



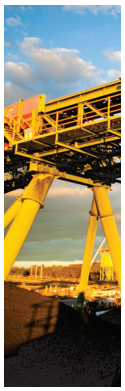

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兖煤澳大利亚有限公司
MOOLARBEN COAL

Moolarben Coal Complex
UG2 Modification

APPENDIX B

GROUNDWATER REVIEW

Australasian Groundwater & Environmental Consultants

Report on

Groundwater Review for Moolarben UG2 Modification

Prepared for
Moolarben Coal Operations Pty Ltd

Project No. MOO1622F.20
November 2021

ageconsultants.com.au

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Groundwater Review for UG2 Modification

1 Introduction

The Moolarben Coal Complex is located approximately 40 kilometres (km) north of Mudgee in the Western Coalfields of New South Wales (NSW) (Figure 1.1).

Moolarben Coal Operations Pty Ltd (MCO) is the operator of the Moolarben Coal Complex on behalf of the Moolarben Joint Venture (Moolarben Coal Mines Pty Ltd [MCM], Yancoal Moolarben [YM] Pty Ltd, and a consortium of Korean power companies). MCO, MCM and YM are wholly owned subsidiaries of Yancoal Australia Limited (Yancoal). MCO is the Applicant for the Modification.

The Moolarben Coal Complex comprises four approved open cut mining areas (OC1 to OC4), three approved underground mining areas (UG1, UG2 and UG4) and other mining related infrastructure (including coal processing and transport facilities) (Figure 1.2).

Mining operations at the Moolarben Coal Complex are currently approved until 31 December 2038 in accordance with Project Approval (05_0117) (Moolarben Coal Project Stage 1) (as modified) and Project Approval (08_0135) (Moolarben Coal Project Stage 2) (as modified).

Since Stage 2 of the Moolarben Coal Complex was approved, exploration activities have continued within MCO's mining tenements, including the UG2 mining area, which identified further resources and geological features that affect the approved UG2 mining layout. As a result, MCO proposes a modification to the Stage 2 Project Approval (08_0135) to optimise the UG2 mining layout and improve resource recovery (Figure 1.3) (the Modification).

An overview of the Modification is provided in Section 1.1. The scope of this Groundwater Review is summarised in Section 1.2.

1.1 Modification Description

The Modification would comprise the following components (Figure 1.3):

- Optimisation of the approved UG2 layout (including the extension of two approved longwall panels).
- Increased UG2 extraction height from 3.0 metres (m) to 3.5 m.
- Revised UG2 mining sequence.
- Increased UG2 run-of-mine (ROM) coal production from 9.4 million tonnes (Mt) to 13.9 Mt.
- Construction and operation of a remote services infrastructure area (RSIA) (including two UG2 service boreholes) within the approved OC4 disturbance footprint to support UG2 operations.
- Development of an additional non-subsiding gate road along the southern boundary of the UG1 mining area to assist with ventilation in UG2.
- Small reduction in the approved OC4 extent to accommodate the optimised UG2 layout.

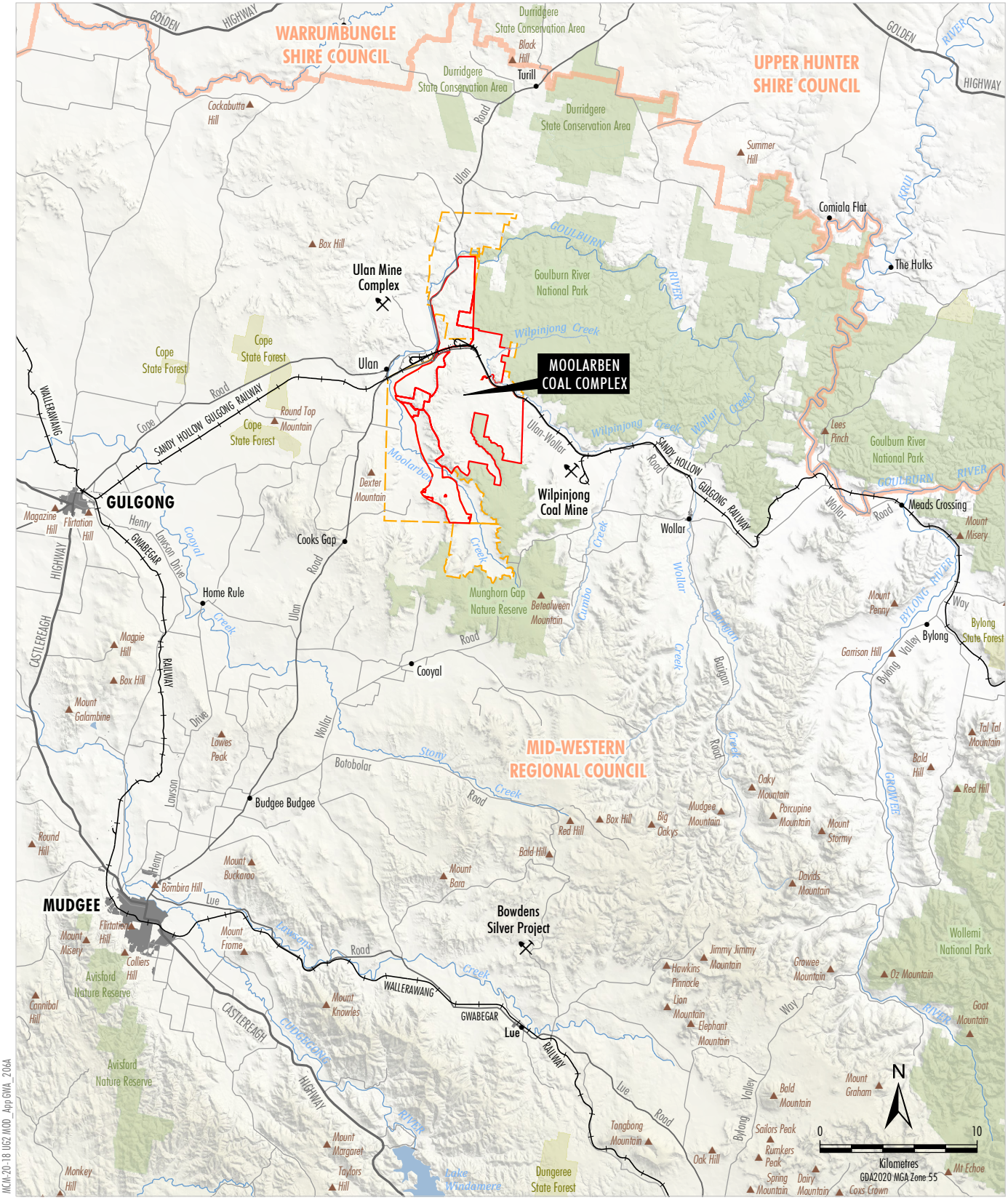
The Modification includes the following optimisations to the approved UG2 layout:

- **Approved UG2 Mining Area** – minor augmentations to the approved UG2 layout within the approved UG2 mining area.
- **Extended UG2 Mining Area** – extensions to two of the approved UG2 longwall panels outside the approved UG2 mining area.

1.2 Scope

The purpose of this Groundwater Review is to assess the potential incremental groundwater impacts of the Modification. This has involved:

- review of previous groundwater assessments and relevant monitoring data;
- preparation of a conceptual groundwater model for the UG2 mining area and identification of potential impact pathways for the Modification;
- updated numerical groundwater modelling in accordance with the Australian Groundwater Modelling Guidelines (Barnett et.al, 2012); and
- review of existing groundwater management and monitoring measures and consideration of their suitability for the Moolarben Coal Complex (incorporating the Modification).



