Appendix J

Request for Information Response

Table of Contents

Figures

Appendices

Abbreviations

%	Percentage
ACARP	Australian Coal Association Research Program
AEP	Annual Exceedance Probability
BaU	Business as usual
BMA	BM Alliance Coal Operations Pty Ltd
CHPP	Coal handling and preparation plant
CMA	Cumulative management area
CVM	Caval Ridge Mine
CWD	Contaminated Water Dam
DCS	Dust Control System
dB	Decibels
dBA	Decibels (A-weighted)
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DES	Department of Environment and Science
EA	Environmental Authority
EIS	Environmental impact statement
EP Act	Environmental Protection Act
EPBC Act	Environment Protection and Biodiversity Conservation Act
ESA	Environmentally Sensitive Areas
ESC	Erosion and sediment controls
ESCP	Erosion and Sediment Control Plan
FoS	Factor of Safety
FY	Financial Year
GDE	Groundwater Dependent Ecosystem
ha	Hectares
IPD	In pit spoil dumps
km	Kilometres
LoM	Life of Mine
MAW	Mine affected water
ML	Mining lease
mm/s	Millimetre per second
MWD	Mine Water Dam
OOPD	Out of pit dump
PRC Plan	Progressive rehabilitation and closure plan
RE	Regional ecosystem
REDD	Regional ecosystem description database
REMP	Receiving environment monitoring program

ROM	Run-of-mine
RPEQ	Registered Professional Engineer Queensland
TKPH	tonne-km-per-hour
TLF	Train load-out facility
WMP	Water Management Plan

1 Introduction

An application to amend the EA, titled the *Horse Pit Extension Project - Environmental Authority Amendment Supporting Information Document* (herein referred to as the EA Amendment Supporting Documentation), was submitted by the Proponent on 15 December 2021 (application reference number A-EA-AMD-100178679). The administering authority considered the EA application is a major amendment and issued the Proponent with a request for further information on 11 April 2022, under Section 140 of the *Environmental Protection Act 1994.*

This addendum document provides the Proponent's response to the administering authority's information request. This document should be read in conjunction with the DES Information Notice *Environmental Protection Act 1994*, dated the 11 April 2022, and the EA Amendment Supporting Documentation.

The information request includes a number of queries relating to rehabilitation. The CVM EA currently contains conditions related to rehabilitation (specifically Schedule E: Land of the EA). BMA propose to maintain these conditions as part of this EA amendment, understanding that a progressive rehabilitation and closure plan (PRC Plan) is imminent for the CVM and it will contain comprehensive detail around rehabilitation matters. The current conditions of the EA would apply until which time the PRC Plan is in place.

In general, relating to matters of rehabilitation, the CVM PRC Plan will deliver the comprehensive details around rehabilitation of the pit in line with the DES Guideline – Progressive rehabilitation and closure plans (PRC Plans) (ESR/2019/4964, DES 2021) requirements. BMA has been issued a transition notice by the DES that specifies the submission date of the CVM PRC Plan as 1 December 2023, and the document is currently under preparation. BMA will be submitting a PRC Plan that includes the CVM existing approved activities and also the extension of Horse Pit (the subject of this EA amendment, scheduled to be approved prior to PRC Plan submission). Where available, PRC Plan related content has been provided in this Response and further details will be included in the CVM PRC Plan submission in accordance with the DES PRC Plan Guideline (DES 2021) requirements.

The final landform design and consequent studies undertaken for the EA Amendment Supporting Documentation and this Response is based on mine planning information and other detail available at the time of preparation of the application for the amendment (submitted 15 December 2021). Mine planning revisions are routinely carried out during the life of open cut mining operations, and therefore studies used in support of the CVM PRC Plan submission will use the most up to date mine planning information available and consequential studies, to further refine landform design and rehabilitation plans.

2 Production Limits

According to Section 3.1 of the EA amendment supporting information, Caval Ridge Mine (CVM) currently produces up to 15Mtpa of ROM coal and 5-11Mtpa of ROM coal is transferred annually from the Peak Downs Mine (PDM). It is unclear if the proposed amendment will result in an increase in the tonnage and production limits of CVM particularly when considering the combined ROM coal and production rates from CVM and PDM.

2.1 BMA Response to Requested Action 1

Requested Action 1: *Confirm the run-of mine coal to be extracted from CVM per annum.*

The annual run-of-mine (ROM) coal to be extracted from the CVM will vary each year depending on a variety of factors. The maximum per annum ROM coal however will be 15 Mtpa, with an average of 12.5 Mtpa over the life of mine (LOM).

Figure 3-6 of the EA Amendment Supporting Documentation (and replicated as Figure 2-1 below) shows the indicative mining schedule outputs featuring indicative annual ROM coal tonnage and Product coal tonnage. The figure has been replicated below for completeness. Mine scheduling indicates output of ROM coal of almost 15 Mtpa in FY2021 with a trending decrease in output as mining progresses to closure.

Figure 2-1 Indicative Mining Schedule Outputs (ROM t and Product Coal t)

2.2 BMA Response to Requested Action 2

Requested Action 2: *Confirm the tonnes of coal to be processed at CVM (including CVM and PDM coal) per annum.*

The volume of product coal produced from a CHPP can vary dependent on coal quality and coal product required. The CVM CHPP has the capacity to produce approximately 10 Mtpa product coal. This is achieved from ROM coal as summarised in Table 2-1.

Table 2-1 Summary of ROM for CVM CHPP

	ROM
CVM	up to 15 Mtpa
PDM	up to 11 Mtpa

3 Out of Pit Dump

The proposed out of pit dump (OOPD) is located on the north-west of ML70403 which is in closer proximity to sensitive receptors. The construction of the OOPD in this location raises a number of concerns, particularly around air quality and the necessity of constructing an OOPD when there is a need for the proposed final void of Horse Pit extension to be decreased where possible.

According to section 3.5.5 of the supporting document, "the OOPD is required due to space constraints within the existing IPDs." Furthermore the following is stated in section 3.5.6 of the supporting document, "BMA plans to explore additional opportunities to reduce the extent of the residual void through further backfilling operations over the life of the Project. Importantly, this may not be economically feasible due to increased haulage involving 'double handling' spoil amongst other factors, which significantly impacts operational costs and the overall economics of the Project."

Further information is required regarding available options for in pit dumping and the final void area and location, and consideration made with regards to the options and influence on the minimisation and management of environmental impacts and long term land use the CVM site.

3.1 BMA Response to Requested Action 3

Requested Action 3: *Complete an options analysis of the final landform with consideration of the estimated costs and benefits of alternative final landforms including the options for the minimising of the disturbance footprint for the extension and minimisation of the final void of Horse Pit. This comparison should be made with consideration of the rehabilitation goals of 'safe, stable, non-polluting, and able to sustain a post-mining land use after rehabilitation as well as any social and economic benefits and consequences. Each option must include an assessment of any variations in impacts to environmental values. The comparison should include consideration of the following options for the final Horse Pit area:*

a) Rehabilitation of the site with no final void(s) or non-use management areas;
b) Rehabilitation with partially backfilling of void(s) above the groundwater level; and
c) Rehabilitation with partially backfilling above the coal seam.

The comparison should include consideration of the following areas for the final landform design and options to minimise the disturbance footprint from these domains:

a) Low wall slope minimisation;
b) Overburden dumps and stockpiles including the proposed out of pit dump;
c) Waste emplacement areas;
d) Alternative locations and configurations of infrastructure and structures; and
e) Minimum rehabilitation.

3.1.1 Introduction

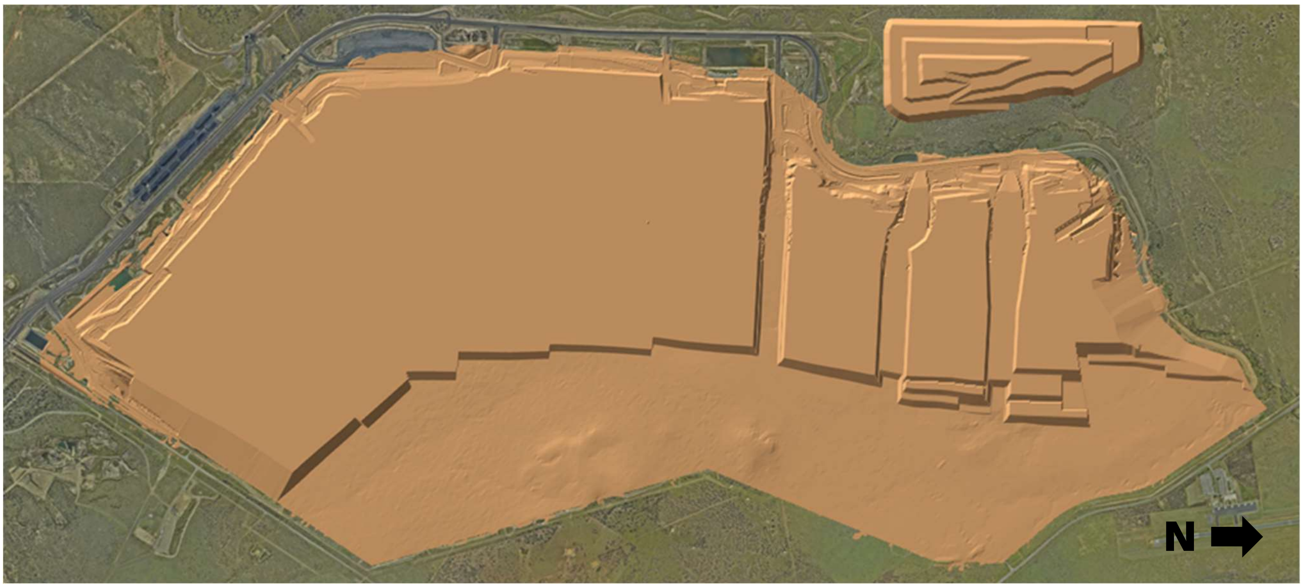
Options analysis of the final landform is undertaken based on substantial information and experience from the mine planning team. The design submitted in the CVM EA Amendment Application includes a final void. The other final landform options compared as part of this action include:

- Option 1: Rehabilitation of the site with no final void (i.e., filling the void to the pre-mining topography);
- Option 2: Rehabilitation with partial backfill above the coal seam (i.e., filling the void to the level of the top coal seam); and
- Option 3: Rehabilitation with partial backfill above the groundwater level (i.e., filling the void to the post-mining modelled groundwater level).

Analysis of each option considering mining, environmental, safety and economic factors is summarised in Table 3-2.

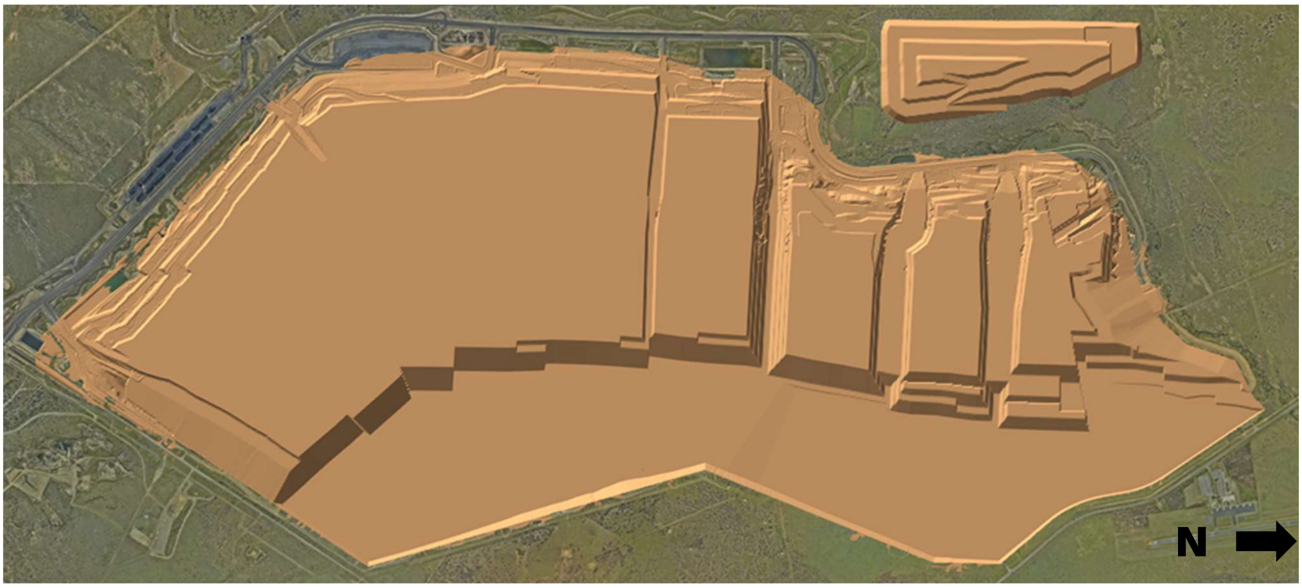
Option 1: Rehabilitation of the site with no final void

To achieve a final landform with no void, the mine void would require backfilling to the pre-mining topography. To achieve this, material from the Horse Pit dump areas will be rehandled and placed into the void using an excavator and haul truck fleet, with ancillary equipment (dozers, graders etc) as required. The material to be rehandled into the void would be mined from the top of the dumps, progressing down, to ensure safe mining of dumped material, until the void is completely filled. The remaining dumps will require reshaping and dump and void areas prepared for rehabilitation activities. This option warrants the highest volume (609 Mm3) of rehandle post completion of coal mining. Only very minimal Horse Pit dump rehabilitation can be completed progressively during mining operations, with the vast majority of the Horse Pit dump rehabilitation delayed until backfill of the void is complete.



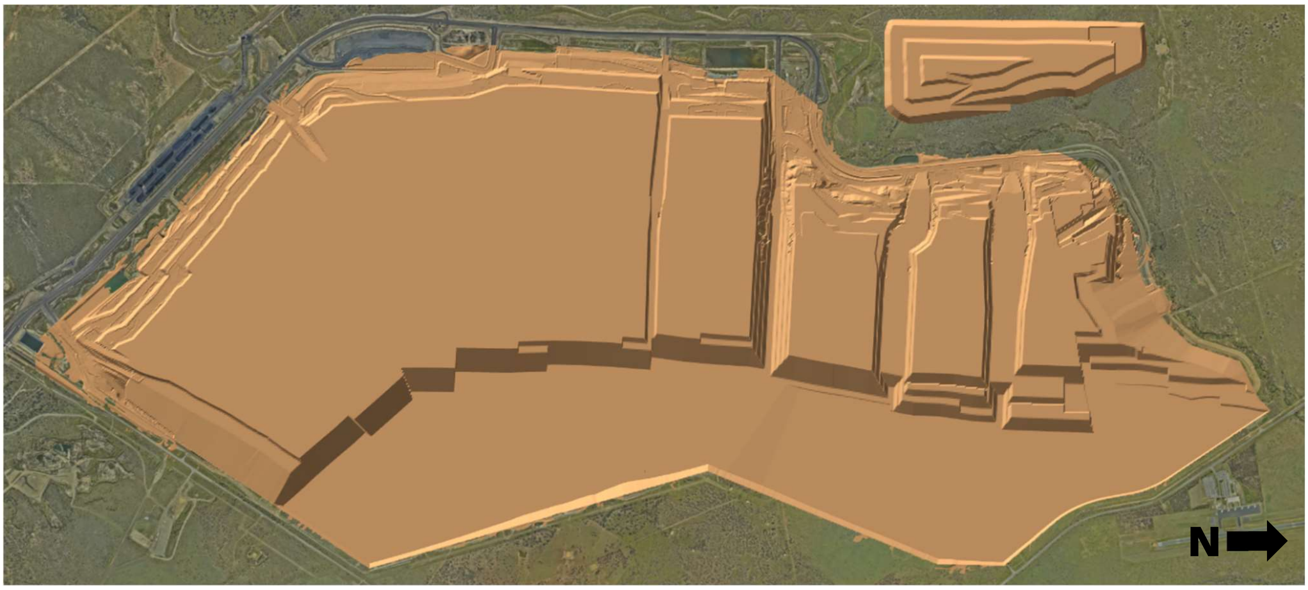
Option 2: Rehabilitation with partial backfill above the coal seam

To achieve a final landform with backfill to above the coal seam, the mine void would be backfilled to the top of the highest coal seam exposed in the highwall. Similar to all options, material from the Horse Pit dumps will be rehandled and placed into the void using an excavator and haul truck fleet, with ancillary equipment (dozers, graders etc) as required. The material to be rehandled into the void would be mined from the top of the dumps, progressing down, to ensure safe mining of dumped material. The remaining dumps will require reshaping and preparation for rehabilitation activities. This option requires 408 Mm3 of rehandle post completion of coal mining. Only minimal Horse Pit dump rehabilitation can be completed progressively during mining operations, with the majority of the Horse Pit dump rehabilitation delayed until partial backfill of the void is complete.



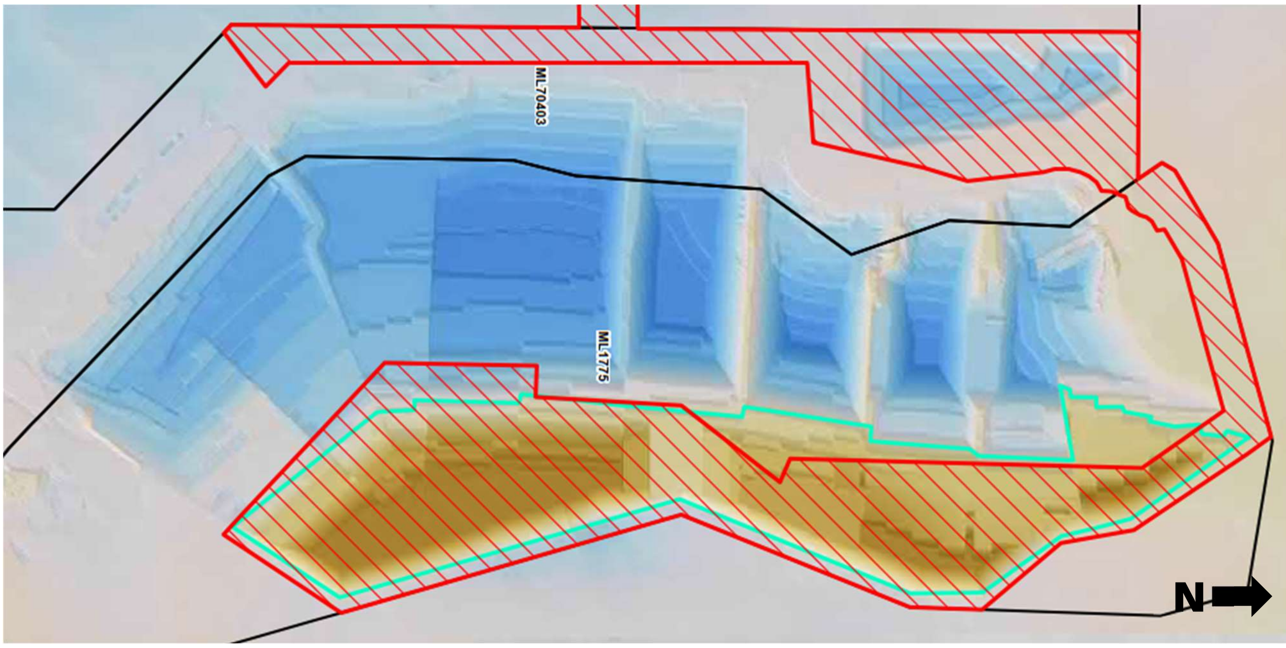
Option 3: Rehabilitation with partial backfill above the groundwater level

To achieve a final landform with backfill to above the groundwater level, the mine void would be backfilled to the depth corresponding to the post-mining modelled groundwater level. Similar to all options, material from the Horse Pit dumps will be rehandled and placed into the void using an excavator and haul truck fleet, with ancillary equipment (dozers, graders etc) as required. The material to be rehandled into the void would be mined from the top of the dumps, progressing down, to ensure safe mining of dumped material. The remaining dumps will require reshaping and preparation for rehabilitation activities. This option requires 415 Mm3 of rehandle post completion of coal mining. Only minimal Horse Pit dump rehabilitation can be completed progressively during mining operations, with the majority of the Horse Pit dump rehabilitation delayed until partial backfill of the void is complete.



CVM EA Amendment Application Option: Rehabilitation with partial backfill and maintaining void

This is the approach put forward in the application and achieves partial backfill of the void during operations (as opposed to additional rehandling of material at the end of mining to further fill the void). As mining continues to the east, mined-out areas in the west will be progressively backfilled where there is capacity. Dump capacity will be satisfied by the existing Horse Pit dump extent and the proposed out of pit dump (OOPD). As dump areas reach capacity, reshaping activities will be required to prepare the surface for rehabilitation activities. The majority of Horse Pit dump rehabilitation can be completed progressively during mining operations.



3.1.2 Options Analysis Approach

Analysis of the three options for the final landform of Horse Pit, and the approach submitted with the CVM EA Amendment Application, has considered environmental, safety and economic factors and a comparison summary is presented in Table 3-2. Each option requires similar type of activities however the scale and period of the activities differs. It is these differences that have been considered in the context of environmental, safety and economic consequences. A summary of the key considerations and how they apply to the Project is provided in Sections 3.1.3, 3.1.4 and 3.1.5.

3.1.3 Environmental Considerations

There are a number of activities associated with the final landform options that have implications for environmental values that need to be considered when assessing each option.

Backfilling as it influences the final rehabilitation schedule

The backfill for the Horse Pit void for all three options requires material to be sourced from the Horse Pit dumps and would occur at the end of coal mining. The dumps would be re-mined in lifts in a top down sequence, for safety reasons, with material transported back to the void for final placement. Due to the significant quantities required for the backfill, progressive rehabilitation of the majority of the Horse Pit dump area would be deferred until mining of the dump area is complete.

Progressive rehabilitation of the Horse Pit dump is associated with several environmental benefits:

- Stabilising the land to avoid erosion from run off and dispersal of sediment to the downstream catchment;

- Stabilising the land to avoid wind erosion and dust generation;
- Establishing habitat values for native flora and fauna; and
- Establishing a land use.

Comparatively, maximising progressive rehabilitation of land within shorter timeframes serves to accelerate the realisation of potential environmental benefits, as opposed to void backfill drawing out the rehabilitation schedule and delaying benefits.

Period of impacts as a result of operational activities

For all three options, the mining fleet, including loading equipment, haul trucks and required ancillary equipment such as dozers, graders and watercarts, would be used for the backfill operations. The extent of backfill required informs the period for which the mining fleet and backfilling activities will be required to continue (after coal mining). This mining method has been selected due to the quantity of material required to be moved and the distance to be moved from the dump to the void. Minor components may be supplemented by dragline and dozer push, however, the volume that can be moved efficiently (using dragline and dozer push alone) would be an immaterial volume compared to the total required to be moved – in turn attributed to the limited operating envelope of dragline and dozers.

A smaller backfilling operation can be undertaken over a shorter time period using fewer excavators and trucks, and vice versa, greater backfilling volumes require a longer period to complete and longer period of use of equipment.

Operation of the backfill fleet is associated with a number of environmental impacts:

- Generation of vehicle exhaust emissions and use of fuels;
- Generation of dust from vehicle movements and material transfers (spoil into and out of trucks);
- Generation of noise from vehicle movements;
- Generation of light from activities; and
- Indirect impacts (as a result of dust, light and noise) to ecological communities and native fauna occupying habitats adjacent to the operational activities.

Comparatively, minimising backfill serves to minimise the environmental impact associated with the operation of the backfill fleet, as opposed to void backfill drawing out the rehabilitation schedule and extending the impacts.

Air

Mining activities are associated with a number of dust generating activities, which will continue for the rehandle backfill and development of a final landform. This would broadly include:

- Load and haul operations;
- Wheel generated dust from transport of material to dumps;
- Dozer operations; and
- Wind erosion from exposed areas including dumps.

For the CVM EA Amendment Application, the planned void backfill occurs as part of operations, with no additional void backfill from rehandling of material. The three options described require material to be mined from the Horse Pit dumps, therefore increasing the time period of dust generation. There is also risk of higher dust emissions from mining the dump material compared to normal mining operations, as it will be further pulverised due to being dozed and hauled over, compacted and handled multiple times.

Sensitive places (as defined in the CVM EA) are described in the Air Quality Impact Assessment (Appendix C of the EA Amendment Application) and impacts discussed in detail for the CVM EA Amendment Application preferred alternative. The sensitive places remain relevant for the other three options and dust monitoring and management practices will be required to continue for the period of development of a final landform. Sensitive places are exposed to potential dust impacts until dust generating activities are finalised and wind erosion sources are stabilised.

Noise and Vibration

Mining activities are associated with a number of noise and vibration generating activities, which will continue for the development of a final landform. For establishment of the final landform this would broadly include:

- Excavation of material using excavators/shovels, trucks and dozers;
- Hauling and placement of material at dump locations;
- Dozer operations; and
- Progressive rehabilitation activities such as backfilling, reshaping dumps, topsoiling and revegetation.

For the CVM EA Amendment Application, the planned void backfill occurs as part of operations, with no additional void backfill from rehandling dump material, as required for the other three options.

Sensitive places (as defined in the CVM EA) are described in the Noise and Vibration Impact Assessment (Appendix D of the EA Amendment Application) with impacts considered. The sensitive places remain relevant for all three options and noise and vibration management practices will be required to continue for the period of development of a final landform. Sensitive places are exposed to potential noise and vibration impacts until mining activities (including final landform development and rehabilitation activities) are finalised.

Groundwater

Final landform options have been assessed to inform potential implications to groundwater from each scenario.

In general the presence, or absence, of a residual void in the final landform of the mine will govern groundwater movement between hydrostratigraphic units on and off lease. The volume of backfill will change the morphology of the final void, and the permeability of the backfill will influence hydraulic connectivity with the regional groundwater systems.

For the three final landform options, assessments have been completed in consideration of recent investigations completed for the Winchester South revised draft EIS (Whitehaven Coal, 2022). The Winchester South revised draft EIS work used numerical groundwater modelling to assess the effect of the three final landform scenarios, in comparison to the proposed optimised landform that would have the pit void base below the final groundwater level and therefore contain long-term evaporative void lakes in direct connection with the groundwater system. Consideration of the Winchester South draft EIS work in the CVM EA Amendment assessment is deemed appropriate given the similarities in the scenarios assessed, the proximity of the Winchester South project to CVM (15km to the south east), the similarities in the hydrostratigraphy modelled (Permian Coal Measures) and the planned mining methodology (open cut metallurgical coal mine).

Numerical modelling completed as part of the Project groundwater assessment (Appendix F of the EA Amendment Application Supporting Document) has been used to assess the CVM EA Amendment option of rehabilitation with partial backfill and maintaining void.

Option 1: Rehabilitation of the site with no final void

The rehabilitation of the site with no final void will result in the backfilling of all proposed residual voids to the surrounding land surface, creating a free drainage landform.

This option was assessed as having potential of turning the rehabilitated void area into a flow-through system with a limited hydraulic gradient towards the backfilled residual voids. The in-pit (i.e. backfilled spoil) and out-of-pit dumps are therefore likely to act as groundwater sources, with groundwater movement predicted to move from the final landform towards the Isaac River alluvium to the east. Without evaporative hydraulic control on groundwater within the final landform, there is no means to contain potentially poor-quality groundwater within the landform arising from water-spoil geochemical interaction.

Groundwater recovery modelling (which included particle tracking) for the Winchester South draft EIS (Whitehaven Coal, 2022) supports this assessment showing that full backfilling does not limit groundwater movement, and groundwater would migrate off-site from the backfilled final landform from deeper groundwater layers into the shallower units.

Based on this it is assessed that the final landform using this option would act as a groundwater source to the surrounding groundwater systems, with the potential for downstream groundwater quality impacts associated with the outflow of water from the final landform.

Option 2: Rehabilitation with partial backfill above the coal seam

This option considers partial backfilling of the final residual void to above the coal seam level. In this scenario groundwater movement will be controlled by the level of backfill above the seam and the permeability of the backfilled material.

To maintain the partially backfilled void as a groundwater sink (preventing off lease seepage of potential contaminants) the backfill level will need to be completed below the base of the shallow aquifer system and below the surrounding regional coal seam aquifer groundwater elevation. The permeability of the backfill material will govern whether the pit void groundwater is hydraulically connected to the regional coal seam aquifer system.

In the event that the backfill material is of very low permeability or effectively impermeable there is potential for the pit lake level to recover to above the pre-mining groundwater levels. As per Option 1, the final landform using this option would then act as a groundwater source to the surrounding groundwater systems, with the potential for downstream groundwater quality impacts associated with the outflow of water from the final landform.

Analysis of the GoldSim water balance results is discussed in the Project's groundwater modelling report (SLR, 2021). It should be noted that the analysis indicated that the groundwater contribution to the final void approximates 4% of the total water inflow to the void that includes surface water runoff and direct rainfall, i.e. the influence of groundwater inflow on final void lake levels is minimal to negligible in comparison to surface water sources contributing the void lakes. Whilst backfilling above the coal seam may limit inflow from coal seam aquifers, it is unlikely to significantly influence the final void lake level in this scenario due to the greater contributions of surface water runoff and direct rainfall into the final landform.

In the event that the backfill material is of sufficient permeability, backfilling above the coal seam level but below pre-mining groundwater level is likely to maintain a hydraulic gradient towards the partially backfilled residual voids. In this scenario poor-quality groundwater arising from water-spoil geochemical interaction is likely to be hydraulically contained within the landform due to the voids acting as groundwater sink. The groundwater recovery modelling results for the Winchester South draft EIS (Whitehaven Coal, 2022) supports this showing that partial backfilling above the coal seam is likely to limit groundwater movement, preventing the off-site migration of poor quality groundwater from deeper groundwater layers into the shallower units.

In summary, depending on the backfill level above the coal seam and the backfill permeability the final landform in this option is assessed as having both the potential to act as groundwater source or sink.

Option 3: Rehabilitation with partial backfill above the groundwater level

This option considers partial backfilling of the final residual void to above the pre-mining groundwater level. Backfilling above the pre-mining groundwater level is likely to result in a reduced hydraulic gradient towards the partially backfilled residual voids, with groundwater movement to the east towards the Isaac River alluvium.

In this option in-pit and out-of-pit waste rock emplacements are likely to act as groundwater sources and therefore the residual void will not act as a sink. The landform may therefore become a 'flow through' system' with the groundwater quality an impact source for the surrounding environment, which includes the Isaac River alluvium to the east.

As discussed the influence of groundwater inflow on final void lake levels is minimal to negligible in comparison to surface water sources contributing the void lakes. It is therefore likely that the salinity of the residual void pit lake will fluctuate in relation to climatic influences (evaporation and rainfall) on the water body. Numerical modelling for this scenario completed for the Winchester South draft EIS supports this, showing that for the same modelled scenario salinity of the residual void water bodies is predicted to oscillate as the water body undergoes wetting and drying cycles, and is predicted to become highly saline (i.e. up to 510,000 microSiemens per centimetre (the maximum solubility of salt in water at 25 degrees Celsius)).

Due to the potentially highly concentrated salinity, the water bodies would not sustain a use post-mining. The residual void pit lakes would also not be suitable for providing a reliable source of water for beneficial use purposes due to times where the water body would go dry.

CVM EA Amendment Application Option: Rehabilitation with partial backfill and maintaining void

It was demonstrated in the Project's groundwater assessment that predicted void lake levels will remain relatively deep, significantly below the pre-mining groundwater level and void crest level, with the difference in elevation between the long-term equilibrated water level in the final void and the surrounding crest elevation being approximately 100 m.

Significant inwards hydraulic gradients to the void are maintained in the long term post-mining with head differences in the order of at least 50 m between the void lake (~120 mAHD) and the surrounding groundwater system (~170 to 190 mAHD) (see Figures 6-22 and 6-23 of the Project's Groundwater Assessment Report). Therefore, recognising that groundwater inflow is only approximately 4% of the total water contribution to the void lakes, it is very unlikely that a change in the void lake level that may result from adoption of alternate spoil recharge rates would manifest in a predicted void lake level that would have the potential for environmental impact (i.e. result in an outwards groundwater flow gradient).

The rehabilitation with partial backfill and maintaining void scenario is predicted to provide the greatest hydraulic control for containing poor quality groundwater. The predicted equilibrated final void water levels are between approximately 70 m and 90 m below the pre-mining groundwater levels. Water within the final void would evaporate from the final void water body surface and draw in groundwater from the surrounding strata and runoff from the final void catchment areas. This means the final void would act as a sink to groundwater flow and local surface water flow, and not form a source of groundwater contamination with the potential to discharge to the receiving environment.

Option Suitability for Minimising Implications to Groundwater

The Queensland Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity)) aims to achieve objectives set out by the Environmental Protection Act 1994 (EP Act); that is, to protect Queensland's water environment whilst allowing for development that is ecologically sustainable. Section 5.4 of the EPP (Water and Wetland Biodiversity) Guideline for developing local water quality guideline values states that, in a policy context:

The intrinsic environmental value of groundwater should be protected, and the groundwater quality should be maintained within the range of natural quality variations … to ensure that no adverse effect on groundwater quality occur.

The default management intent is that there should be 'no change' to the natural variation in groundwater quality. In effect, the EPP (Water and Wetland Biodiversity) under the EP Act therefore prohibits any activity that would potentially cause a variation in natural groundwater quality.

Assessment has shown that Option 1 (complete backfilling of the voids) or Option 3 (backfilling above pre-mining groundwater levels) would result in uncontrolled movement of groundwater through the final landform that would be subject to water-spoil geochemical interaction, this means that compliance with the intent of the EPP (Water and Wetland Biodiversity) would not be possible if these options are implemented.

Assessment of Option 2 (partial backfill above the coal seam) has shown that the final landform may potentially act as a sink (by hydraulically containing) or a source of poor-quality groundwater depending on the backfill level above the coal seam and the permeability of the backfill material. Due to the variability in potential results there is a risk that compliance with the intent of the EPP (Water and Wetland Biodiversity) would not be possible if this option is implemented.

The CVM EA Amendment Application option are deemed the most suitable for achieving 'no change' to the natural variation of groundwater quality, as these scenarios result in the final void acting as a sink, thereby hydraulically controlling the movement of poor quality groundwater.

Ecology

The presence, or absence, of a residual void in the final landform of the mine will influence the total footprint area available for rehabilitation and in turn terrestrial area available to provide ecological values. Where a void is present, the footprint of the void will not provide terrestrial ecological value. However, a scenario whereby the void is fully backfilled, creates an area of landform available for rehabilitation. The extent to which the rehabilitation will provide ecological values will depend on the PMLU chosen for that area (ranging from woodland habitat to agricultural properties).

