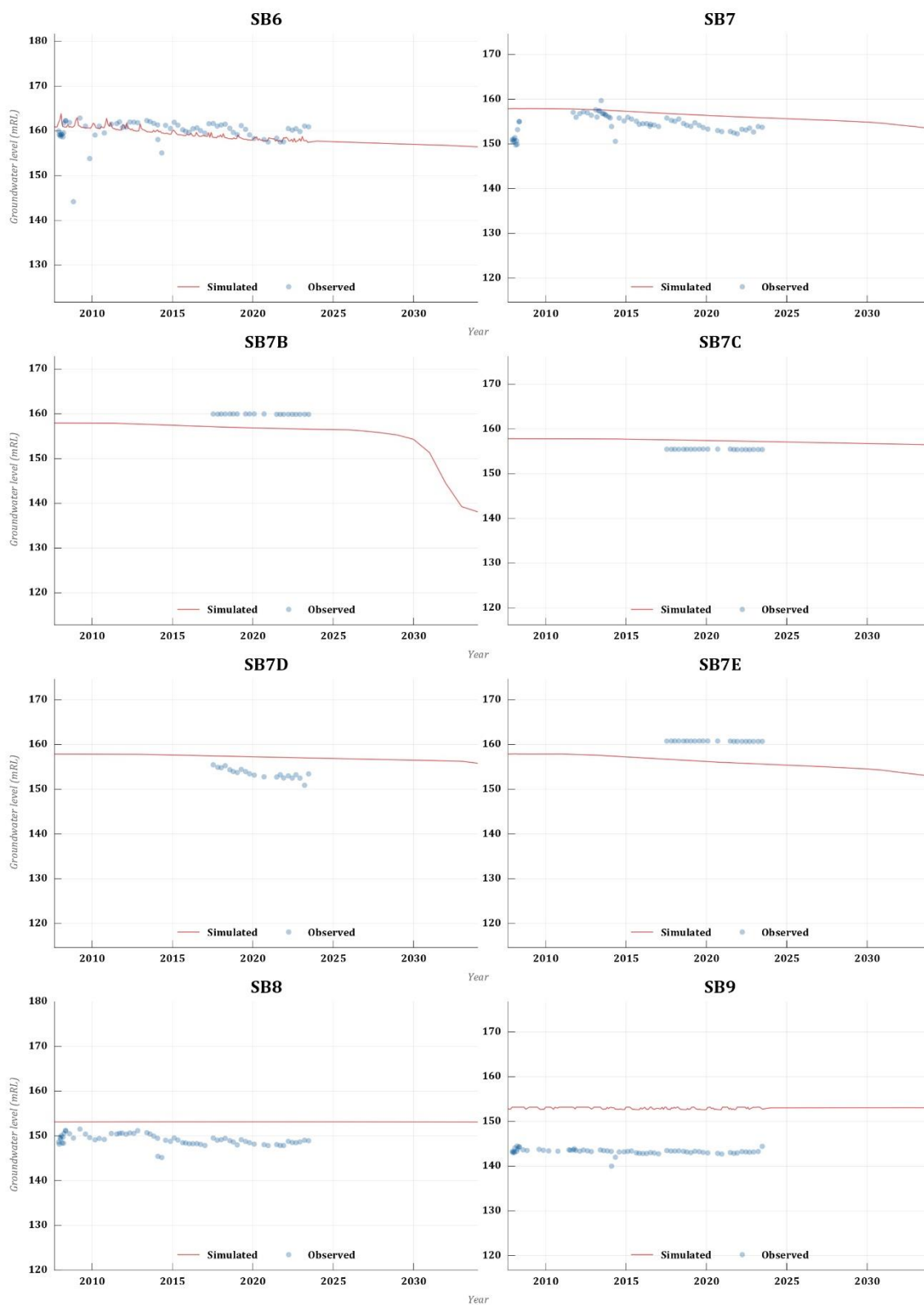
Calibration hydrographs



Australasian Groundwater and Environmental Consultants Pty Ltd
Hydrographs



Australasian Groundwater and Environmental Consultants Pty Ltd
Hydrographs



Australasian Groundwater and Environmental Consultants Pty Ltd
Hydrographs

Appendix G - Sonoma Coal Project Land Resource Assessment Report (GSSE, 2005)



SONOMA COAL PROJECT

LAND RESOURCE ASSESSMENT REPORT

Prepared for:

Environmental & Licensing Professionals Pty Ltd

Prepared by:

R. Masters
Principal
GSS Environmental

Global Soil Systems Project No: MEM 3-1
Issue No. 3
Copy No. 1



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Appendices

Appendix 1	Field Assessment Procedure
Appendix 2	Soil Information
Appendix 3	Soil Test Results

1.0 INTRODUCTION

1.1 Objectives

GSSE Environmental (GSSE) was originally commissioned by McCollum Environmental Management Services Pty Ltd (MEMS) to undertake a land resource assessment of the proposed Sonoma Coal Project study area. Field surveys were conducted by GSSE in June 2004.

The major objectives of the field surveys were to:

- (1) describe and classify soils, land use & suitability within the study area; and
- (2) analyse the various soil units to identify their suitability for topdressing of disturbed areas within the study area.

The following report describes the results of the field surveys undertaken by GSSE. This final report has been submitted to Environmental & Licensing Professionals Pty Ltd (ELP), environmental consultants responsible for coordinating the environmental impact assessment of the coal project.

1.2 Location

The proposed Sonoma Coal Project is located some 6 km south of Collinsville in central Queensland. Coral Creek traverses the northern boundary and Two Mile Creek meanders through the south-west corner of the lease.

The study area lies within EPC 586 and encompasses 2,586 ha of land.

1.3 Regional Setting

The region is underlain by rich coal resources and several coal mines operate in the area, supplying both domestic and export markets. The decommissioned Pipeline Mine adjoins the eastern boundary of the Sonoma lease. Collinsville Mine lies some 6 km north of the Sonoma Project.

1.4 Landform & Topography

The study area comprises alluvial plains and terraces bordering Coral Creek in the north, and plains and low hills bordered by Two Mile Creek in the south. An unnamed drainage line separates the alluvial plains in the north and plains and low hills in the south. All creeks drain into the Bowen River.

1.5 Vegetation

Large areas of the lease have been cleared for grazing in the past. However, there is little indication of recent clearing activity except for weed control and regrowth on a grassland site that may have been weed species. Historic logging and ringbarking in the riparian zone and thinning of the mixed woodlands with the removal of understorey have been undertaken in the past, however, good vegetation cover is now apparent.

The best developed stands of vegetation are woodlands and forests associated with Coral Creek and the alluvial plains between Coral Creek and the unnamed creek. Some well developed stands occur on the low hill running south from the unnamed creek to Two Mile Creek.

The woodlands on the alluvial plains are *Eucalyptus* and *Corymbia* dominated with very little brigalow (*Acacia harpophylla*) remaining. *Eucalyptus tereticornis* and *E. raveretiana* dominate the fringing vegetation on Coral Creek while most of the woodlands on the low hills have a species mix similar to the alluvial plains but also includes patches of *E. orgadophila* dominated woodland.

2.0 SOIL SURVEY METHODOLOGY

2.1 Introduction

A soil survey was undertaken to qualify the reserves of suitable topdressing material to assist planning of future rehabilitation operations and identify any potentially adverse soil materials so that they can be managed during rehabilitation of post-disturbance areas within the project.

2.2 Mapping

An initial soil map was developed using the following resources and techniques:

(i) *Aerial photographs and topographic maps*

Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape and mapping of features related to the distribution of soils in the area.

(ii) *Previous soil survey*

A survey of the region was undertaken by Shields (1984) at a scale of 1 : 250,000. The Sonoma lease area was included in the survey.

(iii) *Stratified observations*

Upon drafting of mapping units, soil profile exposures were visually assessed to ascertain potential mapping units.

2.3 Profiling

During the June 2004 GSSE survey a total of sixteen (16) soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The exposure locations were chosen to provide representative profiles of the soil types encountered over the study area. The soil profile sites are shown in **Figure 2**.

The soil layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Soil observations were also conducted in eroded areas, small access track cuttings, etc by GSSE to confirm soil units and boundaries between different soils.

2.4 Field Assessment

Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. The system remains the benchmark for the Australian coal mining industry.

The system is described in **Appendix 1**.

2.5 Laboratory Testing

Soil samples were taken from exposed soil profiles during the soil survey. The samples were subsequently analysed for the following parameters:

- Particle Size Analysis
- Emerson Aggregate Test
- pH
- Electrical Conductivity
- Colour

A description of the significance of each test and typical values for each soil characteristic are included in **Appendix 2**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas. The soil test results for the soil survey are provided in **Appendix 3**.

3.0 RESULTS

3.1 Soils

3.1.1 *General*

The following soil units were identified within the study area:

- Grey Uniform Clay
- Brown Gradational sandy Loam
- Red Duplex Sandy Loam

The distribution of these soils is illustrated in **Figure 2**.

The Grey Uniform Clay dominates the lease area. The soil unit encompasses some 60% of the study area. The soil is characterised by a self mulching, grey medium clay surface horizon grading to a heavier textured greyish brown clay horizon and eventually to a brown clay (refer **Plate 1**).

The Brown Gradational Sandy Loam adjoins Coral Creek and is generally confined to the floodplain area. The unit represents approximately 15% of the total study area. The soil has a sandy loam topsoil grading to a shallow sandy clay loam and eventually to a deep clay loam.

The Red Duplex Sandy Loam is located on the eastern and southern extremities of the lease. It covers approximately 25% of the total study area. The soil is characterised by a reddish brown clay loam surface grading to a yellowish red medium clay subsoil. Eventually the medium clay subsoil grades to a weathered sandstone (refer **Plate 3**).

3.1.2 *Profile Descriptions*

The following profile descriptions are characteristic of their respective soil unit.

SOIL UNIT: GREY UNIFORM CLAY		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.20	Grey (10YR 5/1) self mulching medium clay. The soil consistence is very firm and crumbly when dry. The layer exhibits strong pedality. Sub-angular blocky peds are 50-100 mm in diameter. Many roots occur. The boundary is gradual and wavy to layer 2.
2	0.20 – 0.60	Greyish brown (10YR 5/2) medium clay. It is moderately consistent and has sub-angular blocky peds. There are some roots. The lower boundary is gradual and wavy to layer 3.
3	0.60 – 1.20+	Brown (7.5YR 5/3) medium clay. The horizon is apedal massive and there are no roots.

SOIL UNIT: BROWN GRADATIONAL SANDY LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.20	Brown (7.5 YR 5/3) sandy loam. It is weakly to moderately consistent; moderately pedal with rough-faced sub-angular blocky peds 20-50 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. Many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.30	Brown (7.5 YR 5/3) sandy clay loam. The structure is weakly pedal and the consistence is strong. Ped shape is sub-angular blocky. Few roots are present. The boundary is gradual and wavy to layer 3.
3	0.30 – 0.90+	Reddish brown (7.5 YR 6/6) clay loam that is slightly mottled (orange and grey). No roots are present.

SOIL UNIT: RED DUPLEX SANDY LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.30	Reddish brown (5YR 4/4) clay loam. It is weakly to moderately consistent; moderately pedal with rough-faced sub-angular blocky peds 50-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. Many roots are present. The lower boundary is clear and wavy to layer 2.
2	0.30– 0.70	Yellowish red (5YR 5/6) medium clay. The structure is weakly pedal and the consistence moderately weak or crumbly. The boundary is clear and wavy to layer 3.
3	0.70 – 1.10+	Dark yellowish brown (10YR 4/6) sandy loam and weathered sandstone.



Plate 1: Grey Uniform Clay.



Plate 2: Brown Gradational Sandy Loam.



Plate 3: Red Duplex Sandy Loam.

3.1.3 Laboratory Testing

All soil samples taken during the GSSE survey were analysed by the Department of Land's Soil and Water Testing Laboratory at Scone, NSW. All soil analytical results are provided in **Appendix 3**. The first numeral in the sample identification (Id) refers to the profile site number (refer **Figure 2**). Soil layers are signified by /1, /2 and /3 in the sample Id with the surface horizon being /1 and subsoil horizons being /2 & /3.

The Grey Uniform Clay has a medium clay texture throughout. The surface soil is structurally stable (Emerson rating of 4). The subsoil can be highly alkaline (pH 9.3), dispersive (Emerson rating of 2) and saline (EC 4.1). An alkaline trend occurs down the profile with surface soil pH being moderately alkaline (pH 8.3 to 8.7) and non-saline.

The Brown Gradational Sandy Loam has coarse textured surface horizons. The clay fraction throughout all horizons is relatively stable (Emerson rating of 3). The soil is non-saline. The surface pH recordings are slightly acidic and the subsurface is slightly alkaline.

The Red Duplex Sandy Loam has a clay loam surface horizon. The subsoil is fine textured but stable. An alkaline trend occurs down the profile with pH recordings of 6.8 at the surface to 7.4 at depth. The profile is non-saline.

3.2 Land Use & Suitability

3.2.1 *Pre - Mining*

The lease area is currently used for low intensity cattle grazing. As a result of this past and existing land use, there has been extensive tree clearing throughout the area. The land use is consistent with that of the adjoining land.

Land suitability of the study area has been assessed largely using criteria provided in the (former) DME Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.

The method of land suitability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use, rather it indicates the potential of the land for such uses as crop production, pasture improvement and grazing.

The system allows for land to be allocated into five possible classes (with land suitability decreasing progressively from Class 1 to Class 5) on the basis of a specified land use that allows optimum production with minimal degradation to the land resource in the long term.

The classes are described as:

- | | |
|---------|--|
| Class 1 | Suitable land with <u>negligible</u> limitations which is highly productive requiring only simple management practices to maintain economic production. |
| Class 2 | Suitable land with <u>minor</u> limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production. |
| Class 3 | Suitable land with <u>moderate</u> limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production. |
| Class 4 | Marginal land with <u>severe</u> limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production). |
| Class 5 | Unsuitable land with <u>extreme</u> limitations that preclude its use for the proposed purpose. |

Land is considered less suitable as the severity of limitations for a land use increase. Increasing limitations may reflect any combination of the following:

- Reduced potential for production;
- Increased inputs to achieve an acceptable level of production; and/or
- Increased inputs required to prevent land degradation.

All land within the Sonoma Coal Project area is Class 2 land and is suitable for grazing of native and improved pastures. The land is not suitable for cultivation on a regular basis owing to a combination of limitations of slope, soil, erosion and climate. Soil conservation practices such as pasture improvement, stocking rate control, application of fertilizer and establishment or re-establishment of permanent pasture are recommended. Buffel Grass (*Cenchrus ciliaris*) is the preferred grass for introduction because of its high nutritional value, drought resistance and tolerance of grazing pressure once established.

3.2.2 Post Mining

The recommended post mining land use objective for the Sonoma site is grazing. The proposal is based on the assessment of the existing site conditions and rehabilitation experience at other sites throughout central Queensland. This final land use goal is considered achievable. The proposal seeks to return land of compatible use but only in accordance with the capability of rehabilitated spoil to sustain the use without degradation. The overriding principle is to create the most beneficial future use of rehabilitated land that can be sustained in view of the range of limiting factors.

Post mining lands proposed for grazing must provide and sustain a sufficient bulk of nutritious forage in addition to the following management considerations:

- The ability to access and manage livestock;
- Flood free and relatively dry ground conditions;
- Adequate stock drinking water and shelter; and
- Stock routes throughout the rehabilitated land.

Provided that environmental controls (particularly erosion & sediment controls) are in place and operating effectively during the proposed mine's construction and operation, there will be no adverse effects to the surrounding grazing enterprises.

The post mining suitability classification for the majority of reshaped and topsoiled spoil areas within the project will be Class 4 land. Rehabilitated infrastructure areas will also attain Class 4 land suitability classification. Final voids will be Class 5 land.

4.0 TOPDRESSING SUITABILITY

Details of the soil test results (refer **Appendix 3**) were used in conjunction with the field assessment (refer **Appendix 1**) to determine the depth or thickness of soil materials that are suitable for stripping and re-use in the rehabilitation of disturbed areas.

Structural and textural properties of soils within the study area are the most significant limiting factors for determination of topdressing suitability. The recommended stripping depth for the Grey Uniform Clay is approximately 20cm. Whilst the surface horizon of this soil unit has a heavy texture (medium clay), it is stable and non-saline. Alkalinity levels are elevated but acceptable. The subsoil clay content is very high. High alkalinity, sodicity and salinity are additional constraints in terms of determining the material's value as a topdressing material, therefore, the subsoil has been deemed unsuitable for re-use in the rehabilitation of the post-mining landform.

The Brown Gradational Sandy Loam is coarse textured and marginally suitable as a topdressing medium. The clay fraction is relatively stable (non-sodic) and the entire profile is non-saline and has near neutral pH. The unit can be stripped to an approximate depth of 100cm for use as a marginal topdressing material.

The Red Duplex Sandy Loam has surface horizon that is physically desirable in terms of structure and texture. The surface soil has low electrical conductivity has a neutral pH and is relatively stable (Emerson rating of 3). The subsurface layer is structurally weak, is texturally fine, has some elevated electrical conductivities and therefore is considered not suitable for stripping, stockpiling and respreading as a topdressing material for reshaped overburden. The recommended stripping depth for this unit is 30cm.

5.0 STRIPPING & STOCKPILING RECOMMENDATIONS

The following stripping and stockpiling techniques are recommended to prevent excessive soil deterioration:

- Strip material in a slightly moist condition. Material should not be stripped in either a dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit).
- Maintain a maximum stockpile depth of 3 m.
- Seed and fertilise stockpiles as soon as possible.

The quality of stockpiled materials can be expected to markedly decrease over time. Stockpiling results in diminished viability of favourable seeds and reduced soil flora and fauna levels in stockpiled material. Unfavourable effects are very pronounced when soils are stockpiled for periods greater than one year.

6.0 LANDFORM DESIGN & EROSION CONTROL RECOMMENDATIONS

Rehabilitation strategies and concepts proposed for Sonoma Mine have been formulated according to results of industry wide research and experience.

6.1 Overburden Regrading

The main objective of regrading is to produce slopes whose angles, lengths and shapes are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising risk of erosion and sedimentation. Regrading should be conducted to maximum slope gradients of 17%.

6.2 Topsoil Respreading

Suitable topsoil (refer Section 4.0 of this report) should be stripped and re-spread onto reshaped areas. Where suitable areas are unavailable for immediate respreading, topsoil should be stockpiled to a maximum depth of 3 m and subsequently applied when the areas become available. The period of storage should (refer Section 5.0) be minimised in order to reduce the detrimental effects of storage on any native seed in the soil. Topsoil should be spread to a minimum depth of 200mm on all regraded spoil.

6.3 Erosion & Sediment Control

The most significant means of controlling surface flow on spoil areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that would cause erosion. As the slope angle increases, the banks or furrows must be spaced closer together until a point is reached where they are no longer effective. Contour ripping is by far the most common form of structural erosion control on mine sites as it simultaneously provides some measure of erosion protection and cultivates the surface in readiness for sowing.

Contour deep ripping can provide a reasonable degree of erosion protection, albeit for a limited time, on slopes of up to approximately 17%.

Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point.

The banks are constructed away from the true contour, at a designed gradient (1% to 2%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam.

Graded bank construction is recommended for all rehabilitation areas within the Sonoma Project. The ideal construction plant is a small bulldozer in the 75 to 100 HP class, equipped with a multi-tyne, rear-mounted ripper and a front angle-and-tilt

blade. Most mining equipment is too large for the job and is unable to work to the exacting tolerances needed to produce satisfactory channel shapes and gradients.

Eventually, runoff that has been intercepted and diverted must be disposed of down slope. The use of engineered waterways using erosion blankets and/or rip rap is recommended to safely dispose of runoff downslope.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff prior to off-site release. Sediment control dams are responsible for improving water quality throughout the mine site and enhance the ecological diversity of the area.

The following points should be considered when selecting sites for sediment control dams:

- Each dam should be located so that runoff may easily be directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge.
- The material from which the dam is constructed must be stable. Highly dispersible clays will require treatment with lime, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most likely in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

6.4 Seedbed Preparation

Thorough site preparation should be undertaken to ensure optimum establishment and growth of vegetation. To minimise erosion, ripping should be undertaken on the contour and the tines lifted for approximately 2m every 200m to reduce the potential for channelised erosion. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing.

All topsoiled areas should be contour ripped (after topsoil spreading) to create a “key” between the soil and the spoil.

7.0 REFERENCES

Elliot, G.L. and Veness, R.A., 1981. Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley, J. Soil Cons. NSW 37 37-40

Macbeth, 1994. Munsell Soil Colour Charts, Revised Edition.

Shields, P.G., 1984. Land Suitability Study of the Collinsville - Nebo – Moranbah Region. Qld Dept Primary Industries.

APPENDIX 1

FIELD ASSESSMENT PROCEDURE

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

APPENDIX 2

SOIL INFORMATION

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

- (1) slight milkiness, immediately adjacent to the aggregate
- (2) obvious milkiness, less than 50% of the aggregate affected
- (3) obvious milkiness, more than 50% of the aggregate affected
- (4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (dS/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australian Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook**. Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook**. Inkata Press, Melbourne.

APPENDIX 3

SOIL TEST RESULTS

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO04/170R1
 Client Reference: Rod Masters
 GSS Environmental
 PO Box 3214
 Wamberal 2260

Lab No	Method Sample Id	P7B/1 Particle Size Analysis (%)					P9B/2 EAT	C1A/4 EC (dS/m)	C2A/3 pH	Colour	
		clay	silt	f sand	c sand	gravel				dry	moist
1	Sonoma SS 2/1	51	14	20	14	1	4	0.15	8.7	10YR5/1	10YR4/1
2	Sonoma SS 2/2	60	14	17	9	0	4	0.34	9.3	10YR5/2	10YR4/2
3	Sonoma SS 2/3	54	18	21	6	1	2(1)	4.1	8.2	7.5YR5/3	7.5YR4/3
4	Sonoma SS 4/1	10	8	50	32	<1	8/3(1)	0.16	6.8	10YR5/4	10YR4/4
5	Sonoma SS 4/2	20	7	48	25	0	3(1)	0.06	7.0	10YR5/4	10YR4/4
6	Sonoma SS 4/3	21	6	58	15	0	3(1)	0.05	7.8	7.5YR5/4	7.5YR4/4
7	Sonoma SS 6/1	12	7	46	35	<1	3(1)	0.06	6.2	7.5YR5/3	7.5YR3/3
8	Sonoma SS 6/2	25	8	38	27	2	3(2)	0.05	6.7	7.5YR5/3	7.5YR4/4
9	Sonoma SS 6/3	34	10	36	20	0	3(1)	0.06	8.0	7.5YR6/6	7.5YR5/6

gshamca

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Page 3 of 3

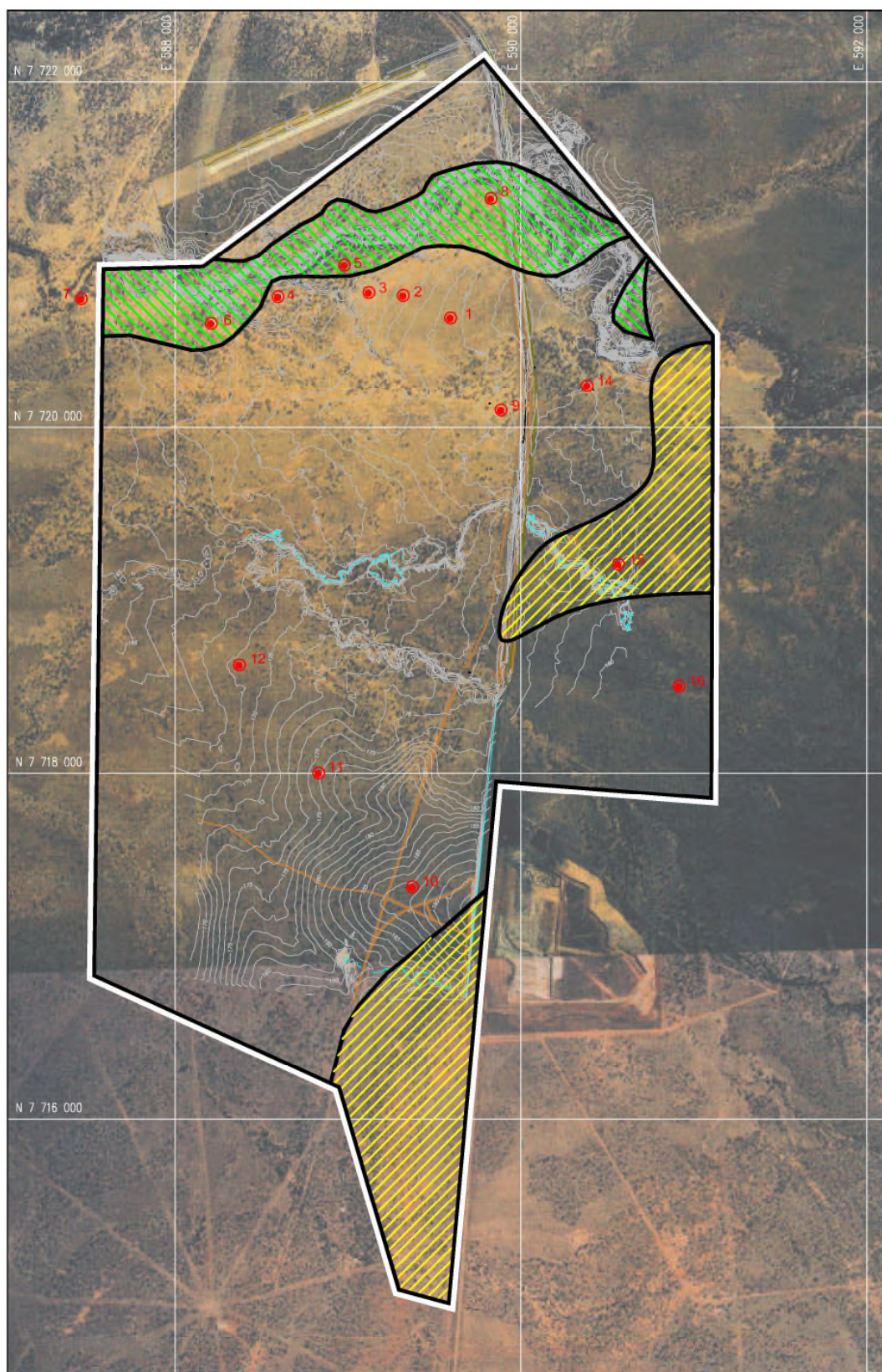
Report No: SCO04/170R1
Client Reference: Rod Masters
GSS Environmental
PO Box 3214
Wamberal 2260

Lab No	Method Sample Id	P7B/1 Particle Size Analysis (%)					P9B/2 EAT	C1A/4 EC (dS/m)	C2A/3 pH	Colour	
		clay	silt	f sand	c sand	gravel				dry	moist
10	Sonoma SS 12/1	57	19	17	7	0	4	0.11	8.3	10YR4/2	10YR3/2
11	Sonoma SS 12/2	57	17	17	8	1	4	0.19	8.9	10YR5/2	10YR4/2
12	Sonoma SS 12/3	60	19	13	8	0	4	0.71	8.9	10YR5/2	10YR4/2
13	Sonoma SS 13/1	35	11	34	19	1	3(1)	0.26	6.9	5YR4/4	5YR3/4
14	Sonoma SS 13/2	53	12	21	14	<1	6	0.41	6.8	5YR5/6	5YR4/6
15	Sonoma SS 13/3	8	3	16	73	0	5	0.11	7.4	10YR4/6	10YR3/6

P7B/1 PSA Sample 15 – failed to completely disperse following standard method



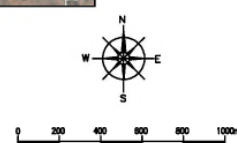
END OF TEST REPORT



Legend

 Soil Profile Site
 Grey Uniform Clay

 Brown Gradational Sandy Loam
 Red Duplex Sandy Loam



GSS Environmental
 Environmental and Land Management Consultants
 Project No. MEM 3-1
 Drawing No. MEM 3-1-2

SONOMA MINE PROJECT
SOIL UNITS

FIGURE 2
As Shown

Appendix H - Drake Coal Project Soils and Land Suitability Assessment (GHD, 2012)



VOLUME 2a | APPENDIX C
SOILS AND LAND SUITABILITY ASSESSMENT



CLIENTS | PEOPLE | PERFORMANCE

Drake Coal Pty Ltd

Drake Coal Project: Environmental Impact Statement

Soils and Land Suitability Assessment

February 2012



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Glossary of Terms

Term	Definition
AHD	Australian Height Datum
ASPAC	Australasian Soil and Plant Analysis Council
Ca:Mg	Calcium to Magnesium Ratio
CEC	Cation Exchange Capacity
°C	Degrees Celsius
EAT	Emerson Aggregate Test
EC	Electrical Conductivity
ECEC	Effective Cation Exchange Capacity
EIS	Environmental Impact Statement
ESP	Exchangeable Sodium Percentage
GHD	GHD Pty Ltd
GQAL	Good Quality Agricultural Land
ha	Hectare
km	Kilometre
m	Metre
mBGS	Metres Below Ground Surface
mm	Millimetre
PAWC	Plant Available Water Capacity
ROM	Run of Mine
SCL	Strategic Cropping Land
ToR	Terms of Reference for the Drake Coal Project EIS



Executive Summary

GHD Pty Ltd (GHD) was engaged by Drake Coal Pty Ltd (the Proponent) to undertake a soil and land suitability assessment as part of the Environmental Impact Statement for the proposed Drake Coal Project. The Project is located 17 kilometres (km) south of the town of Collinsville, Queensland and the Project area covers approximately 9,196 hectares (ha).

The report provides an evaluation of the environmental value of the soils and land suitabilities located within the Project area, in accordance with Sections 4.2.1.5 and 4.2.1.6, respectively, of the Terms of Reference for the Drake Coal Project EIS (DERM, 2010). The investigation addressed the following:

- ▶ A description of the soils across the Project and recommendations on soil stripping depths, if required, for use in rehabilitation activities;
- ▶ An assessment of the land suitabilities for the site; and
- ▶ A description of the Agricultural Land Classes across the Project area.

The soil assessment identified six Land Units within the Project area, being:

- ▶ LU1: Vertosols on low lying areas;
- ▶ LU2: Vertosols on undulating terrain;
- ▶ LU3: Sodosols on undulating low hills;
- ▶ LU4: Sodosols on flood plain, with minor Rudosols;
- ▶ LU5: Dermosols and Vertosols on undulating terrain; and
- ▶ LU6: Tenosols and Rudosols adjacent to Intermittent or Permanent Watercourses.

The first of these Land Units (LU1) was located in the central portion of the site in low lying areas, with a grassland community growing on Vertosols. The second Land Unit (LU2) was also located centrally, appearing as grasslands on gently to moderately inclined slopes with Vertosols. Land Unit 3 (LU3) consisted of Sodosols on the elevated western portion of the site; these are considered highly prone to erosion. In the southern portion of the site, Land Unit 4 (LU4) also contained erosion-prone Sodosols with secondary Rudosol, in the low-lying flood plain of the Bowen River. Land Unit 5 (LU5) was located on the higher ground on the eastern portion of the site, with open eucalypt woodland on Dermosols and Vertosols. The final Land Unit, LU6, was located adjacent to watercourses and drainage features with marked terraces, levees and shallow drainage depressions.

The infrastructure and disturbance areas proposed as part of the Project are largely located in the central and western portions of the mining lease area, coinciding predominantly with Land Units LU1 (2,531 ha), LU2 (852 ha) and LU5 (2,324 ha).

Based on the soil assessment results, topsoil stripping is recommended from three of the Land Units: LU1, LU2 and LU5. These three Land Units cover approximately 62% of the Project area (5,707 ha) and coincide with the majority of Project development. Surface soils from LU3 and LU4 are not suitable for stripping as the high erodibility rating and acidic properties make them unsuitable for plant growth and use in rehabilitation activities. Approximately 58 ha in LU3 and 392 ha in LU4 are proposed for disturbance. Disturbance in these areas is expected to be limited to the vicinity of "Central 3" development and the co-disposal facility proposed in LU4 (southern area of the site).



A land suitability assessment was undertaken for the two current and potential land uses in the Project area: Beef Cattle Grazing and Rainfed Broadacre Cropping. The results indicate that all land units in the Project site had a higher suitability for Beef Cattle Grazing than for Rainfed Broadacre Cropping, with the exception of LU2 which was rated fair for both land uses. Approximately 70% of LU2 is located within the mine disturbance area. All Land Units, with the exception of LU3, were assessed as having 'fair' suitability for Beef Cattle Grazing and therefore, approximately 85% of the Project area is considered suitable for this land use. Land Unit LU3, located on the eastern portion of the site, was considered to have 'low' suitability for Beef Cattle Grazing. The table below provides a summary of the land suitability.

Table A Suitabilities of the Land Units for Cropping and their Agricultural Land Classes

Land Unit	Broadacre Crops		Grazing		Agricultural Land Class
	Suitability	Severe Limitation*	Suitability	Severe Limitation	
LU1	4	Workability and Physical Condition	3	-	C
LU2	3	-	3	-	A
LU3	5	Extreme Water Availability	4	Water Availability	C
LU4	4	Dissected Topography	3	-	C
LU5	4	Water Availability & Erosion	3	-	C
LU6	4	Flooding	3	-	C

Class A Good Quality Agricultural Land (GQAL) was identified on the Project site on Land Unit LU2. The remaining land units (LU1, LU3, LU4, LU5 and LU6) were determined to be Class C GQAL for grazing.

Land Units within a 5 kilometres (km) proximity of the Bowen River were also assessed for irrigation suitability. The results indicate the soil is unsuitable for irrigation, based on either the shrink-swell properties of the Vertosols or the sodic subsoil and high erodibility potential of the Sodosols. LU6 comprises of narrow strips adjacent to Intermittent or Permanent Watercourses with terraces and drainage depressions. The local topography makes it unsuitable for large scale irrigation.

A Strategic Cropping Land Assessment was not conducted for this Project as the Terms of Reference were finalised in December 2010 and a certificate of application for mining leases were issued prior to the cut-off date of 31 May 2011.



1. Introduction

GHD Pty Ltd (GHD) was engaged by Drake Coal Pty Ltd (Drake Coal), a subsidiary of QCoal Pty Ltd (QCoal), to undertake a soil and land suitability assessment as part of the Environmental Impact Statement (EIS) for the Drake Coal Project (the Project).

Drake Coal propose to develop the Drake Coal Project, an open-cut coal mine, located in Queensland's Bowen Basin (Figure 1). Truck and excavator operations are proposed to excavate the coal resource. Mining operations will extract approximately 10 million tonnes per year (Mt/y) of run of mine (ROM) coal for processing to produce 6 Mt/y of product coal for export. The anticipated mine life is 30 years (inclusive of construction, operation and rehabilitation), with the potential to extend the mine life as ongoing exploration activities identify further coal reserves.

The aim of this study was to evaluate the environmental value of the soils and land suitability, in accordance with Sections 4.2.1.5 and 4.2.1.6, respectively, of the Terms of Reference (ToR) for the Drake Coal Project EIS (Department of Environment and Resource Management, (DERM), December 2010).

1.1 Study Area

The proposed Drake Coal Project is located in the Whitsunday Regional Council local government area, and is situated 17 kilometres (km) south of the town of Collinsville (Figure 1). The proposed mining activity will take place entirely within Lot 618 on PH 2106 (land lease) and Lot 9 DK 239 (freehold) and covers an area of 9,196 hectares (ha). Lot 9 DK 239 comprises of 0.4 ha, the remainder of the Project site is located on Lot 618 PH 2106. The proposed infrastructure and areas of disturbance are shown in Figure 2. It is estimated that approximately 3,442 ha will be disturbed by mining operation activities, leaving approximately 5,754 ha of the lease undisturbed.

The mining lease area is bordered by the Bowen Developmental Road and Newlands-Abbot Point railway line to the east, and the Bowen River to the south. Twelve Mile Gully traverses the southern section of the site and forms an upper tributary to the Bowen River. The area surrounding the Project also contains the major coal mines of Collinsville, Sonoma and the decommissioned Pipeline Coal Mine.



1.2 Assessment Objectives

The objectives of the assessment are detailed below. They address Section 4.2.1.5: Soils and Section 4.2.1.6: Land Suitabilities of the ToR for the Drake Coal Project EIS (DERM, December 2010).

Table 1 Terms of Reference

Section	Activity / Impact	Description
4.2.1.5	Soils	- Conduct a soil survey of the area that would be affected by the Project - Undertake soil tests and laboratory analyses of representative samples down the soil profile, with particular reference to the physical and chemical properties of the materials that will influence soil stability, erosion potential, storm water run-off quality, rehabilitation and agricultural productivity of the land - Describe, map and illustrate, at an appropriate scale, soil types and profiles - Document the depth and quality of useable topsoil and subsoil to be stripped and stockpiled for rehabilitation - For areas of the mining tenure along the Bowen River with access to irrigation water (e.g. within 5 km of the river), assess the soils for suitability for irrigation using the suitability scheme in land suitability for irrigated agriculture along the Fitzroy River
4.2.1.6	Land Suitabilities	- Provide an Agricultural Land Class map of the Project site and the surrounding area. Highlight any good cropping land - Describe and map the land use suitabilities and their classes, of the potentially affected area - Show the location of any cropping land in the vicinity of the site, highlighting any potential strategic cropping land, and describe the crops commonly grown on the land, including any rotations

1.3 Guidelines and Standards

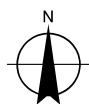
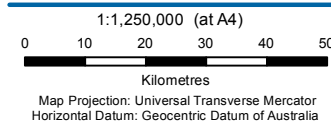
The soil and land suitability assessment was undertaken using the guidelines, standards and the accepted industry publications listed below:

- Guideline for Land Suitability Assessment Techniques (DME, 1995);
- Guideline for Agricultural Land Evaluation in Queensland (DPI, 1990);
- Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI/DHLGP, 1993);
- Protecting Queensland's Strategic Cropping Land: A policy framework (DERM, 2010);
- Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, 2009);
- Australian Soil and Land Survey: Guidelines for conducting surveys (Gunn et al 1988);
- Guidelines for Survey Soil and Land Resources (McKenzie et al, 2nd Ed., 2008); and
- Australian Soil Classification (Isbell, 2002).



LEGEND

- | | | | | | |
|--|------------|--|------------|--|-----------------------|
| | Town | | River | | Project Area |
| | Major Town | | Major Road | | Local Government Area |
| | Railway | | | | |

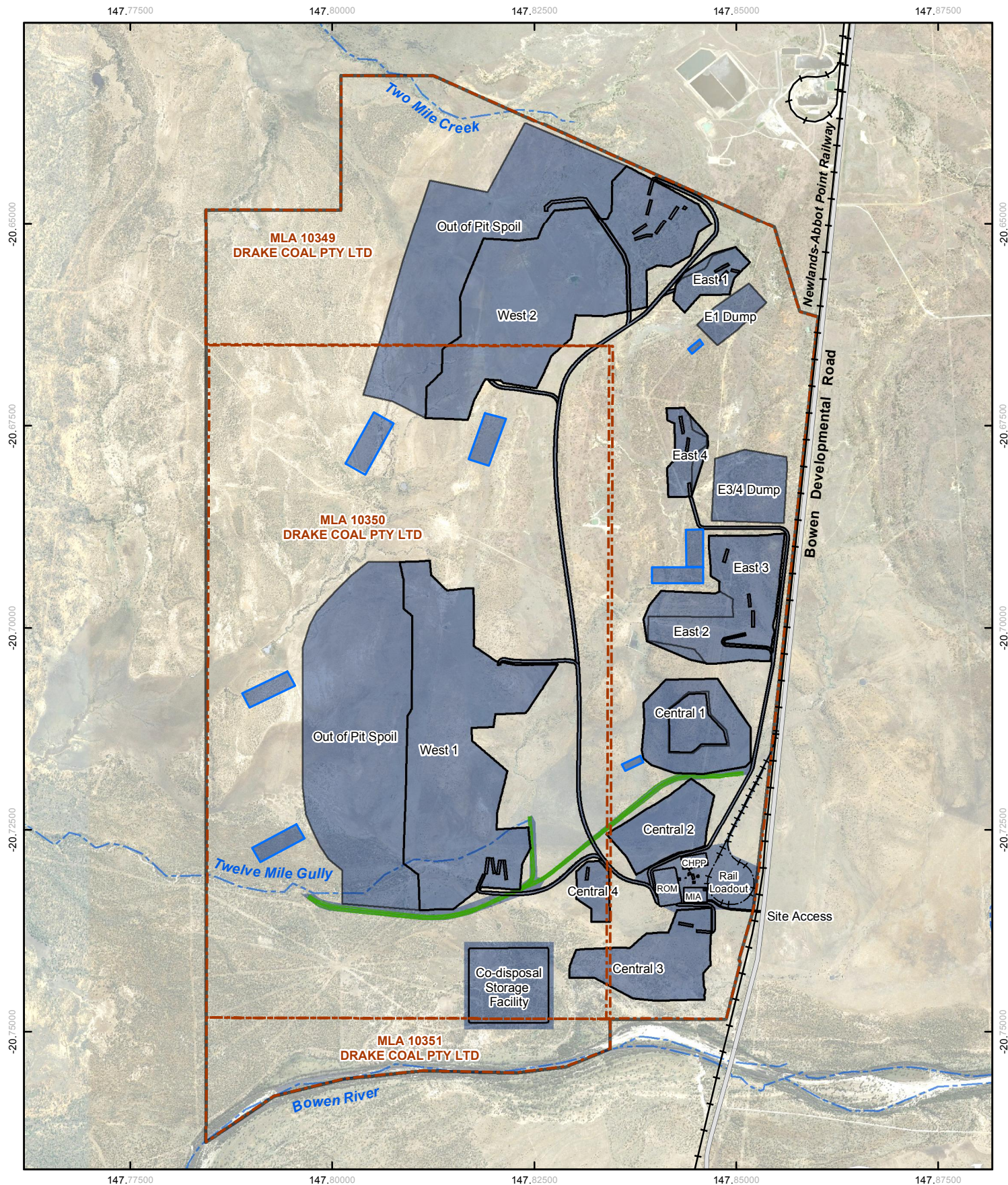


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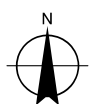
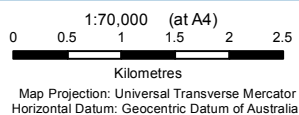
Project Location Plan

Figure 1



LEGEND

- | | |
|----------------------------|-----------------------------------|
| Major Road | Project Area |
| Existing Railway | Mining Lease Application Boundary |
| Proposed Railway | Mine Layout |
| Drainage Feature | Sediment Basin (Indicative) |
| Proposed Diversion Channel | Mine Affected Area |



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Proposed Infrastructure and
Areas of Disturbance

Figure 2



2. Background Information

Information relevant to the soil survey and land suitability assessment was obtained prior to fieldwork and is documented in the following sections. General background information is provided on the existing biophysical environment for the works associated with Sections 4.2.1.5 and 4.2.1.6 or the ToR, but does not seek to address other sections of the ToR.

2.1 Climate

The Collinsville region is dominated by dry tropical / sub-tropical weather patterns which have distinct wet (November to April) and dry (May to October) seasons. The geographic region is strongly influenced by a range of climate extremes including:

- ▶ The Australian monsoon influenced by the *El Niño* and *La Niña* (*El Niño* is associated with lower than average winter / spring rainfall; whilst *La Niña* is associated with higher than average winter, spring and early summer rainfall);
- ▶ General storm activity;
- ▶ Cyclonic events; and
- ▶ Severe heat waves.

Typically the region experiences hot summer months (December to February) and a dry winter season. Heavy rainfall predominately occurs within the summer months (late December to February) of the year, but is not reliable with substantial variation in annual rainfalls. Cloud cover generally increases in the lead up to the wet season with 'build up' thunderstorms starting in late December. Skies are generally clear during the dry season. The average median annual rainfall at Collinsville is approximately 710 mm and rainfall occurs between six to nine days per month in the wet season. The driest months are between May and October when very little rainfall occurs. Rainfall in the area is known to be inconsistent with annual rainfall and commonly is either well above or well below the annual average rainfall for the region. The high annual variability is due to the sporadic incidence of rainfall depressions associated with tropical cyclones and the convective origin of much of the rainfall (Shields, 1984).

Rainfall erosivity risk ratings for the region are based on Bowen (IECA, 2008). Rainfall erosivity is a measure of the ability of rainfall to cause erosion and is a product of the total energy and the maximum intensity for each storm. Rainfall erosivity is an indication of the two most important characteristics of a storm determining its erosivity, being the amount of rainfall, and peak intensity sustained over an extended period.

The rainfall events with the most erosive energies are in the summer months, which also coincide with the highest monthly rainfalls. Contrastingly, the winter months have low rainfalls with low rainfall energies. Details of monthly values in Collinsville for median rainfall, days that rain exceeds 10 mm or 25 mm, and rainfall erosivity risk are included in Table 2.



Table 2 Rainfall Data for Collinsville Region

Month	Rainfall (Median)	Rain Days $\geq$ 10 mm	Rain Days $\geq$ 25 mm	Rainfall Erosivity Risk
January	134.0	3.9	1.6	High
February	164.7	4.4	2.0	
March	93.2	2.7	1.1	
April	41.6	1.0	0.4	Medium
May	32.1	0.8	0.3	
June	27.2	0.7	0.3	Low
July	20.0	0.7	0.2	Very Low
August	18.1	0.5	0.2	
September	11.6	0.4	0.1	
October	21.5	0.8	0.2	Medium
November	50.5	1.5	0.6	
December	95.0	2.7	1.2	High
Total	710.0	20.1	8.2	

Source: Bureau of Meteorology (accessed 20/10/2010), being the average of climate data from Collinsville Post Office.
Rainfall erosivity risk ratings are based on published values for Bowen (IECA, 2008)

Average daily temperatures range from between 21.6 °C to 33.3 °C during the summer months to 10.1 °C to 25.7 °C in the winter months. Summer months typically have low relative humidity (67% at 9 am and 48% at 3 pm). Winter months also have low relative humidity (69% at 9 am and 41% at 3 pm) and are typically warm, mild days with cool to cold nights. Morning frosts throughout the months of May to August are common.

The region tends to have light winds with annual average wind speeds of 6.1 km/hr at 9 am increasing to 8.2 km/hr at 3 pm. In spring and summer, winds prevail from the north to north east. The monsoon trough influences wind direction in the area with light winds tending moderate westerly when the trough dips south of the area (P.G. Shields, 1984). South-easterlies occur during the autumn and winter months with an occasional southerly breeze. Strong or gale force winds are normally associated with tropical cyclones which regularly affect the coastal area from December through to April.

Flooding events have previously been recorded in surrounding coastal communities associated with cyclonic activities. A review of the Emergency Management Australia database indicated that the Collinsville region has no recorded flood damage events in the last 100 years. Flooding events are discussed in greater detail in Volume 1, Chapter 4 – Climate and Chapter 9 – Surface Water. The Local Flood Modelling Assessment is contained in Volume 2a, Appendix H and the Regional Bowen River Flood Assessment is contained in Volume 2a, Appendix I.



2.2 Land Use

The region has been utilised for beef and sugar production and gold mining since the late 1800s. Coal mining commenced in the early 1900s and, as a result, the natural landscape has undergone considerable disturbance and modification in the vicinity of coal mines. Infrastructure development, including rail and road development, has largely been associated with mining activities. Besides mining activities, the two current land uses within the vicinity of the Project area have been identified as Rainfed Broadacre Cropping and Beef Cattle Grazing.

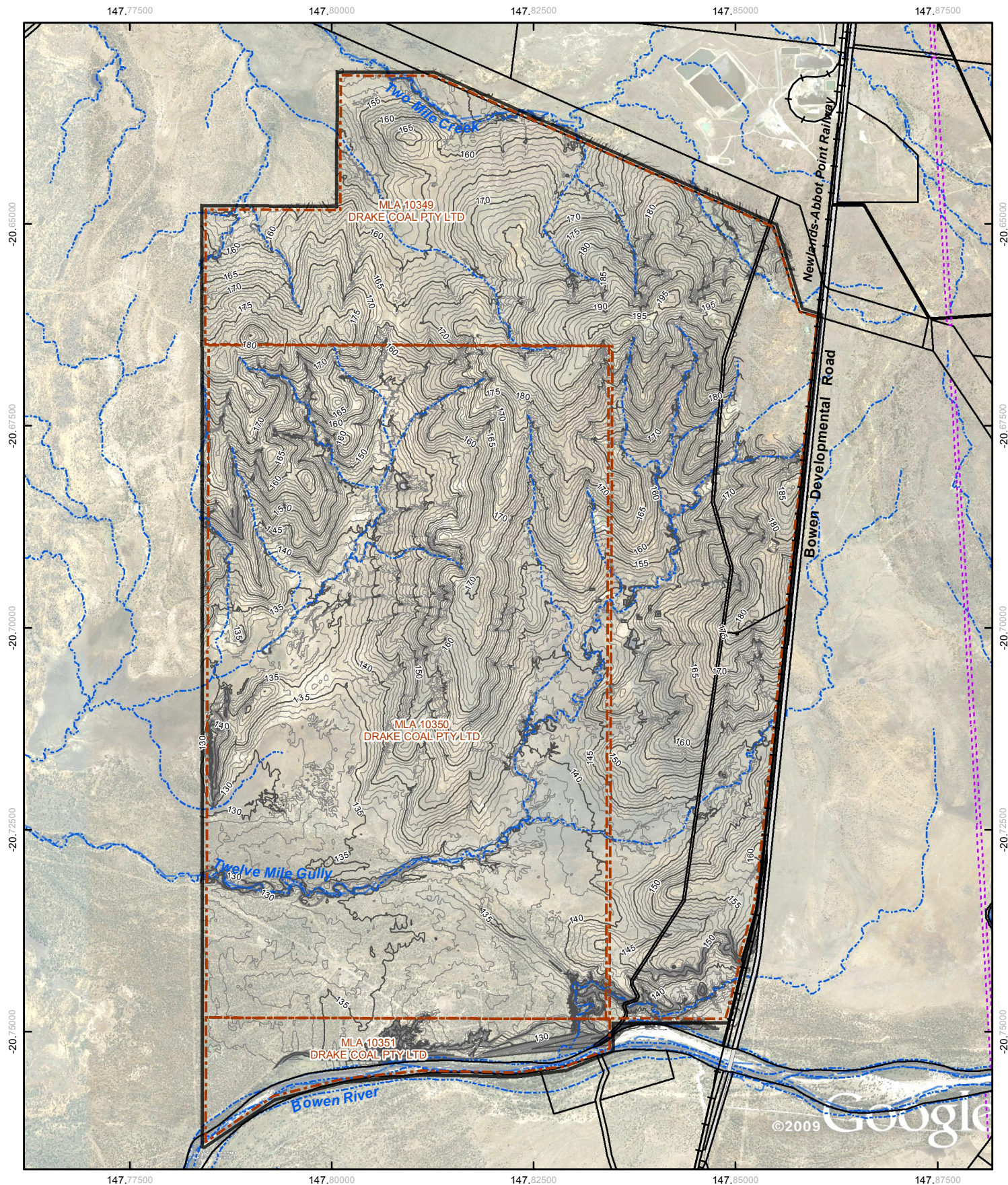
Specifically within the Project area, the land has been largely cleared for cattle grazing. However, there are areas of retained vegetation or regrowth and these remnant vegetation communities include mixed eucalypt woodlands, small areas of native grasslands and acacia shrublands.

2.3 Topography and Drainage

The Project area is characterised by flat to slightly undulating plains across its southern extent, with small hills in the northeast and northwest of the site. The relief ranges between 20 m to 70 m with elevations from 130 to 200 m AHD. The higher elevations occur in the north-eastern corner of the Project area and are associated with a hill crest. Ridge lines descend from this crested area in a radial pattern towards the south, west and north (Figure 3). The slope is $\leq 3\%$ across large areas of the site, with steeper slopes ranging from 3 to 10% in association with hills in the north-eastern section of the site. There are also small pockets of steep gullies, ridgelines and drainage features throughout the site ($\leq 50\%$).

The mining lease area falls within the Burdekin River catchment. The Burdekin River is the second largest river basin on the Queensland coast, covering approximately 130,000 km² and delivers a third of the total median annual water discharge from all coastal catchments to the Great Barrier Reef Lagoon. The four major sub-catchments that contribute to the Burdekin River Basin are the Upper Burdekin, Bellyando / Suttor, Bowen / Broken and the lower Burdekin / Coastal plains catchment. Stream flows reflect rainfall variability and seasonality, with summer flooding and an absence of flow between May and November not being uncommon (Roth et al, 2002). The Drake Coal Project area falls within the Bowen / Broken River sub-catchment area of the Burdekin River catchment and is in the jurisdiction of the Whitsundays Regional Council.

The site is intersected by several ephemeral creeks and gullies. The southern portion of the mine lease area drains into Twelve Mile Gully, which flows towards the south-west and discharges into the Bowen River. The northern part of the lease area drains into the Two Mile Creek catchment, which flows towards the north-west into Pelican Creek. Pelican Creek eventually discharges into the Bowen River approximately 28 km downstream of Twelve Mile Gully's discharge point. These streams are ephemeral in character, only flowing during and immediately after heavy rainfall.

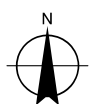


LEGEND

- | | |
|---------------------------------|-----------------------------------|
| Major Road | Project Area |
| Existing Railway | Mining Lease Application Boundary |
| Drainage Feature | Easement |
| Elevation Contour (1m Interval) | Cadastre |
| Elevation Contour (5m Interval) | |

Based on or contains data provided by the State of QLD (DERM) (2011). In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:70,000 (at A4)
0 0.5 1 1.5 2 2.5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



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Drake Coal EIS

Topography of the
Project Area

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Figure 3



2.4 Geology

The Collinsville area has a long history of coal mining with coal extraction and rail transportation to the coast commencing in the 1920s. The major coal mines of Sonoma and Collinsville are located in the area. Mining in the Collinsville area uses both open-cut and underground methods. The Project will be a greenfield open-cut mine. Exploration activities have defined a resource of approximately 200 million tonnes (Mt) of economically recoverable coal. Mining operations will produce up to 6 Mtpa product coal (10 Mtpa ROM) for export markets.

The Project area lies within the Bowen Basin sequence of early Permian to Middle Triassic marine and fluvial deposits, in which thick coal seams are present (Hutton et al., 1998). The sedimentary record shows a series of marine transgressions and regressions, with a significant proportion of the sedimentary units laid down between 299 and 251 million years ago (Permian Age). The overlying sedimentary and volcanic sequences and basalt flows were laid down during the Tertiary or during the past 65 million years (Hutton et al 1998). The Permian sedimentary rocks are dominated by clastic sediments including mudstones, siltstones, sandstones and conglomerates. Limestone and claystone are also present in the Bowen Basin Permian sedimentary sequence but generally are of limited extent. The Permian sediments are unconformably overlain by Tertiary basalt and the younger Tertiary-aged mudstones, siltstones, and sandstones (Hutton et al, 1998). A generalised stratigraphy of the Bowen Basin is provided in Figure 4.

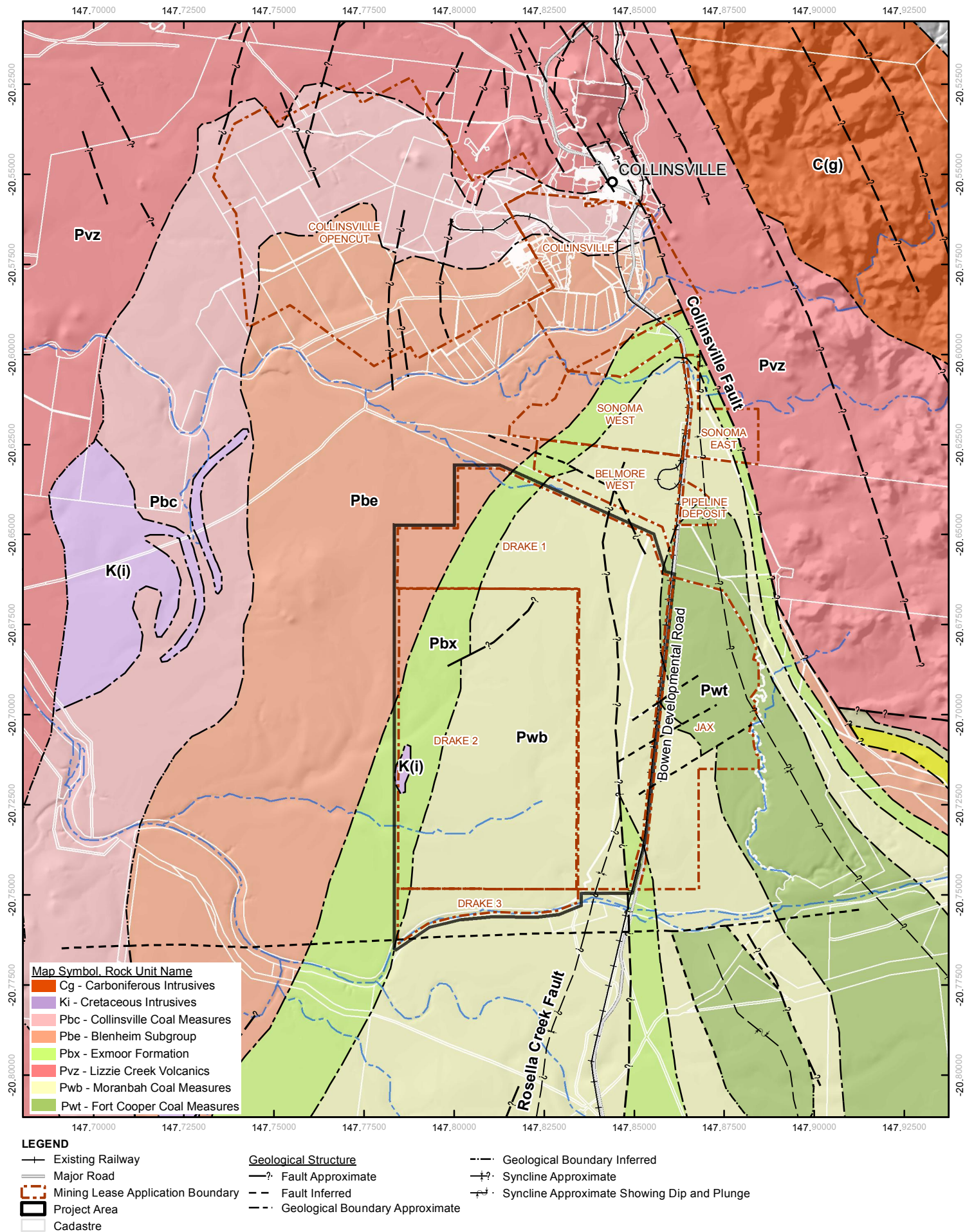
Cainozoic		Sediments & volcanic rocks; and Suttor Formation
Triassic	Rewan Group	Arcadia Formation
		Sagittarius Formation
Late Permian	Blackwater Group	Rangal Coal Measures
		Fort Cooper Coal Measures (NAF) ¹
		Moranbah Coal Measures (NAF)
	Back Creek Group	Exmoor Formation
		Blenheim Formation
Early Permian		Collinsville Coal Measures (PAF)
		Gebbe Formation
		Tiverton Formation
Late Carboniferous		Lizzie Creek Volcanics
		Bulgunnuna Volcanics

¹NAF: Non Acid Forming; PAF: Potential Acid Forming

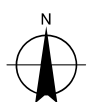
Figure 4 Generalised Stratigraphy of the Northern Bowen Basin (QCoal, 2011)



The surface geology of the Project area is dominated by the Moranbah Coal Measures, which lie in a north-south orientation and have a lithology of labile sandstones, siltstones, carbonaceous shale, coal, local cherty mudstone and occasional plant fossils (Hutton *et al*, 1998). The Moranbah Coal Measures were formed from terrestrial deposition in the late Permian. Surface geology in the west of the Project area consists of the Exmoor Formation (fine grained quartzose sandstones and siltstone) and the Blenheim subgroup (carbonaceous/micaceous quartzose sandstones and siltstone). These two formations were marine deposited and are therefore likely to contain elevated salt concentrations. These properties must be considered during mining operations as they are likely to inhibit plant growth if they are in the plant root zone. The rehabilitation landscape should be designed so that these spoil materials are buried and a more favourable material provided for plant growth. Also represented in minor areas are the Cretaceous Intrusives and Fort Cooper Coal Measures (Figure 5). Fault lines occur along the western margin (trending north-south) of the Project area. Several other fault lines, which trend northeast-southwest, occur along the western margin and in the north-east corner of the site. These fault lines (inferred and approximate locations) are shown in Figure 5.



1:150,000 (at A4)
0 0.5 1 1.5 2 2.5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



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Surface Geology

Figure 5



2.5 Coal Resources

The general stratigraphy of the Project area was assessed through desktop review of existing regional information. A detailed description of the coal resource base, exploration activities, quality and estimated volumes of coal is provided in Volume 2a, Appendix G – Waste Rock Characterisation Assessment of the EIS document. The Project area comprises the Back Creek Group basal Blenheim Formation overlain by the marine Exmoor Formation, non-marine Blackwater Group coal measures and the Tertiary sediments of the Suttor Formation and equivalents. The Blackwater Group within the Project site comprises the younger Moranbah and Fort Cooper Coal Measures.

The Lizzie Creek Volcanics (Early Permian) form the basal unit of the Bowen Basin and comprise andesitic to dacitic flows and pyroclastic rocks, conglomerate and black siltstone. These are unconformably overlain by the Collinsville Coal Measures, which comprise up to nine persistent coal seams. Depositional environments vary from initial fluvial sediments that pass up into marginal marine sandstones. Coal seams grade into carbonaceous shale to the west of Collinsville. The Collinsville Coal Measures are potentially acid forming. The Collinsville Coal Measures are conformably overlain by the Blenheim Formation (Back Creek). The Collinsville Coal Measures are not the target unit for the Project.

Overlying this Back Creek sequence is the Moranbah Coal Measures, which represents the lowermost unit of the Blackwater Group. This is the target sequence for the Project. This unit comprises cross-bedded sandstone, siltstone, mudstone, and coal. Coal seams include only minor tuffaceous and mudstone bands. In turn, the Moranbah Coal Measures are overlain by the Fort Cooper Coal Measures, which are distinguished from the former by the abundance of tuff bands and mudstone partings within coal seams. The sequence contains eight major seams (Figure 6). Historically the seams have been given the letter designations from A to R in accordance with stratigraphic order. The relatively thick, low-ash seams distinguish this unit from the overlying Fort Cooper Coal Measures. Interburden rocks consist of quartz-poor lithic sandstones, siltstone, shale, and mudstone. Some tuffs or tuffaceous mudstone bands are present in the sequence, with the P Tuff (associated with the P seam) being the most prominent.

The Fort Cooper Coal Measures comprise lithic sandstone, conglomerate, mudstone, carbonaceous shale, inferior coal and numerous tuff horizons. The Tertiary Suttor Formation rests unconformably on the underlying Permian Formations and consists predominantly of unconsolidated, fluvial and lacustrine quartz-rich sediments. Minor Tertiary volcanism in the form of volcanic sills and dykes occur in parts of the mining lease area.

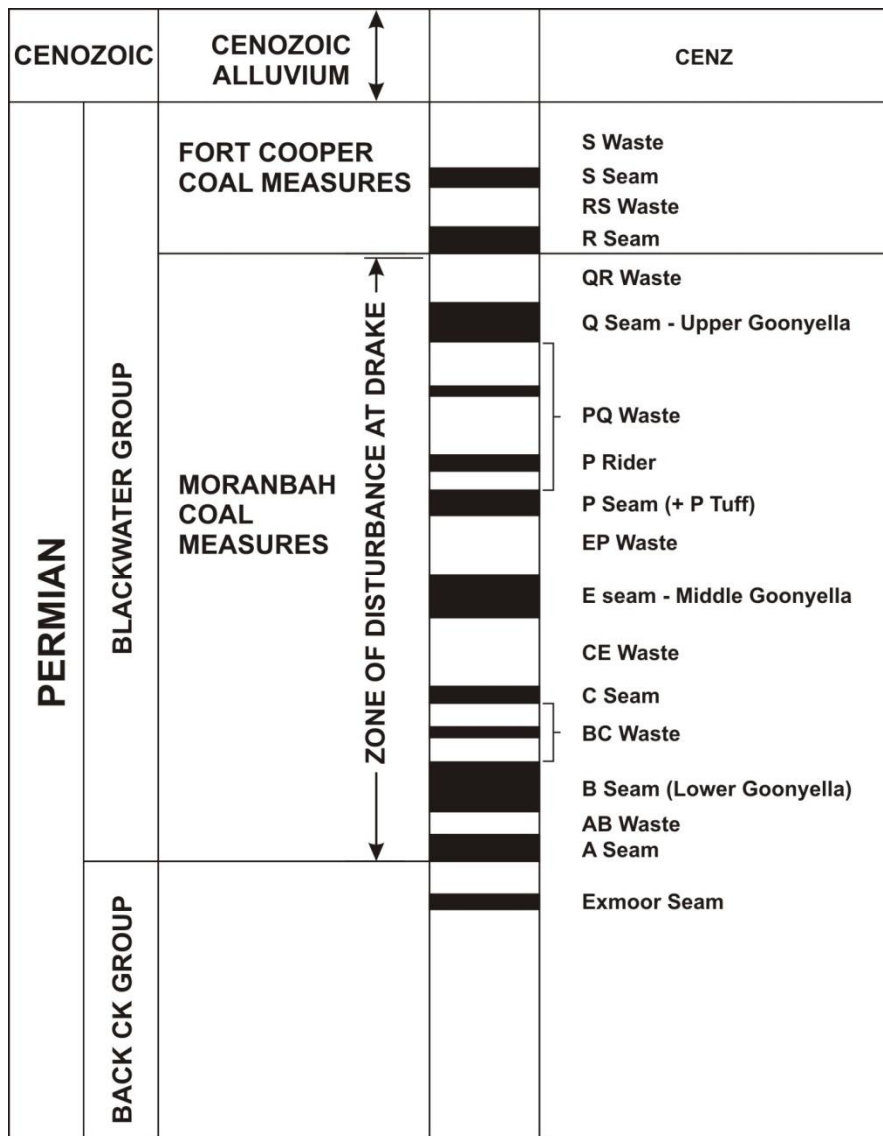


Figure 6 Coal-Seam Nomenclature – Northern Bowen Basin



3. Soil Assessment

The soil assessment provides information of the main types of soils present on the land affected by the proposed mining operations. The methodology and results are provided in the following sections.

3.1 Soil Assessment Methodology

The soil assessment was undertaken in reference to the *Guideline for Land Suitability Assessment Techniques: Section 6.1* (DME, 1995) in the following steps:

- ▶ Initial desktop review of available land resource data and preliminary mapping of the soils and terrain;
- ▶ Review of previous soil profile information collected for the neighbouring Jax and Sonoma Mine sites;
- ▶ Field survey of the site to characterise the soils and landscapes, including laboratory analysis of selected soil samples and classification of the soils in accordance with the Australian Soil Classification; and
- ▶ Mapping of the Land Resource Units based on the units of common soils, landforms, geology and vegetation communities.

3.1.1 Initial Desktop Review

Prior to the commencement of fieldwork, a review was undertaken of available information relevant to the Project area. The resources assessed included aerial photography, digital terrain data, vegetation / geology / soils maps and published reports. The following publications and databases were reviewed:

- ▶ *Soils. Burdekin-Townsville region.* Queensland Resources Series. Department of National Development (DND, 1970);
- ▶ *Land suitability study of the Collinsville-Nebo-Moranbah region.* Queensland Department of Primary Industries (DPI, 1984);
- ▶ *Soil fertility of Central and North-east Queensland Grazing Lands.* Queensland Department of Primary Industries. (DPI, 1994);
- ▶ *Birrilee* (EPC 586) Ecological assessment (ERM, 2007);
- ▶ Combined Soils Data published by the Queensland Department of Environmental and Resource Management (various years);
- ▶ *Appendix 4 Soils Report* (QCoal, 2010); and
- ▶ Regional Ecosystem mapping of Queensland published by the Queensland Department of Environmental and Resource Management.

Information from the desktop review was used to develop initial site maps that broadly identified landform and expected soil patterns. The initial mapping was refined through field study so the soil groups could be further characterised and delineated.



3.1.2 Field Survey Method

The field survey methodology was developed based on the *Guideline for Land Suitability Assessment* (DME, 1995) and the findings of the desktop review and existing regional information. Onsite survey locations were identified from the preliminary land unit map and field investigations were undertaken to confirm soil characterisation at a mapping scale of 1:50,000.

Onsite Soil Survey

Two soil surveys were undertaken within the Project area. The first was undertaken between 17 and 19 November 2009 and the second survey between 30 November and 3 December 2011. A total of 176 ground observation locations were recorded for the 9,196 ha Project area. Detailed soil profile descriptions were undertaken at 53 of these sites. The observation density required by DERM and current guidelines is one site described for every 25 ha of land within the mining area. Consequently, the total disturbance area of 3,442 ha for the Project requires soils to be described from at least 137 sites, with at least 34 of those sites to be described in detail. The number of sites in pit and spoil dump areas is required to be higher than 137 because, taken individually, the smaller pit and dump areas would require additional sites above the absolute minimum in order to provide a statistically valid number of samples; and the guideline states that sampling should be done at a larger scale for disturbance areas. The observation density is greater than one per 52.25 ha which is within the recommended and minimum acceptable range of 1 per 25 ha to 1 to 100 ha in the 1: 50,000 scale mapping.

The techniques used for soil surveying included:

- ▶ *Ground observations* were carried out to determine the broad distribution of soil landscapes across the Project area. These *ground observations* were conducted at 16 locations (GO-#) in November 2009 and at 158 locations (G-#) in November-December 2011. At each location, details were recorded regarding:
 - Landform, vegetation, land surface, and the soil to at least the top of the C horizon¹. Where existing vertical profiles were present, the full soil subsoil profile was described;
 - Erosion, including type (sheet, rill, gully, scald, wind or tunnel) and activity (active, stabilised, partially stabilised) were recorded; and
 - Photographs were taken at all observation sites;
- ▶ *Soil profile descriptions* of each major soil type across the study area was undertaken to provide a detailed characterisation of the main soil landscape units over the site.
 - For descriptions undertaken in November 2009, a backhoe was used to excavate test pits (TP-#) at 3 locations to approximately 1.5 metres Below Ground Surface (mBGS) to allow profile descriptions and sample collection:
 - For each test pit, details were recorded regarding horizon thickness, colour, texture, structure, field pH and roots;
 - Topsoil was collected from the surface 0 - 0.1 mBGS. The sample was a composite of soil obtained from 10 to 20 points within a 10 m radius of the test pit. These point samples were bulked, thoroughly mixed and retained for laboratory analysis. Composite sampling was

¹ The term 'horizon' describes each of the distinctive layers that occur in a soil. The A horizon: Surface soil: Layer of mineral soil with most organic matter accumulation and soil life. The B horizon: Subsoil: This layer accumulates iron, clay, aluminum and organic compounds. The C horizon: Parent Rock: Layer of big unbroken rocks.



- used to reduce the likelihood of a hot spot concentration being detected and to provide a result that was representative of the topsoil in the vicinity of the test pit; and
- Subsequent discrete samples from the soil profile were collected at depths approximating 0.2-0.3, 0.5-0.6, 0.8-0.9 and 1.1-1.2 mBGS to characterise the physical and chemical properties of the soil;
 - In November-December 2011, soil descriptions were recorded from 50 soil cores obtained using a vehicle mounted hydraulic corer (50mm diameter) to a depth of approximately 1.5 mBGS or until refusal on weathered rock:
 - Details were noted regarding horizon thickness, colour, texture, structure, field pH and roots; and
 - Topsoil was sampled from the surface soil (between approximately 0.0 to 0.1 mBGS), as per the 2009 procedure. Subsequent samples were obtained at regular intervals from the soil horizons encountered to a maximum depth of 1.5 mBGS. Selected samples were submitted for analysis to characterise the physical and chemical properties of the soil.

Soil observations obtained during a geotechnical investigation (Ground Environments Pty Ltd, 2010), of the south-east portion of the site provided supporting documentation of soil characteristics and are described in the Desktop Review section (Section 3.2.1).

3.1.3 Laboratory Analysis

To determine the chemical properties for each identified soil landscape unit, soil samples were submitted to analytical laboratories for analysis. Samples obtained during fieldwork conducted in 2009 were submitted to Phosyn Analytical (Andrews, Queensland)² and samples from 2011 were submitted to Nutrient Advantage Laboratory Services (Werribee, Victoria)³. All samples submitted were analysed for pH, salinity, and sodicity parameters, whilst topsoil samples were additionally analysed for fertility parameters (refer to Table 3). A brief description of the relevance of the chemical analyses to soil salinity, soil sodicity and soil dispersion and other soil characteristics are discussed below and guidelines are provided in Appendix D.

Table 3 Soil Analytical Parameters Assessed

Horizon	Analytes
Topsoil	▶ fertility (nitrogen*, phosphorous*, and potassium), organic matter, trace elements (copper, zinc, manganese, and iron), sulfate and boron* ▶ pH* and electrical conductivity (EC), exchangeable cations* (calcium*, magnesium*, sodium*, potassium* & aluminium*) ▶ calculations of exchangeable sodium percentage (ESP) ratio (% sodium of total cations), effective cation exchange capacity (ECEC), and calcium to magnesium ratio (Ca:Mg)
Subsoil	▶ pH* and electrical conductivity (EC), exchangeable cations* (calcium*, magnesium*, sodium*, potassium* & aluminium*) ▶ calculations of exchangeable sodium percentage (ESP) ratio (% sodium of total cations), effective cation exchange capacity (ECEC), and calcium to magnesium ratio (Ca:Mg) ▶ Emerson Aggregate Testing (EAT) on selected samples

Notes: * indicates the Phosyn Analytical laboratory is ASPAC certified for these analyses.

² Phosyn Analytical is certified by the Australasian Soil and Plant Analysis Council (ASPAC) for selected analytes. These analytes are identified in Table 3. Phosyn Analytical is not NATA (National Association of Testing Authorities) accredited.

³ Nutrient Advantage Laboratory is a NATA accredited laboratory.



Soil pH

Soil pH is a determination of the hydrogen ion activity in solution and measures the intensity of the acidity or alkalinity within the soil matrix. For most plants the optimal $pH_{w1:5}$ in soil ranges between 5.5 and 8.5. Outside of this range plant growth tends to be retarded mostly due to changes in the soil chemistry resulting in nutrients and micronutrients becoming either unavailable or toxic to plants.

Soil Salinity

Soil salinity refers to the presence of water soluble salts in water or soils. The most common base for salts is sodium however; potassium, calcium and magnesium cations can also contribute appreciably to salinity. Salts of these cations may be present as chlorides, sulfates or carbonates. The electrical conductivity (EC) from a soil / water suspension (1:5) is commonly used as a measure of salinity in soil.

The relationship between EC and salinity is largely dependent upon the soil texture, in particular clay content of the soil. Where soils have higher clay content, this can reduce the effect of salinity on plants as the strong electronic bonds that exist between particles in clay soils tend to negate the effect of salinity.

Soil Sodicity and Dispersion

A soil is considered sodic when sodium reaches a concentration where it starts to affect soil structure. In Australian soils this is common when the exchangeable sodium percentage (ESP) is greater than 6% (Isbell, *et al* 1983). When sodic soils are wet the sodium weakens the bonds between soil particles, resulting in clay swelling causing slaking or dispersion (Rengasamy and Walters, 1994).

Slaking refers to the rapid disintegration of large aggregates (2 mm to 5 mm diameter) of soil into finer aggregates (i.e. less than 0.25 mm) when wet and is caused primarily by a lack of strong organic particles and micro aggregates. This changes the macroscopic structure of the soil resulting in loss of macropores and alters the porosity and permeability throughout the soil profile.

Dispersion is a second process of structural breakdown and is caused by either high levels of exchangeable sodium or by excessive mechanical disturbance of a soil, particularly when wet. When dispersive soils are wet, aggregates of clay, silt and sand breakdown with individual clay particles going into suspension. Such dispersion may occur in sodic soils without any disturbance at all. The dispersed clay particles can be easily moved by water or wind and can migrate through the soil clogging soil pores and reducing infiltration and drainage and causing higher run-off. This may lead to a range of problems including high erosion rates, water pollution, tunnel formation, reduced workability, difficulty with vegetation establishment, and reduced vegetation growth due to low water holding capacity and root penetration (Raine and Loch, 2003).

All soil samples were analysed for exchangeable cation concentrations. This allowed for the calculations of cation exchange capacity (CEC), ESP, and calcium / magnesium ratios. The calcium/magnesium ratio may be used to produce an indication of dispersion potential. Soils that are high in sodium and magnesium tend to show more dispersion than soils that are high in sodium and calcium (Hazelton and Murphy, 2007). The potential for dispersion may be increased in soils with calcium / magnesium ratios that are less than 1 to 2.



On select samples, Emerson Aggregate Tests (EAT) were conducted to access aggregate stabilities and dispersion. The Emerson Crumb test categorises soils into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. The Emerson Crumb test may only be used as a general guide to sodicity and aggregate stability as there are a large number of factors that determine if slaking or dispersion occurs such as sodicity, salinity, clay type, history of working and speed of wetting (Hazelton and Murphy, 2007).

Soil Fertility

Nutrient availability is one of the major environmental variables affecting competitive balance between plant species and therefore species composition and richness change. Nutrient requirements vary between different plant species, and these may vary quite markedly even in the same community. A general range of some elements within which normal plant growth may be expected is presented in Appendix D. It is important to note that this range of normal plant growth is only a guide and some communities, such as native Australian communities which developed on generally infertile soils, require specific conditions outside this range.

3.2 Soil Assessment Results

3.2.1 Initial Desktop Review Results

Burdekin-Townsville Resource Series (Isbell and Murtha, 1970)

A review of the Burdekin-Townsville Resource Series (Isbell and Murtha, 1970) identified three dominant soil types mapped in the Project area. These soil types are described using the Northcote Factual Key (Northcote, 1979) and are summarised in Table 4. In Australian Soil Classification, CB7 is equivalent to Grey Vertosols, Oa9 and Gb27 are mainly Red or Brown Chromosols or Sodosols.

Table 4 Burdekin – Townsville Resource Series, Soils (1:1,000,000)

Code	Landform	Dominant Soil	Soil Type	General Description	Subsoil
CB7	Moderate to undulating plains with very broad valleys	Ug5.22	Fine cracking, smooth faced peds, grey clay horizon underlain by weathered rock before 1.5m	Grey self-mulching cracking clays. Usually pronounced gilgai.	Ug5.32 Ug5.25 Ug5.16 Ug5.15 Ug5.24 Ug5.37 Dr2.13 Dr2.12 Dy2.13 Db1.13 Db1.33 Dd1.33 Dy2.33 Uf6.3
Oa9	Undulating lands with broad rounded ridge crests & wide shallow valleys. Some rock outcrop on higher ridges	Dr2.13	Duplex red, hard setting A horizon, no A2 horizon, alkaline pedal whole column B horizon	Hard pedal red duplex soils	Dr2.22 Dr2.23 Gn3.12 Db1.12 Db1.13 Ug5.22 Ug5.32 Ug5.14 Dy2.43
Qb27	Gently undulating alluvial flood-plains often with marked terraces levees & shallow drainage depressions	Dr2.22	Duplex red, hard setting A horizon, A2 horizon non-bleached, neutral pedal whole column B horizon	Hard pedal red duplex soils	Dr4.22 Dy2.22 Dy2.33 Dy3.33 Db1.13 Dr2.23 Dy2.43 Dy3.43 Um6.11



Published Land Resource and Soil Survey Reports

A review of the remaining published soil survey literature (listed in Section 3.1.1) identified the following soils in the vicinity of the Project area. These are described using the Australian Soil Classification.

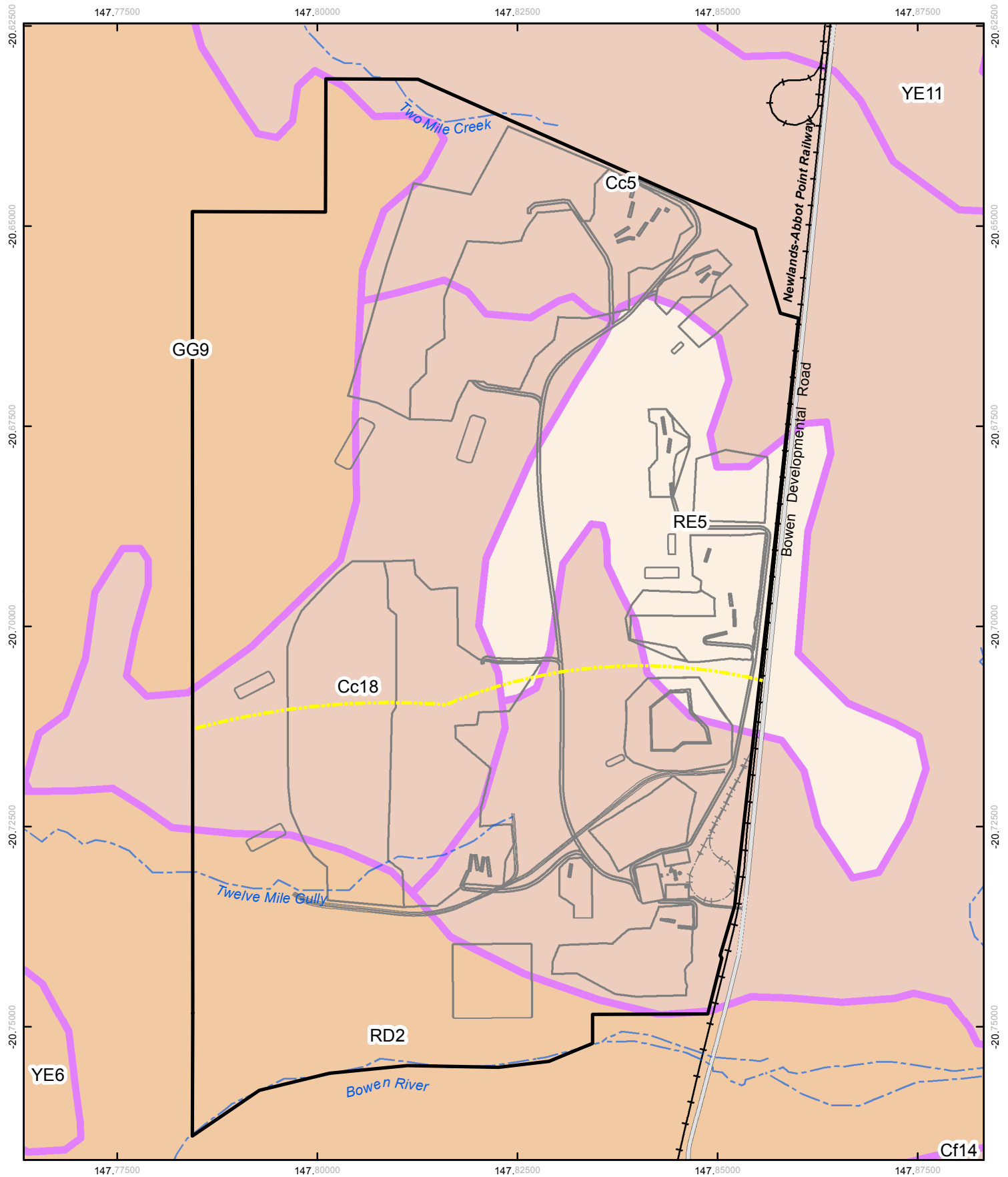
- ▶ Vertosols on level to moderately undulating plains and some on strongly undulating rises. This includes lands with Vertosols with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and / or lenticular structural aggregates. The Vertosols in this area are reported to be deep, structured, self-mulching, cracking clay soils that exhibit microrelief of gilgai and melon holes. This soil information corresponds to the CB7 soil identified in the Burdenkin-Townsville Resource Series. The underlying geology consists of sedimentary rocks and associated unconsolidated sediments. The vegetation is either:
 - Mitchell and Queensland bluegrass grasslands containing a high proportion of black speargrass with isolated trees and gidgee, brigalow and blackwood scrub on plains; and
 - Open woodlands dominated by mountain coolibah, gum-topped bloodwood, inland bloodwood and cabbage gum.
- ▶ Dermosols on moderately undulating to strongly undulating rises. The soils are structured and have a gradual increase in clay content with depth. In this study area they are shallow to moderately deep overlying sedimentary rocks. Vegetation is Eucalypt open woodlands with Queensland grey ironbark, mountain coolibah, gum-topped bloodwood and cabbage gum, with Black speargrass pastures grading to Queensland bluegrass pastures; and
- ▶ Sodosols on level plains to strongly undulating rises and high hills. Sodosols are soils with a strong texture contrast between A horizons and sodic B horizons which are not strongly acidic. The soils in the area are reported as being yellow and grey duplex soils with sodic subsoils overlying sedimentary rocks and associated unconsolidated sediments. Vegetation is Eucalypt woodlands and open woodlands dominated by Queensland grey ironbark, narrow-leaved ironbark, silver-leaved ironbark, Reid River box, poplar box, poplar gum and other box trees, with black speargrass pastures.

Soil Survey of the Sonoma Project (GSS, 2005)

A detailed soils survey by GSS (2005) on the Sonoma Coal Project located immediately north of the Project area, was completed as part of the Sonoma EIS process. This survey found that grey uniform clays dominated the lease area. These soils are characterised by a self-mulching, grey, medium clay surface horizon grading to a heavier textured grey-brown clay horizon and eventually to brown clay. On the eastern and southern extremities of the Sonoma mining leases, red duplex sandy loam was identified. These duplex soils are characterised by a reddish-brown clay loam near the surface grading to yellow-red, medium clay subsoils. At depth, the medium clay subsoil grades into weathered sandstone.

Geotechnical Investigation Report (Ground Environments, 2010)

Existing soil information for the south-east corner of the site (around the proposed rail loop) and the adjacent land to the east was available from the Geotechnical Investigation Report (Ground Environments Pty Ltd, 2010).

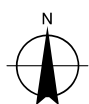
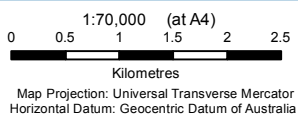


LEGEND

- Major Road
- Existing Railway
- Drainage Feature
- Irrigation within 5km of Bowen River
- Project Area
- Mine Layout
- Soil Code (Burdekin-Townsville Region)
- QLD Combined Soils (1:2M scale)
 - Dermosols
 - Sodosols
 - Vertosols

Refer to report for detailed description of
Soil Codes for the Burdekin-Townsville Region

Cc5	GG9
RD2	RE5
YE6	YE11

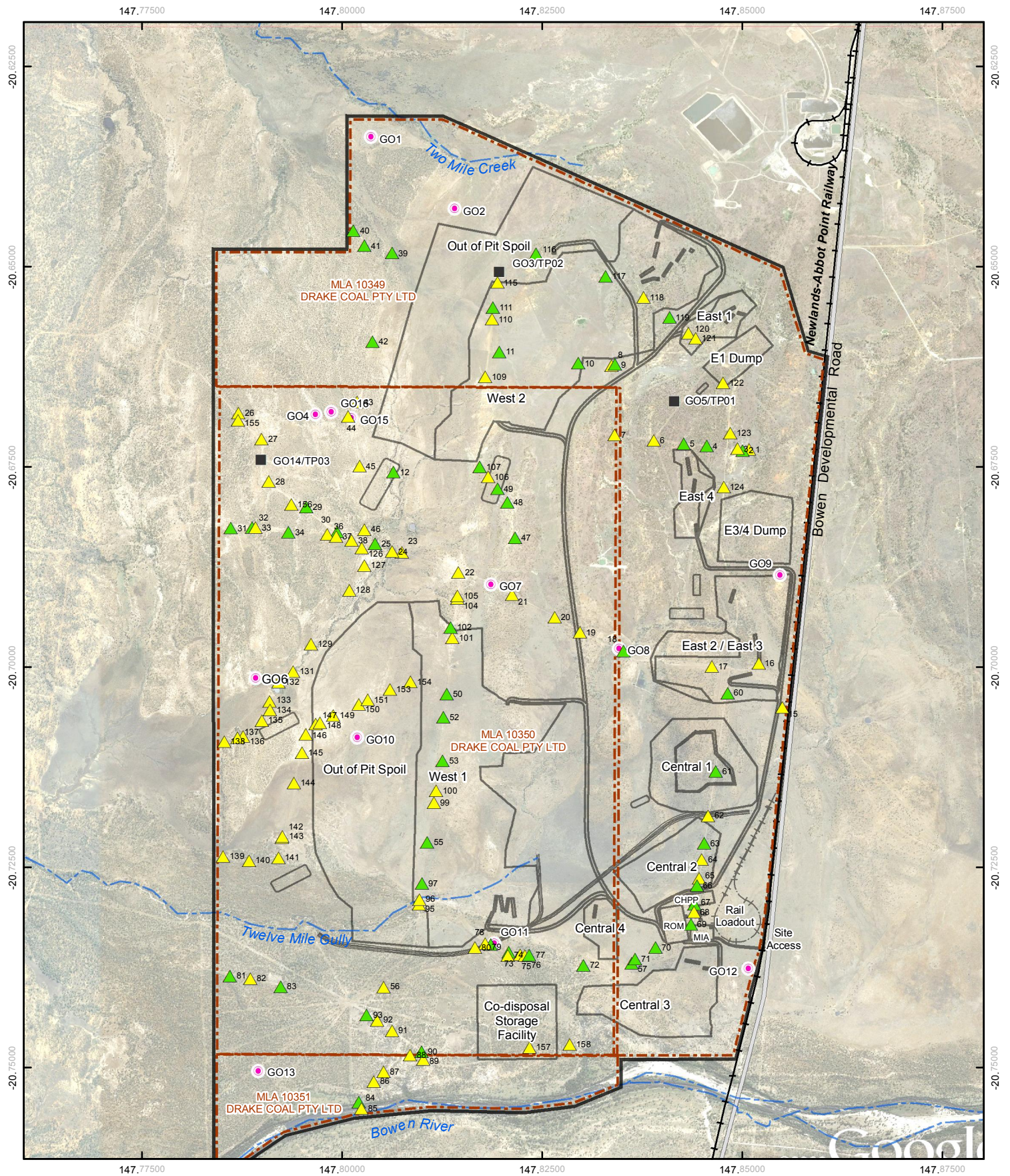


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Soil Groups in the Proposed Project Area (DND, 1970)

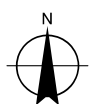
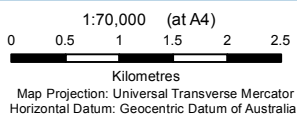
Figure 7



LEGEND

- Soil Profile
- Major Road
- Project Area
- Ground Observation
- Existing Railway
- Mining Lease Application Boundary
- Sample Locations (GSS)
- Drainage Feature
- Mine Layout
- Core Location
- Ground Observation

Based on or contains data provided by the State of QLD (DERM) [2011]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.



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Soil Sampling and Observation Locations

Figure 8



3.2.2 Overview of the Dominant Soil Orders

The soil survey undertaken on the Project area in November 2009 and November-December 2011 identified five soil orders across the site: Vertosols; Dermosols; Sodosols; Tenosols and Rudosols. A summary of the Land Unit characteristics are provided in Table 5 and an overview of the observation locations for each Land Unit are provided in Table 6. Detailed descriptions of the ground observations and soil profiles are included in Appendix A and Appendix B, respectively. The complete laboratory analysis results and certificates of analysis are included in Appendix C and soil interpretation criteria are presented in Appendix D.

Table 5 Summary of the Land Unit Characteristics

Land Unit	Slope	Dominant Vegetation	Soils
LU1 (2,531 ha)	<3%	Cleared for pasture with grasses remaining (Rhodes and buffel grass)	Vertosols: medium clay with high plasticity A horizon to 0.15 mBGS over mottled grey high plasticity clay subsoil to 1.5 mBGS
LU2 (852 ha)	3% to 5%	Cleared for pasture with grasses remaining (Rhodes and buffel grass)	Vertosols: medium clay with high plasticity A horizon to 0.15 mBGS over mottled grey high plasticity clay subsoil to weathered rock at approximately 0.7 to 1.0 mBGS
LU3 (1,567 ha)	3% to 10%	Open eucalypt woodland	Sodosols: acidic loamy sand A horizon to 0.3 mBGS over a highly sodic sandy clay loam subsoil to between 0.8 and 1.5 mBGS
LU4 (1,487 ha)	<3%	Open acacia woodland (<i>A. harpophylla</i>) and Open eucalypt woodland	Sodosols and Rudosols: slightly acidic sandy or sandy loam topsoil to 0.3 mBGS over a light clay (or sand in the Rudosol) subsoil
LU5 (2,324 ha)	3% to 10%	Open eucalypt woodland (<i>E. crebra</i>)	Dermosols and Vertosols: slightly acidic to slightly alkaline sandy clay and loamy clay A horizons to 0.1 mBGS over a non-sodic medium to heavy clay subsoil
LU6 (435 ha)	<3%	Open eucalypt woodland	Rudosols and Tenosols: alluvial soils associated with intermittent creek flow deposition or in the immediate vicinity of the Bowen River.

Based on the soil survey and laboratory results, areas with common landform, vegetation communities, geology and soils were grouped into Land Units. The 9,196 ha study area was divided into six separate Land Units that are described above and presented in Figure 9.

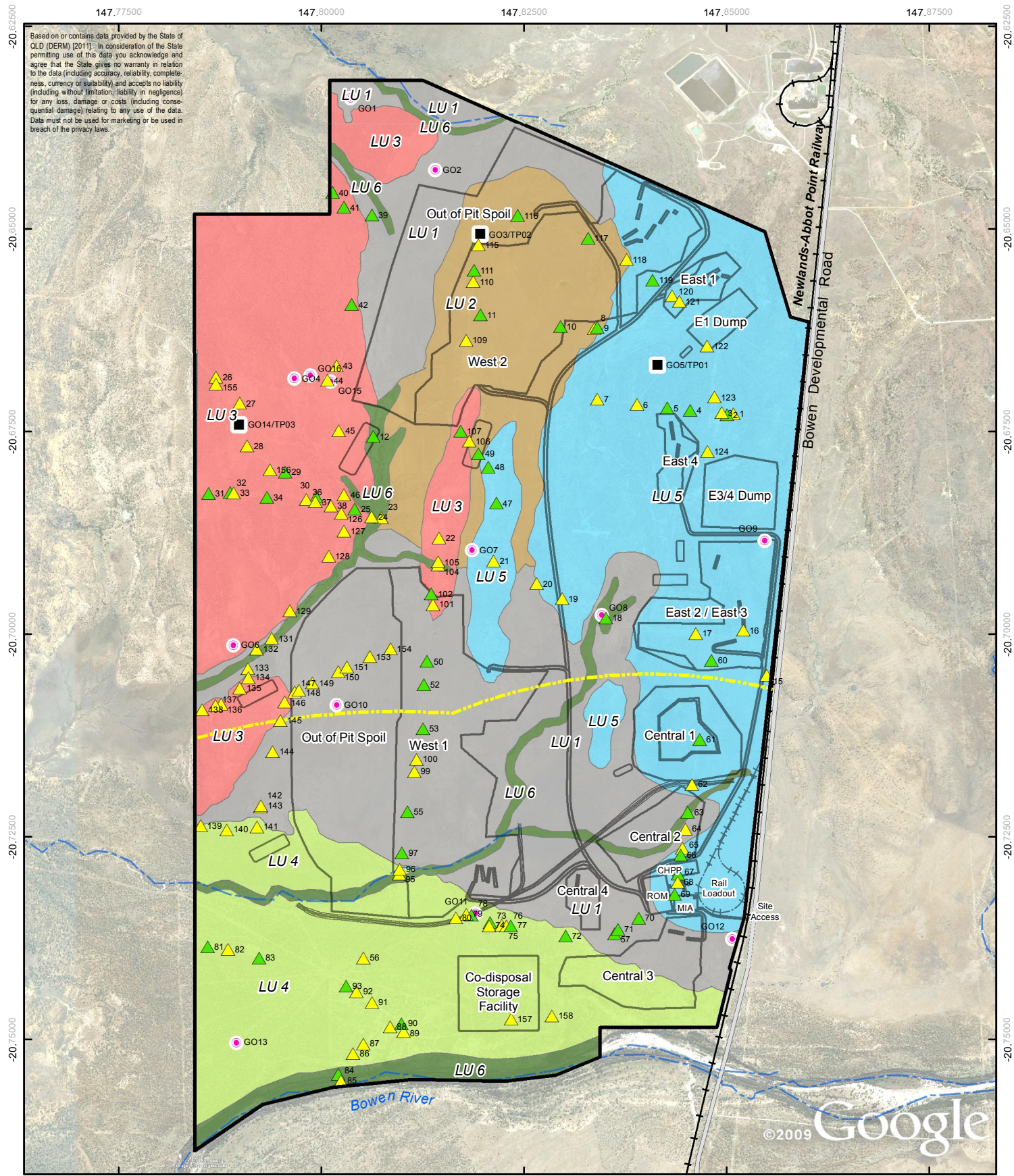


Table 6 Summary of the Observation Locations per Land Unit

Land Unit	Ground Observation Locations (G#)	Soil Profile Description Locations (G#)
LU1	GO1, GO2, GO8, GO10, GO12, 20, 64a, 64b, 99, 100, 133, 142a, 142b, 143, 144, 145, 147, 148, 149, 150, 151, 153, 154	39(C15), 50(C22), 52(C23), 53(C24), 55(C25), 57(C27), 70(C33), 71(C34), 97(44)
LU2	GO3, 8, 106, 109, 110, 115, 118	TP02, 10(C5), 11(C6), 49(C21), 111(C47), 116(C48), 117(C49)
LU3	GO4, GO6, GO14, GO15, GO16, 22, 26, 27, 28, 32a, 32b, 33, 36, 37, 38, 43, 44a, 44b, 45, 46, 101, 105, 126, 127, 128, 129, 134a, 134b, 135a, 135b, 136, 137, 138, 146, 155, 156	TP03, 25(C9), 29(C10), 30(CC), 31(C12), 32(C13), 34(C14), 40(C16), 41(C17), 42(C18), 102(C45), 107(C46)
LU4	GO11, GO13, 56, 74, 75, 76, 79, 80, 82, 86, 87, 88, 89, 91, 92, 95a, 95b, 96, 139, 140, 141, 157, 158	72(C35), 73(C36), 77(C37), 78(C38), 81(C39), 83(C40), 90(C42), 93(C43)
LU5	GO5, GO7, GO9, 1a, 1b, 1c, 3, 6, 7, 9a, 9b, 15, 16, 17, 19, 21, 60a, 60b, 62, 65, 68, 120, 121, 122, 123, 124	TP01, 2(C1), 4(C2), 5(C3), 9(C4), 47(C19), 48(C20), 60(C28), 61(C29), 66(C30), 67(C31), 69(C32), 119(C50)
LU6	23, 24, 85, 104, 131, 132, 157, 158	12(C7), 18(C8), 63(C26), 84(C41)
Sub Total	123	53
Total	176	

Ground Observation Locations – no soil core extracted.

Soil Profile Description Locations – the core identification number is location in the bracket. All November-December 2011 locations were numbered numerically therefore an observation location may coincide with a core e.g. 25(C9) this being the 25th sample location/observation point, and the 9th soil core.



LEGEND

GHD Surveys

● Ground Observation

■ Soil Profile

Sample Locations (GSS)

▲ Core Location

▲ Ground Observation

--- Irrigation within 5km of Bowen River

--- Drainage Feature

--- Major Road

--- Existing Railway

■ Project Area

■ Mine Layout

Land Unit, Dominant Soil

■ LU 1, Vertosols on low lying areas

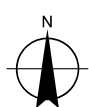
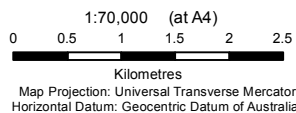
■ LU 2, Vertosols on undulating terrain

■ LU 3, Sodosols on undulating terrain

■ LU 4, Sodosols on flood plain

■ LU 5, Dermosols and Vertosols on undulating terrain

■ LU 6, Tenosols & Rudosols on intermittent or permanent watercourses



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Land Units and Dominant Soils

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Figure 9



3.2.3 Land Unit 1: Vertosols on Low Lying Areas

These areas have the very distinctive cracking clays (Vertosols). The local relief of this Land Unit is relatively gentle, lying between 130 and 150 m AHD, with level to gently inclined slopes less than 3%. The vegetation type is predominantly grasslands consisting of rhodes and buffel grasses with brigalow (*Acacia harpophylla*), whitewood (*Atalaya hemiglauca*), bauhinia (*Lysiphyllum carronii*) and bloodwoods also present.

Soil Overview

These soils have shrink swell properties and exhibit strong cracking when dry and gilgai formations were observed in some areas (for example, G143 and G144). At depth, slickensides and/or lenticular structural aggregates are present. The soils have a neutral to moderately alkaline pH at the surface and become moderately to strongly alkaline with depth. These pH units are not expected to limit plant growth. The soil chemistry summary for profiles described within this Land Unit is provided in Table 7 and Table 8. Photographs of the land unit are provided in Plates 1 and 2. Ground observations and test pits described within this land unit are summarised in Table 6.

Soil Salinity

The salinity is low in the A1 horizon (0 to 0.15 mBGS) and the B21 horizon (0.15 to 0.3 mBGS). However, the salinity increases throughout the B horizon, although it is highly variable between samples. The highest salinity at 1.1 to 1.5 mBGS ranges from medium to very high level (0.48 to 1.53 dS/m). Some of the soils in LU1 will only be suitable for very high salinity tolerant crops.

