



## **ULAN COAL MODIFICATION 6 AMENDMENT – UNDERGROUND MINING EXTENSION**

Response to Independent Expert Scientific Committee on Coal  
Seam Gas and Large Coal Mining Development Advice

**FINAL**

August 2024



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Committee on Coal Seam Gas and Large Coal  
Mining Development Advice

## **FINAL**

Prepared by  
**Umwelt (Australia) Pty Limited**  
on behalf of  
**Ulan Coal Mines Pty Limited**

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Report No. 20020/R12  
Date: August 2024



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## **Acknowledgement of Country**

*Umwelt would like to acknowledge the traditional custodians of the country on which we work and pay respect to their cultural heritage, beliefs, and continuing relationship with the land. We pay our respect to the Elders – past, present, and future.*

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# 1.0 Introduction

Ulan Coal Mines Pty Limited (UCMPL) was granted its current Project Approval (PA) 08\_0184 under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 15 November 2010 for the Ulan Coal – Continued Operations Project (UCCO Project). UCMPL is proposing a modification to PA 08\_0184 to maximise resource recovery from the existing underground mining operations by mining additional coal within existing mining lease and exploration licence areas.

A Modification Report was prepared to assess the environmental and social impacts of the Ulan Coal Modification 6 – Underground Mining Extension (the Proposed Modification) and accompanied the modification application prepared under section 4.55(2) of the EP&A Act.

The Modification Report was placed on public exhibition by the then NSW Department of Planning and Environment (DPE, now Department of Planning, Housing and Infrastructure (DPHI)) from 18 November 2022 to 15 December 2022. A Submissions Report was lodged to the then DPE (now DPHI) in August 2023. In the Submissions Report, UCMPL made refinements to the proposed surface infrastructure to support the additional underground mining at the UCC as a result of:

- ongoing mine design and operational constraints
- improved understanding of mining and geological conditions
- further consultation with government agencies.

Following lodgement of the Submissions Report, further advice was received from the then DPE Water (now DPHI Water) and the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC), in relation to undermining of a 4<sup>th</sup> order stream section of Mona Creek.

In consideration of operational constraints (including development float, dewatering infrastructure and ventilation), UCMPL is seeking to amend the proposed underground mine plan with a reduced underground mining area within the original modification footprint (the Amended Modification). The proposed amendments also result in a set back from the 4<sup>th</sup> order Mona Creek stream banks, limiting the potential for additional direct impacts on Mona Creek from the Amended Modification.

This document has been prepared by Umwelt on behalf of UCMPL and seeks to address the comments raised in the IESC advice. This document has also been prepared with the assistance of:

- Australasian Groundwater & Environmental Consultants (AGE) on groundwater related issues.
- Engeny Water Management (Engeny) on surface water related issues.

## 2.0 Overview of Existing Operations and the Amended Modification

The following sections outline the current operations and the context within which the Amended Modification will occur.

### 2.1 Existing Operations

The Ulan Coal Complex (UCC) is located approximately 38 km north-east of Mudgee and 19 km north-east of Gulgong in New South Wales (NSW) (refer to **Figure 2.1**). The UCC is owned by Glencore Coal Pty Limited (Glencore) and operated by UCMPL, a subsidiary of Glencore.

Mining in the Ulan area has been undertaken since the early 1920s, initially as Ulan No. 1 Colliery Holding for the supply of coal to local markets. The distance to major markets prohibited the continuation of mining and operations ceased. The mine reopened in 1942 and continued operations until 1950. A new mine was developed by Hogan & Gorman in the 1950s further east of the previous mining operations creating the Ulan Colliery Holding No. 2 underground mine to supply coal to a new power station that was built to the north of Ulan Village as well as supplying local markets. This mine is now referred to as Ulan Underground mine. When the power station closed in 1969, mining at Ulan Underground continued on a small scale to supply other domestic markets (Connell Wagner, 1992).

In the late 1970s, Hogan & Gorman registered UCMPL and ownership transferred to White Industries. Part ownership was later transferred to Mitsubishi Operations and NSW State Super Board. An exploration program undertaken in 1976 in the Ulan area proved the existence of extensive coal reserves, and mining operations at the UCC expanded substantially in the 1980s with the establishment of an open cut coal mine. This expansion included the construction of the coal preparation plant and rail loading facility and augmentation of the Ulan Underground in 1982. Traditional bord and pillar underground mining methods were used from the mid-1970s to mid-1980s prior to longwall methods being introduced in 1986 with the commencement of Ulan No. 3. Glencore (formerly Xstrata Coal Pty Limited) purchased 90 per cent of the UCC in 2001. Mining within the open cut continued until mid-2008, when approved reserve recovery areas were exhausted at which time it was placed in care and maintenance. Development of the Ulan West underground commenced in 2011 with longwall mining commencing in 2014.

As detailed in **Section 1.0**, UCMPL was granted PA 08\_0184 under Part 3A of the EP&A Act on 15 November 2010 for the UCCO Project. PA 08\_0184 has since been modified on six occasions. The UCC also holds approvals 2009/5252 and 2015/7511, issued under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is noted that Modification 4 was determined to be not a controlled action under the EPBC Act (EPBC 2018/8337) on 31 January 2019.

Approved mining operations within the UCC consist of underground mining in the Ulan Underground and Ulan West Underground areas as well as open cut mining, and associated coal handling, processing and transport through to 30 August 2033. The open cut operations are currently in care and maintenance.

PA 08\_0184 as modified, provides for:

- mining operations at the UCC until 30 August 2033
- longwall mining of Ulan Underground
- longwall mining of Ulan West Underground
- open cut operations over a 239-hectare area
- CHPP and rail loadout facilities with total coal production capacity of 20 Mtpa product coal
- continued use of existing surface facilities and ancillary activities, and construction and use of approved and new surface facilities and ancillary activities to support the abovementioned operations.

EPBC 2009/5252 provided for extension to the open cut coal mine, development of the Ulan West underground mine, modification or construction of new infrastructure associated with these operations and the Ulan No 3 underground operation. EPBC 2015/7511 provided for extension of the existing Ulan West underground coal mine and surface infrastructure.

### **Environmental Management**

The UCC currently operates 24 hours per day, seven days per week, including construction and maintenance activities. Coal extracted at the UCC is processed at the CHPP (apart from low ash coal that bypasses the CHPP), stockpiled and loaded via the dedicated UCC rail loading facility for transport by rail to domestic markets or to the Port of Newcastle. Most of the coal is sold to the thermal coal export market.

UCMPL has a comprehensive Environmental Management System in place for the existing operations that has been refined over the many years of operations to appropriately address the environmental and social aspects of the mining operation. The UCC Environmental Management System includes environmental management plans and procedures that have been developed to satisfy the requirements of relevant legislative requirements and Glencore policies, and to drive environmental and social performance. These documents provide the strategic context for the environmental and social management of the UCC.

The Ulan Coal Environmental Management Strategy documents and implements the systems and processes in place to provide for effective environmental and social management across the UCC, and aims to:

- ensure adherence to statutory requirements, including regulatory approvals and licences
- comply with applicable legislation, standards, codes and other external requirements
- align UCMPL's operating philosophy with the Glencore Health, Safety, Environment and Community (HSEC) framework and the principles of ISO14001
- manage and minimise environmental impacts.



UCMPL has a number of environmental management plans that have been prepared to assist in the management of key environmental issues. Many these plans have been prepared to satisfy the requirements of PA 08\_0184 and have therefore been prepared in consultation with relevant government agencies and approved for implementation by the DPHI. The environmental management plans will be updated to address issues specific to the Amended Modification, where relevant, should the Amended Modification be approved.

The key existing management plans for the UCC that will assist in the management of mining operations undertaken as part of the Amended Modification include:

- Biodiversity Management Plan
- Bushfire Management Plan
- Air Quality and Greenhouse Gas Management Plan
- Noise Management Plan
- Heritage Management Plan
- Water Management Plan
- Groundwater Monitoring Program
- Surface Water Monitoring Program
- Surface Water and Groundwater Response Plan
- Waste Management Plan.

## 2.2 Overview of Amended Modification

As outlined in **Section 1.0**, UCMPL is proposing a modification to PA 08\_0184 to maximise resource recovery from the existing underground mining operations by mining additional coal within existing mining lease and exploration licence areas.

In addition to proposing to mine additional resources within existing mining lease areas, UCMPL has determined that there is a valuable mineable resource within Exploration Licence (EL) 7542 and is proposing to access this coal resource by extending the currently approved longwall panels into these areas.

The Amended Modification will maximise resource recovery within the existing mining lease and exploration licence areas by extending currently approved longwall panels into these areas to enable the extraction of an additional approximately 16.3 million tonnes (Mt) of product coal. The Amended Modification will not change the current approved coal extraction rate of up to 20 Mt per annum (Mtpa) of product coal.

The Amended Modification will extend the life of the approved UCC operation by approximately two years allowing mining to continue until August 2035. The UCC will continue to utilise the existing approved mine facilities, including the Coal Handling and Preparation Plant (CHPP) and train loading facilities.

To allow for the proposed extension of the underground mining area, the Amended Modification includes changes to the surface infrastructure associated with underground operations, including ventilation, power and dewatering infrastructure.

On 12 September 2022, the Proposed Modification, as referred under the EPBC Act, was determined to be a controlled action (EPBC 2022/09292) requiring assessment and approval under the EPBC Act due to controlling provisions related to listed threatened species and communities, and impacts to a water resource. The Amended Modification will be assessed under the Bilateral Agreement made under section 45 of the EPBC Act between the Commonwealth of Australia and the State of New South Wales.

The components of the Amended Modification that are not covered under current approvals were referred under the EPBC Act. The referral specifically covers:

- additional underground mining areas for Ulan Underground and Ulan West Underground
- additional disturbance to accommodate minor changes to surface infrastructure to support underground mining activities.

**Figure 2.2** illustrates the approved UCC operations and **Figure 2.3** shows the Amended Modification in relation to the currently approved mining operations at UCC. The currently approved Project Area is proposed to be amended to include EL 7542.

The Amended Modification comprises:

- extension of Ulan Underground longwall (LW) panels LWW9 to LWW11 to the west, albeit at a reduced length compared to the originally Proposed Modification 6
- widening of Ulan Underground LWW11 by approximately 30 metres
- extension of Ulan West LW10 to LW12 to the north, noting the removal of the extension to LW9 which was included in the originally Proposed Modification 6.

UCMPL is also proposing some minor changes to surface infrastructure to support underground mining activities including provision of:

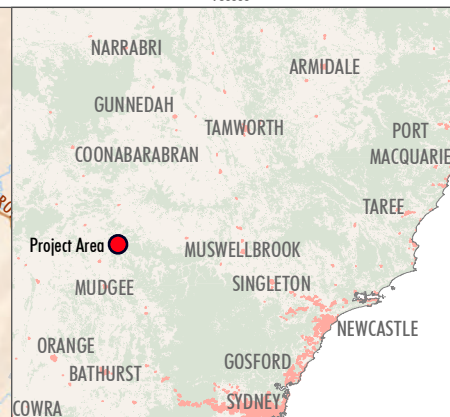
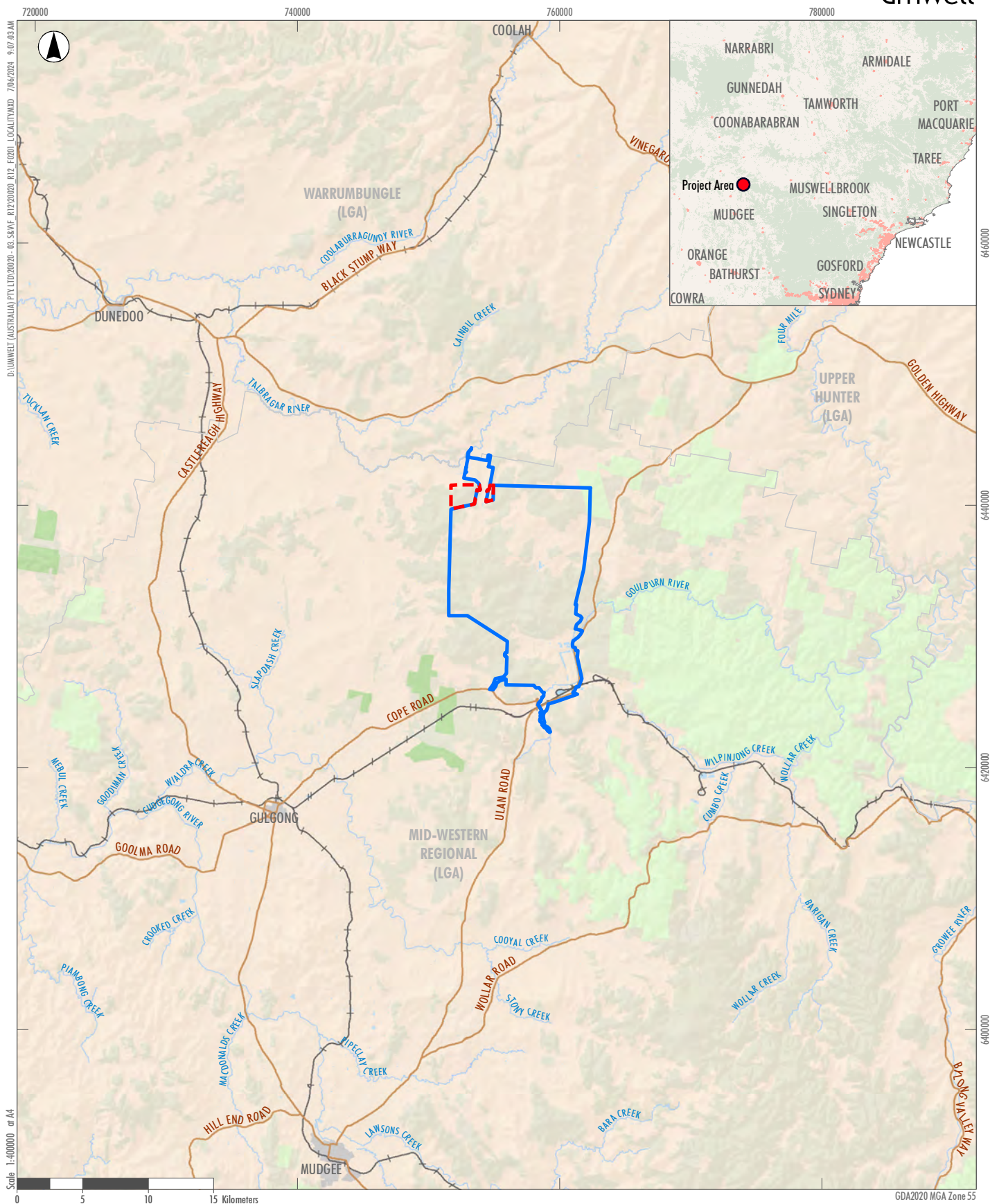
- one ventilation shaft and associated infrastructure corridor (the additional ventilation shaft originally proposed associated with Ulan Underground has been removed due to the reduced length of longwall panels and one of the ventilation shafts at Ulan West originally proposed has been removed following removal of the proposed extension to LW9)
- two dewatering bores and associated infrastructure corridors (an additional three dewatering bores that were originally proposed have been removed)
- an infrastructure corridor and service borehole (to deliver gravel and other construction materials and to provide access and power to the underground mine) to the south-west of Ulan West
- other associated infrastructure required to service the approved and proposed underground mining operations.

The Amended Modification has been designed through a multi-disciplinary social and environmental risk-based approach aimed at maximising resource extraction efficiency and optimising the use of existing site infrastructure, while seeking to minimise impacts on the environment and community. The key learnings from the long history of mining operations at the site, the stakeholder engagement program, and from environmental and social impact assessments, have all been considered in the design of the Amended Modification.

A comparison between the approved development under PA 08\_0184 and the Amended Modification is provided in **Table 2.1**.

**Table 2.1 Comparison of PA 08\_184 and the Amended Modification**

| Key Project Component                      | Approved Development (PA 08_184)                                                                    | Amended Modification                                                                                                                              |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mine life</b>                           | Mining operations until 30 August 2033                                                              | Extension of life of mine until 30 August 2035 (an additional two years)                                                                          |
| <b>Limits of extraction</b>                | 20 million tonnes of coal per annum (including maximum of 4.1 Mtpa ROM from Open Cut)               | No change to existing extraction rate<br>Additional approximately 16.3 Mt of product coal from the Amended Modification                           |
| <b>Operating hours</b>                     | 24 hours per day, 7 days per week                                                                   | No change                                                                                                                                         |
| <b>Project boundary</b>                    | As per PA 08_0184 (refer to <b>Figure 2.2</b> )                                                     | Extension of Project Approval Boundary to include the northern part of EL 7542 (refer to <b>Figure 2.3</b> )                                      |
| <b>Mine plan</b>                           | As per PA 08_0184 (refer to <b>Figure 2.2</b> )                                                     | Extension of Ulan Underground LWW9 to LWW11, and Ulan West LW10 to LW12<br>Widening of Ulan Underground LWW11<br>Refer to <b>Figure 2.3</b>       |
| <b>Mining method</b>                       | Retreat longwall method                                                                             | No change                                                                                                                                         |
| <b>Surface infrastructure</b>              | As per PA 08_0184                                                                                   | Minor changes to infrastructure including dewatering bores, ventilation shafts and associated infrastructure to accommodate the amended mine plan |
| <b>Coal Handling and Preparation Plant</b> | As per PA 08_0184 (refer to <b>Figure 2.2</b> )                                                     | No change                                                                                                                                         |
| <b>Coal transportation</b>                 | All coal transported from the site by rail.<br>No more than 10 laden trains leave the site each day | No change                                                                                                                                         |
| <b>Workforce numbers</b>                   | Approximately 930 people (UCC)                                                                      | No change                                                                                                                                         |

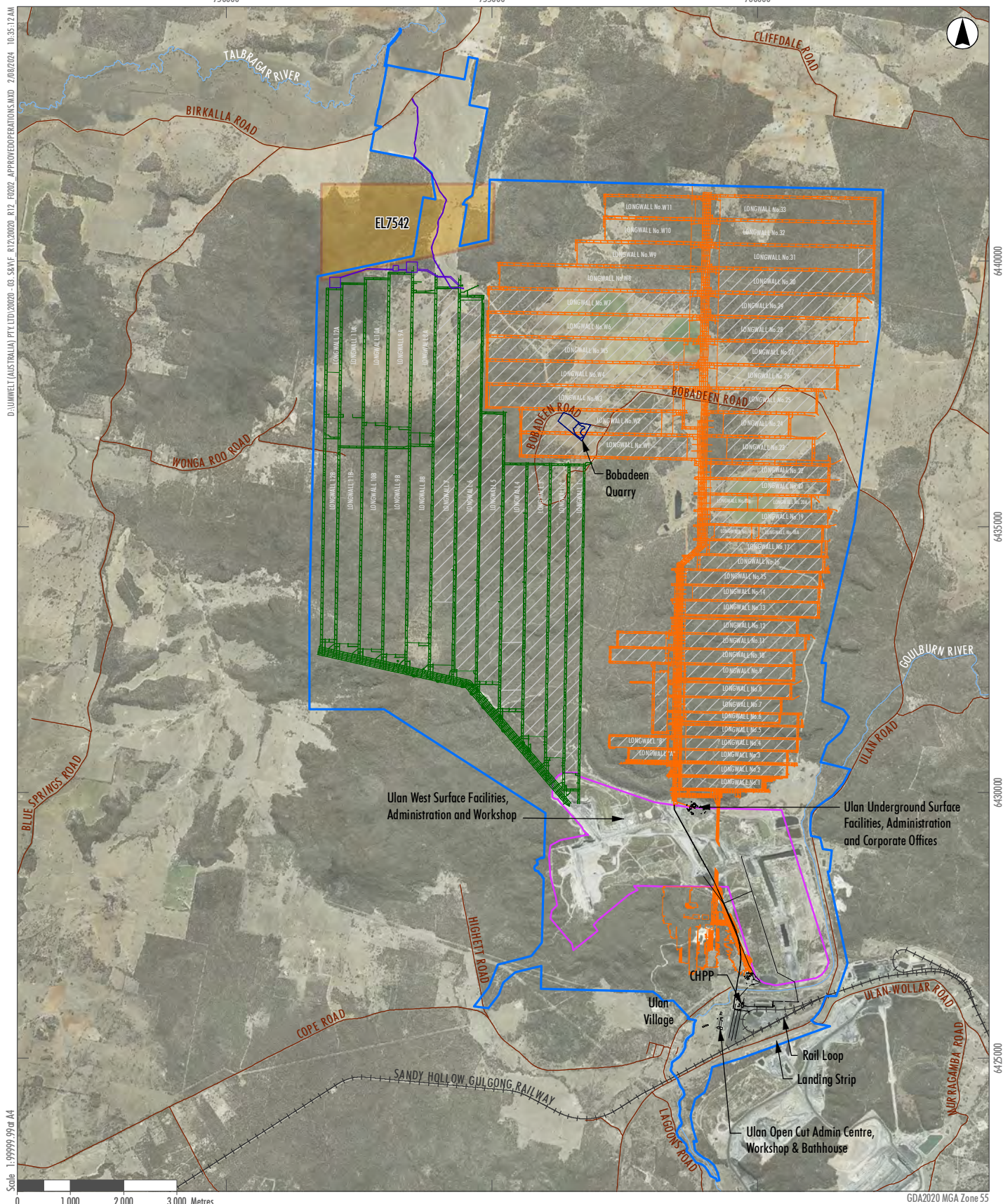


- Legend**
- Project Approval Boundary
  - Proposed Mod 6 Project Approval Boundary
  - Local Government Area (LGA)
  - Road
  - Railway
  - Watercourses
  - State Forest
  - NPWS Estate
  - Native Vegetation

Image Source: ESRI Basemap Data source: NSW DFSI (2020), Ulan (2020)

**FIGURE 2.1**  
**Locality Map**





- Legend**
- Project Approval Boundary
  - Exploration Lease - EL7542
  - Bobadeen Quarry
  - Approved Ulan Open Cut Area
  - Approved Infrastructure related to Mod 6
  - Approved Ulan Underground Mine Plan
  - Approved Ulan West Mine Plan
  - Previously Mined
  - Roads
  - Railway
  - Major Watercourses

FIGURE 2.2

Approved Operations



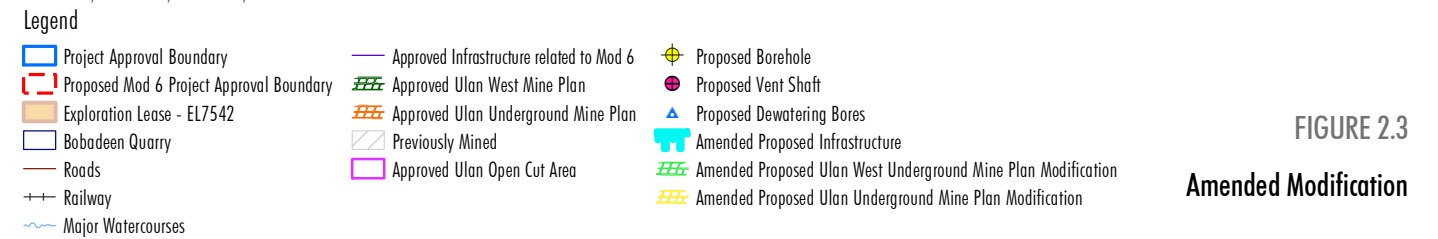
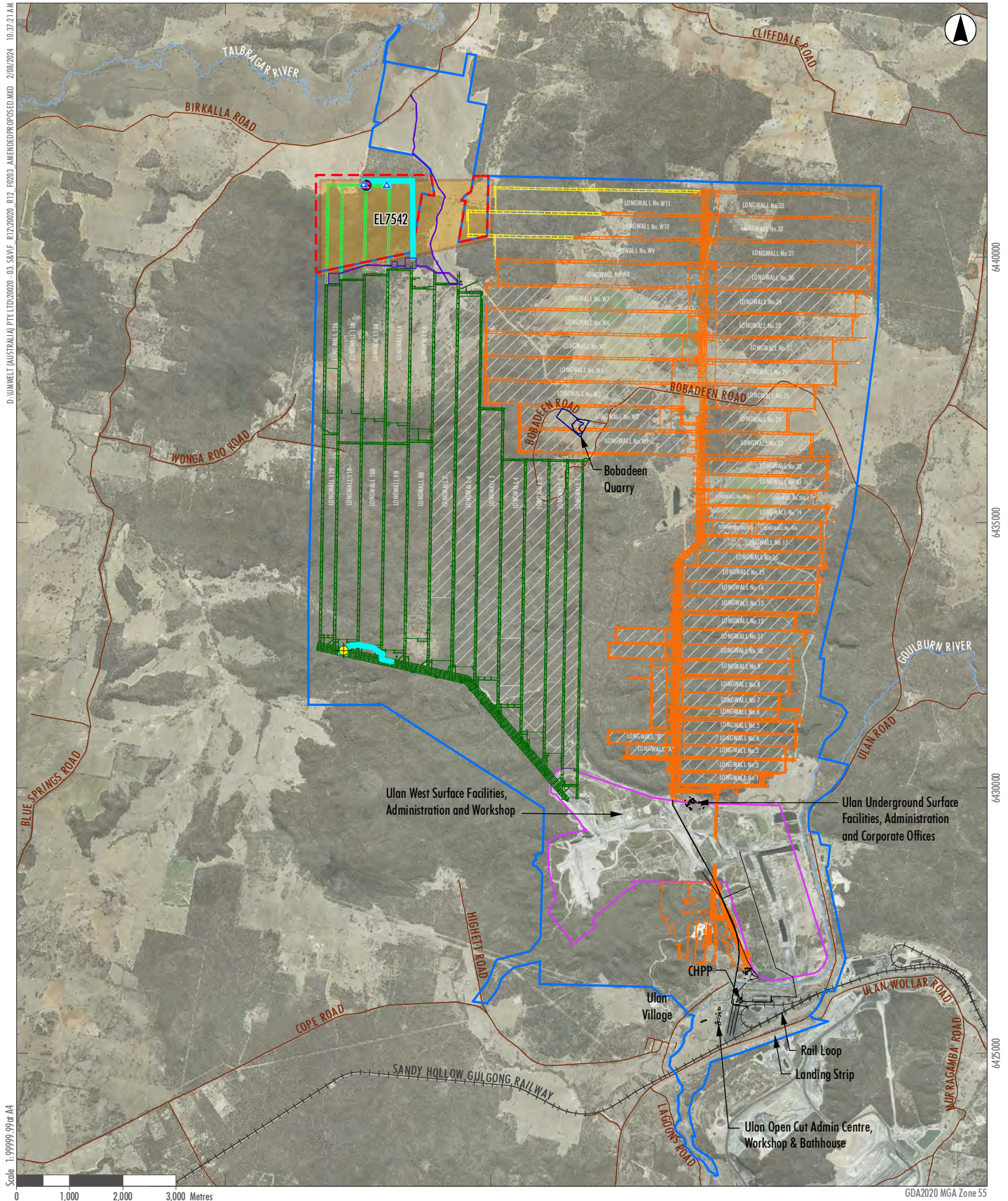


FIGURE 2.3

Amended Modification



## 2.3 Hydrological Context

### 2.3.1 Surface Water

The UCC is located at the headwaters of both the Goulburn River system and the Talbragar River system. The catchments for these river systems are separated by the Great Dividing Range with the Goulburn River system draining east into the Hunter River Catchment and the Talbragar River system draining west to the Macquarie River Catchment and the Murray-Darling Basin. All of the tributaries within the UCC boundary draining to the Goulburn River and Talbragar River are ephemeral by nature.

The additional underground mining area which is the subject of the Amended Modification lies within the Mona Creek catchment. Mona Creek is an ephemeral tributary of the Talbragar River and the catchment is dominated by grazing and cropping land. There is one in-stream farm dam located on Mona Creek above the additional underground mining area. There are no in-stream dams located in the Mona Creek downstream of the additional underground mining area however there are several small farm dams located within the broader Mona Creek flood plain, including one located on what appears to be a paleo channel of Mona Creek.

The catchment includes areas of open grassland (primarily along the creekline and associated floodplain where it has been cleared due to the generally better soils and more arable land in these areas) and forest/woodland along the ridgelines and upper slopes.

The soil landscape within the upper reaches of Mona Creek is the Turill soil landscape. Soils within this soil landscape are generally of low fertility and are well drained but highly susceptible to erosion. The additional underground mining area associated with the Amended Modification also intersects the Ulan soil landscape. Soils in the Ulan soil landscape typically have low fertility, are imperfectly drained and have moderate to high susceptibility to erosion (Yoo et al., 2001). The bed and banks of Mona Creek generally consist of sandy material, while the upper reaches are typically sandy clay. The channel section of Mona Creek is typically shallow in the upper reaches ranging up to two metres deep with bank slopes ranging between gentle gradual slopes to 1:3 (vertical: horizontal). The bed width of the creek ranges from approximately one metre to up to fifty metres. The beds and banks of Mona Creek are in generally good condition with some isolated areas of erosion, despite including soils typically associated with high erosion hazard. The creek bed grade ranges typically between 1% to 2%.

Irrigation water along the Talbragar River is primarily sourced from the river, when flowing, and alluvial systems. No private landholders have been identified using the surface waters of Mona Creek (when present) within or downstream of the area of additional underground mining associated with the Amended Modification, except for stock access via basic landholder rights.

UCMPL monitors water quality and flows in Mona Creek at one location, SW10 (refer to Figure 3.1 in the Amended Surface Water Impact Assessment (SWIA) contained in Appendix 6 of the Amendment Report). Water quality monitoring has been undertaken at this location since February 2012. Flow monitoring has been undertaken since 2015 and currently has a limited data set due to the ephemeral natural of the watercourse combined with the sandy bed conditions.

The regions downstream of the UCC within the Goulburn River catchment are primarily forested. As the Amended Modification is associated with changes within the Talbragar Catchment, the assessment has focused on this area.

## 2.3.2 Groundwater

There are three primary hydrostratigraphic units across the Project Area:

- Unconsolidated alluvial sediments occurring along the creek lines associated with tributaries of the Talbragar and Goulburn Rivers. The tributary of most relevance to the Amended Modification is Mona Creek, an ephemeral creek system which is part of the Talbragar River system. While broad scale geological mapping identifies the Mona Creek floodplain as dominated by alluvial sediments, recent detailed characterisation work undertaken for the Amended Modification has identified that these sediments are colluvial in nature. The limited permeability and porosity within the Mona Creek valley sediments means the material readily absorbs rainfall, resulting in perched groundwater systems forming on top of the underlying lower permeability bedrock. The silt and clay bound nature of the Mona Creek valley sediments means the perched groundwater systems are ephemeral and slowly drain into the underlying bedrock and downgradient to the north over time. Any areas of cleaner sand and gravel are not well connected which serves to slow the movement of groundwater.
- Shallow regolith and near surface weathered rock profiles which can host unconfined groundwater during extended wet periods when the recharge rate exceeds the rate of downward or lateral flow.
- Triassic, Jurassic and Permian sedimentary bedrock formations which contain the coal seams targeted by mining. The Ulan Seam is identified as the main water bearing zone within the Permian strata as the nature of the coal allows the horizontal movement of water more freely than the other Permian units. The Triassic and Jurassic sandstones overlying the Permian coal measures are more porous and permeable.

Salinity is the key restriction on beneficial use of groundwater at the UCC, as it falls between the brackish and moderately saline classifications. Much of it is unsuitable for sensitive uses such as human consumption and irrigation without additional treatment, although may be tolerated by stock or used to irrigate salt-tolerant crops.

The Water Management Plan (WMP) includes a detailed Groundwater Monitoring Program (GWMP) (2019) which outlines a monitoring program to collect data on groundwater levels and quality to allow actual impacts to the local groundwater system to be compared to the predictions of previous environmental assessments. Monitoring piezometers are located both within and outside the approved mining boundary and previously mined areas to address the following elements of both the alluvial and hardrock/coal aquifers:

- groundwater inflows to open cut pit and underground mine workings
- groundwater levels and groundwater quality
- seepage/leachate from the mine water management system
- baseflows in watercourses
- monitoring of 'The Drip'.

In addition to the groundwater monitoring network, annual voluntary monitoring of groundwater levels and water quality for privately-owned bores within the area is undertaken. This monitoring program extends to approximately 12 km away from the approved mine footprint.



## 2.4 Water Management Context

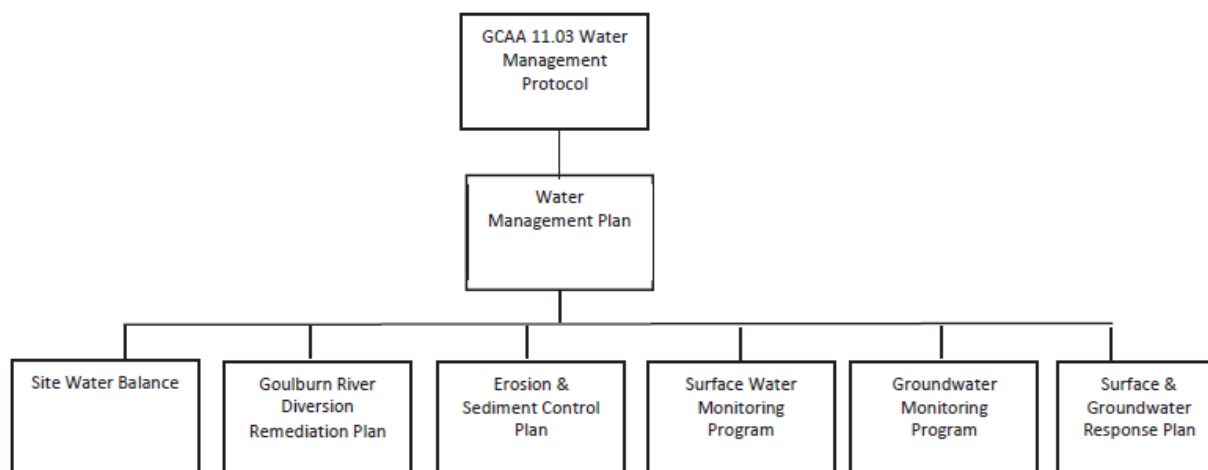
The UCC operational area exists within a well-regulated water resource management system that has been designed to provide for the sustainable management of the State's water resources in line with legislation and guidelines. This includes licensing of allowable water take with consideration of environmental flow requirements of watercourses and the needs of other water users; control of water pollution, including management of sustainable salt loads associated with all water sources, including mine water discharges; and guidelines that govern the appropriate design of water management systems for mines to provide for appropriate water quality in accordance with EPL requirements.

The UCC has a long history of operations and a significant amount of environmental monitoring has been undertaken at the mine, and in the surrounding locality, the results of which document the history of mining impacts over time. This includes impacts to surface water, groundwater, biodiversity and landforms via subsidence. Previous assessments over many years provide a sound understanding of the local surface water and groundwater regimes and mining impacts can be accurately predicted by models that have been updated and calibrated using measured field data. Assessment findings are therefore scientifically robust.

The UCC currently operates within the conditions of PA 08\_0184 and a series of approved Extraction Plans which allow for an approved level of disturbance. The Extraction Plans prescribe the monitoring and management measures to be implemented for each longwall area. Longwall extraction in the proposed additional mining area will be undertaken in accordance with an approved Extraction Plan as required by PA 08\_0184. It should be noted that overall subsidence impacts for the Amended Modification are expected to be consistent with or less than the predictions for the approved operations, subsidence performance measures outlined in PA 08\_0184, and the monitoring experience since PA 08\_0184 was granted.

The approved Water Management Plan (WMP) (2021) was prepared to fulfil the requirements of PA 08\_0184, EPL 394 and applicable statutory requirements. The WMP provides a framework for the management of water and outlines the interaction between the various policies, plans, programs and procedures. The WMP clarifies requirements for surface water and groundwater management during construction and operational phases. It describes the management of environmental and community aspects, impacts and performance relevant to the site's water management system.

The WMP meets the requirements of the Glencore Coal Assets Australia (GCAA) Water Management Protocol (GCAA-625378177-10320) and incorporates six key component documents, as shown in **Figure 2.4**.



**Figure 2.4 Structure of the WMP**

Ongoing surface water, groundwater, biodiversity and subsidence monitoring will be undertaken in a similar manner to the standards detailed in the existing monitoring programs required by the current Extraction Plans, including before, during and after mining survey. This will build upon the existing body of knowledge and further enhance impact prediction into the future.

## 3.0 Response to IESC Submission

The IESC was requested by the DCCEEW and DPHI to provide advice on the Proposed Modification by responding to six questions. The questions were directed at matters specific to the Proposed Modification to be considered during the requesting agencies' assessment process.

The six questions posed to the IESC are included in text boxes in the following sections. The IESC responses, provided as numbered paragraphs, are also included in text boxes. The UCMPL responses are provided in the paragraphs following each text box and reflect the latest available information in relation to the Amended Modification.

The responses to questions related to groundwater have been prepared in consultation with AGE who also prepared the Amended Groundwater Impact Assessment (GIA) for the Amended Modification (refer to Appendix 5 of the Amendment Report). The responses to questions related to surface water have been prepared in consultation with Engeny who also prepared the Amended SWIA for the Amended Modification (refer to Appendix 6 of the Amendment Report). Additional IESC response assessment documentation prepared by AGE and Engeny is provided in **Appendix 1** and **Appendix 2** respectively.

### 3.1 Groundwater

#### Question 1. Groundwater

To what extent can decision makers have confidence in the predictions of potential impacts on groundwater resources, paying particular attention to predicted direct and indirect water take from various groundwater sources, key water features in the project's vicinity (i.e. 'the Drip'), groundwater dependent ecosystems and other water users.

- a) Has an appropriate model been selected and used by the Applicant? Are the assumptions used in the model reasonable, appropriately conservative and appropriately justified?
- b) Has the model been calibrated with sufficient monitoring data to provide meaningful predictions, including worst-case impacts on groundwater resources?
- c) Has the model been appropriately conceptualised?
- d) Has an appropriate sensitivity and uncertainty analysis been undertaken, including consideration of the potential effects of climate change?
- e) Has the groundwater assessment sufficiently assessed surface and groundwater interactions?

1. Confidence in the predictions of potential impacts on groundwater resources from the project is limited by several issues with the groundwater impact assessment and modelling as discussed below.

2. Predicted takes, either direct or indirect, from various groundwater sources have been outlined (AGE 2022, Table 2.1, p. 11), and the model has been updated to enable takes from relevant sources to be identified and estimated (AGE 2022, p. 96). The accuracy of the predicted takes will be affected by the issues discussed in Paragraphs 5–11.

Refer to discussion related to Paragraphs 5–11 below.

3. The IESC agrees that this project is unlikely to impact The Drip, unless the cumulative changes in groundwater level exceed model predictions.

The IESC position regarding The Drip is noted.

4. The proponent has provided limited information about Unnamed Spring (basalt) and Kelly's Spring (Jurassic sandstone), which are located 6 km north of the project area, beyond stating that these springs are recharge-fed (AGE 2022, p. 51). The IESC suggests that the proponent verifies that these springs are fed by perched aquifers and will not be affected by drawdown in the underlying Triassic sandstone aquifers.

In response to the IESC comments, AGE has undertaken additional sampling and assessment to determine the sources of the Unnamed Spring and Kelly's Spring, with results discussed below.

### Unnamed Spring

AGE has sampled the Unnamed Spring and analysed for major cations, anions and heavy metals. Results showed the water to be reasonably fresh (electrical conductivity (EC) of 1,020  $\mu\text{S}/\text{cm}$  and total dissolved solids (TDS) of 565 mg/L with a pH of 7.14). The water type is classified as Mg-Na-Ca- $\text{HCO}_3$ -Cl, a type which has not been observed before in monitoring results from UCC, proving difficult to assign it to a particular source formation. It is, however, similar to a broad range of water types found in the Triassic strata.

Further investigations were made into the nature and source of Unnamed Spring, including aerial photography which indicated the presence of a basalt cap in the vicinity. Geological mapping further indicated that the surface expression of the spring is located down slope from this basalt cap and at the location of the interface between the Jurassic Pilliga and underlying Jurassic Purlewaugh Formations. While the aerial imagery indicates that the soils upgradient from the spring are basaltic in origin, it could be this indication of basalt is simply weathered off the cap and deposited down the slope.

Then, if the geologic mapping of the area is accurate, the location of the spring is not the contact between the basalt and underlying Pilliga Formation, rather it is the contact between the more permeable Pilliga Formation and the tighter underlying Purlewaugh Formation. The Jurassic sediments are noted for having localised perched aquifer systems through the region, which is the likely mechanism for the spring. However, water quality results indicate that the water is generally fresher than typical Jurassic samples, so the spring's source may also be water that is recharged in the basalt cap and then transferred to the Jurassic sediments before discharging.



Unnamed Spring is daylighting at an elevation of approximately 460 mAHD. This elevation is significantly above the ‘regional’ water table for the underlying Triassic sediments and thus it is expected that the spring will remain unaffected by changes to the groundwater regime from underground mining resulting from the Amended Modification.

### Kelly’s Spring

Kelly’s Spring has previously been inspected by AGE staff and field water quality data has been collected in mid-2023. The data shows the water to be fresh with a TDS reading of 53.36 mg/L, indicating that it represents water that was recently recharged into the groundwater system and a relatively short flow path. The pH of the water was 8.52 and the temperature was 9.1°C.

The conceptual model of Kelly’s Spring as being sourced from perched Jurassic sediments (as presented in the Amended GIA) is supported by this water quality data. The spring will be sampled at the next available opportunity for water quality and water chemistry (cations, anions and heavy metals) to complete a background assessment.

5. The adequacy of the assessment of potential impacts to key water features, GDEs and other water users in the project’s vicinity varies. The assessment of these impacts to Mona Creek and any associated GDEs is limited, and additional work and information are required.

a. Up-to-date field surveys to enable characterisation of potential GDEs in the vicinity of the project. The proponent has stated that “no significant GDEs were identified” (AGE 2022, p. 51); however, the data to support this have not been provided. Impacts to GDEs could arise through subsidence, groundwater drawdown, and groundwater mounding post-mining. More detailed consideration of the individual stressors, and cumulative impacts from multiple stressors, is needed.

The groundwater modelling has predicted groundwater level change throughout the life of operations at UCC, starting with pre-mining water levels (steady state conditions prior to mine dewatering), through the active mining phase (conditions at the end of mining), and through to post-mining equilibrium (conditions at a steady state timestep, post-recovery, that incorporates changes in recharge and hydraulic properties due to mining).

**Figure 3.1** shows the modelled depth to water table for the pre-mining, end of mining (predicted water table representing the end of mining including the Amended Modification), and then post mining equilibrium periods. In this comparison the influence of the underground mining where there is no perched water table and where dewatering has reduced water levels can be seen. Pre-mining there are some areas, mostly along surface drainages and in alluvial sediments, where the water table is within 2 m of the ground surface (refer to **Figure 3.2**). Pre-mining the regional groundwater levels are also well below Mona Creek with generally 10 to 20 m depth to water table.

Based on the ecological assessments undertaken for the Amended Biodiversity Development Assessment Report (BDAR) for the Amended Modification (Appendix 8 of the Amendment Report), riparian vegetation observed along Mona Creek, including areas adjacent the additional underground mining areas associated with the Amended Modification is limited to groundcover species only and there are no trees or shrub layer present other than in one small area upstream of site Mona Creek Monitoring Bore (MCMB) 03.

The mapped grasslands present in this area do not contain groundwater dependent species and are not classified as a Groundwater Dependent Ecosystems (GDE).

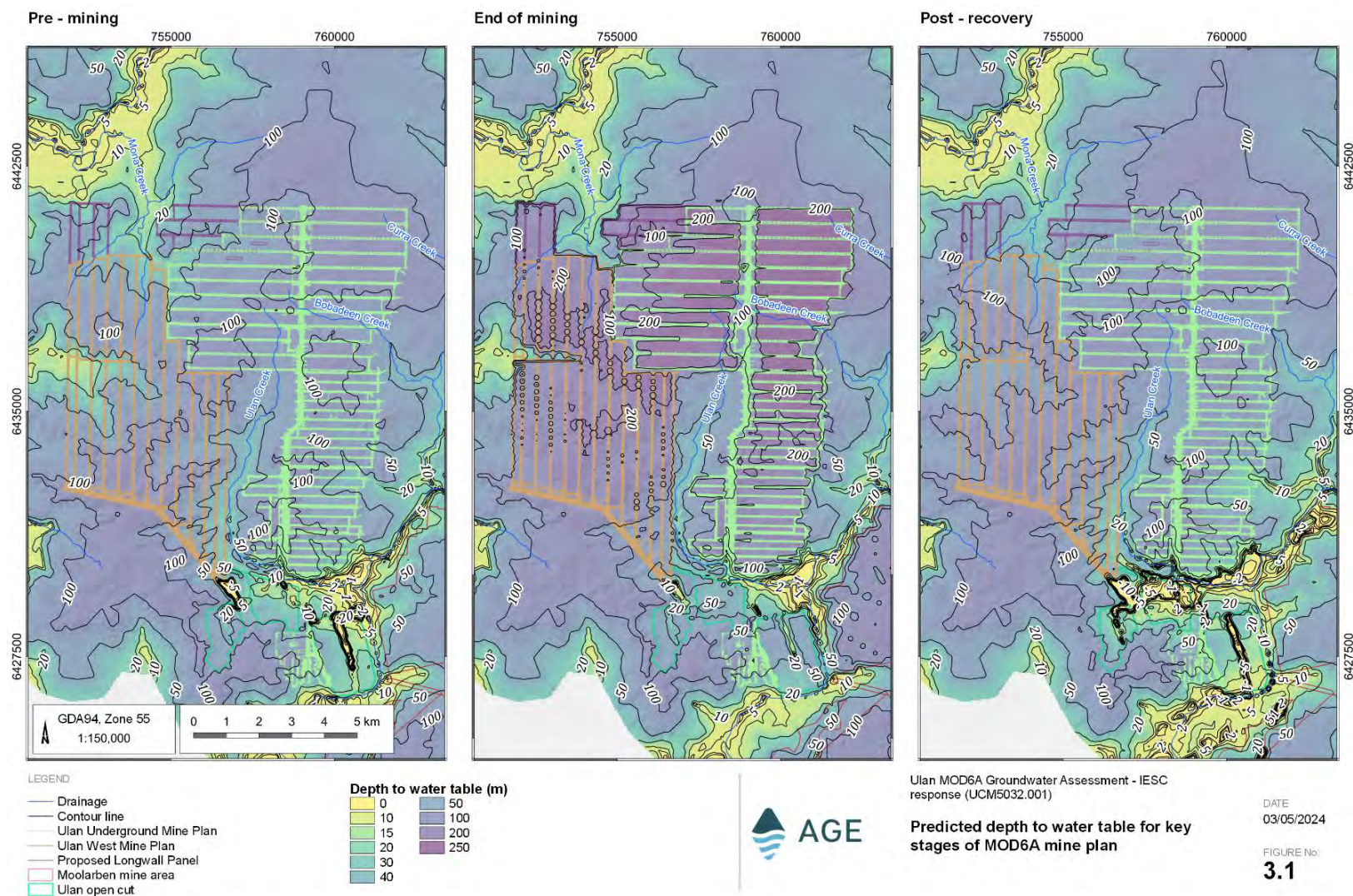
The existing depth to water table (refer to **Figure 3.1**) in the area where woodland is mapped indicates the regional water table is greater than 10 m below ground level (mbgl) and is likely below the rooting depth of these riparian trees. Monitoring from the MCMB01 nested bores suggests the vegetation in the upper catchment of Mona Creek may utilise shallow groundwater in the unconsolidated sediments but also indicates this shallow groundwater is disconnected from the regional groundwater regime. As a result, aquatic and hyporheic ecosystems within the Mona Creek environment (including those related to base flow and refugial pools) will be unaffected by the changes in regional water table associated with mining in this area.

This supports the Bureau of Meteorology (BOM) GDE Atlas <sup>1</sup> mapping of terrestrial vegetation in the Mona Creek areas having low potential of being a GDE. Due to the water table being well below the base of the creek and associated colluvial material, pre-mining and during mining, there is not predicted to be any baseflow to Mona Creek from the regional water table. The only baseflow occurring in Mona Creek would be sourced from storage in bed sediments and interflow (infiltration not reaching the water table).

The minor predicted incremental drawdown in Mona Creek associated with the fracturing due to the Amended Modification (refer to Figure 7.2 in the Amended GIA) will impact areas where the regional water table is already well below the depth of colluvium and likely rooting depth of vegetation and is therefore unlikely to have any adverse impact on any GDEs. The Project is not predicted to have any impact on the shallow and disconnected colluvial aquifer observed at site MCMB01A and vegetation and stygofauna and hyporheic fauna dependent on this shallow aquifer would be unaffected by the Amended Modification.

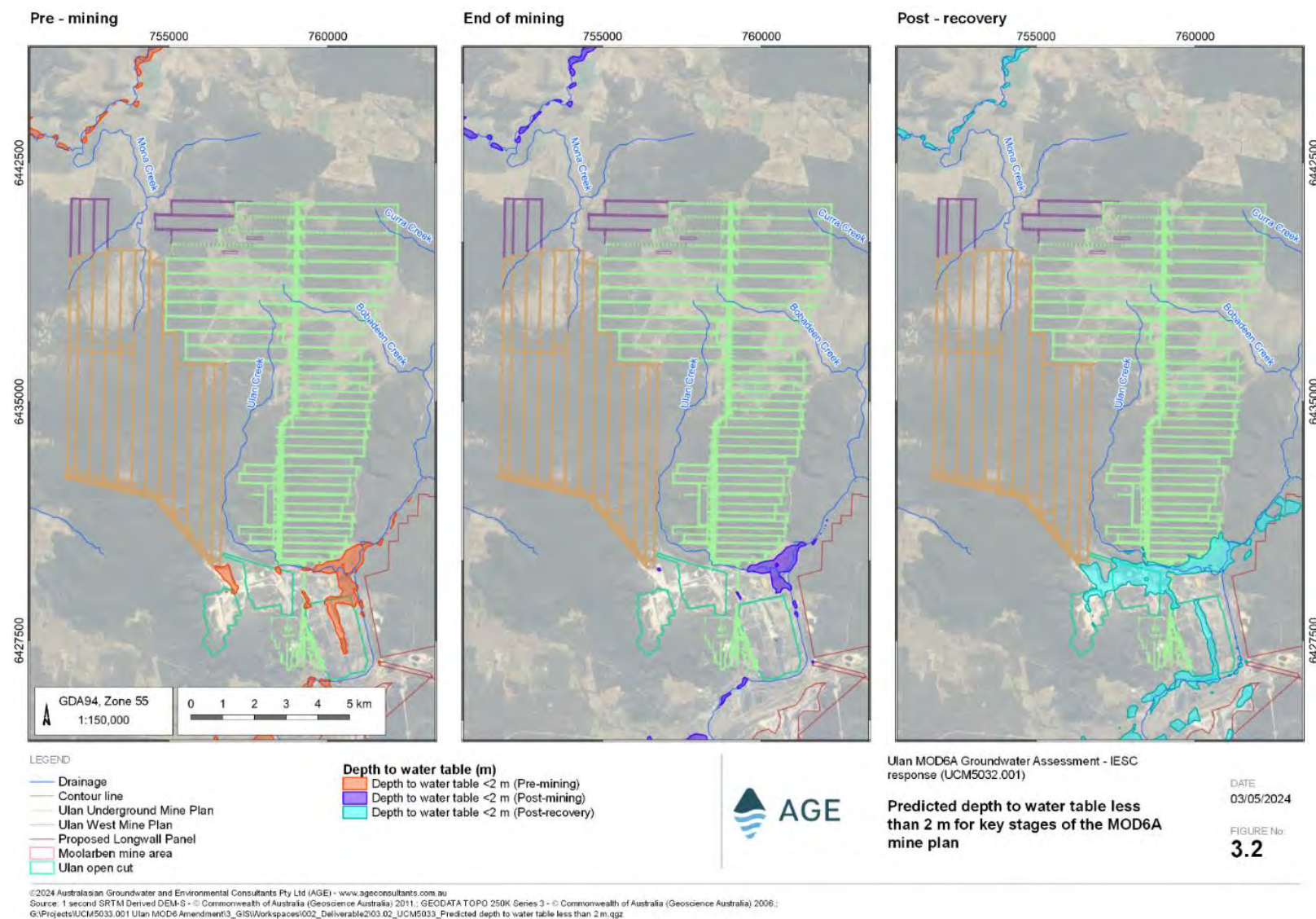
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<sup>1</sup> Refer to <http://www.bom.gov.au/water/groundwater/gde/map.shtml>



**Figure 3.1 Predicted depth to water table for key mining stages of the Amended mine plan**





**Figure 3.2 Predicted depth to water table less than 2 m for key stages of the Amended mine plan**



b. Clear presentation of data collected from the Mona Creek bores is required to establish the baseline groundwater conditions, particularly the depth to groundwater, the extent of the aquifer and groundwater quality.