LEGEND
- State Forest
- National Parks /Nature Reserves
- Local Government Boundary
- Exploration Licence Boundary
- Mining Lease Boundary
- Mining Operation

Source: NSW Spatial Services (2021)

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Regional Location

Figure 1.1

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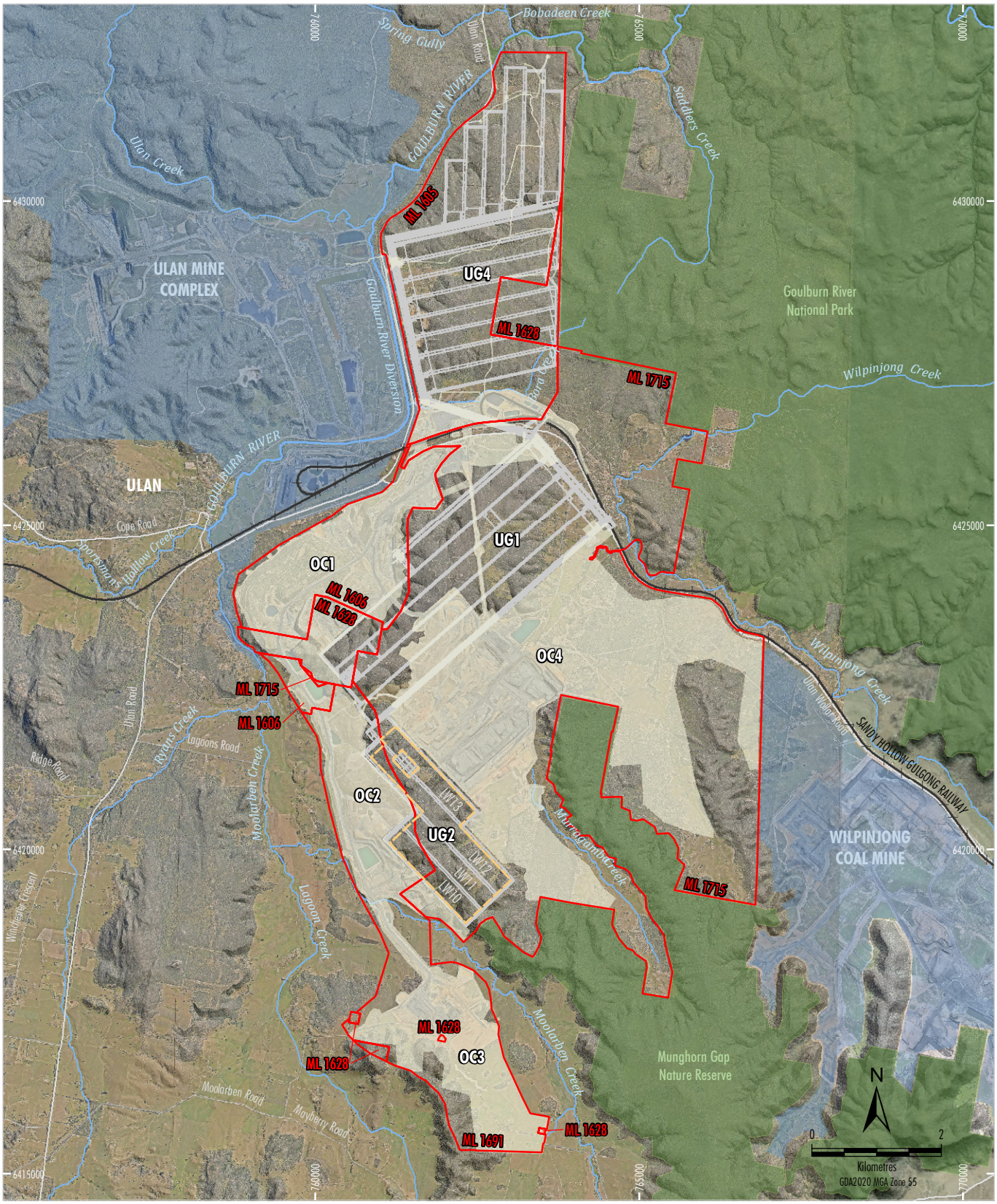

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LEGEND

- National Parks /Nature Reserves
- Other Mining Operation
- Mining Lease Boundary

Existing/Approved Development

- Underground Longwall Layout
- Moolarben Coal Complex Disturbance Footprint
- Approximate Extent of UG2 Longwalls

Source: MCO (2021); NSW Spatial Services (2021)
Orthophoto: MCO (Jan 2021)

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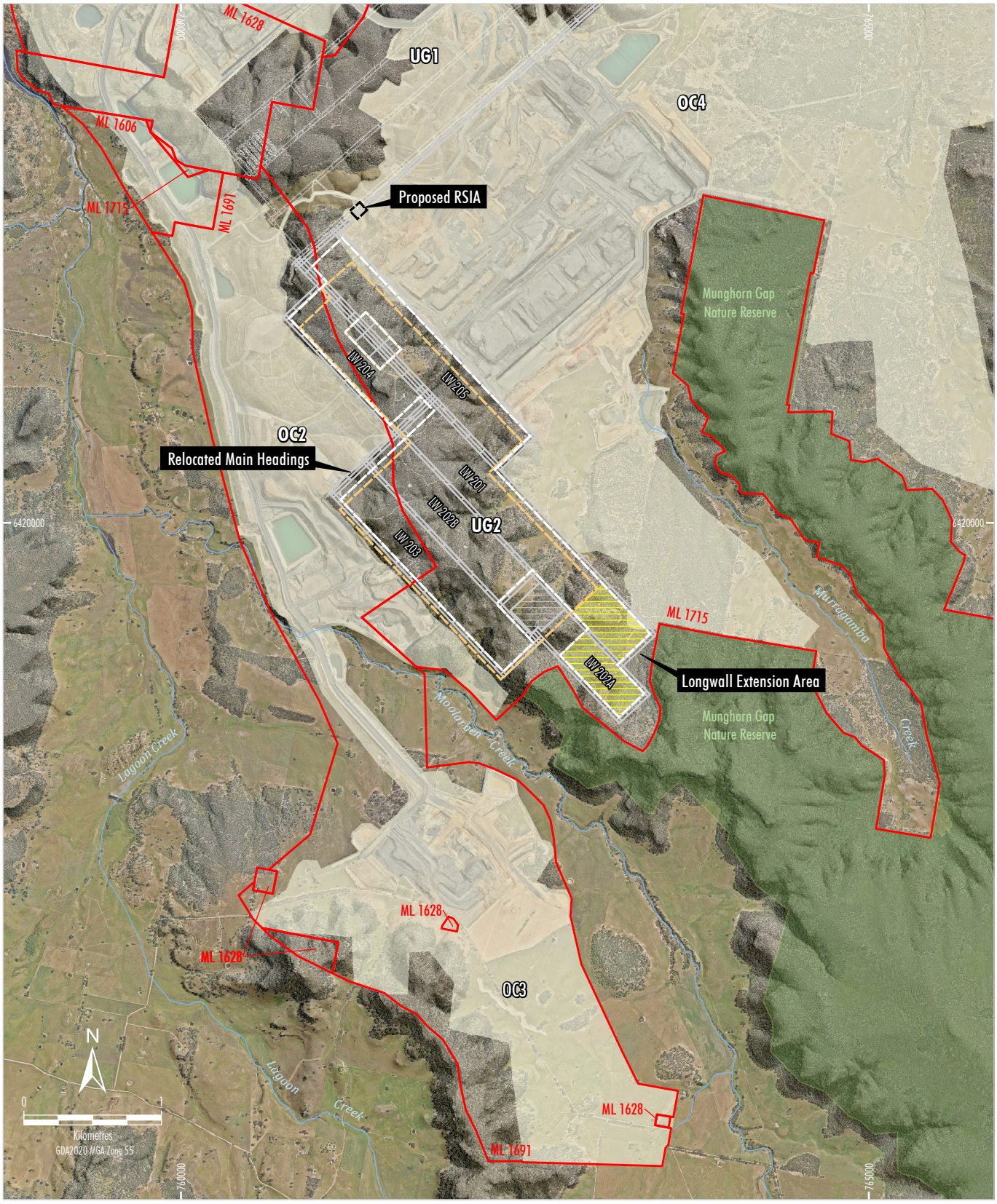
Approved General Arrangement