Soil Stability

The soils are sodic at depths below approximately 0.3 mBGS. They are susceptible to slaking and may disperse after being worked when wet and become extremely susceptible to erosion. The main evidence of erosion was noted adjacent to drainage lines; however this was observed to be either 'partially stabilised' or 'stabilised'.

Fertility

Analytical results indicated that surface soil nitrate is low to medium. Phosphorus concentrations were low to very high. Some soils in LU1 may be limiting for crop or improved pasture growth, but are in the range suitable for native species growth. Soil aluminium is the dominant cation accounting for about 50% of the CEC. It is approaching the limit of 60% aluminium saturation which can be toxic to plants. These soils have a relatively high CEC and calcium dominates the Ca:Mg ratio, thus mitigating some of the potentially dispersive ESP. They also have a high water storage capacity and will readily support the germination and growth of native grasses and trees.

Distribution

This Land Unit is located on the central portion of the Project area and covers approximately 28% (2,531 ha) of the site. Proposed development associated with the Project that is likely to be located on this Land Unit is the majority of "West 1" and associated out of pit spoil, a portion of "West 2" and associated out of pit spoil, "Central 2", a portion of "Central 3", "Central 4" and the north-south haul road.

Management

The soil that is recommended for stripping from this land unit is located in horizon A1 (0 – 0.15m), if required for post mining rehabilitation activities. If the rehabilitation plan involves the planting of improved pasture, the soil will need to be amended with fertiliser.

Additional soil from the subsoil (i.e. the upper B21 horizon 0.15 –0.3 mBGS) may also be stripped if required, due to the low salinity and non-sodic properties of this layer. However, the subsoil is considered to be 'marginal' due to the absence of seed stores, reduced nutrient supply and low organic matter content. Therefore, it should only be used in place of topsoil if no other options are available. It will require additional amendment prior to use.



Plate 1 Vertosols on Low Lying Areas



Plate 2 Shrink Swell Properties of Vertosols



Table 7 LU1 Soil Analytical Results Summary

Horizon	Approximate Depth (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content	Salinity Rating	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio
A1	0 – 0.15	7.4 – 8.5	Mildly to moderately alkaine	0.88 – 0.22	Medium clay	45 – 55	Low	0.4 – 1.8	36.7 – 65.4	3.0 – 7.3
B21	0.15 - 0.30	8.5 – 8.9	Strongly alkaline	0.15 – 0.19	Heavy clay	49 - 58	Low	1.4 – 13.5	37.2 – 68.2	5.0 – 5.8
B21	0.30 – 0.70	8.5 – 9.2	Strong to very strongly alkaline	0.16 – 0.47	Heavy clay	45 – 55	Low – Medium	2.2 – 13.5	38.4 – 69.3	2.2 – 5.2
B22	0.70 – 1.10	8.8 – 9.1	Strongly to very strongly alkaine	0.48 – 1.38	Heavy clay	48 - 65	Medium – Very high	2.2 – 22.3	41.3 – 69.5	1.9 – 5.7
B23	1.10 – 1.50	8.0 – 8.9	Strongly alkaline	0.48 – 1.53	Heavy clay	46 - 58	Medium - Extreme	29.2	34.3	1.6

Table 8 Surface Soil (0 - 0.10 mBGS) Fertility for LU1

Analyte	Soil Concentration	Range Below Which Plant Deficiencies Have Been Recorded*	Range Above Which Plant Toxicities Have Been Recorded*
Organic Matter	1.9 – 4.0%	-	-
Nitrate (Total Nitrogen)	8.5 mg kg ⁻¹ (0.07 – 0.22%)	20-60 mg kg ⁻¹	-
Phosphorus	8.0 – 52.0 mg kg ⁻¹	10 - 30 mg kg ⁻¹	-
Potassium	0.2 – 0.6 meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	7.88 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	27.66 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Aluminium	25.0 mg kg ⁻¹	-	> 3 mg kg ⁻¹
Sulfate	3.4 - 11.0 mg kg ⁻¹	-	-
Boron	0.73 – 1.1 mg kg ⁻¹	-	-
Copper	0.56 – 1.7 mg kg ⁻¹	-	-
Iron	11 – 26 mg kg ⁻¹	-	-
Manganese	3.4 – 17 mg kg ⁻¹	-	-
Zinc	0.14 – 0.69 mg kg ⁻¹	-	-
Chloride	22 mg kg ⁻¹	-	200 – 600 mg kg ⁻¹ †

Notes: * refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D
 † indicates that at concentrations above this range, plant growth can be retarded.



3.2.4 Land Unit 2: Vertosols on Undulating Terrain

These Vertisol areas occur on gently to moderately inclined slopes between 3% and 10%, with elevations between 160 m and 200 m AHD. The vegetation cover is largely grasslands consisting of rhodes and buffel grasses with brigalow (*Acacia harpophylla*) and Mountain Coolibah (*Eucalyptus orgadophila*) communities present.

Soil Overview

These soils have shrink swell properties and exhibit strong cracking when dry and gilgai formations were observed in some areas (for example, G9 and G10). At depth, slickensides and/or lenticular structural aggregates are present. The A1 horizon is typically of medium clay with high plasticity to 0.15 mBGS over high plasticity clay subsoil. Weathered rock was generally encountered in these profiles at depths of between 0.7 m and 1.0 mBGS. The soils have a neutral to moderately alkaline pH at the surface and become strongly alkaline with depth. The pH is not expected to limit plant growth. The soil chemistry summary for profiles described within this land unit is provided in Table 9 and Table 10. Photographs of this land unit are shown in Plates 3 and 4. Ground observations and test pits described within this land unit are summarised in Table 6.

Soil Salinity

The salinity is low in the A1 horizon (0 to 0.15 mBGS). The B21 and B22 horizons (0.15 to 0.6 mBGS). However, the salinity increases from medium to high below the B22 horizon. Root development is expected to be limited with increasing depth due to salinity, sodicity, and the presence of weathered rock. This was supported by field observations where roots were not recorded below depths of between 0.6 m and 1.1 mBGS.

Soil Stability

Field observations indicated minor water erosion on this land unit. The main evidence of sheet erosion was observed where soil was removed from around the bases of the tussocking grasses. However, erosion activity is currently stabilised. The subsoils are sodic at depths below approximately 0.6 mBGS and are therefore susceptible to slaking and may disperse after being worked when wet. They have a low erodibility rating when left insitu.

Fertility

Analytical results indicated that surface soil nitrate and phosphorus concentrations were low and may be limiting for crop or improved pasture growth, but are in the range suitable for native species growth. However, the low fertility can be readily ameliorated with appropriate fertilisers. These soils have a relatively high CEC and calcium dominates the Ca:Mg ratio, thus mitigating some of the potentially dispersive ESP. These soils also have a high water storage capacity and will readily support the germination and growth of native grasses and trees.

Distribution

LU2 is located in the central northern portion of the site and covers approximately 9% (852 ha) of the Project area. The proposed Project infrastructure that coincides with this land unit is mainly "West 2".

Management

The soil is recommended for stripping to recover the surface A1 horizon (0 – 0.15 mBGS) if required for post mining rehabilitation activities. If the rehabilitation plan involves the planting of improved pasture, the soil will need to be amended with fertiliser.

Additional soil from the subsoil (i.e. the B21 and B22 horizons 0.15 – 0.6 mBGS) may also be stripped if required, due to the low salinity and non-sodic properties of this layer. However, the subsoil is considered to be 'marginal' due to the absence of seed stores, reduced nutrient supply and low organic matter content. Therefore, it should only be used in place of topsoil if no other options are available. It will require additional amendment prior to use.



Plate 3 Vertosols on Undulating Terrain



Plate 4 Roots Commonly Observed with Vertosols





Table 9 LU2 Soil Analytical Results Summary

Horizon	Approximate Depth (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content	Salinity Rating	ESP Ratio (%)	CEC (meq %)	Ca/Mg Ratio
A1	0 - 0.15	7.6 – 8.3	Mildly to moderately alkaline	0.10 – 0.19	Medium - heavy clay	40 – 50	Low	0.2 – 1.6	32.1 – 49.0	2.1 – 6.2
B21	0.15 - 0.35	8.4 – 8.7	Moderate to strongly alkaline	0.13 – 0.23	Heavy clay	49 – 60	Low	0.7 – 3.8	33.9 – 69.5	1.7 – 7.3
B22	0.35 – 0.60	8.7 – 9.1	Strongly to very strongly alkaline	0.10 – 0.26	Heavy clay	46 – 59	Low	1.8 – 6.8	41.3 – 61.7	1.9 – 5.1
B23	0.60 – 0.80	8.7 – 9.1	Strongly to very strongly alkaline	0.22 – 0.45	Heavy clay	58 – 60	Medium	7.2 – 11.7	41.3 – 57.9	2.6 – 4.2
B24	0.80 - 1.30	9.1	Very strongly alkaline	0.60	Medium clay	40	High	16.7	36.5	2.3

Table 10 Surface Soil (0 - 0.10 mBGS) Fertility for LU2

Analyte	Soil Concentration	Range Below Which Plant Deficiencies Have Been Recorded*	Range Above Which Plant Toxicities Have Been Recorded*
Organic Matter	1.9 – 4.8%	-	-
Total Nitrogen	0.13 – 0.29%	-	-
Phosphorus	6 – 39 mg kg ⁻¹	10 - 30 mg kg ⁻¹	-
Potassium	0.12 – 0.8 meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	6.6 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	41 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Sulfate	3.6 – 8.3 mg kg ⁻¹	-	-
Boron	0.68 – 1.3 mg kg ⁻¹	-	-
Copper	0.96 – 1.8 mg kg ⁻¹	-	-
Iron	17 – 30 mg kg ⁻¹	-	-
Manganese	4.9 – 14 mg kg ⁻¹	-	-
Zinc	0.28 – 0.9 mg kg ⁻¹	-	-
Chloride	<10 – 550 mg kg ⁻¹	-	200 – 600 mg kg ⁻¹ †
Notes: *	refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D		
†	indicates that at concentrations above this range, plant growth can be retarded.		



3.2.5 Land Unit 3: Sodosols on Undulating Low Hills

This land unit is present on elevated areas along the western portion of the site and the dominant soil order is Sodosols. The topography ranges between 140 and 180 m AHD, with gentle to moderately inclined slopes of 3% to 10%. Grazing and tree clearing is expected to have contributed greatly to accelerated erosion. The dominant vegetation cover is open eucalypt woodland with whitewood (*Atalaya hemiglauca*), bauhinia (*Lysiphyllum carronii*), cassia, box and brigalow (*Acacia harpophylla*) present.

Soil Overview

These Sodosols have a strong texture contrast between the loamy sand or sandy loam A horizon and the sodic sandy clay or medium clay B horizon. The A horizon is strongly acidic and increasingly alkaline, saline and sodic with depth. This strong sodicity is likely to cause limitations to plant growth. The reduced number of roots observed below 0.3 to 0.8 mBGS in the test pits and soil cores confirmed that root growth is restricted in the subsoil. The soil chemistry summary for profiles described within this land unit is provided in Table 11 and Table 12. Photographs of this land unit are shown in Plates 5 and Plates 6. Ground observations and test pits described within this land unit are summarised in Table 6.

Soil Salinity

Salinity was low in the A horizon, but increased to high concentrations in the B horizon. Salinity is one of the limitations expected to impact plant growth in this soil.

Soil Stability

The subsoil is strongly sodic and dispersive. Both the topsoil and subsoil are highly erodible if disturbed or if the vegetation is removed. Field observations and analytical results indicate these subsoils are highly prone to erosion. This erosivity is evident by the common occurrence of tunnel, scalding, sheet, rill and gully erosion that was observed and in some places up to 2 m deep (for example at sites G29 and G32).

Fertility

Analytical results indicated that surface soil nitrate and phosphorus concentrations were low and may be limiting for plant growth. The topsoils and the subsoils have a relatively low CEC, high ESP and low water storage capacity, thus they do not readily support the germination of native grasses and trees if the subsoils are exposed.

Distribution

This land unit covers approximately 17% (1,567 ha) of the Project area. The Project footprint impacts a small portion of this land type, with both "West 1" and "West 2" pits and dumps located on LU3.

Management

The topsoil is not recommended for stripping for use in rehabilitation works.



Plate 5 Sodosols on Undulating Low Hills

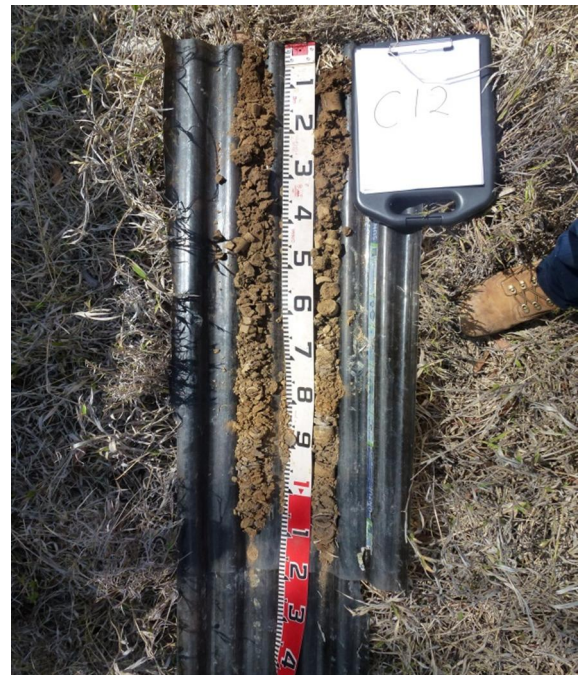


Plate 6 Subsoils are Highly Prone to Erosion if Vegetation is Removed.



Table 11 LU3 Soil Analytical Results Summary

Horizon	Approximate Depth (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content (%)	Salinity Rating	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio
A1	0 – 0.10	5.5 – 7.5	Strongly acidic to mildly alkaline	0.03 – 0.15	Loamy sand	5 - 10	Low	1.1 – 8.1	2.5 – 9.3	1.0 – 3.1
A2	0.10 - 0.30	5.7 – 8.5	Strongly acidic to strongly alkaline	0.30 – 0.46	Loamy sand to sandy loam	10	High	0.80 – 25	5.9 – 16.5	1.1 – 6.7
B21	0.30 – 0.50	6.5 – 9.0	Slightly acidic to very strongly alkaline	0.03 – 0.85	Sandy clay to medium clay	24 - 49	High	9.5 – 38.5	10.2 – 19.2	0.7 -1.1
B22	0.50 - 0.80	8.4 – 9.6	Moderate to very strongly alkaline	0.10 – 0.78	Sandy clay to medium clay	20 - 40	High	15.0 – 53.0	4.0 – 26.5	0.4 – 1.6
BC	0.80 – 1.50	9.0	Very Strongly alkaline	0.08	Loamy sand	6	Low	0.5	26.2	27

Table 12 Surface Soil (0 - 0.10 mBGS) Fertility for LU3

Analyte	Soil Concentration	Range Below Which Plant Deficiencies Have Been Recorded*	Range above which plant toxicities have been recorded*
Organic Matter	0.5 – 2.4%	-	-
Nitrate	< 1.0 mg kg ⁻¹	20-60 mg kg ⁻¹	-
(Total Nitrogen)	(<0.04 – 0.14%)		
Phosphorus	<5 – 8 mg kg ⁻¹	10 - 30 mg kg ⁻¹	-
Potassium	0.17 – 0.29meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	2.1 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	6.5 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Aluminium	28 mg kg ⁻¹	-	> 3 mg kg ⁻¹
Sulfate	2.2 – 11 mg kg ⁻¹	-	-
Boron	0.14 – 0.4mg kg ⁻¹	-	-
Copper	0.17 – 0.82 mg kg ⁻¹	-	-
Iron	13 – 210 mg kg ⁻¹	-	-
Manganese	4.7 – 35 mg kg ⁻¹	-	-
Zinc	0.24 – 2.9 mg kg ⁻¹	-	-
Chloride	13.0 mg kg ⁻¹	-	200 – 600 mg kg ⁻¹ †

Notes: * refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D
† indicates that at concentrations above this range, plant growth can be retarded.



3.2.6 Land Unit 4: Sodosols on Flood Plain with Minor Rudosols

This land unit occurs at the southern portion of the site in the low lying flood plain beside the Bowen River. The elevations range between 110 and 130 m AHD, with level to gently inclined slopes of <3%. The dominant soils are Sodosols with minor Rudosols. The dominant vegetation cover is acacia open woodland, including areas of brigalow (*Acacia harpophylla*) and open eucalypt woodlands, of *Eucalyptus platyphylla*, Ironbarks, Bloodwoods and Moreton Bay Ash.

Soil Overview

Sodosols have a strong texture contrast between the A horizon and sodic B horizon. The A horizon is mildly acidic to a depth of approximately 0.35 mBGS. Field observations indicate these soils have a hard setting surface when dry. The soils become increasingly alkaline, saline and sodic with depth, although they are generally not as sodic or as saline in the subsoil as LU3. Field observations supported this, as roots were observed at greater depths (0.7 – 1.5 mBGS) than in LU3. The soil chemistry summary for profiles described within this land unit are provided in Table 13 and Table 14. Photos of the land unit are shown in Plate 7 and Plate 8. Ground observations and test pits described within this land unit are summarised in Table 6.

Soil Salinity

Salinity is generally low but highly variable between soil profiles and is not expected to be a major limitation to plant growth.

Soil Stability

Whilst the subsoils of the Sodosols are highly prone to erosion, there was little occurrence of severe erosion identified during field activities for much of this land unit. This is probably due to the well maintained surface cover and gentle grades preventing exposure of the sodic subsoils. However, in some areas of the land unit, severe gully erosion was noted (for example, in the vicinity of sites G86 to G89 and G95). The soil surface was also noted to be hard setting and once disturbed, soil stability is likely to be low and these soils will need to be managed.

Fertility

Based on the analytical results, nitrate is expected to be a limitation to plant growth. These soils have a moderate to high level of phosphorus. The topsoil characteristics were a low ESP (favourable for plant growth), relatively low water holding capacity and low CEC. The topsoils might be limiting for crop or improved pasture growth, but are in the range suitable for native species growth. The subsoils have a relatively low CEC, high ESP and low water storage capacity, thus do not readily support the germination of native grasses and trees if the subsoils are exposed.

Distribution

This land unit covers approximately 16% (1,487 ha) of the study area. There is some disturbance of this land type by proposed infrastructure, with the development of “West 1” and associated out of pit spoil, the co-disposal storage facility and also “Central 3” on the south-eastern portion of the land unit.

Management

The topsoil is not recommended for stripping for later use in rehabilitation works.



Plate 7 Sodosols on Flood Plains (GO13 and G38)



Plate 8 Ground Observation Location GO-13 and G89



Table 13 LU4 Soil Analytical Results Summary

Horizon	Approx Depth1 (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content (%)	Salinity Rating	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio
A1	0 - 0.15	5.8 – 7.1	Moderately acidic to neutral	0.03 – 0.15	Loam to sandy loam	5	Low	0.3 – 0.3	3.6 – 6.1	2.3 – 2.5
A2	0.15 - 0.35	6.6 – 6.9	Neutral	0.01 – 0.02	Loam to sandy clay loam	3 – 26	Very Low	0.6 – 1.0	2.97 – 6.17	2.0 – 3.5
B21	0.35 – 0.55	7.1 – 8.7	Neutral to strongly alkaline	0.02 – 0.67	Sandy clay to medium clay	23 – 53	Low to High	0.8 – 18.7	2.4 – 22.8	1.2 – 2.9
B22	0.55 – 0.80	6.8 – 9.0	Neutral to strongly alkaline	0.01 – 0.82	Sandy clay to moderate clay	20 – 55	Low to High	1.5 – 17.9	8.4 – 23.2	1.1 – 3.1
B23	0.80 - 1.50	7.6 – 9.6	Mildly to very strongly alkaline	0.02 – 0.28	Medium clay to sandy clay loam	11 – 23	Medium	4.1 – 15.7	7.8 – 14.5	1.2 – 2.7

Table 14 Surface Soil (0 - 0.10 mBGS) Fertility for LU4

Analyte	Soil Concentration	Range below which plant deficiencies have been recorded*	Range above which plant toxicities have been recorded*
Organic Matter	0.8 – 2.1%	-	-
Total Nitrogen	<0.04 – 0.09%		-
Phosphorus	12 - 40 mg kg ⁻¹	10 - 30 mg kg ⁻¹	-
Potassium	0.19 – 0.58 meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	1.6 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	4.0 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Sulfate	1.1 – 3.8 mg kg ⁻¹	-	-
Boron	0.06 – 0.33mg kg ⁻¹	-	-
Copper	0.14 – 1.3 mg kg ⁻¹	-	-
Iron	23 – 100 mg kg ⁻¹	-	-
Manganese	15 - 61mg kg ⁻¹	-	-
Zinc	0.32 – 0.95 mg kg ⁻¹	-	-
Chloride	< 10 – 610 mg kg ⁻¹		

Notes: * refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D
 † indicates that at concentrations above this range, plant growth can be retarded.



3.2.7 Land Unit 5: Dermosols and Vertosols on Undulating Terrain

LU5 occurs on the higher ground along the eastern portion of the site and is located at elevations between 150 and 200 m AHD. It mostly contains level to gently inclined slopes less than 3% although steeper slopes and rounded crests are also present. The dominant soil orders are Dermosols, with Vertosols occurring secondarily in north-south bands. The dominant vegetation cover is open eucalypt woodland dominated by narrow-leaved ironbark (*Eucalyptus crebra*) with groundcover greater than 90%.

Soil Overview

These soils have slightly acidic to alkaline sandy clay loam or clay loam in the A horizon (0 to 0.15 mBGS) and alkaline sandy clay to medium clay in the upper B horizon (0.15 to 0.30 mBGS). The soil becomes more alkaline with depth until reaching the weathered sandstone (C horizon) at 0.70 to 1.0 mBGS. The soil pH levels are not expected to be limiting to plant growth. The soil chemistry summary for profiles described within this land unit is provided in Table 15 and Table 16. Photographs of the land unit and soil profile morphology are shown in Plates 9 and 10. Ground observations and test pits described within this land unit are summarised in Table 6.

Soil Salinity

The salinity is low throughout the A horizon and increased to medium to high salinity in the B horizon. Root development is expected to be limited with increasing depth due to salinity and sodicity. However, the shallow weathered rock which results in a reduced water storage capacity is likely to be a greater limitation to plant growth. This was supported by field observations where roots were not recorded below depths of approximately 0.6 mBGS.

Soil Stability

The analytical results indicate that these are mainly non-sodic soils that are considered to have low erodibility ratings. This was supported by the field observations, where the occurrence of erosion was noted as being minor, with sheet erosion the primary form.

Fertility

Analytical results indicated that topsoil nitrate and phosphorus concentrations were low and may be limiting for crop or improved pasture growth, but are in the range suitable for native species growth. These soils have a relatively high CEC and calcium dominates the Ca:Mg ratio, thus mitigating some of the potentially dispersive ESP at depth. These soils also have a moderate water storage capacity and will readily germinate and support native grasses and trees.

Distribution

This land unit covers approximately 25% (2,324 ha) on the eastern portion of the site. Proposed Project development located on this land unit are "Central 1", "East 1", "East 2", "MIA", part of "West 1", "East 3", "East 4", and the associated out of pit spoils.

Management

The soil is recommended for stripping to recover the surface A1 horizon (0 – 0.15 m), if it is required for post mining rehabilitation activities. If the rehabilitation plan involves the planting of improved pasture, the soil will need to be amended with fertiliser.

Additional soil from the subsoil (i.e. the B1 horizon 0.15 – 0.30 mBGS) may also be stripped if required, due to the low salinity and non-sodic properties of this layer. However, the subsoil is considered to be ‘marginal’ due to the absence of seed stores, reduced nutrient supply and low organic matter content. Therefore, it should only be used in place of topsoil if no other options are available. It will require additional amendment prior to use.



Plate 9 Dermosols and Vertosols on Undulating Terrain



Plate 10 Ground Observation GO5 / TP1

Table 15 LU 5 Soil Analytical Results Summary

Horizon	Approximate Depth ¹ (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content (%)	Salinity Rating	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio
A1	0 – 0.15	6.5 – 8.4	Slightly acidic to moderately alkaline	0.06 – 0.21	Sandy clay to clay loam	20 – 30	Low	0.2 – 3.5	14.8 – 48.6	2.4 – 7.6
B1	0.15 – 0.30	7.1 – 8.6	Neutral to strongly alkaline	0.04 – 0.15	Sandy clay loam to medium clay	30 – 55	Low	0.2 – 1.2	30.1 – 45.6	2.1 – 52
B2	0.30 – 0.70	7.6 – 9.2	Mildly to very strong alkaline	0.04 – 0.86	Medium to heavy clay	13 – 46	Low to high	0.3 – 13.1	12.4 – 54.3	2.7 – 62
B22 or BC	0.70 – 1.0	8.8 – 9.2	Strongly to very strongly alkaline	0.11 – 1.5	Medium to heavy clay or weather sandstone	11 – 50	Medium to very high	13.3 – 18.4	38.5 – 50.2	2.7 – 54.3



Table 16 Surface Soil (0 - 0.10 mBGS) Fertility for LU5

Analyte	Soil Concentration	Range below which plant deficiencies have been recorded*	Range above which plant toxicities have been recorded*
Organic Matter	0.9 - 3.8%	-	-
Nitrate (Total Nitrogen)	1.7 mg kg ⁻¹ (0.08 – 0.21%)	20 – 60 mg kg ⁻¹	-
Phosphorus	<5.0 -71.0 mg kg ⁻¹	10 – 30 mg kg ⁻¹	-
Potassium	0.13 – 0.59 meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	8.52 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	21.60 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Aluminium	26.0 mg kg ⁻¹	-	> 3 mg kg ⁻¹
Sulfate	1.3 – 7.5 mg kg ⁻¹	-	-
Boron	0.31 – 1.5 mg kg ⁻¹	-	-
Copper	0.17 – 1.7 mg kg ⁻¹	-	-
Iron	3.9 – 57 mg kg ⁻¹	-	-
Manganese	1.8 - 60mg kg ⁻¹	-	-
Zinc	0.13 – 1.4 mg kg ⁻¹	-	-
Chloride	17.0 mg kg ⁻¹	-	200 – 600 mg kg ⁻¹ †

Notes: * refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D
† indicates that at concentrations above this range, plant growth can be retarded.

3.2.8 Land Unit 6: Tenosols and Rudosols Adjacent to Intermittent or Permanent Watercourses

This land unit is located in small bands in the vicinity of intermittent or permanent water courses with marked terraces, levees and shallow drainage depressions. It mostly contains level to gently inclined slopes less than 3%. These soils formed due to alluvial processes and the dominant soil orders are Tenosols and Rudosols.

Soil Overview

These soils have neutral to slightly alkaline sandy loam or clayey loam in the A horizon (0 to 0.6 mBGS). The apedal B horizon extended to 1.5 mBGS as coarse sands or loamy sands. In the case of G12, the underlying soil is buried Vertosol, overlain by alluvial material deposited during intermittent creek flow. As a result of deposition and soil development, this land unit is present in thin bands across the Project site. The summary of the chemical analysis is provided in Table 17. Photographs of the land unit and soil profile morphology are shown in Plates 11 and 12. Ground observations and test pits described within this land unit are summarised in Table 6.

Distribution

This land unit covers approximately 5% (435 ha) of the site along the Bowen River terrace, along Twelve Mile Gully and in other narrow bands along intermittent creek beds. Proposed Project development that is likely to be located on this land unit are “West 1”, “Central 2”, north/south haul road and the associated out of pit spoils.

Management

The land unit occurs in small and narrow bands across disturbance areas, making it difficult to treat this area separately for topsoil removal. On its own, LU6 is not suitable for topsoil removal. However, topsoil removal will occur in accordance with the recommendations for the surrounding adjacent land unit. For example, where LU6 is surrounded by LU1, the topsoil stripping recommendations for LU1 will be followed for both areas.



Plate 11 Tenosols on River Plains (G84)



Plate 12 Ground Observation G84



Table 17 LU 6 Soil Analytical Results Summary

Horizon	Approximate Depth (m)	pH	pH Rating	EC (dS/m)	Texture	Clay Content (%)	Salinity Rating	ESP Ratio (%)	CEC (meq%)	Ca/Mg Ratio
A1	0 – 0.20	6.8 – 7.7	Neutral to mildly alkaline	0.02 – 0.05	Sandy loam to clay loam	1 – 10	Very low	² -	-	-
A2	0.20 - 0.60	7.2 – 8.3	Neutral to moderately alkaline	0.01 – 0.03	Sandy loam to clay loam	3 – 9	Very low	0.3 – 0.6	1.6 – 9.9	3.4 – 3.6
B1	0.60 – 1.0	7.7 – 8.2	Mildly to moderately alkaline	0.01 – 0.02 (0.84) ³	Sand to sandy loam (Medium clay)	6 – 11	Very low (High)	0.3 – 0.5 (15.9)	2.2 – 8.6 (30.2)	2.8 – 3.4 (2.1)
B2	1.0 – 1.5	8.0	Moderately alkaline	0.03 (1.15)	Medium clay (heavy clay)	14	Very low (Very high)	0.5 (16)	10.3 (25.7)	2.9 (2.4)

Table 18 Surface Soil (0 - 0.10 mBGS) Fertility for LU6

Analyte	Soil Concentration	Range below which plant deficiencies have been recorded*	Range above which plant toxicities have been recorded*
Organic Matter	0.9 - 3.8%	-	-
Nitrate	1.7 mg kg ⁻¹	20 – 60 mg kg ⁻¹	-
(Total Nitrogen)	(0.08 – 0.21%)		
Phosphorus	<5.0 -71.0 mg kg ⁻¹	10 – 30 mg kg ⁻¹	-
Potassium	0.13 – 0.59 meq 100g ⁻¹	0.3 – 0.5 meq 100g ⁻¹	-
Magnesium	8.52 meq 100g ⁻¹	0.1 – 0.3 meq 100g ⁻¹	-
Calcium	21.60 meq 100g ⁻¹	0.5 – 1.4 meq 100g ⁻¹	-
Aluminium	26.0 mg kg ⁻¹	-	> 3 mg kg ⁻¹
Sulfate	1.3 – 7.5 mg kg ⁻¹	-	-
Boron	0.31 – 1.5 mg kg ⁻¹	-	-
Copper	0.17 – 1.7 mg kg ⁻¹	-	-
Iron	3.9 – 57 mg kg ⁻¹	-	-
Manganese	1.8 – 60 mg kg ⁻¹	-	-
Zinc	0.13 – 1.4 mg kg ⁻¹	-	-
Chloride	17.0 mg kg ⁻¹	-	200 – 600 mg kg ^{-1†}

Notes: * refers to concentrations necessary for satisfactory vegetative growth. References are provided in Appendix D
† indicates that at concentrations above this range, plant growth can be retarded.



3.2.9 Topsoil Management Summary

Soil considered suitable for stripping and subsequent use in rehabilitation works was identified in Land Units LU1, LU2 and LU5. Useable topsoil resources were confined to the surface A1 horizon, which contains seed stock, micro-organisms, organic matter and nutrients required for plant growth. In some cases, and if no alternative exists, the subsoils from LU1, LU2 and LU5 may also be utilised as surface cover. However, nutrient concentrations and organic matter generally decrease with depth. Therefore, the LU1, LU2 and LU5 subsoil material is considered to be 'marginal' when used in place of topsoil and should only be used in place of topsoil if no other options are available. This subsoil will require additional amendment prior to use to amend the alkalinity, low nutrient status, low organic matter, and absent seed stocks.

Planning

The proposed disturbance areas are shown on Figure 2. Based on the land units within the disturbance areas and the recommended stripping depths, the approximate volume of soil to be removed has been calculated (Table 19). These calculations include a bulking factor which incorporates bulk density changes during soil excavation and transport. The main land unit disturbed is LU1 (1,426 ha), followed by LU5 (898 ha), LU 2 (604 ha). Land Units LU3 and LU6 are both likely to have <61 ha each disturbed by planned operations. Where LU6 is disturbed, the small and narrow areas make it difficult to treat the topsoil removal separately. Therefore topsoil will be treated in accordance with the recommendations for the surrounding land unit and the following calculations have taken this into account.

In total, approximately 6,671,250 m³ of topsoil (from LU1, LU2, LU5 and LU6) and 6,671,250 m³ of subsoil is considered suitable to be stripped from the disturbance areas. The topsoil material should be utilised for surface cover material in preference to the subsoil material.

The disturbance area is 3,442 ha and, assuming a soil re-spreading thickness of 0.25 m, approximately 8,604,000 m³ of cover material is required. If only topsoil was used to create the 0.25 m thickness, 75% of this quantity of cover soil can be provided under the current stripping program. This is less than the required cover material volume. However, it is recommended that the subsoil in LU1, LU2 and LU5 (0.15 to 0.3 m depth) be utilised in the rehabilitation landscape as a subsoil (0.15 m depth) and overlain with recovered topsoil (0.15 m depth) on approximately 50% of the disturbance area. This results in approximately 2,150 ha where topsoil is the only cover material at 0.25 m depth (3,335,625 m³) and 1,300 ha where the soil profile has been recreated with 0.15 m topsoil and 0.15 m subsoil (3,335,625 m³).



Table 19 Approximate Soil Stripping Volumes by Disturbance Area for the Proposed Operations

Disturbance Area Name	Land Unit	Area (ha)	Soil Horizon	Stripping Depth (mBGS)	Stripped Soil Volume* (m³)
Co-disposal Storage	LU4	138	-	-	0
Diversion Channel	LU1	27	A1	0.0 – 0.15	60,750
			B21	0.15 – 0.35	60,750
	LU4	34	-	-	0
	LU5	7	A1	0.0 – 0.15	15,750
			B1	0.15 – 0.35	15,750
	LU6	3	-	-	0
Mine Process Plant	LU1	4	A1	0.0 – 0.15	9,000
			B21	0.15 – 0.35	9,000
	LU5	23	A1	0.0 – 0.15	51,750
			B1	0.15 – 0.35	51,750
Out of Pit Spoil	LU1	720	A1	0.0 – 0.15	1,620,000
			B21	0.15 – 0.3	1,620,000
	LU2	170	A1	0.0 – 0.15	382,500
			B21	0.15 – 0.35	382,500
	LU3	10	-	-	0
	LU4	90	-	-	0
	LU5	280	A1	0.0 – 0.15	630,000
			B1	0.15 – 0.35	630,000
	LU6	19	-	-	0
	Pit	LU1	640	A1	0.0 – 0.15
B21				0.15 – 0.35	1,440,000
LU2		415	A1	0.0 – 0.15	933,750
			B21	0.15 – 0.35	933,750
LU3		10	-	-	-
LU4		115	-	-	0
LU5		430	A1	0.0 – 0.15	967,500
			B1	0.15 – 0.35	67,500



Disturbance Area Name	Land Unit	Area (ha)	Soil Horizon	Stripping Depth (mBGS)	Stripped Soil Volume* (m³)	
Rail	LU6	33	A1	0.0 – 0.15	74,250	
			B1	0.15 – 0.3	74,250	
	LU5	12	A1	0.0 – 0.15	27,000	
			B1	0.15 – 0.35	27,000	
Road	LU1	29	A1	0.0 – 0.15	62,250	
			B21	0.15 – 0.3	62,250	
	LU2		A1	0.0 – 0.15	11,250	
			B21	0.15 – 0.3	11,250	
	LU4	1	-	-	0	
	LU5	55	A1	0.0 – 0.15	123,750	
			B1	0.15 – 0.3	123,750	
	LU6	2	-	-	4,500	
	Sediment Basin	LU1	8	A1	0.0 – 0.15	18,000
				B21	0.15 – 0.35	18,000
LU2		14	A1	0.0 – 0.15	31,50	
			B21	0.15 – 0.3	31,500	
LU3		36	-	-	0	
LU4		1	-	-	0	
LU5		23	A1	0.0 – 0.15	51,750	
			B1	0.15 – 0.3	51,750	
LU6		5	-	-	0	
Miscellaneous		LU1	7	A1	0.0 – 0.15	15,750
	B21			0.15 – 0.3	15,750	
	LU5	63	A1	0.0 – 0.15	141,750	
			B1	0.15 – 0.3	141,750	
Total		3442	13,342,500			
			Topsoil	6,671,250		
			Subsoil	6,671,250		

Note: The volume estimate includes a soil bulking factor of 1.5 g/g, which compensates for soil density changes during excavation and transportation.



Stripping

The areas to be stripped will be surveyed and marked during the topsoil resource assessment, which will be undertaken prior to commencement of mining operations. Stripping of topsoil should occur before any construction commences. Large trees and shrubs should be cleared first and stockpiled separately to the soil. Topsoil should be stripped to the depths nominated in Table 18 for the different land units and stockpiled in accordance with the following section.

Stockpiling

Where possible, topsoil will be spread directly onto areas being rehabilitated. This is the preferred method as it maximises the viability of the soil seed bank, reduces nutrient loss and reduces the area required for stockpiling. Where progressive rehabilitation is not possible, the stripped soil will be stored in stockpiles.

The topsoil and subsoil will be stockpiled separately. The soil stockpiles should be approximately 1 to 2 metres high and be placed away from drainage lines, roads, machinery and transport corridors. The stockpiles may need to be ripped and seeded with a quick establishment pasture to limit erosion and maintain a viable seed bank if the period of stockpiling is greater than one growing season or six months. Topsoils are the preferred cover media as they have a greater seed bank, nutrients and micro-organism content.

Stockpiles will be clearly signposted for identification and to avoid accidental loss.

When used in rehabilitation, the soil will need to be amended with fertiliser if improved pasture is to be planted.

The approximate locations for the proposed stockpiles are shown in Figure 10. This plan will be refined and updated during the topsoil resource assessment.

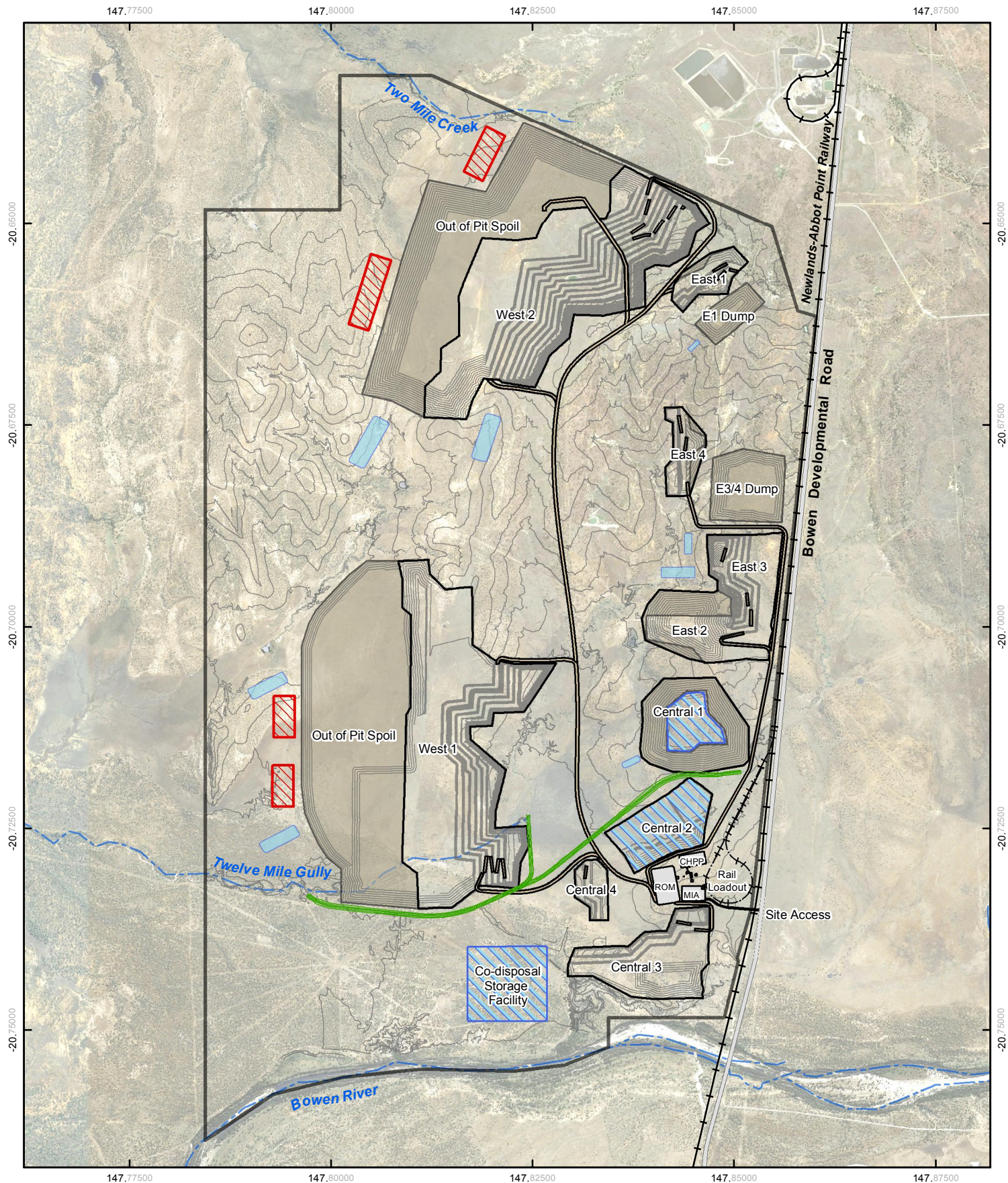
Respreading

Mine rehabilitation planning will include:

- Balancing required topsoil quantities with stored stockpile inventories;
- Planning to maximise the direct spreading of topsoil from stripping areas, rather than stockpiling;
- Minimise the length of time that soil is stored in stockpiles; and
- Use of subsoil in lower relief areas and providing additional amendment to promote vegetation establishment.

Soil will be respread in layers at a thickness appropriate for the intended use of the area being rehabilitated. Once soil is respread, a number of measures will be implemented to protect the topsoil on the rehabilitation areas:

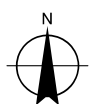
- Contour ripping to encourage infiltration and minimise runoff;
- Fertilisation and reseedling as soon as possible to establish a vegetation cover;
- Installation of slope drainage control to limit slope length and drainage velocity; and
- Installation of sediment control and collection measures.



LEGEND

- | | | |
|------------------------------|-------------------------|--|
| — Major Road | ▬ Project Area | ▨ Proposed Stockpile Location (Indicative) |
| — Existing Railway | ▬ Mine Process Plant | ▨ Co-disposal Storage Facility |
| — Proposed Railway | ▬ Out of Pit Spoil Area | ▨ Sediment Basin (Indicative) |
| — Proposed Diversion Channel | ▬ Haulage Road | |
| — Contour (5m interval) | | |

0 0.5 1 1.5 2 2.5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



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Proposed Soil
Stockpile Locations

Job Number 41-21894
Revision 1
Date 13 Mar 2012

Figure 10



4. Land Assessment

4.1 Land Suitability Assessment

The two methods of land evaluation traditionally used in Queensland are '*land capability*' and '*land suitability*'. '*Land capability*' assessment, as described by Rosser *et al.* (1974) concerns the allocation of land units to one of eight classes on the basis of the extent of limitations for general agricultural use. It is usually applied to broad scale land resource assessment.

'*Land suitability*' rankings are more refined and apply to the capacity of land resources to sustain particular forms of land use such as arable farming, irrigated agriculture, and forestry. Such rankings can be applied to smaller land units and are thus more useful in determining post-mining land use options.

A five-class land suitability classification with suitability decreasing progressively from Class 1 to Class 5 was used for the evaluation of land in the Project area. The land is assessed on the basis of a specified land use that allows optimum production with minimal degradation to the land resource in the long-term (Land Resource Branch Staff, 1990).

Land is considered less suitable as the severity and number of limitations for a land use increase, reflecting either:

- (a) Reduced potential for production;
- (b) Increased inputs to achieve an acceptable level of production; and/or
- (c) Increased inputs required to prevent land degradation.

The five land suitability classes are as follows:

- ▶ **Class 1: Suitable land with negligible limitations.** This is highly productive land requiring only simple management practices to maintain economic production;
- ▶ **Class 2: Suitable land with minor limitations** which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production;
- ▶ **Class 3: Suitable land with moderate limitations** which either further lower production or require more than those management practices of Class 2 land to maintain economic production;
- ▶ **Class 4: Marginal land, which is presently considered unsuitable due to severe limitations.** The long term significance of these limitations on the proposed land use is unknown. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production; and
- ▶ **Class 5: Unsuitable land with extreme limitations** that generally preclude its use for agricultural activities.

The first three classes (Classes 1, 2 and 3) are considered suitable for the specified land use (e.g. *Rainfed Broadacre Cropping, Beef Cattle Grazing, Irrigated Cropping*, etc), as the benefits from using the land for that land use in the long term should outweigh the inputs required to initiate and maintain production. Decreasing land suitability within a region often reflects the need for increased inputs rather than decreased potential production.

Land Class 4 is considered presently unsuitable or is used to classify marginal land where it is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long term.



Additional studies are needed to determine whether the effect of the limitation(s) can be reduced to achieve sustained production.

Land Class 5 is considered unsuitable, having limitations that in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain production in the long term. Some Class 5 lands however, such as escarpments, will always remain unsuitable for agriculture.

4.1.1 Land Suitability Assessment Methodology

A desktop review of the available relevant information was undertaken to assess the land suitabilities currently documented for the region.

Based on the findings of the desktop review, the soil survey and laboratory soil analyses a land suitability assessment was conducted on the six Land Units identified. The assessment was undertaken for the two types of existing land uses identified (Section 2.2, Land Use) as either currently or previously occurring in the Collinsville area:

- ▶ Rainfed Broadacre Cropping; and
- ▶ Beef Cattle Grazing.

The suitability assessment criteria used to assess these two land uses was obtained from *Land Suitability Assessment Techniques* (DME, 1995) and is provided in Appendix E.

Each value of the relevant land quality was assigned a rating from Classes 1 to 5. The overall capability rating was determined by the most limiting factor or factors (i.e. the quality or qualities assigned the highest number). The rating did not change according to how many of the most limiting factors were present. For example, there was no difference in the overall rating for a land unit with a Class 4 rating due only to waterlogging compared with another land unit where Class 4 was due to waterlogging, salinity, flooding and water erosion hazard.

4.1.2 Initial Desktop Review

The land suitability study of the Collinsville-Nebo-Moranbah region (DPI, 1984) was reviewed to determine the cropping potential of the region. The review identified that the major crops grown in Central Queensland included grain sorghum and sunflower during the summer and safflower and wheat during the winter.

Rainfed Broadacre Cropping in the region is restricted to soils with a high plant available water capacity (PAWC). The majority of the rainfall (70%) occurs in the summer months when sorghum and sunflower are grown, however, rainfall variability is so high during this period that PAWC is a critical factor for successful cropping. In the winter months rainfall is negligible so any cropping of wheat and sunflower must rely almost entirely on stored soil moisture.

The only soils that were considered to have some potential for rainfed cropping were the cracking clays (Vertosols). Cracking clays on sedimentary rocks must be deeper than 60 cm to be suitable for cropping in the Collinsville-Nebo areas. The Vertosols with heavy clay subsoils below the self-mulching layer may be susceptible to hardpan development. Hardpans that develop immediately below the plough layer may severely restrict root and water penetration.



Gilgaied Vertosols with deep (40 to 100 mm) melon hole microrelief severely hinders cultivation and land levelling will bring the saline subsoils to the surface resulting in poor crop growth. They were considered unsuitable for rainfed cropping.

Vertosols occur on gently undulating plains and rises. They are moderately to highly erodible. Where they are present on slopes greater than 1%, soil conservation measures would be required to minimise soil losses.

The Sodosols were considered unsuitable for rainfed cropping due to low PAWC and deep hardsetting surface soils. However they were considered suitable for grazing. The sodic nature of the subsoils results in the soils having a high erodibility potential. Relatively flat areas with slopes less than 2% were deemed suitable for pasture improvement, but slopes greater than this are unsuitable for cultivation and should be grazed for native pastures only.

The Dermosols have low PAWC, very low fertility and are unsuitable for rainfed cropping. They tend to support eucalypt woodlands that would be expensive to clear and prone to woody regrowth and are more suited to native pasture grazing.

4.1.3 Land Suitability Results

The site-specific land suitability assessments for Rainfed Broadacre Cropping and Beef Cattle Grazing are presented in the following sections. The detailed results are presented in Appendix F and definitions of the qualities that have been assessed are included in Appendix G.

Land Suitability for Rainfed Broadacre Cropping

The outcomes of the land suitability assessment for each land unit for Rainfed Broadacre Cropping are presented in Table 20 while mapping of the land suitability is presented in Figure 11.

The *Vertosols on undulating terrain* (LU2) are suitable Class 3 land for Rainfed Broadacre Cropping with moderate limitations of water availability because of high salinity below 0.8 mBGS and presence of weathered rocks at depth. As in LU1, soil workability is also a limitation. LU2 has a higher agricultural potential than LU1 mainly because high salinity and sodicity only occur at low depth, below 0.8 mBGS

The *Sodosols on undulating low hills* (LU3) are classified as Class 5 land generally unsuitable for Rainfed Broadacre Cropping with extreme limitations due to limited water availability, which preclude the landuse for Broadacre Cropping. The strongly sodic nature of the subsoil inhibits the infiltration of water into the soil and limits the PAWC of the soil profile to 50 to 75 mm, which is insufficient for cropping. These *Sodosols on undulating low hills* (i.e. moderate slopes of up to 10%) are additionally considered unsuitable for Rainfed Broadacre Cropping as the slopes are considered to present a risk for accelerated erosion and would require the extensive construction of contour banks and other erosion control measures.

Sodosols on flood plains (LU4) are marginal Class 4 land for Rainfed Broadacre Cropping due to the presence of dissected gullies. Other limitations include low water availability and soil physical factors as the soils exhibited hard setting surfaces when dry.



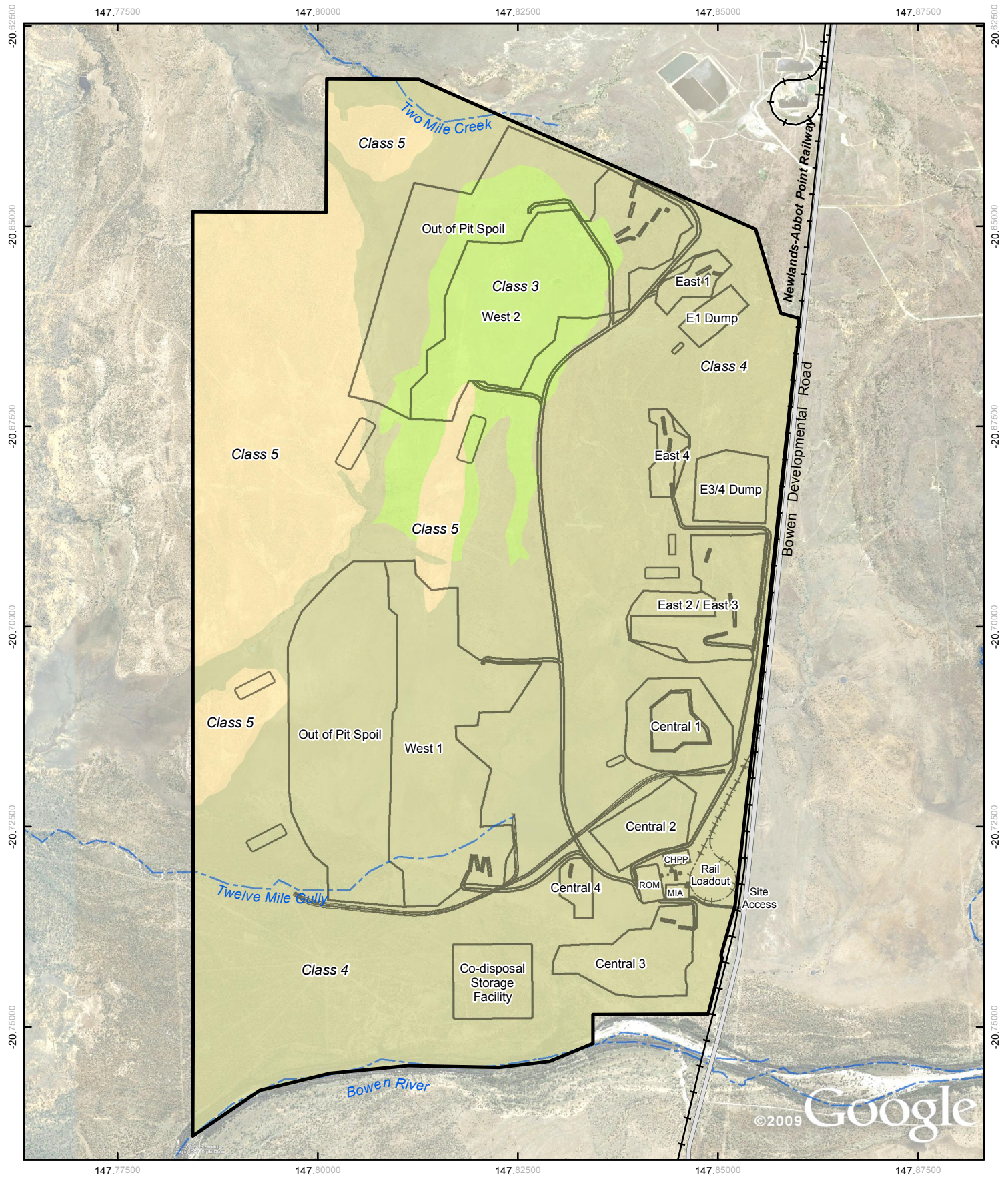
Table 20 Land Suitability Rating for Rainfed Broadacre Cropping

Land Unit	Land Suitability Rating Rainfed Broadacre Cropping	Most Limiting Factor/s
LU1 Vertosols on low lying areas.	Class 4 – marginal land with severe limitations.	Soil workability. Soil physical factors. Subsoil salinity.
LU2 Vertosols on undulating terrain.	Class 3 – suitable land with moderate limitations.	Water availability due to limited soil depth. Soil workability. Soil physical factors. Sodicity. Salinity.
LU3 Sodosols on undulating low hills.	Class 5 – unsuitable land with extreme limitations.	Water availability. Water erosion susceptibility and subsoil erodibility if exposed.
LU4 Sodosols on a flood plain.	Class 4 – unsuitable land with extreme limitations.	Water availability due to sodic subsoil. Soil physical factors. Topography.
LU5 Dermosols and Vertosols on undulating terrain.	Class 4 – marginal land with severe limitations.	Water availability due to saline and sodic subsoil. Water erosion susceptibility.
LU6 Tenosols and Rudosols adjacent to Intermittent or Permanent Watercourses.	Class 4 – marginal land with severe limitations.	Occasional flooding. Topography.

Dermosols and Vertosols on undulating terrain (LU5) are marginal Class 4 land for Rainfed Broadacre Cropping due to low water availability and water erosion limitations. The presence of weathered rock at approximately 0.8 mBGS restricts the volume of plant available water that can be stored in the soils profile resulting in an estimated plant available water holding capacity (PAWC) of 90 to 125 mm, which is low for most crops in the area. In addition, slopes of up to 10% are considered to present a risk for accelerated erosion once topsoil is exposed and would require the extensive construction of contour banks and other measures to minimise effects of overland flows of water on exposed soils.

The *Tenosols and Rudosols adjacent to intermittent or permanent watercourses* (LU6) were determined to be marginal Class 4 land for Rainfed Broadacre Cropping due to occasional flooding. In addition, the terraces within this land unit reduce the arable land area.

In summary only LU2 land is considered suitable Class 3 for Rainfed Broadacre Cropping in the Project. A combination of unfavourable physical and chemical soil characteristics, and topography renders all the other land units (LU1, LU3, LU4, LU5, LU6) marginal land and currently unsuitable for broadacre cropping.

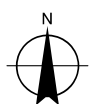


LEGEND

- | | | |
|------------------|--------------|--|
| Major Road | Project Area | Land Suitability Assessment |
| Existing Railway | Mine Layout | |
| Drainage Feature | | |
| | | Class 3 - Suitable land with moderate limitations |
| | | Class 4 - Marginal land with severe limitations |
| | | Class 5 - Unsuitable land with extreme limitations |

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1:70,000 (at A4)
0 0.5 1 1.5 2 2.5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



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Job Number 41-21894
Revision 1
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Land Suitability Assessment for Rainfed Broadacre Cropping

Figure 11



Land Suitability for Beef Cattle Grazing

A summary of the land suitability assessment for Beef Cattle Grazing on each land unit is presented in Table 21, and mapped in Figure 12.

Table 21 Land Suitability Rating for Beef Cattle Grazing

Land Unit	Land Suitability Rating Beef Cattle Grazing	Most Limiting Factor/s
LU1 Vertosols on low lying areas.	Class 3 – suitable land with moderate limitations.	Soil physical factors. Salinity. Subsoil salinity. pH.
LU2 Vertosols on undulating terrain.	Class 3 – suitable land with moderate limitations.	Water availability due to limited soil depth. Soil workability. Sodicity. Salinity.
LU3 Sodosols on undulating low hills.	Class 4 – marginal land with severe limitations.	Water availability. Nutrient deficiency. Water erosion susceptibility and subsoil erodibility if exposed.
LU4 Sodosols on a flood plain.	Class 3 – suitable with moderate limitations.	Water availability due to sodic subsoil. pH.
LU5 Dermosols and Vertosols on undulating terrain.	Class 3 – suitable with moderate limitations.	Water availability due to saline and sodic subsoil. Water erosion susceptibility.
LU6 Tenosols and Rudosols adjacent to intermittent or permanent watercourses.	Class 3 – suitable with moderate limitations.	Occasional flooding, topography.

The *Vertosols on low lying areas* (LU1) and *Vertosols on undulating terrain* (LU2) are suitable Class 3 land for Beef Cattle Grazing with moderate limitations due to soil workability, soil salinity and soil pH. The cracking clays with coarse self mulching peds (>20mm) provide a moderate limitation to pasture growth. The pH of the subsoil was recorded between 8.0 and 9.0, which is considered moderately to strongly alkaline and may lead to nutritional deficiencies in the rooting zone.

The *Sodosols on undulating low hills* (LU3) are marginal Class 4 land currently unsuitable for Beef Cattle Grazing, because of the low water availability. The strongly sodic nature of the subsoil inhibits the infiltration of water into the soil and PAWC of the soil profile is limited to 50 to 75 mm.

The *Sodosols on flood plains* (LU4) are suitable Class 3 land for Beef Cattle Grazing with moderate limitations associated with low water availability and an alkaline pH range within the root zone.



The *Dermosols and Vertosols on undulating terrain* (LU5) are considered suitable Class 3 land for Beef Cattle Grazing with moderate limitations due to water availability, nutritional deficiency and soil pH. The pH of the subsoil was recorded between 8.0 and 9.0 on the Vertosols, which is considered moderately to strongly alkaline and may lead to nutritional deficiencies in the rooting zone.

The *Tenosols and Rudosols adjacent to intermittent or permanent watercourses* (LU6) were considered suitable Class 3 land for Beef Cattle Grazing with limitations due to the topography of the terraces and the narrow areas within this land unit, which makes cultivation for sowing pastures somewhat restricted.

Land Suitability for Irrigation within 5km of Bowen River

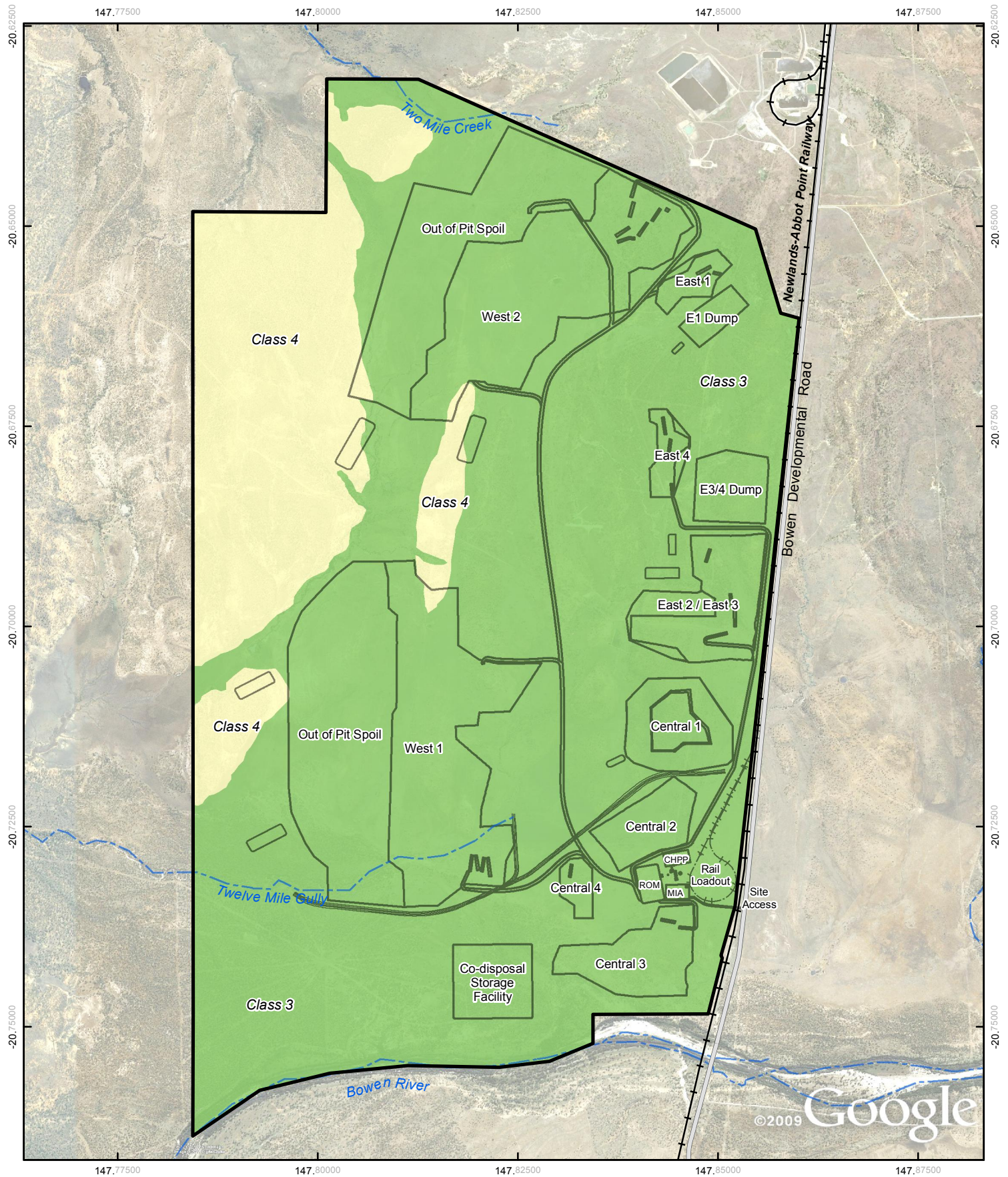
The land located within 5 kilometres (km) of the Bowen River consists of LU1: Vertosols on low lying areas; LU3: Sodosols on undulating low hills; LU4: Sodosols on flood plain, with secondary Rudosols; LU5: Dermosols and Vertosols on undulating terrain and LU6: Tenosols and Rudosols adjacent to intermittent or permanent watercourses. These land units were assessed for irrigation suitability, using Section 4.3 of the *Fitzroy LWMP Reference Manual* (DERM, 2007). Most of the limitations that affect Broadacre Cropping would similarly apply to irrigated crops. However, water availability would no longer be a limitation for most of the soils except Sodosols where there is unavailability of water because of their physical properties.

- ▶ LU6 is comprised of narrow areas of small size, with terraces and drainage depressions. This topography makes it generally unsuitable for large scale irrigation;
- ▶ LU4 is made up of texture contrast soils with a sandy loam A horizon and a sandy clay or medium clay B horizon. Sandy soils generally have rapid water infiltration and deep drainage however, the LU4 soils were noted to have hard setting surface soils and sodic subsoils. The crusted surfaces and sodic clay subsoils result in poor water infiltration properties, poor drainage characteristics and a susceptibility to erosion that makes this land unit unsuitable for irrigation purposes;
- ▶ LU3 is made up of Sodosols on undulating low hills. These soils may exhibit poor permeability in their subsoils and hence are prone to lateral drainage through the A2 horizon which sits above an impermeable B2 horizon. The undulating terrain may exacerbate this feature of these soil types. Soil erosion is another limitation. Soils in LU3 are therefore unsuitable for any irrigated crops; and
- ▶ LU1 is composed of Vertosols and LU5 is comprised of Vertosols and Dermosols. The 'shrink swell' nature of the Vertosol soils result in rapid initial water infiltration through the cracks, but infiltration rates slow rapidly once the clays have swelled and sealed. It is then unlikely that any deep profile drainage would occur. This lack of deep drainage is confirmed by the presence of the sodic, saline and alkaline subsoils within this land unit (i.e. accumulation of salts and sodium cations). The Dermosols do not exhibit the same level of shrink swell as the Vertosols, although they are also comprised of medium to heavy clays with sodic, saline and alkaline subsoils. The low infiltration rates and the alkalinity, salinity, and sodicity of the subsoils may present significant soil chemical challenges to the establishment and growth of irrigated crops. Soils of these two land units may support a restricted range of irrigated crops. Trickle irrigation on these soils may be a possible irrigation method to reduce the soil salinity risk, if irrigation was required.

In summary, LU2 is suitable for irrigated crops; however it is outside the 5 km reach of the Bowen River. The Vertosols and Dermosols of LU1 and LU5 should be suitable for a more restricted range of irrigated crops. Sodosols of LU3 and LU5 have inherent limitations that are not overcome by availability of water therefore they are considered unsuitable for irrigated crops. Tenosols and



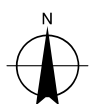
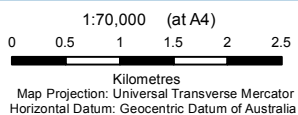
Rudodols of LU6 are not suitable for irrigated crops because of the uneven, fragmented land surface topography.



LEGEND

- | | | |
|----------------------|----------------|---|
| — Major Road | ▬ Project Area | Land Suitability Assessment |
| — Existing Railway | ▬ Mine Layout | Class 3 - Suitable land with moderate limitations |
| --- Drainage Feature | | Class 4 - Marginal land with severe limitations |

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Land Suitability Assessment for Beef Cattle Grazing

Figure 12



4.2 Good Quality Agricultural Land (GQAL)

The Queensland Government recognises the importance of land that is capable of sustaining long-term agricultural practices for present and future agricultural commodities. Therefore, it is required that the location and extent of Good Quality Agricultural Land (GQAL) be identified and included in strategic plans, where present.

GQAL is defined as Agricultural Class A land, and in some areas includes Class B land and better quality Class C land where pastoral industries predominate (Planning Guidelines, DPI/DHLGP, 1993). GQAL is land that is capable of sustainable use for agriculture with a reasonable level of input and without causing degradation of land or other natural resources. There are four Agricultural Land Classes (A to D) defined for Queensland.

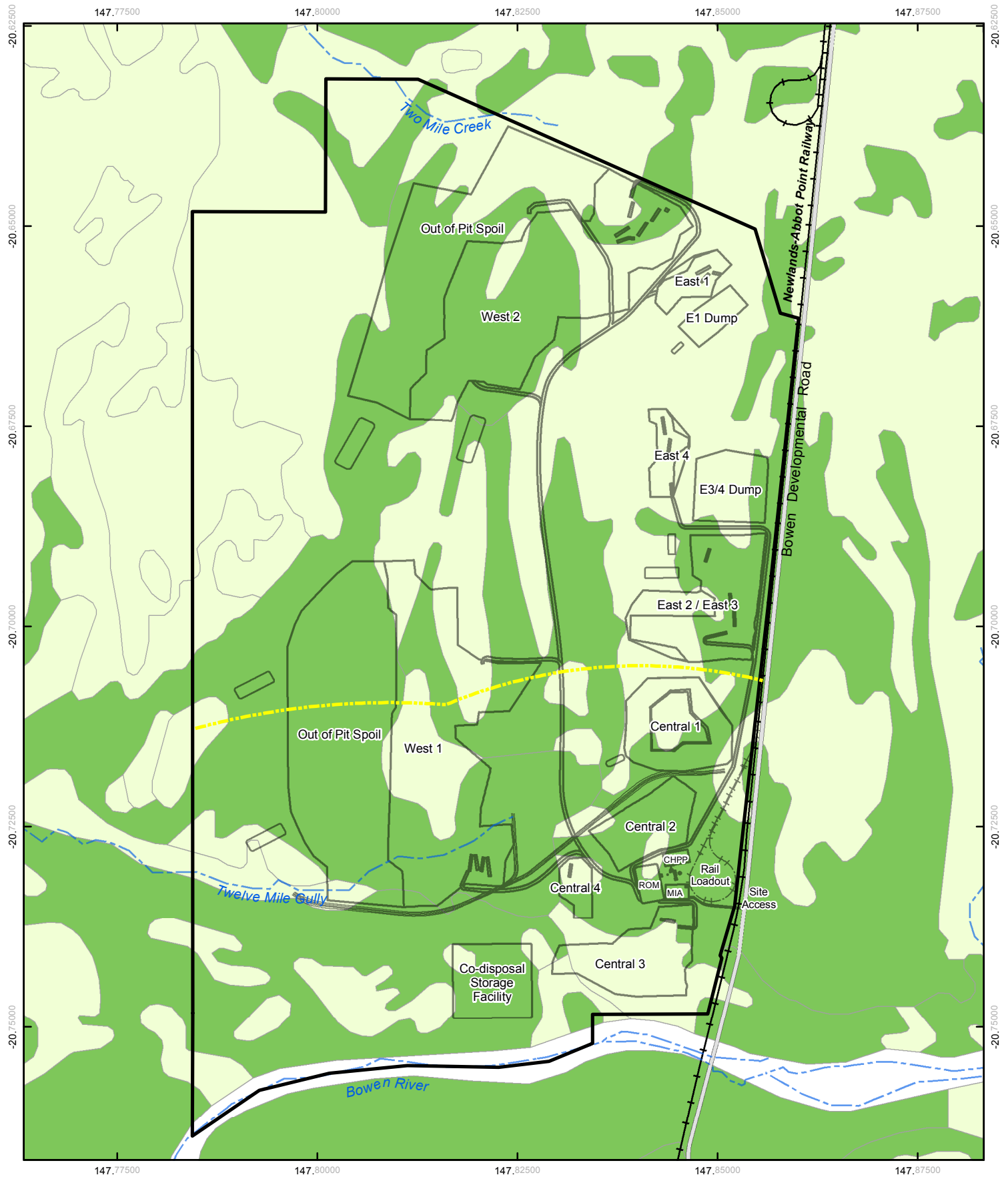
A search of the Bowen Shire Planning Scheme indicated that the Project area is located within a GQAL Special Management Area and that protection of the GQAL is part of the desired environmental outcomes for the Bowen Shire. These areas of GQAL are indicated in Figure 13.

The specific outcome for the GQAL in Bowen Shire is that good quality agricultural land is retained for rural purposes. This will be achieved by:

- ▶ Conducting other uses only if they are not irreversible and do not reduce the productive capacity of the land or alienate its use for rural purposes or result in land use conflicts with adjacent existing rural uses;
- ▶ Avoiding the use of identified land for other uses unless it can be proven that:
 - The land is not actually valuable agricultural land;
 - There is an overriding need in terms of public benefit for the proposal and the proposal cannot be located on alternative sites that are not identified as good quality agricultural land, including if:
 - The proposed location has features that make it desirable for the proposal; and
 - The features are not available in areas not identified as valuable agricultural land.

4.2.1 GQAL Methodology

To determine the presence of any GQAL within the Project area, the land suitability results were assessed against the agricultural land classes, as described in the *Planning Guidelines: The Identification of Good Quality Agricultural Land* (DPI/DHLGP, 1993). The approximate correlation between land suitability for cropping (Land Resource Branch, 1990) and Agricultural Land Classes is provided in Table 22.



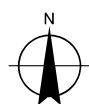
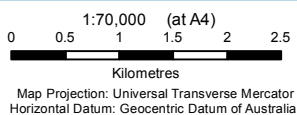
LEGEND

- Major Road
- Existing Railway
- Drainage Feature
- Irrigation within 5km of Bowen River

- Project Area
- Mine Layout

- Collinsville Nebo Moranbah Land Suitability Study (Based on 1:250 000)
- Class A
- Class C

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GQAL in the Vicinity of the Proposed Project Area (DPI, 1984) Figure 13



Table 22 Broadacre Cropping and Grazing Land Suitability Correlation to Agricultural Land Class

Land Suitability Class	Land Suitability Description	Agricultural Land Class Description*	Agricultural Land Class
1	Suitable land with negligible limitations.	Crop Land – land that is suitable for current and potential crops with limitations to production ranging from negligible to moderate levels. Land is considered to be good quality agricultural land (GQAL).	A
2	Suitable land minor limitations.		
3	Suitable land with moderate limitations.		
4	Marginal land, presently unsuitable due to severe limitations.	Limited Crop Land – Land marginal for current and potential crops due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. Land is considered to be GQAL.	B
		Pasture Land – Land that is only suitable 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 or pasture establishment.	C
5	Unsuitable land with extreme limitations.	Non-agricultural Land – Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.	D

4.2.2 GQAL Results

The Agricultural Land Classes for each land unit in the Project area were assessed using calculated Land Suitability (Appendix F) and the correlations provided in Table 22. The subsequent land use suitability and agricultural land class of each land unit are shown in Table 26. Land Unit LU2 was considered to be Class A Agricultural Land which is suitable for potential crops with moderate limitations. Land Units LU1, LU3, LU4, LU5 and LU6 were considered to be Class C Agricultural Land. Class C land 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 (Figure 14).



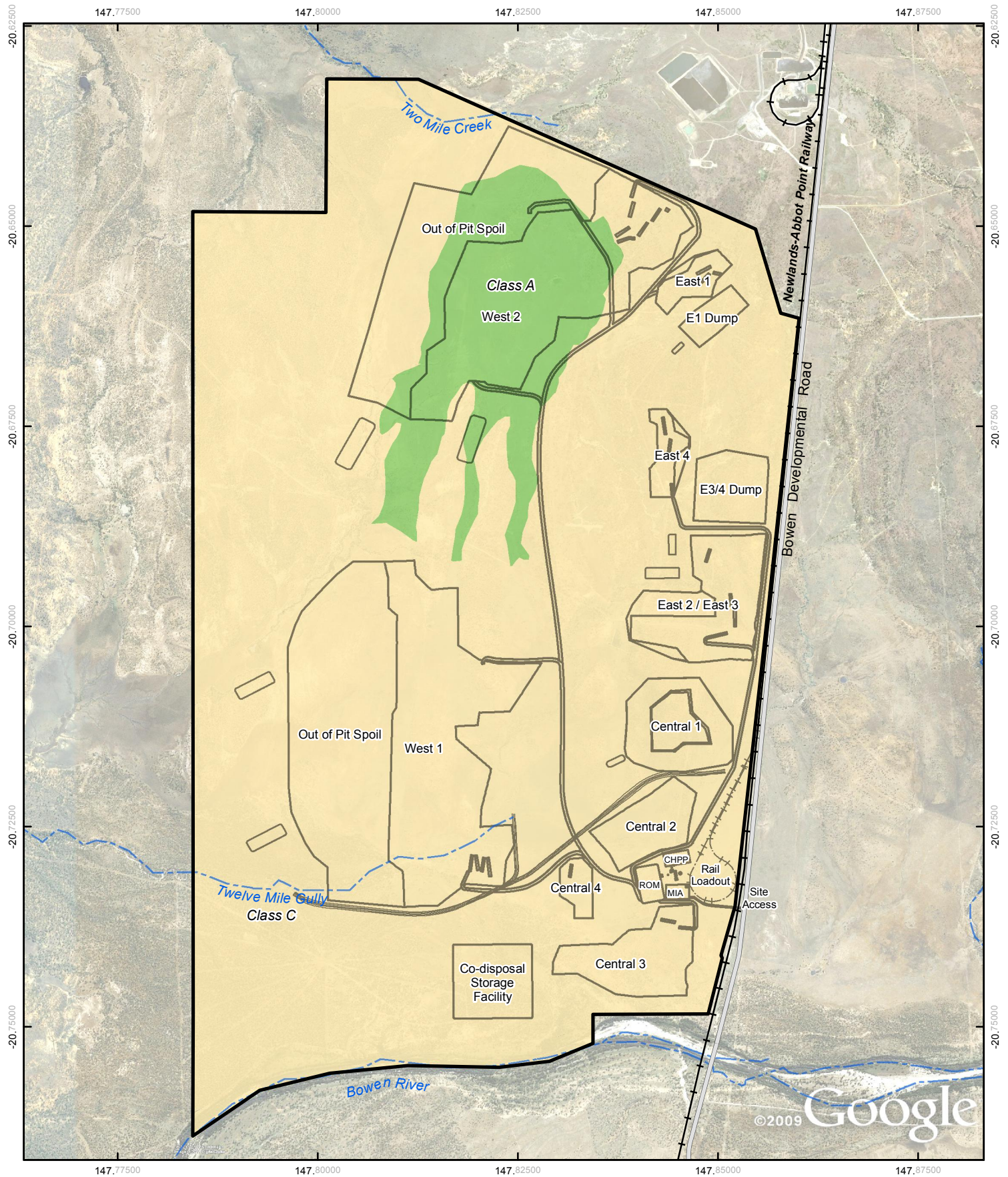
Table 23 Suitabilities of the Land Units for Cropping and their Agricultural Land Classes

Land Unit	Broadacre Crops		Grazing		Agricultural Land Class
	Suitability	Severe Limitation*	Suitability	Severe Limitation	
LU1	4	Workability and physical condition.	3	-	C
LU2	3	-	3	-	A
LU3	5	Extreme Water Availability.	4	Water Availability.	C
LU4	4	Dissected Topography.	3	-	C
LU5	4	Water Availability & Erosion.	3	-	C
LU6	4	Flooding.	3	-	C

A comparison of these results with the regional GQAL maps provided within the Bowen Shire Planning Scheme shows that the Class C land (LU1, LU3, LU4, LU5 and LU6) roughly correlates with the Planning Scheme, with the exception of the southern portion of the area. The Class A (Land Unit LU2) land correlates with the Planning Scheme in the northern portion of the area. However, the Planning Scheme indicates more extensive Class A. Within the remaining area, there are some differences between the findings of this field investigation and the Planning Scheme, and much of the additional Class A land shown on the Planning Scheme map approximately corresponds with the Land Unit LU1 area (Class C land). However, the GQAL results reported by GHD have been based on more intensive field observations within the proposed Project area.

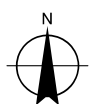
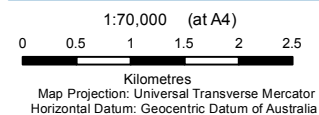
4.3 Strategic Cropping Land

A Strategic Cropping Land Assessment was not conducted and is not required for this Project as the Terms of Reference were finalised in December 2010 and a certificate of application for mining leases were issued prior to the cut-off date of 31 May 2011.



LEGEND

- | | | |
|----------------------|----------------|---|
| — Major Road | ▬ Project Area | Agricultural Land Class(Based on 1:50000) |
| — Existing Railway | ▬ Mine Layout | Class A - Suitable land with negligible limitations |
| --- Drainage Feature | | Class C - Marginal land, presently unsuitable due to severe limitations |



Drake Coal Pty Ltd
Drake Coal EIS

Job Number 41-21894
Revision 1
Date 13 Mar 2012

Agricultural Land Classes

Figure 14



5. Conclusions

Six broad land units were defined within the Project area during the initial desktop review and soil survey.

The first of these Land Units (LU1) with mainly Vertosols was located in the central portion of the site in low lying areas. The second Land Unit (LU2) was also located centrally, appearing as Vertosols on undulating terrain. Land Unit 3 (LU3) consisted of Sodosols on the elevated western portion of the site, and these are considered highly prone to erosion. Land Unit 4 (LU4) also contained hard setting Sodosols, located in the low-lying flood plain adjacent to the Bowen River, in the southern portion of the site. The fifth land unit, LU5 was located on the higher ground on the eastern portion of the site, with open eucalypt woodland on Dermosols and Vertosols. Land Unit (LU6) was located adjacent to intermittent or permanent watercourses with marked terraces, levees and shallow drainage depressions. Proposed infrastructure and areas of disturbance associated with the Drake Coal Project are largely located in the central and western portions of the mining lease area, coinciding predominantly with Land Units (in decreasing order) LU1, LU5, LU2 and LU4. The other two Land Units (LU3 and LU6) are likely to be affected to a much smaller extent.

Based on the soil assessment results, topsoil stripping is recommended from three of the Land Units (LU1, LU2 and LU5) and possibly part of LU6. LU1, LU2 and LU5 cover approximately 62% of the Project area and coincide with the majority of proposed Project development. Surface soil from Sodosols of Land Units LU3 and LU4 is not considered suitable for stripping as its high erodibility and low water availability make the soil unsuitable for plant growth and use in rehabilitation activities. Very little project development is planned for these land units and disturbance is expected to be minimal, except in the vicinity of "Central 3" development.

The land suitability assessment results indicate that all land units in the Project area are better suited to Beef Cattle Grazing than for Rainfed Broadacre Cropping with the exception of LU2 which is suitable for both land uses. LU2 was assessed to be suitable for Broadacre Cropping and approximately 70% of this land unit is located within the development area. All land units, with the exception of LU3, were assessed as suitable for Beef Cattle Grazing and therefore, approximately 85% of the Project area is considered suitable for this land use. The above land units will have the most impact during development of the proposed Project. The remaining land unit (LU3), located on the eastern portion of the site, was considered to be marginal for Beef Cattle Grazing. Land Units within 5 km proximity to the Bowen River were also assessed for suitability for irrigation. The results indicate the soils are generally unsuitable for irrigation, based on either the shrink-swell properties of the Vertosols or the sodic subsoil and high erodibility potential of the Sodosols.

Class A Good Quality Agricultural Land was identified on the Project site on Land Unit LU2. The remaining land units were determined to be Class C agricultural land suitable only for grazing.



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Appendix A

Ground Observation Descriptions

Soil Survey Ground Observations - Drake Coal Project November - December 2011

Location (G#)	Observation Date	Photo No.	Location		Soil Type	Position & Slope (%)	Land Use	Vegetation	Erosion?	Comment
			Latitude	Longitude						
1	30/11/11	596-600	-20,40,22.0728	147,51,3.0708	-	Alluvial Flat	Grazing	Melaleuca sp., Bauhinia, Mountain Coolibah, Buffel grass, Qld Blue grass, Bloodwood	Active Gully to 2m deep	Sandstone and mudstone rocks in gully. Layers of SCL with layers of gravelly LS. SCL light brown, gravelly LS lighter, yellowish brown. White clay at 1.4 m depth. Roots common down to 1.4 m.
1	30/11/11	601-603	-20,40,22.0728	147,51,3.0708	-	Upper slope 3%	Grazing	Mountain Coolibah, Bloodwood, Buffel grass, Spear grass	-	Silty clay loam A1 horizon (black 7.5YR2.5/1). Light clay in B horizon with calcium carbonate nodules (light olive brown 2.5Y5/4)
1	30/11/12	604	-20,40,22.0728	147,51,3.0708	Black Vertosol	-	Grazing	Mountain Coolibah, Acacias, Buffel grass	Minor water sheeting	See Soil Survey Worksheet C1
2	30/11/11	611-613	-20,40,22.5372	147,51,0.162	-	Midslope 3%	Grazing	Bloodwood, Mountain Coolibah	Soft Scald	Crust on surface, overlying a dark grey angular blocky structure, heavy clay. Possibly sodic.
3	30/11/11	614	-20,40,21.6408	147,50,57.8652	Brown Dermosol (Shallow)	Ridge 1%	Grazing	Mountain Coolibah, Ironbark, Buffel grass	Water sheeting	See Soil Survey Worksheet Soil Survey Worksheet C2
4	30/11/11	620	-20,40,20.532	147,50,43.9692	Brown Dermosol (Shallow)	Broad Ridge	Grazing	Ironbark, Bloodwood, Buffel grass	Minor water sheeting	See Soil Survey Worksheet C3
5	30/11/11	628	-20,40,19.5168	147,50,33.684	Black Vertosol	Drainage line	Grazing	Ironbark, Bloodwood	-	Black Vertosol over weathering lithic felspathic sandstones. 1m depth of cracking clay over sandstone bed rock.
6	30/11/11	629-630	-20,40,17.9472	147,50,20.238	-	Ridge	Cell Grazing	Bloodwood, Ironbark	-	Rotational cell grazing. Silty topsoil.
7	30/11/11	631-633	586875.4861	7714040.101	Brown Vertosol	Midslope		Brigalow community	-	Brown Vertosol, wash off siltstone, cracks to 50 mm wide.
8	30/11/11	634	586841.6534	7714998.206	Red Dermosol (Shallow)	Ridge	Grazing	Prickly Acacia, Brigalow, Buffel grass	Minor sheet erosion	See Soil Survey Worksheet C4
9	30/11/11	640	-20,39,43.8732	147,50,2.7348	Black Vertosol (gilgai)	Ridge	Grazing	Prickly Acacia, Brigalow, Buffel grass	Nil	See Soil Survey Worksheet C5
9	30/11/11	660	-20,39,43.8732	147,50,2.7348	Brown Vertosol (gilgai)	Elevated Crest	Grazing	Prickly Acacia, Brigalow	-	Brown Vertosols, minor Gilgai.
10	30/11/11	643	-20,39,43.3152	147,49,46.2972	Black Vertosol (gilgai)	Elevated gentle slope	Grazing	Whitewood, Prickly Acacia, Buffel grass	Nil	See Soil Survey Worksheet C6
11	30/11/11	650	-20,39,38.1852	147,49,10.848	Black Vertosol (Shallow)	Gentle Slope 1%	Grazing	Whitewood, Prickly Acacia, Brigalow, Buffel grass	Nil	See Soil Survey Worksheet C7
12	30/11/11	655	-20,40,32.2068	147,48,23.1948	Alluvium overlying Black Vertosol	Deposition Zone, Flat	Grazing	Bauhinia, Brigalow, Whitewood, Buffel grass	Nil	See Soil Survey Worksheet C8
15	2/12/11	661-662	-204218.8928	147,51,18.5508	Brown Dermosol	1%	Grazing	Bloodwood, Ironbark, Buffel grass	-	Lithic sandstone. Brown dermosol at railway line cutting.
16	2/12/11	663-664	-20,41,58.0992	147,51,7.4268	-	5%	Grazing	Brigalow, Buffel grass, Carissa ovata, Bauhinia, Bloodwood	-	Lithic sandstone rock, outcrop.
17	2/12/11	665-666	-20,41,59.5752	147,50,46.4532	Brown Dermosol	-	Grazing	Bloodwood, Ironbark, Buffel grass	-	Brown Dermosol.
18	2/12/11	667-668	-20,41,52.6488	147,50,6.5688	Rudosol	Alluvial Flat 1%	Grazing	Melaleuca sp., Moreton Bay Ash, Bauhinia, Buffel grass	Gullies to 2m deep	Stratic rudosol.
19	2/12/11	669-671	-20,41,44.1348	147,49,47.01	Red Dermosol (Shallow)	3-5%	Grazing	Brigalow, Bloodwood, Ironbark, Buffel grass	-	Sandstone, Red Dermosol (very shallow).
20	2/12/11	672-674	-20,41,37.4388	147,49,35.6952	Black Vertosol	1%		Brigalow, Buffel grass	Gully to 1.5m	Black Vertosol (becoming shallow on plain).
21	2/12/11	675-676	-20,41,27.33	147,49,16.536	Sodosol	-	Grazing	Ironbark, Bloodwood, Buffel grass	-	Sodosol.
22	2/12/11	677-678	-20,41,17.304	147,48,52.4448	-	5%		Whitewood, Buffel grass	-	lithic sandstone, sodic scald.
23	2/12/11	679-680	-20,41,8.2752	147,48,26.9568	Black Vertosol (Shallow)	Old flood plain	Grazing	Owenia acidulata, Brigalow, Buffel grass	-	Shallow Black Vertosol (less than 1 m deep).
24	2/12/11	681-683	-20,41,7.9008	147,48,22.554	Rudosol	Creek bed	-	Bauhinia, Brigalow, Moreton Bay Ash, Bloodwood, Buffel grass	-	Sandy creek. Stratic rudosol (layered). Layers of sandy loam. Creek running after 30mm of rain.
25	2/12/11	684-685	-20,41,4.3548	147,48,14.9112	-	Alluvial Flat	-	Box trees (open woodland), Buffel grass	-	Alluvial flat.
26	2/12/11	686	-20,40,5.79	147,47,13.47	Brown Sodosol	Crest	-	Box trees (open woodland), Carissa ovata, Buffel grass, Bauhinia	Minor	See Soil Survey Worksheet C9
27	2/12/11	693-694	582,277.092	7,714,008.662	Sodosol	3-5%	-	Box trees, Buffel grass	-	Quarry site, sodic shallow soil, 50 cm soil depth over sandstone, similar to Core 9.
28	2/12/11	695-697	-20,40,36.4188	147,47,27.204	-	Midslope 3-5%	-	Box tree woodland, Buffel grass	Severe gully erosion	Severe gully erosion.
29	2/12/11	698	582,858.096	7,713,063.821	Yellow/Brown Sodosol	Upper slope (Gully)	-	Box woodland, Buffel grass	Severe gully erosion	See Soil Survey Worksheet C10
30	2/12/11	704	-20,40,59.0448	147,47,57.8832	Yellow/Brown Sodosol	Midslope 3-5%	-	Carissa ovata, Bloodwood, Ironbark, Buffel grass	Nil	See Soil Survey Worksheet C11
31	2/12/11	710	-20,40,57.414	147,47,10.1112	Brown Sodosol	Upper slope 2%	-	Cassia brewsteri, Box trees (open woodland), Buffel grass	Minor water erosion	See Soil Survey Worksheet C12
32	2/12/11	722-723	-20,40,57.1548	147,47,19.698	Red Sodosol	Gully	-	Eucalyptus platyphylla, Box tree, Buffel grass, Cassia brewsteri	Severe gully erosion	Severe gully erosion. Soil becomes redder as slope increases. Possibly Red Sodosol. Located adjacent to C13 but up the gully slope.
32	2/12/11	717	-20,40,57.1548	147,47,19.698	Sodic Brown Kandosol	Gully	-	Eucalyptus platyphylla, Box tree, Buffel grass, Cassia brewsteri	Severe gully erosion	See Soil Survey Worksheet C13
33	2/12/11	724-725	-20,40,57.1872	147,47,21.1632	Red Sodosol	Midslope 3-5%	-	Cassia brewsteri, Box woodland, Buffel grass	-	Red Sodosol.
34	2/12/11	726	-20,40,59.2932	147,47,35.9988	Brown Sodosol	Swale	-	Open box woodland, buffel grass	Nil	See Soil Survey Worksheet C14
36	2/12/11	732-733	-20,41,0.1392	147,47,53.484	Red Sodosol	Upper slope	-	Open box/ironbark woodland, buffel grass	-	Red Sodosol.
37	2/12/11	734-735	-20,41,1.1472	147,47,57.4512	Brown Sodosol	Midslope	-	Open box woodland, buffel grass	-	Sodic Brown Sodosol.
38	2/12/11	736-737	-20,41,2.9472	147,48,4.4172	Brown Sodosol	Lower slope	-	Open box woodland, buffel grass	-	Brown Sodosol.
39	2/12/11	738	-20,38,53.8332	147,48,22.6008	Black Vertosol	Flat	Grazing	Brigalow, Box, Cassia brewsteri, Bauhinia, Buffel grass	Nil	See Soil Survey Worksheet C15: Gypsum at 120cm
40	2/12/11	744	-20,38,43.836	147,48,5.166	Brown Sodosol	Swale	Grazing	Open Box woodland, Buffel grass	Minor water erosion	See Soil Survey Worksheet C16
41	2/12/11	749	-20,38,50.5068	147,48,10.17	Brown Sodosol	Midslope 2%	Grazing	Open Box woodland	Nil	See Soil Survey Worksheet C17
42	2/12/11	756	583729.177	7715347.045	Brown Sodosol	Elevated Ridge	-	Brigalow, Box woodland, Cassia brewsteri, Carissa ovata, Whitewood, Buffel grass	Minor water erosion	See Soil Survey Worksheet C18
43	2/12/11	762-763	-20,40,0.7932	147,48,6.912	-	Midslope	Grazing	Open Box woodland	-	Sandstone rock outcrop.
44	2/12/11	766-767	-20,40,7.1868	147,48,2.844	-	Gully	-	Open Box woodland	Severe gully erosion	Demonstrates hard surface setting characteristics.
44	2/12/11	764-765	-20,40,7.1868	147,48,2.844	Yellow/Brown Sodosol	Gully	-	Open Box woodland	Severe gully erosion	Yellow/Brown Sodosol.
45	2/12/11	768-769	-20,40,29.586	147,48,7.956	Sodosol	-	-	-	Tunnel erosion	Tunnel erosion through sodic soils. Gully is accelerating at an increasing rate up the hill.
46	2/12/11	770-771	-20,44,12.8472	147,48,10.2168	Rudosol	-	-	E. platyphylla, Box open woodland	Gully erosion	Soil profile exposed in gully, stratic Rudosol.
47	2/12/11	772	-20,41,1.7412	147,49,17.8572	Brown Dermosol (Shallow)	Midslope 2%	Grazing	Bloodwood, Ironbark	Nil	See Soil Survey Worksheet C19
48	2/12/11	778	-20,40,45.8472	147,49,14.34	Calcarosol	Midslope 1-2%	-	Ironbark, Bloodwood, Bauhinia, Buffel grass	Minor sheet erosion	See Soil Survey Worksheet C20
49	2/12/11	784	-20,40,39.756	147,49,9.9552	Dermosol	Midslope 1-2%	-	Ironbark, Bloodwood, Buffel grass	Minor sheet erosion	See Soil Survey Worksheet C21
50	2/12/11	790	-20,42,12.0168	147,48,47.124	Black Vertosol	Midslope 2%	-	Brigalow, Buffel grass	Minor water erosion	See Soil Survey Worksheet C22
52	2/12/11	795-796	-20,42,22.3632	147,48,45.6372	-	Drainage line	-	Brigalow, Sand paper fig, Owenia acidulata	-	Rounded drainage line, series of drainage lines running south with interfluvies.
53	2/12/11	797	-20,42,41.9508	147,48,45.2808	Red Dermosol	Lower slope 1%	Grazing	Whitewood, regrowth Brigalow, open Buffel grassland	Minor sheet erosion	See Soil Survey Worksheet C23
55	2/12/11	802	-20,43,18.6672	147,48,38.3688	Black Vertosol	Lower Slope 1%	-	Whitewood, Buffel grasslands	Minor sheet erosion	See Soil Survey Worksheet C24
56	2/12/11	808	-20,44,23.5968	147,48,18.81	Brown Sodosol	Flat	Cell grazing	Eucalyptus platyphylla, Ironbark, Bloodwood	Nil	See Soil Survey Worksheet C25
57	2/12/11	815-816	-20,44,12.8472	147,50,10.23	Black Vertosol	Flat	Grazing	Grasslands	-	Change from sodic plains to a Black Vertosol flat.
60	2/12/11	817-818	-20,42,11.5308	147,50,53.3868	-	Ridge	Grazing	Regrowth trees	-	Conglomerate rock. Tertiary siltcrete.
60	2/12/11	835	-204211.5308	147,50,53.3868	Red Dermosol (Shallow)	Ridge 1%	-	Ironbark, Bloodwood, Buffel grass	Nil	See Soil Survey Worksheet C28
61	2/12/11	841	-20,42,46.6992	147,50,48.1272	Brown Dermosol	Upper slope	-	Bloodwood, Brigalow, Bauhinia, Buffel grass	Nil	See Soil Survey Worksheet C29
62	2/12/11	829-834	-20436.582	147,50,44.6568	Red Dermosol (Shallow)	Upper slope 1-2%	Grazing	Bloodwood, Ironbark, Buffel grass	Minor sheet erosion	See Soil Survey Worksheet C27
63	3/12/11	846-847	-20,43,18.948	147,50,42.8208	-	-	-	-	-	Change of slope on flat.
64	3/12/11	848	-20,43,26.3172	147,50,41.7948	Black Vertosol	-	-	-	-	Channel 10 m wide, 1.5 m deep. Black Vertosol.
64	3/12/11	824-828	-20,43,26.3172	147,50,41.7948	Brown Vertosol	Flat	-	Brigalow, Bauhinia, Sesbania, Buffel grass	Minor water erosion	See Soil Survey Worksheet C26
65	3/12/11	849-850	-20,43,34.788	147,50,40.5348	-	-	-	-	-	Edge of flood plain.
66	3/12/11	851	-20,43,37.974	147,50,39.624	Brown Dermosol (Deep)	Upper slope	-	Brigalow, Owenia acidulata, Buffel grass, Whitewood	Nil	See Soil Survey Worksheet C30
67	3/12/11	857	-20,43,46.362	147,50,38.544	Red Dermosol	Midslope 3%	-	Bauhinia, Brigalow, Native Orange, Carissa ovata, Buffel grass	Nil	See Soil Survey Worksheet C31
68	3/12/11	863	-20,43,49.9188	147,50,38.292	-	-	-	-	-	Change of slope and vegetation.
69	3/12/11	863	-20,43,55.452	147,50,36.8988	Red Dermosol	Ridge	-	Bloodwood, Box woodland, Ironbark, Bauhinia, Buffel grass	Minor	See Soil Survey Worksheet C32
70	3/12/11	870	-20,44,5.8488	147,50,21.012	Black Vertosol	Midslope 2-3%	-	Brigalow, Owenia acidulata, Bauhinia, Buffel grass	Nil	See Soil Survey Worksheet C33
71	3/12/11	876	-20,44,10.9788	147,50,11.7852	Black Vertosol	Lower slope	-	Bloodwood, Brigalow, Buffel grass	Nil	See Soil Survey Worksheet C34

Location (G#)	Observation Date	Photo No.	Location		Soil Type	Position & Slope (%)	Land Use	Vegetation	Erosion?	Comment
			Latitude	Longitude						
72	3/12/11	882	-20,44,13.8552	147,49,48.63	Red Chromosol	Upper slope 1%	-	Ironbark, Bloodwood, Buffel grass	Minor water sheeting erosion	See Soil Survey Worksheet C35
73	3/12/11	888	-20,44,9.348	147,49,14.5848	Tenosol	Flat River Terrace	Grazing	Scattered Bloodwood, <i>Eucalyptus platyphylla</i> , grassland	Nil	See Soil Survey Worksheet C36
74	3/12/11	894	585447.5698	7706860.572	-	-	-	-	-	Depression.
75	3/12/11	895-896	-20,44,9.024	147,49,20.262	-	-	-	-	-	Sandy splay.
76	3/12/11	897-898	-20,44,9.4308	147,49,22.3752	-	-	-	-	-	Soil type change.
77	3/12/11	899	-20,44,9.3228	147,49,24.3048	Brown Sodosol	High River Terrace	-	Open woodland, large bloodwoods, large <i>Eucalyptus platyphylla</i> , native grasses	Nil	See Soil Survey Worksheet C37
78	3/12/11	905	-20,44,4.5348	147,49,6.87	Brown Sodosol	Open depression	-	Bloodwood, Moreton Bay Ash, <i>Eucalyptus platyphylla</i> , Buffel grass	Nil	See Soil Survey Worksheet C38
79	3/12/11	911	-20,44,4.1028	147,49,4.5192	-	-	-	-	-	Compacted soil from stock movement.
80	3/12/11	912	-20,44,5.7912	147,48,59.8788	-	River Terrace	-	-	-	First terrace.
81	3/12/11	913	-20,44,18.6828	147,47,9.7188	Red Sodosol	Plain	-	Open woodland (Box and <i>E. platyphylla</i>), 80% grass cover	Minor water erosion	See Soil Survey Worksheet C39
82	3/12/11	919	-20,44,19.7628	147,47,18.8412	-	-	-	-	-	Soil change (transition to cracking soils).
83	3/12/11	920	-20,44,23.5032	147,47,32.514	Brown Sodosol	Flat	-	Open woodland (Box and <i>E. platyphylla</i>), <i>Eremophila</i> , Buffel grass, Qld Blue grass	Nil	See Soil Survey Worksheet C40
84	3/12/11	927	-20,45,15.2532	147,48,7.6608	Tenosol	Flat River Terrace	-	<i>E. tereticornis</i> , <i>E. platyphylla</i> , Bloodwood, Buffel grass	Nil	See Soil Survey Worksheet C41
85	3/12/11	933	-20,45,18.1368	147,48,8.8272	-	River	-	-	-	Bowen river.
85	3/12/11	934	-	-	-	Flat River Terrace	-	-	-	Bowen river, lower terrace.
86	3/12/11	935	-20,45,5.9688	147,48,14.3028	-	-	-	-	Gully erosion	Gully erosion.
87	3/12/11	936	-20,45,1.6992	147,48,18.7452	-	-	-	-	Gully erosion	Gully erosion.
88	3/12/11	937	-20,44,54.1788	147,48,30.744	-	-	-	-	Gully erosion	Gully erosion.
89	3/12/11	938-940	-20,44,56.1588	147,48,36.576	-	-	-	-	Gully erosion	Gully erosion.
90	3/12/11	941	-20,44,52.6632	147,48,35.784	Brown Sodosol	Flat	-	Open woodland (Box, Bloodwood), grassland	Minor sheet erosion	See Soil Survey Worksheet C42
91	3/12/11	946	-20,44,43.2672	147,48,22.6152	Sodosol	-	-	<i>Eremophila</i> sp.	-	Possible presence of sodic soil.
92	3/12/11	947	-20,44,38.5368	147,48,15.8112	Brown Sodosol	-	-	-	-	Brown Sodosol in tree roots.
93	3/12/11	948	-20,44,36.096	147,48,11.1168	Brown Sodosol	Flat	-	Bauhinia, <i>Eremophila</i> , 50% grass cover	Minor sheet erosion	See Soil Survey Worksheet C43
95	3/12/11	954	-20,43,46.326	147,48,34.704	-	-	-	-	Gully erosion	Gully erosion (20 m wide, 3 m deep).
95	3/12/11	955	-	-	-	-	-	-	-	Erodible soils.
97	3/12/11	956	-20,43,37.632	147,48,35.982	Black Vertisol	Midslope 3%	-	Brigalow, Open buffel grassland	Minor sheet erosion	See Soil Survey Worksheet C44
99	3/12/11	962	-20,43,0.8148	147,48,41.3748	Black Vertisol	Lower slope	Cell Grazing	-	-	Gully in Black Vertisol, on lower slope near cell grazing water centre.
100	3/12/11	963	-20,42,55.404	147,48,42.4008	-	Dam	-	-	Eroded	Erosion at dam.
101	3/12/11	964	-20,41,46.734	147,48,49.7052	Brown Sodosol	-	-	-	-	Similar to Core-45.
102	3/12/11	965	-20,41,42.8928	147,48,49.842	Brown Sodosol	Midslope 4%	-	Bloodwood, Bauhinia, Ironbark, Open Buffel grassland	Moderate gully erosion and sheet erosion	See Soil Survey Worksheet C45
104	3/12/11	971	-20,41,29.0652	147,48,51.9588	-	-	-	-	-	Surface sandstone rock.
105	3/12/11	974	-20,41,27.8772	147,48,51.9732	-	Waterway	-	-	-	Broad waterway (30 m wide).
106	3/12/11	975	-20,40,34.2372	147,49,5.7792	-	Gully	-	-	-	Gully - drainage line between flat and ridge.
107	3/12/11	976	-20,40,29.8668	147,49,1.9668	Red Sodosol	Midslope	-	Ironbark, Bloodwood, Bauhinia, Buffel grass	Severe sheet erosion	See Soil Survey Worksheet C46
109	3/12/11	982	-20,39,49.4892	147,49,4.4832	Black Vertisol	Hill Crest	-	-	Badly scalded	Badly scalded area, crest of hill, bare Black Vertosols.
110	3/12/11	983	-20,39,23.5188	147,49,7.5972	-	Gully	-	-	-	Shallow rounded gully.
111	3/12/11	984	-20,39,18.396	147,49,7.9248	Black Vertisol	Lower slope	-	Open Buffel grassland, small Whitewood	Minor gully erosion	See Soil Survey Worksheet C47
115	3/12/11	990	-20,39,7.0308	147,49,9.948	Black Vertisol	Rise	-	-	-	Black Vertisol on rise.
116	3/12/11	991	-20,38,54.0708	147,49,27.3828	Brown Vertisol	Crest rise	-	Box, Brigalow, <i>Owenia acidulata</i> , Buffel grass	Minor sheet erosion	See Soil Survey Worksheet C48
117	3/12/11	997	-20,39,4.212	147,49,58.6092	Tenosol	Midslope 2-3%	-	Bloodwood, Buffel grassland	Moderate sheet erosion	See Soil Survey Worksheet C49
118	3/12/11	1005	-20,39,13.7448	147,50,15.684	-	-	-	-	-	Transition in soil type.
119	3/12/11	1006	-20,39,22.824	147,50,27.2832	Brown Vertisol	Upper slope	-	Open Buffel grassland, mountain Coolibah, Whitewood, Brigalow	Moderate gully erosion	See Soil Survey Worksheet C50
120	3/12/11	1012	-20,39,29.772	147,50,35.88	Dermosol	-	-	-	-	Dermosol in fallen tree root.
121	3/12/11	1013	-20,39,32.202	147,50,39.0192	-	-	-	-	-	Scattered rock on surface.
122	3/12/11	1014	-20,39,52.1172	147,50,51.4212	-	-	-	-	Gully	Erosion Gully.
123	3/12/11	1015	-20,40,14.6748	147,50,54.6612	-	-	-	-	-	Sandstone rock.
124	3/12/11	1016	-20,40,38.91	147,50,51.6408	-	Ridge	-	-	-	Top of ridge, shallow crusted soils.
126	4/12/11	1017	-20,41,6.2772	147,48,9.0288	-	-	-	<i>Urochloa</i> Grass, Box woodland	-	Sandy soil.
127	4/12/11	1018-1021	-20,41,14.19	147,48,10.206	-	-	-	Salt bush	-	Salt bush.
128	4/12/11	1022	-20,41,25.2708	147,48,3.402	Vertisol	-	-	Parthenium	-	Parthenium weed on Vertisol.
129	4/12/11	1023-1024	-20,41,49.4772	147,47,46.1688	-	-	-	-	Gully	Erosion gully.
131	4/12/11	1025-1026	-20,42,1.782	147,47,38.1912	-	-	-	-	Gully	Gully 2m wide and 1.5 m deep, levee on edge of gully.
132	4/12/11	1032-1033	-20,42,6.516	147,47,31.4772	-	Dam	-	-	-	Dam.
132	4/12/11	1027-1031	-20,42,6.516	147,47,31.4772	Brown Vertisol	Alluvial Fan	-	-	-	Brown Vertisol (alluvial fan).
133	4/12/11	1034-1035	-20,42,15.2568	147,47,27.5568	Black Vertisol	-	-	-	-	10YR4/2 Black Vertisol.
134	4/12/11	1037-1038	-20,42,19.17	147,47,27.8052	-	-	-	-	-	Brown loam soil on black clay in gully (5 m wide and 1.5 m depth).
134	4/12/11	1036	-20,42,19.17	147,47,27.8052	Black Vertisol	-	Grazing	-	-	Cattle on Black Vertisol.
135	4/12/11	1039	-20,42,23.8248	147,47,24.0288	-	-	-	-	-	Sandy loam to at least 40 cm deep.
135	4/12/11	1040	-20,42,23.8248	147,47,24.0288	-	-	Grazing	Box woodland	-	Cattle in open Box woodland.
136	4/12/11	1041-1042	-20,42,30.942	147,47,15.6588	-	30-50%	-	-	-	Steep scarp, rocky. (30-50% slope)
137	4/12/11	1043-1044	-20,42,31.4892	147,47,13.1928	Rudosol	Ridge	-	-	-	Sandy lithic Rudosol (hard ridge).
138	4/12/11	1045-1046	-20,42,33.336	147,47,7.188	-	Ridge	-	-	-	Loose sand below ridge.
139	4/12/11	1047-1048	-20,43,24.8988	147,47,6.648	-	Ridge	-	-	-	Sandy soil, below small story ridge.
140	4/12/11	1049-1051	-20,43,26.7492	147,47,18.2508	-	-	-	<i>E. platyphylla</i>	-	Loamy sand soil opening up to the north with more heavy soil east of the ridge line.
141	4/12/11	1052-1053	-20,43,25.392	147,47,31.5312	-	-	-	-	-	Fine sandy loam (grey).
142	4/12/11	1054	582522.1998	7708498.828	Black Vertisol	-	-	-	-	Carbonate nodules on surface of Black Vertisol.
142	4/12/11	1055-1056	582522.1998	7708498.828	Black Vertisol	-	-	-	-	Gilgai puff. Black soil, pH 9.5, A1 light clay.
143	4/12/11	1057-1058	-20,43,15.9708	147,47,33.342	Black Vertisol	-	-	Cane grass	-	Melon hole country medium clay at the top (pH 6) graduating to heavy clay (B horizon), Black Vertisol.
144	4/12/11	1059-1061	-20,42,51.9588	147,47,38.5778	Black Vertisol	-	-	Mitchell grass	-	Mitchell grass on Black Vertisol.
145	4/12/11	1062-1064	-20,42,38.3112	147,47,42.0612	Brown Sodosol	-	-	-	-	Brown Sodosol.
146	4/12/11	1065-1066	-20,42,30.0528	147,47,43.8468	Brown Sodosol	-	-	-	-	Scald on Sodosol.
147	4/12/11	1067	-20,42,25.4628	147,47,48.2892	-	-	-	-	-	Sodic crust.
148	4/12/11	1068-1069	-20,42,24.858	147,47,50.2728	Brown Sodosol	-	-	-	Sheet erosion	Brown Sodosol affected by sheet erosion.
149	4/12/11	1070-1072	-20,42,21.564	147,47,56.1768	-	-	-	-	Sheet erosion	Soft scald with sheet erosion.
150	4/12/11	1073-1074	-20,42,16.4952	147,48,7.6392	Vertisol	-	-	-	-	10YR3/3 brown cracking Vertisol.
151	4/12/11	1075-1078	-20,42,14.508	147,48,11.592	Brown Sodosol	-	-	-	-	Brown Sodosol.
153	4/12/11	1079-1080	-20,42,9.8532	147,48,21.6108	Vertisol	3%	-	-	-	Cracking Vertisol clay.
154	4/12/11	1081-1082	-20,42,6.4188	147,48,30.8808	Black Vertisol	-	-	-	-	Black Vertisol.
155	4/12/11		-20,40.14800	147,47.22300	Brown Sodosol	VG, F	Grazing in remnant woodland on partially improved pastures	<i>Eucalyptus populnea</i> open woodland on light brown sandy clays, ground stratum of tussock grasses (<i>Pennisetum</i> *, <i>Urochloa</i> * and <i>Bothriochloa</i>)	Small scalds in places	Low rolling hills to west of property on landzone 9. Likely brown sodosols. Mixed native and introduced pastures. Remnant vegetation. Minor erosion in drainage depressions. Occasional small scalds.
156	4/12/11		-20,40.78100	147,47.62200	Brown Sodosol		Grazing in remnant woodland on partially improved pastures	<i>Eucalyptus populnea</i> open woodland on light brown sandy clays, ground stratum of tussock grasses (<i>Pennisetum</i> *, <i>Urochloa</i> * and <i>Bothriochloa</i>)	Minor gully erosion in drainagel depressions	Low rolling hills to west of property on landzone 9. Likely brown sodosols. Mixed native and introduced pastures. Remnant vegetation. Minor erosion in drainage depressions. Occasional small scalds.
157	4/12/11		-20,44.84400	147,49.40700	Brown Tensols and Rudosols		Grazing in remnant woodland on partially improved pastures	Mixed open woodland (<i>E. populnea</i> , <i>C. tessellaris</i> , <i>C. platyphylla</i> , <i>C. dallachiana</i>) on alluvial flats. Tussock ground stratum both native and introduced.	nil	Alluvial flats. Likely alluvial rudosols and tensols. Remnant vegetation with mixed native and introduced pastures. No obvious erosion.
158	4/12/11		-20,44.82300	147,49.70900	Brown Tensols and Rudosols		Grazing in remnant woodland on partially improved pastures	Mixed open woodland (<i>E. tessellaris</i> , <i>C. platyphylla</i> , <i>C. dallachiana</i> , <i>E. crebra</i>) on alluvial flats. Tussock ground stratum both native and introduced.	nil	Alluvial flats. Likely alluvial rudosols and tensols. Remnant vegetation with mixed native and introduced pastures. No obvious erosion.