3.1.4 Safety Considerations

All three options present considerations based on both operational complexity and safety associated with mining through the Horse Pit dumps, as opposed to normal mining operations.

The rehandled material will require benching from top to bottom in line with industry practice to ensure safety parameters are achieved. Material in the dumps may be in excess of 40 years old and will include mining through areas of rejects co-disposal. The co-disposal areas have been dumped and covered as part of the general mining operations and are not designed to be re-mined. The rehandling process for the purpose of back fill will require excavation of cells which will present significant challenges with regards to geotechnical stability.

Due to the potential flowable nature of co-disposal material, breaking through into the cells either by top down weight pressure of equipment or outburst sides of the cells, presents a significant risk to people and equipment.

Backfilling of the final void will require loaded hauling to occur downhill. Haul trucks have predominantly been designed to haul waste uphill out of a mining operation. The backfilling of a pit will require trucks to run loaded downhill for the duration of the operation. This not only increases equipment wear and tear as mining trucks are designed to predominately haul loaded uphill, but there would be an increased safety risk due to increased braking and tyre heating and slippage during wet weather which could result in injury and/or property damage. Specifically, a loaded truck will have increased force placed on truck components such as retarders, transmission, axles and bearings due to the additive nature of the rim pull force on a downhill haul as opposed to diminutive nature on an uphill haul.

3.1.5 Economic Considerations

Given the key differences between the three options largely relate to scale and period of activities occurring, economic considerations focus on these aspects also.

When considering backfilling, the volume of waste that would need to be rehandled from the waste dumps back into the void for the assessed options ranges between 408 Mm3 and 609 Mm3.

The magnitude of the backfill costs is significant, ranging between A$1.8B to A$2.7B with no associated revenue and minimal savings for NUMA costs, thus on financial terms this will reduce the economic viability of the CVM by impacting nominal cashflow for up to 30 years (for comparison the scale of the cost is effectively twice as much capital required to start a greenfield coal operation in the region such as the nearby Olive Downs operation (see Pembroke Resources press release – 23/12/21)).

3.1.6 Options Analysis

An options analysis was undertaken to rank the options based on environmental, safety and economic factors to determine the preferred option.

The weighting of each criterion was chosen to focus on the environmental aspects (80%).

For the considerations listed (in Table 3-2), each option was ranked using the ranking scores shown in Table 3-1. Based on the score and weighting of each criterion, a total score for each option is calculated with the highest value representing the preferred option.

Table 3-1 Options analysis ranking scores

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Table 3-2 Landform Options Analysis Summary

	Criteria Weighting	Explanatory Note	CVM EA Amendment Application		Option 1		Option 2		3	
			Partial backfill & maintain void	Score	Complete backfill for no void	Score	Partial backfill to above coal seam	Score	Partial backfill to groundwater level	Score
Data										
Rehandle backfill volume (rehandle is the additional backfill after mining is complete)			0 Mm^3 (planned backfill is completed during mining operations)		609 Mm^3		408 Mm^3		415 Mm^3	
Period of mining/backfill activity			Mine Life		Mine Life + 11 years		Mine Life + 8 years		Mine Life + 8 years	
Magnitude of rehandle backfill fleet			N/A		Mining fleet (5x Excavator + 30x Trucks)		Mining fleet (5x Excavator + 30x Trucks)		Mining fleet (5x Excavator + 30x Trucks)	
% downhill for loaded travel			Maximum of 20%		100% downhill or flat		100%downhill or flat		100% downhill or flat	
Environmental Considerations (total 80% weighting, evenly distributed)										
Progressive rehabilitation schedule	~5.5%	Rehabilitation activities in areas where material must be rehandled and used for backfilling will be postponed until after rehandling	Progressive rehabilitation as area becomes available	2	~1,121 ha delayed	-2	~ 968 ha delayed	-2	~968 ha delayed	-2
Air quality (dust and vehicle emissions during rehabilitation activities)	~5.5%	Dust and vehicle emissions will be generated until rehabilitation activities are complete	As per EA Amendment submission	2	11 years of additional[1] dust generation and potential air quality impacts	-2	8 years of additional[1] dust generation and potential air quality impacts	-1	8 years of additional[1] dust generation and potential air quality impacts	-1
Air quality	~5.5%	Exposed surfaces that remain at closure have	Low wall exposed surface however	-2	No exposed surfaces	2	Low wall exposed surface (smaller area than preferred	0	Low wall exposed surface (smaller area than preferred	0

(dust in perpetuity)		potential to be exposed to dust generation	below ground surface				alternative) however below ground surface		alternative) however below ground surface	
Noise and vibration	~5.5%	Noise will be generated until rehabilitation activities are complete	As per EA Amendment submission	2	11 years of additional[1] potential noise and vibration impacts	-2	8 years of additional[1] potential noise and vibration impacts	-1	8 years of additional[1] potential noise and vibration impacts	-1
Surface water (flooding void)	~5.5%		Final voids will be mitigated from flooding with partial backfill or landforms	0	No final void flood risk	0	Final voids will be mitigated from flooding with partial backfill or landforms	0	Final voids will be mitigated from flooding with partial backfill or landforms	0
Surface water (overland flow)	~5.5%	Where a void is present, overland flow within its catchment will be captured within the void (and therefore removed from the downstream environment)	Final void	0	No final void to capture overland flow	2	Final void	0	Final void	0
Groundwater	~5.5%	The final void has potential to act as a long-term sink, retaining potential contaminants	As per EA Amendment submission modelling indicated final void will act as a sink	2	Potential for contaminants to discharge to shallow aquifer system receiving environment.	-2	Void remains as sink as long as backfill level is below off lease coal seam groundwater elevations.	0	Potential for contaminants to discharge into shallow aquifer system receiving environment.	-2
Ecology	~5.5%	Ecological values may be present depending on the footprint of landform to be rehabilitated	As per EA Amendment submission – final void area will not have a PMLU	-1	Final void backfill can have ecological values depending on PMLU type	2	Partial backfill will provide some area available for rehabilitation and in turn ecological value (when compared to EA Amendment Application scenario)	0	Partial backfill will provide some area available for rehabilitation and in turn ecological value (when compared to EA Amendment Application scenario)	0
Stable landform	~5.5%	Relates to potential for failure of final void	Final void designed to	0	N/A	2	Final void designed to achieve factor of safety ≥ 1.5	0	Final void designed to achieve factor of safety ≥ 1.5	0

[1] When comparing against the CVM EA Amendment Application Preferred Alternative

(geotechnical stability of final void)			achieve factor of safety ≥ 1.5							
Stable Landform (dump and wall slope related erosion)	~5.5%	Relates to potential for failure or erosion of dumps and other slopes	In-pit spoil dumps up to ~160m high Spoil dumps designed to achieve factor of safety ≥ 1.5 Longest slope length - increased erosion potential	-2	In-pit spoil dumps up to ~50m high Spoil dumps designed to achieve factor of safety ≥ 1.5 Smallest slope length - lowest erosion potential	1	In-pit spoil dumps up to ~100m high Spoil dumps designed to achieve factor of safety ≥ 1.5 Mid slope length – mid erosion potential	-1	In-pit spoil dumps up to ~100m high Spoil dumps designed to achieve factor of safety ≥ 1.5 Mid slope length – mid erosion potential	-1
In-pit dump disturbance footprint	~5.5%	In-pit disturbance footprint does not differ between options	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0
OOPD disturbance footprint	~5.5%	OOPD disturbance footprint does not differ between options	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0
Infrastructure disturbance footprint	~5.5%	Infrastructure disturbance footprint does not differ between options	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0	As per EA Amendment submission	0
Post mining land use (PMLU)	~5.5%	A void area may not have any 'use' after mining is complete.	As per EA Amendment submission – final void has no PMLU	-1	No final void, land area can have a PMLU - maximum PMLU area	2	As per EA Amendment submission – final void has no PMLU	-1	As per EA Amendment submission – final void has no PMLU	-1
Safety Considerations (total 10% weighting)										
Mining through unsuitable material	5%	Human safety risks of uncontrolled material movement (mining through unconsolidated fill and rejects in the spoil dump)	N/A No mining of spoil dumps	2	Additional[1] 609 Mm^3 of rehandling activities required and associated safety risk	-2	Additional[1] 408 Mm^3 of rehandling activities required and associated safety risk	-1	Additional[1] 415 Mm^3 of rehandling activities required and associated safety risk	-1
Rehandling material on a downhill	5%	Human safety risks of brake failure and uncontrolled equipment movement (especially in	N/A	2		-2		-1		-1

(risk of equipment failure)		wet weather) associated with hauling material on downhill slopes Vehicle parts typically wear more rapidly for downhill hauling (as opposed to flat)								
Economic Considerations (total 10% weighting)										
Rehandle Backfill Cost	10%	Cost per m³ to rehandle material for backfilling	*$0*		*$2,650M*		*$1,800M*		*$1,770M*	
Void Safety Cost		Highwall bunding, fencing, signage	*$1M*		*$0*		*$1M*		*$1M*	
Low wall Cost		Cost for dozer activities and rock requirements	*$0*		*-$20M*		*-$15M*		*-$15M*	
Void Rehab Cost (PMLU)		Cost per ha to rehabilitate	*$0*		*$12M*		*$0*		*$0*	
Total Cost			$1M	2	$2,642M	-2	$1,786M	-1	$1,756M	-1
Comparative Analysis										
Overall Weighted Score	**100%**			**0.51**		-0.23		-0.54		-0.66

3.1.7 Outcome

The CVM EA Amendment Application assessed the final void of Horse Pit as a NUMA at the end of mine life which when compared to the three options identified, scores a +0.51 for a weighted score. For the other options the weighted scores were determined between -0.23 and -0.66.

While isolated considerations may be more favourable for some options (when compared to the preferred alternative), taking an overall view highlights the benefits of the preferred alternative that was assessed in the CVM EA Amendment Application.

3.2 BMA Response to Requested Action 4

Requested Action 4: *Provide further details of why an out of pit dump is a required option, if proposed.*

An OOPD is proposed in order to provide the dump capacity required to mine the Project.

The Project (Figure 3-1) will continue mining to the east and is earmarked to commence in 2032 (as per current schedules). The northern most component of Horse Pit extends by ~800m (highlighted in Figure 3-2 below) and is limited to within a distance of Horse Creek. In a lead up to start of extension (2032) until the end of mine life, this northern extent is associated with a substantial increase in mining intensity. This is due to progressive closure of Heyford Pit at this time and due to the southern end of Horse Pit being already at capacity at that point in time. This places significant pressure on spoil balance and supports requirement of an OOPD on top of other dumping options already in place.

Current dumping at Horse Pit utilises the existing in-pit dump footprint to the east of Horse Creek and east of the main haul road. The dump plan for Horse Pit includes ramp backfill where it is practical and non-prohibitive to operational flexibility required for coal and waste haulage. The current plan includes two of the three coal haulage ramps being progressively backfilled to topography level by the time the extension to Horse Pit starts in 2032.

A spoil balance assessment for the Project shows there is a dump deficit given the limited dump capacity available within the existing dump footprint and the lack of dump area adjacent to the extension. Further ramp backfill was not considered an option as there is no further practical capacity once the already planned ramp backfill is completed. The OOPD has been designed to meet the deficit in dump capacity of using the existing dump locations.

Standard mining practice includes allowance for ~ 25% buffer for dump capacity. The proposed approach described above, steadily decreases the available dump room down to ~2% of cumulative dig volumes.

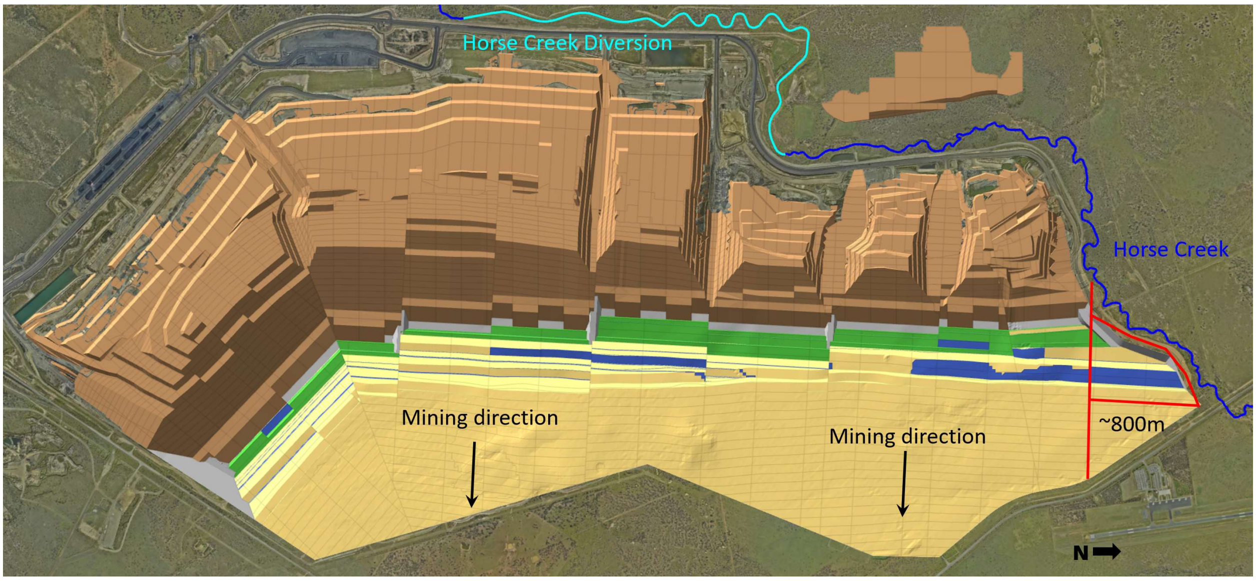


Figure 3-1 Horse Pit Extension

3.2.1 Dump Options for the Horse Pit Extension

Within the mining lease footprint, four waste disposal options were identified for satisfying the dump deficit volume while the strips are extended:

1. Further fill active coal haulage ramps above topography;
2. Haul waste to the Heyford Pit southern void when the area becomes available;
3. Extend the existing Horse Pit dump boundary; and
4. Identify a suitable location for a new OOPD to haul to (as described in the CVM EA Amendment Application).

It is important to note that appropriate haul routes are essential to operations. Access to haul routes can affect the available dump space and maintaining multiple haulage options, particularly for coal, increases flexibility and helps mitigate the risk of being unable to haul coal out of the pit.

3.2.2 Option 1 – Backfill Coal Haulage Ramps

As mentioned above ramp backfill is currently a component of the plan to manage dump capacity prior to commencing the Project. This has the benefit of reducing ramp voids in the final landform but it also reduces operational flexibility for waste and coal haulage.

This option would require further filling of the two coal haulage ramps at the northern end of the pit to above natural ground level. This approach would remove two haulage options which significantly impacts coal haulage, as all coal from the northern section of Horse Pit would need to be hauled via either the low level coal ramp to the south or the northern endwall. Key differences when comparing this option against the proposed OOPD approach include:

- Backfilling the coal ramps will reduce the required footprint of the proposed OOPD approach. However, to maintain coal access from fewer haulage ramp options, low wall ramps would be required which results in less inpit dump capacity. Alternative dump capacity would be required such as raising the dump height (with an impact on environmental factors), however there is limited capacity to increase the height of the dumps due to the front and back dump slope angles;
- The haul distance to dump to the ramps voids is less than to haul to the proposed OOPD;
- Backfilling the coal ramps will increase congestion on the ramps and in turn lead to an increased safety risk; and
- Backfilling the coal ramps will reduce availability of haulage options. If the remaining coal haulage accesses became unavailable for geotechnical, water or operational reasons, hauling access would be diverted to longer hauls (increased haulage costs, larger truck fleet and flow-on impacts on environmental factors (dust, noise, vehicle emissions, light)) and require coal haulage to interact with waste haulage.

3.2.3 Option 2 – Haul to Heyford Pit

This option would require transferring the excess waste (dump deficit) of the Project to the southern end of the Heyford Pit final void, which becomes available for dumping around the same time as the commencement of the Project in the current schedule. This option comes with the following considerations:

- The round-trip haulage distance to the southern end of the Heyford Pit void is approximately 48km, with a cycle time simulated to be in excess of 90 minutes (compared to the haulage cycle time to the OOPD simulated at 36 minutes). Approximately 270% of the truck hours are required to dump at the Heyford Pit void when comparing hours for dumping to the OOPD. For this option, a substantially larger truck fleet would be required to haul the same quantity of material;

- Due to the haulage distance, the speed of the trucks would need to be limited to remain under the tonne-km-per-hour (TKPH) rating of the truck tyres – a measure of the tyre's ability to operate under the heat generated by hauling loaded for long distances. This aspect impacts productivity of the equipment and further increases the truck fleet, plus this is an increased safety risk associated with the tyre fires; and
- The significantly longer haul and larger truck fleet would result in increased environmental impacts (dust, noise, vehicle emissions, light), and increased haulage costs.

3.2.4 Option 3 – Extend Existing Horse Pit Dump Boundary

An increase in available dump space (and buffer) may be achieved by maximising the footprint of the Horse Pit dump within the current disturbance area, to achieve this a combination of the following infrastructure would have to be relocated:

- Horse Pit Coal Stockpile;
- Main Caval Ridge Sediment Dam; and
- Caval Ridge Workshop Facilities.

Relocation of this infrastructure would result in additional disturbance in the new locations and associated environmental impact and cost implications. The operational suitability must be considered for any new locations.

3.2.5 Option 4 – Establish Out of Pit Dump

Establishing an OOPD is described in the CVM EA Amendment Application and detailed assessment of environmental impacts is provided.

3.2.6 Outcome

On consideration of the options described above, the proposed OOPD is the preferred waste disposal option. Most notably the OOPD is associated with shorter haul distance (and dust generation), and less safety risk regarding congestion of routes.

Also to note for context, the volume of waste to be transported via truck and shovel to the proposed OOPD is estimated in the order of 50-60M bank cubic metres (BCM). In the context of the total volume of waste at the CVM (in the order of 1.8B BCM), the OOPD represents approximately 3% of the waste to be moved by truck and shovel at the CVM. Movement of waste to the OOPD does not represent a substantial component of waste transport for the mine (and in turn is not a significant contributor to environmental impacts such as dust generation).

4 Rehabilitation of the Highwall, Low Wall and Ramps

The application does not provide sufficient details regarding the rehabilitation of the pit (including the highwall, lowwall and ramps) in its proposed position indicated by Figures 3-8 to 3-14 and detailed in section 5.1.

As noted in the Introduction, for matters relating to rehabilitation, the CVM PRC Plan will deliver the comprehensive details around rehabilitation of the pit in line with the DES PRC Plan Guideline (DES 2021), and the document is currently under preparation. BMA will be submitting a PRC Plan that includes the CVM existing approved activities and also the extension of Horse Pit. PRC Plan related content has been provided where available in this Response and further details will be included in the CVM PRC Plan submission in accordance with the DES PRC Plan Guideline (DES 2021) requirements. Similarly of note, given mine plans are routinely refined during the life of open cut mining operations, the CVM PRC Plan submission will use the most up to date mine planning information available to inform the landform design and rehabilitation plans.

4.1 BMA Response to Requested Action 5, 6 and 8

Requested Action 5: *Given the close proximity of the proposed highwall to the Peak Downs Highway and the Moranbah Access Road as well as to the township of Moranbah, provide a geotechnical report of the final design of the highwall which includes the following:*

- *Considerations given to the:*
    - *visual amenity of the area; and*
    - *risk to public safety (including access)*
- *Demonstrate that adequate space has been allocated between the highwall and the mining lease boundary to ensure the highwall, in the case of a failure, would still be able to achieve the final design;*
- *Should there be tertiary material in the highwall, demonstrate how would geotechnical stability be achieved given the close location to the mining lease boundary*

A geotechnical stability assessment has been completed to demonstrate that post-closure, the conceptual highwall and set-back design will exhibit long-term geotechnical stability within the mining lease.

This assessment has been completed with the best information currently available. The geotechnical wall designs and set-backs from the mining lease will be reassessed by an appropriately qualified person as mining approaches the final limits, to ensure the final design is based on the latest material and geotechnical data.

Limit equilibrium has been used to geotechnically assess the highwall of Horse Pit. Limit equilibrium is currently accepted by industry as the most practical method available. It compares forces on a surface with (limiting) strength if it was at the point of failing. Defects may be included explicitly as discrete strata when known, but more often are implicit within the strengths of broader material layers.

The final void is designed with the required highwall set-back to achieve a minimum factor of safety (FoS) of 1.5 at the mining lease, the Peak Downs Highway corridor and the Moranbah Access Road corridor. This is illustrated in Figure 4-1. This figure is simplified to show the overall wall angles within the Tertiary, weathered Permian and fresh Permian material. A minimum FoS of 1.5 is generally adopted for long-term stability of civil engineering features which have broad public access, such as road cuttings and dam walls.

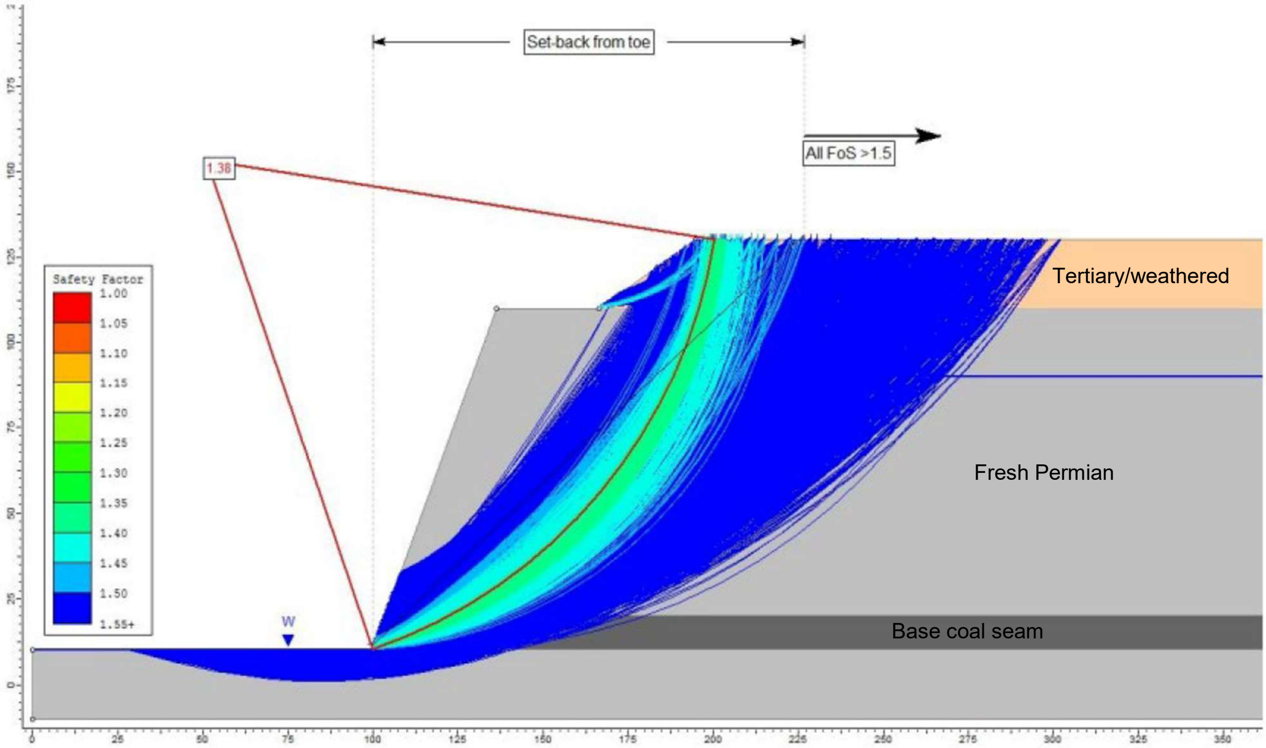


Figure 4-1 Set-back to FoS ≥ 1.5

In the Bowen Basin, predominantly Permian age coal measure sedimentary rocks are unconformably overlain by younger, mainly Tertiary age, sediments. In the context of wall stability, the important geological boundaries are Base of Tertiary and Base of Weathering; however, for this analysis Tertiary and weathered Permian rocks were treated as one material, which is a conservative assumption. Due to the lower strength of the Tertiary and weathered Permian material, the wall is designed with a lower wall angle in this material and a bench at the base.

The material strength properties used in the geotechnical assessment are shown in Table 4-1 and the mined highwall profile parameters are shown in Table 4-2. Based on these inputs, the calculated FoS for the mined Horse Pit highwall ranges from 1.28 to 1.61, with an average of 1.40. The void highwall therefore must be designed with an additional set-back (or space) from the mining lease, the Peak Downs Highway corridor and the Moranbah Access Road corridor to achieve a minimum FoS of 1.5 at these features.

The required highwall set-back to achieve a minimum FoS of 1.5, as determined from the geotechnical assessment for Horse Pit, is shown in Table 4-2. This set-back is the distance from the highwall toe, and ranges from 231m to 409m, with an average set-back of 324m. The set-back is included in the design of the final highwall and ensures adequate space is allocated between the highwall and the mining lease boundary, the Peak Downs Highway corridor and the Moranbah Access Road corridor to ensure the highwall, in the case of a failure, would still achieve the final design.

Table 4-1 Geotechnical wall material strength properties

Material	Cohesion (kPa)	Friction Angle (□)	Unit Weight (kN/m³)
Tertiary/weathered	50	30	22
Fresh Permian	450	42	24
Coal	30	35	15

Table 4-2 Geotechnical wall profiles and results for Horse Pit

Geotechnical wall profile parameters	Average	Range	90% less than
Depth of Tertiary overburden (m)	4	0-14	9
Depth of Tertiary/weathered overburden (m)	27	19-36	32
Average wall angle in Tertiary/weathered overburden (°) (constant)		35	
Bench width at base of Tertiary/weathered overburden (m) (constant)		30	
Depth of fresh Permian (m)	205	153 – 238	234
Overall wall angle in fresh Permian (°)	48	43 – 50	50
Thickness of base coal seam (m)	4	2-5	5
Total Wall depth (m)	231	180 – 272	260
Results			
Wall FoS	1.40	1.28 – 1.61	1.29
Set-back from toe of wall to achieve FoS = 1.5 (m)	324	231 – 409	390

Public safety by restricting access to the void, will be achieved through constructing a safety bund at the geotechnical set-back distance and erecting fencing and signage around the bund.

Requested Action 6: *Provide further details regarding the rehabilitation and final design of the final void, including the rehabilitation of the highwall, lowwall and ramps.*

The final void highwall profile will remain as the final mined wall profile. The mined wall profile includes numerous benches separating mining faces of varying face angles and heights. The overall wall angle in the Tertiary/weathered overburden is 35° and the overall wall angle in the Permian overburden ranges from 43°-50°, resulting in a total overall wall angle of approximately 37° from highwall toe to highwall crest. The overall angle from highwall toe to the outside of the safety bund (which includes the set-back to achieve a minimum FoS of 1.5) is approximately 34° for Horse Pit. These wall angles may vary with the final geotechnical design, which will be developed as mining approaches the final pit limits, to ensure it is based on the latest material and geotechnical data.

The final lowwall and ramp wall profiles within the final void area will remain as the final as-dumped profile. The lowwall profile includes the dragline spoil on the floor of the mined out pit with truck dumps above the dragline spoil. The truck dumps are offset from the dragline spoil by two spoil peaks and each truck dump lift remains at angle of repose with benches between each lift. The overall lowwall angle is approximately 21°. The geotechnical assessment shows that this lowwall profile meets a FoS of 1.5 without any additional set-backs. This wall angle may vary with the final geotechnical design which will be developed as mining approaches the final pit limits, to ensure it is based on the latest material, pit floor and geotechnical data.

Requested Action 8: *Provide additional figures of the final design by domain at a scale that can clearly identify the slopes and extent to demonstrate the final landform.*

Further discussion on the design of the final landform is provided in Section 5.

Section 5.1 of the EA Amendment Supporting Documentation describes the rehabilitation goals and strategies for the Project in line with the current CVM EA conditions.

4.2 BMA Response to Requested Action 7

Requested Action 7: *Provide details of the rehabilitation schedule for Horse Pit that would reduce the potential air emissions from the overburden area.*

The Dust Control System (DCS) for the CVM as discussed in Section 8 will enable BMA to identify the contribution of dust from the OOPD. This will enable adaptive management processes to manage dust levels appropriately. Section 8 also discusses the dust contribution from the proposed OOPD. Further, in accordance with the Mine Land Rehabilitation Policy, land disturbed by mining activities will be progressively rehabilitated as soon as practicable after the land becomes available, to minimise the risks of environmental impacts and reduce cumulative areas of disturbed land.

The schedule for the commencement of rehabilitation proposed for the Project is shown in Table 4-3. The hectares significantly increase from 2057 when the lowwall area of the spoil dump becomes available for rehabilitation.

Table 4-3 Horse Pit Rehabilitation Schedule

Date rehabilitation commences	Area (ha)
10/12/23	15
10/12/25	46
10/12/28	149
10/12/33	262
10/12/38	481
10/12/43	611
10/12/48	777
10/12/53	857
10/12/58	1393
10/12/63	1953

5 Final Void

The supporting document to the application proposes a final void of 680ha in area with conflicting final land outcomes: Section 3.5.6 states that the "final void will provide a usable water storage or biologically viable water storage" however, there is also reference of the final void having "no-use" as per section 5.3.3 of the supporting document.

The proposed disturbance for the Horse Pit Extension is 655.65ha, however 680ha of a final void is being proposed. The application document states that mined out areas will be progressively back-filled and rehabilitated where practical to reduce the final void. This is insufficient to support a proposed final void of 680ha. In addition to the options analysis of request item 3, further information is sought about the final void location, area and use.

The administering authority (Department of Environment and Science) will not approve an area that does not sustain a post-mining land use, unless the applicant (BHP) can demonstrate that the proposed treatment of the land meets current best practice management, and:

- *rehabilitating the area would pose a greater environmental risk than not rehabilitating, or*
- *the environmental risks from the area are localised, and the cost of rehabilitation would be so excessive as to not be in the public interest.*

The department's expectations for best practice management of a NUMA would result in the area being made safe and structurally stable so that it causes no environmental harm, despite a post-mining land use not being achievable. A proposed NUMA that cannot satisfy one or more of these elements must be supported by evidence.

PRC Plan related content has been provided where available in this Response and further details will be included in the CVM PRC Plan submission in accordance with the DES PRC Plan Guideline (DES 2021) requirements. Similarly of note, given mine plans are routinely refined during the life of open cut mining operations, the CVM PRC Plan submission will use the most up to date mine planning information available to inform the landform design and rehabilitation plans.

5.1 BMA Response to Requested Action 9

Requested Action 9: *Clarify whether the proposed 680ha is for the combined Horse Pit (existing and extension) or proposed for Horse Pit extension only.*

The conceptual final landform and proposed residual void area presented in the EA Amendment Supporting Documentation reflects the void area for Horse Pit at closure, i.e. combined Horse Pit (existing and extension).

5.2 BMA Response to Requested Action 10

Requested Action 10: *Confirm the land outcome for the final void.*

The Horse Pit final void will be a residual void.

5.3 BMA Response to Requested Action 11

Requested Action 11: *If a post mining land use is proposed, provide the following:*

a) What is the land use?
b) Provide an assessment of how such land use will be achieved considering the modelled water quality and water levels detailed in Appendix F of the application's supporting document. Modelling is expected to be based on a minimum of 500 years.
c) Provide specific completion criteria for the proposed use of the final void.
d) Accessibility for use and viability of the use.

The void will be a residual void with no post-mining land use proposed.

5.4 BMA Response to Requested Action 12

Requested Action 12: *If a non-use management area is proposed, provide the following:*

a) Details of if the land can achieve a safe and structurally stable landform.
b) Details of any impacts from the release of contaminants from the final void and how the volume of such contaminants will be minimised.
c) Details of why the land cannot be rehabilitated to achieve a PMLU.
d) Detail the type and extent of environmental harm that is likely to occur if the NUMA is not rehabilitated to a stable condition. This assessment should factor in any best practice management measures that will be implemented to mitigate environmental impacts over the life of the project and into the future.
e) Identifies the most achievable rehabilitation option from those considered for the land as part of the PMLU assessment.
f) Provide specific completion criteria that assures achievement of stable condition and detail any ongoing management requirements for the NUMA.

The void will be a residual void with no post-mining land use proposed. This is consistent with the EA conditions that apply to the existing Horse Pit void. As described below, the residual void will be safe, structurally stable and cause no environmental harm outside of the tenure boundary.

The residual void is designed to achieve an area that is safe and structurally stable. Structural stability is achieved through geotechnical assessments to include wall set-backs at natural ground level to achieve a factor of safety of 1.5 (refer to Actions 5, 6 and 8), therefore no geotechnical damage is expected beyond the set-back. Safety features are incorporated to prevent unrestricted access by humans and livestock and will include a safety bund constructed at the set-back distance to achieve a factor of safety of 1.5, as well as fencing and signage.

The location of the residual void will not present an unacceptable risk of environmental harm outside of the tenure boundary due to:

- Mitigating the risk of flooding into the residual void up to the 0.1% Annual Exceedance Probability (AEP) flood level through backfilling of the north end of the final void at the end of mining;
- Containing potential site-wide contaminants within the mining tenements as the residual voids:
    - Act as long-term groundwater sinks;
    - Do not overtop (release void water to surface waters or the surrounding landscape) as long-term pit water levels remain well below the spill point; and
- Preventing interconnectivity between the deeper Permian and shallower alluvial aquifers).

Completion criteria for the area includes:

- Achievement of structural stability:
    - The required high-wall, end-wall and low-wall set-back to achieve a FoS ≥1.5, is determined by an appropriately qualified person;
- Achievement of surface requirements:
    - Safety bund (minimum 2m height and 4m base width) is constructed, where required, at the geotechnical set-back distance;
    - Fencing erected around perimeter of safety bund, where required;
    - Warning signage placed along the fence line (nominally one sign every 100m);
- Achievement of sufficient improvement:
    - Certification from an appropriately qualified person that the residual void is safe to humans and livestock; and
    - Certification from an appropriately qualified person that the residual void will not present an unacceptable risk of environmental harm outside of the tenure boundary.

6 Mine Disturbance Footprint

The application provides the progressive landform for 5 yearly periods between 2025 to 2050 and the proposed conceptual final landform in section 3.5.3 of the supporting information. However, the figures lack details as to the different domains, extent of the areas and progression of rehabilitation.

6.1 BMA Response to Requested Action 13

Requested Action 13: *Show the mine disturbance footprint at various stages over the extension period and final landform design/rehabilitation including:*

a) Domains;
b) Extent of pits (including area);
c) Progression of rehabilitation.