Figure 1.2



LEGEND

National Parks /Nature Reserves

Mining Lease Boundary

Existing/Approved Development

Underground Longwall Layout

Approximate Extent of UG2 Longwalls

Moolarben Coal Complex Disturbance Footprint

Proposed UG2 Modification

Optimised UG2 Longwall Layout

UG2 Longwall Extension Area

Non-subsiding UG2 Secondary Workings

Approximate Extent of Proposed Modified Longwalls

Proposed Extent of RSIA

Source: MCO (2021); NSW Spatial Services (2021)
Orthophoto Mosaic: MCO (Jan 2021)

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Proposed Modified General Arrangement

Figure 1.3

2 Previous Groundwater Assessments

A comprehensive groundwater assessment report was prepared by Peter Dundon and Associates Pty Ltd (PDA) for inclusion in the Moolarben Coal Project Stage 1 Environmental Assessment (EA) (PDA, 2006). This included assessment of the impacts from open cuts OC1, OC2 and OC3, and underground mine UG4.

The Moolarben Coal Project Stage 2 EA which incorporates one open cut (OC4) and two underground mines (UG1 and UG2), lodged with the Minister for Planning in 2008, was supported by a groundwater impact assessment completed by Aquaterra Consulting Pty Ltd (2008).

A revised groundwater impact assessment for the Moolarben Coal Project Stage 2 Preferred Project Report (PPR) was completed by RPS Aquaterra (2011). After the PPR was placed on public exhibition in 2012, a number of written submissions were received in response to the PPR (Hansen Bailey, 2012a). A further groundwater impact assessment report addressing issues raised in the submissions was prepared by RPS Aquaterra (2012).

Additional groundwater investigations that have been undertaken since Stage 2 of the Moolarben Coal Complex was approved include:

- Moolarben Coal Project Stage 1 Optimisation Modification Groundwater Assessment (Australasian Groundwater & Environmental Consultants Pty Ltd [AGE], 2013);
- Moolarben Coal Complex – UG1 Optimisation Modification – Groundwater Assessment (Dundon Consulting Pty Ltd, 2015) and supporting Groundwater Modelling Assessment (HydroSimulations, 2015a);
- Moolarben Coal Open Cut Optimisation Modification Groundwater Assessment (HydroSimulations, 2017); and
- Groundwater Technical Report on UG4 LW401-LW408 Extraction Plan (AGE, 2021).

This Groundwater Review builds upon the extensive existing groundwater knowledge base established through the studies summarised above.

3 Statutory Framework

This Groundwater Review has been prepared in consideration of the following:

- NSW *Water Management Act 2000* and relevant water sharing plans;
- NSW Aquifer Interference Policy (AIP) (NSW Government, 2012);
- NSW *Protection of the Environment Operations Act 1997* (POEO Act); and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 2000* (EPBC Act), including the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources* (Significant Impact Guidelines for Water Resources) (Department of the Environment [DotE], 2013).

The following sections summarise the intent of the above legislation, policy and guidelines, and how they apply to the Modification.

3.1 Water Management Act 2000

The *Water Management Act 2000* incorporates the provisions of various prior Acts relating to the management of surface and groundwater in NSW. It provides a single statute for regulation of water access, use and works (e.g. pumps or bores) that affect the licensing of surface water and both alluvial and non-alluvial (i.e. porous rock) groundwater in the vicinity of the Moolarben Coal Complex.

The *Water Management Act 2000* aims to provide sustainable and integrated management of the water sources of NSW for the benefit of both present and future generations. The Moolarben Coal Complex is regulated under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* and the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*.

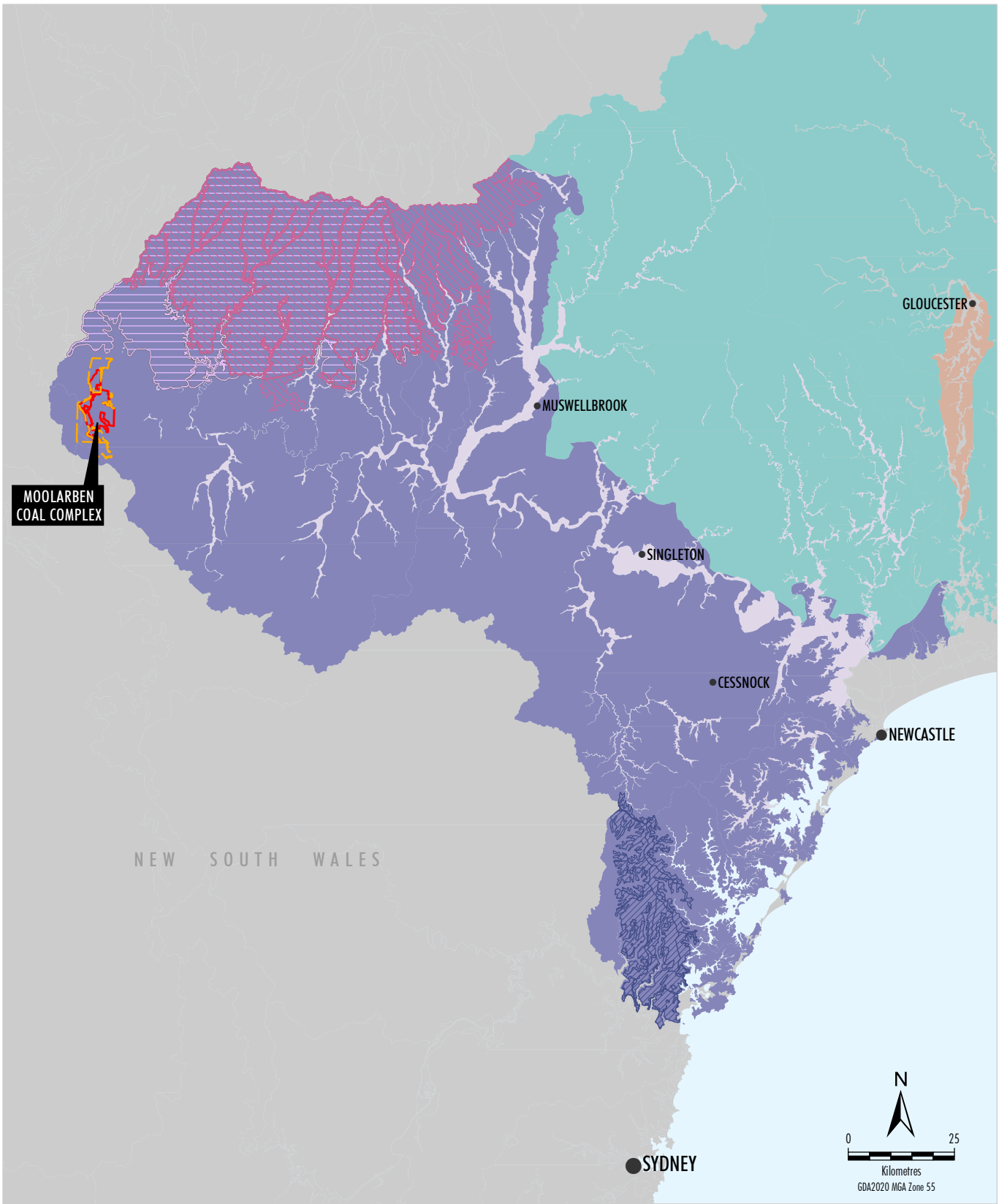
The following water sources are relevant to the Moolarben Coal Complex (Figure 3.1 and Figure 3.2):

- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*:
  - Sydney Basin – North Coast Groundwater Source.
- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*:
  - Upper Goulburn River Water Source; and
  - Wollar Creek Water Source.