Notes
 --indicates no information was recorded

Ground Observation Location: GO#1



Australian Soil Classification	Vertosol
Date / Time	17 November 2009 / 1220
Slope	1%
Aspect	300°
Elevation	153 m
Eastings / Northings	5837265 / 7718175
Depth to Free Water	None

Vegetation

Pasture with isolated trees. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology	Fine-grained sedimentary rocks
Landform	Flat
Surface Soil Condition	Periodic cracking
Runoff	Slow
Permeability	High
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Extensive clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Light Clay, brown (10 YR 5/3 dry), dry, moderate pedality, 5-10 mm, subangular blocky, rough, moderate strength. High plasticity (normal), moderately sticky. Roots common. Depth ~0.18 m.

Comments

Stable surface, gilgai micro relief, macropores 10-20 mm wide.

Ground Observation Location: GO#2



Australian Soil Classification Vertosol

Site Details

Date / Time	17 November 2009 / 1320
Slope	1%
Aspect	30°
Elevation	161 m
Eastings / Northings	584809 / 7717179
Depth to Free Water	None

Vegetation

Pasture with isolated trees. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Mid slope
Surface Soil Condition	Periodic cracking
Runoff	Moderately rapid
Permeability	High
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Extensive clearing
Type of Observation	Existing vertical exposure

Soil Description

Not described

Comments

Stable surface, macropores 20-50 mm wide.

Ground Observation Location: GO#3 (TP2)



Australian Soil Classification Vertosol

Site Details

Date / Time	17 November 2009 / 1351
Slope	1%
Aspect	270°
Elevation	173 m
Eastings / Northings	585379 / 7716309
Depth to Free Water	None

Vegetation

Pasture with isolated trees. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 70%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Flat
Surface Soil Condition	Periodic cracking
Runoff	Moderately rapid
Permeability	High
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Partially stabilised
Wind Erosion	None
Water Erosion	Minor sheet
Gully Erosion Depth	None
Disturbance of Site	Extensive clearing
Type of Observation	Auger boring

Soil Description

Medium Clay, very dark grey (5Y 3/1 dry), dry, strong pedality, 10-20 mm, subangular blocky, rough, moderately firm strength. High plasticity (normal), moderately sticky. Trace manganese nodules < 5 mm. Field pH 7.0. Many roots. Depth ~0.1 m.

Comments

Stable surface, macropores 10-20 mm wide.

Ground Observation Location: GO#4



Australian Soil Classification

Sodosols

Site Details

Date / Time	17 November 2009 / 1045
Slope	3%
Aspect	90°
Elevation	165 m
Eastings / Northings	582985 / 7714343
Depth to Free Water	None

Vegetation

Dichanthium spp. and *Astrebla spp.* grassland; *Eucalyptus populnea* and *Acacia harpophylla* open forest; and *Eucalyptus crebra* woodland.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Lower slope and gully drainage line
Surface Soil Condition	Hard setting
Runoff	Rapid
Permeability	Slow
Drainage	Poorly drained
Rock Outcrop	None
Erosion Activity	Active
Wind Erosion	None
Water Erosion	Severe sheet, rill, and gully
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Existing vertical exposure

Soil Description

Not described

Comments

Severe scalding present and loss of topsoil. Tunnel erosion of subsoil is evident. There are a lot of dead lot of dead trees along the drainage line.

Ground Observation Location: GO#5 / TP1



Australian Soil Classification

Dermosol

Date / Time 19 November 2009 / 0820
Slope 2%
Aspect 250°
Elevation 187 m
Eastings / Northings 589376 / 7713518
Depth to Free Water None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; *Eucalyptus crebra* woodland; *Eucalyptus melanophloia* +/- *E. orgadophila* woodland. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform Crest
Surface Soil Condition Firm
Runoff Moderately rapid
Permeability Moderate
Drainage Well drained
Rock Outcrop None
Erosion Activity Stabilised
Wind Erosion None
Water Erosion None
Gully Erosion Depth None
Disturbance of Site Limited clearing
Type of Observation Auger boring

Topsoil Description

Sandy Clay Loam, dark brown (7.5YR 4/3 dry), dry, moderate pedality 10-20 mm, sub angular blocky, rough fabric, moderately weak strength, fine grained sand fraction. Non plastic, non sticky. Field pH 6.5. Estimated depth 0.16m.

Comments

Periodic surface cracking < 5mm.

Ground Observation Location: GO#6



Australian Soil Classification Sodosol

Site Details

Date / Time	18 November 2009 / 1630
Slope	4%
Aspect	100°
Elevation	135 m
Eastings / Northings	582183 / 7710705
Depth to Free Water	None

Vegetation

Dichanthium spp. and *Astrebla* spp. grassland; *Eucalyptus populnea* and *Acacia harpophylla* open forest; and *Eucalyptus crebra* woodland. Groundcover is approximately 95%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Mid slope
Surface Soil Condition	Soft
Runoff	Rapid
Permeability	Slow
Drainage	Poorly drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	Minor sheet
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Clayey Sand, yellowish brown (10YR 5/4 dry), dry, weak pedality 2-5 mm, angular blocky, sandy fabric, moderately weak strength, fine grained, subangular. Non plastic, non sticky. Roots common. Field pH 5.5. Depth ~0.2 m.

Subsoil: Light Clay, brown with red mottle (7.5YR 5/4; 10R 4/8; dry) , dry, very strong strength, moderate plasticity, moderately sticky. Few roots. Field pH 5.5.

Comments

Stable surface.

Ground Observation Location: GO#7



Australian Soil Classification	Dermosol
Date / Time	17 November 2009 / 1500
Slope	2%
Aspect	280°
Elevation	170 m
Eastings / Northings	583284 / 7711988
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; *Eucalyptus crebra* woodland; *Eucalyptus melanophloia* +/- *E. orgadophila* woodland. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology	Fine-grained sedimentary rocks
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Land surface

Landform	Crest
Surface Soil Condition	Firm
Runoff	Moderately rapid
Permeability	Moderate
Drainage	Moderately well drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Topsoil Description

Light Clay, dark brown (10YR 3/3 dry), dry, moderate pedality 2-5 mm, sub angular blocky, rough fabric, moderately firm strength, fine grained sand fraction. Moderate-high plasticity (normal), very sticky. Field pH 6.5

Comments

Periodic surface cracking < 5mm. Coarse fragments across surface < 2 % abundance, 200-600 mm diameter, subrounded.

Ground Observation Location: GO#8



Australian Soil Classification Vertosol

Site Details

Date / Time	17 November 2009 / 1440
Slope	1%
Aspect	20 °
Elevation	149 m
Eastings / Northings	586914 / 7711095
Depth to Free Water	None

Vegetation

Pasture with isolated trees. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Flat
Surface Soil Condition	Periodic cracking
Runoff	Moderately rapid
Permeability	High
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Extensive clearing
Type of Observation	Existing vertical exposure

Topsoil Description

Not described

Comments

Stable surface, macropores 20-50 mm wide. Adacent drainage line is partially stabilised with some minor streambank erosion.

Ground Observation Location: GO#9



Australian Soil Classification	Dermosol
Date / Time	17 November 2009 / 1620
Slope	2%
Aspect	270°
Elevation	179 m
Eastings / Northings	589015 / 7712098
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; *Eucalyptus crebra* woodland; *Eucalyptus melanophloia* +/- *E. orgadophila* woodland . Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 85%.

Geology	Fine-grained sedimentary rocks
Land surface	
Landform	Crest
Surface Soil Condition	Firm
Runoff	Moderately rapid
Permeability	Moderate
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Light Clay, dark brown (10YR 3/3 dry), dry, moderate pedality 5-10 mm, sub angular blocky, rough fabric, moderately firm strength, fine grained sand fraction. Moderate plasticity (normal), slightly sticky. Field pH 6.5. Depth ~0.15 m. Common roots.

Comments

Periodic surface cracking < 5mm.

Ground Observation Location: GO#10



Australian Soil Classification Vertosol

Site Details

Date / Time	18 November 2009 / 1530
Slope	1%
Aspect	290°
Elevation	134 m
Eastings / Northings	583512 / 7709876
Depth to Free Water	None

Vegetation

Pasture with isolated trees. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 80%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Flat
Surface Soil Condition	Periodic cracking
Runoff	Moderately rapid
Permeability	High
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Partially stabilised
Wind Erosion	None
Water Erosion	Minor sheet
Gully Erosion Depth	None
Disturbance of Site	Extensive clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Light Medium Clay, dark brown (7.5Y 4/2 dry), dry, strong pedality, 10-20mm, subangular blocky, rough, moderately firm strength. High plasticity (normal), moderately sticky. Field pH 6.5. Many roots. Depth ~ 0.1m.

Comments

Stable surface with cracks 10-20 mm wide.

Ground Observation Location: GO#11



Australian Soil Classification Rudosol

Site Details

Date / Time	18 November 2009 / 1320
Slope	1%
Aspect	200°
Elevation	138 m
Eastings / Northings	585268 / 7707026
Depth to Free Water	None

Vegetation

Eucalyptus crebra and *Corymbia dallachiana* woodland; *Eucalyptus platyphylla* and *Corymbia* spp. woodland; *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland. Groundcover is approximately 95%.

Geology

Floodplain complexes on Cainozoic alluvial plains.

Land surface

Landform	Flat
Surface Soil Condition	Loose
Runoff	Slow
Permeability	High
Drainage	Rapidly drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Sand, dark brown (10YR 3/3 dry), dry, weak pedality 2-5 mm, angular blocky, sandy fabric, fine to coarse grained, poorly sorted. Trace fine gravel, subrounded. Common roots. Field pH 6.5. Depth ~0.3 m.

Subsoil: Sand, light yellowish brown (10YR 6/4 dry), dry, apedal single, fine to coarse grained, poorly sorted. Trace fine gravel, subrounded. Common roots. Field pH 6.5. Depth >0.9 m.

Comments

Stable surface.

Ground Observation Location: GO#12



Australian Soil Classification	Dermosol
Date / Time	18 November 2009 / 0830
Slope	1%
Aspect	300°
Elevation	159 m
Eastings / Northings	588574 / 7706673
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; *Eucalyptus crebra* woodland; *Eucalyptus melanophloia* +/- *E. orgadophila* woodland . Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 85%.

Geology	Fine-grained sedimentary rocks
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Land surface

Landform	Upper slope
Surface Soil Condition	Firm
Runoff	Moderately rapid
Permeability	Moderate
Drainage	Well drained
Rock Outcrop	None
Erosion Activity	Partially stabilised
Wind Erosion	None
Water Erosion	Moderate sheet
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Sandy Clay Loam, dark brown (7.5YR 4/3 dry), dry, moderate pedality 10-20 mm, subangular blocky, rough fabric, moderately firm strength, fine grained sand fraction. Low plasticity (normal), slightly sticky. Field pH 6.5.

Comments

Coarse fragments across surface < 2-10 % abundance, 5-200 mm diameter, subrounded.

Ground Observation Location: GO#13



Australian Soil Classification Sodosol

Site Details

Date / Time	18 November 2009 / 1420
Slope	1%
Aspect	60°
Elevation	133 m
Eastings / Northings	582197 / 7705287
Depth to Free Water	None

Vegetation

Eucalyptus crebra and *Corymbia dallachiana* woodland; *Eucalyptus platyphylla* and *Corymbia* spp. woodland; *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland. Groundcover is approximately 95%.

Geology

Floodplain complexes on Cainozoic alluvial plains.

Land surface

Landform	Flat
Surface Soil Condition	Firm
Runoff	Moderately rapid
Permeability	Slow
Drainage	Poorly drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Sandy Loam, dark brown (7.5YR 4/2 dry), dry, moderate weak pedality 10-20 mm, subangular blocky, sandy fabric, moderately weak strength, fine grained sand. Non plastic, very sticky. Many roots. Field pH 6.5. Depth ~0.25m.

Subsoil: Light Clay, yellowish brown (10YR 5/4 dry), dry, apedal massive, moderate plasticity (normal), very sticky. Few roots. Field pH 6.5.

Comments

Stable surface.

Ground Observation Location: GO#14 (TP3)



Australian Soil Classification Sodosol

Site Details

Date / Time	19 November 2009 / 1330
Slope	1%
Aspect	230°
Elevation	174 m
Eastings / Northings	582266 / 7713721
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; and *Eucalyptus crebra* woodland. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 85%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Upper slope
Surface Soil Condition	Loose
Runoff	Moderately rapid
Permeability	Slow
Drainage	Imperfectly drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Soil pit

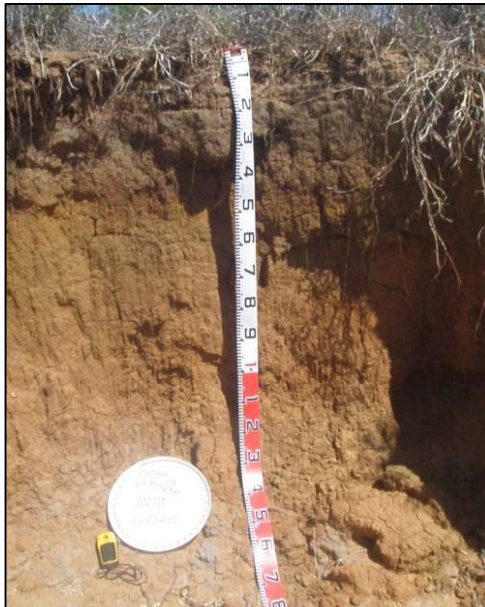
Topsoil Description

Loamy Sand, light yellowish brown (10YR 6/4 dry), dry, weak pedality 10-20 mm, angular blocky, sandy fabric, moderately weak strength, fine grained sand, non plastic. Field pH 6.0. Depth ~0.35 m.

Comments

Stable surface in the observation area; however there was evidence of severe rill and gully erosion at lower portions of the slope.

Ground Observation Location: GO#15



Australian Soil Classification	Sodosols
Date / Time	17 November 2009 / 0940
Slope	2%
Aspect	120°
Elevation	162 m
Eastings / Northings	583450 / 7714297
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; and *Eucalyptus crebra* woodland. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Mid slope
Surface Soil Condition	Hard setting
Runoff	Moderately rapid
Permeability	Slow
Drainage	Poorly drained
Rock Outcrop	None
Erosion Activity	Active
Wind Erosion	None
Water Erosion	Severe sheet, rill, and gully
Gully Erosion Depth	1.5-3.0 m
Disturbance of Site	Limited clearing
Type of Observation	Existing vertical exposure

Soil Description

Topsoil: Sandy Clay Loam, yellowish brown (10YR 5/4 dry), dry, weak pedality 10-20 mm, subangular blocky, sandy fabric, fine grained, subangular. Moderately firm strength, low plasticity. Common roots. Field pH 6.5. Depth 0.19m.

Subsoil: Light Clay, brownish yellow and red mottle (10YR 6/6, 10R 5/6, dry), dry, apedal massive, earthy fabric. Few roots.

Comments

Gully development continues down to the underlying siltstone/mudstone at ~2.0m. Erosion is partially stabilised.

Ground Observation Location: GO#16



Australian Soil Classification Sodosols

Site Details

Date / Time	17 November 2009 / 1120
Slope	2%
Aspect	160°
Elevation	168 m
Eastings / Northings	583193 / 7714380
Depth to Free Water	None

Vegetation

Eucalyptus populnea and *Acacia harpophylla* open forest; and *Eucalyptus crebra* woodland. Groundcover is tussocking grass, predominately buffel (*Cenchrus ciliaris*), with an estimated coverage of 90%.

Geology

Fine-grained sedimentary rocks

Land surface

Landform	Mid slope
Surface Soil Condition	Soft
Runoff	Moderately rapid
Permeability	Slow
Drainage	Imperfectly drained
Rock Outcrop	None
Erosion Activity	Stabilised
Wind Erosion	None
Water Erosion	None
Gully Erosion Depth	None
Disturbance of Site	Limited clearing
Type of Observation	Auger boring

Soil Description

Topsoil: Loamy Sand, brown (10YR 5/3 dry), dry, weak pedality 5-10 mm, angular blocky, sandy fabric, fine grained, subangular. Field pH 6.0. Depth ~0.32m.

Comments

Stable surface.



Appendix B

Soil Profile Descriptions

Soil Survey Worksheet

Location: (P604-610) G2	Date: 30/11/2011
Assessors: BOLM HANR LAWS	Site Number: C1

Location Characteristics

Geology and Topography Observations	greatly inclined upper reaches of low open depression
Landuse and Vegetation Observations	Scattered trees (Mountain Coolibah, Acacia) Buffel grass → Grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black Vertisol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable with cracks.			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor Water Sheeting			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine + abundant w AI / few to 120 cm			
Horizon Layer (Layers in Profile)	1 AI	2 A2	3 B1	4 B2
Horizon Depth (eg 0.00 to 0.15m)	CM 0-15	15-45	45-80	80-120.
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-15	(15-25)(25-35)	(35-55)(55-65)	(65-80)(80-120)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	7.5 YR 3/1 BL	BL	Dark grey	Dark greyish brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	Poor	Poor	Poor
Field Texture Grade (sand/silt/clay)	MC	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100	100-200	100-200	100-200
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB.	PR	PR	AB.
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	5% Scattered Mudstone to 200mm	10% Isolated Ironstone	20% Weathered Siltstone	20% Weathered Siltstone
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	W	I

Field Comments

Weathered Siltstone at 1.2 M. Roots present to	
Weathered rock. Scattered stones on surface.	
A1 = pH 8.5	B1 = pH 8.0
A2 = pH 9.0	B2 = pH 7.5.

Soil Survey Worksheet

Location: 614-619	G4.	Date: 30/4/2011
Assessors: BOLM HANR LAWS		Site Number: C2.

Location Characteristics

Geology and Topography Observations	Ridge 1% slope Weathered mudstone at 55 cm.
Landuse and Vegetation Observations	Maintain Coolibah, Ironbark, Buffel grass - grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Shallow Brown Dermosol.			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Surface crust (vesicular)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Water sheeting			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 55 cm			
Horizon Layer (Layers in Profile)	A1-A2 ¹	² B21	B22 ³	Weathered Rock
Horizon Depth (eg 0.00 to 0.15m)	0-5	5-25	25-55	55-
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-5	5-25	25-55	55-65
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown 7.5YR4/2	Brown 7.5YR4/4	Strong Brown 7.5YR5/6	-
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Poor	Poor	Moderate	-
Field Texture Grade (sand/silt/clay)	SCL	ZC.	LC.	-
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	W	-
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	20-50	2-5	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL.	AB.	PO.	-
Consistence Force (weak, moderate, strong)	Moderate	Strong	Moderate	-
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	-
Boundary Shape (even, wavy, irregular, broken)	W	C	I	-

Field Comments

A1-A2 = 6.5 pH.
B21 = 7.0 pH.
B22 = 8.5 pH.

Soil Survey Worksheet

Location: 620-627. G5.	Date: 30/11/2011
Assessors: BOLM, HANR, LAWJ.	Site Number: C3.

Location Characteristics

Geology and Topography Observations	Broad ridge - weathered sandstone over siltstone
Landuse and Vegetation Observations	Ironbark, Bloodwood, Bullockgrass grazing.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Lithic Tenosol or very Shallow Brown Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Surface Crust (vesicular)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor water sheeting			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Medium roots to 30cm / fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1 ¹	B21 ²	B22.	4
Horizon Depth (eg 0.00 to 0.15m)	CM 0-10	10-20	20-30	
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	10-20	25-35	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown 7.5 YR 3/2	Dark Brown 7.5 YR 3/3	Brown with orange mottles 30%	
Mottle Characteristics (% & Colour)	-	-	ORANGE mottles 30%.	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor.	
Field Texture Grade (sand/silt/clay)	ZCL	ZC	SCL.	
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	20-50.	50-100	10-20.	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	AB	AB.	
Consistence Force (weak, moderate, strong)	Strong	Strong	Moderate	
Seggregations (Type and amount %)	-	-	Car CO ₂ (30%)	
Stones - Type & Amount (Type and amount %)	-	-	-	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	C	C.	
Boundary Shape (even, wavy, irregular, broken)	E	E	E.	

Field Comments

Weathered sandstone beyond 30 cm.
1 cm cracks in surface of soil.

Soil Survey Worksheet

Location: 634-39	G9.	Date: 30/11/2011
Assessors: BOLM HANK LAWS		Site Number: C4

Location Characteristics

Geology and Topography Observations	Scattered stones on surface; namely Sandstone, petrified wood. • Elevated ridge
Landuse and Vegetation Observations	Prickly Acacia, Brigalow Buffel grass - Grazing.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Dermosol (Shallow)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 60 cm			
Horizon Layer (Layers in Profile)	1 A1	2 B2	B/C ³	Weathered Sandstone
Horizon Depth (eg 0.00 to 0.15m)	CM 0-10	10-25	25-40	40 -
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-10	10-25	25-35	-
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	-
Field Colour (brown, red, yellow, yellowish brown)	Brown 7.5YR 4/3	Reddish brown 5YR 4/3	Strong Brown 7.5YR 4/6	-
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Well	-
Field Texture Grade (sand/silt/clay)	Sandy Clay	MC	Sandy Clay	-
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	M	-
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	10-20.	5-10.	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	SB	AB	PO.	-
Consistence Force (weak, moderate, strong)	Strong	Strong	Moderate	-
Seggregations (Type and amount %)	-	-	<5% Manganese nodules	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	C	C	-
Boundary Shape (even, wavy, irregular, broken)	E	E	W.	-

Field Comments

A1 = pH 7.0
B2 = pH 7.0.
B/C = pH 7.0.
Weathered Rock pH 8.5

Soil Survey Worksheet

Location: 640-642.	G10.	Date: 30/11/2011
Assessors: BDM, HANR, LANR.	Site Number: C5	

Location Characteristics

Geology and Topography Observations	Minor gilgai (Melon hole) on an elevated ridge.
Landuse and Vegetation Observations	Calcareous silt stone. Brigalow, Prickly Acacia, Buffel grass - grazing.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black vertisol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable and cracking			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1 ¹	B1 ²	B21 ³	B22 ⁴
Horizon Depth (eg 0.00 to 0.15m)	CM 0-25	25-65	65-80	80-95
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-25	(25-35)(35-55)	(65-80)(80-95)	80-95
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown 7.5YR 3/3	Dark Brown 7.5YR 3/2	Very Dark Grey 7.5YR 3/1	Dark Reddish Brown 5YR 3/4
Mottle Characteristics (% & Colour)	—	20% Red Mottle	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	Poor
Field Texture Grade (sand/silt/clay)	MC	MHC	HC	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	M
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	20-50	20-50	10-20
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	po.
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	E	E

Field Comments

Scattered sandstone rocks (100-300mm) on soil surface.

Soil Survey Worksheet

Location: 643-649 G11	Date: 30/11/2011
Assessors: BCLM, HANR, LAWS	Site Number: C6

Location Characteristics

Geology and Topography Observations	Elevated, gentle slope. Calcareous Siltstone.
Landuse and Vegetation Observations	White Wood, Prickly Acacia, Buffel grass. grazing! (Crabhole country - J. Lawrie)

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black Vertosol				
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable, Cracking				
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil.				
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Coarse roots to 60cm, fine roots to 85cm				
Horizon Layer (Layers in Profile)	1 A1	B11 2	B12 3	B2 4	
Horizon Depth (eg 0.00 to 0.15m)	CM	10-35	35-65	65-85	
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM	10-25	25-35	35-55	55-65
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	moist	moist	moist	
Field Colour (brown, red, yellow, yellowish brown)	Brown 7.5 YR 4/2	7.5 YR 4/2	7.5 YR 4/2	Dark greyish brown 10YR 1/2	
Mottle Characteristics (% & Colour)	-	-	-	-	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	Poor.	
Field Texture Grade (sand/silt/clay)	MC	HC	HC	HC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	20-50	20-50	10-20.	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	PO.	
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong	
Seggregations (Type and amount %)	-	-	-	-	
Stones - Type & Amount (Type and amount %)	-	-	Iron strong 10%	Iron strong 10%	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	C	
Boundary Shape (even, wavy, irregular, broken)	W	W	W	W	

Field Comments

Weathered rock beyond 85 cm.

0-25 = pH 7
25-35 = pH 8.5
35-55 = pH 8
55-65 = pH 8.

Soil Survey Worksheet

Location: 650-654	G12	Date: 30/11/2011
Assessors: BCLM, HANR, LAWS		Site Number: C7

Location Characteristics

Geology and Topography Observations	Slope-Gentle (1%), rolling
Landuse and Vegetation Observations	Brigalow, whitewood, Prickly Acacia, Buffel grass - grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Shallow Black vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable, Cracking			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1 ¹	B11 ²	B12 ³	4
Horizon Depth (eg 0.00 to 0.15m)	CM 0-10	10-25	25-65	
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-10	(10-25)(25-35)(35-55)(55-65)		
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Mod. moist	
Field Colour (brown, red, yellow, yellowish brown)	Dark greyish brown 10YR 4/2	10YR 4/2	10YR 4/2	
Mottle Characteristics (% & Colour)	-	-	-	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	
Field Texture Grade (sand/silt/clay)	MC	HC	HC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	10-20	20-50	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	PR	PR	
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	
Seggregations (Type and amount %)	-	-	-	
Stones - Type & Amount (Type and amount %)	-	-	-	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	G	D.	
Boundary Shape (even, wavy, irregular, broken)	E	W	I.	

Field Comments

Weathered siltstone > 65 cm	
0-10 = pH 7.5	35-55 = pH 8.0.
10-25 = pH 8.0.	55-65 = pH 9.0.
25-35 = pH 8.0.	

Soil Survey Worksheet

Location: 655-659 G13	Date: 30/11/2011
Assessors: Bole, HANE, LAWS	Site Number: C8

Location Characteristics

Geology and Topography Observations	Flat, interfluvial Deposition Zone (Layer 1+2 deposited over last 100 years)
Landuse and Vegetation Observations	Bamboo, Brigalow, Whitewood Buffel grass - grazing.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)		Recent Alluvium - Overlying Black Vertisol				
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)		Crusted				
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)		Nil				
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)		Fine roots to 70cm				
Horizon Layer (Layers in Profile)	Layer 1 ¹	Layer 2 ²	A1 ³	B1 ⁴	B2.	
Horizon Depth (eg 0.00 to 0.15m)	CM 0-15	15-35	35-65	65-85	85-130	
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-10 (10-25) (25-35) (35-55) (55-65)			(65-85)	(85-130)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Dry	Dry	Dry	Dry	
Field Colour (brown, red, yellow, yellowish brown)	7.5YR 4/2	7.5YR 4/3	Very dark Brown 7.5YR 2.5/2	Dark Brown 7.5YR 3/2	Dark Brown 7.5YR 4/2	
Mottle Characteristics (% & Colour)	-	-	-	-	-	
Drainage (Poor, Moderate, Well, Rapid)	Poor	Poor	Poor	Poor	Poor	
Field Texture Grade (sand/silt/clay)	2 CL.	LC	MC	HC	MHC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	5-10	10-20.	20-50	10-20	10-20	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	AB	AB	
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong	Strong	
Seggregations (Type and amount %)	-	-	-	-	-	
Stones - Type & Amount (Type and amount %)	-	-	-	-	-	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C	C	
Boundary Shape (even, wavy, irregular, broken)	W	I	E	E	E	

Field Comments	0-10 =	pH	8
	10-25 =	pH	8
	25-35 =	pH	7.5
	35-65 =	pH	7.5
	65-85 =	pH	8.0
	85-130 =	pH	8.0

Soil Survey Worksheet

Location: <u>686-692</u>	G25	Date: <u>2/12/11</u>
Assessors: <u>BoLM, HANR, LAWT</u>		Site Number: <u>C9</u>

Location Characteristics

Geology and Topography Observations	<u>Crest</u>
Landuse and Vegetation Observations	<u>Box tree open woodland, currant bush</u> <u>Buggel Grass, Bauhinia</u>

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)		<u>Brown Sodosol</u>		
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)		<u>Soft</u>		
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)		<u>Minor</u>		
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)		<u>Roots to 65cm</u>		
Horizon Layer (Layers in Profile)	<u>A1</u>	<u>B21</u>	<u>B22</u>	4
Horizon Depth (eg 0.00 to 0.15m)	<u>0-25</u>	<u>25-50</u>	<u>50-65</u>	
Sample Depth Range (m) (eg 0.05 to 0.10m)	<u>0-25</u>	<u>25-35</u>	<u>(35-55)(55-65)</u>	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	<u>Moist</u>	<u>Dry</u>	<u>Dry</u>	
Field Colour (brown, red, yellow, yellowish brown)	<u>Dark Brown</u> <u>(7.5YR 3/4)</u>	<u>Brown</u> <u>(7.5YR 5/4)</u>	<u>Brown</u>	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	<u>Moderate</u>	<u>Poor</u>	<u>Poor</u>	
Field Texture Grade (sand/silt/clay)	<u>LS</u>	<u>Sandy Clay</u>	<u>Clay</u>	
Structure Pedality Grade (Apedal or weak/moderate/strong)	<u>W</u>	<u>S</u>	<u>S</u>	
Structure Ped Size (mm) (eg 10 to 20 mm)	<u>2-5mm</u>	<u>20-50mm</u>	<u>20-50mm</u>	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	<u>PL</u>	<u>SB</u>	<u>SB</u>	
Consistence Force (weak, moderate, strong)	<u>weak</u>	<u>Strong</u>	<u>Strong</u>	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	<u>A</u>	<u>A</u>	<u>A</u>	
Boundary Shape (even, wavy, irregular, broken)	<u>W</u>	<u>W</u>	<u>W</u>	

Field Comments

Duplex soil

Weathered sandstone (red) below 65cm

A1 = pH 6

B21, B22 = pH 8.5

Soil Survey Worksheet

Location: 698-703	G29	Date: 2/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C10

Location Characteristics

Geology and Topography Observations	Upper Slope Gully
Landuse and Vegetation Observations	Box woodland Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Yellow/brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Severe gully erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-22	22-35	35-55	55-85
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-22	22-35	35-55	(55-65)(65-80)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown (7.5YR 4/3)	7.5YR 7/3	10YR 4/4	10YR 4/4
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	SCL	SL	Clay	Clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	W	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	2-5	200-500mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	AB	AB
Consistence Force (weak, moderate, strong)	weak	weak	strong	strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Highly erodible
Soil Sodidity present.

Soil Survey Worksheet

Location: 704 - 709	G30	Date: 2/12/11
Assessors: BOLM, HANR, LAWS		Site Number: C11

Location Characteristics

Geology and Topography Observations	Midslope 3-5%.
Landuse and Vegetation Observations	Currant bush Bloodwood, Ironbark Buffelgrass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Yellow / brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 80cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-20	20-50	50-70	70-85
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-20	25-35	35-55 (55-65)	65-80
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	7.5YR 4/3	7.5YR 7/3	10YR 4/4	10YR 4/4
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	SCL	SL	clay	clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	20-50mm	20-50mm	20-50mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	AB	AB	AB
Consistence Force (weak, moderate, strong)	weak	strong	strong	strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 710-716 G31	Date: 2/12/11
Assessors: BOLM, HANR, LAWT	Site Number: C12

Location Characteristics

Geology and Topography Observations	Upper Slope of ridge (2% slope)
Landuse and Vegetation Observations	Cassia brewsteri Open Box woodland Buffel Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 80cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-13	13-25	25-45	45-65
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-13	13-25	25-35)(35-55)	55-65
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	7.5YR 4/3	7.5YR 5/4(dry)	Brown	Brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	LS	SL	Clay	Clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	weak	weak	strong	strong
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	2-5mm	20-50mm	20-50mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	AB	AB
Consistence Force (weak, moderate, strong)	weak	weak	strong	strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	E	E

Field Comments

Weather rock at 65cm

Soil Survey Worksheet

Location: 717-721 G32	Date: 2/12/11
Assessors: BOLM, HANR, LAWI	Site Number: C13

Location Characteristics

Geology and Topography Observations	Eroded Gully
Landuse and Vegetation Observations	Eucalyptus platyphylla, Box Buffel grass, Cassia brewsteri

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Sodic Brown Kandosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Severe gully erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	large roots to 110cm			
Horizon Layer (Layers in Profile)	A1	A2	B2	4
Horizon Depth (eg 0.00 to 0.15m)	0-13	13-45	45-110	
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-13	(13-25)(25-35)	(55-65)(65-110)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Dry	
Field Colour (brown, red, yellow, yellowish brown)	redish Brown	lighter redish brown	Yellow brown	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	
Field Texture Grade (sand/silt/clay)	LS	SL	LS	
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	M	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	20-50mm	200-500mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	
Consistence Force (weak, moderate, strong)	Weak	Moderate	strong	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	
Boundary Shape (even, wavy, irregular, broken)	E	E	E	

Field Comments

weathered rock at 110cm

Soil Survey Worksheet

Location: 726-731 G35	Date: 2/12/11
Assessors: BOLM, HANR, LAWT	Site Number: C14

Location Characteristics

Geology and Topography Observations	Swale
Landuse and Vegetation Observations	Open Box woodland Buffel Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 80cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-12	12-25	25-35	35-90
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-12	12-25	(25-35)(35-55)	(55-90)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Moist	Moist
Field Colour (brown, red, yellow, yellowish brown)	Brown	light Brown	Dark Brown	Yellow brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Poor	Poor
Field Texture Grade (sand/silt/clay)	LS	S	MC	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	Apedal-loose	Apedal-loose	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	-	-	20-50mm	20-50mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	-	-	SB	SB
Consistence Force (weak, moderate, strong)	weak	weak	Strong	Strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	some sandstone
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	E	E

Field Comments **Bottom 20cm (70-90cm) has red**

Weathered sandstone

Weathered sandstone beyond 90cm

Soil Survey Worksheet

Location: 738-743. G 39	Date: 2/12/2011
Assessors: BOLD, HANR, LAWJ	Site Number: C15

Location Characteristics

Geology and Topography Observations	Flat
Landuse and Vegetation Observations	Brigalow, Box, Cassia brewsteri, Banahua, buffel grass, grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black Vertosol				
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable				
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil				
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 90cm				
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B1 ³	B21 ⁴	B22
Horizon Depth (eg 0.00 to 0.15m)	CM 0-15	15-35	35-65	65-90	90-140
Sample Depth Range (m) (eg 0.05 to 0.10m)	CM 0-15	(15-25)	(25-35)	(35-55)	(55-65)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Moist	Moist
Field Colour (brown, red, yellow, yellowish brown)	Black	Dark Grey	Dark Brown	Brown	Brown
Mottle Characteristics (% & Colour)	-	-	-	-	ORANGE 60%
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	Poor	Poor
Field Texture Grade (sand/silt/clay)	LMC	HC	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20	10-20	20-50	20-50	20-50
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PR	PR	PR	PR	PR
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	-	-	-	-	Gypsum 10%
Stones - Type & Amount (Type and amount %)	-	ferricrete gravel 10%	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	W	W	W

Field Comments

Gypsum (Calcium Sulphate) at 120cm.

Soil Survey Worksheet

Location: 744-748	G40	Date: 2/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C16

Location Characteristics

Geology and Topography Observations	Swale
Landuse and Vegetation Observations	Open Box woodland Grazing, Boffel Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-30	30-60	60-100
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	(65-100)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark Brown	Dark Brown	Strong Brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	well	Poor	Poor
Field Texture Grade (sand/silt/clay)	LS	SL	MC	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	W	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	5-10mm	5-10mm	20-50mm	20-50mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	SB	SB
Consistence Force (weak, moderate, strong)	weak	weak	strong	strong
Seggregations (Type and amount %)	-	-	-	Carbonates 10%
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C
Boundary Shape (even, wavy, irregular, broken)	I	I	E	E

Field Comments

Weathered sandstone at 100cm

Soil Survey Worksheet

Location: 749 - 755	G41	Date: 2/12/2011
Assessors:		Site Number: C17.

Location Characteristics

Geology and Topography Observations	Mid slope 2%.
Landuse and Vegetation Observations	Open Box Woodland, Grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 65cm			
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B21 ³	B22 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-30	30-45	45-65
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	10-30	30-45	45-65
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark Brown	Dark Brown	Yellowish Brown
Mottle Characteristics (% & Colour)	-	-	10% Orange	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Poor	Poor
Field Texture Grade (sand/silt/clay)	loamy sand	loamy sand	Sandy clay	Sandy clay.
Structure Pedality Grade (Apedal or weak/moderate/strong)	weak	weak.	strong	strong.
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	2-5	20-50	20-50.
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	AB	AB.
Consistence Force (weak, moderate, strong)	Weak	Weak	Strong	Strong.
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C.
Boundary Shape (even, wavy, irregular, broken)	W	W	E	E

Field Comments

- Weathered red lithic rock > 65cm - Duplex soil.

Soil Survey Worksheet

Location: 756-761 G42	Date: 2/12/11
Assessors: BOLM, HANR, LAWT	Site Number: C18

Location Characteristics

Geology and Topography Observations	Elevated Ridge
Landuse and Vegetation Observations	Box woodland, Currant Bush, whitewood, Brigalow, Cassia brewsteri, Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Solosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 70cm			
Horizon Layer (Layers in Profile)	A1	B21	B22	4
Horizon Depth (eg 0.00 to 0.15m)	0-25	25-55	55-75	
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-25	(25-35)/(35-55)	(55-65)/(65-75)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	
Field Colour (brown, red, yellow, yellowish brown)	Brown	Dark Brown	Orangey brown	
Mottle Characteristics (% & Colour)	-	-	-	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	
Field Texture Grade (sand/silt/clay)	LS	Sandy clay	Sandy clay	
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	5-10mm	20-50mm	20-50mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	
Consistence Force (weak, moderate, strong)	weak	strong	strong	
Seggregations (Type and amount %)	-	-	carbonate 10%	
Stones - Type & Amount (Type and amount %)	-	-	-	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	C	C	
Boundary Shape (even, wavy, irregular, broken)	W	E	E	

Field Comments

Soil Survey Worksheet

Location: 772-777	G47	Date: 2/12/2011
Assessors:		Site Number: C19

Location Characteristics

Geology and Topography Observations	Mid slope 2%.
Landuse and Vegetation Observations	Bloodwood, Ironbark. Grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Shallow Brown Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1 ¹	B21 ²	B22 ³	4
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-35	35-70.	
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	35-70.	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist.	Dry	
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark reddish brown	Pale Brown	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	
Field Texture Grade (sand/silt/clay)	Sandy Clay	MC	Sandy Clay.	
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	V	
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	10-20	— 10-30.	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB.	—	
Consistence Force (weak, moderate, strong)	Weak	Strong	Moderate	
Seggregations (Type and amount %)	—	Carbonate 30%	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	
Boundary Shape (even, wavy, irregular, broken)	E	E	E	

Field Comments

Weathered rock beyond 70cm

Soil Survey Worksheet

Location: 778-783	G48	Date: 2/12/2011
Assessors: BOLM, HANR, LAWT		Site Number: C20

Location Characteristics

Geology and Topography Observations	Midslope (1-2% slope)
Landuse and Vegetation Observations	Ironbark, Bloodwood, Bahinia, Buffel grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Calcarosol (CA)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1	B11	B12	4
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-25	25-65	
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Light Brown	Cream	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	
Field Texture Grade (sand/silt/clay)	Sandy Clay	SCL	SCL	
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	M	M	
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	50-100mm	50-100mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	
Consistence Force (weak, moderate, strong)	Moderate	Moderate	Moderate	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	A	C	C	
Boundary Shape (even, wavy, irregular, broken)	E	E	E	

Field Comments

A1 = pH 8
B11 = pH 8.5
B12 = pH 8.5



Soil Survey Worksheet

Location:	784-789	C49	Date:	2/12/2011
Assessors:			Site Number:	C21.

Location Characteristics

Geology and Topography Observations	Mud slope (1-2%).
Landuse and Vegetation Observations	Irony bark, Bloodwood, Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)		Der mosol.		
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)		Crusted		
Erosion Type, Severity & Present Condition (nil, sheet, wind - minor, moderate, severe - stabilised, active)		minor water sheet erosion		
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)		roots to 65cm.		
Horizon Layer (Layers in Profile)	A1 ¹	B1 ²	B2 ³	B/C horizon
Horizon Depth (eg 0.00 to 0.15m)	0-15	15-40	40-65	65-85
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-15	(15-25)(25-35)	35-55	65-85
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark reddish brown	Brown	Cream
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	M	M	M	M
Field Texture Grade (sand/silt/clay)	MC	MC	MC	Sandy Clay.
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	V
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	10-20	10-20	15-20
Structure Ped Shape (platy, prismatic, blocky, round, etc)	SB	SB	SB	-
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong.
Seggregations (Type and amount %)	-	-	-	20% Calcium Carbonate
Stones - Type & Amount (Type and amount %)	Ferricrete and fossilised wood etc.	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 790-794	GSO	Date: 2/12/11
Assessors: BOLM, HANR, LAWJ		Site Number: C22

Location Characteristics

Geology and Topography Observations	2°/s slope
Landuse and Vegetation Observations	Brigalow, Baffle grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1	B11	B12	B13
Horizon Depth (eg 0.00 to 0.15m)	0-15	15-60	60-100	100-130
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-15	(15-25)/(25-35)	(35-55)/(65-100)	(100-130)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Dry	Moist	Moist	Moist
Field Colour (brown, red, yellow, yellowish brown)	Black	Black	Dark grey	Brownish Black
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	MC	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	100-200mm	100-200mm	100-200mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	SA	SA	SA	SA
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	20% Carbonate nodules
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Weathered Rock Beyond 130cm

Soil Survey Worksheet

Location: 797-801	452	Date: 2/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C23

Location Characteristics

Geology and Topography Observations	Lower slope (1% slope)
Landuse and Vegetation Observations	Whitewood regrowth, Brigalow, Buffel Grass, open grass land grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 80cm.			
Horizon Layer (Layers in Profile)	A1	B21	B22	B23
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-25	25-40	40-80
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	10-25	(25-35) (35-55)	(55-65) (65-80)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark brown	Dark Brown	Dark Red	Red.
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	Sandy Clay	MC	MC	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	50-100mm	50-100mm	50-100mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	SB
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	Carbonate nodules (5%)
Stones - Type & Amount (Type and amount %)	ferricrete (10%)	ferricrete (20%)		
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Silcrete on surface.

Soil Survey Worksheet

Location: 802-807	G53	Date: 2/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C24

Location Characteristics

Geology and Topography Observations	1% Slope
Landuse and Vegetation Observations	Seathered shrubs (Whitewood) Buffel grasslands

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor sheet erosion.			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1	B1	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-35	35-65	65-95
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	(65-95)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Black	Black	Black	Black
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Poor	Poor	Poor
Field Texture Grade (sand/silt/clay)	Mc	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20mm	20-50mm	50-100mm	50-100mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	SB	AB	AB	AB
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	Red stone 70%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 808-814	G54	Date: 2/12/2011
Assessors: BOLM, NARR, LAWO.		Site Number: C25

Location Characteristics

Geology and Topography Observations	Flat terrain.
Landuse and Vegetation Observations	Euc. platyphylla, Bloodwood, Ironbark Cattle grazing

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Braun Sodosol (Depending on chemical analysis - ESP)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Soft			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 150cm			
Horizon Layer (Layers in Profile)	A1¹	A2²	B21³	B22⁴
Horizon Depth (eg 0.00 to 0.15m)	0-15	15-30	30-80	80-150.
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-15 (15-25) (25-35) (35-55) (55-65) (65-80) (80-150)			
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	light Brown	Orange brown	light Orange brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	L	SL	MC with Sand	Sandy Clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	M	S	V
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	2-5	20-50	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	Round	Round	PL	-
Consistence Force (weak, moderate, strong)	Weak	Moderate	Strong	Strong.
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

A1 = pH 6
A2 = pH 6
B21 = pH 6.5
B22 = pH 9.0
> 80cm = pH 8.0.

Soil Survey Worksheet

Location: 824-828	G63	Date: 2/12/11
Assessors: BOLM, HANR, LAWJ		Site Number: C26

Location Characteristics

Geology and Topography Observations	Plat terrain
Landuse and Vegetation Observations	Brigalow, Bauhinia Sesbania, Boggel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 20cm			
Horizon Layer (Layers in Profile)	A1	Bp1	Bp2	4
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-60	60-130	
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-10)	(10-25) (25-35)	(35-55) (55-65)	(65-130)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Moist	
Field Colour (brown, red, yellow, yellowish brown)	Brown	Dark Brown	Dark Brown	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Poor	Poor	Poor	
Field Texture Grade (sand/silt/clay)	MC	HC	HC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	5-10mm	100-200mm	100-200mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PR	PR	PR	
Consistence Force (weak, moderate, strong)	moderate	Strong	Strong	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	D	D	
Boundary Shape (even, wavy, irregular, broken)	E	I	I	

Field Comments

Soil Survey Worksheet

Location: <u>Belu Camerar</u> (Confirm: <u>Gelac</u>)	Date: <u>2/12/2011</u>
Assessors: <u>829-834</u>	Site Number: <u>C27</u>

Location Characteristics

Geology and Topography Observations	<u>Upper Slope (1-2%)</u>
Landuse and Vegetation Observations	<u>Blodwood, Ironbark, Bulbilgrass - grazing.</u>

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	<u>Shallow Red Dermosol</u>			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	<u>Loose</u>			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	<u>Minor water sheet erosion.</u>			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	<u>Fine roots to 80cm</u>			
Horizon Layer (Layers in Profile)	<u>A1¹</u>	<u>A2²</u>	<u>B1³</u>	<u>B2⁴</u>
Horizon Depth (eg 0.00 to 0.15m)	<u>0-12</u>	<u>12-25</u>	<u>25-45</u>	<u>45-75</u>
Sample Depth Range (m) (eg 0.05 to 0.10m)	<u>0-12</u>	<u>(12-25)(25-35)</u>	<u>35-55</u>	<u>55-65</u>
Field Moisture (Dry, Moist, Moderately Moist, Wet)	<u>Moist</u>	<u>Mod. Moist</u>	<u>Dry</u>	<u>Dry</u>
Field Colour (brown, red, yellow, yellowish brown)	<u>Dark Brown</u>	<u>Brown</u>	<u>Reddish Brown</u>	<u>late Brown</u>
Mottle Characteristics (% & Colour)	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
Drainage (Poor, Moderate, Well, Rapid)	<u>Well</u>	<u>Well</u>	<u>Well</u>	<u>Well.</u>
Field Texture Grade (sand/silt/clay)	<u>LC (with sand)</u>	<u>LMC</u>	<u>MC</u>	<u>Sandy Clay</u>
Structure Pedality Grade (Apedal or weak/moderate/strong)	<u>M</u>	<u>S</u>	<u>S</u>	<u>S</u>
Structure Ped Size (mm) (eg 10 to 20 mm)	<u>20-50</u>	<u>20-50</u>	<u>20-50</u>	<u>20-50</u>
Structure Ped Shape (platy, prismatic, blocky, round, etc)	<u>PL</u>	<u>PO</u>	<u>PO</u>	<u>PO.</u>
Consistence Force (weak, moderate, strong)	<u>Moderate</u>	<u>Strong</u>	<u>Strong</u>	<u>Strong</u>
Seggregations (Type and amount %)	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
Stones - Type & Amount (Type and amount %)	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	<u>C</u>	<u>C</u>	<u>C</u>	<u>C</u>
Boundary Shape (even, wavy, irregular, broken)	<u>E</u>	<u>E</u>	<u>E</u>	<u>E</u>

Field Comments

Scattered sandstone rock on surface.
Weathered lithic sandstone > 75 cm

Soil Survey Worksheet

Location: 835-840	G60 synchronised	Date: 3/12/11
Assessors:		Site Number: C28

Location Characteristics

Geology and Topography Observations	Top of ridge (1% slope)
Landuse and Vegetation Observations	Ironbark, Bloodwood, Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Shallow Red Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 50cm			
Horizon Layer (Layers in Profile)	A1	B21	B22	BC
Horizon Depth (eg 0.00 to 0.15m)	0-15	15-25	25-50	50-60
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-15	15-25	25-55	55-65
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod. Moist.	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark Brown	Reddish Brown	Pale Brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	Sandy Clay	Sandy Clay	MC	weathered Rock.
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	50-100mm	10-20mm	10-20mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	Round	Round
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 841-865	G61	Date: 3/12/2011
Assessors:		Site Number: C29

Location Characteristics

Geology and Topography Observations	Upper Slope
Landuse and Vegetation Observations	Bloodwood, Brigalow, Bauhinia, Buffel grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 60cm			
Horizon Layer (Layers in Profile)	A1 ¹	B21 ²	B22 ³	Weathered Sandstone
Horizon Depth (eg 0.00 to 0.15m)	0-1.5	1.5-4.5	4.5-8.0	8.0-10.0
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-1.5	(1.5-2.5) (2.5-3.5)	3.5-5.5	(5.5-6.5) (6.5-8.0)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Brown	Brown	Cream
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	Silty Clay	MC	MC	-
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	-
Structure Ped Size (mm) (eg 10 to 20 mm)	5-10	10-20.	20-50.	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PO	PO.	-
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	-
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	Sandstone 5%	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	-
Boundary Shape (even, wavy, irregular, broken)	E	E	E	-

Field Comments

Sparsely Sandstone rock on surface

Soil Survey Worksheet

Location: 851-856	G66	Date: 3/12/11
Assessors: BOLM, HANR, LAWJ		Site Number: L30

Location Characteristics

Geology and Topography Observations	Upper slope
Landuse and Vegetation Observations	Brigalow, Owenia acidulata Buffel grass, whitewood.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Deep Brown Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	4
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-35	35-140	
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-10)	(10-25)(25-35)	(35-55)(55-65)(65-140)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	mod moist	mod moist	
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Brown	Brown	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	
Field Texture Grade (sand/silt/clay)	Silty Clay	MC	MC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	S	S	
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20mm	50-100mm	100-200mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PR	PR	
Consistence Force (weak, moderate, strong)	weak	Strong	Strong	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	
Boundary Shape (even, wavy, irregular, broken)	E	E	E	

Field Comments

Some vertical cracking.

Soil Survey Worksheet

Location: 857-862 G67	Date: 3/12/2011
Assessors: BCLM, HANR, LAWS.	Site Number: C31

Location Characteristics

Geology and Topography Observations	Mid Slope 3%.
Landuse and Vegetation Observations	Bauhinia, Brigalow, Native Orange, Currant Bush, Buffel Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Dermosol						
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted						
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil.						
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 50cm						
Horizon Layer (Layers in Profile)	A1 ¹	B21 ²	B22 ³	Weathered Rock			
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-35	35-50	50-100			
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)	(25-35)	(35-55)	(55-65)	(65-100)	(100-150)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Moist	Dry			
Field Colour (brown, red, yellow, yellowish brown)	Brown	Reddish Brown	Reddish Brown	-			
Mottle Characteristics (% & Colour)	-	-	-	-			
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	-			
Field Texture Grade (sand/silt/clay)	Silty Clay	MC	MC.	-			
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	S	-			
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20.	50-100	50-100	-			
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	-			
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	-			
Seggregations (Type and amount %)	-	-	-	-			
Stones - Type & Amount (Type and amount %)	1% ferricrete	-	-	-			
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	-			
Boundary Shape (even, wavy, irregular, broken)	E	E	E	-			

Field Comments

Decomposed rock to 150 cm.
Ferricrete on surface (upto 20mm)

Soil Survey Worksheet

Location: 863-869	G69	Date: 3/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C32

Location Characteristics

Geology and Topography Observations	Top of Ridge
Landuse and Vegetation Observations	Bloodwood, Box, Ironbark Bauhinia, Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Dermosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	firm crust.			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 10cm			
Horizon Layer (Layers in Profile)	A1	A2	B2	70-100
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-30	30-70	weathered Rock
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown	Reddish Brown	Dark Red (2.5YR 3/6)	
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	well	well	well
Field Texture Grade (sand/silt/clay)	Sandy Clay	LC	MC	
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	M	M	
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	50-100mm	50-100mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	SB	
Consistence Force (weak, moderate, strong)	weak	moderate	moderate	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	
Boundary Shape (even, wavy, irregular, broken)	E	E	E	

Field Comments

Scattered sandstone rock (< 150mm) & ferricrete on surface.

Soil Survey Worksheet

Location: 870-875 G 70.	Date: 3/12/2011
Assessors: BOM, HANG, LAUJ.	Site Number: C33.

Location Characteristics

Geology and Topography Observations	Mid slope (2-3%)
Landuse and Vegetation Observations	Brigalow, Owenia acidulata, Baobab, Buffel grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black Vertisol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine to coarse roots to 90cm.			
Horizon Layer (Layers in Profile)	A1 ¹	B1 ²	B2 ³	B/C ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-70	70-95	95-130.
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	(70-95)(95-130)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Mod Moist	Mod Moist	—
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	10YR 3/2	Dark greyish brown 10YR 3/2	—
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	—
Field Texture Grade (sand/silt/clay)	MC	HC	HC	—
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	S	—
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20.	200-500	200-500	—
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	AB	AB.	—
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	—
Seggregations (Type and amount %)	—	—	5% Carbonate	—
Stones - Type & Amount (Type and amount %)	5% Ferricrete/ Silcrete	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	G	C	—
Boundary Shape (even, wavy, irregular, broken)	E	I	E.	—

Field Comments

Sandstone rocks on surface.

Soil Survey Worksheet

Location: 876-881	G 71	Date: 3/12/2011
Assessors: BCLM, HANZ, LAWS.		Site Number: C34

Location Characteristics

Geology and Topography Observations	Lower slope
Landuse and Vegetation Observations	Bloodwood, Brigalow, Buff grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black. vertosol.			
Surface Condition (crusted, mulched, soil, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil.			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 100 cm			
Horizon Layer (Layers in Profile)	A1 ¹	B1 ²	B2 ³	B/C ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-85	85-120	120-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)(35-55)(55-65)	(65-120)	(120-150)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Mod Moist	Mod Moist	Mod Moist
Field Colour (brown, red, yellow, yellowish brown)	Black	Black 7.5 YR 2.5/1	Black	Black into Weathered sandstone
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	Moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	MC	HC	HE	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100	200-500	200-500	100-200.
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	AB
Consistence Force (weak, moderate, strong)	S	S	S	S
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	Siltcrete/ferricrete 5%	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	G
Boundary Shape (even, wavy, irregular, broken)	I	I	I	I

Field Comments

Siltcrete + ferricrete observed on
soil surface

Soil Survey Worksheet

Location: 882-887 G72.	Date: 3/12/2011
Assessors: BOLM, HANR, LAWJ	Site Number: C35.

Location Characteristics

Geology and Topography Observations	Upper slope, low rise 1% slope
Landuse and Vegetation Observations	Ironbark, Bloodwood, Buffel Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Chromosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Seasonally Hard Setting.			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor water sheeting erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Medium roots to 80cm			
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B21 ³	B22 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-20	20-45	45-85
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-10)	(10-25)	(25-35)	(35-55)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Mod Moist	Mod Moist	Mod Moist
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Reddish Brown	Dark Reddish Brown	Dark Reddish Brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Well	Moderate
Field Texture Grade (sand/silt/clay)	(fine) SL	SCL	LMC (subplastic)	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	M	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	10-20	100-200	100-200
Structure Ped Shape (platy, prismatic, blocky, round, etc)	Round	SB	SB	SB
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	Strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	Silcrete 60%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	G
Boundary Shape (even, wavy, irregular, broken)	I	I	I	I

Field Comments

A1 = pH 6.5
A2 = pH 6.0
B21 = pH 7.0
B22 = pH 7.0.

Soil Survey Worksheet

Location: 888-893	G 73	Date: 3/12/2011
Assessors:		Site Number: C36.

Location Characteristics

Geology and Topography Observations	Level Terrace
Landuse and Vegetation Observations	Scattered Blackwood, Euc. platyphylon, Grassland - grazing.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Tenisol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Firm			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil.			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 50cm			
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B11 ³	B12 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-25	25-60	60-85	85-140
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-10)(10-25)	(25-35)	(35-55)	(55-65)(65-100)(100-140)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown	Cream	Pale Orange	light orange
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Well	Well.
Field Texture Grade (sand/silt/clay)	Coarse Sand	Coarse Sand	Coarse Sand	Coarse Sand
Structure Pedality Grade (Apedal or weak/moderate/strong)	Apedal	Apedal	Apedal	Apedal
Structure Ped Size (mm) (eg 10 to 20 mm)	—	—	—	—
Structure Ped Shape (platy, prismatic, blocky, round, etc)	—	—	—	—
Consistence Force (weak, moderate, strong)	Weak	Weak	Weak	weak
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	G
Boundary Shape (even, wavy, irregular, broken)	W	W	W	W

Field Comments

Old flood deposit
Splay deposit

Soil Survey Worksheet

Location: 899-904	G77	Date: 3/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C37

Location Characteristics

Geology and Topography Observations	Higher Terrace
Landuse and Vegetation Observations	Open woodland, large bloodwood, large Euc. platyphylla, native grasses

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 120cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	1-25	25-55	55-100	100-140
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-10)(10-25)	(25-35)(35-55)	(55-65)(65-100)	(100-140)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	7.5YR 6/2 light brown (dry)	7.5YR 4/6 strong brown	Pale orange/brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	well	moderate	Well
Field Texture Grade (sand/silt/clay)	SL	SL	Sandy Clay	SCL
Structure Pedality Grade (Apedal or weak/moderate/strong)	Apedal	Apedal	S	M
Structure Ped Size (mm) (eg 10 to 20 mm)	—	—	50-100mm	50-100mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	—	—	SB	V
Consistence Force (weak, moderate, strong)	weak	weak	strong	moderate
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	G	G
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

A2 (not bleached).

Soil Survey Worksheet

Location: 905-910 G78	Date: 3/12/2011
Assessors:	Site Number: C38

Location Characteristics

Geology and Topography Observations	Open depression.
Landuse and Vegetation Observations	Scattered Bloodwood, Moreton Bay Ash, Euc. platyphylla, Buffel grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 70cm			
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B21 ³	B22 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-7	7-30	30-70	70-100
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-7	(7-25), (25-35)	(35-55), (55-65)	(65-100)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Grey	Pale Grey	Yellowish brown 10YR 5/6	Orange/Brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	SL	LS	Sandy Clay	SCL
Structure Pedality Grade (Apedal or weak/moderate/strong)	Apedal	Apedal	Weak	(v) Massive
Structure Ped Size (mm) (eg 10 to 20 mm)	-	-	20-50mm	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	-	-	SB	-
Consistence Force (weak, moderate, strong)	-	-	Weak	-
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	10% Sandstone	30% Sandstone
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	Clear	Clear	G	G
Boundary Shape (even, wavy, irregular, broken)	Wavy	Wavy	W	W

Field Comments

A2 sporadically bleached

Soil Survey Worksheet

Location: 913-918 681	Date: 3/12/11
Assessors: BOLM, HANR, LAWJ	Site Number: C39

Location Characteristics

Geology and Topography Observations	Level Plain
Landuse and Vegetation Observations	Open woodland - Box, Euc. platyphylla 80% grass ground cover

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	seasonably hard setting			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor water erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 120cm			
Horizon Layer (Layers in Profile)	A1	A2	B21	B22
Horizon Depth (eg 0.00 to 0.15m)	0-25	25-37	37-90	90-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-25	(25-35)(35-55)	(55-65)(65-90)	(90-150)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown	5YR 4/6 yellow red	yellowish red	Yellow red
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	fine Sandy loam	Fine SL	MC	SCL
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	W	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20mm	10-20mm	50-100mm	50-100mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	SB	SB
Consistence Force (weak, moderate, strong)	weak	weak	strong	strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	G
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 920-925 G83	Date: 3/12/2011
Assessors: BOB M, HANR, LAWS	Site Number: C40-

Location Characteristics

Geology and Topography Observations	Mainly flat, sloping gently to the west
Landuse and Vegetation Observations	Open woodland - Box, Euc. platyphylla, Eremophila, Buffel grass, Old Blue Grass

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol				
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Loose				
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil				
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 100cm				
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B21 ³	B22.	B23
Horizon Depth (eg 0.00 to 0.15m)	0-15	15-30	30-55	55-80	80-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-15	(15-25)(25-35)	(35-55)(55-65)	(65-80)	80-140
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Pale Brown	Brown	Reddish Br	Yellowish Brown
Mottle Characteristics (% & Colour)	-	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Well	Well	Moderate	Mod	Mod
Field Texture Grade (sand/silt/clay)	ZL	L	MC	MC	Somewhat Clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	M	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5	20-50	50-100	50-100	50-100
Structure Ped Shape (platy, prismatic, blocky, round, etc)	round	SB	SB	SB	SB
Consistence Force (weak, moderate, strong)	Weak	Moderate	Strong	Strong	Strong
Seggregations (Type and amount %)	-	-	-	Carbonate 10%	-
Stones - Type & Amount (Type and amount %)	-	-	Silcrete 3%	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E	E

Field Comments

Seasonally hard setting.
Carbonate nodules at 55-80 cm

Soil Survey Worksheet

Location: 927-932	G84	Date: 3/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C41

Location Characteristics

Geology and Topography Observations	2nd terrace on Bowen River
Landuse and Vegetation Observations	Enc. platyphylla, Bloodwood, Buffelgrass River terrace, Euc tereticornis

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Stratic Tenosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Nil			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Roots to 150cm			
Horizon Layer (Layers in Profile)	A1	A2	B1	B2
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-65	65-100	100-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10(10-25)	(25-35)(35-55)	(55-65)(65-100)	(100-140)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Moist	Mod Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Grey	Grey	Pale Brown	Brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	well	well	well
Field Texture Grade (sand/silt/clay)	SL	LS	LS	LS
Structure Pedality Grade (Apedal or weak/moderate/strong)	Apedal	Apedal	Apedal	Apedal
Structure Ped Size (mm) (eg 10 to 20 mm)	—	—	—	—
Structure Ped Shape (platy, prismatic, blocky, round, etc)	—	—	—	—
Consistence Force (weak, moderate, strong)	weak	weak	weak	weak
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 941-945	G90	Date: 3/12/11
Assessors: BOLM, HANM, LAWT		Site Number: C42

Location Characteristics

Geology and Topography Observations	Mainly flat terrain
Landuse and Vegetation Observations	Open woodland, Box, Bloodwood, grassland.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine root to 100cm			
Horizon Layer (Layers in Profile)	A1	A2-1	A22	B2
Horizon Depth (eg 0.00 to 0.15m)	0-17	17-40	40-55	55-130
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-17	(17-25)(25-35)	(35-55)	(55-65)(65-130)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown	Pale Brown	Pale Brown	orange brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Well	well	well	Moderate
Field Texture Grade (sand/silt/clay)	SL	SL	SL	MC (with sand)
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	W	W	S
Structure Ped Size (mm) (eg 10 to 20 mm)	20-50mm	20-50mm	20-50mm	50-100mm.
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	PL	PL	SB
Consistence Force (weak, moderate, strong)	weak	weak	weak	strong
Seggregations (Type and amount %)	—	—	—	manganese 10%
Stones - Type & Amount (Type and amount %)	—	—	—	silcrete 10%.
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Soil Survey Worksheet

Location: 948-953 G93	Date: 3/12/2011
Assessors: BDM, HANZ, LAWS.	Site Number: C.43.

Location Characteristics

Geology and Topography Observations	Flat terrain.
Landuse and Vegetation Observations	Bauhinia Eremophila, 50% grass cover

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted (Sodic)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor water sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1 ¹	A2 ²	B21 ³	B22 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-10	10-35	35-60	60-140.
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-10	(10-25)(25-35)	(35-55)(55-65)	(65-100)(100-140)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Mod Moist	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Dark Brown	Yellowish Brown	Yellowish Brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	L	SCL	MC	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	M	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	10-20.	20-50	20-50	50-100
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	Round	SB	SB
Consistence Force (weak, moderate, strong)	Weak	Moderate	Strong	Strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	Silcrete 5%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	G
Boundary Shape (even, wavy, irregular, broken)	E	E	W	W

Field Comments

Soil Survey Worksheet

Location: 956-961	G97	Date: 3/12/11
Assessors: BOLM, HANR, LAWT	(Re-synchronised with Gtac)	Site Number: C44

Location Characteristics

Geology and Topography Observations	Mid Slope (3-1%)
Landuse and Vegetation Observations	Scattered Brigalow, Open Buffel grassland.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	(water) minor sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine + medium roots to 110cm			
Horizon Layer (Layers in Profile)	A1	B11	B12	B13
Horizon Depth (eg 0.00 to 0.15m)	0-13	13-80	80-110	110-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-13)	(13-25)	(25-35)	(35-55)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	very dark greyish brown	Dark brown	Dark brown	Grey clay
Mottle Characteristics (% & Colour)	-	-	-	Brown mottles (10%)
Drainage (Poor, Moderate, Well, Rapid)	well	moderate	Poor	Poor
Field Texture Grade (sand/silt/clay)	MC	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100mm	200-500mm	200-500mm	200-500mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	AB
Consistence Force (weak, moderate, strong)	strong	strong	strong	strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	iron stone (5%)	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	G	G	G
Boundary Shape (even, wavy, irregular, broken)	E	W	W	W

Field Comments

Soil Survey Worksheet

Location: 965-970	C102	Date: 3/12/2011
Assessors: BOLM, HANR, LAUS		Site Number: C45

Location Characteristics

Geology and Topography Observations	Mid Slope 4% Slope Rolling topography.
Landuse and Vegetation Observations	Bloodwood, Banahima, Iron bark, Open Buffel grassland!

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Moderate gully erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 40cm			
Horizon Layer (Layers in Profile)	A1 ¹	B21 ²	B22 ³	B/C ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-11	11-40	40-60	60-100
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-11	(11-25) (25-35)	(35-55) (55-65)	(65-80)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Light brown	Pale Brown	Green
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	SCC.	Sandy Clay	CS	LS.
Structure Pedality Grade (Apical or weak/moderate/strong)	Moderate	Moderate	Apical	Apical
Structure Ped Size (mm) (eg 10 to 20 mm)	20-50	20-50	-	-
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	Round	-	-
Consistence Force (weak, moderate, strong)	Moderate	Moderate	Weak	weak.
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	-	-
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	C	C
Boundary Shape (even, wavy, irregular, broken)	W	W	W	W.

Field Comments

Much of the original topsoil had been washed away due to sheet erosion.

Soil Survey Worksheet

Location: 976-981	G107	Date: 3/12/11
Assessors: BOLM, HANR, LAWT		Site Number: C46

Location Characteristics

Geology and Topography Observations	Mid Slope %
Landuse and Vegetation Observations	Scatter, Ironbark, Bloodwood, Bauhinia, Buffel grassland.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Red Sodosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	loose			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Severe water sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 80cm			
Horizon Layer (Layers in Profile)	A1	B21	B22	B/C
Horizon Depth (eg 0.00 to 0.15m)	0-22	22-55	55-75	75-140
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-22)(22-35)	(35-55)	(55-65)(65-90)	(90-120)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Brown	Yellowish Red 5YR 4/6	Orange Brown	Cream
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	moderate	moderate	moderate
Field Texture Grade (sand/silt/clay)	SL	MC	MC	Sandy Clay
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	S	S	M
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	20-50mm	50-100mm	50-100mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	Round	SB	SB	S13
Consistence Force (weak, moderate, strong)	weak	strong	strong	moderate
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	—	—
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	C	C	C
Boundary Shape (even, wavy, irregular, broken)	E	E	E	E

Field Comments

Severely eroded slope.

Soil Survey Worksheet

Location: 984-989 G111	Date: 3/12/11
Assessors: BOLM, HANR, LAWJ	Site Number: C47

Location Characteristics

Geology and Topography Observations	Bottom of slope
Landuse and Vegetation Observations	Open Buffel grassland Scatter small white wood

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Black vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	friable, cracking			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	minor gully erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 140cm			
Horizon Layer (Layers in Profile)	A1	B11	B12	B13
Horizon Depth (eg 0.00 to 0.15m)	0-12	12-35	35-65	65-150
Sample Depth Range (m) (eg 0.05 to 0.10m)	0-12	(12-25)(25-35)	(35-55)(55-65)	(65-90)(90-120)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Black	Dark Brown 7.5YR 3/2	Dark Brown	Dark Brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	moderate	moderate	moderate
Field Texture Grade (sand/silt/clay)	HC	HC	HC	HC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	200-500mm	200-500mm	200-500mm	200-500mm
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	AB
Consistence Force (weak, moderate, strong)	strong	strong	strong	strong
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	—	—	ferricrete 30%	ferricrete 30%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	G
Boundary Shape (even, wavy, irregular, broken)	W	W	W	W

Field Comments

- very dense soil (possible hard pan from stock traffic)

- ferricrete on soil surface

Soil Survey Worksheet

Location: 991-996 G116	Date: 3/12/2011
Assessors: BOLM, HANK, LAJ	Site Number: C48

Location Characteristics

Geology and Topography Observations	Lower side of crest.
Landuse and Vegetation Observations	Box, Brigalow, Quercus acidulata, Buffel grass.

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Brown Vertosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Minor water sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Fine roots to 80cm			
Horizon Layer (Layers in Profile)	A ₁	B ₁ ²	B ₂ ³	B ₃ ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-13	13-50	50-80	80-130
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-13)	(13-25)	(25-35)	(35-55)
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown 7.5 YR 3/2	7.5 YR 3/3	Dark Brown	Dark Brown
Mottle Characteristics (% & Colour)	-	-	-	-
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	MC	He	He	MC
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	20-50	200-500	200-500	200-500
Structure Ped Shape (platy, prismatic, blocky, round, etc)	AB	AB	AB	AB
Consistence Force (weak, moderate, strong)	Strong	Strong	Strong	Strong
Seggregations (Type and amount %)	-	-	-	-
Stones - Type & Amount (Type and amount %)	-	-	ferricrete 5%	ferricrete 5%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	G	G	G
Boundary Shape (even, wavy, irregular, broken)	E	W	W	W

Field Comments

Soil Survey Worksheet

Location: 997-1004	G117	Date: 3/12/11
Assessors: BOLM, HANR, LAWJ		Site Number: C49

Location Characteristics

Geology and Topography Observations	Midslope (2-3% slope)
Landuse and Vegetation Observations	Scattered Bloodwood Buffel grassland

Soil Profile Properties

Soil Type Field Name (Australian Soil Classification)	Lithic Tenosol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Crusted			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	moderate sheet erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	fine roots to 85cm			
Horizon Layer (Layers in Profile)	A1	B11	B12	4
Horizon Depth (eg 0.00 to 0.15m)	0-25	25-55	55-60	
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-25)	(25-35)(35-55)	(55-65)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod moist	Dry	Dry	
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	Cream	pale cream	
Mottle Characteristics (% & Colour)	—	—	—	
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	
Field Texture Grade (sand/silt/clay)	LC (with sand)	SCL	SCL	
Structure Pedality Grade (Apedal or weak/moderate/strong)	W	W	W	
Structure Ped Size (mm) (eg 10 to 20 mm)	2-5mm	20-50mm	2-5mm	
Structure Ped Shape (platy, prismatic, blocky, round, etc)	PL	SB	round	
Consistence Force (weak, moderate, strong)	weak	weak	weak	
Seggregations (Type and amount %)	—	—	—	
Stones - Type & Amount (Type and amount %)	—	—	—	
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	G	G	G	
Boundary Shape (even, wavy, irregular, broken)	W	W	W	

Field Comments

dry weathered sandstone beyond 60cm

Soil Survey Worksheet

Location: 1006-1011 G-119	Date: 3/12/2011
Assessors: BOUM, HANZ, LAUJ.	Site Number: C50.

Location Characteristics

Geology and Topography Observations	Upper Slope on undulating landform
Landuse and Vegetation Observations	Open Buffel grassland. Scattered Mountain Coolibah, Whitebark, Brigalow.

Soil Profile Properties

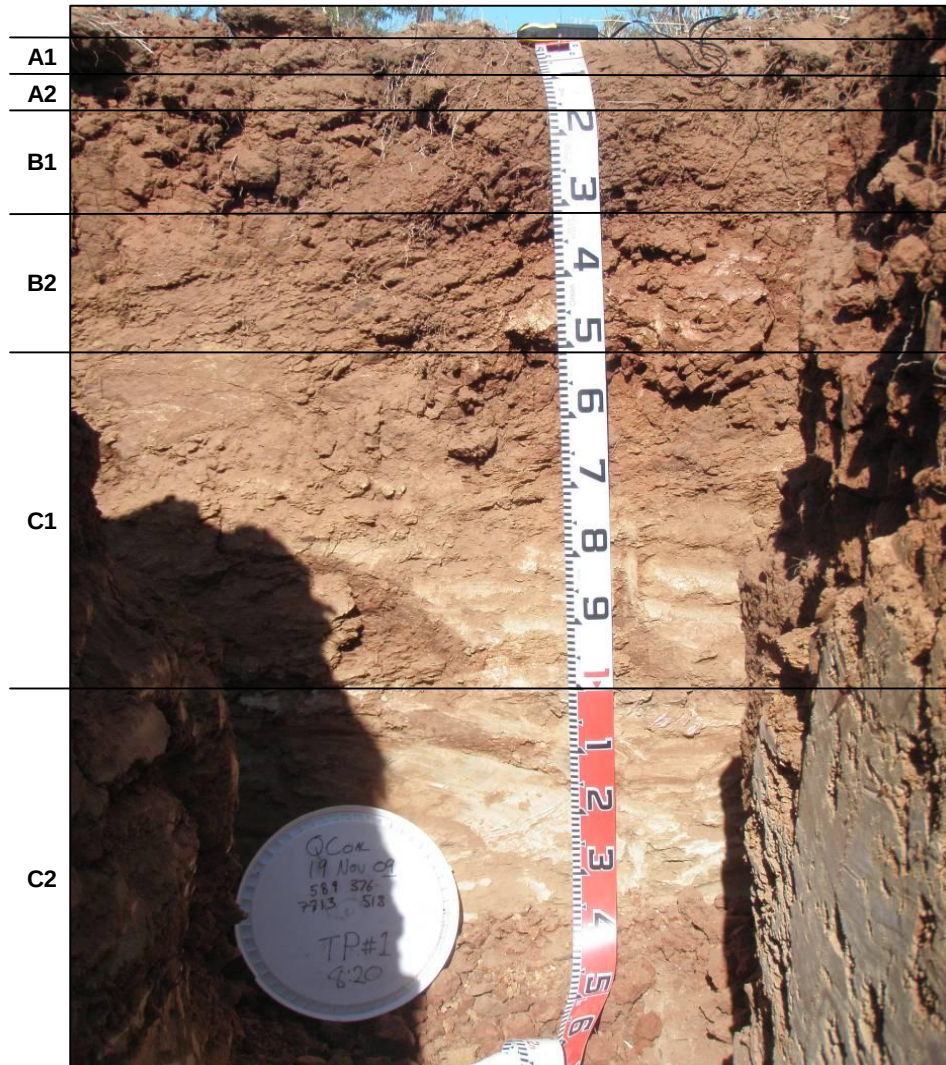
Soil Type Field Name (Australian Soil Classification)	Brown vertisol			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)	Friable			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)	Moderate gully erosion			
Root Depth, Type & Amount (eg 0.30m, fine/medium/coarse, few/common/many/abundant)	Medium to fine roots to 100cm			
Horizon Layer (Layers in Profile)	A1 ¹	B11 ²	B12 ³	B13 ⁴
Horizon Depth (eg 0.00 to 0.15m)	0-22	22-40	40-90	90-130
Sample Depth Range (m) (eg 0.05 to 0.10m)	(0-22)(22-35)	(35-55)(55-65)	(65-90)(90-130)	
Field Moisture (Dry, Moist, Moderately Moist, Wet)	Mod Moist	Dry	Dry	Dry
Field Colour (brown, red, yellow, yellowish brown)	Dark Brown	10YR 4/3 Brown	Brown	Brown
Mottle Characteristics (% & Colour)	—	—	—	—
Drainage (Poor, Moderate, Well, Rapid)	Moderate	Moderate	Moderate	Moderate
Field Texture Grade (sand/silt/clay)	MC	HE	HE	LMC.
Structure Pedality Grade (Apedal or weak/moderate/strong)	S	S	S	S
Structure Ped Size (mm) (eg 10 to 20 mm)	50-100	200-500	200-500	50-100.
Structure Ped Shape (platy, prismatic, blocky, round, etc)	Round	AB	AB	AB
Consistence Force (weak, moderate, strong)	Moderate	Strong	Strong	Moderate
Seggregations (Type and amount %)	—	—	—	—
Stones - Type & Amount (Type and amount %)	ferricrete 5%	—	—	sandstone/mudstone 5%
Boundary Distinctness (sharp, abrupt, clear, gradual, diffuse)	C	G	G	G
Boundary Shape (even, wavy, irregular, broken)	E	W	W	W

Field Comments

• Moderate Gully Erosion
• Some Calcium Carbonate nodules on Soil Surface

Soil Profile Description: TP1 - Dermosol

Associated Ground Observation GO#5



Description

A1: 0.0 - 0.08 m

Sandy Clay Loam, dark brown (7.5YR 4/3 dry), dry, moderate pedality 10-20 mm, sub angular blocky, rough fabric, moderately weak strength, macropore cracks <5 mm, fine grained sand fraction. Non plastic, non sticky. Field pH 6.5. Many roots. Sharp smooth change to:

A2: 0.08 - 0.16 m

Sandy Clay Loam, dark brown (7.5YR 4/4 dry), dry, moderate pedality 10-20 mm, sub angular blocky, rough fabric, moderately weak strength, macropore cracks <5 mm, fine grained sand fraction. Non plastic, non sticky. Field pH 6.5. Many roots. Abrupt smooth change to:

B1: 0.16 - 0.31 m

Light Clay, weak red (10R 4/3 dry), dry, strong pedality 20-50 mm, sub angular blocky, rough fabric, moderately firm strength, macropore cracks <5 mm, fine grained sand fraction. Very plastic, moderately sticky. Field pH 6.0. Common roots. Clear smooth change to:

B2: 0.31 - 0.51 m

Light Clay, weak red and pale yellow mottle (10R 4/4 dry), dry, strong pedality 20-50 mm, sub angular blocky, rough fabric, moderately firm strength, macropore cracks <5 mm, fine grained sand fraction. Very plastic, moderately sticky. Field pH 6.0. Common roots. Clear wavy change to:

C1: 0.51 - 1.0 m

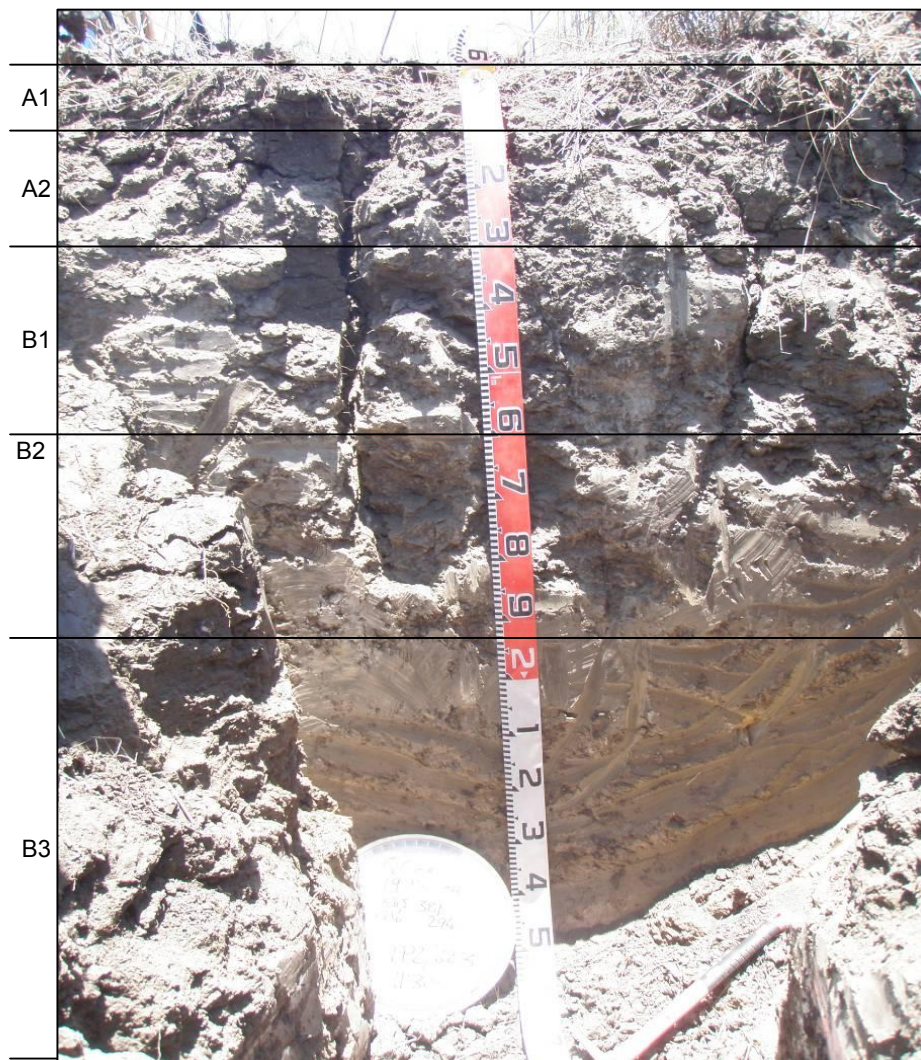
Weathered sandstone, reddish yellow. No roots.

C2: 1.0 - 1.4 m

Weathered sandstone, mottled light grey, pale yellow, and dark orange. No roots.

Soil Profile Description: TP2 - Vertisol

Associated Ground Observation GO#3



A1: 0.0 - 0.1 m

Medium Clay, very dark grey (5Y 3/1 dry), dry, strong pedality, 10-20 mm, subangular blocky, rough, moderately firm strength, macropore cracks 10-20 mm. High plasticity (normal), moderately sticky. Trace manganese nodules < 5 mm. Field pH 7.0. Many roots. Gradual smooth change to:

A2: 0.1 - 0.3 m

Medium Clay, dark grey (5Y 4/1 dry), dry, strong pedality, 20-50mm, subangular blocky, rough, very strong strength, macropore cracks 10-20 mm. High plasticity (normal), moderately sticky. Trace manganese nodules < 5 mm. Field pH 7.0. Many roots. Gradual smooth change to:

B1: 0.3 - 0.6 m

Medium Clay, dark grey (5Y 5/2 dry), dry, strong pedality, 20-50mm, subangular blocky, rough, very strong strength, macropore cracks 10-20 mm. High plasticity (normal), moderately sticky. Field pH 7.0. Roots common. Gradual smooth change to:

B2: 0.6 - 0.93 m

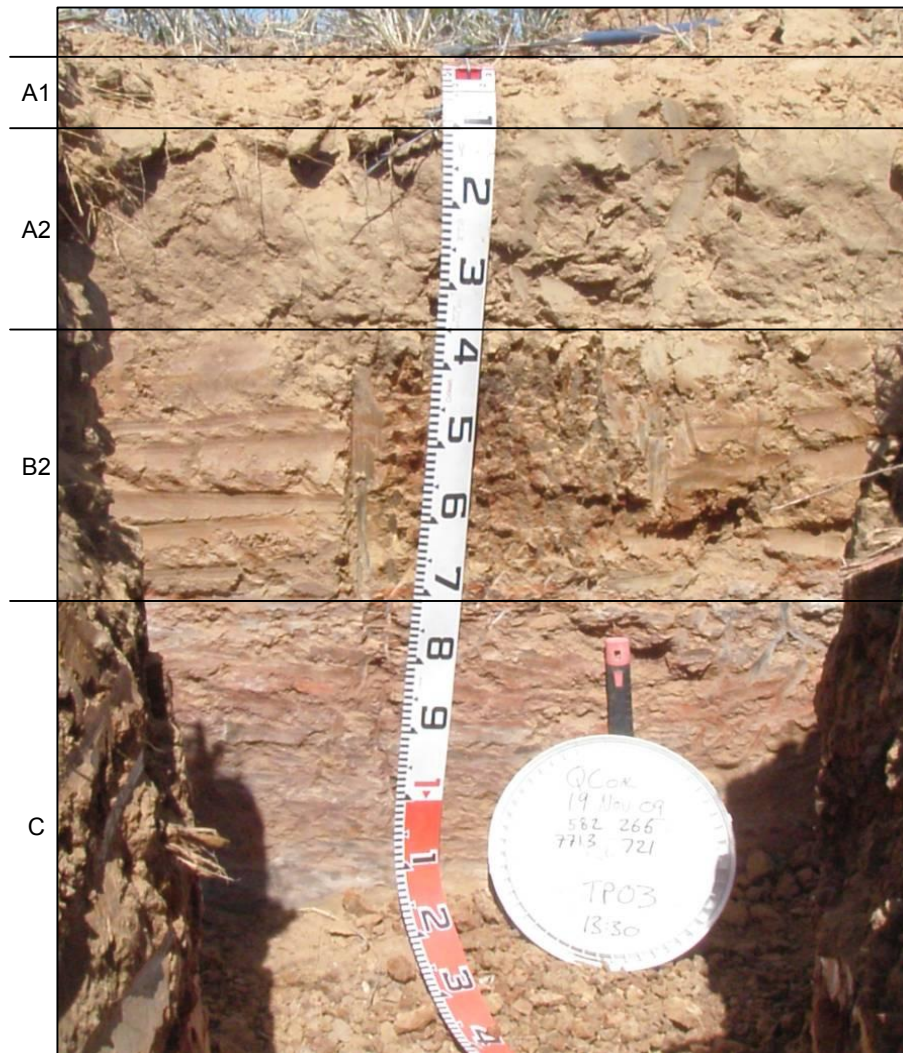
Medium Clay, dark grey and orange mottle (5Y 6/2 dry), slightly moist, strong pedality, 20-50mm, subangular blocky, rough, very strong strength, macropore cracks 10-20 mm. High plasticity (normal), moderately sticky. Field pH 7.0. Few roots. Clear smooth change to:

B3: 0.93 - 1.5 m

Medium Clay, dark grey (5Y 4/2 dry), slightly moist, strong pedality, 20-50mm, subangular blocky, rough, very strong strength, macropore cracks 10-20 mm. High plasticity (normal), moderately sticky. Field pH 7.0. No roots.

Soil Profile Description: TP3 - Sodosol

Associated Ground Observation GO#14



A1: 0.0 - 0.1 m

Loamy Sand, light yellowish brown (10YR 6/4 dry), dry, weak pedality 10-20 mm, angular blocky, sandy fabric, moderately weak strength, fine grained sand, non plastic. Field pH 6.0. Many roots. Abrupt smooth change to:

A2: 0.1 - 0.35 m

Loamy Sand, very pale brown (10YR 7/3 dry), dry, weak pedality 10-20 mm, angular blocky, sandy fabric, moderately weak strength, fine grained sand, non plastic. Field pH 6.0. Many roots. Abrupt smooth change to:

B2: 0.35 - 0.71 m

Sandy Clay Loam, dark brown (7.5YR 3/4 dry), dry, moderate pedality 20-50 mm, sub angular blocky, rough fabric, moderately firm strength, macropore cracks <5 mm, fine grained sand fraction. Moderate plasticity, slightly sticky. Field pH 6.0. Few roots. Sharp smooth change to:

C: 0.71 - 1.2 m

Weathered sandstone, reddish and dark grey. No roots.