The Mona Creek Monitoring Bores (MCMB) are a group of six monitoring bores installed in 2020 nearby to Mona Creek in the northern extent of the UCC Project Area boundary. The bores were installed at three locations each consisting of one bore installed into unconsolidated sediments and one into the Triassic strata. The bores are identified by prefix “MCMB” followed by a numeric identifier (e.g. “01”) then a letter to identify if it is completed into shallow sediments (“A”) or bedrock (“B”) (refer to Table 3.1 and Figure 3.4 in **Appendix 1** for bore location and construction information).

The MCMB were installed with the purpose of characterising the nature of groundwater movement in the surficial unconsolidated material and the extent that the surficial aquifer is connected to the deeper Triassic bedrock aquifer.

Initial assessment of the Mona Creek groundwater flow regime by AGE (2021) proposed a conceptual hydrogeologic model of the unconsolidated groundwater regime as a perched aquifer system where groundwater is recharged primarily from rainfall and constrained from deeper percolation into the bedrock by the presence of clay and weathered regolith that forms the base of the unconsolidated sediments.

The MCMB have been measured quarterly since 2021 and water levels are typically around 4 to 7 mbgl in MCMB01A, 13 to 15 mbgl in MCMB03A and B, and 4 to 6 mbgl in MCMB04A and B. When adjusted to elevations, groundwater levels are highest in MCMB01 and lowest in MCMB04. This trend follows the land surface elevation of the bores and Mona Creek and implies that groundwater is flowing roughly parallel to Mona Creek. Bore MCMB01B has been reported as dry since it was installed. Bore MCMB03A was reported as dry at times in 2021, 2022 and 2023 but otherwise reports groundwater levels within 1.5 m from the bottom of the bore.

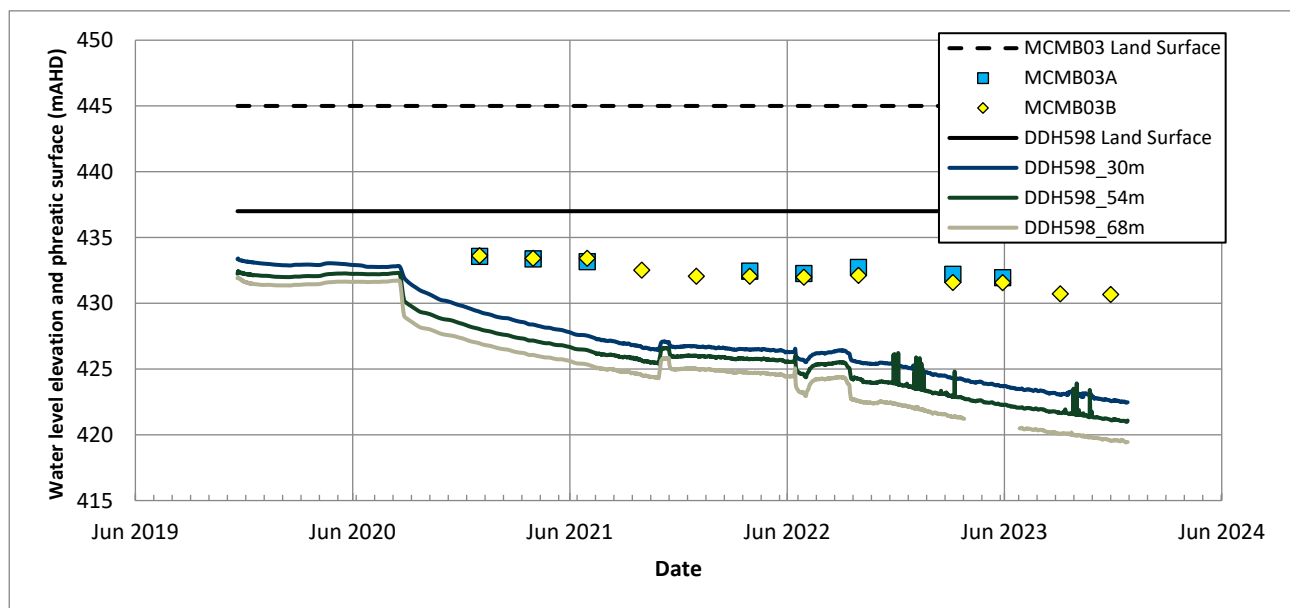
The differences in groundwater levels between shallow and deep bores are used to infer the level of connection between the unconsolidated sediments and bedrock aquifers. Since there is no data from MCMB01B, only MCMB03 and MCMB04 sites can be compared in this fashion, however the fact that the deeper bore at MCMB01 is dry while the shallow bore has water demonstrates the perched nature of the colluvial sediments.

Groundwater level differences in MCMB03 begin in 2021 as negative, with the shallow bore (MCMB03A) reporting groundwater levels slightly below the bedrock bore (MCMB03B). The maximum difference in 2021 is 0.25 m. Since 2022, however, the direction changes and the shallow bore reports higher groundwater levels than the bedrock bore, with a maximum difference of 0.6 m at the end of 2022. There are only two measurements in MCMB03A in 2023 but groundwater levels are still above MCMB03B. Groundwater level differences in the MCMB04 paired bores show a very similar groundwater level elevation through the data set, with differences less than 0.1 m and MCMB04B above MCMB04A.

**Figure 3.3** below also shows the potentiometric surface of the Vibrating Wireline Piezometer (VWP) array for DDH598 along with the water levels in MCMB03A and B. VWP array DDH598 is located approximately 600 m away from the MCMB03 bore location and upstream with respect to Mona Creek. The surface elevations of MCMB03 and DDH598 are 445 m and 437 m, respectively. Despite being located downstream, MCMB03 bores are located on an elevated hillock adjacent to Mona Creek and, therefore, the elevations of the base of MCMB03B and the DDH598\_30m sensor in DDH598 are considerably different: 415 mAHD for MCMB03B and 407 mAHD for DDH598\_30m. Comparison of groundwater level elevations between the bores and the VWPs indicates a significant separation between the monitoring bores and the shallow VWPs. The three shallowest VWPs all show similar phreatic surface elevations (within 2 m) and very similar trends of gently declining porewater pressure. The MCMB03 bore show a considerably different trend with only a slight decline between 2021 and 2023, and water levels approximately 6 m higher than the VWPs. This suggests that the MCMB03 bores are recording water levels in a shallow, perched, aquifer that is separated from the regional groundwater flow regime measured by the VWPs, which is also supported by the dry deeper bore at MCMB01.

Limited water quality data is available from the MCMB monitoring bores and trigger levels are yet to be derived. These monitoring sites will be added to the UCMPL monitoring network with groundwater level triggers to be derived by statistical analysis or by evaluation against the latest groundwater model results.

Groundwater quality measured across the site is presented in annual reviews that UCMPL supply to the NSW DPHI. The water quality data over the last decade is presented in plots in Attachment A to **Appendix 1**.



**Figure 3.3** Groundwater level and phreatic surface for MCMB and VWP site DDH598

c. Identification and mapping of persistent pools (AGE 2022, p. 29) and the CEEC (Umwelt 2022a, p. 114) that occur within the Mona Creek area.

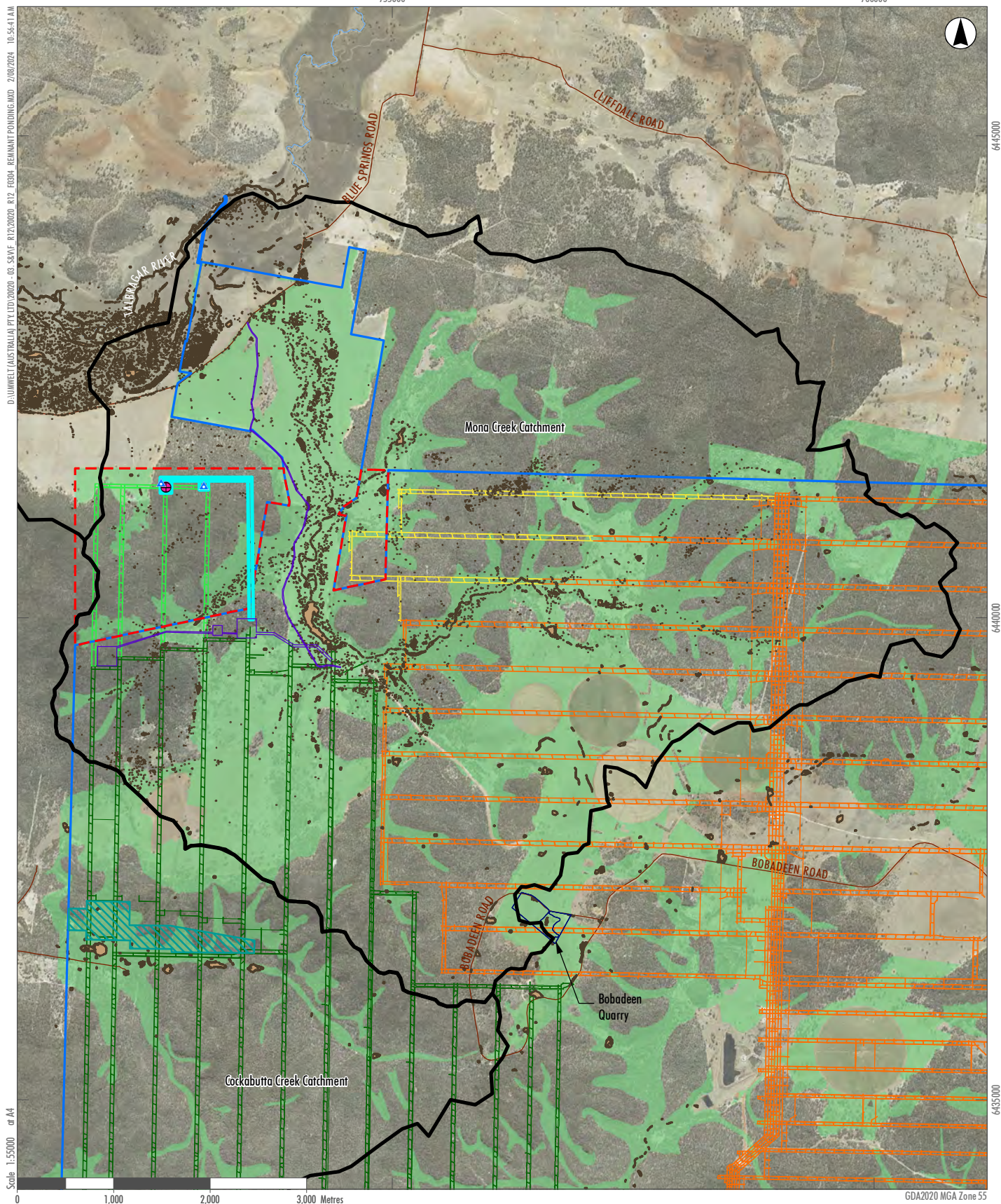
The extent of White Box – Yellow Box – Blakely’s Red Gum Critically Endangered Ecological Community (Box Gum Woodland CEEC) was mapped in the Amended BDAR for the Amended Modification (Appendix 8 of the Amendment Report). This mapping has been overlain on the Mona Creek catchment area with current areas of remnant ponding in **Figure 3.4** below. It is noted that most of the Mapped CEEC within the Mona Creek Catchment is derived grassland and not woodland vegetation.

d. Mapping of the current depth to the water table, overlain with persistent pools and any potential groundwater-dependent vegetation to help understand the likely groundwater dependence as recommended by the peer review of the groundwater model (AGE 2022, App. C1, p. 2).

Refer to **Figure 3.5** below and text provided in response to Paragraph 5a above.

As noted in **Figure 3.5**, the water table in the Mona Creek catchment is greater than 10 mbgl however the depth to the water table decreases closer to the Talbragar River. While a shallow perched aquifer is present in the area around MCMB01, the deeper regional water table is currently at least 30 mbgl at this location. While there may be some local connectivity between the shallow perched aquifer around MCMB01, current monitoring data and modelling indicates that remnant pools within Mona Creek are not connected to the regional groundwater regime.





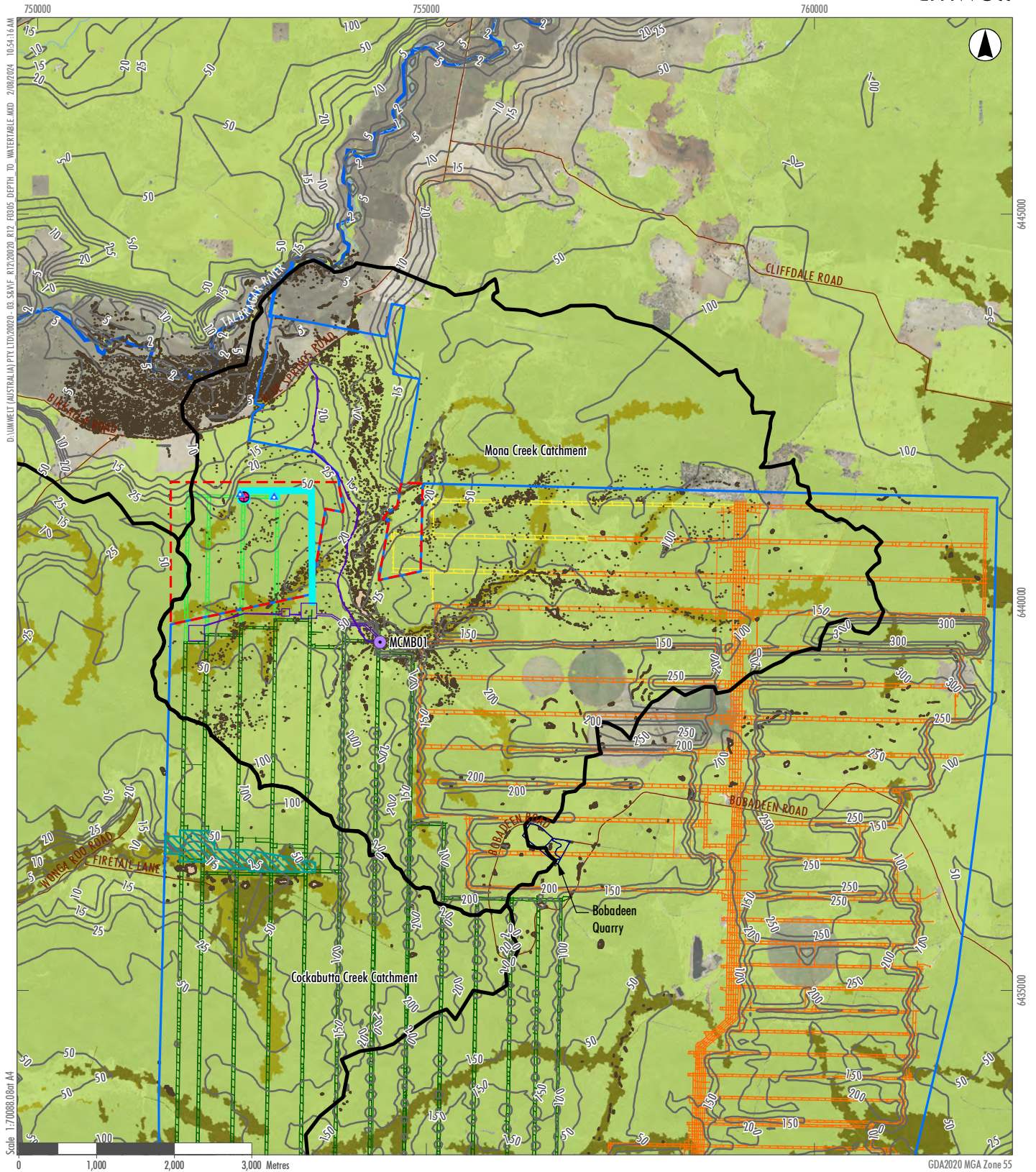
## Legend

- Project Approval Boundary
- Proposed Mod 6 Project Approval Boundary
- Bobadeen Quarry
- Brokenback Conservation Area
- Roads
- ~ Major Watercourses
- Approved Infrastructure related to Mod 6
- Approved Ulan West Mine Plan
- Approved Ulan Underground Mine Plan
- + Proposed Vent Shaft
- ▲ Proposed Dewatering Bores
- Amended Proposed Infrastructure
- Amended Proposed Ulan West Underground Mine Plan Modification
- Amended Proposed Ulan Underground Mine Plan Modification
- Catchment Boundary
- Remnant Ponding
- White Box - Yellow Box - Blakely's Red Gum CEEC

FIGURE 3.4

Remnant Ponding  
and CEEC within  
Mona Creek Catchment





# Legend

- Project Approval Boundary
- Proposed Mod 6 Project Approval Boundary
- Monitoring Bore
- Bobadeen Quarry
- Brokenback Conservation Area
- Roads
- Major Watercourses
- Approved Infrastructure related to Mod 6
- Approved Ulan West Mine Plan
- Approved Ulan Underground Mine Plan
- Proposed Vent Shaft
- Proposed Dewatering Bores
- Amended Proposed Infrastructure
- Amended Proposed Ulan West Underground Mine Plan Modification
- Amended Proposed Ulan Underground Mine Plan Modification

- Catchment Boundary
- Remnant Ponding
- Depth to Water Table
- Terrestrial GDE
  - High potential GDE - from regional studies
  - Moderate potential GDE - from regional studies
  - Low potential GDE - from regional studies
- Aquatic GDE
  - High potential GDE - from national assessment
  - Moderate potential GDE - from national assessment
  - Unclassified potential GDE - from regional studies

FIGURE 3.5

Current Depth to Water Table

e. Field-based assessments of groundwater dependence (see Doody et al., 2019 for possible methods) of potential GDEs such as Blakely's Red Gum (*Eucalyptus blakelyi*).

As discussed in the BDAR, riparian vegetation is present in some areas of UCC; however, these areas will not be impacted by the Amended Modification, with no significant additional impacts on baseflow noted and the incremental reduction in water table associated with the Amended Modification will not have any additional impact on vegetation (including Blakely's Red Gum) due to the water table in this area already being below the rooting depth of this species and no deep rooted vegetation being present in areas of shallower water table (noting that the Project's incremental impact on drawdown in areas where the shallow water table is potentially accessible by deeper rooted vegetation is less than 1 m and unlikely to have a material impacts on groundwater dependent vegetation).

Riparian vegetation associated with Mona Creek has largely been cleared for agricultural purposes in the areas where underground mining panels are proposed for the Amended Modification. The riparian vegetation of Mona Creek has been mapped as consistent with the derived native grassland (DNG) condition state of the White Box – Yellow Box – Blakely's Red Gum CEEC. Parts of these grassland areas are highly disturbed and therefore may not meet the EPBC condition thresholds for the CEEC, however have conservatively been associated with the CEEC as parts of the zone meet the thresholds. Given the already disturbed nature of this vegetation zone (lacking mid and canopy strata, high density of weed species and low native diversity), any potential minor incremental changes in groundwater associated with the Amended Modification are unlikely to result in a reduction in condition of this vegetation.

Field based assessments of groundwater dependence are therefore not considered to be warranted.

f. Assessment of potential impacts to stream flow and persistent pools where connected fracturing (or desaturation) reaches the unconsolidated sediments of Mona Creek. Clarification is required of the magnitude of uncertainty that connected fracturing intersects the alluvium below Mona Creek. A hydraulic connection between the dewatered coal seam and the alluvium of Mona Creek is plausible given uncertainty in predictions of the height of connected fracturing above the coal seam (AGE 2022, EPBC Assessment requirements response, Table 3, p. 10). The uncertainty in height of connected fracturing is not shown in Figure 5.24 (AGE 2022, p. 63) (Cross-section B-B).

The groundwater model used for the original GIA and the Amended model adopts the approach of Ditton-Merrick in determining the height of connected fracturing above longwall panels (refer to Section A 4.6.4.3 in the Amended GIA). This approach was driven by monitoring data, and specifically the lack of response in shallow monitoring points (i.e., upper parts of the Triassic formations and above) to underground mining.

A comparison of the calculated height of connected fracturing (HoF) using the Ditton-Merrick, Tammetta and ACARP (both high and low estimates) methods was undertaken by AGE (refer to Section 3.6 of **Appendix 1**).

The Tammetta method estimates HoF reaching the land surface at all three depths of overburden (deep, average and shallow) (i.e., height of connected fracturing greater than depth of overburden). This level of connection and associated desaturation has not been observed in shallow groundwater level data across the underground mined areas to date, indicating that this estimate is not applicable to the conditions observed at the UCC.

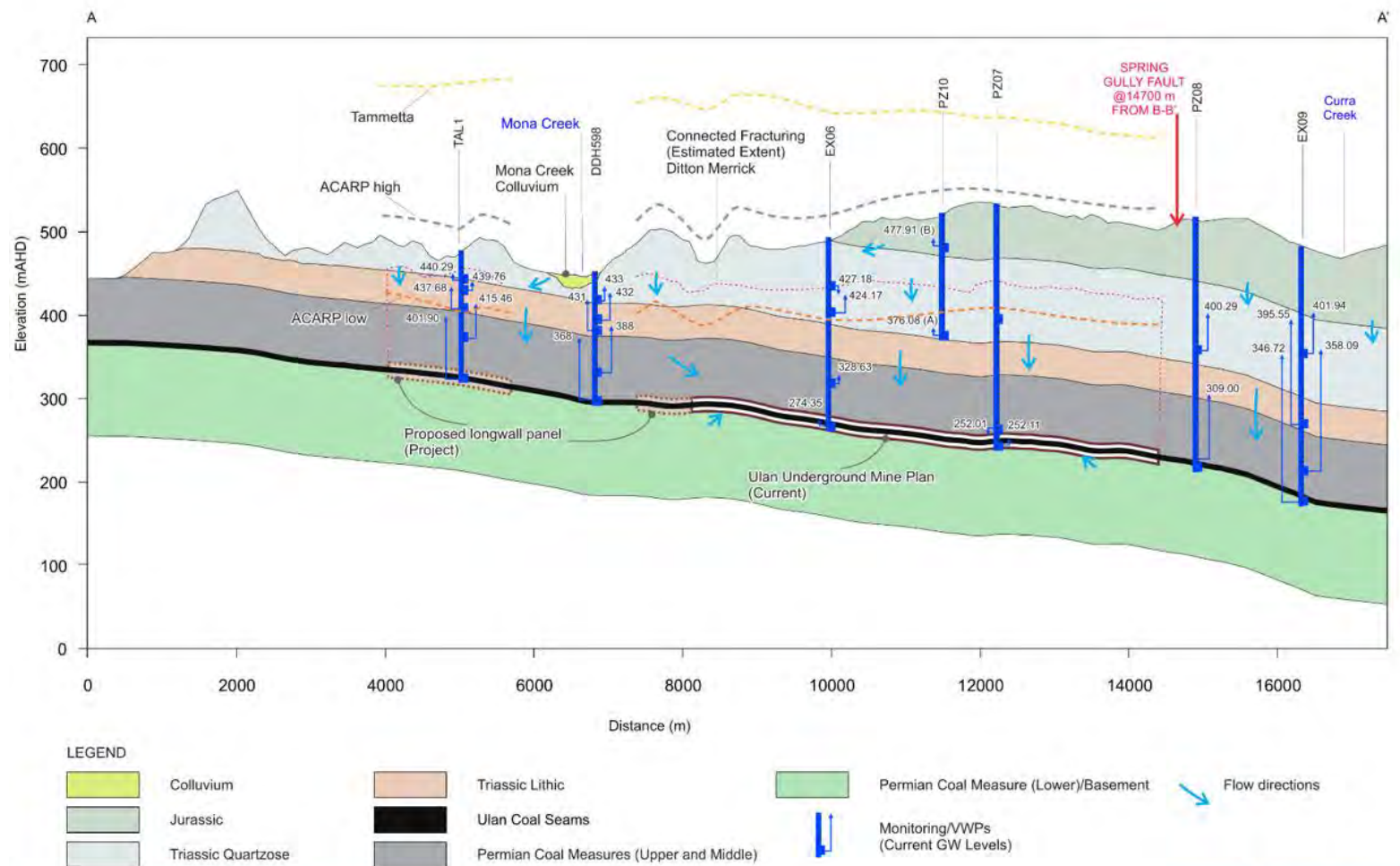
The ACARP range is large, with the ACARP-High estimate resulting in HoF above land surface, and the ACARP-Low estimate generally below the adopted Ditton-Merrick method. It is noted that as the seam gets deeper the Ditton-Merrick estimated HoF gets slightly lower than the lower end of the range that the ACARP method predicts.

Where the coal seams are nearer the land surface, there have been indications the HoF does get close to the land surface. Surface cracking beyond the shallow tensile cracks has been observed in areas where the mined seam is shallower, and it is understood some remedial work was required on cracks in the southern extent of the Ulan West LW1. Similar works have not been required north of that area indicating HoF does not reach near to the land surface where the seam is deeper. These observations mean that the Ditton-Merrick approach is providing more realistic changes due to mining that the Tammetta model provides at this stage and understanding.

To demonstrate the various HoF estimation methods in relation to the UCC, a conceptual cross-section was produced showing the adopted fracture height and a comparison with the other three methods (refer to **Figure 3.6**). Both the Tammetta and ACARP-High methods predict a HoF or height of depressurisation that would result in continuous fracturing to the ground surface. Fractures coming to the surface have not been observed across the majority of the underground mine footprint, rather it has only been observed in specific areas in the south where the depth of cover is very low (80 to 100 m). The adopted Ditton-Merrick model does estimate this occurring in these areas.

It is clear from the cross section in **Figure 3.6** that if the Tammetta or ACARP-High methods were appropriate there would be significant depressurisation of all the overlying strata across the site. This has not been observed in the monitoring bores targeting shallow strata and, instead, only the lower parts of the Triassic strata have shown response to the fracturing. This can be seen where the cross section displays current observed water levels in the specific bores. The observed groundwater monitoring data is consistent with the predictions in the Ditton-Merrick model and it is therefore considered the most appropriate for the Ulan area.





**Cross section showing the range of fracture heights from different sources**

**Figure - 3.26**

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)"

"G:\Projects\UCM5033.001 Ulan MOD6 Amendment\3\_GIS\Workspaces\002\_Deliverable\2\03.26\_UCM5033\_Cross section showing the range of fracture heights from different sources.cdr"



**Figure 3.6 Cross section showing the range of fracture heights from different sources**



g. Predicted groundwater drawdown needs to show the maximum drawdown and mounding (spatial extent, magnitude and timing) so that potential impacts can be identified as recommended by the peer review of the groundwater model (AGE 2022, App. C1, p. 2).

The approach to representing post-mining conditions was reconsidered in light of the magnitude of mounding predicted for the original model, with the Amended Modification assessment adopting a more plausible representation of recharge to the open pit mine voids, which is the dominant pathway for recharging the underground workings. As a result, a direct comparison between the Modification and Amended Modification mine plans is not possible for the post-mining period.

At the cessation of mining, the dewatering infrastructure will be turned off and decommissioned, and the open cut areas at the south of the mine will be reshaped and revegetated. This will allow for recharging of the surrounding aquifers through percolation of rainfall into the unconsolidated spoil that has been placed in the open cut areas. Recharged water will flow northwards while groundwater gradients toward the underground prevail and will add recharge to the underground mine areas. These underground mined areas will also receive ongoing gradient-based inflow from the adjacent connected strata as these areas repressurise.

In the Proposed Modification GIA (AGE, 2022), the assumption was made that voids would exist and would receive 110% of rainfall across the void area, with the additional 10% accounting for any catchment outside of the voids being redirected to them. This resulted in a prediction of mounding almost everywhere post mining, and the regional water table rising to 20+ metres above pre-mining levels across the mine workings.

In the Amended Modification GIA (AGE, 2024), there has been a more plausible consideration of recharge to the mined area in the southern part of UCC, with the assumption that recharge to this area will be more typical of recharge to spoil areas, so the assumption of 5% of rainfall has been applied. This recharge value is in line with previous modelling of spoil recharge by AGE (AGE 2020). This has resulted in changes to the equilibrium post mining groundwater levels, with some areas predicted to have higher groundwater elevations and some areas lower than pre-mining conditions.

Figure 3.13 to Figure 3.21 of **Appendix 1** present the uncertainty analysis results examining the likelihood that cumulative drawdown will exceed 1 m and 2 m through the mining and post mining phase.

As can be seen in Figures 3.13 and 3.17 of **Appendix 1**, the predicted drawdown in the alluvium and colluvium (layer 1) did not register any areas greater than 2 m drawdown due to the incremental impacts from the Amended Modification only. This is a reduced level of drawdown relative to that predicted for the Proposed Modification model, where there was a small area along the colluvium of Mona Creek that would have experienced greater than 2 m of additional drawdown. The difference in the model responsible for this is the shortening of Ulan Underground longwall panels to no longer extend under Mona Creek. The majority of impacts in units overlying the Permian units are due to enhanced hydraulic connection due to vertical propagation of fracturing above the longwall panels. Since there is no additional mining directly under Mona Creek in the amended groundwater model (relative to approved), there is no mechanism for enhanced vertical connection.

Apart from the Ulan Seam (Figure 3.21 in **Appendix 1**), these maximum drawdowns are likely to be experienced in the beginning of the post-mining phase.

h. Assessment of the potential impacts of post-mining groundwater mounding on Mona Creek and associated GDEs and vegetation. This is required as the proponent has predicted that groundwater levels in parts of the Mona Creek area may rise by 10 m (AGE 2022, p. 87). Although current groundwater levels have not been clearly mapped, a rise of 10 m could result in the water table being above the ground surface in some areas as well as posing a risk of adverse effects of waterlogging on vegetation. This rise in groundwater level may also alter the direction and magnitude of surface water-groundwater exchanges in Mona Creek, impacting on hyporheic processes such as carbon processing (Paragraph 18) and nutrient cycling in the saturated sediments.

Refer to response to Paragraph 5g above.

It is noted that the groundwater level rise of 10 m referenced in Paragraph 5h above by the IESC was predicted by the original GIA in relation to the Proposed Modification mine plan. The Amended GIA predicted groundwater drawdown post-mining in parts of Mona Creek of around 5 m. Additional details are provided below and in **Appendix 1**.

When mining finishes at Ulan West and Ulan Underground, the area around the existing portals in the open cut pits will be backfilled and regraded to have the current East Pit void form a minor topographical low point of the area. The current plan involves the water level in the void being maintained at an elevation of 359 mAHD.

In the period following the cessation of mining, the drawdown presented in previous sections will continue to propagate outwards until there is sufficient recovery of groundwater levels throughout the mined area. This means that bores further from the mine will continue to decline after mining has ceased. The rate at which the 2 m drawdown extent expands will reduce as the gradient back to the dewatered area decreases. Open cut pits that are backfilled with unconsolidated sediments (spoil) are areas where groundwater is expected to mound up (relative to pre-mining) due to an increase in groundwater recharge.

Eventually the groundwater system that surrounds Ulan mine will reach a new equilibrium. Due to the changes in hydraulic properties due to fracturing above longwall panels, the recovered groundwater levels across the mine area will form a relatively uniform level. This is because the system is more connected post mining than the pre-mining conditions. This means that some groundwater levels will be lower, and some groundwater levels will be higher than pre-mining groundwater levels.

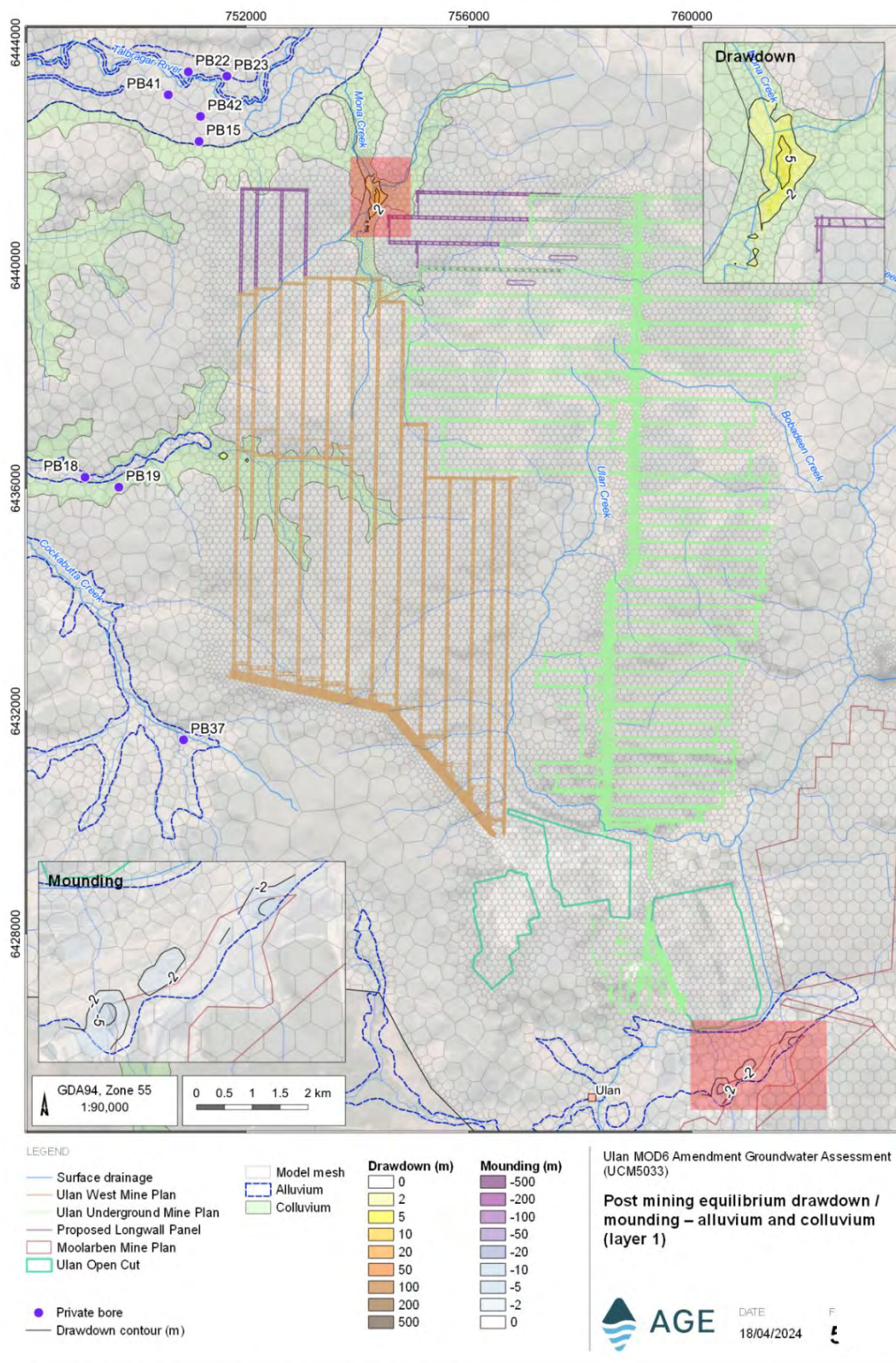
The Proposed Modification assessment (AGE, 2022) considered a post mining situation for the voids that resulted in a significant amount of recharge being applied (110% of rainfall). This resulted in locations having up to 50 m of mounding predicted at equilibrium in comparison to pre-mining conditions. This did not cause any surface expression of groundwater with the predicted water table below the ground surface across most of the model domain, and only close (<2 m) in expected locations where shallow groundwater exists. It was found that no adverse water logging would occur, and springs would remain unimpacted through post mining. This initial assessment used an estimate at the upper bound of the likely recharge volume into the void.

The Amended GIA has treated the recharge volume into the void areas in a more conservative way by assigning a recharge rate that is consistent with spoil (5% of rainfall). After this change, the Amended Modification model predicts there will be areas where groundwater levels will be lower than pre-mining, creating a residual drawdown of water.

The predicted long term residual drawdown/mounding has been derived from a steady state stress period in the groundwater model which represents the system in a state of equilibrium (year 4035). **Figure 3.7** to **Figure 3.11** show the cumulative residual post mining impacts, incorporating the approved Ulan mine plan plus the Amended Modification and the neighbouring Moolarben mine. It was assumed that the mining at Moolarben ceased at the same time as the UCC and the model changes were applied to both sites to represent the post mining conditions.

**Figure 3.7** shows the long-term residual drawdown and mounding for the alluvium and colluvium. The colluvium associated with Mona Creek is expected to see continued lower water levels post mining. The figure also shows that there is mounding predicted in the mapped alluvium adjacent to Moolarben and this is probably the result of the high recharge into the adjacent spoil piles at Moolarben and is unrelated to mining at the UCC.

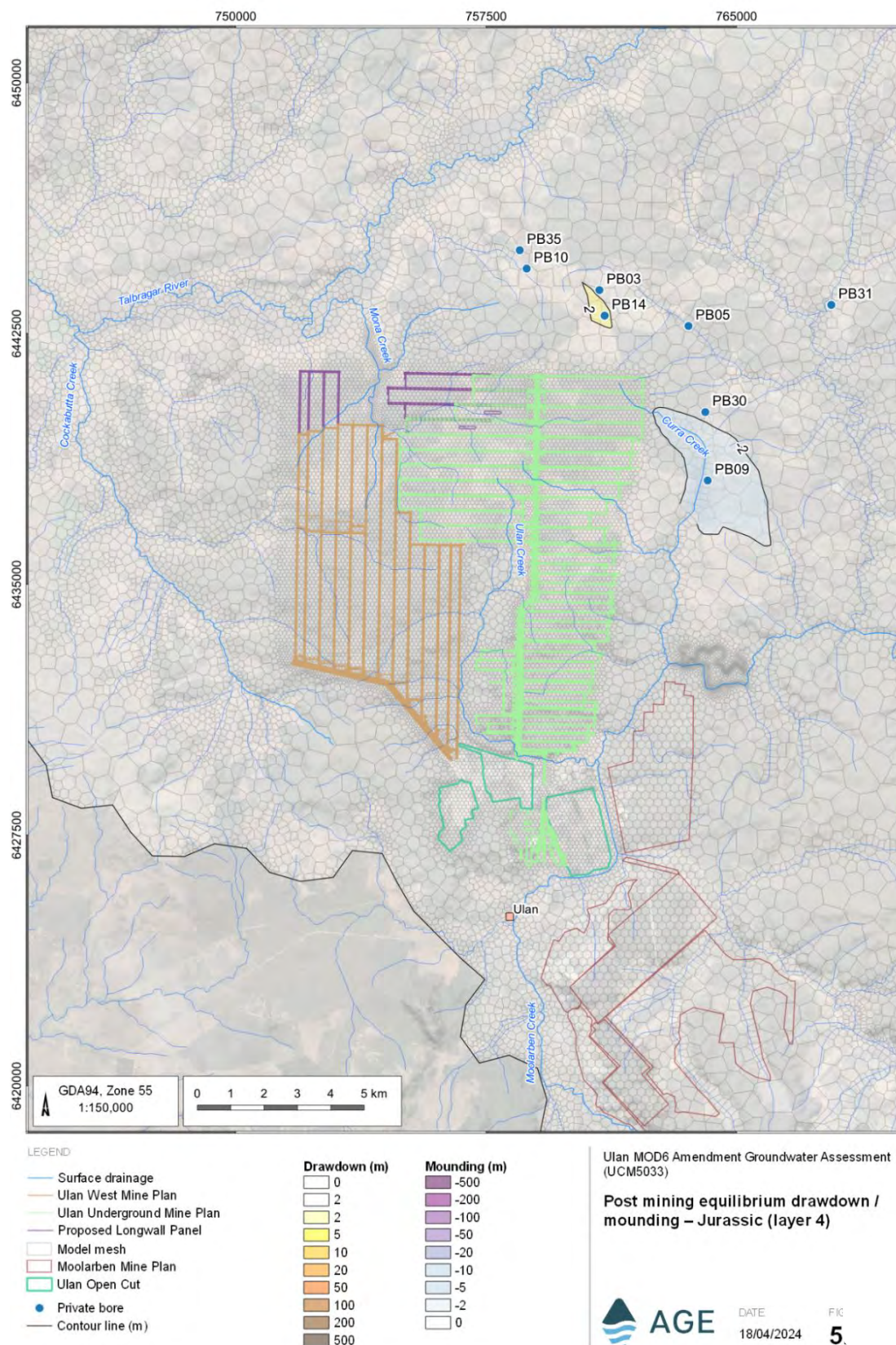




**Figure 3.7** Post mining equilibrium drawdown/mounding – alluvium and colluvium (layer 1)

Source: AGE, 2024.

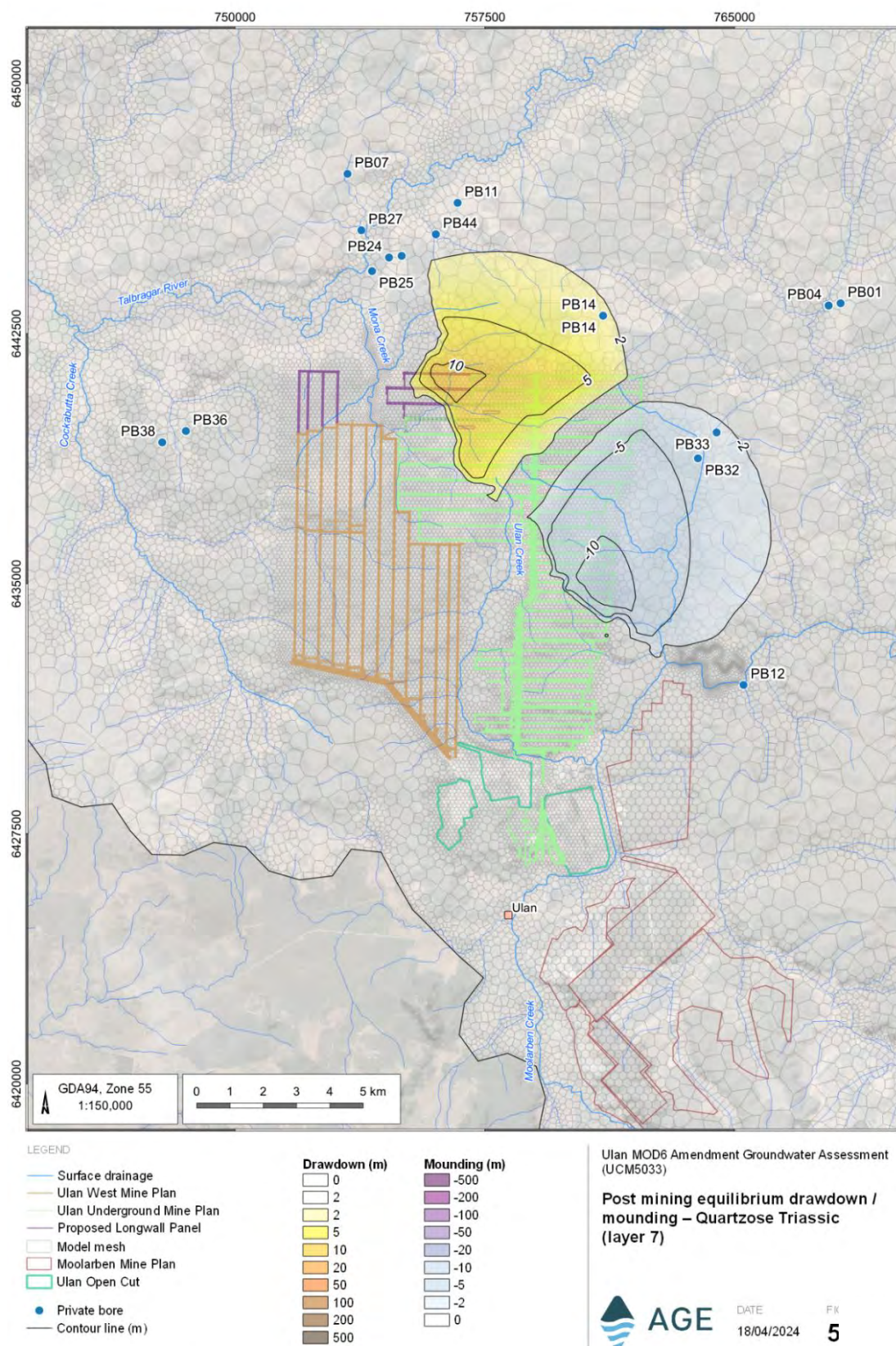




**Figure 3.8 Post mining equilibrium drawdown/mounding – Jurassic (layer 4)**

Source: AGE, 2024.

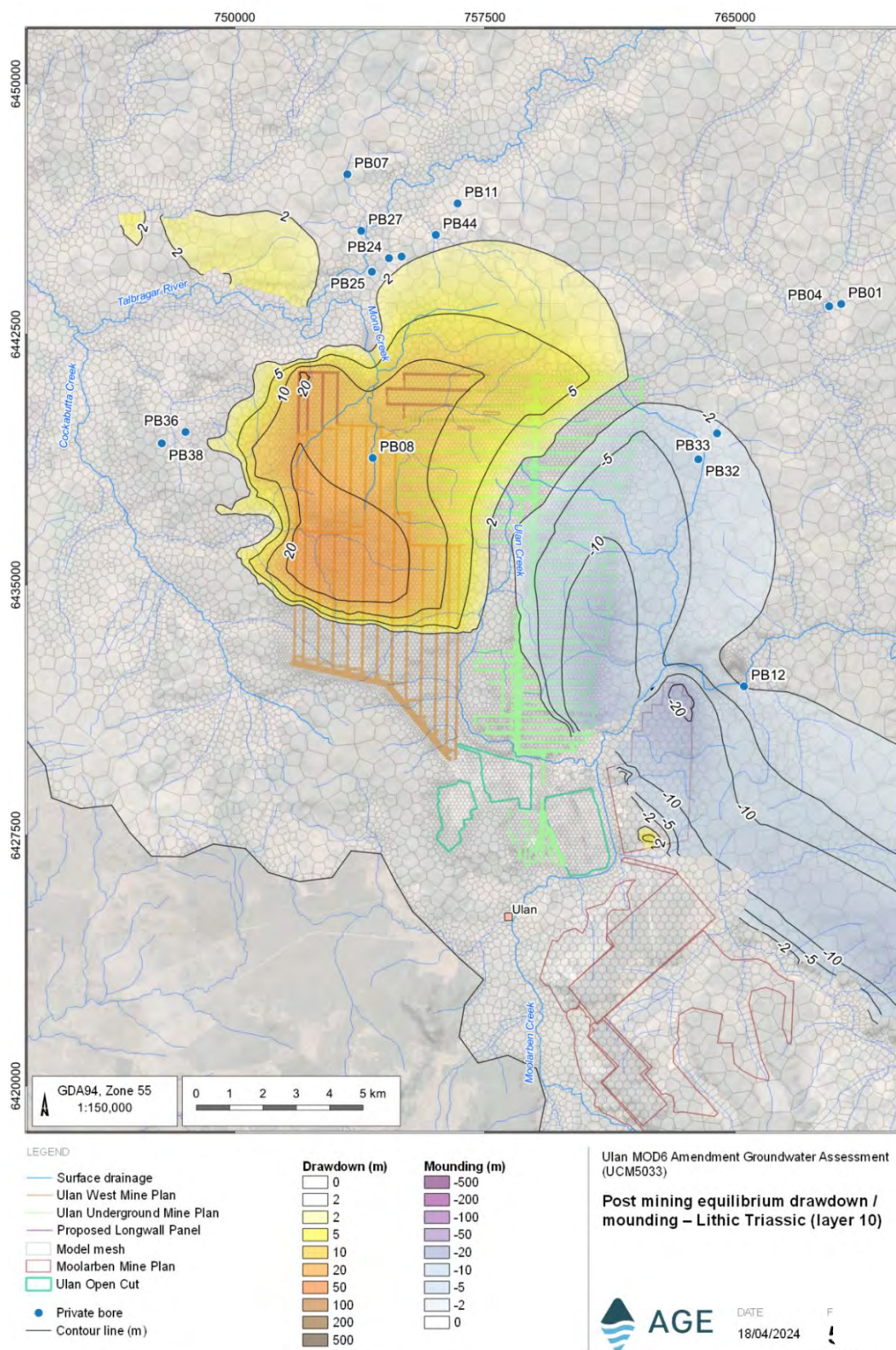




**Figure 3.9 Post mining equilibrium drawdown/mounding – Quartzose Triassic (layer 7)**

Source: AGE, 2024.



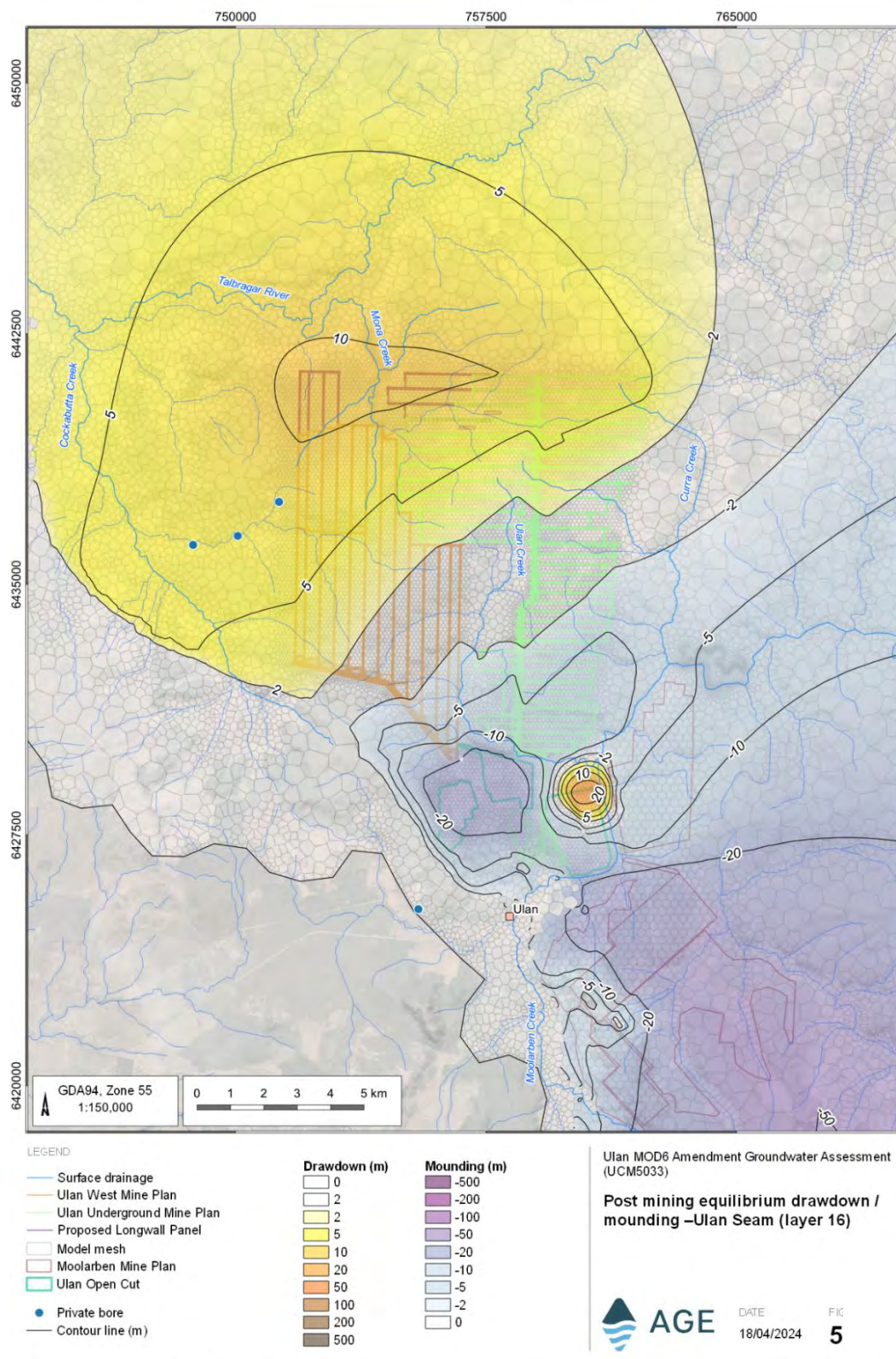


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 Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006;  
 G:\Projects\UCM5033.001 Ulan MOD6 Amendment\GIS\Workspaces\001\_Deliverable\105.12\_UCM5033\_Post mining equilibrium drawdown - mounding - Jurassic (layer 4).qgz

**Figure 3.10 Post mining equilibrium drawdown/mounding – Lithic Triassic (layer 10)**

Source: AGE, 2024.





**Figure 3.11 Post mining equilibrium drawdown/mounding – Ulan Seam (layer 16)**

Source: AGE, 2024.