Figures 3-8 through to 3-14 of the EA Amendment Supporting Documentation have been amended to include additional detail on the location and extent of features such as the OOPD and active pit.

7 Rehabilitation of the Horse Creek Levees

Section 5.5.5.6 of the supporting document states that with the removal of the Horse Creek levees the final landform will form part of the Horse Creek floodplain.

"The final landform includes areas of raised ground, which act as bunding for the final void from the 0.1% AEP event. These bunds are very stable, rising from 10 m to 20 m height over a length of 1 km, with top widths of approximately 50 m. These areas will be well vegetated to prevent erosion and to mitigate the potential for increased sediment load downstream."

7.1 BMA Response to Requested Action 14

Requested Action 14: *Provide final landform designs of the areas located within the Horse Creek floodplain to demonstrate how the removal of the temporary levees within the area will continue to maintain protection from a 0.1% AEP event*.

Flood modelling indicated that Horse Pit final void requires flood protection for a 0.1% AEP flood event once the temporary levee is removed. The final landform design for Horse Pit includes the removal of haul roads and levees and backfilling of the northern end of the void to provide the required flood mitigation from Horse Creek up to and including the 0.1% AEP flood level. The designed void backfill covers approximately 9% of the final void to a level one metre above the 0.1% AEP flood levels (including the worst-case modelled climate change scenario), to provide adequate protection of the residual void from ingress of flood waters.

7.2 BMA Response to Requested Action 15 and 16

Requested Action 15: *Provide further details of the materials used to construct these bunds and the timeframes of construction and subsequent rehabilitation.*

Requested Action 16: *It is anticipated that the initial construction of the bunds has the potential to result in an increase sediment load downstream, provide further details as to the mitigation measures which will be implemented to ensure there is no additional risk to downstream environmental values and no residual impact.*

The purpose of the levees will be to maintain a 0.1% AEP flood immunity during mining operations, working to avoid water from the wider catchment flooding Horse Pit and becoming mine affected. These levees described will be temporary and will be removed at closure.

The levees will be designed and constructed in accordance with the conditions in Schedule G of the CVM EA. The levees will be regulated structures and as a result Condition G6 will require:

'Construction of a regulated structure is prohibited unless the environmental authority holder has submitted a consequence category assessment report and certification to the administering authority has been certified by a suitably qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant condition of this environmental authority.'

Similarly, the structures will be designed and constructed in accordance with and conform to the requirements of the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (in accordance with CVM EA Condition G8).

Design details (including determining the construction materials, timeframes for construction, interim stabilisation requirements, construction management requirements and revegetation requirements) will be developed in the lead up to pit progression reaching the point where the levees will be required.

The design process will address the EA condition requirements, including those relevant to the management of erosion and runoff to the adjacent Horse Creek watercourse during construction and operation. Where appropriate, temporary erosion and sediment controls will be implemented to avoid the release of sediments to the watercourse and downstream during the construction of the structures, in accordance with CVM EA Condition F26 for stormwater and water sediment controls. As described in Section 5.5.5.1 of the EA Amendment Supporting Documentation, all water management structures will be designed and constructed using practical hydraulic parameters based on an appropriate risk-based rainfall event, catchment size, slopes, discharge design and soil types. The design criteria will be as per relevant BMA standards and guidelines for Mine Affected Water (MAW) management and erosion and sediment control, and in accordance with EA conditions. Implementing these measures aims to avoid the potential impact of sediment transport to the downstream environment.

The purpose of the BMA Erosion and Sediment Control (ESC) and MAW Standard (the BMA Standard) is to provide guidance on the management, minimum design standards and application of the ESC and MAW at BMA operations. Its primary objective is to comply with the CVM EA conditions and reduce impacts to the receiving waters from site operations. The BMA Standard notes sediment control measures shall be designed and constructed in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018).

8 Air – Environmental Objective 1 and Performance Outcome 1.2

The Project must continue to implement effective environmental strategies with regards to Air, including all of the following performance outcomes:

a) fugitive emissions of contaminants from storage, handling and processing of materials and transporting materials within the site are prevented or minimised;

b) contingency measures will prevent or minimise adverse effects on the environment from unplanned emissions and shut down and start up emissions of contaminants to air;

c) releases of contaminants to the atmosphere for dispersion will be managed to prevent or minimise adverse effects on environmental values.

The application document states an increase in the operational risks associated with air quality impacts to sensitive and commercial receptors, particularly in relation to dust deposition and PM10 emissions. Air quality modelling results show a potential impact and exceedance of the air quality objectives of the Environmental Protection (Air) Policy 2019 for dust deposition and PM10 emissions under unmitigated scenarios.

8.1 BMA Response to Requested Action 17

Requested Action 17: *Provide an air quality assessment that demonstrates the following:*

a) *The correlation of the surrogate systems/monitoring points installed and implemented on Caval Ridge and the sensitive and commercial locations to which they represent for Site 2 Long Pocket Rd East as a surrogate for Moranbah Township.*
b) *Modelling, and details of required mitigation measures, for how the CVM trigger action response plan (TARP) will perform against the Environmental Protection (Air) Policy 2019 dust deposition and PM10 limits at the following commercial and sensitive places:*
   i. *Site 2 Long Pocket Rd East as a surrogate for Moranbah Township*
   ii. *Site 6 Long Pocket West*
   iii. *Site 8 Moranbah Airport*

8.1.1 Action 17a Correlation of monitoring points with relevant locations

Information specific to the correlation of monitoring points with neighbouring receptor locations has been included in Section 6.5 of Appendix C of the CVM EA Amendment Supporting Document (which has been updated in response to this RFI query).

8.1.2 Action 17b Model mitigation scenarios

Modelled mitigation scenarios are provided in Section 5.4.4.2 of the CVM EA Amendment Supporting Document. The results provided show the extent to which mitigation measures may be required in order to meet CVM EA Condition B6. The selection of mitigation measures is informed by the TARP. The scenarios presented focus on mitigation measures that target waste handling by truck shovel mining methods given this activity being highlighted as one of the key drivers to predicted impacts.

The results of the modelling suggest the range of mitigation measures available to site will be sufficient to adequately manage operational dust risk.

Demonstrating performance against the EPP(Air) requires combining results for the Project (as summarised in Sections 5.4.3.4 and 5.4.4.3 of the CVM EA Amendment Supporting Document and detailed in Appendix C) and background levels. 'Background' refers to the state of the air quality environment that would occur in the absence of CVM mining operations and includes both anthropogenic and non-anthropogenic dust emission sources. Commonly, a single fixed value to estimate background levels of dust is used for assessment purposes, while other assessments include a variable background (in accordance with the NSW EPA approved methods for assessment. The background dust environment at Moranbah (DES Moranbah (Utah Street) dust monitoring station data) is known to be highly variable and hence interpretation of results based on dust dispersion models in accordance with the EPP(Air) can be complicated. Similar to the study of performance against EA Condition B6, dispersion modelling for mitigation scenarios when performance is measured against the EPP(Air) objective for the 24 hour average concentration of PM10 based on variable background conditions, also suggests the range of mitigation measures available to site will be sufficient to adequately manage operational dust risk.

8.2 BMA Response to Requested Action 18

Requested Action 18: *What are the drivers causing the potential for exceedances at sensitive and commercial receptors located at Moranbah Airport, the Township of Moranbah, and Long Pocket West?*

Operationally, the key dust emission sources will vary based on the location of mining activities relative to the monitoring stations, mining intensity and meteorological conditions. The key drivers for potential exceedances at sensitive and commercial receptors is documented in Section 5.4.4.1 of the CVM EA Amendment Supporting Document and detailed in Appendix C (both of which has been updated in response to this RFI query).

8.3 BMA Response to Requested Action 19

Request Action 19: *Provide evidence or a case study on the effectiveness of both the previous Dust Control System and the current upgraded Dust Control System which demonstrates:*

a) *The ability of the system to trigger an alert to conditions indicating a possible exceedance in dust deposition and PM_{10} emissions;*
b) *The response including mitigation and management measures implemented; and*
c) *The outcome of the potential or actual exceedance events.*

Case studies and other relevant information regarding the Dust Control Systems is documented in Attachment F of Appendix C of the CVM EA Amendment Supporting Document (which has been updated in response to this RFI query).

8.4 BMA Response to Requested Action 20

Response Action 20: *Provide a detailed description including trigger levels of how a revised TARP will incorporate the new data streams from the Dust Control System upgrade project (Figure 11 – Appendix B Air Quality Assessment) to ensure no exceedances occur at a sensitive or commercial places.*

Details of the TARP and trigger levels is considered to be commercially sensitive information and is not provided in detail in this response. Broadly, the TARP provides a procedure for the implementation of additional dust mitigation measures in response to alarms triggered by the CVM dust control system (DCS).

The DCS monitors sensor data on a continuous basis which is processed based on a set of rules for estimating/calculating key parameters. Alarms are triggered based on dust levels at any of five monitoring locations, and are associated with a series of notifications to site teams and the BMA integrated remote operations centre. There are three escalating levels of alarms. When an alarm is triggered by the DCS, the roles and responsibilities for each of the relevant team members are outlined in the TARP.

8.5 BMA Response to Requested Action 21

Response Action 21: *Describe in detail the steps in the TARP and how it works, including but not limited to, the provision of a risk matrix with the different levels of PM_{10} emissions and dust deposition emissions triggered by the Dust Control System and what actions and responses would be carried out at CVM for the different risk levels.*

Note: The department recognises the response and actions would be dependent on a range of factors informing the Dust Control System, however some examples of the different steps which would be considered would be beneficial to understand more about the TARP.

See response to Requested Action 20.

8.6 BMA Response to Requested Action 22

Response Action 22: *Model the worst-case scenario for the release of dust and PM_{10} emissions from the out of pit dump and provide details of the required mitigation measures to achieve the Environmental Protection (Air) Policy 2019 limits for dust deposition and PM_{10} emissions at each of the sensitive or commercial places. Please provide modelling based on the following three scenarios:*

a) The out of pit dump is to remain where it is currently proposed; or

b) In pit backfilling (no out of pit dump required);

c) Haulage to another area of CVM.

In the context of the total volume of waste at the CVM (in the order of 1.8B BCM), the OOPD represents approximately 3% of the waste to be moved by truck and shovel at the CVM. The volume of waste to be transported via truck and shovel to the proposed OOPD is estimated in the order of 50-60M BCM. Movement of waste to the OOPD does not represent a substantial component of waste transport for the mine (and in turn is not a significant contributor to environmental impacts such as dust generation).

Specific to the OOPD, PM10 modelling was conducted for the Project With Case (includes the OOPD) and the Project Without Case (excludes the OOPD) in order to consider the scale of any difference. (‘Project With Case’ is modelling that includes the extension of Horse Pit). Activities related to the OOPD will include truck hauling and dumping of waste and stockpile shaping by dozer. These activities are explicitly accounted for within the mine plan which is the basis of the air quality assessment for the Project With Case.

Details of the modelled contribution of the OOPD to PM10 emissions is documented in Attachment E of Appendix C of the CVM EA Amendment Supporting Document (which has been updated in response to this RFI query). In addition, Section 3.2 of this document discusses dump options in the context of the requirement for an OOPD.

8.7 BMA Response to Requested Action 23

Response Action 23: *Provide details of how rehabilitation planning at the project will ensure that total area of disturbance at any one time is minimised to reduce the potential for wind-blown dust or air emissions and assure rehabilitation is commenced and completed as soon as reasonably practicable. Include a schedule of the planned rehabilitation that assures the accelerated rehabilitation* of areas of influence on air quality impacts at sensitive receptors.

The rehabilitation schedule and aspects relating to planning are described in Section 5.2 of the CVM EA Amendment Supporting Document and Sections 4, 5, 6 and 7 of this appendix.

9 Water – Environmental Objective 2 and Performance Outcome 2.2

The Project must continue to implement effective environmental strategies with regards to Water, including all of the following performance outcomes:

a) the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks;

b) contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water;

c) the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment;

f) any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland;

h) the activity will be managed so that adverse effects on environmental values are prevented or minimised.

Note— Some activities involving releases of dissolved inorganic nitrogen or fine sediment to Great Barrier Reef are prohibited under section 41AA of the EP Regulation, refer to GBR considerations above. The proposed amendment includes the relocation of mine water dams and pipelines. The proposed levees particularly the north levee are designed to ensure infrastructure and mining areas are protected from flooding from Horse Creek and Cherwell Creek.

9.1 BMA Response to Requested Action 24, 25 and 31

Response Action 24: *Illustrate how any regulated structure on site would be managed during periods of high incidental rainfall and/or various flood scenarios so that any potential impacts to land or water are minimised.*

Structures will be managed in accordance with Schedule G of the CVM EA. Each structure will have a consequence category assessment (CCA) completed in accordance with the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933).

High or significant category structures will be regulated and designed, constructed and operated in accordance with the CVM EA conditions and the Manual. The regulated structures require a certified operational plan developed with included management methods for high rainfall and flood events.

Low consequence category structures are not regulated and are managed in accordance with BMAs ESC Standard. The new ESC structures and changes to existing MAW storages associated with the Project are considered to be low consequence classifications and therefore not regulated structures. This will be reviewed and confirmed as part of the detailed design of these storages. All water structures will be designed to comply with the CVM EA and the BMA Standard.

For new ESC structures minimum design standards require the trapping or retention of sediment via ‘sediment controls’ supported by erosion and drainage controls to prevent or minimise erosion. Drains or bunds separate catchments of different water types and each catchment is risk assessed. The catchment risk assessment is used to define the sediment control structure design, in particular the sizing. Sediment control measures are designed and constructed in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). Where sediment basins are required they are designed to trap a proportion of entrained sediment in catchment runoff. The detention volume determines the proportion of sediment that falls out of suspension.

For the changes to existing MAW storages the BMA Standard requires at least two CCA assessments (one under the Manual and one under the Canadian Dam Association Technical Bulletin: Application of Dam Safety Guidelines to Mining Dam). MAW dams shall have at least an additional 10% of their design storage allocated as sediment storage and those dams with an anticipated design life of >20 years shall consider climate change as part of their design. The CVM WBM informs design features and including the Design Storage Allowance while hydraulic assessment inform the Maximum Reporting Level or the Maximum Allowable operating level. The operating levels will be detailed in the structure's operating manual to assist operational readiness.

If there are MAW dams that rely on pump operation to achieve acceptable overtopping frequency and likelihood these shall be fitted with automated stop/start and remote monitoring. They are de-watered to the site MAW management system within five days of a rain event subject to being safe to do so and access permitting. Water quality samples aim to be acquired within a week of the rain event.

ESC structures, levees and MAW dams are inspected pre and post wet season (at a minimum) and operational controls require dewatering to reset to the minimum operational level and provide the required settling storage for rainfall events. The spillway capacity of the dams is designed specific to the consequence category and catchment risk.

Response Action 25: *Describe how risks associated with dam or storage failure, seepage through the floor, embankments of the dams, and/or overtopping of the structures will be avoided, minimised or mitigated to protect people, property and the environment.*

Structures will be designed and assessed in accordance with the Manual which includes an assessment for, failure to contain overtop, failure to contain seepage and dam break. The CCA and population at risk will also be assessed in accordance with ANCOLD and Canadian Dam Association guidelines. Design and management of high or significant structures are managed in accordance with schedule G of the EA and designed, constructed and managed in accordance with the Manual and associated dam specific document required there in. Low consequence structures will be managed in accordance with BMA's standard. Water infrastructure with a design like of 20 years or greater shall consider climate change.

BMAs Standard includes appropriate avoidance, maintenance, and risk minimisation activities in accordance with the nature and type of structure. The standard references other best practice guidelines and includes risk minimisation or mitigation measures such as:

- Avoidance through separation of clean and disturbance areas;
- Progressive rehabilitation;
- Locating and or scheduling of works to minimise required controls or likelihood of runoff entering waterways;
- Permanent and temporary ESC works in accordance with risk and industry standards; and
- Performance indicators, maintenance requirements and incident reporting.

The CVM's WMP and ESC plan will be used to provide continued monitoring and management of the system and will be updated annually by a suitably qualified person under conditions F25 and F26 of the EA. If inspections identify potential embankment integrity issues or failures, then the downstream must be cleared of personnel, downstream landholders contacted (if applicable) and situation referred to the site Responsible Dam Engineer.

***Response Action 31:** What additional mitigation and management measures would need to be implemented to ensure a 0.1% AEP flood immunity of all water running off from the OOPD?*

Under the definition of MAW in the EA, rainfall runoff from the OOPD does not meet the classification of MAW. Drains around the OOPD will be ESC drains and were incorrectly reported as MAW drains in Appendix E of the EA Amendment Supporting Documentation. BMA have assigned the design criteria for ESC drains in accordance with the BMA Standard which is formed from the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). The drains around the OOPD provide conveyance of a 10% AEP event to the associated ESC dams. This ESC system provides for settling of sediment and is standard for similar systems across the site. ESC will be managed under the sites ESC plan. The plan includes management measures such as review of the sediment deposition that is in excess of the design allowed sediment storage volume. There are no new stockpiles associated with the Project with the existing facilities being utilised.

9.2 BMA Response to Requested Action 26

***Response Action 26:** Provide details of any additional flood risk to sensitive receptors and downstream structures due to the construction of the proposed levees.*

The proposed levees are designed to prevent ingress of clean water from Horse Creek to the mine pits. Flooding in excess of the design criteria which may result in a breach of the levees (rarer than a 0.1% AEP) could result in ingress of water to the mine pit. This water would then become MAW contained in the pit and would not pose risks to any sensitive downstream receptors or structures, as it would to be managed within the MAW management system.

The flood behaviour within the Horse Creek channel was also reviewed against the Australian Coal Industry Research program (ACARP) design criteria and existing flood behaviour. The results presented in Appendix E of the EA Amendment Supporting Documentation indicate the construction of the levee does not change the key stability criteria noted in ACARP and as such impacts to downstream sensitive receptors and structures is expected to be minimal.

The levee will be designed in accordance with the existing EA conditions and the Manual (ESR/2016/1933). Potential for scour and erosion is considered as part of the levees detailed design and mitigation measures incorporated where required. Measures to mitigate risks to downstream receptors and structures during construction of the levees are stated in Section 6 in Appendix E of the EA Amendment Supporting Documentation and will include local sediment and erosion control measures during construction and will be detailed in the ESC Plan for the levee.

9.3 BMA Response to Requested Action 27

***Response Action 27:** Confirm that, as a result of the proposed amendment, there is no residual impact due to an increase in fine sediments or dissolved inorganic nitrogen being released to Horse Creek?*

The proposed amendment largely results in additional requirements for ESC structures from non-MAW sources which are not considered as point source releases of interest under the reef discharge standards (ESR/2021/5627 - Version 1.02, May 2022). As outlined in Section 9 the sediment dams have been designed in accordance with the relevant standards and guidelines with controls informed based on a risk based approach to water management, where there is a balance between capturing and treating water running off disturbed areas and providing for good quality water to continue to flow downstream for users and the environment.

The proposed changes to the MAW system as part of the Project include relocation and increases to the capacity of mine water dams (MWD) N1 and N2, which will then pump back to the designated release point at 12N dam. The proposed increase to these storages is to manage the additional MAW from the proposed amendment such that MAW can continue to be managed in accordance with the existing release conditions of the EA. There are no proposed releases of MAW from the relocated MAW dams, with water being pumped back to the 12N clean water dam for release in accordance with the EA including relevant water quality conditions.

The water management system and the likelihood and magnitude of releases and spills have been examined using a water balance model. The basis of this water balance model was BMAs Central Regional Water Network (CRWN) model. The CRWN model is a linked water balance model which includes modelling of all four BMA mines in the vicinity of the Project, including CVM, PDM, Saraji Mine (SRM) and South Saraji Mine (SSRM) (formally Norwich Park Mine). The model also includes a good representation of the receiving waterways including impacts of upstream water storage on flow patterns.

The model considers climate variability and is based on 500 replicates of probabilistic rainfall data to allow for uncertainties and variability associated with the climate.

The combined model provides BMA with a tool that greatly reduces the number of unknowns, providing a greater confidence to the predictions across all operations (e.g., influence of cumulative releases on water quality and the potential need to reduce release rates). It also allows the system to transfer water between mine sites utilizing the CRWN mine affected water pipeline. This seeks to reduce the amount of raw water used on the site and reduce environmental harm by allowing water to be stored and released appropriately. This subsequently reduces the likelihood of uncontrolled releases across all sites and provides confidence in release volumes and impacts, considering cumulative releases on water quality. The model accounts for the EA conditions on all releases at all mines and considers the water quality requirements in the source / release storage and receiving waterbody.

While the CRWN pipeline does allow water to be sent to other mines this is predominantly undertaken to allow for water reuse at other operations during times of water scarcity and not for release. The ephemeral nature of all creeks which form approved release points for the CRWN mine result in a relatively short window of a potential release. The CRWN capacity varies over its length, but maximum capacity is typically in the order of 400 L/s. Capacity between CVM and PDM is in the order of 270 L/s. Even at this capacity the time required to move water to alternative release points means, coupled with infrastructure bottlenecks on the release infrastructure dams (such as their capacity), mean transfer of water to facilitate additional release of mine affected water is unlikely.

The Project presents results for dry, average and wet years. These are based on the 500 probabilistic climate records simulated in the water balance model where the dry is the 5th percentile result across all records, average the 50th percentile and wet the 95th percentile. The average is typical of historical climate observations. The modelling predicts that when these events are occurring the quantum of flows in the receiving waterway (based on the gauge at Deverill) would be between 20 m^3/s and 250 m^3/s for average and wet climate conditions. These are presented graphically against the daily flow frequency curve from the DNRM Deverill Gauge in Figure 9-1. That is, during the average or wet events the receiving waterways will be flowing in significant volumes. In context, typical releases during these events would be 0.3 m^3/s and 1 m^3/s.

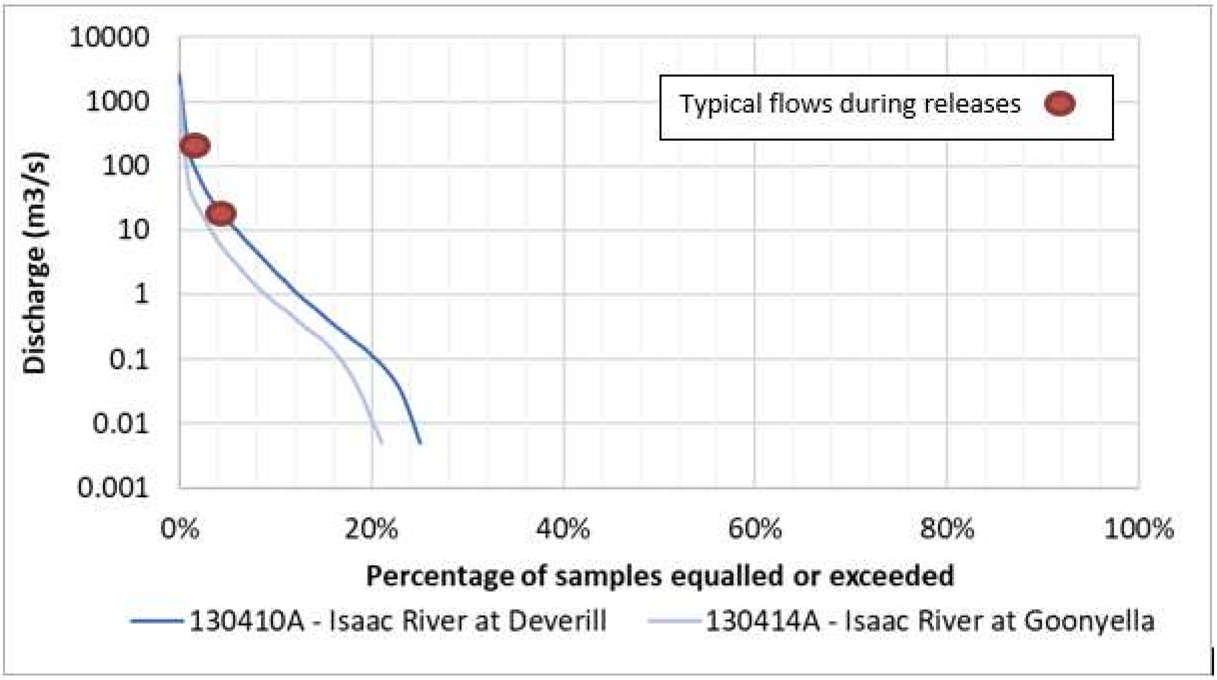


Figure 9-1 Daily Discharge Exceedance Curves

Salinity studies for the Fitzroy Partnership on River Health in 2011 (Jones, 2013) also indicate that although cumulative mine water releases in the Fitzroy River Basin accounted for 9% to 25% of the total salinity, the actual water quality monitoring within existing storages on site was within acceptable limits (Kafle et al. 2018).

Overall, the disturbance footprint for the Project is a very small portion of the catchment:

- 7 % of Horse Creek;
- 0.5 % of Grosvenor Creek;
- 0.4 % of Cherwell Creek; and
- 0.2 % of the Isaac River catchment at the Grosvenor Creek confluence.

Groundwater input to the system is even smaller, with 198 ML/annum[2] vs the 1,600 ML/annum of surface water runoff from rainfall in an average year and 6,000 to 7,000 ML/annum in a very wet year. Of this between 1,100 ML/annum and 800 ML/annum is lost to evaporation (depending on climate) with only 60 ML/annum released during a median year and 1,200 ML/annum during a very wet year (releases and overflows).

[2] Groundwater inflow to the CVM pits generally occurs as damp or low flow seeps in the mining faces, making the direct measurement of the groundwater inflow virtually impossible. Most of the groundwater inflow evaporates directly from the mining face, and it is only any remaining groundwater that pools at the base of pits. This water is then left to evaporate, or is pumped out of the pit, along with any captured surface water runoff. The inflow estimate provided by the groundwater model includes groundwater that evaporates from the pit floor and face before being 'seen'.
This means the GW inflow numbers provided by the model are, at best, a highly conservative upper limit estimate of the volumes that might report to the mine water management system and need to be considered in a physical mine water balance.

9.4 BMA Response to Requested Action 28

***Response Action 28:** Confirm that the existing mitigation and management measures to be implemented will be able to meet the listed performance outcomes with the expanded scale of the Project.*

The performance of the existing water management system for the Project has been examined through both flood modelling and water balance modelling for a range of scenarios with the modelling indicating that the system is able to meet the design criteria stated for the relevant structure. The performance of the system will be continuously reviewed as part of the sites ESC Plan and WMP.

Monitoring is an essential part of the CVM environmental systems and WMP. This includes monitoring through the REMP and as required by the EA. Monitoring is conducted against local water quality objectives defined through the REMP sampling (Aquatic Ecology Assessment, ESP 2021). The REMP monitoring will be continued for this Project, and amended as additional data becomes available.

This Project is located adjacent to Horse Creek which flows into Grosvenor and north of Caval Creek which flows into Cherwell Creek, both reporting to the Isaac River. These tributaries have relatively small catchment areas: Horse Creek 57 km^2, Cherwell to the Harrow Creek confluence 631 km^2 and Grosvenor Creek 633 km^2. This compares to the 1,214 km^2 and 4,092 km^2 Isaac River Catchments at Goonyella and Deverill (refer to Figure 9-1 for flow duration). Hydrologic modelling undertaken for the Project indicates that even during extreme events, these creeks are only in flow for approximately 6 h. As such, monitoring on these waterways is difficult and is likely to include only limited sampling, which makes decision making in response to the sampling difficult.

BMA will also continue monitoring for their adjacent sites, in accordance with the relevant EAs. This monitoring extends the collective BMA monitoring program along the Isaac River.

9.5 BMA Response to Requested Action 29

***Response Action 29:** Where the existing mitigation and management measures cannot achieve the listed performance outcomes, provide details of what additional and/or modified mitigation and management measures will be implemented to meet these performance outcomes.*

The proposed water infrastructure achieves compliance with regulatory requirements and guidelines such as the Manual and BMAs MAW and ESC Standard. The performance of the system against these design standards has been examined through flood and water balance modelling.

BMA will continue monitoring for their adjacent sites, in accordance with the relevant EAs. This monitoring extends the collective BMA monitoring program along the Isaac River. BMA propose that regular visual assessments of these receiving waterways are carried out on a routine basis and post any flow events, to identify potential erosion and sedimentation of the watercourses as well as any pools of water that may support opportunistic sampling (which may include sediment sampling). Mitigation actions will be developed by BMA following any adverse findings and actioned based on procedures to be outlined in the WMP.

9.6 BMA Response to Requested Action 30

***Response Action 30:** What are the likely impacts to environmental values in the instance of an overflow of mine affected water from the stockpile area?*

There are no new stockpiles associated with the Project with the existing facilities being utilised. The OOPD was incorrectly referred to as a stockpile in Appendix E of the EA Amendment Supporting Documentation. Impacts to environmental values from the overflow of ESC water from the OOPD ESC structures is considered to be minimal with the system designed to capture a 10% AEP 24-hour event allowing for settlement of sediments from rainfall runoff in the OOPD. Please refer to Requested Action 27 for further detail on the likely impacts to the surrounding environment.

9.7 BMA Response to Requested Action 32

Response Action 32: *If the OOPD was not to be constructed, but alternatively waste rock used to backfill Horse Pit, would the existing mitigation and management measures be able to maintain pit flood immunity up to 0.1% AEP?*

The surface water impacts of the Project have been assessed based on the Project outlined in the Project Description with the Project Justification and Alternatives presented in Section 4 of the EA Amendment Supporting Documentation. A scenario of no OOPD has not been considered. Please refer to Sections 3.2 for further discussion on the OOPD.

9.8 BMA Response to Requested Action 33

Response Action 33: *Confirm that, mine affected water drains within the OOPD area will not result in a residual impact due to an increase in fine sediments or dissolved inorganic nitrogen being released to Horse Creek?*

As stated in Section 9.3, there are no MAW drains proposed, with the drains surrounding the OOPD being ESC structures. Water is only released from the MAW system at designated release points in accordance with the EA. The proposed changes to the MAW system as part of the Project include relocation and increases to the capacity of MWD N1 and N2, which will then pump back to the designated release point at 12 N dam. Releases will occur in accordance with the current EA conditions which consider the water quality of the waters being released and flow in the receiving waterway. The likelihood of uncontrolled releases from the MAW dams MWD N1 and N2 was assessed as part of the Project's water balance modelling with the likelihood of an unplanned or uncontrolled release being less than 1% AEP.

9.9 BMA Response to Requested Action 34

Response 34: *If there is a residual impact, the requirements under section 41AA must be considered*

As discussed in Sections 9.3 and 9.6, residual impacts are not expected. However, BMAs MAW and ESC Standard and subsequent WMP and ESC Plan for the site includes several avoidance and minimisation measures based on minimisation of disturbance, separation of clean and disturbed areas, progressive rehabilitation and maintenance measures. Minimum sampling (dam water) requirements for all ESC and MAW dams include:

- Initial: sampling following a minimum of three rain events
- Event-based: sample sediment dams that have the potential to discharge to the receiving environment following at least one rainfall event per year, using full REMP analysis suite.
- Ongoing: sample full REMP analysis suite following controlled discharge events

Monitoring of surface water quality will continue to occur under the REMP in accordance with condition F20 REMP of the EA. In addition to this, monitoring of contaminants from any authorised releases will continue to be carried out in accordance with condition F4 of the EA. The monitoring undertaken includes for Nitrate and Total Nitrogen parameters and trigger levels are defined by conditions of the EA. Exceedance of any triggers requires notification, investigation, and actions to prevent environmental harm.

10 Groundwater – Environmental Objective 4 and Performance Outcome 4.2

The Project must continue to implement effective environmental strategies with regards to Groundwater, including the performance outcome of:

'the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.'

Figure 8-1 of Appendix F indicates that the groundwater monitoring bores of the proposed monitoring network are within the pit extent of the extension project. Additionally, there is a lack of bores on the western side of the mine for identification of upgradient concentrations.

10.1 BMA Summary of Responses to Groundwater

A summary of BMAs groundwater RFI response is provided in the following text. Further details on each RFI are provided in the following subsections.

In response to Action 35 and 38 the model is deemed fit for purpose for use in the assessment based on the following:

- In accordance with IESC Guideline requirements under the EPBC Act, the Project's groundwater model was subject to an Independent Peer Review (Appendix J1) by an expert hydrogeologist/modeller who confirmed it meets mostly Class 2 criteria at a minimum;
- In accordance with the 2012 Australian Groundwater Modelling guidelines the model meets mainly Class 3 criteria with elements of Class 1 and Class 2; Class 3 models are considered suitable for the scale of the Project;
- Alluvium is limited in extent horizontally to creek channels;
- Depth to the water table across the Project Area show the shallow groundwater system to comprise Tertiary sediments and weathered Permian units, with alluvium (where present) unsaturated;
- The model was designed using an unstructured grid with varying Voronoi cell sizes. The grid is specifically refined around surface drainage features to improve model resolution in the vicinity of these features;
- Layer 1 extents (horizontal and vertical) were defined using a variety of sources including site exploration drilling and monitoring bore lithology data, the CVM geological model, state geological mapping and CSIRO regolith survey data;
- High resolution (1m) Digital Elevation Model (DEM) data was used to define local surface elevation within the Project Area including the upstream parts of Horse Creek. Outside the extents of the DEM dataset for the Project, LiDAR data from were used to define surface elevation where available, including at several mines/projects adjacent the Isaac River;
- Surface water drainage features were built into the model using MODFLOW-USG RIV package, including Isaac River, Grosvenor Creek, Cherwell Creek, and Horse Creek. The model included seven (7) specific recharge zone, with areas of alluvium characterised as one of three recharge zones;
- The MODFLOW Evapotranspiration (EVT) package was used to simulate evapotranspiration from the groundwater system. An EVT rate of 0 was assigned to the model cells representing the rivers so that EVT cells were not in conflict with RIV cells;
- There is sufficient groundwater data available within the shallow groundwater system to enable robust calibration of the model; and
- The model has a mild tendency to over-estimation of heads, especially at lower elevations (i.e. predict higher groundwater levels than is measured, which would result in a more conservative assessment of potential impacts on shallow environmental receptors such as Groundwater Dependent Ecosystems (GDEs)).