Appendix C

Laboratory Certificates of Analysis



Nutrient Advantage[®]

Nutrient Advantage Advice[®]

Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001777
Paddock Name: 02-12-2011
Sample Name: SITE 12
Sample Depth (cm): 25 To 35

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.00
pH (1:5 CaCl ₂)		6.80
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	90
Chloride	mg/kg	27.0
Electrical Conductivity	dS/m	0.10
Cation Exchange Capacity	meq/100g	14.80
Calcium (Amm-acet.)	%	41.000
Calcium (Amm-acet.)	meq/100g	6.000
Magnesium (Amm-acet.)	%	49.000
Magnesium (Amm-acet.)	meq/100g	7.200
Sodium (Amm-acet.)	%	9.500
Sodium (Amm-acet.)	meq/100g	1.400
Potassium (Amm-acet.)	%	1.600
Potassium (Amm-acet.)	meq/100g	0.230
Calcium/Magnesium Ratio		0.8
Potassium to Magnesium Ratio		0.0
% Clay	%	40
% Sand (Fine)	%	47
% Sand (Coarse)	%	2
% Silt	%	11
Sansilclay Texture		Sandy Clay



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

Email: lab.feedback@incitecpivot.com.au





Nutrient Advantage®

Nutrient Advantage Advice®

Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001777
Paddock Name: 02-12-2011
Sample Name: SITE 12
Sample Depth (cm): 25 To 35

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

The results reported pertain only to the sample submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001778
Paddock Name: 02-12-2011
Sample Name: SITE 12
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.60
pH (1:5 CaCl ₂)		7.50
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	58
Chloride	mg/kg	210.0
Electrical Conductivity	dS/m	0.23
Cation Exchange Capacity	meq/100g	12.20
Calcium (Amm-acet.)	%	23.000
Calcium (Amm-acet.)	meq/100g	2.800
Magnesium (Amm-acet.)	%	52.000
Magnesium (Amm-acet.)	meq/100g	6.300
Sodium (Amm-acet.)	%	25.000
Sodium (Amm-acet.)	meq/100g	3.000
Potassium (Amm-acet.)	%	1.200
Potassium (Amm-acet.)	meq/100g	0.150
Calcium/Magnesium Ratio		0.4
Potassium to Magnesium Ratio		0.0
% Clay	%	21
% Sand (Fine)	%	64
% Sand (Coarse)	%	5
% Silt	%	10
Sand/clay Texture		Sandy Clay Loam



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

Email: lab.feedback@incitecpivot.com.au





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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001778
Paddock Name: 02-12-2011
Sample Name: SITE 12
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001779
Paddock Name: 02-12-2011
Sample Name: SITE 13
Sample Depth (cm): 0 To 13

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		6.60
pH (1:5 CaCl ₂)		5.70
Organic Carbon (OC)	%	0.29
Total Nitrogen	%	<0.04
Phosphorus (Colwell)	mg/kg	<5
Phosphorus (BSES)	mg/kg	9
Potassium (Nitric K)	meq/100g	1.70
Sulphate Sulphur (MCP)	mg/kg	2.2
Zinc (DTPA)	mg/kg	0.24
Copper (DTPA)	mg/kg	0.21
Iron (DTPA)	mg/kg	13.0
Manganese (DTPA)	mg/kg	4.70
Boron (Hot CaCl ₂)	mg/kg	0.14
Electrical Conductivity	dS/m	0.03
Silicon (BSES)	mg/kg	96
Organic Matter	%	0.5

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GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001780
Paddock Name: 02-12-2011
Sample Name: SITE 13
Sample Depth (cm): 25 To 35

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		5.70
pH (1:5 CaCl ₂)		4.80
Aluminium Saturation	%	1.7
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	41
Chloride	mg/kg	490.0
Electrical Conductivity	dS/m	0.30
Cation Exchange Capacity	meq/100g	5.91
Aluminium (KCl)	mg/kg	<9.00
Aluminium (KCl)	meq/100g	0.10
Calcium (Amm-acet.)	meq/100g	2.200
Calcium (Amm-acet.)	%	37.000
Magnesium (Amm-acet.)	meq/100g	2.000
Magnesium (Amm-acet.)	%	34.000
Sodium (Amm-acet.)	meq/100g	1.500
Sodium % of Cations (ESP)	%	25.000
Potassium (Amm-acet.)	meq/100g	0.110
Potassium (Amm-acet.)	%	1.900
Calcium/Magnesium Ratio		1.1
Potassium to Magnesium Ratio		0.1
% Clay	%	10
% Sand (Fine)	%	62



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001780
Paddock Name: 02-12-2011
Sample Name: SITE 13
Sample Depth (cm): 25 To 35

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
% Sand (Coarse)	%	15
% Silt	%	14
Sansilclay Texture		Sandy Loam

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001781
Paddock Name: 02-12-2011
Sample Name: SITE 13
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		5.70
pH (1:5 CaCl ₂)		5.00
Aluminium Saturation	%	2.5
Nitrate Nitrogen (NO ₃)	mg/kg	1.0
Available Potassium	mg/kg	21
Chloride	mg/kg	640.0
Electrical Conductivity	dS/m	0.47
Cation Exchange Capacity	meq/100g	4.00
Aluminium (KCl)	mg/kg	<9.00
Aluminium (KCl)	meq/100g	0.10
Calcium (Amm-acet.)	meq/100g	0.650
Calcium (Amm-acet.)	%	16.000
Magnesium (Amm-acet.)	meq/100g	1.100
Magnesium (Amm-acet.)	%	28.000
Sodium (Amm-acet.)	meq/100g	2.100
Sodium % of Cations (ESP)	%	53.000
Potassium (Amm-acet.)	meq/100g	0.053
Potassium (Amm-acet.)	%	1.300
Calcium/Magnesium Ratio		0.6
Potassium to Magnesium Ratio		0.0
% Clay	%	6
% Sand (Fine)	%	69



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001781
Paddock Name: 02-12-2011
Sample Name: SITE 13
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
% Sand (Coarse)	%	23
% Silt	%	3
Sansilclay Texture		Sand

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001782
Paddock Name: 02-12-2011
Sample Name: SITE 14
Sample Depth (cm): 0 To 12

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		5.60
pH (1:5 CaCl ₂)		4.70
Organic Carbon (OC)	%	1.30
Total Nitrogen	%	0.10
Phosphorus (Colwell)	mg/kg	15
Phosphorus (BSES)	mg/kg	14
Potassium (Nitric K)	meq/100g	1.90
Sulphate Sulphur (MCP)	mg/kg	11.0
Zinc (DTPA)	mg/kg	1.30
Copper (DTPA)	mg/kg	0.32
Iron (DTPA)	mg/kg	210.0
Manganese (DTPA)	mg/kg	12.00
Boron (Hot CaCl ₂)	mg/kg	0.25
Electrical Conductivity	dS/m	0.15
Silicon (BSES)	mg/kg	140
Organic Matter	%	2.2

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD

Sample No: 030001819

Paddock Name: 02-12-2011

Sample Name: SITE 31

Sample Depth (cm): 100 To 150

Nearest Town: BRISBANE

Test Code: ADMINSOIL

Sample Type: Soil

Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.80
pH (1:5 CaCl ₂)		8.00
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	53
Chloride	mg/kg	<10.0
Electrical Conductivity	dS/m	0.11
Cation Exchange Capacity	meq/100g	38.50
Calcium (Amm-acet.)	%	94.000
Calcium (Amm-acet.)	meq/100g	36.000
Magnesium (Amm-acet.)	%	5.500
Magnesium (Amm-acet.)	meq/100g	2.100
Sodium (Amm-acet.)	%	0.620
Sodium (Amm-acet.)	meq/100g	0.240
Potassium (Amm-acet.)	%	0.360
Potassium (Amm-acet.)	meq/100g	0.140
Calcium/Magnesium Ratio		17.0
Potassium to Magnesium Ratio		0.1
% Clay	%	11
% Sand (Fine)	%	63
% Sand (Coarse)	%	8
% Silt	%	18
Sansilclay Texture		Sandy Loam



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Grower Name : GHD PTY LTD
Sample No: 030001819
Paddock Name: 02-12-2011
Sample Name: SITE 31
Sample Depth (cm): 100 To 150

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

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GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001820
Paddock Name: 02-12-2011
Sample Name: SITE 32
Sample Depth (cm): 0 To 10

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		6.50
pH (1:5 CaCl ₂)		6.00
Organic Carbon (OC)	%	1.20
Total Nitrogen	%	0.08
Phosphorus (Colwell)	mg/kg	14
Phosphorus (BSES)	mg/kg	32
Potassium (Nitric K)	meq/100g	2.80
Sulphate Sulphur (MCP)	mg/kg	7.3
Zinc (DTPA)	mg/kg	1.40
Copper (DTPA)	mg/kg	0.65
Iron (DTPA)	mg/kg	14.0
Manganese (DTPA)	mg/kg	29.00
Boron (Hot CaCl ₂)	mg/kg	0.53
Electrical Conductivity	dS/m	0.07
Silicon (BSES)	mg/kg	320
Organic Matter	%	2.1

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BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001821
Paddock Name: 02-12-2011
Sample Name: SITE 32
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		7.50
pH (1:5 CaCl ₂)		6.80
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	220
Chloride	mg/kg	12.0
Electrical Conductivity	dS/m	0.06
Cation Exchange Capacity	meq/100g	12.40
Calcium (Amm-acet.)	%	81.000
Calcium (Amm-acet.)	meq/100g	10.000
Magnesium (Amm-acet.)	%	15.000
Magnesium (Amm-acet.)	meq/100g	1.800
Sodium (Amm-acet.)	%	0.670
Sodium (Amm-acet.)	meq/100g	0.083
Potassium (Amm-acet.)	%	4.400
Potassium (Amm-acet.)	meq/100g	0.550
Calcium/Magnesium Ratio		5.6
Potassium to Magnesium Ratio		0.3
% Clay	%	50
% Sand (Fine)	%	29
% Sand (Coarse)	%	16
% Silt	%	5
Sansilclay Texture		Clay



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001821
Paddock Name: 02-12-2011
Sample Name: SITE 32
Sample Depth (cm): 55 To 65

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

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BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001822
Paddock Name: 02-12-2011
Sample Name: SITE 33
Sample Depth (cm): 35 To 55

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.80
pH (1:5 CaCl ₂)		8.00
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	110
Chloride	mg/kg	<10.0
Electrical Conductivity	dS/m	0.17
Cation Exchange Capacity	meq/100g	45.40
Calcium (Amm-acet.)	%	81.000
Calcium (Amm-acet.)	meq/100g	37.000
Magnesium (Amm-acet.)	%	16.000
Magnesium (Amm-acet.)	meq/100g	7.100
Sodium (Amm-acet.)	%	2.200
Sodium (Amm-acet.)	meq/100g	1.000
Potassium (Amm-acet.)	%	0.620
Potassium (Amm-acet.)	meq/100g	0.280
Calcium/Magnesium Ratio		5.2
Potassium to Magnesium Ratio		0.0
% Clay	%	45
% Sand (Fine)	%	25
% Sand (Coarse)	%	19
% Silt	%	11
Sansilclay Texture		Clay



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001822
Paddock Name: 02-12-2011
Sample Name: SITE 33
Sample Depth (cm): 35 To 55

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

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GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001823
Paddock Name: 02-12-2011
Sample Name: SITE 34
Sample Depth (cm): 0 To 10

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.50
pH (1:5 CaCl ₂)		7.80
Organic Carbon (OC)	%	1.10
Total Nitrogen	%	0.07
Phosphorus (Colwell)	mg/kg	10
Phosphorus (BSES)	mg/kg	39
Potassium (Nitric K)	meq/100g	3.10
Sulphate Sulphur (MCP)	mg/kg	3.4
Zinc (DTPA)	mg/kg	0.14
Copper (DTPA)	mg/kg	0.56
Iron (DTPA)	mg/kg	6.7
Manganese (DTPA)	mg/kg	3.40
Boron (Hot CaCl ₂)	mg/kg	0.55
Electrical Conductivity	dS/m	0.16
Silicon (BSES)	mg/kg	1400
Organic Matter	%	1.9

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BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001861
Paddock Name: 02-12-2011
Sample Name: SITE 16
Sample Depth (cm): 0 To 10

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		5.50
pH (1:5 CaCl ₂)		4.50
Organic Carbon (OC)	%	1.20
Total Nitrogen	%	0.10
Phosphorus (Colwell)	mg/kg	8
Phosphorus (BSES)	mg/kg	14
Potassium (Nitric K)	meq/100g	2.00
Sulphate Sulphur (MCP)	mg/kg	5.6
Zinc (DTPA)	mg/kg	1.40
Copper (DTPA)	mg/kg	0.82
Iron (DTPA)	mg/kg	150.0
Manganese (DTPA)	mg/kg	35.00
Boron (Hot CaCl ₂)	mg/kg	0.28
Electrical Conductivity	dS/m	0.07
Silicon (BSES)	mg/kg	180
Organic Matter	%	2.1

The results reported pertain only to the sample submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

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Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

Email: lab.feedback@incitecpivot.com.au





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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001862
Paddock Name: 02-12-2011
Sample Name: SITE 16
Sample Depth (cm): 35 To 55

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		6.50
pH (1:5 CaCl ₂)		5.20
Aluminium Saturation	%	1.0
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	50
Chloride	mg/kg	240.0
Electrical Conductivity	dS/m	0.20
Cation Exchange Capacity	meq/100g	10.20
Aluminium (KCl)	mg/kg	<9.00
Aluminium (KCl)	meq/100g	0.10
Calcium (Amm-acet.)	meq/100g	3.000
Calcium (Amm-acet.)	%	29.000
Magnesium (Amm-acet.)	meq/100g	4.200
Magnesium (Amm-acet.)	%	41.000
Sodium (Amm-acet.)	meq/100g	2.800
Sodium % of Cations (ESP)	%	27.000
Potassium (Amm-acet.)	meq/100g	0.130
Potassium (Amm-acet.)	%	1.300
Calcium/Magnesium Ratio		0.7
Potassium to Magnesium Ratio		0.0
% Clay	%	24
% Sand (Fine)	%	52



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001862
Paddock Name: 02-12-2011
Sample Name: SITE 16
Sample Depth (cm): 35 To 55

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
% Sand (Coarse)	%	9
% Silt	%	15
Sansilclay Texture		Sandy Clay Loam

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD

Sample No: 030001863

Paddock Name: 02-12-2011

Sample Name: SITE 16

Sample Depth (cm): 65 To 100

Nearest Town: BRISBANE

Test Code: ADMINSOIL

Sample Type: Soil

Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		9.60
pH (1:5 CaCl ₂)		8.80
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	64
Chloride	mg/kg	470.0
Electrical Conductivity	dS/m	0.78
Cation Exchange Capacity	meq/100g	17.20
Calcium (Amm-acet.)	%	38.000
Calcium (Amm-acet.)	meq/100g	6.500
Magnesium (Amm-acet.)	%	23.000
Magnesium (Amm-acet.)	meq/100g	4.000
Sodium (Amm-acet.)	%	38.000
Sodium (Amm-acet.)	meq/100g	6.500
Potassium (Amm-acet.)	%	0.930
Potassium (Amm-acet.)	meq/100g	0.160
Calcium/Magnesium Ratio		1.6
Potassium to Magnesium Ratio		0.0
% Clay	%	20
% Sand (Fine)	%	66
% Sand (Coarse)	%	10
% Silt	%	4
Sand/clay Texture		Sandy Clay Loam



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001863
Paddock Name: 02-12-2011
Sample Name: SITE 16
Sample Depth (cm): 65 To 100

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

The results reported pertain only to the sample submitted.

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001864
Paddock Name: 02-12-2011
Sample Name: SITE 17
Sample Depth (cm): 0 To 10

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		6.10
pH (1:5 CaCl ₂)		5.10
Organic Carbon (OC)	%	0.64
Total Nitrogen	%	0.06
Phosphorus (Colwell)	mg/kg	8
Phosphorus (BSES)	mg/kg	12
Potassium (Nitric K)	meq/100g	1.50
Sulphate Sulphur (MCP)	mg/kg	3.2
Zinc (DTPA)	mg/kg	0.36
Copper (DTPA)	mg/kg	0.10
Iron (DTPA)	mg/kg	100.0
Manganese (DTPA)	mg/kg	6.20
Boron (Hot CaCl ₂)	mg/kg	0.36
Electrical Conductivity	dS/m	0.05
Silicon (BSES)	mg/kg	83
Organic Matter	%	1.1

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Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

Email: lab.feedback@incitecpivot.com.au





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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001865
Paddock Name: 02-12-2011
Sample Name: SITE 17
Sample Depth (cm): 30 To 45

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		8.00
pH (1:5 CaCl ₂)		6.90
Nitrate Nitrogen (NO ₃)	mg/kg	<1.0
Available Potassium	mg/kg	110
Chloride	mg/kg	350.0
Electrical Conductivity	dS/m	0.29
Cation Exchange Capacity	meq/100g	14.20
Calcium (Amm-acet.)	%	22.000
Calcium (Amm-acet.)	meq/100g	3.100
Magnesium (Amm-acet.)	%	50.000
Magnesium (Amm-acet.)	meq/100g	7.100
Sodium (Amm-acet.)	%	26.000
Sodium (Amm-acet.)	meq/100g	3.700
Potassium (Amm-acet.)	%	2.000
Potassium (Amm-acet.)	meq/100g	0.290
Calcium/Magnesium Ratio		0.4
Potassium to Magnesium Ratio		0.0
% Clay	%	36
% Sand (Fine)	%	57
% Sand (Coarse)	%	3
% Silt	%	4
Sansilclay Texture		Sandy Clay



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001865
Paddock Name: 02-12-2011
Sample Name: SITE 17
Sample Depth (cm): 30 To 45

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

The results reported pertain only to the sample submitted.

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Nutrient Report

GHD PTY LTD

201 Charlotte Street

BRISBANE

QLD 4000

Report Print Date: 31/01/2012

Agent/Dealer:

Advisor/Contact: David Doolan

Phone:

Purchase Order No: 4121894

Grower Name : GHD PTY LTD
Sample No: 030001866
Paddock Name: 02-12-2011
Sample Name: SITE 17
Sample Depth (cm): 45 To 65

Nearest Town: BRISBANE
Test Code: ADMINISOIL
Sample Type: Soil
Sampling Date:

Analyte / Assay	Units	Value
pH (1:5 Water)		9.30
pH (1:5 CaCl ₂)		8.50
Nitrate Nitrogen (NO ₃)	mg/kg	1.3
Available Potassium	mg/kg	71
Chloride	mg/kg	450.0
Electrical Conductivity	dS/m	0.50
Cation Exchange Capacity	meq/100g	17.30
Calcium (Amm-acet.)	%	32.000
Calcium (Amm-acet.)	meq/100g	5.500
Magnesium (Amm-acet.)	%	39.000
Magnesium (Amm-acet.)	meq/100g	6.800
Sodium (Amm-acet.)	%	28.000
Sodium (Amm-acet.)	meq/100g	4.800
Potassium (Amm-acet.)	%	1.000
Potassium (Amm-acet.)	meq/100g	0.180
Calcium/Magnesium Ratio		0.8
Potassium to Magnesium Ratio		0.0
% Clay	%	29
% Sand (Fine)	%	62
% Sand (Coarse)	%	5
% Silt	%	5
Sand/clay Texture		Sandy Clay Loam



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Nutrient Report

Grower Name : GHD PTY LTD
Sample No: 030001866
Paddock Name: 02-12-2011
Sample Name: SITE 17
Sample Depth (cm): 45 To 65

Nearest Town: BRISBANE
Test Code: ADMINSOIL
Sample Type: Soil
Sampling Date:

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001747 ADMINSOIL	030001748 ADMINSOIL	030001749 ADMINSOIL	030001750 ADMINSOIL	030001751 ADMINSOIL	030001752 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 3	SITE 3	SITE 3	SITE 4	SITE 4	SITE 5
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 10	10 - 20	25 - 35	0 - 10	10 - 25	0 - 25
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.30	8.20	8.70	7.20	7.50	7.60
pH (1:5 CaCl2)		6.50	7.60	7.90	6.80	6.60	6.90
Organic Carbon (OC)	%	1.10	0.53		1.60		1.10
Nitrate Nitrogen (NO3)	mg/kg			<1.0		<1.0	
Total Nitrogen	%	0.09	0.06		0.21		0.13
Phosphorus (Colwell)	mg/kg	26	9		71		21
Phosphorus (BSES)	mg/kg	100	230		130		29
Available Potassium	mg/kg			49		220	
Potassium (Nitric K)	meq/100g	5.00	1.40		13.00		5.30
Sulphate Sulphur (MCP)	mg/kg	2.6	1.6		7.5		5.6
Zinc (DTPA)	mg/kg	0.13	0.32		0.77		0.34
Copper (DTPA)	mg/kg	0.92	0.27		1.10		1.80
Iron (DTPA)	mg/kg	12.0	3.9		33.0		30.0
Manganese (DTPA)	mg/kg	18.00	1.80		35.00		11.00
Boron (Hot CaCl2)	mg/kg	0.50	0.31		0.76		1.10
Chloride	mg/kg			<10.0		<10.0	
Electrical Conductivity	dS/m	0.06	0.15	0.12	0.19	0.06	0.10
Cation Exchange Capacity	meq/100g			43.80		30.10	
Calcium (Amm-acet.)	%			96.000		90.000	
Calcium (Amm-acet.)	meq/100g			42.000		27.000	
Magnesium (Amm-acet.)	%			3.400		8.300	



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Summary Report

Sample No Test Code	030001747 ADMINSOIL	030001748 ADMINSOIL	030001749 ADMINSOIL	030001750 ADMINSOIL	030001751 ADMINSOIL	030001752 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 3	SITE 3	SITE 3	SITE 4	SITE 4	SITE 5
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 10	10 - 20	25 - 35	0 - 10	10 - 25	0 - 25
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g			1.500		2.500	
Sodium (Amm-acet.)	%			0.300		0.260	
Sodium (Amm-acet.)	meq/100g			0.130		0.078	
Potassium (Amm-acet.)	%			0.300		1.900	
Potassium (Amm-acet.)	meq/100g			0.130		0.570	
Calcium/Magnesium Ratio				28.0		11.0	
Potassium to Magnesium Ratio				0.1		0.2	
Silicon (BSES)	mg/kg	1200	690		1000		1400
% Clay	%			25		39	
% Sand (Fine)	%			37		34	
% Sand (Coarse)	%			11		11	
% Silt	%			26		16	
Sansilclay Texture				Sandy Clay Loam		Clay Loam	
Organic Matter	%	1.9	0.9		2.8		1.9

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by Nutrient Advantage Advice as being equivalent to the level of reporting for both calculation and interpretive purposes

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001753 ADMINSOIL	030001754 ADMINSOIL	030001755 ADMINSOIL	030001756 ADMINSOIL	030001757 ADMINSOIL	030001758 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 5	SITE 5	SITE 5	SITE 6	SITE 6	SITE 6
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	55 - 65	65 - 95	0 - 10	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.70	8.70	8.70	7.60	8.40	8.60
pH (1:5 CaCl2)		7.90	7.90	7.90	7.00	7.70	7.90
Organic Carbon (OC)	%				2.80		
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0	<1.0		<1.0	2.9
Total Nitrogen	%				0.29		
Phosphorus (Colwell)	mg/kg				21		
Phosphorus (BSES)	mg/kg				120		
Available Potassium	mg/kg	220	230	220		310	260
Potassium (Nitric K)	meq/100g				7.30		
Sulphate Sulphur (MCP)	mg/kg				8.3		
Zinc (DTPA)	mg/kg				0.90		
Copper (DTPA)	mg/kg				1.60		
Iron (DTPA)	mg/kg				23.0		
Manganese (DTPA)	mg/kg				14.00		
Boron (Hot CaCl2)	mg/kg				1.30		
Chloride	mg/kg	<10.0	<10.0	<10.0		<10.0	24.0
Electrical Conductivity	dS/m	0.18	0.21	0.22	0.19	0.19	0.24
Cation Exchange Capacity	meq/100g	48.40	47.00	43.40		69.50	61.70
Calcium (Amm-acet.)	%	81.000	79.000	76.000		86.000	81.000
Calcium (Amm-acet.)	meq/100g	39.000	37.000	33.000		60.000	50.000
Magnesium (Amm-acet.)	%	16.000	17.000	18.000		12.000	16.000

Nutrient Advantage Advice®

Summary Report

Sample No Test Code	030001753 ADMINSOIL	030001754 ADMINSOIL	030001755 ADMINSOIL	030001756 ADMINSOIL	030001757 ADMINSOIL	030001758 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 5	SITE 5	SITE 5	SITE 6	SITE 6	SITE 6
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	55 - 65	65 - 95	0 - 10	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	7.600	7.800	7.900		8.200	9.900
Sodium (Amm-acet.)	%	2.500	3.400	4.400		0.750	1.800
Sodium (Amm-acet.)	meq/100g	1.200	1.600	1.900		0.520	1.100
Potassium (Amm-acet.)	%	1.200	1.300	1.300		1.200	1.100
Potassium (Amm-acet.)	meq/100g	0.570	0.590	0.560		0.800	0.660
Calcium/Magnesium Ratio		5.1	4.7	4.2		7.3	5.1
Potassium to Magnesium Ratio		0.1	0.1	0.1		0.1	0.1
Silicon (BSES)	mg/kg				1600		
% Clay	%	54	54	49		60	59
% Sand (Fine)	%	25	28	28		27	26
% Sand (Coarse)	%	6	4	5		3	4
% Silt	%	15	14	18		10	11
Sansilclay Texture		Clay	Clay	Clay		Clay	Clay
Organic Matter	%				4.8		

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by Nutrient Advantage Advice as being equivalent to the level of reporting for both calculation and interpretive purposes

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001759 ADMINSOIL	030001760 ADMINSOIL	030001761 ADMINSOIL	030001762 ADMINSOIL	030001763 ADMINSOIL	030001764 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 6	SITE 7	SITE 7	SITE 7	SITE 8	SITE 8
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 85	0 - 10	10 - 25	35 - 55	10 - 25	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.70	7.80	8.40	9.00	7.80	8.10
pH (1:5 CaCl2)		8.00	7.10	7.40	8.20	7.10	7.00
Organic Carbon (OC)	%		1.40			1.10	
Nitrate Nitrogen (NO3)	mg/kg	<1.0		<1.0	<1.0		3.3
Total Nitrogen	%		0.13			0.11	
Phosphorus (Colwell)	mg/kg		6			18	
Phosphorus (BSES)	mg/kg		19			35	
Available Potassium	mg/kg	220		220	190		150
Potassium (Nitric K)	meq/100g		5.20			2.90	
Sulphate Sulphur (MCP)	mg/kg		3.6			7.0	
Zinc (DTPA)	mg/kg		0.82			1.90	
Copper (DTPA)	mg/kg		1.80			1.30	
Iron (DTPA)	mg/kg		25.0			43.0	
Manganese (DTPA)	mg/kg		12.00			12.00	
Boron (Hot CaCl2)	mg/kg		0.68			0.65	
Chloride	mg/kg	<10.0		<10.0	22.0		62.0
Electrical Conductivity	dS/m	0.24	0.13	0.13	0.25	0.10	0.14
Cation Exchange Capacity	meq/100g	57.90		33.90	41.30		25.40
Calcium (Amm-acet.)	%	78.000		59.000	61.000		67.000
Calcium (Amm-acet.)	meq/100g	45.000		20.000	25.000		17.000
Magnesium (Amm-acet.)	%	19.000		35.000	31.000		25.000



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

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Sample No Test Code	030001759 ADMINSOIL	030001760 ADMINSOIL	030001761 ADMINSOIL	030001762 ADMINSOIL	030001763 ADMINSOIL	030001764 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011	30-11-2011
Sample Name	SITE 6	SITE 7	SITE 7	SITE 7	SITE 8	SITE 8
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 85	0 - 10	10 - 25	35 - 55	10 - 25	35 - 55
Sampling Date						

Analyte / Assay		Unit	Value				
Magnesium (Amm-acet.)	meq/100g	11.000		12.000	13.000		6.300
Sodium (Amm-acet.)	%	2.200		3.800	6.800		6.700
Sodium (Amm-acet.)	meq/100g	1.300		1.300	2.800		1.700
Potassium (Amm-acet.)	%	0.980		1.700	1.200		1.500
Potassium (Amm-acet.)	meq/100g	0.570		0.570	0.480		0.380
Calcium/Magnesium Ratio		4.1		1.7	1.9		2.7
Potassium to Magnesium Ratio		0.1		0.0	0.0		0.1
Silicon (BSES)	mg/kg		1400			650	
% Clay	%	60		49	48		44
% Sand (Fine)	%	24		31	29		35
% Sand (Coarse)	%	4		6	9		1
% Silt	%	13		15	14		20
Sansilclay Texture		Clay		Clay	Clay		Clay
Organic Matter	%		2.4			1.9	

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001765 ADMINSOIL	030001766 ADMINSOIL	030001767 ADMINSOIL	030001768 ADMINSOIL	030001769 ADMINSOIL	030001770 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	30-11-2011	30-11-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 8	SITE 8	SITE 9	SITE 9	SITE 9	SITE 10
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 85	85 - 130	0 - 25	25 - 35	35 - 55	0 - 22
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.20	8.00	6.40	7.70	8.60	6.60
pH (1:5 CaCl2)		7.70	7.60	5.10	6.30	7.60	5.70
Organic Carbon (OC)	%			0.43			0.96
Nitrate Nitrogen (NO3)	mg/kg	<1.0	1.8		<1.0	<1.0	
Total Nitrogen	%			<0.04			0.07
Phosphorus (Colwell)	mg/kg			6			<5
Phosphorus (BSES)	mg/kg			10			9
Available Potassium	mg/kg	130	130		80	65	
Potassium (Nitric K)	meq/100g			1.50			2.00
Sulphate Sulphur (MCP)	mg/kg			2.6			4.7
Zinc (DTPA)	mg/kg			2.90			0.27
Copper (DTPA)	mg/kg			0.29			0.41
Iron (DTPA)	mg/kg			44.0			39.0
Manganese (DTPA)	mg/kg			14.00			15.00
Boron (Hot CaCl2)	mg/kg			0.23			0.40
Chloride	mg/kg	390.0	380.0		39.0	53.0	
Electrical Conductivity	dS/m	0.84	1.15	0.03	0.09	0.21	0.05
Cation Exchange Capacity	meq/100g	30.20	25.70		13.10	12.70	
Calcium (Amm-acet.)	%	56.000	58.000		34.000	39.000	
Calcium (Amm-acet.)	meq/100g	17.000	15.000		4.500	4.900	
Magnesium (Amm-acet.)	%	27.000	25.000		49.000	45.000	



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Sample No Test Code	030001765 ADMINSOIL	030001766 ADMINSOIL	030001767 ADMINSOIL	030001768 ADMINSOIL	030001769 ADMINSOIL	030001770 ADMINSOIL
Lab Results Received Date Paddock Name	09/01/2012 30-11-2011	09/01/2012 30-11-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011
Sample Name	SITE 8	SITE 8	SITE 9	SITE 9	SITE 9	SITE 10
Sample Type Sample Depth (cm) Sampling Date	Soil 65 - 85	Soil 85 - 130	Soil 0 - 25	Soil 25 - 35	Soil 35 - 55	Soil 0 - 22

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	8.100	6.300		6.400	5.700	
Sodium (Amm-acet.)	%	16.000	16.000		15.000	15.000	
Sodium (Amm-acet.)	meq/100g	4.800	4.100		2.000	1.900	
Potassium (Amm-acet.)	%	1.100	1.300		1.500	1.300	
Potassium (Amm-acet.)	meq/100g	0.320	0.330		0.200	0.170	
Calcium/Magnesium Ratio		2.1	2.4		0.7	0.9	
Potassium to Magnesium Ratio		0.0	0.1		0.0	0.0	
Silicon (BSES)	mg/kg			86			200
% Clay	%	49	39		39	31	
% Sand (Fine)	%	34	56		48	51	
% Sand (Coarse)	%	1	4		11	13	
% Silt	%	16	1		3	5	
Sansilclay Texture		Clay	Sandy Clay		Sandy Clay	Sandy Clay Loam	
Organic Matter	%			0.7			1.7

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001777 ADMINSOIL	030001778 ADMINSOIL	030001779 ADMINSOIL	030001780 ADMINSOIL	030001781 ADMINSOIL	030001782 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 12	SITE 12	SITE 13	SITE 13	SITE 13	SITE 14
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	55 - 65	0 - 13	25 - 35	55 - 65	0 - 12
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.00	8.60	6.60	5.70	5.70	5.60
pH (1:5 CaCl2)		6.80	7.50	5.70	4.80	5.00	4.70
Aluminium Saturation	%				1.7	2.5	
Organic Carbon (OC)	%			0.29			1.30
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0		<1.0	1.0	
Total Nitrogen	%			<0.04			0.10
Phosphorus (Colwell)	mg/kg			<5			15
Phosphorus (BSES)	mg/kg			9			14
Available Potassium	mg/kg	90	58		41	21	
Potassium (Nitric K)	meq/100g			1.70			1.90
Sulphate Sulphur (MCP)	mg/kg			2.2			11.0
Zinc (DTPA)	mg/kg			0.24			1.30
Copper (DTPA)	mg/kg			0.21			0.32
Iron (DTPA)	mg/kg			13.0			210.0
Manganese (DTPA)	mg/kg			4.70			12.00
Boron (Hot CaCl2)	mg/kg			0.14			0.25
Chloride	mg/kg	27.0	210.0		490.0	640.0	
Electrical Conductivity	dS/m	0.10	0.23	0.03	0.30	0.47	0.15
Cation Exchange Capacity	meq/100g	14.80	12.20				
Cation Exchange Capacity	meq/100g				5.91	4.00	
Aluminium (KCl)	mg/kg				<9.00	<9.00	



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Summary Report

Sample No Test Code	030001777 ADMINSOIL	030001778 ADMINSOIL	030001779 ADMINSOIL	030001780 ADMINSOIL	030001781 ADMINSOIL	030001782 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 12	SITE 12	SITE 13	SITE 13	SITE 13	SITE 14
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	55 - 65	0 - 13	25 - 35	55 - 65	0 - 12
Sampling Date						

Analyte / Assay		Unit	Value				
Aluminium (KCl)	meq/100g				0.10	0.10	
Calcium (Amm-acet.)	%	41.000	23.000				
Calcium (Amm-acet.)	meq/100g	6.000	2.800		2.200	0.650	
Calcium (Amm-acet.)	%				37.000	16.000	
Magnesium (Amm-acet.)	%	49.000	52.000				
Magnesium (Amm-acet.)	meq/100g	7.200	6.300		2.000	1.100	
Magnesium (Amm-acet.)	%				34.000	28.000	
Sodium (Amm-acet.)	%	9.500	25.000				
Sodium (Amm-acet.)	meq/100g	1.400	3.000		1.500	2.100	
Sodium % of Cations (ESP)	%				25.000	53.000	
Potassium (Amm-acet.)	%	1.600	1.200				
Potassium (Amm-acet.)	meq/100g	0.230	0.150		0.110	0.053	
Potassium (Amm-acet.)	%				1.900	1.300	
Calcium/Magnesium Ratio		0.8	0.4		1.1	0.6	
Potassium to Magnesium Ratio		0.0	0.0		0.1	0.0	
Silicon (BSES)	mg/kg			96			140
% Clay	%	40	21		10	6	
% Sand (Fine)	%	47	64		62	69	
% Sand (Coarse)	%	2	5		15	23	
% Silt	%	11	10		14	3	
Sansilclay Texture		Sandy Clay	Sandy Clay Loam		Sandy Loam	Sand	
Organic Matter	%			0.5			2.2

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001771 ADMINSOIL	030001772 ADMINSOIL	030001773 ADMINSOIL	030001774 ADMINSOIL	030001775 ADMINSOIL	030001776 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 10	SITE 10	SITE 11	SITE 11	SITE 11	SITE 12
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 85	0 - 20	55 - 65	65 - 85	0 - 13
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.00	9.20	5.90	9.00	9.50	7.00
pH (1:5 CaCl2)		7.30	8.30	4.50	8.00	8.70	6.30
Organic Carbon (OC)	%			0.46			1.40
Nitrate Nitrogen (NO3)	mg/kg	1.2	1.3		<1.0	1.0	
Total Nitrogen	%			<0.04			0.14
Phosphorus (Colwell)	mg/kg			6			5
Phosphorus (BSES)	mg/kg			7			13
Available Potassium	mg/kg	79	65		72	60	
Potassium (Nitric K)	meq/100g			1.80			2.60
Sulphate Sulphur (MCP)	mg/kg			3.4			3.5
Zinc (DTPA)	mg/kg			1.30			1.40
Copper (DTPA)	mg/kg			0.17			0.33
Iron (DTPA)	mg/kg			62.0			46.0
Manganese (DTPA)	mg/kg			6.40			16.00
Boron (Hot CaCl2)	mg/kg			0.20			0.62
Chloride	mg/kg	1000.0	370.0		180.0	330.0	
Electrical Conductivity	dS/m	0.85	0.59	0.03	0.24	0.37	0.08
Cation Exchange Capacity	meq/100g	19.20	14.60		13.10	13.80	
Calcium (Amm-acet.)	%	24.000	29.000		37.000	43.000	
Calcium (Amm-acet.)	meq/100g	4.700	4.300		4.900	6.000	
Magnesium (Amm-acet.)	%	36.000	30.000		43.000	36.000	



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Summary Report

Sample No Test Code	030001771 ADMINSOIL	030001772 ADMINSOIL	030001773 ADMINSOIL	030001774 ADMINSOIL	030001775 ADMINSOIL	030001776 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 10	SITE 10	SITE 11	SITE 11	SITE 11	SITE 12
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 85	0 - 20	55 - 65	65 - 85	0 - 13
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	6.900	4.400		5.600	5.000	
Sodium (Amm-acet.)	%	39.000	39.000		18.000	20.000	
Sodium (Amm-acet.)	meq/100g	7.400	5.700		2.400	2.700	
Potassium (Amm-acet.)	%	1.000	1.200		1.400	1.100	
Potassium (Amm-acet.)	meq/100g	0.200	0.170		0.180	0.150	
Calcium/Magnesium Ratio		0.7	1.0		0.9	1.2	
Potassium to Magnesium Ratio		0.0	0.0		0.0	0.0	
Silicon (BSES)	mg/kg			67			250
% Clay	%	49	26		34	24	
% Sand (Fine)	%	37	58		52	56	
% Sand (Coarse)	%	5	7		4	7	
% Silt	%	9	9		10	14	
Sansilclay Texture		Clay	Sandy Clay Loam		Sandy Clay Loam	Sandy Clay Loam	
Organic Matter	%			0.8			2.4

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

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Summary Report

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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001783 ADMINSOIL	030001784 ADMINSOIL	030001785 ADMINSOIL	030001786 ADMINSOIL	030001787 ADMINSOIL	030001788 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 14	SITE 14	SITE 15	SITE 15	SITE 21	SITE 21
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	55 - 90	0 - 15	35 - 55	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.10	8.40	7.80	9.10	7.70	8.70
pH (1:5 CaCl2)		6.30	7.60	7.00	8.20	6.70	7.90
Organic Carbon (OC)	%			1.20			
Nitrate Nitrogen (NO3)	mg/kg	<1.0	1.1		<1.0	<1.0	<1.0
Total Nitrogen	%			0.09			
Phosphorus (Colwell)	mg/kg			11			
Phosphorus (BSES)	mg/kg			13			
Available Potassium	mg/kg	95	77		130	210	150
Potassium (Nitric K)	meq/100g			4.40			
Sulphate Sulphur (MCP)	mg/kg			5.7			
Zinc (DTPA)	mg/kg			0.44			
Copper (DTPA)	mg/kg			1.10			
Iron (DTPA)	mg/kg			26.0			
Manganese (DTPA)	mg/kg			9.60			
Boron (Hot CaCl2)	mg/kg			0.81			
Chloride	mg/kg	700.0	710.0		230.0	<10.0	<10.0
Electrical Conductivity	dS/m	0.66	0.85	0.15	0.47	0.05	0.15
Cation Exchange Capacity	meq/100g	16.30	15.50		38.40	33.80	44.50
Calcium (Amm-acet.)	%	25.000	18.000		60.000	83.000	88.000
Calcium (Amm-acet.)	meq/100g	4.000	2.800		23.000	28.000	39.000
Magnesium (Amm-acet.)	%	37.000	33.000		26.000	14.000	10.000



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Nutrient Advantage Advice®

Summary Report

Sample No Test Code	030001783 ADMINSOIL	030001784 ADMINSOIL	030001785 ADMINSOIL	030001786 ADMINSOIL	030001787 ADMINSOIL	030001788 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 14	SITE 14	SITE 15	SITE 15	SITE 21	SITE 21
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	55 - 90	0 - 15	35 - 55	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	6.000	5.100		9.900	4.900	4.500
Sodium (Amm-acet.)	%	37.000	48.000		14.000	1.000	1.400
Sodium (Amm-acet.)	meq/100g	6.100	7.400		5.200	0.340	0.610
Potassium (Amm-acet.)	%	1.500	1.300		0.890	1.600	0.830
Potassium (Amm-acet.)	meq/100g	0.240	0.200		0.340	0.530	0.370
Calcium/Magnesium Ratio		0.7	0.6		2.3	5.7	8.7
Potassium to Magnesium Ratio		0.0	0.0		0.0	0.1	0.1
Silicon (BSES)	mg/kg			1500			
% Clay	%	45	40		49	46	41
% Sand (Fine)	%	41	47		32	33	45
% Sand (Coarse)	%	6	6		10	8	11
% Silt	%	8	8		9	13	3
Sansilclay Texture		Sandy Clay	Sandy Clay		Clay	Clay	Sandy Clay
Organic Matter	%			2.1			

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by Nutrient Advantage Advice as being equivalent to the level of reporting for both calculation and interpretive purposes

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001789 ADMINSOIL	030001790 ADMINSOIL	030001791 ADMINSOIL	030001792 ADMINSOIL	030001793 ADMINSOIL	030001794 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 21	SITE 22	SITE 22	SITE 22	SITE 23	SITE 23
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 15	0 - 15	35 - 55	65 - 100	0 - 10	25 - 35
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.50	7.80	8.90	8.80	7.40	8.50
pH (1:5 CaCl2)		6.80	7.20	8.00	8.20	6.70	7.80
Organic Carbon (OC)	%	1.80	2.30			1.60	
Nitrate Nitrogen (NO3)	mg/kg			<1.0	<1.0		<1.0
Total Nitrogen	%	0.16	0.22			0.13	
Phosphorus (Colwell)	mg/kg	<5	27			8	
Phosphorus (BSES)	mg/kg	45	130			13	
Available Potassium	mg/kg			190	200		170
Potassium (Nitric K)	meq/100g	4.80	4.50			3.50	
Sulphate Sulphur (MCP)	mg/kg	4.5	11.0			5.4	
Zinc (DTPA)	mg/kg	0.46	0.69			0.55	
Copper (DTPA)	mg/kg	0.99	1.70			0.87	
Iron (DTPA)	mg/kg	23.0	23.0			22.0	
Manganese (DTPA)	mg/kg	18.00	8.30			17.00	
Boron (Hot CaCl2)	mg/kg	0.58	1.10			0.73	
Chloride	mg/kg			<10.0	820.0		<10.0
Electrical Conductivity	dS/m	0.10	0.20	0.19	0.80	0.08	0.15
Cation Exchange Capacity	meq/100g			69.30	69.50		37.20
Calcium (Amm-acet.)	%			79.000	68.000		83.000
Calcium (Amm-acet.)	meq/100g			55.000	47.000		31.000
Magnesium (Amm-acet.)	%			17.000	22.000		14.000



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

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Summary Report

Sample No Test Code	030001789 ADMINSOIL	030001790 ADMINSOIL	030001791 ADMINSOIL	030001792 ADMINSOIL	030001793 ADMINSOIL	030001794 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 21	SITE 22	SITE 22	SITE 22	SITE 23	SITE 23
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 15	0 - 15	35 - 55	65 - 100	0 - 10	25 - 35
Sampling Date						

Analyte / Assay		Unit	Value				
Magnesium (Amm-acet.)	meq/100g			12.000	15.000		5.300
Sodium (Amm-acet.)	%			2.600	10.000		1.400
Sodium (Amm-acet.)	meq/100g			1.800	7.000		0.520
Potassium (Amm-acet.)	%			0.690	0.720		1.100
Potassium (Amm-acet.)	meq/100g			0.480	0.500		0.420
Calcium/Magnesium Ratio				4.6	3.1		5.8
Potassium to Magnesium Ratio				0.0	0.0		0.1
Silicon (BSES)	mg/kg	900	1500			760	
% Clay	%			64	65		49
% Sand (Fine)	%			28	22		33
% Sand (Coarse)	%			1	1		11
% Silt	%			8	11		8
Sansilclay Texture				Clay	Clay		Clay
Organic Matter	%	3.1	4.0			2.8	

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001795 ADMINSOIL	030001796 ADMINSOIL	030001797 ADMINSOIL	030001798 ADMINSOIL	030001799 ADMINSOIL	030001800 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 23	SITE 24	SITE 24	SITE 24	SITE 25	SITE 25
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	55 - 65	0 - 10	25 - 35	55 - 65	0 - 15	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.80	8.40	8.90	9.20	6.50	8.00
pH (1:5 CaCl2)		8.00	7.80	8.00	8.20	5.50	6.70
Organic Carbon (OC)	%		1.60			0.92	
Nitrate Nitrogen (NO3)	mg/kg	<1.0		<1.0	<1.0		<1.0
Total Nitrogen	%		0.15			0.06	
Phosphorus (Colwell)	mg/kg		42			40	
Phosphorus (BSES)	mg/kg		150			67	
Available Potassium	mg/kg	150		150	120		150
Potassium (Nitric K)	meq/100g		2.70			5.30	
Sulphate Sulphur (MCP)	mg/kg		5.0			2.1	
Zinc (DTPA)	mg/kg		0.41			0.88	
Copper (DTPA)	mg/kg		1.10			0.61	
Iron (DTPA)	mg/kg		14.2			93.0	
Manganese (DTPA)	mg/kg		5.50			34.00	
Boron (Hot CaCl2)	mg/kg		0.97			0.29	
Chloride	mg/kg	11.0		<10.0	20.0		<10.0
Electrical Conductivity	dS/m	0.16	0.17	0.19	0.26	0.04	0.04
Cation Exchange Capacity	meq/100g	41.30		68.30	67.70		12.80
Calcium (Amm-acet.)	%	82.000		81.000	74.000		55.000
Calcium (Amm-acet.)	meq/100g	34.000		55.000	50.000		7.000
Magnesium (Amm-acet.)	%	15.000		16.000	19.000		38.000



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Nutrient Advantage Advice®

Summary Report

Sample No Test Code	030001795 ADMINSOIL	030001796 ADMINSOIL	030001797 ADMINSOIL	030001798 ADMINSOIL	030001799 ADMINSOIL	030001800 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 23	SITE 24	SITE 24	SITE 24	SITE 25	SITE 25
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	55 - 65	0 - 10	25 - 35	55 - 65	0 - 15	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	6.000		11.000	13.000		4.900
Sodium (Amm-acet.)	%	2.200		2.800	6.500		3.800
Sodium (Amm-acet.)	meq/100g	0.910		1.900	4.400		0.480
Potassium (Amm-acet.)	%	0.900		0.590	0.470		3.100
Potassium (Amm-acet.)	meq/100g	0.370		0.400	0.320		0.400
Calcium/Magnesium Ratio		5.7		5.0	3.8		1.4
Potassium to Magnesium Ratio		0.1		0.0	0.0		0.1
Silicon (BSES)	mg/kg		1300			270	
% Clay	%	48		58	56		31
% Sand (Fine)	%	31		28	27		38
% Sand (Coarse)	%	13		4	5		21
% Silt	%	9		10	13		10
Sansilclay Texture		Clay		Clay	Clay		Sandy Clay Loam
Organic Matter	%		2.8			1.6	

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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GHD PTY LTD
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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001801 ADMINSOIL	030001802 ADMINSOIL	030001803 ADMINSOIL	030001804 ADMINSOIL	030001805 ADMINSOIL	030001806 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 25	SITE 25	SITE 26	SITE 26	SITE 26	SITE 27
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 80	80 - 120	0 - 10	35 - 55	65 - 130	0 - 12
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.80	9.00	8.30	8.80	9.10	7.10
pH (1:5 CaCl2)		7.60	7.90	7.70	8.10	8.30	6.50
Organic Carbon (OC)	%			1.40			1.60
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0		2.1	<1.0	
Total Nitrogen	%			0.13			0.13
Phosphorus (Colwell)	mg/kg			52			44
Phosphorus (BSES)	mg/kg			240			59
Available Potassium	mg/kg	150	120		240	180	
Potassium (Nitric K)	meq/100g			6.50			15.00
Sulphate Sulphur (MCP)	mg/kg			7.7			3.9
Zinc (DTPA)	mg/kg			0.57			0.71
Copper (DTPA)	mg/kg			1.20			1.10
Iron (DTPA)	mg/kg			11.0			36.0
Manganese (DTPA)	mg/kg			4.50			40.00
Boron (Hot CaCl2)	mg/kg			1.10			0.45
Chloride	mg/kg	<10.0	14.0		<10.0	54.0	
Electrical Conductivity	dS/m	0.07	0.08	0.22	0.33	0.48	0.10
Cation Exchange Capacity	meq/100g	13.20	11.90		54.40	52.20	
Calcium (Amm-acet.)	%	53.000	55.000		72.000	65.000	
Calcium (Amm-acet.)	meq/100g	7.000	6.500		39.000	34.000	
Magnesium (Amm-acet.)	%	39.000	37.000		22.000	23.000	



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Summary Report

Sample No Test Code	030001801 ADMINSOIL	030001802 ADMINSOIL	030001803 ADMINSOIL	030001804 ADMINSOIL	030001805 ADMINSOIL	030001806 ADMINSOIL
Lab Results Received Date Paddock Name	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011
Sample Name	SITE 25	SITE 25	SITE 26	SITE 26	SITE 26	SITE 27
Sample Type Sample Depth (cm) Sampling Date	Soil 65 - 80	Soil 80 - 120	Soil 0 - 10	Soil 35 - 55	Soil 65 - 130	Soil 0 - 12

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	5.100	4.400		12.000	12.000	
Sodium (Amm-acet.)	%	5.300	5.500		5.100	11.000	
Sodium (Amm-acet.)	meq/100g	0.700	0.650		2.800	5.700	
Potassium (Amm-acet.)	%	2.900	2.600		1.100	0.900	
Potassium (Amm-acet.)	meq/100g	0.380	0.310		0.610	0.470	
Calcium/Magnesium Ratio		1.4	1.5		3.3	2.8	
Potassium to Magnesium Ratio		0.1	0.1		0.1	0.0	
Silicon (BSES)	mg/kg			1400			930
% Clay	%	29	21		58	58	
% Sand (Fine)	%	42	52		25	25	
% Sand (Coarse)	%	21	18		1	1	
% Silt	%	9	9		16	16	
Sansilclay Texture		Sandy Clay Loam	Sandy Clay Loam		Clay	Clay	
Organic Matter	%			2.4			2.8

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001807 ADMINSOIL	030001808 ADMINSOIL	030001809 ADMINSOIL	030001810 ADMINSOIL	030001811 ADMINSOIL	030001812 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 27	SITE 27	SITE 28	SITE 28	SITE 28	SITE 29
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	55 - 65	0 - 15	25 - 35	55 - 65	25 - 35
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.30	7.60	6.80	7.10	7.60	8.40
pH (1:5 CaCl2)		6.30	6.40	6.00	6.00	6.30	7.80
Organic Carbon (OC)	%			1.40			
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0		<1.0	<1.0	<1.0
Total Nitrogen	%			0.12			
Phosphorus (Colwell)	mg/kg			21			
Phosphorus (BSES)	mg/kg			35			
Available Potassium	mg/kg	190	130		170	88	320
Potassium (Nitric K)	meq/100g			13.00			
Sulphate Sulphur (MCP)	mg/kg			2.7			
Zinc (DTPA)	mg/kg			0.66			
Copper (DTPA)	mg/kg			0.86			
Iron (DTPA)	mg/kg			30.0			
Manganese (DTPA)	mg/kg			60.00			
Boron (Hot CaCl2)	mg/kg			0.48			
Chloride	mg/kg	<10.0	<10.0		<10.0	<10.0	<10.0
Electrical Conductivity	dS/m	0.05	0.04	0.05	0.03	0.03	0.15
Cation Exchange Capacity	meq/100g	31.60	34.80		32.80	39.20	50.40
Calcium (Amm-acet.)	%	66.000	72.000		76.000	82.000	91.000
Calcium (Amm-acet.)	meq/100g	21.000	25.000		25.000	32.000	46.000
Magnesium (Amm-acet.)	%	31.000	26.000		22.000	17.000	6.900



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Sample No Test Code	030001807 ADMINSOIL	030001808 ADMINSOIL	030001809 ADMINSOIL	030001810 ADMINSOIL	030001811 ADMINSOIL	030001812 ADMINSOIL
Lab Results Received Date Paddock Name	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011
Sample Name	SITE 27	SITE 27	SITE 28	SITE 28	SITE 28	SITE 29
Sample Type Sample Depth (cm) Sampling Date	Soil 25 - 35	Soil 55 - 65	Soil 0 - 15	Soil 25 - 35	Soil 55 - 65	Soil 25 - 35

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	9.900	9.100		7.300	6.700	3.500
Sodium (Amm-acet.)	%	0.700	1.100		0.290	0.590	0.190
Sodium (Amm-acet.)	meq/100g	0.220	0.370		0.096	0.230	0.096
Potassium (Amm-acet.)	%	1.500	0.920		1.300	0.560	1.600
Potassium (Amm-acet.)	meq/100g	0.480	0.320		0.440	0.220	0.820
Calcium/Magnesium Ratio		2.1	2.7		3.4	4.8	13.0
Potassium to Magnesium Ratio		0.0	0.0		0.1	0.0	0.2
Silicon (BSES)	mg/kg			890			
% Clay	%	46	26		34	18	50
% Sand (Fine)	%	31	44		38	35	26
% Sand (Coarse)	%	7	15		11	35	5
% Silt	%	16	15		18	13	19
Sansilclay Texture		Clay	Sandy Clay Loam		Sandy Clay Loam	Sandy Loam	Clay
Organic Matter	%			2.4			

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001813 ADMINSOIL	030001814 ADMINSOIL	030001815 ADMINSOIL	030001816 ADMINSOIL	030001817 ADMINSOIL	030001818 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 29	SITE 30	SITE 30	SITE 31	SITE 31	SITE 31
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	55 - 65	35 - 55	65 - 140	0 - 10	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.90	9.00	8.80	8.10	8.40	8.70
pH (1:5 CaCl2)		8.00	8.00	8.30	7.50	7.70	7.90
Organic Carbon (OC)	%				2.20		
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0	<1.0		<1.0	<1.0
Total Nitrogen	%				0.20		
Phosphorus (Colwell)	mg/kg				36		
Phosphorus (BSES)	mg/kg				350		
Available Potassium	mg/kg	150	190	180		220	59
Potassium (Nitric K)	meq/100g				10.00		
Sulphate Sulphur (MCP)	mg/kg				4.6		
Zinc (DTPA)	mg/kg				0.89		
Copper (DTPA)	mg/kg				0.76		
Iron (DTPA)	mg/kg				21.0		
Manganese (DTPA)	mg/kg				12.00		
Boron (Hot CaCl2)	mg/kg				0.72		
Chloride	mg/kg	<10.0	41.0	1300.0		<10.0	<10.0
Electrical Conductivity	dS/m	0.12	0.23	1.07	0.15	0.14	0.11
Cation Exchange Capacity	meq/100g	42.30	46.40	50.20		45.60	46.10
Calcium (Amm-acet.)	%	90.000	78.000	60.000		94.000	95.000
Calcium (Amm-acet.)	meq/100g	38.000	36.000	30.000		43.000	44.000
Magnesium (Amm-acet.)	%	8.700	16.000	22.000		4.400	4.100



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Sample No Test Code	030001813 ADMINSOIL	030001814 ADMINSOIL	030001815 ADMINSOIL	030001816 ADMINSOIL	030001817 ADMINSOIL	030001818 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 29	SITE 30	SITE 30	SITE 31	SITE 31	SITE 31
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	55 - 65	35 - 55	65 - 140	0 - 10	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	3.700	7.200	11.000		2.000	1.900
Sodium (Amm-acet.)	%	0.470	5.800	17.000		0.110	0.190
Sodium (Amm-acet.)	meq/100g	0.200	2.700	8.700		0.052	0.087
Potassium (Amm-acet.)	%	0.870	1.000	0.900		1.200	0.330
Potassium (Amm-acet.)	meq/100g	0.370	0.480	0.450		0.560	0.150
Calcium/Magnesium Ratio		10.0	5.0	2.7		22.0	23.0
Potassium to Magnesium Ratio		0.1	0.1	0.0		0.3	0.1
Silicon (BSES)	mg/kg				1200		
% Clay	%	44	45	46		45	21
% Sand (Fine)	%	31	30	31		30	44
% Sand (Coarse)	%	6	13	9		12	19
% Silt	%	20	13	14		13	16
Sansilclay Texture		Clay	Clay	Clay		Clay	Sandy Clay Loam
Organic Matter	%				3.8		

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001825 ADMINSOIL	030001826 ADMINSOIL	030001827 ADMINSOIL	030001828 ADMINSOIL	030001829 ADMINSOIL	030001830 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	11/01/2012	11/01/2012	09/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 34	SITE 35	SITE 35	SITE 35	SITE 35	SITE 36
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 120	0 - 10	25 - 35	55 - 65	65 - 90	0 - 25
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.90	6.10	6.60	6.80	6.80	6.80
pH (1:5 CaCl2)		8.20	5.10	5.50	5.90	5.90	5.80
Organic Carbon (OC)	%		0.83				0.50
Nitrate Nitrogen (NO3)	mg/kg	<1.0		<1.0	<1.0	<1.0	
Total Nitrogen	%		0.05				<0.04
Phosphorus (Colwell)	mg/kg		12				9
Phosphorus (BSES)	mg/kg		20				25
Available Potassium	mg/kg	120		91	78	72	
Potassium (Nitric K)	meq/100g		2.20				1.80
Sulphate Sulphur (MCP)	mg/kg		3.8				<1.0
Zinc (DTPA)	mg/kg		0.47				0.17
Copper (DTPA)	mg/kg		0.46				0.15
Iron (DTPA)	mg/kg		26.0				10.0
Manganese (DTPA)	mg/kg		61.00				17.00
Boron (Hot CaCl2)	mg/kg		0.33				0.09
Chloride	mg/kg	560.0		<10.0	<10.0	<10.0	
Electrical Conductivity	dS/m	0.78	0.04	0.02	0.02	0.02	0.02
Cation Exchange Capacity	meq/100g	51.60		6.17	10.60	12.00	
Calcium (Amm-acet.)	%	54.000		71.000	71.000	71.000	
Calcium (Amm-acet.)	meq/100g	28.000		4.400	7.500	8.500	
Magnesium (Amm-acet.)	%	29.000		24.000	26.000	27.000	



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Sample No Test Code	030001825 ADMINSOIL	030001826 ADMINSOIL	030001827 ADMINSOIL	030001828 ADMINSOIL	030001829 ADMINSOIL	030001830 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	11/01/2012	11/01/2012	09/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 34	SITE 35	SITE 35	SITE 35	SITE 35	SITE 36
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 120	0 - 10	25 - 35	55 - 65	65 - 90	0 - 25
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	15.000		1.500	2.800	3.200	
Sodium (Amm-acet.)	%	16.000		0.580	0.820	1.300	
Sodium (Amm-acet.)	meq/100g	8.300		0.036	0.087	0.150	
Potassium (Amm-acet.)	%	0.600		3.700	1.900	1.600	
Potassium (Amm-acet.)	meq/100g	0.310		0.230	0.200	0.190	
Calcium/Magnesium Ratio		1.9		2.9	2.7	2.7	
Potassium to Magnesium Ratio		0.0		0.2	0.1	0.1	
Silicon (BSES)	mg/kg		150				110
% Clay	%	56		26	53	55	
% Sand (Fine)	%	25		30	19	20	
% Sand (Coarse)	%	10		39	22	20	
% Silt	%	9		5	6	5	
Sansilclay Texture		Clay		Sandy Clay Loam	Clay	Clay	
Organic Matter	%		1.4				0.9

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Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Report Print Date: 13/01/2012
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Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001831 ADMINSOIL	030001832 ADMINSOIL	030001833 ADMINSOIL	030001834 ADMINSOIL	030001835 ADMINSOIL	030001836 ADMINSOIL
Lab Results Received Date	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 36	SITE 36	SITE 37	SITE 37	SITE 37	SITE 37
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 100	0 - 10	25 - 35	55 - 65	65 - 100
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.30	7.50	6.60	6.90	7.20	7.60
pH (1:5 CaCl2)		6.30	6.40	5.60	5.80	6.00	6.30
Organic Carbon (OC)	%			0.48			
Nitrate Nitrogen (NO3)	mg/kg	1.3	<1.0		<1.0	<1.0	<1.0
Total Nitrogen	%			<0.04			
Phosphorus (Colwell)	mg/kg			13			
Phosphorus (BSES)	mg/kg			65			
Available Potassium	mg/kg	43	58		91	200	210
Potassium (Nitric K)	meq/100g			3.80			
Sulphate Sulphur (MCP)	mg/kg			1.1			
Zinc (DTPA)	mg/kg			0.32			
Copper (DTPA)	mg/kg			0.14			
Iron (DTPA)	mg/kg			23.0			
Manganese (DTPA)	mg/kg			15.00			
Boron (Hot CaCl2)	mg/kg			0.16			
Chloride	mg/kg	<10.0	<10.0		<10.0	<10.0	<10.0
Electrical Conductivity	dS/m	0.01	0.01	0.03	0.01	0.02	0.02
Cation Exchange Capacity	meq/100g	1.68	2.20		2.97	11.40	12.60
Calcium (Amm-acet.)	%	71.000	68.000		61.000	57.000	60.000
Calcium (Amm-acet.)	meq/100g	1.200	1.500		1.800	6.500	7.500
Magnesium (Amm-acet.)	%	21.000	24.000		31.000	37.000	35.000



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Sample No Test Code	030001831 ADMINSOIL	030001832 ADMINSOIL	030001833 ADMINSOIL	030001834 ADMINSOIL	030001835 ADMINSOIL	030001836 ADMINSOIL
Lab Results Received Date	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 36	SITE 36	SITE 37	SITE 37	SITE 37	SITE 37
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 100	0 - 10	25 - 35	55 - 65	65 - 100
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	0.350	0.530		0.910	4.200	4.400
Sodium (Amm-acet.)	%	<1.310	<1.000		1.000	1.300	1.500
Sodium (Amm-acet.)	meq/100g	<0.022	<0.022		0.031	0.150	0.190
Potassium (Amm-acet.)	%	6.500	6.800		7.700	4.500	4.200
Potassium (Amm-acet.)	meq/100g	0.110	0.150		0.230	0.510	0.530
Calcium/Magnesium Ratio		3.4	2.8		2.0	1.5	1.7
Potassium to Magnesium Ratio		0.3	0.3		0.3	0.1	0.1
Silicon (BSES)	mg/kg			170			
% Clay	%	3	6		4	26	29
% Sand (Fine)	%	13	20		43	35	39
% Sand (Coarse)	%	82	68		43	30	24
% Silt	%	3	5		10	9	9
Sansilclay Texture		Sand	Sand		Loamy Sand	Sandy Clay Loam	Sandy Clay Loam
Organic Matter	%			0.8			

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001837 ADMINSOIL	030001838 ADMINSOIL	030001839 ADMINSOIL	030001840 ADMINSOIL	030001841 ADMINSOIL	030001842 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 38	SITE 38	SITE 38	SITE 39	SITE 39	SITE 39
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 7	7 - 25	65 - 110	0 - 25	35 - 55	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		6.10	6.60	7.90	5.80	7.10	7.10
pH (1:5 CaCl2)		5.10	5.50	6.70	4.70	5.70	5.70
Organic Carbon (OC)	%	0.97			0.63		
Nitrate Nitrogen (NO3)	mg/kg		<1.0	<1.0		<1.0	<1.0
Total Nitrogen	%	0.07			0.05		
Phosphorus (Colwell)	mg/kg	33			14		
Phosphorus (BSES)	mg/kg	64			26		
Available Potassium	mg/kg		110	230		110	110
Potassium (Nitric K)	meq/100g	3.30			4.80		
Sulphate Sulphur (MCP)	mg/kg	1.6			2.0		
Zinc (DTPA)	mg/kg	0.87			0.43		
Copper (DTPA)	mg/kg	0.73			0.28		
Iron (DTPA)	mg/kg	77.0			55.0		
Manganese (DTPA)	mg/kg	21.00			21.00		
Boron (Hot CaCl2)	mg/kg	0.15			0.12		
Chloride	mg/kg		<10.0	<10.0		<10.0	<10.0
Electrical Conductivity	dS/m	0.03	0.02	0.02	0.03	0.02	0.02
Cation Exchange Capacity	meq/100g		4.42	11.30		11.80	12.80
Calcium (Amm-acet.)	%		72.000	71.000		51.000	51.000
Calcium (Amm-acet.)	meq/100g		3.200	8.000		6.000	6.500
Magnesium (Amm-acet.)	%		21.000	23.000		44.000	45.000



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Sample No Test Code	030001837 ADMINSOIL	030001838 ADMINSOIL	030001839 ADMINSOIL	030001840 ADMINSOIL	030001841 ADMINSOIL	030001842 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 38	SITE 38	SITE 38	SITE 39	SITE 39	SITE 39
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 7	7 - 25	65 - 110	0 - 25	35 - 55	55 - 65
Sampling Date						

Analyte / Assay		Unit	Value				
Magnesium (Amm-acet.)	meq/100g		0.910	2.600		5.200	5.700
Sodium (Amm-acet.)	%		0.900	1.400		2.500	2.400
Sodium (Amm-acet.)	meq/100g		0.040	0.160		0.300	0.310
Potassium (Amm-acet.)	%		6.100	5.100		2.300	2.200
Potassium (Amm-acet.)	meq/100g		0.270	0.580		0.270	0.280
Calcium/Magnesium Ratio			3.5	3.1		1.2	1.1
Potassium to Magnesium Ratio			0.3	0.2		0.1	0.0
Silicon (BSES)	mg/kg	240			170		
% Clay	%		6	16		28	33
% Sand (Fine)	%		17	18		53	48
% Sand (Coarse)	%		64	60		9	9
% Silt	%		13	6		11	11
Sansilclay Texture			Loamy Sand	Sandy Loam		Sandy Clay Loam	Sandy Clay Loam
Organic Matter	%	1.7			1.1		

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Report Print Date: 13/01/2012
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Advisor/Contact: David Doolan
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Sample No Test Code	030001843 ADMINSOIL	030001844 ADMINSOIL	030001845 ADMINSOIL	030001846 ADMINSOIL	030001847 ADMINSOIL	030001848 ADMINSOIL
Lab Results Received Date	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 39	SITE 40	SITE 40	SITE 40	SITE 40	SITE 41
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	90 - 150	0 - 15	35 - 55	65 - 80	80 - 140	0 - 10
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.40	6.10	8.00	8.80	8.80	6.80
pH (1:5 CaCl2)		7.00	5.10	6.80	8.10	7.80	5.90
Organic Carbon (OC)	%		1.20				1.20
Nitrate Nitrogen (NO3)	mg/kg	<1.0		<1.0	<1.0	<1.0	
Total Nitrogen	%		0.09				0.10
Phosphorus (Colwell)	mg/kg		24				75
Phosphorus (BSES)	mg/kg		44				380
Available Potassium	mg/kg	120		110	110	100	
Potassium (Nitric K)	meq/100g		6.00				6.60
Sulphate Sulphur (MCP)	mg/kg		3.6				2.8
Zinc (DTPA)	mg/kg		0.95				0.97
Copper (DTPA)	mg/kg		1.30				0.53
Iron (DTPA)	mg/kg		100.0				57.0
Manganese (DTPA)	mg/kg		46.00				13.00
Boron (Hot CaCl2)	mg/kg		0.40				0.35
Chloride	mg/kg	<10.0		78.0	240.0	140.0	
Electrical Conductivity	dS/m	0.04	0.05	0.11	0.31	0.16	0.05
Cation Exchange Capacity	meq/100g	12.40		22.80	23.20	14.50	
Calcium (Amm-acet.)	%	48.000		48.000	56.000	48.000	
Calcium (Amm-acet.)	meq/100g	6.000		11.000	13.000	7.000	
Magnesium (Amm-acet.)	%	44.000		43.000	35.000	40.000	



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Sample No Test Code	030001843 ADMINSOIL	030001844 ADMINSOIL	030001845 ADMINSOIL	030001846 ADMINSOIL	030001847 ADMINSOIL	030001848 ADMINSOIL
Lab Results Received Date Paddock Name	11/01/2012 03-12-2011	09/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	09/01/2012 03-12-2011
Sample Name	SITE 39	SITE 40	SITE 40	SITE 40	SITE 40	SITE 41
Sample Type Sample Depth (cm) Sampling Date	Soil 90 - 150	Soil 0 - 15	Soil 35 - 55	Soil 65 - 80	Soil 80 - 140	Soil 0 - 10

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	5.500		9.900	8.200	5.800	
Sodium (Amm-acet.)	%	4.600		7.000	7.300	9.700	
Sodium (Amm-acet.)	meq/100g	0.570		1.600	1.700	1.400	
Potassium (Amm-acet.)	%	2.300		1.300	1.300	1.800	
Potassium (Amm-acet.)	meq/100g	0.290		0.290	0.290	0.260	
Calcium/Magnesium Ratio		1.1		1.1	1.6	1.2	
Potassium to Magnesium Ratio		0.1		0.0	0.0	0.0	
Silicon (BSES)	mg/kg		410				460
% Clay	%	20		45	34	23	
% Sand (Fine)	%	53		38	41	56	
% Sand (Coarse)	%	11		3	6	8	
% Silt	%	16		14	19	14	
Sansilclay Texture		Sandy Clay Loam		Clay	Sandy Clay Loam	Sandy Clay Loam	
Organic Matter	%		2.1				2.1

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001849 ADMINSOIL	030001850 ADMINSOIL	030001851 ADMINSOIL	030001852 ADMINSOIL	030001853 ADMINSOIL	030001854 ADMINSOIL
Lab Results Received Date	11/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 41	SITE 41	SITE 41	SITE 42	SITE 42	SITE 42
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	25 - 35	65 - 100	100 - 150	0 - 17	25 - 35	55 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.20	7.70	8.00	6.20	6.90	7.30
pH (1:5 CaCl2)		6.20	6.70	7.00	5.30	5.80	5.90
Organic Carbon (OC)	%				0.45		
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0	<1.0		1.7	<1.0
Total Nitrogen	%				<0.04		
Phosphorus (Colwell)	mg/kg				16		
Phosphorus (BSES)	mg/kg				41		
Available Potassium	mg/kg	100	74	76		97	88
Potassium (Nitric K)	meq/100g				2.20		
Sulphate Sulphur (MCP)	mg/kg				1.8		
Zinc (DTPA)	mg/kg				0.47		
Copper (DTPA)	mg/kg				0.13		
Iron (DTPA)	mg/kg				36.0		
Manganese (DTPA)	mg/kg				16.00		
Boron (Hot CaCl2)	mg/kg				0.06		
Chloride	mg/kg	<10.0	<10.0	<10.0		<10.0	<10.0
Electrical Conductivity	dS/m	0.03	0.02	0.03	0.03	0.02	0.02
Cation Exchange Capacity	meq/100g	9.90	8.62	10.30		2.40	8.44
Calcium (Amm-acet.)	%	76.000	75.000	73.000		63.000	55.000
Calcium (Amm-acet.)	meq/100g	7.500	6.500	7.500		1.500	4.600
Magnesium (Amm-acet.)	%	21.000	22.000	25.000		26.000	40.000



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

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Summary Report

Sample No Test Code	030001849 ADMINSOIL	030001850 ADMINSOIL	030001851 ADMINSOIL	030001852 ADMINSOIL	030001853 ADMINSOIL	030001854 ADMINSOIL
Lab Results Received Date Paddock Name	11/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	09/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011
Sample Name	SITE 41	SITE 41	SITE 41	SITE 42	SITE 42	SITE 42
Sample Type Sample Depth (cm) Sampling Date	Soil 25 - 35	Soil 65 - 100	Soil 100 - 150	Soil 0 - 17	Soil 25 - 35	Soil 55 - 65

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	2.100	1.900	2.600		0.620	3.400
Sodium (Amm-acet.)	%	0.270	0.340	0.470		1.100	2.500
Sodium (Amm-acet.)	meq/100g	0.027	0.029	0.048		0.027	0.210
Potassium (Amm-acet.)	%	2.700	2.200	1.800		10.000	2.700
Potassium (Amm-acet.)	meq/100g	0.270	0.190	0.190		0.250	0.230
Calcium/Magnesium Ratio		3.6	3.4	2.9		2.4	1.4
Potassium to Magnesium Ratio		0.1	0.1	0.1		0.4	0.1
Silicon (BSES)	mg/kg				110		
% Clay	%	9	11	14		3	23
% Sand (Fine)	%	66	72	64		44	30
% Sand (Coarse)	%	15	11	12		45	40
% Silt	%	10	6	10		9	8
Sansilclay Texture		Loamy Sand	Loamy Sand	Sandy Loam		Sand	Sandy Clay Loam
Organic Matter	%				0.8		

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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001855 ADMINSOIL	030001856 ADMINSOIL	030001857 ADMINSOIL	030001858 ADMINSOIL	030001859 ADMINSOIL	030001860 ADMINSOIL
Lab Results Received Date	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 42	SITE 43	SITE 43	SITE 43	SITE 43	SITE 44
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 130	0 - 10	25 - 35	55 - 65	100 - 140	0 - 13
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.70	7.10	8.70	9.00	9.60	8.20
pH (1:5 CaCl2)		6.00	6.10	8.10	8.40	8.60	7.60
Organic Carbon (OC)	%		0.78				1.70
Nitrate Nitrogen (NO3)	mg/kg	<1.0		<1.0	<1.0	<1.0	
Total Nitrogen	%		0.07				0.17
Phosphorus (Colwell)	mg/kg		25				25
Phosphorus (BSES)	mg/kg		61				72
Available Potassium	mg/kg	82		86	88	130	
Potassium (Nitric K)	meq/100g		5.70				4.00
Sulphate Sulphur (MCP)	mg/kg		2.6				4.7
Zinc (DTPA)	mg/kg		0.44				0.63
Copper (DTPA)	mg/kg		0.88				1.60
Iron (DTPA)	mg/kg		45.0				24.0
Manganese (DTPA)	mg/kg		32.00				6.60
Boron (Hot CaCl2)	mg/kg		0.60				0.80
Chloride	mg/kg	<10.0		610.0	330.0	12.0	
Electrical Conductivity	dS/m	0.02	0.15	0.67	0.82	0.28	0.19
Cation Exchange Capacity	meq/100g	7.83		25.70	36.40	28.00	
Calcium (Amm-acet.)	%	54.000		54.000	60.000	61.000	
Calcium (Amm-acet.)	meq/100g	4.200		14.000	22.000	17.000	
Magnesium (Amm-acet.)	%	40.000		26.000	21.000	23.000	



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Summary Report

Sample No Test Code	030001855 ADMINSOIL	030001856 ADMINSOIL	030001857 ADMINSOIL	030001858 ADMINSOIL	030001859 ADMINSOIL	030001860 ADMINSOIL
Lab Results Received Date Paddock Name	11/01/2012 03-12-2011	09/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	09/01/2012 03-12-2011
Sample Name	SITE 42	SITE 43	SITE 43	SITE 43	SITE 43	SITE 44
Sample Type Sample Depth (cm) Sampling Date	Soil 65 - 130	Soil 0 - 10	Soil 25 - 35	Soil 55 - 65	Soil 100 - 140	Soil 0 - 13

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	3.100		6.700	7.700	6.300	
Sodium (Amm-acet.)	%	4.100		19.000	18.000	16.000	
Sodium (Amm-acet.)	meq/100g	0.320		4.800	6.500	4.400	
Potassium (Amm-acet.)	%	2.700		0.860	0.630	1.200	
Potassium (Amm-acet.)	meq/100g	0.210		0.220	0.230	0.330	
Calcium/Magnesium Ratio		1.4		2.1	2.9	2.7	
Potassium to Magnesium Ratio		0.1		0.0	0.0	0.1	
Silicon (BSES)	mg/kg		710				1200
% Clay	%	20		28	23	11	
% Sand (Fine)	%	33		47	47	52	
% Sand (Coarse)	%	38		2	6	7	
% Silt	%	9		24	24	30	
Sansilclay Texture		Sandy Clay Loam		Sandy Clay Loam	Sandy Clay Loam	Sandy Loam	
Organic Matter	%		1.3				2.9

The results reported pertain only to the samples submitted.

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Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

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210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001861 ADMINSOIL	030001862 ADMINSOIL	030001863 ADMINSOIL	030001864 ADMINSOIL	030001865 ADMINSOIL	030001866 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 16	SITE 16	SITE 16	SITE 17	SITE 17	SITE 17
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 10	35 - 55	65 - 100	0 - 10	30 - 45	45 - 65
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		5.50	6.50	9.60	6.10	8.00	9.30
pH (1:5 CaCl2)		4.50	5.20	8.80	5.10	6.90	8.50
Aluminium Saturation	%		1.0				
Organic Carbon (OC)	%	1.20			0.64		
Nitrate Nitrogen (NO3)	mg/kg		<1.0	<1.0		<1.0	1.3
Total Nitrogen	%	0.10			0.06		
Phosphorus (Colwell)	mg/kg	8			8		
Phosphorus (BSES)	mg/kg	14			12		
Available Potassium	mg/kg		50	64		110	71
Potassium (Nitric K)	meq/100g	2.00			1.50		
Sulphate Sulphur (MCP)	mg/kg	5.6			3.2		
Zinc (DTPA)	mg/kg	1.40			0.36		
Copper (DTPA)	mg/kg	0.82			0.10		
Iron (DTPA)	mg/kg	150.0			100.0		
Manganese (DTPA)	mg/kg	35.00			6.20		
Boron (Hot CaCl2)	mg/kg	0.28			0.36		
Chloride	mg/kg		240.0	470.0		350.0	450.0
Electrical Conductivity	dS/m	0.07	0.20	0.78	0.05	0.29	0.50
Cation Exchange Capacity	meq/100g			17.20		14.20	17.30
Cation Exchange Capacity	meq/100g		10.20				
Aluminium (KCl)	mg/kg		<9.00				



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Summary Report

Sample No Test Code	030001861 ADMINSOIL	030001862 ADMINSOIL	030001863 ADMINSOIL	030001864 ADMINSOIL	030001865 ADMINSOIL	030001866 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 16	SITE 16	SITE 16	SITE 17	SITE 17	SITE 17
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 10	35 - 55	65 - 100	0 - 10	30 - 45	45 - 65
Sampling Date						

Analyte / Assay		Unit	Value				
Aluminium (KCl)	meq/100g		0.10				
Calcium (Amm-acet.)	%			38.000		22.000	32.000
Calcium (Amm-acet.)	meq/100g		3.000	6.500		3.100	5.500
Calcium (Amm-acet.)	%		29.000				
Magnesium (Amm-acet.)	%			23.000		50.000	39.000
Magnesium (Amm-acet.)	meq/100g		4.200	4.000		7.100	6.800
Magnesium (Amm-acet.)	%		41.000				
Sodium (Amm-acet.)	%			38.000		26.000	28.000
Sodium (Amm-acet.)	meq/100g		2.800	6.500		3.700	4.800
Sodium % of Cations (ESP)	%		27.000				
Potassium (Amm-acet.)	%			0.930		2.000	1.000
Potassium (Amm-acet.)	meq/100g		0.130	0.160		0.290	0.180
Potassium (Amm-acet.)	%		1.300				
Calcium/Magnesium Ratio			0.7	1.6		0.4	0.8
Potassium to Magnesium Ratio			0.0	0.0		0.0	0.0
Silicon (BSES)	mg/kg	180			83		
% Clay	%		24	20		36	29
% Sand (Fine)	%		52	66		57	62
% Sand (Coarse)	%		9	10		3	5
% Silt	%		15	4		4	5
Sansilclay Texture			Sandy Clay Loam	Sandy Clay Loam		Sandy Clay	Sandy Clay Loam
Organic Matter	%	2.1			1.1		

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001867 ADMINSOIL	030001868 ADMINSOIL	030001869 ADMINSOIL	030001870 ADMINSOIL	030001871 ADMINSOIL	030001872 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 18	SITE 18	SITE 18	SITE 19	SITE 19	SITE 19
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 75	0 - 25	0 - 10	25 - 35	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		9.00	9.40	5.90	6.90	7.30	8.20
pH (1:5 CaCl2)		8.20	8.60	4.60	6.00	6.20	7.60
Organic Carbon (OC)	%			0.56	2.00		
Nitrate Nitrogen (NO3)	mg/kg	<1.0	1.0			<1.0	<1.0
Total Nitrogen	%			0.05	0.17		
Phosphorus (Colwell)	mg/kg			<5	55		
Phosphorus (BSES)	mg/kg			8	140		
Available Potassium	mg/kg	75	80			170	130
Potassium (Nitric K)	meq/100g			1.20	5.80		
Sulphate Sulphur (MCP)	mg/kg			2.5	4.4		
Zinc (DTPA)	mg/kg			1.70	0.78		
Copper (DTPA)	mg/kg			0.40	0.37		
Iron (DTPA)	mg/kg			98.0	65.0		
Manganese (DTPA)	mg/kg			6.40	29.00		
Boron (Hot CaCl2)	mg/kg			0.12	0.58		
Chloride	mg/kg	470.0	810.0			<10.0	<10.0
Electrical Conductivity	dS/m	0.46	0.67	0.04	0.06	0.04	0.16
Cation Exchange Capacity	meq/100g	16.40	17.80			37.40	52.90
Calcium (Amm-acet.)	%	34.000	31.000			91.000	95.000
Calcium (Amm-acet.)	meq/100g	5.500	5.500			34.000	50.000
Magnesium (Amm-acet.)	%	41.000	36.000			7.500	4.500



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Sample No Test Code	030001867 ADMINSOIL	030001868 ADMINSOIL	030001869 ADMINSOIL	030001870 ADMINSOIL	030001871 ADMINSOIL	030001872 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012	09/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011	02-12-2011
Sample Name	SITE 18	SITE 18	SITE 18	SITE 19	SITE 19	SITE 19
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	35 - 55	65 - 75	0 - 25	0 - 10	25 - 35	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	6.700	6.400			2.800	2.400
Sodium (Amm-acet.)	%	24.000	32.000			0.480	0.320
Sodium (Amm-acet.)	meq/100g	4.000	5.700			0.180	0.170
Potassium (Amm-acet.)	%	1.200	1.100			1.200	0.640
Potassium (Amm-acet.)	meq/100g	0.190	0.200			0.440	0.340
Calcium/Magnesium Ratio		0.8	0.9			12.0	21.0
Potassium to Magnesium Ratio		0.0	0.0			0.2	0.1
Silicon (BSES)	mg/kg			83	770		
% Clay	%	29	29			51	40
% Sand (Fine)	%	54	55			27	34
% Sand (Coarse)	%	11	6			6	8
% Silt	%	6	10			16	19
Sansilclay Texture		Sandy Clay Loam	Sandy Clay Loam			Clay	Clay
Organic Matter	%			1.0	3.4		

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

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QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030001873 ADMINSOIL	030001874 ADMINSOIL	030001875 ADMINSOIL	030002123 ADMINSOIL	030002124 ADMINSOIL	030002125 ADMINSOIL
Lab Results Received Date	09/01/2012	09/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012
Paddock Name	02-12-2011	02-12-2011	02-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 20	SITE 20	SITE 20	SITE 44	SITE 44	SITE 44
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 10	10 - 25	35 - 55	35 - 55	65 - 110	110 - 150
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.20	8.60	8.90	8.90	8.50	8.00
pH (1:5 CaCl2)		7.50	7.80	8.00	8.00	8.10	7.60
Organic Carbon (OC)	%	1.50					
Nitrate Nitrogen (NO3)	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Total Nitrogen	%	0.15					
Phosphorus (Colwell)	mg/kg	8					
Phosphorus (BSES)	mg/kg	260					
Available Potassium	mg/kg		120	50	170	160	80
Potassium (Nitric K)	meq/100g	5.70					
Sulphate Sulphur (MCP)	mg/kg	2.5					
Zinc (DTPA)	mg/kg	0.26					
Copper (DTPA)	mg/kg	0.17					
Iron (DTPA)	mg/kg	11.0					
Manganese (DTPA)	mg/kg	10.00					
Boron (Hot CaCl2)	mg/kg	0.60					
Chloride	mg/kg		<10.0	<10.0	88.0	1700.0	2300.0
Electrical Conductivity	dS/m	0.12	0.12	0.09	0.29	1.38	1.53
Cation Exchange Capacity	meq/100g		44.20	36.80	46.40	49.30	34.30
Calcium (Amm-acet.)	%		97.000	98.000	73.000	57.000	44.000
Calcium (Amm-acet.)	meq/100g		43.000	36.000	34.000	28.000	15.000
Magnesium (Amm-acet.)	%		1.900	1.600	17.000	20.000	27.000

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Sample No Test Code	030001873 ADMINSOIL	030001874 ADMINSOIL	030001875 ADMINSOIL	030002123 ADMINSOIL	030002124 ADMINSOIL	030002125 ADMINSOIL
Lab Results Received Date Paddock Name	09/01/2012 02-12-2011	09/01/2012 02-12-2011	09/01/2012 02-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011
Sample Name	SITE 20	SITE 20	SITE 20	SITE 44	SITE 44	SITE 44
Sample Type Sample Depth (cm) Sampling Date	Soil 0 - 10	Soil 10 - 25	Soil 35 - 55	Soil 35 - 55	Soil 65 - 110	Soil 110 - 150

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g		0.820	0.580	7.900	9.900	9.100
Sodium (Amm-acet.)	%		0.170	0.350	8.800	22.000	29.000
Sodium (Amm-acet.)	meq/100g		0.074	0.130	4.100	11.000	10.000
Potassium (Amm-acet.)	%		0.700	0.350	0.950	0.830	0.580
Potassium (Amm-acet.)	meq/100g		0.310	0.130	0.440	0.410	0.200
Calcium/Magnesium Ratio			52.0	62.0	4.3	2.8	1.6
Potassium to Magnesium Ratio			0.4	0.2	0.1	0.0	0.0
Silicon (BSES)	mg/kg	770					
% Clay	%		30	13	54	58	46
% Sand (Fine)	%		41	35	28	24	26
% Sand (Coarse)	%		11	36	4	3	1
% Silt	%		18	16	14	16	28
Sansilclay Texture			Sandy Clay Loam	Sandy Loam	Clay	Clay	Clay
Organic Matter	%	2.6					

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by Nutrient Advantage Advice as being equivalent to the level of reporting for both calculation and interpretive purposes

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030002126 ADMINSOIL	030002127 ADMINSOIL	030002128 ADMINSOIL	030002129 ADMINSOIL	030002130 ADMINSOIL	030002131 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 45	SITE 45	SITE 45	SITE 45	SITE 46	SITE 46
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 11	0 - 11	55 - 65	65 - 80	0 - 22	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		7.50	8.50	8.80	9.10	6.90	7.30
pH (1:5 CaCl2)		6.90	7.80	8.10	8.30	6.20	6.20
Organic Carbon (OC)	%	1.20				0.54	
Nitrate Nitrogen (NO3)	mg/kg		<1.0	<1.0	1.0		<1.0
Total Nitrogen	%	0.11				0.04	
Phosphorus (Colwell)	mg/kg	110				6	
Phosphorus (BSES)	mg/kg	470				22	
Available Potassium	mg/kg		110	69	52		120
Potassium (Nitric K)	meq/100g	5.70				2.70	
Sulphate Sulphur (MCP)	mg/kg	7.1				1.6	
Zinc (DTPA)	mg/kg	0.52				0.47	
Copper (DTPA)	mg/kg	0.46				0.48	
Iron (DTPA)	mg/kg	25.0				22.0	
Manganese (DTPA)	mg/kg	14.00				31.00	
Boron (Hot CaCl2)	mg/kg	0.46				0.12	
Chloride	mg/kg		<10.0	<10.0	<10.0		<10.0
Electrical Conductivity	dS/m	0.13	0.10	0.10	0.09	0.04	0.03
Cation Exchange Capacity	meq/100g		16.50	26.50	25.20		17.40
Calcium (Amm-acet.)	%		85.000	91.000	87.000		86.000
Calcium (Amm-acet.)	meq/100g		14.000	24.000	22.000		15.000
Magnesium (Amm-acet.)	%		13.000	7.900	11.000		11.000



Analyses conducted by **Nutrient Advantage Laboratory Services**

NATA Accreditation No: 11958

Certificate of Analysis is available upon request.

8 South Road, Werribee VIC 3030

Tel: 1800 803 453

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Sample No Test Code	030002126 ADMINSOIL	030002127 ADMINSOIL	030002128 ADMINSOIL	030002129 ADMINSOIL	030002130 ADMINSOIL	030002131 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 45	SITE 45	SITE 45	SITE 45	SITE 46	SITE 46
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 11	0 - 11	55 - 65	65 - 80	0 - 22	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g		2.100	2.100	2.800		1.900
Sodium (Amm-acet.)	%		0.850	0.790	1.100		1.100
Sodium (Amm-acet.)	meq/100g		0.140	0.210	0.270		0.190
Potassium (Amm-acet.)	%		1.600	0.680	0.520		1.700
Potassium (Amm-acet.)	meq/100g		0.270	0.180	0.130		0.300
Calcium/Magnesium Ratio			6.7	11.0	7.9		7.9
Potassium to Magnesium Ratio			0.1	0.1	0.0		0.2
Silicon (BSES)	mg/kg	580				180	
% Clay	%		14	11	6		30
% Sand (Fine)	%		46	28	38		32
% Sand (Coarse)	%		40	51	48		30
% Silt	%		0	10	8		9
Sansilclay Texture			Loamy Sand	Sandy Loam	Loamy Sand		Sandy Clay Loam
Organic Matter	%	2.1				0.9	

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030002132 ADMINSOIL	030002133 ADMINSOIL	030002134 ADMINSOIL	030002135 ADMINSOIL	030002136 ADMINSOIL	030002137 ADMINSOIL
Lab Results Received Date	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 46	SITE 46	SITE 47	SITE 47	SITE 47	SITE 47
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 95	95 - 120	0 - 12	25 - 35	55 - 65	65 - 90
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.70	9.00	7.80	8.70	8.90	8.90
pH (1:5 CaCl2)		8.00	8.10	7.20	7.80	8.00	8.00
Organic Carbon (OC)	%			2.00			
Nitrate Nitrogen (NO3)	mg/kg	<1.0	<1.0		<1.0	<1.0	<1.0
Total Nitrogen	%			0.21			
Phosphorus (Colwell)	mg/kg			39			
Phosphorus (BSES)	mg/kg			41			
Available Potassium	mg/kg	91	68		210	200	200
Potassium (Nitric K)	meq/100g			4.80			
Sulphate Sulphur (MCP)	mg/kg			7.4			
Zinc (DTPA)	mg/kg			0.57			
Copper (DTPA)	mg/kg			1.70			
Iron (DTPA)	mg/kg			24.0			
Manganese (DTPA)	mg/kg			11.00			
Boron (Hot CaCl2)	mg/kg			0.96			
Chloride	mg/kg	<10.0	<10.0		<10.0	67.0	130.0
Electrical Conductivity	dS/m	0.10	0.08	0.16	0.16	0.26	0.33
Cation Exchange Capacity	meq/100g	28.60	26.20		49.90	50.10	48.90
Calcium (Amm-acet.)	%	94.000	95.000		78.000	68.000	65.000
Calcium (Amm-acet.)	meq/100g	27.000	25.000		39.000	34.000	32.000
Magnesium (Amm-acet.)	%	4.200	3.500		18.000	24.000	25.000



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Sample No Test Code	030002132 ADMINSOIL	030002133 ADMINSOIL	030002134 ADMINSOIL	030002135 ADMINSOIL	030002136 ADMINSOIL	030002137 ADMINSOIL
Lab Results Received Date	11/01/2012	11/01/2012	09/01/2012	11/01/2012	11/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 46	SITE 46	SITE 47	SITE 47	SITE 47	SITE 47
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	65 - 95	95 - 120	0 - 12	25 - 35	55 - 65	65 - 90
Sampling Date						

Analyte / Assay	Unit	Value					
Magnesium (Amm-acet.)	meq/100g	1.200	0.910		9.100	12.000	12.000
Sodium (Amm-acet.)	%	0.490	0.460		2.600	7.200	9.000
Sodium (Amm-acet.)	meq/100g	0.140	0.120		1.300	3.600	4.400
Potassium (Amm-acet.)	%	0.800	0.650		1.100	1.000	1.000
Potassium (Amm-acet.)	meq/100g	0.230	0.170		0.530	0.510	0.510
Calcium/Magnesium Ratio		23.0	27.0		4.3	2.8	2.7
Potassium to Magnesium Ratio		0.2	0.2		0.1	0.0	0.0
Silicon (BSES)	mg/kg			1400			
% Clay	%	13	6		53	55	58
% Sand (Fine)	%	29	26		28	23	21
% Sand (Coarse)	%	49	62		6	8	7
% Silt	%	9	6		14	15	15
Sansilclay Texture		Sandy Loam	Loamy Sand		Clay	Clay	Clay
Organic Matter	%			3.4			

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

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Summary Report

GHD PTY LTD
210 CHARLOTTE ST

BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030002138 ADMINSOIL	030002139 ADMINSOIL	030002140 ADMINSOIL	030002141 ADMINSOIL	030002142 ADMINSOIL	030002143 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 48	SITE 48	SITE 48	SITE 48	SITE 49	SITE 49
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 13	35 - 55	65 - 90	90 - 120	0 - 22	35 - 55
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.30	9.10	9.10	9.10	8.30	8.80
pH (1:5 CaCl2)		7.70	8.20	8.30	8.30	7.60	7.90
Organic Carbon (OC)	%	1.60				1.60	
Nitrate Nitrogen (NO3)	mg/kg		<1.0	<1.0	<1.0		<1.0
Total Nitrogen	%	0.14				0.15	
Phosphorus (Colwell)	mg/kg	8				6	
Phosphorus (BSES)	mg/kg	18				200	
Available Potassium	mg/kg		130	120	110		47
Potassium (Nitric K)	meq/100g	4.00				3.40	
Sulphate Sulphur (MCP)	mg/kg	4.5				3.0	
Zinc (DTPA)	mg/kg	0.28				0.33	
Copper (DTPA)	mg/kg	0.96				0.33	
Iron (DTPA)	mg/kg	17.0				8.1	
Manganese (DTPA)	mg/kg	4.90				6.10	
Boron (Hot CaCl2)	mg/kg	1.00				0.65	
Chloride	mg/kg		16.0	260.0	550.0		<10.0
Electrical Conductivity	dS/m	0.17	0.23	0.45	0.66	0.14	0.10
Cation Exchange Capacity	meq/100g		44.90	41.00	36.50		34.20
Calcium (Amm-acet.)	%		71.000	63.000	58.000		96.000
Calcium (Amm-acet.)	meq/100g		32.000	26.000	21.000		33.000
Magnesium (Amm-acet.)	%		22.000	24.000	25.000		2.700



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Sample No Test Code	030002138 ADMINSOIL	030002139 ADMINSOIL	030002140 ADMINSOIL	030002141 ADMINSOIL	030002142 ADMINSOIL	030002143 ADMINSOIL
Lab Results Received Date	09/01/2012	11/01/2012	11/01/2012	11/01/2012	09/01/2012	11/01/2012
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011	03-12-2011
Sample Name	SITE 48	SITE 48	SITE 48	SITE 48	SITE 49	SITE 49
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth (cm)	0 - 13	35 - 55	65 - 90	90 - 120	0 - 22	35 - 55
Sampling Date						

Analyte / Assay		Unit	Value				
Magnesium (Amm-acet.)	meq/100g		9.900	9.900	9.100		0.910
Sodium (Amm-acet.)	%		6.000	12.000	17.000		0.560
Sodium (Amm-acet.)	meq/100g		2.700	4.800	6.100		0.190
Potassium (Amm-acet.)	%		0.730	0.760	0.770		0.350
Potassium (Amm-acet.)	meq/100g		0.330	0.310	0.280		0.120
Calcium/Magnesium Ratio			3.2	2.6	2.3		36.0
Potassium to Magnesium Ratio			0.0	0.0	0.0		0.1
Silicon (BSES)	mg/kg	1100				830	
% Clay	%		46	45	40		19
% Sand (Fine)	%		27	26	29		46
% Sand (Coarse)	%		12	10	10		10
% Silt	%		15	19	21		25
Sansilclay Texture			Clay	Clay	Clay		Sandy Loam
Organic Matter	%	2.8				2.8	

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

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BRISBANE
QLD 4000

Report Print Date: 13/01/2012
Agent/Dealer:
Advisor/Contact: David Doolan
Phone:

Sample No Test Code	030002144 ADMINSOIL	030002145 ADMINSOIL	030002146 ADMINSOIL	030002147 ADMINSOIL		
Lab Results Received Date	11/01/2012	09/01/2012	11/01/2012	11/01/2012		
Paddock Name	03-12-2011	03-12-2011	03-12-2011	03-12-2011		
Sample Name	SITE 49	SITE 50	SITE 50	SITE 50		
Sample Type	Soil	Soil	Soil	Soil		
Sample Depth (cm)	55 - 65	0 - 22	35 - 55	65 - 90		
Sampling Date						

Analyte / Assay	Unit	Value					
pH (1:5 Water)		8.90	8.80	8.80	8.70		
pH (1:5 CaCl2)		8.00	8.00	8.20	8.20		
Organic Carbon (OC)	%		1.20				
Nitrate Nitrogen (NO3)	mg/kg	<1.0		5.4	140.0		
Total Nitrogen	%		0.13				
Phosphorus (Colwell)	mg/kg		7				
Phosphorus (BSES)	mg/kg		160				
Available Potassium	mg/kg	47		140	130		
Potassium (Nitric K)	meq/100g		4.80				
Sulphate Sulphur (MCP)	mg/kg		11.0				
Zinc (DTPA)	mg/kg		0.18				
Copper (DTPA)	mg/kg		1.10				
Iron (DTPA)	mg/kg		12.0				
Manganese (DTPA)	mg/kg		4.50				
Boron (Hot CaCl2)	mg/kg		1.50				
Chloride	mg/kg	<10.0		730.0	1700.0		
Electrical Conductivity	dS/m	0.09	0.21	0.86	1.54		
Cation Exchange Capacity	meq/100g	34.30		49.80	54.30		
Calcium (Amm-acet.)	%	96.000		66.000	59.000		
Calcium (Amm-acet.)	meq/100g	33.000		33.000	32.000		
Magnesium (Amm-acet.)	%	2.900		20.000	22.000		



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Summary Report

Sample No Test Code	030002144 ADMINSOIL	030002145 ADMINSOIL	030002146 ADMINSOIL	030002147 ADMINSOIL		
Lab Results Received Date Paddock Name	11/01/2012 03-12-2011	09/01/2012 03-12-2011	11/01/2012 03-12-2011	11/01/2012 03-12-2011		
Sample Name	SITE 49	SITE 50	SITE 50	SITE 50		
Sample Type Sample Depth (cm) Sampling Date	Soil 55 - 65	Soil 0 - 22	Soil 35 - 55	Soil 65 - 90		

Analyte / Assay		Unit	Value			
Magnesium (Amm-acet.)	meq/100g	0.990		9.900	12.000	
Sodium (Amm-acet.)	%	0.610		13.000	18.000	
Sodium (Amm-acet.)	meq/100g	0.210		6.500	10.000	
Potassium (Amm-acet.)	%	0.350		0.720	0.590	
Potassium (Amm-acet.)	meq/100g	0.120		0.360	0.320	
Calcium/Magnesium Ratio		33.0		3.3	2.7	
Potassium to Magnesium Ratio		0.1		0.0	0.0	
Silicon (BSES)	mg/kg		880			
% Clay	%	14		51	50	
% Sand (Fine)	%	33		23	21	
% Sand (Coarse)	%	37		5	5	
% Silt	%	16		21	25	
Sansilclay Texture		Sandy Loam		Clay	Clay	
Organic Matter	%		2.1			

The results reported pertain only to the samples submitted.

Analyses performed on soil dried at 40 degrees Celsius and ground to <2mm (excluding moisture assay)

Analyses performed on plant material dried at 70 degrees Celsius and ground to <2mm

Water analyses performed on an 'as received' basis

Analytical results reported by the laboratory as 'less than' the level of reporting, will be deemed by Nutrient Advantage Advice as being equivalent to the level of reporting for both calculation and interpretive purposes

Disclaimer: Laboratory analyses and fertiliser recommendations are made in good faith, based on the best technical information available as at the date of this report. Incitec Pivot Limited, its officers, employees, consultants, Agents and Dealers do not accept any liability whatsoever arising from or in connection with the analytical results, interpretations and recommendations provided, and the client takes the analytical results, interpretations and recommendations on these terms. In respect of liability which cannot be excluded by law, Incitec Pivot's liability is restricted to the re-supply of the laboratory analysis or the cost of having the analysis re-supplied.





Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP1 (0-0.08m)
Sample No B046487-01 / SAC3713
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	6.4
pH [CaCl2]	5.9
Organic Matter (%)	2.6
CEC (meq/100g)	14.78
EC (dS/m)	0.05
NO3-N (ppm)	1.7
Phosphorus [Olsen] (ppm)	6
Potassium (meq/100g)	0.98
Calcium (meq/100g)	9.51
Magnesium (meq/100g)	3.90
Sulphur (ppm)	6
Boron (ppm)	1.1
Copper (ppm)	1.0
Iron (ppm)	35
Manganese (ppm)	50.5
Zinc (ppm)	1.0
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	0.1
Chloride (ppm)	17
Ca base saturation (%)	64.3
K base saturation (%)	6.6
Mg base saturation (%)	26.4
Na base saturation (%)	0.7
Ca:Mg Ratio	2.4
Aluminium Base Sat. (%)	1.90
Potassium (ppm)	383.0
Magnesium (ppm)	472.0
Calcium (ppm)	1902.0
Sodium (ppm)	25.0
Aluminium (ppm)	25.0



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Analysis Results (SOIL)

Customer	GHD COLLINSVILLE	Distributor	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	TP1 (0.08-0.16m)	Date Received	04/12/2009
Sample No	B046487-02 / SAC3714		
Crop	DATA ONLY		

Analysis	Result
pH [H2O]	6.2
CEC (meq/100g)	17.01
EC (dS/m)	0.04
Potassium (meq/100g)	0.76
Calcium (meq/100g)	11.41
Magnesium (meq/100g)	4.43
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	0.1
Ca base saturation (%)	67.1
K base saturation (%)	4.5
Mg base saturation (%)	26.0
Na base saturation (%)	0.8
Ca:Mg Ratio	2.6
Aluminium Base Sat. (%)	1.60
Potassium (ppm)	297.0
Magnesium (ppm)	536.0
Calcium (ppm)	2282.0
Sodium (ppm)	30.0
Aluminium (ppm)	25.0

Additional Comments

You should consult your local agronomist and/or Yara representative before deciding upon any course of action based on this report.