6. The groundwater model used by the proponent is suitable for the purpose of assessing regional drawdown and take due to the project. However, it is not able to adequately represent the complexity where subsidence and connected fracturing occur beneath Mona Creek or simulate local surface water-groundwater interactions. Issues that need to be addressed are outlined below.

a. The implementation of connected fracturing from subsidence in the groundwater model, and the assessment of potential impacts from this on Mona Creek and potential GDEs within the area of groundwater depressurisation, require further discussion and justification. The current predictions indicate that there will be no constrained zone above the longwall panels and that groundwater depressurisation will be extensive (AGE 2022, p. 87). Further assessment of the uncertainties in the timing and extent of full depressurisation is needed to help ensure that all potentially impacted GDEs can be clearly identified and assessed, including those occurring beyond the project area. Further information to support the parameterisation of the groundwater model and the selection of hydraulic parameters to replicate connected fracturing is also needed.

Refer to responses to Paragraphs 5a and 5f above.

b. There are no field-derived data for the parameterisation of the Mona Creek sediments. Mona Creek is the key area potentially impacted by this project. Current parameterisation appears to be based on observations from the Talbragar River alluvium and the Goulburn River alluvium (AGE 2022, p. 35) with limited justification provided for this extrapolation.

Refer to response to Paragraph 5b above.

The parameterisation of the Mona Creek sediments has been based on observations from these bores in combination with observations from the Talbragar River alluvium and Goulburn River alluvium.

c. The representation of surface water features in the groundwater model requires further justification. Currently, river cells are stated to be able to discharge groundwater but not recharge the groundwater system (AGE 2022, App. A, p. 8) which does not appear consistent with alluvium being identified as a primary source of groundwater recharge (Umwelt 2022a, p. 56). Consideration should also be given to improving the model's spatial discretisation around Mona Creek and its confluence with Talbragar River, given the reported current cell size is 200 m by 200 m (AGE 2022, p. 72). Model results, supported by characterisation and monitoring data (refer to Paragraphs 5b, 5c, 5d, 5e and 6b) should be reported specifically for the Mona Creek area.

The model mesh has been refined around the Mona Creek area to help with delineation of impacts. This was in the original model previously (and maintained in the Amended Modification model), but not highlighted in the GIA (AGE, 2022). The creek has been represented by model cells which are 50 m across and then increase in size up to the resolution across the underground mining area at approximately 125 m. The refinement around Mona Creek provides better spatial resolution, which assists in providing better vertical resolution of the creek bed and better representation of the true land surface. Figure 3.4 in **Appendix 1** shows the refinement in the model mesh representing Mona Creek.

The model represents river interaction through the MODFLOW-USG River (RIV) package. The model cell size is less important as the specified RIV conductance term incorporates the dimensions (i.e. length and width) of the stream channel within the model cells, and assigns the appropriate interaction with groundwater within the model cell. While smaller cell size does provide better resolution, the model predictions continue to indicate that the baseflow is occurring north of the Proposed Modification and Amended Modification proposed longwall panels (AGE, 2024).

7. Model calibration has appropriately utilised the available groundwater level and pressure monitoring data. The IESC suggests that the calibration results be presented to identify any trends in calibration adequacy spatially or within hydrostratigraphic layers. Additionally, where available, existing baseflow data should be used as a calibration check for groundwater-surface water connectivity. If measured underground mine inflows are available for different sections of the mine (AGE 2022, p. 163), these could be used in the calibration process as a check on flux predictions.

The overall measure of the calibration through the Scaled Root Mean Square (SRMS) has been separated by formation types to provide more information from the calibration process. **Table 3.1** shows the number of observations used, the minimum, maximum, and range observed values, the RMS and the SRMS for each formation.

The data provided in the amended groundwater model also includes an update of the calibration dataset through the end of 2023. The original calibration had a SRMS of 3.94%, and updating the dataset has reduced the SRMS slightly by 0.21% to 3.73%.

The SRMS ranges between 3.93% (Quartzose Triassic formation) and 8.89% (Basalt formation) and so all formations are within the advocated performance targets in the Australian Modelling Guidelines (Barnett et al., 2012). Figure 3.29 in **Appendix 1** presents for each formation the observed and simulated groundwater levels graphically as a scattergram for the historical transient calibration.

**Table 3.1 Summary statistics of calibration per geology type**

| Parameter                              | Alluvium/<br>Colluvium | Basalt | Jurassic | Quartzose<br>Triassic | Lithic<br>Triassic | Permian | Overall        |
|----------------------------------------|------------------------|--------|----------|-----------------------|--------------------|---------|----------------|
| Observation<br>count                   | 159                    | 18     | 240      | 894                   | 2,602              | 6,707   | <b>10,620</b>  |
| Minimum<br>observed<br>value<br>(mAHD) | 236.3                  | 310.94 | 317.8    | 265.05                | 347.15             | 223.287 | <b>223.287</b> |
| Maximum<br>observed<br>value<br>(mAHD) | 488.64                 | 672.7  | 634.53   | 513.05                | 511.54             | 492.4   | <b>672.7</b>   |
| Observed<br>values range<br>(m)        | 252.34                 | 361.76 | 316.73   | 248                   | 164.39             | 269.113 | <b>449.413</b> |
| RMS (m)                                | 10.11                  | 32.17  | 28.08    | 9.75                  | 14.51              | 17.83   | <b>16.78</b>   |
| SRMS (%)                               | 4.01                   | 8.89   | 8.87     | 3.93                  | 8.83               | 6.63    | <b>3.73</b>    |



8. Conceptualisation of the groundwater system at the project site appears consistent with previous versions of the groundwater model (AGE 2022, p. 59). However, further information is required on the following points:

a. the conceptualisation of the Mona Creek perched groundwater system occurring in a series of disconnected lenses which are charged following rainfall (AGE 2022, pp. 28–29);

Refer to response to Paragraph 5b above.

b. the applied recharge rates specific to hydrostratigraphic units, using approaches such as environmental water tracers (OWS 2020). Evidence should be provided to justify the large differences in assumed recharge rates in different areas (e.g., to alluvium and colluvium and through spoil); and

Groundwater recharge occurs in the Amended Modification underground mining area through direct infiltration of rainfall and downwards percolation through the weathered cover into the underlying hard rock. Recharge rates have been derived from calibration and the non-uniqueness has been explored in uncertainty analysis. The range of recharge has been guided by previous modelling in the area by Mackie Environmental Research (MER, 2009) which considered groundwater recharge to the underlying hard rock to vary from less than 1% to approximately 2% of rainfall.

To support these recharge estimates, a chloride mass balance assessment was undertaken using observations of chloride concentrations from the main geologic formations. This analysis found that the average percentage of rainfall potentially becoming recharge ranged from 0.2% (range: 0.08–0.41%) for Jurassic strata, to 1.51% (range: 0.4–2.72%) for Permian strata, and 1.65% (range: 0.49–2.96%) for Triassic strata. The chloride mass balance method provides a guide for estimating recharge rates, but is not a precise measure. There are many things that affect these estimates, as indicated by the range calculated, and recharge is expected to be variable even within a particular formation.

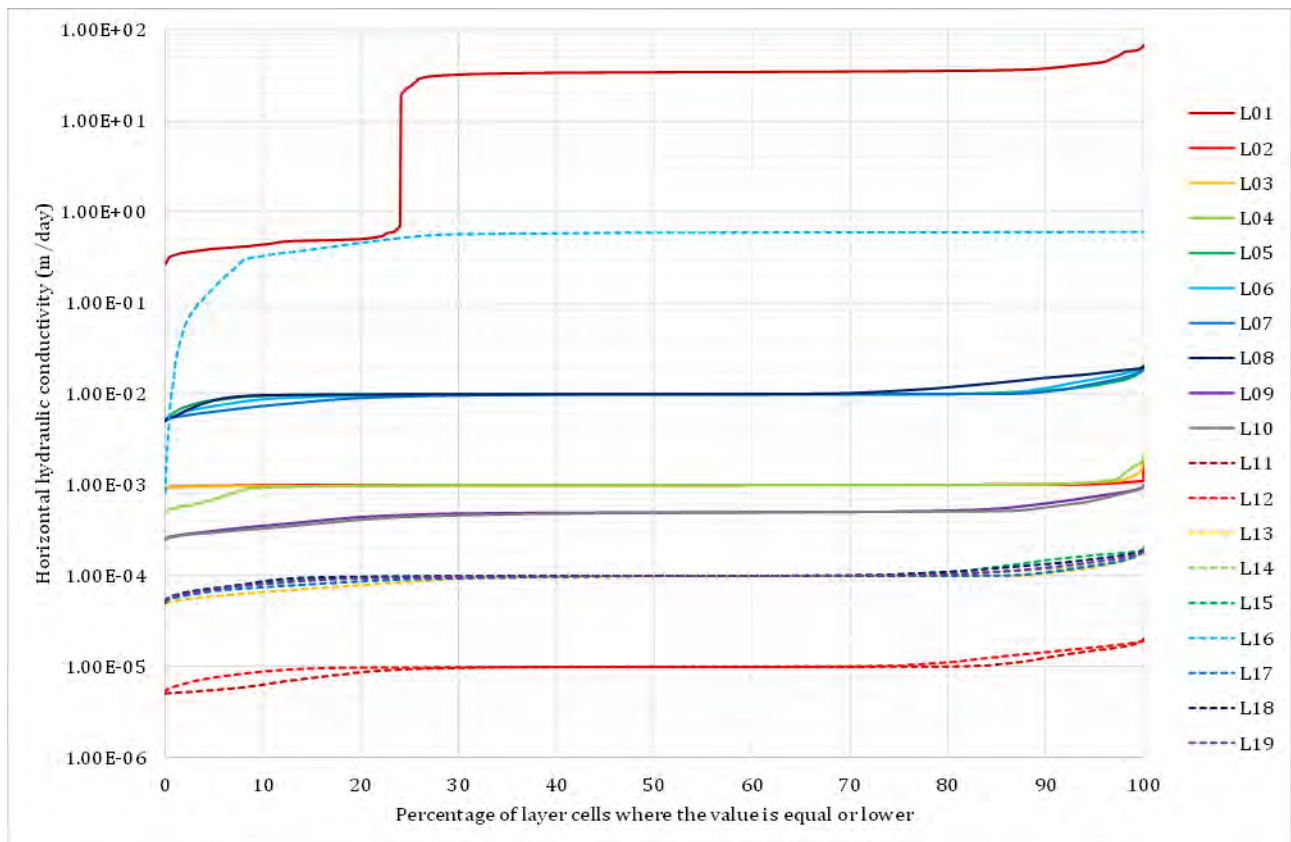
To apply the recharge rate over the broad regional model, AGE have simplified the variability into a single rate for each outcropping formation. These rates have been calibrated with hydraulic conductivities (within measured ranges), to match regional water level behaviour and mine inflows across a combined steady state and transient simulation. While the final recharge values used in the model are somewhat low, they were required to match the depth of the regional water table which sits low in the strata, and represent the low deep percolation volumes arriving through the unsaturated zone.

c. the adopted hydraulic conductivity values and ranges, especially vertical hydraulic conductivities, to demonstrate consistency with the presented conceptualisation.

The adopted hydraulic conductivity distributions were summarised in two charts in Appendix A of the Amended GIA. These have been reproduced below as **Figure 3.12** and **Figure 3.13**. Re-calibration of the model was not undertaken for the Amended Modification update but is currently being completed and will be utilised for future assessments. The data is presented for each model layer, and **Table 3.2** lists the layer(s) representing each formation.

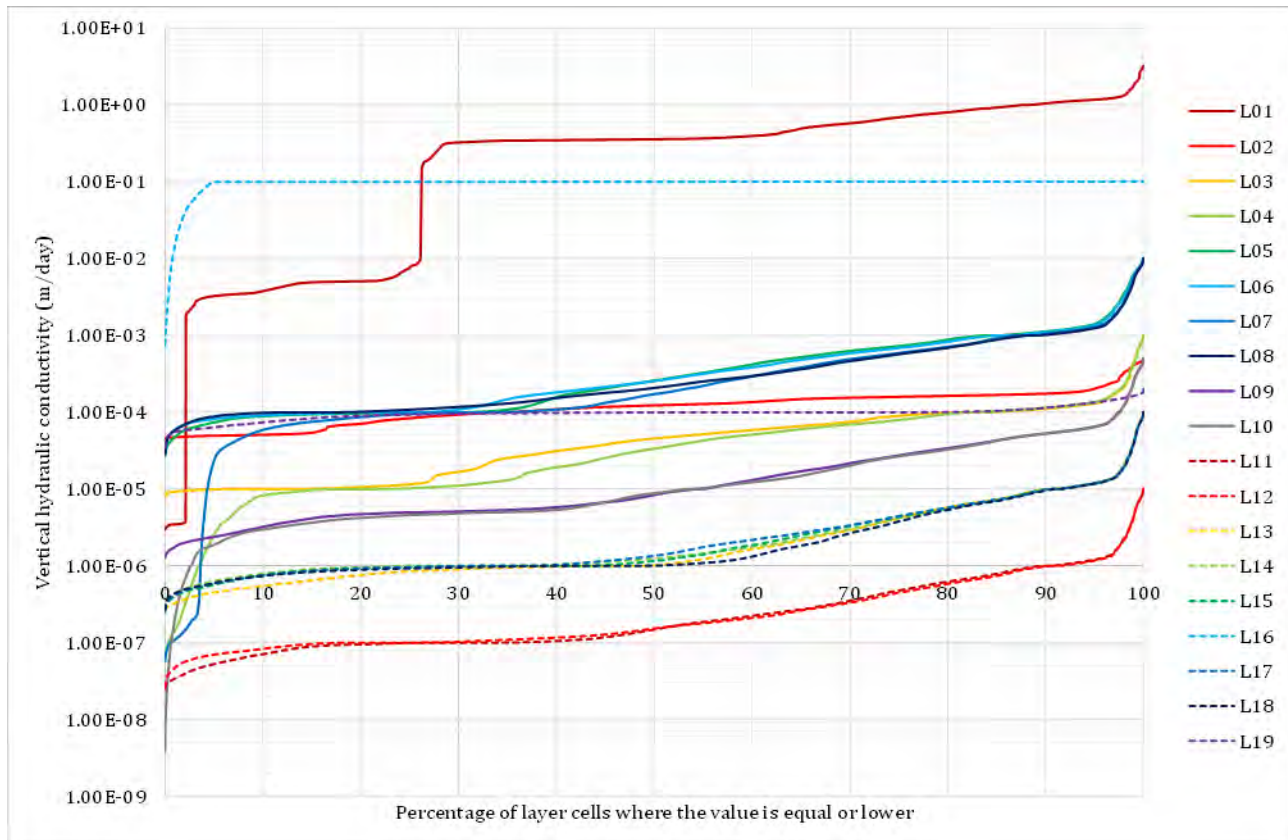
**Table 3.2 Relationship Between Layer and Geological Formation**

| Layer(s) | Formation              |
|----------|------------------------|
| 1        | Alluvium and Colluvium |
| 2        | Basalt                 |
| 3–4      | Jurassic               |
| 5–8      | Quartzose Triassic     |
| 9–10     | Lithic Triassic        |
| 11–19    | Permian                |
| 16       | Ulan Coal Seam         |



**Figure 3.12 Calibrated horizontal hydraulic conductivity distribution per model layer**

Source: AGE, 2024.



**Figure 3.13** Calibrated vertical hydraulic conductivity distribution per model layer

Source: AGE, 2024.

9. Uncertainty analysis was undertaken using a calibration-constrained Monte Carlo approach (AGE 2022, p. 101). The IESC notes that the reported uncertainty analysis has not fully explored potential worst-case impacts on groundwater resources. The following improvements to the uncertainty analysis are suggested:

a. parameter ranges for storage and recharge should be explored and reported;

Parameter ranges for storage and recharge are provided in Table 3.7 and Table 3.8 of **Appendix 1**.

b. the range of results for baseflow changes and mounding should have been reported as recommendation by the peer review of the groundwater model (AGE 2022, App. C1, p. 2). These are some of the key impacts associated with this project and the range of potential outcomes should be clearly communicated; and

Section 3.5 in **Appendix 1** presents the results of the updated uncertainty analysis for both the incremental impacts from the Amended Modification and the cumulative maximum drawdown impacts from the Amended Modification.



Figure 3.13 to Figure 3.16 in **Appendix 1** show the uncertainty around the predicted 1 m additional drawdown due to the Amended Modification only (i.e. incremental drawdown). These figures are comparable to Figures 9.2 to 9.5 in the GIA (AGE, 2022) but are for the amended mine plan. With the inclusion of storage properties in the analysis, the zones of uncertainty have increased slightly over the previous uncertainty analysis, especially for areas unaffected by the Amended Modification changes. The notable exception is the incremental drawdown in the Ulan Seam (refer to Figure 3.16 in **Appendix 1**). This shows a reduction in the 'very unlikely' to exceed range, which could be due to the variability of storage properties and increased impact predicted in the layers above.

Figure 3.17 to Figure 3.21 in **Appendix 1** present the uncertainty analysis results examining the maximum cumulative drawdown (approved mine plan plus amended mine plan) through the mining and post mining equilibrium phases. The analysis shows the probability that a 2 m drawdown will be exceeded. These results confirm what was identified in the indirect takes from formations increasing post mining. Apart from the Ulan Seam (refer to Figure 3.21 in **Appendix 1**), these maximum drawdowns are likely to be experienced near the beginning of the post-mining phase. Figure 3.21 in **Appendix 1** shows that the drawdown in the Ulan Seam is likely to intercept the model boundary. These boundaries are simulated as no flow, which have an amplifying influence on the predicted depressurisation in the Ulan Seam, because drawdown cannot propagate further outward past the boundaries and instead propagates vertically, thus overpredicting depressurisation in the layers above and below the seam and making the predictions cautious over-estimates of impacts.

Figure 3.22 in **Appendix 1** shows the probability of the water table being 2 mbgl or less at the post-mining equilibrium stage, with the base case represented by the black line. The results show that it is very unlikely that the depth to water table will be within 2 m of the ground surface across a broader Mona Creek colluvium.

The updated uncertainty analysis also examined the predicted baseflow losses from cumulative mining (approved plus Amended Modification). The baseflow take from the Goulburn River is predicted to reach its predicted highest values at the end of mining (2032) and will begin declining shortly after mining ceases. As the mining at the UCC has moved north, the baseflow loss has also increased in the Talbragar River and is expected to increase further post mining, after recovery begins as drawdown will continue to propagate outward. Eventually both river systems will experience an increase in baseflow as the post mining recovery of water levels creates higher gradients toward the surface drainages. Figure 3.23 and Figure 3.24 of **Appendix 1** show the probability that baseflow loss is exceeded for the Goulburn River and the Talbragar River respectively.

Under the Amended Modification mine plan and model, there are no predicted impacts to Mona Creek baseflow in any of the model scenarios (no-mine, approved, Amended Modification). This is largely due to the perched nature of the alluvium aquifer underlying Mona Creek and that the depth to the regional water table is greater than 10 m under most of Mona Creek (refer to **Figure 3.1**).

c. there should be justification for the number of realisations and whether they are sufficient, noting also that there is some inconsistency in reporting the number of adequately calibrated realisations.

The calibration criteria used to filter realisations that are extreme and are not considered calibrated was 10% Scaled RMS for water levels. The rerun of the uncertainty analysis by AGE involved 400 realisations, of which 198 runs converged and met the calibration criteria.

To understand if 198 runs are sufficient for the uncertainty analysis to cover the range of potential predictions, analysis of specific output has been undertaken. This analysis involved calculating metrics which describe the distribution of the outputs and how this cumulatively changes as more model runs are added from the pool of converged and calibrated realisations. The results of this analysis are presented in Figure 3.10 and Figure 3.11 of **Appendix 1** for the predicted baseflow loss across the model domain and for predicted maximum drawdown in the Lithic Triassic formation represented by private bore PB33.

10. Potential effects of climate change were explored through additional model runs using different recharge rates derived from predicted changes to precipitation under the selected climate change scenario of RCP4.5 (AGE 2022, EPBC Assessment requirements response, p. 2). The IESC recommends that this analysis be expanded with reference to RCP8.5. Understanding the potential effects of climate change on the predicted impacts of this project is important given the long time over which impacts will continue to be observed (potentially thousands of years, e.g., AGE 2022, Table 8.6, p. 99), and that climate change is likely to have an effect on the magnitude of mounding, the key long-term potential impact of this project.

The groundwater model was calibrated using historical rainfall and future predictions based on the long-term averages of the historical data. Since the future rainfall is calculated from historic data, this assumption does not account for potential climate change.

To address impacts from climate change, several model runs were undertaken under different future climate scenarios. These model runs were set up to be consistent through the mining phase, then employ different recharge rates across the post-mining and post-recovery equilibrium phases. The different recharge rates were sourced from predicted changes in rainfall from climate change modelling.

There are several climate models available, and the RCP-8.5 case for the Central Slopes is adopted as the most relevant. In terms of rainfall, the climate model provides an estimate of the percent of increase or decrease in annual rainfall total at various times in the future.

Three model runs were undertaken adopting the predicted annual rainfall change percentage in 2090 across the recovery period, covering the most likely 50th percentile, and the extremes at 90<sup>th</sup> and 10<sup>th</sup> percentiles as shown in **Table 3.3** below.

**Table 3.3 Simulated changes to rainfall input due to climate change**

| Model   | Percentile of prediction | Predicted change in rainfall at 2090 |
|---------|--------------------------|--------------------------------------|
| RCP-8.5 | 10 <sup>th</sup>         | Reduced by 22.98%                    |
| RCP-8.5 | 50 <sup>th</sup>         | Reduced by 5.91%                     |
| RCP-8.5 | 90 <sup>th</sup>         | Increased by 17.59%                  |

The simulations for climate change predictions were run over a 500-year window post mining as this comparison with different climate change predictions was considered appropriate for this period of time. The model was initially run through to 2090 in line with the source predicted changes in rainfall, but there was no discernible difference between the various climate scenarios, so this model was extended to represent 500 years post mining (2532) of recovery to allow differences to be identified and quantified.

The change in rainfall, which affects recharge rates, ultimately results in changes to the level of residual drawdown and mounding predicted in the model during recovery. Figure 3.5 to Figure 3.9 in **Appendix 1** present the changes in the predicted 2 m and 5 m drawdown contours under the different recharge scenarios after 500 years of recovery. These figures show that the level of impact associated with potential climate change from the RCP-8.5 model does not significantly change the predicted 2 m and 5 m drawdown and mounding patterns.

The Amended Modification reporting included recovery predictions for the long-term equilibrium conditions generated from a steady state solution appended as the last stress period of the model. An attempt was also made to apply the various climate scenarios to this steady state stress period, but the steady state solution only requires that volumetric inputs and outputs are equal. Thus, the results between water levels from the various climate scenarios were found to be highly non-linear and, although the model found viable solutions for each climate scenario, the solutions were not consistent. The 500-year method, however, provided consistent and intuitive results and thus was adopted.

The variability in results was further impacted by the majority of recharge driving the recovery occurring in the spoil at the open cut areas of the UCC, which are at the southern end of the mined footprint. The bulk of the recharge to the northern area of the mine footprint is water that enters at the open cut and then flows north through the coal seam and mined goaf.

The change in drawdown and mounding also changes the amount of post-recovery equilibrium baseflow predicted to occur during recovery. Baseflow changes are presented in **Table 3.4** for the Goulburn and Talbragar rivers (including modelled tributaries) within the model domain after 500 years of recovery.

**Table 3.4 Predicted long-term baseflow changes in climate change scenarios**

| Case                        | Change in rainfall (%) | Increase in baseflow for the Goulburn River and tributaries (ML/year) | Increase in baseflow for the Talbragar River and tributaries (ML/year) |
|-----------------------------|------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------|
| Basecase                    | No change              | 25.8                                                                  | -28.2                                                                  |
| 10 <sup>th</sup> percentile | Reduced by 22.975%     | 4.3                                                                   | -28.4                                                                  |
| 50 <sup>th</sup> percentile | Reduced by 5.91%       | 20.7                                                                  | -27.7                                                                  |
| 90 <sup>th</sup> percentile | Increased by 17.588%   | 46.4                                                                  | -24.5                                                                  |

The key aspect of these results is that simulation of the RCP-8.5 climate model produces some minor changes to the extent of post-recovery drawdown (or mounding) in the model domain, but results in even more variation in baseflow rates. This indicates that the baseflow, or more specifically the discharge of groundwater to surface drainages, is controlling the extent of mounding and is more directly impacted by changes in recharge. It should be noted that these baseflow estimates are still only a small component of the annual flow currently gauged in the creeks and rivers, with the Talbragar system discharging in the order of 10 to 100 ML/day and the Goulburn system discharging 30 to 160 ML/day on average (noting that values presented in **Table 3.4** are in ML/year).



11. The groundwater assessment predicts changes to surface water and groundwater interactions. However, the IESC has identified several limitations of this assessment.

a. The project is predicted to increase baseflow losses in the Talbragar River and its tributaries, including Mona Creek, above the levels already approved (Umwelt 2022a, p. 56). These losses are likely to affect ecologically important components of the flow regime (e.g., increases in the number of low- or no-flow days), with subsequent impacts on aquatic and riparian biota, especially if refugial pools (AGE 2022, p. 59) are lost. However, as discussed in Paragraph 7, these baseflow losses are not adequately simulated by the current model. Furthermore, the proponent should quantify the ecological effects of these impacts.

As previously discussed, Mona Creek is an ephemeral, fourth order watercourse and flows in a north-westerly direction to the Talbragar River. Flow regimes in the river and creek systems which are expected to be impacted by the Amended Modification were modelled to assess the impact of any potential reduction in baseflows. The estimated baseflow loss provided by the Amended GIA (refer to Appendix 5 of the Amendment Report) was applied to the calibrated models to assess any impacts on baseflows in affected rivers and creeks.

Consistent with the predictions for the originally Proposed Modification, the model for the Amended Modification indicates negligible impacts to the estimated frequency of no flow periods and no increase in average annual dry days (defined as flows less than 0.1 ML/day) in the Talbragar River (at SW09, Dunedoo and Elong Elong) relative to the currently approved mining operations.

As a result of the predicted subsidence impacts there are no predicted changes to catchment areas in Mona Creek or baseflow to the creek system (refer to Appendix 5 of the Amendment Report). As such, the Amended Modification is not expected to have any impact on streamflow sequences in Mona Creek.

The Amended SWIA found that the predicted changes to flow regimes both during and following the Amended Modification are predicted to be negligible in the context of ephemeral streams and the Talbragar River. The changes to flow regimes are also considered to be negligible on a regional scale. The assessment concluded that the Amended Modification is consequently considered likely to have negligible impact on ecosystems and downstream users as the predicted impact is within the natural variation of the existing creek systems.

Ecological monitoring across the UCC in areas that have previously been subject to underground mining have not demonstrated any significant impacts to aquatic and riparian biota. Given there is no predicted change to flow regimes in Mona Creek and negligible changes to flow regimes in the Talbragar River, there is not predicted to be any impacts on aquatic and riparian biota as a result of the Amended Modification.

b. There are areas where the Ulan Seam sub-crops to the Talbragar River Alluvium (AGE 2022, p. 73). These areas should be identified, mapped and potential impacts discussed further given that it is predicted that drawdown in the Ulan Seam will extend under large areas of the Talbragar Alluvium (see AGE 2022, Figure 7.5, p. 81).

Figure 3.38 in **Appendix 1** shows the location of the model cells where the Ulan Seam sub-crops directly under the alluvium and colluvium areas. In the model this is where layer 16 is directly below layer 1 with no intervening model layers.

c. Limited discussion has been provided on the effects of the predicted long-term groundwater mounding (post-mining) on surface water. The ecological impacts of reducing baseflow during operations, followed by increasing baseflow post-mining require further assessment.

Refer to response to Paragraph 5a above.

12. As stated in Paragraph 6a, an integrated approach to surface water and groundwater assessments is required.

An integrated approach to all relevant assessments has been undertaken for the Amended Modification. This has included integrations of the surface water, groundwater, subsidence and biodiversity assessments. Each assessment has incorporated relevant outputs, where required.

For example, the estimated baseflow losses applied to the calibrated models to determine any impacts on baseflows to affected rivers and creeks in the Amended SWIA was sourced from the Amended GIA.

13. The proponent has provided limited groundwater quality monitoring data (pH, EC, major ions) for this assessment. The IESC notes that additional monitoring (e.g., metals) has occurred in line with the proponent's Groundwater Monitoring Plan and suggests that the proponent provide these data. This will enable pre-project conditions to be established and facilitate understanding of any potential changes to groundwater quality that may occur associated with subsidence and predicted postmining mounding.

Refer to response to Paragraph 5b above.

## 3.2 Surface Water

### Question 2. Surface Water

To what extent can decision makers have confidence in the predictions of potential impacts on surface water resources, having regard to the proximity of the project to local watercourses including Mona Creek and the Talbragar River.

- a) Have appropriate models been selected and used by the Applicant? Are the assumptions used in the models reasonable?
- b) Has the model been calibrated with sufficient monitoring data to provide meaningful predictions, including worst-case impacts on surface water resources?
- c) Has an appropriate sensitivity and uncertainty analysis been undertaken, including consideration of the potential effects of climate change?

14. Although the water resource model selected by the proponent is appropriate and sufficient data have been used in its calibration, the modelling of predicted impacts on the flow regime (i.e., on overall runoff volumes, low flows and cease-to-flow characteristics) depends on the adequacy of the estimated impacts on subsidence and baseflows. Given the IESC's concerns about the assessment of subsidence and groundwater interaction (Paragraph 6), it is not possible to have confidence in the conclusions drawn about the likely impacts on surface water resources.

The assessment of predicted impacts associated with groundwater is covered in further detail in **Section 3.1**.

As outlined in **Section 2.0**, there is a long history of mining at the UCC. The approach to estimating the subsidence effects of the Amended Modification was based on a review of previous site experience over more than 40 longwall panels at the UCC. This method is an empirical approach suitable for providing a reasonable estimate of the upper limit of key subsidence parameters. The estimates incorporate improved understanding of subsidence behaviour based on the monitoring conducted since the original UCCO Project assessment was prepared. Recognition of natural variation is also considered.

The Amended SWIA for the Amended Modification has considered the subsidence predictions which are considered to have a high level of confidence based on the experience at UCC.

It should be noted that the Amended SWIA considers both a range of climatic scenarios, including consideration of climate change, on rainfall and evaporation and subsequently streamflow and flooding impacts associated with the Amended Modification. Further to this, the analysis of historical streamflow data, subsequent flow duration modelling and site observations indicate that Mona Creek is an ephemeral creek system with little baseflow contribution occurring. Similarly, the Talbragar River, adjacent to the Project Area, displays intermittent flow characteristics with little baseflow contribution seen.



15. Little consideration has been given to exploring the sensitivity (or uncertainty) of the surface water modelling on the key assumptions related to the impacts of subsidence or changed baseflow exchanges with the surrounding groundwater system. The water resource model has not been used to assess worst-case impacts on surface water resources. The investigation into impacts of climate change on surface water resources only considers changes to baseflow as predicted by the groundwater model and does not consider changes in rainfall or evaporation amounts on catchment runoff. Potential effects of climate change on the site water balance also do not appear to have been considered.

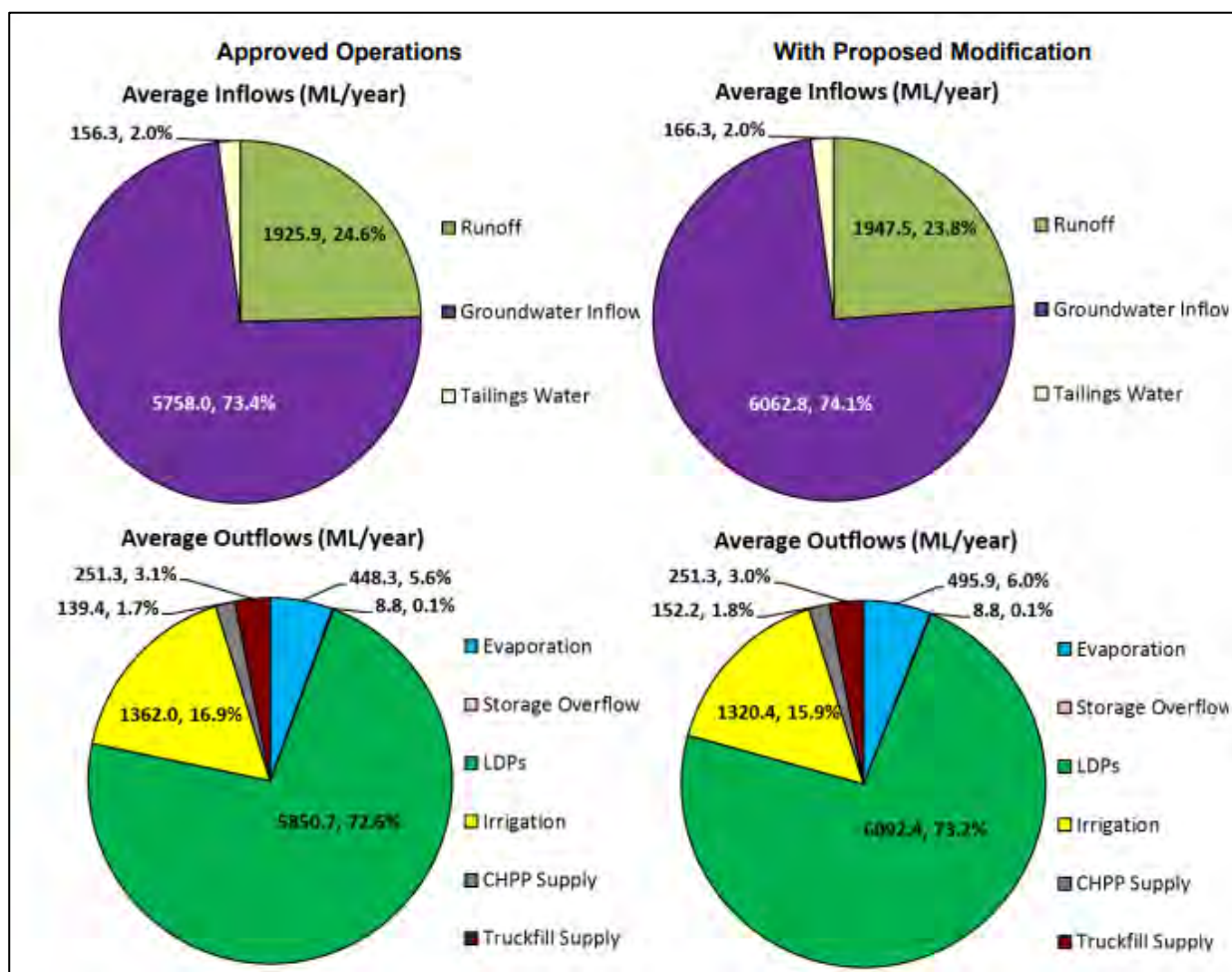
As discussed in the Amended SWIA, data from a SILO Data Drill (1889 to 2021) was used to represent the long-term rainfall and evaporation data set for the Amended Modification. The SILO data drill is a derived data set from a combination of interpolated recorded data between weather stations and derived long-term average values. As such, by using SILO data in the analysis the long-term variations in rainfall and evaporation were considered in the assessment of impacts on flow regimes.

Predicted baseflow impacts used in the assessment were sourced from the Amended GIA and are based on predicted subsidence impacts. The determination of predicted baseflow impacts is discussed in **Section 3.1**. The Amended GIA was prepared in accordance with relevant guidelines, including a detailed uncertainty analysis and the predictions are considered to be conservative and therefore appropriate for use in the assessment of surface water resources.

A climate change assessment was undertaken to understand the sensitivity of potential streamflow and flooding impacts to climate change and was included in Section 4.10 of the Amended SWIA. Climate projections for the Amended Modification were obtained using the Climate Futures Tool provided on the Climate Change in Australia website and applied using methodologies outlined in Climate Change in Australia Technical Report (CSIRO, 2015). Data for the Representative Concentration Pathway 4.5 (RCP 4.5) emission scenarios and modelled for mean predictions for 2050 and 2090 were used in the assessment. These values were applied to the SILO daily rainfall and evaporation data set for the streamflow assessment, as well as application of predicted changes to storm rainfall intensity for the flooding assessment.

As such, the investigation into impacts of climate change on surface water resources considers the predicted impacts of changes to baseflows, as predicted by the groundwater model, combined with predicted climate changes in rainfall and evaporation amounts on catchment runoff.

The potential impacts of climate change on the site water balance were considered to be negligible and hence were not assessed. The site water balance for the existing and Amended Modification is driven primarily by groundwater inflows. **Figure 3.14** below, sourced from HEC (2022), shows how the runoff from surface catchments into the site water balance model is in the order of 24% to 25% of the total inflows to the site water balance. Using the Climate Futures Tool (as discussed above) the estimated average annual catchment runoff will reduce in 2050 to 97% of existing runoff volumes and in 2090 to 80% of existing runoff volumes. The predicted reduction in catchment runoff will result in a reduction in inflows into the site water balance in the range of 1% to 5% in the future due to climate change. The resulting impact is a reduction in average estimated site discharges.



**Figure 3.14 Average Modelled System Inflows and Outflows**

Source: HEC, 2022 (Figure 20).

16. Appropriate models have been selected for estimating flood impacts and these have been adequately verified and parameterised. The flood models have been used to estimate worst-case events and include an assessment of the impacts of climate change using approaches that are consistent with current national guidelines (Ball et al., 2019).

Noted.

### 3.3 Cumulative Impacts

#### Question 3. Cumulative Impacts

Does the Modification Report provide an adequate assessment of cumulative impacts to surface and groundwater resources during the mining operations and during the post-mining recovery phase. Do these assessments adequately consider surface and groundwater interactions?

17. The proponent has, in the context of the groundwater impact assessment, provided some conceptual and impact pathway information (AGE 2022, pp. 59–71). However, this analysis could be expanded through the inclusion of suitably geo-referenced ecohydrological conceptual models and associated impact pathway diagrams. These would provide a useful overview of potential impacts, including cumulative ones, that may potentially occur due to this project, and clearly link groundwater, surface water and subsidence impacts to potential ecological responses (e.g., adverse effects on GDEs, persistent pools, aquatic biota, riparian vegetation). These conceptual models would also help to identify and justify where further monitoring and mitigation measures are required.

The action under consideration is the Amended Modification. The Amended GIA includes analysis of the incremental impacts associated with the Amended Modification which indicates the key incremental impacts are limited to the mining period and drawdown impacts are restricted to the Mona Creek areas only. The analysis in **Section 3.1** in relation to Paragraph 5a provides further conceptualisation of the interrelationship between groundwater and surface water in this area and indicates there are unlikely to be any GDEs present in the area of incremental impact attributable to the Amended Modification. As such, the preparation of more detailed ecohydrological conceptual models and impact pathway diagrams is not considered to be necessary to further the assessment of potential impacts on GDEs in this area associated with potential drawdown impacts.

Notwithstanding the above, further work has been undertaken to investigate post-mining management options to mitigate the possibility of groundwater mounding and its potential impact. To address this, the Amended Modification model incorporated a recharge mitigation strategy that would reduce groundwater recharge across the open cut void during the post-mining recovery period (which then flows into the underground goaf and voids). Specifically, the model was set up to be consistent with previous models through the mining phase, but then employ a closure approach that reduces the groundwater recharge across the open cut void area to 5% of the total rainfall during the post-mining phase. This scenario provides insight on the impact of reducing recharge in the area to manage the potential for mounding. Figure 3.32 in **Appendix 1** presents the predicted post-mining equilibrium depth to water table under this recharge management scenario.

The implementation of this recharge mitigation strategy in the Amended GIA results in changes to the level of residual drawdown and mounding occurring in the model at the post-mining equilibrium stage. Figure 3.33 to Figure 3.37 in **Appendix 1** present the predicted drawdown and mounding contours with the recharge mitigation strategy.

These figures can be compared to Figures 7.10 through 7.17 in the original GIA report (AGE 2022) and show that, generally speaking, the recharge mitigation strategy reduces the extent of mounding in all layers around the mine area, but also leads to areas of prolonged residual drawdown, especially in the deeper layers (note that the Proposed Modification mine plan included mined panels that extend beneath Mona Creek whereas the Amended Modification mine plan has shortened those panels). The effects on the alluvium/colluvium layer are only observed along the Goulburn River south of the UCC and along Mona Creek. Direct comparison to Mona Creek is especially problematic because of the reduced mine footprint between the Proposed Modification and Amended Modification mine plan, but under the current plan and recharge mitigation strategy, the model predicts small residual drawdown (maximum just over 5 m) along Mona Creek (refer to Figure 3.33 in **Appendix 1**). **Figure 3.1** shows that the predicted depth to water table, even at post-mining equilibrium, is over 10 m below ground level along much of Mona Creek, indicating no likely impact to GDEs or baseflow.



The change in drawdown and mounding due to the reduced recharge also changes the predicted long-term baseflow. The changes to baseflow are presented in **Table 3.5** for the Goulburn and Talbragar rivers and their modelled tributaries within the model domain, and compared to the Proposed Modification mine plan (as above, consideration of the change in the mine plan also has an impact). The Goulburn River is predicted to have a slight increase over pre- mining baseflow from the general mounding predicted in its catchment, and the Talbragar River is predicted to have a residual reduction in the baseflow compared to pre-mining conditions. For both rivers, these predictions will be imperceptible with baseflow impacts essentially returning to pre-mining conditions.

The key aspect of these results is that the implementation of a mitigation strategy that constrains the rainfall recharge across the void areas to 5% of the total rainfall would significantly reduce the long-term mounding effect and its impact on the baseflow of the rivers but will result in some residual drawdown remaining in areas to the north and north-west of the mine.

**Table 3.5 Predicted long-term baseflow changes in the management scenario**

| Case                                                 | % change in void recharge | Increase in baseflow for Goulburn River and tributaries (ML/year) | Increase in baseflow for Talbragar River and tributaries (ML/year) |
|------------------------------------------------------|---------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Proposed Modification case</b>                    | No change                 | 283                                                               | 133                                                                |
| <b>Amended Modification with mitigation strategy</b> | Reduced by 105%           | 70.9                                                              | -10.3 (reduction)                                                  |

### 3.3.1 Groundwater

18. The groundwater model has included approved mining at Ulan Coal Mine Complex and the adjacent mines of Moolarben and Wilpinjong. However, the assessment of cumulative impacts is limited and does not adequately consider surface and groundwater interactions.

Cumulative impacts from the UCC and Moolarben are simulated in the groundwater model and this includes predicted impacts on baseflows. The groundwater modelling incorporates the influence of surface drainage on the groundwater system at an appropriate level, capturing the potential impacts from both mines.

Modelling shows that the Amended Modification has minimal additional impacts to those of the approved operation at the UCC and there is minimal interaction with neighbouring Moolarben Coal mine, hence there is no potential for significant cumulative groundwater impacts.

Other than the base flow impacts discussed above, the Amended Modification does not result in any changes to surface flow catchments impacted by Wilpinjong and Moolarben (both of which are located in the Goulburn River Catchment). Additional consideration of cumulative impacts associated with these operations is therefore not warranted.

a. The impacts on water-dependent ecological assets from the combination of drawdown and subsidence are not considered. There is also no adequate assessment of the cumulative impacts of an initial reduction in water levels followed by long-term and potentially considerable increases (mounding) in water levels, especially on vegetation that may experience waterlogging and substantially altered redox conditions in the root zone.

Refer to response to Paragraph 5a above.

The groundwater modelling has considered the predicted subsidence impacts associated with the Amended Modification and approved operations across the UCC (and Moolarben).

The Amended GIA considers impacts to water-dependent ecological assets. As outlined in the Amended GIA, no high priority GDEs have been identified in WSPs covering the UCC. The only creek system potentially impacted by the Amended Modification is Mona Creek where riparian vegetation has largely been cleared for agricultural purposes in the areas where longwall panels are proposed. As discussed in the response to Paragraph 5a, the Amended Modification is unlikely to contribute to impacts on GDEs in the Mona Creek catchment. Cockabutta Creek will not be impacted by the Amended Modification and baseflow impacts to the Talbragar River are unlikely to be observable.

b. Potential cumulative impacts to surface water and groundwater interactions, and changes to these, are not assessed, particularly in the context of effects on ecologically important components of flow regimes or changes to directions and/or magnitudes of surface water-groundwater exchanges in the hyporheic zone of Mona Creek when it is flowing or a string of pools. The hyporheic zones of ephemeral streams have been shown to be active zones for carbon processing (Burrows et al., 2017) and may also support diverse invertebrate and microbial communities that contribute to ecosystem resilience (Bruno et al., 2020).

As per previous responses, potential cumulative impacts to surface water and groundwater interactions, and changes to these, have been assessed.

In regard to Mona Creek, the only baseflow that is predicted to occur is near the confluence with the Talbragar River, well north of the proposed additional mining footprint.

c. The cumulative drawdown predictions for the Ulan Seam extend beyond the boundaries of the groundwater model (AGE 2022, Figure 7.9, p. 86), which reduces confidence in these predictions as they are likely to be influenced by the boundary conditions.

Refer to response to Paragraph 5g above.

Further, the depressurisation that occurs in the coal seam at the boundaries of the model can be seen to extend along the boundaries because the boundaries are no-flow. The broader cone of depressurisation near the mine and near monitoring points remains unaffected by the influence of the boundaries because they are set a sufficient distance away from the area of interest. The reduction of confidence in the key predictions would be negligible.

### 3.3.2 Surface Water

19. Modelled impacts to flood depths and velocities do not extend beyond the area predicted to be impacted by subsidence (Engeny 2022, p. 29), and thus it is reasonable to assume that the cumulative impacts on downstream reaches are negligible.

Noted.

20. The proponent does not intend to extract water from nor release water to Mona Creek, and intends to undertake erosion and sediment control measures in line with the existing Water Management Plan (Engeny 2022, p. 46). However, there is uncertainty around the potential local impacts on baseflow from groundwater drawdown, subsidence and post-mining mounding. The IESC suggests that the proponent reassess cumulative impacts once adequate assessment of potential local impacts is conducted as suggested within this advice.

There are no predicted impacts on baseflows in Mona Creek in the Amended GIA (AGE, 2024) and impacts associated with drawdown and mounding on baseflow are discussed in the response to **Paragraph 5a**. As such there are no predicted impacts on streamflow in Mona Creek associated with the Amended Modification.

The potential impacts of the predicted baseflow losses with the Amended Modification are assessed for three locations on the Talbragar River in Section 4.2 of the Amended SWIA.

## 3.4 Avoidance, Mitigation and Monitoring

### Question 4. Avoidance, Mitigation and Monitoring

Does the Modification Report provide reasonable strategies to effectively avoid, mitigate or minimise the likelihood, extent and significance of impacts, including cumulative impacts, to significant water-related resources?

21. The project did not provide details of avoidance or mitigation strategies in relation to groundwater impacts. The project should aim to return groundwater levels to pre-mining conditions by changing the design of the final landform as discussed in AGE (2022, EPBC assessment requirements report, p. 9). For example, the possibility of groundwater mounding could be mitigated by design of spoil to control recharge rates. Management plans and a trigger action response plan (TARP) are currently in operation for approved mining and will likely be extended to include this project. Potential improvements to these plans are discussed in the response to Question 5.



Mitigation measures associated with potential mounding are discussed in the response to Paragraph 17 above. The implementation of the recharge mitigation strategy in the Amended GIA results in changes to the level of drawdown occurring in the model at the post-mining equilibrium stage. Figure 3.33 to Figure 3.37 in **Appendix 1** present the predicted drawdown and mounding contours with the recharge mitigation strategy.

The change in drawdown and mounding due to the reduced recharge also changes the predicted long-term baseflow. The changes to baseflow are presented in **Table 3.5** for the Goulburn and Talbragar rivers and their modelled tributaries within the model domain, and compared to the Proposed Modification mine plan. The Goulburn River is predicted to have a slight increase over pre-mining baseflow from the general mounding predicted in its catchment, and the Talbragar River is predicted to have a residual reduction in the baseflow compared to pre-mining conditions. For both rivers, these predictions will be imperceptible with baseflow impacts essentially returning to pre-mining conditions.

The key aspect of these results is that the implementation of a mitigation strategy that constrains the rainfall recharge across the void areas to 5% of the total rainfall would significantly reduce the long-term mounding effect and its impact on the baseflow of the rivers but will result in some residual drawdown remaining in areas to the north and northwest of the mine.

22. The Modification Report does not provide strategies to effectively avoid, mitigate or minimise potential impacts of 1.7 to 2.1 m (SCT 2022, p. 4) of subsidence.

The Amended Modification will provide for the efficient recovery of approximately 16.3 Mt of additional coal resource at the UCC with minor changes to the currently approved environmental and social impacts.

The Amended Modification represents the most efficient method of extracting the additional 16.3 Mt of coal resources to the north of the existing Ulan West operations, and west of the existing Ulan Underground operations. The Amended Modification represents a relatively small change to the currently approved mine layout and subsequently will result in relatively minor changes to the currently predicted impacts associated with the approved underground operations and surface disturbance.

UCMPL has a track record of modifying underground mining operations to protect key ecological and heritage features, where relevant. Within the additional underground mining area subject of the Amended Modification, this was not considered necessary. UCMPL have modified surface infrastructure to avoid sensitive environmental features, including CEEC.

Overall, subsidence impacts are predicted to be consistent with or less than the predictions for the approved operations subsidence performance measures, and the monitoring experience since PA 08\_0184 was granted (refer to the Amended Subsidence Assessment in Appendix 4 of the Amendment Report).

There is no change to the forecast of impacts or consequences for Ulan, Mona and Cockabutta Creeks expected from additional underground mining associated with the Amended Modification. Therefore, compliance with the subsidence performance measures outlined in Table 14 of Condition 24, Schedule 3 of PA 08\_0184 is expected.

23. The project poses potential impacts to Mona Creek and associated riparian vegetation (for example, increased ponding, groundwater drawdown and subsidence-related disturbance of caves, overhangs or crevices which are habitat to EPBC Act-listed species of bat). The IESC recommends that the proponent investigate altered mine design options or rehabilitation strategies to avoid or mitigate potential long-term impacts to Mona Creek, EPBC Act-listed species and the CEEC.

As has been undertaken in the past, UCMPL will continue to prepare the required Extraction Plans (EPs) to satisfy conditions of PA 08\_0184 for the existing and future mining areas. Specific surface water monitoring relevant to the active extraction plans is described within each extraction plan.

EPs have typically included the following key monitoring components to measure and evaluate the subsidence performance measure for surface water impacts, including:

- water quality
- channel stability, including ponding
- stream health
- surface cracking.

Consistent with previous project commitments, if monitoring indicates that remediation works are required, remediation works will need to maintain channel grades and take into consideration landform/channel stabilities and existing landform/channel characteristics. This will be managed through the processes outlined in the EP, Water Management Plan, Surface Water and Groundwater Response Plan and Biodiversity Management Plan for the site. These plans will be developed/updated as required by the project approval as per the commitments in the Amended SWIA.

Subsidence modelling indicates potential for some rockfall or cracking, however no significant collapse or otherwise of the cliff line habitats. The Amended BDAR confirms that no maternity roosts have been identified in the Potential Indirect Impact Area, however potential habitat exists. The probability of any significant impact on any threatened microbat breeding or roosting caves within the Potential Indirect Impact Area is possible, however likely to be rare (refer to Section 5.2.1.3 of the Amended BDAR). Despite this, the Amended BDAR also includes the requirement for the preparation of a Microbat Management Plan to set out strategies to reduce and mitigate potential prescribed impacts on threatened micro-bats (specifically large-eared pied-bat, large bent-wing bat and eastern cave bat). The Microbat Management Plan would include as a minimum:

- identification of potential microbat habitats and potential for impacts on those habitats
- detailed monitoring program with measurable performance measures and performance indicators (consistent with SMART principles)
- a trigger, action, response plan (TARP)
- detailed descriptions of potential management responses should performance indicators be exceeded or triggers met
- contingency for review of the Management Plan every 5 years to allow for adaptive management.

UCMPL has committed to the design and implementation of a comprehensive biodiversity mitigation strategy to manage the unavoidable impacts of the Amended Modification. The following specific control measures, as detailed in the existing approved UCC Biodiversity Management Plan (BMP) (UCMPL, 2019), are considered to be integral to the mitigation of impacts on the biodiversity features of the UCC and will be implemented for the Amended Modification:

- monitoring and reporting of subsidence impacts
- performance measures, triggers and contingency measures for impacts relating to subsidence
- disease management and hygiene controls
- salvage of biodiversity features for habitat augmentation
- revegetation methodologies (in the event that vegetation is impacted by subsidence)
- creek and drainage line remediation
- weed and vertebrate pest management
- erosion, sediment and soil management
- dust minimisation and suppression measures
- environmental management measures to minimise the potential for indirect impacts
- workforce education and training.