In response to Action 36 and 37 the groundwater monitoring network proposed for the extension project is suitable for assessing predicted impacts for the lifetime of the Project on the following:

- The proposed Horse Pit Extension (HPE) groundwater monitoring network at CVM comprises nine (9) existing EA monitoring bores, nine (9) monitoring bores installed for HPE Project assessment, one (1) additional monitoring bore and two (2) VWP sensor arrays that were installed for the HPE Project assessment;
- The Project groundwater monitoring network has been suitably designed to enable continued assessment of predicted impacts to all relevant hydrostratigraphic units and associated receptors up and down hydraulic gradient of the Project area;
- BMA commit to the installation of a shallow monitoring bore to monitor potential seepage from the proposed out of pit storage area proposed in the northwest of the ML;
- BMA will not install additional monitoring bores in the vicinity of existing and proposed water storage structures (sediment dams, mine water dams and process water dams) as operation and monitoring requirements of these structures is incorporated under the structures operational plan;
- Monitoring of bore MB20CVM01A will enable assessment of Project impacts to the shallow groundwater system in the northeast of the mining lease and will enable early identification of potential impacts to potential terrestrial GDEs located downstream at the confluence of Horse Creek and Grosvenor Creek;
- BMA commit to the replacement of monitoring bores 2yrs prior to being mined out by the Project activities; and
- BMA commit to the replacement of PZ01 2yrs prior to being mined out by the Project activities. PZ01 will continue to be monitored as per current EA conditions until this date.

In response to Action 39:

- There are limited Project activities with the potential to cause groundwater quality impacts. Mitigation measures deemed required to prevent impacts from mining activities on groundwater quality are limited to appropriate design of workshops and storage areas (i.e. mine supporting infrastructure where potential contamination sources will be present). Other potential groundwater quality impacts that may arise from waste rock emplacements and void water storage will be naturally managed by the inwards hydraulic flow gradients that will exist between the mine pit voids and the surrounding groundwater environment that will inhibit outflow of any mine affected water to the broader receiving groundwater environment.
- Groundwater inflow will continue to be estimated in accordance with the Department of Resources guidelines for quantifying the volume of associated water taken under a mining lease or mineral development licence.

10.2 BMA Response to Requested Action 35

Requested Action 35: *Provide further details as to any additional impacts or risks to groundwater or groundwater users which would result from the proposed amendment.*

Section 5, Appendix F, Groundwater Resources Assessment, of the EA Amendment Supporting Documentation provides a detailed hydrogeological conceptualisation of the Project and greater study area. This includes identification of relevant environmental values and groundwater users. Numerical modelling has been completed and peer reviewed in accordance with groundwater modelling guidelines (including the DES Guideline for site-specific and amendment applications – underground water rights (ESR/2016/3275) (DES 2021), and the Independent Expert Scientific Committee (IESC) Information guidelines for proponents preparing coal seam gas and large coal mining development proposals (IESC 2018)).

The report provides a detailed risk and impact assessment based on the conceptual understanding and numerical model results. As a result, there are no additional risks or impacts to those reported in the submitted material to note. The groundwater assessment is considered robust and no further assessments are considered required. The Project is currently under assessment by Preliminary Documentation under the EPBC Act and the IESC will be providing input to the approval assessment process.

10.2.1 Independent Peer Review

In accordance with IESC Guideline requirements under the EPBC Act, the Project's groundwater model was subject to an Independent Peer Review (Appendix J1) by an expert hydrogeologist/modeller, Dr Noel Merrick of HydroAlgorithmics Pty Ltd. Dr Merrick is a groundwater modeller, hydrogeologist and geophysicist with over 40 years' experience in groundwater management and policy, and a former Associate Professor at the University of Technology, Sydney, where he was Director of the National Centre for Groundwater Management. Dr Merrick is also a groundwater modelling advisor to the Commonwealth government and to four State governments.

Dr Merrick's review was conducted in accordance with the 137-question Review Checklist in National Water Commission guidelines (2012), and is provided as Attachment A. In particular, Dr Merrick found that:

- The Project's groundwater assessment is best practice and the modelling methodology is "state-of-art";
- The Project's groundwater model is fit for the purpose of meeting the objectives defined in Section 1.3 of The Project's Groundwater Assessment report;
- The Project's groundwater modelling has been conducted to a very high standard; and
- A rigorous Monte Carlo uncertainty analysis as reported in the Project Groundwater Assessment offsets much of the uncertainty that is inherent in a groundwater model.

The outcomes of the Independent Peer Review are therefore taken to validate the appropriateness and robustness of the groundwater modelling undertaken to inform the Project's groundwater assessment.

10.2.2 Model Classification

The 2012 Australian Groundwater Modelling Guidelines provides for a model classification based on a "model confidence level" (Class 1, Class 2 or Class 3 in order of increasing confidence) typically depending on:

- Available data (and the accuracy of that data) for the conceptualisation, design and construction;
- Calibration procedures that are undertaken during model development;
- Consistency between the calibration and predictive analysis; and
- Level of stresses applied in predictive models.

It is generally expected that a model confidence level of Class 2 is required for mining environmental impact assessment; in support of this the 2012 Australian Groundwater Modelling Guidelines state that a Class 2 model may be used for assessing impacts associated with mine dewatering (Barnett et al. 2012).

Table 6.1 of Appendix F provided a summary of the Project's groundwater model classification criteria, significantly simplified from the relevant Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines. It is noted that the table presented as Table 6.1 of Appendix F was over-simplified from the relevant Guideline table, and provided an out of date model classification based on earlier revisions of the model (i.e. a classification based on the earlier Olive Downs Project groundwater model that was not updated when the model was revised for the Project). That is, the classification presented in Table 6.1 of Appendix F did not consider the significant iterative updates to the model completed since the foundational Olive Downs Project model version.

A revised classification table detailing the subjective qualitative criteria allowing model classification, based upon the full expanded version of Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines, is provided as Table 10-1. The classification of the Project's model as presented in the updated table (Table 10-1) has been assessed subjectively by a Principal level groundwater modeller and reviewed by a Technical Director level hydrogeologist/modeller, whereby the classification table was subjectively reviewed and the specialists mutually decided, in their professional opinion, which box most appropriately describes the various characteristics of the model. Thereafter, the assessors assigned an overall classification class for the model based on the characteristics selected, i.e. which class has the most selected characteristics.

The revised assessment shown in Table 10-1 indicates that, overall, the Project's groundwater model can be classified as primarily Class 3 using the 2012 Australian Groundwater Modelling Guidelines classification system (effectively "high confidence"), with some aspects meeting the lower Class 2 criteria. This is considered an appropriate level for the Project impact assessment context in line with the 2012 Australian Groundwater Modelling Guidelines. The classification of the model as meeting mostly at least Class 2 criteria has been validated by an independent expert hydrogeologist/modeller as Peer Reviewer (HydroAlgorithmics, 2021), with the Peer Reviewer noting that "all models are in fact mixtures of Class 1, Class 2 and Class 3".

Table 10-1 Revised Groundwater Model Classification Table[1,2]

Class	Model Characteristics					
		Data		Calibration		Prediction
1		Few or poorly distributed data points		Not possible		Predictive timeframe >> calibration timeframe
		Unavailable or sparse data in areas of greatest interest		Unacceptable levels of error		Temporal discretisation is different to calibration
	✓	No metered groundwater extraction data		Inadequate distribution of data		Transient prediction but steady state calibration
		Remote climate data		Targets incompatible with model purpose		Unacceptable validation
		Little or no useful data on land-use, soils, or river flows and stage elevations				
2		Some data but may not be adequate throughout domain	✓	Reasonable calibration statistics with errors in parts of the model	✓	Predictive timeframe > calibration timeframe
		Some metered groundwater extraction data		Long-term trends not replicated in all parts of domain		Long stress periods compared to calibration
	✓	Streamflow and stage measurements are available at some points		Transient calibration not extending to present day		New stresses not in calibration
		Reliable irrigation application data available in part	✓	Weak seasonal replication		Poor validation
				No use of calibration targets compatible with model purpose		
			✓	Validation not undertaken		
3	✓	Spatial and temporal distribution of data adequate	✓	Scaled RMS error or other calibration statistics are acceptable		Predictive timeframe ~ calibration timeframe
		Clearly defined aquifer geometry	✓	Long-term trends adequately replicated where important	✓	Temporal discretisation in predictive model consistent with transient calibration
		Reliable metered groundwater extraction data		Seasonal fluctuations adequately replicated	✓	Similar stresses to those in calibration
	✓	Rainfall and evaporation data is available	✓	Transient calibration is current		Steady state prediction consistent with steady state calibration
	✓	Aquifer testing data to define key parameters	✓	Model is calibrated to heads and fluxes		Model validation suggests calibration is appropriate
	✓	Good quality and adequate spatial coverage of DEM	✓	Key modelling outcomes dataset used in calibration		Steady-state predictions when the model is calibrated in steady-state
		Streamflow and stage measurements are available at many points				
		Reliable land-use and soil-mapping data available				
		Reliable irrigation application data available				

1. Refer Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines (Barnett et al. 2012)
2. Grey highlighted cells = model has been subjectively assessed to meet the classification criteria for that Class
3. Green text = revised classification after submission
4. Red text = previous classification now deemed incorrect

10.2.3 Model Layer 1 Characterisation

Layer 1 in the Project's groundwater model represents surface cover including alluvium. The following provides a summary of how Layer 1 was represented in the Project's groundwater assessment and supporting numerical groundwater model, with particular reference to Horse Creek / Grosvenor Creek.

Geological Distribution & Groundwater Occurrence
The geological distribution of alluvium was described in Section 4.2.1 of the Project's Groundwater Assessment report, and the following provides a summary. Furthermore, additional assessment of the Horse Creek alluvium has been developed for this response documentation and is outlined herein.

State Geological Mapping
State (Queensland Government) Detailed Surface Geology (SDSG) mapping shows that Quaternary alluvium (Qa, defined in the SDSG as clay, silt, sand and gravel; flood-plain alluvium) is localised along the Isaac River and parts of Grosvenor Creek, to the north and east of the Project, but is not mapped along Horse Creek or Cherwell Creek. The minimum distance between the Project open cut pit and the mapped extent of Qa alluvium is approximately 2.1 km (Grosvenor Creek).

Horse Creek is mapped in the SDSG as traversing over Quaternary colluvium (Qr) on and near to the CVM ML, and Tertiary basalt (Tb) closer to the confluence with Grosvenor Creek. Qr is defined in the SDSG as clay, silt, sand, gravel and soil; colluvial and residual deposits; that is, part of the Regolith unit with respect to the Project's groundwater assessment.

SDSG mapping shows older Tertiary-Quaternary alluvium (TQa) deposits distributed in the areas south of Horse Pit closer to Cherwell Creek. TQa is defined in the SDSG as a poorly consolidated or unconsolidated alluvial deposit in an ancestral valley, which has been dissected by more recent channel activity. SDSG mapping shows that the TQa deposits are located 1.7 km to the south of Horse Pit, extending to the south and southeast along the courses of Cherwell Creek and Harrow Creek.

CVM Drill Data
Drill hole logs for monitoring bores located in the north of the Project Area show the Qr colluvium in the area near to Horse Creek to comprise 2 to 3m of silt and sandy clay, overlying weathered claystone/siltstone/sandstone. Based on channel features noted on aerial imagery and SDSG mapping, the inferred extent of any un-mapped alluvial deposits associated with Horse Creek is constrained to the creek channel, with no evidence of deposition beyond these extents.

Groundwater drilling investigations undertaken by BMA at CVM in 2009, 2019 and 2020 have confirmed the presence of a localised alluvial deposit associated with Cherwell Creek. Drilling logs correlate with the SDSG mapping showing that the Tertiary-Quaternary alluvium (TQa) extends along Cherwell Creek onto the CVM site. Review of the available drilling logs shows that the thickness of the alluvium decreases towards Horse Pit and is thickest in immediate proximity to the modern creek channel.

Further detail of the drill hole data, including lithological cross section in the areas of Horse Creek and Cherwell Creek, is presented in Appendix J2.

Additional Alluvium Mapping
In the Project's groundwater assessment, the extent of alluvium in the vicinity of CVM was characterised using the SDSG surface geological mapping discussed above, which was then supplemented/refined using the CVM geological model, CVM drilling logs, topographic slope break analysis, and aerial imagery. The additional analysis undertaken for the Project's groundwater

assessment identified a relatively narrow distribution of alluvium along Horse Creek, Cherwell Creek and Harrow Creek, extending onto the CVM ML (refer Figure 4-4 of the Project's groundwater assessment).

In the vicinity of CVM the thickness of the alluvium was interpreted from Queensland Globe bore log lithology data and supplemented with CVM drilling logs. This process identified areas of alluvium outside of SDSG surface geological mapping that were then incorporated into the model; that is, the representation of alluvium occurrence in the model is significantly improved as compared to a theoretical representation based on SDSG mapping alone. These additional areas and extents (horizontal and vertical) of alluvium identified in the groundwater assessment were deemed conceptually representative of the local lithology and as such were adopted in the Project's groundwater model Layer 1 design.

Groundwater Occurrence
Available hydrogeological data suggests that:

- There is very little groundwater present within alluvial sediments associated with Horse and Cherwell Creeks at CVM.
- Where it exists, the shallow groundwater system in the vicinity of Horse and Grosvenor creeks is recharged by seepage of stream flow from the creeks during times of flow.
- There is minimal, if any, alluvium development along Horse Creek, and alluvium development along Grosvenor Creek further downstream is very limited.
- Groundwater levels are sufficiently deep such that where the shallow groundwater system exists in the vicinity of Horse and Grosvenor creeks, it is associated with Tertiary aged formations and weathered Permian coal measures that underlie any alluvium (i.e. the water table lies within the Regolith), and there is likely little to no shallow groundwater present in any of the alluvial sediments.
- The depth to groundwater in the vicinity of Cherwell, Horse and Grosvenor creeks is sufficiently deep such that only the deepest-rooted terrestrial vegetation (e.g. River Red Gums) might access the groundwater table for some of their water requirements. Previous work completed for the Project's GDE Assessment identify that these terrestrial species would only form facultative GDEs at best, i.e. they are not wholly reliant on groundwater but likely only access it during times of limited soil moisture. Most of the terrestrial, and particularly aquatic, potential GDEs mapped along Horse Creek and Grosvenor Creek in the GDE Atlas cannot be GDEs given the depth to groundwater; in particular, it is highly unlikely that aquatic GDEs would be present.

Evidence supporting this assessment is provided in the following text.

Review of standing water levels for bores screened within the shallow groundwater system show that the water table intersects the Tertiary sediments and/or weathered Permian units indicating that the overlying alluvium (where present) is consistently unsaturated.

Grosvenor Creek and Horse Creek are characterised as ephemeral flow systems that lose water to the underlying strata during times of flow via vertical seepage through the stream base. That is, the underlying shallow groundwater system is supported by stream flow when it occurs, and groundwater does not support or provide baseflow to the creeks.

This characterisation is supported by comparison of available groundwater elevation data against creek bed elevations within and outside the Project Area. Due to the ephemeral nature of both creeks, surface water flow data is generally absent and as such to be conservative comparisons of groundwater elevations have been made against the creek bed elevation.

Monitoring bore MB20CVM01A was installed adjacent Horse Creek at the northern CVM boundary approximately 2.2km upstream of the confluence of Horse Creek and Grosvenor Creek. MB20CVM01A was installed in mid-2020 (Figure 10-1), aiming to assess the potential for, and monitor, shallow groundwater occurrence in the vicinity of the creek. Drilling results indicated the shallow sediments comprised 1 m of alluvial clay overlying Quaternary/Tertiary sandy gravelly clay to a depth of 6 m below ground level. That is, no significant highly transmissive alluvium was intersected that might form an aquifer. Below 6 m depth a low strength weathered consolidated sandstone was intersected, interpreted as the upper Permian coal measures (Regolith).

Monitoring bore MB20CVM01A was constructed with a screen interval from 5 to 8 m depth, i.e. across both the Quaternary/Tertiary clay and the weathered Permian coal measures. Measured groundwater levels at MB20CVM01A have generally varied between 7.2 and 7.7 m since installation, i.e. coincident with the weathered Permian coal measures forming the water table and indicating that the Q/T sediments associated with Horse Creek are dry on the CVM ML.

In the vicinity of MB20CVM01A the creek bed elevation of Horse Creek is approximately 216m AHD. Groundwater elevations at MB20CVM01A have ranged between 211.9m AHD and 212.4m AHD, indicating losing conditions during times of flow.

Monitoring bore MB20CVM04T was installed in close proximity to Horse Creek at the north western CVM boundary in mid-2020 (Figure 10-1). Drilling results indicated the shallow sediments comprised 2m of colluvial sandy clay overlying weathered Tertiary basalt to a depth of 10 m. Tertiary gravelly sands were encountered between 10 and 19 m, overlying moderately weathered Tertiary basalt to a depth of 27m. As per MB20CVM01A, no significant highly transmissive alluvium was intersected that might form an aquifer. A groundwater bore was constructed with a screen interval from 22 to 28 m depth, i.e. across the weathered basalt. Measured groundwater levels at MB20CVM04T have generally varied between 15.8 and 16.4 m since installation, i.e. coincident with the weathered Tertiary basalt and sediments forming the water table and indicating that the Q/T sediments associated with Horse Creek are dry across the CVM ML.

A review of the Queensland registered bore database (GWDB) has been conducted to assess publicly available information for water bores along Grosvenor Creek. The review identified six bores installed along Grosvenor Creek in the vicinity of the confluence with Horse Creek (Figure 10-1 and Table 10-3.

The review indicates:

- One bore (RN 162140) is installed at the confluence with Horse Creek, and is a dedicated mine monitoring bore (MB01) installed as part of Anglo Americans Moranbah South Project to monitor shallow groundwater in the vicinity of the Grosvenor Creek and Horse Creek confluence. The geological log for this bore shows alluvial sediments are only developed to 0.3 m depth. Monitoring records obtained from Anglo American show that since 2012 DTW at MB01 has ranged from between 3.1 and 6m bgl.
- Four of the six bores have records that contain sufficient information to assess the potential for an alluvial aquifer associated with the Creek.
- None of the bores have a geological log indicating the potential presence of surficial alluvial sediments more than 2 m thick.
- None of the records indicate intersection of groundwater within shallow Quaternary sediments.
- The records indicate that shallow groundwater is associated with Tertiary sediments and Basalt (i.e. “Regolith”), with the shallowest water bearing zone intersected at RN 162140 at 3.1 m depth in Basalt.
- Overall, there is no indication of a shallow Quaternary alluvial aquifer system associated with Grosvenor Creek.

Table 10-2 GWDB Records along Grosvenor Creek in the vicinity of Horse Creek

Registered Number	Drill Date	Purpose	Screen Interval (mGL)	Screened Unit	Base Q seds (mGL)	Base Tertiary (mGL)	Standing water level (mGL)
162140	10-07-2012	Mine Monitoring	9.8 - 12.8	Basalt	0.3	60	3.4
162142	08-07-2012	Mine Monitoring	131 - 137	MCM	1	48	22.7
162806	< 1950	n/a	n/a	n/a	n/a	n/a	8.3
162807	< 1950	n/a	n/a	n/a	n/a	n/a	n/a
182164	24-08-2018	Water Supply	36 - 58	Basalt	0	58	15
182166	04-12-2018	Water Supply	15 - 30	Tertiary seds	2	n/a	12

Figure 10-1 Registered Bores and Potential GDEs along Grosvenor Creek in the vicinity of Horse Creek

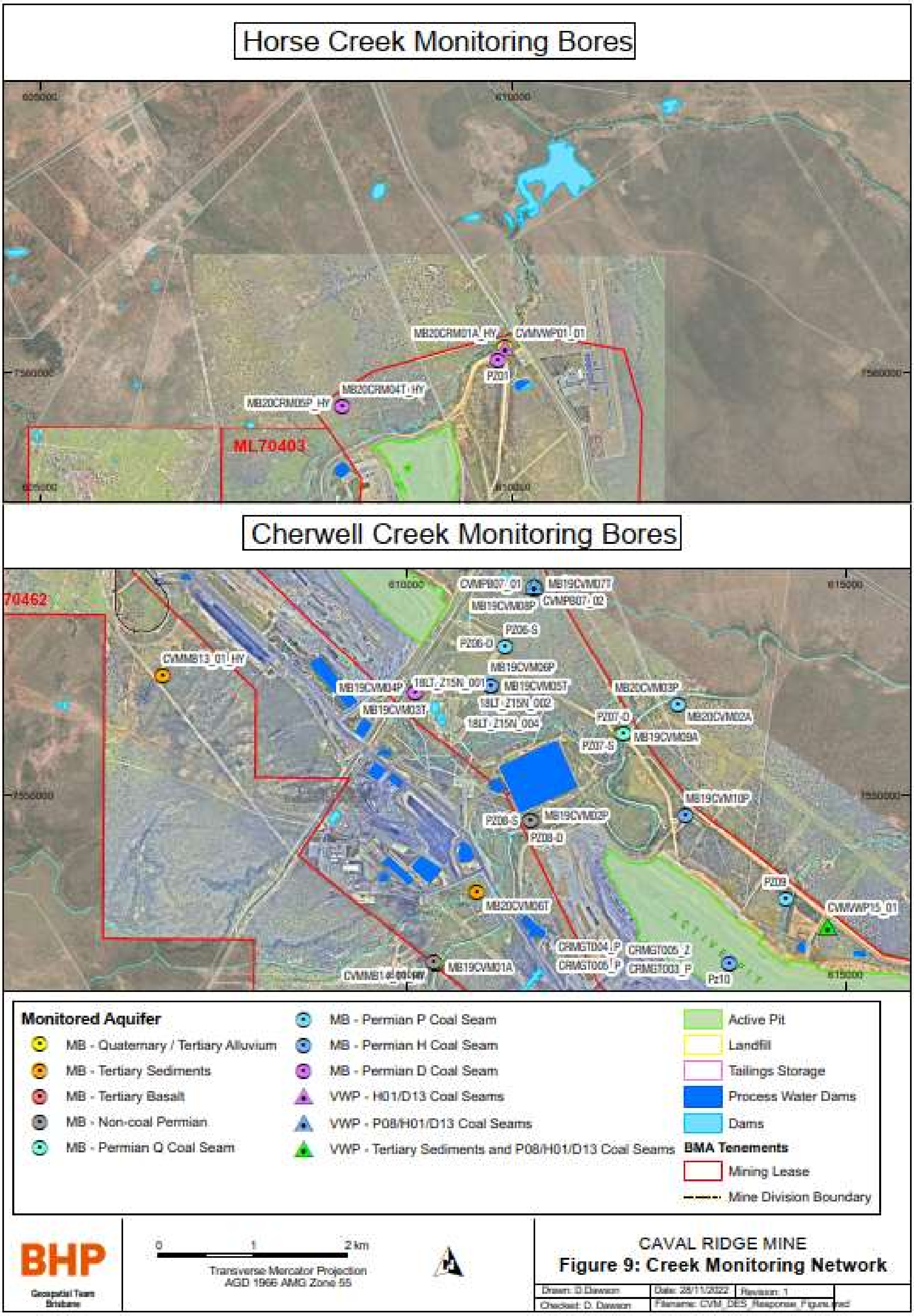


Figure 10-2 Horse Creek and Cherwell Creek Monitoring Network

In the vicinity of Cherwell Creek shallow monitoring bores include MB19CVM01A, MB20CVM06T and PZ08-S in the west; PZ07-S, MB19CVM09A and MB20CVM02A in the east; and MB19CVM03T, MB19CVM05T and MB19CVM07T to north (between Cherwell Creek and Horse Pit) as presented in Figure 10-2. Depth to water ranges from approximately 11.8m bgl at MB20CVM06T in the west to 14.5m bgl at MB20CVM02A in the east. To the north of Cherwell Creek depth to water is similar, measuring approximately 13.5m bgl at MB19CVM07T. PZ07-S and PZ08-S (both screened across the base of the alluvium and top of the Tertiary sediments) have been reported dry since July and August 2020. As seen at Horse Creek, observed depth to water measurements are coincident with the weathered Tertiary basalt and sediments forming the water table and indicating that the Q/T alluvium associated with Cherwell Creek are dry across the CVM ML.

Observed depth to water across the Project Area shows that the source aquifer for potential terrestrial GDEs is associated with Tertiary aged formations and weathered Permian coal measures, not alluvial systems. Terrestrial GDE species will therefore be limited to those with rooting depths greater than the water table which in the vicinity of Horse Creek is greater than 7m bgl and in the vicinity of Cherwell Creek greater than 12m bgl. This is also the case in the vicinity of the confluence of Grosvenor Creek and Horse Creek where water level measurements for registered water bores screened within the shallow Tertiary formations range from 3 to 15m. Only the deepest-rooted terrestrial vegetation (e.g. River Red Gums) might therefore access the groundwater table for some of their water requirements.

Model Translation

The following provides a summary of how the alluvium was translated to Layer 1 of the numerical model as described in the Project's groundwater modelling technical report. Sections 2.3.2.1 and 2.3.2.2 of the Project's groundwater modelling technical report provide details on how Layer 1 boundary conditions and model mesh have been appropriately designed consistent with industry practice to represent surface water drainage features including Horse Creek and Grosvenor Creek. Section 2.4 details why calibration of Layer 1 is robust and suitable for the assessment requirements.

It is worth noting that the Project's groundwater model is a refinement/update of an earlier existing groundwater model that was first developed for the Olive Downs Project EIS and later the Moorvale South Project Associated Water License Application. The groundwater modelling for those two projects was subject to scrutiny by both State (both projects) and Commonwealth (Olive Downs Project) regulators and technical advisors, in particular the Commonwealth's Independent Expert Scientific Committee (IESC) for the Olive Downs Project. In both cases, the groundwater modelling was found to be appropriate for the purpose of mining impact assessment and particularly assessment of possible impacts to potential shallow groundwater system receptors. It is also worth noting that those two projects are located immediately adjacent the Isaac River in much closer proximity to potential shallow groundwater receptors, with a higher likelihood that those receptors are in fact reliant to some degree on shallow groundwater, than the potential receptors in the vicinity of CVM.

Model Mesh (Grid) Design

The model was designed using an unstructured grid with varying Voronoi cell sizes. Varying Voronoi cell sizes allows appropriate refinement around areas of interest, for example around surface water features, while a coarser resolution elsewhere reduces the total cell count to a manageable size. Surface water drainage features (including Horse and Grosvenor Creeks) are represented in the model with a 50 m Voronoi cell size constraint, compared to 100 m cell size constraint for CVM mining and 200-400 m for other mining areas. That is, the grid is specifically refined around surface drainage features including Horse and Grosvenor Creeks to improve model resolution in the vicinity of these features.

Layer 1 Boundary Conditions

Surface water drainage features were built into the model using MODFLOW-USG RIV package, including Isaac River, Grosvenor Creek, Cherwell Creek, and Horse Creek. This approach is consistent with industry practice for MODFLOW simulation of ephemeral drainage features.

Diffuse rainfall recharge to the model was represented using the MODFLOW-USG Recharge package (RCH). The recharge rates were established through the calibration process, with bounds based on the conceptual understanding of the system and comparing them with other groundwater models prepared for the region. Areas of alluvium were characterised as one of three recharge zones:

- Isaac River Flood Plain Alluvium;
- Isaac River Channel Alluvium; and
- Alluvium – Rest of the model (including alluvium associated with Horse Creek and Grosvenor Creek).

The MODFLOW Evapotranspiration (EVT) package was used to simulate evapotranspiration from the groundwater system. Extinction depths were set to 2 m below ground across the model domain. Maximum potential rates were set using actual evapotranspiration values (from the Bureau of Meteorology), with the average value (600 mm/year) used as the transient calibration evapotranspiration rate. An EVT rate of 0 was assigned to the model cells representing the rivers so that EVT cells were not in conflict with RIV cells. This approach is consistent with industry practice.

10.2.4 Calibration

The model calibration methodology and results presented in the Project's groundwater assessment are considered appropriate for the alluvium and other aquifers across the model domain. The calibration of the model has been reviewed by an independent expert hydrogeologist/modeller as Peer Reviewer (HydroAlgorithmics, 2021), with the Peer Reviewer noting the following in relation to the model's calibration:

- Visual hydrographic history matching is exceptionally good at CVM Permian monitoring sites.
- Calibration performance is generally good in most areas of the model.
- Locally (i.e. at CVM), the absolute performance is better but the relative performance (compared to other areas of the model) appears larger because the range in measured water levels is less.
- The CVM site has better average calibration residual and average absolute residual statistics than any of the other included mines.
- The model has a mild tendency to over-estimation of heads, especially at lower elevations (i.e. predict higher groundwater levels than is measured in reality, which would result in a more conservative assessment of potential impacts on shallow environmental receptors such as GDEs).

As described in Section 2.6 of the Project's groundwater modelling technical report, the groundwater model was calibrated to 4,342 measured groundwater levels between January 2008 and December 2020, measured at 400 bores/VWPs across the model domain including 43 bores/VWPs at CVM. Calibration across the entire model achieved a 12.5 m root mean square (RMS) error, equating to a 5.4% Scaled RMS (SRMS) error, which is within the recommended range (i.e. 10%) in the Australia Groundwater Modelling Guidelines (Barnett et al., 2012). Observations from the CVM bores in the transient calibration achieved an RMS error of 5.6 m, which is lower than the RMS error for the entire model, reflecting slightly better calibration performance at CVM when compared to the entire model calibration dataset. Calibrated hydraulic parameters were shown to be all within the range of available field data, and therefore, given this and the fact that calibration statistical performance was within the recommended range (i.e. 10% SRMS) in the Australia Groundwater Modelling Guidelines (Barnett et al., 2012) the calibration was deemed acceptable for the purposes of the Project's groundwater assessment.

For the alluvium, Table 2-6 of the Project's groundwater modelling technical report showed that 114 individual bores containing 1,198 groundwater head measurements were used to calibrate Layer 1 in the model. That is, the Layer 1 calibration in the model is based on an extensive regional dataset and not limited to only the CVM dataset.

In relation to the shallow groundwater system associated with Horse Creek, calibration performance was shown to be excellent at the single CVM monitoring bore installed in this area (MB20CVM01A, Figure 10-3 below from Appendix A of the Project's groundwater modelling technical report; refer Figure 10-1 for locality plan).

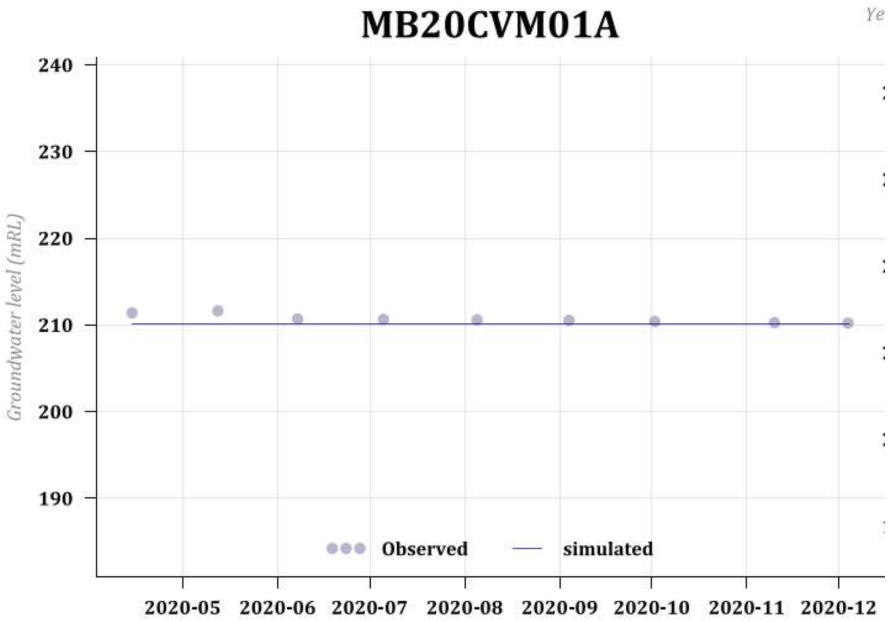


Figure 10-3 Calibration Hydrograph – MB20CVM01A (Horse Creek shallow groundwater system)

Overall, the methodology and results are proven to show that the model calibration is appropriate for the purposes of the Project's groundwater assessment, with this finding validated by an independent Peer Reviewer.

10.3 BMA Response to Requested Action 36

Requested Action 36: *With the proposed relocation of infrastructure and the proposed out of pit dump, confirm that the groundwater monitoring program is sufficient to monitoring for any impacts the result of mining activities for the life of CVM and the proposed extension.*

The proposed groundwater monitoring bore network is designed to be adequate for the monitoring of the Project in the near term. The following bores of the proposed network will be impacted by the Project as mining progresses:

- PZ01 (located 2m from the Project footprint and will likely be entrained by mining in FY32); and
- PZ12-S and PZ12-D (will be entrained by mining in FY47).

The adequacy of the network is reviewed on an annual basis in accordance with the CVM Groundwater Monitoring and Management Plan (GMMP) which will be updated as required. The review includes (though not limited to) identification of bores which need to be replaced prior to being mined out. Bores identified are scheduled to be replaced so that at least 2 years of overlapping data with the existing bore (which is being replaced) can be collected.

Replacement bores will be:

- Installed to a similar depth or equivalent formation (whichever is shallower);
- Installed as close as possible to the bore being replaced but not in an area:
- Where more than 2m of drawdown is predicted to occur within 5 years of bore installation; or
- Where the replacement bore will be mined out within 5 years' time;
- Monitored for the same parameters and at the same frequency as the bore being replaced.

In response to DES comment 'There is a lack of bores on the western side of the mine for identification of upgradient concentrations', the following clarification is provided. Bores on the western side of the mine for collection of "upgradient data" have been a consideration however, as reported in the Groundwater Resources Assessment (Appendix F of the EA Amendment Supporting Documentation), Moranbah Coal Measures contain the mined coal seams for the Project. The coal seams have been identified as confined aquifers with the interburden between seams as aquitards. The groundwater assessment has shown negligible drawdown from project activities within the shallow hydrostratigraphic units, with drawdown limited to the coal seams due to dewatering as the pit progresses. In the Project Area, the Moranbah Coal Measures subcrop at the ML boundary and are not present to the west. Permian strata to the west of the mine comprises of the Back Creek Group which is not believed to be in hydraulic continuity with the Moranbah Coal Measures.

Any Permian bores located to the west of the mine would not be installed in the same hydrostratigraphic unit as what will be impacted by the mine. Monitoring data collected would not be representative of the Moranbah Coal Measures. No additional monitoring bores to the west of the Project Area are proposed to be installed.