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Date Printed : 09/12/2009



Analysis Results (SOIL)

Customer	GHD COLLINSVILLE	Distributor	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	TP1 (0.16-0.31m)	Date Received	04/12/2009
Sample No	B046487-03 / SAC3715		
Crop	DATA ONLY		

Analysis	Result
pH [H2O]	6.2
CEC (meq/100g)	22.51
EC (dS/m)	0.03
Potassium (meq/100g)	0.66
Calcium (meq/100g)	14.51
Magnesium (meq/100g)	6.76
Aluminium (meq/100g)	0.31
Sodium (meq/100g)	0.3
Ca base saturation (%)	64.5
K base saturation (%)	2.9
Mg base saturation (%)	30.0
Na base saturation (%)	1.2
Ca:Mg Ratio	2.2
Aluminium Base Sat. (%)	1.40
Potassium (ppm)	258.0
Magnesium (ppm)	818.0
Calcium (ppm)	2902.0
Sodium (ppm)	62.0
Aluminium (ppm)	28.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP1 (0.4-0.5m)
Sample No B046487-04 / SAC3716
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	6.4
CEC (meq/100g)	31.58
EC (dS/m)	0.04
Potassium (meq/100g)	0.64
Calcium (meq/100g)	21.60
Magnesium (meq/100g)	8.52
Aluminium (meq/100g)	0.29
Sodium (meq/100g)	0.5
Ca base saturation (%)	68.4
K base saturation (%)	2.0
Mg base saturation (%)	27.0
Na base saturation (%)	1.7
Ca:Mg Ratio	2.5
Aluminium Base Sat. (%)	0.90
Potassium (ppm)	250.0
Magnesium (ppm)	1031.0
Calcium (ppm)	4320.0
Sodium (ppm)	122.0
Aluminium (ppm)	26.0

Additional Comments

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Analysis Results (SOIL)

Customer	GHD COLLINSVILLE	Distributor	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	TP1 (0-0.08m)	Date Received	04/12/2009
Sample No	B046487-01 / SAC3713		
Crop	DATA ONLY		

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP1 (0.7-0.8m)
Sample No B046487-05 / SAC3717
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	6.8
CEC (meq/100g)	34.75
EC (dS/m)	0.04
Potassium (meq/100g)	0.56
Calcium (meq/100g)	25.15
Magnesium (meq/100g)	8.10
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	0.7
Ca base saturation (%)	72.4
K base saturation (%)	1.6
Mg base saturation (%)	23.3
Na base saturation (%)	1.9
Ca:Mg Ratio	3.1
Aluminium Base Sat. (%)	0.80
Potassium (ppm)	219.0
Magnesium (ppm)	980.0
Calcium (ppm)	5030.0
Sodium (ppm)	152.0
Aluminium (ppm)	25.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP2 (0-0.1m)
Sample No B046487-06 / SAC3718
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	7.3
pH [CaCl2]	6.9
Organic Matter (%)	3.0
CEC (meq/100g)	37.57
EC (dS/m)	0.18
NO3-N (ppm)	8.5
Phosphorus [Olsen] (ppm)	6
Potassium (meq/100g)	1.08
Calcium (meq/100g)	27.66
Magnesium (meq/100g)	7.88
Sulphur (ppm)	8
Boron (ppm)	2.0
Copper (ppm)	2.2
Iron (ppm)	52
Manganese (ppm)	23.6
Zinc (ppm)	0.8
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	0.7
Chloride (ppm)	22
Ca base saturation (%)	73.6
K base saturation (%)	2.9
Mg base saturation (%)	21.0
Na base saturation (%)	1.8
Ca:Mg Ratio	3.5
Aluminium Base Sat. (%)	0.70
Potassium (ppm)	422.0
Magnesium (ppm)	953.0
Calcium (ppm)	5532.0
Sodium (ppm)	154.0
Aluminium (ppm)	25.0



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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP2 (0.2-0.3m)
Sample No B046487-07 / SAC3719
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	8.4
CEC (meq/100g)	45.18
EC (dS/m)	0.15
Potassium (meq/100g)	0.97
Calcium (meq/100g)	30.94
Magnesium (meq/100g)	11.01
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	2.0
Ca base saturation (%)	68.5
K base saturation (%)	2.1
Mg base saturation (%)	24.4
Na base saturation (%)	4.4
Ca:Mg Ratio	2.8
Aluminium Base Sat. (%)	0.60
Potassium (ppm)	379.0
Magnesium (ppm)	1332.0
Calcium (ppm)	6188.0
Sodium (ppm)	455.0
Aluminium (ppm)	25.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP2 (0.5-0.6m)
Sample No B046487-08 / SAC3720
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	8.7
CEC (meq/100g)	40.40
EC (dS/m)	0.26
Potassium (meq/100g)	0.89
Calcium (meq/100g)	21.85
Magnesium (meq/100g)	12.86
Aluminium (meq/100g)	0.27
Sodium (meq/100g)	4.5
Ca base saturation (%)	54.1
K base saturation (%)	2.2
Mg base saturation (%)	31.8
Na base saturation (%)	11.2
Ca:Mg Ratio	1.7
Aluminium Base Sat. (%)	0.70
Potassium (ppm)	348.0
Magnesium (ppm)	1556.0
Calcium (ppm)	4370.0
Sodium (ppm)	1042.0
Aluminium (ppm)	24.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP2 (0.8-0.9m)
Sample No B046487-09 / SAC3721
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	8.1
CEC (meq/100g)	35.97
EC (dS/m)	1.04
Potassium (meq/100g)	0.77
Calcium (meq/100g)	16.49
Magnesium (meq/100g)	13.33
Aluminium (meq/100g)	0.30
Sodium (meq/100g)	5.1
Ca base saturation (%)	45.8
K base saturation (%)	2.1
Mg base saturation (%)	37.1
Na base saturation (%)	14.1
Ca:Mg Ratio	1.2
Aluminium Base Sat. (%)	0.80
Potassium (ppm)	301.0
Magnesium (ppm)	1613.0
Calcium (ppm)	3298.0
Sodium (ppm)	1168.0
Aluminium (ppm)	27.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP2 (1.1-1.2m)
Sample No B046487-10 / SAC3722
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	8.0
CEC (meq/100g)	31.61
EC (dS/m)	0.97
Potassium (meq/100g)	0.70
Calcium (meq/100g)	13.25
Magnesium (meq/100g)	12.41
Aluminium (meq/100g)	0.28
Sodium (meq/100g)	5.0
Ca base saturation (%)	41.9
K base saturation (%)	2.2
Mg base saturation (%)	39.3
Na base saturation (%)	15.7
Ca:Mg Ratio	1.1
Aluminium Base Sat. (%)	0.90
Potassium (ppm)	274.0
Magnesium (ppm)	1502.0
Calcium (ppm)	2650.0
Sodium (ppm)	1143.0
Aluminium (ppm)	25.0

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP3 (0-0.1m)
Sample No B046487-11 / SAC3723
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	5.5
pH [CaCl2]	5.0
Organic Matter (%)	0.6
CEC (meq/100g)	2.51
EC (dS/m)	0.02
NO3-N (ppm)	< 1.0
Phosphorus [Olsen] (ppm)	5
Potassium (meq/100g)	0.38
Calcium (meq/100g)	0.86
Magnesium (meq/100g)	0.87
Sulphur (ppm)	5
Boron (ppm)	1.2
Copper (ppm)	0.3
Iron (ppm)	67
Manganese (ppm)	5.0
Zinc (ppm)	0.3
Aluminium (meq/100g)	0.31
Sodium (meq/100g)	0.1
Chloride (ppm)	13
Ca base saturation (%)	34.3
K base saturation (%)	15.1
Mg base saturation (%)	34.7
Na base saturation (%)	3.6
Ca:Mg Ratio	1.0
Aluminium Base Sat. (%)	12.40
Potassium (ppm)	149.0
Magnesium (ppm)	105.0
Calcium (ppm)	172.0
Sodium (ppm)	21.0
Aluminium (ppm)	28.0



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Analysis Results (SOIL)

Customer	GHD COLLINSVILLE	Distributor	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	TP2 (0-0.1m)	Date Received	04/12/2009
Sample No	B046487-06 / SAC3718		
Crop	DATA ONLY		

Additional Comments

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Analysis Results (SOIL)

Customer	GHD COLLINSVILLE	Distributor	ENVIRONMENTAL SOIL SOLUTIONS 5 DUNPHY ST SUNNYBANK HILLS QLD
Sample Ref	TP3 (0-0.1m)	Date Received	04/12/2009
Sample No	B046487-11 / SAC3723		
Crop	DATA ONLY		

Additional Comments

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Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP3 (0.1-0.3m)
Sample No B046487-12 / SAC3724
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	5.0
CEC (meq/100g)	2.46
EC (dS/m)	0.03
Potassium (meq/100g)	0.21
Calcium (meq/100g)	0.70
Magnesium (meq/100g)	0.92
Aluminium (meq/100g)	0.41
Sodium (meq/100g)	0.2
Ca base saturation (%)	28.5
K base saturation (%)	8.5
Mg base saturation (%)	37.4
Na base saturation (%)	8.9
Ca:Mg Ratio	0.8
Aluminium Base Sat. (%)	16.70
Potassium (ppm)	82.0
Magnesium (ppm)	111.0
Calcium (ppm)	140.0
Sodium (ppm)	51.0
Aluminium (ppm)	37.0

Additional Comments

You should consult your local agronomist and/or Yara representative before deciding upon any course of action based on this report.

Please Note

Whilst every care is taken to ensure that the Results from Analysis are as accurate as possible, it is important to note that the analysis relates to the sample received by the laboratory, and is representative only of that sample. No warranty is given by the laboratory that the Results from Analysis relates to any part of a field or growing area not covered by the sample received. It is important to ensure that any soil, leaf, silage or fruitlet sample sent for analysis is representative of the area requiring analysis and that samples are obtained in accordance with established sampling techniques. A leaflet containing instructions on how to take soil, leaf, herbage, silage and fruit samples for analysis is available from the laboratory on request.



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Date Printed : 09/12/2009



Analysis Results (SOIL)

Customer GHD
COLLINSVILLE

Distributor ENVIRONMENTAL SOIL SOLUTIONS
5 DUNPHY ST
SUNNYBANK HILLS
QLD

Sample Ref TP3 (0.5-0.6m)
Sample No B046487-13 / SAC3725
Crop DATA ONLY

Date Received 04/12/2009

Analysis	Result
pH [H2O]	5.2
CEC (meq/100g)	11.81
EC (dS/m)	0.35
Potassium (meq/100g)	0.35
Calcium (meq/100g)	1.59
Magnesium (meq/100g)	6.89
Aluminium (meq/100g)	0.50
Sodium (meq/100g)	2.5
Ca base saturation (%)	13.5
K base saturation (%)	3.0
Mg base saturation (%)	58.3
Na base saturation (%)	21.0
Ca:Mg Ratio	0.2
Aluminium Base Sat. (%)	4.20
Potassium (ppm)	137.0
Magnesium (ppm)	834.0
Calcium (ppm)	318.0
Sodium (ppm)	570.0
Aluminium (ppm)	45.0

Additional Comments

You should consult your local agronomist and/or Yara representative before deciding upon any course of action based on this report.

Please Note

Whilst every care is taken to ensure that the Results from Analysis are as accurate as possible, it is important to note that the analysis relates to the sample received by the laboratory, and is representative only of that sample. No warranty is given by the laboratory that the Results from Analysis relates to any part of a field or growing area not covered by the sample received. It is important to ensure that any soil, leaf, silage or fruitlet sample sent for analysis is representative of the area requiring analysis and that samples are obtained in accordance with established sampling techniques. A leaflet containing instructions on how to take soil, leaf, herbage, silage and fruit samples for analysis is available from the laboratory on request.



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Date Printed : 09/12/2009



Appendix D

Soil Criteria



Generalised Interpretation of Soil pH_{w1:5} in Water

pH	Rating	pH	Rating
> 9.0	Very strongly alkaline	6.5 – 6.1	Slightly acid
9.0 – 8.5	Strongly alkaline	6.0 - 5.6	Moderately acidic
8.4 - 7.9	Moderately alkaline	5.5 – 5.1	Strongly acidic
7.8 – 7.4	Mildly alkaline	5.0 – 4.5	Very strongly acidic
7.3 – 6.6	Neutral	< 4.4	Extremely acidic

Sourced: Hazelton and Murphy, 2007.

Soil Salinity Ratings with EC_{1:5} for Different Soil Textures

Crop Tolerance	EC for a range of clay contents (dS/m)				Soil Salinity Rating
	10 – 20%	20 – 40%	40 – 60%	60 – 80%	
Sensitive	< 0.07	< 0.09	< 0.12	< 0.15	Very low
Moderately sensitive	0.07 – 0.15	0.09 – 0.19	0.12 – 0.24	0.15 – 0.30	Low
Moderately tolerant	0.15 – 0.34	0.19 – 0.45	0.24 – 0.56	0.30 – 0.70	Medium
Tolerant	0.34 – 0.63	0.45 – 0.76	0.56 – 0.96	0.70 – 1.18	High
Very tolerant	0.63 – 0.93	0.76 – 1.21	0.96 – 1.53	1.18 – 1.87	Very high
Generally too saline for crops	> 0.93	> 1.21	> 1.53	> 1.87	Extreme

Sourced: Shaw, 1999.

Sodicity Rating Based on ESP

Sodicity Rating	Exchangeable Sodium Percentage (ESP)
Non-sodic	0 – 6%
Marginally sodic to sodic	6 – 14%
Strongly sodic	>14%

Sourced: Hazelton and Murphy, 2007.

Guidelines for Some Element Soil Concentrations Necessary for Satisfactory Vegetative Growth

Element	Extract Method	Range below which deficiencies identified	Range above which toxicities identified	Remarks	References
Nitrate	KCl	20 – 60 mg kg ⁻¹		Leaf analysis is thought to be a better guide than soil concentrations to deficiencies	(Dickson <i>et al.</i> 1993; Menzel <i>et al.</i> 1992; Strong 1990; Taylor <i>et al.</i> 1988)
Phosphorus	0.5 M NaHCO ₃	10 – 30 mg kg ⁻¹		For soil P results to be useful, they must be correlated to crop yield or growth responses to increasing soil P availability. Phosphorus buffering capacity is known to strongly influence availability of P	(Bruce and Bruce 1972; Charman 2000b; Moody and Bolland 1999; Rayment <i>et al.</i> 1977)
Potassium	1 M NH ₄ Cl	0.3 – 0.5 meq 100g ⁻¹		Potassium buffering capacity is known to strongly influence the availability of K	(Charman 2000b; Doll and Lucas 1973; Gourley 1999; Standley 1981)
Calcium	1 M NH ₄ Cl	0.5-1.4 meq 100g ⁻¹		Ratios of Ca:Mg in exchangeable form of 5:1 to 1:1 are desirable for good plant production	(Armour <i>et al.</i> 1985; Charman 2000b; Kingston and Aitken 1996)
Magnesium	1 M NH ₄ Cl	0.1 - 0.3 meq 100g ⁻¹		Texture influences the deficiency range, with Mg ²⁺ deficiencies at >0.2 cmol ₍₊₎ kg ⁻¹ in sandy soils or >0.5 cmol ₍₊₎ kg ⁻¹ in clay soils. A K:Mg ratio of <0.4 is desirable for adequate magnesium nutrition	(Aitken and Scott 1999; Charman 2000b)
Aluminium	0.01 M CaCl ₂		>3 mg kg ⁻¹	Soluble aluminium concentration increases with decreasing pH, decreasing organic matter levels and increasing soluble salt levels	(Charman 2000b; Dolling <i>et al.</i> 1991; Geeves <i>et al.</i> 1992; Helyar and Conyers 1994; Horsnell 1995)
Chloride			200 – 600 mg kg ^{-1*}		(Bruce and Rayment 1982)

Notes: * indicates plant growth can be retarded where concentrations exceed this range.



Appendix E

Land Suitability Classification Criteria



Suitability for Rainfed Broadacre Cropping

Limitation	Land suitability class				
	1	2	3	4	5
Water availability (See Table 1.3)	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 <0.1 mS/cm or Rootzone CI <300 ppm	Rootzone EC 0.15-0.3 mS/cm or Rootzone CI 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm or Rootzone CI 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm, or Rootzone CI 900-1500 ppm	Rootzone EC >1.2 mS/cm or Rootzone CI ≥1500 ppm
Rockiness	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	10-20% coarse surface gravel and rock outcrop	20-50% surface cobble (6-20 cm diam.) and rock outcrop	50-90% surface cobble and rock outcrop, or 20-50% stone and boulders (>20 cm diam.)	>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 surrounded by mounds)	Melonholes 30-60 cm deep cover <20% surface area or Melonholes >60 cm deep cover <10% surface area	Melonholes 30-60 cm deep cover 20-50% of surface area or Melonholes >60 cm deep cover 10-20% surface area	Melonholes 60-100 cm deep cover 50 % surface area	Melonholes at least 100 cm deep cover 50% 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 low-lying 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 non-sodic 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 non-sodic 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)



Suitability For Beef cattle Grazing

Limitation	Land suitability class (see Table 2.4)				
	1	2	3	4	5
Water availability (See Table 1.3)	PAWC >125 mm	PAWC 100-125 mm	PAWC 75-100mm	PAWC 50-75 mm	PAWC ≤50 mm
Nutrient deficiency	Brigalow, gidgee, blackwood or softwood scrub soils and former scrub soils <u>with</u> Bicarbonate P >10 ppm	Eucalypt vegetation and downs <u>with</u> Bicarbonate P >10 ppm	Other soils with Bicarbonate P 5-10 ppm <u>except</u> 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, <u>with</u> Bicarbonate P 5-10 ppm, <u>or</u> Bicarbonate P ≤4 ppm	
Soil physical factors	Cracking clays with very fine self-mulch (peds <2 mm), <u>or</u> Rigid soils with a loose, soft or firm surface when dry	Cracking clays with fine self-mulch (peds 2-10 mm), <u>or</u> 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 <u>or</u> Rootzone Cl <300 ppm	Rootzone EC 0.15-0.3 mS/cm <u>or</u> Rootzone Cl 300-600 ppm	Rootzone EC 0.3-0.9 mS/cm <u>or</u> Rootzone Cl 600-900 ppm	Rootzone EC 0.9-1.2 mS/cm <u>or</u> Rootzone Cl 900-1500 ppm	Rootzone EC >1.2 mS/cm <u>or</u> 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 <u>or</u> 5.0-5.6	8.0-9.0 <u>or</u> 4.5-5.0	9.0-10.0 <u>or</u> 4.0-4.5	>10.0 <u>or</u> < 4.0
ESP (10cm)% Exchangeable Sodium Percentage	<5.0	5-10	10-15	15-30	>30
Wetness	Undulating terrain or elevated plains	Low-lying level plains, <u>or</u> Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface, <u>or</u> Non-sodic rigid soils with coarse pale grey and yellow mottles within 50 cm of the surface	Shallow seasonal and permanent swamps		Permanent lakes and deep swamps
Topography				Many deep gullies make cultivation for sowing pastures impractical, <u>or</u> 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 <u>or</u> Slopes <3% on all other soils	Slopes 1-3% on sodic rigid soils <u>or</u> Slopes 3-6% on cracking clays, <u>or</u> Slopes 3-12% on non-sodic rigid soils	Slopes 3-6% on sodic rigid soils <u>or</u> Slopes 6-9% on cracking clays, <u>or</u> Slopes 12-20% on non-sodic rigid soils	Slopes 6-12% on sodic rigid soils <u>or</u> Slopes 9-15% on cracking clays <u>or</u> 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, <u>or</u> Queensland bluegrass grasslands, <u>or</u> Mountain coolabah, bloodwood and ironbark open woodlands	Brigalow, gidgee or blackwood scrub with melonholes, <u>or</u> Box and ironbark woodlands without wattle understorey, <u>or</u> Coolabah woodlands on flooded country		Eucalypt woodlands with wattle understorey <u>or</u> Broad-leaved teatree woodlands	



Appendix F

Land Suitability Assessment Tables



Land Unit 1: Vertosols on Low Lying Areas

Limitation	Land Quality	Land Suitability Class	
		Broadacre Cropping	Grazing
Water availability	120-150 mm	2	1
Nutrient deficiency	P: >10 ppm, Brigalow vegetation community	1	1
Soil physical factors	Cracking clays with coarse self mulching peds >20 mm	4	3
Soil workability	Cracking clays with coarse self mulch > 10 mm	3	NA
Salinity	EC of root zone 0.085 – 0.8 dS/m; Cl: 11-820 ppm	3	3
Rockiness	Coarse surface gravel (> 6 cm diameter) and rock outcrop <10%	1	1
Micro relief	Melon holes < 0.3-0.6m deep across <10% of the surface.	2	1
pH	7.4-9.2	NA	3
ESP upper 0.1m	<5.0	NA	1
Wetness	Low-lying level plains with melon holes covering <25% of the surface	2	2
Topography	Occasional deep gullies impede cultivation slightly	2	1
Water erosion	Slopes 1-3% on melon holes clays	2	1
Flooding	Rare flooding	2	2



Land Unit 2: Vertosols on Undulating Terrain

Limitation	Land Quality	Land Suitability Class	
		Broadacre Cropping	Grazing
Water availability	90-125 mm	3	2
Nutrient deficiency	P >10 ppm, Brigalow vegetation community	1	1
Soil physical factors	Cracking clays with self mulching peds 10-20 mm	3	2
Soil workability	Friable cracking clay soils	1	NA
Salinity	EC of root zone < 0.1 to 0.45 dS/m	2	2
Rockiness	Coarse surface gravel (> 6 cm diameter) and rock outcrop <10%	1	1
Micro relief	Minor melon holes	2	1
Soil pH	7.6-9.1	NA	3
ESP upper 0.1m	<5.0	NA	1
Wetness	Undulating terrain or elevated plains	1	1
Topography	Occasional deep gullies impede cultivation slightly	2	1
Water erosion	Slopes <3% on cracking clay soils	2	1
Flooding	No flooding	1	1



Land Unit 3: Sodosols on Undulating Low Hills

Limitation	Land Quality	Land Suitability Class	
		Broadacre Cropping	Grazing
Water availability	50-75 mm	5	4
Nutrient deficiency	P: <5-10 ppm, K: <0.3 meq/100g	3	3
Soil physical factors	Rigid soils with a loose, soft or firm surface when dry.	1	1
Soil workability	Rigid soils with a loose, soft or firm surface when dry.	1	NA
Salinity	EC of root zone 0.3 - 0.9 dS/m	3	3
Rockiness	Coarse surface gravel (> 6 cm diameter) and rock outcrop <10%	1	1
Micro relief	No melon holes	1	1
pH	5.5-9.0	NA	2
ESP upper 0.1m	5.0 – 10	NA	2
Wetness	Undulating terrain or elevated plains	1	1
Topography	Many deep gullies reduce arable land area < 33%	3	1
Water erosion	Slopes >3% on sodic rigid soils	5	3
Flooding	No flooding	1	1



Land Unit 4: Sodosols on a Flood Plain with Secondary Rudosols

Limitation		Land Quality	Land Suitability Class	
			Broadacre Cropping	Grazing
Water availability	75-125 mm		3	3
Nutrient deficiency	P: >10 ppm, K: >0.3 meq/100g		1	2
Soil physical factors	Rigid soils with a hard setting surface when dry		3	2
Soil workability	Rigid soils with a hardsetting surface when dry		2	NA
Salinity	EC of root zone 0.01 - 0.82 dS/m; Cl <10-300ppm		2	2
Rockiness	Coarse surface gravel (> 6 cm diameter) and rock outcrop <10%		1	1
Micro relief	No melon holes		1	1
pH	5.8-9.0		NA	3
ESP upper 0.1m	<5.0		NA	1
Wetness	Low lying plains		2	2
Topography	Gully dissection reduces arable area		4	1
Water erosion	Slopes 0.5-1% on sodic rigid soils		2	2
Flooding	Infrequent flooding		3	2



Land Unit 5: Dermosols and Vertosols on Undulating Terrain

Limitation	Land Quality	Land Suitability Class	
		Broadacre Cropping	Grazing
Water availability	75-100 mm	4	3
Nutrient deficiency	P >10 ppm, K >0.3 meq/100g	1	2
Soil physical factors	Rigid soils with a loose, soft or firm surface when dry	1	1
Soil workability	Rigid soils with a loose, soft or firm surface when dry	1	NA
Salinity	EC of root zone 0.15 - 0.3 dS/m	2	2
Rockiness	Coarse surface gravel (> 6 cm diameter) and rock outcrop <10%	1	1
Micro relief	No melon holes	1	1
pH	6.5-8.6	NA	3
ESP upper 0.1m	<5.0	NA	1
Wetness	Undulating terrain or elevated plains	1	1
Topography	Occasional deep gullies impede cultivation slightly	2	1
Water erosion	Slopes 4-6% on non sodic rigid soils	4	2
Flooding	No flooding	1	1



Land Unit 6: Tenosols and Rudosols Adjacent to Intermittent or Permanent Watercourses

Limitation	Land Quality	Land Suitability Class	
		Broadacre Cropping	Grazing
Water availability	>150 mm	1	1
Nutrient deficiency	P: >10 ppm; Eucalypt woodlands	1	2
Soil physical factors	Rigid soils with a loose or firm surface when dry	1	1
Soil workability	Rigid soils with a loose or firm surface when dry	1	NA
Salinity	EC of root zone 0.01 - 0.3 dS/m;	1	1
Rockiness	<10% surface gravel (> 6 cm diameter) and rock outcrop <10%	1	1
Micro relief	No melon holes	1	1
pH	6.8-7.7	NA	2
ESP upper 0.1m	<5.0 ¹	NA	1
Wetness	Low lying plains	2	2
Topography	Terrace slopes reduce arable area for sowing pastures	4	3
Water erosion	Slopes <3% on non rigid soils	3	1
Flooding	Infrequent flooding	4	2

¹ The ESP of the A1 horizon was not assessed for this small land unit. ESP results for the 2 horizon were included as they are considered representative



Appendix G

Land Quality Definitions



Land Qualities used in the assessment are based on the *Land Suitability Assessment Techniques* (EPA, 1995); *Guidelines for Agricultural Land Evaluation in Queensland*, (DPI, 1990), and *Land evaluation standards for land resource mapping* (DoA, 2005).

Water availability

Soils with very low water storage are likely to limit crop yields in most seasons, whilst those with low water storage are likely to limit yields in low rainfall seasons or where distribution of the rainfall is irregular. Poor ground cover associated with low yields increases the risk of wind and water erosion as well as contributing to recharge leading to the development of salinity. Deep-rooted crops such as lupins are an option on deep sands with low soil water storage.

On soils with very low water storage, pastures are less productive and dry off rapidly. Poor ground cover increases the risk of wind and water erosion as well as contributing to recharge leading to the development of salinity.

Nutrient deficiency

Plants and animals require adequate, but not excessive levels of nutrients to maintain growth. Periods of inadequate supply may cause reductions in plant yield, particularly during critical periods such as flowering or fruiting. Livestock production may be limited by either reduction in pasture growth or nutritive value caused by low soil nutrients.

The addition of fertilisers is an accepted practice for many landuses where inherent fertility between soil types are not considered important enough to downgrade suitability. However nutrient deficiency may be used to downgrade suitability where returns may be too low or unreliable to justify the application of fertilisers in more extensive land uses such as grazing or broad acre rainfed cropping in marginal areas.

Soil physical factors

Surface soil structure decline, subsurface acidification, subsurface compaction and water repellence all affect pasture production but are rarely prohibitive. Management practices to control and alleviate these problems have been developed. However wide scale adoption has yet to be achieved and land is still deteriorating in many areas. Adoption is more economic in higher rainfall areas where there is greater production per hectare.

Soil workability

Rock outcrops and large stones on or near the surface make cultivation difficult and can damage machinery. Heavy soils can also be hard to work, especially if they are sodic.

Salinity

Whilst crop tolerance to salinity varies it is the combination of salinity and waterlogging that has the greatest impact on crops. Management of affected areas can include increasing plant water use in recharge areas, improving site drainage and establishment of salt tolerant pastures.

On grazing land salinity can be a serious limitation to production while the establishment of low water use annual pastures contributes to development of salinity. Land with high to extreme surface salinity is generally unsuited to conventional grazing though some productivity from saltland pastures may be possible. Management of affected areas can include increasing plant water use in recharge areas, improving site drainage and establishment of salt tolerant pastures.



Rockiness

Stony or rocky soils influence soil properties such as infiltration, erosivity, susceptibility to compaction, and soil water storage, as well as causing an impedance to cultivation and damage to machinery. Surface scree or outcrops of large stones limit production by reducing the surface area available for plant growth and may lead to difficulties in mustering livestock and fencing.

Microrelief

The presence of gilgai, small gullies, or small differences in topography will increase the amount of levelling and earthworks required for that for cultivation alone. Melonholes greater than 60 cm deep over 50% of the area can result in the land being unsuitable to cultivation.

pH

Extremes of pH affect the availability of nutrients resulting in deficiencies and/or toxicities that adversely affect production. Management options are limited to growing tolerant crops or the use of lime to increase the pH of acidic soils.

In pasture highly acidic soils reduce production of most legume species. Management options include growing tolerant species and using acid-tolerant Rhizobia and/or applications of lime. Medics can be selected for highly alkaline soils.

Exchangeable Sodium Percentage of the Upper 0.1m

A soil is considered sodic when sodium reaches a concentration where it starts to affect soil structure, which in Australian soils is commonly at exchangeable sodium percentage (ESP) is > 6% (Isbell, *et al* 1983).

Wetness

Waterlogging reduces crop yields especially if it occurs early in crop development or when the temperatures are higher in spring. Management options include cropping on raised beds, improved site drainage and/or growing tolerant crops such as oats or faba beans.

Waterlogging can limit pasture production with varying degrees of severity. The effects of waterlogging are often far from obvious. Mildly waterlogged pastures can look healthy but have significant yield reductions. Management options include the uses of waterlogging tolerant pasture species and the construction of surface drains.

Topography

The cost of earthworks to level land sufficiently to enable cultivation or furrow irrigation may make the land use uneconomic. Slopes greater than 20% are regarded as unsafe for machinery use and therefore regarded as unsuitable. The presence of many gullies may result in discontinuities make cultivation and sowing of pastures impracticable, whilst greatly dissected terrain (i.e. >75% of the area) may prevent adequate herd management.

Water erosion

Water erosion can reduce crop yields; result in the loss of nutrients and reduce productive potential. As a general rule, the risk of water erosion is likely to become limiting on slopes with gradients in excess of 10 per cent. Management options include the adoption of no-till systems, sowing on the contour and installing banks to control the length of slope and/or reduce waterlogging.



Water erosion and *Wind erosion* generally lead to a slow decline in productivity, though extreme events can have a more immediate impact. Management can include excluding stock from highly susceptible areas, maintaining ground cover through control of stocking rates, the construction of earthworks to control runoff and the establishment of windbreaks.

Flooding

Floods can damage crops greatly reducing the yield. Areas prone to flooding also have a higher risk of water erosion. For grazing land uses flood hazard is only severe if flooding would affect pasture production or endanger stock.

Vegetation regrowth

After clearing, some native species will rapidly re-establish to a density greater than before. Where cultivation and cropping is practiced this regrowth is controlled; however in some extensive grazing land uses the cost of timber clearing and regrowth is considered significant to determining suitability.



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F	G Kopittke	J Loi.	K. Woods	*On File	09/2/12 20/02/12
G	G Kopittke	J Loi.	K. Woods	*On File	29/02/12

Appendix I - Sonoma PRC Plan Community Consultation Register



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Sonoma Coal Mine Progressive Rehabilitation and Closure Plan Consultation Register

Date	Interest Group	Interest Type	Interest Description	Consultation Details	Consultation Outcomes
2005-2006	Mr Chris Wallin	Direct – Underlying / Adjacent Landholder	Landholder: - Lot 1 on SP190745 - Lot A on AP2839	- Consultation during SCM EIS process - Public notification of SCM EIS. - Interested party submissions to EIS - Proponent responses to submissions documented in Addendum to EIS. - Compensation agreements with relevant parties developed to enable the granted of the SCM MLs	- EIS finalised via EIS Assessment Report. - EA issued, with the community consultation used to inform the rehabilitation outcomes in the EA (the primary LOD) - Compensation agreements finalised for grant of the SCM MLs. - SCM MLs subsequently granted - Subsequent to the approval of the EIS, and grant of the ML and EA, there have been no changes to the PMLU and other land outcomes, as currently approved in the SCM LODs (EA and RMP), therefore the EIS consultation remains relevant.
	Mrs Amanda Rae Watts and Mr Shane Andrew Watts	Direct – Underlying / Adjacent Landholder	Landholder: - Lot 25 on SP190745		
	Whitsunday Regional Council	Direct – Adjacent Landholder	Landowner: - Lot A on AP2839		
	Bowen River Coal Pty Ltd	Land use – Adjacent Tenure Holder	Owner of adjoining Cows Coal Mine		
18/08/2021	Whitsunday Regional Council	Direct – Adjacent Landholder	Landowner: - Lot A on AP2839	Discussion including: - Proposed CCM/SCM Final Landform - CCM/SCM PMLU - WRC's future intentions for road reserve underlying CCM /adjoining SCM - Potential for future permanent road closure	WRC subsequently confirmed they have no intention of changing the existing use of the road reserve.

Date	Interest Group	Interest Type	Interest Description	Consultation Details	Consultation Outcomes
27/06/2022	Shane Watts	Direct – Underlying / Adjacent Landholder	Landholder: - Lot 57 on HT379	- Discussed current and proposed final landforms and post-mining land-use - Discussed the development of a written agreement for the retention of infrastructure (dams, haul roads and hardstand areas) within the Sonoma property	Agreed that a written agreement for infrastructure retention would be proposed by QCS for further discussion (no agreement in place to date)
29/06/2022	Mr Chris Wallin	Direct – Underlying / Adjacent Landholder	Landholder: - Lot 1 on SP190745 - Lot A on AP2839	- Overview of SCM PRC Plan, PMLU and PRCP Schedule.	Nil
29/06/2022	Bowen River Coal Pty Ltd (Mr Chris Wallin – Managing Director)	Land use – Adjacent Tenure Holder	Owner of adjoining Cows Coal Mine	- Overview of SCM PRC Plan, PMLU and PRCP Schedule.	Nil

Appendix J - Sonoma Coal Project – Overburden Assessment Report (Parsons Brinckerhoff, 2006)

Sonoma coal project - Overburden assessment report

May, 2006

Q Coal Pty Ltd



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Date: 31/5/2006.....

Distribution: Q Coal Pty Ltd.....

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Glossary

Term	Meaning
Alluvium	Any stream laid sediment.
ANZECC	Australian and New Zealand Environment and Conservation Council.
Atterberg limits	A set of arbitrarily defined boundary conditions in soils related to water (moisture) content. The limits are as follows: - shrinkage limit (SL) – the moisture content from which a soil will continue to dry out without further change in volume (rarely determined) - liquid limit (LL) – the moisture content at which the soil will flow under a specified small disturbing force (defined by the conditions of the test) - plastic limit (PL) – the moisture content at which the soil can be deformed plastically. It is defined as the minimum water content at which the soil can be rolled into a 3 mm thick thread - plasticity index (PI) – the range of moisture content over which the soil is in the plastic condition. $PI = LL - PL$.
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.
Backfill	Fill placed in an excavation.
Batter (rake)	- the uniform side slope of walls, banks, cuttings - the degree of such slope, usually expressed as a ratio of x horizontal to 1 vertical in distinction from grade.
Bearing capacity	The load per unit area which a supporting medium can carry without failure or unacceptably large settlements.
Bedrock	A general term meaning rock of considerable thickness and extent underlying relatively soft or variable surface strata.
Berm	A ledge formed at the top or bottom of an earth slope or at some intermediate level.
Borehole	A hole produced in the ground by drilling or driving.
Bored pile	A pile formed by casting concrete into a hole bored in the ground.
California bearing ratio (CBR)	A measure of the bearing capacity of a soil obtained from a standard soil penetration resistance test.
CHPP	Coal handling and preparation plant.
Clay	A natural earthy material possessing plastic properties and consisting of fine particles of complex hydrous silicate smaller than 2 μm .
Cobble	A stone usually between 60 mm and 200 mm in size.
Cohesion	The ability of a material to resist, by means of internal forces of attraction, the separation of its constituent particles.
Compaction (compact)	Reduction in volume of a material by inducing closer packing of its particles by rolling, tamping, vibrating or other processes to reduce the air voids content.
Compaction factor/ratio	Ratio of the final volume of the soil to the initial volume, after subjection to compaction of standard form or according to field practice.
Cone penetration test	A test in which the effort to push or drive a standard steel cone into soil at a controlled rate is used as a measure of certain soil properties.
Consolidation	The process by which soil reduces in volume under load over a period of time due to drainage of water from the voids.
Core	- a piece inserted into a mould for concrete before casting, to form a hole for a bolt, prestressing cable, or other use - a cylinder drilled out of soil, concrete, rock or other material for testing or other

Term	Meaning
	purposes.
Cut	- the depth from natural surface of the ground to the subgrade level - the material excavated from a cutting.
Emerson crumb dispersion test	This test determines dispersion characteristics of a soil in distilled water. Soils are divided into seven classes on the basis of their coherence in water with one further class being distinguished by the presence of calcium-rich minerals. The test is carried out as per the relevant Australia Standard.
Emerson number	Result as determined from the emerson crumb dispersion test.
Factor of safety	- the ratio of load or stress causing failure to the design load or stress - the ratio of the load causing failure to the actual load.
Feldspar	A group of abundant rock forming minerals of the general formula $MAI (Al, Si)_3O_8$, where M can be potassium (K), sodium (Na), calcium (Ca), barium (Ba), rubidium (Rb), strontium (Sr) or iron (Fe).
Fill (filling)	- the depth from the subgrade level to the natural surface - that portion of a road where the formation is above the natural surface - the material placed in an embankment.
Footing	The widening at the base of a structure to spread the load to the foundation material.
Formation	- the surface of the finished earthworks, excluding cut or fill batters - type of a geological stratigraphic unit.
Foundation	The soil or rock upon which a structure rests.
Geomorphic	Pertaining to the form of the earth or its surface features.
Geotextile (filter fabric, geofabric)	A synthetic cloth used for various purposes including embankment reinforcing and stabilisation, as a filter layer between dissimilar materials and as a strain absorbing membrane between paving layers.
Gravel	A mixture of mineral or lithic particles occurring in natural deposits, usually passing a 75 mm sieve and with a substantial portion retained on a 4.75 mm sieve.
Groundwater	The water below the water table.
Holocene	The most recent epoch of geological time.
Hydrology	To do with the waters of the earth and its atmosphere.
Hydrous silicate	Formed from silicon and oxygen combined with various elements, classified by their crystalline structures and containing or combined chemically with water molecules.
Indurated	Said of a soil or rock hardened or consolidated by pressure, cementation or heat.
Interbedded	Said of beds lying between or alternating with others of different character, especially said of rock material laid down in sequence between other beds.
Internal friction angle	Shear strength parameter of a soil representing the angle of shearing resistance.
Iron pyrite	Or fool's gold, mineral composed of iron sulphide, FeS_2 , the most common sulphide mineral.
kPa	Kilopascal. A unit of pressure equal to 1,000 pascals.
Leachate	Water that has dissolved soluble substances from rock or soil.
Linear shrinkage	The percentage decrease in length of a soil sample in a mould when oven dried from the liquid limit state.
Liquid limit	See Atterberg limit(s).
Lugeon	The unit expressing the water acceptance of one litre per N.m per minute obtained during a packer test at a pressure of 1,000 kN/m ² flow.
Matrix	The soil or rock in which something such as a fossil, crystal, or mineral is embedded.
Maximum dry density	The greatest dry density of a soil obtained when a soil is compacted in a specified manner

Term	Meaning
(MDD)	over a full range of moisture content. The moisture content at which this density is reached is called the optimum moisture content. Two amounts of compactive effort are commonly specified, referred to as standard and modified.
Moisture content (water content)	The quantity of water which can be removed from a material by heating to 105° C till no further significant change in a mass occurs, usually expressed as a percentage of the dry mass.
NATA	National Association of Testing Authorities Australia.
Optimum moisture content	That moisture content of a soil at which a specified amount of compaction will produce the maximum dry density under specified test conditions.
Outcrop	The exposure, at the surface, of a material (usually rock).
Overburden	The soil or other mineral matter which has to be removed to gain access to the underlying material.
Particle size distribution (grading)	The quantities of the various particle sizes present in a soil or other material, expressed as a percentage of the whole.
Penetration test	A test carried out with a standard instrument to determine the load bearing capacity of soil.
Permeability	The property of a material by virtue of which a fluid such as water can pass through it.
Plasticity index	The numerical difference between the value of the liquid limit and the value of the plastic limit of a soil.
Point load index strength (I _s (50)) test	Method of determining rock strength by crushing core samples in a specialised test apparatus. I _s (50) can be correlated with UCS.
Pore water pressure	The pressure of the water in the voids of a soil.
RQD	A measure of fracture density in rock.
Quartz	Crystalline silica (SiO ₂), an important rock forming mineral. It is the commonest gangue (waste) mineral of ore deposits, forms the major proportion of most sands, and has a wide distribution in igneous (especially granitic), metamorphic and sedimentary rocks.
Quaternary sediments	Sediments deposited during the geological period of time from the present to two million years ago.
Retaining wall	A wall constructed to resist lateral pressure from the adjoining ground, or to maintain in position a mass of earth.
Sand	Natural mineral particles which will pass through a defined sieve (normally 4.75 mm or 2.36 mm) and which are free of appreciable quantities of clay and silt.
Scour	The erosion of a material by the action of flowing water.
Seismic refraction survey	Method of determining general soil and rock types based on the refraction of seismic waves as they cross the boundaries between different materials.
Seismic velocity	The rate of propagation of an elastic wave through a rock mass, usually measured in km/second. The wave velocity depends on the type of wave, as well as the material through which it travels.
Settlement	A downward movement of the soil or of the structure it supports (see also differential settlement).
Shear/crushed zones	Zone along which movement has occurred within the rock mass which has resulted in shearing or crushing of the surrounding rock.
Silt	All material intermediate in particle size between sand and clay. It is usually non-plastic.
Site investigation	The examination of all those characteristics of a site which might affect the planning, design, construction and operation or performance of any engineering works on the site. Site investigation is not limited to determining subsurface condition but includes consideration of other aspects such as access, drainage, liability to flooding, availability of public utility services and construction materials.
Slope	the inclination of a surface with respect to the horizontal, expressed as rise or fall in a certain longitudinal distance. An inclined surface.

Term	Meaning
Sodicity	A characteristic of soils containing an amount of exchangeable sodium that is adversely affecting soil stability, plant growth and soil/land use.
Soil (earth)	- that part of the upper weathered layer of the earth's crust which can support plant growth - any naturally occurring loose or soft deposit forming part of the earth's crust and resulting from weathering or breakdown of rock formation or from the decay of vegetation.
Soil profile	The profile of soil encountered below the natural ground surface.
Spos	Peroxide oxidisable sulphur.
SPT	Standard penetration test.
Standard penetration test (SPT)	A standard split spoon sampler, about 50 mm in diameter, is driven into the ground by blows from a drop hammer weighing 64 kgs and falling 0.76 m. The sampler is driven 0.15 m into the soil at the bottom of a borehole, and the number of blows (<i>N</i>) required to drive it a further 0.3 m is then recorded. Although the test is entirely empirical, considerable experience with its use has enabled a reasonably reliable correlation to be established between the <i>N</i> value and certain soil properties.
Subgrade	The trimmed or prepared portion of the formation on which the pavement is constructed.
Subgrade reaction modulus (k)	Modulus used for simulating elastic soil properties for use in structural design.
Subsurface profile	The profile of soil and rock encountered below the natural ground surface.
Test pit	An excavation for examination of subsurface conditions.
Toe	- the part of the base of a retaining wall which is on the side remote from the retained material - the tip of a pile - the base of an earthen slope.
Topsoil	The top layer of soil that supports vegetation.
Triaxial test	A test to determine the stress-strain properties of a pavement material in which a cylindrical specimen of the material is subjected to a three dimensional stress system, and the axial strain is related to the applied stress.
Unconfined compressive strength (UCS)	The strength of a material determined in a triaxial test apparatus when the confining pressure is zero (i.e. unconfined).
Voids	The spaces within the bulk of material not occupied by solid matter.
Voids content	The ratio of the volume of voids to the total volume of the material, expressed as a percentage.
Voids ratio	The ratio of the volume of voids to the solid volume of a material.
Water table	The natural level at which water stands in a borehole, well, or other depression, under conditions of equilibrium.
Soil horizons	O – Surface layer of organic materials in various stages of decomposition. A – Top layer of soil (topsoil) with a high level of organic matter, a darker colour and maximum biological activity relative to the horizons underneath. A2 – Similar to A but paler in colour, poorer in structure and less fertile, may be bleached (loss of colour). B – Layer below A, finer texture (more clay) than A, more dense and stronger colour. Strong development because of accumulation of silicate clays, and/or iron, aluminium, organic material leached from above. C – Weathered materials below B, unaffected by biological processes.
Duplex soil	Where the texture of the surface horizons is noticeably different (coarser) than the clayey (finer) B horizon.

1. Introduction

1.1 Summary of technical paper

An overburden assessment was carried out for the Sonoma coal project (SCP) as part of the environmental impact statement investigations. The assessment was undertaken to define overburden characteristics relevant to environmental management mine planning and re-usability potential of overburden materials.

The investigation comprised field work, review of existing data, laboratory testing and analysis of data. The field work for the investigation comprised drilling and sampling of 4 boreholes located within SCP site.

In general terms the boreholes of the current and previous investigations encountered the following geological units:

- Tertiary/Quaternary age clay, silt and silty, clayey and/or gravely sand was encountered from surface to between 13 m and 19.5 m depths
- Permian age claystone, mudstone, carbonaceous mudstone, siltstone and sandstone was encountered as distinct layers or interbedded sequences underlying the Tertiary age sediments. The sandstones ranged from lithic-feldspathic, quartz-feldspathic to tuffaceous. The degree of weathering, strength and chemical characteristics of these rocks varies both laterally and with depth.
- acid to intermediate intrusions forming localised sills and dykes.

Previous soil and geotechnical investigations also encountered clayey and sandy near-surface soils throughout the site.

Laboratory test results indicated that all overburden samples have negative net acid producing potential meaning that the maximum theoretical acid production would be less than the theoretical capacity of the rock to neutralise the produced acid.

Carbonaceous mudstone and layers adjacent to coal seams were noted to contain minor pyrite and/or siderite. These pyritic layers could produce some acid drainage if they are concentrated near the surface of the spoil.

It is suggested that layers of coal roof and floor material, and any material that is visually assessed at the time of mining as containing pyrite, should not be concentrated near the surface of the spoil stockpile.

Alluvial soils encountered were mainly of low to moderate salinity ($EC < 600 \mu S/cm$, intermediate pH ($< pH 9$) value and ESP values less than 15 and are considered suitable for spoil stockpile capping material.

The breakdown products of the weathered Permian rocks are estimated to have intermediate to moderate salinity and sodicity and moderately high pH value. They are considered as suitable for spoil stockpile capping material with moderate erosion potential and moderate growth medium characteristics for re-establishment of vegetation. Spreading of topsoil and re-shaping of spoil stockpiles to reduce potential for concentrated runoff would reduce the erosion potential of these soils.

Fresh Permian age claystone, mudstone, siltstone and labile sandstone encountered to about 70 m depth are considered as less suitable for spoil stockpile capping material than

sandstone. High alkalinity of rocks from below about 70 m depth is indicating potential for dispersion that was also confirmed by ESP values. Potentially highly dispersible soils are not considered suitable for use as spoil stockpile capping layer due to their high erosion potential, even when covered by re-spread topsoil.

Preliminary geomaterial reconnaissance results indicate that clayey materials considered suitable for levee and dam embankment are distributed throughout the alluvial plains of both Coral Creek in the northern portion of the site and the tributaries of Two Mile Creek in the southern and western part of the site.

Tertiary/Quaternary age clayey sands and sandy clays and weathered or fresh Permian age siltstones and sandstone are considered suitable as potential road and rail embankment and pavement materials provided selected excavation is possible and practical. The use of these materials is generally restricted to bulk fill (formation level embankment) and sub-base due to their contamination by weak materials, inconsistent quality and low California Bearing Ratio (CBR).

1.2 Background

This document presents the results of an overburden assessment at Sonoma coal deposit for the proposed (SCP).

The project will comprise an open cut coal mine, mine infrastructure area, water management structures and other auxiliary structures. It is proposed that mining will be carried out by truck and shovel method.

Overburden assessment was undertaken:

- to define overburden characteristics relevant to environmental management of spoil stockpiles
- to enable optimisation of mine planning and mining operations to effectively manage spoil placement
- to define constraints related to spoil properties that will impact on re-usability potential of spoil materials.

The study comprised a review of existing geotechnical and overburden data, result of drilling, provided by Energy Minerals logging and by sampling of four (4) boreholes and laboratory testing. Based on the information obtained, comments and recommendations are made in this report on:

- dispersion and erosion potential of various overburden materials
- acid generation potential of overburden materials
- suitability of various overburden materials as capping layer for the spoil stockpiles.

The overburden assessment was carried out using the principles and methods recommended in 'Land suitability assessment techniques' (Department of Minerals and Energy, 1995).

1.3 Previous investigations

Previous investigations that provided information about overburden characteristics at the site include:

- Sonoma Project – Railway spur and geomaterial assessment, geotechnical report, PB, 2005.
- Sonoma Project – Infrastructure, Preliminary geotechnical investigation, PB, 2006.
- Sonoma Project – Additional geotechnical report, PB, 2006.
- Environmental Impact Statement, Version February 2006, ELP, 2006
- Coal exploration boreholes, Energy Minerals, 2006

Previous reports were reviewed and selected data was re-interpreted to assist in overburden assessment.

2. Site description and regional geology

2.1 Site description

The SCP is located approximately 6 km south of Collinsville in Central Queensland. The proposed mine site is located west of Collinsville - Mt Coolon Road and south of Coral Creek. The proposed rail spur would join the main Collinsville-Newlands railway line on a grazing property Sonoma but the southern section of the spur and the rail loop is on Belmore Downs. The ROM, the first stage of the co-disposal dam, the MIA and the CHP are all proposed to be located south of Belmore Gully. Belmore Gully, and another unnamed gully further north, are the tributaries of Two Mile Creek and join the creek west of the project site. The provisional layout of the proposed pits and structures is shown on Drawings: SK-001 and SK-002 in Appendix A.

The topography of the site comprises the following terrain elements:

- A flat-top spur, forming a topographic high, extends north-west of the proposed mine access road intersection with Collinsville - Mt Coolon Road. The proposed product pad, coal stacker and sizing station is located on this spur, while the MIA is proposed to be located on its western slopes.
- To the north, the spur is bounded by the floodplain of Belmore Gully. The transition between the 2 units in the northern portions of the proposed rail loop is very distinct. To the west, the lower slopes of the spur are very gently sloping and the transition into the floodplain appears to be gradual.
- The floodplains of Belmore Gully and Coral Creek appear to be separated by a low ridge in the east, along the Collinsville - Mt Coolon Road, and join to form a generally low lying area in the west.

The bulk of the site was cleared of original vegetation and is now grazing land. Stands of regrowth vegetation forming open woodlands were noted throughout the site.



Figure 2-1: General view of SCP area from the low ridge in the south-east of the site at the proposed rail loop. Note generally flat floodplain area with stands of open woodland in the background.

2.2 Regional geology

Reference to the Geological Survey of Queensland's 1:250,000 series Bowen sheet and previous investigations indicates that soils and rocks of SCP and surrounds are from 2 main geological units:

- Permian age Lizzie Creek Volcanics comprising basalt, andesite, agglomerate, lithic and tuffaceous sediments and minor acid volcanics. These rocks are mainly located to the east of the proposed mining areas.
- Permian age Blackwater Group sediments comprising siltstone, coal, lithic and quartzose sandstone, carbonaceous shale, pebble and cobble conglomerate, dolomitic and calcareous sandstones and tuff. The economic coal seams are located within the Moranbah Coal Measure sequence.

The field investigation confirmed the presence of these 2 units together with Tertiary/Quaternary age sand, gravel and sandy/clayey soils of inferred alluvial origin. Sedimentary rocks in parts of the spur at the western portion of the proposed rail loop are lateritised with accumulations of ferruginized siltstone fragments on the surface.

A detailed description of the lithology encountered at the borehole locations is described in Section 4.1 below and in Sections 3.4.4.4 and 4.7 of the EIS (ELP, 2006 February version).

3. Investigation methodology

The overburden assessment comprised fieldwork and laboratory testing. Locations of boreholes were selected based on existing exploration data and on locations of proposed mining and infrastructure elements. Laboratory testing program was carried out to determine chemical and physical characteristics of overburden materials relevant to mine spoil stockpile management and rehabilitation.

Details of borehole locations are shown on Figure SK-002 in Appendix A.

Borehole logs are attached in Appendix B. Detailed laboratory test result sheets are attached in Appendix C and described in Section 4.2.

3.1 Field work

The field work for the investigation was undertaken in April 2006 and comprised:

- drilling and sampling of 4 boreholes at SCP site

All field activities were supervised and all samples were delivered to PB by Energy Minerals Pty Ltd personnel.

3.2 Test bores

Overburden characterisation was based on assessment of samples from the following boreholes:

1. BR215 drilled to 64 m depth in the western central part of the site
2. PC138 drilled to 87 m depth in the northern part of the site
3. BR204 drilled to 150 m depth in the central part of the site
4. BR194 drilled to 129 m depth in the southern part of the site.

3.3 Laboratory testing

Selected soil and rock samples were tested in a NATA registered laboratory for particle size distribution and dispersivity in accordance to Australian Standard: *Testing of Soils for Engineering Purposes*, AS 1289; and chemical characteristics by validated analytical laboratory methods:

- Particle size distribution, (AS 1289. 3.6.1).
- Emerson Class number, (AS 1289.3.8.1).
- Conductivity (EC), pH and Cation Exchange Capacity (CEC) of soils, (Australian Laboratory Services "in-house" methods).
- Net acid generation at pH7 (NAG); pH after oxidation; Acid production potential (APP); Acid neutralising capacity (ANC); Net acid producing potential (NAPP); and Total S content of overburden.

Exchangeable sodium percentage (ESP) was also calculated from the above laboratory results.

4. Investigation results

4.1 Test bores

Overburden and interburden encountered in the assessed test bores of Energy Minerals current drilling program mainly comprised the following soil and rock types:

- Tertiary/Quaternary age clay, silt and silty, clayey and/or gravely sand was encountered from surface to between 13 m and 19.5 m depths.
- Permian age claystone, mudstone, carbonaceous mudstone, siltstone and sandstone was encountered as distinct layers or interbedded sequences underlying the Tertiary age sediments. The sandstones ranged from lithic-feldspathic, quartz-feldspathic to tuffaceous. The degree of weathering, strength and chemical characteristics of these rocks varies both laterally and with depth.
- Interburden (rocks between coal seams) material comprises the same rock types as the overburden.

Previous investigations also encountered acid to intermediate intrusions forming localised sills and dykes.

Thickness of the alluvial sequence and the depth of weathering within the SCP site are shown on Figure 3.9 and 3.10 in Section 3.4.4.4 of the EIS (ELP, 2006 February ver.).

4.2 Laboratory testing

Laboratory testing was undertaken to assess particle size distribution, dispersivity and physio-chemical characteristics of encountered soils and rocks.

4.2.1 Particle size distribution

Particle size distribution was determined on 6 soil samples. Results are shown in Table 4-1 and were used for soil classification and assessment of erosion potential.

Table 4-1: Particle size distribution results

Test location and depth (m)	Sieve size (mm) and accumulative % passing										Classification
	19.0	9.5	4.75	2.36	1.18	0.60	0.425	0.30	0.15	0.075	
PC138 (12)	100	99	92	81	73	65	56	49	41	36	Medium to coarse grained clayey sand
BR194 (14)	100	98	91	86	83	79	76	73	62	52	Sandy clay
BR204C (3)		100	98	96	95	92	91	88	76	63	Sandy clay
BR204C (6)		100	99	94	86	74	67	60	50	46	Medium grained clayey sand
BR204C (16)	100	91	84	78	72	65	61	57	47	39	Fine grained clayey gravely sand
BR215 (18)		100	98	96	93	90	87	81	60	47	Fine grained clayey sand

4.2.2 Emerson class number

Dispersion potential of soils is assessed by Emerson class number test. Classes 1 to 3 are considered dispersive, class 4 indicates the presence of carbonate or gypsum, classes 5 and 6 are considered non-dispersive, and classes 7 and 8 are non-slaking.

The Emerson class number test results are tabulated in Table 4-2:

Table 4-2: Emerson class number test results

Test location and depth (m)	Soil description	Emerson class number
BR194 (14)	Sandy clay	6
BR204C (3)	Sandy clay	5
BR204C (16)	Clayey gravely sand	6
BR204C (33)	Weathered siltstone	6
BR215 (6)	Sandy clay	2

4.2.3 Physio-chemical characteristics

Selected overburden and interburden samples were tested for acid drainage generating potential, actual acidity and electrical conductivity.

Acid mine drainage generating potential

The acid mine drainage generating potential of overburden material was assessed by comparison of the materials acid generating potential with its acid neutralising capacity. 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 with 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 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 measured acid producing potential (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 producer.

Total Sulfur (%)

Measure of the total sulfur content of the rock. Materials with more than 0.5% total sulphur are considered potentially acid producing materials.

Net acid generation (at pH 7) (NAG)

NAG differs from NAPP by measuring actual acid production and neutralisation of the rock and not the total theoretical potential.

Exchangeable sodium percentage (ESP)

Chemically exchangeable sodium can weaken the bonds between clay particles thus acts as a dispersing agent. Soils with ESP of more than 15% are considered highly dispersive and soils with ESP less than 5% are commonly considered as non-dispersive.

Cation exchange capacity (CEC)

A soil capacity to hold nutrients is estimated by CEC. Low values (below 5) are indicating that the soil is prone to leaching and therefore is likely to be a poor growth medium.

The summary of analytical test results is shown in Table 4-3 and Table 4-4.

Table 4-3: Acid generation and neutralisation potential test results

Sample	pH after oxidation	NAPP (kgH ₂ SO ₄ /t)	NAG (@pH7) (kgH ₂ SO ₄ /t)	ANC (kgH ₂ SO ₄ /t)	Sulphur (%)
BR194 (21 m)	11.1	-75.1	<0.1	75.1	<0.01
BR194 (34 m)	10.3	-35.7	<0.1	39.1	0.11
BR194 (61 m)	9.8	-71.7	<0.1	73.2	0.05
BR194 (90 m)	10.2	-50.5	<0.1	51.7	0.04
BR194 (106 m)	10.2	-49.3	<0.1	50.5	0.04
BR194 (129 m)	10.8	-57.0	<0.1	57.6	0.02
BR204C (33 m)	10.4	-86.8	<0.1	89.3	0.08
BR204C (42 m)	10.0	-59.2	<0.1	62.6	0.11
BR204C (61 m)	10.9	-80.6	<0.1	81.2	0.02
BR204C (72 m)	10.8	-66.2	<0.1	67.1	0.03
BR204C (100 m)	10.6	-69.2	<0.1	70.1	0.03
BR204C (107 m)	11.1	-75.8	<0.1	77.9	0.07
BR215 (21 m)	9.7	-39.8	<0.1	39.8	<0.01
BR215 (33 m)	9.9	-45.4	<0.1	47.2	0.06
PC138 (25 m)	10.9	-104	<0.1	105	0.02
PC138 (34 m)	10.8	-112	<0.1	113	0.03
PC138 (49 m)	10.8	-57.6	<0.1	59.1	0.05
PC138 (59 m)	8.2	-58.8	<0.01	61.2	0.08

Acidity and conductivity

Actual acidity and electrical conductivity was determined on selected overburden and interburden samples. The results shown in Table 4-4 are indicative of likely behaviour and suitability of the rocks and soils as spoil stockpile capping layers.

Table 4-4: Actual acidity, electrical conductivity, CEC and ESP test results

Sample	pH	Conductivity (μ S/cm)	CEC (meq/100g)	ESP (%)*
BR194 (14 m)	8.3	299	49.6	2
BR194 (21 m)	8.4	296	27.0	4
BR194 (34 m)	8.6	238	27.8	4
BR194 (61 m)	8.6	405	28.8	12
BR194 (90 m)	9.2	567	18.8	34
BR194 (106 m)	9.2	564	21.4	34
BR194 (129 m)	9.0	296	29.0	8
BR204C (3 m)	8.0	380	51.4	4
BR204C (6 m)	8.0	613	46.2	4
BR204C (16 m)	7.8	595	39.4	4
BR204C (33 m)	7.7	434	31.7	3
BR204C (42 m)	8.0	360	24.1	7
BR204C (61 m)	8.8	477	35.0	15
BR204C (72 m)	9.2	604	30.7	22
BR204C (100 m)	8.4	675	29.4	20
BR204C (107 m)	9.1	397	26.6	14
BR215 (6 m)	8.6	924	53.8	18
BR215 (18 m)	8.3	511	42.6	9
BR215 (21 m)	8.1	343	28.8	6
BR215 (33 m)	7.8	488	31.2	3
PC138 (12 m)	8.4	574	42.9	7
PC138 (25 m)	8.0	511	34.4	5
PC138 (34 m)	8.1	461	31.3	7
PC138 (49 m)	8.9	383	25.1	14
PC138 (59 m)	8.1	408	21.0	13

* Calculated from CEC results

Note:

Shaded results represent samples that are either excessively alkaline (pH > 9.0), contain excessive amount of dissolved solids (i.e. salts, EC > 600 μ S/cm) or are considered having high potential for dispersivity (ESP > 15).

4.3 Results of previous investigations

4.3.1 Emerson class number

The Emerson class number test was carried out on 7 selected samples from the central-southern portion of the site and the results are shown in Table 4-5. The samples represent both alluvial soils (IS01 to IS24) and weathered Permian sedimentary rocks (samples SG26 and SG28) (from PB, 2006(a)).

Table 4-5: Emerson class number

Test location and depth (m)	Soil description	Emerson class number
IS01 (1.4-1.6)	Sandy clay, brown	4
IS06 (0.6-0.7)	Clayey sand with gravel, brown	5
IS07 (1.1-1.2)	Sandy clay, brown	4
IS22 (0.4-0.6)	Silty clay, dark grey	4
IS24 (0.4-0.6)	Sandy clay, brown	4
SG26 (0.6-0.8)	Siltstone, extremely weathered	4
SG28 (0.5-0.7)	Siltstone, extremely weathered	4

4.3.2 Particle size distribution

Particle size distribution tests were conducted on 6 samples. All samples were collected from the Tertiary/Quaternary age alluvium in the central-southern portion of the site (PB, 2006(a)). The test results are shown in Table 4-6.

Table 4-6: Particle size distribution results

Test location and depth (m)	AS sieve size (mm) and accumulative percentage passing (%)												Classification
	37.5	26.5	19	9.5	4.75	2.36	1.18	0.600	0.425	0.300	0.150	0.075	
IS01 (1.4-1.6)					100	98	95	86	80	74	63	56	Sandy clay
IS01 (2.8-2.9)			100	98	94	88	79	58	42	30	19	15	Coarse grained silty sand
IS06 (0.6-0.7)			100	97	92	86	77	60	49	40	29	24	Medium grained clayey sand
IS21 (0.6-0.8)	100	97	90	67	81	33	23	19	18	17	14	12	Coarse grained gravelly silty sand
IS23 (2.1-2.3)	100	99	95	84	69	52	32	19	15	12	9	7	Fine grained sandy gravel with silt
SG35 (1.1-1.2)					100	99	95	89	85	80	68	55	Sandy clay

4.3.3 Dispersivity index

The dispersivity index is a ratio expressed as percentage of percentage particles passing 0.002 mm measured with and without the use of dispersing agent in a suspension. The results of dispersion index tests are shown in Table 4-7. These results are used to assess material dispersivity potential. Soils and weathered rocks with Dispersion Index < 30% are considered non-dispersive. The samples represent the residual soils and the weathered Permian sedimentary rocks in the central-southern portion of the site (from PB, 2005).

Table 4-7: Dispersivity index test results

Test location and depth (m)	Soil description	Dispersion index (%)
SR08 (0.4-0.5)	Silty clay, grey-brown	2
SR08 (1.2-1.4)	Siltstone/ sandstone, extremely weathered	3
SR08 (2.4-2.5)	Sandstone, extremely weathered	3
SR09 (1.9-2.0)	Mudstone, extremely weathered	6

5. Comments and discussion of results

5.1 Overburden and interburden material assessment

Overburden and interburden material was assessed for acid mine drainage and erosion potential in mine spoil piles and suitability as a sub-soil growth medium in stockpile capping layers.

The stockpile capping layer is defined as the uppermost layer of overburden that is placed on the spoil stockpile before shaping and topsoil spreading. It should have low potential to any form of erosion.

5.1.1 Acid production potential

Laboratory test results (as previously shown in Tables 4-3) indicated that all samples have negative net acid producing potential meaning that the maximum theoretical acid production would be less than the theoretical capacity of the rock to neutralise the produced acid. All the overburden samples tested have relatively high acid neutralising potential.

Net acid generation results indicate that when exposed to oxidising conditions in general the mine spoil (except for the carbonaceous mudstone layers) will not generate acid or the generated acid will be neutralised by materials present in the rock.

Carbonaceous mudstone and layers adjacent to coal seams were noted to contain pyrite and therefore their total sulphur content would be higher than the bulk samples tested. These pyritic layers could produce some acid drainage if they would be concentrated near the surface of the spoil.

It is suggested that layers of coal roof and floor material, and any material that is visually assessed at the time of mining as containing pyrite, should not be placed near the surface of the spoil stockpile.

All samples tested as part of the current investigation plot in the right side of the diagram in Figure 5-1 in the top right quadrant. They are all considered not acid forming, which was confirmed by after oxidation pH values that are generally above pH 8 (see Table 4-3).

Figure 5-1: Classification of acid production potential

Not acid forming; high sulphur; high neutralising capacity > 0.5% Sulphur	Not acid forming; low sulphur; high neutralising capacity < 0.5% Sulphur
Potentially acid forming; low neutralising capacity	Low potential of acid formation; low neutralising capacity

Overburden and interburden test results of this investigation correlate well with preliminary (desk-top) assessment based on exploration data (see chapter 3.4.4.4 of draft EIS; ELP, 2006 February version) and previous experience at the adjacent, now decommissioned, Pipeline Mine.

In summary, the overburden and interburden soils and rocks are considered not acid forming materials. Rocks within 5 m of coal seams should not be concentrated near the surface of the spoil stockpiles.

5.1.2 Salinity, sodicity and actual acidity

Laboratory test results (Table 4-4) indicate that overburden materials from all areas of the site have similar salinity, sodicity and actual acidity characteristics. It is likely that they represent a lateral continuity of the same geological units from the south to the north of the site.

Salinity, sodicity and acidity classifications used in this document are based on classification tables in Rayment et.al. (2003).

Tertiary/Quaternary age alluvium

Electrical conductivity and pH values vary little within the Tertiary/Quaternary sequence. This relative uniformity is likely to be due to similar conditions throughout the site at the time of deposition and subsequent drainage history.

The Tertiary/Quaternary soils are generally slightly alkaline (pH between 7.8 and 8.6) and of low salinity (around 200 $\mu\text{S}/\text{cm}$) to moderate salinity (up to 675 $\mu\text{S}/\text{cm}$). Only 1 sample returned relatively elevated electrical conductivity result (BR215 from 6 m depth, 924 $\mu\text{S}/\text{cm}$), indicating moderately high salinity (Table 4-4).

The Permian age sedimentary and intrusive/volcanic rocks currently outcropping to the east of the site are considered as the possible source area of these alluvial soils. Since these rocks themselves are considered having low salinity, it is expected that the alluvial sediments derived from them will have low salinity, provided the depositional area is well drained. The single, moderately saline soil sample result, could be regarded as a localised anomaly within an otherwise well drained, low salinity environment.

Alluvial soils with low to moderate salinity ($\text{EC} < 600 \mu\text{S}/\text{cm}$, low pH ($< \text{pH } 9$) value and ESP values less than 15 are considered suitable for spoil stockpile capping material.

The high CEC values reported for all soils may be partially due to relatively high pH values that can inflate exchangeable calcium values in the tested soils. Even after factoring in some potentially inflated CEC values, the alluvial soils are considered suitable for use as subsoils with moderate plant growth potential on rehabilitated spoil stockpiles. Water holding capacity of these soils is considered low.

Weathered Permian age materials

A summary of exploration data shown in the draft EIS on Figure 3.10 suggests that the Permian rocks are mainly weathered to between about 25 m to 35 m depth that is about 5 m to 10 m below the base of the Tertiary/Quaternary age alluvium. It is estimated that these rocks, when exposed to atmospheric conditions on the surface of a spoil stockpile, would break down further to form sandy/clayey soils.

Laboratory results (Table 4-4) indicate that these weathered sedimentary rocks have similar salinity, sodicity and alkalinity characteristics as the overlying alluvial soils.

The breakdown products of the weathered Permian rocks are estimated to have low to moderate salinity and sodicity and moderately high pH value. They are considered as suitable for spoil stockpile capping material with moderate erosion potential and moderate growth medium characteristics for re-establishment of vegetation. Spreading of topsoil and re-shaping of spoil stockpiles to reduce potential for concentrated runoff would reduce the erosion potential of these soils.

Fresh Permian age materials

Typically, the tested fresh Permian rocks have moderately high alkalinity levels and low to moderate salinity to about 70 m depth. A trend of high alkalinity values was detected in boreholes BR194 and BR204C below about 70 m depth indicating potential dispersivity especially after exposure to atmospheric conditions and subsequent weathering. The high dispersivity potential was also indicated by high ESP values that generally correspond with the high pH values in these boreholes.

Below about 70 m depth the claystones, mudstones and siltstones are considered as having higher potential to rapidly break down into dispersive, erosion prone, weathered material than the sandstones. Fresh sandstones in the overburden and interburden are less likely to weather rapidly when excavated. If the sandstone would remain largely fresh then it would be considered as a suitable capping layer for spoil stockpiles.

Fresh Permian age claystone, mudstone, siltstone and porous or feldspathic sandstone should be considered as less suitable for spoil stockpile capping material. High alkalinity indicates potential for dispersion that was also confirmed by ESP values (see Table 4-4). Potentially highly dispersible soils are not considered suitable for use as spoil stockpile capping layer due to their high erosion potential, even when covered by re-spread topsoil.

5.1.3 Construction materials

Mine infrastructure works for the SCP include water management structures (dams and levees), haul roads, access roads, ROM, rail loop and a mine industrial area. Most of these structures will require embankment and bulk fill material but material quality requirements range widely.

Embankment materials for water management structures should generally have high clay content, intermediate plasticity and low dispersibility potential. Bulk fill for roads and industrial structures will require physical characteristics that would make them withstand loads and remain durable in service.

Tertiary/Quaternary age alluvial and residual soils encountered on site comprise sand, silt, clayey sand, sandy clay and silty clays. Field observations and laboratory test results (Tables 4-1, 4-2, 4-5, 4-6 and 4-7) indicate that most of the sandy and silty clays are considered suitable for dam and levee embankment construction but their physical, mineralogical and chemical characteristics will need to be confirmed for each structure at each location.

Of the 16 near surface soil samples tested in the laboratory only 1 sample indicated high potential for dispersivity (BR215 from 6 m depth in Tables 4-2 and 4-4). Based on preliminary laboratory test results the alluvial and residual sandy and silty clay soils are considered as having low potential for dispersive behaviour but individual soil units will need confirmation by laboratory testing prior to use.

The alluvial soils generally show an upward fining trend therefore soils with high clay content, suitable for levee and dam embankment construction will mainly be located at shallow depth. After topsoil stripping, these soils could be excavated by conventional earthmoving equipment (such as dozers and scrapers).

Preliminary geomaterial reconnaissance results (PB, 2005 and PB 2006(a)) indicate that clayey materials considered suitable for levee and dam embankment are distributed throughout the alluvial plains of both Coral Creek in the northern portion of the site and the tributaries of Two Mile Creek in the southern and western part of the site.

Tertiary/Quaternary age clayey sands and sandy clays could be considered as potential bulk fill material for roads but unsuitable for use as base or wearing surface materials. The alluvial sandy gravels/gravelly sands could be considered for reinforced earth backfill materials. These soils may have to be blended to achieve specified quality parameters.

Weathered or fresh Permian age siltstones and sandstone are considered suitable as potential road building materials provided selected excavation is possible and practical. The use of these materials is generally restricted to bulk fill (formation level embankment) and sub-base due to their contamination by weak materials, inconsistent quality and low CBR.

Base (top-course) and wearing surface quality materials will likely have to be imported.

6. References

Department of Minerals and Energy, 1995. 'Land suitability assessment techniques' in Technical guidelines for the environmental management of exploration and mining in Queensland

Rayment, G.E. 2003, Testing properties of soils and water and interpreting the results, Department of Natural Resources-Natural Resource Sciences, Indooroopilly

PB, 2005, Sonoma Project – Railway spur and geomaterial assessment, geotechnical report

PB, 2006(a), Sonoma Project – Infrastructure, Preliminary geotechnical investigation

PB, 2006(b), Sonoma Project – Additional geotechnical report

ELP, 2006, Environmental Impact Statement, February 2006 Version

Energy Minerals, 2006, Coal exploration boreholes.

Appendix A

Test locations

Appendix B

Borehole logs

BOREHOLE SUMMARY

DATE : 2.02.2005
BOREHOLE HEADER TABLE : BOWENHD

PROJECT NAME :
BOREHOLE NAME : BR204C

COLLAR CO-ORDINATES :
EASTING : 589421.57 METRES
NORTHING : 7720051.36 METRES
ELEVATION : 173.60 METRES

GRID TYPE : AUSTRALIAN MAP GRID
ACCURACY : SURVEYED
DATUM : AUSTRALIAN HEIGHT DATUM
UNITS : METRES

FINAL DEPTH OF HOLE : 50.00 METRES
INCLINATION :
AZIMUTH :

SHEET REF NO. :
INDEX NO. : 8456
COUNTY :
PARISH :
PORTION :

DATE COMMENCED : 19.12.2
DATE COMPLETED : 19.12.2

DRILLING CONTRACTOR : GLOBAL DRILLING
DRILL TYPE : GARDNER DENVER

LOGGING ORGNIS : ENERGY MINERALS
LOGGED BY : CHRIS PATTISON

HOLE TYPE : PARTLY CORED HOLE
CORED INTERVALS :
CORED THICKNESS (m) : 0.77

HOLE DIAMETER (mm) :
CORE DIAMETER (mm) :
STANDING WATER LEVEL :
CASED DEPTH : 21.00 METRES
PLUG DEPTHS : METRES

GEOPHYS. OPERATOR : REEVES WIRELINE
PROBES RUN : NATURAL GAMMA, LONG SPACED DENSITY,
BED RESOLUTION DENSITY, CALIPER

BOREHOLE LOG

PAGE 1

DATE : 2.02.2005

BOREHOLE DATA TABLE : BOWENLI

BOREHOLE NAME : BR204C

STRAT /SEAM NAME	DOWN HOLE FROM (METRES)	TO (METRES)	APPARENT THICKNESS (METRES)	DESCRIPTION	SAMPLE NUMBER	REDUCED LEVEL
-- TOP OF CAINOZOIC AT 0.00M --						
CENZ	0.00	0.30	0.30	SOIL, SLIGHTLY CLAYEY, MEDIUM BROWN.		173.30
CENZ	0.30	1.00	0.70	SOIL, SANDY, MEDIUM BROWN.		172.60
CENZ	1.00	4.50	3.50	SOIL, SANDY SOME PEBBLY BANDS, LIGHT BROWN.		169.10
CENZ	4.50	16.00	11.50	ALLUVIUM, SANDY GRANULAR LENSES, RED BROWN, FINE GRAINED TO GRANULE.		157.60
CENZ	16.00	19.50	3.50	GRAVEL, CLAYEY MATRIX, GREEN MULTICOLOURED, VERY COARSE GRAINED TO PEBBLE SIZE.		154.10
PEBBLES (+ MINOR COBBLES) COMPRISE VOLCANICS & FELDSPAR PORPHYRY						
----- BASE OF CAINOZOIC AT 19.50M, THICKNESS 19.50M -----						
	19.50	20.00	0.50	SANDSTONE, QUARTZ LITHIC, LIGHT GREY, MEDIUM GRAINED, VERY WEAK, MODERATELY WEATHERED.		153.60
	20.00	21.00	1.00	SANDSTONE, QUARTZ LITHIC, LIGHT GREY, MEDIUM GRAINED, WEAK, SLIGHTLY WEATHERED.		152.60
BASE OF WEATHERING: 21.00M						
	21.00	22.00	1.00	SANDSTONE, MEDIUM GREY, FINE GRAINED, MODERATELY WEAK, FRESH.		151.60
	22.00	32.00	10.00	SANDSTONE, VOLCANOLITHIC SOME COALY WISPS, GREEN GREY, FINE TO MEDIUM GRAINED, SUB-ROUNDED TO SUB-ANGULAR, MODERATELY WEAK.		141.60
	32.00	33.00	1.00	SANDSTONE, SLIGHTLY CARBONACEOUS, DARK GREY, FINE GRAINED, MODERATELY WEAK.		140.60
	33.00	34.00	1.00	CARBONACEOUS SILTSTONE, BLACK, MODERATELY WEAK.		139.60
	34.00	35.14	1.14	SILTSTONE 70 PERCENT, SOME BANDS OF COAL LENSES, MEDIUM TO DARK GREY, MODERATELY WEAK, 30 PERCENT INTERMIXED CLAYSTONE, LIGHT TO MEDIUM BROWN, WEAK.		138.46
START CORE RUN #1 (35.14-37.42M) 2.44M RECOVERED; 0.16M OVERSHOOT						
	35.14	35.43	0.29	MUDSTONE, PARTLY CARBONACEOUS, DARK GREY, MODERATELY WEAK, CORE DISCED.		138.17
	35.43	35.44	0.01	CARBONACEOUS MUDSTONE, BLACK, MODERATELY WEAK, CORE DISCED.		138.16
	35.44	35.48	0.04	MUDSTONE, PARTLY CARBONACEOUS, MEDIUM GREY, MODERATELY WEAK, CORE DISCED.		138.12
CORE IN BAD SHAPE. 2 PEBBLES (FROM GRAVELS) WITHIN CORE SPLITS @ 36.02M DEPTH ADJUSTMENT REQUIRED						
	35.48	35.49	0.01	MUDSTONE, DARK GREY, WEAK, ABUNDANT, PLANT IMPRESSION, CORE DISCED.		138.11
	35.49	35.64	0.15	CARBONACEOUS MUDSTONE, CLAYEY IN PART, BROWN BLACK, VERY WEAK, ABUNDANT, PLANT IMPRESSION, CORE DISCED.		137.96
	35.64	35.69	0.05	POSSIBLE TUFF, CLAYEY, BLACK, VERY WEAK, SHEARED, ABUNDANT, COALY WISPS, SLICKENSIDED FRACTURE, CORED.		137.91
	35.69	35.71	0.02	COAL, BRIGHT (B), BLACK, SECONDARY CALCITE IN CLEATS, CORE BROKEN.		137.89
	35.71	35.88	0.17	MUDSTONE, SLIGHTLY CARBONACEOUS, BLACK, MODERATELY WEAK, SHEARED, SLICKENSIDED FRACTURE, CORE BROKEN.		137.72
CSEA	35.88	35.90	0.02	COAL, STONEY, BLACK, CORED.	204-1	137.70
CSEA	35.90	35.96	0.06	COAL, DULL AND BRIGHT BANDS (DB), BLACK, CORE BROKEN.	204-1	137.64
CSEA	35.96	36.01	0.05	COAL, DULL AND BRIGHT BANDS (DB), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.59
CSEA	36.01	36.20	0.19	COAL, DULL WITH FREQUENT BRIGHT BANDS (DB), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.40
CSEA	36.20	36.46	0.26	COAL, DULL AND BRIGHT BANDS (DB), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.14
CSEA	36.46	36.47	0.00	TUFF, FAWN, WEAK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.14
CSEA	36.47	36.53	0.06	COAL, BRIGHT WITH SOME DULL BANDS (Bd), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.07
CSEA	36.53	36.55	0.02	CLAYSTONE, SOME COALY WISPS, MEDIUM GREY BROWN, MODERATELY WEAK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	137.05
CSEA	36.55	36.71	0.16	COAL, DULL AND BRIGHT BANDS (DB), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	136.89
CSEA	36.71	36.84	0.13	COAL, BRIGHT WITH SOME DULL BANDS (Bd), BLACK, BEDDING DIP IS 5 DEGREES, SECONDARY CLAY IN CLEATS, GOOD CORE - UNBROKEN.	204-1	136.76
CSEA	36.84	36.86	0.02	CLAYSTONE, MEDIUM BROWN, MODERATELY WEAK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	136.74
CSEA	36.86	36.87	0.01	COAL, DULL WITH MINOR BRIGHT BANDS (Dmb), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	136.73
CSEA	36.87	36.90	0.03	COAL, DULL WITH MINOR BRIGHT BANDS (Dmb), DARK BROWN, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-1	136.70
CSEA	36.90	36.99	0.09	COAL, BRIGHT WITH SOME DULL BANDS (Bd), BLACK, BEDDING DIP IS 5 DEGREES, SECONDARY CLAY IN CLEATS, GOOD CORE - UNBROKEN.	204-1	136.61
CSEA	36.99	37.02	0.03	CLAYSTONE, DARK BROWN, MODERATELY WEAK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-2	136.58
CSEA	37.02	37.06	0.04	TUFF, FAWN, WEAK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-2	136.54
CSEA	37.06	37.19	0.13	COAL, DULL WITH MINOR BRIGHT BANDS (Dmb), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-2	136.41
CSEA	37.19	37.32	0.13	COAL, DULL AND BRIGHT BANDS (DB), BLACK, BEDDING DIP IS 5 DEGREES, SECONDARY CLAY IN CLEATS, GOOD CORE - UNBROKEN.	204-2	136.28
CSEA	37.32	37.39	0.07	COAL, DULL (D), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-2	136.21
CSEA	37.39	37.42	0.03	COAL, DULL WITH MINOR BRIGHT BANDS (Dmb), BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-2	136.18
START CORE RUN #2: (37.42-41.14M); 3.72M RECOVERED, NO KL						
CSEA	37.42	37.48	0.06	HEAT AFFECTED COAL, BLACK, CORE BROKEN.	204-3	136.12
CSEA	37.48	38.01	0.53	COAL, DULL AND BRIGHT BANDS (DB), BLACK, CORE BROKEN.	204-3	135.59
CSEA	38.01	38.03	0.02	SANDSTONE, PYRITIC, DARK GREY, FINE GRAINED, STRONG, SECONDARY PYRITE DISSEMINATED THROUGHOUT UNIT, GOOD CORE - UNBROKEN.	204-3	135.57

BOREHOLE LOG

PAGE 2

DATE : 2.02.2005
BOREHOLE DATA TABLE : BOWENLI

BOREHOLE NAME : BR204C

STRAT /SEAM NAME	DOWN FROM (METRES)	HOLE TO (METRES)	APPARENT THICKNESS (METRES)	DESCRIPTION	SAMPLE NUMBER	REDUCED LEVEL
----- TOP OF C SEAM AT 35.88M -----						
CSEA	38.03	38.49	0.46	COAL, DULL WITH MINOR BRIGHT BANDS (Dmb) SLIGHTLY HEAT AFFECTED, BLACK, CORE DISCED.	204-3	135.11
CSEA	38.49	38.50	0.01	CLAYSTONE, MEDIUM BROWN, VERY WEAK, CORE BROKEN.	204-4	135.10
CSEA	38.50	39.22	0.72	COAL, DULL AND BRIGHT BANDS (DB) SLIGHTLY HEAT AFFECTED, BLACK, CORE BROKEN.	204-4	134.38
CSEA	39.22	39.30	0.08	CARBONACEOUS MUDSTONE, BLACK, MODERATELY WEAK, SHEARED, SUBHORIZONTAL SLICKENSIDED FRACTURE, CORE BROKEN.	204-5	134.30
CSEA	39.30	40.40	1.10	HEAT AFFECTED COAL, BLACK, BEDDING DIP IS 5 DEGREES, FIVE SUBVERTICAL SLICKENSIDED FRACTURE, GOOD CORE - UNBROKEN.	204-5	133.20
CSEA	40.40	41.14	0.74	HEAT AFFECTED COAL, BLACK, BEDDING DIP IS 5 DEGREES, GOOD CORE - UNBROKEN.	204-5	132.46
START CORE RUN #3: (41.14-42.88M); 1.74M RECOVERED, NO KL						
CSEA	41.14	41.20	0.06	HEAT AFFECTED COAL, BLACK, CORE BROKEN.	204-5	132.40
CSEA	41.20	41.35	0.15	COAL, DULL AND BRIGHT BANDS (DB) SLIGHTLY HEAT AFFECTED, BLACK, CORE BROKEN.	204-5	132.25
CSEA	41.35	41.49	0.14	COAL, BRIGHT WITH SOME DULL BANDS (Bd) SLIGHTLY HEAT AFFECTED, BLACK, CORE BROKEN.	204-5	132.11
----- BASE OF C SEAM AT 41.49M, THICKNESS 5.61M -----						
	41.49	42.10	0.61	MUDSTONE, MINOR COALY WISPS, MEDIUM GREY BROWN, MODERATELY WEAK, LAMINATED, CORE BROKEN.		131.50
	42.10	42.14	0.04	COAL, BRIGHT WITH SOME DULL BANDS (Bd), BLACK, BEDDING DIP IS 5 DEGREES, SECONDARY CLAY IN CLEATS, GOOD CORE - UNBROKEN.		131.46
	42.14	42.28	0.14	MUDSTONE, SHEARED, COMMON SUB-HORIZONTAL TO SUB-VERTICAL SLICKENSIDED FRACTURE, CORE BROKEN.		131.32
	42.28	42.33	0.05	CARBONACEOUS SILTSTONE, SHEARED, COMMON SUB-HORIZONTAL TO SUB-VERTICAL SLICKENSIDED FRACTURE, CORE BROKEN.		131.27
	42.33	42.88	0.55	SILTSTONE, SOME COALY WISPS, MEDIUM TO DARK GREY, MODERATELY WEAK, CORE BROKEN.		130.72
END CORING @ 42.88M						
	42.88	44.00	1.12	CARBONACEOUS MUDSTONE, SOME COALY BANDS, BLACK, MODERATELY WEAK.		129.60
	44.00	48.50	4.50	SILTSTONE, MEDIUM TO DARK GREY, MODERATELY WEAK.		125.10
	48.50	50.00	1.50	SANDSTONE, VOLCANOLITHIC ABUNDANT ANDESITIC FRAGMENTS, LIGHT GREEN GREY, MEDIUM TO COARSE GRAINED, MODERATELY WEAK.		123.60
	50.00	58.00	8.00	SANDSTONE, VOLCANOLITHIC, LIGHT GREEN GREY, MEDIUM TO COARSE GRAINED, MODERATELY STRONG.		115.60
	58.00	66.00	8.00	SANDSTONE, LIGHT TO MEDIUM GREY, FINE TO MEDIUM GRAINED, MODERATELY STRONG.		107.60
	66.00	72.00	6.00	SANDSTONE, SLIGHTLY CARBONACEOUS IN PART, MEDIUM TO DARK GREY, FINE GRAINED, MODERATELY STRONG.		101.60
	72.00	74.00	2.00	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, FINE TO VERY FINE GRAINED, MODERATELY STRONG.		99.60
	74.00	75.50	1.50	CARBONACEOUS MUDSTONE, BLACK, MODERATELY STRONG.		98.10
	75.50	77.50	2.00	INTRUSIVE, DARK GREEN, MODERATELY STRONG.		96.10
	77.50	79.00	1.50	SANDSTONE, MEDIUM TO DARK GREY, FINE TO MEDIUM GRAINED.		94.60
	79.00	81.50	2.50	SANDSTONE, QUARTZ LITHIC, MEDIUM BROWN GREY, MEDIUM GRAINED, MODERATELY STRONG.		92.10
	81.50	90.00	8.50	SANDSTONE, LIGHT BLUE GREY, FINE TO MEDIUM GRAINED, MODERATELY STRONG.		83.60
	90.00	96.00	6.00	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, VERY FINE GRAINED, MODERATELY STRONG.		77.60
	96.00	97.00	1.00	CARBONACEOUS SILTSTONE, BLACK, MODERATELY STRONG.		76.60
	97.00	100.00	3.00	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, FINE GRAINED, MODERATELY STRONG.		73.60
	100.00	106.45	6.45	CARBONACEOUS MUDSTONE, BLACK, MODERATELY STRONG.		67.15
	106.45	107.40	0.95	INTRUSIVE, LIGHT GREY, STRONG.		66.20
	107.40	107.85	0.45	CLAYSTONE, MEDIUM BROWN, MODERATELY STRONG.		65.75
	107.85	108.20	0.35	INTRUSIVE, LIGHT GREY GREY, MODERATELY STRONG.		65.40
	108.20	109.00	0.80	CARBONACEOUS MUDSTONE, SOME COALY LENSES, BLACK, MODERATELY STRONG.		64.60
----- TOP OF B SEAM AT 109.00M -----						
BSEA	109.00	109.50	0.50	STONEY COAL, BLACK, MODERATELY WEAK.		64.10
BSEA	109.50	109.75	0.25	MUDSTONE, DARK GREY, MODERATELY STRONG.		63.85
BSEA	109.75	110.50	0.75	HEAT AFFECTED COAL, BLACK, MODERATELY STRONG.		63.10
BSEA	110.50	111.30	0.80	COAL, BLACK, WEAK.		62.30
BSEA	111.30	112.10	0.80	SILTSTONE, MEDIUM TO DARK GREY, MODERATELY STRONG.		61.50
BSEA	112.10	113.15	1.05	HEAT AFFECTED COAL, MODERATELY WEAK.		60.45
BSEA	113.15	113.60	0.45	CINDERED COAL, STRONG.		60.00
BSEA	113.60	116.10	2.50	INTRUSIVE, MOTTLED WHITE GREEN, STRONG.		57.50
BSEA	116.10	116.90	0.80	CINDERED COAL, GREY BLACK, STRONG.		56.70
BSEA	116.90	117.10	0.20	MUDSTONE, DARK BROWN GREY, MODERATELY STRONG.		56.50
BSEA	117.10	117.55	0.45	CINDERED COAL, GREY BLACK, MODERATELY STRONG.		56.05
BSEA	117.55	117.70	0.15	CARBONACEOUS MUDSTONE, BLACK, MODERATELY STRONG.		55.90
BSEA	117.70	118.00	0.30	COAL, BLACK, WEAK.		55.60
BSEA	118.00	118.15	0.15	CLAYSTONE, MEDIUM BROWN, MODERATELY WEAK.		55.45
BSEA	118.15	118.55	0.40	COAL, BLACK, WEAK.		55.05
BSEA	118.55	119.35	0.80	STONEY COAL, BLACK, MODERATELY WEAK.		54.25
BSEA	119.35	119.70	0.35	MUDSTONE, MEDIUM BROWN, MODERATELY STRONG, COMMON, PLANT IMPRESSION.		53.90
BSEA	119.70	123.55	3.85	COAL, BLACK, MODERATELY WEAK.		50.05
----- BASE OF B SEAM AT 123.55M, THICKNESS 14.55M -----						
	123.55	126.00	2.45	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, FINE TO VERY FINE GRAINED, MODERATELY STRONG, WHITE MICA DISSEMINATED THROUGHOUT UNIT.		47.50
	126.00	127.00	1.00	CARBONACEOUS SILTSTONE, BLACK, MODERATELY STRONG, WHITE MICA DISSEMINATED THROUGHOUT UNIT.		46.60
	127.00	131.00	4.00	CARBONACEOUS SANDSTONE, BLACK, FINE TO VERY FINE GRAINED, MODERATELY STRONG, WHITE MICA DISSEMINATED THROUGHOUT UNIT.		42.60

BOREHOLE LOG

PAGE 3

DATE : 2.02.2005
BOREHOLE DATA TABLE : BOWENLI

BOREHOLE NAME : BR204C

STRAT /SEAM NAME	DOWN HOLE FROM (METRES)	TO (METRES)	APPARENT THICKNESS (METRES)	DESCRIPTION	SAMPLE NUMBER	REDUCED LEVEL
	131.00	133.50	2.50	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, FINE TO MEDIUM GRAINED, MODERATELY STRONG, WHITE MICA DISSEMINATED THROUGHOUT UNIT.		40.10
	133.50	135.20	1.70	STONEY COAL, NUMEROUS STONE BANDS, BLACK, MODERATELY WEAK.		38.40
	135.20	135.80	0.60	MUDSTONE 70 PERCENT, DARK BROWN GREY, MODERATELY STRONG, COMMON, PLANT IMPRESSION, 30 PERCENT INTERMIXED INTRUSIVE, LIGHT GREY, MODERATELY STRONG.		37.80
	135.80	141.00	5.20	STONEY COAL, NUMEROUS STONE BANDS, BLACK, MODERATELY WEAK.		32.60
	141.00	142.00	1.00	SANDSTONE, LIGHT GREY, MEDIUM GRAINED, MODERATELY STRONG.		31.60
	142.00	143.00	1.00	SILTSTONE, SOME COALY LENSES, LIGHT GREY BROWN, MODERATELY STRONG.		30.60
	143.00	144.50	1.50	COAL, BLACK, STRONG.		29.10
	144.50	145.00	0.50	SANDSTONE, PARTLY CARBONACEOUS, DARK GREY, FINE GRAINED, MODERATELY STRONG.		28.60
	145.00	146.00	1.00	INTRUSIVE, DARK GREEN, PORPHYRITIC, STRONG.		27.60
	146.00	146.50	0.50	CINDERED COAL, BLACK, MODERATELY STRONG.		27.10
	146.50	147.50	1.00	HEAT AFFECTED COAL, BLACK, MODERATELY WEAK.		26.10
	147.50	148.50	1.00	SANDSTONE, SOME COALY BANDS, BROWN GREY, FINE TO MEDIUM GRAINED, MODERATELY STRONG.		25.10
	148.50	150.00	1.50	SANDSTONE, SOME COALY BANDS, MEDIUM BROWN GREY, FINE TO MEDIUM GRAINED, MODERATELY STRONG, OCCASIONAL, PLANT IMPRESSION.		23.60
TD	150.00	150.00	0.00			23.60

INDICATED TOTAL DEPTH FOR HOLE BR204C AT 150M

BOREHOLE SUMMARY

DATE : 2.02.2005
BOREHOLE HEADER TABLE : BOWENHD

PROJECT NAME :
BOREHOLE NAME : BR221

COLLAR CO-ORDINATES :
EASTING 589256.65 METRES
NORTHING 7719384.35 METRES
ELEVATION 171.37 METRES

GRID TYPE : AUSTRALIAN MAP GRID
ACCURACY : SURVEYED
DATUM : AUSTRALIAN HEIGHT DATUM
UNITS : METRES

FINAL DEPTH OF HOLE : 168.00 METRES
INCLINATION :
AZIMUTH :

SHEET REF NO. :
INDEX NO. : 8456
COUNTY :
PARISH :
PORTION :

DATE COMMENCED : 16.03.3
DATE COMPLETED : 28.06.4

DRILLING CONTRACTOR : GLOBAL DRILLING
DRILL TYPE : GARDNER DENVER

LOGGING ORGNIS : ENERGY MINERALS
LOGGED BY : KRISTY LYTLE

HOLE TYPE : ROTARY OPEN HOLE
CORED INTERVALS :
CORED THICKNESS (m) :

HOLE DIAMETER (mm) : 125.00
CORE DIAMETER (mm) :
STANDING WATER LEVEL : METRES
CASED DEPTH : 19.00 METRES
PLUG DEPTHS : METRES

GEOPHYS. OPERATOR : AUSLOG
PROBES RUN : NATURAL GAMMA, LONG SPACED DENSITY,
BED RESOLUTION DENSITY, CALIPER

BOREHOLE SUMMARY

DATE : 26.02.2004
BOREHOLE HEADER TABLE : BOWENHD

PROJECT NAME :
BOREHOLE NAME : BR215

COLLAR CO-ORDINATES :
EASTING 588693.15 METRES
NORTHING 7719658.26 METRES
ELEVATION 169.72 METRES

GRID TYPE : AUSTRALIAN MAP GRID
ACCURACY : SURVEYED
DATUM : AUSTRALIAN HEIGHT DATUM
UNITS : METRES

FINAL DEPTH OF HOLE : 64.00 METRES
INCLINATION :
AZIMUTH :

SHEET REF NO. :
INDEX NO. : 8456
COUNTY :
PARISH :
PORTION :

DATE COMMENCED : 15.03.3
DATE COMPLETED : 15.03.3

DRILLING CONTRACTOR : GLOBAL DRILLING
DRILL TYPE : GARDNER DENVER

LOGGING ORGNIS : ENERGY MINERALS
LOGGED BY : KRISTY LYTLE

HOLE TYPE : ROTARY OPEN HOLE
CORED INTERVALS :
CORED THICKNESS (m) :

HOLE DIAMETER (mm) : 125.00
CORE DIAMETER (mm) :
STANDING WATER LEVEL : METRES
CASED DEPTH : 21.00 METRES
PLUG DEPTHS : METRES

GEOPHYS. OPERATOR : REEVES WIRELINE
PROBES RUN : NATURAL GAMMA, LONG SPACED DENSITY,
BED RESOLUTION DENSITY, CALIPER

BOREHOLE LOG

PAGE 1

DATE : 26.02.2004
BOREHOLE DATA TABLE : BOWENLI

BOREHOLE NAME : BR215

STRAT /SEAM NAME	DOWN HOLE FROM (METRES)	TO (METRES)	APPARENT THICKNESS (METRES)	DESCRIPTION	SAMPLE NUMBER	REDUCED LEVEL
-- TOP OF CAINOZOIC AT 0.00M --						
CENZ	0.00	3.00	3.00	ALLUVIUM, LITHIC FRAGMENTS SANDY CLAYEY, MEDIUM ORANGE BROWN, VERY COARSE GRAINED TO GRANULE SIZE, SOFT, HIGHLY WEATHERED.		166.72
CENZ	3.00	8.00	5.00	ALLUVIUM, CLAYEY SANDY, MEDIUM ORANGE BROWN, FINE TO MEDIUM GRAINED, FIRM, HIGHLY WEATHERED.		161.72
CENZ	8.00	10.00	2.00	ALLUVIUM, CLAYEY SLIGHTLY SANDY, MEDIUM ORANGE BROWN, FINE TO MEDIUM GRAINED, STIFF, HIGHLY WEATHERED.		159.72
CENZ	10.00	14.00	4.00	ALLUVIUM, CLAYEY SANDY SPORADIC LITHIC FRAGMENTS, MEDIUM ORANGE BROWN, FINE TO MEDIUM GRAINED, SOFT, HIGHLY WEATHERED.		155.72
CENZ	14.00	16.70	2.70	ALLUVIUM, CLAYEY SANDY SLIGHTLY CARBONACEOUS, MEDIUM ORANGE BROWN, FINE TO MEDIUM GRAINED, FIRM, HIGHLY WEATHERED.		153.02
CENZ	16.70	20.00	3.30	GRAVEL, DARK BLACK GREEN, STRONG.		149.72
----- BASE OF CAINOZOIC AT 20.00M, THICKNESS 20.00M -----						
	20.00	21.70	1.70	CLAY, LIGHT GREY BROWN, HIGHLY WEATHERED, BASE OF WEATHERING: 21.70M		148.02
	21.70	25.50	3.80	SANDSTONE 50 PERCENT, SLIGHTLY CARBONACEOUS, LIGHT GREY, FINE GRAINED, WEAK, FRESH, 40 PERCENT INTERMIXED SILTSTONE, SLIGHTLY CARBONACEOUS, MEDIUM TO DARK GREY, MODERATELY STRONG.		144.22
	25.50	31.00	5.50	SANDSTONE, PARTLY CARBONACEOUS STRINGERS OF COAL MICACEOUS NEAR BASE OF UNIT, MEDIUM TO DARK GREY, FINE GRAINED, MODERATELY WEAK.		138.72
	31.00	34.35	3.35	CARBONACEOUS SILTSTONE, STRINGERS OF COAL MICACEOUS NEAR TOP OF UNIT, DARK BLACK GREY, MODERATELY STRONG.		135.37
----- TOP OF B SEAM AT 34.35M -----						
BSEA	34.35	34.80	0.45	COAL, DULL AND BRIGHT BANDS (DB), BLACK, MODERATELY WEAK.	BSM1	134.92
BSEA	34.80	35.00	0.20	COAL 50 PERCENT, DULL WITH MINOR BRIGHT BANDS (Dwb), BLACK, 50 PERCENT INTERMIXED CARBONACEOUS MUDSTONE, BLACK, MODERATELY STRONG.	BSM1	134.72
BSEA	35.00	35.45	0.45	COAL, DULL AND BRIGHT BANDS (DB), BLACK.	BSM1	134.27
BSEA	35.45	35.70	0.25	SANDSTONE, MICACEOUS SLIGHTLY CARBONACEOUS, MEDIUM BEIGE BROWN, MODERATELY WEAK.	BSM1	134.02
BSEA	35.70	37.95	2.25	COAL, DULL AND BRIGHT BANDS (DB), BLACK, MODERATELY WEAK.	BSM1	131.77
BSEA	37.95	38.20	0.25	SILTSTONE, MEDIUM TO DARK GREY, MODERATELY STRONG.		131.52
BSEA	38.20	39.10	0.90	COAL, DULL WITH FREQUENT BRIGHT BANDS (DB), BLACK, MODERATELY STRONG.	BSM2	130.62
BSEA	39.10	39.50	0.40	SILTSTONE, MEDIUM TO DARK GREY, MODERATELY STRONG.	BSM2	130.22
BSEA	39.50	39.65	0.15	CINDERED COAL, GRANULAR, GREY BLACK, MODERATELY STRONG.	BSM2	130.07
BSEA	39.65	40.30	0.65	INTRUSIVE, FELDSPATHIC PORPHYRITIC, LIGHT GREY, VERY COARSE GRAINED TO GRANULE SIZE, MODERATELY STRONG.	BSM2	129.42
BSEA	40.30	40.95	0.65	CINDERED COAL, GRANULAR, DARK BLACK GREY, STRONG.	BSM2	128.77
BSEA	40.95	41.60	0.65	COAL, DULL WITH FREQUENT BRIGHT BANDS (DB) FUSAINOUS IN PART, BLACK, MODERATELY STRONG.	BSM2	128.12

Appendix C

Laboratory test results

EMERSON CLASS NUMBER TEST REPORT

Test Method: AS1289 3.8.1

Client: Parsons Brinckerhoff Pty Ltd Report No. 605269-EM
 Project: 2108115C Test Date: 10/05/06 & 12/05/06
 Report Date: 16/05/06

Sample No.	605269	605270	605272	605274	605275
Client ID:	204C	204C	BR215	BR194	BR204C
Depth (m):	3	16	6	14	33
Description:	(CI) SILTY SANDY CLAY – brown.	(SC) GRAVELLY CLAYEY SAND - brown	SILTY CLAY – brown and dark brown.	SANDY CLAY with gravel - brown	(GC) CLAYEY GRAVEL – grey
Emerson Class No.:	5	6	2	6	6

Remarks: Tested with distilled water at 24°C

Sample/s supplied by the client

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Authorised Signatory

G. Hamilton

G. Hamilton

Manager

NATA Accredited Laboratory Number 9926
 Form Number: GT007-5

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	Parsons Brinckerhoff Pty Ltd	Report No.	605268-G
Project:	2108115C	Test Date:	12/05/06
		Report Date:	16/05/06

Sample No.	605268	605269	605270	605271	605273	605274
Client ID:	BR204C	204C	204C	PC138	BR215	BR194
Depth (m):	6	3	16	12	18	14
Moisture (%)	15.1	13.0	30.3	31.9	39.8	10.2

AS SIEVE SIZE (mm)	PERCENT PASSING					
26.5						
19			100	100		100
9.5	100	100	91	99	100	98
4.75	99	98	84	92	98	91
2.36	94	96	78	81	96	86
1.18	86	95	72	73	93	83
0.600	74	92	65	65	90	79
0.425	67	91	61	56	87	76
0.300	60	88	57	49	81	73
0.150	50	76	47	41	60	62
0.075	46	63	39	36	47	52

Sample/s supplied by the client

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Authorised Signatory

G. Hamilton

Manager

CERTIFICATE OF ANALYSIS

Client	: PARSONS BRINCKERHOFF AUST P/L	Laboratory	: ALS Environmental Brisbane	Page	: 1 of 9
Contact	: MR JOSEF MAJOR	Contact	: Michael Heery	Work Order	: EB0604507
Address	: GPO BOX 2907 BRISBANE QLD AUSTRALIA 4000	Address	: 32 Shand Street Stafford QLD Australia 4053		
E-mail	: jmajor@pb.com.au	E-mail	: Michael.Heery@alsenviro.com		
Telephone	: 07 3218 2222	Telephone	: 61-7-32437222		
Facsimile	: 07 3831 4223	Facsimile	: 61-7-32437259		
Project	: 2108115c	Quote number	: ----		
Order number	: 45118	Date received	: 10 May 2006		
C-O-C number	: 112595	Date issued	: 25 May 2006		
Site	: - Not provided -	No. of samples	- Received	: 25	
			Analysed	: 25	

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ACCREDITATION

This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Position	Department
Cass Sealby	Inorganics Supervisor	Inorganics - NATA 825 (818 - Brisbane)
Kim McCabe		Inorganics - NATA 825 (818 - Brisbane)

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Client : PARSONS BRINCKERHOFF AUST P/L
Work Order : EB0604507

Comments

This report for the ALSE reference EB0604507 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Analytical results for samples submitted

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insufficient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.