#### **Question 5. Avoidance, Mitigation and Monitoring**

Are there any additional mitigation, monitoring, management or offsetting measures that should be considered by decision makers to address the residual impacts of the Project on water resources?

24. Monitoring and mitigation actions for groundwater impacts at existing approved operations in the Ulan Coal Complex include the use of a TARP, which is detailed within the Surface Water and Groundwater Response Plan. The IESC notes that the current plan will require review and updating to incorporate the proposed project. This should include:

- a. an analysis of the current groundwater conditions (level/pressure and quality) to enable the derivation of robust site-specific guideline values (or triggers) for use in the updated TARP; and
- b. groundwater quality sampling is currently undertaken annually. At bores where site-specific guideline values are used, the frequency of sampling will need to be increased to ensure the associated TARP functions in a timely manner.

UCMPL has committed to the review and updating of all existing management plans to incorporate the Amended Modification, where required. This would include an updated analysis of current groundwater conditions and an increase in the frequency of groundwater quality sampling as required in line with IESC advice.

25. The proponent states that ‘there is predicted to be some drawdown in parts of the Talbragar alluvium, however, the drawdown is not expected to fully desaturate the alluvium therefore no significant impacts are expected on stygofauna’ (AGE 2022, p. 100). The proponent has not provided any data to support this claim, despite being required to provide a stygofauna assessment in the alluvium and colluvium of Mona Creek and the Talbragar River as part of the Department of Climate Change, Energy, the Environment and Water’s assessment requirements (Umwelt 2022a, p. 124). If a baseline survey indicates the presence of stygofauna, then the proponent should continue monitoring during operations, particularly targeting the Talbragar River alluvium. The program should include monitoring for changes in groundwater level and species diversity and abundance of stygofauna.

UCMPL will undertake baseline survey to assess the presence of stygofauna. Should the presence of stygofauna be confirmed, UCMPL will continue monitoring during operations, particularly targeting the Talbragar River alluvium. The monitoring program would include monitoring for changes in groundwater level and species diversity and abundance of stygofauna.

26. The proponent has not adequately characterised the remnant riparian vegetation along Mona Creek or its likely dependence on groundwater. Due to the predicted groundwater drawdown and postmining groundwater mounding impacts along Mona Creek, the IESC suggests that the proponent conducts field surveys, including ground-truthing for riparian vegetation and potential GDEs (including Blakely’s Red Gum which is a component of the EPBC Act-listed CEEC) along Mona Creek. Information from this survey can then be used to inform the development of a monitoring plan to identify any changes to vegetation composition or condition due to impacts from the project.

This issue is addressed in the response to Paragraphs 5 in **Section 3.1**.

Additionally, as outlined above, UCMPL has committed to the design and implementation of a comprehensive biodiversity mitigation strategy to manage the unavoidable impacts of the Amended Modification. Should the Amended Modification be approved, UCMPL will update the existing BMP in accordance with any relevant development consent requirements. The BMP includes monitoring across the UCC and would be updated to include the additional underground mining area, including Mona Creek.

27. The proponent does not discuss any potential impacts of releases which may occur to the Talbragar River (Engeny 2022, p. 12). It is possible, but not clear from the documentation provided, that the release point on the Talbragar River has been previously approved and conditioned. If the proponent plans to make controlled releases to the Talbragar River, additional parameters including metals, metalloids and dissolved organic carbon should be monitored in Mona Creek and the Talbragar River.

The Amended Modification does not propose any changes to the currently approved discharge arrangements in relation to the UCC.



PA 08\_0184 included approval for a water treatment facility, staging dams, pipeline and discharge structure in the northern part of the Project Area, referred to as the Ulan West Water Treatment Facility. To date this infrastructure has not been constructed.

Activities that may lead to pollution of waters in NSW are regulated by the EPA under the *Protection of the Environment Operations Act 1997* (POEO Act). Where discharge of waters is permitted it is controlled by licence conditions such that discharges do not result in significant impacts on water resources.

Prior to discharges to the Talbragar River EPL 394 would need to be varied. An application for a variation would be submitted to the EPA. The requirements of the EPA in regard to discharge volume/rate and water quality limits, as well as monitoring requirements would be required in the licence variation.

Should the Ulan West Water Treatment Facility be progressed, relevant monitoring would be required and undertaken.

28. Establishment of a biomonitoring program, incorporating algae and macroinvertebrates, will provide essential information on changes in the ecological condition of Mona Creek and the Talbragar River resulting from the project.

The Amended Modification will have a negligible impact to the ecological condition of Mona Creek and the Talbragar River.

UCMPL currently undertakes comprehensive monitoring across the UCC, in accordance with current State and Commonwealth approvals. UCMPL propose to continue existing monitoring programs and update them to include the Amended Modification, where relevant.

29. The proponent has not provided a subsidence monitoring plan with this assessment. The proponent mentioned that there is current monitoring, and a proposed expansion of the subsidence monitoring lines (SCT 2022, p. 6). However, a map and information about the location of the current and proposed monitoring lines were not provided in the documentation. The IESC suggests that the proponent provide an updated subsidence monitoring plan, including maps and information about the locations of subsidence monitoring lines, for further review.

UCMPL currently operates in accordance with approved Extraction Plans which prescribe the monitoring and management measures to be implemented for each longwall area. Longwall extraction in the additional mining area will be undertaken in accordance with an approved Extraction Plan prepared in accordance with the requirements of PA 08\_0184.

Ongoing subsidence monitoring in a similar manner to the standards detailed in the existing subsidence monitoring programs required by the current Extraction Plans will be undertaken, including before, during and after mining survey of monitoring lines and surface and landscape feature visual monitoring inspections. Approved Extraction Plans are available on the UCC website:

<https://www.glencore.com.au/operations-and-projects/coal/current-operations/ulan-coal/management-plans>

The Subsidence Assessment concluded that additional subsidence monitoring lines are not required for the Amended Modification, unless the previously recommended new cross-panel subsidence monitoring line for LW7 to LW12 at Ulan West Underground is not able to be established and monitored through agreement with a private property landholder. If agreement for this additional line is not able to be reached, then the Subsidence Assessment recommends a new east-west line over the centre of the proposed extension areas of Longwall W9 (or W10) and across Longwalls 9A-12A through the undeveloped native vegetation environment on UCMPL and Crown Land.

30. Maps clearly showing the hydrostratigraphic target of monitoring bores should be provided to ensure all monitoring bores and cumulative impact monitoring are accurately represented and consistent across relevant figures (see AGE 2022, Figure 5.5, p. 38).

Refer to Figure 3.30 in **Appendix 1** which presents the groundwater monitoring locations and geological formations being monitored at each location.

### 3.5 Significance of Impacts

#### Question 6. Significance of Impacts

Subject to confidence in the predictions of potential impacts, will impacts to the key surface and groundwater features be significant?

31. The IESC considers that the significance of the impacts to water resources, including surface waters, groundwaters, and water-dependent ecosystems, species and habitats, cannot be determined without the further information outlined in this advice being provided to the regulators.

The environmental, social and economic impacts of the Amended Modification have been identified and subject to a detailed environmental assessment based on:

- assessment of the site characteristics (existing environment)
- focused consultation with relevant government agencies
- engagement with local community and other stakeholders
- application of the principles of ecologically sustainable development, including the precautionary principle, inter-generational equity and conservation of biological diversity and ecological integrity
- expert technical assessment.

The key issues identified were subject to comprehensive specialist assessment to identify the potential impacts of the Amended Modification on the existing environment. These assessments are detailed in the Amendment Report and the Appendices to that document.

The detailed impact assessment undertaken concludes that with the implementation of feasible and reasonable mitigation measures, the Amended Modification can proceed within acceptable environmental standards. The impacts of the Amended Modification have been kept to a minimum through:

- obtaining a detailed understanding of the issues and impacts by scientific evaluation and stakeholder engagement
- commitment to proactive and appropriate strategies to avoid, minimise, mitigate, offset or manage a range of potential environmental impacts, building on the experience gained from many years of mining operations at the UCC site.

The Amended Modification is located in an area that has a long history of coal mining, with the Project Area itself subject to mining activity since the 1920s. The UCC is a well-established mining operation situated within the Western Coalfields of NSW.

The Amended Modification will involve the extension of existing longwalls into adjacent exploration leases, and construction of related infrastructure to support these additional underground mining activities. These longwall extensions adjoin and are continuous with the existing approved mining areas providing an efficient mine plan to recover the coal resources in this area. The Amended Modification will ensure that recovery of the coal resource present at the UCC is maximised and will build upon existing approved activities and utilise existing infrastructure wherever possible. There would be minimal additional impacts on private and public assets or environmental features, consistent with those previously approved under PA 08\_0184.

## 4.0 References

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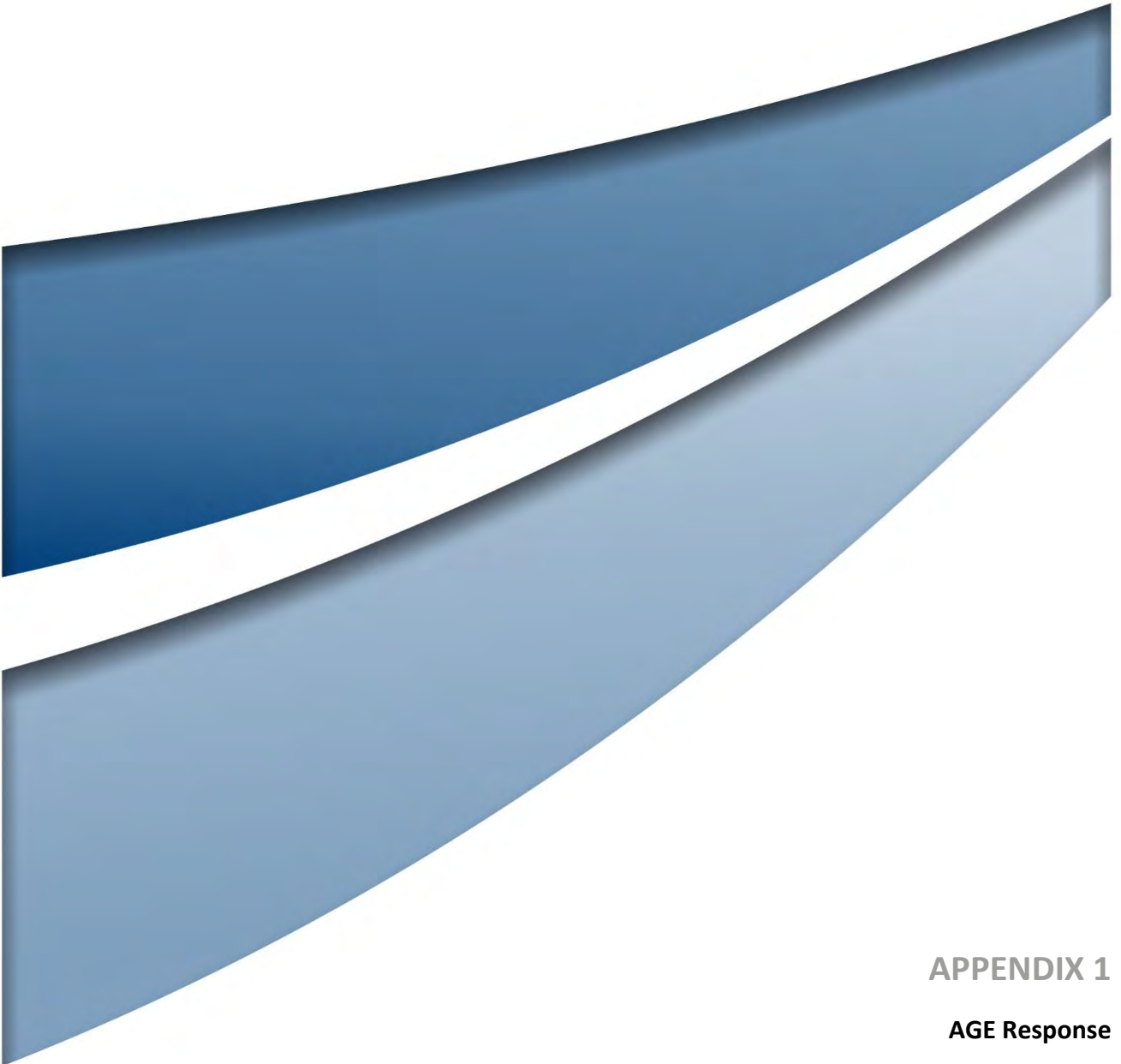
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## APPENDIX 1

### AGE Response



8 August 2024

Ulan Coal Mines Pty Ltd, Glencore  
4505 Ulan Road  
Ulan 2850, NSW

Attention: Bradley Tanswell  
via email: Bradley.Tanswell@glencore.com.au

Dear Brad,

# Ulan Coal Modification 6 – Independent Expert Scientific Committee Response

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## 1 Introduction

Ulan Coal Mine Complex (UCC) is operated by Ulan Coal Mines Pty Limited (UCMPL), which is 100% owned and managed by Glencore Coal Pty Ltd (Glencore). The UCC is in the central west of New South Wales near the town of Ulan and is approximately 45 km northeast of Mudgee.

UCMPL was granted NSW Project Approval (PA) 08\_0184 under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 15 November 2010 for the Ulan Coal – Continued Operations Project. The existing UCC operations are also approved by Controlled Activity approvals 2009/5252 and 2015/7511, issued under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

UCMPL is seeking a modification to PA 08\_0184 to extend underground mining at the Ulan West and Ulan Underground operations through Modification 6 (MOD6) or the Proposed Action.

UCMPL referred MOD6 to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) for consideration under the EPBC Act. Subsequent to this the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC) have provided advice dated 15 March 2023 in response to the Ulan Coal Modification 6 Groundwater Impact Assessment (AGE, 2022).

Since this time, UCMPL have undertaken further optimisation of the proposed MOD6 mine plan and have amended the modification relative to the originally proposed MOD6 that was reviewed by the IESC. The amended mine plan is referred to as 'MOD6A' to distinguish it from the original MOD6 mine plan. The IESC advice and comments were made on the original MOD6 assessment, which has since been superseded by MOD6A. Where practical, the comments have been taken on board with the MOD6A assessment and are responded to in the following sections from the perspective of MOD6A.

This document was prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to respond to the groundwater specific feedback from the IESC and to provide supplemental information to the original Groundwater Impact Assessment (GIA) report (AGE, 2022) where it has been requested.

## 1.1 MOD6 and Amended MOD6 (MOD6A) mine plans

In the period since the IESC provided advice, UCMPL have adjusted the proposed mine plan for MOD6 and assessed and Amended MOD6 (MOD6A) as detailed below.

Under the original MOD6 mine plan, UCMPL had proposed to modify PA 08\_0184 to facilitate extensions to several longwall panels at Ulan West and Ulan Underground Operations. The proposed MOD6 mine plan comprised:

- extension of Ulan Underground longwall (LW) panels LWW9 to LWW11 to the west;
- widening of Ulan Underground LWW11 by approximately 30 metres; and
- extension of Ulan West LW9 to LW12 to the north.

The new MOD6A mine plan proposes limiting the westward extension of longwall panels LWW9 to LWW11 by between 1.5 and 2 km (see Figure 1.1 – shown with original MOD6 mine plan for comparison) and removes the extension of Ulan West LW9. The widening of LWW11 and extension of LW10 to LW12 are still incorporated in MOD6A mine plan.

UCMPL have also proposed minor changes to surface infrastructure to support underground mining activities including provision of (changes from MOD6 to MOD6A are presented in *italicised* brackets):

- one ventilation shaft and associated infrastructure corridor (the additional ventilation shaft originally proposed associated with Ulan Underground has been removed due to the reduced length of longwall panels and one of the ventilation shafts at Ulan West originally proposed has been removed following removal of the proposed extension to LW9)
- two dewatering bores and associated infrastructure corridors (an additional three dewatering bores that were originally proposed have been removed)
- an infrastructure corridor and service borehole, to deliver gravel and other construction materials and to provide access and power to the underground mine, to the south-west of Ulan West
- other associated infrastructure required to service the approved and proposed underground mining operations.

No changes are proposed to coal handling and preparation facilities, water management systems, offices, or ancillary facilities.

The timing used in the model for the currently approved (MOD4) and proposed MOD6A panels are presented below in Table 1.1 and Table 1.2. As the model was prepared in early 2024, some dates are now passed. Comparing these dates to those presented in Table 1.1 and Table 1.2 in the original GIA (AGE 2022) shows that the Ulan West panels are now proposed to be completed two years earlier than the original MOD6. Ulan Underground is now proposed to be active for an additional nine months.

Table 1.1 Panel commencement dates, Ulan West

| Longwall Panel | Approved (MOD4) Mine Plan  |                          | MOD6A Mine Plan            |                          |
|----------------|----------------------------|--------------------------|----------------------------|--------------------------|
|                | Longwall commencement date | Longwall completion date | Longwall commencement date | Longwall completion date |
| LW08a          | May 2024                   | Feb 2025                 | May 2024                   | Nov 2024                 |
| LW08b          | Mar 2025                   | Jan 2026                 | Jan 2025                   | Nov 2025                 |
| LW09a          | Mar 2026                   | Dec 2026                 | Nov 2025                   | Jun 2026                 |
| LW09b          | Jan 2027                   | Dec 2027                 | Aug 2026                   | Jun 2027                 |
| LW10a          | Jan 2028                   | Oct 2028                 | Jul 2027                   | Jun 2028                 |
| LW10b          | Nov 2028                   | Oct 2029                 | Jul 2028                   | May 2029                 |
| LW11a          | Nov 2029                   | Jul 2030                 | Jun 2029                   | May 2030                 |
| LW11b          | Aug 2030                   | Jul 2031                 | Jul 2030                   | Apr 2031                 |
| LW12a          | Aug 2031                   | Jan 2032                 | May 2031                   | Nov 2031                 |
| LW12b          | Feb 2032                   | Jan 2033                 | Jan 2032                   | Aug 2032                 |

Source: UCMPL, per email (7 November 2023).

Table 1.2 Panel commencement dates, Ulan Underground

| Longwall Panel | Approved Mine Plan         |                          | MOD6A Amended Mine Plan    |                          |
|----------------|----------------------------|--------------------------|----------------------------|--------------------------|
|                | Longwall commencement date | Longwall completion date | Longwall commencement date | Longwall completion date |
| LWW8           | Aug 2023                   | Aug 2024                 | Jul 2025                   | Nov 2026                 |
| LW31           | Sept 2024                  | Sept 2025                | Jan 2024                   | May 2025                 |
| LWW9           | Jan 2026                   | Sept 2026                | Jan 2028                   | Apr 2029                 |
| LW32           | Oct 2026                   | Jul 2027                 | Jul 2027                   | Nov 2027                 |
| LWW10          | Sept 2027                  | April 2028               | June 2030                  | Aug 2031                 |
| LW33           | May 2028                   | Feb 2029                 | Jun 2029                   | May 2030                 |
| LWW11          | Mar 2029                   | Sept 2029                | Oct 2031                   | Nov 2032                 |

Source: UCMPL, per email (11 November 2023).

The model used to assess the potential MOD6A impacts remained unchanged from the one used in the MOD6 assessment, apart from:

- The mine footprint was modified in the model input;
- The model timing was modified to fit with the updated mine plan;
- The post mining recharge to the disturbed areas (open cuts) was modified to reflect proposed post-mining conditions.





## 2 IESC comments

For completeness, the relevant groundwater IESC comments are shown below in Table 2.1 with reference to the additional assessments (Section 3) relating to that comment, where required. Many comments have similar themes and some additional information presented responds to a number of comments at once.

Table 2.1 Groundwater IESC Comments

| Comment Number | IESC Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Response reference                       |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 4              | The proponent has provided limited information about Unnamed Spring (basalt) and Kelly's Spring (Jurassic sandstone), which are located 6 km north of the project area, beyond stating that these springs are recharge-fed (AGE 2022, p. 51). The IESC suggests that the proponent verifies that these springs are fed by perched aquifers and will not be affected by drawdown in the underlying Triassic sandstone aquifers.                                                                                                                                                                                                                                                           | See Section 3.11                         |
| 5              | The adequacy of the assessment of potential impacts to key water features, GDEs and other water users in the project's vicinity varies. The assessment of these impacts to Mona Creek and any associated GDEs is limited, and additional work and information are required.                                                                                                                                                                                                                                                                                                                                                                                                              | -                                        |
| 5a             | Up-to-date field surveys to enable characterisation of potential GDEs in the vicinity of the project. The proponent has stated that "no significant GDEs were identified" (AGE 2022, p. 51); however, the data to support this have not been provided. Impacts to GDEs could arise through subsidence, groundwater drawdown, and groundwater mounding post-mining. More detailed consideration of the individual stressors, and cumulative impacts from multiple stressors, is needed.                                                                                                                                                                                                   | See Sections 3.1                         |
| 5b             | Clear presentation of data collected from the Mona Creek bores is required to establish the baseline groundwater conditions, particularly the depth to groundwater, the extent of the aquifer and groundwater quality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | See Section 3.2                          |
| 5c             | Identification and mapping of persistent pools (AGE 2022, p. 29) and the CEEC (Umwelt 2022a, p. 114) that occur within the Mona Creek area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Refer to IESC Response Document (Umwelt) |
| 5d             | Mapping of the current depth to the water table, overlain with persistent pools and any potential groundwater-dependent vegetation to help understand the likely groundwater dependence as recommended by the peer review of the groundwater model (AGE 2022, App. C1, p. 2)                                                                                                                                                                                                                                                                                                                                                                                                             | See Sections 3.1                         |
| 5e             | Field-based assessments of groundwater dependence (see Doody et al., 2019 for possible methods) of potential GDEs such as Blakely's Red Gum ( <i>Eucalyptus blakelyi</i> ).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | See Sections 3.1                         |
| 5f             | Assessment of potential impacts to stream flow and persistent pools where connected fracturing (or desaturation) reaches the unconsolidated sediments of Mona Creek. Clarification is required of the magnitude of uncertainty that connected fracturing intersects the alluvium below Mona Creek. A hydraulic connection between the dewatered coal seam and the alluvium of Mona Creek is plausible given uncertainty in predictions of the height of connected fracturing above the coal seam (AGE 2022, EPBC Assessment requirements response, Table 3, p. 10). The uncertainty in height of connected fracturing is not shown in Figure 5.24 (AGE 2022, p. 63) (Cross-section B-B). | See Section 3.6                          |
| 5g             | Predicted groundwater drawdown needs to show the maximum drawdown and mounding (spatial extent, magnitude and timing) so that potential impacts can be identified as recommended by the peer review of the groundwater model (AGE 2022, App. C1, p. 2).                                                                                                                                                                                                                                                                                                                                                                                                                                  | See Section 3.5                          |



| Comment Number | IESC Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Response reference |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| 5h             | Assessment of the potential impacts of post-mining groundwater mounding on Mona Creek and associated GDEs and vegetation. This is required as the proponent has predicted that groundwater levels in parts of the Mona Creek area may rise by 10 m (AGE 2022, p. 87). Although current groundwater levels have not been clearly mapped, a rise of 10 m could result in the water table being above the ground surface in some areas as well as posing a risk of adverse effects of waterlogging on vegetation. This rise in groundwater level may also alter the direction and magnitude of surface water-groundwater exchanges in Mona Creek, impacting on hyporheic processes such as carbon processing (Paragraph 18) and nutrient cycling in the saturated sediments.                                                                                                     | See Sections 3.1   |
| 6              | The groundwater model used by the proponent is suitable for the purpose of assessing regional drawdown and take due to the project. However, it is not able to adequately represent the complexity where subsidence and connected fracturing occur beneath Mona Creek or simulate local surface water-groundwater interactions. Issues that need to be addressed are outlined below.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -                  |
| 6a             | The implementation of connected fracturing from subsidence in the groundwater model, and the assessment of potential impacts from this on Mona Creek and potential GDEs within the area of groundwater depressurisation, require further discussion and justification. The current predictions indicate that there will be no constrained zone above the longwall panels and that groundwater depressurisation will be extensive (AGE 2022, p. 87). Further assessment of the uncertainties in the timing and extent of full depressurisation is needed to help ensure that all potentially impacted GDEs can be clearly identified and assessed, including those occurring beyond the project area. Further information to support the parameterisation of the groundwater model and the selection of hydraulic parameters to replicate connected fracturing is also needed. | See Sections 3.1   |
| 6b             | There are no field-derived data for the parameterisation of the Mona Creek sediments. Mona Creek is the key area potentially impacted by this project. Current parameterisation appears to be based on observations from the Talbragar River alluvium and the Goulburn River alluvium (AGE 2022, p. 35) with limited justification provided for this extrapolation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | See Section 3.2    |
| 6c             | The representation of surface water features in the groundwater model requires further justification. Currently, river cells are stated to be able to discharge groundwater but not recharge the groundwater system (AGE 2022, App. A, p. 8) which does not appear consistent with alluvium being identified as a primary source of groundwater recharge (Umwelt 2022a, p. 56). Consideration should also be given to improving the model's spatial discretisation around Mona Creek and its confluence with Talbragar River, given the reported current cell size is 200 m by 200 m (AGE 2022, p. 72). Model results, supported by characterisation and monitoring data (refer to Paragraphs 5b, 5c, 5d, 5e and 6b) should be reported specifically for the Mona Creek area.                                                                                                 | See Section 3.3    |
| 7              | Model calibration has appropriately utilised the available groundwater level and pressure monitoring data. The IESC suggests that the calibration results be presented to identify any trends in calibration adequacy spatially or within hydrostratigraphic layers. Additionally, where available, existing baseflow data should be used as a calibration check for groundwater-surface water connectivity. If measured underground mine inflows are available for different sections of the mine (AGE 2022, p. 163), these could be used in the calibration process as a check on flux predictions.                                                                                                                                                                                                                                                                         | See Section 3.9    |
| 8              | Conceptualisation of the groundwater system at the project site appears consistent with previous versions of the groundwater model (AGE 2022, p. 59). However, further information is required on the following points:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | -                  |
| 8a             | The conceptualisation of the Mona Creek perched groundwater system occurring in a series of disconnected lenses which are charged following rainfall (AGE 2022, pp. 28-29);                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | See Section 3.2    |

| Comment Number | IESC Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Response reference                       |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 8b             | The applied recharge rates specific to hydrostratigraphic units, using approaches such as environmental water tracers (OWS 2020). Evidence should be provided to justify the large differences in assumed recharge rates in different areas (e.g., to alluvium and colluvium and through spoil); and                                                                                                                                                                                                                                                                                                                                                                                                                                                | See Section 3.7                          |
| 8c             | The adopted hydraulic conductivity values and ranges, especially vertical hydraulic conductivities, to demonstrate consistency with the presented conceptualisation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | See Section 3.8                          |
| 9              | Uncertainty analysis was undertaken using a calibration-constrained Monte Carlo approach (AGE 2022, p. 101). The IESC notes that the reported uncertainty analysis has not fully explored potential worst-case impacts on groundwater resources. The following improvements to the uncertainty analysis are suggested:                                                                                                                                                                                                                                                                                                                                                                                                                              | -                                        |
| 9a             | Parameter ranges for storage and recharge should be explored and reported;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | See Section 3.5                          |
| 9b             | The range of results for baseflow changes and mounding should have been reported as recommendation by the peer review of the groundwater model (AGE 2022, App. C1, p. 2). These are some of the key impacts associated with this project and the range of potential outcomes should be clearly communicated; and                                                                                                                                                                                                                                                                                                                                                                                                                                    | See Section 3.5                          |
| 9c             | There should be justification for the number of realisations and whether they are sufficient, noting also that there is some inconsistency in reporting the number of adequately calibrated realisations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | See Section 3.5                          |
| 10             | Potential effects of climate change were explored through additional model runs using different recharge rates derived from predicted changes to precipitation under the selected climate change scenario of RCP4.5 (AGE 2022, EPBC Assessment requirements response, p. 2). The IESC recommends that this analysis be expanded with reference to RCP8.5. Understanding the potential effects of climate change on the predicted impacts of this project is important given the long time over which impacts will continue to be observed (potentially thousands of years, e.g., AGE 2022, Table 8.6, p. 99), and that climate change is likely to have an effect on the magnitude of mounding, the key long-term potential impact of this project. | See Section 3.4                          |
| 11             | The groundwater assessment predicts changes to surface water and groundwater interactions. However, the IESC has identified several limitations of this assessment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -                                        |
| 11a            | a. The project is predicted to increase baseflow losses in the Talbragar River and its tributaries, including Mona Creek, above the levels already approved (Umwelt 2022a, p. 56). These losses are likely to affect ecologically important components of the flow regime (e.g., increases in the number of low- or no-flow days), with subsequent impacts on aquatic and riparian biota, especially if refugial pools (AGE 2022, p. 59) are lost. However, as discussed in Paragraph 7, these baseflow losses are not adequately simulated by the current model. Furthermore, the proponent should quantify the ecological effects of these impacts                                                                                                | See Sections 3.1                         |
| 11b            | There are areas where the Ulan Seam sub-crops to the Talbragar River Alluvium (AGE 2022, p. 73). These areas should be identified, mapped and potential impacts discussed further given that it is predicted that drawdown in the Ulan Seam will extend under large areas of the Talbragar Alluvium (see AGE 2022, Figure 7.5, p. 81).                                                                                                                                                                                                                                                                                                                                                                                                              | See Section 3.13                         |
| 11c            | Limited discussion has been provided on the effects of the predicted long-term groundwater mounding (post-mining) on surface water. The ecological impacts of reducing baseflow during operations, followed by increasing baseflow post-mining require further assessment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | See Sections 3.1                         |
| 12             | As stated in Paragraph 6a, an integrated approach to surface water and groundwater assessments is required.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Refer to IESC Response Document (Umwelt) |



| Comment Number | IESC Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Response reference                                                                                                                                                                                                                                                 |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13             | The proponent has provided limited groundwater quality monitoring data (pH, EC, major ions) for this assessment. The IESC notes that additional monitoring (e.g., metals) has occurred in line with the proponent's Groundwater Monitoring Plan and suggests that the proponent provide these data. This will enable pre-project conditions to be established and facilitate understanding of any potential changes to groundwater quality that may occur associated with subsidence and predicted post-mining mounding.                                                                                                                                                                                                                                                                     | See Section 3.2                                                                                                                                                                                                                                                    |
| 17             | The proponent has, in the context of the groundwater impact assessment, provided some conceptual and impact pathway information (AGE 2022, pp. 59-71). However, this analysis could be expanded through the inclusion of suitably geo-referenced ecohydrological conceptual models and associated impact pathway diagrams. These would provide a useful overview of potential impacts, including cumulative ones, that may potentially occur due to this project, and clearly link groundwater, surface water and subsidence impacts to potential ecological responses (e.g., adverse effects on GDEs, persistent pools, aquatic biota, riparian vegetation). These conceptual models would also help to identify and justify where further monitoring and mitigation measures are required. | See Section 3.12                                                                                                                                                                                                                                                   |
| 18             | The groundwater model has included approved mining at Ulan Coal Mine Complex and the adjacent mines of Moolarben and Wilpinjong. However, the assessment of cumulative impacts is limited and does not adequately consider surface and groundwater interactions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Cumulative impacts from Ulan and Moolarben are simulated in the groundwater model.<br>The groundwater modelling incorporates the influence of surface drainage on the groundwater system at an appropriate level, capturing the potential impacts from both mines. |
| 18a            | The impacts on water-dependent ecological assets from the combination of drawdown and subsidence are not considered. There is also no adequate assessment of the cumulative impacts of an initial reduction in water levels followed by long-term and potentially considerable increases (mounding) in water levels, especially on vegetation that may experience waterlogging and substantially altered redox conditions in the root zone.                                                                                                                                                                                                                                                                                                                                                  | See Sections 3.1                                                                                                                                                                                                                                                   |
| 18b            | Potential cumulative impacts to surface water and groundwater interactions, and changes to these, are not assessed, particularly in the context of effects on ecologically important components of flow regimes or changes to directions and/or magnitudes of surface water-groundwater exchanges in the hyporheic zone of Mona Creek when it is flowing or a string of pools. The hyporheic zones of ephemeral streams have been shown to be active zones for carbon processing (Burrows et al., 2017) and may also support diverse invertebrate and microbial communities that contribute to ecosystem resilience (Bruno et al., 2020).                                                                                                                                                    | In regard to Mona Creek the only baseflow that is predicted to occur is near the confluence with the Talbragar River, well north of the proposed additional mining footprint.                                                                                      |
| 18c            | The cumulative drawdown predictions for the Ulan Seam extend beyond the boundaries of the groundwater model (AGE 2022, Figure 7.9, p. 86), which reduces confidence in these predictions as they are likely to be influenced by the boundary conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | See Section 3.5                                                                                                                                                                                                                                                    |
| 21             | The project did not provide details of avoidance or mitigation strategies in relation to groundwater impacts. The project should aim to return groundwater levels to pre-mining conditions by changing the design of the final landform as discussed in AGE (2022, EPBC assessment requirements report, p. 9). For example, the possibility of groundwater mounding could be mitigated by design of spoil to control recharge rates. Management plans and a trigger action response plan (TARP) are currently in operation for approved mining and will likely be extended to include this project. Potential improvements to these plans are discussed in the response to Question 5.                                                                                                       | See Section 3.12                                                                                                                                                                                                                                                   |

| Comment Number | IESC Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Response reference                       |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 24             | Monitoring and mitigation actions for groundwater impacts at existing approved operations in the Ulan Coal Complex include the use of a TARP, which is detailed within the Surface Water and Groundwater Response Plan. The IESC notes that the current plan will require review and updating to incorporate the proposed project. This should include:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | -                                        |
| 24a            | An analysis of the current groundwater conditions (level/pressure and quality) to enable the derivation of robust site-specific guideline values (or triggers) for use in the updated TARP; and                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Refer to IESC Response Document (Umwelt) |
| 24b            | Groundwater quality sampling is currently undertaken annually. At bores where site-specific guideline values are used, the frequency of sampling will need to be increased to ensure the associated TARP functions in a timely manner                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Refer to IESC Response Document (Umwelt) |
| 25             | The proponent states that 'there is predicted to be some drawdown in parts of the Talbragar alluvium, however, the drawdown is not expected to fully desaturate the alluvium therefore no significant impacts are expected on stygofauna' (AGE 2022, p. 100). The proponent has not provided any data to support this claim, despite being required to provide a stygofauna assessment in the alluvium and colluvium of Mona Creek and the Talbragar River as part of the Department of Climate Change, Energy, the Environment and Water's assessment requirements (Umwelt 2022a, p. 124). If a baseline survey indicates the presence of stygofauna, then the proponent should continue monitoring during operations, particularly targeting the Talbragar River alluvium. The program should include monitoring for changes in groundwater level and species diversity and abundance of stygofauna. | Refer to IESC Response Document (Umwelt) |
| 26             | The proponent has not adequately characterised the remnant riparian vegetation along Mona Creek or its likely dependence on groundwater. Due to the predicted groundwater drawdown and post-mining groundwater mounding impacts along Mona Creek, the IESC suggests that the proponent conducts field surveys, including ground-truthing for riparian vegetation and potential GDEs (including Blakely's Red Gum which is a component of the EPBC Act-listed CEEC) along Mona Creek. Information from this survey can then be used to inform the development of a monitoring plan to identify any changes to vegetation composition or condition due to impacts from the project.                                                                                                                                                                                                                      | Refer to IESC Response Document (Umwelt) |
| 30             | Maps clearly showing the hydrostratigraphic target of monitoring bores should be provided to ensure all monitoring bores and cumulative impact monitoring are accurately represented and consistent across relevant figures (see AGE 2022, Figure 5.5, p. 38).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | See Section 3.10                         |

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## 3 Additional assessments

The following sections provide details on the additional work undertaken and additional information extracted from the groundwater model in response to the feedback provided in the IESC Advice (IESC, 2023) which is summarised in Table 2.1. The sections also reference the specific numbered comment of the IESC Advice that is being addressed by the response.

### 3.1 Depth to water table (5a, 5d, 5e, 5h, 6a, 11a, 11c, 18a)

The groundwater modelling has predicted groundwater level change throughout the life of operations at UCC, starting with pre-mining water levels (steady state conditions prior to mine dewatering), through the active mining phase (conditions at the end of mining), and through to post-mining equilibrium (conditions at a steady state timestep, post-recovery, that incorporates changes in recharge and hydraulic properties due to mining). The post-mining equilibrium conditions simulated in the original MOD6 assumed that most of the open cut areas at the UCC and neighbouring Moolarben mines are voids partially backfilled with spoil, with the UCC's East Pit void maintained at a water level of 359 metres Australian Height Datum (mAHD). This assumption resulted in a heightened recharge rate in the surface disturbance areas, contributing to post-mining recovery, in addition to rainfall-driven recharge across the overlying strata.

The heightened recharge from the void and spoil areas allowed the groundwater levels to recover above the pre-mining water levels (Figure 3.1). These predictions have been presented in the original GIA (AGE, 2022) however the full context was not presented. Given the predicted post-mining equilibrium water levels were more than 20 m above pre-mining levels, it is understandable that the IESC had concerns relating to the potential for water being close to the surface, if not expressing at the surface, and causing waterlogged conditions.

When the post-mining equilibrium predictions of groundwater level were first reviewed, comparisons were made to the ground surface elevation, however the results did not form part of the reporting in the GIA. For the MOD6A mine plan, these comparisons identified that even with the upper range of the post-mining recharge, there were only limited areas where the predicted depth to water table was within 2 m of the ground surface, which were generally along surface drainage lines (Figure 3.2).

The original assumptions around post-mining conditions in the open cut areas in the MOD6 GIA (AGE, 2022) have been revised with the current MOD6A mine plan (AGE, 2024). The assumption under the MOD6A mine plan is that the open cut areas will be backfilled post-mining and the full results for the MOD6A groundwater model, including post-mining assumptions, are presented in AGE (2024). The depth to water table results for MOD6A are presented in Figure 3.1 at key stages in the lifetime of the model. The post-mining equilibrium conditions predict a mixture of slight mounding in some areas but also residual drawdown in others (see Section 3.12).

There are areas where the pre-mining depth to water table is less than 2 m below ground level (mbgl) (Figure 3.2). These areas are mostly along surface drainages and in alluvial sediments. At the end of mining, these areas south of the mine retract, as expected, then expand again during recovery through the post-recovery stage, notably around the open cut areas which have been simulated as backfilled with spoil (still with higher recharge rates than surrounding native landscape but less than when represented as open cut as in MOD6). Figure 3.2 highlights these areas where the depth to water table is less than 2 mbgl, particularly the backfilled open pits in the southeast. The depth to water table along the Talbragar River is generally less than 2 mbgl but unchanged through the mining stages.

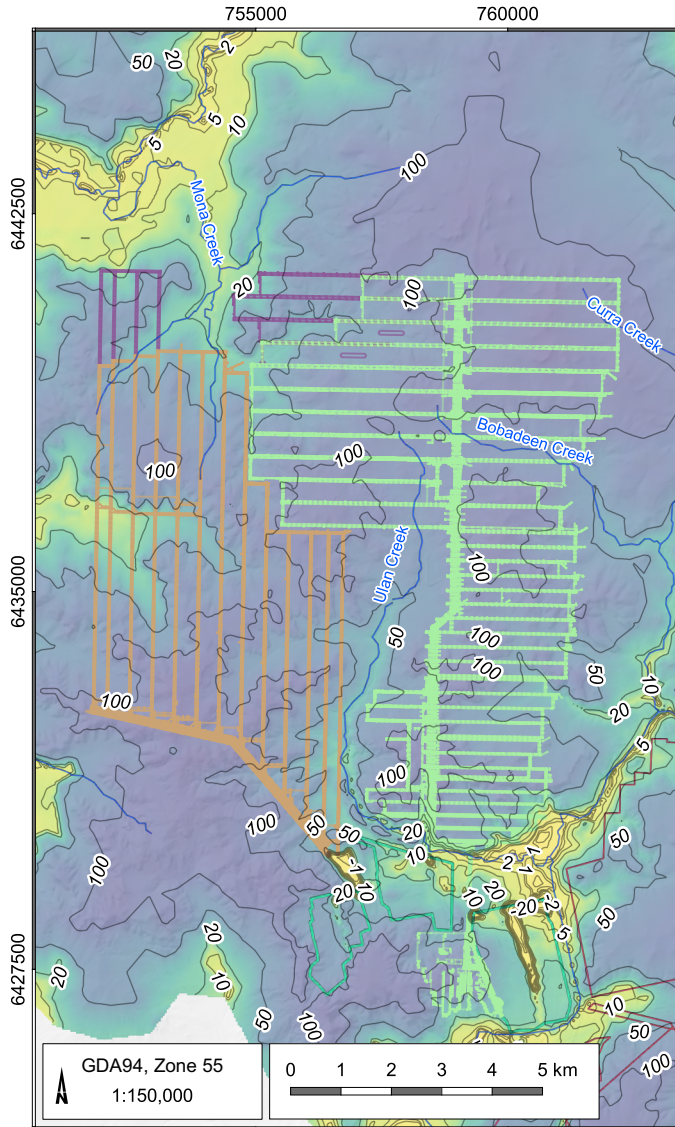
Regional groundwater levels are also well below Mona Creek, generally 10 to 20 m depth below the land surface (Figure 3.1 and section 3.2). These results support the Bureau of Meteorology (BOM) GDE Atlas<sup>1</sup> mapping of terrestrial vegetation in the Mona Creek areas having low potential of being a GDE (Figure 5.19 in the GIA [AGE, 2022]). Pre-mining and during mining, there is no predicted baseflow to Mona Creek from the regional water table (Figure 3.2).

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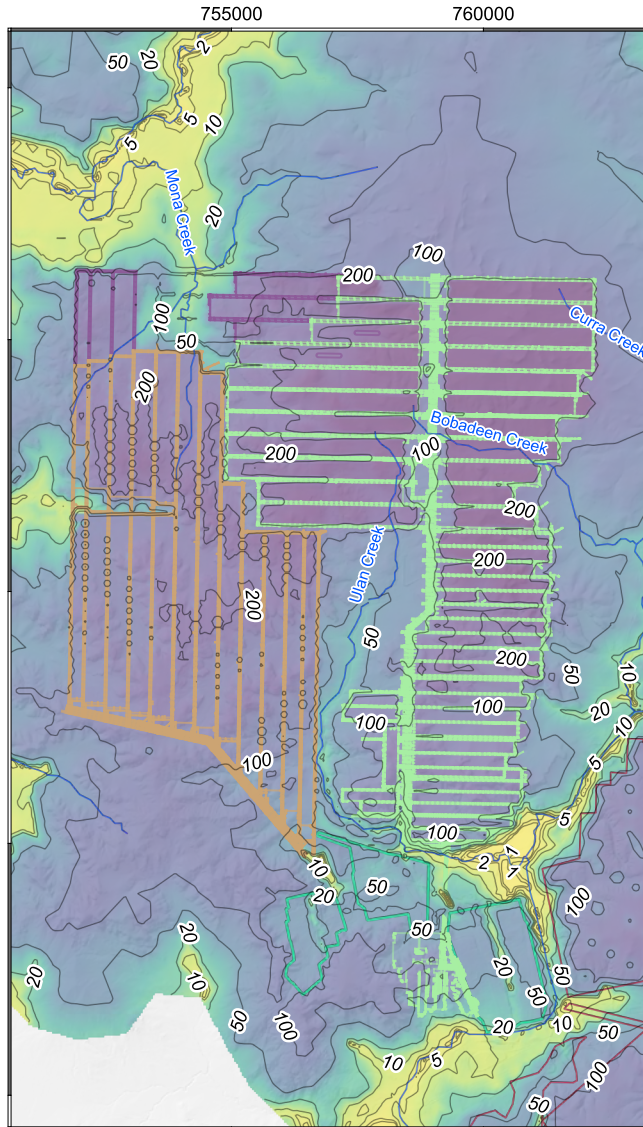
<sup>1</sup> <http://www.bom.gov.au/water/groundwater/gde/map.shtml>.



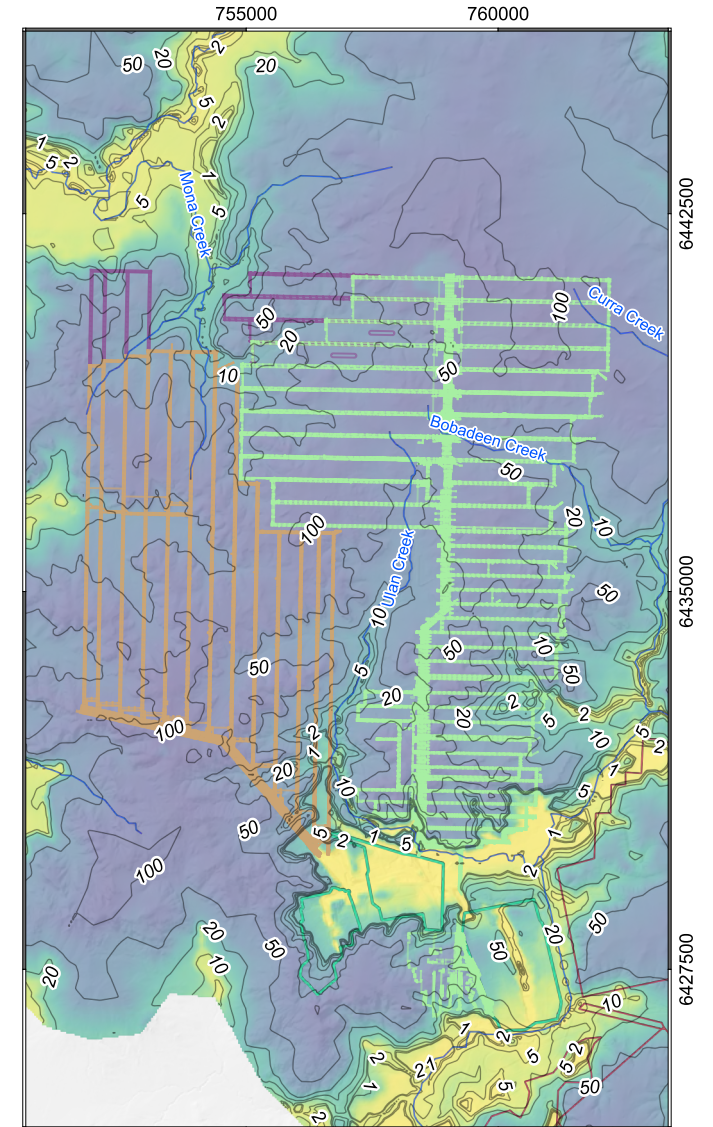
## Pre - mining



## Post - mining



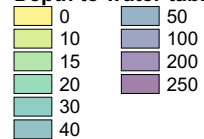
## Post - recovery



### LEGEND

- Drainage
- Contour line
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Moolarben mine area
- Ulan open cut

### Depth to water table (m)



Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

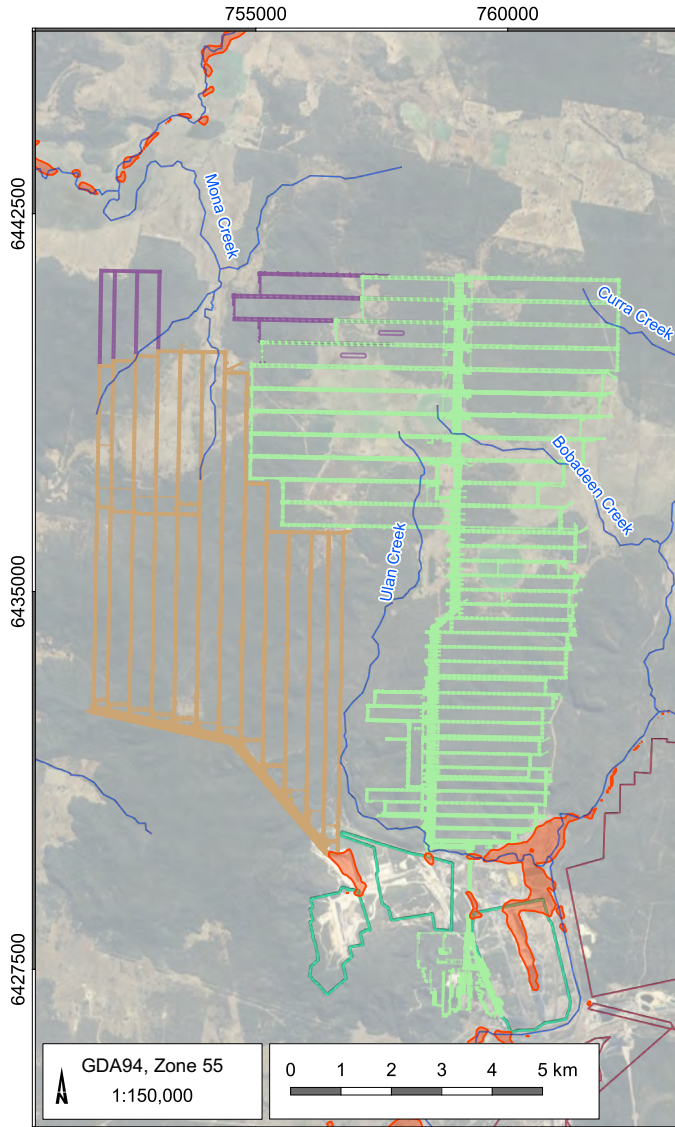
**Predicted depth to water table for key stages of MOD6A mine plan**

DATE  
03/05/2024

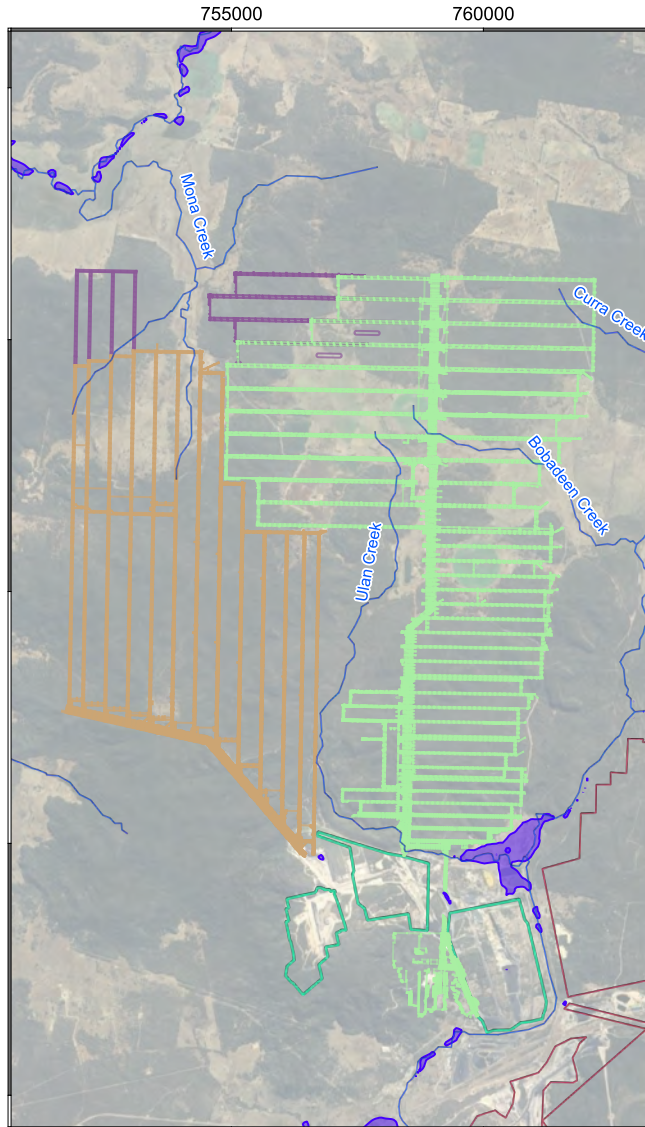
FIGURE No:  
**3.1**



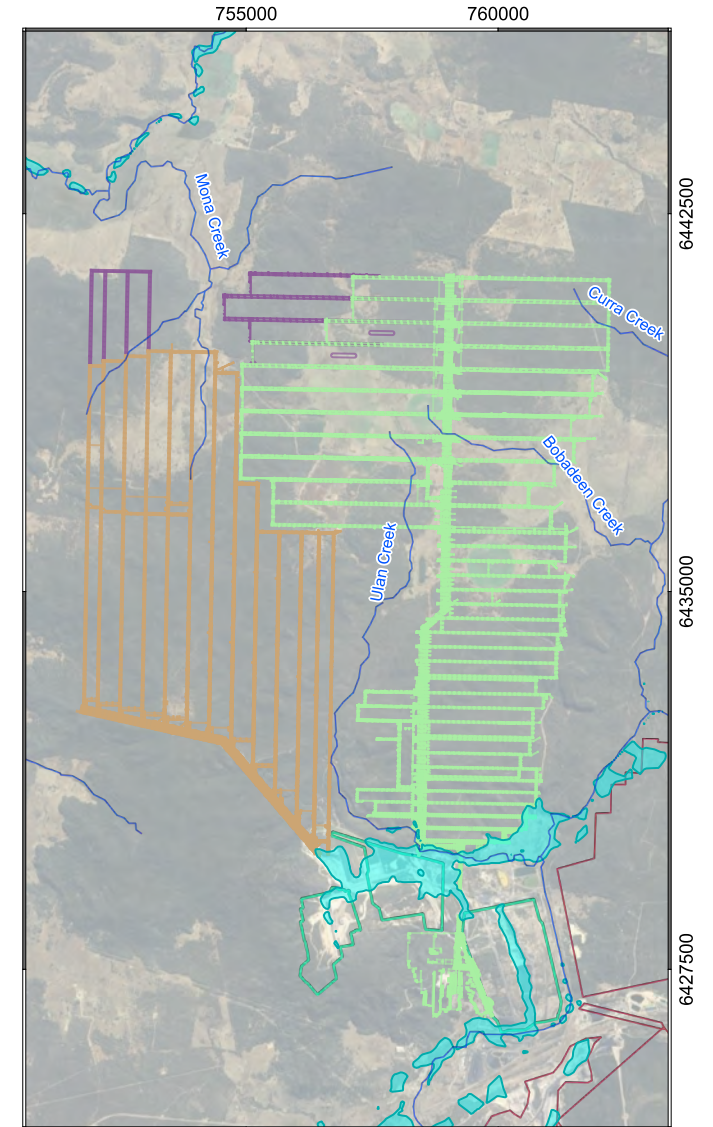
## Pre - mining



## Post - mining



## Post - recovery



### LEGEND

- Drainage
- Contour line
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Moolarben mine area
- Ulan open cut

### Depth to water table (m)

- Depth to water table <2 m (Pre-mining)
- Depth to water table <2 m (Post-mining)
- Depth to water table <2 m (Post-recovery)



Ulan MOD6A Groundwater Assessment - IESC  
response (UCM5032.001)

**Predicted depth to water table less  
than 2 m for key stages of the MOD6A  
mine plan**

DATE  
03/05/2024

FIGURE No:  
**3.2**

### 3.1.1 Impacts on the Talbragar River

The MOD6A groundwater model predicts that the areas identified as having the depth to water table less than 2 m along the Talbragar River alluvium will remain the same at post-recovery equilibrium as at pre-mining conditions. The post-recovery equilibrium water levels in the area of Mona Creek, and more-specifically from approximately the location of bore MCMB01 (see Figure 3.4 for bore location) downstream to the confluence with the Talbragar River, is not expected to reach within 2 mbgl and little change to the depth to water table along the Talbragar River is predicted (see Figure 3.2). Based on the observations presented in Figure 3.2, and the inferred separation between the shallow Mona Creek colluvium aquifer and the deeper bedrock aquifer, it is difficult to estimate how the post-recovery equilibrium regional groundwater regime will affect the Mona Creek shallow aquifer but it is largely unaffected by the MOD6A mine plan.