A summary of water access licences (WALs) held by MCO for the Moolarben Coal Complex is provided in Table 3.1. Yancoal operates a number of mines in the Sydney Basin-North Coast Groundwater Source, which provides opportunities to trade licences between Yancoal-owned assets to meet the specific licensing requirements for each site, which fluctuate from year-to-year. The trading of WAL entitlements is a recognised and legally approved mechanism under the *Water Management Act 2000* to maximise the efficient use of the state's water resources.

Table 3.1 MCO Water Access Licences and Annual Entitlements

Water Source	WAL	Category	Entitlement (Units)	Total Source Entitlement (units)
Sydney Basin-North Coast Groundwater Source	WAL 39799	Aquifer	2,950	2,950
Upper Goulburn River Water Source	WAL 41888	Aquifer	90	99
	WAL 37582	Unregulated River	9	
Wollar Creek Water Source	WAL 36340	Aquifer	218	228
	WAL 19424	Unregulated River	10	
	WAL 37583	Unregulated River	0	



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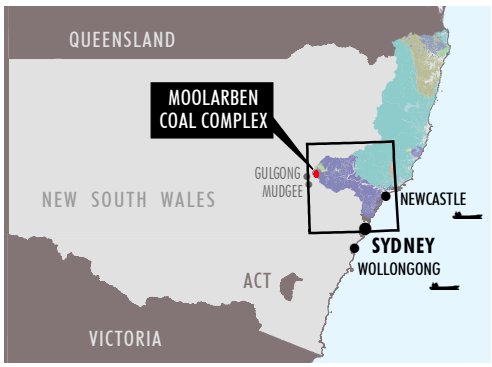

LEGEND

- Exploration Licence Boundary
- Mining Lease Boundary
- Oxley Basin Coast Groundwater Source
- Liverpool Ranges Basalt Coast Groundwater Source
- Kulnura Mangrove Mountain Groundwater Source
- Sydney Basin - North Coast Groundwater Source
- New England Fold Belt Coast Groundwater Source
- Gloucester Basin Groundwater Source
- Alluvial and Coastal Sands Groundwater Sources covered by other Water Sharing Plans
- Surface Water Feature

Source: NSW Spatial Services (2021)

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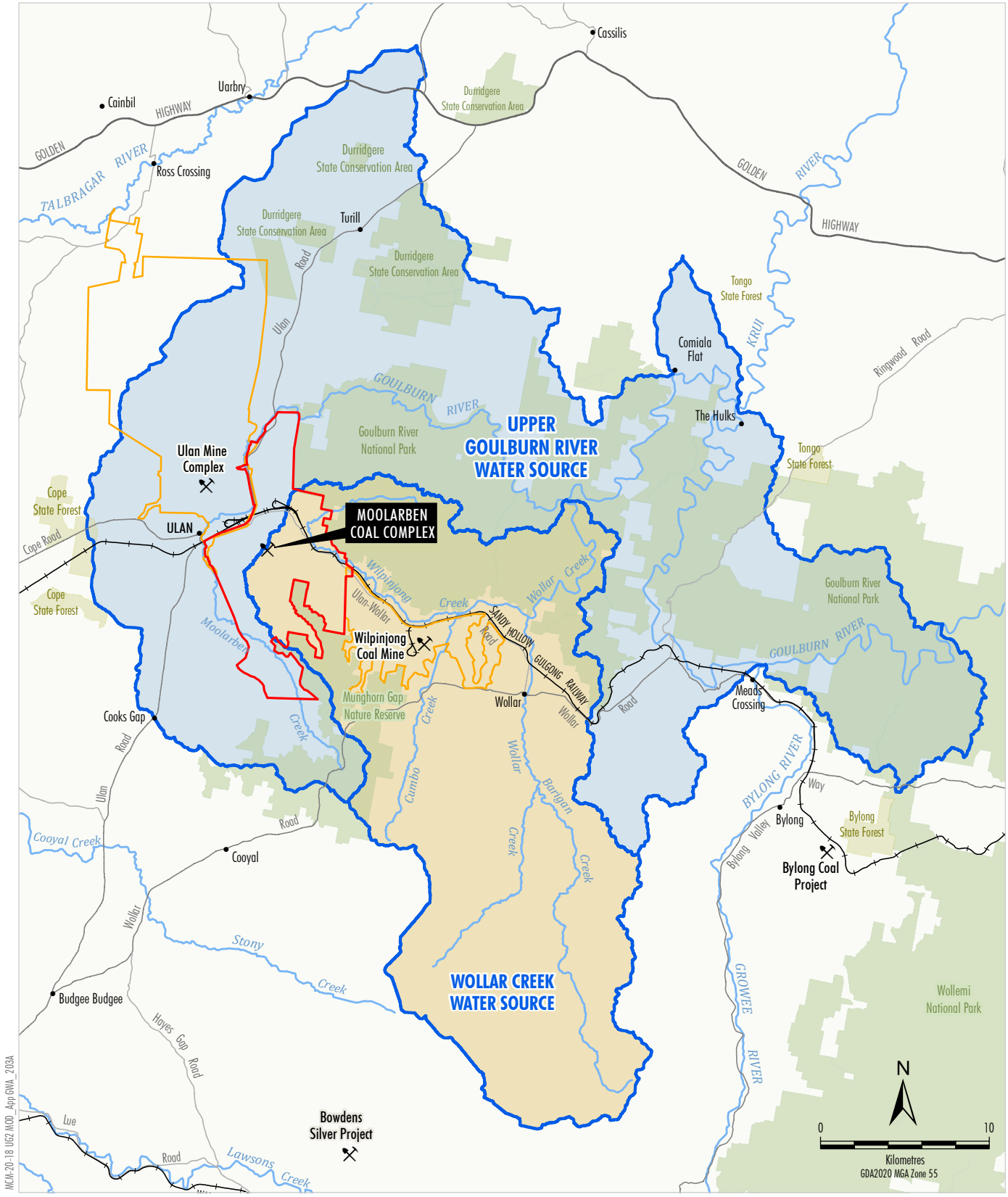
Water Sharing Plan for the
North Coast Fractured and Porous Rock
Groundwater Sources

Figure 3.1



LEGEND

- National Parks /Nature Reserves
- State Forest
- MCC Approval Boundary
- Other Mining Operation
- Mining Operation
- Relevant Water Sharing Plan Water Source Boundary

Source: Water NSW (2021); NSW Spatial Services (2021)

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Water Sharing Plan for the Unregulated Hunter Catchment - Upper Goulburn River and Wollar Creek Water Sources

Figure 3.2

3.2 NSW Aquifer Interference Policy

The AIP (NSW Government, 2012) was developed by the NSW Government as a component of the NSW Government's Strategic Regional Land Use Policy. The AIP applies state-wide and details water licence and impact assessment requirements. The AIP has been developed to ensure equitable water sharing between various water users and proper licensing of water that is taken by aquifer interference activities, so that the take is accounted for in the water budget and water sharing arrangements.