- Surrogate control limits

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure 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 herein. Reference methods from which ALSE methods are based are provided in parenthesis.



ALS Environmental

Analytical Results

Analytical Results

Analyte	CAS number	Client Sample ID :		204C/107 ROCK 8 May 2006 15:00 EB0604507-001	204C/72 ROCK 8 May 2006 15:00 EB0604507-002	204C/61 ROCK 8 May 2006 15:00 EB0604507-005	215/33 ROCK 8 May 2006 15:00 EB0604507-006	215/21 ROCK 8 May 2006 15:00 EB0604507-007
		Sample Matrix Type / Description :	Sample Date / Time :					
		Laboratory Sample ID :						
		LOR	Units					
EA002 : pH (Soils)								
pH Value	12408-02-5	0.1	pH Unit	9.1	9.2	8.8	7.8	8.1
EA009: Nett Acid Production Potential								
Net Acid Production Potential		0.5	kg H2SO4/t	-75.8	-66.2	-80.6	-45.4	-39.8
EA010: Conductivity								
Electrical Conductivity @ 25°C		1	µS/cm	397	604	477	488	343
EA011: Net Acid Generation								
pH (OX)		0.1	pH Unit	11.1	10.8	10.9	9.9	9.7
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	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4		0.5	kg H2SO4 equ	77.9	67.1	81.2	47.2	39.8
ED007: Exchangeable Cations								
Exchangeable Calcium		0.1	meq/100g	21.1	20.6	24.0	21.5	20.0
Exchangeable Magnesium		0.1	meq/100g	0.9	1.7	3.6	6.7	6.4
Exchangeable Potassium		0.1	meq/100g	0.7	1.7	2.1	2.0	0.7
Exchangeable Sodium		0.1	meq/100g	3.8	6.8	5.3	1.0	1.8
Cation Exchange Capacity		0.1	meq/100g	26.6	30.7	35.0	31.2	28.8
ED042T: Total Sulphur by LECO								
Sulphur - Total as S (LECO)		0.01	%	0.07	0.03	0.02	0.06	<0.01

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ALS Environmental

Analytical Results

Analytical Results

Analyte	CAS number	Client Sample ID :		204C/100 ROCK 8 May 2006 15:00 EB0604507-008	204C/33 ROCK 8 May 2006 15:00 EB0604507-009	204C/42 ROCK 8 May 2006 15:00 EB0604507-010	PC138/25 ROCK 8 May 2006 15:00 EB0604507-011	PC138/34 ROCK 8 May 2006 15:00 EB0604507-012
		Sample Matrix Type / Description :	Sample Date / Time :					
		Laboratory Sample ID :	LOR					
EA002 : pH (Soils)								
pH Value	12408-02-5	0.1	pH Unit	8.4	7.7	8.0	8.0	8.1
EA009: Nett Acid Production Potential								
Net Acid Production Potential		0.5	kg H2SO4/t	-69.2	-86.8	-59.2	-104	-112
EA010: Conductivity								
Electrical Conductivity @ 25°C		1	µS/cm	675	434	360	511	461
EA011: Net Acid Generation								
pH (OX)		0.1	pH Unit	10.6	10.4	10.0	10.9	10.8
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	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4		0.5	kg H2SO4 equ	70.1	89.3	62.6	105	113
ED007: Exchangeable Cations								
Exchangeable Calcium		0.1	meq/100g	19.2	23.2	16.6	22.3	22.8
Exchangeable Magnesium		0.1	meq/100g	2.2	6.4	4.4	7.9	4.5
Exchangeable Potassium		0.1	meq/100g	2.2	1.2	1.4	2.5	1.9
Exchangeable Sodium		0.1	meq/100g	5.9	1.0	1.7	1.7	2.2
Cation Exchange Capacity		0.1	meq/100g	29.4	31.7	24.1	34.4	31.3
ED042T: Total Sulphur by LECO								
Sulphur - Total as S (LECO)		0.01	%	0.03	0.08	0.11	0.02	0.03



ALS Environmental

Analytical Results

Analyte	CAS number	Client Sample ID :		PC138/59 ROCK 8 May 2006 15:00 EB0604507-013	BR204C/16 ROCK 8 May 2006 15:00 EB0604507-014	PC138/49 ROCK 8 May 2006 15:00 EB0604507-015	BR194/106 ROCK 8 May 2006 15:00 EB0604507-019	BR194/61 ROCK 8 May 2006 15:00 EB0604507-020
		Sample Matrix	Type / Description : Sample Date / Time : Laboratory Sample ID :					
EA002 : pH (Soils)								
pH Value	12408-02-5	0.1	pH Unit	8.1	7.8	8.9	9.2	8.6
EA009: Nett Acid Production Potential		0.5	kg H ₂ SO ₄ /t	-58.8	-----	-57.6	-49.3	-71.7
EA010: Conductivity		1	µS/cm	408	595	383	564	405
EA011: Net Acid Generation								
pH (OX)		0.1	pH Unit	8.2	-----	10.8	10.2	9.8
NAG (pH 4.5)		0.1	kg H ₂ SO ₄ /t	<0.1	-----	<0.1	<0.1	<0.1
NAG (pH 7.0)		0.1	kg H ₂ SO ₄ /t	<0.1	-----	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H ₂ SO ₄		0.5	kg H ₂ SO ₄ equ	61.2	-----	59.1	50.5	73.2
ED007: Exchangeable Cations								
Exchangeable Calcium		0.1	meq/100g	12.6	29.5	15.0	9.6	19.5
Exchangeable Magnesium		0.1	meq/100g	4.1	7.6	4.7	2.8	4.6
Exchangeable Potassium		0.1	meq/100g	1.5	0.5	1.7	1.7	1.2
Exchangeable Sodium		0.1	meq/100g	2.7	1.7	3.6	7.4	3.5
Cation Exchange Capacity		0.1	meq/100g	21.0	39.4	25.1	21.4	28.8
ED042T: Total Sulphur by LECO								
Sulphur - Total as S (LECO)		0.01	%	0.03	-----	0.05	0.04	0.05

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ALS Environmental

Analytical Results

Analytical Results

Analyte	Client Sample ID :						
	Sample Matrix Type / Description :						
	Sample Date / Time :						
Laboratory Sample ID :							
CAS number	LOR	Units	EB0604507-022				
EA002 : pH (Soils)			EB0604507-023				
pH Value	12408-02-5	0.1	pH Unit	8.6	9.0	9.2	8.4
EA009: Nett Acid Production Potential			EB0604507-024				
Net Acid Production Potential		0.5	kg H2SO4/t	-35.7	-57.0	-50.5	-75.1
EA010: Conductivity							
Electrical Conductivity @ 25°C	1		µS/cm	238	296	567	296
EA011: Net Acid Generation							
pH (OX)		0.1	pH Unit	10.3	10.8	10.2	11.1
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	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity							
ANC as H2SO4		0.5	kg H2SO4 equ	39.1	57.6	51.7	75.1
ED007: Exchangeable Cations							
Exchangeable Calcium		0.1	meq/100g	23.4	23.8	8.0	22.4
Exchangeable Magnesium		0.1	meq/100g	2.4	2.3	2.6	2.9
Exchangeable Potassium		0.1	meq/100g	0.7	0.6	1.8	0.6
Exchangeable Sodium		0.1	meq/100g	1.2	2.3	6.5	1.2
Cation Exchange Capacity		0.1	meq/100g	27.8	29.0	18.8	27.0
ED042T: Total Sulphur by LECO							
Sulphur - Total as S (LECO)		0.01	%	0.11	0.02	0.04	<0.01

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ALS Environmental

Analytical Results

Client Sample ID :
Sample Matrix Type / Description :
Sample Date / Time :
Laboratory Sample ID :

Analyte	CAS number	LOR	Units	204C/6 SOIL 8 May 2006 15:00 EB0604507-003	204C/3 SOIL 8 May 2006 15:00 EB0604507-004	PC138/12 SOIL 8 May 2006 15:00 EB0604507-016	BR215/6 SOIL 8 May 2006 15:00 EB0604507-017	BR215/18 SOIL 8 May 2006 15:00 EB0604507-018
EA002 : pH (Soils)								
pH Value	12408-02-5	0.1	pH Unit	8.0	8.0	8.4	8.6	8.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	1		µS/cm	613	380	574	924	511
ED007: Exchangeable Cations								
Exchangeable Calcium	0.1		meq/100g	28.0	32.5	28.3	27.4	28.4
Exchangeable Magnesium	0.1		meq/100g	15.3	14.7	10.7	15.8	9.8
Exchangeable Potassium	0.1		meq/100g	1.1	2.0	0.9	1.1	0.6
Exchangeable Sodium	0.1		meq/100g	1.8	2.2	3.1	9.6	3.8
Cation Exchange Capacity	0.1		meq/100g	46.2	51.4	42.9	53.8	42.6

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ALS Environmental

Analytical Results

Analytical Results

Client Sample ID :		Sample Matrix Type / Description :		Sample Date / Time :		Laboratory Sample ID :	
BR194/14		SOIL		8 May 2006		EB0604507-021	
15:00							
Analyte	CAS number	LOR	Units				
EA002 : pH (Soils)							
pH Value	12408-02-5	0.1	pH Unit	8.3			
EA010: Conductivity							
Electrical Conductivity @ 25°C							
ED007: Exchangeable Cations		1	µS/cm	299			
Exchangeable Calcium							
Exchangeable Magnesium		0.1	meq/100g	35.3			
Exchangeable Potassium		0.1	meq/100g	12.1			
Exchangeable Sodium		0.1	meq/100g	1.1			
Cation Exchange Capacity		0.1	meq/100g	1.2			
		0.1	meq/100g	49.6			

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Surrogate Control Limits

- No surrogates present on this report.

Appendix K - Drake Coal Project SEIS Excavated Waste Characterisation Report (GHD, 2013)



Drake Coal Pty Ltd
Environmental Impact Statement
Excavated Waste Characterisation Report

February 2013

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Appendices

- Appendix A –Geochemical sample descriptions
- Appendix B – ALS laboratory results
- Appendix C – Whole rock metals and global abundance index results
- Appendix D – Leachate results
- Appendix E – Dispersivity results

List of Abbreviations

Term	Definition
ABA	Acid base account
ABCC	Acid buffering capacity curve
ALS	Australian Laboratory Services
AMD	Acid and metalliferous drainage
ANC	Acid neutralising capacity (kgH ₂ SO ₄ /tonne)
ARD	Acid rock drainage
CEC	Cation exchange capacity
CHPP	Coal handling and preparation plant
CRS	Chromium reducible sulfur
EC	Electrical conductivity
EIS	Environmental impact statement
EPC	Exploration permit coal
ESP	Exchangeable sodium percent
GAI	Global abundance index
ha	Hectares
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled optical emission spectroscopy
kg	Kilogram
M	Million
Mt	Million tonnes
Mtpa	Million tonnes per annum
m	Metre
mbgs	Metres below ground surface
MPA	Maximum potential acidity calculated assuming that all sulfur is present as pyrite (kgH ₂ SO ₄ /tonne)
NAF	Non-acid forming - a classification in regard to potential for rock to be acid forming
NAG	Net acid generation (kgH ₂ SO ₄ /tonne)
NAPP	Net acid producing potential (kgH ₂ SO ₄ /tonne)
NMD	Neutral mine drainage
NPR	Net Potential Ratio
PAF	Potentially acid forming - a classification in regard to potential for rock to be acid forming
PAF-LC	Potentially acid forming and of low capacity to produce acid
pH	Negative logarithm of the concentration of hydrogen ions
ROM	Run of mine
SD	Saline drainage
t	Tonnes
TDS	Total dissolved salts
TIC	Total inorganic carbon
TOC	Total organic carbon

Term	Definition
tpa	Tonnes per annum
UC	Uncertain – a classification in regard to potential for rock to be acid forming

Executive Summary

The proposed Drake Coal Mine (the Project), located approximately 17 km south of Collinsville, Queensland, is being developed by Drake Coal Pty Ltd (Drake Coal; the Proponent); a wholly owned subsidiary of QCoal Pty Ltd (QCoal).

This excavated waste characterisation report was completed to ascertain the risk for over and interburden units proposed for disturbance at the Project to generate acid, neutral or alkaline drainage (AMD) as stated in the Drake Coal Mine Environmental Impact Statement (EIS) Terms of Reference (ToR).

Due to ongoing site access constraints at Drake, the Proponent had been unable to enter the proposed mine site area to undertake intrusive geochemical sampling for subsequent analysis to inform the excavated waste section of the Drake EIS. Therefore, the Proponent submitted a desktop excavated waste assessment in the Drake EIS submitted for Project approval in May 2012. Within that desktop report, the Proponent committed to completing additional sampling and analysis to further characterise the excavated waste material on site, to better inform the forward risk of handling and storing the excavated waste rock on site.

This report therefore, forms a stand-alone technical report within the Drake Coal Mine Supplementary Environmental Impact Statement (SEIS) to add to the desktop excavated waste assessment in the Drake EIS submitted for Project approval.

Drake Coal are seeking approval to mine up to 10 million tonnes per annum (Mtpa) of run of mine (ROM) coal over the anticipated 30 year mine life, netting approximately 6 Mtpa of product export coal. There are 10 open cut pits proposed at Drake, with the two main pits West 1 and West 2, accounting for approximately 75% of the estimated 1,190 million bank cubic metres, or 2,708 million tonnes, of over and interburden on site. Additionally, Drake Coal propose to build a coal handling and preparation plant (CHPP) on site, which will generate coarse reject and tailings streams. To geochemically characterise the excavated waste and assess the risk of acid, neutral or alkaline, in addition to assessing the suitability of the respective waste units for use during progressive rehabilitation of waste rock dumps at Drake, a drilling and sampling program was completed in October and November 2012. Sixteen boreholes were drilled during this program with 329 geochemical samples collected.

Based on the data reviewed herein, the key findings of the excavated waste geochemical characterisation were:

- That all seven lithological waste groups, in addition to the tailings results, were classified as non-acid forming (NAF) using data from 284 sample analyses;
- That all seven lithological waste groups, in addition to the tailings results, had no mean individual total metal value elevated above a global abundance index of 3, using data from 292 sample analyses;
- That all seven lithological waste groups, in addition to the tailings results, had some leachable metal concentrations, above the adopted trigger values, from the 92 samples that underwent ASLP tests. The elements most commonly present in leachate above the trigger values, from the excavated waste, were aluminium, arsenic, lead, zinc and selenium; and
- Based on data from 295 sample analyses across the seven lithological waste groups and the tailings samples; the carbonaceous material, coaly material, mudstone and tailings

showed a high dispersivity risk. The siltstone showed a medium dispersivity risk, while the sandstone and intrusive lithological waste groups showed low to medium dispersivity risk. The soil unit showed a low dispersivity risk.

Therefore, based on the data reviewed herein, the soil, then weathered sandstone, then fresh sandstone appear to be the most appropriate lithological waste groups to use on site in progressive capping of out of pit waste rock dumps. Higher-risk, potentially dispersive materials that should be managed through on-site burial / encapsulation include the carbonaceous material, the coaly material, the mudstone and the tailings; particularly the fresh component of each of those four lithological waste groups.

Based on the data reviewed herein, the intrusive unit is also appropriate for beneficial use, although has very high leachate pH values that exceed stock watering guidelines; therefore, any drainage must be contained and managed appropriately. Additionally, the intrusive unit may be useful as a neutralising agent for any marginal acid producing tailings through co-disposal in engineered tailings structures on site.

Considering the above, and based on the data assessed herein, it may be concluded that there is a low risk of acid drainage at Drake. There is a risk of metalliferous drainage at neutral to alkaline drainage pH values given the results of the 92 ASLP leachate samples analysed; however, it should be noted that considering mean leachate pH values for the same 92 samples of 8.0; that the elements of concern being aluminium, arsenic, lead, zinc and selenium will be sparingly soluble and have limited environmental ecotoxicological risk at such a drainage pH value. This observation is in addition to the existing surface water drainage controls being the proposed engineered environmental dams and dirty water drainage on site; both of which will also reduce risk. The surface water drainage mitigation and management strategies outlined in the Drake Water Management Plan in the 2012 EIS are appropriate to manage this risk.

Additional to the surface water drainage mitigation and management strategies as outlined in the Drake Water Management Plan, would be the excavated waste handling and long term storage by lithological waste group based on geochemical risk. This would include storage of the carbonaceous material, the coaly material, the mudstone and the tailings, particularly the fresh component of each of those four lithological waste groups, in in-pit facilities. Additionally, these materials should not be used as waste rock storage facility capping materials during progressive site rehabilitation activities.

The above notwithstanding, it would appear that there is a very low risk of acid drainage being generated from the excavated waste at Drake. This conclusion is consistent with the low risk in coal mines adjacent to Drake in the northern Bowen Basin, including Sonoma and Belmore-Pipeline for example, where alkaline conditions prevail (QCoal 2011).

1. Introduction

1.1 Background and Context

1.1.1 The Proponent and Project Location

Drake Coal Pty Ltd (the Proponent); a wholly owned subsidiary of QCoal Pty Ltd (QCoal), is developing the proposed Drake Coal Mine (the Project), located approximately 17 kilometres (km) south of Collinsville, Queensland (Figure 1).

1.1.2 Environmental Approvals Context

On 1 April 2010, the Proponent made an application to the (then) Queensland Department of Environment and Resource Management (DERM) (now Queensland Department of Environment and Heritage Protection (DEHP)) to prepare a voluntary Environmental Impact Statement (EIS) under sections 70 and 71 of the *Queensland Environmental Protection Act 1994*.

Subsequent to the Proponent's submission, DERM approved the application to prepare a voluntary EIS on 9 April 2010. The draft EIS Terms of Reference (ToR) were released for public and advisory agency comment between 30 August 2010 and 8 October 2010. The final EIS ToR, which considered public submissions received during the comment period, were issued to the Proponent in December 2010. The Proponent subsequently compiled an EIS which went on public display in May and June 2012.

Due to ongoing site access constraints at Drake, the Proponent has been unable to enter the proposed mine site area to undertake intrusive geochemical sampling for subsequent analysis to inform the excavated waste section of the ToRs (Section 3.6.2 – Excavated Waste). As such, the Proponent compiled a desktop assessment to meet the excavated waste ToR requirements using geochemical data from mine sites proximal with Drake (GHD 2012c). Within the desktop mine waste report, the Proponent committed to completing additional sampling and analysis to further characterise the excavated waste material on site, to better inform the forward risk of handling and storing the excavated waste rock on site.

This report therefore, forms a stand-alone technical appendix within the Drake Coal Mine Supplementary Environmental Impact Statement (SEIS) which will be assessed by DEHP for Project approval under the *Queensland Environmental Protection Act 1994*.

As noted above, the contents of this report aim to address specific requirements within the Project's final ToR; and in particular, Section 3.6.2 – Excavated Waste. The report may also inform other ToR requirements, potentially including:

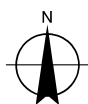
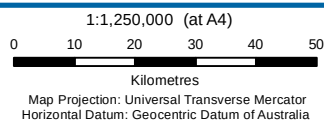
- Section 3.6.3 – Tailings or Fine Rejects;
- Section 3.7 – Rehabilitation and Decommissioning;
- Section 4.4 – Waste;
- Section 4.5 – Water; and/or
- Section 5 – Environmental Management Plan.



LEGEND

- | | | | | | |
|--|------------|--|------------|--|-----------------------|
| | Town | | River | | Project Area |
| | Major Town | | Major Road | | Local Government Area |
| | Railway | | | | |

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.



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Job Number 41-25138
Revision A
Date 31 Jan 2013

Project Location Plan

Figure 1

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Data source: QCOAL: Study Area (2010); GA: 250K V3 Topo/2009; DERM: Local Government Area. Created by: TH, WW

Finally, it remains important for overall holistic Project environmental assessment and management, that the contents of this report are considered in conjunction with information reported in other EIS technical reports, including, though potentially not limited to:

- Soil and Land Suitability Assessment (GHD 2012a, Volume 2a, Appendix C);
- Groundwater Report (GHD 2012b, Volume 2b, Appendix J);
- Waste Rock Characterisation Report (GHD 2012c, Volume 2a, Appendix G);
- Environmental Management Plan (GHD 2012d, Volume 3, Appendix A); and
- Water Management Plan (GHD 2012e, Volume 3, Appendix B).

1.2 Report Aims, Scope and Structure

1.2.1 Report Aim and Method

The primary aim of this report is to assess the potential for excavated mineral waste at the Project site to generate acid, neutral or alkaline drainage. Accordingly, and as noted in Section 1.1.2, the report intends to address specific requirements of the EIS ToR; in particular, Section 3.6.2 – Excavated Waste. Content from Section 3.6.2 of the ToRs is provided in Table 1 for ease of reference.

Table 1: Excavated waste terms of reference

Section	Activity / Impact	Description
3.6.2	Excavated Waste	Describe the materials to be excavated as waste. Also, describe and illustrate the location, design and methods for constructing dumps for waste rock and any subsoil that will not be replaced in rehabilitation. Estimate the tonnage and volume of waste rock and subsoil to be excavated during the various stages of operation. Estimates will be made for each separate rock and soil type. Describe the chemical and physical properties of the waste rock and subsoil, and assess the properties that affect their erosion and leaching potential. Discuss the potential for acid, neutral or alkaline drainage from waste dumps. Characterise the potential quality of leachate from the mined waste under field conditions, including contaminants such as sulfate, pH, chloride, iron, major cations and anions, and any chemical species in sufficient quantity that is likely to cause environmental harm including nuisance. Use the estimated amounts and characteristics of excavated waste to develop appropriate measures for dealing with that waste, including designs for waste dumps, and alternatives for excavated waste disposal such as in-filling of voids, off-site options and treatment of contaminated soil.

The method utilised herein to assess the primary report aims was to undertake a geochemical sampling and analysis program, and assessing the results against appropriate industry guidelines within the context of the proposed Drake mine plan. The geochemical results were then used to inform future materials handling, storage and rehabilitation of the excavated waste.

1.3 Information and Data Sources

GHD did not undertake any primary data generation by intrusive site investigations and/or sample collection and analysis for this report. All data used within this report, therefore, was generated by the Proponent. In that regard, GHD was reliant on the quality assurance processes of third parties with respect to data integrity during sample collection, transport, and analysis.

Information for use in this report was sourced from:

- A draft waste rock report supplied by Drake Coal (Drake Coal, 2011);
- Other electronic and hard copy reports (complete and incomplete) provided by QCoal for the Project site;
- Meetings, telephone conversations and emails with Drake Coal staff involved in the Drake Project between April 2011 and January 2013;
- Geochemical data generated by ALS as provided to GHD by the Proponent;
- Publically available information including books, theses, journal articles, and Government Department websites; and/or
- Drake Coal Project EIS chapters and/or technical reports, including the initial desktop waste rock characterisation report (GHD 2012c).

Technical guidelines considered when scoping and completing the contents of this report included:

- ACARP (2008). *Development of ARD assessment for coal process wastes*. Project C15034. Undertaken by Miller S. and Levay and Co Environmental Services;
- AMIRA (2002). *ARD Test Handbook*. Project P387A Prediction and kinetic control of acid mine drainage;
- Commonwealth Government - Department of Industry, Tourism and Resources (2007). *Leading Practice Sustainable Development Program for the Mining Industry: Managing Acid and Metalliferous Drainage*. Canberra;
- INAP (The International Network for Acid Prevention) (2009). *Global Acid Rock Drainage Guide*. Available at www.gardguide.com;
- Queensland Department of Mines and Energy (1995). *Assessment and Management of Acid Drainage*. Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland;
- Queensland Department of Mines and Energy (1995a). *Assessment and Management of Saline and Sodic Wastes*. Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland; and
- Queensland Department of Mines and Energy (1995b). *Tailings Management*. Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.

1.4 Limitations

This report has been prepared by GHD for Drake Coal Pty Ltd and may only be used and relied on by Drake Coal Pty Ltd for the purpose agreed between GHD and the Drake Coal Pty Ltd as set out in Section 1.2.1 of this report. GHD otherwise disclaims responsibility to any person other than Drake Coal Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on information provided in the inputs to this report (refer Section 1.3). GHD disclaims liability arising from any of the information being incorrect.

GHD has prepared this report utilising geochemical data provided by Drake Coal Pty Ltd which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

1.5 Report Structure

The report is structured as follows:

- Section 1: Introduction;
- Section 2: Project Description and Excavated Waste Volumes;
- Section 3: Boreholes, Sampling and Analysis;
- Section 4: Results and Discussion;
- Section 5: Summary and Conclusions;
- Section 6: References; and
- Appendices.

2. Project Description and Excavated Waste Volumes

The Project description remains consistent with that provided in the Drake EIS (QCoal 2012). A brief summary is provided below for ease of reference and application for this excavated waste report.

2.1 Project Overview and Location

As noted in Section 1.1, the Proponent is developing the Project, which located approximately 17 kms south of Collinsville in Queensland (Figure 1).

Exploration by the Proponent on the Drake site over recent years has resulted in the discovery of a new, shallow coal resource of over 200 million tonnes (Mt), over which the Proponent presently has three mining lease applications (MLAs).

Given the surficial proximity of the mineable reserves, ranging from 20 m to 140 m below surface, the Proponent proposes to establish a 10 pit, open-cut operation, using conventional on-site excavators and truck fleets. Primary mining activities will include:

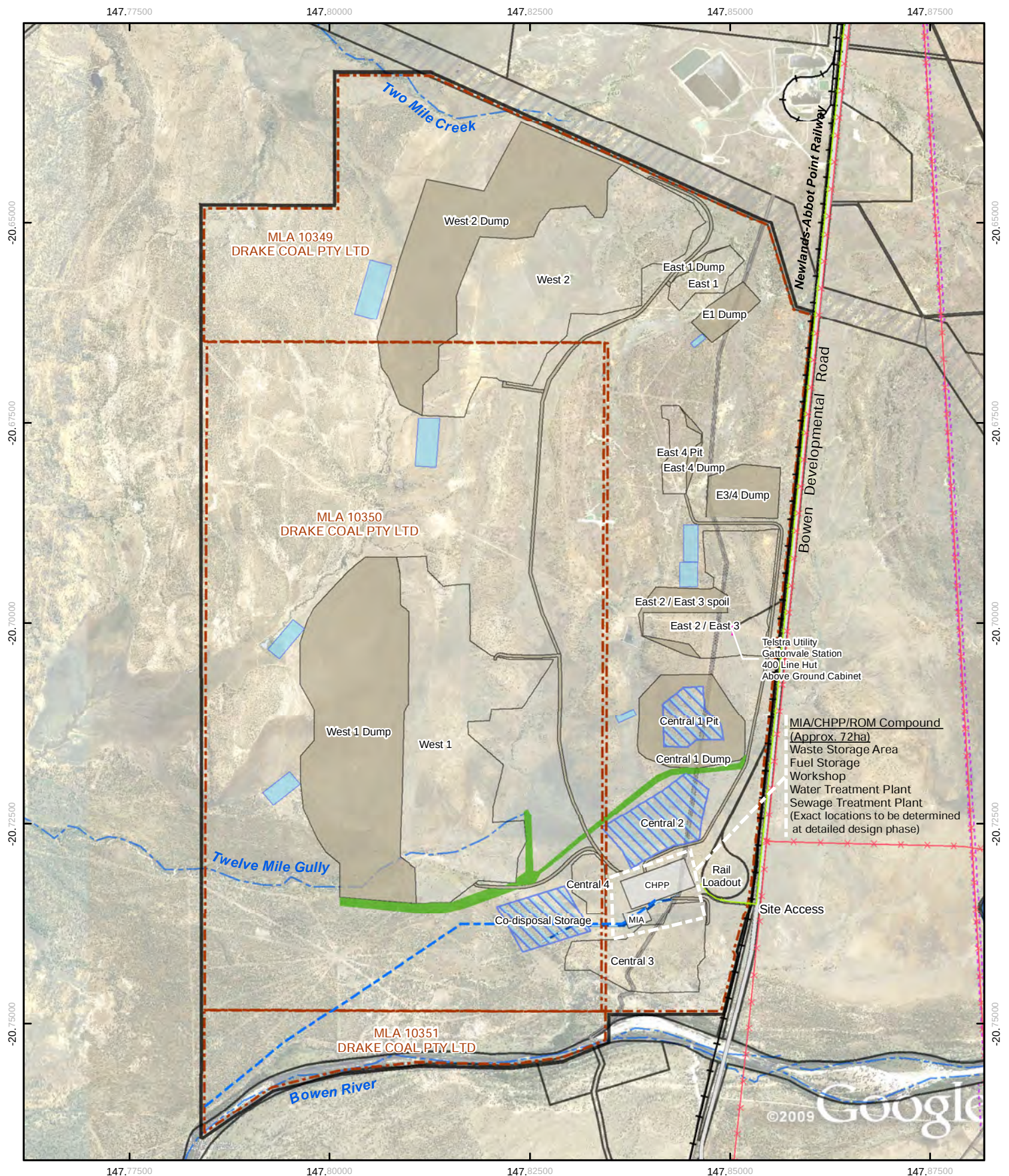
- Clearing vegetation;
- Stripping topsoil as appropriate;
- Removing over and interburden to out of pit, and later, in-pit dumps;
- Coal mining;
- Coal improvement through a coal handling and preparation plant (CHPP) as required; and
- Progressive rehabilitation.

The Project will seek approval to mine up to 10 million tonnes per annum (Mtpa) of run of mine (ROM) coal over the anticipated 30 year mine life, netting approximately 6 Mtpa of product export coal. The Project will produce both coking and thermal coal products, which will be railed to Abbot Point via load out by a yet to be constructed on-site rail loop.

The Proponent anticipates that a total area of approximately 3,442 hectares (ha) will be disturbed over the mine life.

Key elements relevant to this excavated waste assessment include (Figure 2):

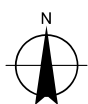
- The development of 10 open-cut pits on-site;
- Out of pit over- and interburden dumps to the west of each pit. It is proposed that once sufficient air space has been created in each void, pits will be progressively backfilled with over- and interburden during on-going mining operations;
- A water management system will be constructed that diverts clean water run-on, and captures and manages both dirty water runoff and pit water for beneficial reuse; and
- A CHPP is to be constructed on-site with a designed throughput of 1,400 tonnes per hour (tph). The presence of a CHPP will generate two mine waste streams, being;
 - Coarse rejects; and
 - Coal wash fines, or tailings.



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- | | | | |
|-------------------------|--------------------------------------|-------------------------|---------------------|
| — Major Road | — Water Supply Pipeline (Indicative) | — Mine Process Plant | — Sediment Basin |
| — Existing Railway | — Slurry Pipeline (Indicative) | — Out of Pit Spoil Area | — Pit |
| — Contour (5m interval) | — Telstra Utility | — Haulage Road | — Diversion Channel |
| — Powerline | — Project Area | — Co-disposal Storage | — Proposed Rail |
| — Proposed | — Mining Lease Application Boundary | | |
| — Existing | | | |

1:70,000 (at A4)
0 0.5 1 1.5 2 2.5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



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Project Layout Plan

Figure 2

The two CHPP waste streams are to be managed by transferring the material into to be constructed, on-site co-disposal facilities (Figure 2).

Pending approval for the Project, it is anticipated that construction will commence in mid-2013, with commissioning and first coal production scheduled for late 2014.

2.2 Target geology

A detailed description of the regional and local geology for the northern Bowen Basin and the Drake site respectively were presented in GHD (2012c). Therefore, only a brief summary is provided below.

The target coal seams for the Project are located within the Permian aged Moranbah Coal Measures within the Blackwater Group (Table 2).

Table 2: Northern Bowen Basin Coal Group Nomenclature

Age	Million years before present ² (approx.)	Group	Geological Units (Northern Bowen Basin)		Tectonic formative event ¹
Late Permian	258-253	IV	Blackwater Group	Rangal Coal Measures Fort Cooper Coal Measures ³	Flexural loading phase
	263-258	III		Moranbah Coal Measures	
Early Permian	284-270	II	Back Creek Group	Blenheim Subgroup Collinsville Coal Measures	Thermal sag phase
	325-284	I	Lizzie Creek Volcanics Reids Dome Beds		Rift Phase

1: Michaelson (2000, 2000a)

2: Fielding *et al.* (2000)

3: Included as Group III A by Mallet *et al.* (1995).

The full sequence of coal seams present within the Moranbah Coal Measures, from the A to the Q seam inclusive, are present at Drake and are planned for exploitation. The target seams are presented schematically in Figure 3. Note that not all seams are present in all pits on site due to localised faulting, in addition to a stratigraphic dip of approximately 5-7° ESE.

As seen on Figure 3, regionally adopted Moranbah Coal Measure nomenclature has the coal seams at the Project site alphabetised from the stratigraphically oldest 'A Seam' to the youngest 'Q or Upper Goonyella' Seam. The overlying R and S Seams present on adjacent mining tenures will not be disturbed at the Project site as they are either not present, or are not economically viable. They have been included herein for stratigraphical completeness. The inter- and overburden units shown in Figure 3 have been demarcated by the author based on the existing coal seam nomenclature for simplicity.

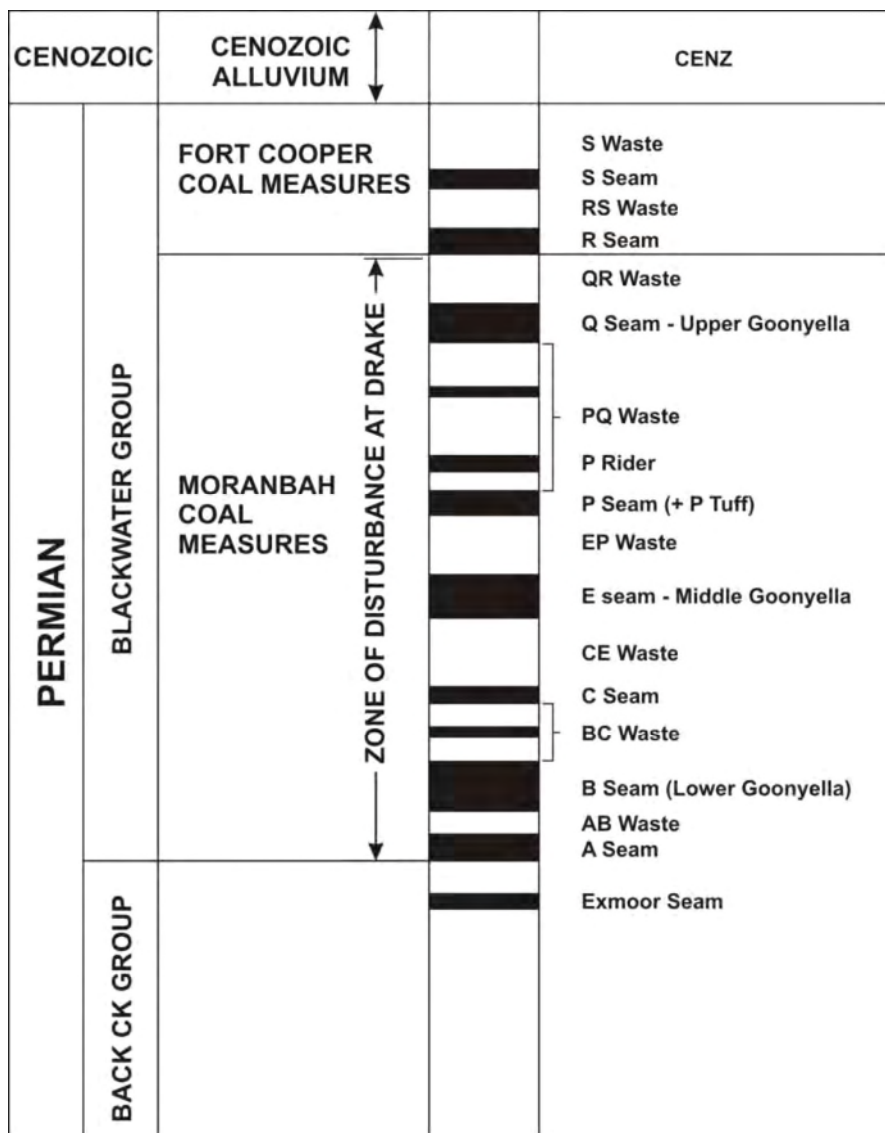
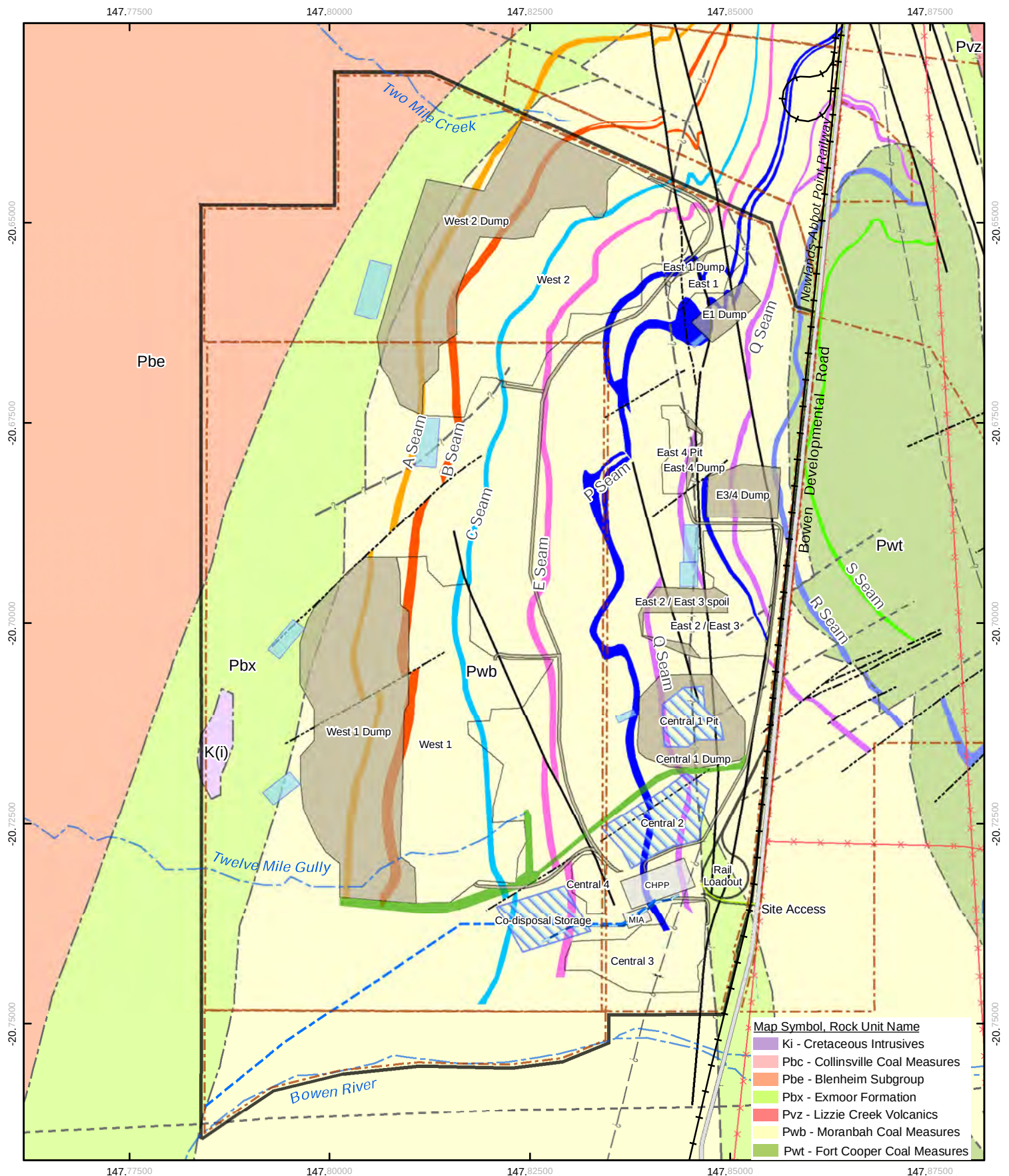


Figure 3: Schematic of the Targeted Drake Stratigraphy

Note: Seams A to Q inclusive to be mined at Drake at various locations.
Dip of coal seams normalised to zero for illustrative purposes.

The surface geological expression as represented by the outcropping of individual coal seams as they relate to the proposed mine pits on the Project site are shown on Figure 4.

Two schematic cross sections constructed from site exploration drilling depicting the target coal seams within the western (West 1 and West 2 pits) side of the Drake lease are shown in Figure 5 and Figure 6 respectively.

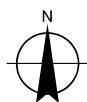


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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia

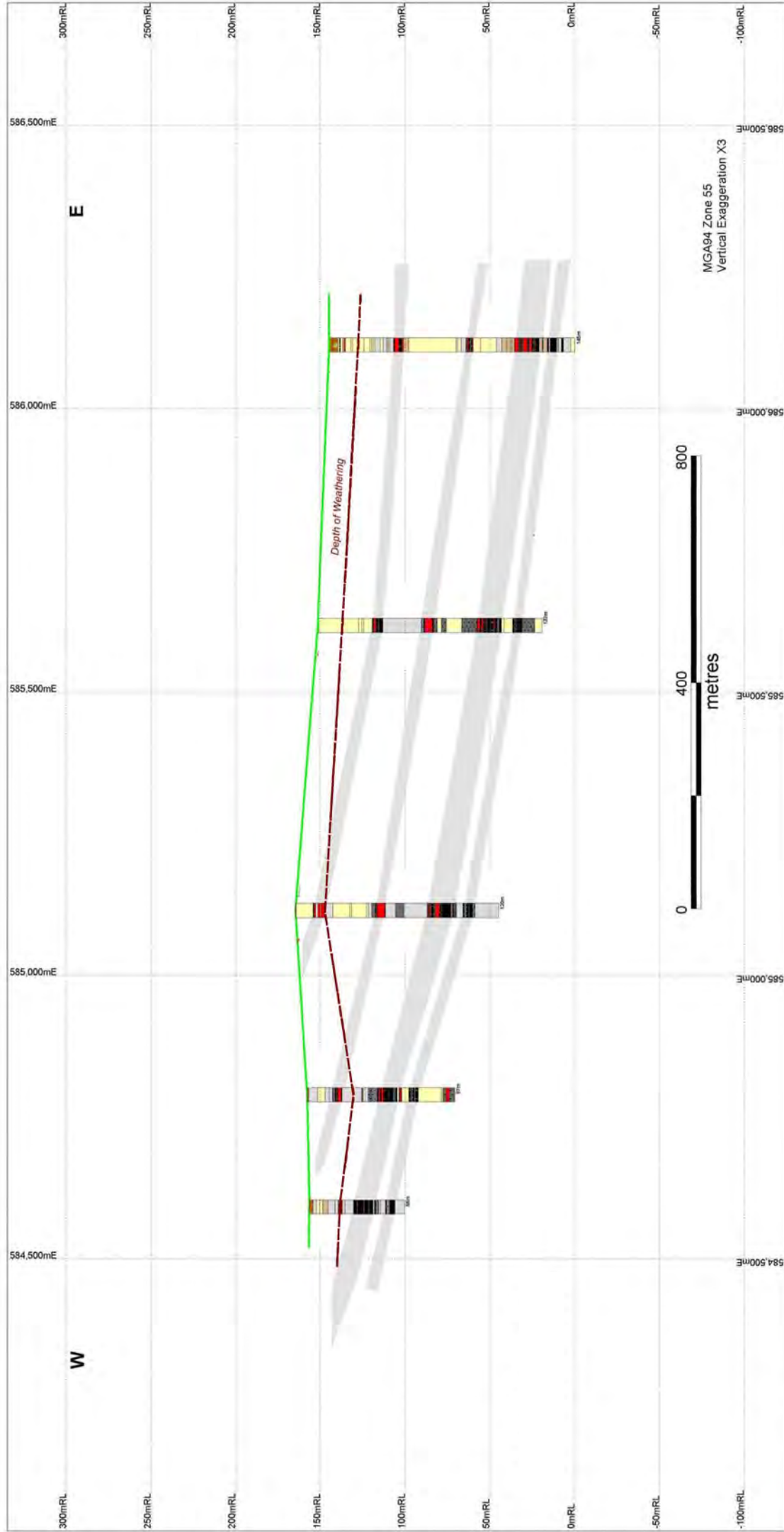


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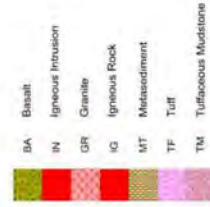
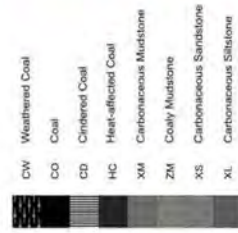
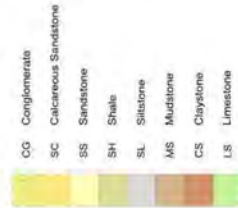
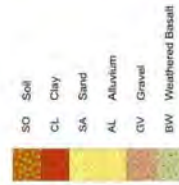
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and Geology

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Figure 4



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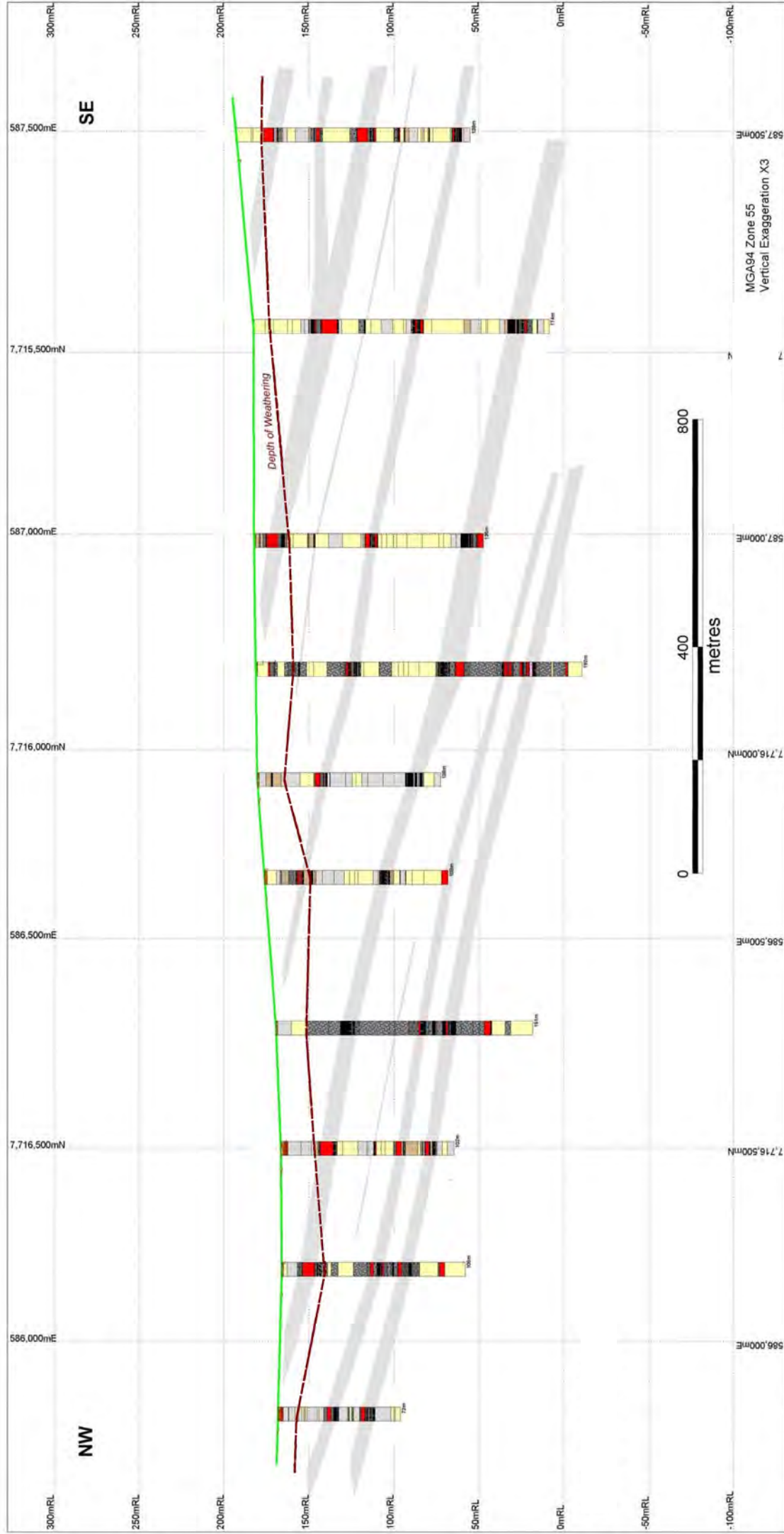
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W-E x-section through
West Pit 1

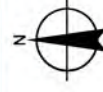
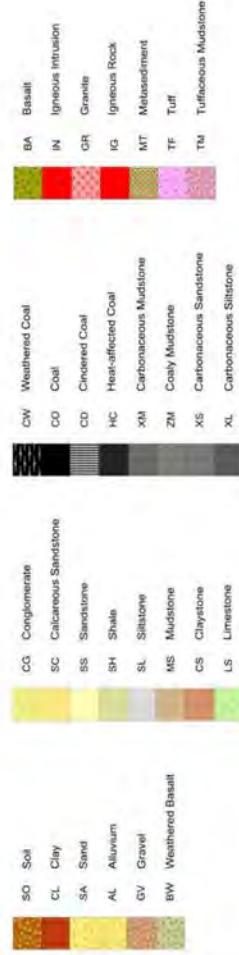
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Figure 5

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Data source: OCOAL Mine Layout (2011). Created by: JB



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Figure 6

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Data source: OCOAL, Mine Layout (2011). Created by: JB

2.3 Mine Plans

2.3.1 Pits and Mining Method

The proposed site plan for the Project was presented in Figure 2 and Figure 4; which show two main pits (West 1 and West 2), with eight proposed satellite pits (East 1 – 4 and Central 1 to 4 inclusive).

Target seams, run-of-mine (ROM) coal, waste volume and approximate disturbance area for each of the 10 proposed pits are shown in Table 3.

Table 3: Drake Pit Information

Pit	Target Seams	ROM Coal (mt)	Waste Volume ¹ (million bcm)
Central 1	P3, Q3	3.3	11.2
Central 2	P Rider, P3, C, E3, B Plies	7.1	78.2
Central 3	C and E3	8.4	69.0
Central 4	C and E3	1.3	8.0
West 1	P Rider, P3, C, E3, B Plies, A2	80.9	342.7
West 2	Q3, P Rider, P3, C, E3, B Plies, A2	83.6	543.7
East 1	P Rider, P	2.6	11.9
East 2	E3, Q3, P Rider, P3	1.4	16.2
East 3	Q3, P Rider, P3, C, E3, B Plies	11.5	100.1
East 4	Q3, P Rider, P3	1.7	10.1
Total	A, B, C, E, P, Q	201.8	1,191.1

1: Bank cubic metres refer to the *in situ* volume of waste material. Appropriate bulk densities have been applied to convert bank cubic metres to tonnages in Table 4.

The Proponent proposes to extract the ROM coal using hydraulic excavators and rear dump trucks in a series of traditional strip mines. Mining is scheduled to commence in the north western corner of pit West 1, in addition to Central 1; the latter being prepared as a co-disposal location for CHPP waste materials. Refer to Section 3.4.4 of GHD (2012) for additional detail on mine sequencing.

Mining would proceed by initially stripping surface vegetation, ahead of topsoil removal and stockpiling for reuse during progressive rehabilitation. Over- and interburden material above the limit of oxidation (LOX); reported as between approximately 12 to 25 m below surface from exploration borelogs, would be free-dug using a hydraulic excavator. Any non-weathered interburden below the LOX line would be blasted prior to removal. Initially, the Proponent proposes to haul the excavated waste material to out of pit spoil areas (Figure 4), prior to placing all subsequent mine waste in-pit as soon as practicable given mine scheduling.

The coal seams themselves would be free-dug using hydraulic excavators, or wheel loaders, with coal either being transported by dump truck to the ROM stockpile, or dumped directly into the ROM crusher facility depending on processing capacity at the time.

Multiple mining blocks would be active within a given mining strip, and at times, multiple active strips would be exploited over the life of mine to manage production rates against the technical challenges of mining the multiple plies within many of the Drake coal seams. Multiple mining blocks and mining strips would also allow for managing production dips due to the presence of igneous intrusions in the lower seams.

2.3.2 Waste Rock

Classification of the excavated waste material at Drake as reported herein is by:

- Stratigraphic inter- and overburden waste unit as delineated in Figure 3 (e.g. BC Waste); and
- Major lithological grouping as determined by drilling metres in the 2012 drilling program as reported by Drake Coal (e.g. carbonaceous material).

Table 4 provides a summary of estimated mine waste tonnages by waste unit for the Project.

Table 4: Summary of Total Mine Waste Volumes and Tonnages by Unit at Drake

↑ Stratigraphically younger	Excavated Waste Unit ¹	Estimated Life of Mine Waste Volumes (million bcm)	Estimated Life of Mine Tonnes ² (mt)	Percentage (%) by Weight
	CENZ ⁵	299.1	478.5	25.1
	QR Waste	12.6	31.5	1.6
	PQ Waste	21.7	54.3	1.8
	EP Waste	96.5	241.3	8.1
	CE Waste	137.2	343.1	11.5
	BC Waste	491.8	1,229.6	41.3
	AB Waste	131.9	329.7	11.1
	Total ³	1,190.8 ⁴	2,708.0	100.5 ⁴

1: Refer to Figure 3. 2: Bulk densities used for conversion and relative percent geologic units were estimated using exploration drilling data from Drake Coal at Drake in 2008 and 2012. Bulk densities used for volume to mass conversion for fresh material was sandstone 2.45, siltstone, mudstone including carbonaceous material 2.6. Remaining units were coal and igneous. Mean bulk density for approximate conversion used across all units was 2.5. Bulk density of 1.6 used for CENZ / soil / weathered waste units. 3: Excludes igneous intrusive waste rock. Approximately 7% of total waste tonnage estimated to be igneous distributed across units as determined by drilling data. 4: Variance from total in Table 3 and 100% due to rounding errors. 5: Note that CENZ as referred to herein refers to all topsoil and weathered material, including weathered Permian material. Whilst not technically correct, it was initially defined by a previous QCoal geological consultant and has been retained herein for continuity.

2.3.3 CHPP Waste

In addition to the over- and interburden waste for the Project described in Section 2.3.2, mine waste will be generated from a proposed 1,400 tonnes per hour (tph) Coal Handling and

Preparation Plant (CHPP) on-site. The CHPP will generate two discrete waste streams; those being:

- Coarse rejects; and
- Tailings.

It is important to consider the potential for AMD generation from these waste streams as the Proponent proposes to store the coarse rejects and tailings in three dedicated, on-site co-disposal facilities (Figure 2 and Figure 4); being:

1. Initial co-disposal storage located west of Central 3 Pit;
2. Subsequent storage into Central 1 Pit; and
3. Additional storage into Central 2 Pit.

If any pyrite is present in the coal seams themselves, the beneficiation process utilised in the CHPP will have the effect of concentrating the sulphidic content prior to on-site disposal. It is therefore important to understand the geochemistry of the CHPP waste streams to determine AMD potential. Table 5 details the approximate tonnages of CHPP waste (coarse rejects and tailings) from each of the 10 pits.

Table 5: Approximate CHPP Waste Volumes by Pit at Drake

Pit ¹	Coarse Rejects (million tonnes)	Tailings (million tonnes)	Total CHPP Waste (million tonnes)
Central 1	0.74	0.25	0.99
Central 2	1.79	0.60	2.39
Central 3	2.29	0.76	3.05
Central 4	0.35	0.17	0.52
West 1	24.05	8.02	32.07
West 2	24.12	8.04	32.16
East 1	0.67	0.22	0.89
East 2	0.29	0.10	0.39
East 3	2.95	0.98	3.93
East 4	0.44	0.15	0.59
Total	57.69	19.29	76.98

1: Refer to Figures 2 and 4 for pit locations.

The Initial Co-Disposal storage will be built at the start of the mine operations and will be ready to receive the first co-disposal material from the CHPP. After year 2, Central 1 Pit becomes available; whereby all co-disposal material will be stored therein. The next available storage will be Central 2 Pit, which will be taken into production at the start of mine year 3, and is planned to

be exhausted by the end of mine year 5. Additional co-disposal storage capacity is likely to be required at the beginning of year 11, whereby West 1 Pit is proposed for utilisation.

2.3.4 Summary of Mine Waste Streams at Drake

Based on the site geology, proposed mine plans, and site coal processing technology; an estimate of mine waste volumes generated at the Project over the life of mine are summarised in Table 6.

Table 6: Summary of Life-of-Mine Waste Mass

Waste Stream	Million Tonnes	Percentage (%) Total Waste by Weight
Waste Rock		
CENZ	478.5	25.1
QR Waste	31.5	1.6
PQ Waste	54.3	1.8
EP Waste	241.3	8.1
CE Waste	343.1	11.5
BC Waste	1,229.6	41.3
AB Waste	329.7	11.1
Total Waste Rock	2,708	97.2
CHPP Waste		
Coarse Rejects	57.7	2.1
Tailings	19.3	0.7
Total CHPP Waste	77.0	2.5
Total Waste	2,785.0	100.0

3. Boreholes, Sampling and Analysis

3.1 Borehole locations

For the stated purposes of geochemically characterising the geological material on-site and assessing any subsequent AMD potential, a mine waste sampling and analysis plan was developed and approved by DEHP in mid-2012. Initially, 14 new boreholes were proposed, with 16 actually drilled. The drilling and sampling program completed in October and November 2012, therefore, drilled 16 boreholes (Figure 7) for a cumulative total depth of 1,583 m.

The sampling and analysis plan aimed to achieve an appropriate distribution of boreholes across the project site, such that the geochemical samples collected would be broadly representative of the geological makeup of the excavated waste, such that the AMD risk could be informed. It was also based on:

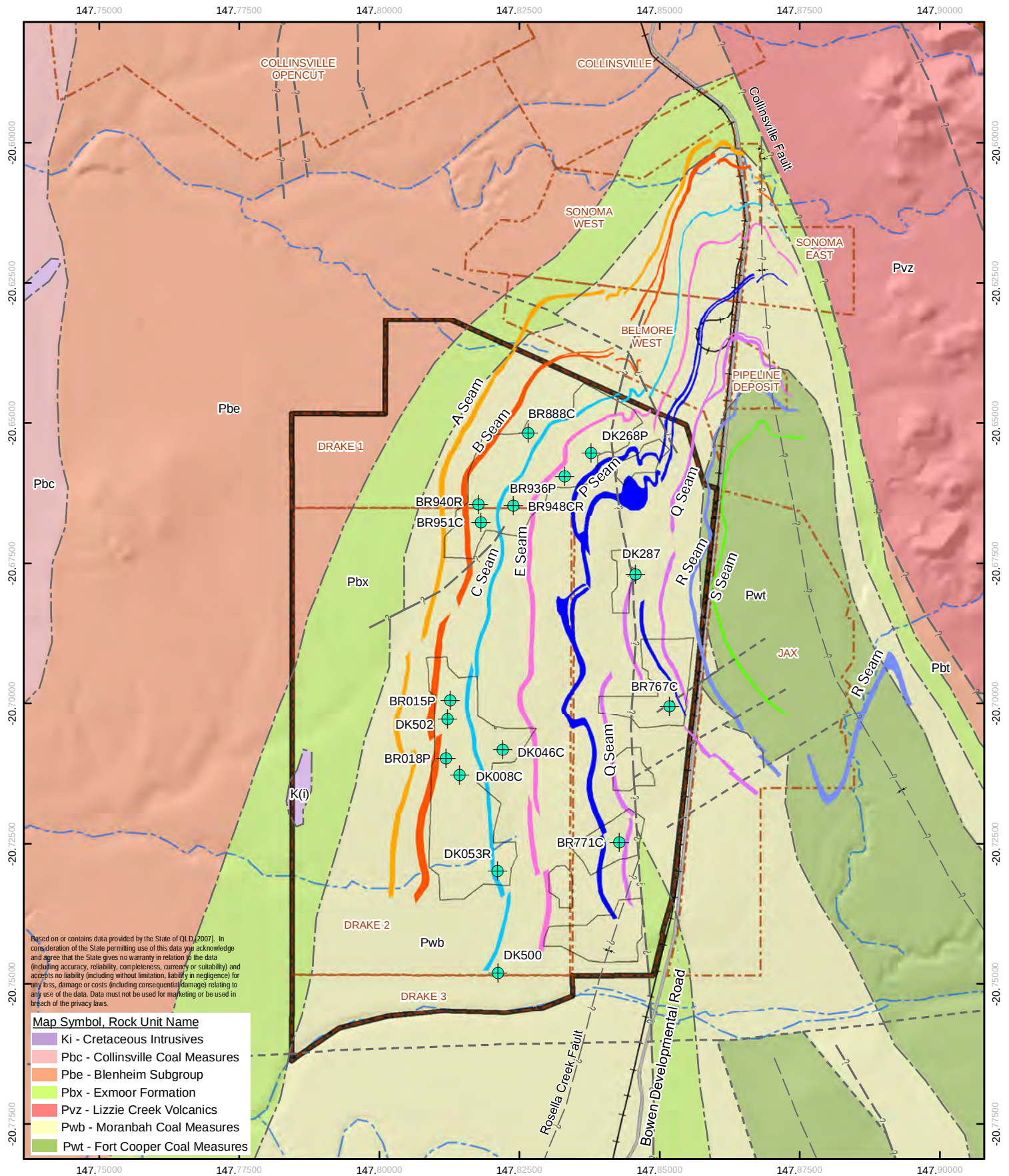
- The proposed location of the 10 pits at Drake;
- The location of the lithological units present that would contribute to excavated waste; and
- Drilling, sampling and analysis costs.

The holes were drilled by Global Drilling Pty Ltd and Focus Drilling Pty Ltd, with both contractors utilising variants of the Mayhew 1000 style rotary drilling rig along with a combination of drilling bits. In general, PCD (poly crystalline diamond) bits were used for both coring and chipping operations due to the hardness of the interburden rocks and intrusion within coal seams. In areas where downhole rock hardness was less, and coal seams were largely un-intruded, conventional tungsten carbide drill bits were used. The chip drill bits have an external diameter of 125 mm, while the core bits produce 100 mm (4 inch) drill core.

At Drake, all drill holes were lithologically logged by a geologist and rock types sampled with the assistance of a field technician. Geophysical logs were obtained from the holes in order to assist in the interpretation of parameters including rock density, clay composition, and coal quality.

In chipped holes, and chipped sections of holes, drill cuttings returned to the surface were collected and placed on the ground at 1m depth intervals (the average weight per meter per pile was in the order of 2 kg). Once lithologically logged by the geologist the chip piles were sub-sampled by hand based on rock type and observable physical/compositional variance. Based on the nature of the sedimentary sequence, this invariably resulted in sampling densities of approximately one sample per 1-3 m. In thicker more homogenous rock units, i.e. some sandstone units, the sampling density was decreased marginally but generally did not exceed a 5 m interval. The average sample weight throughout the program was in the order of 1-1.5 kg. The samples were placed in sealable plastic bags and stored in a cool, dark environment prior to transport to ALS in Brisbane.

The sampling of drill core involved the continuous quartering of the core by way of a hammer and chisel. As with the chip sampling, the endeavour of the core sampling was to gather representative samples of various rock types at a sufficient enough sampling density to ensure a statistically relevant result. Core sample intervals were similar to those of the chip program, but due to the greater specific gravity of the core sample, weights were significantly higher (up to 3 kg per metre sub-sampled). As with the chip sampling, the core samples were sealed in plastic bags and stored in a cool dark environment prior to transportation to ALS in Brisbane for analysis.



LEGEND

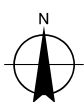
- Geochemical Borehole Locations
- Drainage Feature
- Mining Lease Application Boundary
- Project Area
- Pit
- Geological Structure
- Fault Approximate
- Fault Inferred
- Geological Boundary Approximate
- Geological Boundary Inferred
- Syncline Approximate
- Syncline Approximate Showing Dip and Plunge

1:100,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia



CLIENTS|PEOPLE|PERFORMANCE



Drake Coal Pty Ltd
Drake Coal EIS

Geochemical Borehole
Locations

Job Number 41-25138
Revision B
Date 11 Feb 2013

Figure 7

A list of sample numbers collected from each of the 16 boreholes is shown in Table 7. Lithological descriptives as provided by QCoal for the 329 geochemical samples are provided in Appendix A. The number of geochemical samples by lithological group is discussed below.

Table 7: Geochemical sample numbers by borehole

Borehole	Sample number	Borehole	Sample number
BR015P	9	BR951C	21
BR018P	11	DK008C	5
BR767C	23	DK046C	20
BR771C	25	DK053R	32
BR888C	22	DK268P	36
BR936P	34	DK287	16
BR940R	22	DK500	18
BR948CR	25	DK502	10
		Total	329

3.2 Lithological units sampled

Eight (including coal) broad lithological groups were identified from the 329 geochemical samples collected during the October and November 2012 field program; including coal (Table 8). The coal group was assessed separately herein as a surrogate for CHPP tailings.

As noted above in Section 3.1, samples were collected to be broadly representative of the volumes of each respective stratigraphic and lithological waste unit being excavated under the Proponent's current mine plans. Each stratigraphic waste unit itself comprises several lithological waste groups as determined using the drill core metres and geologists' notes from the October and November 2012 drilling program (Appendix A).

Table 8 presents the lithological waste groups, the length of drill core logged (and relative percentage of total length drilled), the number of fresh and weathered samples selected for each group (and relative percent of lithological samples by group).

Broadly, geochemical sample numbers correlated with the respective volume of excavated waste by lithological unit, as determined by drilled metres. The carbonaceous materials were purposely over represented as previous experience has determined that they are often amongst the higher risk lithologies with respect to the potential for AMD generation. This phenomenon is due to sulfide minerals forming through sulfate reduction during coal formation. As a result, there remains the potential for material in and adjacent to coal seams to have higher sulphidic material present than the overlying bedrock, and therefore, a higher AMD risk. Note that the coal lithological unit has been reported upon separately in this report as a surrogate for CHPP tailings (refer Sections 4.6 to 4.9 respectively).

Table 8: Geochemical samples by lithological group

Lithological group	Sum of 2012 drillhole length	% by drillhole length	No. of fresh samples	No. of weathered samples ³	Total samples	% by total samples
Soil	30.2	1.9	0	19	19	5.8
Siltstone	217.1	13.7	36	18	54	16.4
Sandstone	441.5	27.9	77	33	110	33.4
Mudstone	175.5	11.1	37	14	51	15.5
Intrusion	112.6	7.1	25	7	32	9.7
Coaly material	14.7	0.9	7	1	8	2.4
Carbonaceous material	117.8	7.4	51	4	55	16.7
Coal	473.1	29.9	NA ²	NA ²	NA ²	NA ²
Total	1,582.5	99.9 ¹	233	96	329	100

1: Variance from total in Table 3 and 100% due to rounding errors.

2: NA – not applicable. Coal samples were collected and analysed as surrogates for CHPP generated coal tailings. Refer to Sections 4.6 to 4.9 respectively.

3: Weathered samples are representative of the CENZ waste group (Tables 4 and 6) which accounts for approximately 25.1% of the excavated waste at Drake. 96 of the 329 samples analysed were weathered representing approximately 29.2% of the samples collected.

3.3 Geochemical Analysis

Geochemical analyses as shown in Table 9 were undertaken on the samples collected from Drake, and are reported herein. The data in Table 9 excludes the six coal seam composite samples analysed as surrogates for CHPP tailings (refer Sections 4.6 to 4.9 respectively).

ALS Environmental, Brisbane, conducted all geochemistry analysis and coordinated all sub-contracted testing. Metals analysis was completed by ALS Minerals in Brisbane through an internal ALS sub-consultancy. Laboratory results and QA/QC are presented in Appendix B. Individual detailed laboratory methods are available from ALS at <http://test.alsglobal.com>.

Table 9: Geochemical analysis

Analysis	Samples analysed	Method
Analysis on solid samples		
Slurry pH and EC	329	Soil / Water 1:5 (APHA 21 st ed. 4500H+)
Total sulphur	284	LECO at 1350 deg C.
Sulphate sulphur	284	HCl digestion then ICP-AES
Sulphide sulphur	284	By calculation
Acid neutralising capacity (ANC)	284	USEPA 600/2-78-054 / Modified Sobek
Maximum potential acidity (MPA)	284	By calculation
Net acid production potential (NAPP)	284	By calculation
Oxidation pH and single addition net acid generation (NAG)	284	AMIRA (2002) / Miller (1996)
Chloride	280	Chloride discrete analyser
Exchangeable cations and cation exchange capacity (CEC)	295	Rayment and Higginson (1992). Method 15A2. Ammonium chloride contact and then ICP-AES.
Exchangeable sodium percentage (ESP)	295	By calculation
35 element metals analysis on solids	292	35 elements by aqua-regia acid digestion and ICP-AES.
Australian Standard Leaching Procedure (ASLP)	92	AS 4439.2
Leachate pH and EC	92	APHA 21 st edition Procedure 4500 H+ B and APHA 2510 B.
Leachate alkalinity and acidity	92	APHA 21 st edition Procedure 2320B and 2310B respectively.
Leachate sulphate and chloride	92	ICP-AES and chloride discrete analyser
Leachate metals	92	ICP-AES

4. Results and Discussion

4.1 Introduction

The following section presents the analytical results and discusses any implications from those results with respect to AMD risk. The results are presented as follows:

1. Excavated waste results:
 - a. Geochemistry;
 - b. Metals;
 - c. Leachate; and
 - d. Dispersivity.
2. CHPP waste / tailings results:
 - a. Geochemistry;
 - b. Metals;
 - c. Leachate; and
 - d. Dispersivity.

Sample results are initially assessed by lithological waste group (e.g. sandstone), with subsequent correlation and discussion relative to excavated waste stratigraphic units for selected pits (e.g. AB waste in West 1 pit).

4.2 Excavated waste: Geochemistry

4.2.1 Slurry pH, EC and chloride

Slurry pH, electrical conductivity (EC) and chloride parameters provide a relatively cheap and rapid indication of the acidity and salinity of a sample at the time of testing. The degree of weathering the material has undergone, in addition to the availability of readily soluble salts may be inferred from these parameters.

The method used herein was a 1:5 solid to water ratio, which is an alternative to the AMIRA (20012) 1:2 method as approved under Queensland Government guidelines (DME 1995).

An acidic slurry paste pH ($\text{pH}_{1:5}$) value of less than approximately 5 may indicate the presence of stored acidity, or stored sulphide oxidation products within a sample, and subsequent potential for acid generating conditions. Conversely, alkaline slurry $\text{pH}_{1:5}$ values may indicate the presence of reactive neutralising minerals in a sample.

Slurry electrical conductivity ($\text{EC}_{1:5}$) may provide an indication of soluble salt loads associated with the sample. If the sample originates from a naturally saline environment, elevated slurry $\text{EC}_{1:5}$ values may indicate salinity. This is unlikely to be the case at Drake based on the depositional palaeoenvironment (see GHD 2012c for example). However, where natural salinity is low, elevated slurry $\text{EC}_{1:5}$ values would likely indicate the presence of salt from sulphide mineral oxidation.

Slurry chloride values are an alternative method of measuring the accumulation of water soluble salts in the soil sample, or the salinity of the sample. It most commonly measures chloride dissolved from sodium salts, although can also measure chloride dissolved from potassium and/or calcium salts.

Acidic slurry pH_{1:5} values, and/or elevated slurry EC_{1:5} and/or chloride values may be indicative of the potential of a sample to negatively impact the quality of drainage water emanating from waste stockpiles following dissolution of minerals following rainfall.

Sample classification for slurry pH_{1:5}, EC_{1:5} and chloride values against indicative classification values (DME 1995) are presented below. DME (1995) classification guidelines are reproduced in Table 10 for ease of reference.

Table 10: Slurry pH, EC and chloride classification

Test	Unit	Very low	Low	Med.	High	Very high
pH (1:5)	pH unit	<4.5	4.5 – 5.5	5.5 – 7.0	7.0 – 9.0	>9.0
EC (1:5)	µS/cm	150	150 - 450	450 - 900	900 – 2,000	>2,000
Chloride (1:5)	ppm	<100	100 - 300	300 - 600	600 – 2,000	>2,000

Slurry pH_{1:5} values

Slurry pH_{1:5} values are shown by fresh and weathered lithological waste groups in Table 11. Classification using the mean value as it compares to data in Table 10 is also provided.

The data presented in Table 11 indicates that the lithological waste groups at Drake are alkaline. All lithological waste groups; both fresh and weathered, are classified as having a 'very high' pH_{1:5} value (mean pH_{1:5} value in excess of 9.0 pH units), with the exception of the weathered soil and weathered carbonaceous material lithological waste groups, which were classified as 'high' (mean pH_{1:5} values between 7.0 and 9.0).

The excavated waste is highly unlikely to produce acidic drainage in the short term. This is based on the results of 329 Drake excavated waste samples returning a mean slurry pH_{1:5} classification of 'very high'; which suggests the presence of reactive neutralising minerals within the lithology. Note that the static geochemical testing used herein can only be used in predicting short term outcomes, with longer term material responses being predicted using kinetic geochemical testing. However, the static geochemical results are considered appropriate for the stated purpose of providing an indication of AMD risk for the excavated waste. Given the consistency of the dataset, in addition to consideration of the additional geochemical results provided in Section 4 of this report, longer term kinetic leaching would appear redundant in determining acid generation for the Drake samples.

Table 11: Excavated waste slurry pH_{1.5} values by lithological waste group

	Count	Mean	Median	Max.	Min.	St. Dev.	Classification ¹
Waste group	No.	← pH _{1.5} units →					
Soil - fresh	0	NA	NA	NA	NA	NA	NA
Soil - w eathered	19	8.5	8.4	9.7	7.4	0.6	High
Soil - all	19	8.5	8.4	9.7	7.4	0.6	High
Siltstone - fresh	36	9.5	9.6	9.9	8.5	0.3	Very high
Siltstone - w eathered	18	9.3	9.3	9.8	8.8	0.3	Very high
Siltstone - all	54	9.4	9.5	9.9	8.5	0.3	Very high
Sandstone - fresh	77	9.4	9.5	9.9	8.3	0.3	Very high
Sandstone – w eathered	33	9.2	9.2	9.7	8.2	0.3	Very high
Sandstone - all	110	9.4	9.4	9.9	8.2	0.3	Very high
Mudstone - fresh	37	9.5	9.5	9.9	8.5	0.3	Very high
Mudstone - w eathered	14	9.1	9.1	9.5	8.2	0.4	Very high
Mudstone - all	51	9.3	9.4	9.9	8.2	0.4	Very high
Intrusion - fresh	25	9.7	9.6	10.1	9.1	0.3	Very high
Intrusion – w eathered	7	9.1	9.0	9.8	8.8	0.4	Very high
Intrusion - all	32	9.5	9.5	10.1	8.6	0.4	Very high
Coaly material - fresh	7	9.2	9.1	9.7	8.8	0.3	Very high
Coaly material - w eathered	1	9.8	9.8	9.8	9.8	0	Very high
Coaly material - all	8	9.3	9.2	9.8	8.8	0.4	Very high
Carb. material - fresh	51	9.4	9.4	10.0	8.2	0.4	Very high
Carb. material - w eathered	4	8.8	8.7	9.4	8.4	0.4	High
Carb. material - all	55	9.3	9.4	10.0	8.2	0.4	Very high
Total - fresh	233	9.5	9.5	10.1	8.2	0.3	Very high
Total – w eathered	96	9.0	9.1	9.8	7.4	0.5	Very high
Total – all	329	9.3	9.4	10.1	7.4	0.4	Very high

1: Classification as determined from Table 1 (DME 1995) – refer Table 10. NA: Not applicable as no samples in this category.

Slurry EC_{1:5}

Slurry EC_{1:5} values are shown by fresh and weathered lithological waste groups in Table 12. Classification using the mean value as it compares to data in Table 10 is also provided.

The data presented in Table 12 indicates that the lithology at Drake is non-saline. All lithological units; both fresh and weathered, are classified as having a 'low' EC_{1:5} value (mean EC_{1:5} value between 150 and 450 µS/cm), with the exception of the weathered mudstone and weathered coaly units which were both classified as 'medium' (mean EC_{1:5} values between 450 and 900 µS/cm).

Table 12: Excavated waste slurry EC_{1:5} values by lithological waste group

Waste group	Count	Mean	Median	Max.	Min.	St. Dev.	Classification ¹
	No.	←		µS/cm		→	
Soil - fresh	0	NA	NA	NA	NA	NA	NA
Soil - w eathered	19	234	191	593	93	151	Low
Soil - all	19	234	191	593	93	151	Low
Siltstone - fresh	36	215	193	403	80	91	Low
Siltstone - w eathered	18	348	293	862	109	190	Low
Siltstone - all	54	259	213	862	80	145	Low
Sandstone - fresh	77	200	175	485	64	87	Low
Sandstone – w eathered	33	332	303	763	93	192	Low
Sandstone - all	110	251	189	763	64	144	Low
Mudstone - fresh	37	210	189	416	46	86	Low
Mudstone - w eathered	14	459	454	840	199	214	Medium
Mudstone - all	51	278	232	840	46	173	Low
Intrusion - fresh	25	253	246	556	113	112	Low
Intrusion – w eathered	7	290	239	594	167	153	Low
Intrusion - all	32	261	243	594	113	121	Low
Coaly material - fresh	7	140	131	197	91	44	Very low
Coaly material - w eathered	1	544	544	544	544	0	Medium
Coaly material - all	8	190	147	544	91	149	Low
Carb. material - fresh	51	198	185	402	57	86	Low
Carb. material - w eathered	4	150	137	196	129	31	Low

	Count	Mean	Median	Max.	Min.	St. Dev.	Classification ¹
Carb. material - all	55	195	182	402	57	84	Low
Total - fresh	233	207	184	556	46	91	Low
Total – w eathered	96	326	267	862	93	193	Low
Total – all	329	245	198	862	46	141	Low

1: Classification as determined from Table 1 (DME 1995) – refer Table 10. NA: Not applicable as no samples in this category.

Additionally, the fresh coaly material was classified as ‘very low’ having mean slurry EC_{1:5} values of 140 µS/cm.

The overall slurry EC_{1:5} classification for the 329 Drake excavated waste samples as ‘low’ suggests that the lithology is non-saline, and would imply that the excavated waste is highly unlikely to produce saline drainage in the short term. These findings are consistent with weathering characteristics of lithologies deposited in deltaic and fluvial, rather than marine environments within the Bowen Basin in the late Permian (Hunt 1987).

Chloride

Slurry chloride values are shown by fresh and weathered lithological units in Table 13. Classification using the mean value as it compares to data in Table 10 is also provided.

The data presented in Table 13 broadly supports the EC_{1:5} data and indicates that the lithology at Drake is generally non-saline. All lithological units; both fresh and weathered are classified as having either a ‘very low’ or ‘low’ chloride value (mean chloride value below 100 ppm and between 100 and 300 ppm respectively), with the exception of the weathered mudstone unit which was classified as ‘medium’ (mean chloride values between 300 and 600 ppm). This finding is broadly consistent with the EC_{1:5} data, presented above.

As may be expected, mean chloride concentrations in all lithological groups was higher in the weathered samples relative to the fresh samples, likely due to an increase secondary salts as the geology weathers.

The overall slurry chloride classification for the Drake excavated waste samples as ‘very low’ further suggests that the lithology is non-saline, and would imply that the excavated waste is highly unlikely to produce saline drainage in the short term. As with the EC_{1:5} data presented above, these findings are consistent with weathering characteristics of lithologies deposited in deltaic and fluvial, rather than marine environments within the Bowen Basin in the late Permian (Hunt 1987).

Table 13: Excavated waste chloride values by lithological waste group

	Count	Mean	Median	Max.	Min ² .	St. Dev.	Classification ¹
Waste group	No.	←		mg/kg	→		
Soil - fresh	0	NA	NA	NA	NA	NA	NA
Soil - weathered	11	121	60	500	5	167	Low
Soil - all	11	121	60	500	5	167	Low
Siltstone - fresh	36	38	30	290	5	54	Very low
Siltstone - weathered	9	242	100	660	10	277	Low
Siltstone - all	45	79	30	660	5	152	Very low
Sandstone - fresh	76	35	30	220	5	31	Very low
Sandstone – weathered	17	260	170	890	5	262	Low
Sandstone - all	93	76	30	890	5	143	Very low
Mudstone - fresh	37	35	20	160	5	32	Very low
Mudstone - weathered	8	504	490	1,110	5	413	Medium
Mudstone - all	45	118	30	1,110	5	247	Low
Intrusion - fresh	23	62	20	820	5	166	Very low
Intrusion – weathered	4	225	55	750	40	350	Low
Intrusion - all	27	86	20	820	5	203	Very low
Coaly material - fresh	7	11	10	20	5	7	Very low
Coaly material - weathered	1	300	300	300	300	0	Low
Coaly material - all	8	47	10	300	5	102	Very low
Carb. material - fresh	49	34	30	120	5	24	Very low
Carb. material - weathered	2	120	120	200	40	113	Low
Carb. material - all	51	37	30	200	5	33	Very low
Total - fresh	228	37	30	820	5	62	Very low
Total – weathered	52	238	135	1,110	5	289	Low
Total – all	280	78	30	1,110	5	161	Very low

1: Classification as determined from Table 1 (DME 1995) – refer Table 10.

2: Laboratory detection limit was 10 ppm; a value of 50% of this limit was used for statistical purposes, i.e. 5 ppm.

NA: Not applicable as no samples in this category.

4.2.2 Acid base accounting

Acid base accounting is a term that incorporates a range of static geochemical tests to determine the theoretical maximum potential acidity (MPA) of a sample through the oxidation of sulphide minerals, the theoretical maximum acid neutralising capacity (ANC) of a sample through the dissolution of alkaline carbonates, the displacement of exchangeable bases, and the weathering of silicates, and therefore, the net acid producing potential (NAPP) of a sample (AMIRA 2002). These static geochemical techniques are defined by AMIRA (2002) as initial screening tools. The results are used to classify the samples and identify any uncertain samples whereby additional, more detailed testing may be required.

In order to determine the MPA of a sample, the total sulphur percent must first be determined. At Drake, 284 geochemical samples underwent total sulphur and sulphate sulphur analysis, with the net of total sulphur minus sulphate sulphur being defined as the reactive (or sulphide) sulphur content of the sample. This procedure assumes that all remaining sulphur is 'pyritic' or reactive, and available to form acid upon oxidation; an assumption that does not always hold true with coal waste samples (ACARP 2008) due to the presence of organic, non-acid producing sulfur. The procedure may therefore overestimate the acid potential of a sample, and is therefore deemed to be a somewhat conservative approach for the purposes of this study and was undertaken in lieu of more detailed sulphur speciation in the interests of budgetary considerations (Stewart *et al.* 2005; ACARP 2008).

Sample classification using acid base accounting was undertaken using the ANC/MPA ratio (or net potential ratio - NPR) whereby as a general rule, a NPR ratio of approximately 2 or greater signifies that there is a high probability that the material will remain near neutral, and should not be problematic with respect to AMD; all other factors being equal (AMIRA 2002).

The above methodology may also overestimate the acid neutralising potential of a sample due to assumptions related to the type of carbonate present; i.e. that it is all present as neutralising calcite (Skousen *et al.* 1997; Weber *et al.* 2004). This is in addition to potentially overestimating the MPA of a sample as noted above despite the adjustment for sulphate sulphur. This is as non-acid forming sulphur species may be present in the samples; for example, organic sulphur.

The above consideration notwithstanding, the acid base accounting results provide a useful first pass screening tool for assessing the likely acid risk from the Drake samples upon oxidation, and are therefore deemed appropriate for the stated aims of this study.

The summary acid base accounting results by lithological waste group are presented in Table 14, with NPR classification by lithology then plotted in Figure 8 to Figure 15 respectively. Note that the total sulphur value on the 'x axis' in Figure 8 to Figure 15 inclusive is an adjusted reactive sulphur (or sulphide sulphur) value, calculated as total sulphur minus sulphate sulphur; i.e. the reactive sulphur values in Table 14.

Table 14: Waste Rock Acid Base Accounting Geochemical Results by Lithological Waste Group

Waste Unit	Stat.	Total S		Sulphate S m g/kg	Reactive S ³ %	MPA ¹		ANC kg H ₂ SO ₄ tonne	NAPP		NPR ² ratio
		%				←	→				
Carbonaceous material	Count	52		52	52			52	52		50 ⁵
	Mean	0.07		128	0.06	1.8		32.2	-30.4		49.0
	S.D.	0.08		126	0.08	2.3		23.5	23.3		NA ⁶
	Range	0.01-0.50		50-910	0.0 ⁴ -0.5	0.0-15.1		6.6-124.0	-120.5 to -3.7		2.2 – 323.5
Coaly material	Count	8		8	8			8	8		7
	Mean	0.09		86	0.08	2.4		27.1	-24.7		10.4
	S.D.	0.05		51	0.05	1.5		22.8	23.1		NA
	Range	0.005-0.15		50-170	0.0-0.15	0.0-4.5		6.1-60.1	-58.1 to -2.9		1.9-30.2
Intrusion	Count	29		29	29			29	29		26
	Mean	0.06		83	0.06	1.7		89.5	-87.8		125.5
	S.D.	0.08		59	0.08	2.5		54.5	54.2		NA
	Range	0.005-0.38		50-240	0.0-0.36	0.0-10.9		16.3-315.0	-315.0 to -14.9		10.2-644.4
Mudstone	Count	45		45	45			45	45		36
	Mean	0.05		152	0.04	1.2		36.8	-35.6		79.8
	S.D.	0.05		126	0.05	1.5		23.5	23.7		NA
	Range	0.005-0.29		50-630	0.0-0.28	0.0-8.5		9.5-116.0	-115.9 to -8.4		3.9-1,263.6
Sandstone	Count	95		95	95			95	95		78
	Mean	0.03		132	0.02	0.6		68.9	-68.3		225.5
	S.D.	0.02		86	0.02	0.7		59.4	59.5		NA
	Range	0.005-0.11		50-450	0.0-0.1	0.0-2.9		4.7-426.0	-425.7 to -3.6		4.4-2,120.9
Siltstone	Count	45		45	45			45	45		36
	Mean	0.04		139	0.03	0.8		40.3	-39.5		73.3
	S.D.	0.04		108	0.04	1.2		25.2	25.4		NA
	Range	0.005-0.26		50-620	0.0-0.24	0.0-7.3		5.9-114.0	-114.0 to -4.6		4.6-530.1
Soil	Count	10		10	10	10		10	10		1

Waste Unit	Stat.	Total S	Sulphate S	Reactive S ³	MPA ¹	ANC	NAPP	NPR ²
		%	mg/kg	%	← kg H ₂ SO ₄ →	tonne	→	ratio
	Mean	0.01	225	0.001	0.02	42.8	-42.8	110.0
	S.D.	0.005	148	0.002	0.05	31.5	31.5	NA
	Range	0.005-0.2	50-510	0.0-0.005	0.0-0.15	9.4-85.2	-85.2 to -9.4	110.0-110.0
	Count	52	52	52	52	52	52	13
Weathered samples	Mean	0.01	120	0.006	0.2	63.3	-63.1	129.8
	S.D.	0.02	131	0.01	0.5	64.0	64.0	NA
	Range	0.005-0.11	50-630	0.0-0.075	0.0-0.295	7.9-360.0	-7.4 to -360.0	6.3-530.0
	Count	232	232	232	232	232	232	221
Fresh samples	Mean	0.06	127	0.04	1.3	50.2	-48.9	124
	S.D.	0.06	99	0.06	1.8	41.7	41.8	NA
	Range	0.005-0.5	50-910	0.0-0.5	0.0-15.1	4.7-426.0	-425.7 to -2.9	1.9-2,120.9
	Count	284	284	284	284	284	284	234
All samples	Mean	0.048	132	0.04	1.1	52.6	-51.5	123.9
	S.D.	0.056	107	0.05	1.65	46.7	46.8	NA
	Range	0.005-0.5	50-910	0.0-0.5	0.0-15.1	4.7-426.0	-425.7 to -2.9	1.9-2,120.9
	Count	284	284	284	284	284	284	234

1: Stoichiometrically calculated from results. Adjusted to consider sulphate sulphur results, and is therefore an adjusted value. When total S was < lab PQL of 0.01 mg/kg, a value of 0.005 was used. When sulphate sulphur was < lab PQL of 100 mg/kg, a value of 50 mg/kg was used. MPA (kg H₂SO₄ per tonne) = (total S – sulphate S) * 30.6.

2: Calculated from results. Generally, an ANC/MPA ratio of greater than 2 indicates a suitable excess of inherent acid buffering capacity in the waste material (AMIRA 2002).

3: Total S – sulphate S.

4: Where the sulphate concentration exceeded the total S concentration, within the allowable laboratory error, resulting in a negative reactive S value, a value of 0 was used.

5: Count may be different due to Note 4, above, in which case the MPA becomes zero and a NPR cannot be calculated due to a return of 'not divisible by zero'. The NPR is effectively a redundant measure in this instance as there is 0.0% reactive S in the sample.

6: NA = not applicable as the NPR is a ratio rather than an absolute number for statistical purposes.

The data in Table 14 indicates overall that there appears to be little risk of AMD generating from either the fresh or weathered samples in all lithological waste groups at Drake in the short term. Indeed, only one sample returned an NPR value less than 2; a sample of coaly material which returned a NPR of 1.9. The total sulphur values within all lithologies, including the coaly material and the carbonaceous material; generally regarded as higher AMD risk, had a maximum value of 0.5%. This is consistent with the broader literature on the late Permian coal measures of the Bowen Basin (Hunt 1987).

As a consequence of the low total sulphur values, the adjusted 'sulphide sulphur' values mean that all lithological waste units retain a very low potential to generate acid upon oxidation of the sulphidic material, with a maximum value of 15.2 kg H₂SO₄ / tonne for a sample of carbonaceous material.

Despite a single MPA reading of 15.2 kg H₂SO₄ / tonne for a sample of carbonaceous material, the carbonaceous material lithological waste group as a whole (52 samples) had a mean MPA value of 1.8 kg H₂SO₄ / tonne, and a mean NPR of 49, thereby indicating a surfeit of acid neutralising capacity relative to the unit's ability to generate acid upon sulphide oxidation (refer Table 14). The data for the carbonaceous material provides increased confidence that the unit is not an AMD risk, notwithstanding the dearth of carbon speciation data (i.e. total, organic, carbonate etc).

Evidence of the likely presence of reactive carbonate minerals in the carbonaceous material lithological group was a mean 'fizz rating' of 1.3 (not reported; refer laboratory results in Appendix B). A 'fizz rating' is determined prior to undertaking net acid generation (NAG) tests whereby a few drops of hydrochloric acid are added to the sample and the visible reaction observed. The 'fizz rating' is measured on a scale of 0 to 5, where 0 is no reaction and 5 is lime, or pure calcite (CaCO₃). A mean rating of 1.3 indicates a 'fizz rating' of between slight and moderate; indicative of the presence of reactive carbonate minerals.

The most reactive samples in the 'fizz test' were the intrusive material (a mean value of 2.2) followed by sandstone (a mean value of 1.9). The intrusive material reacting to acid with a moderate to strong response, is consistent with its mean NAPP value of -87.8 kg H₂SO₄ / tonne; almost an acid consuming result. This is consistent with potentially acid consuming mineralogy of the intrusives in the northern Bowen Basin as described by Mallet *et al.* (1995) which includes trachyte, latite, quartz diorite (or andesite), feldspar porphyry and subordinate diorite. The presence of alkali feldspar, biotite and even olivine in such rocks may add to the potential acid neutralising capacity of the intrusive lithology.

The sandstone unit had a mean NAPP value of -68.3 kg H₂SO₄ / tonne, and notwithstanding a lack of carbon speciation data, appears to have the potential to be a suitable capping material for waste rock dumps, should the material not be dispersive. Mean adjusted MPA values of 1.7 and 0.6 kg H₂SO₄ / tonne for the intrusive and the sandstone lithological group respectively (refer Table 14) indicates a very low potential for both units to generate acid upon oxidation; and would further suggest that there is an excess of neutralising minerals in the two lithologies relative to any residual sulphidic material. Note that total sulphur on the 'x-axis' in Figure 8 to Figure 15 respectively is a visual surrogate for MPA.

The weathered material returned a lower adjusted mean MPA value of 0.2 kg H₂SO₄ / tonne than the fresh samples (1.3 kg H₂SO₄ / tonne); likely indicative of less residual, unoxidised sulphidic minerals in the weathered units relative to the fresh units.

The acid base accounting data plotted on Figure 8 to Figure 15 inclusive is simply a visual representation of the information summarised in Table 14. The data shows that all but one sample has a NPR of greater than 2, indicating that all lithological groups likely have sufficient buffering capacity to offset any acid generated through sulphide oxidation, on the basis of the analytical data assessed. The one sample with an NPR below 2 was a fresh coaly material sample as noted above and shown in Figure 9.

The propensity for the weathered material to have a lower mean MPA value than the fresh samples as the bulk of the sulphidic minerals present have oxidised (as noted above) is visually represented by the bulk of the lighter blue squares plotting proximal to the 'y axis' on Figure 8 to Figure 15 inclusive. Figure 15 has a logarithmic 'y axis' to highlight this point. This is important as the CENZ waste unit is represented by the soil lithological group, in addition to all other excavated weathered material above the limit of oxidation at Drake; in total approximately 480 million tonnes, or 25 percent of the excavated waste. It is therefore important that the weathered material is adequately assessed such that any AMD risk is understood, in addition to subsequently understanding its potential for beneficial reuse in progressive site rehabilitation.