- The proposed Project's monitoring network at CVM comprises nine (9) existing EA monitoring bores, nine (9) monitoring bores installed for HPE Project assessment, one (1) additional monitoring bore and two (2) VWP sensor arrays that were installed for the HPE Project assessment (Section 10.3.1);
- The proposed Project's monitoring network has been suitably designed to enable continued assessment of predicted impacts to all relevant hydrostratigraphic units and associated receptors up and down hydraulic gradient of the Project area (Section 10.3.1);
- BMA commit to the installation of a shallow monitoring bore to monitor potential seepage from the proposed out of pit storage area proposed in the north west of the ML (Section 10.3.2);
- BMA will not install additional monitoring bores in the vicinity of existing and proposed water storage structures (sediment dams, mine water dams and process water dams) as operation and monitoring requirements of these structures is incorporated under the structures operational plan (Section 10.3.2);
- Monitoring of bore MB20CVM01A will enable assessment of Project impacts to the shallow groundwater system in the north east of the mining lease and will enable early identification of potential impacts to potential terrestrial GDEs located downstream at the confluence of Horse Creek and Grosvenor Creek (Section 10.3.3);
- BMA commit to the replacement of monitoring bores 2yrs prior to being mined out by the Project activities (Section 10.3.3); and
- BMA commit to the replacement of PZ01 2yrs prior to being mined out by the Project's activities. PZ01 will continue to be monitored as per current EA conditions until this date.

10.3.1 Proposed HPE Groundwater Monitoring Network

The following section describes the monitoring infrastructure proposed to monitor predicted Project impacts. 19 monitoring bores (18 existing and 1 proposed) and two (2) VWP sensor arrays have been nominated in up and downgradient locations across the Project Area. Proposed monitoring infrastructure detail and rationale are presented in Table 10-3 with locations displayed in Figure 10-4.

Table 10-3 Monitoring Bores

Bore ID	Easting (AGD66 Z55s)	Northing (AGD66 Z55s)	Target Aquifer	Monitoring Frequency	Monitoring Rationale
PZ01	609841	7560145	MCM Coal - D Seam	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore to monitor predicted drawdown in economic coal seam. Located in close proximity to MB20CRM01A and CVMVWP01 enabling monitoring and assessment of interconnectivity between HSUs. Important to show if predicted drawdown propagates into shallow aquifer potentially acting as water source to terrestrial GDEs.
PZ04	610731	7555326	MCM Coal - Q Seam	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore on east of ML to monitor predicted drawdown in intercepted coal seam aquifer.
PZ07-D	612465	7550704	MCM Coal -Q Seam	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore on east of ML to monitor predicted drawdown in intercepted coal seam aquifer.
PZ09	614326	7548822	MCM Coal - P Seam	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore located to east of Cherwell Pit / south east HPE to monitor predicted drawdown in intercepted coal seam aquifer.
PZ11-D	616791	7547600	MCM Coal - P Seam	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore on east of ML to monitor predicted drawdown in intercepted coal seam aquifer. .
PZ12-S	610721	7557164	Tertiary Sediments	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore on east of ML to monitor predicted drawdown in shallow unconfined aquifer (Tertiary Sediments).
PZ12-D	610712	7557219	MCM Interburden	WQ annually WL quarterly	Existing EA bore. Downgradient monitoring bore on east of ML to monitor predicted drawdown in MCM interburden.
MB19CVM09A	612446	7550699	Tertiary Quaternary Alluvium	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient monitoring bore in south east of HPE to monitor predicted drawdown shallow aquifer (TQa). Required for continued assessment of availability of water for potential GDEs identified along Cherwell Creek. To be used for early identification of impacts to GDEs to downstream reaches of Cherwell Creek.
MB19CVM02P	611424	7549705	MCM Coal - D Seam	WQ annually	Existing EA bore. Upgradient monitoring bore on west of ML/ south

Bore ID	Easting (AGD66 Z55s)	Northing (AGD66 Z55s)	Target Aquifer	Monitoring Frequency	Monitoring Rationale
				WL quarterly	of Horse Pit to monitor predicted drawdown in intercepted coal seam aquifer.
MB19CVM07T	611464	7552357	Tertiary Basalt	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient monitoring bore in south east of HPE to monitor predicted drawdown in Tertiary basalt. Co-located with MB19CVM08P and CVMPB07_02 to monitor for potential propagation of predicted impacts from intercepted coal seams to shallower HSUs.
MB19CVM08P	611465	7552346	MCM Coal - H Seam	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient monitoring bore in south east of HPE to monitor predicted drawdown in intercepted coal seam aquifer. Co-located with MB19CVM07T and CVMPB07_02 to monitor for potential propagation of predicted impacts from intercepted coal seams to shallower HSUs
MB20CVM01A	609915	7560272	Tertiary Quaternary Alluvium	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient monitoring bore in north east of HPE to monitor predicted drawdown shallow aquifer (TQa). Required for continued assessment of availability of water for potential GDEs identified along Horse Creek. To be used for early identification of impacts to GDEs at Grosvenor Creek / Horse Creek Confluence. Co-located with CVMVWP01 and in close proximity to PZ01, enabling monitoring of interconnectivity of HSUs.
MB20CVM04T	608193	7559651	Tertiary Basalt	WQ quarterly. WL quarterly	Existing HPE bore. Upgradient bore monitoring shallow water table aquifer (Tertiary basalt) in north west of Project. Co-located with MB20CRM05P to monitor interconnectivity between coal seams and shallow units. Will also provide a downgradient seepage monitoring location to the proposed OOPD.
MB20CVM05P	608198	7559646	MCM Coal - D Seam	WQ quarterly. WL quarterly	Existing HPE bore. Upgradient bore monitoring D Seam in the north west of Project. Co-located with MB20CRM04T to monitor interconnectivity between coal seams and shallow units.
MB20CVM06A	610802	7548890	Tertiary Sediments	WQ quarterly. WL quarterly	Existing HPE bore. Upgradient bore monitoring located adjacent to upstream reach of Cherwell creek. TQa bore to monitor background conditions of shallow aquifer.

Bore ID	Easting (AGD66 Z55s)	Northing (AGD66 Z55s)	Target Aquifer	Monitoring Frequency	Monitoring Rationale
CVMMB16_01	611144	7558320	Tertiary Sediments	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient bore monitoring of shallow aquifer (Tertiary sediments) in the north east of Project. Co-located with CVMMB16_02 to monitor interconnectivity between coal seams and shallow units.
CVMMB16_02	611135	7558315	MCM Coal - H Seam	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient bore monitoring H Seam in the north east of Project. Co-located with CVMMB16_02 to monitor interconnectivity between coal seams and shallow units.
CVMPB07_02	611452	7552362	MCM Coal - P Seam	WQ quarterly. WL quarterly	Existing HPE bore. Downgradient monitoring bore in south east of HPE to monitor predicted drawdown in intercepted coal seam aquifer. Co-located with MB19CVM07T and MB19CVM08P to monitor for potential propagation of predicted impacts from intercepted coal seams to shallower HSUs
CVMVWP01_01	609915	7560272	MCM Coal H Seam / D Seam	WQ quarterly. WL quarterly	Existing HPE VWP. Downgradient VWP array co-located with MB20CRM01A in north east of the project. Monitoring of water levels in multiple coal seams to monitor predicted impacts and allow continued assessment of potential interconnectivity between impacted coal seams and shallow aquifers.
CVMVWP15_01	609915	7560272	Tertiary Sediments / MCM Coal - P Seam / H Seam / D Seam	WQ quarterly. WL quarterly	Existing HPE VWP. Monitoring of water levels in multiple HSUs to monitor predicted impacts and allow continued assessment of potential interconnectivity between impacted coal seams and shallow aquifers.
CVMMB100_01	607640	7558446	TBC - Water Table aquifer	WQ quarterly. WL quarterly	Proposed MB to monitor potential seepage around proposed OOPD

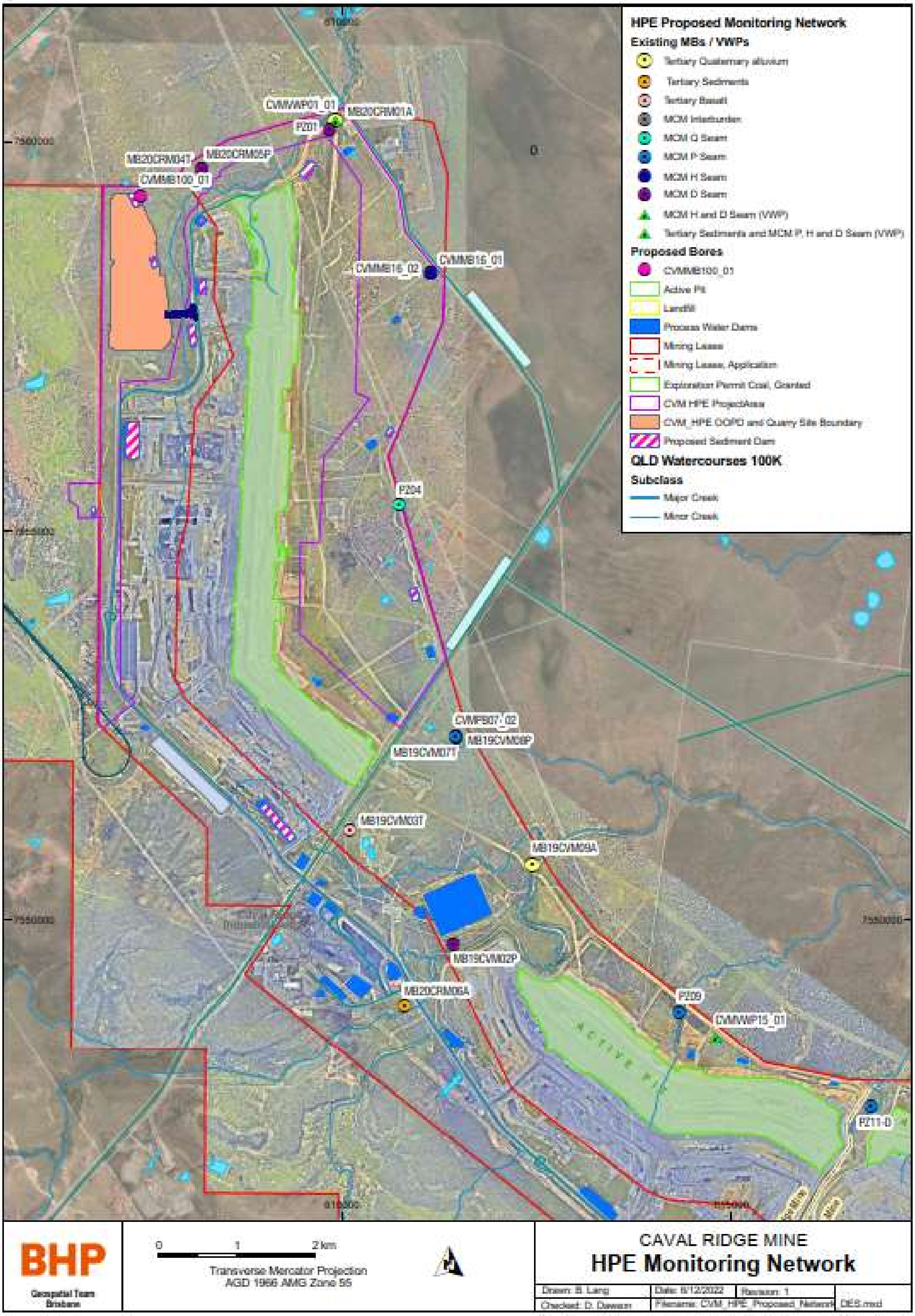


Figure 10-4 HPE Monitoring Network

10.3.2 Monitoring of Potential Contaminant Sources

As per DES comments received on 14th October 2022, BMA agree to install and incorporate an additional monitoring bore adjacent to the proposed OOPD into the Project's groundwater monitoring bore network.

BMA do not propose to install additional bores adjacent to existing dam structures (sediment dams N2, N3A and N3B and Mine Dams N1 and N2). Seepage monitoring requirements of these structures are prescribed by the Structure conditions within the EA.

EAs and development approvals include conditions that require EA holders to have the consequence category of structures (being dams or levees, that are constructed as part of a project) assessed by a 'suitably qualified and experienced person' (called a consequence assessment). As per Section 2.3.3 of the guidelines the 'Consequence Category' approach (which is consistent with ANCOLD 2012) is a classification of adverse consequences resulting from a dam failure. It quantitatively identifies the severity of dam failure consequences including life safety, damage to property and infrastructure, economic, health, social and environmental effect (including groundwater).

The consequence assessment determines whether a structure is a 'regulated structure' for the purpose of the EA. Regulated structures require certified design plans to be submitted to the administering authority, and are subject to annual inspection and reporting by a suitably qualified and experienced person.

In accordance with Dam Safety Management Guidelines sediment dams N2, N3A and N3B and Mine Dams N1 and N2 are not regulated structures and have been assessed as having a low to very low failure consequence. Given the consequence assessment it is deemed that monitoring of seepage is not required around these structures as environmental effects from dam failure (which includes seepage) have been assessed as low. If these structures or the proposed N3G and N3H sediment dams are reassessed as structures with 'High' or 'Extreme' consequence and become regulated structures, then seepage monitoring will be completed in accordance with the EA Structure conditions and as per the structure operational plan.

10.3.3 Monitoring of Impacts to the Shallow Groundwater System

Routine monitoring of bore MB20CVM01A in the north of the Project Area is deemed sufficient for monitoring impacts to water levels within the limited shallow groundwater system in the vicinity of the confluence of Horse Creek and Grosvenor Creek.

Review of the hydrographs presented as Figure 10-5 shows that groundwater levels within the shallow aquifer unit (MB20CVM01A) have remained relatively stable at around 212m AHD, with observed fluctuations attributed to climatic conditions. This is the case despite the occurrence of drawdown in the deeper groundwater system as a result of mining operations within the intercepted coal seams (bore PZ01 and VWPs CVMVWP01_01 and CVMVWP01_02 on Figure 10-5).

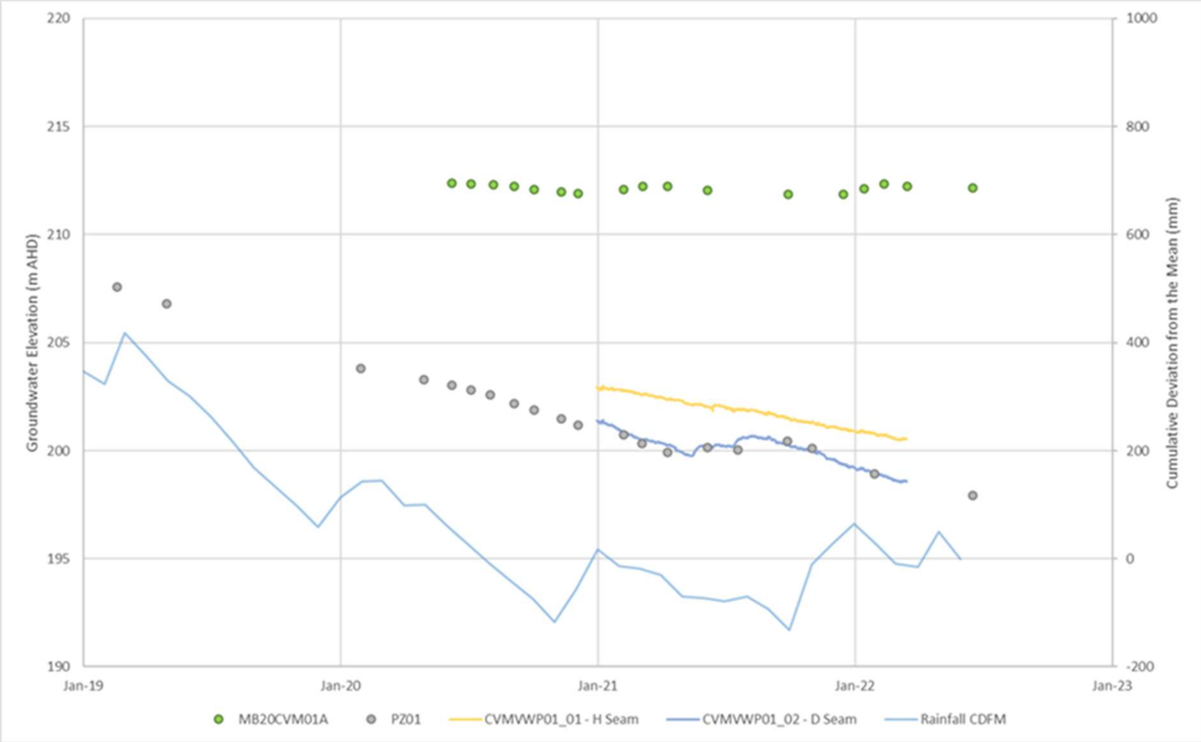


Figure 10-5 Hydrograph of Horse Creek Monitoring Bores

Monitoring data has been obtained from Anglo American for monitoring bore MB01 located at the confluence of Horse Creek and Grosvenor Creek. As discussed in Section 2.3.1.4 MB01 is screened within the Tertiary basalt, that is, the shallow groundwater system at this location lies within the basalt. Review of the hydrograph for MB01 (Figure 10-6) shows that groundwater elevations correlate with the CRD. Comparisons of groundwater elevations at MB01 (and PZ01) indicate that there is no influence of mining activities on water levels within the shallow groundwater system along Horse Creek and Grosvenor Creek. Monitoring records for MB01 show that DTW has ranged from 3.5 to 6m bgl since 2013. Modelled depth to water in the vicinity of MB01 aligns with observed measurements of approximately 3m bgl.

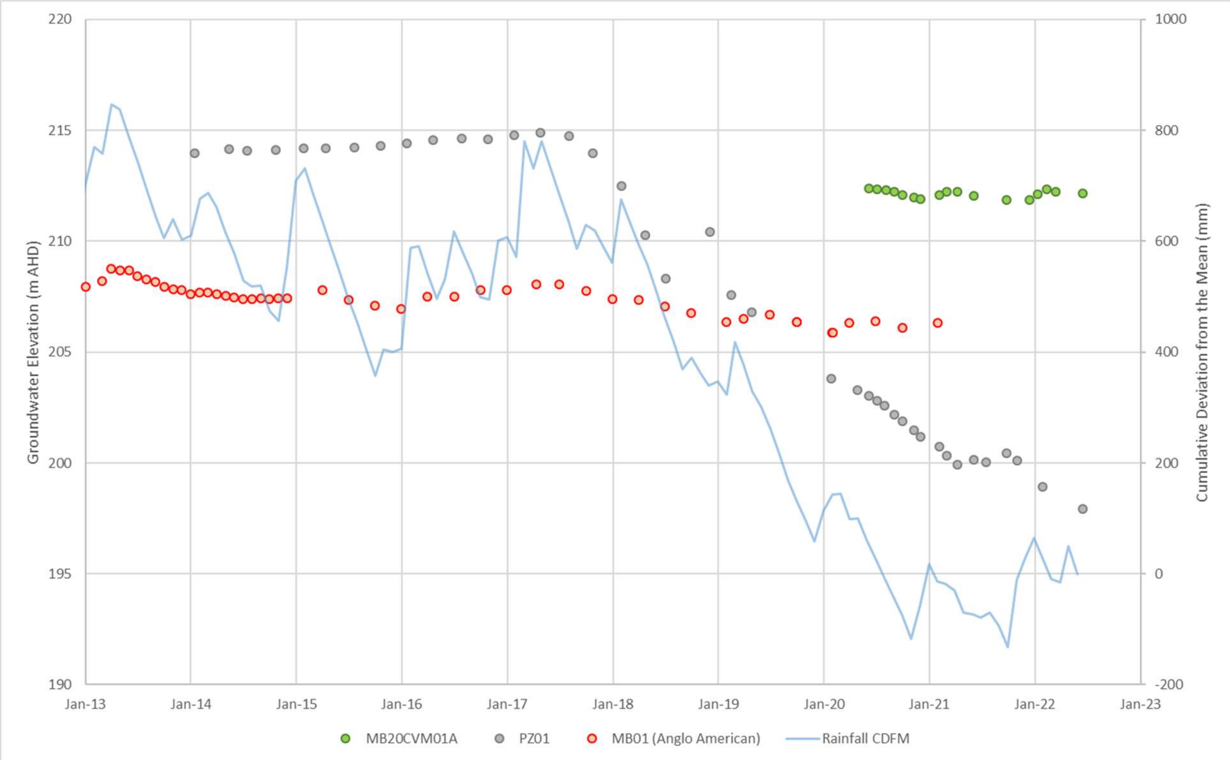


Figure 10-6 Hydrograph of Horse Creek and Grosvenor Creek Monitoring Bores

Hydrographs presented in Figure 10-5 and Figure 10-6 support the conceptualisation that there is limited vertical hydraulic connectivity between the shallow aquifer unit and mined coal seams. Given the limited connectivity it is unlikely that impacts to water levels observed within the intersected coal seam aquifers will propagate to the shallow groundwater system.

As presented in Section 6.3 of the Project Groundwater Assessment report, there are no drawdown impacts from the Project predicted for the Quaternary alluvium (Layer 1) within or around the CVM area.

As discussed, the shallow aquifer system in the vicinity of Horse Creek and downstream at its confluence of Grosvenor Creek is conceptually represented by Layer 2 of the model - termed the 'regolith' in the Project Groundwater Assessment report, representing shallow geologic strata lying above the Permian coal measures but distinct from Quaternary alluvium. The Project Groundwater Assessment report described how the regolith is only sporadically saturated and does not represent a widespread groundwater bearing unit. The predicted drawdown extent within the regolith is largely confined to the Project Area, and is influenced by the somewhat limited distribution of predicted saturated zones in the regolith. At the northern end of the CVM mining lease, 1 m drawdown influence is predicted to extend up to 2.9 km north of the lease boundary in the regolith. Review of SDSG mapping shows that the predicted drawdown intercepts basalt deposits located to the north east of the Project Area. As presented in Figure 6-2 of the Project Groundwater Assessment no drawdown from the Project within Layer 2 is predicted at the potential GDE site mapped in the vicinity of the confluence of Horse Creek and Grosvenor Creek. As presented in Section 10.2 it is considered that the numerical model is fit for purpose for the scale of the Project and as such predicted drawdowns are sufficiently robust for assessing risks to GDEs.

Monitoring of MB20CVM01A (Figure 10-1) will provide an indication of whether drawdown to the shallow groundwater system is occurring and if this drawdown is greater than predicted at this location. No further monitoring bores are therefore proposed downstream of the Project Area, specifically at the confluence of Grosvenor and Horse Creeks, as it is believed monitoring of

MB20CVM01A will sufficiently capture impacts to groundwater levels in the potential terrestrial GDE source aquifer in the area.

10.4 BMA Response to Requested Action 37

***Requested Action 37:** If additional monitoring bores are required to be installed or included in the groundwater monitoring network, provide the location of such bores and detail the sufficiency of the groundwater triggers and conditions by comparison with these additional bores.*

As stated in Section 10.3, the adequacy of the monitoring network will be reviewed on an annual basis for the life of the CVM and proposed extension. Where required, replacement bores will be drilled and installed a minimum of 2 years before a bore becomes inactive due to mining activities. This will allow sufficient time to collect sufficient data for the development of groundwater triggers and update to conditions.

Relocation of Impacted Bores

A number of existing monitoring bores proposed to be incorporated in the Project groundwater monitoring bore network are likely to be mined-out as mining progresses. BMA is committed to replacing these bores at least 2 years prior to being mined-out. Bores will be relocated outside of the proposed future mining footprint and screened within the same hydrostratigraphic unit as the replaced bore to enable monitoring of predicted impacts to continue.

Replacement of PZ01

As discussed above, BMA commit to the relocation of monitoring bore PZ01 2 years prior to it being mined-out as a result of mine progression. However, immediate relocation of PZ01 is not deemed to be required due to the utilisation of existing monitoring infrastructure at the CVM.

Bore MB20CVM01A is located very close to PZ01, and is co-located with a VWP array CVMVWP01A that has sensors installed across both the H seam (Sensor 1) and D seam (Sensor 2) of the Moranbah Coal Measures. PZ01 is located 150m south west of the MB20CVM01A co-located site and is screened across the D Seam.

Hydrographs of MB20CVM01A, PZ01, CVMVWP01A Sensor 1 and Sensor 2 are presented in Figure 10-5. Comparison of the hydrograph of CVMVWP01A Sensor 2 and PZ01 show matching groundwater elevations recorded at both locations. It is proposed that PZ01 should therefore be retained to enable monitoring of water quality of the D Seam. CVMVWP01A is included in the proposed monitoring network to enable continued monitoring of groundwater elevations within the coal seam aquifers and shallow groundwater system. This data will be used to make a continued assessment on the limited interconnectivity between the unconfined shallow groundwater system and deeper confined coal seam.

10.5 BMA Response to Requested Action 38

***Requested Action 38:** Confirm that the existing mitigation and management measures to be implemented will be able to meet the listed performance outcomes with the expanded scale of the Project.*

Performance outcome PO4.2 from Schedule 8, Part 3 of the Environmental Protection Regulation 2019 is:

The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

The Groundwater Resources Assessment (Appendix F of the EA Amendment Supporting Documentation) did not identify risks to groundwater users or surface ecological systems and therefore no active groundwater mitigation measures will be implemented by the Project. Active management will be in the form of the implementation of the GMMP. The GMMP document details the monitoring network including sampling methodologies, QA/QC procedures, monitoring parameters, frequencies of sampling and triggers, reporting requirements and notification requirements. Routine monitoring and data analysis will enable unexpected impacts from the Project to be identified early, enabling sufficient investigation and development of mitigation measures to be implemented. One of the objectives of the monitoring program is to confirm impact assessment predictions and also to capture early, unexpected signs that adverse effects should they occur. By identifying effects early, further investigation and mitigation measures (if required) can be identified and implemented at an early enough stage to prevent impacts to groundwater users or to remedy unavoidable impacts.

10.6 BMA Response to Requested Action 39

Requested Action 39: *Where the existing mitigation and management measures cannot achieve the listed performance outcomes, provide details of how additional or altered mitigation and management measures will be implemented to meet these performance outcomes.*

Mitigation Measures

Potential impacts to groundwater quality from the Project were described in Section 7.4 of the Project's groundwater assessment (Appendix F of the EA Amendment application supporting information report). As described therein, potential sources of groundwater contamination impacts were identified as:

- Out of pit waste rock emplacement areas;
- In-pit waste rock emplacement areas;
- Final void; and
- Workshops and storage areas (i.e. mine supporting infrastructure).

The out of pit waste rock emplacement areas may produce seepage as a result of rainfall inundation that theoretically could alter the existing groundwater quality if that seepage enters the groundwater system. However, in-situ Cainozoic sediments present in the out-of-pit waste rock emplacement areas generally comprise surficial soil and clays, up to 10 m in thickness, that would inhibit potential seepage from the out-of-pit waste rock emplacement to the underlying shallow groundwater system. Furthermore, the inward hydraulic flow gradients from the waste emplacement areas to the open cut pit void would inhibit migration of any seepage that enters the shallow groundwater system from discharging to the broader receiving environment. Notwithstanding, the seepage (i.e. leachate from the out-of-pit waste rock emplacement) would generally be fresh and low in sulfur content, minimising the potential for a change in groundwater quality should the seepage enter the groundwater system. Runoff from out of pit waste rock emplacement areas would be captured in the sediment and MAW dams and managed under the mine water management system that is designed to capture all such water (as described in Appendix E of the EA Amendment application supporting information report). Therefore, it is anticipated that there would be limited potential for seepage from the out-of-pit waste rock emplacement to impact on groundwater quality and therefore identification of specific mitigation measures is not warranted.

During Project operations, the in-pit waste rock emplacement areas would be rehabilitated progressively as the mining operations progress. The Project would involve progressively backfilling the open cut pit as space becomes available, with water levels within backfilled areas predicted to recover back towards pre-mining levels. A continual void will be present ahead of the in-pit waste rock emplacement areas where active mining is taking place, which would act as a sink to groundwater flow and local surface water flow and capture any MAW coming from the in-pit waste rock emplacement areas. As such, the in-pit waste rock emplacement areas would not form a source of groundwater contamination with the potential to discharge to the receiving environment, and therefore identification of specific mitigation measures to manage discharge of void water is not warranted.

The predicted equilibrated final void water levels are between approximately 70 m and 90 m below the pre-mining groundwater levels. Water within the final void would evaporate from the final void water body surface and draw in groundwater from the surrounding strata and runoff from the final void catchment areas. This means the final void would act as a sink to groundwater flow and local surface water flow, and not form a source of groundwater contamination with the potential to discharge to the receiving environment, and therefore identification of specific mitigation measures to manage discharge of void water is not warranted.

All workshop and fuel/chemical storage areas at the CVM are developed in accordance with current Australian Standards. This includes refuelling areas and chemical storage areas to be designed with adequate bunding and equipped for immediate spill clean-up. These controls represent standard practice and a legislated requirement at mining operations for preventing the contamination of the groundwater regime. Therefore, there is considered to be limited potential for groundwater contamination to occur with relation to workshops and fuel/chemical storage, and therefore identification of specific mitigation measures to manage contamination (other than appropriate design) is not warranted at the present time. Such mitigation measures, in the unlikely event that they would be required, would include standard contaminated land management practices designed for the specific contaminant and local hydrogeological setting in accordance with industry standards and guidelines.

Groundwater Inflow Measurements

Groundwater take at the CVM (i.e. associated water as defined in the Mineral Resources Act 1989; MR Act) is entirely due to passive groundwater inflow to active mine pits. Dewatering via extraction bores placed ahead of mining is not required. Groundwater inflow to the pits occurs as damp or low flow seeps in the mining faces, making direct measurement of the groundwater inflow virtually impossible. The majority of the groundwater inflow evaporates directly from the mining face (pit walls and floor) and any minor volumes of remaining groundwater pools at the base of the pits within in-pit sumps, along with direct rainfall and any surface water run-off. The water is then left to evaporate or is pumped out from the pit sumps as necessary to storage dams. At the CVM captured groundwater inflow volume in the in-pit sumps is very low, and because of direct rainfall and surface water run-off, the resulting total volume of water pumped from the pits is much greater than the actual groundwater inflow.

In accordance with the requirements of the MR Act, CVM report the volume of associated water taken to the Department of Resources (DoR, formally DNRME) annually in accordance with the DoR's guidelines (DNRME, 2020) for quantifying the volume of associated water taken under a mining lease or mineral development licence. Due to the uncertainty regarding the data inputs (i.e. changes in dam water storages may be as a result of water moved between dams rather than direct take from the mining pits), the method is considered conservative often resulting in an overestimation of groundwater take. This method, and the resultant estimate of groundwater inflow, is therefore not considered suitable to use for calibrating the numerical groundwater model used for HPE EA Amendment Application.

Groundwater inflow will continue to be estimated in accordance with the DoR guidelines.

There are limited Project activities with the potential to cause groundwater quality impacts. Mitigation measures deemed required to prevent impacts from mining activities on groundwater quality are limited to appropriate design of workshops and storage areas (i.e. mine supporting infrastructure where potential contamination sources will be present). Other potential groundwater quality impacts that may arise from waste rock emplacements and void water storage will be naturally managed by the inwards hydraulic flow gradients that will exist between the mine pit voids and the surrounding groundwater environment, that will inhibit outflow of any MAW to the broader receiving groundwater environment.

Groundwater inflow will continue to be estimated in accordance with the Department of Resources guidelines for quantifying the volume of associated water taken under a mining lease or mineral development licence.

10.7 BMA Response – Summary of Groundwater Comments

The DES, following review of the HPE EA Amendment Application groundwater assessment, communicated concerns over the suitability of the numerical groundwater model for predicting drawdown at a Project Scale to assess impacts to groundwater receptors from the Project. Specifically, concerns regarding the calibration of Layer 1 for the assessing impacts to potential terrestrial GDEs located in the vicinity of Horse Creek in the north of the ML.

In addition, comments were provided on the proposed groundwater monitoring network, specifically where it was deemed additional infrastructure was required.

BMA consider the Project's hydrogeological conceptualisation and numerical groundwater model fit for purpose, and as such the assessment that the Project will not result in any significant impacts to groundwater receptors is robust. Furthermore, the proposed monitoring network will enable continuous evaluation of actual drawdown against predicted Project impacts. This assessment is based on the information presented within this document and the supporting documents to the EA Amendment application and is summarised as follows:

- Layer 1 in the Project's groundwater model represents surface cover including alluvium. There is minimal, if any, alluvium development along Horse Creek, and alluvium development along Grosvenor Creek downstream of Horse Creek is very limited. Where alluvium has been identified in the Project's groundwater assessment, including areas outside of previously known/mapped alluvium, its representation in the groundwater model has been applied using industry best practice techniques as validated by an expert Independent Peer Reviewer.
- Groundwater levels are sufficiently deep such that the shallow groundwater system in the vicinity of Horse and Grosvenor creeks is associated with Tertiary aged formations and weathered Permian coal measures that underlie any alluvium (i.e. the water table lies within the Regolith), and there is likely little to no shallow groundwater present in any of the alluvial sediments.
- The shallow groundwater system in the vicinity of Horse and Grosvenor creeks is recharged by seepage of stream flow from the creeks during occasional times of flow.
- The depth to groundwater in the vicinity of Cherwell, Horse and Grosvenor creeks is sufficiently deep such that only the deepest rooted terrestrial vegetation (e.g. River Red Gums) might access the groundwater table for some of their water requirements. Previous work completed for the Project's GDE Assessment identify that these terrestrial species would only form facultative GDEs at best, i.e. they are not wholly reliant on groundwater but likely only access it during times of limited soil moisture.
- Most of the terrestrial, and particularly aquatic, potential GDEs mapped along Horse Creek and Grosvenor Creek in the GDE Atlas cannot be GDEs given the depth to groundwater; in particular, it is highly unlikely that aquatic GDEs would be present as there are no known surface expressions of groundwater on these creeks.
- In accordance with IESC Guideline requirements under the EPBC Act, the Project's groundwater model was subject to an Independent Peer Review by an expert hydrogeologist/modeller; who concluded:
    - the Project's groundwater assessment is best practice and the modelling methodology is "state-of-art"
    - the Project's groundwater model is fit for the purpose of meeting the objectives defined in Section 1.3 of the Project's Groundwater Assessment report.
    - the Project's groundwater modelling has been conducted to a very high standard.
    - a rigorous monte carlo uncertainty analysis as reported in the Project Groundwater Assessment offsets much of the uncertainty that is inherent in a groundwater model.
- Monitoring bore MB20CVM01A is sufficient for monitoring impacts to GDEs in the vicinity of Horse Creek. Changes to groundwater levels at this location as a result of Project activities will

provide an early indication of changes to the shallow groundwater system downstream of the CVM.