The groundwater model over-cautiously predicts that parts of the colluvium will have residual drawdown under the currently approved mine plan. However, based on satellite imagery and site visits, there does not appear to be considerable phreatophyte vegetation along Mona Creek. Based on the ecological assessment, riparian vegetation observed along Mona Creek, including areas adjacent the additional underground mining areas associated with MOD6A, is limited to groundcover species only and there are no trees or shrub layer present other than in one small area upstream of site MCMB03 (see Figure 3.4 for bore site location). The mapped grasslands are not classified as a groundwater-dependent community.

The existing depth to water table in the area where woodland is mapped (discussed further in Section 3.2 below) indicates the regional water table is greater than 10 mbgl and is likely below the rooting depth of these riparian trees. Monitoring from the MCMB01 nested bores suggests the vegetation in the upper catchment of Mona Creek may utilise shallow groundwater in the unconsolidated sediments, but also indicates this shallow groundwater is disconnected from the regional groundwater regime (see Section 3.2). Therefore, aquatic and hyporheic ecosystems within the Mona Creek environment (including those related to base flow and refugial pools) will be unaffected by the changes in regional water table associated with mining under MOD6A in this area.

## 3.2 Mona Creek groundwater monitoring (5b, 6b, 8a, 13)

The Mona Creek monitoring bores (MCMB) are a group of six monitoring bores installed in 2020 nearby to Mona Creek in the northern extent of the UCC Project Area boundary (see Figure 3.4). The bores were installed at three locations each consisting of one bore installed into unconsolidated sediments and one into the Triassic strata. The bores are identified by prefix “MCMB” followed by a numeric identifier (e.g. “01”) then a letter to identify if it is completed into shallow sediments (“A”) or bedrock (“B”). MCMB bore location and construction information are provided in Table 3.1 and details on bore installation can be found in AGE (2021).

These bores were installed with the purpose of characterising the nature of groundwater movement in the surficial unconsolidated material and the extent that the surficial aquifer is connected to the deeper Triassic bedrock aquifer. Initial assessment of the Mona Creek groundwater flow regime by AGE (2021) proposed a conceptual hydrogeologic model of the unconsolidated groundwater regime as a perched aquifer system where groundwater is recharged primarily from rainfall and constrained from deeper percolation into the bedrock by the presence of clay and weathered regolith that forms the base of the unconsolidated sediments.

The MCMB bores have been measured quarterly since 2021 and water levels are typically around 4 to 7 mbgl in MCMB01A, 13 to 15 mbgl in MCMB03A and B, and 4 to 6 mbgl in MCMB04A and B. When adjusted to elevations, groundwater levels are highest in MCMB01 and lowest in MCMB04 (Figure 3.3). This trend follows the land surface elevation of the bores and Mona Creek and implies that groundwater is flowing roughly parallel to Mona Creek. Bore MCMB01B has been reported as dry since it was installed. Bore MCMB03A was reported as dry at times in 2021, 2022, and 2023 but otherwise reports groundwater levels within 1.5 m from the bottom of the bore.

Groundwater level differences between shallow and deep bores are used to infer the level of connection between the unconsolidated sediments and bedrock aquifers. Since there is no data from MCMB01B, only MCMB03 and MCMB04 sites can be compared in this fashion, however the fact that the deeper bore at MCMB01 is dry while the shallow bore has water demonstrates the perched nature of the colluvial sediments.

Groundwater level differences in MCMB03 begin in 2021 as negative, with the shallow bore (MCMB03A) reporting groundwater levels slightly below the bedrock bore (MCMB03B) (Figure 3.3). The maximum difference in 2021 is 0.25 m. Since 2022, however, the direction changes and the shallow bore reports higher groundwater levels than the bedrock bore, with a maximum difference of 0.6 m at the end of 2022. There are only two measurements in MCMB03A in 2023 but groundwater levels are still above MCMB03B. Groundwater level differences in the MCMB04 paired bores show very similar groundwater level elevation through the data set, with differences less than 0.1 m and MCMB04B above MCMB04A (not shown).

Figure 3.3 also shows the potentiometric surface of the VWP array for DDH598 along with the water levels in MCMB03A and B. VWP array DDH598 is located approximately 600 m away from the MCMB03 bore location and upstream with respect to Mona Creek. The surface elevations of MCMB03 and DDH598 are 445 m and 437 m, respectively. Despite being located downstream, MCMB03 bores are located on an elevated hillock adjacent to Mona Creek and, therefore, the elevations of the base of MCMB03B and the DDH598\_30m sensor in DDH598 are considerably different: 415 mAHD for MCMB03B and 407 mAHD for DDH598\_30m. Comparison of groundwater level elevations between the bores and the VWPs indicates a significant separation between the monitoring bores and the shallow VWPs. The three shallowest VWPs all show similar phreatic surface elevations (within 2 m) and very similar trends of gently declining porewater pressure. The MCMB03 bores show a considerably different trend with only a slight decline between 2021 and 2023, and water levels approximately 6 m higher than the VWPs. This suggests that the MCMB03 bores are recording water levels in a shallow, perched, aquifer that is separated from the regional groundwater flow regime measured by the VWPs, which is also supported by the dry deeper bore at MCMB01.

Limited water quality data is available from the MCMB monitoring bores and trigger levels are yet to be derived. These monitoring sites will be added to UCMPL's monitoring network with groundwater level triggers to be derived by statistical analysis or by evaluation against the latest groundwater model results. Groundwater quality measured across the site is presented in annual reviews that UCMPL supply to the NSW Department of Planning and Environment (most recently AGE 2024b).

Table 3.1 Mona Creek monitoring bore summary

| Hole ID | Target unit              | Easting* (m) | Northing* (m) | Collar elevation (mAHD) | Total depth (mBGL) | Screen depth (mBGL) | Gravel pack (mBGL) | Bentonite seal (mBGL) | Grout seal (mBGL) | Stick up height (m) | Completion date | Groundwater level (mBGL) | Date of water level |
|---------|--------------------------|--------------|---------------|-------------------------|--------------------|---------------------|--------------------|-----------------------|-------------------|---------------------|-----------------|--------------------------|---------------------|
| MCMB01A | Unconsolidated sediments | 754407       | 6439482       | 456.42                  | 6.37               | 3.4 - 6.4           | 2.6 - 6.4          | 1.2 - 2.6             | 0 - 1.2           | 0.74                | 29/09/2020      | 2.36                     | 26/04/2021          |
| MCMB01B | Sandstone                | 754399       | 6439484       | 456.53                  | 30.45              | 24.5 - 30.5         | 21.7 - 30.5        | 19.5 - 21.7           | 0 - 19.5          | 0.73                | 29/09/2020      | Dry <sup>†</sup>         | 26/04/2021          |
| MCMB03A | Unconsolidated sediments | 754216       | 6441099       | 445.17                  | 14.00              | 8.0 - 14.0          | 5.0 - 14.0         | 4.0 - 5.0             | 0 - 4.0           | 0.84                | 04/10/2020      | 10.70                    | 26/04/2021          |
| MCMB03B | Sandstone                | 754222       | 6441097       | 444.82                  | 30.00              | 24.0 - 30.0         | 22.0 - 30.0        | 19.0 - 22.0           | 0 - 18.0          | 0.65                | 04/10/2020      | 10.60                    | 26/04/2021          |
| MCMB04A | Unconsolidated sediments | 753967       | 6443249       | 434.72                  | 9.70               | 6.7 - 9.7           | 5.9 - 9.7          | 4.3 - 5.9             | 0 - 4.3           | 0.70                | 30/10/2020      | 5.99                     | 26/04/2021          |
| MCMB04B | Sandstone                | 753968       | 6443241       | 434.79                  | 17.30              | 14.3 - 17.3         | 12.5 - 17.3        | 10.4 - 12.5           | 0 - 10.4          | 0.75                | 29/10/2020      | 5.89                     | 26/04/2021          |

**Notes:** \* Geocentric Datum of Australia 1994, zone 55.

mAHD: metres Australian Height Datum.

mBGL: metres Below Ground Level.

Collar elevation: refers to the elevation of the top of the bore monument in closed position.

Stick up height refers to the top height of PVC above ground.

Completion date: refers to the date by which final construction was completed.

<sup>†</sup> MCMB01B was measured to be dry on 26/04/2021. The bore initially had a water level of 29.99 mtoc (metres top of PVC casing) following development on 29/09/2020.



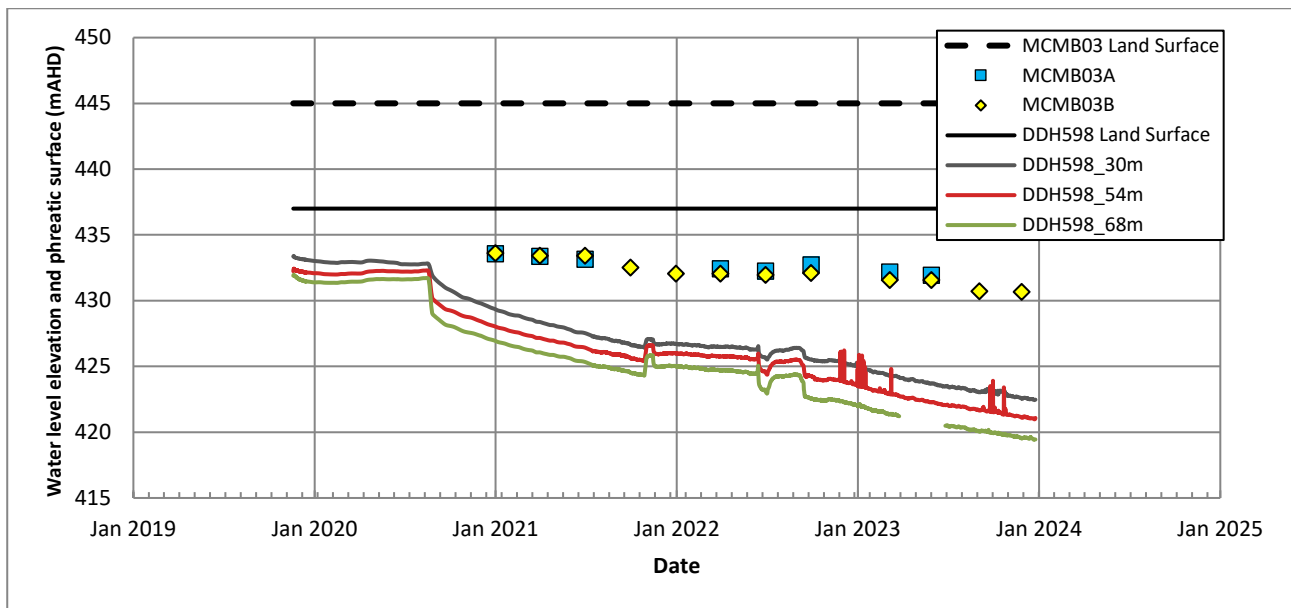
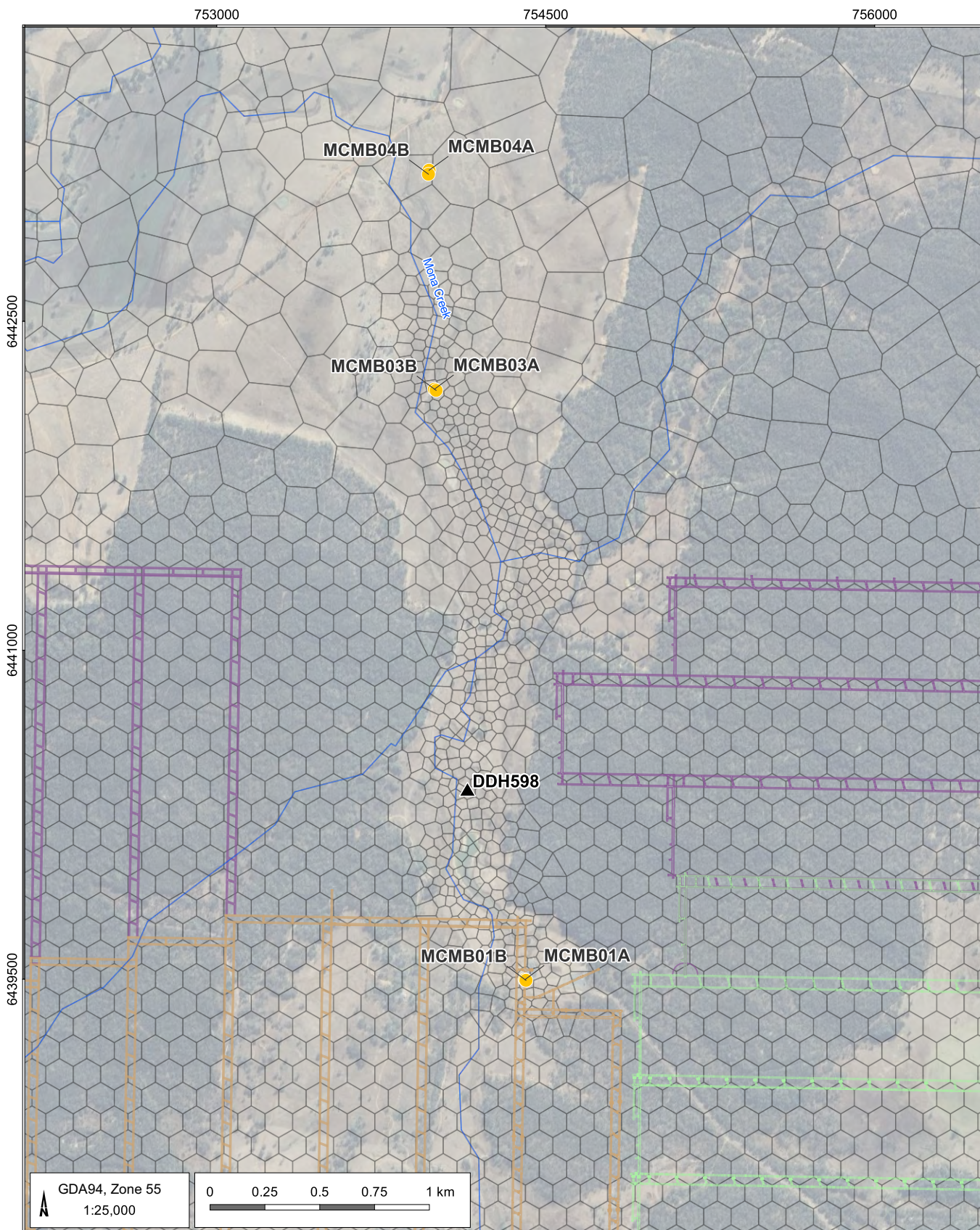


Figure 3.3 Groundwater level and phreatic surface for Mona Creek monitoring bores and VWP site DDH598

### 3.3 Mona Creek model mesh resolution (6c)

The model mesh has been refined around the Mona Creek area to help with delineation of impacts. This was in the MOD6 model previously (and maintained in the MOD6A model), but not highlighted in the GIA (AGE 2022). The creek has been represented by model cells which are 50 m across and then increase in size up to the resolution across the underground mining area at approximately 125 m. The refinement around Mona Creek provides better spatial resolution, which assists in providing better vertical resolution of the creek bed and better representation of the true land surface. Figure 3.4 shows the refinement in the model mesh representing Mona Creek.

The model represents river interaction through the MODFLOW-USG River (RIV) package. The model cell size is less important as the specified RIV conductance term incorporates the dimensions (i.e. length and width) of the stream channel within the model cells and assigns the appropriate interaction with groundwater within the model cell. While smaller cell size does provide better resolution, the model predictions continue to indicate that baseflow is occurring north of the original MOD6 and amended MOD6A proposed longwall panels.



#### LEGEND

- Drainage
- MCMN Bores
- ▲ DDH598
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Model mesh
- Moolarben Mine Plan
- Ulan Open Cut

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Model mesh detail around Mona Creek



**AGE**

DATE  
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FIGURE No:  
**3.4**



### 3.4 Climate change predictions (10)

The groundwater model was calibrated using historical rainfall and future predictions based on the long-term averages of the historical data. Since the future rainfall is calculated from historic data, this assumption does not account for potential climate change.

To address impacts from climate change, several model runs were undertaken under different future climate scenarios. These model runs were set up to be consistent through the mining phase, then employ different recharge rates across the post-mining and post-recovery equilibrium phases. The different recharge rates were sourced from predicted changes in rainfall from climate change modelling.

There are several climate models available, and the RCP-8.5 case for the Central Slopes is adopted as the most relevant. In terms of rainfall, the climate model provides an estimate of the percent of increase or decrease in annual rainfall total at various times in the future. Three model runs were undertaken adopting the predicted annual rainfall change percentage in 2090 across the recovery period, covering the most likely 50<sup>th</sup> percentile, and the extremes at 90<sup>th</sup> and 10<sup>th</sup> percentiles as shown in Table 3.2 below.

Table 3.2 Simulated changes to rainfall input due to climate change

| Model   | Percentile of prediction | Predicted change in rainfall at 2090 |
|---------|--------------------------|--------------------------------------|
| RCP-8.5 | 10 <sup>th</sup>         | Reduced by 22.98 %                   |
| RCP-8.5 | 50 <sup>th</sup>         | Reduced by 5.91 %                    |
| RCP-8.5 | 90 <sup>th</sup>         | Increased by 17.59 %                 |

The simulations for climate change predictions were run over a 500-year window post mining as this comparison with different climate change predictions was considered appropriate for this period of time. The model was initially run through to 2090 in line with the source predicted changes in rainfall, but there was no discernible difference between the various climate scenarios, so this model was extended to represent 500 years post mining (2532) of recovery to allow differences to be identified and quantified.

The change in rainfall, which affects recharge rates, ultimately results in changes to the level of residual drawdown and mounding predicted in the model during recovery. Figure 3.5 through Figure 3.9 present the changes in the predicted 2 m and 5 m drawdown contours under the different recharge scenarios after 500 years of recovery. These figures show that the level of impact associated with potential climate change from the RCP-8.5 model does not significantly change the predicted 2 m and 5 m drawdown and mounding patterns.

MOD6A reporting included recovery predictions for the long-term equilibrium conditions generated from a steady state solution appended as the last stress period of the model. An attempt was also made to apply the various climate scenarios to this steady state stress period, but the steady state solution only requires that volumetric inputs and outputs are equal. Thus the results between water levels from the various climate scenarios were found to be highly non-linear and, although the model will find viable solutions for each climate scenario, the solutions were not consistent. The 500 year method, however, provided consistent and intuitive results and thus was adopted.

The variability in results was further impacted by the majority of recharge driving the recovery occurring in the spoil at the open cut areas of the UCC, which are at the southern end of the mined footprint. The bulk of the recharge to the northern area of the mine footprint is water that enters at the open cut and then flows north through the coal seam and mined goaf.

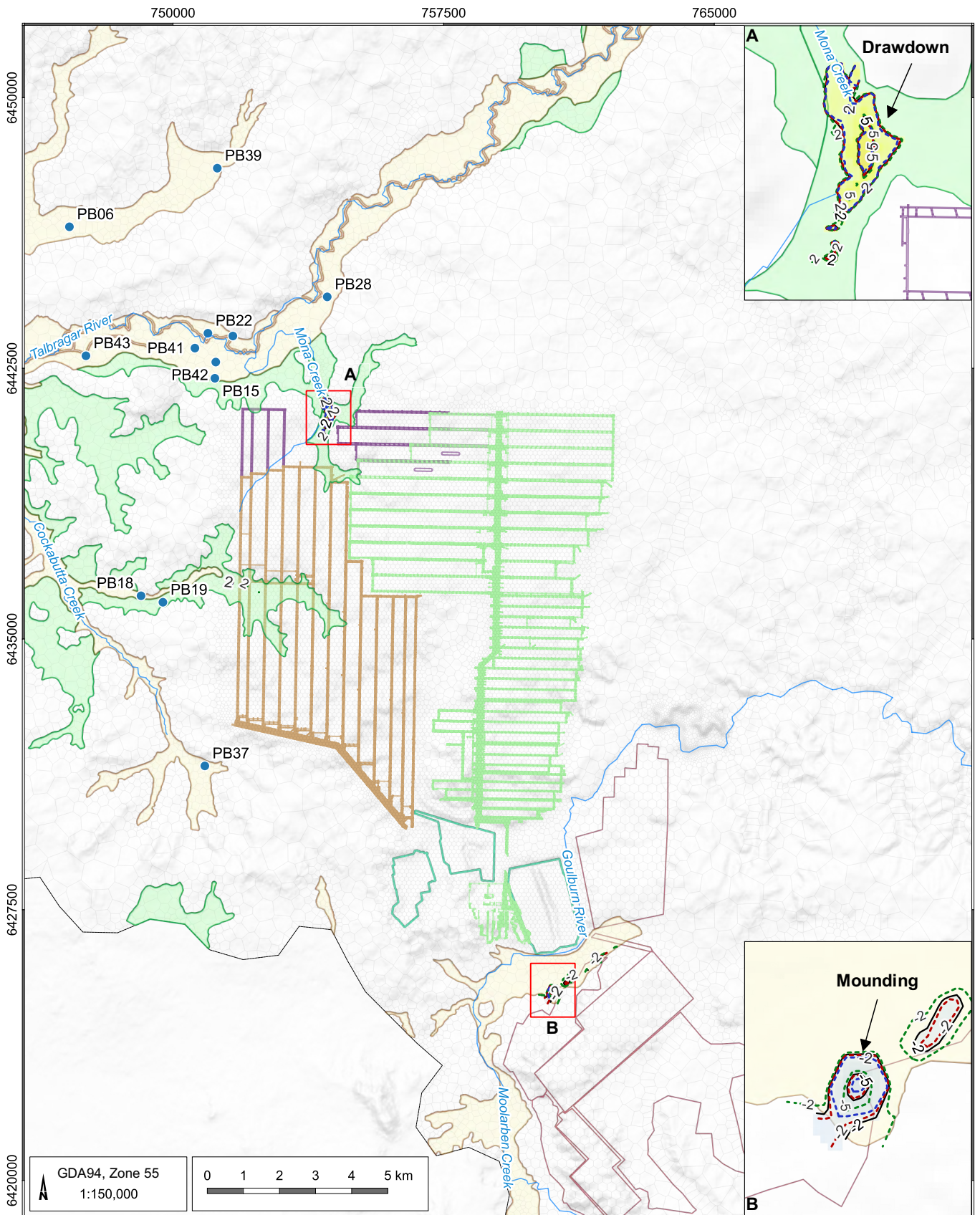
The change in drawdown and mounding also changes the amount of baseflow predicted to occur during recovery. Baseflow changes are presented in Table 3.3 for the Goulburn and Talbragar rivers (including modelled tributaries) within the model domain after 500 years of recovery.

Table 3.3 Predicted baseflow changes in climate change scenarios

| Case                        | % Change in rainfall  | Increase in Baseflow for<br>Goulburn River and tribs<br>(ML/year) | Increase in Baseflow for<br>Talbragar River and tribs<br>(ML/year) |
|-----------------------------|-----------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|
| Basecase                    | no change             | 25.8                                                              | -28.2                                                              |
| 10 <sup>th</sup> Percentile | Reduced by 22.975 %   | 4.3                                                               | -28.4                                                              |
| 50 <sup>th</sup> Percentile | Reduced by 5.91 %     | 20.7                                                              | -27.7                                                              |
| 90 <sup>th</sup> Percentile | Increased by 17.588 % | 46.4                                                              | -24.5                                                              |

The key aspect of these results is that simulation of the RCP-8.5 climate model produces some minor changes to the extent of post-recovery drawdown (or mounding) in the model domain but results in even more variation in baseflow rates. This indicates that the baseflow, or more specifically the discharge of groundwater to surface drainages, is controlling the extent of mounding and is more directly impacted by changes in recharge. It should be noted that these baseflow estimates are still only a small component of the annual flow currently gauged in the creeks and rivers, with the Talbragar system discharging on the order of 10 to 100 ML/day and the Goulburn system discharging 30 to 160 ML/day on average (note that Table 3.3 presents values in ML/year).





#### LEGEND

- Private bore
- Major drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Basecase - Drawdown/Mounding contour (m)
- 10<sup>th</sup> percentile - Climate change predictions
- 50<sup>th</sup> percentile - Climate change predictions
- 90<sup>th</sup> percentile - Climate change predictions
- Alluvium
- Colluvium
- Model domain
- Moolarben Mine Plan
- Ulan Open Cut

| Drawdown (m) | Mounding (m) |
|--------------|--------------|
| 0            | -10          |
| 2            | -5           |
| 5            | -2           |
| 10           | 0            |

Ulan MOD6 Amendment IESC response  
(UCM2021.001)

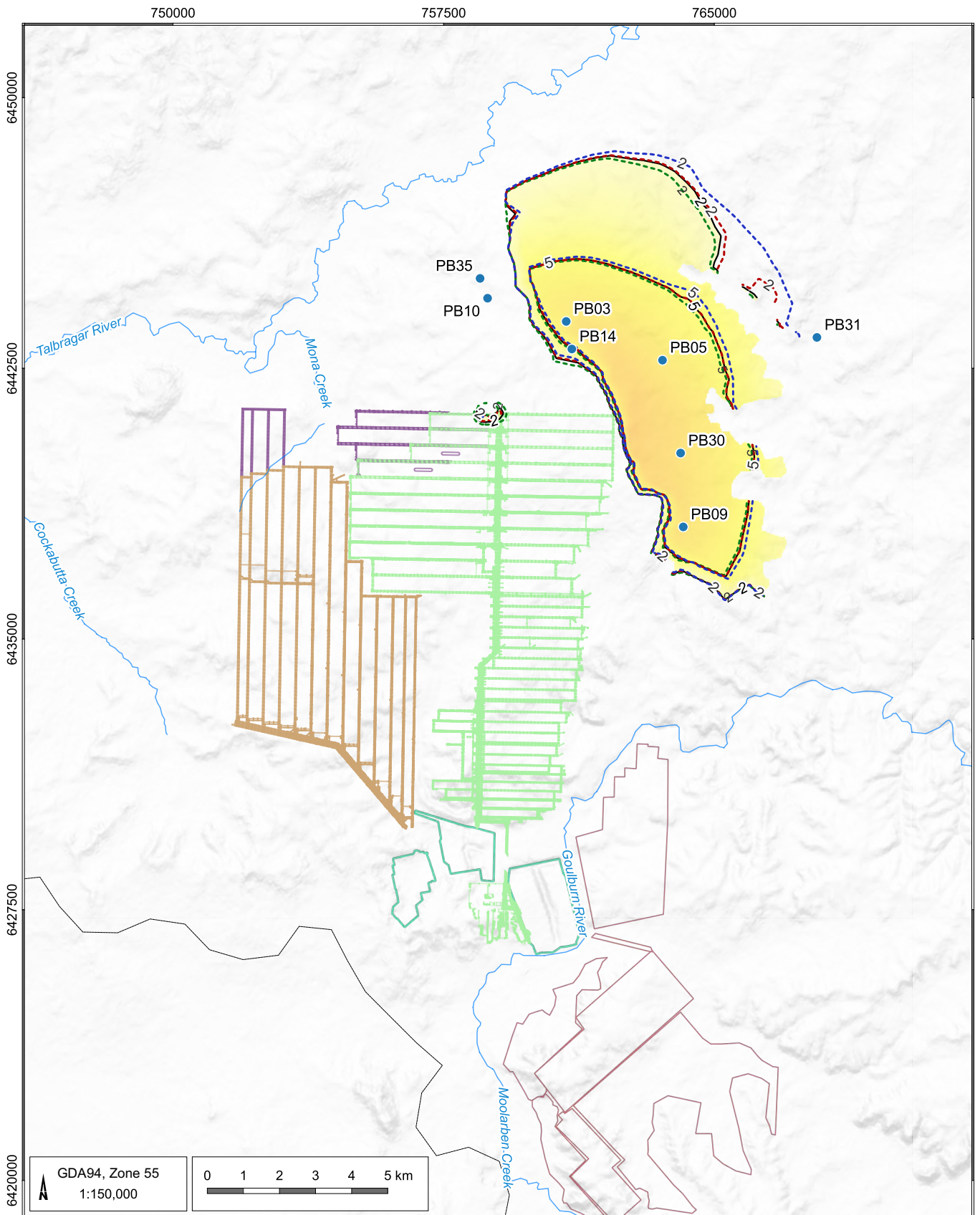
#### Long-term drawdown (and mounding) in alluvium / colluvium (layer 1) - climate change scenarios



AGE

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FIGURE No:  
**3.5**



#### LEGEND

- Private bore
- Major drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase - Drawdown/Mounding contour (m)
- 10<sup>th</sup> percentile - Climate change predictions
- 50<sup>th</sup> percentile - Climate change predictions
- 90<sup>th</sup> percentile - Climate change predictions
- Model domain
- Moolarben Mine Plan
- Ulan Open Cut

#### Drawdown (m)

- 0
- 2
- 5
- 10
- 20

#### Mounding (m)

- 20
- 10
- 5
- 2
- 0

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

### Long-term drawdown (and mounding) in Jurassic (layer 4) - climate change scenarios

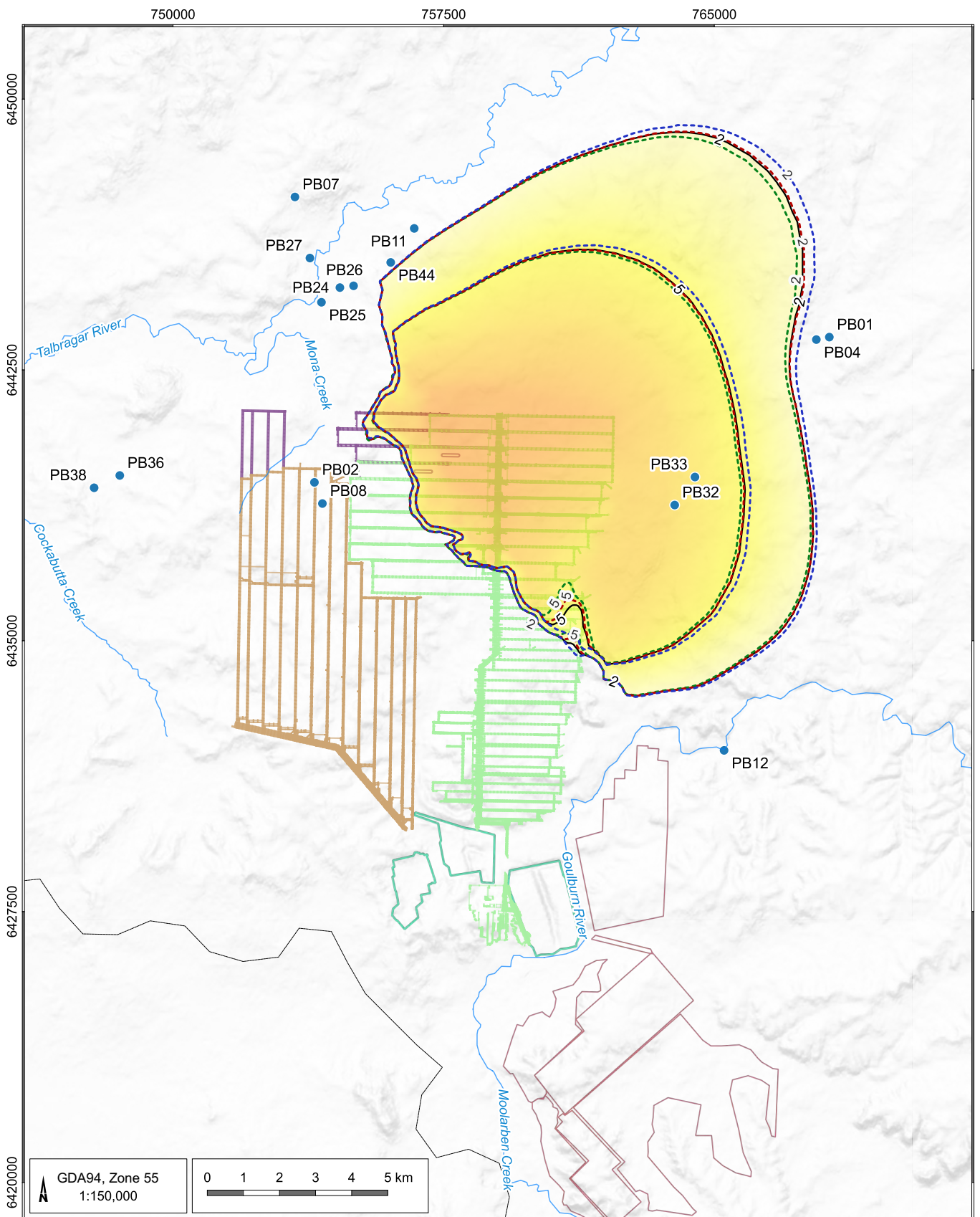


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FIGURE No:  
**3.6**





#### LEGEND

- Private bore
- Major drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase - Drawdown/Mounding contour (m)
- 10<sup>th</sup> percentile - Climate change predictions
- 50<sup>th</sup> percentile - Climate change predictions
- 90<sup>th</sup> percentile - Climate change predictions
- Model domain
- Moolarben Mine Plan
- Ulan Open Cut

#### Drawdown (m)

- 0
- 2
- 5
- 10
- 20

#### Mounding (m)

- 20
- 10
- 5
- 2
- 0

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

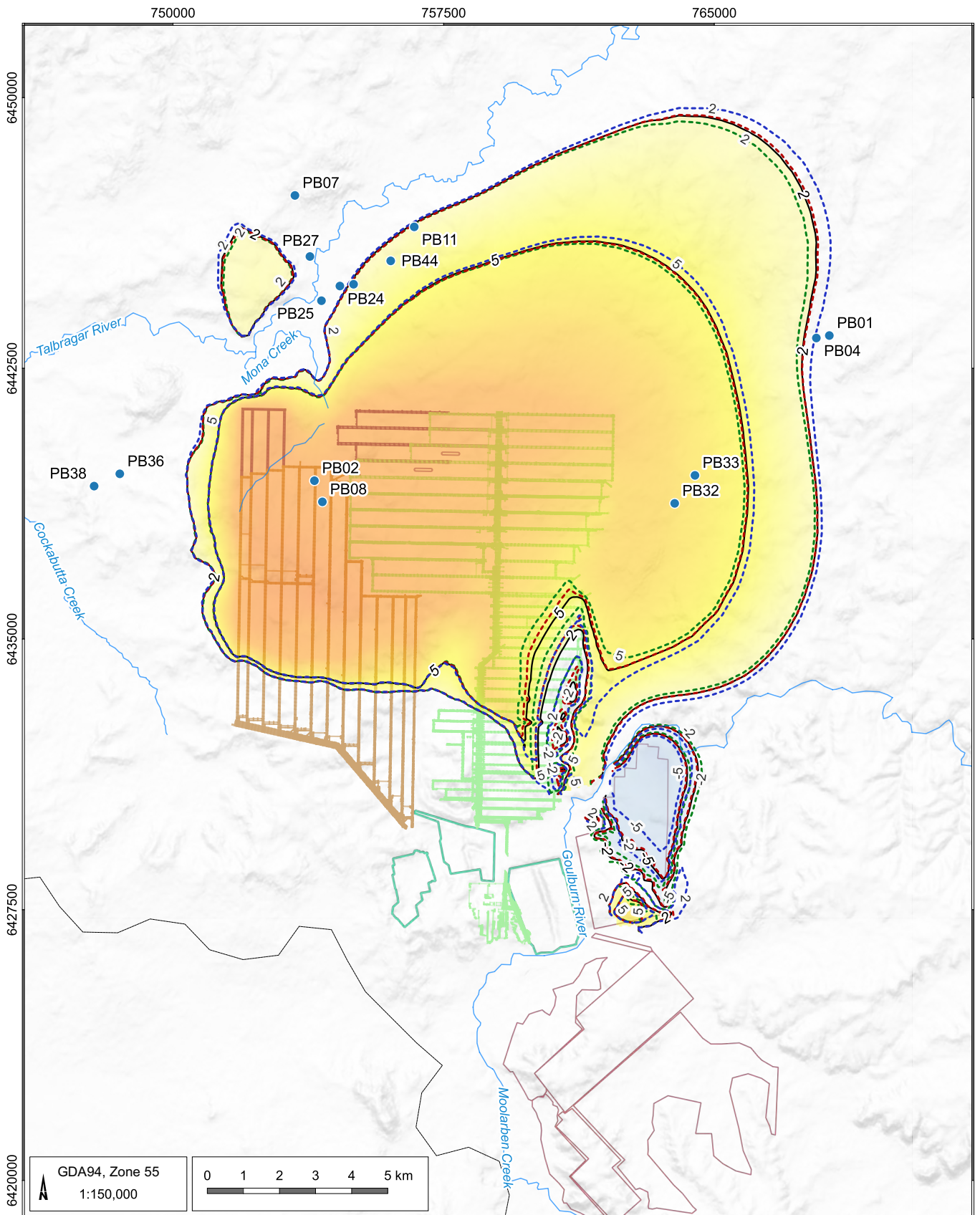
### Long-term drawdown (and mounding) in Quartzose Triassic (layer 7) - climate change scenarios



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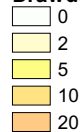
FIGURE No:  
**3.7**



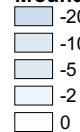
#### LEGEND

- Private bore
- Major drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase - Drawdown/Mounding contour (m)
- 10<sup>th</sup> percentile - Climate change predictions
- 50<sup>th</sup> percentile - Climate change predictions
- 90<sup>th</sup> percentile - Climate change predictions
- Model domain
- Moolarben Mine Plan
- Ulan Open Cut

#### Drawdown (m)



#### Mounding (m)



Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

### Long-term drawdown (and mounding) in Lithic Triassic (layer 10) - climate change scenarios

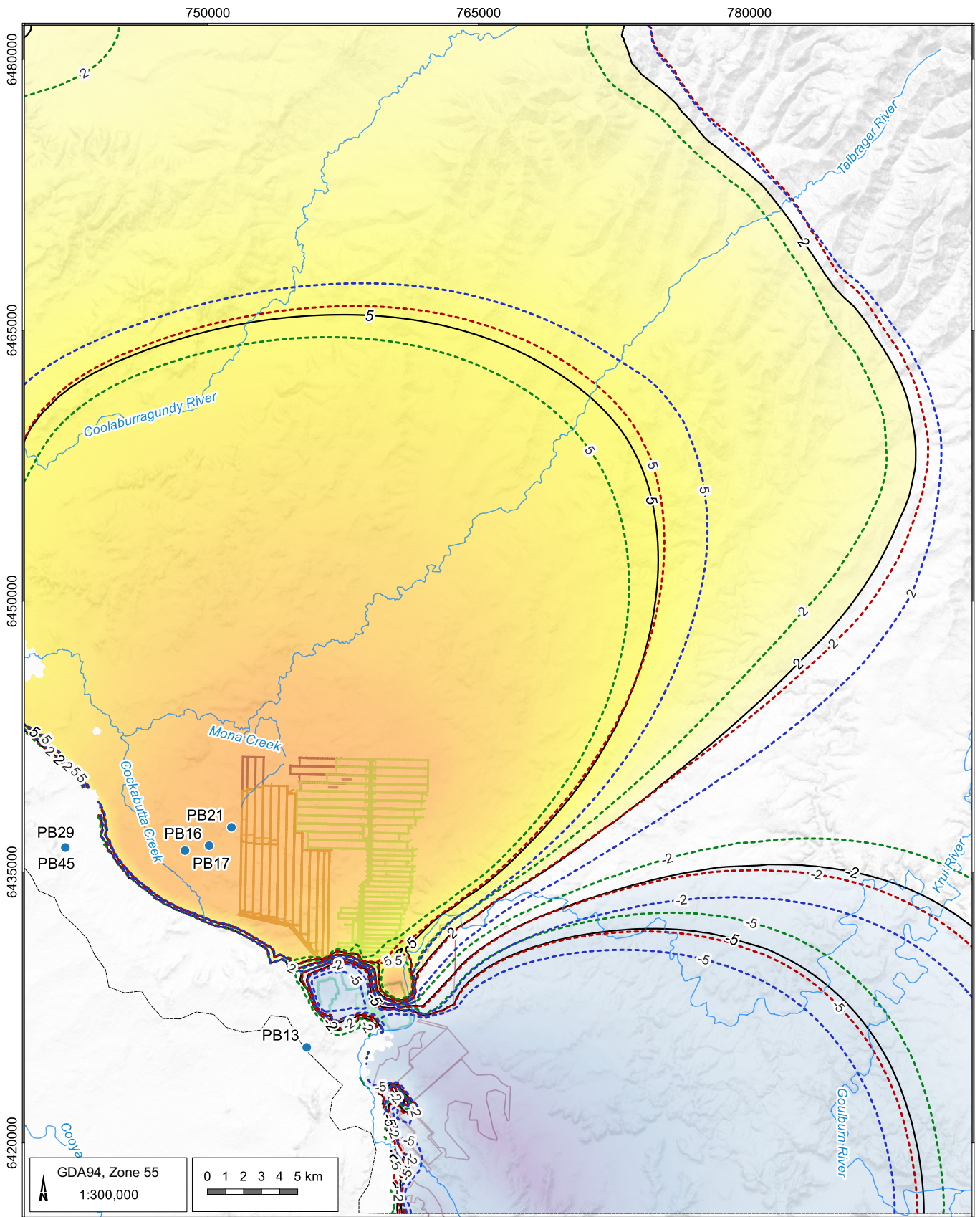


AGE

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FIGURE No:  
**3.8**





#### LEGEND

- Private bore
- Major drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase - Drawdown/Mounding contour (m)
- 10<sup>th</sup> percentile - Climate change predictions
- 50<sup>th</sup> percentile - Climate change predictions
- 90<sup>th</sup> percentile - Climate change predictions
- Model domain
- Moolarben Mine Plan
- Ulan Open Cut

#### Drawdown (m)

- 0
- 2
- 5
- 10
- 20

#### Mounding (m)

- 20
- 10
- 5
- 2
- 0

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

### Long-term drawdown (and mounding) in Ulan Seam (layer 16) - climate change scenarios



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FIGURE No:  
**3.9**

### 3.5 Expanded uncertainty analysis (5g, 9a, 9b, 9c, 18c)

The IESC advice suggested the uncertainty analysis be expanded to include additional parameters and additional reporting on the set up and on the post-mining conditions. The IESC suggested that aquifer storage properties be considered in the uncertainty analysis. Consequently, specific yield (Sy) and specific storage (Ss) have been included in the uncertainty analysis for the MOD6A groundwater model. The IESC advice has been addressed and the uncertainty analysis rerun with these additional outputs. The parameter ranges explored in the uncertainty analysis are shown in Table 3.4 through Table 3.8.

The IESC also recommended that recharge should be included in the uncertainty analysis. This was already included in the analysis but the details were missing from the original GIA reporting (AGE 2022). Further information on recharge zones presented in Table 3.8 can be found in the GIA report.

The calibration criteria used to filter realisations that are extreme and not considered calibrated was 10% Scaled RMS for water levels. The rerun of the uncertainty analysis has involved 400 realisations, of which 198 runs converged and met the calibration criteria.

To understand if 198 runs are sufficient for the uncertainty analysis to cover the range of potential predictions, analysis of specific output has been undertaken. This analysis involves calculating metrics which describe the distribution of the outputs and how this cumulatively changes as more model runs are added from the pool of converged and calibrated realisations. The results of this analysis are presented below for the predicted baseflow loss across the model domain (Figure 3.10), and for predicted maximum drawdown in the Lithic Triassic formation represented by private bore PB33 (Figure 3.11).