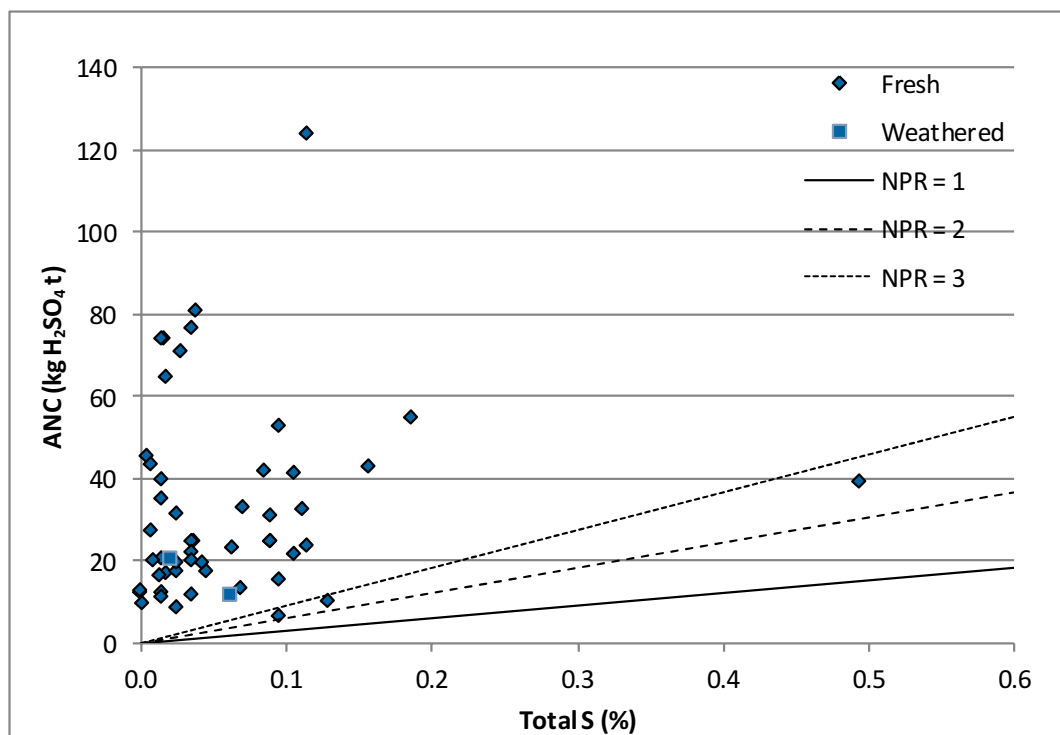


Figure 8: Carbonaceous material acid base account plot

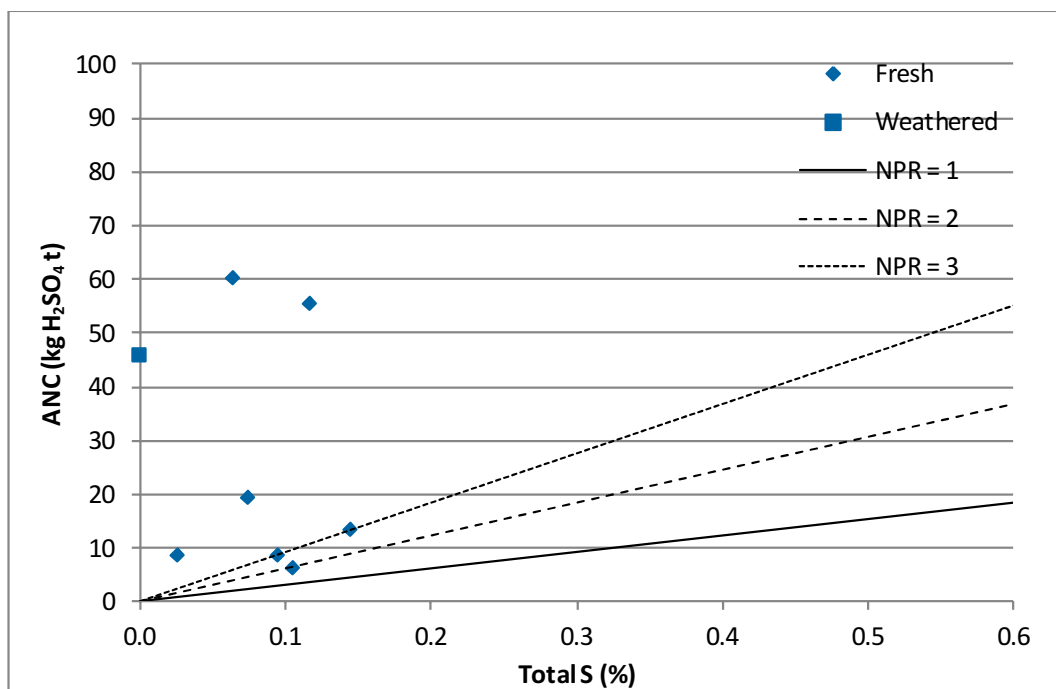


Figure 9: Coaly material acid base account plot

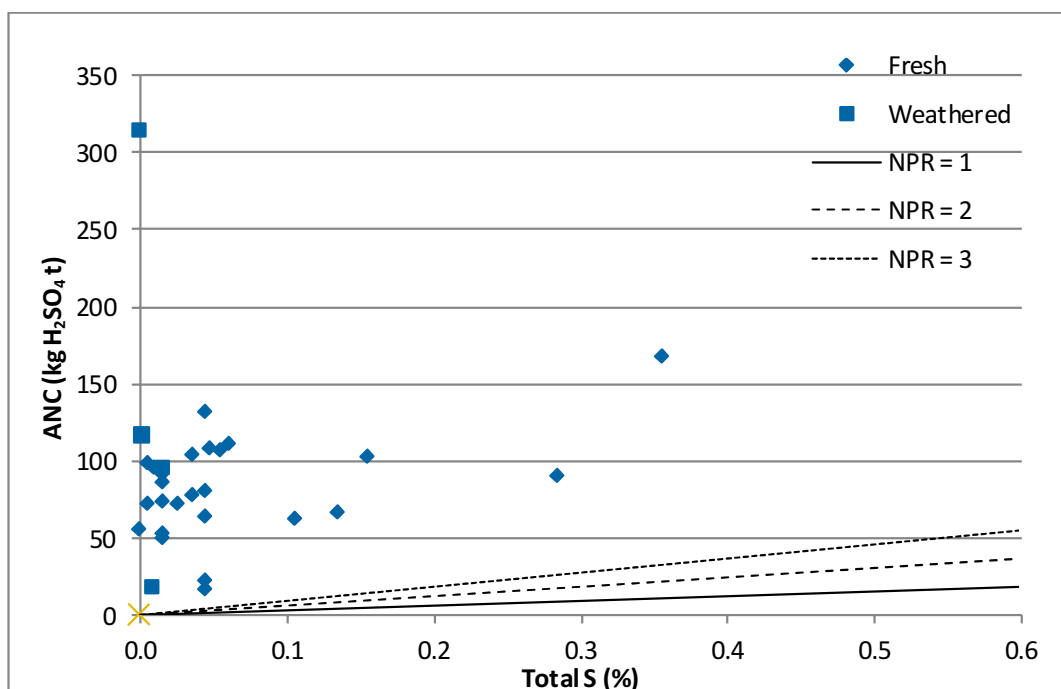


Figure 10: Intrusive material acid base account plot

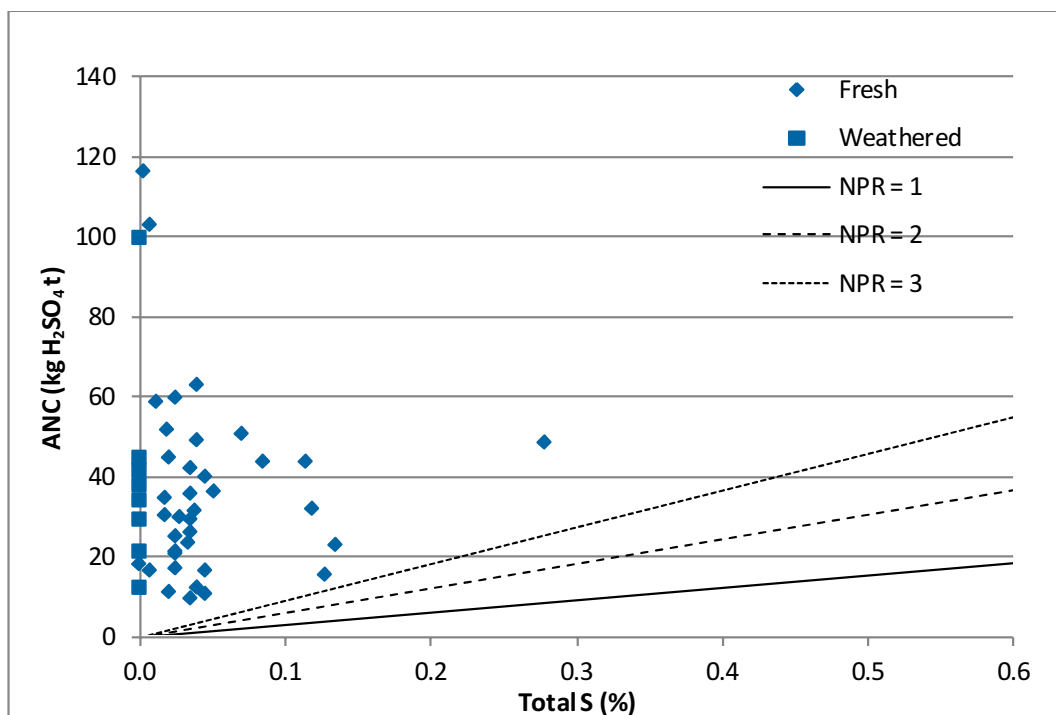


Figure 11: Mudstone acid base account plot

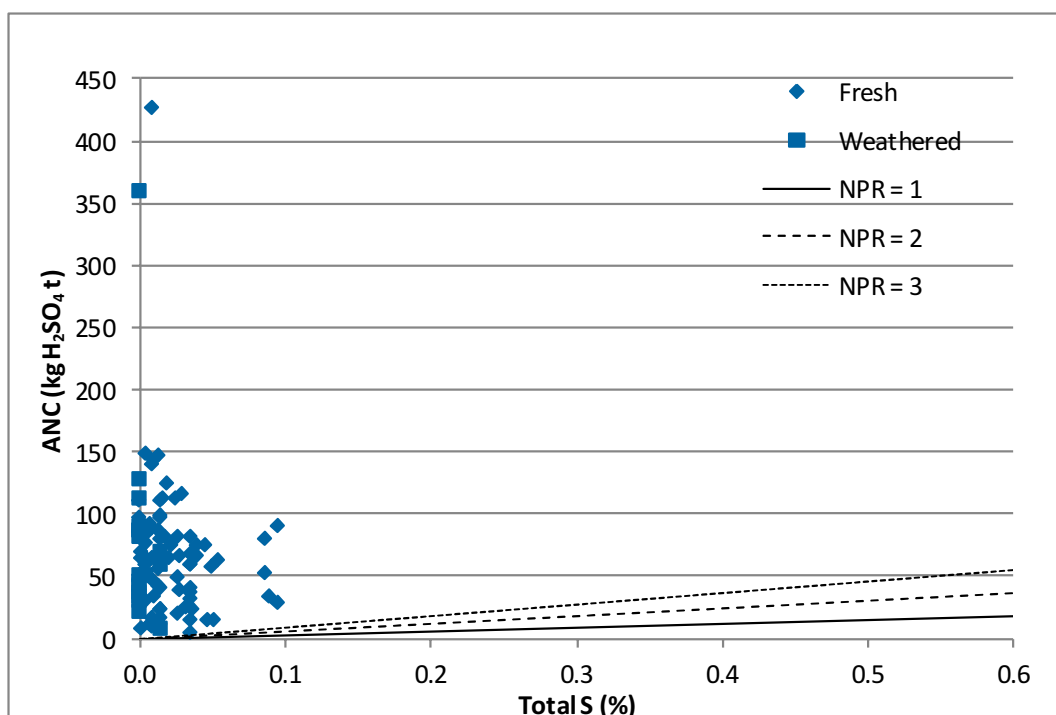


Figure 12: Sandstone acid base account plot

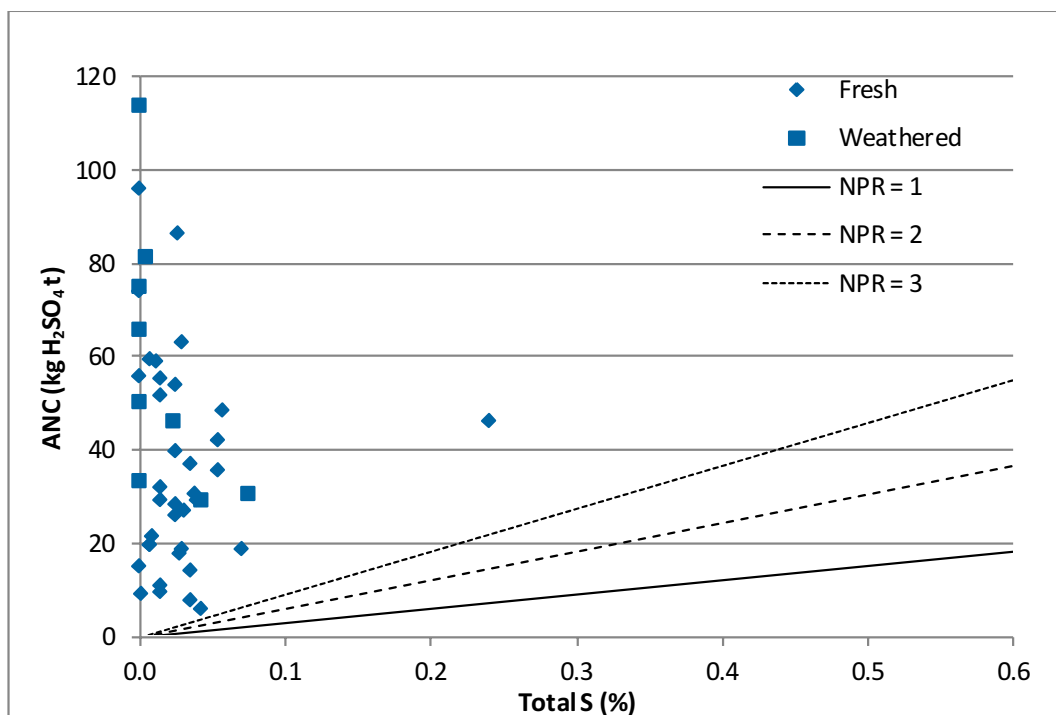


Figure 13: Siltstone acid base account plot

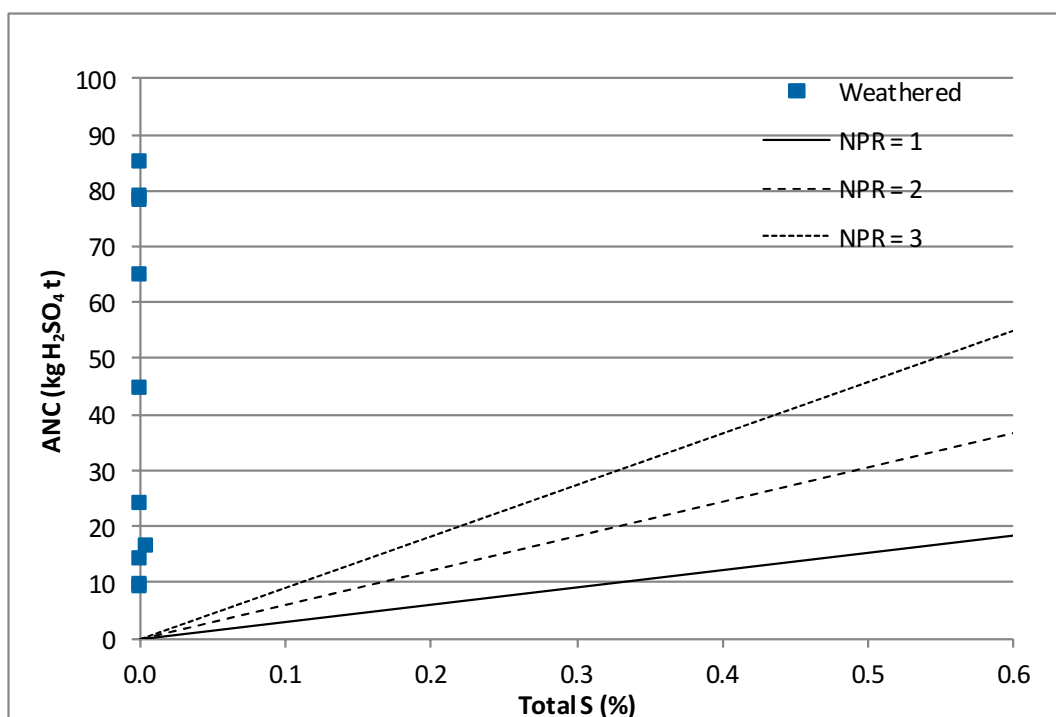


Figure 14: Soil acid base account plot

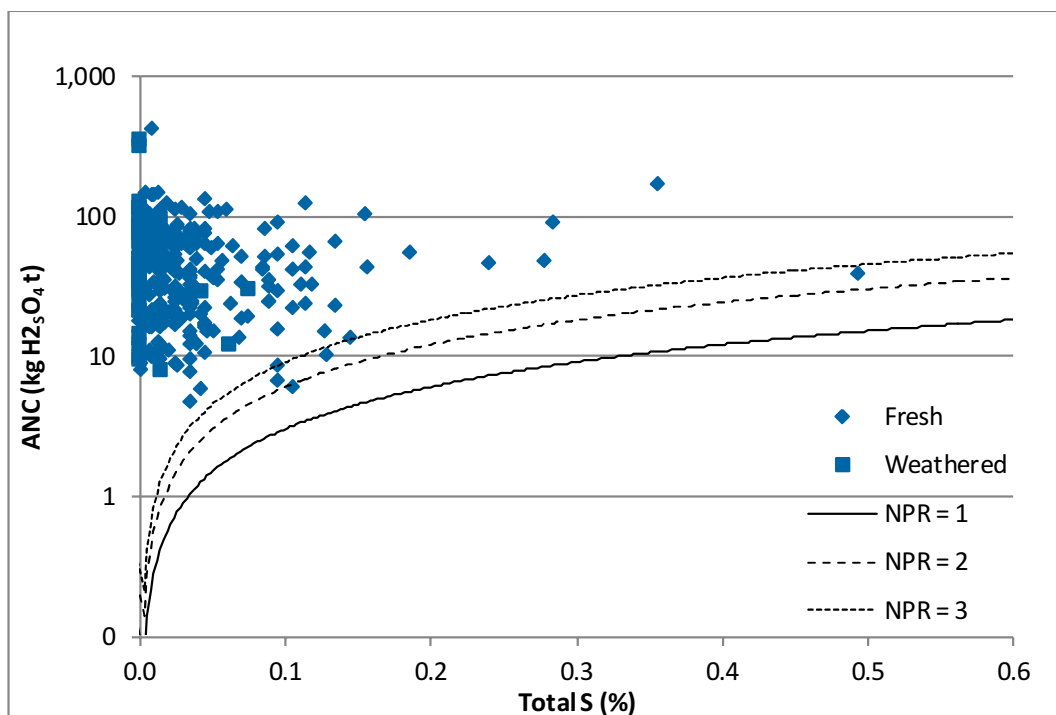


Figure 15: All lithologies acid base account plot

4.2.3 Net acid generation

The single addition net acid generation (NAG) test is used in association with the NAPP value to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test, acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity, and is expressed in the same units as NAPP; i.e. kg H₂SO₄ / tonne (AMIRA 2002).

The single addition NAG test involves adding a known volume of a known concentration of hydrogen peroxide to a known mass of a sample. The peroxide is allowed to react with the sample overnight, with the sample being gently heated the following day to accelerate the oxidation of any remaining sulphides. The sample is then vigorously boiled for several minutes to decompose any residual hydrogen peroxide. When cool, the pH (NAGpH, or pH(OX) as reported by ALS in the results provided in Appendix B) and acidity of the NAG liquor are measured. The acidity of the liquor is then used to estimate the net amount of acid produced per unit weight of sample by titration against a base (hydrogen peroxide) (AMIRA 2002).

Titration to pH 4.5 generally accounts for acidity attributable to free acid (H₂SO₄), and/or acid from soluble ferric iron and aluminium generated during the oxidation of sulphide minerals that has subsequently been neutralised by any contained neutralising capacity at the same pH range. Titration from pH 4.5 to pH 7 then generally accounts for acidity associated with metallic ions, such as copper for example, that are mostly soluble at pH 4.5, though precipitate as hydroxides at pH values between 4.5 and 7.0.

Past research has shown that the single addition NAG test completely oxidises the pyritic, or reactive, sulphide in samples with a 'reactive sulphur' (total sulphur minus sulphate sulphur) value of less than approximately 1% (AMIRA 2002). It was therefore applicable for use on the Drake samples. However, subsequent research (ACARP 2008) has indicated that the single addition NAG test may be unsuitable for samples with elevated organic carbon contents of greater than approximately 5 to 7%. This is as reaction of the hydrogen peroxide with any organic matter tends to produce organic acids; thereby artificially elevating the NAG capacity results, and providing a false (positive) measure of the sulphidic acid potential. This is especially so in samples with sulphidic sulphur concentrations below approximately 1%. Alternative tests including sequential NAG and/or kinetic NAG tests, or alternatively, the chromium reducible sulphur test, may be more appropriate in those circumstances (ACARP 2008). Alternatively, carbon speciation through the use of total carbon, total organic carbon, total inorganic carbon and/or carbonate carbon tests may provide more accurate acid neutralising capacity results; as may use of the acid buffering characteristics curve (ABCC).

The above notwithstanding, and due to budgetary and schedule constraints, single addition NAG tests were completed on 284 Drake samples. The single addition NAG testing undertaken was considered an appropriate first pass indicator of acid risk for the stated purposes of this study; with any addition testing recommended at the appropriate juncture in the text. Summary results are provided in Table 15. The samples have been further classified using the mean NAPP data shown in Table 14 and the mean NAGpH (Table 15) as per the classification scheme developed from Miller (1996) and presented in AMIRA (2002) and ACARP (2008) for example. The classification scheme is shown in Table 16.

The summary data in Table 15 indicates that the excavated waste at Drake has a very low potential to generate acid upon oxidation, as demonstrated by none of the 284 NAG (pH 4.5) results returning a reading over the laboratory level of reporting (LOR) of $<0.1 \text{ kg H}_2\text{SO}_4 / \text{tonne}$.

In addition, only 6 of 284 samples returned a NAG (pH 7.0) result above the laboratory level of reporting of $<0.1 \text{ kg H}_2\text{SO}_4 / \text{tonne}$, being;

- one fresh carbonaceous material sample that returned a value of $3 \text{ kg H}_2\text{SO}_4 / \text{tonne}$;
- two coaly material samples that returned values of 7 and $11 \text{ kg H}_2\text{SO}_4 / \text{tonne}$;
- one fresh sandstone sample that returned a value of $0.6 \text{ kg H}_2\text{SO}_4 / \text{tonne}$;
- one fresh siltstone sample that returned a value of $0.2 \text{ kg H}_2\text{SO}_4 / \text{tonne}$; and
- one weathered soil sample that returned a value of $0.4 \text{ kg H}_2\text{SO}_4 / \text{tonne}$.

Table 15: NAG geochemical results

Waste Group	Stat.	pH (ox)	NAG (pH 4.5)	NAG (pH 7.0)	Classification
		pH units	← kg H ₂ SO ₄ / tonne →	(Table 16)	
Carbonaceous material	Count	52	52	52	NAF
	Mean	8.8	<0.1 ¹	0.11	
	S.D.	1.1	<0.1	0.41	
	Range	5.2-10.6	<0.1	0.05-3.0	
Coaly material	Count	8	8	8	NAF
	Mean	7.6	<0.1	0.1	
	S.D.	1.8	<0.1	4.2	
	Range	4.6-9.4	<0.1	<0.01-11.0	
Intrusion	Count	29	29	29	NAF
	Mean	10.0	<0.1	<0.1	
	S.D.	0.8	<0.1	<0.1	
	Range	8.4-11.2	<0.1	<0.1	
Mudstone	Count	45	45	45	NAF
	Mean	9.1	<0.1	<0.1	
	S.D.	0.9	<0.1	<0.1	
	Range	7.4-10.7	<0.1	<0.1	
Sandstone	Count	95	95	95	NAF
	Mean	9.7	<0.1	0.06	
	S.D.	0.9	<0.1	0.06	
	Range	6.6-11.3	<0.1	0.05-0.6	
Siltstone	Count	45	45	45	NAF
	Mean	9.1	<0.1	0.05	
	S.D.	0.9	<0.1	0.02	
	Range	6.8-10.6	<0.1	0.05-0.2	
Soil	Count	10	10	10	NAF
	Mean	8.7	<0.1	0.09	
	S.D.	1.0	<0.1	0.11	
	Range	6.9-10.2	<0.1	0.05-0.4	
Weathered samples	Count	52	52	52	NAF
	Mean	9.2	<0.1	0.06	
	S.D.	0.8	<0.1	0.05	
	Range	6.9-11.2	<0.1	0.05-0.4	
Fresh samples	Count	232	232	232	NAF
	Mean	9.3	<0.1	0.14	
	S.D.	1.1	<0.1	0.87	
	Range	4.6-11.3	<0.1	0.05-11.0	

Waste Group	Stat.	pH (ox)	NAG (pH 4.5)	NAG (pH 7.0)	Classification (Table 16)
		pH units	← kg H ₂ SO ₄ / tonne →		
All samples	Count	284	284	284	
	Mean	9.3	<0.1	0.13	NAF
	S.D.	1.1	<0.1	0.79	
	Range	4.6-11.3	<0.1	0.05-11.0	

1: The laboratory detection limit was <0.1. Where a non-detect was returned, a value of 50% of the laboratory detection limit was used for statistical analysis purposes.

Table 16: NAG / NAPP Geochemical Classification Scheme

Primary Geochemical Material Type	NAPP ¹ (kgH ₂ SO ₄ /tonne)	NAG pH ¹ (pH units)
Potentially Acid Forming (PAF)	> 10	<4.5
Potentially Acid Forming – Low Capacity (PAF-LC)	0 – 10 ²	<4.5
Non-Acid Forming (NAF)	Negative	≥4.5
Acid Consuming (AC)	< -100	≥4.5
Uncertain ³	Positive	≥4.5
	Negative	<4.5
	Positive	<4.5

1: From Miller (1996), AMIRA (2002), ACARP (2008) and INAP (2009).

2: Site specific but typically in the range of 5 to 20 kgH₂SO₄/tonne.

3: Further testing required to confirm material classification.

The acid produced from the six samples dot-pointed above is potentially acidity generated from heavy metals hydrolysis rather than being from free acid (H₂SO₄) and/or from soluble ferric iron and/or aluminium generated during the oxidation of sulphide minerals. The oxidation pH values were broadly consistent with the pH_{1.5} values shown in Table 11, with both returning mean pH values of 9.3. This would imply that the indicative leachate pH value from persistent rain on an excavated waste dump on site as represented by the pH_{1.5} results, is a good indicator for pH values when oxidation and reduction reactions go to completion. The only large variance between the two pH data sets was a minimum mean value of 4.6 (pH OX) as against 8.8 (pH_{1.5}) for the coaly material and a minimum mean value of 5.2 (pH OX) as against 8.2 (pH_{1.5}) for the carbonaceous material. Mean values remained largely consistent however, thereby indicating that the minimum values were statistical outliers and/or the results of organic acid generating during the NAG test.

A further observation is that the coaly material and the carbonaceous material returned the highest reactive sulphide values of all lithological units, being 0.08 and 0.06% respectively (Table 14); which would be consistent with lower minimum pH (OX) values. (This comment notes that the

intrusive unit also had a mean sulphide sulphur value of 0.06% although had a higher mean ANC value of 89.5 kg H₂SO₄ / tonne as against the carbonaceous group (32.2 kg H₂SO₄ / tonne), thereby having a lower NAPP).

As noted above, additional classification of the lithological units based on mean NAPP values (Table 14) and mean NAG values (Table 15) are presented in Table 15. It shows that all lithological units are classified as non-acid forming (NAF), as are the weathered and fresh sample groups, and finally, the entire sample group. The (adjusted considering sulphide or reactive sulphur) NAPP and NAG values for samples in each lithological unit have also been graphed in Figure 16 to Figure 23 inclusive. This classification scheme accepts that no detailed carbon speciation analysis has been undertaken and may therefore slightly overestimate ANC, and therefore slightly underestimate (adjusted) NAPP values. It is, however, deemed an appropriate first pass methodology to be indicative of the AMD potential within the lithological units at Drake for the stated purposes of this report. Note that the scale on the 'x axis' varies between in Figure 16 to Figure 23 to provide a better fit for the data points.

The data plotted in Figure 16 to Figure 23 inclusive indicates that all 284 data points fall within the non-acid forming (NAF) upper left quadrant of the graphs. This translates to all seven lithological waste groups, and therefore, the combined lithologies, being classified as NAF. Interestingly, both the carbonaceous material and coaly material lithological waste group were both classified as NAF.

The lithological waste groups likely to contain higher carbon concentrations, such as the carbonaceous and coaly material groups, may benefit from further sulphur speciation tests (chromium reducible sulphur for example), in addition to sequential NAG testing for example. This would assist with better defining the AMD risk from the two samples with the lowest NAG pH values in Figure 17, and the one sample with the lowest pH value in Figure 16. It would assist with clarifying whether the low pH values are due to the formation of organic acids upon rapid oxidation, rather than from oxidising sulphides.

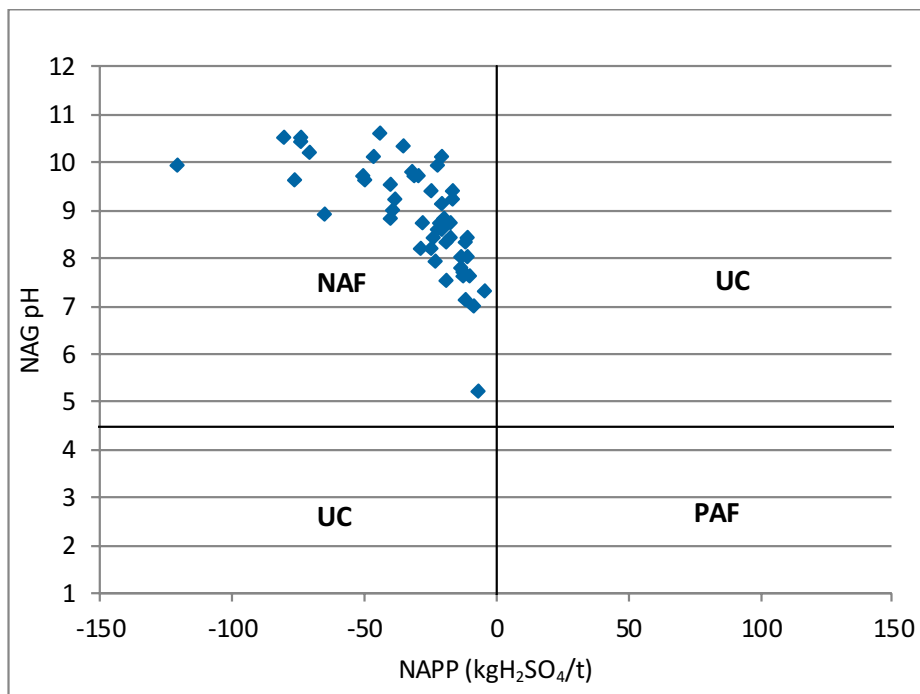


Figure 16: Carbonaceous material NAG/NAPP classification plot

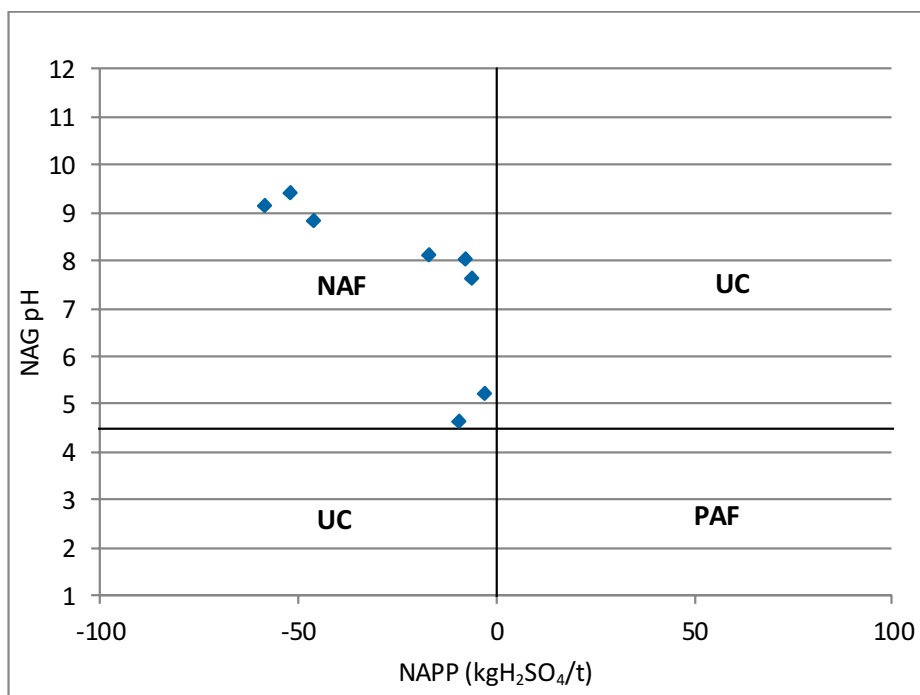


Figure 17: Coaly material NAG/NAPP classification plot

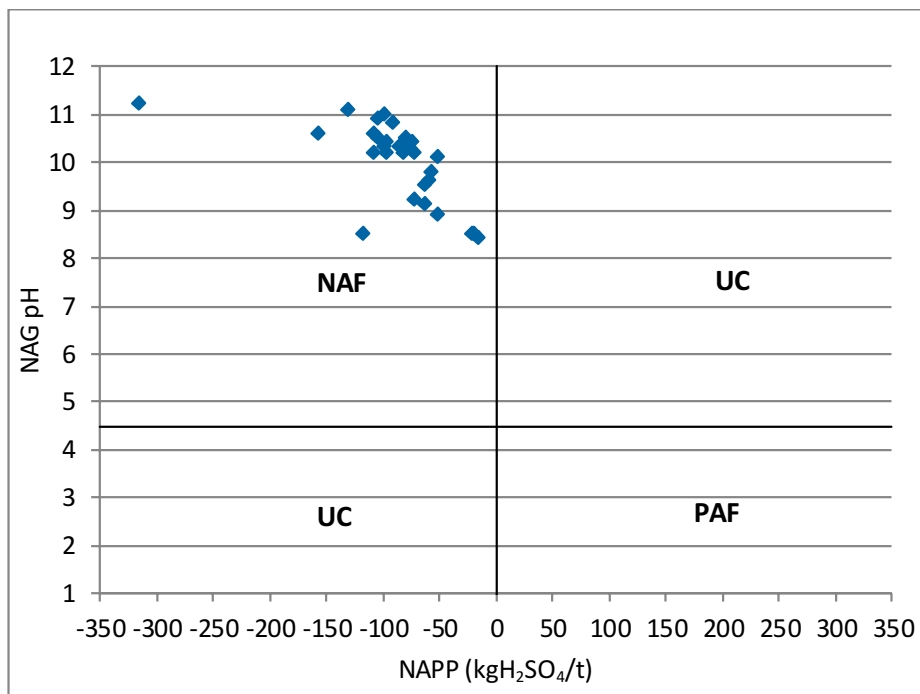


Figure 18: Intrusive material NAG/NAPP classification plot

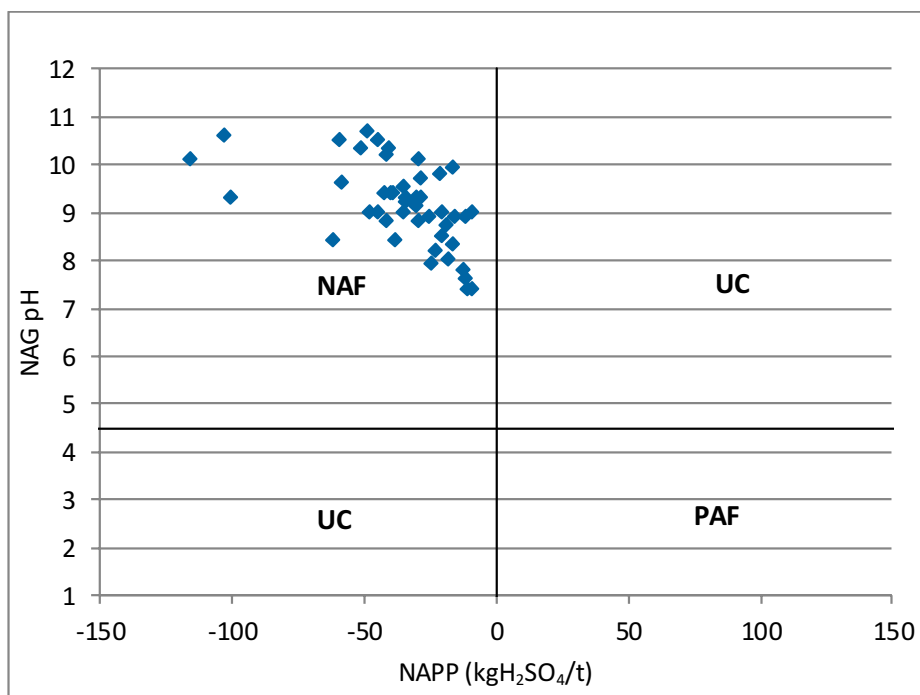


Figure 19: Mudstone NAG/NAPP classification plot

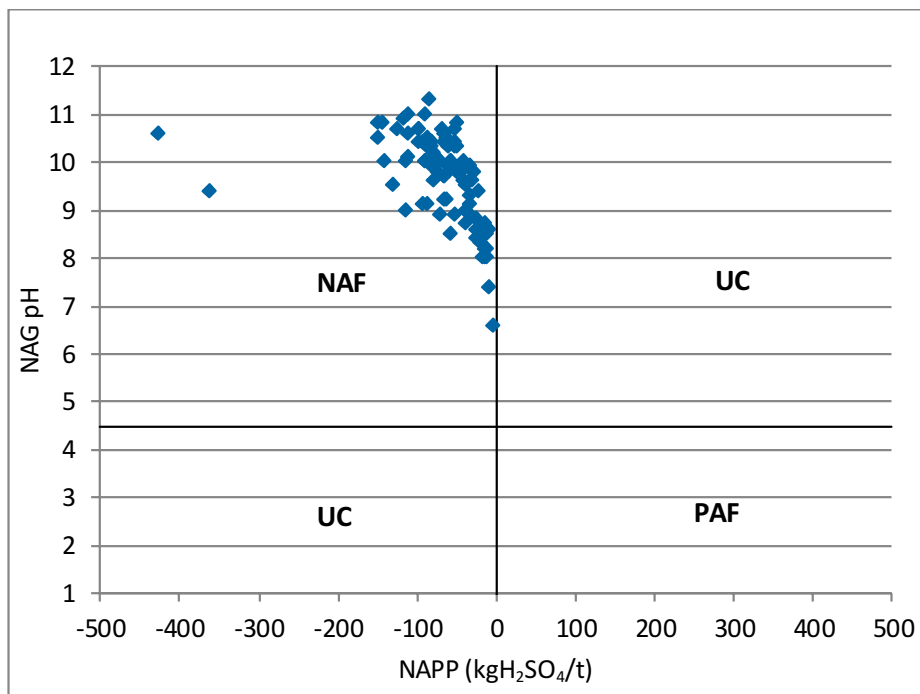


Figure 20: Sandstone NAG/NAPP classification plot

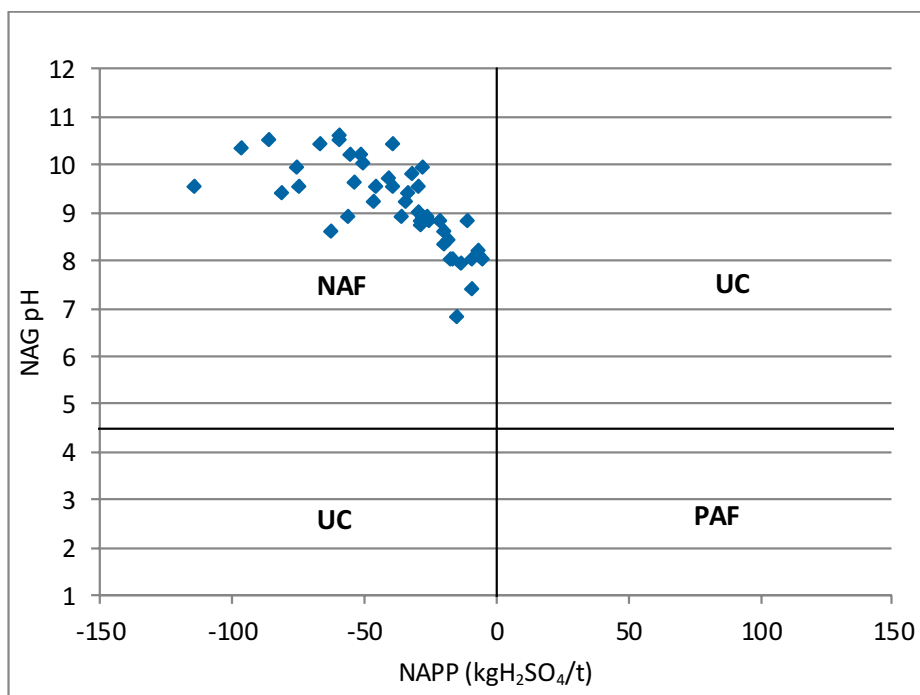


Figure 21: Siltstone NAG/NAPP classification plot

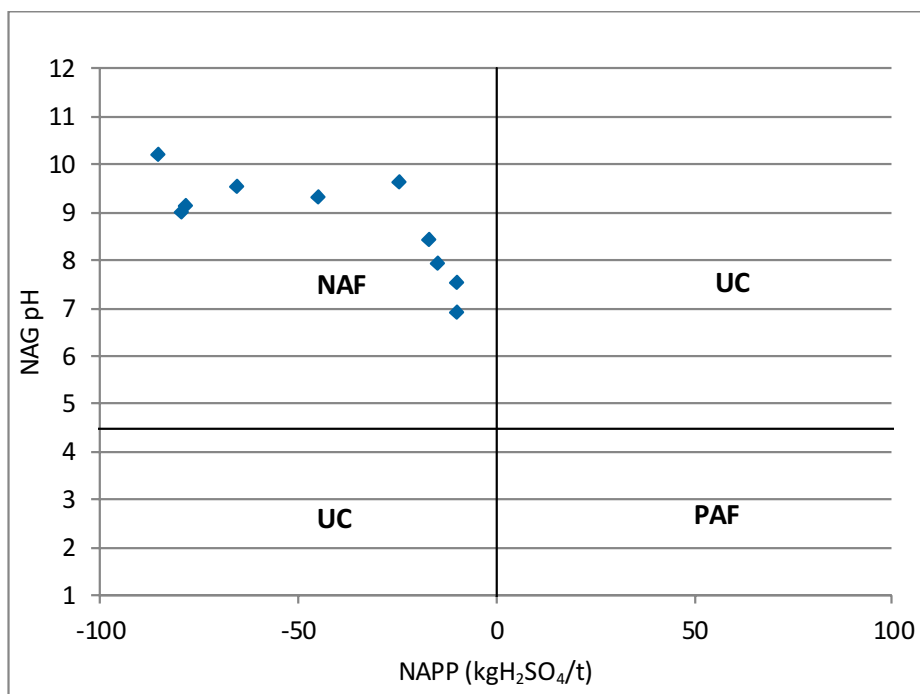


Figure 22: Soil NAG/NAPP classification plot

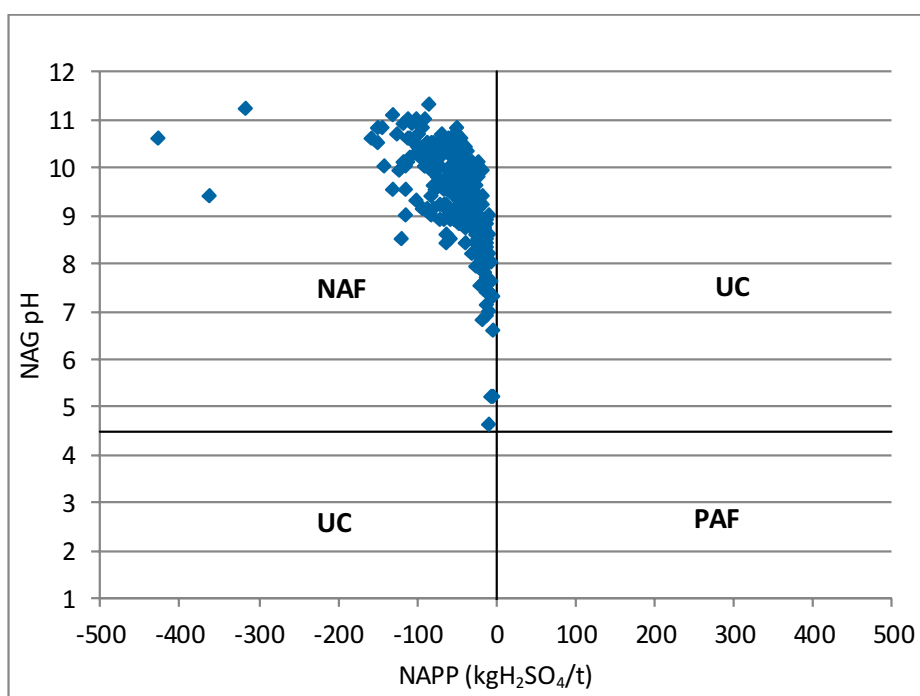


Figure 23: All samples NAG /NAPP classification plot

Similarly, it would be prudent to select a representative sub-set of samples from each lithological waste group on which to have additional carbon speciation (total organic and total inorganic) analysis undertaken, along with some ABCCs completed to better define the availability of any neutralising potential. Nevertheless, it is likely that the majority of the lithological waste groups contain a reasonable amount of available acid neutralising capacity in the form of reactive calcite as evidenced by the pH (1:5), pH (OX) and 'fizz test' results. Refer to Appendix B for the latter results.

4.3 Excavated waste: Metals

To assess the risk of metalliferous drainage at Drake, the process was twofold. The first stage was to undertake a multi-elemental scan of a sub set of geochemical samples. Accordingly, 292 samples across the seven major lithological waste groups were acid digested and analysed for 34 metals and metalloids using ICP-AES, with mercury also analysed using ICP-MS.

A direct comparison of each individual result, in addition to median results by lithological, weathered and fresh group, and finally, all results, was made against the reported abundance of elements found in nature. The latter information was crustal average data sourced from Bowen (1979) and Price (1997). Where there were no data for crustal average, mean values for either shale or sandstone sedimentary rocks were used (Price 1997), as mudstone, claystone, sandstone and siltstone make up the majority of excavated waste at Drake.

As the abundance of elements varies significantly, a log base 2 index has been historically developed to simplify comparison of measured values with average abundance. The index, called the global, or geochemical abundance index (GAI), and method, is documented in INAP (2009).

INAP (2009) describes the Geochemical Abundance Index (GAI) as a measure to compare the elemental concentration in a sample to the median abundance in the most relevant media (soils, crustal abundance etc). It was initially described by Förstner *et al.* (1993). The purpose is to provide a relative indication of any elemental enrichment that may be of environmental importance. The GAI for an element is calculated by:

$$GAI = \log_2 [C / (1.5 * S)]$$

Where: C is the elemental concentration in a sample; and S is the median content for that element in the reference material.

The GAI is measured on a scale of 0 to 6; whereby 0 indicates the element is present at a concentration similar to, or less than, median global abundance, and 6 indicates an approximate 100 fold, or greater, enrichment above global abundance (Table 17). As a general guide, a GAI of 3 or above is considered significant, and such enrichment may warrant further investigation. GAI values are presented in Table 17 for individual results.

Table 17: Global abundance exceedances and GAI number

Sample exceeds crustal average by	GAI
1.5 < sample < 3	0
3 ≤ sample < 6	1
6 ≤ sample < 12	2
12 ≤ sample < 24	3
24 ≤ sample < 48	4
48 ≤ sample < 96	5
96 ≤ sample < 192	6

As noted above, 292 samples from the seven major lithological waste groups were submitted for whole rock assay metals analysis. Elements that were identified as enriched as defined by the median value for the discrete lithological waste group exceeding the GAI by a factor of 3 or greater as shown in Table 17, are shown in Table 18. Individual sample exceedances are also shown in Table 18. Note that if the individual sample result returned a non-detect at the laboratory limit of reporting (LOR); a value of 50% of that LOR was used for GAI calculation purposes.

Table 18: Elevated metals by lithological waste group median value

Lithological unit	GAI assessment method	Metals > GAI 3
Carbonaceous material	Median value	Nil
Coaly material	Median value	Nil
Intrusion	Median value	Nil
Mudstone	Median value	Nil
Sandstone	Median value	Nil
Siltstone	Median value	Nil
Sand	Median value	Nil
Weathered	Median value	Nil
Fresh	Median value	Nil
Individual samples exceedances	Individual result	As (19 – carb 3, mudstone 1, sandstone 10, siltstone 3, soil 2), S (1 – carb.).

The results in Table 18 show that there are no elevated metals concentrations relative to the crustal average for the seven lithological waste groups when the median value for each of those seven lithological waste groups was compared to the crustal abundance. When the individual results for the 292 whole rock metals assays were compared to the crustal abundance, there were 19 arsenic concentrations and 1 sulphur result that returned a GAI of 3 or greater.

The second stage in identifying metalliferous drainage risk is to assess the metal leaching potential from the excavated waste at Drake. Due to schedule constraints, leaching analysis was undertaken concurrently with whole rock metals assay for the Drake samples, rather than following whole rock assay. Metal leaching results are presented below in Section 4.4

4.4 Excavated waste: Leachate

In order to determine any leachable elements from the Drake excavated waste, a total of 92 leachate tests were completed on samples from the seven lithological units. Note that the leach tests are intended to be indicative only to identify potentially leachable elements that may require the development of proactive management strategies. The leachate results cannot therefore, be directly extrapolated to predict leachate quality in the field; however, remain useful as being an indicator of potentially leachable elements within the discrete lithological waste groups.

The leachate results reported herein have been compared to 'Stock Watering' water quality guidelines (ANZECC/ARMCANZ 2000a) to identify any elevated elements that potentially may be of significance relative to the proposed final site landuse of low intensity grazing (GHD 2012, Volume 1, Chapter 3). It has been assumed for the stated purposes of this indicative leachate investigation that the proposed, engineered surface water management structures being environmental dams, have been appropriately designed to contain and manage any contaminated leachate should it be generated, and that any subsequent aquatic ecosystem risk is minimal GHD (2012; Volume 1, Chapter 9). This assumption notwithstanding, the mean elemental concentrations that returned values in excess of the laboratory detection limits were also compared to 95% freshwater aquatic ecosystem survival guideline trigger values (ANZECC/ARMCANZ 2000). Again, this was an indicative comparison only; as trigger values were not corrected for water hardness as per the ANZECC/ARMCANZ (2000) methodology; a correction that would likely increase the trigger values for metals by a maximum of approximately 27 times, based on the bicarbonate alkalinity values reported on leachate samples at Drake (Appendix D).

The 92 leachate tests were completed using Australian Standard Leaching Procedure (ASLP) which uses an Australian Standard procedure (AS4439 – 1997) to identify elevated concentrations of elements in leachate. ASLP uses a leaching pH value of 7.0 and is intended to provide data that is indicative of *in situ* rainwater leachate. It is designed to provide longer term accelerated weathering data than the pH_{1.5} and EC_{1.5} tests reported earlier, which are intended to provide indicative, 'contact' results between rain water and mineral waste on site.

Summary results comparing the mean value for each discrete lithological waste group to the relevant guideline value for the leaching tests are presented in Table 19, with complete results shown in Appendix D. Again, a value of 50% of the LOR for the respective analyte was used to calculate summary statistics in Table 19 and Appendix D. Summary data presented in Table 19 contains mean leachate results by lithological waste group for the two elements (As and S) reported in Table 18 that were shown to have an individual GAI value of 3 or greater; i.e. were

elevated relative to the global average; to assess their leaching potential. Table 19 also shows summary results for selenium, as it is an element often found in leachable concentrations in the Bowen Basin. Mean results in Table 19 that exceed the stock watering guideline trigger value are italicised, while mean values that exceed the 95% freshwater species survival (unadjusted for hardness) trigger value are highlighted in bold.

In addition to the summary leachate data presented in Table 19, Table 20 presents a summary of leachable elements that returned concentrations of metals or metalloids above the laboratory detection limit for each respective element.

The summary results shown in Table 19 indicate that the leachate is generally slightly alkaline and mildly saline across all seven lithological waste groups, although broadly within the stock watering guidelines. There was one exceedance of the stock watering guidelines for the intrusive lithological group pH values (9.7 pH units); likely a reflection of the geology of the intrusive lithological unit (refer GHD 2012c). There was also evidence of leachable selenium above the stock watering guideline value of 0.02 mg/L; with a maximum mean leachable concentration of 0.4 mg/L in the carbonaceous lithological group. Leachable sulphate and chloride values were low and would not be expected to detrimentally impact water quality based on the data reviewed herein.

The summary data in Table 20 indicates that a total of 16 metals or metalloids were detected in leachates from the 92 leached samples across the seven lithological waste groups. No mean leachate value exceeded the stock watering criteria; however, aluminium, arsenic, copper, lead, selenium and zinc exceeded the 95% species survival trigger value for freshwater ecosystems. Note, however, that once hardness corrections and leachate pH values are considered, it is likely that many of the reported leachable metals would be only sparingly soluble at the alkaline pH values expected *in situ*. This would have concomitant positive implications for drainage ecotoxicity risk given the likely reduced availability of the leachable elements of concern due to solubility constants; and would therefore act as a natural impact mitigation method through natural attenuation.

Table 19: Excavated waste leach test summary data

Lithological Group	Stat.	pH	EC µS/cm	Sulphate	Chloride	As mg/L	Se
		pH value					
Stock watering trigger value ¹							
Carbonaceous material	Count	14	14	14	14	14	14
	Mean	7.9	3,941	4.6	5.3	0.014	0.01
	S.D.	0.3	991	2.0	2.9	0.018	0.01
	Range	7.5-8.3	2,300-5,620	2.0-8.0	2.0-12.0	<0.01-0.07	<0.01- 0.04
	Count	5	5	5	4	5	5
Coaly material	Mean	7.9	3,520	3.6	3.5	0.04	0.01
	S.D.	0.3	636	1.5	1.3	0.07	0.01
	Range	7.5-8.3	3,020-4,270	2.0-6.0	2.0-5.0	<0.01-0.17	<0.01-0.02
	Count	9	9	9	9	9	9
	Mean	8.3	4,137	2.2	7.4	<0.01	0.01
Intrusion	S.D.	0.6	1,096	1.8	4.1	0	0.01
	Range	7.8-9.7	3,080-6,140	<0.1-6.0	3.0-14.0	<0.01-<0.01	<0.01-0.02
	Count	19	19	19	19	19	19
	Mean	8.0	4,164	3.1	10.6	0.015	0.01
	S.D.	0.2	684	2.1	8.7	0.019	0.01
Mudstone	Range	7.6-8.5	2,370-5,070	<0.1-9.0	2.0-36.0	<0.01-0.08	<0.1- 0.03
	Count	25	25	25	25	25	25
	Mean	8.1	3,904	3.6	8.1	0.015	0.01
	S.D.	0.2	978	2.1	6.5	0.029	0.01
	Range	7.6-8.6	2,320-6,220	0.5-8.0	2.0-29.0	<0.01-0.14	<0.1- 0.03
Sandstone	Count	15	15	15	15	15	15
	Mean	7.9	4,176	4.8	9.0	<0.01	0.01
	S.D.	0.3	1,161	2.7	9.6	0	0.01

Lithological Group	Stat.	pH	EC µS/cm	Sulphate	Chloride	As mg/L	Se
		pH value					
Soil	Range	7.5-8.5	2,370-6,470	1.0-12.0	9.6-35.0	<0.01-<0.01	<0.1- 0.03
	Count	5	5	5	5	5	5
	Mean	7.8	3,884	2.2	6.6	<0.01	0.01
	S.D.	0.1	715	1.1	3.0	0	0.0
	Range	7.7-7.9	3,100-4,500	1.0-4.0	3.0-11.0	<0.01-<0.01	<0.1-0.01
Weathered samples	Count	32	32	32	32	32	32
	Mean	8.0	3,996	2.6	12.2	<0.01	0.01
	S.D.	0.1	827	1.9	9.6	0	0.0
	Range	7.6-8.2	2,320-5,570	0.5-6.0	9.6-36.0	<0.01-<0.01	<0.1-0.02
	Count	60	60	60	60	60	60
Fresh samples	Mean	8.0	4,215	4.2	5.7	0.02	0.1
	S.D.	0.3	989	2.2	3.1	0.03	0.01
	Range	7.5-9.7	2,300-6,470	1.0-12.0	2.0-16.0	<0.01-0.17	<0.1- 0.4
	Count	92	92	92	91	92	92
	Mean	8.0	4,009	3.6	8.0	0.01	0.1
All samples	S.D.	0.3	931	2.2	6.9	0.03	0.01
	Range	7.5-9.7	2,300-6,470	0.5-12.0	2.0-36.0	<0.01-0.17	<0.1- 0.4

1: ANZECC/ARMCANZ (2000a).

2: Adjusted from total dissolved solids guideline value of 5,000 using a conversion factor as recommended in ANZECC/ARMCANZ (2000a).

ND: No data.

Italicised values exceed stockwatering criteria (ANZECC/ARMCANZ 2000a); bold exceed 95% aquatic ecosystem criteria ANZECC/ARMCANZ (2000).

Table 20: Elevated leachate metals by lithological waste group – individual summary data

Leachable element	No. detected	Leaching from	Mean leachate concentration	Stock watering trigger value / (95% freshwater value)
	Count	Lithological waste group	←	mg/L →
Aluminium	69	All 7 units	0.27	5.0 / (0.055)
Antimony	2	Coaly material, sandstone	0.02	NGV / (ID)
Arsenic	23	Carbonaceous, coaly, sandstone, siltstone	0.04	0.5 / (0.013)
Barium	90	All 7 units	0.94	NGV / (NGV)
Boron	7	Carbonaceous, coaly, mudstone, siltstone	0.13	5.0 / (0.37)
Copper	1	Mudstone	0.05	1.0 / (0.0014) ¹
Iron	19	Carbonaceous, mudstone, siltstone, sandstone, soil	0.07	Not sufficiently toxic / (ID)
Lead	8	Carbonaceous, coaly, mudstone, siltstone	0.05	0.1 / (0.0034) ²
Manganese	43	All 7 units	0.03	Not sufficiently toxic / (1.9)
Selenium	25	All 7 units	0.02	0.02 / (0.011)
Strontium	92	All 7 units	1.5	NGV / (NGV)
Titanium	23	Carbonaceous, coaly, mudstone, siltstone, sandstone	0.02	NGV / (NGV)
Vanadium	3	Intrusion, mudstone	0.03	NGV / (ID)
Zinc	52	All 7 units	0.23	20 / (0.008) ³
Molybdenum	35	Carbonaceous, coaly, mudstone, siltstone, sandstone	0.02	0.15 / (ID)
Thallium	9	Carbonaceous, mudstone, siltstone, sandstone, soil	0.01	NGV / (ID)

NGV: No given value. The value in brackets is the default criteria of 95% freshwater species survival (ANZECC/ARMCANZ 2000a).

ID: Insufficient data so no trigger value provided.

1: Laboratory detection limit (0.01) exceeds trigger value (0.0014).

2: Laboratory detection limit (0.01) exceeds trigger value (0.0034).

3: Laboratory detection limit (0.01) exceeds trigger value (0.008).

4.5 Excavated waste: Dispersivity

In order to assess the suitability of the Drake excavated waste lithological groups for use in progressive site rehabilitation, a soil and land suitability report was completed as part of this EIS (GHD 2012a; Volume 2a, Appendix C). This section, therefore, provides an indicative first pass to assess the suitability of deeper lithological units as cover material for mine rehabilitation at the Project site. It also incorporates selected soil chemistry data from the November/December 2011 soils study (as reported in GHD 2012c; Volume 2a, Appendix C), by combining that data with data from weathered samples from all lithological waste groups assessed herein. The sum of these data groups subsequently represents the CENZ stratigraphic waste unit, which represents approximately 479 million tonnes, or 25%, of the excavated waste at Drake.

Soil salinity / sodicity classification guidelines are reproduced below in Table 21, with the summary results provided in Table 22. Individual results are provided in Appendix E. Soil total chloride data as presented previously in Table 13 was also considered when classifying lithological waste units.

Generally speaking, a soil may be considered sodic when sodium concentrations begin to affect soil structure. This is generally recognised to occur in Australia when the exchangeable sodium percentage (ESP) is greater than 6; while strongly sodic soils are reported to have ESPs of greater than 14 (Northcote and Skene 1972) or greater than 15 (Isbell *et al* 1983). When sodic soils become wet; as sodium is a monovalent cation as compared with the bivalent cations magnesium and calcium; the bonds weaken and the soils can become dispersive or slake. Therefore, a high level of exchangeable sodium is not desirable in soils for mine rehabilitation, as it can lead to dispersion, tunnel erosion and surface crusting; with individual clay particles going into suspension potentially leading to decreased surface water quality (Charman and Murphy 2001).

Secondary consequences include surface hard-setting as soil structure breaks down, with decreased infiltration leading to difficulties in establishing vegetation and therefore, ongoing erosion from bare surfaces.

Another indicator of dispersion potential in soils is the Ca:Mg ratio. Soils that are high in sodium and magnesium tend to show more dispersion than soils that are high in sodium and calcium (Hazelton and Murphy, 2007). The potential for dispersion may be increased in soils with Ca:Mg ratios of below approximately 1-2. This is based on the fact that Ca^{2+} ions flocculate, or open, soils; while Mg^{2+} ions tend to coagulate, or close, soils. Low Ca:Mg ratio soils are sometimes known as high magnesium soils. A Ca:Mg ratio of approximately 4-6 is generally considered ideal; although ultimately, it becomes a function of the crop/vegetation's tolerance to specific soil chemistry profiles (NSW Agriculture 2002).

At a broader level; low cation exchange capacity (CEC) of, nominally, <5 meq indicates that the soils has a low ability to hold nutrients.

Table 21: Indicative Excavated Waste Salinity / Sodicity Classification Parameters (DME 1995)

Test	Units	Very Low	Low	Medium	High	Very High
pH (1:5) ¹	pH units	<4.5	4.5-5.5	5.5-7.0	7.0-9.0	>9.0
Electrical Conductivity (1:5) ¹	µS/cm	150	150-450	450-900	900-2,000	>2,000
Chloride	(ppm)	<100	100-300	300-600	600-2,000	>2,000
Exchangeable Sodium Percentage (ESP)	%	<2	2-6	6-12	12-20	>20
Ca/Mg	ratio	<1	1-2	2-5	>5	-

1: Values become approx. 200, 200-400, 400-800, 800-1,600 and <1,600 if analysis undertaken by saturated extract/paste. Drake analysis varied between 1:5 and saturated paste; therefore, values are indicative only.

The summary data in Table 22 indicates that all lithological units have low mean salinity values as represented by chloride and EC (1:5) values. The inherent risk of saline leachate forming, based on the information assessed, is therefore deemed low. This goes against the leachate data presented in Section 4.4, with leachate EC values being approximately an order of magnitude higher than EC_{1:5} results. It may be that prolonged agitation of samples promotes breakdown and leaching of salts as shown by the leachate EC results; intended to represent longer term accelerated weathering of samples. The elevated leachate EC values may also be caused by the prolonged leaching tests causing bicarbonates of calcium and/or magnesium to liberate into solution (refer alkalinity data in Appendix D). The EC_{1:5} results remain consistent with baseline local surface water quality data reported for the proposed Drake mine site (GHD 2012e, Volume 3; Appendix B).

The mean Ca:Mg ratios for all lithological units also appear to be at levels that would potentially preclude the excavated wastes being dispersive (3.5 – 11.7). However, the exchangeable sodium percentage (ESP) data suggests that the carbonaceous material (20.3), coaly material (14.5), mudstone (13.2), and siltstone (10.8) are all potentially dispersive; and therefore, should not be used as capping material in progressive site rehabilitation.

Considering the ESP and leachate EC values combined, when agitated, it would appear that the higher relative percentages of exchangeable sodium in the carbonaceous material, coaly material, mudstone and siltstone becomes mobile and enters solution in the ASLP tests. This characteristic was not evident in the shorter term EC_{1:5} results. This has potential implications for longer-term water quality, should the carbonaceous material, coaly material, mudstone and/or siltstone be used as capping material in progressive site rehabilitation activities. Ideally, these four lithological waste units should be backfilled into pits or encapsulated inside waste rock dumps later capped with less reactive material.

The most appropriate units for use as capping material in progressive rehabilitation, based on the mean ESP data in Table 22 would be the soil unit (3.6), intrusive (6.2), and sandstone units (6.7). The intrusive unit has been shown to potentially also have acid consuming capabilities (a mean NAPP of -88 kg H₂SO₄ / tonne), and may therefore be used to actively manage any PAF material on site through co-disposal, blending and/or encapsulation as required.

Perhaps unsurprisingly, the weathered material appears to have a lower dispersivity potential based on the mean ESP value of 3.5 as shown in Table 22 than does the fresh material, which has a mean ESP value of 13.3. This would likely be explained through long term leaching of the upper lithological horizons above the limit of oxidation on site.

Soil chemistry data from an additional 126 soil samples collected to a depth of 1.5 m below ground surface in November and December 2011, and reported by GHD (2012c, Volume 2a, Appendix C) was combined with the 86 data points generated for the combined weathered lithological waste groups reported herein to represent the CENZ stratigraphic waste unit. The mean ESP value for the combined 212 data points was 6.2, which had the material classified as low salinity and at the very low end of the medium sodicity range. Therefore, if appropriately managed, the CENZ unit appears to be suitable for use in progressive site rehabilitation. The CENZ unit also has a high mean (total) cation exchange capacity value of 30.0 meq / 100g; consistent with a 35% clay content as reported by GHD (2012c, Volume 2a, Appendix C) for 111 soil samples. A very high mean calcium value of 21.3 meq / 100g is also consistent with the high mean soil pH value of 8.4 for the CENZ unit. The alkaline pH values within the lithological waste groups is also consistent with local baseline drainage conditions as represented by surface water quality data as reported in GHD (2012c, Volume 1; Chapter 9).

Table 22: Excavated waste dispersivity summary data

Lithological Unit	Stat	pH	Basic Cations							Classification ¹
			EC	Ca	Mg	K	Na	CEC	ESP	
		pH units	µS/cm	←		meq/100g		→	%	
Carbonaceous material	Count	55	55	47	47	47	47	47	47	Low salinity, high sodicity. High dispersion risk
	Mean	9.3	195	11.0	2.9	0.7	3.3	18.0	20.3	
	S.D.	0.4	84	6.5	2.0	0.2	2.5	5.9	15.6	
	Range	8.2-10.0	57-402	3.6-25.6	0.9-9.7	0.2-1.1	0.2-8.8	7.4-30.8	1.2-55.1	
Coaly material	Count	8	8	6	6	6	6	6	6	Low salinity, high sodicity. High dispersion risk
	Mean	9.3	190	10.0	2.4	0.8	2.0	15.2	14.5	
	S.D.	0.4	140	6.0	1.4	0.3	2.7	4.3	18.2	
	Range	8.8-9.8	91-544	4.9-19.6	1.1-4.8	0.3-1.1	0.05-2.7	10.1-21.2	0.4-47.1	
Intrusion	Count	32	32	24	24	24	24	24	24	Low salinity, medium sodicity. Low to medium dispersion risk
	Mean	9.5	261	20.7	3.1	0.3	1.4	25.5	6.2	
	S.D.	0.4	121	7.4	3.9	0.2	1.4	9.8	6.6	
	Range	8.6-10.1	113-594	6.7-39.2	0.9-18.9	0.1-0.9	0.2-5.4	12.6-57.5	0.9-26.7	
Mudstone	Count	51	51	41	41	41	41	41	41	Low salinity, high sodicity. High dispersion risk
	Mean	9.3	278	11.5	4.0	9.6	2.0	18.9	13.2	
	S.D.	0.4	173	6.6	3.2	0.2	1.9	8.1	13.7	
	Range	8.2-9.9	46-840	2.5-31.4	0.5-11.7	0.3-1.1	0.2-7.8	6.2-38.8	1.2-49.4	
Sandstone	Count	110	110	101	101	101	101	101	101	Low salinity, medium sodicity. Low to medium dispersion risk
	Mean	9.4	251	15.2	4.7	0.5	1.2	21.6	6.7	
	S.D.	0.3	144	7.5	3.0	0.2	1.4	8.8	9.1	
	Range	8.2-9.7	64-763	4.3-33.5	1.3-16.2	0.2-0.9	0.05-7.4	9.4-43.6	0.3-52.9	
Siltstone	Count	54	54	57	57	57	57	57	57	Low salinity, medium sodicity. Medium dispersion risk
	Mean	9.4	259	12.4	4.3	0.6	1.7	19.1	10.8	
	S.D.	0.3	145	6.6	2.9	0.2	1.7	7.4	11.9	
	Range	8.5-9.9	80-862	1.2-28.3	0.5-11.0	0.05-1.0	0.05-6.6	1.7-38.3	0.05-42.2	
Soil	Count	19	19	19	19	19	19	19	19	Low salinity, low

	Mean	8.5	234	29.4	6.8	0.5	0.9	37.7	3.6	6.8	sodicity.
	S.D.	0.6	152	12.3	4.2	0.3	1.1	13.7	7.1	6.3	Low dispersion risk
	Range	7.4-9.7	93-593	2.2-47.2	1.6-15.7	0.1-1.1	0.05-3.5	9.6-61.4	0.1-31.8	0.5-18.4	
	Count	96	96	86	86	86	86	86	86	86	
Weathered	Mean	9.0	326	20.5	7.9	0.5	1.0	29.8	3.5	3.5	Low salinity, low sodicity.
	S.D.	0.5	193	10.5	3.3	0.2	1.0	11.4	4.1	3.7	Low dispersion risk
	Range	7.4-9.8	93-862	2.2-47.2	1.6-18.9	0.1-1.1	0.1-5.4	9.6-61.4	0.1-31.8	0.4-18.4	
	Count	233	233	209	209	209	209	209	209	209	
Fresh	Mean	9.5	207	12.4	2.9	0.6	2.1	17.9	13.3	5.8	Low salinity, low sodicity.
	S.D.	0.4	91	6.6	1.6	0.2	2.1	6.1	13.7	4.8	Low dispersion risk
	Range	8.2-10.1	46-556	1.2-26.6	0.5-8.4	0.1-1.1	0.1-8.8	1.7-31.4	0.1-55.1	0.9-21.9	
	Count	329	329	295	295	295	295	295	295	295	
All samples	Mean	9.3	245	14.7	4.3	0.6	1.8	21.4	10.4	5.1	Low salinity, medium sodicity.
	S.D.	0.4	141	8.7	3.2	0.2	1.9	9.7	12.5	4.6	Medium dispersion risk
	Range	7.4-10.1	46-862	1.2-47.2	0.5-18.9	0.1-1.1	0.1-8.8	1.7-61.4	0.1-55.1	0.4-21.9	
	Count	160	160	126	126	126	126	126	126	126	
Nov/Dec 2011 soil samples ²	Mean	8.0	225	21.8	5.9	0.4	2.0	30.1	8.1	5.9	Low salinity, medium sodicity.
	S.D.	1.0	286	15.9	3.7	0.2	2.6	18.3	11.0	9.2	Medium dispersion risk
	Range	5.5-9.6	10-1,540	0.7-60.0	0.4-15.0	0.1-1.9	0.01-11.0	1.7-69.5	0.1-53.0	0.4-62.0	
	Count	256	256	212	212	212	212	212	212	212	
CENZ ³	Mean	8.4	263	21.3	6.7	0.4	1.6	30.0	6.2	4.9	Low salinity, medium sodicity.
	S.D.	1.0	259	13.9	3.6	0.2	2.1	15.8	9.1	7.5	Low to medium dispersion risk
	Range	5.5-9.8	10-1,540	0.7-60.0	0.4-18.9	0.1-1.9	0.01-11.0	1.7-69.5	0.1-53.0	0.4-62.0	
	Count	256	256	212	212	212	212	212	212	212	

1: Qld DME (1995a). 2: 111 samples for chloride for a mean of 190 ppm. 3: 163 samples for chloride for a mean of 212 ppm.

4.6 CHPP coarse rejects and tailings: Geochemistry

It remains important to assess the AMD risk from CHPP-generated coarse rejects and tailings as cumulatively; they comprise 2.5% of the total mineral waste at Drake. No samples were available to assess the risk of AMD for the tailings waste stream that will be generated from the onsite CHPP at Drake. Therefore, one composite sample from each commercial coal seam (Seams A, B, C, E, P and Q) was sent to ALS in Brisbane for the same suite of geochemical analytes as the waste rock samples (refer Table 9) to be assessed as a surrogate for future tailings waste from the on-site CHPP; being one of the two CHPP waste streams.

The geochemical, whole rock metals assay, leachate and dispersivity data generated from the excavated waste analysis and reported herein in Sections 4.2 to 4.5 respectively, effectively becomes the default data from which AMD risk was assessed from the CHPP coarse rejects; i.e. the second CHPP waste stream.

Sample classification for slurry pH_{1.5}, EC_{1.5} and chloride values against indicative values as per DME (1995) guidelines are presented below. The DME (1995) classification data were reproduced in Table 10 for ease of reference.

4.6.1 Slurry pH_{1.5}, slurry EC_{1.5} and chloride values

Slurry pH_{1.5}, slurry EC_{1.5} and chloride values are shown for the surrogate tailings samples in Table 23. Classification for each composite coal seam sample, in addition to the mean value for all samples as it compares to data in Table 10, is also provided.

The data presented in Table 23 indicates that the surrogate tailings samples at Drake are broadly consistent with the excavated waste mean slurry pH_{1.5}, slurry EC_{1.5} and chloride data as shown in Table 11, Table 12 and Table 13 respectively. The data indicates that the coal seam samples, and therefore by default, the tailings, may be classified as having a very high mean pH_{1.5} value (9.3 pH units); the same value as for the excavated waste samples. The surrogate tailings samples have mean slurry EC_{1.5} values of 107 µS/cm, being a very low value and being lower than the mean value of 245 µS/cm for the excavated waste samples. Finally, the surrogate tailings samples have a mean chloride value of 6.7 mg/kg, being a very low value and being lower than the mean value of 78 mg/kg for the excavated waste samples.

Table 23: Surrogate tailings sample slurry pH_{1:5}, EC_{1:5} and chloride values

	Count	pH _{1:5} value	EC _{1:5}	Chloride	Classification ¹
Coal seam sample	No.	pH units	µS/cm	mg/kg	Table 10
Composite A Seam	1	9.8	192	<10	pH Very high EC Low Chloride Very low
Composite B Seam	1	9.1	74	<10	pH Very high EC Very low Chloride Very low
Composite C Seam	1	8.8	72	10	pH High EC Very low Chloride Very low
Composite E Seam	1	9.9	116	<10	pH Very high EC Very low Chloride Very low
Composite P Seam	1	9.1	41	10	pH Very high EC Very low Chloride Very low
Composite Q Seam	1	9.3	146	<10	pH Very high EC Very low Chloride Very low
All samples (mean)	6	9.3	107	6.7	pH Very high EC Very low Chloride Very low

1: Classification as determined from Table 1 (DME 1995) – refer Table 10.

4.6.2 Acid base accounting

Acid base accounting (ABA) assessment was undertaken on the surrogate tailings samples as per the excavated waste samples reported in Section 4.2.2. Results for the ABA assessment are shown in Table 24. Sample classification using acid base accounting was undertaken using the ANC/MPA ratio (or net potential ratio - NPR) whereby as a general rule, a NPR ratio of approximately 2 or greater signifies that there is a high probability that the material will remain near neutral, and should not be problematic with respect to AMD; all other factors being equal (AMIRA 2002).

The results shown in Table 24 indicate a mean total sulphur concentration from the six seams of 0.22%. This is consistent with low total sulphur concentrations as reported in the literature for the northern Bowen Basin (e.g. Hunt 1987), and suggests that there is little risk of significant AMD being generated from the coal tailings. The A Seam composite sample had the highest total sulphur value of 0.43%, while Seam Q had the lowest, being 0.07%.

Interestingly, all composite samples returned an ANC value ranging from 2.6 to 34 kg H₂SO₄ per tonne, for a mean ANC value of 15.9 kg H₂SO₄ per tonne. Summing the MPA and ANC values results in NAPP values of between -27 and 4.6 kg H₂SO₄ per tonne. An ANC/MPA ratio (or NPR) of between 0.3 and 14.6 indicates some risk of any excess neutralising minerals not being able to neutralise any acid produced; with composite samples from Seams A, B and P being the higher

risk. A mean NPR of 5.3 however, suggests that if all tailings were combined in real time in a storage facility, then there appears to be sufficient neutralising capacity over acid producing potential to mitigate any significant risk, based on the data considered herein. This statement is qualified with the fact that carbon speciation testing was not undertaken on the Drake surrogate tailings samples, and that the ANC of some samples therefore may be overstated. This is further explored in Section 4.6.3 using NAG data.

The acid base accounting data plotted on Figure 24 is simply a visual representation of the information summarised in Table 24.

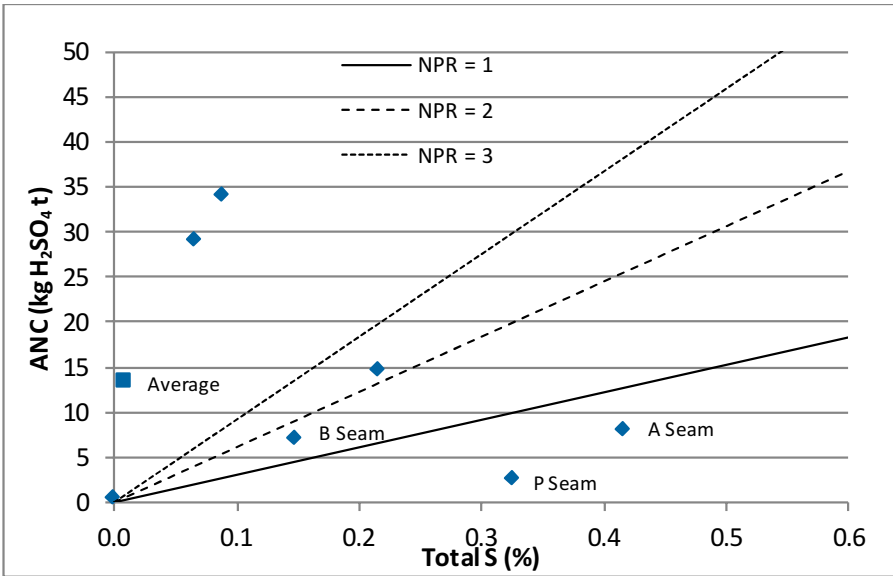


Figure 24: Surrogate tailings sample acid base account plot

The data shows that the A and P Seam composites have NPR values less than 1; while the B Seam composite has an NPR value less than 2. Composite samples from Seams C, E and Q had NPR values greater than 3; as did the mean value for the six composite samples.

Table 24: Surrogate tailings sample acid base accounting results

Count		Total S	Sulphate S	Reactive S ³	MPA ¹	ANC	NAPP	NPR ²
Coal seam samples	No.	%	mg/kg	%	←	kg H ₂ SO ₄ tonne	→	ratio
Composite A Seam	1	0.43	140	0.42	12.7	8.1	4.6	0.6
Composite B Seam	1	0.16	120	0.15	4.5	7.1	-2.6	1.6
Composite C Seam	1	0.10	110	0.09	2.7	34.0	-31.3	12.5
Composite E Seam	1	0.22	<100	0.22	6.6	14.6	-8.0	2.2
Composite P Seam	1	0.33	<100	0.33	9.9	2.6	7.3	0.3
Composite Q Seam	1	0.07	<100	0.07	2.0	29.0	-27.0	14.6
All samples (mean)	6	0.22	87	0.21	6.4	15.9	-9.5	5.3

1: Stoichiometrically calculated from results. Adjusted to consider sulphate sulphur results, and is therefore an adjusted value. When total S was <lab PQL of 0.01 mg/kg, a value of 0.005 was used. When sulphate sulphur was <lab PQL of 100 mg/kg, a value of 50 mg/kg was used. MPA (kg H₂SO₄ per tonne) = (total S – sulphate S) * 30.6.

2: Calculated from results. Generally, an ANC /MPA ratio of greater than 2 indicates a suitable excess of inherent acid buffering capacity in the waste material (AMIRA 2002).

3: Total S – sulphate S.

4.6.3 Net acid generation

As per the excavated waste samples, the surrogate tailings samples underwent single addition NAG testing. Results are provided in Table 25.

The samples have been further classified using the mean NAPP data shown in Table 24, and the mean NAGpH (Table 25) as per the classification scheme developed from Miller (1996) and presented in AMIRA (2002), ACARP (2008) and INAP (2009) for example. The classification scheme is shown in Table 16.

Table 25: Surrogate tailings NAG geochemical results

	Count	pH (ox)	NAG ¹ (pH 4.5)	NAG ¹ (pH 7.0)	Classification
Coal seam sample	No.	pH units	←kg H ₂ SO ₄ / tonne→		Table 16
Composite A Seam	1	5.0	<0.1	4.7	UC
Composite B Seam	1	6.4	<0.1	0.4	NAF
Composite C Seam	1	8.8	<0.1	<0.1	NAF
Composite E Seam	1	5.4	<0.1	7.2	NAF
Composite P Seam	1	3.0	32.7	73.9	PAF (low capacity)
Composite Q Seam	1	9.8	<0.1	<0.1	NAF
All samples (mean)	6	6.4	5.5	14.4	NAF

1: When NAG pH was <lab PQL of 0.1 kg H₂SO₄ / tonne, a value of 0.05 was used for statistical purposes.

The summary data in Table 25 indicates that the composite A Seam sample is classified as Uncertain (UC); as it has a positive NAPP value and a NAG pH greater than 4.5. Intuitively, such data represents a conflict, however is best explained by a likely overestimation of the available reactive sulphur. The data in Table 24 shows that the laboratory results returned a total sulphur value of 0.43%; still relatively low for a coal sample. Once adjusted for sulphate sulphur, the net sulphur, or reactive sulphur value of 0.42% leads to a MPA of 12.7 kg H₂SO₄ / tonne. This exceeds the ANC of 8.1 kg H₂SO₄ / tonne, resulting in a positive NAPP. Intuitively, given pyritic sulphur and ANC values that result in a positive NAPP value, the sample should return a NAGpH value of less than 4.5. This was not the case. This composite sample would benefit from undergoing additional sulphur speciation testing, such as chromium reducible sulphur, with any subsequent revisit of the NAG/NAPP classification may see it re-classified as non-acid forming. Additionally, the acidity generated through the NAG test was from titration between 4.5 and 7.0, potentially indicating hydrogen ion release during metals hydrolysis, rather than from free acid formed during pyrite oxidation.

The composite P Seam sample was classified as potentially acid forming (low capacity) as it has a positive NAPP value of between 0 and 10 kg H₂SO₄ / tonne, and a NAG pH value of less than 4.5. A total sulphur value of 0.33%, when adjusted for sulphate sulphur, resulted in a MPA of 9.9 kg H₂SO₄ / tonne. A small ANC value of 2.6 kg H₂SO₄ / tonne means a positive NAPP value of 7.3 kg H₂SO₄ / tonne. When combined with a NAG pH value of 3.0, a NAG pH (4.5) value of 32.7 kg H₂SO₄ / tonne, and a NAG (pH 7.0) value of 73.0 kg H₂SO₄ / tonne; a PAF (low capacity) classification results.

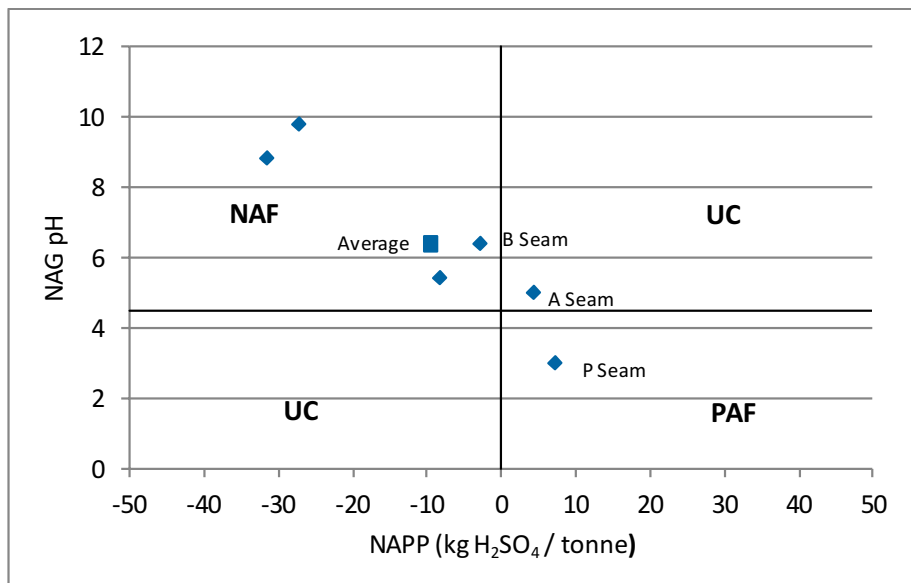


Figure 25: Surrogate tailings NAG/NAPP classification plot

The composite P Seam results may be the result of organic acid generation affecting the NAG tests; given the relatively low reactive sulphur concentration in the coal. This sample would likely also benefit from additional sulphur speciation to refine the classification.

The above commentary notwithstanding, the average NAG/NAPP classification for the six composite coal seam samples is NAF. A mean reactive sulphur value of 0.21%, when combined with a mean ANC value of 15.9 kg H₂SO₄ / tonne, results in a negative NAPP. The mean NAG pH value of 6.4 then confirms the NAF classification. A lack of carbon speciation analysis aside, based on the current data set, it appears that if managed correctly, co-disposal of the tailings from the various seams in a single repository is unlikely to generate acidic drainage in the short term. i.e. there appears to be sufficient self-neutralising capacity in the coal seams to offset any acid generation based on the information at hand. This is demonstrated by a mean NPR of 5.3 (Table 24). This statement, however, must consider relative volumes of the respective coal seam wastes, and an appropriate stoichiometrically based relative assessment being undertaken based on proposed mine plans and schedules to confirm the low risk.

4.7 CHPP coarse rejects and tailings: Metals

To determine the metalliferous drainage risk from the surrogate tailings samples, the six composite coal samples underwent whole rock assay analysis using the same methodology as the 292

excavated waste samples. The analytical methodology and comparative assessment relative to crustal abundances was described in Section 4.3. Results are provided below in Table 29.

Table 26: Elevated whole rock assay metals results by coal seam

Lithological unit	GAI assessment method	Metals > GAI 3
Composite A Seam	Individual result	As (1)
Composite B Seam	Individual result	Nil
Composite C Seam	Individual result	Nil
Composite E Seam	Individual result	Nil
Composite P Seam	Individual result	Nil
Composite Q Seam	Individual result	Nil
All samples (median)	Individual result	Nil

The results in Table 26 show that there was one elevated metal concentrations relative to the crustal average for the six composite coal samples when the concentration of each of those six coal samples was compared to the crustal abundance; being elevated arsenic in the A Seam.

The second stage in identifying metalliferous drainage risk is to assess the elemental leaching potential. Leachate results are presented below in Section 4.8.

4.8 CHPP coarse rejects and tailings: Leachate

Following the whole rock assay reported in Section 4.7, the six composite coal samples underwent leaching tests using the ASLP methodology reported in Section 4.4. Summary leachate data is presented in Table 27.

The summary data presented in Table 27 shows that leachate from the 6 composite coal seam samples is alkaline and slightly saline, although not at levels that exceed stock watering guidelines. All samples returned low leachable chloride and sulphate results, and all samples returned non-detectable leachate concentrations for arsenic and selenium.

In addition to the data presented in Table 27, a summary of individual leachate concentrations that returned results in excess of the laboratory detection limit is provided in Table 28. Results in Table 28 that exceed the stock watering guideline trigger value are italicised (no exceedances), while values that exceed the 95% freshwater species survival (unadjusted for hardness) trigger value are highlighted in bold (zinc).

The data shown in Table 28 indicates that leachable concentrations of barium, manganese, strontium and zinc were detected from all composite coal seam samples. Additionally, boron was detected leaching from the A Seam sample, and molybdenum from the A, C and Q Seam samples. No element leached at mean concentrations that exceeded the stock watering trigger value, while the mean zinc concentration exceeded the 95% freshwater species survival trigger

value (ANZECC/ARMCANZ 2000a). Note, however, that once hardness corrections and leachate pH values are considered, it is likely that many of the reported leachable elements may be only sparingly soluble at the alkaline pH values expected *in situ*. This would have concomitant implications for drainage ecotoxicology given the likely reduced availability of the reported leachate elements.

Table 27: Leachate summary data by coal seam

Lithological Unit	pH	EC	Sulphate	Chloride	As	Se
	pH value	µS/cm	←		mg/L	→
Stock watering trigger value ¹	4-9	7,463 ²	1,000	ND	0.5	0.02
Composite A Seam	8.8	5,540	9	10	<0.01	<0.01
Composite B Seam	8.3	5,490	5	9	<0.01	<0.01
Composite C Seam	8.2	5,550	6	10	<0.01	<0.01
Composite E Seam	8.8	5,560	2	9	<0.01	<0.01
Composite P Seam	7.8	5,460	3	9	<0.01	<0.01
Composite Q Seam	8.4	5,540	5	10	<0.01	<0.01
All samples (mean)	8.4	5,523	5	10	NA	NA

1: ANZECC/ARMCANZ (2000a).

Table 28: Elevated leachate elements from coal composite samples

Leachable element	No. detected	Leaching from	Mean leachate concentration	Stock watering trigger value (95% freshwater value)
	Count	Lithological unit	mg/L	mg/L
Barium	6	All 6 seams	2.2	NGV (NGV)
Boron	1	A Seam	0.1	5.0 (0.37)
Manganese	6	All 6 seams	0.03	Not sufficiently toxic (1.9)
Strontium	6	All 6 seams	2.4	NGV (NGV)
Zinc	6	All 6 seams	0.04	20 (0.008) ¹
Molybdenum	3	A, C and Q Seams	0.02	0.15 (ID)

NGV: No given value. The value in brackets is the default criteria of 95% freshwater species survival (ANZECC/ARMCANZ 2000a).

ID: Insufficient data so no trigger value provided.

1: Laboratory detection limit (0.01) exceeded trigger value (0.008).

4.9 CHPP coarse rejects and tailings: Dispersivity

As per the excavated waste samples, the surrogate tailings samples underwent salinity and sodicity testing to determine the risk of saline and/or alkaline drainage. Results are provided in Table 29. The summary data in Table 29 indicates that whilst all six composite coal samples returned alkaline pH values (8.8 to 9.8 for a mean of 9.3), they returned low salinity values (ECs of 41 to 192 for a mean of 107) and very low chloride concentrations (Table 23; <10 to 10 ppm for a mean of 6.7 ppm).

The sodicity, and therefore dispersibility risk fell into two clear categories. Composite samples from Seams A (28.9), E (46.3) and P (21.3) show very high ESP ratios, while composite seam samples B (3.3), C (2.1) and Q (2.3) have low ESP ratios. A mean ESP of 17.4 for all six composite samples suggests that if all tailings were co-disposed in equal proportions into one repository, the material is sodic, although non-saline based on the data in Table 29. Based on the data shown in Table 29, therefore, the combined surrogate tailings material has a low risk of generating saline drainage. As for the excavated waste samples, these data somewhat contradict the EC data from the leaching tests reported in Section 4.8. The elevated leachate EC values may be caused by the prolonged leaching tests causing bicarbonates of calcium and/or magnesium to liberate into solution (refer alkalinity data in Appendix D), rather than sodium salts.

As a general rule, however, coal rejects and tailings should not be used as surface rehabilitation material, and should be stored on site in designated repositories as proposed by Drake Coal.

Table 29: Surrogate tailings NAG salinity and sodicity summary data

Sample	Count	pH	EC	Ca	Mg	K	Na	CEC	ESP	Ca:Mg	Classification ¹
Unit	No.	pH units	µS/cm	←		meq/100g		→	%	ratio	Table 21
Composite A Seam	1	9.8	192	10.3	2.1	0.4	5.2	18.0	28.9	4.9	Low salinity, very high sodicity High dispersivity risk
Composite B Seam	1	9.1	74	3.8	1.7	0.2	0.2	6.0	3.3	2.2	Low salinity, low sodicity Low dispersivity risk
Composite C Seam	1	8.8	72	6.0	7.4	0.6	0.3	14.3	2.1	0.8	Low salinity, low sodicity Low dispersivity risk
Composite E Seam	1	9.9	116	6.5	1.0	0.4	6.8	14.7	46.3	6.5	Low salinity, very high sodicity High dispersivity risk
Composite P Seam	1	9.1	41	3.3	1.3	0.2	1.3	6.1	21.3	2.5	Low salinity, very high sodicity High dispersivity risk
Composite Q Seam	1	9.3	146	26.0	3.2	0.5	0.7	30.5	2.3	8.1	Low salinity, low sodicity Low dispersivity risk
All samples (mean)	6	9.3	107	9.3	2.8	0.4	2.4	14.9	17.4	4.2	Low salinity, high sodicity High dispersivity risk

1: Qld DME 1995a

4.9.1 Overall material classification and management implications

The previous sections presented analytical data for geochemistry, dispersivity, metals and metals leaching for the seven excavated waste lithologies, in addition to the six composited coal seam samples; intended to be surrogates for tailings samples in lieu of actual tailings samples.

The information was assessed to inform:

- The risk of acid, metalliferous, neutral and/or saline drainage from each individual excavated waste lithological group in addition to CHPP tailings; and
- The salinity/sodicity; and any potential for structural breakdown and dispersion should the waste units be utilised as capping material in progressive mine site rehabilitation.

The characteristics of saline, neutral, and acid rock drainage are illustrated schematically on Figure 26. Not shown on Figure 26; metalliferous drainage is generally found in mine drainage with acidic or highly alkaline pH values that enable certain metals species to remain dissolved in solution. INAP (2009) defines both saline and neutral mine drainage as occurring above a pH value of approximately 6.0, with dissolved sulphate concentrations of greater than 1,000 mg/L being the threshold between NMD and saline drainage.

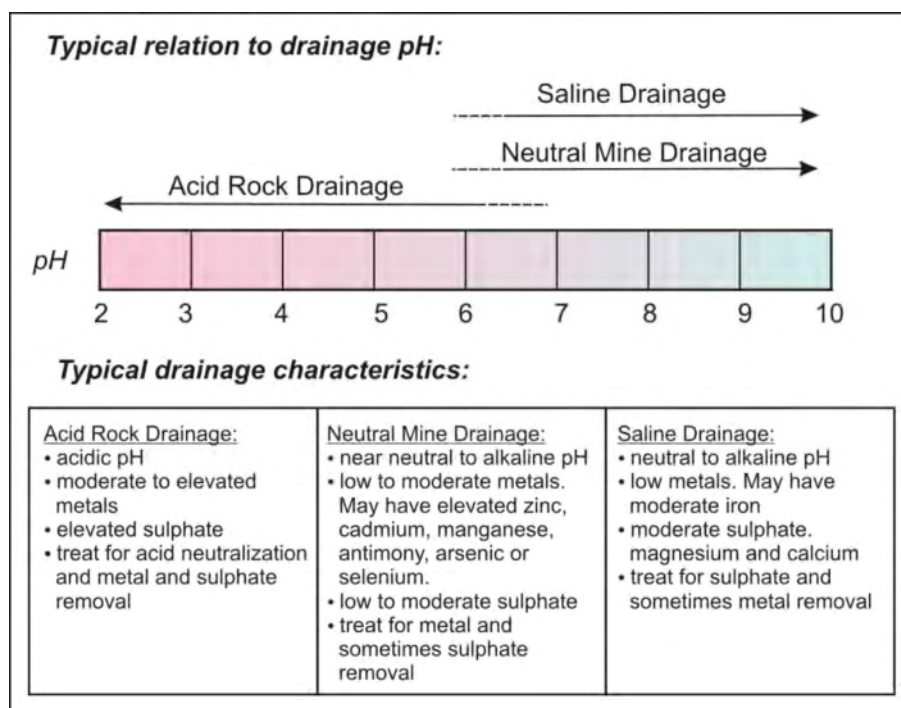


Figure 26: Mine drainage characteristics

Source: INAP 2009.

A summary of the data presented in Section 4 for both excavated and CHPP waste at Drake is presented in Table 30 as a materials characterisation reference source.

Table 30: Summary Waste Materials Classification

Sample nos.	pH _{1:5}	EC _{1:5}	Chloride	NAG/NAPP	Whole rock metals	Leachability	Dispersivity risk	
								Comments
	329	329	280	284	292	92	295	
Classf'n by:	DME (1995)	DME (1995)	DME (1995)	AMIRA (2002)	Mean GAI ≥ 3	ANZECC/ARMCANZ (2000 and 2000a)	DME (1995a)	
Carbonaceous material	Very high	Low	Very low	NAF	Nil ¹ (refer comments column)	ANZECC/ARMCANZ (2000) < mean Al, As, Pb, Zn < ANZECC/ARMCANZ (2000a) < Se	High	1. Mean is nil. 3 indiv. samples As > GAI 3 and 1 S > GAI 3.
Coaly material	Very high	Low	Very low	NAF ¹	Nil	ANZECC/ARMCANZ (2000) < mean Al, As, Pb, Zn < ANZECC/ARMCANZ (2000a)	High	1. Mean is NAF. 1 sample has NPR < 2.
Intrusion	Very high	Low	Very low	NAF ¹	Nil	ANZECC/ARMCANZ (2000) < mean Al, Zn, Se < ANZECC/ARMCANZ (2000a) < pH	Low - Med	1. Bordering on acid consuming (ANC ≈ - 85 kg H ₂ SO ₄ / tonne.
Mudstone	Very high	Low	Low	NAF	Nil ¹	ANZECC/ARMCANZ (2000) < mean Al, Cu, Pb, Zn < ANZECC/ARMCANZ (2000a) < Se	High	1. Mean is nil. 1 indiv. sample As > GAI 3.
Sandstone	Very high	Low	Very low	NAF	Nil ¹	ANZECC/ARMCANZ (2000) < mean Al, As, Zn < ANZECC/ARMCANZ (2000a) < Se	Low - Med	1. Mean is nil. 10 indiv. samples As > GAI 3.
Siltstone	Very high	Low	Very low	NAF	Nil ¹	ANZECC/ARMCANZ (2000) < mean Al, As, Pb, Zn < ANZECC/ARMCANZ (2000a) < Se	Medium	1. Mean is nil. 3 indiv. samples As > GAI 3.

	pH _{L1.5}	EC _{1.5}	Chloride	NAG/NAPP	Whole rock metals	Leachability	Dispersivity risk
Sample nos.	329	329	280	284	292	92	295
Classf'n by:	DME (1995)	DME (1995)	DME (1995)	AMIRA (2002)	Mean GAI ≥ 3	ANZECC/ARMCANZ (2000 and 2000a)	DME (1995a)
Soil	High	Low	Low	NAF	Ni ¹	ANZECC/ARMCANZ (2000) < mean Al, Zn, Se < ANZECC/ARMCANZ (2000a)	Low 1. Mean is nil. 3 indiv. samples As > GAI 3.
Weathered	Very high	Low	Low	NAF	Nil	Refer individ. units	Low -
Fresh	Very high	Low	Very low	NAF	Nil	Refer individ. units	Low -
All samples	Very high	Low	Very low	NAF	Nil	Refer individ. units	Medium -
Tailings (6 samples)	Very low	Very low	Very low	NAF ¹	Ni ²	ANZECC/ARMCANZ (2000) < Zn < ANZECC/ARMCANZ (2000a)	1. Mean is NAF. Seams A, B, P have NPR < 2. Seam P is PAF (LC) and Seam A is UC. 2. Mean is nil. Seam A As > GAI 3.

1, 2: refer commentscolumn.

The summary classification data in Table 30 were presented by mean value for each of the seven lithological waste groups, with comments on any individual results or points of note annotated in the comments column. Mean data were calculated from the seven lithological waste groups from 329 samples for paste pH1:5 and EC1:5, 280 chloride samples, 284 NAG/NAPP samples, 292 whole rock assay metals samples with 92 leachability analyses, and 295 dispersivity analyses.

The geochemical characterisation summary results presented in Table 30 can be considered against estimated stratigraphic waste unit volumes and tonnages within the context of excavated waste materials handling and long term on site placement at Drake. Based on geological modelling using the 2011 drilling logs completed when collecting geochemical samples, Table 31 provides estimates of the volume waste by lithological group as a function of the stratigraphic waste units present. This is provided as an example of the mine planning, materials handling and placement information that can be estimated utilising the data in the excavated waste report to reduce forward cost and risk on site. Pits West 1 and 2 were selected as they represent approximately 75%, or approximately 890 million bank cubic metres of excavated waste at Drake, based on current mine plans.

Excluded from Table 31 is the CENZ waste unit, which as noted before in this report, was previously defined as a stratigraphic waste unit by a previous QCoal geological consultant. It has been re-defined herein as the soil lithological waste unit plus all weathered material from all stratigraphic waste units above the limit of oxidation.

The data in Table 30 and Table 31 shows that the largest waste unit on site (other than the CENZ unit) is the sandstone lithological waste group from pits West 1 and 2 from the BC stratigraphic waste unit with a volume of approximately 263 million bank cubic metres (bcm). Subsequent reference to Table 30 indicates that the sandstone unit as a whole contained very high pH1:5 values, low EC1:5 values, very low chloride concentrations, was classified as non-acid forming (NAF) and had a no median whole rock assay metals significantly above the crustal average; despite having 10 individual samples return concentrations of arsenic above the global abundance index.

Additionally, the sandstone lithological group contained mean concentrations of leachable selenium above the stock water guideline ANZECC/ARMCANZ (2000a), and mean concentrations of leachable aluminium, arsenic and zinc above the ANZECC/ARMCANZ (2000) 95% species protection (aquatic ecosystem) guidelines. The sandstone also had a mean dispersivity risk of low to the lower end of medium. Therefore, the sandstone lithological waste group within the BC stratigraphic waste unit in West pits 1 and 2 would be more appropriate for beneficial reuse as waste rock dump capping material for example, than would the 39 million bcm of carbonaceous material, or the 70 million bcm of mudstone removed from the same two pits; based on the mean dispersivity risk.

Similar AMD risk estimates may be made for the excavated waste from the 8 satellite pits based on the summary geochemical characterisation information presented in Table 30, and the detailed characterisation results presented within this report.

Table 31: Estimated West 1 and West 2 pit lithological and stratigraphic waste tonnages

Stratigraphic Waste Unit	Lithological Waste Group							
	Total West 1 and 2 volume.	Carbonaceous Material	Intrusive	Mudstone	Siltstone	Sandstone	Soil	Coaly material
	Total BCM (x 1,000,000)							
AB Waste	131.90	27.00	13.34	32.31	27.00	32.25	0.00	0.00
BC Waste	491.57	38.70	36.12	78.69	75.23	262.83	0.00	0.00
CE Waste	137.20	10.55	20.12	6.20	34.56	59.25	6.53	0.00
EP Waste	96.50	11.39	18.50	6.05	33.82	26.74	0.00	0.00
PQ Waste	21.70	2.88	1.98	2.36	3.68	10.62	0.00	0.18
QR Waste	12.60	0.00	0.00	0.00	2.27	10.33	0.00	0.00
Approx. total	891.47	90.5	90.1	125.6	176.6	402.0	6.53	0.18

1 : Differs from total of 886.4 million BCM in Table 3 as data in Table 3 generated by a previous QCoal consultant.
Data in Table 31 generated by GHD.

The key points of note from the geochemical characterisation data presented within this report are:

- That all seven lithological waste groups, in addition to the tailings results, had high to very high mean pH_{1.5} results (DME 1995);
- That all seven lithological waste groups, in addition to the tailings results, had low to very low mean EC_{1.5} results (DME 1995). Using the Anderson-Darling normality test, there was a 95% probability that mean EC_{1.5} for all 329 samples is less than 246 µS/cm; a low classification (DME 1995);
- That all seven lithological waste groups, in addition to the tailings results, had low to very low mean chloride results (DME 1995);
- That all seven lithological waste groups, in addition to the tailings results, were classified as non-acid forming (NAF) using AMIRA (2002) guidelines. This was despite the tailings sample from Seam P being individually classified as potentially acid forming – low capacity (PAF-LC), and Seam A being classified as uncertain. Using the Anderson-Darling normality test, there was a 95% probability that mean total sulphur concentrations from all 284 excavated waste samples of less than 0.54%; leading to a maximum (mean) maximum potential acidity of 1.7 kg H₂SO₄ per tonne. This result is countered by a 95% probability from all 284 excavated waste samples that mean acid neutralising capacity is greater than 47.1 H₂SO₄ per tonne. Based on the data assessed herein, there would appear to be an excess of acid consuming minerals in the excavated waste at Drake relative to potentially acid forming minerals;
- Whilst there is a high degree of confidence on the summary geochemical classification results above, they could be further refined by having a sub-set of samples undergo additional sulphur and carbon speciation, in addition to more detailed NAG testing. These tests may include:
 - Total carbon, total organic carbon, total inorganic carbon, total carbonate carbon, and acid buffering characteristic curve tests (ABCC);
 - Chromium reducible sulphur; and
 - Modified NAG tests such as the extended boil test to eliminate the likely influence of organic acids on the NAG/NAPP classification on higher samples with higher carbon content; such as from the coaly material and carbonaceous material lithological waste groups.