- The proposed HPE groundwater monitoring network is suitable for monitoring Project impacts to groundwater. Monitoring of multiple co-located bores will enable direct impacts between impacted coal seam aquifers to the shallow groundwater system to be identified if they occur. Collection of groundwater levels across the monitoring network will enable robust recalibration and refinement of the numerical groundwater model in the future.
- An additional monitoring bore will be installed in the vicinity of the proposed OOPD to enable monitoring of potential seepage from this infrastructure.
- Where applicable, monitoring bores will be replaced 2 years prior being mined-out by planned mining activities to enable continuation of groundwater monitoring data and to establish an appropriate baseline dataset at the new bore prior to the mining-out of the existing bore.

11 Noise – Environmental Objective 5 and Performance Outcome 5.2

11.1 BMA Response to Requested Action 40

The Project must continue to implement effective environmental strategies with regards to Noise, including the following performance outcome:

a) The release of sound to the environment from the activity is managed so that adverse effects on environmental values including health and wellbeing and sensitive ecosystems are prevented or minimised.

The proposed amendment specifies in the Noise and Vibration Impact Assessment that the progressive replacements of steel rollers with quieter polymer rollers is a reasonable and practicable noise mitigation measure which will be effective in eliminating the marginal exceedance (at sensitive receptor R2 – Skyvile) over time.

***Response Action 40:** Confirm the timeframe for implementing proposed polymer rollers or specify what additional mitigation measures will be in place during adverse weather conditions to meet the conditions of the EA and avoid a noise exceedance at sensitive receptor R2 – Skyville.*

A marginal 1 dBA exceedance of the 30 dBA LA_{eq}, adj, 15 min CVM EA noise limit was predicted for noise sensitive receptor R7 (Skyville). This predicted exceedance is primarily attributable to the overland conveyor from PDM (i.e. not a direct result of the Project). It is noted however that the exceedance modelled is a predicted marginal 1 dBA exceedance of the existing CVM EA noise limit. It is commonly accepted within the acoustics industry that differences in noise levels of 1 or 2 dB are negligible and imperceptible to the human ear, particularly for steady-state noise sources such as conveyor noise.

In any case, the rollers on the conveyor will be progressively replaced from FY23 to FY31. This is based on the typical life for a condition-based replacement of up to 8 years.

11.2 BMA Response to Requested Action 41

The application does not indicate the completion of a noise and vibration impact assessment for the Moranbah Airport.

The supporting information indicates that all project blasts will be able to comply with current blasting conditions. However with the project moving closer to the Moranbah Airport, a commercial place frequented by the public. Further information is required to understand the influence impacts associated with blasts and overpressure on the Moranbah airport.

***Response Action 41:** Conduct a noise and vibration assessment for any impacts that may occur at the Moranbah Airport and provide details of how additional and/or modified mitigation measures will be implemented to effectively reduce any potential impacts or exceedances.*

The following section presents an assessment of Project airblast overpressure and ground vibration impacts for the Moranbah Airport.

The assessment states that the actual Project blast design would be determined via a detailed design process to be undertaken by the proponent's blasting contractor. It is anticipated that compliance with the EA airblast overpressure limits can be achieved with effective blast management and monitoring measures in place.

Furthermore, the assessment predicts that ground vibration levels indicate that the 10 mm/s (1% exceedance allowance) criterion can be achieved at the Moranbah Airport terminal building for all Project blasting. The assessment below presents the safe working distances, for each of the four assessed blast sizes, to achieve compliance with the existing EA airblast overpressure limits.

11.2.1 Blasting Noise and Vibration Criteria

The current CVM EA (EPML00562013) prescribes ground vibration and airblast overpressure criteria in Tables C2 and C3 respectively. These criteria are reproduced below in Table 11-1.

Table 11-1 EA Table C2 and C3 - Blasting Vibration and Airblast Overpressure Limits

Parameter	Sensitive or Commercial Place Blasting Limits
Ground vibration peak particle velocity	For vibrations of more than 35 Hz – no more than 25 mm/s peak particle velocity at any time.
	For vibrations of no more than 35 Hz – no more than 10 mm/s peak particle velocity at any time.
Airblast overpressure level	115 dB (Linear peak) for four (4) out of five (5) consecutive blasts regardless of the interval between blasts, and not greater than 120 dB (Linear peak) at any time.

As noted in Table 11-1, the EA criteria apply to both sensitive and commercial receptors and therefore is appropriate to apply to the Moranbah Airport.

11.2.2 CVM Blasting Site Law

As detailed in the noise and vibration impact assessment report for the Project, SLR developed a composite blast site law (summarised in Table 11-2) from 120 historical blast logs recorded between January 2019 and November 2020 at CVM.

Table 11-2 Summary of ROM for CVM CHPP

Blast Category	Exceedance Allowance	CVM Blast Site Laws	
		Ground Vibration (mm/s)	Airblast Overpressure (dBL)
All Project blast types	20% (i.e. 4 out of 5 blasts)	PVS(80%) = 110 * SD ^ -1.00	SPL(80%)=-19.5 * LOG(SD) + 155.7
	1% (i.e. maximum)	PVS(99%) = 312 * SD ^ -1.00	SPL(99%)=-19.5 * LOG(SD) + 164.7

'PVS' mean Vibration Velocity Peak Vector Sum in millimetres per second (mm/s).
'SPL' mean Sound Pressure Level.
'SD' means Scaled Distance, being a function of distance (between blast and measurement point) and MIC (in kgs).

In addition to the derived composite blast site laws, MICs to be used for the assessment of potential blasting impacts to the Moranbah Airport are summarised in Table 11-3. The MICs in Table 11-3 represent the historical range in MICs recorded from the BMA supplied dataset for the CVM and are relevant to future blasts for the Project.

Table 11-3 Project Blast Parameters – Assessment MICs

Blast Category	MIC (kg)			
	Minimum	10th Percentile	Average	90th Percentile
All Project blast types	106	586	1,313	2,377

11.2.3 Ground Vibration Assessment

The EA ground vibration criteria prescribes a maximum ground vibration level of 10 mm/s (assumed as a 1% exceedance to facilitate predictions through the site law formula). Correspondingly, '1% exceedance' ground vibration prediction formula was generated for the CVM ground vibration site laws. Peak Vector Sum (PVS) represents the level of ground vibration (mm/s), above which 1% of the total population (of data points) will lie respectively, assuming that the population has the same statistical distribution as the underlying measured sample.

Based on the proposed minimum separation distance between the Project blasting and the Moranbah Airport terminal building, determined to be approximately 400 m, the CVM site law predicted ground vibration levels are presented in Table 11-4. The ground vibration levels are predicted external to the terminal building.

Table 11-4 Predicted Ground Vibration Levels at the Moranbah Airport Terminal Building

Blast Category	Assessed MIC (kg)	Distance to Airport (m)	Ground vibration (mm/s) 10 mm/s Criterion (1% Exceedance Allowance)
All Project blast types	106	400	0.8
	586	400	1.9
	1,313	400	2.9
	2,377	400	3.9

The range in prediction represent the average and upper 10th percentile of MIC's for the Project.

The predicted ground vibration levels presented in Table 11-4 indicate that the 10 mm/s (1% exceedance allowance) criterion can be achieved at the Moranbah Airport terminal building for all Project blasting.

11.2.4 Airblast Overpressure Assessment

The EA airblast overpressure criteria cater for the inherent variation in emission levels from a given blast design by allowing 20% (i.e. four (4) out of five (5) blasts) exceedance of the 115 dBL criterion and up to a 120 dBL maximum (assumed at 1% exceedance). Sound Pressure Level (SPL) represents the level of airblast overpressure (dBLinear or dBL), above which 1% and 20% of the total population (of data points) will lie respectively, assuming that the population has the same statistical distribution as the underlying measured sample.

Based on the proposed minimum separation distance between the Project blasting and the Moranbah Airport terminal building (i.e. approximately 400 m), the CVM site law predicted airblast overpressure levels are presented in Table 11-5. The airblast overpressure levels are predicted external to the terminal building.

Table 11-5 also presents the safe working distances, for each of the four assessed blast sizes, to achieve compliance with the existing EA airblast overpressure limits.

Table 11-5 Predicted Airblast Overpressure Levels at the Moranbah Airport Terminal Building

Blast Category	Assessed MIC (kg)	Distance to Airport (m)	Airblast Overpressure (dBL)		Safe Working Distance to Comply With	
			115 dBL Criterion 20% Exceedance Allowance	120 dBL Criterion 1% Exceedance Allowance	115 dBL Criterion 20% Exceedance Allowance	120 dBL Criterion 1% Exceedance Allowance
All Project blast types	106	400	118	127	540 m	875 m
	586	400	123	132	975 m	1,550 m
	1,313	400	125	134	1,250 m	2,025 m
	2,377	400	127	136	1,525 m	2,450 m

The range in prediction represent the average and upper 10th percentile of MIC's for the Project.

The predicted airblast overpressure levels presented in Table 11-5 indicate that both the 115 dBL (20% exceedance) and 120 dBL (maximum) blasting criteria would likely be exceeded for the Project based on the current CVM blast site law.

Based on the CVM site law, a maximum MIC of 43 kg is calculated to achieve compliance with the 115 dBL level. An MIC of 43 kg (or less) would likely represent a significant constraint on operations for CVM and therefore it will be necessary for BMA to apply all practicable measures to mitigate airblast overpressure levels if MICs larger than 43 kg are required.

With reference to Table J6.1 of Australian Standard 2187 (AS 2187) Explosives – Storage and use Part 2: Use of explosives 2006, "significant" reduction of airblast overpressure levels is typically achieved through the following measures:

- Ongoing optimisation of blasts to reduce the impact of airblast overpressure may include a combination of the following, dependent on the location and type of blast being planned:
    - Reduced powder factor;
    - Reduced blast volume;
    - Explosives product selection (density and type);
    - Appropriate stemming material and height for effective confinement;
    - Delay control;
    - Utilise decking;
    - Utilise electronic initiation systems to avoid build-up in wavefront reinforcement;
- Firing away from the Moranbah Airport where possible;
- Considering forecast temperature inversion when planning the blast;
- Considering delaying or cancelling the blast by not loading if the weather forecast is unfavourable; and
- Data collection (both blasting inputs and monitoring results) to assist making better informed decisions particularly given blasting for the Project will over time progress closer to the Airport (i.e. blasting for the Project will not commence at the closest point to the Airport).

Notwithstanding the airblast limits prescribed in the CVM EA, Table J5.4(A) of AS 2187 notes that an airblast limit of 125 dBL has previously been applied by regulatory authorities to occupied commercial premises. A limit of 125 dBL would likely be suitable for the Airport given the potential for annoyance to occupants, in particular transiting passengers, would be expected to be low.

In addition to the above, BMA have the flexibility to schedule blasts to occur outside of times when flights are scheduled with sufficient time before and after the flight to accommodate arrivals and departures to the Airport to ensure attendance by members of the public would be at a minimum. Airport staff would be briefed of impending blasts as part of routine communication.

For CVM blasts that coincide with the Airport terminal building being unoccupied, an airblast limit of 133 dBL would apply to avoid damage as per the guidance in Table J5.4(B) of AS 2187. Based on the CVM site law, a maximum MIC of 1000 kg is calculated to achieve compliance with the 133 dBL level.

On the basis of the above preliminary assessment and noting that the actual Project blast design would be determined via a detailed design process to be undertaken by BMA's blasting contractor, it is anticipated that compliance with the EA airblast overpressure limits can be achieved with effective blast management and monitoring measures in place.

12 Land – Environmental Objective 7 and Performance Outcome 7.2

According to section 5.7 of the supporting document, there have been a number of surveys that have been conducted to 'ground-truth' the project area with some of the results which may differ from Queensland Government mapping which include ground-truthing of:

- *Category B environmentally sensitive areas;*
  - *Regulated vegetation;*
  - *Connectivity areas;*
- *Terrestrial ecology values*
  - *Regional ecosystems;*
  - *Terrestrial fauna (ornamental snake habitat);*
  - *GDEs.*

12.1 BMA Response to Requested Action 42

Response Action 42: *For formal assessment by the QLD herbarium of applicant ground-truthed data, provide ground-truthed data in the form of:*

a) Digital shapefiles of the regional ecosystem mapping polygons that they want changed;
b) Digital shapefiles of the site locations from which survey data was collected;
c) Site data sheets; and
d) Any photographs taken at site location.

The regional ecosystem (RE) mapping for the Study Area has been updated and validated by a detailed field survey which included the collection of data from 23 field sites (BioCondition, Quaternary and Tertiary Habitat Quality Assessments). The updated map delineates 112.40 ha of remnant vegetation across the Study Area comprising three REs.

Of the remnant vegetation mapped, 108.47 ha is classified with an Of Concern Biodiversity status, and the remaining 3.93 ha is classified as Not of Concern. The updated RE mapping will be used to update mapping of ESAs regulated under the Environmental Protection Act 1994.

A RE Amendment Report (Appendix J3) with supporting documentation has been submitted to the Queensland Herbarium (by DES).

13 Change to the Exercise of Underground Water Rights

13.1 BMA Response to Requested Action

The area surrounding CVM has multiple groundwater users. As part of the proposed amendment, the application proposes the exercise of underground water rights during the period in which resource activities will be carried out on ML1775.

Requested Action: *Please be advised an Underground water impact report (UWIR) may be required. The Underground Water Assessment Team within the Department's Energy and Extractive unit can assist in determining if a UWIR is required.*

Email: UndergroundWater@des.qld.gov.au

Provide details of the UWIR requirements for the project.

In 2017 it was determined that BMA is authorised under existing water licence on ML1775. The Project is a continuation of the operations approved on ML1775. The Project is exempt from requiring an UWIR under Chapter 3, Part 2 of the Water Act 2000 (Qld) (Water Act).

For the relevant exemption to apply under s 369A(1) the following criteria under s 369A(2) must be established:

a) the holder of the mineral development licence or mining lease is authorised, under a water licence or water permit, to take or interfere with underground water in the area of the licence or lease; and
b) the taking or interference happens during the course of, or results from, the carrying out of an authorised activity for the licence or lease.

In addition, an exemption can only apply if the licence or lease is not a cumulative management area (CMA) tenure (s 369A(4)(a)).

Notwithstanding the foregoing, the Chief Executive may use their discretion to decide, having regard to the impact considerations relating to the holder, that Chapter 3, Part 2 does apply to the holder (s 369A(4)(b)).

Under section 362 of the Water Act, impact considerations, in relation to a resource tenure holder means the following:

a) the impacts, or likely impacts, of the exercise of the holder's underground water rights on a water bore or spring;
b) the location and area of the holder's resource tenure;
c) the holder's water monitoring authorities;
d) existing water monitoring infrastructure or equipment put in place by the holder;
e) existing make good agreements entered into by the holder;
f) existing agreements entered into by the holder with other resource tenure holders about managing the impacts of the exercise of underground water rights.

The following exemption criteria apply to this Project.

1. Establishment of s369A(1) Criteria

Dewatering works at the CVM are currently authorised under water licence 608364, which covers ML70403 and ML1775. The water licence was granted on 29th August 2013, with the water table first intercepted by mining activities in 2014. Mining extents for the Project at the CVM are entirely within the boundary of ML1775, with groundwater take expected to occur under the same process i.e. evaporation from pit and/or pumping of in pit sumps. Further, updated modelling has shown that anticipated groundwater extraction volumes including the Horse Pit Extension are less than previously expected under the existing water licence 608364.

The administering authority for the water licence, the Department of Regional Development, Manufacturing and Water (DRDMW) requested that the groundwater numerical model required under the licence conditions be reviewed and recalibrated. The results were presented in the 2021 annual water licence monitoring report to DRDMW. The numerical model was updated by SLR (2021) to simulate the same mining scenario (i.e. the base case) as the peer reviewed Horse Pit Extension numerical model.

The review found that the previous numerical model (GHD, 2017) of the CVM operations (i.e. excluding the Project) had over predicted pit inflows by 400%, with inflows of 4ML/day predicted by the original model compared to 0.93 ML/day predicted using the updated model (Appendix B of Appendix F: Groundwater Resources Assessment of the EA Amendment Supporting Documentation). Numerical modelling of the CVM with the Project shows inflow predictions of 1.06ML/day which are marginally higher than the predicted inflows of the current mining scenario but significantly (more than 80%) lower than the previously assumed groundwater inflow predictions rates.

2. Tenure Location within CMA

Review of the DES website (Cumulative Management Area | Environment | Department of Environment and Science, Queensland (des.qld.gov.au), accessed 29/06/2022) found that the tenure is not located in a CMA. Therefore s 369A(4)(a) does not apply.

3. Relevant Impact Considerations

The groundwater assessment completed for the Project shows the location and area of the resource tenure, the existing monitoring bores at the CVM and a proposed monitoring program on approval of the Project.

The groundwater assessment sufficiently shows the impacts related to the Project through the development of a peer reviewed numerical groundwater model. Review of the predicted model drawdown across each identified hydrostratigraphic unit and comparison with identified groundwater environmental values found that there is little to no risk to identified groundwater users during the lifetime of the Project.

The conditions of the existing water licence also include ‘make good’ commitments when pre-existing bores have been unduly affected by dewatering activities.

A census of all registered bores was completed as part of the assessment, providing a baseline condition of all landholder bores currently in use, within 5km from the Project boundary. The information collected by the census will be used for any future investigations of potential project impacts to groundwater users.

The current requirements of the water licence include monitoring, reporting and notification which would continue to adequately manage risks to groundwater associated with mining at the CVM.

Consideration of the above impact considerations (as defined under the Water Act) does not support a decision under s 369A(4)(b) that Chapter 3, Part 2 of the Water Act should apply.

Summary

In summary the Project will therefore be exempt from requiring an UWIR given that:

- BMA is authorised under water licence 608364 to take underground water on ML1775;
- The water licence was granted before 6 December 2016, with first interference of groundwater also occurring before this date;
- Underground water take for the Project will be undertaken within the boundaries of ML1775;
- Underground water take for the Project will occur under the same process as the currently approved authorised activity at the CVM;
- Underground water take rates / volumes will not significantly differ from what is currently authorised under the existing water license and are significantly less than previously predicted for the CVM operation;
- The tenure is not located within a CMA;
- The groundwater assessment has adequately documented the resource tenure and area, existing monitoring infrastructure and proposed future monitoring program;
- The groundwater assessment has adequately identified groundwater users, predicted impacts to hydrostratigraphic units and assessed potential risk from the Project;
- Risk to groundwater users from the Project has found to be low;
- Underground water obligations will be appropriately managed through the conditions of the existing water licence;
- Make good commitments will be managed through existing water licence conditions; and
- The groundwater assessment included a bore census identifying pre-existing bore use within 5km of the Project boundary.

14 References

BMA (2020), BMA Standard Erosion and Sediment Control and Mine Affected Water Standard (the Standard)

Department of Environment and Heritage Protection (DEHP) 2019 Structures which are dams or levees constructed as part of environmentally relevant activities, ESR/2016/1934 Version 9.00 Effective: 01 April 2019

DEHP (2016) Manual for Assessing Hazard Categories and Hydraulic Performance of Dams EM635 Version 5, DEHP, March 2016

DEHP (2013a) Model water conditions for coal mines in the Fitzroy basin ESR/2015/1561 Version 3.01 Effective: 31 March 2013

Department of Natural Resources, Mines and Energy (DNRME) Water Monitoring Information Portal (WMIP) Streamflow Data <https://water-monitoring.information.qld.gov.au/>, available from, accessed November 2022

DES 2016. Manual: Manual for assessing consequence categories and hydraulic performance of structures. ESR/2016/1933, Version 5.02, Effective: 29 Mar 2016.

DES 2020. Information sheet: Voids in flood plains. ESR/2019/4966, Version 1.00, Effective: 11 Mar 2020.

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

DES 2021. Guideline: Requirements for site-specific and amendment applications – underground water rights. ESR/2016/3275, Version 1.03, Last reviewed, 27 Apr 2021.

DES 2022. Guideline: Reef discharge standards for industrial activities. ESR/2021/5627, Version 1.02, Last reviews: 6 May 2022.

GHD 2017. BHP Caval Ridge Mine Numerical Groundwater Model. December 2017.

Hart et al (2008) Review of the Fitzroy River Water Quality Issues- Report to Queensland Premier Water Science Pty Ltd and Water Studies in collaboration with University of Queensland and International Water Centre.

IESC 2018. Information guidelines for proponents preparing coal seam gas and large coal mining development proposals, Commonwealth of Australia 2018.

International Erosion Control Association (Australasia), November 2008, Best Practice Erosion and Sediment Control.

Jones, M. A. and Davison, L. (2013) Salinity and salt load of the Fitzroy River during the water year 2010 - 2011. Report to the Fitzroy Partnership for River Health, Rockhampton.

Kafle et al (2018) Caval Ridge Mine Report AQUA-ECO Health Sampling 2018 Wet Season.

Appendix J1 Independent Groundwater Peer Review Documents

HydroAlgorithmics Pty Ltd ● ABN 25 163 284 991
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noel.merrick@hydroalgorithmics.com

DATE: 13 August 2021

TO: BM Alliance Coal Operations Pty Ltd
480 Queen Street
Brisbane QLD 4000

FROM: Dr Noel Merrick

RE: Caval Ridge Mine Horse Pit Extension Project – Groundwater Peer Review

YOUR REF: PO 4510585992

OUR REF: HA2021/10

1. Introduction

This report provides a peer review of the groundwater assessment (GA) and associated modelling for the Caval Ridge Mine (CVM) Horse Pit Extension (HPE) Project (the Project). The GA has been prepared by SLR Consulting Australia Pty Ltd (SLR) for the client BM Alliance Coal Operations Pty Ltd (BMA). The Project is a metallurgical open cut coal mine within the Bowen Basin, Queensland, about 5 km south of Moranbah, about 30 km north-west of the recently-approved Olive Downs South Coking Coal Project, and immediately north of the existing Peak Downs and Saraji coal mines.

The main elements of the Project that are relevant to groundwater assessment are:

- Life of Project approximately 30 years.
- One open cut pit with a single final void outside the floodplain, and one out-of-pit dump to the west.
- Mining of the Q, P, H and D seams in the Moranbah Coal Measures.
- Many surrounding coal mines and one coal seam gas operation to the east.

The Project is based on an extension of the existing Horse Pit to the east, at the northern end of the CVM. Mining is to run approximately parallel to Isaac River, at distances of about 5-9 km, but the alluvium of the Isaac River will not be intercepted.

2. Documentation

The review is based on the following report:

1. SLR, 2021, Caval Ridge Mine Horse Pit Extension Project Groundwater Assessment. Report 620.13593.00005-R01-v4.0 prepared for BMA, August 2021. 173p (main) + 5 Appendices.

Groundwater modelling details are in Appendix B of Document #1:

2. SLR, 2021, Caval Ridge Mine Horse Pit Extension Project Groundwater Modelling Technical Report. Appendix B, 620.13593.00005-R02-v5.0 prepared for BMA, August 2021. 110p + 5 Appendices.

Document #1 has the following major sections:

1. Introduction
2. Legislative Requirements and Relevant Guidelines
3. Existing Conditions
4. Geology
5. Hydrogeology
6. Groundwater Simulation Model
7. Impacts on Groundwater Resources
8. Management and Mitigation Measures
9. Limitations
10. References

The Appendices are:

A1. CVM and Project Groundwater Monitoring Network
A2. Groundwater Quality
A3. CVM Bore Census Surveys
A4. Groundwater Monitoring Well Drilling Reports
B. Groundwater Modelling Technical Report

Document #2 is structured as follows:

1. Introduction
2. Model Construction and Development
3. Predictive Modelling
4. Recovery Model
5. Sensitivity Analysis
6. Uncertainty Analysis
7. Model Confidence Level Classification
8. Groundwater Model and Data Limitations
9. Conclusions
10. References.

The Appendices are:

A. Calibration Residuals
B. Calibration Hydrographs
C. Hydraulic Parameters and Recharge Zone Distribution
D. Cumulative Drawdown Predictions
E. Uncertainty Analysis Parameters Distribution

3. Review Methodology

While there are no standard procedures for peer reviews of entire groundwater assessments, there are two accepted guides to the review of groundwater models: the Murray-Darling Basin Commission (**MDBC**) Groundwater Flow Modelling Guideline[1], issued in 2001, and guidelines issued by the National Water Commission (**NWC**) in June 2012 (Barnett *et al.*, 2012[2]). Both guides also offer techniques for reviewing the non-modelling components of a groundwater impact assessment.

The NWC national guidelines were built upon the original MDBC guide, with substantial consistency in the model conceptualisation, design, construction and calibration principles, and the performance and review criteria, although there are differences in details.

[1] MDBC (2001). Groundwater flow modelling guideline. Murray-Darling Basin Commission. URL: www.mdbc.gov.au/nrm/water_management/groundwater/groundwater_guides

[2] Barnett, B, Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. (2012). *Australian Groundwater Modelling Guidelines*. Waterlines report 82, National Water Commission, Canberra.

The NWC guide promotes the concept of "model confidence level", which is defined using a number of criteria that relate to data availability, calibration, and prediction scenarios. The NWC guide is almost silent on coal mine modelling and offers no direction on best practice methodology for such applications. There is, however, an expectation of more effort in uncertainty analysis, although the guide is not prescriptive as to which methodology should be adopted.

Guidelines on uncertainty analysis for groundwater models were issued by the Independent Expert Scientific Committee (**IESC**) on Coal Seam Gas and Large Coal Mining Development in February 2018 in draft form and finalised in December 2018[3].

The groundwater guides include useful checklists for peer review. This groundwater assessment has been reviewed according to the 137-question Review Checklist in NWC (2012). This checklist has questions on (1) Planning; (2) Conceptualisation; (3) Design and construction; (4) Calibration and sensitivity; (5) Prediction; (6) Uncertainty; (7) Solute transport[4]; and (8) Surface water-groundwater interaction. In addition, this review includes the 10-question Compliance Checklist in NWC (2012).

This review has been conducted progressively through attendance at six video-conference workshops at key GA project milestones, several direct discussions with the modelling team, and review of progress reports and slideshow presentations. After each meeting, a log of issues was prepared and updated for consideration in the preparation of the final GA report, as well as progressive completion and disclosure of the Review Checklist. All issues have been addressed satisfactorily. Video-conference meetings were held on the following dates in 2021: 23 February, 31 March, 28 April, 3 June, 10 June and 15 July.

4. Checklists

Checklist assessments are provided in **Table 1** and **Table 2**.

Table 1 is the NWC Compliance Checklist, which concludes that the groundwater model is “fit for purpose”, where the purpose is the prediction of quantitative potential water level impacts and inferred qualitative potential water quality and ecosystem impacts due to the extension of mining at the CVM Horse Pit.

Table 2 provides a detailed assessment according to the NWC (2012) guide, excluding the inapplicable *Solute transport* set of questions.

Supplementary comments are offered in Sections 5, 6 and 7.

[3] Middlemis H and Peeters LJM (2018) *Uncertainty analysis—Guidance for groundwater modelling within a risk management framework*. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2018.

[4] Not relevant to this assessment (15 questions)

Table 1. Compliance Checklist

Question	*Yes/No*
1. Are the model objectives and model confidence level classification clearly stated?	(1) Yes (2) Yes
2. Are the objectives satisfied?	Yes
3. Is the conceptual model consistent with objectives and confidence level classification?	Yes
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes
5. Does the model design conform to best practice?	Yes
6. Is the model calibration satisfactory?	Yes
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes
8. Do the model predictions conform to best practice?	Yes
9. Is the uncertainty associated with the predictions reported?	Yes
10. Is the model fit for purpose?	Yes

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
1. Planning		
1.1 Are the project objectives stated?	Y	Section 1.3
1.2 Are the model objectives stated?	Y	S1. Three objectives (inflow, drawdown, management measures)
1.3 Is it clear how the model will contribute to meeting the project objectives?	Y	
1.4 Is a groundwater model the best option to address the project and model objectives?	Y	No alternative
1.5 Is the target model confidence-level classification stated and justified?	Y	Table 7-1. Mostly Class 2. Counts: 1 (class 1), 12 (class 2), 6 (class 3).
1.6 Are the planned limitations and exclusions of the model stated?	Y	Table 8-1.
2. Conceptualisation		
2.1 Has a literature review been completed, including examination of prior investigations?	Y	S5.2: prior hydraulic tests; neighbouring mine investigations. Fig.5-3. App.A2. S5.2.3: review of fault papers.
2.2 Is the aquifer system adequately described?	Y	Good coverage of solid geology and surface geology with maps of elevations and thicknesses or depths, and two cross-sections.
2.2.1 hydrostratigraphy including aquifer type (porous, fractured rock ...)	Y	Two cross-sections N-S and W-E (Figs. 4-6, 4-7). Categorised in S5.
2.2.2 lateral extent, boundaries and significant internal features such as faults and regional folds	Y	Faults addressed in S4.2.4 and S5.2.3. Maps show extents of target coal seams.
2.2.3 aquifer geometry including layer elevations and thicknesses	Y	Structure contours and formation thicknesses: Surficial units, Triassic (Figs.4-5, 4-9). Structure contours and depth of cover: 4 coal seams (Figs.4-10 to 4-13). Average thicknesses for 19 layers (Table 2-1).
2.2.4 confined or unconfined flow and the variation of these conditions in space and time?	OK	Some perching (S5.3.1.2). Unconfined or confined conditions are self-evident. Potentiometric levels and vertical gradients are discussed.
2.3 Have data on groundwater stresses been collected and analysed?	Y	CVM inflow ~1100 ML/a (Table 5-5). CVM + Peak Downs + Saraji ~9000 ML/a in 2019-20 (Table 5-6). 16 other coal mines (13 OC, 3 UG) & Bowen Gas Project CSG; 10 included for cumulative assessment.
2.3.1 recharge from rainfall, irrigation, floods, lakes	Y	Rainfall & RMC; stations and SILO. Recharge described in S5.3.1.2, etc., per formation.
2.3.2 river or lake stage heights	Y	Several Isaac River gauges – ephemeral (flows 27% of time). Generally losing conditions near the Project. Graphs of stage and discharge included.
2.3.3 groundwater usage (pumping, returns etc)	Y	Section 5.5: database search; volumes not available. Landholder bores mentioned S5.3.1.2. Censuses: Figure 5-32. Project census (26 bores) in App.A3 – insignificant usage.
2.3.4 evapotranspiration	Y	Potential & actual. Discharge described in S5.3.1.2, etc., per formation.

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
2.3.5 other?	Y	Land use. Water quality. Leachate analysis. Stygofauna.
2.4 Have groundwater level observations been collected and analysed?	Y	S5.1 groundwater monitoring network: 47 sites; 2008 & 2019-2020; 9 separate formations. Very many at other mines (Table 5-3). Analysed in Section 5. Not all alluvial bores respond to rainfall.
2.4.1 selection of representative bore hydrographs	Y	All.
2.4.2 comparison of hydrographs	Y	Done well, by formation.
2.4.3 effect of stresses on hydrographs	Y	Cause-and-effect analysis via RMC and mining proximity.
2.4.4 watertable maps/piezometric surfaces?	Y	Piezometric surfaces for all formations Figures 5-6, 5-8, 5-9, 5-14 to 5-18. TDS map Figure 5-31.
2.4.5 If relevant, are density and barometric effects taken into account in the interpretation of groundwater head and flow data?	N/A	
2.5 Have flow observations been collected and analysed?	Y	Inflow rates stated for CVM, Peak Downs, Saraji. Not for CSG produced water (to east).
2.5.1 baseflow in rivers	N/A	Isaac River flows only 27% of time and is losing near the Project. Baseflow is not occurring (except as rare events) and cannot be used for calibration.
2.5.2 discharge in springs	N/A	
2.5.3 location of diffuse discharge areas?	OK	Self-evident. Surface geology map.
2.6 Is the measurement error or data uncertainty reported?	OK	Some mentions of anomalous data. Qualitative comments on data limitations in Table 8-1.
2.6.1 measurement error for directly measured quantities (e.g. piezometric level, concentration, flows)	N	
2.6.2 spatial variability/heterogeneity of parameters	Y/N	S5.2 demonstrates heterogeneity based on site hydraulic tests, but maps of spatial variability are not included. K(z) decay is demonstrated (Fig.5-3).
2.6.3 interpolation algorithm(s) and uncertainty of gridded data?	N	Assumed kriging (of minor importance).
2.7 Have consistent data units and geometric datum been used?	Y	Metric and AHD.
2.8 Is there a clear description of the conceptual model?	Y	S5.7.
2.8.1 Is there a graphical representation of the conceptual model?	Y	Three cross-sections (Figs. 5-34. 5-35, 5-36) – before, during, and after. Very good.
2.8.2 Is the conceptual model based on all available, relevant data?	Y	
2.9 Is the conceptual model consistent with the model objectives and target model confidence level classification?	Y	Consistent with Class 2 target (Table 7-1) and model objectives (S1).
2.9.1 Are the relevant processes identified?	Y	On Figs. 5-34. 5-35, 5-36
2.9.2 Is justification provided for omission or simplification of processes?	OK	All described physical processes will carry across to the numerical model other than perching (although, in theory, MODFLOW-USG could handle this – but unwarranted).
2.10 Have alternative conceptual models been investigated?	N	Not warranted, as only one numerical model should be built.