Table 3.4 Prior and posterior statistics of horizontal hydraulic conductivity

| Group (layers)           | Prior (m/d) |         |         |         | Posterior (m/d) |         |         |         | Difference (%) |      |       |       |
|--------------------------|-------------|---------|---------|---------|-----------------|---------|---------|---------|----------------|------|-------|-------|
|                          | Min         | Max     | Mean    | Std     | Min             | Max     | Mean    | Std     | Min            | Max  | Mean  | Std   |
| Alluvium & Colluvium (1) | 4.1E-02     | 5.1E+02 | 3.2E+01 | 2.8E+01 | 4.1E-02         | 5.1E+02 | 3.1E+01 | 2.8E+01 | 0.0%           | 0.0% | 1.3%  | 1.0%  |
| Tertiary (2)             | 1.2E-04     | 1.2E-02 | 1.1E-03 | 6.2E-04 | 1.2E-04         | 1.1E-02 | 1.1E-03 | 6.5E-04 | 0.0%           | 9.1% | -1.7% | -5.1% |
| Jurassic (3-4)           | 5.5E-05     | 1.9E-02 | 1.2E-03 | 7.0E-04 | 5.5E-05         | 1.9E-02 | 1.2E-03 | 7.0E-04 | 0.0%           | 0.0% | -0.3% | -0.2% |
| Triassic Quartzose (5-8) | 5.3E-04     | 1.9E-01 | 1.2E-02 | 8.0E-03 | 5.3E-04         | 1.9E-01 | 1.2E-02 | 8.0E-03 | 0.0%           | 0.0% | -0.3% | -0.4% |
| Triassic Lithic (9-10)   | 2.7E-05     | 9.4E-03 | 5.7E-04 | 3.9E-04 | 2.7E-05         | 9.4E-03 | 5.8E-04 | 4.0E-04 | 0.0%           | 0.0% | -0.3% | -1.5% |
| Permian (11-15; 17-18)   | 5.2E-07     | 1.9E-03 | 9.1E-05 | 8.6E-05 | 5.4E-07         | 1.9E-03 | 9.1E-05 | 8.6E-05 | -3.7%          | 0.0% | -0.3% | -0.3% |
| Ulan coal seam (16)      | 1.2E-04     | 6.0E-01 | 4.7E-01 | 1.7E-01 | 1.2E-04         | 6.0E-01 | 4.7E-01 | 1.7E-01 | 0.0%           | 0.0% | -0.2% | -0.1% |
| Bedrock (19)             | 5.4E-06     | 1.8E-03 | 1.2E-04 | 8.1E-05 | 5.7E-06         | 1.8E-03 | 1.2E-04 | 8.1E-05 | -5.3%          | 0.0% | 0.1%  | 0.1%  |

Table 3.5 Prior and posterior statistics of vertical hydraulic conductivity

| Group (layers)           | Prior (m/d) |         |         |         | Posterior (m/d) |         |         |         | Difference (%) |       |       |       |
|--------------------------|-------------|---------|---------|---------|-----------------|---------|---------|---------|----------------|-------|-------|-------|
|                          | Min         | Max     | Mean    | Std     | Min             | Max     | Mean    | Std     | Min            | Max   | Mean  | Std   |
| Alluvium & Colluvium (1) | 9.8E-08     | 1.3E+02 | 6.4E-01 | 1.2E+00 | 9.8E-08         | 1.3E+02 | 6.3E-01 | 1.2E+00 | 0.0%           | 0.0%  | 1.9%  | 0.4%  |
| Tertiary (2)             | 3.5E-06     | 3.0E-02 | 1.7E-04 | 3.1E-04 | 4.0E-06         | 2.1E-02 | 1.8E-04 | 3.3E-04 | -12.5%         | 42.9% | -4.9% | -5.9% |
| Jurassic (3-4)           | 1.2E-09     | 8.4E-02 | 8.8E-05 | 3.7E-04 | 1.2E-09         | 8.4E-02 | 9.1E-05 | 3.6E-04 | 0.0%           | 0.0%  | -3.0% | 3.0%  |
| Triassic Quartzose (5-8) | 1.9E-09     | 6.7E-01 | 8.0E-04 | 4.1E-03 | 2.7E-09         | 6.7E-01 | 8.1E-04 | 4.1E-03 | -29.6%         | 0.0%  | -1.2% | -0.2% |
| Triassic Lithic (9-10)   | 9.5E-11     | 4.2E-02 | 3.4E-05 | 1.7E-04 | 9.5E-11         | 4.2E-02 | 3.4E-05 | 1.8E-04 | 0.0%           | 0.0%  | -1.7% | -3.7% |
| Permian (11-15; 17-18)   | 3.1E-10     | 9.0E-03 | 4.5E-06 | 2.8E-05 | 4.4E-10         | 9.0E-03 | 4.6E-06 | 2.8E-05 | -29.5%         | 0.0%  | -1.0% | 1.0%  |
| Ulan Seam (16)           | 2.0E-05     | 1.0E-01 | 9.5E-02 | 1.7E-02 | 2.0E-05         | 1.0E-01 | 9.5E-02 | 1.7E-02 | 0.0%           | 0.0%  | 0.1%  | -1.0% |
| Bedrock (19)             | 6.1E-07     | 1.0E-02 | 1.4E-04 | 1.5E-04 | 9.6E-07         | 1.0E-02 | 1.4E-04 | 1.5E-04 | -36.5%         | 0.0%  | 0.2%  | 1.9%  |

Table 3.6 Prior and posterior statistics of specific yield

| Group (layers)           | Prior (m/d) |          |          |          | Posterior (m/d) |          |          |          | Difference (%) |      |       |       |
|--------------------------|-------------|----------|----------|----------|-----------------|----------|----------|----------|----------------|------|-------|-------|
|                          | Min         | Max      | Mean     | Std      | Min             | Max      | Mean     | Std      | Min            | Max  | Mean  | Std   |
| Alluvium & Colluvium (1) | 1.08E-02    | 2.69E-01 | 6.00E-02 | 3.58E-02 | 1.08E-02        | 2.69E-01 | 5.99E-02 | 3.59E-02 | 0.0%           | 0.0% | 0.2%  | -0.3% |
| Tertiary (2)             | 4.00E-03    | 9.99E-02 | 2.53E-02 | 1.83E-02 | 4.00E-03        | 9.99E-02 | 2.53E-02 | 1.84E-02 | 0.0%           | 0.0% | -0.2% | -0.5% |
| Jurassic (3-4)           | 1.50E-03    | 3.75E-02 | 9.45E-03 | 6.83E-03 | 1.50E-03        | 3.75E-02 | 9.44E-03 | 6.84E-03 | -0.1%          | 0.0% | 0.1%  | 0.0%  |
| Triassic Quartzose (5-8) | 6.00E-03    | 1.50E-01 | 3.80E-02 | 2.75E-02 | 6.01E-03        | 1.50E-01 | 3.81E-02 | 2.75E-02 | -0.1%          | 0.1% | -0.3% | -0.2% |
| Triassic Lithic (9-10)   | 2.00E-03    | 5.00E-02 | 1.28E-02 | 9.29E-03 | 2.00E-03        | 4.99E-02 | 1.28E-02 | 9.29E-03 | 0.0%           | 0.1% | -0.2% | 0.1%  |
| Permian (11-15; 17-18)   | 1.89E-03    | 4.71E-02 | 1.20E-02 | 8.74E-03 | 1.89E-03        | 4.71E-02 | 1.20E-02 | 8.71E-03 | -0.1%          | 0.1% | 0.1%  | 0.3%  |
| Ulan coal seam (16)      | 4.00E-03    | 9.72E-02 | 2.23E-02 | 1.36E-02 | 4.01E-03        | 9.70E-02 | 2.24E-02 | 1.36E-02 | -0.1%          | 0.2% | -0.3% | -0.2% |
| Bedrock (19)             | 2.00E-04    | 5.00E-03 | 1.28E-03 | 9.31E-04 | 2.00E-04        | 5.00E-03 | 1.28E-03 | 9.38E-04 | -0.1%          | 0.0% | 0.0%  | -0.7% |

Table 3.7 Prior and posterior statistics of specific storage

| Group (layers)           | Prior (m/d) |          |          |          | Posterior (m/d) |          |          |          | Difference (%) |      |       |       |
|--------------------------|-------------|----------|----------|----------|-----------------|----------|----------|----------|----------------|------|-------|-------|
|                          | Min         | Max      | Mean     | Std      | Min             | Max      | Mean     | Std      | Min            | Max  | Mean  | Std   |
| Alluvium & Colluvium (1) | 1.80E-06    | 4.49E-05 | 1.14E-05 | 8.22E-06 | 1.80E-06        | 4.49E-05 | 1.14E-05 | 8.25E-06 | 0.0%           | 0.0% | -0.3% | -0.4% |
| Tertiary (2)             | 1.00E-06    | 2.50E-05 | 6.36E-06 | 4.60E-06 | 1.00E-06        | 2.50E-05 | 6.43E-06 | 4.66E-06 | -0.1%          | 0.1% | -1.0% | -1.2% |
| Jurassic (3-4)           | 1.00E-06    | 2.50E-05 | 6.33E-06 | 4.57E-06 | 1.00E-06        | 2.50E-05 | 6.35E-06 | 4.60E-06 | -0.1%          | 0.1% | -0.4% | -0.7% |
| Triassic Quartzose (5-8) | 2.00E-06    | 5.00E-05 | 1.27E-05 | 9.18E-06 | 2.00E-06        | 5.00E-05 | 1.27E-05 | 9.20E-06 | 0.0%           | 0.0% | -0.2% | -0.2% |
| Triassic Lithic (9-10)   | 2.00E-03    | 4.99E-02 | 1.28E-02 | 9.28E-03 | 2.00E-03        | 4.99E-02 | 1.27E-02 | 9.22E-03 | -0.1%          | 0.1% | 0.2%  | 0.6%  |
| Permian (11-15; 17-18)   | 2.86E-07    | 7.14E-06 | 1.82E-06 | 1.33E-06 | 2.86E-07        | 7.13E-06 | 1.82E-06 | 1.32E-06 | -0.1%          | 0.1% | 0.2%  | 0.4%  |
| Ulan Seam (16)           | 4.00E-07    | 9.99E-06 | 2.55E-06 | 1.86E-06 | 4.00E-07        | 9.98E-06 | 2.54E-06 | 1.86E-06 | 0.0%           | 0.1% | 0.4%  | 0.2%  |
| Bedrock (19)             | 2.00E-07    | 5.00E-06 | 1.27E-06 | 9.26E-07 | 2.01E-07        | 5.00E-06 | 1.27E-06 | 9.22E-07 | -0.3%          | 0.0% | -0.2% | 0.5%  |



Table 3.8 Prior and posterior statistics of recharge zones

| Group   | Prior (m/d) |          |          |          | Posterior (m/d) |          |          |          | Difference (%) |        |        |        |
|---------|-------------|----------|----------|----------|-----------------|----------|----------|----------|----------------|--------|--------|--------|
|         | Min         | Max      | Mean     | Std      | Min             | Max      | Mean     | Std      | Min            | Max    | Mean   | Std    |
| rch_z1  | 2.45E-02    | 9.68E-02 | 5.12E-02 | 1.55E-02 | 2.47E-02        | 9.67E-02 | 5.10E-02 | 1.57E-02 | -0.48%         | 0.05%  | 0.33%  | -0.84% |
| rch_z2  | 1.02E-03    | 3.98E-03 | 2.07E-03 | 6.28E-04 | 1.02E-03        | 3.52E-03 | 1.97E-03 | 5.89E-04 | 0.00%          | 13.34% | 5.07%  | 6.60%  |
| rch_z3  | 3.54E-04    | 1.40E-03 | 7.44E-04 | 2.31E-04 | 3.54E-04        | 1.40E-03 | 7.43E-04 | 2.23E-04 | 0.00%          | 0.00%  | 0.06%  | 3.99%  |
| rch_z4  | 4.56E-05    | 1.80E-04 | 9.55E-05 | 2.87E-05 | 4.84E-05        | 1.74E-04 | 9.48E-05 | 2.65E-05 | -5.78%         | 3.71%  | 0.71%  | 8.43%  |
| rch_z5  | 4.10E-06    | 1.63E-05 | 8.57E-06 | 2.64E-06 | 4.26E-06        | 1.63E-05 | 8.62E-06 | 2.64E-06 | -3.84%         | 0.00%  | -0.55% | 0.18%  |
| rch_z6  | 5.02E-06    | 1.85E-05 | 1.05E-05 | 2.97E-06 | 5.02E-06        | 1.83E-05 | 1.06E-05 | 3.08E-06 | 0.00%          | 0.99%  | -0.84% | -3.53% |
| rch_z7  | 5.50E-07    | 2.17E-06 | 1.15E-06 | 3.63E-07 | 5.59E-07        | 2.09E-06 | 1.17E-06 | 3.45E-07 | -1.60%         | 3.85%  | -1.28% | 5.21%  |
| rch_z8  | 4.65E-07    | 1.67E-06 | 9.08E-07 | 2.71E-07 | 4.65E-07        | 1.67E-06 | 9.11E-07 | 2.73E-07 | 0.00%          | 0.00%  | -0.28% | -0.52% |
| rch_z9  | 5.11E-08    | 1.97E-07 | 1.03E-07 | 3.11E-08 | 5.59E-08        | 1.97E-07 | 1.06E-07 | 3.18E-08 | -8.63%         | 0.00%  | -2.89% | -1.99% |
| rch_z10 | 1.96E-08    | 6.94E-08 | 3.89E-08 | 1.18E-08 | 1.96E-08        | 6.93E-08 | 3.93E-08 | 1.17E-08 | 0.00%          | 0.11%  | -1.03% | 1.04%  |
| rch_z12 | 2.48E-04    | 9.79E-04 | 5.21E-04 | 1.61E-04 | 2.56E-04        | 9.79E-04 | 5.19E-04 | 1.60E-04 | -3.09%         | 0.00%  | 0.24%  | 0.64%  |

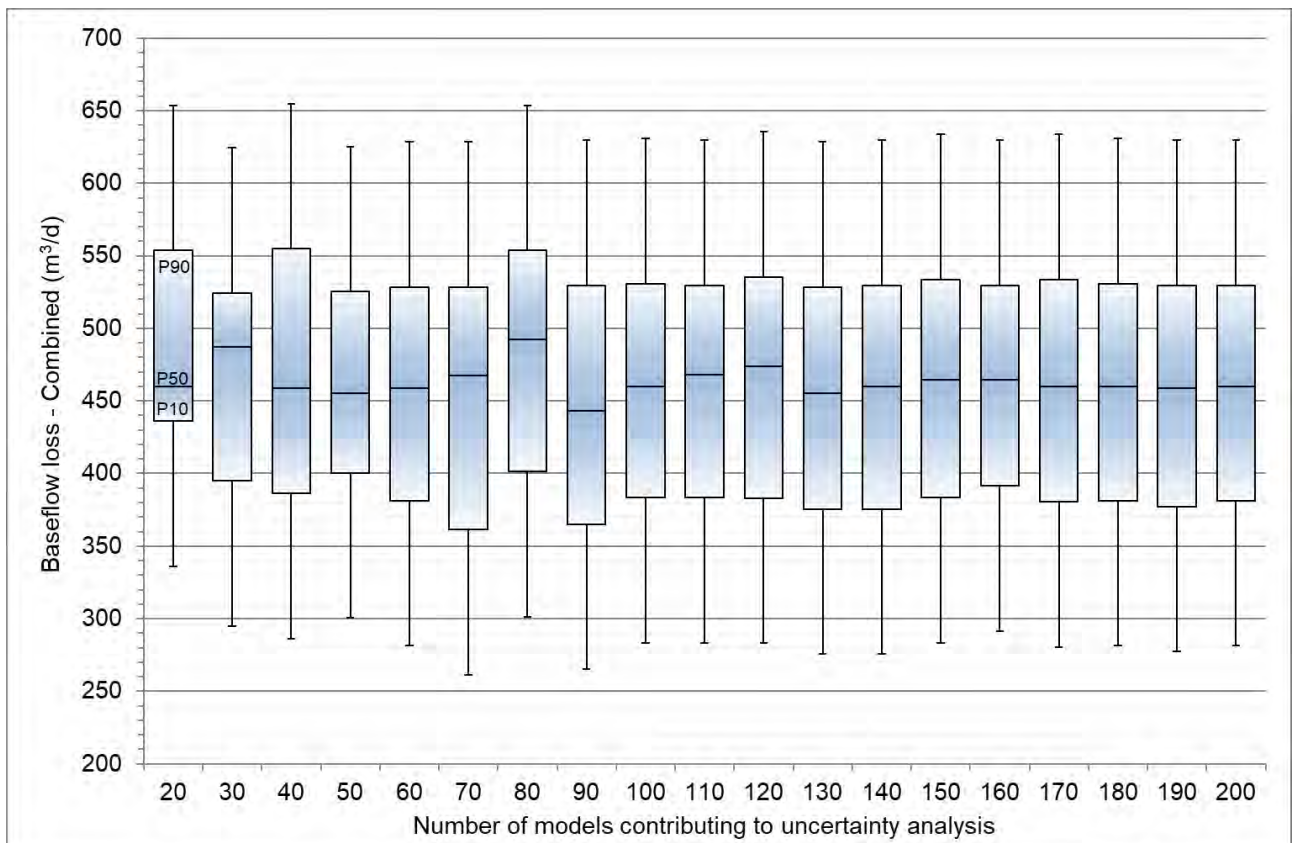


Figure 3.10 Baseflow loss summary as the number of included realisations increases.

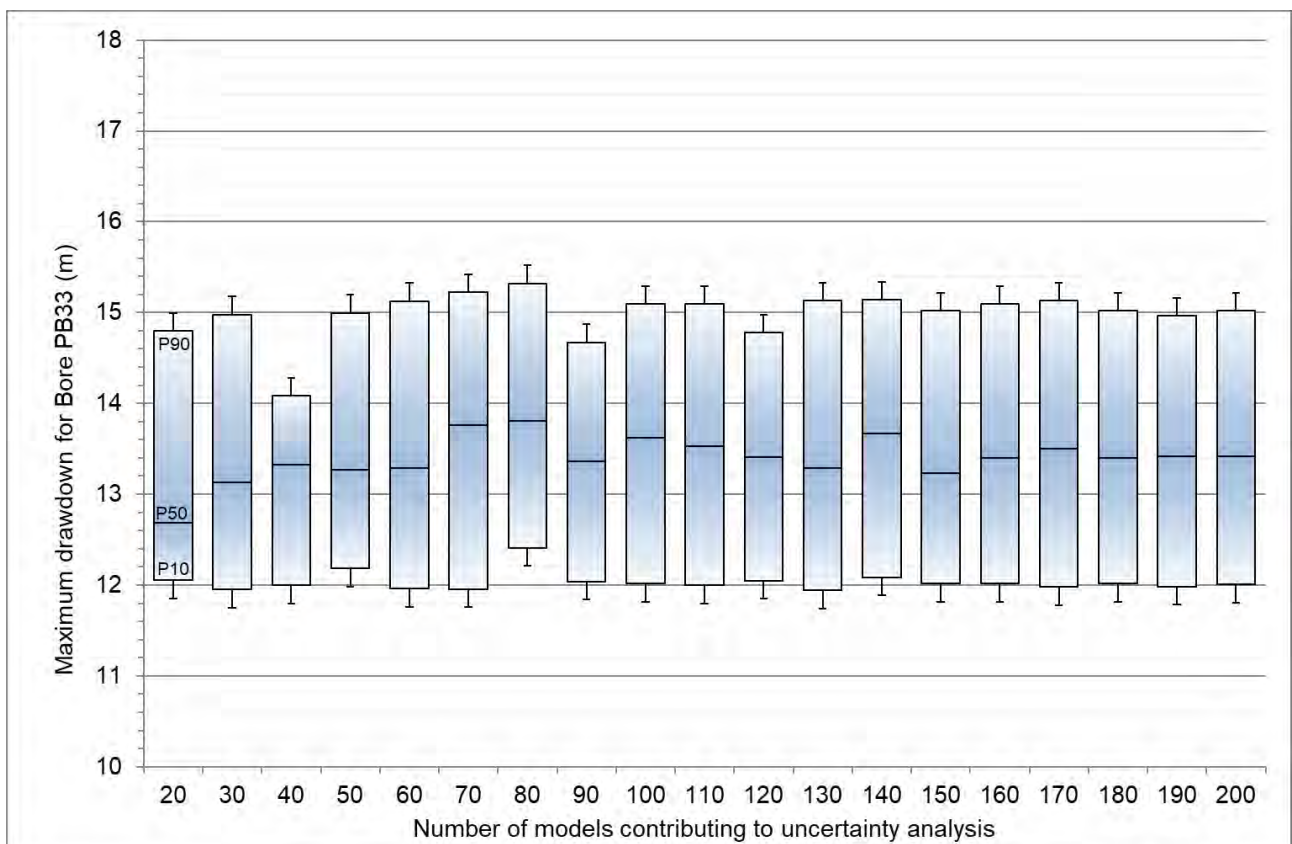


Figure 3.11 Maximum predicted drawdown in Lithic Triassic as the number of included realisations increases.

Figure 3.12 presents the uncertainty around the predicted mine inflow for MOD6A, specifically, the probability that the predicted mine inflow rate will be exceeded. While it is difficult to make direct comparisons between these results (MOD6A) and the results in Figure 9.1 of the GIA (which presents the original MOD6 mine plan), we would generally expect these results here to be broader due to the inclusion of storage parameters ( $S_y$  and  $S_s$ ) into the uncertainty analysis, which allows for a wider range of likely mine inflow than if they were excluded.

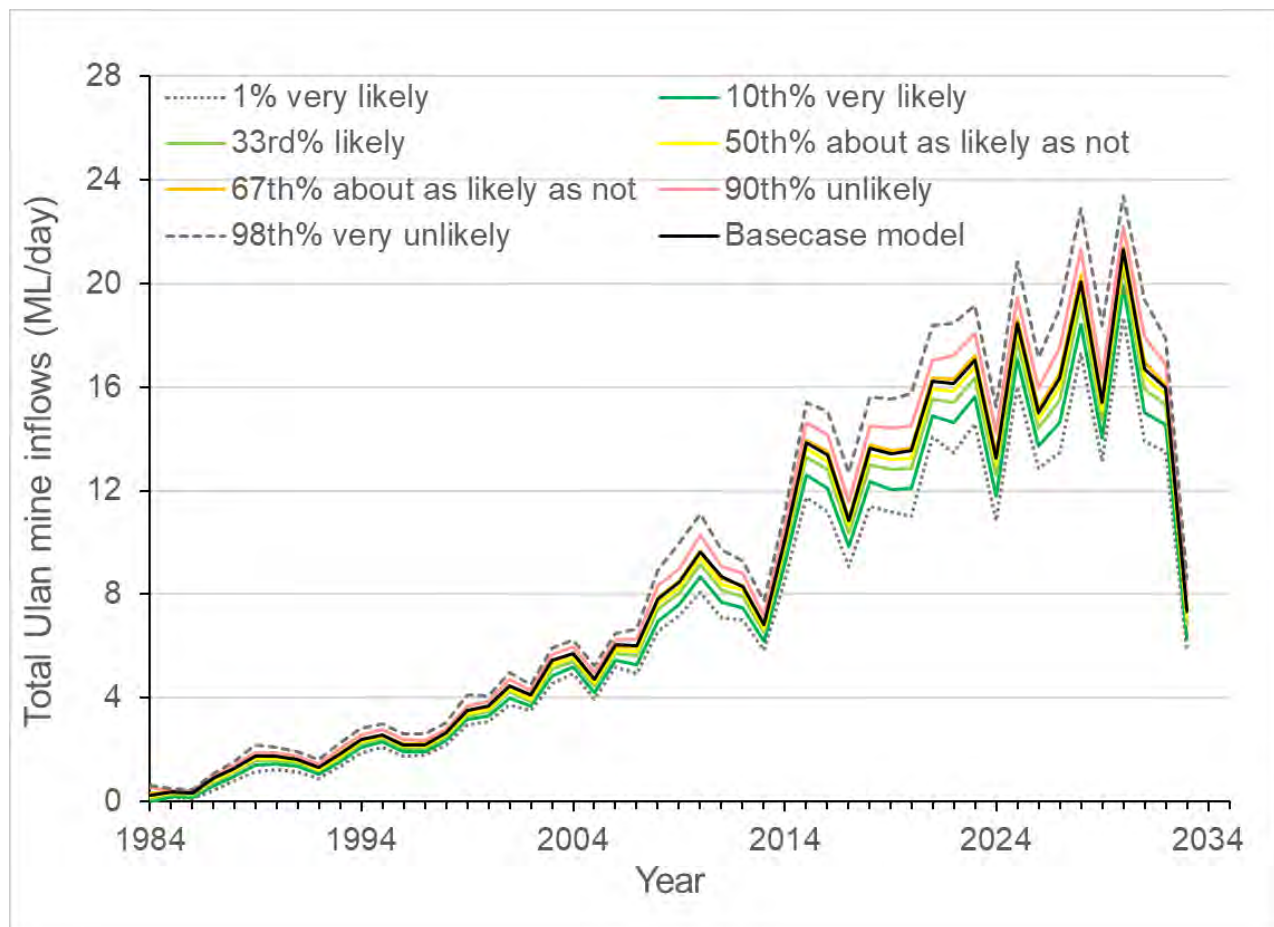


Figure 3.12 Probability distribution for Ulan mine inflow rate

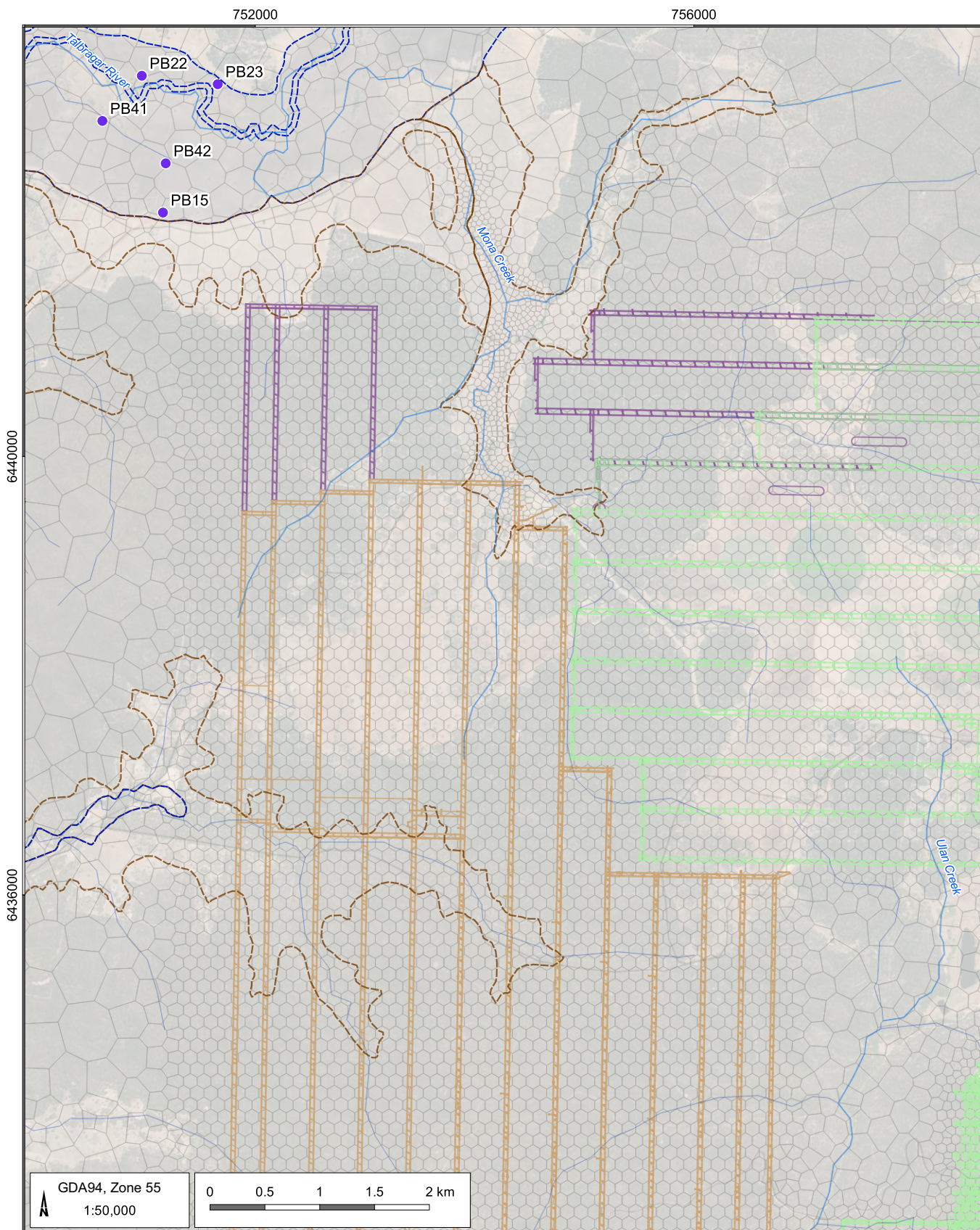
Figure 3.13 to Figure 3.16 show the uncertainty around the predicted 1 m additional drawdown due to MOD6A only (i.e. 'incremental' drawdown). These figures are comparable to Figures 9.2 to Figure 9.5 in the GIA (AGE 2022) but are for the MOD6A mine plan. With the inclusion of storage properties ( $S_y$  and  $S_s$ ) in the analysis the zones of uncertainty have increased slightly over the previous uncertainty analysis, especially for areas unaffected by the MOD6A changes. The notable exception is incremental drawdown in the Ulan Seam (Figure 3.16), which shows a reduction in the "very unlikely" to exceed range. This could be due to the variability of storage properties and increased impact predicted in the layers above.

Figure 3.17 to Figure 3.21 present the uncertainty analysis results examining the maximum cumulative drawdown (approved mine plan plus MOD6A mine plan) through the mining and post-mining equilibrium phases. The analysis shows the probability that a 2 m drawdown will be exceeded. These results confirm what was identified in the indirect takes from formations increasing post mining. Apart from the Ulan Seam (Figure 3.21), these maximum drawdowns are likely to be experienced near the beginning of the post-mining phase.

Figure 3.21 shows that the drawdown in the Ulan Seam is likely to intercept the model boundary. These boundaries are simulated as no flow, which have an amplifying influence on the predicted depressurisation in the Ulan Seam because drawdown cannot propagate further outward past the boundaries and instead propagates vertically, thus overpredicting depressurisation in the layers above and below the seam and making these predictions cautious over-estimates of impacts.

Figure 3.22 shows the probability of the depth to water table being 2 mbgl or less at the post-mining equilibrium stage, with the base case represented by the black line. The results show that it is very unlikely that the depth to water table will be within 2 m of the ground surface across a broader Mona Creek colluvium.





#### LEGEND

- Private bore
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase 1 m drawdown
- Drainage
- Model mesh
- Model domain
- Alluvial
- Colluvial

#### Likelihood of 1 m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Uncertainty in predicted incremental drawdown from proposed modification for alluvium / colluvium at end of mining**

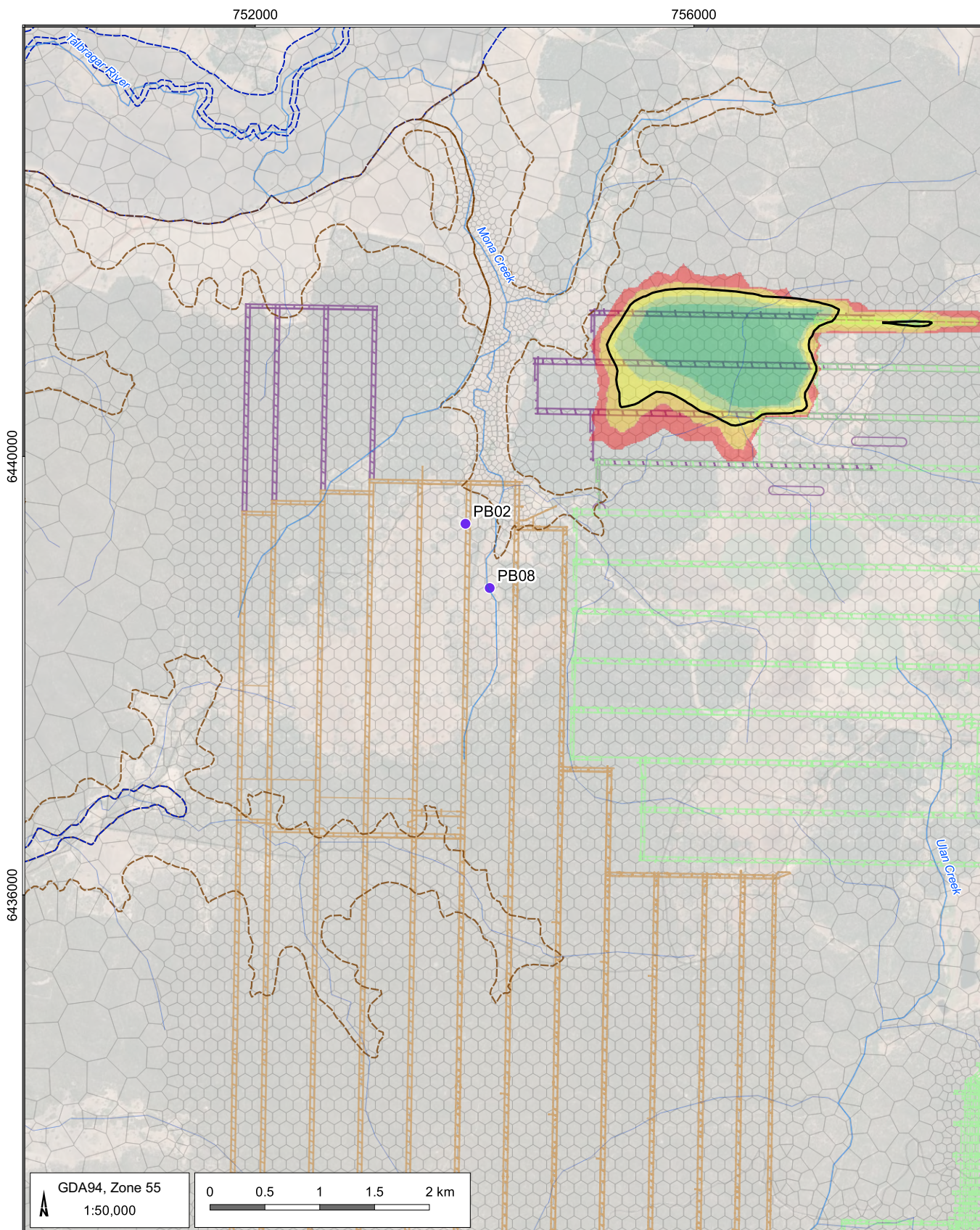


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FIGURE No:  
**3.13**





#### LEGEND

- Private bore
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase 1 m drawdown
- Drainage
- Model mesh
- Model domain
- Alluvial
- Colluvial

#### Likelihood of 1 m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Uncertainty in predicted incremental drawdown from proposed modification for Quartzose Triassic at end of mining**

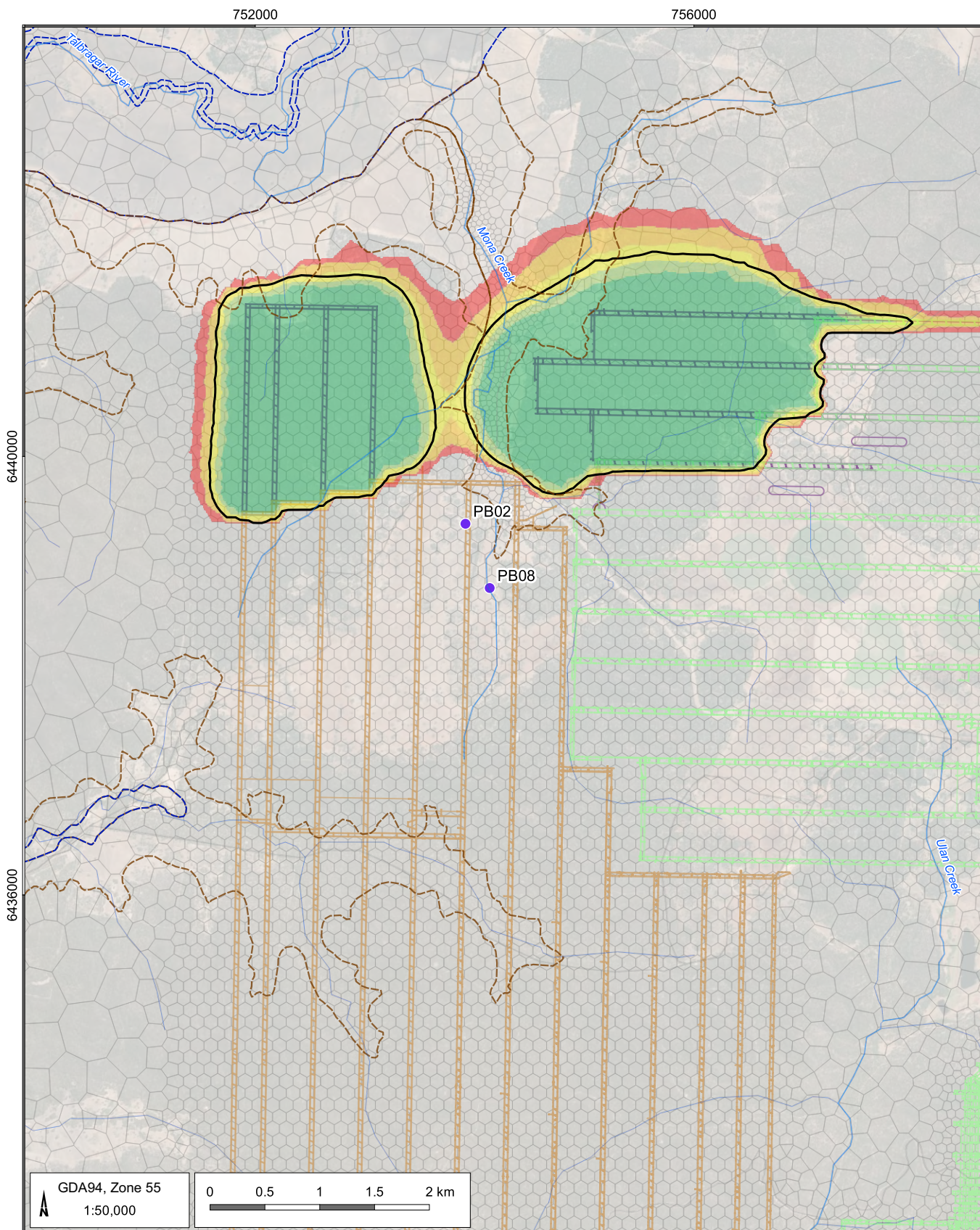


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FIGURE No:  
**3.14**





#### LEGEND

- Private bore
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase 1 m drawdown
- Drainage
- Model mesh
- Model domain
- Alluvial
- Colluvial

#### Likelihood of 1 m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Uncertainty in predicted incremental drawdown from proposed modification for Lithic Triassic at end of mining

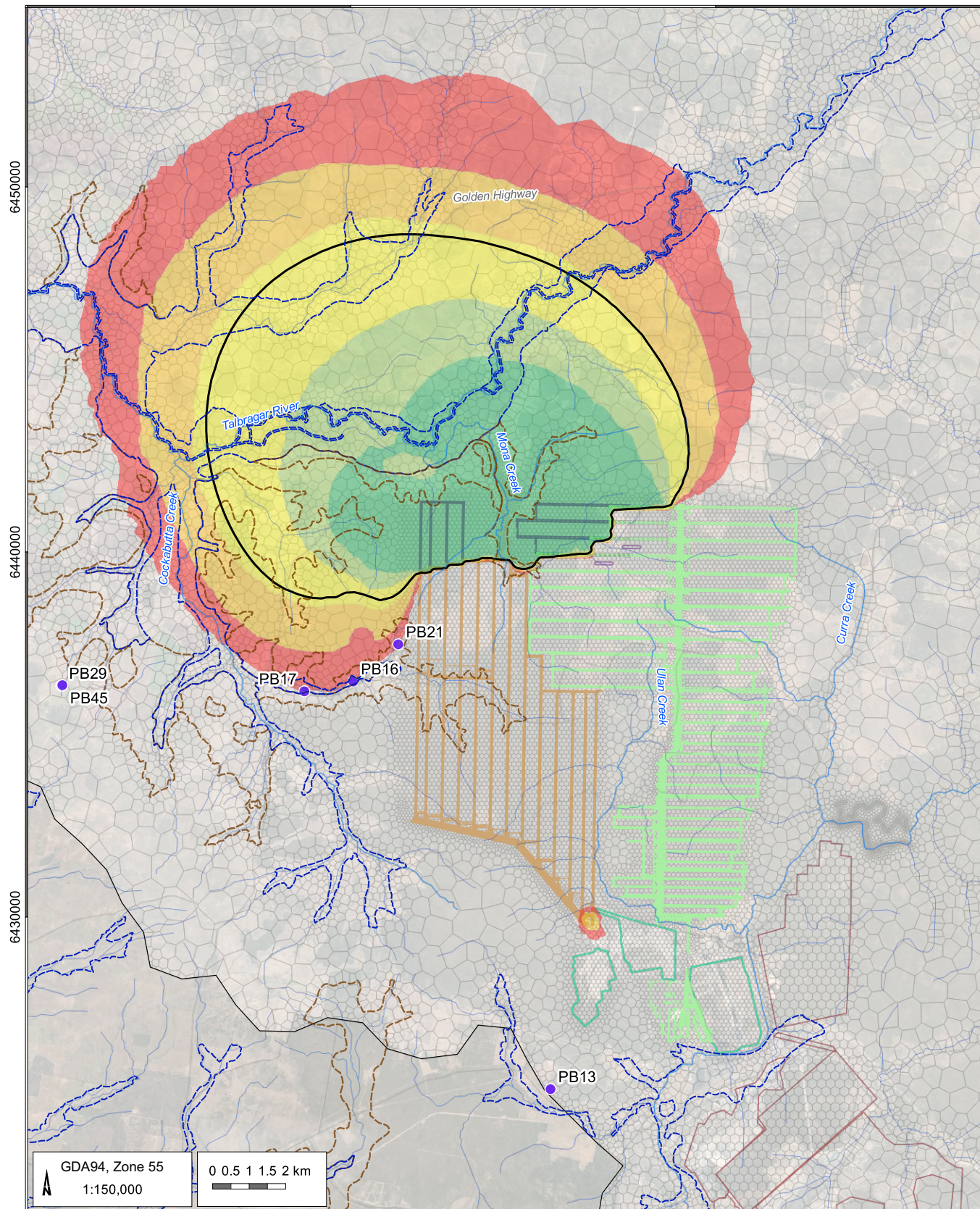


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FIGURE No:  
**3.15**





## LEGEND

- Private bore
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Basecase 1 m drawdown
- Drainage
- Model mesh
- Model domain
- Alluvial
- Colluvial

## Likelihood of 1 m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

### Uncertainty in predicted incremental drawdown from proposed modification for Ulan Seam at end of mining

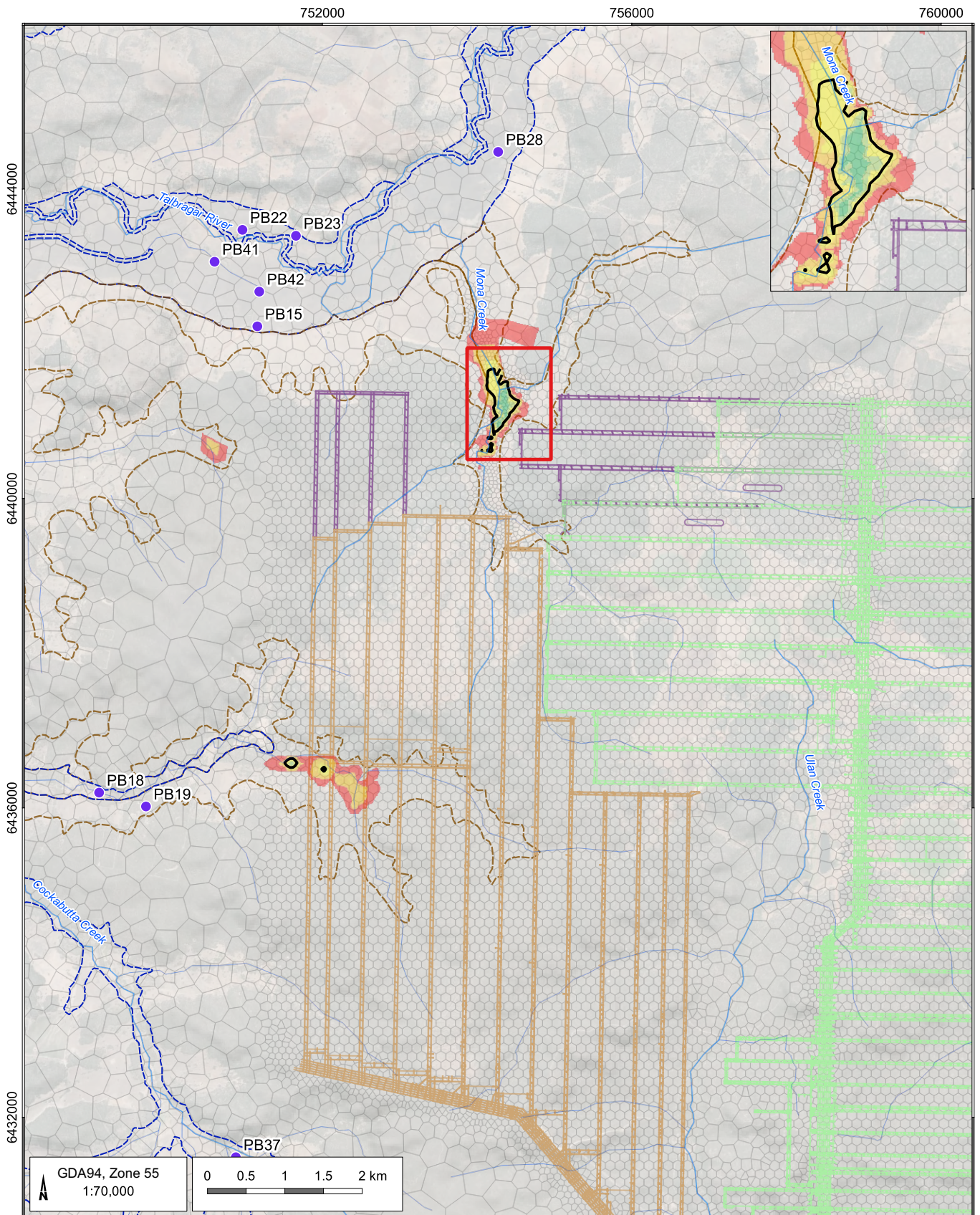


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FIGURE No:  
**3.16**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Basecase 2m drawdown
- Model mesh
- Alluvium
- Colluvium

- Private bore
- Likelihood of 2 m drawdown**
- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Probability of predicted cumulative maximum drawdown exceeding 2 m for alluvium / colluvium**

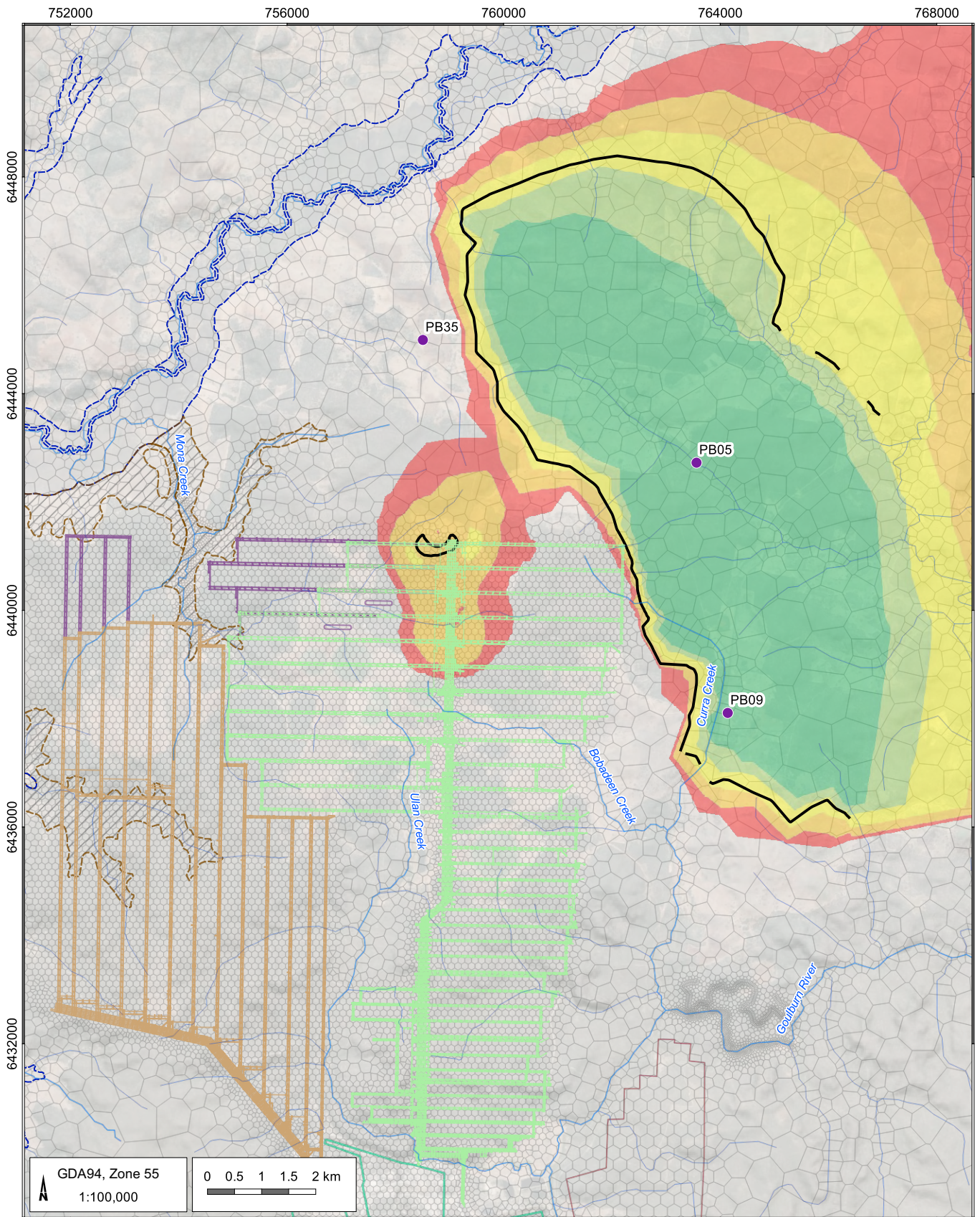


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FIGURE No:  
**3.17**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Basecase 2m drawdown
- Model mesh
- Alluvium
- Colluvium

- Private bore
- Likelihood of 2 m drawdown**
- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Probability of predicted cumulative maximum drawdown exceeding 2 m for Jurassic sediments

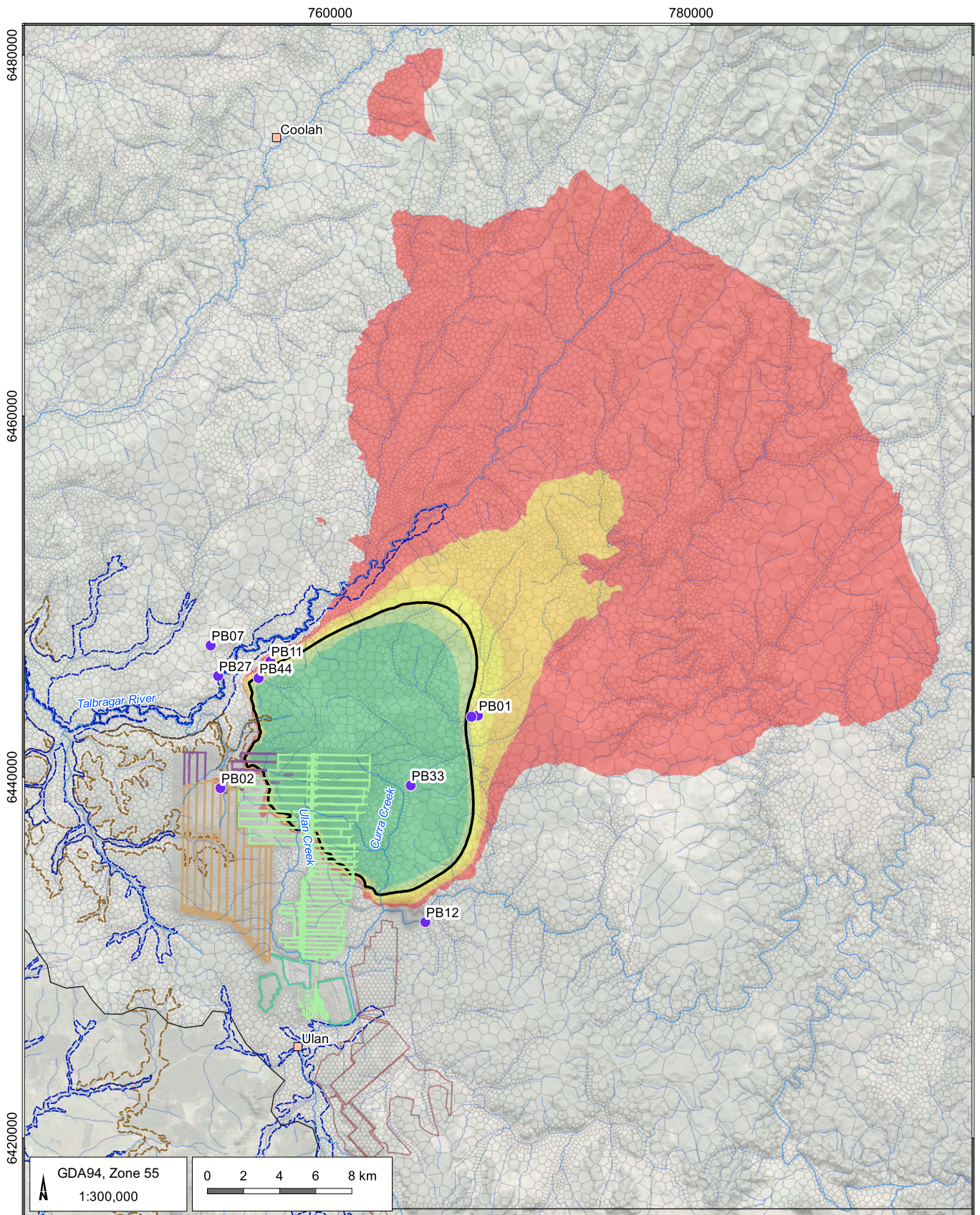


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FIGURE No:  
**3.18**





#### LEGEND

- Populated place
- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Likelihood of 2 m drawdown
- Model mesh
- Alluvium
- Colluvium
- Model domain

● Private bore

#### Basecase 2m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Probability of predicted cumulative maximum drawdown exceeding 2 m for Quartzose Triassic**

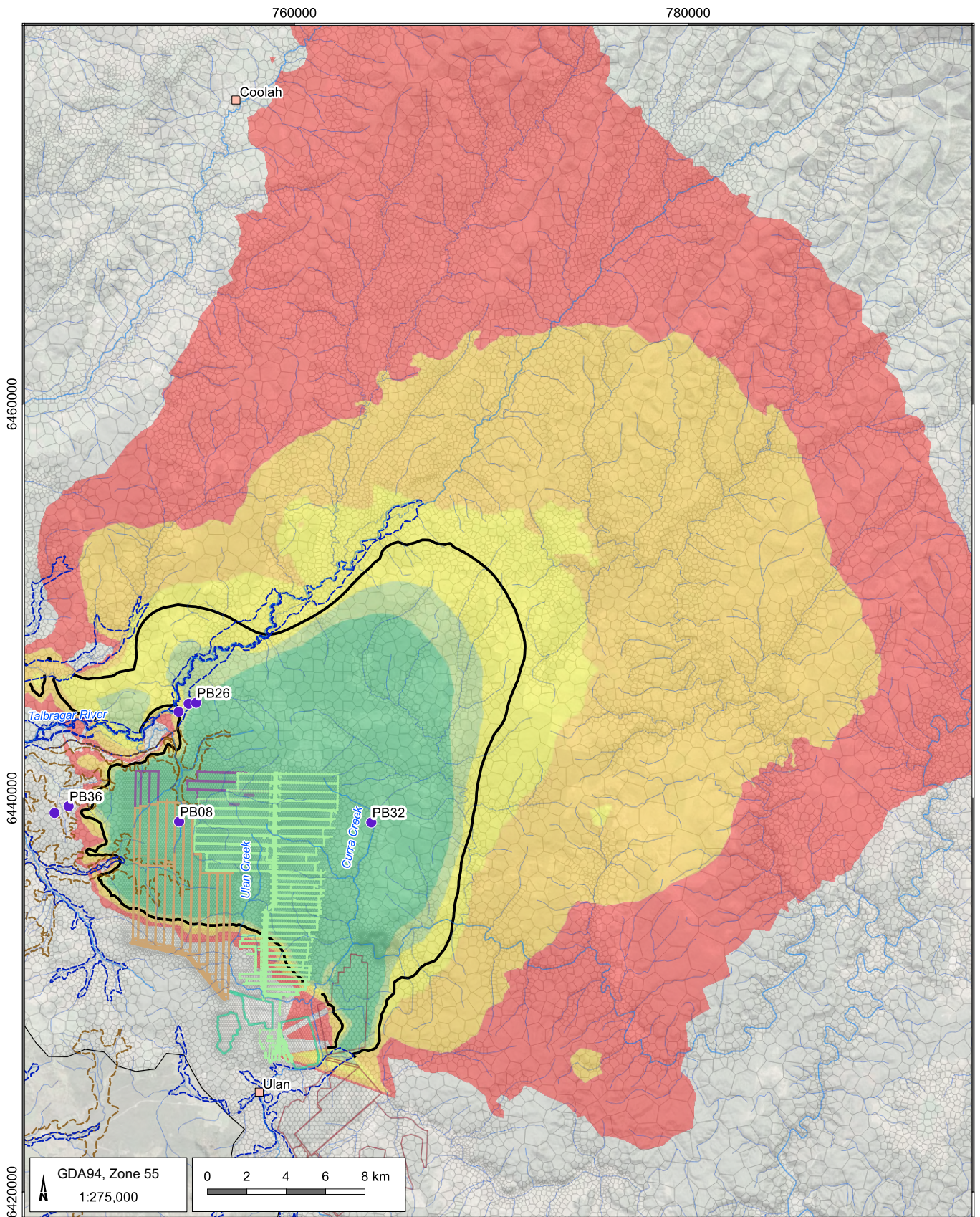


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FIGURE No:  
**3.19**





#### LEGEND

- Populated place
- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Likelihood of 2 m drawdown
- Model mesh
- Alluvium
- Colluvium