The AIP also includes minimal impact considerations relating to watertable and groundwater pressure drawdown and changes in groundwater and surface water quality. The AIP establishes minimal impact considerations for groundwater categories of both 'highly productive' and 'less productive' groundwater. 'Highly productive groundwater' is defined by the AIP as a groundwater source that is declared in the Regulations and is based on the following criteria (NSW Government, 2012):

a) has total dissolved solids of less than 1,500 milligrams per litre (mg/L), and
b) contains water supply works that can yield water at a rate greater than 5 litres per second (L/sec).

Groundwater that does not meet the AIP requirements for 'highly productive' is considered 'less productive'.

3.3 NSW Protection of the Environment Operations Act 1997

The POEO Act provides the framework for the regulation and reduction of pollution and waste in NSW. The POEO Act is administered by the NSW Environment Protection Authority (EPA), which issues environment protection licences (EPLs) for certain activities scheduled in the POEO Act, including those that may impact on groundwater quality.

MCO holds EPL 12932 which permits activities scheduled under the POEO Act (coal works, extractive activities and mining for coal) at the Moolarben Coal Complex. EPL 12932 also provides criteria for approved discharges to the receiving environment, including the release of treated water to the Goulburn River.

3.4 Environment Protection and Biodiversity Conservation Act 2000

The EPBC Act is administered by the Commonwealth Department of Agriculture, Water and the Environment (DAWE) to protect national environmental assets, otherwise known as Matters of National Environmental Significance (MNES).

The Moolarben Coal Project Stage 1 operations are approved to be undertaken in accordance with Approval Decisions EPBC 2007/3297 granted on 24 October 2007, EPBC 2013/6926 granted on 13 November 2014, and EPBC 2017/7974 granted on 6 September 2019 under the EPBC Act.

The Moolarben Coal Project Stage 2 operations are approved to be undertaken in accordance with Approval Decision EPBC 2008/4444 granted on 18 May 2015 under the EPBC Act.

The relevant controlling provisions were:

- listed threatened species and communities (sections 18 and 18A of the EPBC Act); and
- a water resource, in relation to coal seam gas development and large coal mining development (sections 24D and 24E of the EPBC Act).

The Modification may be referred to the Commonwealth Minister to confirm if the proposed activities are a "Controlled Action" under the EPBC Act. Accordingly, the Significant Impact Guidelines for Water Resources (DotE, 2013) have been considered where relevant in this report.

4 Groundwater Regime

The groundwater regime at the Moolarben Coal Complex and surrounds has been extensively described in previous groundwater assessments. A summary of the groundwater regime in the vicinity of the UG2 mining area is provided below.

The UG2 mining area is bordered by (Figure 1.3):

- Open Cut 2 (OC2) to the immediate west;
- Open Cut 4 (OC4) to the immediate north-east;
- Underground 1 (UG1) to the immediate north-west;
- Munghorn Gap Nature Reserve to the south.

Comprehensive groundwater monitoring is undertaken at the Moolarben Coal Complex in accordance with the approved Groundwater Management Plan (MCO, 2020). Hydrogeological data has been collected during the mining of UG1, including groundwater extraction, groundwater levels, groundwater quality and subsurface fracturing above or immediately adjacent the longwall panels.

4.1 Hydrogeology

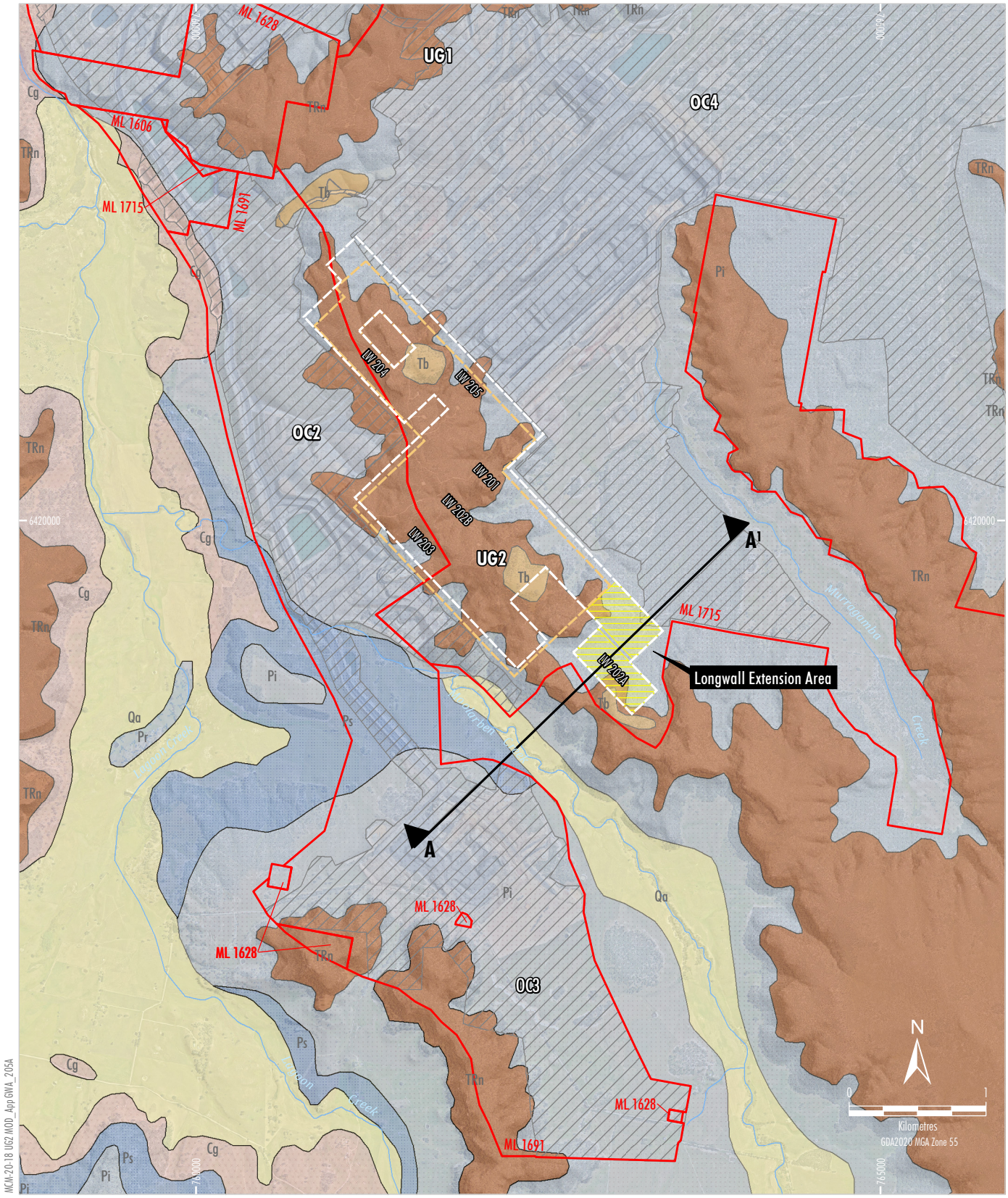
Longwall mining within the UG2 mining area will be undertaken in the Ulan Seam, which has been historically mined at the Moolarben Coal Complex (including the adjacent OC2, OC3, OC4 and UG1 mining areas) and at the adjacent operations (Ulan Mine Complex and Wilpinjong Coal Mine).