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
3. Design and construction		
3.1 Is the design consistent with the conceptual model?	Y	Key processes are included.
3.2 Is the choice of numerical method and software appropriate?	Y	MODFLOW-USG + AlgoMesh + PEST.
3.2.1 Are the numerical and discretisation methods appropriate?	Y	Voronoi grid for internal spatial detail. Temporal periods are appropriate – quarterly for calibration; yearly for prediction.
3.2.2 Is the software reputable?	Y	State-of-art.
3.2.3 Is the software included in the archive or are references to the software provided?	OK	References. AlgoMesh is proprietary.
3.3 Are the spatial domain and discretisation appropriate?	Y	Total 1.14m cells.
3.3.1 1D/2D/3D		3D
3.3.2 lateral extent		About 62km x 95km
3.3.3 layer geometry?		19 layers.
3.3.4 Is the horizontal discretisation appropriate for the objectives, problem setting, conceptual model and target confidence level classification?	Y	Min 50m cell size.
3.3.5 Is the vertical discretisation appropriate? Are aquitards divided in multiple layers to model time lags of propagation of responses in the vertical direction?	Y N	19 layers. Aquitards are individual layers – a pragmatic compromise with so many layers and a model size already >1 million cells.
3.4 Are the temporal domain and discretisation appropriate?	Y	
3.4.1 steady state or transient		Both
3.4.2 stress periods	Y	54 SP for warm-up (20 yrs 1988-2007) and calibration (qtly Dec.2007-Dec.2020). Stress periods are suitable.
3.4.3 time steps?	Y	Model uses ATS (S2.5) – automatic time stepping – to set dynamic time steps.
3.5 Are the boundary conditions plausible and sufficiently unrestrictive?	Y	Extended to north and west from existing model; reduced on eastern edge.
3.5.1 Is the implementation of boundary conditions consistent with the conceptual model?	Y	
3.5.2 Are the boundary conditions chosen to have a minimal impact on key model outcomes? How is this ascertained?	Y	Sufficiently distant.
3.5.3 Is the calculation of diffuse recharge consistent with model objectives and confidence level?	Y	8 zones based on lithology.
3.5.4 Are lateral boundaries time-invariant?	Y	
3.6 Are the initial conditions appropriate?	Y	Based on steady-state pre-1988
3.6.1 Are the initial heads based on interpolation or on groundwater modelling?		Model
3.6.2 Is the effect of initial conditions on key model outcomes assessed?	N	But buffeted by intervening warm-up period
3.6.3 How is the initial concentration of solutes obtained (when relevant)?	N/A	
3.7 Is the numerical solution of the model adequate?	Y	
3.7.1 Solution method/solver		USG solver and options are not stated
3.7.2 Convergence criteria		Mass discrepancy 0.0%

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
3.7.3 Numerical precision		Assumed single
4. Calibration and sensitivity		**2008-2020**
4.1 Are all available types of observations used for calibration?	Y	Heads quantitatively and fluxes qualitatively.
4.1.1 Groundwater head data	Y	4,342 target heads at 400 bores; 47 local CVM sites. Fewer targets than predecessor models due to sampling density
4.1.2 Flux observations	Y	Not sufficiently reliable for quantitative targets. Reality check carried out: list of predicted inflows to each mine (S2.6.3.2) – 0.1 to 1.8 ML/day.
4.1.3 Other: environmental tracers, gradients, age, temperature, concentrations etc.	N	No use of horizontal or vertical gradients for calibration. Statement on consistent vertical gradients.
4.2 Does the calibration methodology conform to best practice?	Y	PEST + manual.
4.2.1 Parameterisation		Laterally uniform in lithologies (no pilot points). Vertical depth functions.
4.2.2 Objective function	Y	PEST phi (sum of squares) 651,580 m^2.
4.2.3 Identifiability of parameters	Y	Section 5.1.2 (GENLINPRED software).
4.2.4 Which methodology is used for model calibration?		PEST + manual.
4.3 Is a sensitivity of key model outcomes assessed against…?	Y	Section 5.1 (Relative Composite Sensitivity).
4.3.1 parameters	Y	Kx, Kz/Kx, K(z)_slope, Sy, Ss
4.3.2 boundary conditions	N	*Not essential*
4.3.3 initial conditions	N	*Not essential*
4.3.4 stresses	Y	Recharge
4.4 Have the calibration results been adequately reported?	Y	Section 2.6.
4.4.1 Are there graphs showing modelled and observed hydrographs at an appropriate scale?	Y	Figures 2-9 to 2-12.
4.4.2 Is it clear whether observed or assumed vertical head gradients have been replicated by the model?	N	Not clear as VWP plots are individual rather than stacked. Bore 1235C: obs.115-140; sim.153mAHD. Bore 2183: obs.135-155; sim.168mAHD. Bore 2218: obs.148-152; sim.164mAHD. Bore 2226: obs.154-162; sim.167mAHD. Bore 2372: obs.142-150; sim.160mAHD. Bore 2375: obs.140-145; sim.160mAHD. S2.6.2.2 notes a simulated vertical gradient at the Project, as observed.
4.4.3 Are calibration statistics reported and illustrated in a reasonable manner?	Y	Table 2-5, key statistics 5.4 %RMS, 12.5 mRMS (global), 9.8 %RMS, 5.6 mRMS (local).
4.5 Are multiple methods of plotting calibration results used to highlight goodness of fit robustly? Is the model sufficiently calibrated?	Y	Scattergrams regional (Figure 2-5) and CVM only (Figure 2-6) – generally linear over a wide range of elevations (~100 m) – weaker at low levels <150 mAHD. Histogram (Figure 2-7). Calibration generally good close to CVM.

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
4.5.1 spatially	Y	Residuals by layer (Table 2-6) and by site (Table 2-7). Average residual spatial map (Fig.2-8) and Appendix A table.
4.5.2 temporally	Y	Figures 2-9 to 2-12; Appendix B.
4.6 Are the calibrated parameters plausible?	Y	Table 2-12. Recharge rates similar to predecessor models (0.01-0.52%) except Tertiary basalt (from 5% to 0.3%). Rewan (not at site) permeabilities are higher than predecessor models.
4.7 Are the water volumes and fluxes in the water balance realistic?	Y	In cumulative simulations, Isaac River is losing on the whole (Table 3-2), but slightly gaining for the null run (Table 3-4). Total mine inflow 1988-2020 (6.3 ML/day average) is the sum of 9 mine inflows from 0.1 to 1.8 ML/day (S2.6.3.2) - of the right order.
4.8 has the model been verified?	N	No data have been withheld from calibration – normal practice.
5. Prediction		**2021-2055 + recovery (200-500 years)**
5.1 Are the model predictions designed in a manner that meets the model objectives?	Y	• *"Assess the groundwater inflow to the mine workings as a function of mine position and timing;* • *Simulate and predict the extent and area of influence of dewatering, and the level and rate of drawdown at specific locations; and* • *Identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary."* All objectives able to be assessed by the model design.
5.2 Is predictive uncertainty acknowledged and addressed?	Y	In Section 6.
5.3 Are the assumed climatic stresses appropriate?	OK	Not stated but normal practice is long-term average (no seasonality).
5.4 Is a null scenario defined?	Y	
5.5 Are the scenarios defined in accordance with the model objectives and confidence level classification?	Y	With and without Project including cumulative effects. Compared with null case.
5.5.1 Are the pumping stresses similar in magnitude to those of the calibrated model? If not, is there reference to the associated reduction in model confidence?	Y	Continuation of mining.
5.5.2 Are well losses accounted for when estimating maximum pumping rates per well?	N/A	
5.5.3 Is the temporal scale of the predictions commensurate with the calibrated model? If not, is there reference to the associated reduction in model confidence?	Y	Calibration: quarterly. Prediction: annual and then 5-yearly.
5.5.4 Are the assumed stresses and timescale appropriate for the stated objectives?	Y	
5.6 Do the prediction results meet the stated objectives?	Y	The three stated objectives at Q5.1 are assessed.
5.7 Are the components of the predicted mass balance realistic?	Y	In Section 3.2. There is a reality check for predicted mine inflow compared to historical takes (S2.6.3.2).

Table 2. Review checklist (2012 National Guidelines)

(Main Report - black)

(Technical Report - purple)

Review questions	*Yes/No*	*Comment*
5.7.1 Are the pumping rates assigned in the input files equal to the modelled pumping rates?	N/A	
5.7.2 Does predicted seepage to or from a river exceed measured or expected river flow?	N	Exchange rates very much less than river flow. Isaac River is said to be losing near the Project. Predicted change in leakage is negligible.
5.7.3 Are there any anomalous boundary fluxes due to superposition of head dependent sinks (e.g. evapotranspiration) on head-dependent boundary cells (Type 1 or 3 boundary conditions)?	N	Not evident.
5.7.4 Is diffuse recharge from rainfall smaller than rainfall?	Y	Percentage << 100.
5.7.5 Are model storage changes dominated by anomalous head increases in isolated cells that receive recharge?	N	Not evident.
5.8 Has particle tracking been considered as an alternative to solute transport modelling?	N	Not required
6. Uncertainty		
6.1 Is some qualitative or quantitative measure of uncertainty associated with the prediction reported together with the prediction?	Y	Qualitative in Table 8-1. Quantitative stochastic analysis in Section 6.
6.2 Is the model with minimum prediction-error variance chosen for each prediction?	Y	Proof of convergence in Figures 6-6 (pit inflow) and 6-7 (max.drawdown).
6.3 Are the sources of uncertainty discussed?	Y	Quantified through identifiability analysis. Significance assessed by Type I – Type IV analysis.
6.3.1 measurement of uncertainty of observations and parameters	Y	Parameters, not observations – but QA performed.
6.3.2 structural or model uncertainty	Y	Discussed in Table 8-1. Normal practice is to implement a single model geometry
6.4 Is the approach to estimation of uncertainty described and appropriate?	Y	Robust and extensive. Latin Hypercube Sampling.
6.5 Are there useful depictions of uncertainty?	Y	Compliant with IESC guide.
7. Solute transport	N/A	
8. Surface water–groundwater interaction		
8.1 Is the conceptualisation of surface water–groundwater interaction in accordance with the model objectives?	Y	• *"Identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary."* Potential for enhanced leakage and reduced flow duration are assessed.
8.2 Is the implementation of surface water–groundwater interaction appropriate?	Y	RIV for Isaac River. DRN for creeks
8.3 Is the groundwater model coupled with a surface water model?	Loosely	Only for final void recovery. Iterative exchange of model outputs.
8.3.1 Is the adopted approach appropriate?	Y	Stage-discharge curve from groundwater model to surface water model. Final void water level(t) from surface water model to groundwater model. Implemented as CHD(t).
8.3.2 Have appropriate time steps and stress periods been adopted?	N/A	
8.3.3 Are the interface fluxes consistent between the models?	N/A	

5. Report Matters

The GA report is a high-quality document of about 170 pages length, with an additional 770 pages in four Appendices that contain information on monitoring bore details, groundwater quality, bore census surveys and field investigations. A separate numerical modelling technical report occupies another 200 pages approximately.

The main report is well-structured, well-written and the graphics are of very high quality and designed to ease understanding by readers. The report serves well as a standalone document, with no undue dependence on earlier work. However, the report is missing an Executive Summary and a Conclusion section for a summary of the findings of the groundwater assessment. This summation could be in the over-arching main approvals documentation not seen by this reviewer.

The technical modelling report does have a Conclusions chapter and includes five Appendices that contain information on calibration residuals, hydrograph comparison, property fields, cumulative drawdown predictions and posterior distributions for the uncertainty analysis (although prior distributions are not compared). This report is structured appropriately with sufficient detail and disclosure of methods and results. It is not intended as a standalone report because some of the key results are reported only in the main GA report.

Progressive review comments on factual and editorial matters, on both reports, have been considered by SLR and have been accommodated satisfactorily in revisions of the reports.

The groundwater assessment objectives are stated clearly in the GA at the outset (Section 1.3) in the form of 15 dot points. Although the objectives are met, there is no Conclusion section that addresses those objectives in summary form.

The modelling objectives are itemised in Section 6.1.1 of the main report, and in Section 1 of the technical appendix, in the form of three dot points:

- *"assess the groundwater inflow to the mine workings as a function of mine position and timing;*
- *simulate and predict the extent and area of influence of dewatering, and the level and rate of drawdown at specific locations; and*
- *identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary."*

The model has been constructed and applied to address these objectives satisfactorily.

Overall, there are no significant matters of concern in the reports as to structure or depth of coverage, and there is a clear focus on regulatory requirements.

6. Data Matters

The geology, though complex, is reasonably well known as a result of the extensive mining and exploration history in this part of the Bowen Basin. It is illustrated by maps of outcropping geology, solid geology, structural faults and cross-sections. Structure contours and thickness maps are provided for Superficial and Triassic units, while the geometry of the four target coal seams is characterised by structure contours and depths of cover.

The Project is supported by an existing network for the Caval Ridge Mine of 47 groundwater monitoring sites including three multi-sensor vibrating wire piezometer (VWP) holes (installed November 2020). The network was established in 2008 and expanded in 2019-2020. This network supplements an extensive regional network associated with neighbouring mines consisting of 78 monitoring sites (67 listed standpipes and 11 VWP bores). Calibration hydrographs are reported for a total set of 222 sensor locations.

The Project has also benefitted from considerable effort conducted by others for neighbouring groundwater assessments with regard to resolution of different interpretations of alluvial extent associated with the Isaac River, included geophysical surveys (AgTEM and DC resistivity), slope break analysis, CSIRO regolith inference, LiDAR and bore logs.

Cause-and-effect analysis of groundwater hydrographs has been presented separately for bores in alluvium, regolith, basalt, Permian interburden, and each of the four Permian coal seams, compared in each case with rainfall residual mass to infer potential relationships with infiltrating rain water. The earliest measurements in the region date from 2008. The Isaac River stream hydrograph is compared with a near-river bore hydrograph to infer groundwater / surface water connectivity, demonstrating that the Isaac River generally has a “losing” status.

Groundwater flow directions can be inferred from groundwater head contours for alluvium (Figure 5-8, Document #1) and the Moranbah Coal Measures (Figure 5-14, Document #1).

Hydraulic conductivity estimates for modelling are informed by significant investigations for other mining projects and by slug tests, core laboratory measurements and two packer tests into known faults elsewhere in the modelled area. The packer tests found hydraulic conductivity values in the faulted material of the order of 10^{-4} to 10^{-3} m/day. There is now a large database of hydraulic conductivity values in this part of the Bowen Basin. Overall, there is a clear expression of decrease with depth (Figures 2-13 and 2-14 in Document #2).

A thorough analysis is presented for groundwater quality signatures, primarily using Piper diagrams.

A clear and defensible description of hydrogeological conceptualisation is promoted in Section 5.7 of Document #1, illustrated by schematics for pre-mining, during-mining and post-mining conditions in cross-section.

7. Model Matters

The CVM groundwater model has developed from the well-received groundwater model for the recently-approved Olive Downs South Coking Coal Project to the east of the Project. This foundational model has undergone a number of updates for more precise geometry at individual coal mines. For this Project, the model required extension to the north and north-west beyond Moranbah and also farther west from the Caval Ridge Mine. Model cell sizes have been refined across the CVM site, and an extra five layers were added in the model to give better vertical resolution of the strata within the Moranbah Coal Measures.

The reviewer concurs with the entire modelling methodology described in Document #2 and recognises it as "state-of-art".

Key features of the modelling approach are:

- MODFLOW-USG plus AlgoMesh software platform for better mass balance and better spatial resolution;
- conventional PEST calibration for steady-state and transient conditions;
- application of an identifiability procedure during the calibration process to replace sensitivity analysis by perturbation, in which many more model properties can be included, and relative sensitivities are produced as a matter of course; the downside is an absence of reporting on calibration performance (if a sensitive parameter were varied); the considered parameters are horizontal hydraulic conductivity, hydraulic conductivity anisotropy, specific storage, specific yield and diffuse recharge; the highest identifiabilities were found for horizontal hydraulic conductivity and recharge;
- assessment of the sensitivity of the magnitude of key model predicted outputs by a Type I to IV identifiability analysis; the considered outputs are pit inflows and maximum cumulative drawdown; the storage properties of two layers in the Moranbah Coal Measures interburden are isolated as having the potential to cause large changes in predictions for small changes

in their adopted values; and

- a *monte carlo* style rigorous procedure for uncertainty analysis.

The model extent is necessarily large, being about 50-70 km in an east-west direction and about 90 km in a north-south direction. Given the large area and 19 layers, a minimum cell dimension of 50 m, and incorporation of many neighbouring open cut and underground mines, a total cell count of 1.14 million remains efficient but is nearing the limit of a manageable model size. Separate layers are designated for the four target coal seams (Q, P, H, D) in the Moranbah Coal Measures. Although there are no mapped faults within the CVM mine area, many structural faults are included in the wider model as zones of finer discretisation (100 m) with properties separate from the host materials. Conceptualisation of faults as barriers was supported during previous PEST calibration which allowed faults to range from a strong barrier to a conduit, although their identifiability proved subsequently to be low except for the Isaac fault zone (Section 5.1.2, Document #2).

In terms of model confidence level classifications, Document #1 states:

> *"...the groundwater model developed for this Groundwater Assessment may be classified as primarily Class 2 (effectively "medium confidence") with some items meeting Class 3 criteria, which is considered an appropriate level for this Project context."*

The reviewer agrees with this conclusion. Although Class 2 is appropriate, all models are in fact mixtures of Class 1, Class 2 and Class 3. The relative proportions of the different classes have been established by annotating the classification table of attributes in the IESC Explanatory Note on Uncertainty Analysis, reproduced as Table 6-1 in Document #1. This classifies the model as about 65% Class 2, about 30% Class 3, and about 5% Class 1.

Visual hydrographic history matching is exceptionally good at CVM Permian monitoring sites, as illustrated in Figures 2-10 and 2-11 of Document #2. Elsewhere, calibration performance is generally good in most areas of the model, based on about 4,300 measurements of groundwater level at 400 sites, with overall unweighted statistics of 5.4 %RMS and 12.5 mRMS. Locally, the absolute performance (5.6 mRMS) is better but the relative performance (9.8 %RMS) appears larger because the range in measured water levels is less (about 60 m compared to about 150 m regionally). Table 2-7 in Document #2 shows that the CVM site has better average residual (-0.2 m) and average absolute residual (4.3 m) statistics than any of the other included mines. Scattergrams are generally linear with a mild tendency to over-estimation of heads, especially at lower elevations. The model still has a weakness in not replicating vertical head gradients well in areas of the model distant from the Project.

The primary predictive results are presented in Document #2 as maps of:

- groundwater level at end of mining in alluvium, regolith and D Seam with and without the Project;
- maximum incremental drawdown (due to the Project alone) for regolith and each of the four target seams;
- maximum cumulative drawdown for alluvium, regolith, each of the four target seams, and the two mined seams (Leichhardt and Vermont) in the Rangal Coal Measures to the east.

A sub-set of maps is presented in Document #1 with additional post-closure maps:

- maximum incremental drawdown (due to the Project alone) for regolith and each of the four target seams;
- maximum cumulative drawdown for alluvium, regolith, each of the four target seams, and the two mined seams (Leichhardt and Vermont) in the Rangal Coal Measures to the east;
- groundwater level at equilibrium in alluvium, regolith and each of the four mined seams in the Moranbah Coal Measures.

A comprehensive IESC-compliant Type-3 uncertainty analysis has been undertaken by means of a *monte carlo* technique, using 250 alternative calibrated realisations out of a trial set of 1,100 selections (obtained by Latin Hypercube Sampling). A severe threshold was imposed on each simulation which required the calibration statistic to be better or the same as the base case model (5.4 %RMS). The parameters subject to variation were horizontal hydraulic conductivity, hydraulic conductivity anisotropy, specific yield, specific storage and diffuse recharge. The assumed standard deviations were 0.5 (log10 space) for all properties, which is the standard being adopted by industry practitioners (in the absence of guidelines on this aspect). Proof of convergence, as encouraged by the IESC Explanatory Note on Uncertainty Analysis, is offered for total pit inflow and maximum drawdown.

The base case model has ~30% less pit inflow than the 50th percentile of the 250 realisations. This could be due to the imposition of many constraints on the selection of parameters for a realisation. In other words, parameters cannot be chosen with full freedom from their designated distributions. See Tables 6-1 to 6-5 in Document #2.

The temporal uncertainty results are presented in Document #2 in Figure 6-1 as 5th, 33rd, 50th, 66th and 95th percentiles for progressive pit inflow. The spatial uncertainty results are presented in Document #2 in Figures 6-2 to 6-4 as 5%, 50% and 95% probabilities of exceeding 1 m drawdown in regolith and Q and H seams; the base case extent is also shown. The same drawdown maps are included as Figures 6-25 to 6-27 in Document #1.

Recovery in the presence of a final void has been modelled in two steps using initially the "high-K" lake approach, and subsequently time-varying constant heads provided from the surface water model. The reviewer endorses deference to surface water modelling for a more robust analysis of final void behaviour than is readily achievable in a groundwater model. The freeboard in the single final void is predicted to be about 100 m, giving confidence that it will remain as a perpetual groundwater sink.

8. Conclusion

The reviewer is of the opinion that the documented groundwater assessment is best practice and concludes that the model is *fit for purpose*, where the purpose is defined by the objectives listed in Document #1:

- *"Review relevant groundwater, geotechnical and environmental reports to characterise the geological and hydrogeological setting of the Project.*
- *Review publicly available hydrogeological data such as the Queensland Government's spatial data system (Queensland Globe) and the Bureau of Meteorology's (BoM) National Groundwater Information System (NGIS) (BoM, 2019).*
- *Undertake a census of groundwater supply bores near to the Project to confirm locations, usage and groundwater quality.*
- *Characterise the existing groundwater resources, including properties and quality.*
- *Conceptualise the groundwater regime of the Project Area and Study Area.*
- *Assess the potential interaction between the alluvium of proximal watercourses (Cherwell Creek, Horse Creek and Isaac River) and the Project.*
- *Identify the potential for groundwater dependent ecosystems (GDEs) to occur in proximity to the project.*
- *Construction and calibration of a numerical groundwater flow model suitable for assessment of potential impacts of the Project, in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and Murray Darling Basin Commission guidelines (Middlemis et al., 2001).*
- *Perform predictive modelling for the scale and extent of mining impacts upon groundwater levels, groundwater quality and groundwater users at various stages during mine operations and post closure.*
- *Model the cumulative impacts of Project and surrounding existing and proposed mines.*

- *Assess the extent of groundwater impacts as a result of the operation of the Project; including long-term impacts on regional groundwater levels, water quality impacts on environmental flows and baseflows.*
- *Assess potential impacts on GDEs resulting from short and/or long-term changes in the quantity and quality of groundwater.*
- *Assess the potential third party impacts (i.e. private bores) as a result of changes to the regional groundwater system.*
- *Develop feasible mitigation and management strategies where potential adverse impacts are identified.*
- *Develop a groundwater monitoring program and management measures."*

The groundwater modelling has been conducted to a very high standard and a rigorous *monte carlo* uncertainty analysis offsets much of the uncertainty that is inherent in a groundwater model, as noted in the Limitations Section 9 of Document #1.

The primary output of the uncertainty analysis, with respect to potential off-site impacts, is presented in Document #1 in Figures 6-25 to 6-27 as 5%, 50% and 95% probabilities of exceeding 1 m drawdown in regolith and Q and H seams. Two water supply bores in the model layer above the Q Seam are unlikely to be impacted by the Project, with a near-maximum predicted drawdown of about 1.5 m due to the Project, but this is less than the *Water Act 2000* threshold of 5 m for bores in consolidated formations. No alluvial bores are predicted to be impacted by the Project and no material impact on Isaac River seepage is anticipated. The reviewer supports the validity of these conclusions.

Dr Noel Merrick

APPENDIX J2 ADDITIONAL CVM DRILL DATA REVIEW

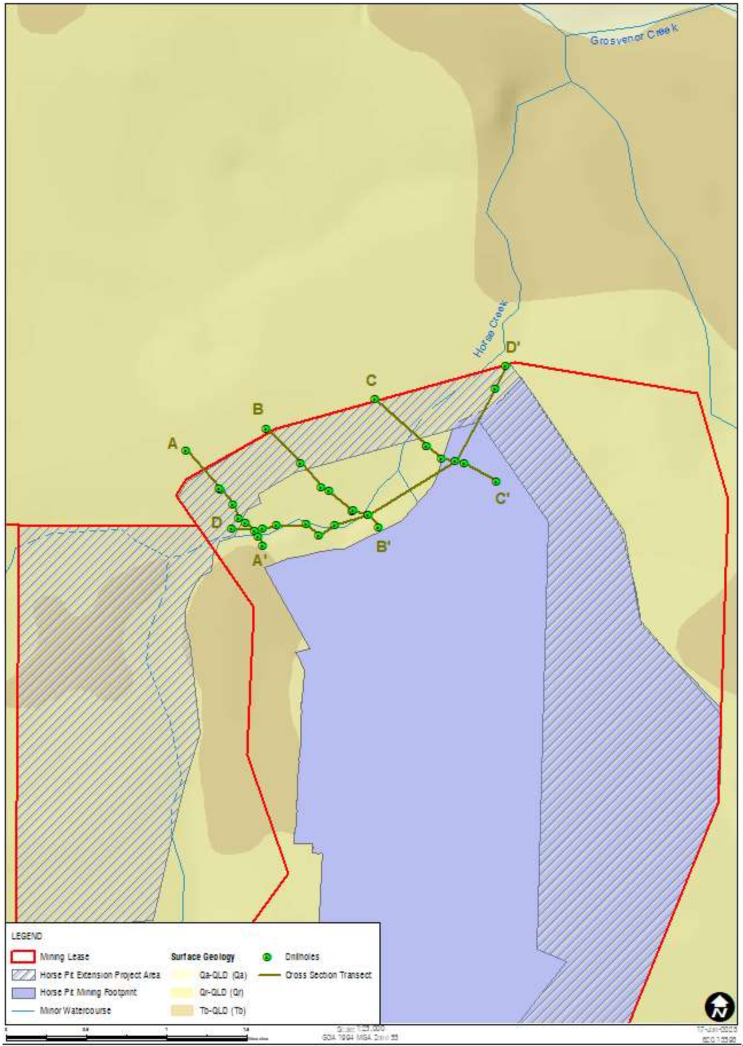
Review of CVM exploration drilling logs has been undertaken to further characterise the shallow stratigraphy in the vicinity of Horse Creek. Figure 1 shows three transects (A – A' to C – C') aligned perpendicular across Horse Creek located west to east through the ML. An additional transect (D-D') runs west to east in parallel to Horse Creek. Lithological cross sections for each transect are presented in Figures 2 to 7 below. Given the nature of exploration drilling it should be noted that logging of surficial deposits is often simplified with only the base of Tertiary units defined. Nevertheless, drill hole data is still of use to determine the major components of the shallow strata and give an indication of the sediments that may support or inhibit the existence of a shallow groundwater system.

Review of section A-A' (Figure 2) shows that, in the west of the ML, surficial colluvial deposits are typically limited to 1 to 3m of clay / sandy clay overlying weathered Tertiary basalts. A maximum thickness of 4m is logged for the Tertiary clay at drillhole 19669 which is located approximately 20m north of Horse Creek.

Drillhole 48753 is located approximately 50m north of Horse Creek and is the closest drillhole to the creek on Section B-B' (Figure 3). Review of the log for this drillhole shows approximately 4.5m of potential colluvium / alluvium (sandy clay/clayey sand) overlying 5m of weathered Permian siltstone. Review of Section B-B' shows that the colluvium is limited in extent between 300-500m north of Horse Creek in this area before transitioning to clay. All drill hole logs show that the colluvium / Tertiary sediments overlie approximately 5 to 10m of weathered Permian siltstone / fine grained sandstone. BHWL denoted on the drill logs indicate water strikes encountered when drilling. As can be seen, where noted water levels were generally recorded at the base of the Tertiary sediments / upper sections of the weathered Permian units.

Drillhole 46318 is located approximately 20m east of Horse Creek and is the closest drillhole to the creek on Section C-C' (Figure 4). Review of the log for drillhole 46318 shows approximately 5m of Tertiary clay overlying 7.5m of weathered Permian claystone. Review of Section C-C' shows that the Tertiary sediments extend at least 400m north of Horse Creek in this area at a consistent depth of 5m. Again, all drillhole logs show that the Tertiary sediments overlie approximately 5 to 10m of weathered Permian fine grained sandstone.

Section D-D' (Figure 5) shows logs for drillholes located adjacent to Horse Creek as it runs west to east along the northern section of the ML. As shown, adjacent to Horse Creek surficial Tertiary sediments generally comprise of 3 to 5m of clay, overlying weathered Tertiary basalt in the west and weathered Permian siltstone and/or fine-grained sandstone further east.