● Private bore

#### Basecase 2m drawdown

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Probability of predicted cumulative maximum drawdown exceeding 2 m for Lithic Triassic**

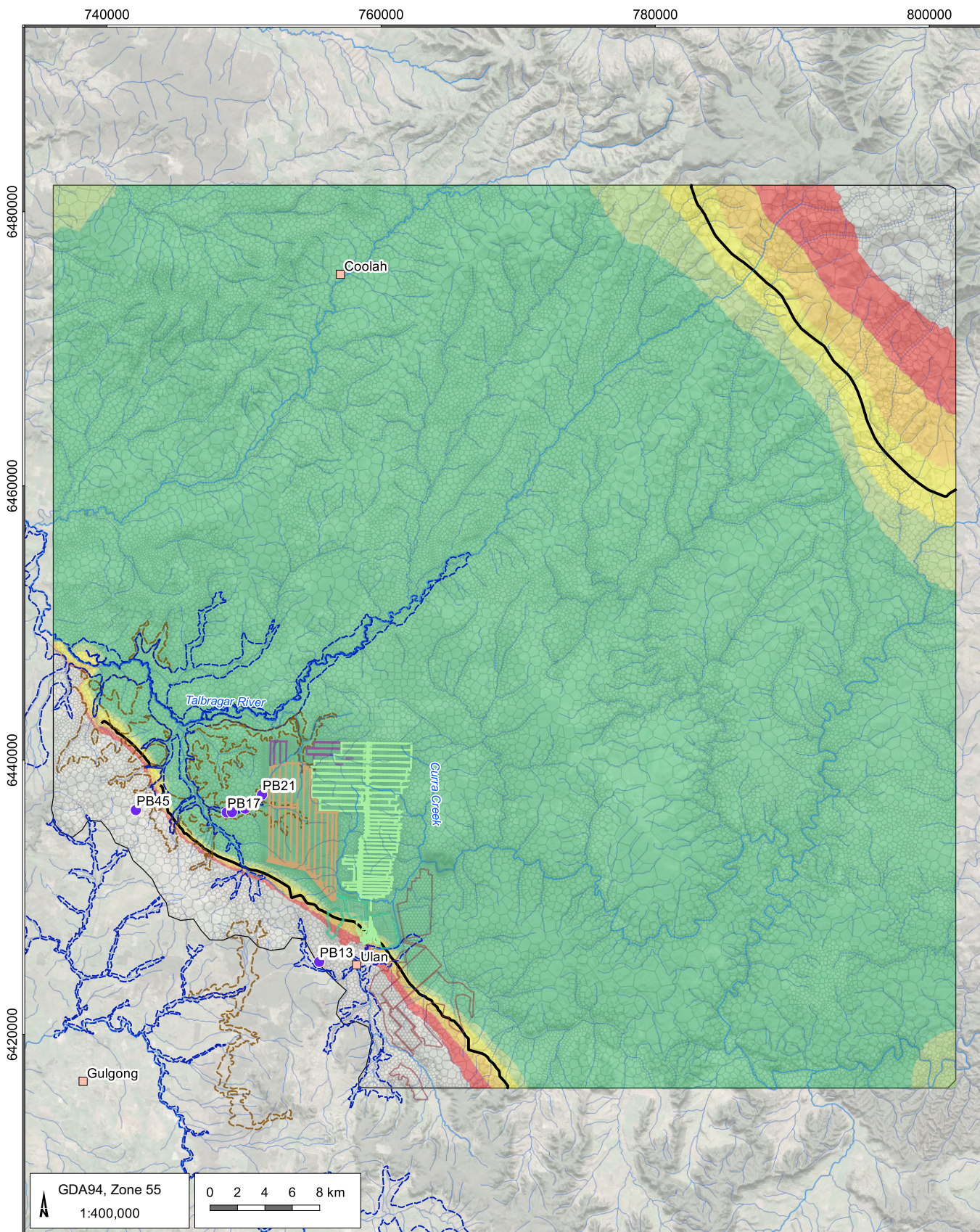


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FIGURE No:  
**3.20**





#### LEGEND

- Populated place
- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Likelihood of 2 m drawdown
- Ulan Open Cut
- Moolarben Mine Plan
- Model mesh
- Alluvium
- Colluvium
- Model domain

- Private bore
- Basecase 2m drawdown**
  - Very unlikely
  - Unlikely
  - About as likely as not
  - Likely
  - Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Probability of predicted cumulative maximum drawdown exceeding 2 m for Ulan Seam

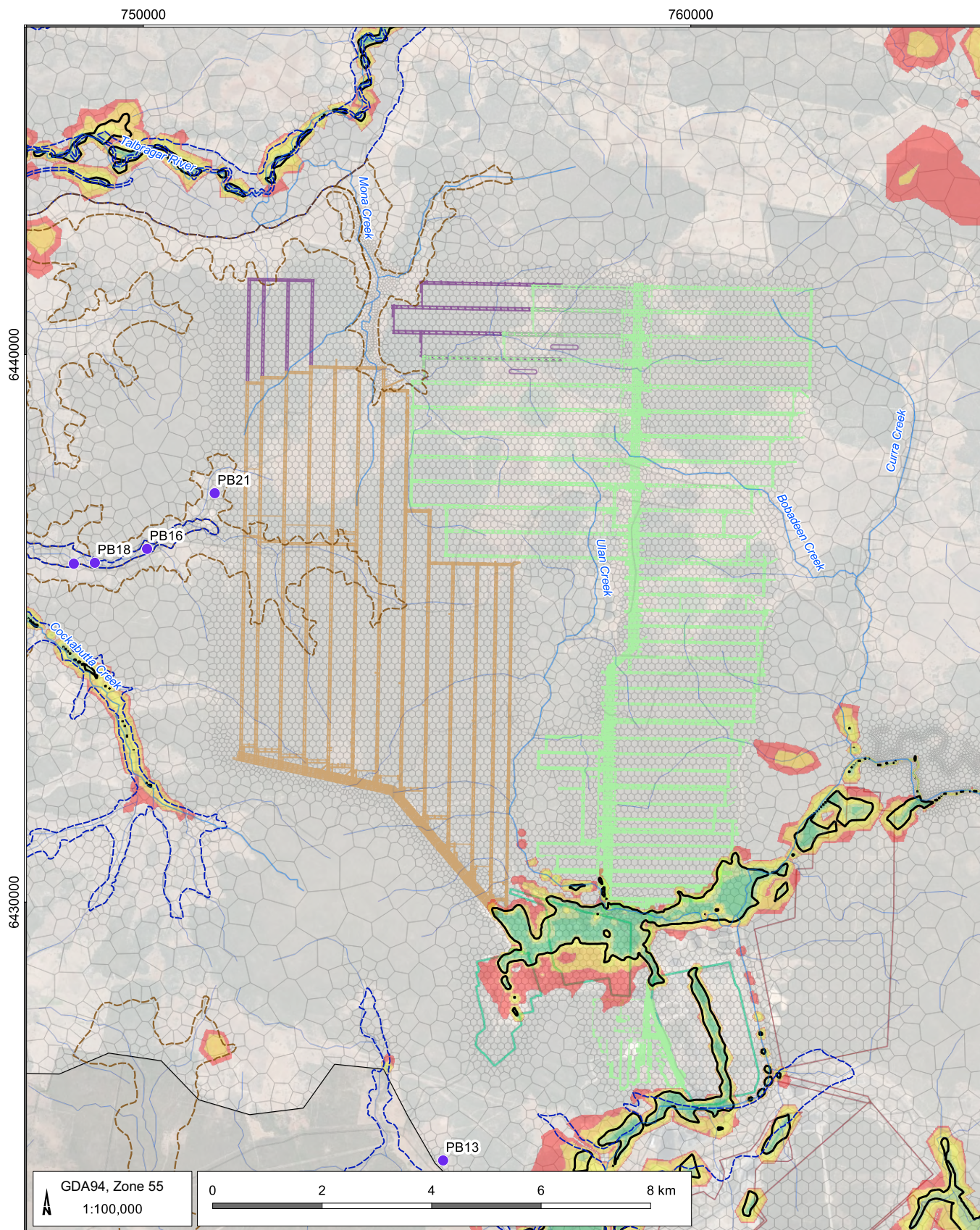


AGE

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29/07/2024

FIGURE No:  
**3.21**





#### LEGEND

- Private bore
- Basecase 2 m drawdown
- Drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Moolarben Mine Plan
- Ulan Open Cut
- Model mesh
- Model domain
- Alluvial
- Colluvial

#### Likelihood of 2 m depth to water

- Very unlikely
- Unlikely
- About as likely as not
- Likely
- Very likely

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Probability that depth to water table is less than 2 m at post-mining equilibrium**



AGE

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29/07/2024

FIGURE No:  
**3.22**



The updated uncertainty analysis also examined the predicted baseflow losses from cumulative mining, (approved plus MOD6A). The baseflow take from the Goulburn River is predicted to reach its predicted highest values at the end of mining (2032) and will begin declining shortly after mining ceases (Figure 3.23). As the mining at the UCC has moved north, the baseflow loss has also increased in the Talbragar River and is expected to increase further post mining (Figure 3.24) after recovery begins, as drawdown will continue to propagate away from the mine. Eventually, both river systems will experience an increase in baseflow as the post-mining recovery of water levels creates higher gradients toward the surface drainages.

Under the MOD6A mine plan and model, there are no predicted impacts to Mona Creek baseflow in any of the model scenarios (no-mine, approved, MOD6A). This is largely due to the perched nature of the alluvium aquifer underlying Mona Creek and that the depth to the regional water table is greater than 10 m under most of Mona Creek (see Figure 3.1)

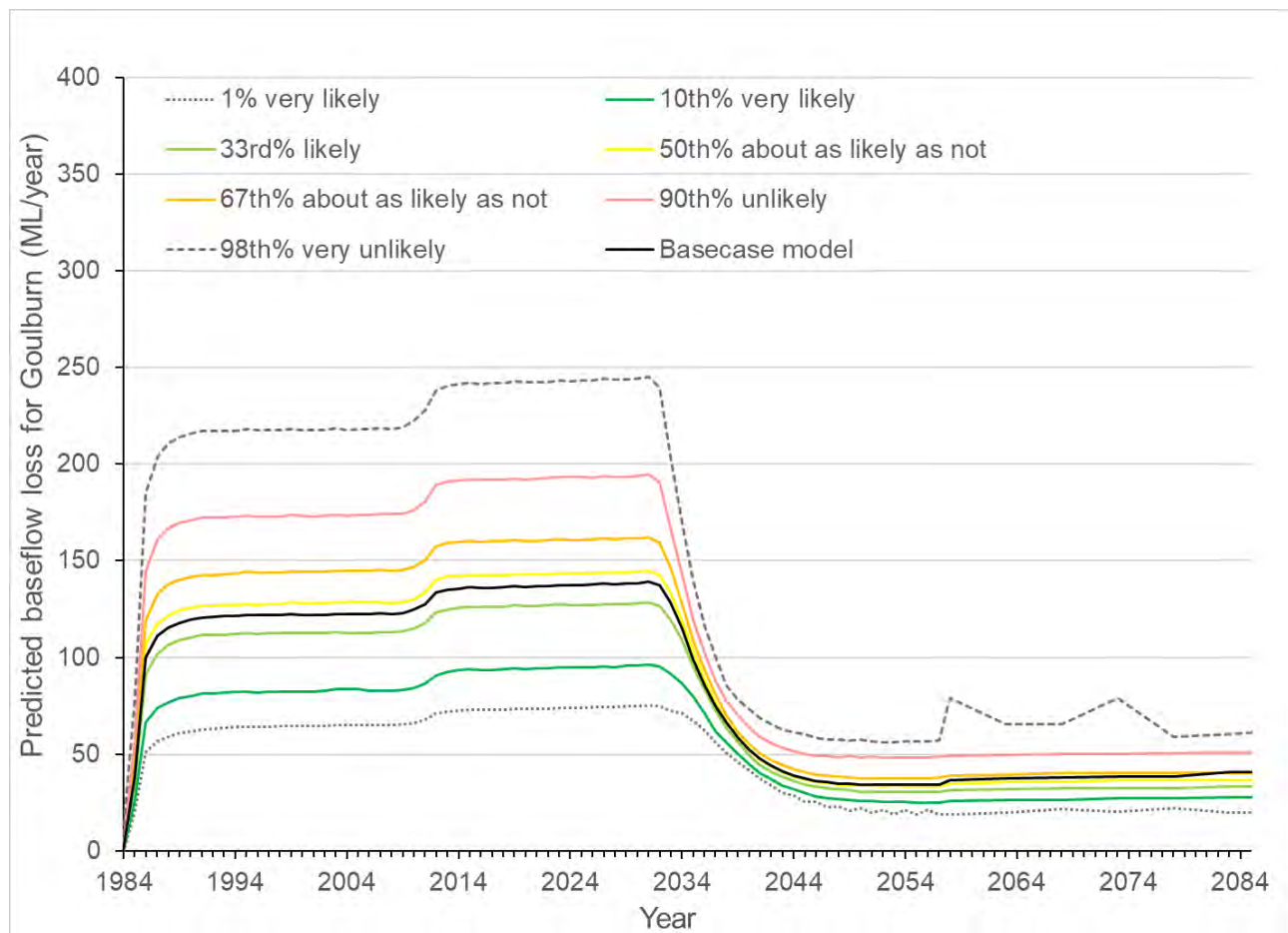


Figure 3.23 Probability that baseflow loss is exceeded for Goulburn River



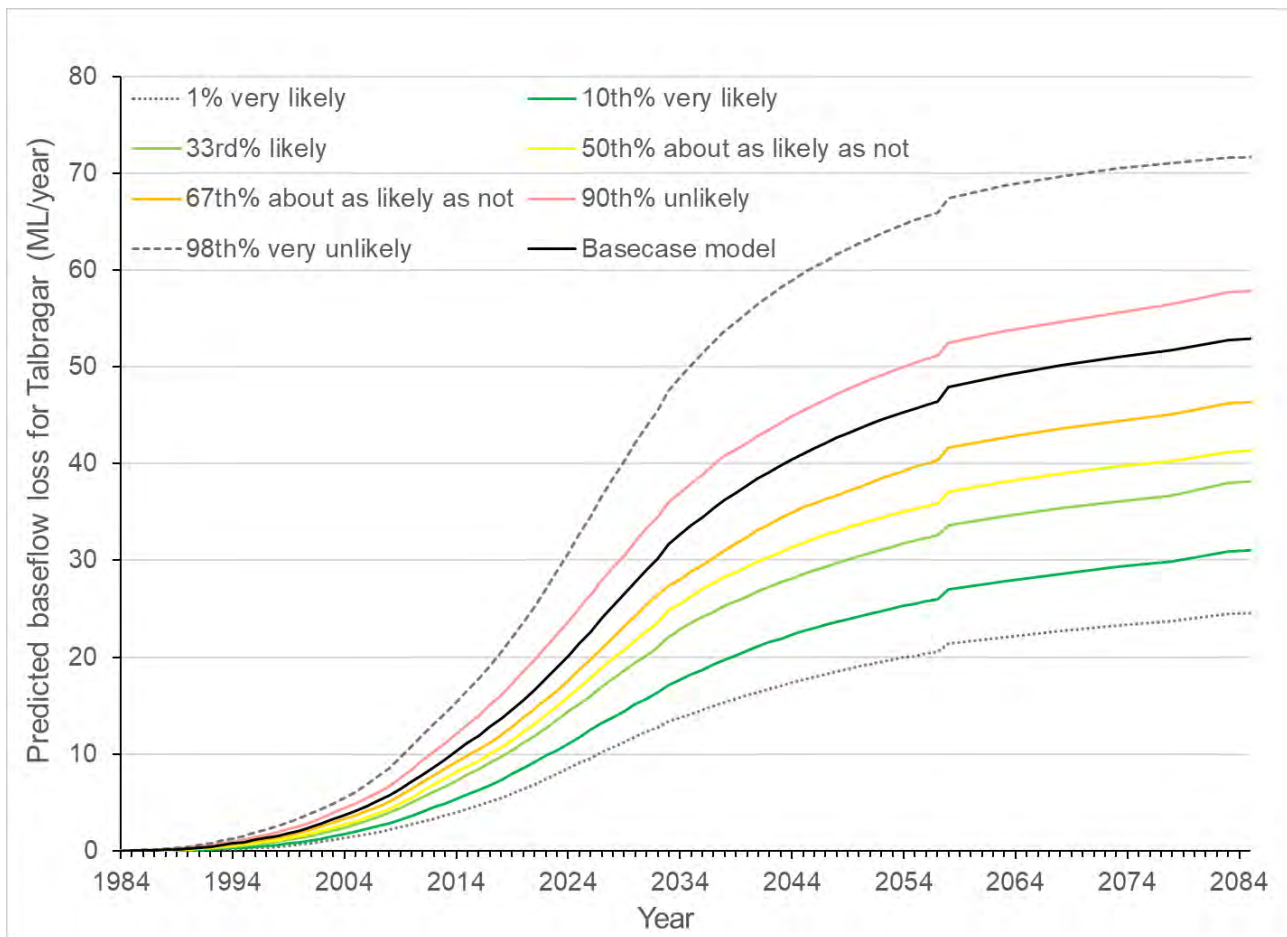


Figure 3.24 Probability that baseflow loss is exceeded for Talbragar River

### 3.6 Fracture height calculations (5f)

The groundwater model used for the original GIA and MOD6A model adopts the approach of Ditton-Merrick (Ditton and Merrick, 2014) in determining the height of connected fracturing above longwall panels (see Section A 4.6.4.3 in the GIA). This approach has been driven by monitoring data, and specifically the lack of response in shallow monitoring points (i.e. upper parts of the Triassic strata and above) to underground mining. Despite this, other methods are discussed here for completeness.

The other significantly documented method is the Tammetta method (Tammetta, 2013). The Tammetta approach relates panel width, overburden thickness (depth of cover), and the mined thickness to define the upper limit to the height of connected fractures, or the zone where there is desaturation.

The Tammetta equation is:

$$H = 1438 \ln(4.325 \times 10^{-5}u + 0.9818) + 26$$

and

$$u = wt^{1.4}d^{0.2}$$

where  $H$  is the height of connected fracturing (or desaturation),  $w$  is the longwall panel width,  $t$  is the mined thickness, and  $d$  is the depth of overburden cover.

A recent ACARP project (C27045) (Adhikary et. al., 2020) provided further advice around the likely range of the height of connected fracturing, and presented the equation below to be used in estimations:

$$H = \alpha W' t + c$$

where  $\alpha$  and  $c$  are coefficients and  $W'$  is the minimum value between the width of the panel and the overburden depth (both in metres). The coefficients  $\alpha$  and  $c$  can be assigned values that provide upper ( $\alpha = 0.325 \text{ m}^{-1}$ ,  $c = 0 \text{ m}$ ) and lower ( $\alpha = 0.18 \text{ m}^{-1}$ ,  $c = -15 \text{ m}$ ) limits for the height of connected fracturing.

A comparison of the calculated height of connected fracturing (HoF) for the Ditton-Merrick, Tammetta, and ACARP (both high and low estimates) methods are presented in Table 3.9 and displayed graphically in Figure 3.25. Table 3.9 provides estimates across the range of cover depths encountered at the UCC and for the average depth of cover across the proposed MOD6A underground mining.

**Table 3.9 Comparison of methods to estimate height of connected fracture (HoF)**

| Parameter                | Deep example | Average of MOD6A footprint | Shallow example |
|--------------------------|--------------|----------------------------|-----------------|
| Panel Width (m)          | 400          | 400                        | 400             |
| Mined Thickness (m)      | 3.5          | 3.5                        | 3.5             |
| Depth of overburden (m)  | 331          | 130                        | 72              |
| HoF model results        |              |                            |                 |
| HoF (m) - Tammetta       | 403          | 342                        | 308             |
| HoF (m) - ACARP-High     | 377          | 148                        | 81.9            |
| HoF (m) - ACARP-Low      | 194          | 67                         | 30.4            |
| HoF (m) - Ditton-Merrick | 188          | 121                        | 67              |

The Tammetta method estimates HoF reaching the land surface at all three depths of overburden (i.e. height or connected fracturing is greater than depth of overburden). This level of connection, and associated desaturation, has not been observed in shallow groundwater level data across the underground mined areas to date, indicating that this estimate is not applicable to the conditions observed at the UCC. The ACARP range is large, with the ACARP-High estimate resulting in HoF above land surface, and the ACARP-Low estimate generally below the adopted Ditton-Merrick method. It is noted that as the seam gets deeper, the Ditton-Merrick estimated HoF gets slightly lower than the lower end of the range that the ACARP method predicts.

Where the coal seams are nearer the land surface, there have been indications the HoF does get close to the land surface. Surface cracking, beyond the shallow tensile cracks, has been observed in areas where the mined seam is shallower, and it is understood some remedial work was required on cracks in the southern extent of the Ulan West LW1. Similar works have not been required north of that area indicating HoF does not reach near to the land surface where the seam is deeper. These observations mean that the Ditton-Merrick approach is providing more realistic changes due to mining than the Tammetta model provides at this stage and understanding.

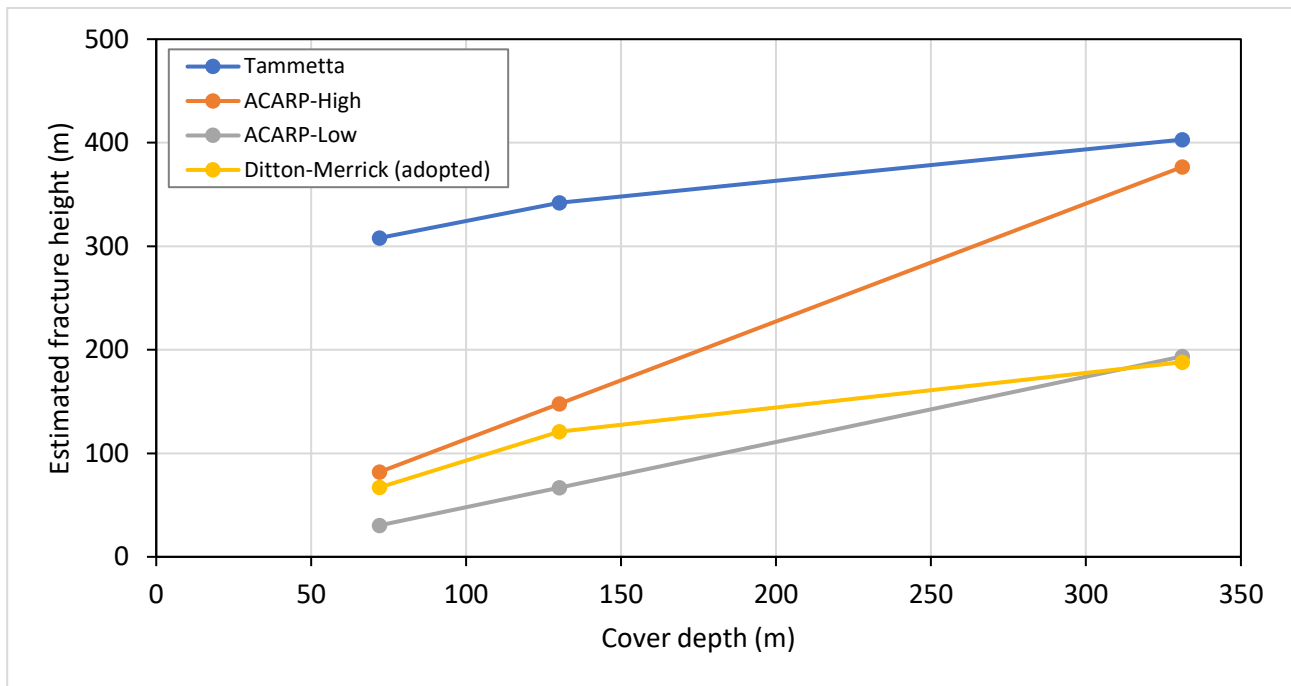
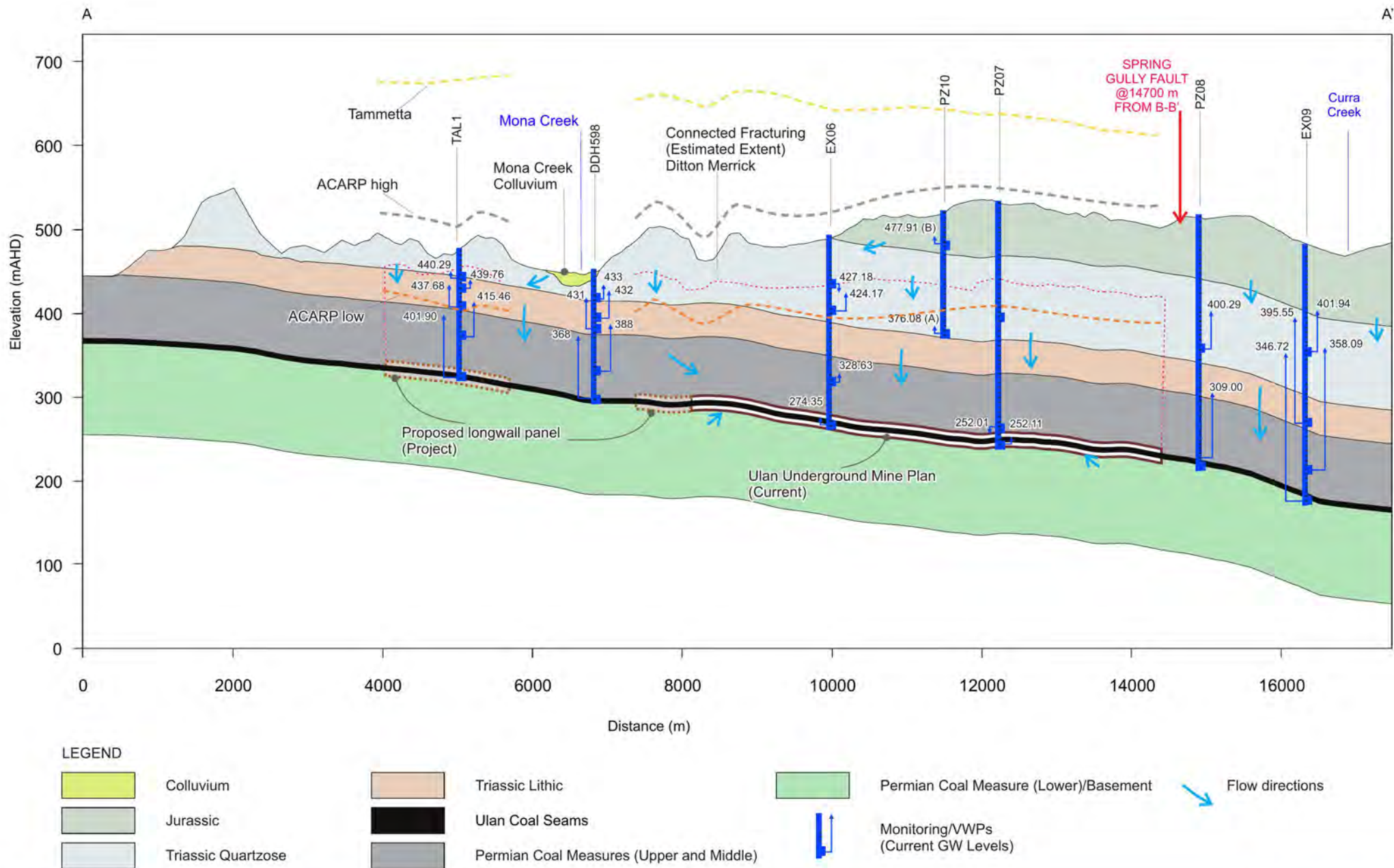


Figure 3.25 Estimated fracture height - method comparison

To demonstrate the various HoF estimation methods in relation to the UCC, a conceptual cross-section is provided in Figure 3.26 showing the adopted fracture height and how the three methods compare. Both the Tammetta and ACARP-High methods predict a HoF or height of depressurisation that would result in continuous fracturing to the ground surface. Fractures coming to the surface have not been observed across the majority of the underground mine footprint, rather it has only been observed in specific areas in the south where the depth of cover is very low (80 to 100 m). The adopted Ditton-Merrick model does estimate this occurring in these areas.

It is clear from Figure 3.26 that if the Tammetta or ACARP-High methods were appropriate there would be significant depressurisation of all the overlying strata across the site. This has not been observed in the monitoring bores targeting shallow strata and, instead, only the lower parts of the Triassic strata have shown response to the fracturing. This can be seen where the cross section displays current observed water levels in the specific bores. This confirms that the adopted Ditton-Merrick model is the most appropriate for the Ulan area.





**Cross section showing the range of fracture heights from different sources**

**Figure - 3.26**

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)"



### 3.7 Further recharge considerations (8b)

Groundwater recharge occurs in the MOD6A underground mining area through direct infiltration of rainfall and downward percolation through the weathered cover into the underlying hard rock. Recharge rates have been derived from calibration and the non-uniqueness has been explored in uncertainty analysis (see Section 3.5). The range of recharge has been guided by previous modelling in the area by Mackie Environmental Research (MER, 2009) which considered groundwater recharge to the underlying hard rock to vary from less than 1% to approximately 2% of rainfall.

To support these recharge estimates, a chloride mass balance assessment was undertaken using observations of chloride concentrations from the main geologic formations. This analysis found that the average percentage of rainfall potentially becoming recharge ranged from 0.2% (range: 0.08 - 0.41%) for Jurassic strata, to 1.51% (range: 0.4 - 2.72%) for Permian strata, and 1.65% (range: 0.49 - 2.96%) for Triassic strata. The chloride mass balance method provides a guide for estimating recharge rates but is not a precise measure. There are many things that affect these estimates, as indicated by the range calculated, and recharge is expected to be variable even within a particular formation.

To apply the recharge rate over the broad regional model we have simplified the variability into a single rate for each outcropping formation. These rates have been calibrated with hydraulic conductivities (within measured ranges) to match regional water level behaviour and mine inflows across a combined steady state and transient simulation. While the final recharge values used in the model are somewhat low, they were required to match the depth of the regional water table, which sits low in the strata (see the first panel in Figure 3.1), and represent the low deep percolation volumes arriving through the unsaturated zone.

### 3.8 Further information on hydraulic properties (8c)

The adopted hydraulic conductivity distributions were summarised in two charts in Appendix A of the GIA (AGE 2022) and have been reproduced below in Figure 3.27 and Figure 3.28. Re-calibration of the model was not part of the MOD6A update but is planned for 2024. The data is presented for each model layer and Table 3.10 provides what layers represent which formations.

Table 3.10 Model layers and represented geologic strata

| Layer/s | Formation            |
|---------|----------------------|
| 1       | Alluvium & Colluvium |
| 2       | Basalt               |
| 3 - 4   | Jurassic             |
| 5 - 8   | Quartzose Triassic   |
| 9 - 10  | Lithic Triassic      |
| 11 - 19 | Permian              |
| 16      | Ulan Coal Seam       |

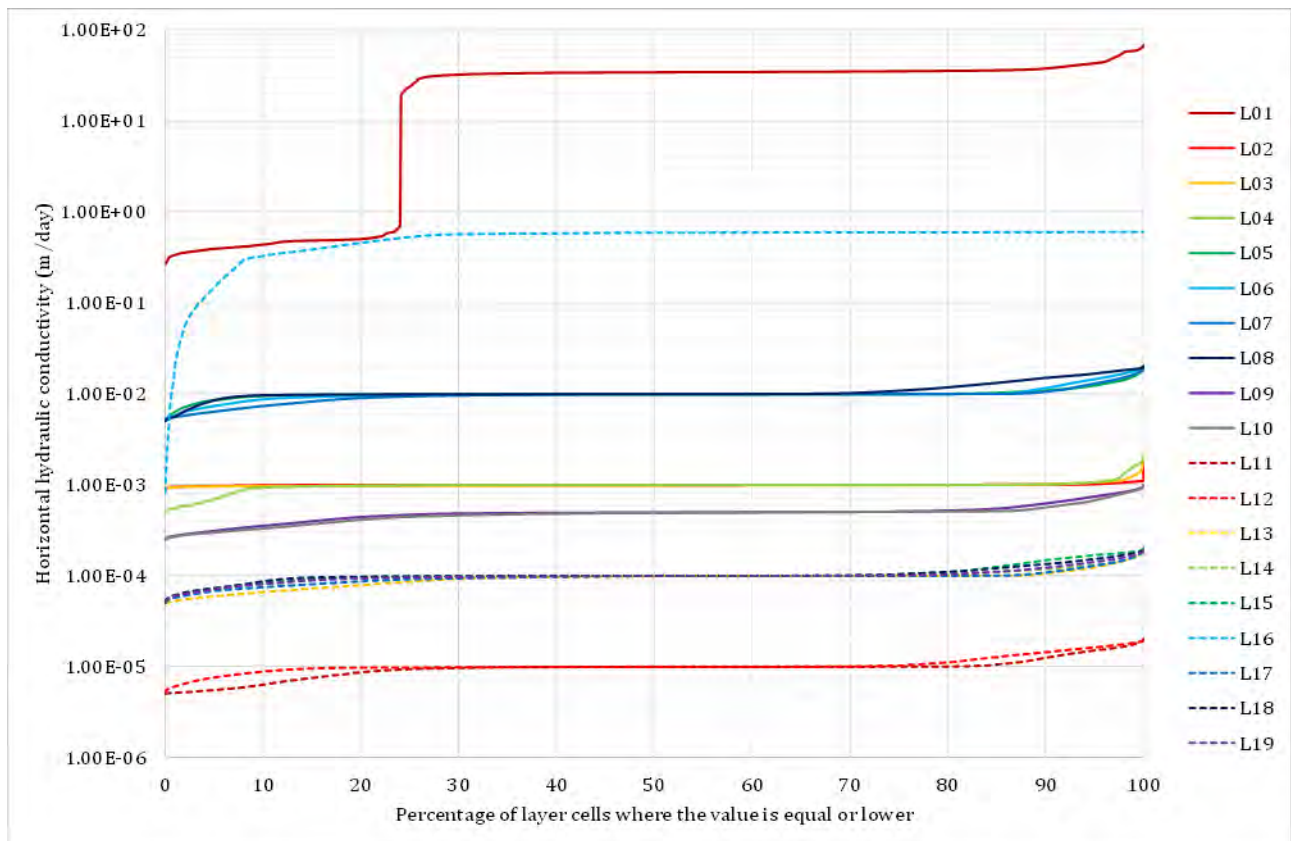


Figure 3.27 Calibrated horizontal hydraulic conductivity distribution per model layer

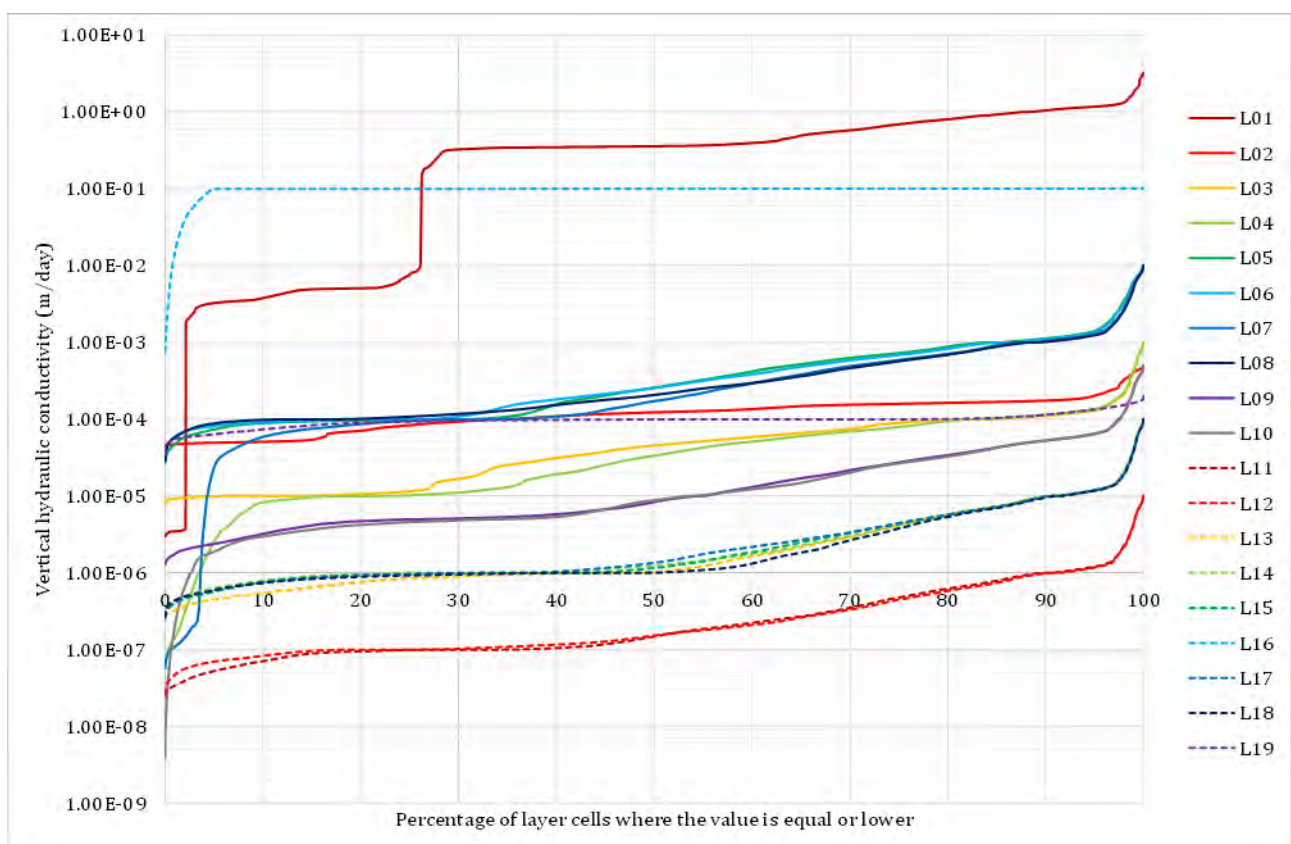


Figure 3.28 Calibrated vertical hydraulic conductivity distribution per model layer



### 3.9 Further calibration summary (7)

The overall measure of the calibration through the Scaled Root Mean Square (SRMS) has been separated by formation types in Table 3.11 to provide more information from the calibration process. Table 3.11 shows the number of observations used, the minimum, maximum, and range of observed values, the RMS, and the SRMS for each formation.

The data provided in the MOD6A model also includes an update of the calibration dataset through the end of 2023. The original calibration (MOD6) had a SRMS of 3.94% and updating the dataset has reduced the SRMS by 0.21% to 3.73%.

The SRMS, per formation, ranges between 3.93% (Quartzose Triassic formation) and 8.89% (Basalt formation) and so all formations are within the advocated performance targets in the Australian Modelling Guidelines (Barnett, 2012).

Figure 3.29 presents the observed and simulated groundwater levels for each formation as a scattergram for the historical transient calibration.

Table 3.11 Summary statistics of calibration per geology type

| Formation            | Observation count | Min observed value (mAHD) | Max observed value (mAHD) | Observed values range (m) | RMS (m)      | SRMS (%)    |
|----------------------|-------------------|---------------------------|---------------------------|---------------------------|--------------|-------------|
| Alluvium - Colluvium | 159               | 236.3                     | 488.64                    | 252.34                    | 10.11        | 4.01        |
| Basalt               | 18                | 310.94                    | 672.7                     | 361.76                    | 32.17        | 8.89        |
| Jurassic             | 240               | 317.8                     | 634.53                    | 316.73                    | 28.08        | 8.87        |
| Quartzose Triassic   | 894               | 265.05                    | 513.05                    | 248                       | 9.75         | 3.93        |
| Lithic Triassic      | 2602              | 347.15                    | 511.54                    | 164.39                    | 14.51        | 8.83        |
| Permian              | 6707              | 223.287                   | 492.4                     | 269.113                   | 17.83        | 6.63        |
| <b>Overall</b>       | <b>10620</b>      | <b>223.287</b>            | <b>672.7</b>              | <b>449.413</b>            | <b>16.78</b> | <b>3.73</b> |

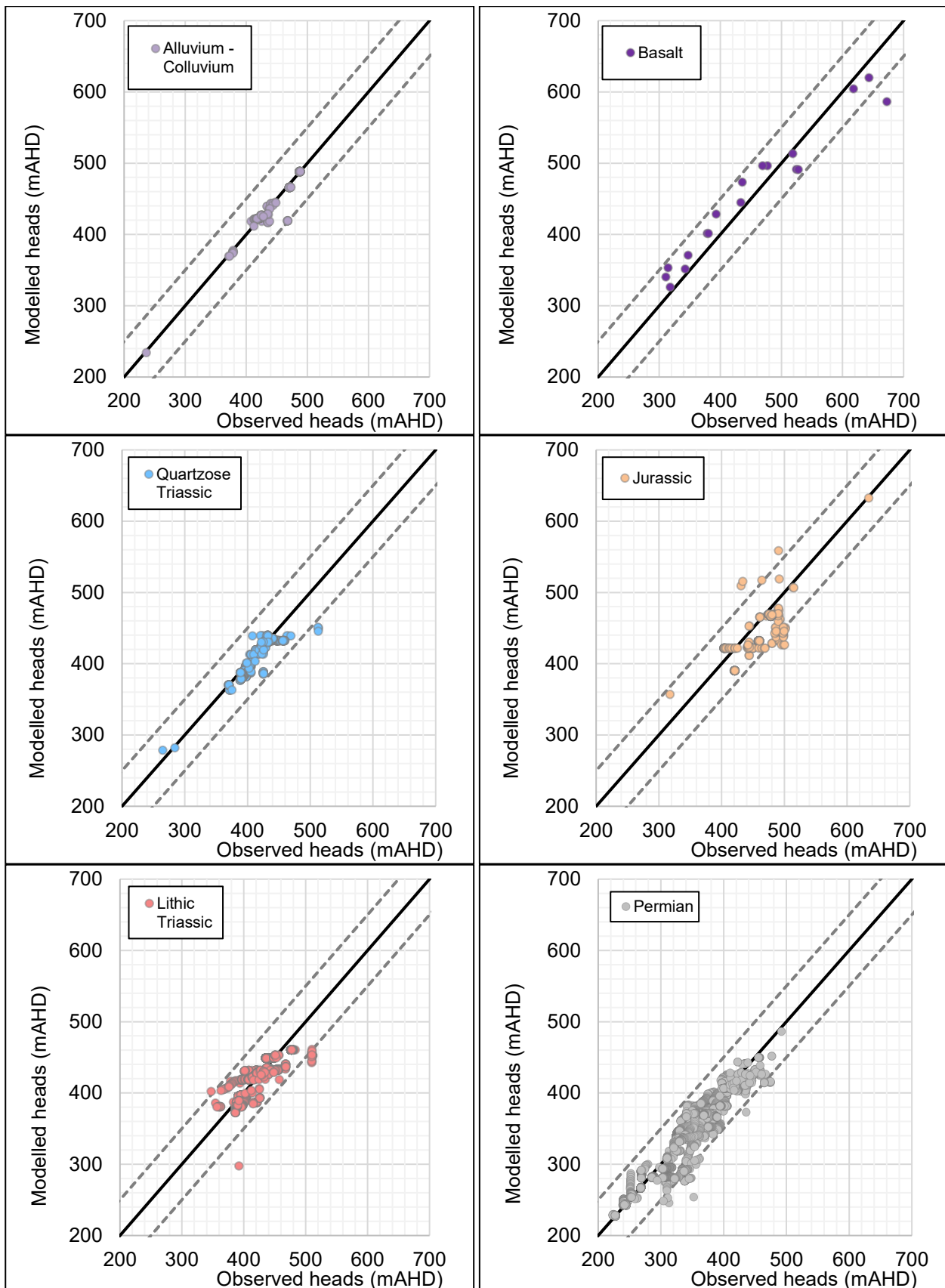


Figure 3.29 Scatter diagrams for observed water levels in each geology type (solid diagonal is 1:1; dashed diagonals are +/- 50 m)

### 3.10 Monitoring of different formations (30)

As requested, Figure 3.30 presents the groundwater monitoring locations and identifies the geological formation(s) being monitored at each location.



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 Project: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011 ; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006 ;  
 G:\Projects\UCM5033\_001\Ilan\MODE\Amendment3\_GIS\Workspaces\002\_Deliverable2\03\_00\_UCM5033\_Monitoring locations indicating formations monitored.gpx



### 3.11 Further information on springs (4)

Two springs have been identified north of the proposed MOD6A underground mining footprint and these have been designated “Unnamed Spring” and “Kellys Spring”. At the time of formulating the conceptual model for the MOD6 GIA, the available data indicated that the adjacent basalt cap was the likely source of water for the Unnamed Spring, while Kelly’s Spring was located within a large area of Jurassic sediments from which it was likely sourced. Each spring is discussed separately in the following sub-sections.

#### 3.11.1 Unnamed Spring

Recent efforts to obtain a water sample from both springs has produced only one sample collected at the Unnamed Spring. The sample was analysed for major cations and anions and heavy metals. Analysis of the sample showed the water to be reasonably fresh (EC of 1020  $\mu\text{S}/\text{cm}$ , TDS of 565 mg/L) with a pH of 7.14. The water type is classified as Mg-Na-Ca- $\text{HCO}_3\text{-Cl}$  (Figure 3.31). This water type does not appear in previous water sample results available from the North Monitoring Network at the UCC, so at this stage it is difficult to assign it to a particular source formation, however, it is similar to a broad range of water types found in the Triassic strata.

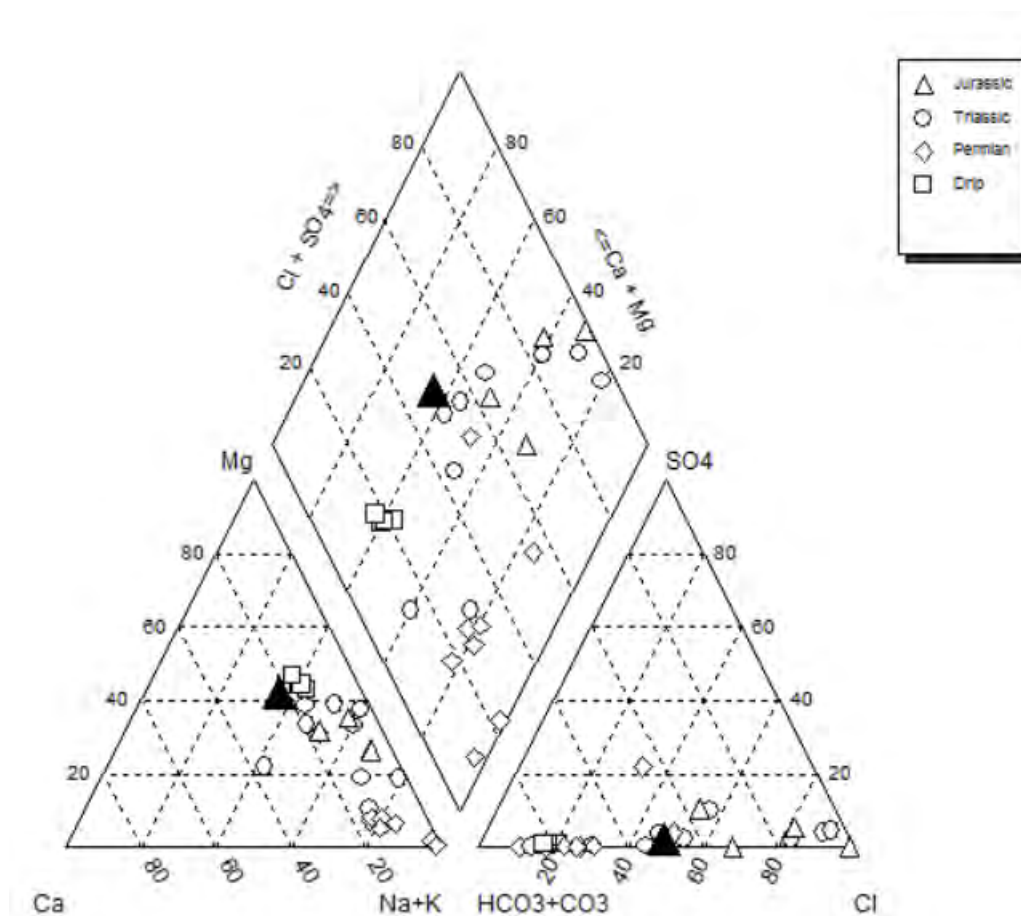


Figure 3.31 Piper plot of water samples from North Monitoring Network bores (open shapes classified by geology) and Unnamed Spring (black triangle)

Further investigations were made into the nature and source of Unnamed Spring, including aerial photography, which indicated the presence of a basalt cap in the vicinity. Geological mapping further indicated that the surface expression of the spring was located down slope from this basalt cap and at the location of the interface between the Jurassic Pilliga and underlying Jurassic Purlewaugh formations. While the aerial imagery indicates that the soils upgradient from the spring are basaltic in origin, it could be this indication of basalt is simply weathered off the cap and deposited down the slope.

If the geologic mapping of the area is accurate, the location of the spring is not the contact between the basalt and underlying Pilliga formation, rather it is the contact between the more-permeable Pilliga Formation and the tighter underlying Purlawaugh Formation. The Jurassic sediments are noted for having localised perched aquifer systems through the region, which is the likely mechanism for the spring. However, water quality indicates it is generally fresher than typical Jurassic samples, so the spring's source may also be water that is recharged in the basalt cap and then transferred to the Jurassic sediments before discharging.

Unnamed Spring is daylighting at an elevation of approximately 460 mAHD. This elevation is significantly above the 'regional' water table for the underlying Triassic sediments and thus it is expected that the spring will remain unaffected by changes to the groundwater regime from the underground mining.

### 3.11.2 Kelly's Spring

Kellys Spring has previously been inspected by AGE staff, and field water quality data has been collected in mid-2023. The data shows the water to be fresh with a TDS reading of 53.36 mg/L, meaning it represents water that was recently recharged into the groundwater system and a relatively short flowpath. The pH of the water was 8.52 and the temperature was 9.1°C.

The conceptual model of this spring as being sourced from perched Jurassic sediments, which is how it is presented in the MOD6A groundwater model, is supported by this water quality data. Furthermore, it has been recommended that both springs be sampled at the next available opportunity for water quality and water chemistry (cations, anions and heavy metals) to complete a background assessment.

## 3.12 Additional consideration to post mining management options to reduce predicted mounding (17, 21)

The MOD6 and MOD6A post-mining predictions did not take into account post-mining management options that would mitigate the possibility of groundwater mounding and its impacts. To address this, the MOD6A model incorporated a recharge mitigation strategy that would reduce groundwater recharge across the open cut void area during the post-mining recovery period (which then flows into the underground goaf and voids). Specifically, the model was set up to be consistent with previous models (MOD4 and MOD6) through the mining phase, but then employ a closure approach that reduces the groundwater recharge across the open cut void area to 5% of the total rainfall during the post-mining phase. This scenario provides insight on the impact of reducing recharge in the area to manage the potential for mounding. Figure 3.32 presents the predicted post-mining equilibrium depth to water table under this recharge management scenario.

The implementation of this recharge mitigation strategy in MOD6A results in changes to the level of residual drawdown and mounding occurring in the model at the post-mining equilibrium stage. Figure 3.33 to Figure 3.37 present the predicted drawdown and mounding contours with the recharge mitigation strategy. These figures can be compared to Figures 7.10 through 7.17 in the original MOD6 report (AGE 2022) and show that, generally speaking, the recharge mitigation strategy reduces the extent of mounding in all layers around the mine area, but also leads to areas of prolonged residual drawdown, especially in the deeper layers (note that the MOD6 mine plan includes mined panels that extend beneath Mona Creek whereas MOD6A mine plan has shortened those panels). The effects on the alluvium/colluvium layer is only observed along the Goulburn River south of the UCC and along Mona Creek. Direct comparison to Mona Creek is especially problematic because of the reduced mine footprint between the MOD6 and MOD6A mine plan, but under the current plan (MOD6A) and recharge mitigation strategy, the model predicts small residual drawdown (maximum just over 5 m) along Mona Creek (see Figure 3.33). However, Figure 3.1 shows that the predicted depth to water table, even at post-mining equilibrium, is over 10 m below ground level along much of Mona Creek, indicating not likely impact to GDEs or baseflow.