The UG2 mining area is located beneath an elevated ridgeline of outcropping Triassic Narrabeen Group sandstone (Figure 4.1). Where present, the Triassic sandstone ranges between 14 m and 55 m thick across the UG2 area (MSEC, 2021). The Permian aged Illawarra Coal Measures underly the Triassic and the target Ulan Seam. The Illawarra Coal Measures comprise interbedded claystones, siltstones, sandstones (fine to coarse grained) and coal seams.

The Permian and overlying Triassic strata generally dip in a north-easterly direction away from the edge of the Sydney Basin, which is located in close proximity to the subcropping Ulan Seam.

None of the hydrogeological units surrounding the Moolarben Coal Complex are considered to be ‘highly productive’ as defined under the AIP (Section 3.2). A combination of low permeability and/or observed groundwater salinity effectively classifies the units as ‘less productive’.

There has been extensive depressurisation of hard rock aquifers in the vicinity of the UG2 mining area, as a result of previous and current mining operations. The Triassic strata overlying the UG2 mining area are unsaturated, either naturally or from depressurisation caused by previous mining activities. Perched water tables might be sustained at higher elevations in the Munghorn Gap Nature Reserve due to the presence of occasional mudstone/siltstone beds between the sandstone layers (HydroSimulations, 2015b).



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LEGEND

Mining Lease Boundary

Existing/Approved Development

Moolarben Coal Complex Disturbance Footprint

Approximate Extent of UG2 Longwalls

Proposed UG2 Modification

UG2 Longwall Extension Area

Approximate Extent of Proposed Modified Longwalls

Alluvium (Qa)

Tertiary Basalt (Tb)

Narrabeen Group (TRn)

Illawarra Coal Measures (Pi)

Shoalhaven Group (Nile Subgroup) (Ps)

Rhylstone Volcanics (Pr)

Carboniferous Granite (Cg)

Source: MCO (2021); NSW Spatial Services (2021); NSW Department of Priminary Industries - Western Coalfields (2012)
Orthophoto Mosaic: MCO (Jan 2021)

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Regionally Mapped Surface Geology

Figure 4.1

4.2 Recharge and Discharge

Recharge to the groundwater system occurs by the direct infiltration of rainfall and downward percolation through the near surface weathered rock. Recharge to the deeper units within the Permian coal measures predominantly occurs by downward seepage into the units where they subcrop beneath the alluvium or weathered rock cover.

Recharge to the UG2 mining area has been limited by the existing open cut mining area (OC2) located immediately west of UG2.

4.3 Groundwater and Surface Water Interaction

Surface drainage over the area of UG2 is characterised by steep, first order, ephemeral drainage lines with gradients typically in the range of 4% to 11%. The drainage lines located above LW201, LW202 and LW205 drain north-east to OC4. The drainage lines located above LW203 and LW204 drain south-west to OC2 (WRM, 2021).

Larger water courses in the vicinity of the Moolarben Coal Complex include the Goulburn River, Moolarben Creek and Wilpinjong Creek. The UG2 mining area is separated from these features by UG1, OC2 and OC4. A short length of the upper reaches of Moolarben Creek occurs adjacent the Modification area, however no baseflow contributions are known to occur along this reach of the creek.

4.4 Groundwater Quality

A detailed description of the available groundwater quality data is provided in the previous groundwater assessments listed in Section 2. In summary (PDA 2006; RPS Aquaterra, 2012):

- groundwater quality across the Moolarben Coal Complex area is variable, both in terms of field parameters such as salinity and pH, and also in terms of major and minor analytes;
- salinity of groundwater across the Moolarben Coal Complex area varies considerably. Groundwater from the less permeable zones within the Permian coal measures is often more saline than groundwater from within coal seams (Ulan Seam and shallower seams) and is believed to be related to the lack of groundwater recharge and lower permeability. Generally, the Ulan Seam has low to moderate salinity, however significant local variations have been noted;
- recorded pH measurements indicate the majority of groundwaters to be mildly acidic, while the groundwater pH typically ranges from 5.0 to 8.5;
- moderately elevated dissolved metal concentrations occur naturally in groundwater across the Moolarben Coal Complex area; and
- review of data for major ion composition show that, in general, groundwater across the area is of a broadly similar type, being typically dominated by sodium and potassium cations, and a combination of carbonate / bicarbonate and chloride anions.

Annual groundwater monitoring data is available in the Annual Reviews which are available on the MCO website.

4.5 Groundwater Dependent Assets

4.5.1 Groundwater Users

Groundwater usage in the area is primarily composed of mine dewatering for the Moolarben Coal Complex and the neighbouring Ulan Mine Complex and Wilpinjong Coal Mine.

There is one private bore in the vicinity of the Moolarben Coal Complex, located over 10 km from the UG2 mining area to the northeast of UG4. The bore is relatively shallow (24 m) developed in Triassic strata and connected to the river alluvium. The bore is separated from the UG2 mining area by UG1, OC1 and UG4.

There are no privately-owned bores in the vicinity of the UG2 mining area.

4.5.2 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are ecosystems that rely upon groundwater for their continued existence. GDEs may be completely dependent on groundwater, such as aquifer GDEs, or may utilise groundwater intermittently when it is available as a component of its lifecycle water requirements, such as riparian tree species in arid and semi-arid areas (Doody, Hancock and Pritchard, 2018).

GDEs can require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Doody, Hancock and Pritchard, 2018).

No 'high priority' GDEs listed in the Water Sharing Plan for the *Hunter Unregulated and Alluvial Water Sources 2009* are in the vicinity of the Moolarben Coal Complex. The closest 'high priority' GDE to the Moolarben Coal Complex is the Wappinguy Spring, which is located approximately 28 km north from the Goulburn River at its closest point.