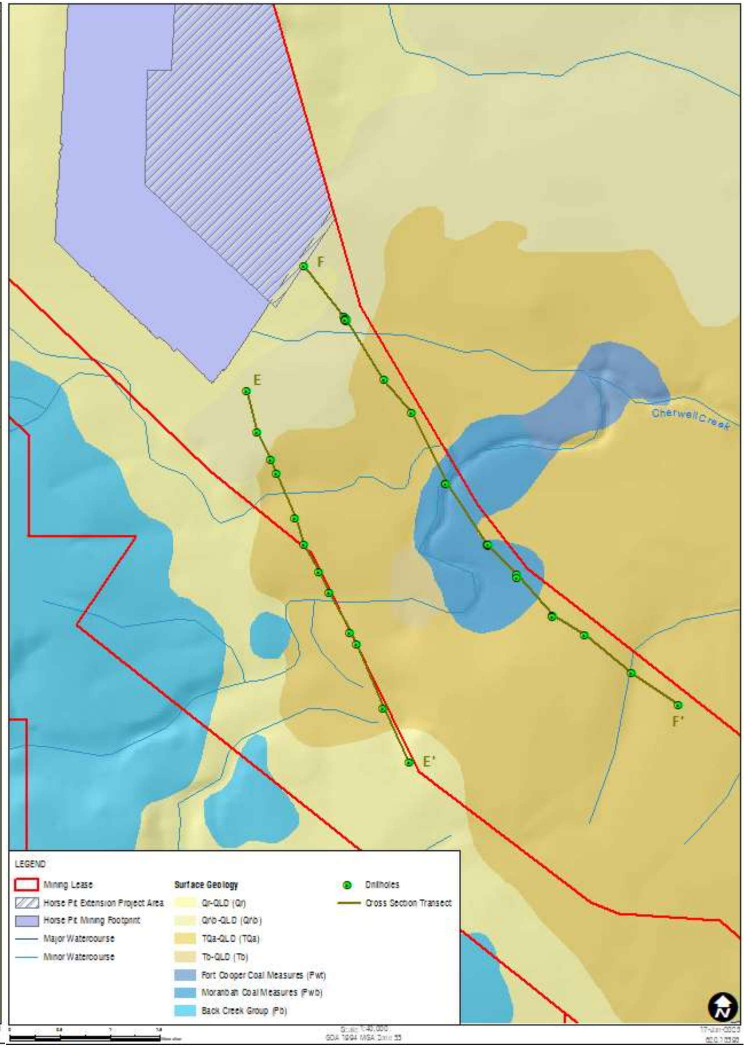


Figure 1: Lithological Cross Section Transect Plan

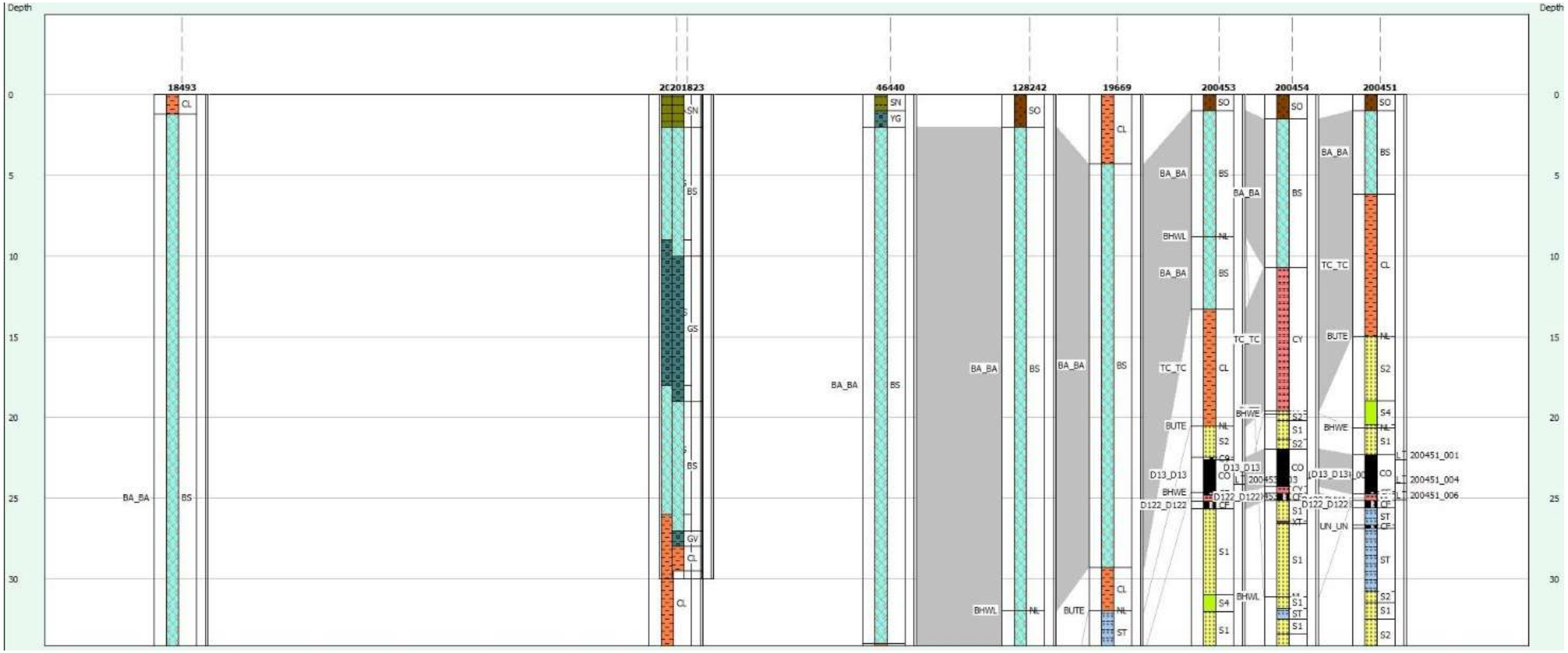


Figure 2: Cross Section A-A' – West of Northern ML Area

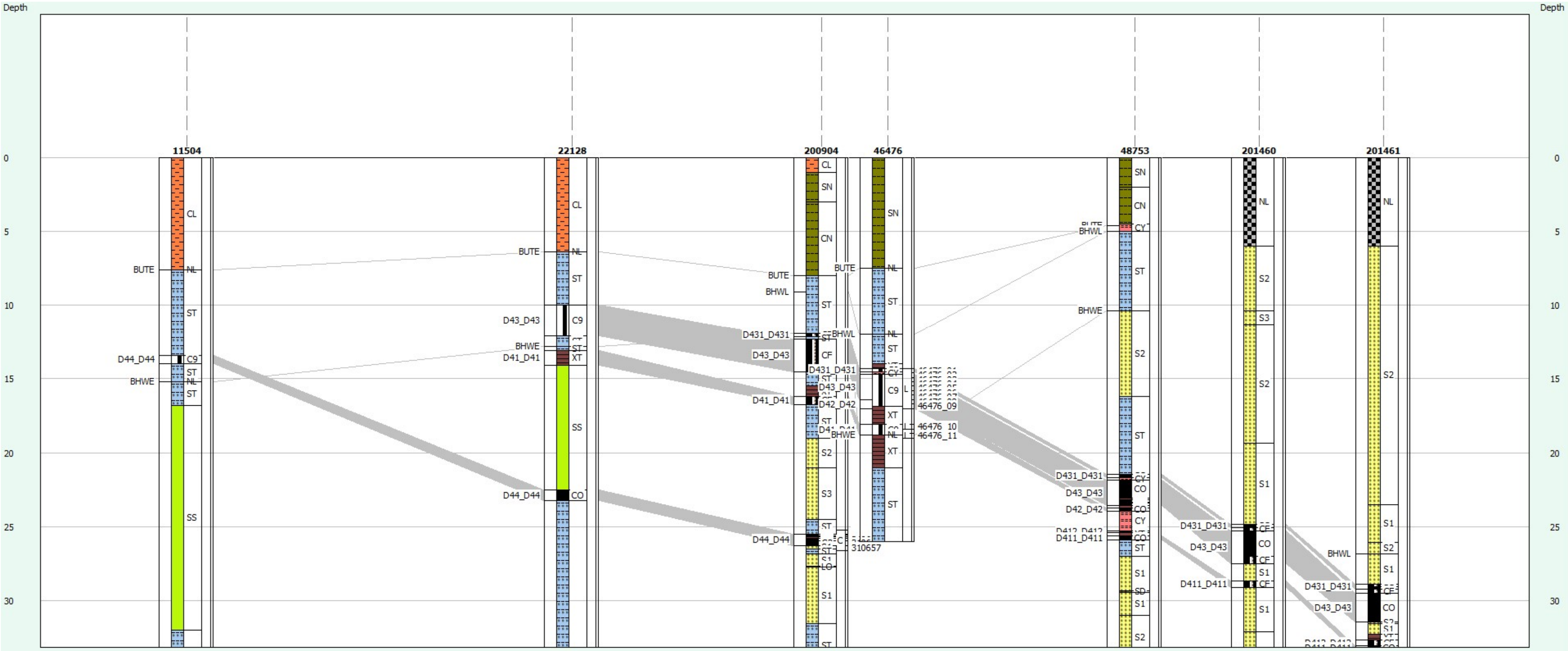


Figure 3: Cross Section B-B' – Middle of Northern ML Area

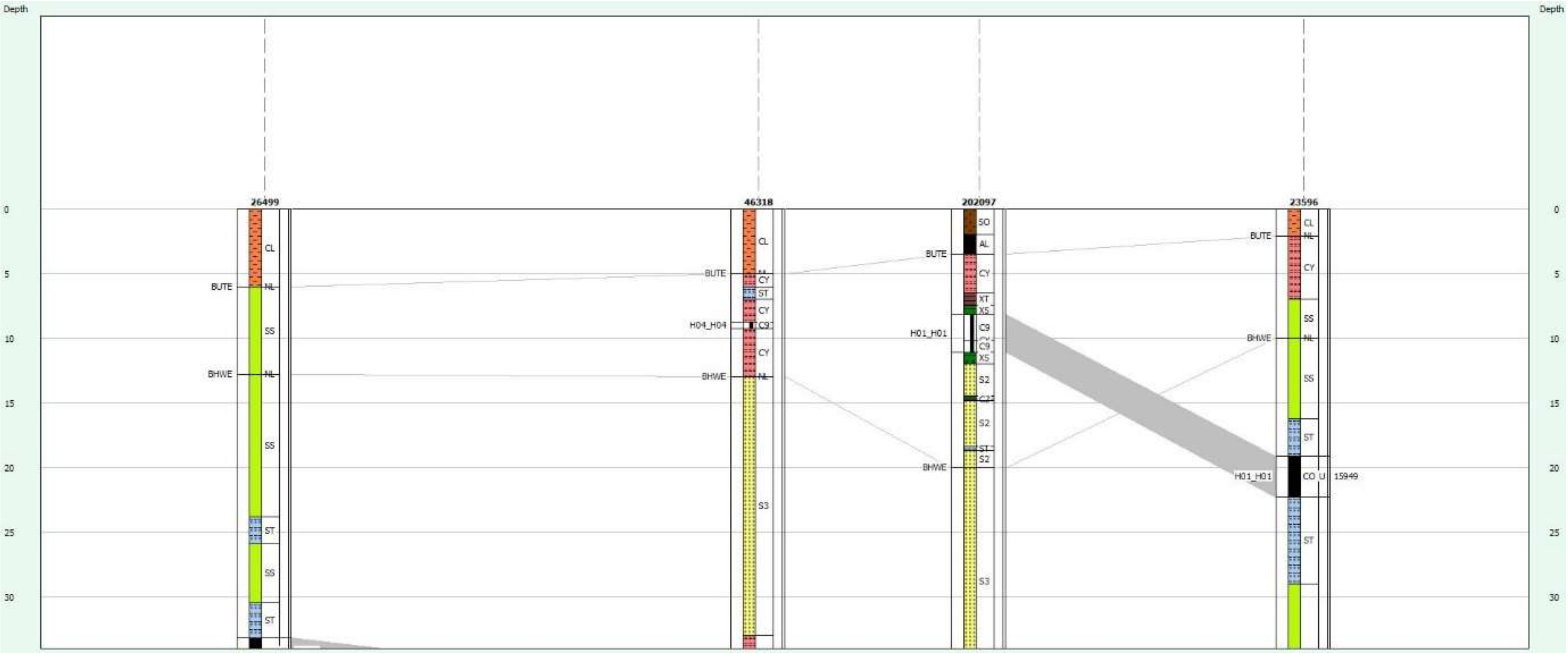


Figure 4: Cross Section C-C' – East of Northern ML Area

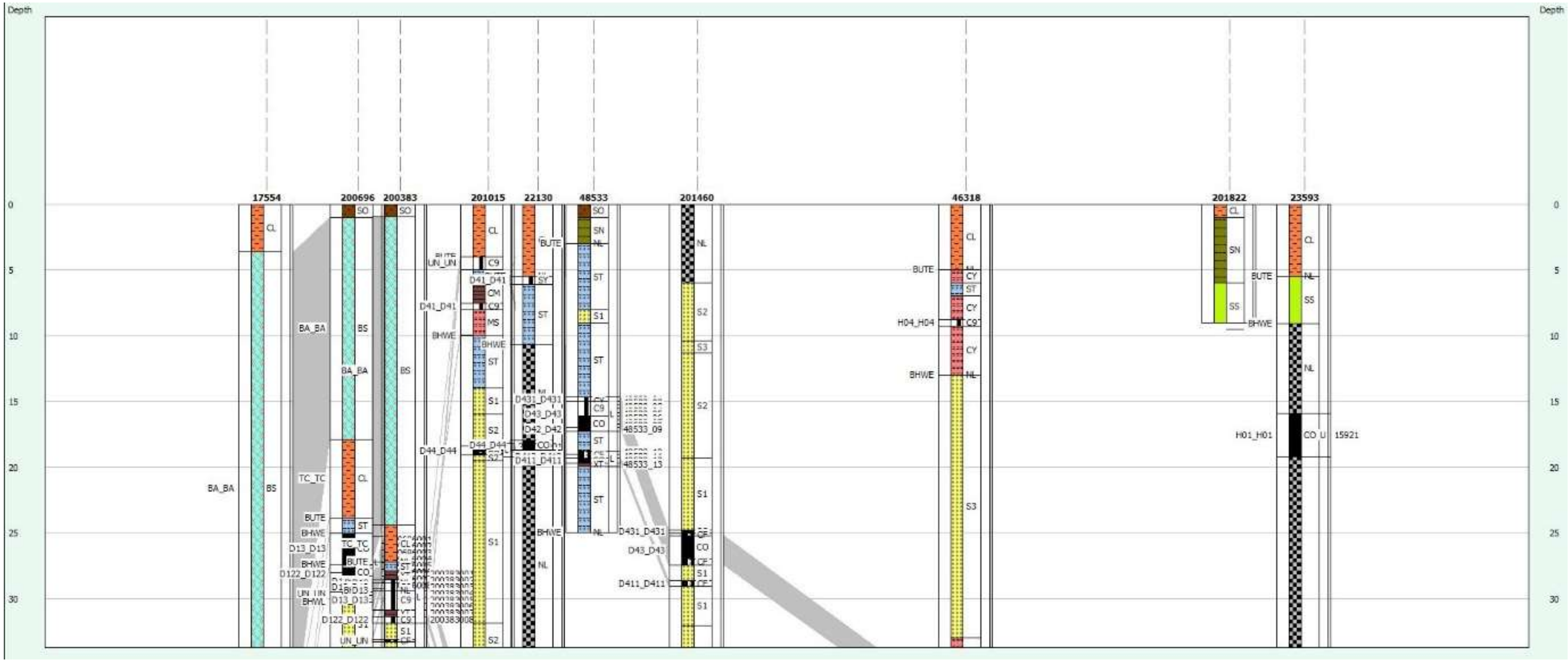


Figure 5: Cross Section D-D' – West to East Parallel to Horse Creek across Northern ML area

Drill hole logs for monitoring bores located in the north of the Project Area support the exploration drillhole data showing the Qr colluvium in the area near to Horse Creek to comprise 2 to 3m of silt and sandy clay, overlying weathered claystone/siltstone/sandstone.

Lithological cross sections have also been developed using exploration drilling logs aligned in a north to south direction across Cherwell Creek (Figure 1), with section E-E' (Figure 6) located to the west and section F-F' (Figure 7) located to the East of Dam 12N.

Section E-E', located in the east of the ML, shows that in the vicinity of the creek (drillhole 24664) the TQa comprises 5m of clay underlain by 7m of sand. In general the thickness of TQa deposits deepens in the vicinity of 12N dam before becoming thinner towards the existing Horse Pit. Towards Heyford Pit, immediately south of Cherwell Creek, the thickness of the TQa alluvium is more consistent, generally around 7 to 8m.

Section F-F', located in the east of the ML, shows that the alluvium is thickest in the vicinity of the creek (drillhole 127743). Although not displayed on the section, review of the lithological log for monitoring bore PZ07-S shows similar lithology with surficial clay and silt logged to 8m, underlain by 8m of medium to coarse sand. The cross section shows that the alluvium does not extend to the north of PZ07-S or south of 122743, supporting the conceptualisation that it is limited to the vicinity of the creek channel.

Groundwater drilling investigations undertaken by BMA at CVM in 2009, 2019 and 2020 have confirmed the presence of a localised alluvial deposit associated with Cherwell Creek. Drilling logs for monitoring bores MB20CVM06T, PZ07-S and PZ08-S show alluvial silt and sands up to 10m thick directly adjacent to Cherwell Creek in the west and east of the Project Area. This correlates with the SDSG mapping showing that the Tertiary-Quaternary alluvium (TQa) extends along Cherwell Creek onto the CVM site. The alluvium does not extend north of Cherwell Creek towards Horse Pit, with drilling logs for monitoring bores MB20CVM03T, MB19CVM05T and MB20CVM07T showing surficial sediments comprising Tertiary clay overlying weathered Tertiary basalt or weathered Permian coal measures.

Review of the drillhole data presented in cross sections in the vicinity of Cherwell Creek confirm that the thickness of the alluvium decreases towards Horse Pit and is thickest in immediate proximity to the modern creek channel.

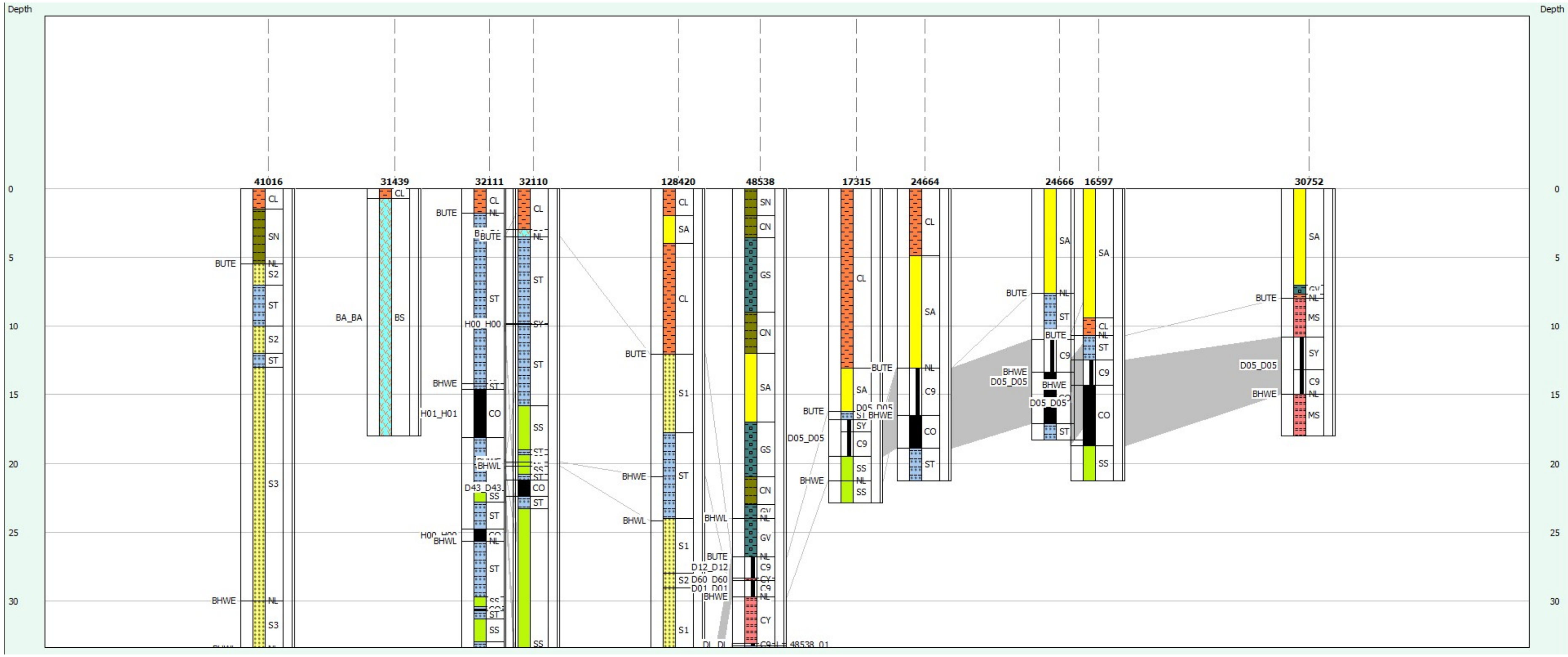


Figure 6: Cross Section E-E' – Western Cherwell Creek Section

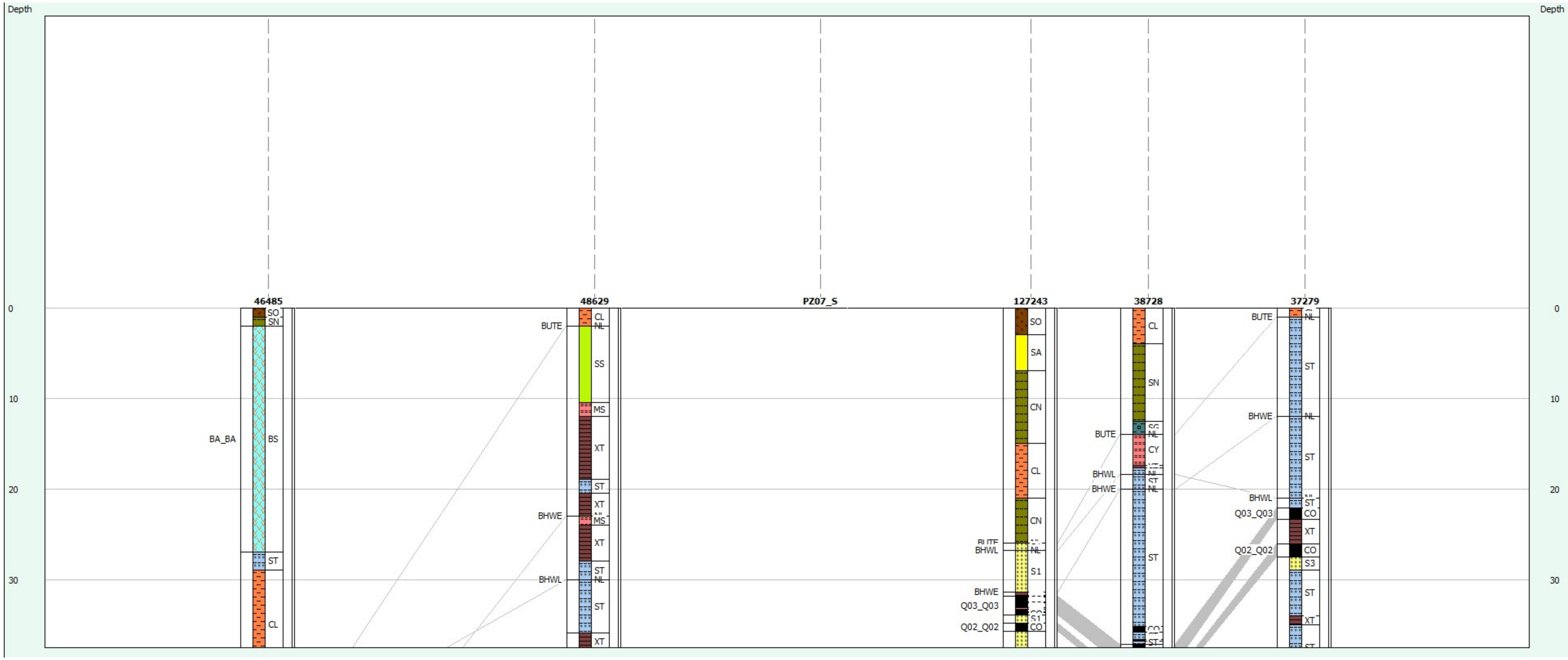


Figure 7: Cross Section F-F' – Eastern Cherwell Creek Section

APPENDIX J3 REGIONAL ECOSYSTEM AMENDMENT REPORT

Horse Pit Extension Project: Regional Ecosystem Map Amendment

28 June 2022

Caval Ridge Mine

Document Management

Rev.	Issue Date	Description	Author (s)	Approved	Signature
A	28/06/2022	Issue for review	J. van Osta	B. Dreis	

Document Reference: JOBS\~2022\QEJ22029\DELIVERABLES\QEJ22029_Horse_Pit_RE_Amendment.docx

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Contents

List of Tables

List of Figures

Appendices

Abbreviations

Abbreviation	Description
API	Aerial Photographic Interpretation
BMA	BM Alliance Coal Operations Pty Ltd
DES	Queensland Department of Environment and Science
DoR	Queensland Department of Resources
E2M	E2M Pty Ltd
EA	Environmental Authority
EDL	Ecological Dominant Layer
EIS	Environmental Impact Statement
ESA	Environmentally Sensitive Area
GDA94	Geocentric Datum of Australia 1994
GPS	Global Positioning System
IBRA	Interim Biogeographic Regionalisation of Australia
MAR	Map Amendment Request
RE	Regional Ecosystem
REDD	Queensland Herbarium Regional Ecosystem Description Database
sp.	Singular species. For example, *Eucalyptus* sp. refers to a single species of *Eucalyptus*
spp.	Multiple species. For example, *Eucalyptus* spp. refers to multiple species of *Eucalyptus*
TEA	Terrestrial Ecological Assessment

1 Introduction

1.1 Project background

The BM Alliance Coal Operations Pty Ltd (BMA) own and operate the Caval Ridge Mine (CVM) located approximately six kilometres (km) south of Moranbah in central Queensland. The CVM has been in operation since 2014, producing and processing hard coking coal pursuant to the conditions prescribed in the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* Approval 2008/4417 (DSEWPAC 2011), the Environmental Authority (EA) Permit EPML00562013 (DEHP, 2017) and the Coordinator-General's Report (2010).

To enable changes in mine sequencing and reflect the current Life of Asset Plan, BMA propose to extend mining operations within one of CVM's active open-cut pits, known as Horse Pit (herein referred to as the Project). E2M Pty Ltd (E2M) was engaged by SLR Consulting Australia Pty Ltd (SLR) on behalf of BMA to conduct a terrestrial ecology assessment within the Horse Pit Study Area (the Study Area). The Study Area incorporates ML 1775 and ML 70403 north of the Peak Downs Highway (excluding the Moranbah Airport) (Figure 1).

BMA is seeking to submit a Map Amendment Request (MAR) to the Queensland Department of Environment and Science (DES) in order to amend the Regional Ecosystem (RE) mapping within the Study Area (Figure 1). This MAR is required to update the RE mapping within the Study Area and to update associated mapping of Environmentally Sensitive Areas (ESAs) under the *Environmental Protection Act 1994*.

1.2 Scope and objectives

E2M has prepared a RE Amendment Report with supporting documentation to submit to the Queensland Herbarium for the Study Area. This report will include:

- description of the survey methods and results based on data collected during ecological surveys
- confirmation and description of vegetative communities within each RE assessment unit in accordance with the *Queensland Herbarium Regional Ecosystem Description Database* (REDD)
- associated amendments to RE polygon boundaries and extents; and
- summary of the proposed changes to RE mapping in the area.

Findings of the assessment, along with supporting evidence such as photos and maps and RE summaries will assist in a formal RE map amendment for the Study Area in accordance with the *Queensland Herbarium's Regional Ecosystem Assessment Kit* (Queensland Herbarium, 2012).

Legend

Road

Mining Lease

Study Area

DES Mapped Regional Ecosystems

Endangered - Dominant

Endangered - Sub-dominant

Of Concern - Dominant

No concern at present

Non-remnant

N

Scale 1:45,000 (A4)

0 500 1,000 1,500 2,000

Metres

Coordinate System: GCS GDA 1994

Document Path: X:\JOBS\~2022\QEJ22029\GIS\QEJ22029_1_DES_RE.mxd

Moranbah

Dysart

Notes:
Aerial Imagery: © ESRI 2022
Cadastre: © DoR 2022
Ordered Drainage: © DoR 2022
Road: © DoR 2021

A	Issued for Review	DL	JVO	13/06/2022
Rev	**Description**	**Drawn**	**Approved**	**Date**

e2m

FIGURE 1: DES MAPPED REGIONAL ECOSYSTEMS

Horse Pit Regional Ecosystem Map Amendment
BMA Caval Ridge

Map Number	Job Number	Rev
1 of 1	QEJ22029	A

2 Methods

2.1 Desktop assessment and legislative review

A desktop assessment was conducted to review available vegetation mapping and databases. Sources reviewed as part of the desktop assessment included:

- Department of Resource (DoR) Regulated Vegetation Management Map and associated Regional Ecosystem mapping (i.e. Vegetation Management Supporting Map)
- DES Biodiversity Status of Remnant Regional Ecosystems Mapping (Version 12.2)
- DES Regional Ecosystem Description Database (Version 12.1) (Queensland Herbarium, 2021)
- DES Queensland Biodiversity status of pre-clearing regional ecosystems mapping (Version 12.2)
- DoR Queensland Detailed Geology
- Geoscience Australia scanned 1:250,000 Geological Maps
- GeoScience Australia 1:100,000 drainage network of Queensland
- land system descriptions; and
- latest available aerial photography (Nearmap and QGlobe).

The Environmental Impact Statement for Caval Ride Mine (BMA, 2009) was also reviewed to inform habitat features, vegetation condition and composition previously identified within the Study Area.

2.2 Field validation

Preliminary vegetation mapping was undertaken throughout the Study Area through Aerial Photographic Interpretation (API) and review of data including existing RE mapping (DES and DoR), geology and land-systems mapping. This was undertaken to accurately map vegetation communities at a scale to allow for accurate delineation of vegetation communities and assist in determining field survey sites.

The field validation results are based on data collected during ecological surveys completed for the Terrestrial Ecological Assessment (TEA) (E2M, 2021). RE verification was undertaken across the Study Area by E2M over two surveys periods from 25 November to 2 December 2019 and 19 to 27 March 2020. Information collected at each site comprised Tertiary and Quaternary site assessments in accordance with:

- *Methodology for surveying and mapping of regional ecosystems and vegetation communities in Queensland* (Version 5) (Neldner et al., 2019)
- 'Sheet D' from the *Regional Ecosystem Assessment Kit* (Queensland Herbarium, 2012); and
- *BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual* (Version 1.3) (Eyre *et al*., 2015).

In addition to the above, ad hoc notes were made on hard copy maps and used in the subsequent finalisation of the mapping, although this latter information is not presented with this report. Information collected at each site included:

- dominant species (from Ecological Dominant Layer (EDL) +/- from other layers)
- cover and median height class of the upper (+/- mid and ground) layer

- landform element; and
- previous mapped (version 10.1) and updated (from field verification) RE code +/- description of soils, geology map unit, interpreted photograph of vegetation community (+/- soil surface).

In accordance with Neldner et al. (2022), remnant vegetation was defined as 'vegetation which forms the predominant canopy of the vegetation—

- covering more than 50% of the undisturbed predominant canopy; and
- averaging more than 70% of the vegetation's undisturbed height; and
- composed of species characteristic of the vegetation's undisturbed predominant canopy.'

Trimble Nomad Global Positioning System (GPS) devices were used to delineate the extent of vegetation communities within the site and record flora and fauna species encountered. All site locations and mapping are rectified to the GDA94 datum.

The data and notes collected during field validation were then finalised and compared to the RE descriptions in the current REDD to update and finalise the RE mapping for the Study Area.

3 Results

3.1 Bioregion

The Study Area is located within the Brigalow Belt bioregion, occurring over 364,000 km^2 of central Queensland, extending from Townsville in the north to the Narrabri in New South Wales (Sattler & Williams, 1999). The Interim Biogeographic Regionalisation of Australia (IBRA) divides the Brigalow Belt bioregion into the Brigalow Belt North and Brigalow Belt South (Sattler & Williams, 1999). The geology of the Brigalow Belt North bioregion is characterised by Permian volcanics and Permian-Triassic sediments, Carboniferous and Devonian sediments and volcanics and Cambrian/Ordovician rocks (and associated Tertiary deposits) (Department of Resources, 2020).

The Brigalow Belt North bioregion comprises 13 sub-regions, of which the Study Area is wholly located within the Northern Bowen Basin sub-region.

3.2 Landform, soils, geology and land zones

DoR detailed surface Geology Mapping (2020) and GeoScience Australia 1:250,000 geology mapping (Sheet SF 55 - 11) identified three potential land zones mapped within the Study Area. A summary of geology units and associated land zones within the Study Area is provided in Table 1.

A large proportion of the Study Area is dominated by flat to gently undulating plains consisting of Quaternary/Cainozoic colluvium and residual deposits (Qr). These areas are generally shown on available Geology mapping where much of the vegetation has been previously cleared and converted to improved pastures. These areas were consistent with land zones 4, which comprises a heterogeneous distribution of fine to coarse grained sand, clay, sandstone, and claystone. Basalt derived Quaternary residual and colluvial deposits (Qr/b) comprised black soils, silts and muds. These areas were consistent with land zone 4 or 8. Isolated patches of Tertiary aged basalt areas were present in the north of the Study Area (Tb). The field assessment verified that these areas are consistent with land zone 8. Unmapped area of Cainozoic lateritic duricrusts associated with land zone 7, also occur throughout the Study Area.

Table 1 Geology and land zones within the Study Area

Geology	Description	Land Zone
Tb	Cainozoic olivine basalt glows and some plugs.	8
Qr	Cainozoic clay deposits and gently undulating clay plains (colluvial), sometimes containing gilgai micro-relief.	4
Qr/b	Black soil, silt and mud; residual and colluvial deposits (commonly basalt-derived or over limestone in Georgina Basin).	4 or 8
Td	Duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces.	7

3.3 Regional Ecosystems

A total of 112.40 ha of remnant vegetation comprising three REs was recorded within the Study Area (refer to Table 2). The field verified RE mapping for the Study Area is provided in Figure 2. The extent of remnant vegetation throughout the Study Area was largely consistent with DNRME Vegetation Management mapping. Inconsistencies between the DNRME mapped and ground-truthed extents within the Study Area included:

- areas of DNRME mapped regrowth (Category C) vegetation within the eastern extent of the Study Area was found to have structure and cover consistent with remnant vegetation; and
- areas of DNRME mapped remnant RE 11.8.5 and a small heterogenous polygon of RE 11.4.9/11.4.8 was not found to be consistent with remnant vegetation (lacked sufficient canopy height and cover). These areas were mapped as containing regrowth vegetation.

The extent of remnant RE communities recorded within the Study Area differed slightly from those reported during assessments undertaken as part of the EIS (BMA 2009). Differences in extents are likely attributed to works undertaken in association with the mine as well as changes to the mapping of Regulated Vegetation under the VM Act (i.e. regulated regrowth vegetation not previously mapped during 2009 assessments).

Remnant REs identified within the Study Area are summarised in Table 2 with detailed assessment results provided in Appendix A.

Table 2 Field verified remnant REs within the Study Area

RE	VM Act Status[1]	Biodiversity Status[2]	RE Description	Vegetation class	Area within the Study Area (ha)
11.7.1	LC	OC	*Acacia harpophylla* and/or *Casuarina cristata* and *Eucalyptus thozetiana* or *E. microcarpa* woodland on lower scarp slopes on Cainozoic lateritic duricrust	Remnant	77.03
11.8.11	OC	OC	*Dichanthium sericeum* grassland on Cainozoic igneous rocks	Remnant	31.44

[1]E (endangered), OC (Of Concern), LC (Least Concern) under the QLD *Vegetation Management Regulation 2012*

[2]E (endangered), OC (Of Concern), NC (No Concern at Present) under the REDD

Legend

- Road
- Mining Lease
- Study Area
- Tertiary Site
- Quaternary Site
- BioCondition Site

Ground-truthed Regional Ecosystem
- 11.7.1
- 11.8.11

N

Scale 1:45,000 (A4)

0 500 1,000 1,500 2,000

Metres

Coordinate System: GCS GDA 1994

Moranbah

Dysart

Notes:
Aerial Imagery: © ESRI 2022
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Rev	Description	Drawn	Approved	Date
A	Issued for Review	DL	JVO	15/06/2022

FIGURE 2: GROUND-TRUTHED REGIONAL ECOSYSTEMS

Regional Ecosystem Map Amendment
BHP Horse Pit

Map Number	Job Number	Rev
1 of 1	QEJ22029	A

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4 Conclusion

The RE mapping for the Study Area has been updated and validated by a detailed field survey which included the collection of data from 23 field sites (BioCondition, Quaternary and Tertiary Habitat Quality Assessments). The updated map delineates 112.40 ha of remnant vegetation across the Study Area comprising three REs.

Of the remnant vegetation mapped, 108.47 ha is classified with an Of Concern Biodiversity status, and the remaining 3.93 ha is classified as Not of Concern. The updated RE mapping will be used to update mapping of ESAs regulated under the *Environmental Protection Act 1994*.

5 References

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Neldner, V. J., Wilson, B. A., Dillewaard, H. A., Ryan, T. S., Butler, D. W., McDonald, W. J. F., Richter, D., Addicott, E. P., & Appelman, C. N. (2022). *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland v.6.0*. Queensland Herbarium, Queensland Department of Environment and Science.

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Appendix A Detailed RE Assessments

RE 11.7.1

Site Name(s): HPQ01, HPQ02, HPQ05, HPQ19, HPQ23, HPQ29, HPQ30, HPQ31, HPQ33, HPQ36, HPQ46, T15, B16, B17, B18, HPT1 and HPT9.	
Recorders: Brad Dreis and Peter Wagner	
Date: September 2020 and January 2021	
Locality: Cavil Ridge Mine Horse Pit Extension Area ML 70403 and ML1775	

Site Co-ordinates

HPQ01: -22.1217, 148.0374	HPQ36: -22.1052, 148.0363
HPQ02: -22.1201, 148.0374	HPQ46: -22.1043, 148.0701
HPQ05: -22.1090, 148.0376	T15: -22.1211, 148.0363
HPQ19: -22.0783, 148.0702	B16: -22.1019, 148.0731
HPQ23: -22.1023, 148.0733	B17: -22.1034, 148.0706
HPQ29: -22.1206, 148.0367	B18: -22.1080, 148.0716
HPQ30: -22.1185, 148.0365	HPT1: -22.1251, 148.0377
HPQ31: -22.1134, 148.0365	HPT9: -22.1251, 148.0706
HPQ33: -22.1225, 148.0365	

DES mapped RE: 11.4.9/11.4.8/11.5.5/11.7.2/11.5.9c and non-remnant	**Observed RE:** 11.7.1
Landform: Low hills	**Geology/Soils:** Qr/ Colluvial clay deposits
Land zone: 7	**Landform system:** Isaac Comet (Humboldt)
Structural formation: Woodland	**Ecologically Dominant Layer (EDL):** T1

T1

Height interval: 8-12 m	**Median Height:** 10 m	**Estimated Cover Density:** Sparse (S)

Species: *Eucalyptus thozetiana (d), Acacia catenulata (s)*

T2

Height interval: 7-11 m	**Median Height:** 9 m	**Estimated Cover Density:** Very Sparse (V)

Species: *Acacia catenulata, Acacia shirleyi, Acacia harpophylla, Eucalyptus thozetiana*		
S1		
Height interval:2-3 m	**Median Height:** 2.5 m	**Estimated Cover Density:** Very Sparse
Species: *Carissa ovata, Wikstroemia indica, Eucalyptus thozetiana, Flindersia dissosperma*		
Groundcover		
Estimated Cover Density: 30%		
Species: *Chloris divaricata*, *Cenchrus ciliaris**, *Enchylaena tomentosa, Melinis repens**		

RE 11.8.11

Site Name(s): HPQ54, HPQ58, HPQ60, HPT2, B4, B6	
Recorders: Brad Dreis and Peter Wagner	
Date: September 2020	
Locality: Cavil Ridge Mine Horse Pit Extension Area ML 70403 and ML1775	

Site Co-ordinates		
HPQ54: -22.0806, 148.0437 HPQ58: -22.0695, 148.0450 HPQ60: -22.0633, 148.0474	HPT2: -22.0785, 148.0439 B4: -22.0796, 148.0438 B6: -22.0689, 148.0447	
DES mapped RE: 11.5.3/ 11.8.11/ 11.4.9/11.4.8/11.8.5 and non-remnant	**Observed RE:** 11.8.11	
Landform: gently undulating plain	**Geology/Soils:** Tb/ Olivine basalt and Qr/ colluvial clay deposits	
Land zone: 8	**Landform system:** Isaac Comet (Connors)	
Structural formation: Grassland	**Ecologically Dominant Layer (EDL):** G	
Emergent		
Height interval: 11-22 m	**Median Height:** 3 m	**Estimated Cover Density:** Vey Sparse
Species: *Atalaya hemiglauca (d), Acacia salicina (d) Terminalia oblongata (s), Lysiphyllum carronii (s)*		
Groundcover		
Estimated Cover Density: 80-90%		
Species: *Iseilema vaginiflorum (d), Cenchrus ciliaris*, Digitaria brownii, Panicum decompositum*		