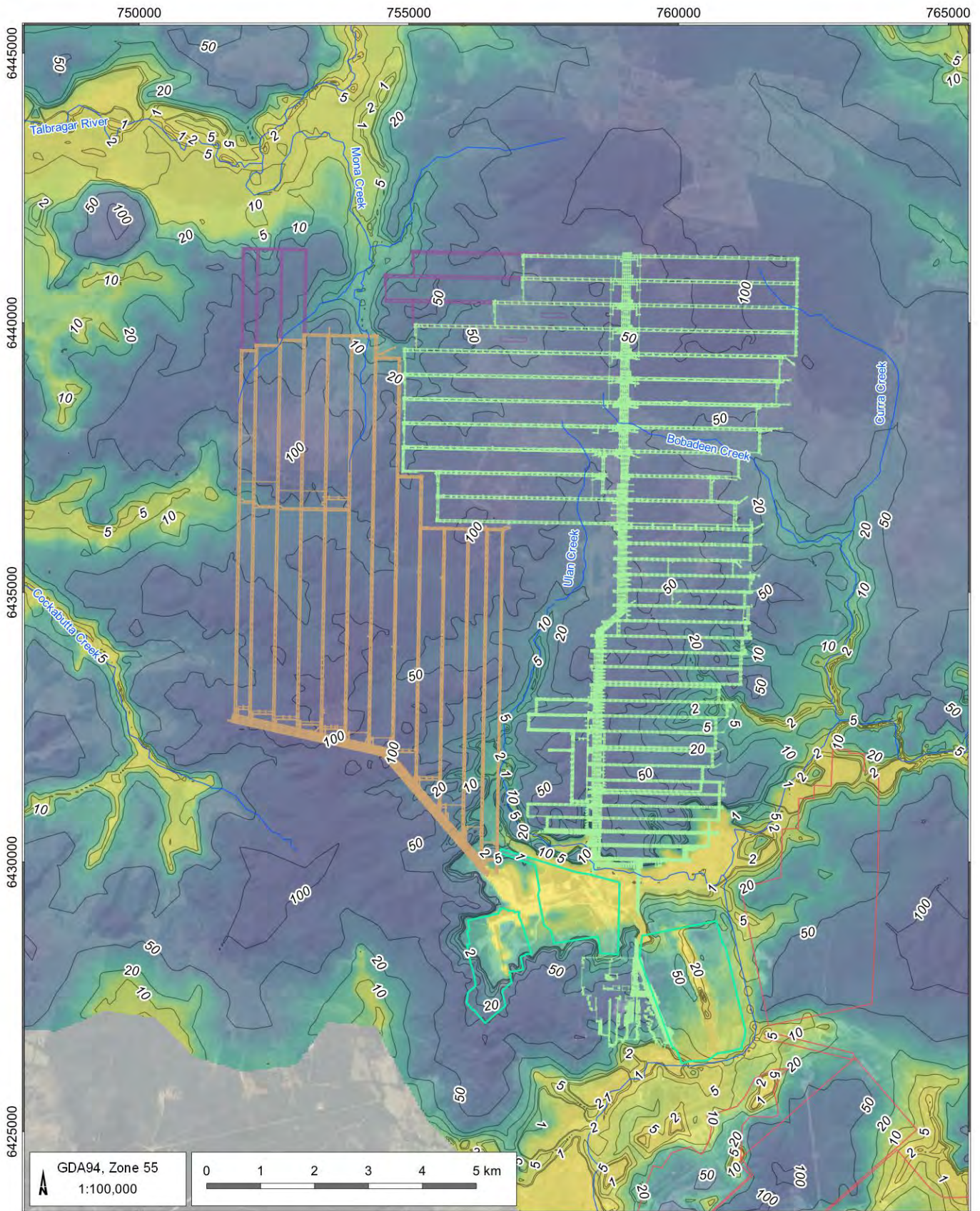
The change in drawdown and mounding due to the reduced recharge also changes the predicted long-term baseflow. The changes to baseflow are presented in Table 3.12 for the Goulburn and Talbragar rivers and their modelled tributaries within the model domain, and compared to the original MOD6 mine plan (as above, consideration of the change in the mine plan has an impact as well). The Goulburn River is predicted to have a slight increase over pre-mining baseflow from the general mounding predicted in its catchment, and the Talbragar River is predicted to have a residual reduction in the baseflow compared to pre-mining conditions. For both rivers, these predictions will be imperceptible with baseflow impacts essentially returning to pre-mining conditions.



The key aspect of these results is that the implementation of a mitigation strategy that constrains the rainfall recharge across the void areas to 5% of the total rainfall would significantly reduce the long-term mounding effect and its impact on the baseflow of the rivers but will result in some residual drawdown remaining in areas to the north and northwest of the mine.

Table 3.12 Predicted long-term baseflow changes in the management scenario

| Case                           | % Change in void recharge | Increase in Baseflow for Goulburn River and tribs (ML/year) | Increase in Baseflow for Talbragar River and tribs (ML/year) |
|--------------------------------|---------------------------|-------------------------------------------------------------|--------------------------------------------------------------|
| Original MOD6 assessment       | no change                 | 283                                                         | 133                                                          |
| MOD6A with Mitigation strategy | Reduced by 105 %          | 70.9                                                        | -10.3 (reduction)                                            |



#### LEGEND

- Drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Depth to water table contour
- Moolarben mine area
- Ulan open cut

#### Depth to water table

- 0
- 10
- 15
- 20
- 30
- 40
- 50
- 100
- 200
- 250

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Predicted long-term depth to water table of the management scenario**

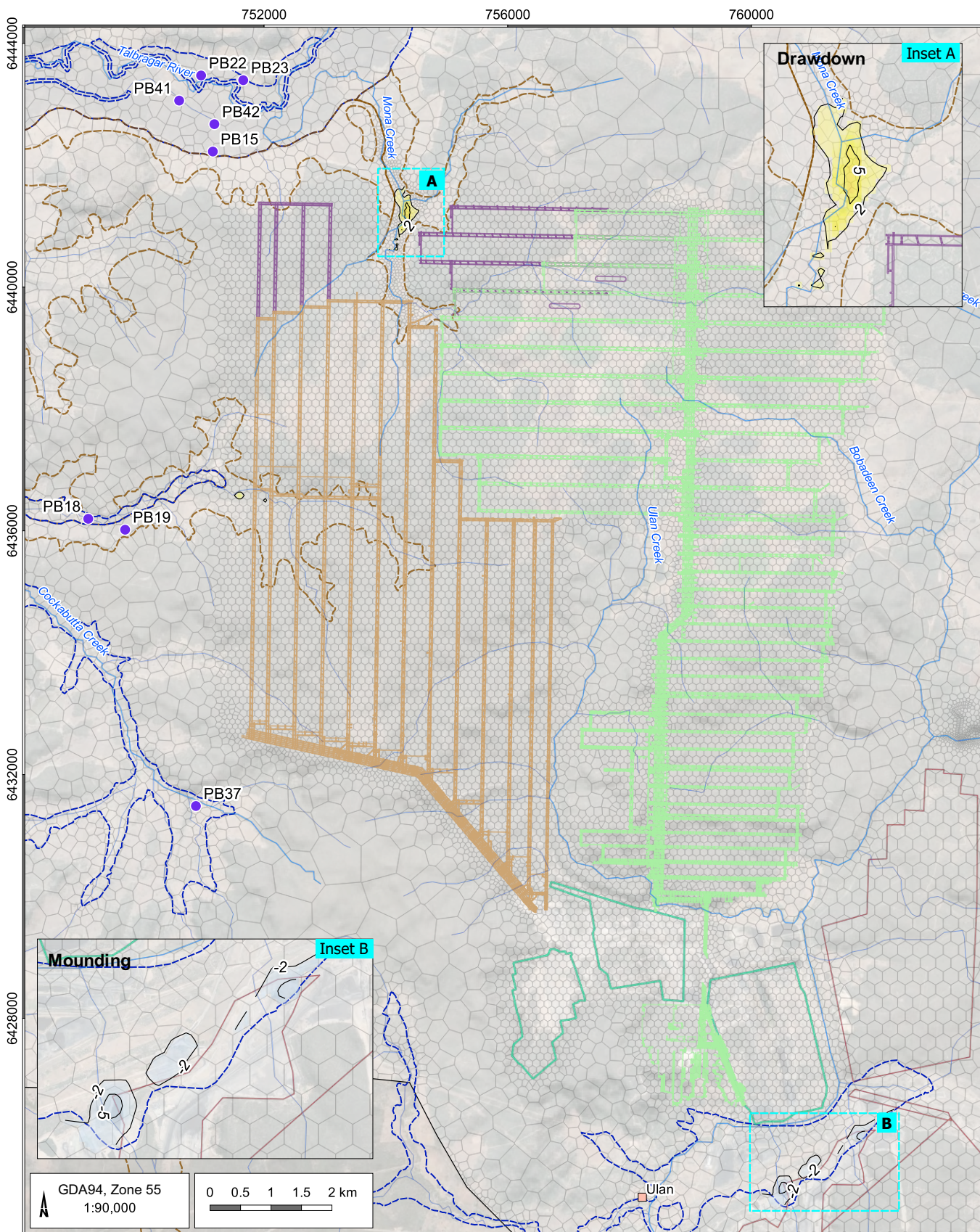


**AGE**

DATE  
01/05/2024

FIGURE No:  
**3.32**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Moolarben Mine Plan
- Ulan Open Cut

- Private bore
- Drawdown contour (m)

- Model mesh
- Alluvium
- Colluvium

- Drawdown (m)**
- 0
  - 2
  - 5
  - 10
  - 20
  - 50
  - 100
  - 200
  - 500

- Mounding (m)**
- -500
  - -200
  - -100
  - -50
  - -20
  - -10
  - -5
  - -2
  - 0

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Long-term drawdown (and mounding) in alluvium / colluvium (layer 1) – post mining management scenario**

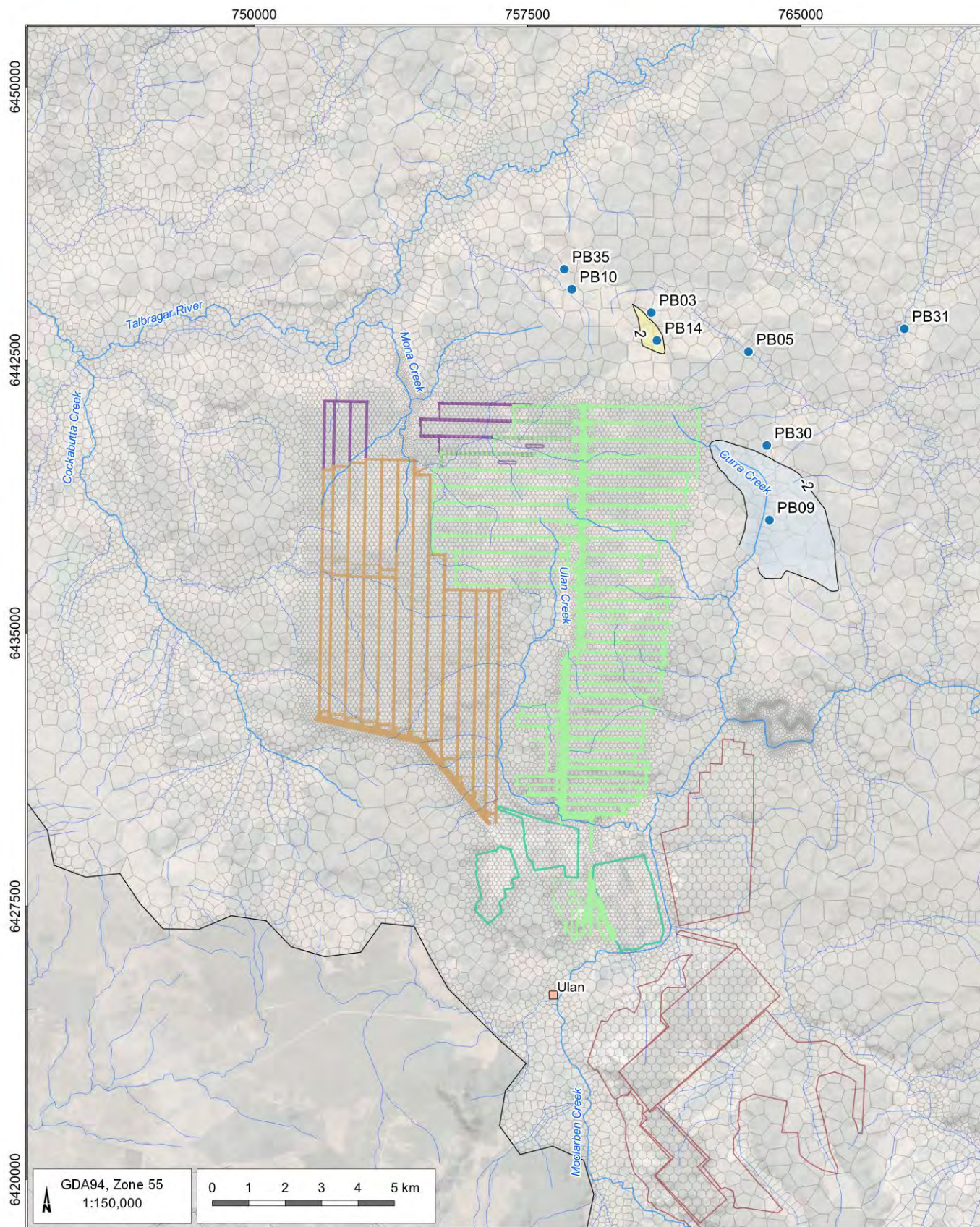


**AGE**

DATE  
30/07/2024

FIGURE No:  
**3.33**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Model mesh
- Moolarben Mine Plan
- Ulan Open Cut
- Private bore
- Contour line (m)

#### Drawdown (m)

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

#### Mounding (m)

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

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

**Long-term drawdown (and mounding) in Jurassic (layer 4) – post mining management scenario**

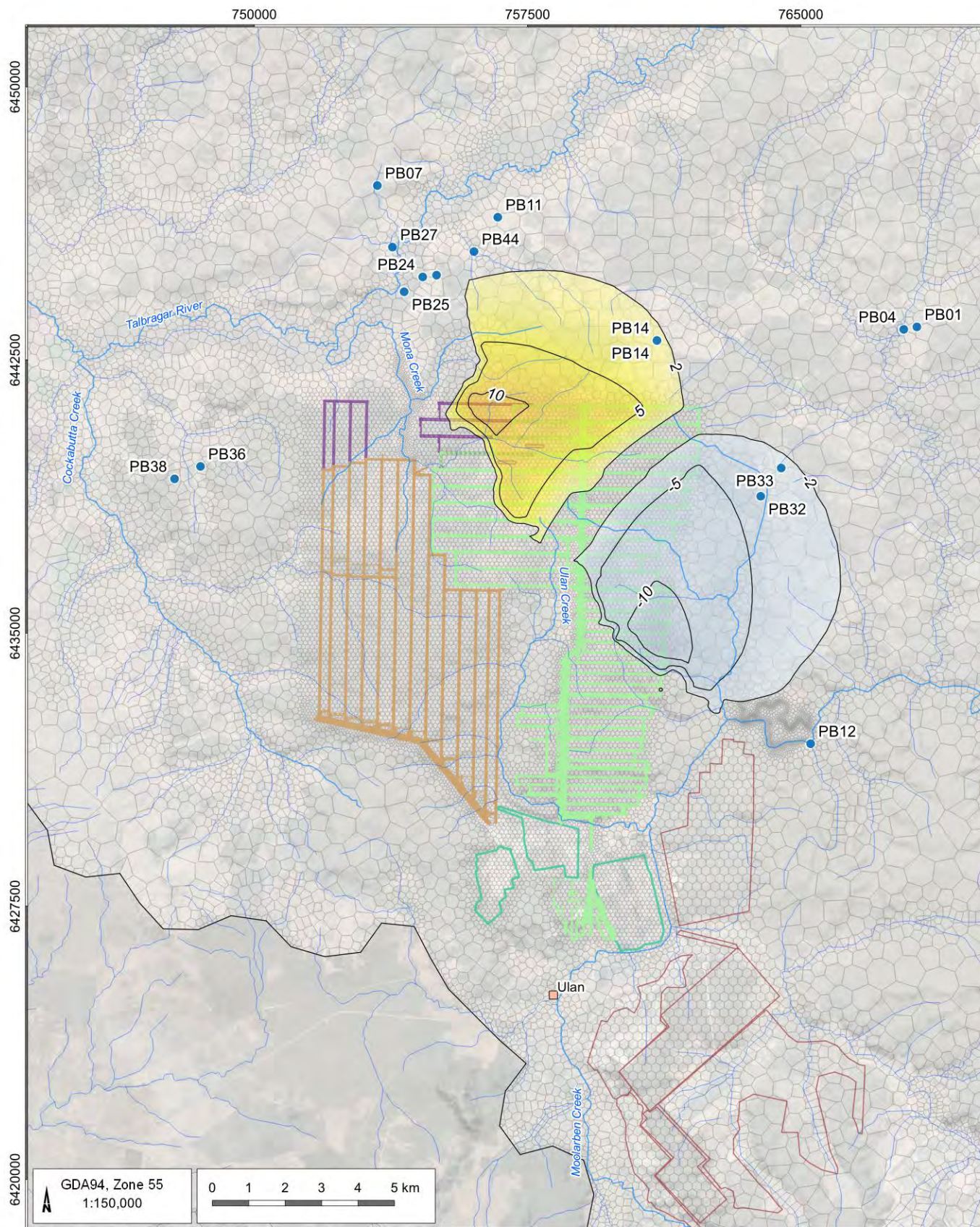


AGE

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30/04/2024

FIGURE No:  
**3.34**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Model mesh
- Moolarben Mine Plan
- Ulan Open Cut
- Private bore
- Contour line (m)

#### Drawdown (m)

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

#### Mounding (m)

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

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

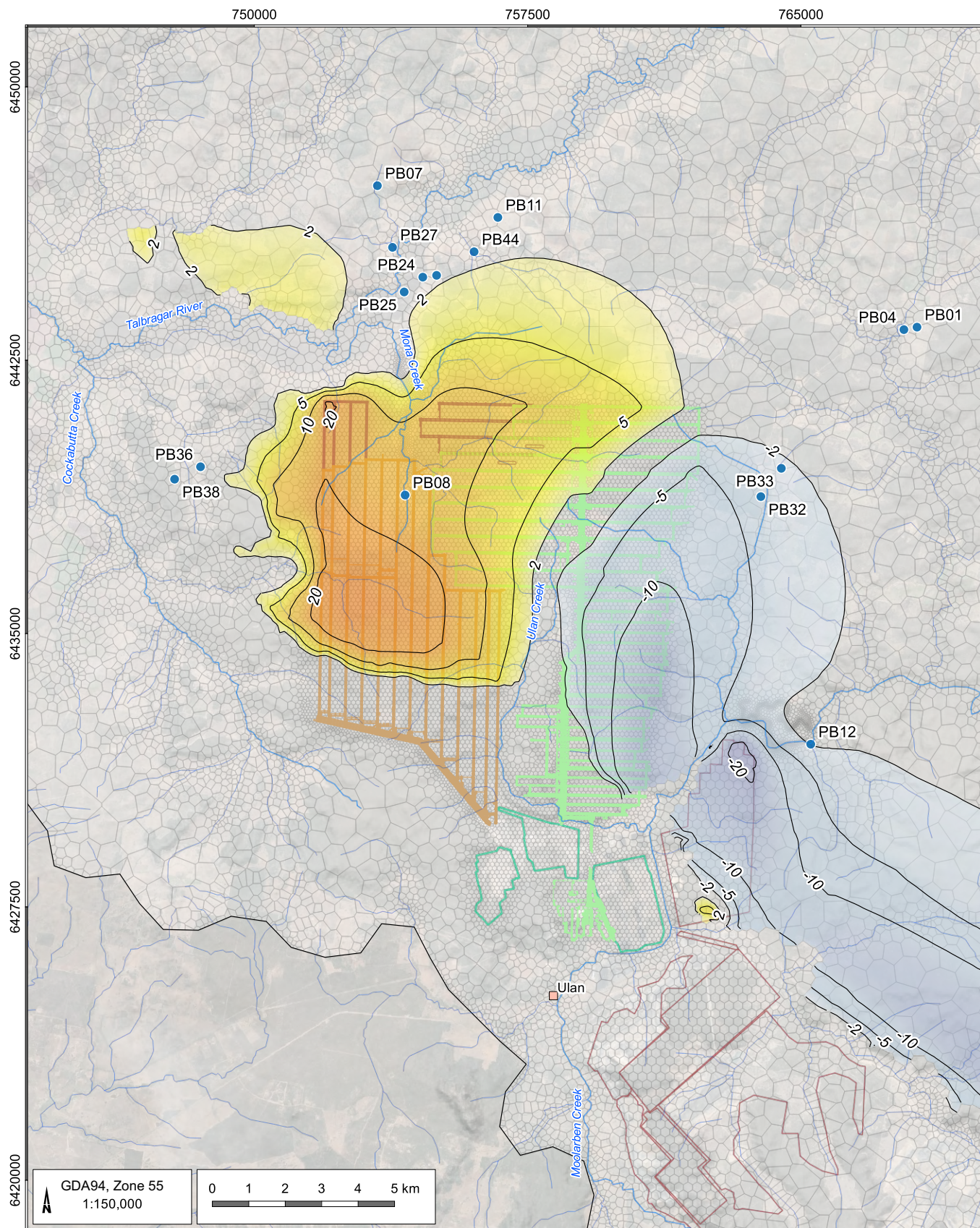
**Long-term drawdown (and mounding) in Quartzose Triassic (layer 7) – post mining management scenario**



DATE  
30/04/2024

FIGURE No:  
**3.35**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Model mesh
- Moolarben Mine Plan
- Ulan Open Cut
- Private bore
- Contour line (m)

#### Drawdown (m)

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

#### Mounding (m)

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

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Long-term drawdown (and mounding) in Lithic Triassic (layer 10) – post mining management scenario

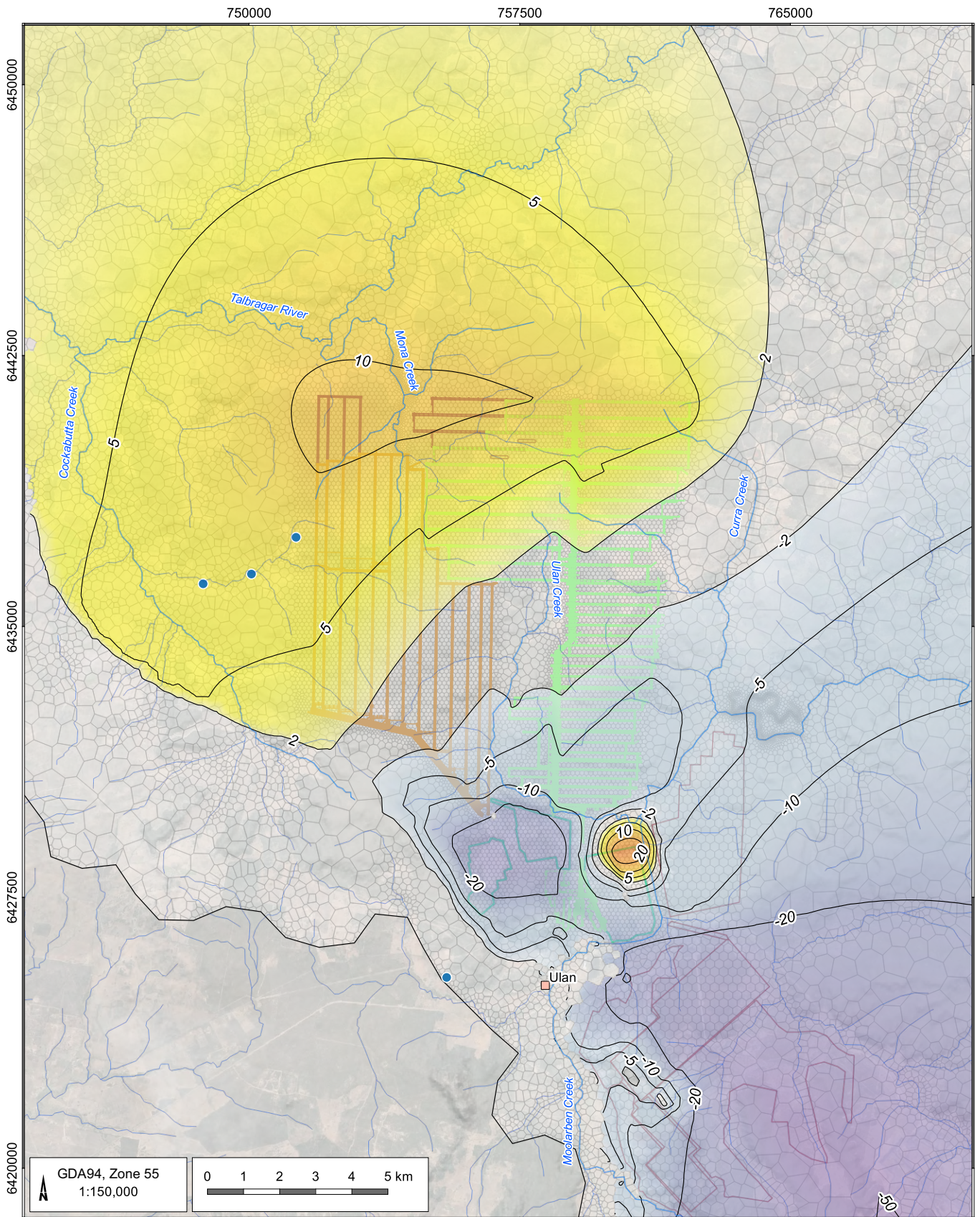


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07/08/2024

FIGURE No:  
**3.36**





#### LEGEND

- Surface drainage
- Ulan West Mine Plan
- Ulan Underground Mine Plan
- Proposed Longwall Panel
- Model mesh
- Moolarben Mine Plan
- Ulan Open Cut
- Private bore
- Contour line (m)

#### Drawdown (m)

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

#### Mounding (m)

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

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

### Long-term drawdown (and mounding) in Ulan Seam (layer 16) – post mining management scenario



AGE

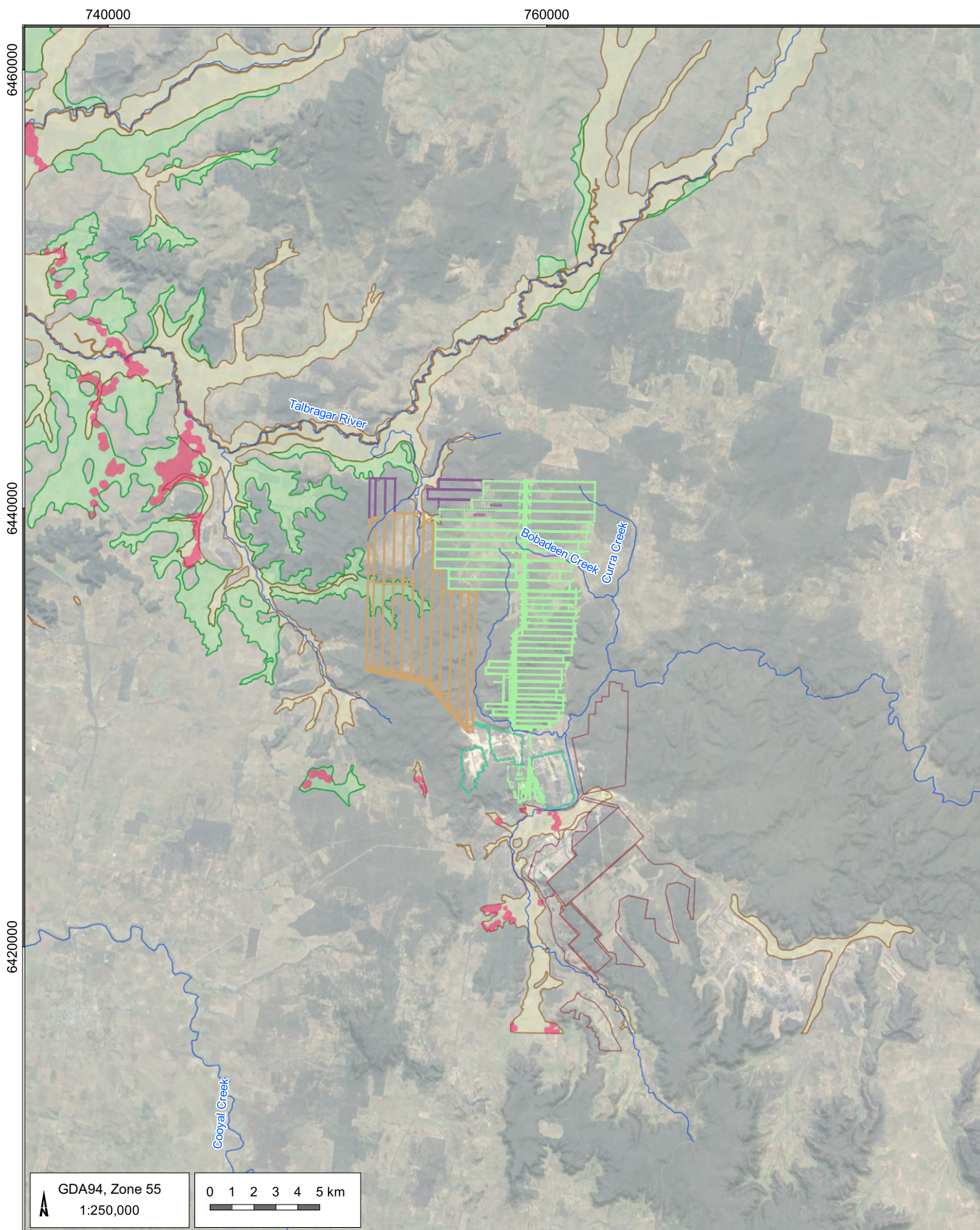
DATE  
07/08/2024

FIGURE No:  
**3.37**

### 3.13 Location of the Ulan Seam sub-cropping under the alluvium (11b)

As requested, Figure 3.38 shows the location of the model cells where the Ulan Seam sub-crops directly under the alluvium and colluvium areas. In the model this is where layer 16 is directly below layer 1 with no intervening model layers.





#### LEGEND

- Drainage
- Ulan Underground Mine Plan
- Ulan West Mine Plan
- Proposed Longwall Panel
- Alluvial
- Colluvial
- Moolarben Mine Plan
- Ulan Open Cut
- Ulan seam subcrop cells

Ulan MOD6A Groundwater Assessment - IESC response (UCM5032.001)

#### Location of model cells where Ulan Seam sub-crops the alluvium area



AGE

DATE  
03/05/2024

FIGURE No:  
**3.38**



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## 4 References

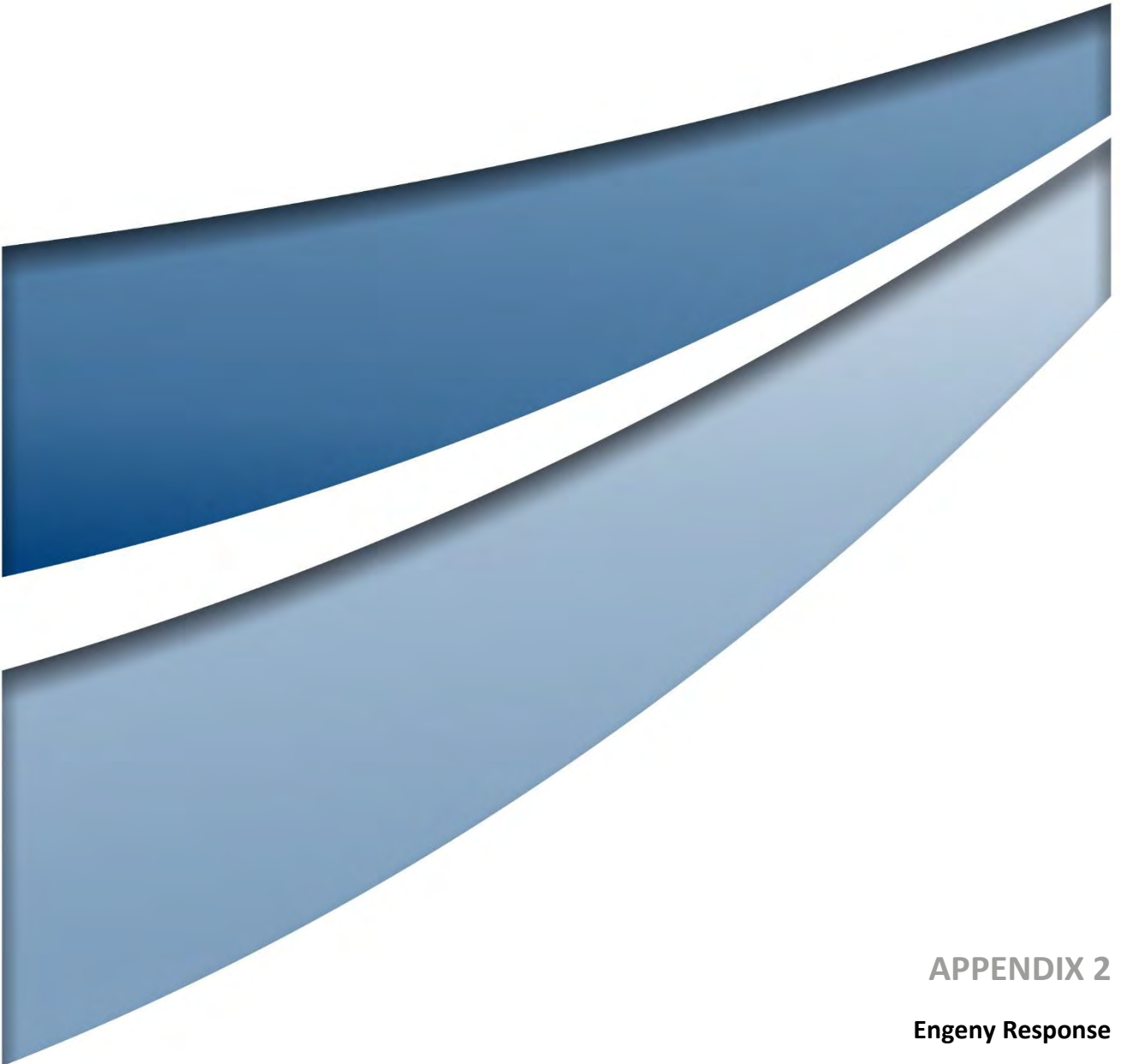
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Yours faithfully,



**Andrew Durick**  
Director / Principal Modeller  
Australasian Groundwater and  
Environmental Consultants Pty Ltd





## APPENDIX 2

### Engeny Response

6 June 2024

Umwelt (Australia) Pty Ltd  
75 York Street  
Teralba NSW 2283

Attention: Matthew Copeland - Senior Environmental Consultant

Dear Matthew,

**RE: IESC Advice – Responses – Ulan Coal Mine Expansion Amended Modification 6 – Surface Water Impact Assessment**

Advice was received from the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC) (dated 15 March 2023) in response to the Ulan Coal Modification 6 Surface Water Impact Assessment (SWIA) (Engeny, 2022). It is noted that Modification 6 has been amended since the originally proposed Modification 6 was reviewed by the IESC. This provides responses to the IESC advice, as it relates to the Amended Modification 6 (Amended Modification).

## QUESTION 2: SURFACE WATER

To what extent can decision makers have confidence in the predictions of potential impacts on surface water resources, having regard to the proximity of the project to local watercourses including Mona Creek and the Talbragar River.

- (a) Have appropriate models been selected and used by the applicant? are the assumptions used in the models reasonable?
- (b) Has the model been calibrated with sufficient monitoring data to provide meaningful predictions, including worst-case impacts on surface water resources?
- (c) Has an appropriate sensitivity and uncertainty analysis been undertaken, including consideration of the potential effects of climate change?

A flow chart has been prepared to show the interactions of the groundwater and ecological assessments with the SWIA. The flow chart is included as Attachment A to this letter. This flow chart remains applicable with the Amended Modification.

### Item 14:

*Although the water resource model selected by the proponent is appropriate and sufficient data have been used in its calibration, the modelling of predicted impacts on the flow regime (i.e., on overall runoff volumes, low flows and cease-to-flow characteristics) depends on the adequacy of the estimated impacts on subsidence and baseflows. Given the IESC's concerns about the assessment of subsidence and groundwater interaction (Paragraph 6), it is not possible to have confidence in the conclusions drawn about the likely impacts on surface water resources.*

The assessment of predicted impacts associated with groundwater is covered in further detail in the Groundwater Response to Submissions and the Groundwater Impact Assessment for the Amended Modification. It should be noted that the SWIA considers both a range of climatic scenarios, including consideration of climate change, on rainfall and evaporation and subsequently streamflow and flooding impacts associated with the Amended Modification. Further to this the analysis of historical streamflow data, subsequent flow duration modelling and site observations indicate that Mona Creek is an ephemeral creek system with little baseflow contribution occurring. Similarly, the Talbragar River, adjacent to the project area, displays intermittent flow characteristics with little baseflow contribution seen.



## Item 15:

*Little consideration has been given to exploring the sensitivity (or uncertainty) of the surface water modelling on the key assumptions related to the impacts of subsidence or changed baseflow exchanges with the surrounding groundwater system. The water resource model has not been used to assess worst-case impacts on surface water resources. The investigation into impacts of climate change on surface water resources only considers changes to baseflow as predicted by the groundwater model and does not consider changes in rainfall or evaporation amounts on catchment runoff. Potential effects of climate change on the site water balance also do not appear to have been considered.*

As discussed in the Amended Modification SWIA, data from a SILO Data Drill (1889 to 2021) was used to represent the long-term rainfall and evaporation data set. The SILO data drill is a derived data set from a combination of interpolated recorded data between weather stations and derived long-term average values. As such by using SILO data in the analysis the long-term variations in rainfall and evaporation were considered in the assessment of impacts on flow regimes.

Predicted baseflow impacts used in the assessment were sourced from the Amended Modification Groundwater Impact Assessment (AGE, 2024) (GWIA). The determination of predicted baseflow impacts are discussed in the Groundwater Response to Submissions and the Amended Modification GWIA.

A climate change assessment was undertaken to understand the sensitivity of potential streamflow and flooding impacts to climate change and was included in Section 4.10 of the SWIA. Climate projections for the Amended Modification were obtained using the Climate Futures Tool provided on the Climate Change in Australia website and applied using methodologies outlined in Climate Change in Australia Technical Report (CSIRO, 2015). Data for the Representative Concentration Pathway 4.5 (RCP 4.5) emission scenarios and modelled for mean predictions for 2050 and 2090 were used in the assessment. These values were applied to the SILO daily rainfall and evaporation data set for the streamflow assessment, as well as application of predicted changes to storm rainfall intensity for the flooding assessment.

As such the investigation into impacts of climate change on surface water resources considers the predicted impacts of changes to baseflows, as predicted by the groundwater model, combined with predicted climate changes in rainfall and evaporation amounts on catchment runoff.

The potential impacts of climate change on the site water balance were considered to be negligible and hence were not assessed. The site water balance for the existing and Amended Modification is driven primarily by groundwater inflows. The inset below (Figure 1), sourced from HEC (2022) shows how the runoff from surface catchments into the site water balance model is in the order of 24% to 25% of the total inflows to the site water balance. The site water balance did not require updating for the Amended Modification and as such Figure 1 remains current.

Using the Climate Futures Tool (see earlier) the estimated average annual catchment runoff will reduce in 2050 to 97% of existing runoff volumes and in 2090 to 80% of existing runoff volumes. The predicted reduction in catchment runoff will result in a reduction in inflows into the site water balance in the range of 1% to 5% in the future due to climate change. The resulting impact is a reduction in average estimated site discharges.

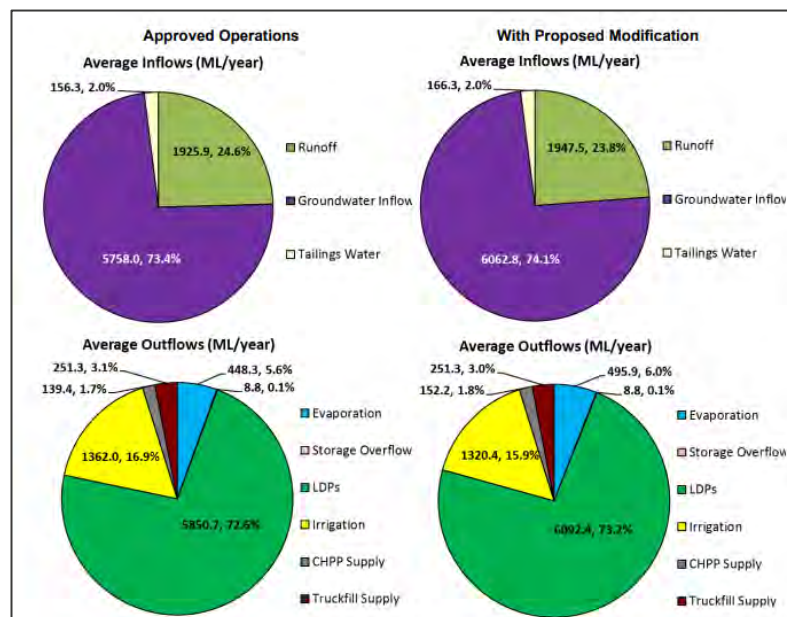


Figure 1: Average Modelled System Inflows and Outflows (Source: HEC, 2022 – Figure 20)

## QUESTION 3: CUMULATIVE IMPACTS

Does the modification report provide an adequate assessment of cumulative impacts to surface and groundwater resources during the mining operations and during the post-mining recovery phase. do these assessments adequately consider surface and groundwater interactions?

### Item 20:

*The proponent does not intend to extract water from nor release water to Mona Creek and intends to undertake erosion and sediment control measures in line with the existing Water Management Plan (Engeny 2022, p. 46). However, there is uncertainty around the potential local impacts on baseflow from groundwater drawdown, subsidence and post-mining mounding. The IESC suggests that the proponent reassess cumulative impacts once adequate assessment of potential local impacts is conducted as suggested within this advice.*

There are no predicted impacts on baseflows in Mona Creek in the GWIA (AGE, 2024). As such there are no predicted impacts on streamflow in Mona Creek with the Amended Modification. The potential impacts of the predicted baseflow losses with the Amended Modification was assessed for 3 locations on the Talbragar River in Section 4.2 of the Amended Modification SWIA.

## QUESTION 4: AVOIDANCE, MITIGATION, AND MONITORING

Does the modification report provide reasonable strategies to effectively avoid, mitigate or minimise the likelihood, extent, and significance of impacts, including cumulative impacts, to significant water-related resources?

### Item 23:

*The project poses potential impacts to Mona Creek and associated riparian vegetation (for example, increased ponding, groundwater drawdown and subsidence-related disturbance of caves, overhangs or crevices which are habitat to EPBC Act-listed species of bat). The IESC recommends that the proponent investigate altered mine design options or rehabilitation strategies to avoid or mitigate potential long-term impacts to Mona Creek, EPBC Act-listed species and the CEEC.*

As has been undertaken in the past, Ulan Coal Mines Pty Limited (UCMPL) will continue to prepare the required Extraction Plans (EPs) to satisfy conditions of PA 08\_0184 for the existing and future mining areas. Specific surface water monitoring relevant to the active extraction plans is described within each extraction plan.

EPs have typically included the following key monitoring components to measure and evaluate the subsidence performance measure for surface water impacts, including:

- Water quality.
- Channel stability, including ponding.
- Stream health.
- Surface cracking.

Consistent with previous project commitments, if monitoring indicates that remediation works are required, remediation works will need to maintain channel grades and take into consideration landform/channel stabilities and existing landform/channel characteristics. This will be managed through processes outlined in the EP, Water Management Plan, Surface Water and Groundwater Response Plan for the site. These plans will be developed/updated as required by the project approval as per the commitments in the Amended Modification SWIA.

Impacts to habitats are assessed in a separate section of the Response to Submissions.



## QUESTION 5: AVOIDANCE, MITIGATION, AND MONITORING

Are there any additional mitigation, monitoring, management, or offsetting measures that should be considered by decision makers to address the residual impacts of the project on water resources?

### Item 27:

*The proponent does not discuss any potential impacts of releases which may occur to the Talbragar River (Engeny 2022, p. 12). It is possible, but not clear from the documentation provided, that the release point on the Talbragar River has been previously approved and conditioned. If the proponent plans to make controlled releases to the Talbragar River, additional parameters including metals, metalloids and dissolved organic carbon should be monitored in Mona Creek and the Talbragar River.*

Project approval was granted for the Ulan Coal - Continued Operations Project by the Minister for Planning on 15 November 2010 (Project Approval (PA 08\_0184). PA08\_0184 authorises current and proposed mining of the Ulan Mine Complex for the next 21 years, and production of up to 20 Mtpa (million tonnes per annum) of product coal. The approval provides for an open cut and Ulan West and Ulan Underground mines to operate twenty-four hours a day, 7 days per week.

PA08\_0184 also included approval for an additional water treatment facility, staging dams, pipeline and discharge structure in the northern part of the Project Area, referred to as the Ulan West Water Treatment Facility. As described in Umwelt (2009) the approval included managing water by pumping to the staging dams, prior to treatment in the proposed Ulan West Water Treatment Facility and pumped via a pipeline to the proposed discharge structure on the Talbragar River. The discharge pipeline was proposed to be an above ground pipeline to be constructed adjacent to Mona Creek to Uarby Road and then continue to the Talbragar River. The approved Talbragar River discharge structure was proposed to use an existing rock bar structure on the Talbragar River to assist in minimising the potential for scour and erosion at the discharge point. A concept design of the Talbragar River discharge structure was included in Umwelt (2009). In addition, Umwelt (2009) also included assessments of the following potential impacts associated with the discharge to the Talbragar River:

- Erosion impacts.
- Annual flow volumes.
- Water quality.
- Reinstatement of crossing point (i.e., the existing damaged farm crossing point located at the approved discharge location).

Activities that may lead to pollution of waters in NSW are regulated by the EPA under the Protection of the Environment Operations Act 1997 (POEO Act). Where discharge of waters is permitted, it is controlled by licence conditions such that discharges do not result in significant impacts on water resources.

Under Section 120 of the POEO Act, it is an offence to pollute waters or cause harm unless licensed to do so. Pollution in NSW is regulated by the POEO Act with discharges from mine water management systems requiring licensing by an EPL if the discharge would otherwise constitute a pollution of waters (Section 120 of the POEO Act).

A commitment was made in Umwelt (2009) in regard to the Ulan West Water Treatment Facility and associated discharge to the Talbragar River to request a variation to Environment Protection Licence (EPL) No. 394 to allow the proposed discharge to Talbragar River.

Prior to discharges to the Talbragar River, EPL No. 394 will need to be varied. An application for a variation would be submitted to the EPA. The requirements of the EPA in regard to discharge volume/rate and water quality limits, as well as monitoring requirements will be required in the licence variation.

It should be noted that no construction has occurred to date of the Ulan West Water Treatment Facility or associated infrastructure. Further to this, no application has been made to date in regard to a variation to EPL No. 394 for discharges to the Talbragar River.

## REFERENCES

Australasian Groundwater and Environment Consultants, 2024. Ulan Coal Mines Modification 6 (MOD6) Groundwater Impact Assessment.

CSIRO, 2015. *Climate Change in Australia Technical Report*.

Engeny, 2022. *Ulan Coal Mines Pty Ltd – Surface Water Impact Assessment*.

HEC, 2021. *Water Balance Assessment*.

UCMPL, 2021. *Ulan Coal Water Management Plan*.

UCMPL, 2021. *Ulan Coal Surface Water Monitoring Program*.

UCMPL, 2021. *Ulan Coal Surface Water and Groundwater Response Plan*.

Umwelt (Australia) Pty Limited, 2009. *Ulan Coal – Continued Operations Environmental Assessment - Surface Water Assessment*, prepared on behalf of Ulan Coal Mines Limited.

Regards,



Georgia Cowen  
Environmental Specialist

Enc.      Attachment 1: SWIA Process Schematic

## DISCLAIMER

This letter has been prepared on behalf of and for the exclusive use of Umwelt (Australia) Pty Ltd and is subject to and issued in accordance with Umwelt (Australia) Pty Ltd instruction to Engeny Australia Pty Ltd (Engeny). The content of this letter was based on previous information and studies supplied by Umwelt (Australia) Pty Ltd

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Author  
GC

Reviewer  
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Project Manager  
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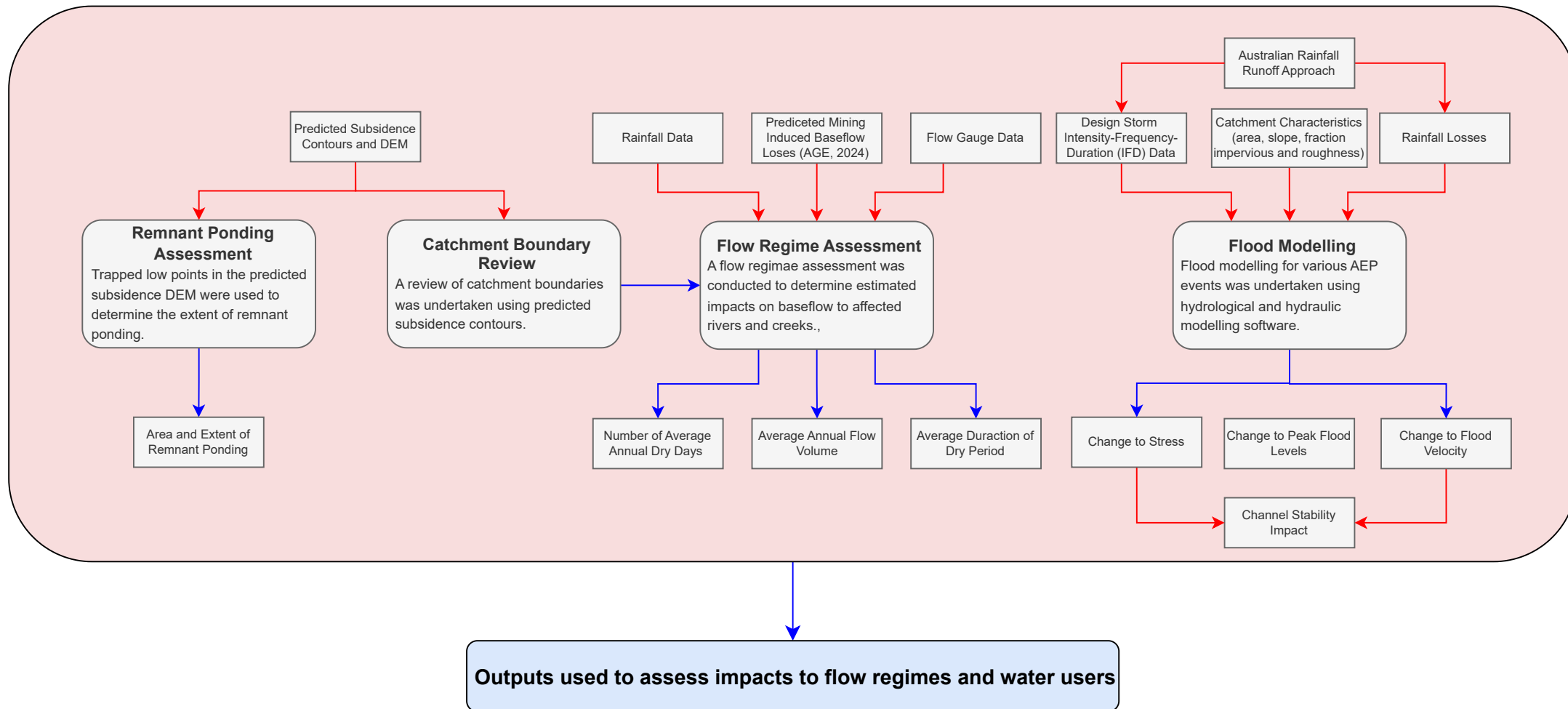
Project Director  
SES

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## ATTACHMENT 1: SWIA PROCESS SCHEMATIC







|                                                                                                                                                                                                           |  |                                                                                                                                                                                                                     |  |                                                                                       |  |                                                                     |                                                                                        |
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| <b>Legend</b><br><div> <div>Subassessment</div> <div>Assessment input/output</div> <div>Output</div> </div> <div> <div>Input</div> <div>Overarching inputs</div> <div>Overarching assessment</div> </div> |  | Level 5, 45 Hunter Street, Newcastle NSW, 2300<br>PO Box 787, Newcastle, NSW, 2300<br>www.engeny.com.au<br>P: 02 4926 1225<br> |  |  |  | Ulan Coal Mines Pty Ltd<br>Ulan Modification SWIA Process Schematic | Job Number: NC4003_001<br>Revision: 2<br>Drawn: GC<br>Checked: SES<br>Date: 06/06/2024 |
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