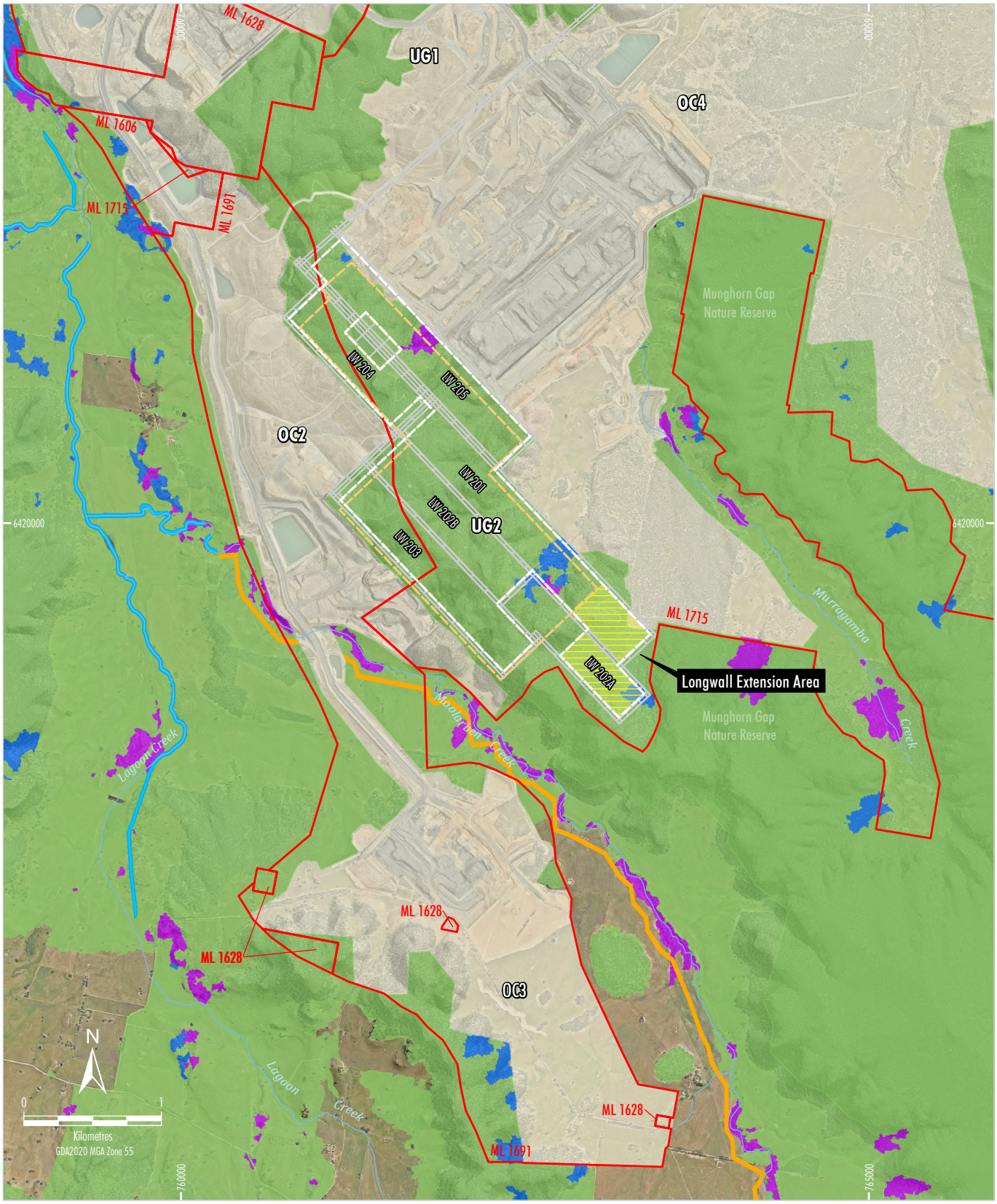
The Groundwater Dependent Ecosystem Atlas (GDE Atlas) was developed by the Commonwealth Bureau of Meteorology (BOM) as a national dataset of Australian GDEs to inform groundwater planning and management (BOM, 2018). GDEs derived in the GDE Atlas are mapped according to the following classifications:

- high potential for groundwater interaction;
- moderate potential for groundwater interaction; and
- low potential for groundwater interaction.

The GDE Atlas identifies a regionally mapped patch of Central Tableland Ribbon Gum-Apple Gully Forest within the Modification Longwall Extension Area as having moderate potential for groundwater interaction (Figure 4.2). Niche Environment and Heritage (Niche) has completed detailed mapping of the vegetation communities within the Modification Longwall Extension Area in accordance with the *Biodiversity Conservation Act 2016* and NSW Biodiversity Assessment Method. None of the vegetation communities mapped within the Modification Longwall Extension Area are consistent with the regionally mapped Central Tableland Ribbon Gum-Apple Gully Forest or exhibit groundwater dependent traits (Niche, 2021).

The Drip is a prominent local dripping sandstone feature located on the northern side of the Goulburn River to the north of UG4 and the Moolarben Coal Complex. Groundwater discharges from The Drip are derived from the perching of groundwater in zones that are exposed in the cliff faces. The perching occurs in the Triassic Narrabeen Group sediments and is formed by accumulations of groundwater above less permeable horizons in the Triassic sequence to the north of the Goulburn River. The groundwater seepages are only observed on the northern side of the Goulburn River.

The Drip is located over 10 km from the UG2 mining area and would be unaffected by the Modification.



LEGEND

National Parks /Nature Reserves

Mining Lease Boundary

Existing/Approved Development

Approximate Extent of UG2 Longwalls

Moolarben Coal Complex Disturbance Footprint

Proposed UG2 Modification

Optimised UG2 Longwall Layout

UG2 Longwall Extension Area

Approximate Extent of Proposed Modified Lon

Potential Aquatic Groundwater Dependent Ecosystems

Moderate potential GDE - from national assessment

Low potential GDE - from national assessment

Potential Terrestrial Groundwater Dependent Ecosystems

High potential GDE - from regional studies

Moderate potential GDE - from regional studies

Low potential GDE

Note: Mapped GDEs within approved surface disturbance areas are not shown on this figure

Source: MCO (2021); NSW Spatial Services (2021)
Orthophoto Mosaic: MCO (Jan 2021)

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Potential Groundwater Dependent Ecosystems
BOM GDE Atlas Mapping

Figure 4.2

4.6 Groundwater Response to Mining

During longwall mining, the removal of coal causes the overburden to subside into the spent longwall void (goaf). The resultant strain imposed on the rock strata develops a fracture network of varying connectivity according to the height above the longwall panel. The thickness of the mined section, the effective width of the longwall panel, and the geological properties of the overburden all influence the degree of fracturing which results from the collapsing of the longwall panel (post mining).

Figure 4.3 shows a schematic of the fracture network and identified zones which are produced above a collapsed longwall panel.