There remains the opportunity to implement these additional geochemical tests throughout life-of-mine validation testing as required.

The above notwithstanding, it would appear that there is a very low risk of acid drainage being generated from the excavated waste at Drake. This conclusion is consistent with the low risk in coal mines adjacent to Drake in the northern Bowen Basin including Sonoma and Belmore-Pipeline for example, where alkaline conditions prevail. For example, analysis of the 25 secondary samples from Belmore-Pipeline collected from the QR Waste unit returned a mean total sulphur concentration of 0.01%, a mean ANC of 77.5 kg H₂SO₄/tonne for a mean NAPP of -77.3 kg H₂SO₄/tonne (QCoal 2008, Drake Coal 2011). Such results show the regional nature of the low sulphur, net neutralising material.

The geochemical results, and in particular, the total sulphur data, are also consistent with the literature; in particular Hunt and Telfer (1983), Hunt and Brakel (1985), and Hunt (1987) who suggested that research showed that the mid to late Permian coal deposits of the Bowen Basin, which include the Moranbah Coal Measures, contain low (<0.55%) to

medium (0.55- 1.0%) sulphur, commensurate with their fluvial depositional environment through time and space.

Hunt (1987) noted that sulphur isotopes from the mid-low sulphur, late Permian Coal Measures correlated with modern day plant matter in freshwater environments (rather than marine sulphur), thereby indicating that the sulphur sources from the late Permian Bowen Basin coal beds (Moranbah Coal Measures and stratigraphically above) were likely derived from fresh water sulphate reduced by the peat-forming flora. Therefore, any residual sulphur from this formative environment tends to be contained in the coal sequences as organically bound, rather than in pyritic form, as would be the case for marine influenced depositional environments (Hunt and Brakel, 1985); the implications of which result in a low net AMD risk. Thus the potential to further speciate the sulphur on Drake samples to fine-tune the information;

- That all seven lithological waste groups, in addition to the tailings results, had no mean individual metal value for the 292 whole rock assays undertaken elevated above a global abundance index (GAI) of above 3. This essentially means, based on the data reviewed, that there are no mean elevated metals concentrations relative to appropriate control data. That said; 19 of the 292 individual samples showed arsenic concentrations elevated above a GAI of 3, in addition to 1 sulphur sample being elevated above a GAI of 3. The surrogate tailings sample from Seam A also showed arsenic elevated above a GAI of 3, despite the mean tailings results showing no metal above crustal abundance;
- That all seven lithological waste groups, in addition to the tailings results, showed that there were some leachable metals from the 92 samples that underwent ASLP tests. The most commonly leached elements from the excavated waste were aluminium, arsenic, lead, zinc and selenium. Leachable concentrations that exceeded stock watering guidelines (ANZECC/ARMCANZ 2000a) included pH values (intrusive lithological group) and selenium (carbonaceous, sandstone, siltstone and mudstone lithological groups); and
- Based on percent exchangeable sodium (ESP) from 295 samples across the seven excavated waste lithological waste groups and the tailings samples; the carbonaceous material, coaly material, mudstone and tailings showed a high dispersivity risk. The siltstone showed a medium dispersivity risk, while the sandstone and intrusive lithological waste groups showed low to medium dispersivity risk. The soil unit showed a low dispersivity risk.

Further, the 96 weathered samples returned a mean ESP value of 3.5 indicating a low dispersivity risk, while the 209 fresh samples returned a mean ESP value of 13.3 indicating a medium dispersivity risk. When the 96 weathered samples were combined with 116 soil samples collected to a depth of approximately 1.5 m below ground surface in a 2011 soil survey (GHD 2012a; Volume 2a, Appendix C), the combined 212 samples returned a mean ESP value of 6.2, indicating a low to medium dispersivity risk (assuming the transition from low to medium occurs at an ESP of approximately 6.0; Northcote and Skene 1972, DME 1995).

Therefore, considering all other factors in Table 30; it would appear that the soil, then weathered sandstone, then fresh sandstone are the most appropriate lithological waste groups to use on site in progressive capping of out of pit waste rock dumps. The CENZ material, which includes the soil lithological waste group in addition to all other weathered material, is also appropriate. Higher risk, potentially dispersive materials that should be managed through on site burial / encapsulation include the carbonaceous material, the coaly material, the mudstone and the tailings; particularly the fresh component of each of those four lithological waste groups.

The intrusive unit is also appropriate for use, although it has very high leachate pH values that exceed stock watering guidelines; therefore, any drainage must be contained and managed

appropriately. This is also the case for all lithological waste groups being utilised in progressive rehabilitation, as all leached selected elements to some degree in ASLP testing. Refer to the Drake Water Management Plan (GHD 2012e; Volume 3, Appendix B) for details of engineered environmental dams on site for site dirty water management. Given its mean net acid production potential (NAPP) value of approximately – 88 kg H₂SO₄ per tonne, the intrusive unit may be useful as a neutralising agent for any marginal acid producing tailings (e.g. Seam P and/or Seam A) through co-disposal in engineered tailings structures on site (refer Figure 2).

The indicative dispersivity assessment undertaken herein, using 295 ESP values, would benefit through additional, representative validation sampling and analysis on individual stockpiles earmarked for reuse in site rehabilitation. Additional testing may include geotechnical, particle size analysis, soil fertility, ESP and/or Emerson aggregate testing for example to ensure that each waste unit is appropriate for use as capping material prior to final landform planning and construction.

These findings are consistent with those of PB (2006) at the adjacent Sonoma site who found that the more weathered sandstones were suitable for use as capping material, while the fresh labile sandstones, mudstones, siltstones, and claystones, particularly around the B Seam, should not be used as capping material as they were deemed erosive and sodic.

In addition to the summary, using the Anderson-Darling normality test, there was a 95% probability that mean leachable sulphur concentrations from the 92 ASLP samples would be less than 4.1 mg/L; well below the INAP (2009) threshold for saline drainage of 1,000 mg/L. That fact notwithstanding, there is also a 95% probability that mean leachable EC concentrations from the 92 ASLP samples would be less than 4,200 µS/cm. While this mean reading cannot be classified under DME (1995) guidelines due to it being leachate from ASLP, rather than a 1:5 soil/water mix, it does suggest that slightly saline leachate may be generated as a result of longer-term weathering, if the excavated material is not effectively managed. It is likely that the EC reading is a function of bicarbonate alkalinity (refer Appendix D), rather than leachate sulphate.

Considering the above, and based on the data assessed herein, it may be concluded that there is a low risk of acid and/or saline drainage at Drake. There is a risk of metalliferous drainage at neutral to alkaline pH values, given the results of the 92 ASLP leachate samples analysed; however, it should be noted that the mean leachate pH value of the same 92 samples was 8.0, meaning that the elements of concern, being Al, As, Pb, Zn and Se, will be sparingly soluble and have limited environmental ecotoxicological risk at such a drainage pH value. This observation is in addition to the existing surface water drainage controls being the proposed - engineered environmental dams and dirty water drainage on site - both of which will also reduce risk.

If there is any risk at all from the excavated waste and tailings, geochemical characterisation data reported upon herein best aligns with the characteristics of neutral mine drainage (Figure 27). INAP (2009) recommend that, should neutral mine drainage be an issue on site, the most common water treatment management required would be for metals, and potentially, sulphate. Based on the data reviewed herein, it is unlikely that elevated sulphate concentrations will be a problem at Drake. There may be low concentrations of drainage metals concentrations to manage; however, the surface water drainage mitigation and management strategies outlined in the Drake Water Management Plan (GHD 2012e; Volume 3, Appendix B) appear appropriate.

Additional to the surface water drainage mitigation and management strategies as outlined in the Drake Water Management Plan (GHD 2012e; Volume 3, Appendix B), would be the excavated waste handling and long-term storage, by lithological waste group, as outlined above based on geochemical risk. This would include storage of the carbonaceous material, the coaly material, the mudstone and the tailings; particularly the fresh component of each of those four

lithological waste groups, in in-pit facilities. Additionally, these materials should not be used as waste rock storage facility capping materials during progressive site rehabilitation activities.

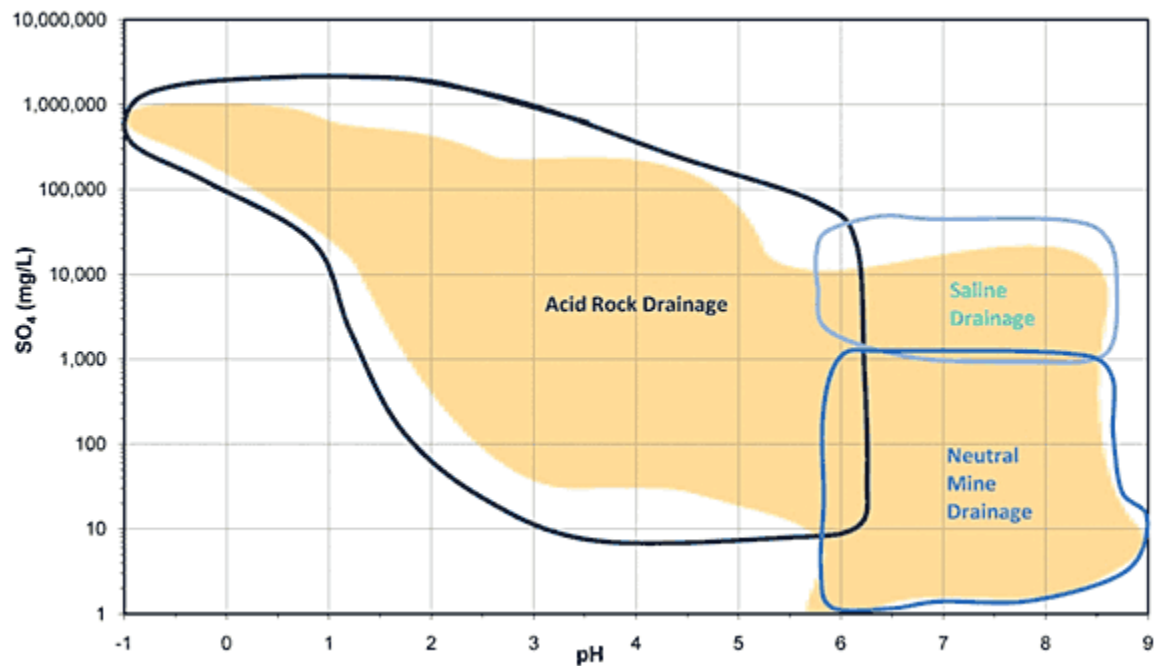


Figure 27: Schematic of mine drainage types

Source: INAP 2009.

5. Summary and Conclusions

5.1 Summary and Conclusions

This report presented, interpreted and reported in analytical data for geochemistry, dispersivity, metals and metals leaching for the seven excavated waste lithological groups at Drake, in addition to the six composited coal seam samples; intended to be surrogates for tailings samples in lieu of actual tailings samples.

The information was assessed to inform:

- The risk of acid, metalliferous, neutral and/or saline drainage from each individual excavated waste lithological group in addition to CHPP tailings; and
- The salinity/sodicity; and any potential for structural breakdown and dispersion should the waste units be utilised as capping material in progressive mine site rehabilitation.

Based on the data reviewed herein, key findings were:

- That all seven lithological waste groups, in addition to the tailings results, were classified as non-acid forming (NAF) using data from 284 samples;
- That all seven lithological waste groups, in addition to the tailings results, had no mean individual whole-rock metal value elevated above a geochemical abundance index using data from 292 samples;
- That all seven lithological waste groups, in addition to the tailings results, had some leachable metals from the 92 samples that underwent ASLP tests. The most commonly leached elements from the excavated waste were aluminium, arsenic, lead, zinc and selenium; and
- Based on data from 295 samples across the seven lithological waste groups and the tailings samples; the carbonaceous material, coaly material, mudstone and tailings showed a high dispersivity risk. The siltstone showed a medium dispersivity risk, while the sandstone and intrusive lithological waste groups showed low to medium dispersivity risk. The soil unit showed a low dispersivity risk.

Therefore, based on the data reviewed herein, the soil, then weathered sandstone, then fresh sandstone appear to be the most appropriate lithological waste groups to use on site in progressive capping of out of pit waste rock dumps. The CENZ material which includes the soil lithological waste group in addition to all other weathered material is also appropriate. Higher-risk potentially dispersive materials that should be managed through on site burial / encapsulation include the carbonaceous material, the coaly material, the mudstone and the tailings; particularly the fresh component of each of those four lithological waste groups.

Based on the data reviewed herein, the intrusive unit is also appropriate for beneficial use, although has very high leachate pH values that exceed stock watering guidelines; therefore, any drainage must be contained and managed appropriately. Additionally, the intrusive unit may be useful as a neutralising agent for any marginal acid producing tailings through co-disposal in engineered tailings structures on site.

Considering the above, and based on the data assessed herein, it is concluded that there is a low risk of acid drainage at Drake. There is a risk of metalliferous drainage at neutral to alkaline drainage pH values given the results of the 92 ASLP leachate samples analysed; however, it should be noted that the mean leachate pH value of the same 92 samples was 8.0, meaning that the elements of concern being Al, As, Pb, Zn and Se will be sparingly soluble and have limited environmental ecotoxicological risk at such a drainage pH value. This observation is in

addition to the existing surface water drainage controls being the proposed engineered environmental dams and dirty water drainage on site; both of which will also reduce risk. The surface water drainage mitigation and management strategies outlined in the Drake Water Management Plan (GHD 2012e; Volume 3, Appendix B) are appropriate to manage this risk.

Additional to the surface water drainage mitigation and management strategies as outlined in the Drake Water Management Plan (GHD 2012e; Volume 3, Appendix B), would be the excavated waste handling and long-term storage by lithological waste group as outlined above, based on geochemical risk. i.e. storage of the carbonaceous material, the coaly material, the mudstone and the tailings; particularly the fresh component of each of those four lithological waste groups, in in-pit facilities. Additionally, these materials should not be used as waste rock storage facility capping materials during progressive site rehabilitation activities

The above notwithstanding, based on the data reviewed herein, there is a very low risk of acid drainage being generated from the excavated waste at Drake. This conclusion is consistent with the low risk in coal mines adjacent to Drake in the northern Bowen Basin including Sonoma and Belmore-Pipeline for example, where alkaline conditions prevail (QCoal 2011).

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Appendices

Appendix A – Geochemical sample details

Hole No.	Waste Interval	Sample No.	From (m)	To (m)	Thickness (m)	Lithology (Qcoal descriptive)	Date Sampled	Geo.	Weathering
Carbonaceous Material Lithological Waste Group (n = 55)									
DK287	Q_P	287017	32.00	36.00	4.00	Siltstone, carbonaceous, indurated	16.10.12	R.McW	F
BR018P	B_A	18012	42.00	45.00	3.00	Carbonaceous mudstone	24.10.12	R.McW	F
BR888C	B_A	888024	58.00	60.00	2.00	Siltstone, carbonaceous, micaceous	30.10.12	R.McW	F
BR888C	B_A	888030	80.00	85.88	5.88	Carbonaceous mudstone, minor coaly laminae	30.10.12	R.McW	F
BR888C	B_A	888027	70.00	74.00	4.00	Carbonaceous mudstone	30.10.12	R.McW	F
BR888C	B_A	888029	76.20	80.00	3.80	Carbonaceous mudstone	30.10.12	R.McW	F
BR936P	B_A	936035	127.00	128.00	1.00	Carbonaceous mudstone, indurated	14.11.12	R.McW	F
BR940R	B_A	940019	55.00	57.00	2.00	carbonaceous siltstone	26.10.12	S.C	F
BR940R	B_A	940022	59.00	62.00	3.00	carbonaceous siltstone	26.10.12	S.C	F
BR940R	B_A	940026	72.00	74.00	2.00	carbonaceous siltstone	26.10.12	S.C	F
BR940R	B_A	940024	64.00	67.00	3.00	carbonaceous siltstone minor coal and sandstone	26.10.12	S.C	F
BR948CR	B_A	948040	100.00	101.00	1.00	Carbonaceous mudstone	29.10.12	S.C	F
BR948CR	B_A	948039	96.00	100.00	4.00	Carbonaceous siltstone	29.10.12	S.C	F
BR951C	B_A	951037	44.00	49.00	5.00	carbonaceous mudstone	26.10.12	S.C	F
BR951C	B_A	951040	52.00	53.00	1.00	carbonaceous mudstone	26.10.12	S.C	F
BR951C	B_A	951038	49.00	52.00	3.00	carbonaceous siltstone	26.10.12	S.C	F
BR951C	B_A	951043	57.00	59.00	2.00	carbonaceous siltstone	26.10.12	S.C	F
BR951C	B_A	951048	68.00	69.00	1.00	carbonaceous siltstone	26.10.12	S.C	F
DK046C	B_A	46062	102.00	103.00	1.00	carbonaceous siltstone	19.10.12	S.C	F
DK268P	B_A	268036	144.00	145.00	1.00	Carbonaceous mudstone, minor coaly laminae	16.11.12	R.McW	F
DK008C	A_B	8050	70.84	71.82	0.98	carbonaceous siltstone	21.10.12	S.C.	F
DK500	B_A	500019	109.00	110.00	1.00	Carbonaceous mudstone, micaceous	14.10.12	R.McW	F
DK500	B_A	500020	114.00	115.00	1.00	Carbonaceous mudstone, micaceous, coaly laminae	14.10.12	R.McW	F
DK500	B_A	500016	90.00	91.00	1.00	Carbonaceous siltstone, micaceous	14.10.12	R.McW	F
DK053R	B_A	53036	98.00	100.00	2.00	carbonaceous siltstone	23.10.12	S.C.	F
DK500	B_C	500010	56.00	57.00	1.00	Carbonaceous mudstone, indurated	14.10.12	R.McW	F
DK500	B_C	500011	58.20	60.00	1.80	Carbonaceous, siltstone, white micas	14.10.12	R.McW	F
DK500	B_C	500007	31.00	32.00	1.00	Slightly carbonaceous mudstone	14.10.12	R.McW	F
BR015P	C_B	15006	18.00	21.00	3.00	Carbonaceous mudstone, minor cindered coal	17.10.12	R.McW	W
BR888C	C_B	888008	23.00	28.91	5.91	Siltstone, slightly carbonaceous	30.10.12	R.McW	F
BR888C	C_B	888011	31.52	31.82	0.30	Carbonaceous mudstone, indurated	30.10.12	R.McW	F
BR936P	C_B	936008	24.00	25.00	1.00	Carbonaceous mudstone, minor coaly laminae	14.11.12	R.McW	F
BR940R	C_B	940008	16.00	18.00	2.00	carbonaceous siltstone	26.10.12	S.C	W
BR951C	C_B	951007	16.00	19.00	3.00	Carbonaceous siltstone	25.10.12	S.C	W
DK046C	C_B	46039	68.00	69.00	1.00	carbonaceous siltstone	18.10.12	S.C	F
DK053R	C_B	53026	69.00	71.00	2.00	carbonaceous siltstone	23.10.12	S.C	F
DK053R	C_B	53027	71.00	72.00	1.00	carbonaceous siltstone and intrusion	23.10.12	S.C	F
DK268P	C_B	268022	81.00	82.00	1.00	Carbonaceous mudstone, minor coaly laminae	16.11.12	R.McW	F
DK502	C_B	502007	16.00	18.00	2.00	Carbonaceous mudstone, minor coaly laminae	24.10.12	R.McW	W
DK008	C_B	8018	49.00	50.00	1.00	Carbonaceous siltstone	19.10.12	S.C	F
DK053R	E_C	53015	44.00	45.00	1.00	Carbonaceous siltstone	23.10.12	S.C.	F
DK268P	E_C	268015	47.30	52.00	4.70	Siltstone, slightly carbonaceous	16.11.12	R.McW	F
DK268P	E_C	268019	70.00	73.00	3.00	Carbonaceous mudstone, micaceous	16.11.12	R.McW	F
DK268P	P_E	268010	30.00	32.00	2.00	Carbonaceous mudstone, micaceous	16.11.12	R.McW	F
DK268P	P_E	268013	40.00	42.00	2.00	Carbonaceous mudstone, micaceous	16.11.12	R.McW	F
DK268P	P_E	268014	42.00	45.00	3.00	Carbonaceous mudstone, minor coaly laminae	16.11.12	R.McW	F
DK287	P_E	287015	79.00	83.00	4.00	Carbonaceous mudstone	16.10.12	R.McW	F
BR771C	P_E	771041	114.95	115.76	0.56	Carbonaceous siltstone, tuffaceous	10.10.12	R.McW	F
BR767C	Q_P	767029	53.00	54.00	1.00	carbonaceous mudstone rare intrusion fragments	21.10.12	S.C	F
BR767C	Q_P	767028	51.00	53.00	2.00	carbonaceous siltstone	21.10.12	S.C	F
BR767C	Q_P	767020	26.65	27.40	0.75	Carbonaceous siltstone	21.10.12	S.C	F
BR767C	Q_P	767033	61.00	62.00	1.00	Carbonaceous shale	21.10.12	S.C.	F
BR771C	Q_P	771005	22.00	23.00	1.00	Siltstone, indurated, carbonaceous	10.10.12	R.McW	F
BR771C	Q_P	771025	48.14	51.00	2.86	Carbonaceous mudstone, minor cindered coal	10.10.12	R.McW	F
BR771C	Q_P	771008	27.40	27.75	0.35	Carbonaceous sandstone	10.10.12	R.McW	F
Coaly Material Lithological Waste Group (n = 8)									
BR767C	P_E	767044	71.00	72.00	1.00	Siltstone and coal	21.10.12	S.C	F
DK046C	B_A	951036	43.00	44.00	1.00	Coal stoney frequent mudstone bands	26.10.12	S.C	F
BR951C	B_A	53033	90.00	93.00	3.00	Coaly mudstone	23.10.12	S.C	F
DK053R	BSEA	936022	74.00	75.00	1.00	Cindered coal tending stoney	14.11.12	R.McW	F
DK053R	C_B	46027	48.13	48.81	0.68	Siltstone minor coaly bands	18.10.12	S.C	F
DK287	P_E	287013	68.00	69.00	1.00	Coaly mudstone	16.10.12	R.McW	F
BR767C	Q_P	287003	4.00	7.00	3.00	Coal weathered, earthy	16.10.12	R.McW	W
BR936P	Q_P	767031	55.00	56.00	1.00	Cindered coal	21.10.12	S.C	F
Intrusive Waste Group (n = 32)									
DK053R	B_A	53035	95.00	98.00	3.00	Intrusion	23.10.12	S.C	F
BR940R	B_A	940020	57.00	58.00	1.00	Intrusion	26.10.12	S.C	F
BR951C	B_A	951041	53.00	56.00	3.00	Intrusion	26.10.12	S.C	F
BR888C	B_A	888028	74.00	76.20	2.20	Intrusion	30.10.12	R.McW	F
BR888C	B_A	888032	87.89	88.35	0.46	Intrusion	30.10.12	R.McW	F
BR936P	ASEA	936036	129.00	135.00	6.00	Intrusion	14.11.12	R.McW	F
BR936P	ASEA	936037	135.00	139.00	4.00	Intrusion	14.11.12	R.McW	F
BR948CR	ASEA	948041	101	105	4	Intrusion	29.10.12	S.C	F
DK053R	C_B	53021	56.00	57.00	1.00	Intrusion	23.10.12	S.C	F
DK053R	C_B	53022	57.00	59.00	2.00	Intrusion	23.10.12	S.C	F
BR940R	C_B	940010	21.00	26.00	5.00	Intrusion	26.10.12	S.C	F
DK046C	C_B	46045	82.00	83.69	1.69	Intrusion	19.10.12	S.C	F
DK502	C_B	502008	18.00	20.00	2.00	Intrusion	24.10.12	R.McW	W
BR018P	C_B	18002	1.00	3.20	2.20	Intrusion	24.10.12	R.McW	W
BR888C	C_B	888012	32.41	33.00	0.59	Intrusion	30.10.12	R.McW	F
BR936P	BSEA	936023	75.00	77.00	2.00	Intrusion	14.11.12	R.McW	F
DK268P	C_B	268021	79.40	81.00	1.60	Intrusion	16.11.12	R.McW	F
DK268P	C_B	268035	139.80	142.20	2.40	Intrusion	16.11.12	R.McW	F

BR936P	CSEA	936002	1.20	3.30	2.10	Intrusion	14.11.12	R.McW	W
BR936P	CSEA	936005	9.00	12.00	3.00	Intrusion	14.11.12	R.McW	W
BR936P	CSEA	936007	20.00	23.40	3.40	Intrusion	14.11.12	R.McW	F
DK268P	E_C	268020	74.00	76.00	2.00	Intrusion	16.11.12	R.McW	F
DK287	ESEA	287014	70.00	79.00	9.00	Intrusion	16.10.12	R.McW	F
DK268P	P_E	268008	22.00	25.00	3.00	Intrusion	16.11.12	R.McW	F
DK268P	P_E	268009	25.00	30.00	5.00	Intrusion	16.11.12	R.McW	F
BR767C	Q_P	767030	54.00	55.00	1.00	Intrusion	21.10.12	S.C	F
BR767C	Q_P	767032	56.00	61.00	5.00	Intrusion	21.10.12	S.C	F
DK287	Q_P	287002	0.30	4.00	3.70	Intrusion	16.10.12	R.McW	W
BR771C	Q_P	771019	39.85	41.07	1.22	Intrusion	10.10.12	R.McW	F
BR940R	C_B	940009	18.00	21.00	3.00	Intrusion with some cindred coal	26.10.12	S.C	W
DK268P	P_E	268007	15.00	16.00	1.00	Intrusion, slightly clayey	16.11.12	R.McW	W
DK287	ESEA	287016	83.00	91.00	8.00	Intrusion_ fault repeated	16.10.12	R.McW	F
Mudstone Waste Group (n = 51)									
BR888C	B_A	888021	50.00	55.00	5.00	Interbedded mudstone siltstone	30.10.12	R.McW	F
DK053R	B_A	951029	32.92	33.12	0.20	Mudstone	25.10.12	S.C	F
DK500	B_A	500021	115.00	119.80	4.80	Mudstone	14.10.12	R.McW	F
BR940R	B_A	502012	43.00	46.00	3.00	Mudstone	24.10.12	R.McW	F
BR951C	B_A	888026	65.00	70.00	5.00	Mudstone	30.10.12	R.McW	F
DK500	B_A	936027	91.00	94.00	3.00	Mudstone	14.11.12	R.McW	F
DK502	B_A	888020	49.25	50.00	0.75	Mudstone slightly carbonaceous, micaceous	30.10.12	R.McW	F
BR888C	B_A	15010	46.00	47.00	1.00	Mudstone, indurated	17.10.12	R.McW	F
BR936P	B_A	500017	91.00	94.00	3.00	Mudstone, indurated	14.10.12	R.McW	F
DK053R	B_A	936033	120.00	125.00	5.00	Mudstone, indurated	14.11.12	R.McW	F
BR948CR	B_A	15008	38.00	39.00	1.00	Mudstone, minor coaly laminae	17.10.12	R.McW	F
BR948CR	B_A	18010	32.00	33.00	1.00	Mudstone, slightly carbonaceous	24.10.12	R.McW	F
BR948CR	B_A	948036	83.78	84.71	0.93	Mudstone and siltstone; carbonaceous in part	29.10.12	S.C.	F
BR015P	B_A	936031	111.00	115.00	4.00	Mudstone, slightly carbonaceous	14.11.12	R.McW	F
BR015P	B_A	936032	115.00	120.00	5.00	Mudstone, slightly carbonaceous	14.11.12	R.McW	F
DK500	B_A	936034	125.00	127.00	2.00	Mudstone, slightly carbonaceous, indurated	14.11.12	R.McW	F
BR936P	B_A	502010	37.00	38.00	1.00	Mudstone, slightly carbonaceous, micaceous	24.10.12	R.McW	F
DK268P	B_A	268037	145.00	150.00	5.00	Mudstone, slightly carbonaceous, micas	16.11.12	R.McW	F
BR936P	B_A	502011	38.00	43.00	5.00	Mudstone, slightly tuffaceous	24.10.12	R.McW	F
DK287	B_A	18011	33.00	42.00	9.00	Mudstone, slightly tuffaceous	24.10.12	R.McW	F
BR771C	B_A	15009	39.00	46.00	7.00	Mudstone, tuffaceous, micaceous	17.10.12	R.McW	F
BR948CR	B_C	500008	32.00	42.00	10.00	Mudstone	14.10.12	R.McW	F
BR888C	B_C	500013	72.00	77.00	5.00	Mudstone, slightly carbonaceous	14.10.12	R.McW	F
DK502	C_B	940003	3.00	6.00	3.00	Claystone	26.10.12	S.C	W
BR018P	C_B	53017	48.00	49.00	1.00	Mudstone	23.10.12	S.C	F
BR018P	C_B	948015	24.00	27.00	3.00	Mudstone	28.10.12	S.C	F
BR015P	C_B	15005	13.00	18.00	5.00	Mudstone	17.10.12	R.McW	W
DK500	C_B	15007	21.00	26.00	5.00	Mudstone	17.10.12	R.McW	F
BR936P	C_B	936012	35.00	39.00	4.00	Mudstone	14.11.12	R.McW	F
BR936P	C_B	268034	128.00	129.00	1.00	Mudstone	16.11.12	R.McW	F
BR018P	C_B	502002	0.20	2.70	2.50	Mudstone, clayey	24.10.12	R.McW	W
BR936P	C_B	18003	3.20	4.50	1.30	Mudstone, clayey	24.10.12	R.McW	W
BR771C	C_B	502003	2.70	3.20	0.50	Mudstone, ferruginous	24.10.12	R.McW	W
BR018P	C_B	18004	4.50	5.00	0.50	Mudstone, ferruginous	24.10.12	R.McW	W
BR936P	C_B	18008	12.20	13.00	0.80	Mudstone, minor coaly laminae	24.10.12	R.McW	W
BR936P	C_B	936013	39.00	40.00	1.00	Mudstone, minor coaly laminae	14.11.12	R.McW	F
BR018P	C_B	18009	13.00	20.50	7.50	Mudstone, slightly carbonaceous	24.10.12	R.McW	W
BR018P	C_B	936009	25.00	27.00	2.00	Mudstone, slightly carbonaceous	14.11.12	R.McW	F
BR936P	C_B	268023	82.00	84.00	2.00	Mudstone, slightly carbonaceous	16.11.12	R.McW	F
DK268P	C_B	15003	7.00	8.00	1.00	Mudstone, slightly ferruginous	17.10.12	R.McW	W
DK268P	C_B	502009	20.00	25.40	5.40	Mudstone, slightly tuffaceous	24.10.12	R.McW	F
BR936P	E_C	936004	6.00	9.00	3.00	Mudstone	14.11.12	R.McW	W
DK500	E_C	936003	3.30	6.00	2.70	Mudstone, indurated	14.11.12	R.McW	W
DK502	E_C	500006	24.00	26.00	2.00	Mudstone, slightly carbonaceous, indurated	14.10.12	R.McW	F
DK268P	P_E	287009	43.00	46.00	3.00	Mudstone	16.10.12	R.McW	F
BR015P	P_E	771037	87.00	92.00	5.00	Mudstone	10.10.12	R.McW	F
DK502	P_E	268006	12.00	15.00	3.00	Mudstone, slightly carbonaceous, ferruginous	16.11.12	R.McW	W
BR018P	P_E	771046	124.50	125.00	0.50	Mudstone, slightly tuffaceous	10.10.12	R.McW	F
DK502	Q_P	771026	51.00	64.00	13.00	Mudstone, minor coaly laminae	10.10.12	R.McW	F
BR771C	Quat	53002	1.00	5.00	4.00	Claystone	23.10.12	S.C	W
BR015P	Quat	500002	1.00	5.30	4.30	Claystone	14.10.12	R.McW	W
Sandstone Waste Group (n = 110)									
BR888C	C_B	888005	10.00	14.00	4.00	Interbedded sandstone, siltstone	30.10.12	R.McW	W
BR888C	B_A	888023	57.00	58.00	1.00	Sandstone	30.10.12	R.McW	F
BR936P	B_A	936028	94.00	100.00	6.00	Sandstone	14.11.12	R.McW	F
BR936P	B_A	936030	105.00	111.00	6.00	Sandstone	14.11.12	R.McW	F
BR940R	B_A	940013	40.00	43.00	3.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940014	43.00	44.00	1.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940015	44.00	46.00	2.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940017	47.00	50.00	3.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940018	50.00	55.00	5.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940023	62.00	64.00	2.00	Sandstone	26.10.12	S.C	F
BR940R	B_A	940025	67.00	72.00	5.00	Sandstone	26.10.12	S.C	F
BR951C	B_A	951030	33.12	33.56	0.44	Sandstone	25.10.12	S.C	F
BR951C	B_A	951031	33.56	35.00	1.44	Sandstone	25.10.12	S.C	F
BR951C	B_A	951033	36.00	40.00	4.00	Sandstone	25.10.12	S.C	F
BR951C	B_A	951034	40.00	42.00	2.00	Sandstone	25.10.12	S.C	F
BR951C	B_A	951042	56.00	57.00	1.00	Sandstone	26.10.12	S.C	F
BR951C	B_A	951047	65.00	68.00	3.00	Sandstone	26.10.12	S.C	F
DK046C	B_A	46061	97.00	102.00	5.00	Sandstone	19.10.12	S.C	F

DK053R	B_A	53031	87.00	89.00	2.00	Sandstone	23.10.12	S.C	F
DK053R	B_A	53032	89.00	90.00	1.00	Sandstone	23.10.12	S.C	F
DK053R	B_A	53034	93.00	95.00	2.00	Sandstone and intrusion	23.10.12	S.C	F
DK500	B_C	500009	42.00	48.00	6.00	Sandstone	14.10.12	R.McW	F
DK500	B_C	500012	64.50	72.00	7.50	Sandstone	14.10.12	R.McW	F
BR018P	C_B	18007	7.50	12.20	4.70	Sandstone, slightly carbonaceous	24.10.12	R.McW	W
BR888C	C_B	888002	1.00	3.00	2.00	Sandstone	30.10.12	R.McW	W
BR888C	C_B	888003	3.00	7.00	4.00	Sandstone	30.10.12	R.McW	W
BR888C	C_B	888004	7.00	10.00	3.00	Sandstone	30.10.12	R.McW	W
BR936P	C_B	936015	43.00	50.00	7.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936016	50.00	55.00	5.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936017	55.00	60.00	5.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936018	60.00	65.00	5.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936019	65.00	70.00	5.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936020	70.00	73.00	3.00	Sandstone	14.11.12	R.McW	F
BR936P	C_B	936010	27.00	33.00	6.00	Sandstone, slightly tuffaceous	14.11.12	R.McW	F
BR940R	C_B	940004	6.00	10.00	4.00	Sandstone	26.10.12	S.C	W
BR948CR	C_B	948016	27.00	32.00	5.00	Sandstone	28.10.12	S.C	F
BR948CR	C_B	948017	32.00	36.00	4.00	Sandstone	28.10.12	S.C	F
BR948CR	C_B	948018	36.00	40.00	4.00	Sandstone	28.10.12	S.C	F
BR948CR	C_B	948020	45.00	50.00	5.00	Sandstone	28.10.12	S.C	F
BR948CR	C_B	948021	50.00	53.00	3.00	Sandstone	28.10.12	S.C	F
BR948CR	C_B	948022	53.00	55.00	2.00	Sandstone	29.10.12	S.C	F
BR948CR	C_B	948023	55.00	59.00	4.00	Sandstone	29.10.12	S.C	F
BR948CR	C_B	948024	59.00	61.00	2.00	Sandstone	29.10.12	S.C	F
BR948CR	C_B	948025	61.00	65.00	4.00	Sandstone	29.10.12	S.C	F
BR948CR	C_B	948026	65.00	68.00	3.00	Sandstone	29.10.12	S.C	F
BR951C	C_B	951002	1.00	5.00	4.00	Sandstone	25.10.12	S.C	W
BR951C	C_B	951004	8.00	11.00	3.00	Sandstone	25.10.12	S.C	W
DK046C	C_B	46020	27.00	30.00	3.00	Sandstone	18.10.12	S.C	F
DK046C	C_B	46021	30.00	33.00	3.00	Sandstone	18.10.12	S.C	F
DK046C	C_B	46022	33.00	37.00	4.00	Sandstone	18.10.12	S.C	F
DK046C	C_B	46024	41.00	46.00	5.00	Sandstone	18.10.12	S.C	F
DK046C	C_B	46026	47.00	48.13	1.13	Sandstone	18.10.12	S.C	F
DK046C	C_B	46019	24.63	27.00	2.37	Sandstone and siltstone	18.10.12	S.C	F
DK053R	C_B	53018	49.00	52.00	3.00	Sandstone	23.10.12	S.C	F
DK053R	C_B	53019	52.00	53.00	1.00	Sandstone	23.10.12	S.C	F
DK053R	C_B	53020	53.00	56.00	3.00	Sandstone	23.10.12	S.C	F
DK053R	C_B	53023	59.00	60.00	1.00	Sandstone	23.10.12	S.C	F
DK053R	C_B	53024	60.00	65.00	5.00	Sandstone	23.10.12	S.C	F
DK268P	C_B	268025	90.00	93.00	3.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268026	93.00	96.00	3.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268028	97.00	105.00	8.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268030	110.00	115.00	5.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268031	115.00	120.00	5.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268032	120.00	124.00	4.00	Sandstone	16.11.12	R.McW	F
DK268P	C_B	268024	84.00	90.00	6.00	Sandstone, micaceous	16.11.12	R.McW	F
DK502	C_B	502004	3.20	9.00	5.80	Sandstone	24.10.12	R.McW	W
DK502	C_B	502005	9.00	12.00	3.00	Sandstone	24.10.12	R.McW	W
BR948CR	E_C	948002	1.00	5.00	4.00	Sandstone	28.10.12	S.C	W
BR948CR	E_C	948003	5.00	9.00	4.00	Sandstone	28.10.12	S.C	W
BR948CR	E_C	948004	9.00	12.00	3.00	Sandstone	28.10.12	S.C	W
BR948CR	E_C	948005	12.00	14.00	2.00	Sandstone	28.10.12	S.C	W
DK046C	E_C	46002	1.00	4.00	3.00	Sandstone	17.10.12	S.C	W
DK046C	E_C	46003	4.00	9.00	5.00	Sandstone	17.10.12	S.C	W
DK046C	E_C	46004	9.00	13.00	4.00	Sandstone	17.10.12	S.C	W
DK046C	E_C	46005	13.00	14.93	1.93	Sandstone	17.10.12	S.C	W
DK046C	E_C	46006	14.93	15.78	0.85	Sandstone	17.10.12	S.C	W
DK046C	E_C	46007	15.78	16.47	0.69	Sandstone	17.10.12	S.C	W
DK053R	E_C	53003	5.00	8.00	3.00	Sandstone	23.10.12	S.C	W
DK053R	E_C	53006	14.00	16.00	2.00	Sandstone	23.10.12	S.C	W
DK053R	E_C	53008	20.00	25.00	5.00	Sandstone	23.10.12	S.C	F
DK053R	E_C	53010	26.00	30.00	4.00	Sandstone	23.10.12	S.C	F
DK053R	E_C	53011	30.00	33.00	3.00	Sandstone	23.10.12	S.C	F
DK500	E_C	500004	12.00	17.00	5.00	Sandstone	14.10.12	R.McW	W
DK500	E_C	500005	19.00	24.00	5.00	Interbedded sandstone, siltstone	14.10.12	R.McW	W
BR771C	P_E	771039	106.00	111.00	5.00	Interbedded sandstone, siltstone	10.10.12	R.McW	F
BR771C	P_E	771036	75.75	87.00	11.25	Sandstone	10.10.12	R.McW	F
BR771C	P_E	771045	119.67	124.50	4.83	Sandstone, slightly tuffaceous	10.10.12	R.McW	F
DK268P	P_E	268005	9.00	12.00	3.00	Interbedded sandstone, siltstone	16.11.12	R.McW	W
DK268P	P_E	268004	3.00	9.00	6.00	Sandstone	16.11.12	R.McW	W
DK268P	P_E	268003	2.00	3.00	1.00	Sandstone, minor calcrete	16.11.12	R.McW	W
DK268P	P_E	268002	0.50	2.00	1.50	Sandstone, slightly clayey	16.11.12	R.McW	W
DK287	P_E	287011	57.00	62.00	5.00	Sandstone	16.10.12	R.McW	F
BR767C	Q_P	767022	30.00	34.00	4.00	Sandstone	21.10.12	S.C	F
BR767C	Q_P	767023	34.00	38.00	4.00	Sandstone	21.10.12	S.C	F
BR767C	Q_P	767025	42.00	45.00	3.00	Sandstone	21.10.12	S.C	F
BR767C	Q_P	767026	45.00	49.00	4.00	Sandstone	21.10.12	S.C	F
BR767C	Q_P	767027	49.00	51.00	2.00	Sandstone	21.10.12	S.C	F
BR771C	Q_P	771009	27.75	31.13	3.38	Interbedded sandstone, siltstone	10.10.12	R.McW	F
BR771C	Q_P	771011	31.97	32.75	0.78	Interbedded sandstone, siltstone	10.10.12	R.McW	F
BR771C	Q_P	771031	69.33	70.47	1.14	Interbedded sandstone, siltstone	10.10.12	R.McW	F
BR771C	Q_P	771004	14.00	22.00	8.00	Sandstone	10.10.12	R.McW	W
BR771C	Q_P	771013	33.22	34.45	1.23	Sandstone slightly tuffaceous	10.10.12	R.McW	F
BR771C	Q_P	771006	23.00	26.00	3.00	Sandstone, slightly tuffaceous	10.10.12	R.McW	F

DK287	Q_P	287006	20.00	24.00	4.00	Sandstone	16.10.12	R.McW	F
DK287	Q_P	287007	24.00	25.00	1.00	Sandstone	16.10.12	R.McW	F
DK287	Q_P	287008	25.00	32.00	7.00	Sandstone	16.10.12	R.McW	F
BR767C	R_Q	767002	1.00	5.00	4.00	Sandstone	21.10.12	S.C	W
BR767C	R_Q	767003	5.00	8.00	3.00	Sandstone	21.10.12	S.C	W
BR767C	R_Q	767004	8.00	12.00	4.00	Sandstone	21.10.12	S.C	W
BR767C	R_Q	767005	12.00	15.00	3.00	Sandstone	21.10.12	S.C	W
Siltstone Waste Group (n = 54)									
DK008C	A_Exm	8063	77.36	78.52	1.16	Siltstone	21.10.12	S.C	F
BR888C	B_A	888022	55.00	57.00	2.00	Siltstone, micaceous	30.10.12	R.McW	F
BR888C	B_A	888025	60.00	65.00	5.00	Siltstone	30.10.12	R.McW	F
BR936P	B_A	936025	82.00	86.00	4.00	Siltstone	14.11.12	R.McW	F
BR936P	B_A	936026	86.00	91.00	5.00	Siltstone	14.11.12	R.McW	F
BR948CR	B_A	948037	84.71	88.00	3.29	Siltstone	29.10.12	S.C	F
BR948CR	B_A	948038	91.00	96.00	5.00	Siltstone	29.10.12	S.C	F
DK046C	B_A	46060	95.30	97.00	1.70	Siltstone	19.10.12	S.C	F
DK053R	B_A	53030	82.00	87.00	5.00	Siltstone	23.10.12	S.C	F
DK500	B_A	500018	96.00	109.00	13.00	Siltstone, micaceous	14.10.12	R.McW	F
DK008	A_B	8046	64.39	64.52	0.13	Siltstone	20.10.12	S.C.	F
BR015P	C_B	15002	1.30	7.00	5.70	Siltstone	17.10.12	R.McW	W
BR015P	C_B	15004	8.00	13.00	5.00	Siltstone	17.10.12	R.McW	W
BR888C	C_B	888006	14.00	18.00	4.00	Siltstone, indurated	30.10.12	R.McW	W
BR888C	C_B	888007	18.00	23.00	5.00	Siltstone	30.10.12	R.McW	W
BR936P	C_B	936011	33.00	35.00	2.00	Siltstone, slightly tuffaceous	14.11.12	R.McW	F
BR936P	C_B	936014	40.00	43.00	3.00	Siltstone	14.11.12	R.McW	F
BR936P	C_B	936021	73.00	74.00	1.00	Siltstone	14.11.12	R.McW	F
BR940R	C_B	940002	1.00	3.00	2.00	Siltstone ironstone and claystone	26.10.12	S.C	W
BR940R	C_B	940005	10.00	12.00	2.00	Siltstone	26.10.12	S.C	W
BR940R	C_B	940006	12.00	14.00	2.00	Siltstone	26.10.12	S.C	W
BR940R	C_B	940007	14.00	16.00	2.00	Siltstone	26.10.12	S.C	W
BR951C	C_B	951003	5.00	8.00	3.00	Siltstone	25.10.12	S.C	W
BR951C	C_B	951005	11.00	15.00	4.00	Siltstone	25.10.12	S.C	W
BR951C	C_B	951006	15.00	16.00	1.00	Siltstone	25.10.12	S.C	W
DK046C	C_B	46023	37.00	41.00	4.00	Siltstone	18.10.12	S.C	F
DK053R	C_B	53025	65.00	69.00	4.00	Siltstone	23.10.12	S.C	F
DK268P	C_B	268027	96.00	97.00	1.00	Siltstone	16.11.12	R.McW	F
DK268P	C_B	268033	124.00	128.00	4.00	Siltstone	16.11.12	R.McW	F
BR948CR	C_B	948027	68.00	70.00	2.00	Siltstone	29.10.12	S.C.	F
DK053R	E_C	53007	16.00	20.00	4.00	Siltstone	23.10.12	S.C	W
DK053R	E_C	53013	36.00	41.00	5.00	Siltstone	23.10.12	S.C	W
DK053R	E_C	53014	41.00	44.00	3.00	Siltstone	23.10.12	S.C	F
DK268P	E_C	268017	60.00	65.00	5.00	Siltstone, slightly tuffaceous	16.11.12	R.McW	F
DK268P	E_C	268018	65.00	70.00	5.00	Interbedded siltstone, mudstone	16.11.12	R.McW	F
DK268P	E_C	268016	52.00	60.00	8.00	Siltstone	16.11.12	R.McW	F
BR767C	P_E	767043	68.43	71.00	2.57	Siltstone	21.10.12	S.C	F

Appendix L - QNH Mine Waste Management Plan



QCoal Northern Hub

Mine Waste Management Plan



QCoal Northern Hub
Mine Waste Management Plan

Document information	
Report type	QCoal Northern Hub Mine Waste Management Plan
Author(s)	Environment – QCoal Group
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Project(s)	Sonoma Coal Mine Cows Coal Mine Drake Coal Mine Jax Coal Mine
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1 Introduction

QCoal Pty Ltd (QCoal) manages four adjacent open cut coal mines located approximately 6km south of the town of Collinsville in central Queensland. The four mines are the Sonoma Coal Mine (SCM), Cows Coal Mine (CCM), Drake Coal Mine (DCM) and Jax Coal Mine (JCM), and pits, dumps, roads and water management infrastructure span the boundaries of the various mining leases (MLs). Each mine has its own environmental authority (EA); however, as with physical infrastructure, the operational and environmental management (and resources) are integrated across the four mines.

Accordingly, these four mines are collectively managed and operated as a single multiple-pit operation, which is referred to as the QCoal Northern Hub (QNH).

1.1 Background

The QNH is located approximately 6 km south of the town of Collinsville, and 78 km southwest of the regional centre of Bowen (see **Figure 1**). The four QNH mines are directly adjacent to one another on the western side of Bowen Development Road and the parallel Newlands rail line, apart from JCM, which is on the eastern side.

The QNH sites each have separate ownership makeups as follows:

- SCM is a joint venture between QCoal Sonoma Pty Ltd, JS Sonoma Pty Ltd, CSC Sonoma Pty Ltd and Watami (Qld) Pty Ltd.
- DCM is a joint venture between Northern Hub (Drake) Pty Ltd and Drake Coal Pty Ltd.
- CCM is owned by Bowen River Coal Pty Ltd.
- JCM is owned by Jax Coal Pty Ltd.

QCoal Sonoma Pty Ltd, Northern Hub (Drake) Pty Ltd, Drake Coal Pty Ltd, Bowen River Coal Pty Ltd and Jax Coal Pty Ltd, are wholly or majority owned subsidiaries of QCoal Pty Ltd.

The QNH is run by a standard industry model of contract mining, with contractors providing most of the mining workforce and plant.

Mining operations on the QNH comprise multi-pit extraction of waste rock and Run-of-Mine (ROM) coal, subsequent processing, and railing of product coal. Mining methods involve standard drill and blast operations, and conventional excavator and truck movements.

Stripped topsoil is either stockpiled for later use in rehabilitation or placed on areas already shaped and prepped for rehabilitation works. Waste rock materials are placed in either out-of-pit or in-pit dumps.

The QNH mines share water management infrastructure, haul roads, equipment, resources, and other infrastructure. ROM coal from all sites is sent to the Coal Handling and Processing Plant (CHPP) and train load-out facility located on the SCM. Processed coal is transported to Abbott Point Coal Terminal for shipment to customers.

Coal rejects material generated during processing at the CHPP are placed into a co-disposal facility located on the SCM.

QCoal Northern Hub Mine Waste Management Plan

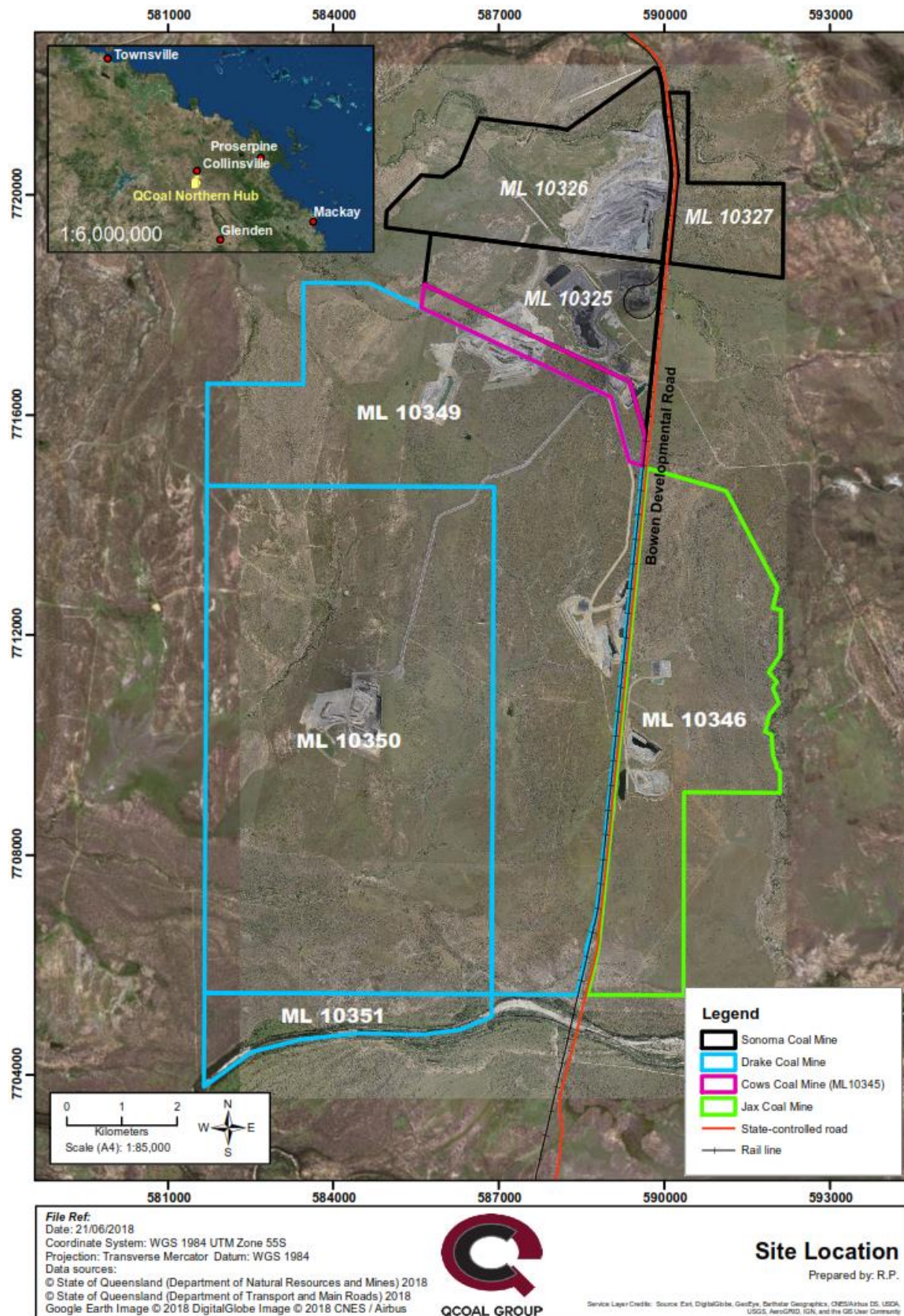


Figure 1 – QCoal Northern Hub Location

1.2 Purpose of this Management Plan

The *QCoal Northern Hub Mine Waste Management Plan* (MWMP) has been prepared to inform the operational management of mining waste at the QNH mines. Rehabilitation of mine waste disposal structures is not addressed in this document, as all QNH rehabilitation is addressed in the current version of the *QCoal Northern Hub Rehabilitation Management Plan*.

1.3 Legislative Requirements

Each QNH mine has an associated EA which it must comply with, as follows:

- SCM – EPML00707713 (dated 6 March 2020);
- CCM – EPML00334613 (dated 3 March 2020);
- DCM – EPML00393013 (dated 9 March 2020); and
- JCM – EPML00337613 (dated 5 June 2020).

Condition H7 is identical between the four QNH EAs, with the exception of H7(h), which relates to the management of tailings and is only present in the SCM and DCM EAs (where processing of coal is authorised). It is noted however that only the SCM actively processes coal and manages tailings.

Table 1 duplicates the conditions of Condition H7 and identifies where they are addressed in this MWMP.

Table 1 – QNH EAs Condition H7

QNH EAs Condition H7	Section of MWMP
Mining Waste Management A waste rock and spoil disposal plan must be developed and include, where relevant, at least:	
a) effective characterisation of the waste rock and spoil to predict under the proposed placement and disposal strategy the quality of runoff and seepage generated concerning potentially environmentally significant effects including salinity, acidity, alkalinity and dissolved metals, metalloids and non-metallic inorganic substances;	Section 3
b) a program of progressive sampling and characterisation to identify dispersive and non-dispersive spoil and the salinity, acid and alkali producing potential and metal concentrations of waste rock;	Section 6
c) a materials balance and disposal plan demonstrating how potentially acid forming and acid forming waste rock will be selectively placed and/or encapsulated to minimise the potential generation of acid mine drainage;	Section 4
d) where relevant, a sampling program to verify encapsulation and/or placement of potentially acid-forming and acid-forming waste rock;	Section 6
e) how often the performance of the plan will be assessed;	Section 8
f) the indicators or other criteria on which the performance of the plan will be assessed;	Section 8
g) rehabilitation strategy; and	Section 4.7
h) identification of areas proposed to contain tailings*.	Section 4.6.2
Monitoring or rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of the placed materials, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.	Section 6

* - Condition H7(h) is only present in the Sonoma and Drake EAs.

2 Background

2.1 Mining Waste Definition

As part of the mining process at the QNH, overburden, interburden, sub-economic coaliferous material and ROM coal are excavated. ROM coal is then either washed at the CHPP (located on the SCM), or crushed by a mobile bypass crusher to generate product coal for sale. The overburden, interburden and in some cases sub-economic coaliferous material is referred to as waste rock, which is disposed of in either in-pit or out-of-pit waste rock dumps.

The CHPP washing process generates a waste stream of coal rejects, which primarily comprise material from the coal seam roof, parting and floor, which gets mined along with the ROM coal extraction. Coal rejects are categorised by particle size, with fine rejects <1.4 mm (typically called tailings) and coarse rejects >1.4 mm. Fine rejects are further categorised as Ultra-Fine Rejects when rejects material is smaller than 0.25 mm. At the QNH, all rejects from the SCM CHPP are generally disposed of together in a co-disposal facility, with some minor quantities of coarse reject disposed of in waste rock dumps (in-pit or out-of-pit).

Crushed ROM coal does not generate any mining-related wastes requiring management.

Mine waste, for the purpose of this MWMP, is therefore defined as waste rock (overburden and interburden) and coal rejects (coarse and fine tailings).

2.2 QNH Geology

The QNH is located in the northern Bowen Basin, where active subsidence and deposition during the Permo-Triassic was centred within an extensional terrain known as the Taroom Trough. This deposition centre was situated marginal to the Collinsville Shelf in the west, which typically behaved as a stable platform throughout. The deformed Taroom Trough of the northern Bowen Basin is defined by the Nebo Synclinorium, where contained sediments and volcanics of the western two-thirds dip gently toward the major synclinal axis in the east. Post-depositional compression has resulted in a fold-and-thrust style of deformation, particularly on the eastern side of the basin where sediments along this margin tend to dip steeply west.

The QNH is underlain by the late Permian Blackwater Group consisting of lithic sandstone, siltstone, shale, conglomerate, dolomite and tuff, and minor coal. This is surrounded and underlain by the low to upper Permian Blenheim Subgroup described as a succession of siltstone, sandstone, concretion and limestone (i.e. the Blackwater Group is an outlier surrounded by the Blenheim Subgroups). The Collinsville Coal Measures underlie the Blenheim Group.

Regionally, the stratigraphic sequence is summarised as follows: the Permo-Triassic sediments of the Bowen Basin are overlain by a veneer of unconsolidated Quaternary alluvium and colluvium, poorly consolidated Tertiary sediments and, in places, remnants of Tertiary basalt flows. The stratigraphy comprises basal Lizzie Creek Volcanics and overlying marine Back Creek Group, non-marine Blackwater Group, and Tertiary sediments of the Sutor Formation.

Geological detail in the QNH area is intermittently obscured by a cover of alluvium and gravel, especially adjacent to creeks and watercourses. This recent (Cainozoic) cover comprises unconsolidated fine to very coarse-grained sand, along with occasional irregularly interbedded silt, clay and gravel lenses. The most persistent gravel bed occurs at the base of the unit and generally comprises markedly rounded pebble to cobble-sized clasts of predominantly andesitic to basaltic composition, set in a silt to clay-rich matrix. Generally, the alluvial unit is a thin veneer becoming thicker along rivers and watercourses in the region.

QNH stratigraphy is presented in **Figure 2** (please note that both the Fort Cooper Coal Measures and Moranbah Coal Measures are mined on the QNH). The geology of the QNH is well understood and comprises a consistent contiguous geology across the four mines. Throughout the QNH area, the geological structure has been subject to igneous intrusions which, where present, have either intruded or otherwise rendered sections of the target coal seams uneconomic.

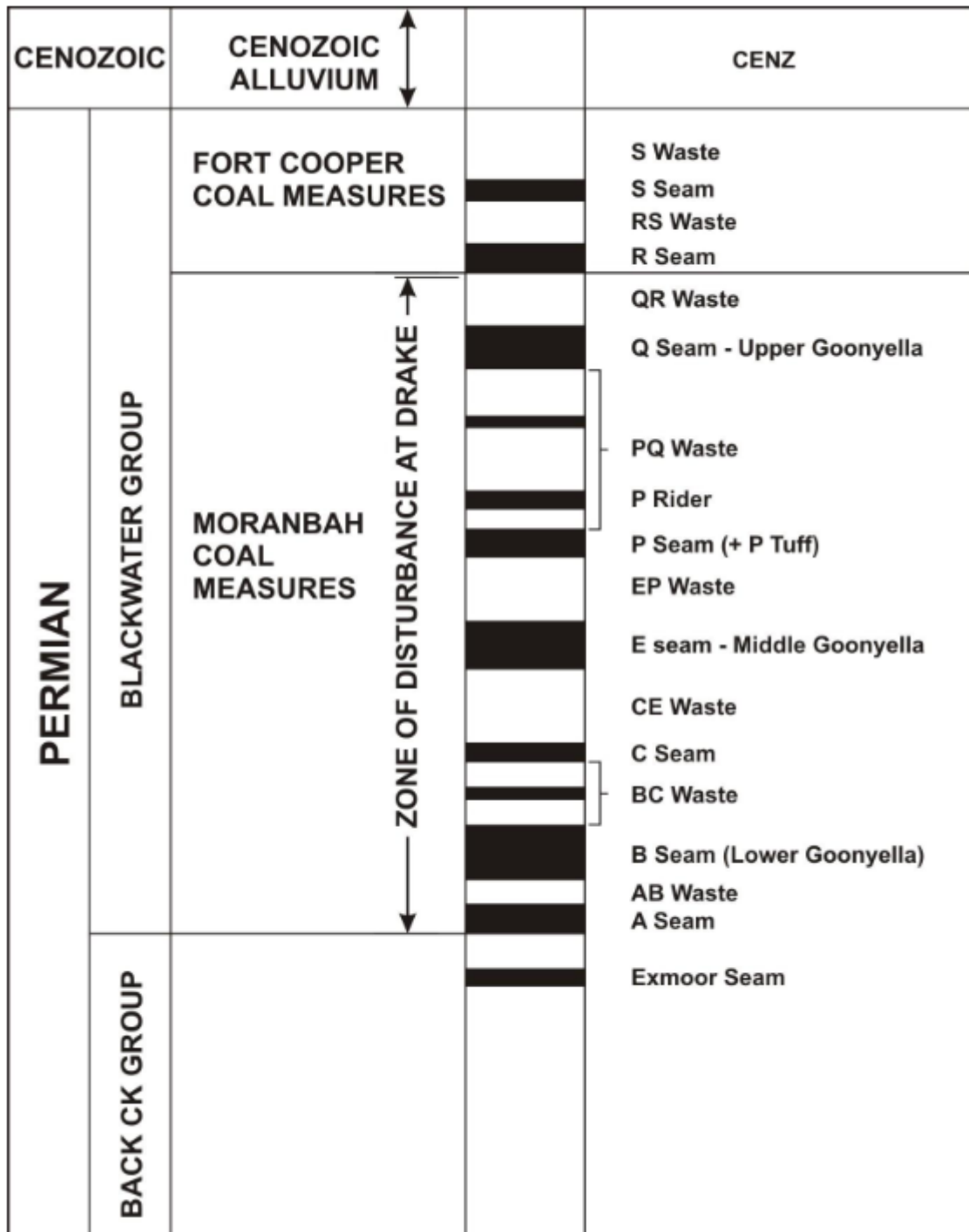


Figure 2 – Schematic of Targeted Stratigraphy (Drake EIS, 2013)

2.3 Mining Process and General Mining Waste Management

Coal is mined at the QNH by conventional drill and blast, truck and shovel bench-mining methods. Overly intruded coal is avoided where possible to maximise ROM coal extraction and minimise load contamination from poor-quality coal or non-coal materials. Where overly intruded, heat-affected, or otherwise uneconomical coal, including thin seams, is mined, it is handled as waste rock.

Topsoil is stripped and stockpiled for future use in rehabilitation. Waste rock is then mined, trucked and disposed of in waste rock dumps (out-of-pit or in-pit), from the surface to the first economic extraction seam.

2.4 Coal Processing

ROM coal from all QNH mines is processed at the SCM CHPP through a series of washing steps, which produces coal product, and coal rejects (coarse and fine) by-product. Coarse and fine coal rejects are pumped to a co-disposal facility on the SCM. The co-disposal facility at the SCM is an in-pit co-disposal located in the Sonoma Main pit where mining has ceased. Previously coal rejects were pumped to an above-ground (out-of-pit) co-disposal facility on the SCM, which has reached the end of its operational life and, at the time of issue of this MWMP, is being rehabilitated.

Depending on the coal seam being processed, fine rejects typically account to 20-60% (by weight) of coal rejects pumped to the co-disposal facility, with coarse rejects making up the remainder. Occasionally coarse rejects are recovered at the CHPP separately from the co-disposal stream (referred to as bunkered reject) and used in the construction of ROM and product pads or roads, disposed of separately in waste rock dumps (out-of-pit or in-pit), or campaign trucked to the co-disposal.

3 Geochemical Characteristics of QNH Mining Wastes

3.1 Waste Rock Results

Waste rock is broadly categorised as either overburden or interburden material. Overburden material is rock removed to access the uppermost coal seam, and interburden is the rock material between the targeted coal seams.

As part of the DCM EIS, geochemical data from analyses undertaken at the JCM and SCM were collated with the data collected for the DCM EISs, to provide a characterisation of waste rock across the QNH. Waste rock was found to be Non-Acid Forming (NAF), with only one sample found in carbonaceous shale returning an Uncertain classification (see **Figure 3**). Waste rock was also found to have a low potential for metal leaching and saline runoff. Therefore, the conclusive majority of waste rock materials on the QNH is classified as low risk, with the bulk waste rock material having a net buffering capacity.

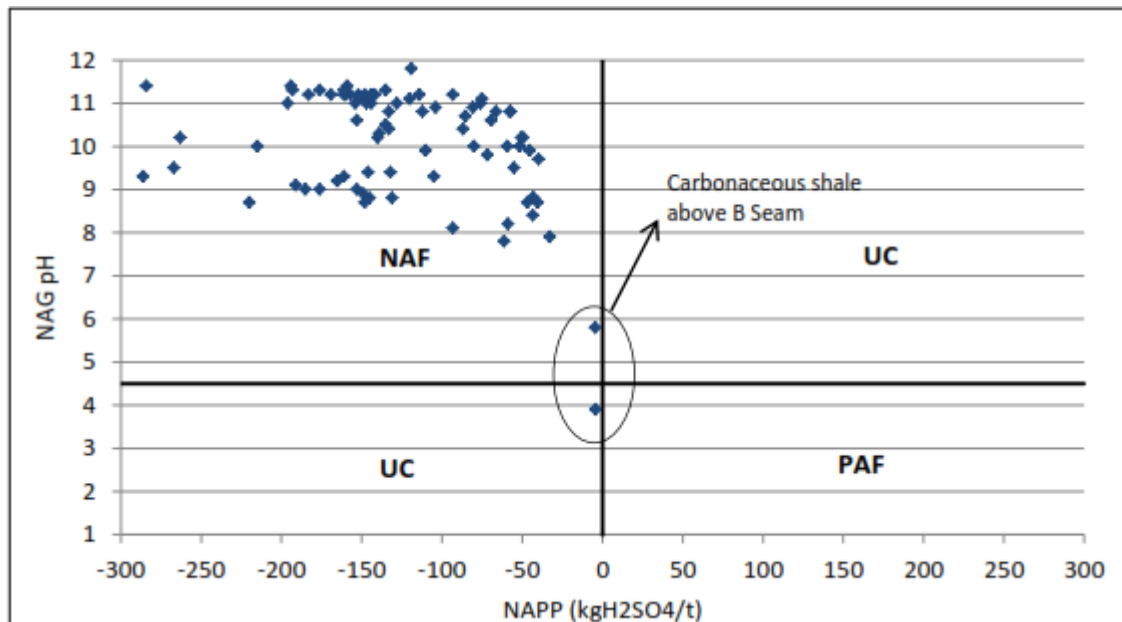


Figure 3 – QNH Waste Rock Categorisation (Drake EIS, 2013)

3.2 Coal Reject Results

Based on the analysis of 89 coal reject samples by Terrenus (2013), the general observations, found below, were made regarding bulk coal reject material as sampled on the SCM. These observations were confirmed by additional sampling and analysis undertaken by Terrenus in late 2013.

- Coal reject will generate alkaline, generally low-salinity run-off and seepage following surface exposure (see **Figure 4**).
- Total sulfur concentration in coal rejects is generally low (median sulfur content of 0.21%) (see **Figures 5 and 6**); however, in approximately 5% of samples, sulfide concentrations were sufficient to generate acid. Sulfide-sulfur comprises between 14% and 99% of the total sulfur concentration of coal reject; however, for most coal reject material, sulfide-sulfur comprises about 50% of the total sulfur concentration.

- Conservatively, 90% of coal reject materials are expected to be NAF, with a third of these NAF samples classified as ‘barren’ with respect to sulfur concentration.
- Approximately 5% of coal reject materials are anticipated to be Potentially Acid Forming (PAF) and Potentially Acid Forming – Low Capacity (PAF-LC). Coal rejects are likely to have relatively low total sulphur concentrations (typically less than 1%), and therefore are regarded as low risk, with the main potential for environmental impact likely to be the generation of sulfate salts (see **Figure 7**).
- Approximately 5% of coal reject materials are anticipated to be classified as Uncertain, with low sulphur concentrations, making these materials low risk.
- Total metal and metalloid concentrations in coal rejects are expected to be low, and below the applied health-based investigation levels for soils. However, there is potential for the concentrations of some metals (particularly Ba, Co, Cu, Mn, Ni, and V) to exceed the applied ecological investigation level. Some coal reject materials may produce leachate containing slightly elevated soluble Al, Se, and potentially As concentrations, as is common in Permian coal measures in the Bowen Basin.

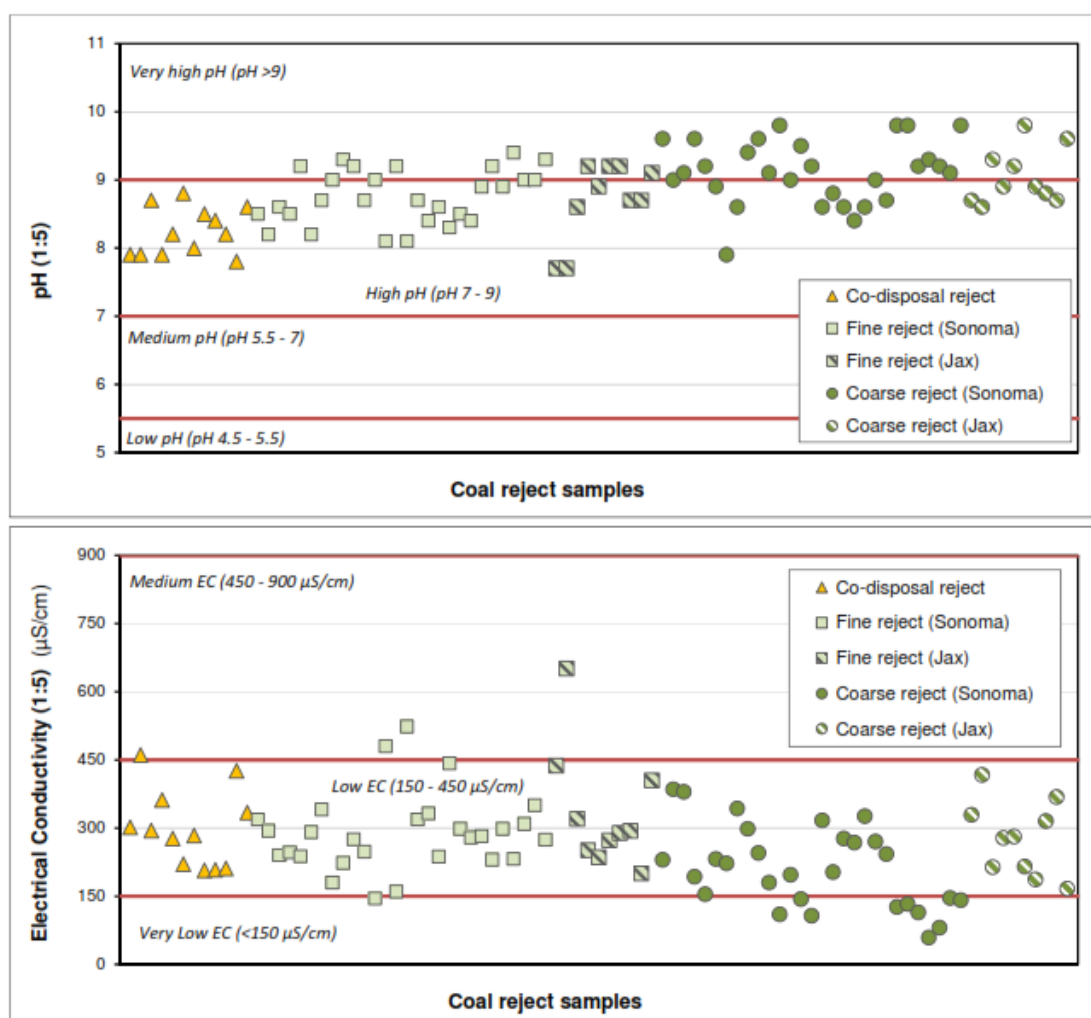


Figure 4 – Coal Rejects pH and Electrical Conductivity (Drake EIS, 2013)

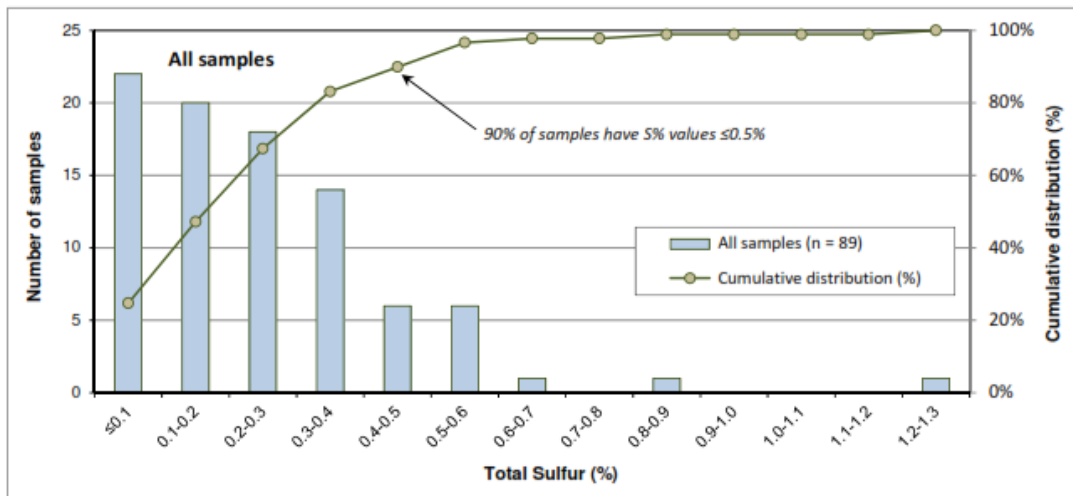


Figure 5 – Coal Rejects Total Sulfur (Drake EIS, 2013)

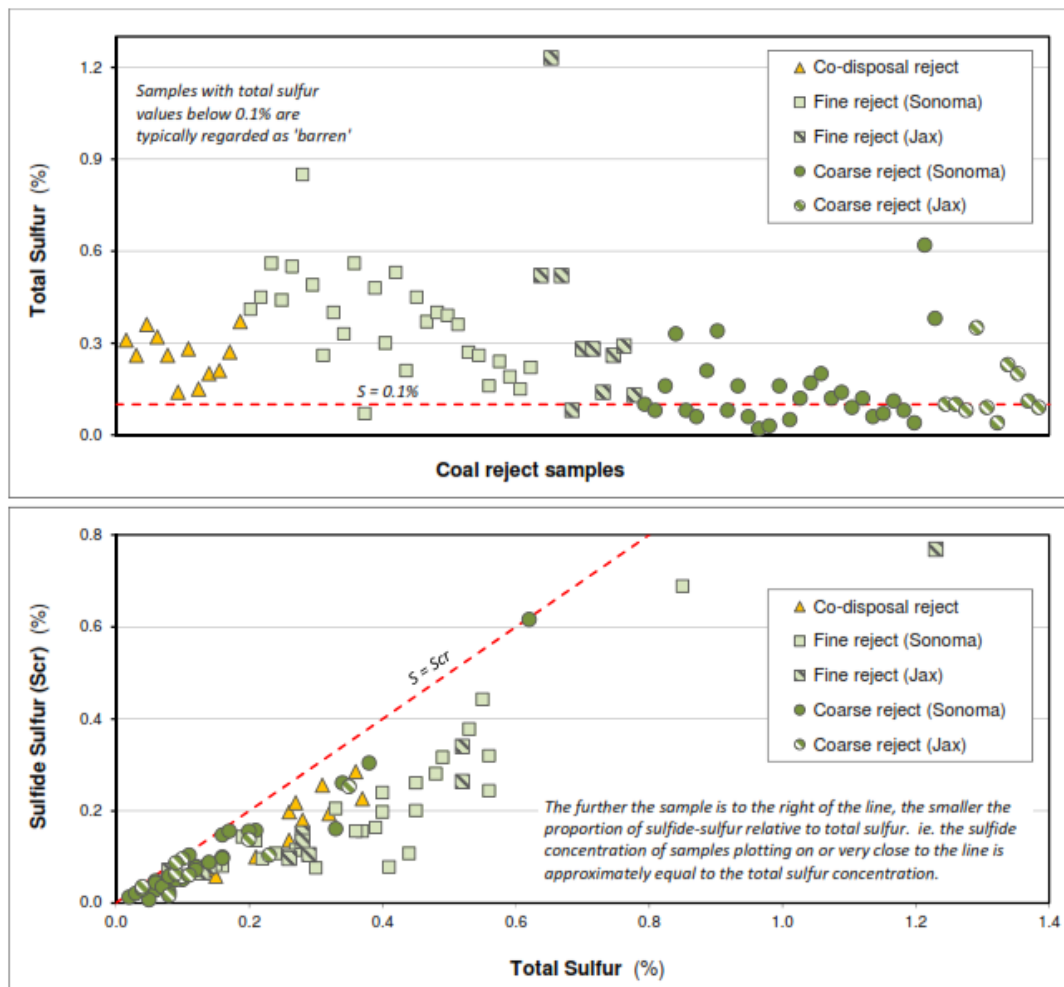


Figure 6 – Coal Rejects Total Sulfur and Sulfide Sulfur (Drake EIS, 2013)

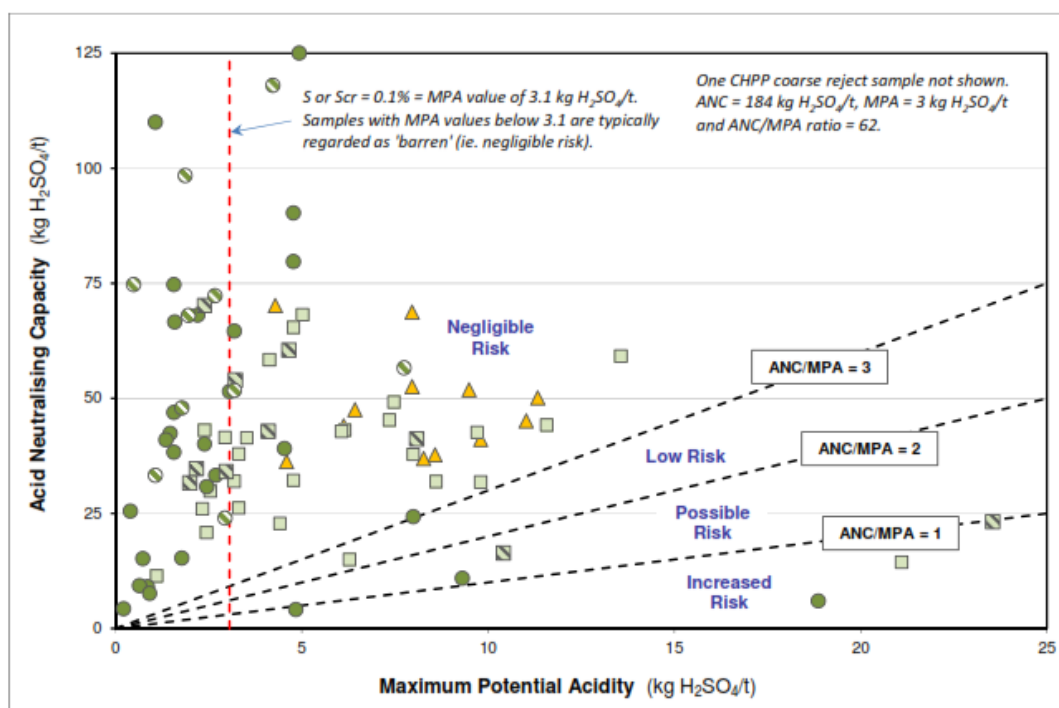


Figure 7 – Coal Rejects ANC vs MPA (Drake EIS, 2013)

3.3 Environmental Risk Categories

Potential environmental risks associated with mining waste and coal rejects are mainly associated with Acid Mine Drainage (AMD), the related mobilisation of metals, and saline drainage. Waste rock and coal rejects material is classed qualitatively as having low, medium or high risk of generating AMD as follows:

- **Low Risk:** Non-Acid Forming (NAF) material. Where geochemical testing of mining waste and coal rejects shows that materials have a very low likelihood of generating AMD.
- **Medium Risk:** Material with some capacity to generated AMD. This is referred to as Potentially Acid Forming – Low Capacity (PAF-LC). Geochemical testing of these materials indicate that these wastes may or will generate small quantities of AMD. A medium risk classification applies to all mining waste and coal rejects material not classed as low or high risk.
- **High Risk:** Potentially Acid Forming (PAF) material. Geochemical testing of these materials shows that these materials will almost certainly generate AMD. This classification may also apply to materials of less acid generating capacity, but with a short lag period until the onset of AMD.

All waste rock and coal rejects materials on the QNH have been classified as **Low Risk** NAF (with some buffering capacity) with the exception of *Fine-grained and carbonaceous material associated with coal seams* (some materials found immediately adjacent to coal seams are commonly carbonaceous such as carbonaceous siltstone, which can contain reactive sulphide materials, and are therefore classified as Medium Risk).

No mining waste materials of the QNH have been classified as high risk.

Waste rock and coal rejects are handled and dumped in bulk, as such when classified in bulk (as is appropriate for the handling methodologies) mining waste (both waste rock and coal rejects) has been classified as **Low Risk** NAF with relatively low salt and metals concentrations.

4 Management Strategies

Results of geochemical studies across the QNH have indicated that the majority of mining wastes (including waste rock, waste coal, and coal rejects) are classified as low-risk, and, as such, will not require selective handling, placement or additional management.

When considered in bulk, the medium risk materials will be buffered by the low-risk materials (buffering capacity and overwhelming percentage by volume) and therefore QNH mining wastes are considered to have a low AMD risk overall (see **Section 3.3**); as such, minimal active management of mining waste is required.

4.1 Management Categories

In order to assist the management of mining wastes on the QNH, mining wastes are grouped into four (4) management categories based on risk classification, as shown in **Table 2**. Management categories have been adapted from Terrenus 2012, in consideration of actual practical handling limits and observed material properties over the last 13 years of mining at QNH.

Table 2 – Mine Waste Categories

Management Category	Risk Classification	Material	Estimated Percentage of Waste Rock
Topsoil	Low	Soil (including sub-soil) to a nominal depth of 1 m below natural surface. Three types of topsoil typically occur across the site including: - Grey uniform clay - Brown gradational sandy loam - Red duplex sandy loam	na
Waste Rock - Category 1	Low	Waste rock – Upper: - Non-coal and non-carbonaceous material above the coal seams, and not within 1 m above or below ROM coal. - Typically weathered or moderately weathered.	>96%
	Low-Medium	Waste rock – Lower: - Non-coal and non-carbonaceous material below the upper seam, and not within 1 m above or below ROM coal. - Typically fresh or slightly weathered.	
Waste Rock - Category 2	Medium	Carbonaceous waste rock and unsuitable coal: - Carbonaceous material, material located within 1 m of ROM coal seams. - Sub-economic coal, intruded coal or heat-affected coal.	<4%
Coal Rejects	Low	CHPP rejects (coarse and fine) as co-disposal slurry.	na

An example of categorised waste rock mining wastes is presented in **Figure 3**.

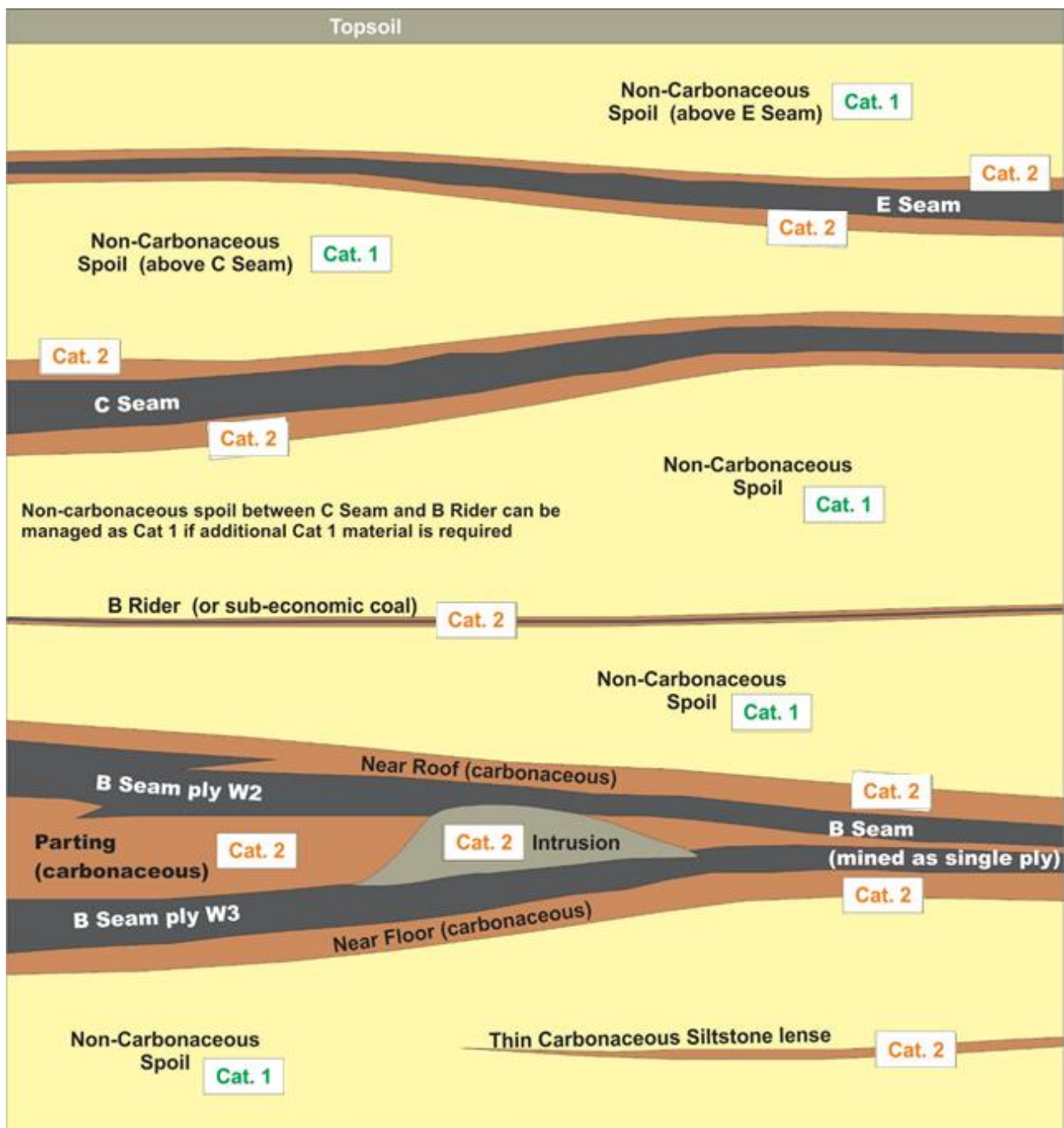


Figure 8 – Conceptual Mining Waste Classification (adapted from Terrenus, 2013)

Strategies are provided in the following sub-sections for each of the Management Categories identified.

4.2 Topsoil

Topsoil is to be managed in accordance with the current version of the *QCoal Northern Hub Topsoil Management Plan*,

4.3 Waste Rock - Category 1

The majority of waste rock excavated on the QNH will be designated as Category 1, and should be managed as follows:

- Materials are to be identified by a mine geologist and communicated to excavator and haul truck operators.
- Place material in overburden dumps (out-of-pit and/or in-pit).
- Materials may be used as site construction material, provided it meets geotechnical and engineering specifications.
- Materials may be used as a sub-soil cover material for rehabilitation of co-disposal facilities, ROM pads, and sediment dams at mine closure, prior to application of topsoil.
- Possible use as a final growth medium, should the geochemical and geophysical composition designate as suitable for such an application.
- Materials should be blended/diluted with Waste Rock – Category 2 during normal excavation, haulage and dumping.
- Where there is insufficient blending/dilution of Waste Rock - Category 2 with Waste Rock - Category 1, (such as instances where there is a significant volume of Waste Rock – Category 2 being mined and dumped for an extended period without any accompanying Waste Rock – Category 1), then Waste Rock – Category 1 should be used to encapsulate Waste Rock – Category 2 to a depth of at least 5m.

4.4 Waste Rock - Category 2

A minimal proportion of excavated waste rock (by volume) will be classified as Category 2. The material is to be managed as follows:

- Materials are to be identified by a mine geologist and communicated to excavator and haul truck operators.
- Materials should be blended/diluted with Waste Rock – Category 1 during normal excavation, haulage and dumping.
- Where there is insufficient blending/dilution of Waste Rock - Category 2 with Waste Rock - Category 1, (such as instances where there is a significant volume of Waste Rock – Category 2 being mined and dumped for an extended period without any accompanying Waste Rock – Category 1), then Waste Rock – Category 1 should be used to encapsulate Waste Rock – Category 2 to a depth of at least 5m.
- Traffic compact material (where practical) prior to encapsulation (where required).

4.5 Coal Rejects

The emplacement of rejects at the QNH occurs only on the SCM.

Previously rejects disposal was undertaken in an above ground (out-of-pit) co-disposal, which has ceased operation and at the time of this MWMP is being rehabilitated. As such this facility is not considered further as part of this MWMP.

Rejects are currently disposed of in an in-pit co-disposal, located in an SCM pit where mining has ceased. Specific tailings disposal procedures are required by the SCM EA and are in place for the

in-pit co-disposal. Therefore, this MWMP defers to the relevant documents with regard to management strategies for co-disposal rejects.

4.6 Water and Leachate Management

4.6.1 Waste Rock Dumps

Water management associated with waste rock dumps is generally related to surface runoff. Runoff from fresh (un-rehabilitated) waste rock is considered mine-affected and is required to be captured and managed under the approved QNH water management plan (WMP). The WMP for mine-affected water includes consideration of capture, storage capacity requirements, and quality in relation to releases. Monitoring of waste rock dump runoff is discussed in **Section 6.3**.

4.6.2 Co-disposal

The in-pit co-disposal includes a “decant” or “return water” lake, which is located at the lowest point of the pit. The water in the lake comprises a blend of supernatant water separating from the rejects stream (the majority of water is from this source), a small portion of direct rainfall into the pit and a small portion of pit-inflow from the surrounding coal seams, all flowing to the “return” lake.

Water from the “return” lake is pumped back to the CHPP for re-use.

The mining pit in which the in-pit co-disposal has been located, has previously been determined to be a groundwater sink (as per the *Residual Voids on the QCoal Northern Hub Mining Complex* (QCoal, 2020)). As such leachate does not require specific management consideration in terms of either structural stability (as it is an in-pit disposal not requiring reject walls) or in terms of environmental management as leachate is contained within the pit.

A Consequence Category Assessment (CCA) undertaken by an RPEQ (in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933)) determined that the in-pit co-disposal is not a regulated structure.

4.7 Rehabilitation

Rehabilitation of waste rock dumps (out-of-pit and in-pit) and the above ground (out-of-pit) co-disposal facility (including capping requirements) is to be undertaken in accordance with the current version of the *QCoal Northern Hub Rehabilitation Management Plan* (RMP).

The in-pit co-disposal does not require specific rehabilitation as the pit itself remains a final void without a specific post mining land use and has been modelled to be a void lake with declining water quality. This detail is also captured in the RMP. The RMP will be informed by the management strategies outlined in this document for the various mine waste categories.

5 Mine Planning and Control

5.1 Waste Rock

As part of ongoing operations at the QNH, a 16 week rolling schedule is used to plan material movements including planning of what materials (waste rock, interburden, intrusions, roof/floor, or coal) is mined in what location and at what time.

The rolling schedule and the quantities therein as well as the mine plan (layout) can be used where required to confirm that sufficient blending/dilution of Waste – Rock Category 2 materials is being achieved, or to ensure that areas of Waste Rock - Category 2 material will ultimately be encapsulated by Waste Rock - Category 1 materials.

The rolling schedule and quantities can also be used to plan any required confirmatory geochemical sampling.

5.2 Coal Rejects

The co-disposal facility should be operated as per the procedures referenced in **Section 4.6.2**.

6 Mine Waste Sampling and Analysis

6.1 Rehabilitated Areas (Topsoil applied)

Rehabilitated areas are to be managed and monitored in accordance with the current version of the *QCoal Northern Hub Rehabilitation Management Plan*.

6.2 Waste Rock

6.2.1 Waste Rock - Category 1

Monitoring of runoff and/or seepage from active waste rock dumps for water quality is undertaken in accordance with the QNH EAs.

Where evidence of potential AMD (being acid, metalliferous and/or saline drainage) is observed from active waste rock dumps, actions will be taken to minimise and mitigate the AMD. Such actions are not designated in this MWMP, as they would be issue specific and will be addressed on an as needed basis at the direction of QCoal environmental staff and the Mining Superintendent in consultation with a geochemist as required.

6.2.2 Waste Rock – Category 2

Waste Rock - Category 2 material will either be adequately blended/diluted or encapsulated by Waste Rock – Category 1 materials. As such, this material does not report to final land surfaces, and, ongoing sampling, analysis and monitoring of these materials is not required

The results of ongoing mining waste characterisation and assessment program will dictate whether changes to the mining waste management strategy are required.

6.2.3 Ongoing Classification of Waste Rock

6.2.3.1 Sampling Program

Waste rock geochemical characteristics at the QNH are well understood and as such no specific ongoing sampling/analysis is required, except under the following circumstances:

- Evidence of potential AMD (acid, metalliferous and/or saline) is observed originating from waste rock dumps;
- A new, previously un-sampled geology is encountered during mining operations; or
- Mining operations is being undertaken in areas where there is no knowledge of the geochemical characteristics of the material.

Should one of these circumstances occur, representative samples of overburden, interburden, immediate¹ coal seam roof, parting and floor shall be collected for geochemical analysis to assess the waste designation categories as follows.

- A representative number of samples (drilling cores or from active mining areas) shall be collected by the mine geologist.
- Collect 1 kg of each sample, and place into a strong plastic bag, seal and store out of the weather prior to transport to the laboratory.
- Record the sample ID, location, type, depth, seam and any other relevant observations.
- Samples will undergo testing for a 'standard' suite of static geochemical tests.

6.2.3.2 Laboratory Analysis

Each sample shall undergo analysis at a laboratory that is NATA-certified for the following analytes:

- NAPP (Acid Neutralising Capacity, Acid Production Potential and Total Sulfur);
- pH and electrical conductivity (EC) 1:5
- Major Cations (Ca, Mg, Na, K) 1:5
- Major Anions (Cl⁻, SO₄, and alkalinity) 1:5
- Total Metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn);
- Water soluble metals as above.

Additionally, for Category 1 waste, the following analyses are also to be undertaken:

- Exchangeable cations (Al, Ca, Mg, Na, K)
- Emerson class.

6.3 Coal Rejects

Operation and monitoring of the CHPP is outside of the scope of this MWMP.

The CHPP and co-disposal facility operators will be responsible for regularly assessing the condition of the in-pit co-disposal facility and will revise the operational procedures strategy as required.

¹ "immediate" coal seam roof, parting and floor refers to the zone up to 0.5 m immediately above and below ROM coal.

Operations of the co-disposal cells and decant dam will be monitored on a daily basis and information recorded on a daily operator's log.

6.3.1 Ongoing Classification of Coal Reject

6.3.1.1 Sampling Program

Rejects geochemical characteristics at the QNH are well understood and as such no specific sampling/analysis is required, except under the following circumstances:

- Evidence of potential AMD (acid, metalliferous and/or saline) is observed originating from rejects;
- A new, previously un-sampled coal type is encountered during mining operations; or
- Mining operations is being undertaken in areas where there is no knowledge of the geochemical characteristics of the material.

Should one of these circumstances occur, representative samples of rejects material shall be collected for geochemical analysis to assess the waste designation categories as follows.

- A representative number of samples shall be collected by the mine geologist.
- Collect 1 kg of each sample, and place into a strong plastic bag, seal and store out of the weather prior to transport to the laboratory.
- Record the sample ID, location, type, depth, seam and any other relevant observations.
- Samples will undergo testing for a 'standard' suite of static geochemical tests.

6.3.1.2 Laboratory Analysis

Each sample shall undergo analysis at a laboratory that is NATA-certified for the following analytes:

- NAPP (Acid Neutralising Capacity, Acid Production Potential and Total Sulfur)
- pH and electrical conductivity (EC) 1:5
- Major Cations (Ca, Mg, Na, K) 1:5
- Major Anions (Cl⁻, SO₄, and alkalinity) 1:5
- Total Metals (Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn)
- Water soluble metals as above

6.4 Water and Leachate Sampling

Sampling of water from the waste rock dumps and in-pit co-disposal dams should target the following separate streams:

- Out-of-pit waste rock dump
 - Runoff from fresh waste rock collected in dams located at the toes of waste rock dump slopes
 - Runoff from topsoiled rehabilitated areas collected in dams located at the toes of waste rock dump slopes
- In-pit Co-disposal

- “Decant/Return water” lake – rejects water collected at the “return water” lake and re-used in the CHPP

Sampling and analysis are to be undertaken in accordance with the QNH EAs.

6.4.1 Field Analysis

Each sample is to be analysed in-situ by a suitably qualified environmental professional for pH, EC and turbidity using a calibrated water quality meter.

6.4.2 Laboratory Analysis

Each sample shall be analysed at a laboratory which is NATA-accredited for the following:

- pH and EC
- Total suspended solids
- Major Cations (Ca, Mg, Na, K)
- Major Anions (Cl⁻, SO₄, and alkalinity)
- Total and dissolved metals (Al, Be, B, Ba, Be, Cd, Cr, Co, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, V, Zn).

6.5 Interpretation of Results

The results of mine waste and water quality monitoring are to be assessed by a suitably qualified person. Ongoing reviews of the MWMP are to be undertaken based on the interpreted results (see **Section 8**).

7 Roles and Responsibilities

7.1 Waste Rock

The roles and responsibilities for waste rock management at the QNH are presented in **Table 3**.

Table 3 – QNH Waste Rock Responsibilities

Role*	Responsibility
QNH Environmental Officer	- Ensure the MWMP is effectively implemented, including audits. - Ensure compliance against the site EA. - Undertake sampling as per Section 6.
QCoal Environment Manager or Delegate	- Approve and periodically review the MWMP. - Ensure adequate resource are available for the implementation of the MWMP.
Mine Geologist and/or Engineer	- Identify zones of Category 1 and Category 2 mining waste to allow adequate resourcing and planning for waste disposal strategies. - Work with the Mining Superintendent to plan and implement correct management as per the MWMP. - Quantify the various categories as part of the rolling schedule. - Plan a dumping schedule to accommodate the various disposal requirements of Category 1 and Category 2 materials.
Mining Manager	- Work with the Mine Geologist and/or Engineer to plan and implement correct management as per the MWMP. - Provide the MWMP to mining contractors and brief them about the principles of the MWMP, including their roles and responsibilities. - Provide training or instruction to mining contractors about specific MWMP tasks. - Implementation of strategies to address audit non-compliances and prevent future non-compliances. - Provide feedback to the Environmental Officer regarding improvements to the MWMP.
QNH Manager	- Periodically review the MWMP. - Provide adequate resources to facilitate the implementation of the MWMP.

* - Note: While these roles may not exist by these names on site, these responsibilities are designated to those site personnel who would be reasonably assumed to fit these descriptions.

7.2 Coal Reject

The roles and responsibilities for coal reject management at the QNH are presented in **Table 4**.

Table 4 – QNH Coal Rejects Responsibilities

Role*	Responsibility
QNH Environmental Officer	- Ensure the MWMP is effectively implement, including audits. - Ensure compliance against the site EA.
QCoal Environment Manager or Delegate	- Approve and periodically review the MWMP. - Ensure adequate resource are available for the implementation of the MWMP
CHPP/Co-disposal Engineer	Work with the CHPP Manager to plan and implement the management of coal rejects as per the MWMP and/or co-disposal procedures.
CHPP/Co-disposal Manager	- Work with the Mine Geologist and/or Engineer to plan and implement management of coal rejects as per the MWMP and co-disposal procedures. - Provide the MWMP to CHPP operators and brief them on the principles in the MWMP, including their roles and responsibilities. - Provide training or instruction to CHPP operators regarding specific MWMP tasks. - Implementation of strategies to address audit non-compliances and prevent future non-compliances. - Implement a monitoring program for ongoing characterisation of coal reject materials. - Provide feedback to QNH Environmental Staff regarding potential improvements to the MWMP.
QNH Manager	- Periodically review the MWMP. - Provide adequate resources for the implementation of the MWMP.

* - Note: While these roles may not exist by these names on site, these responsibilities are designated to those site personnel who would be reasonably assumed to fit these descriptions.

8 Review and Revision

This MWMP is designed to be a dynamic document and should be regularly reviewed to determine its ongoing suitability based on:

- The results of mine waste monitoring (as per **Section 7**);
- Any change in mining methodology;
- Changes to the CHPP;
- When a previously un-sampled geology is encountered; and
- When mining in previously un-sampled areas of the MLs.

Where a review has identified the MWMP is no longer suitable, an update should be prepared and distributed to relative parties as per **Section 7**.