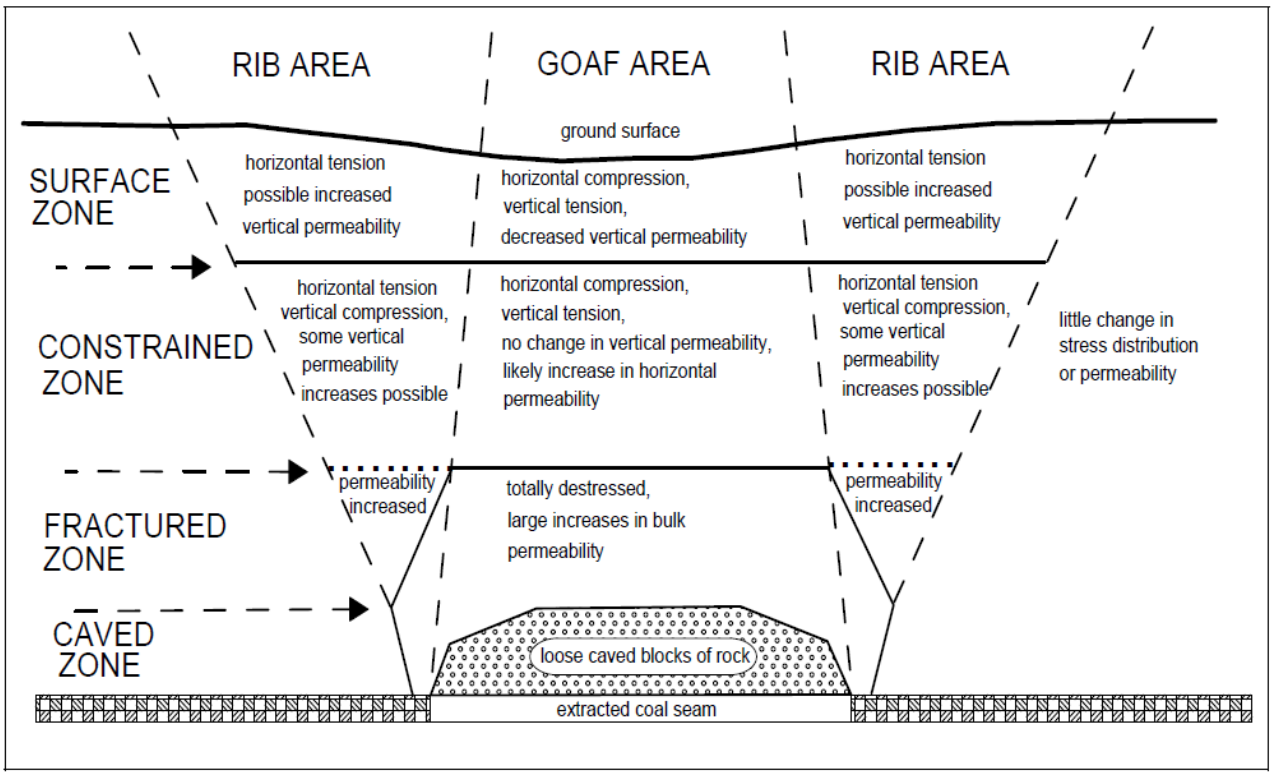
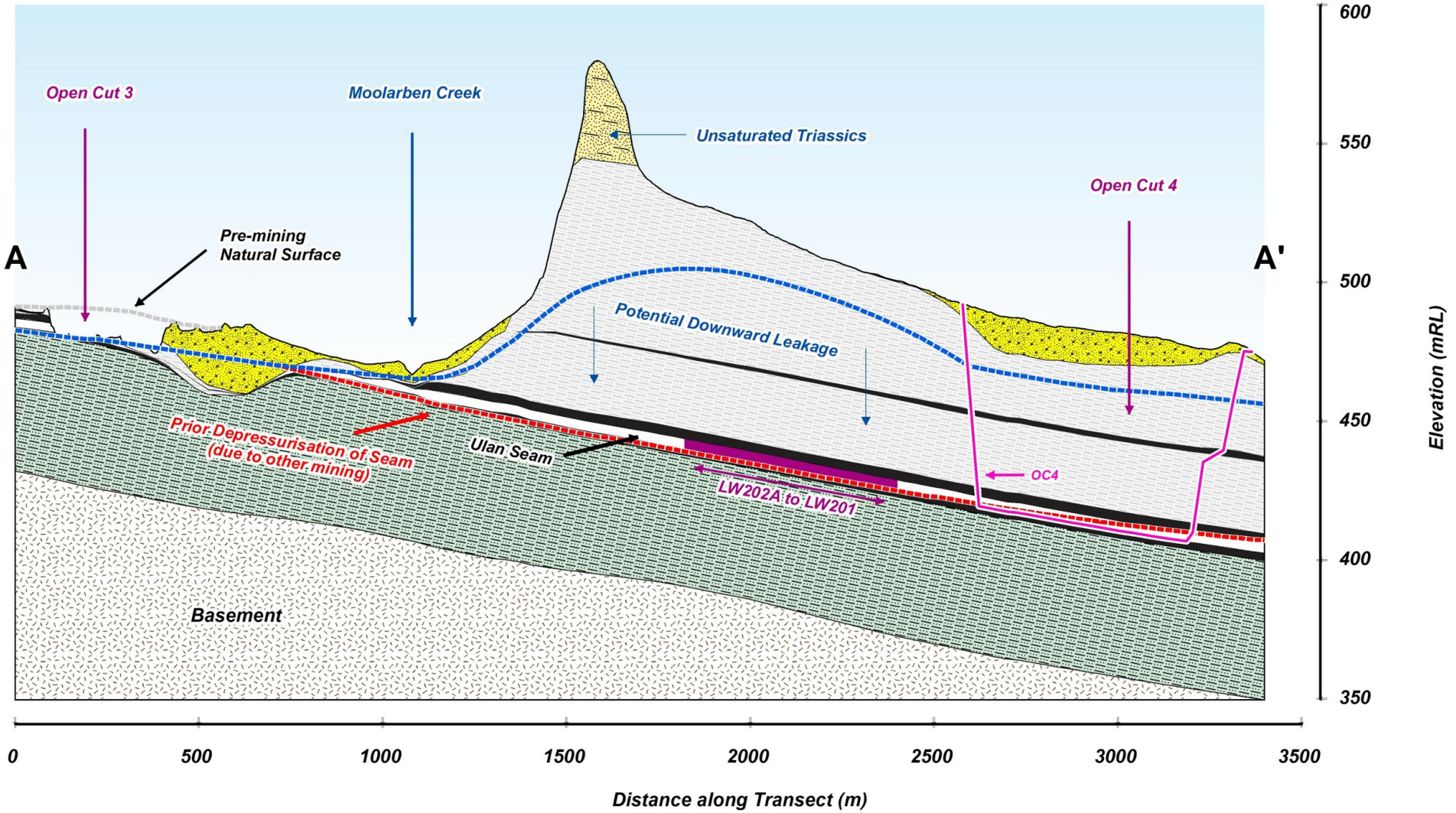


Figure 4.3 Processes which occur above a longwall panel (Forster and Enever, 1992)

4.7 Conceptual Groundwater Model

Conceptual hydrogeological models are simplifications of a groundwater system, which show graphically the salient features of the hydrogeological system, based upon the contemporary knowledge of the system. Features typically include the thickness of key hydrostratigraphic units, the lateral continuity of these units, groundwater levels and flow directions, and any other salient features which affect the dynamics of the groundwater system (i.e faulting). This section describes the hydrogeological processes occurring within and in proximity to the UG2 area.

The conceptual groundwater model for the UG2 mining area is presented on Figure 4.4. The transect for the conceptual cross-section is shown on Figure 4.1.



SCALE

Vertical Exaggeration as shown is **1:7.5**

NOTES:

** Unconsolidated Material includes alluvium, colluvium, tertiary palaeochannel sediments and regolith. The extents and depth of the unconsolidated material have been based on the detailed Yancoal Geological Model.
^^ Permian Underburden may include the Marrangaroo Conglomerate.

Hydrogeological Conceptual Section A-A'
Moolarben Groundwater Conceptualisation - UG2 Antecedent Groundwater Conditions
Moolarben Coal Operations - UG2 Modification (G1622F)

AGE

DATE 18/11/2021

FIGURE No: **4.4**

The following can be inferred from the conceptual groundwater model:

- the UG2 mining area is located beneath an elevated ridgeline of outcropping Triassic Narrabeen Group sandstone;
- the Permian and overlying Triassic strata generally dip in a north-easterly direction;
- mining within the approved OC3 mining area occurs up dip of the extended UG2 mining area (while mining within OC2 has occurred up dip of the majority of the approved UG2 mining area);
- mining has occurred down dip of the approved UG2 mining area and is approved and planned to occur down dip of the extended UG2 mining area at OC4 (and also UG1, which is not shown due to the transect location);
- earlier mining at the Moolarben Coal Complex, Ulan Mine Complex and Wilpinjong Coal Mine has resulted in dewatering of the Ulan Seam. The Triassic strata overlying the UG2 mining area are unsaturated, either naturally or from depressurisation caused by previous mining activities;
- depressurisation of any saturated strata above the UG2 mining area is predicted to occur as a result of subsurface fracturing;
- existing mining activities to the immediate north, east and west of the UG2 mining area limit the potential for depressurisation (groundwater drawdown) to propagate away from UG2; and
- the Triassic strata in the Munghorn Gap Nature Reserve to the south of the UG2 mining area is expected to be unsaturated, however some perched watertables might be sustained due to the presence of occasional mudstone/siltstone beds between the sandstone layers.

5 Groundwater Model Predictions

The most recent numerical groundwater model developed for the UG4 Extraction Plan has been used to assess the potential impacts of the Modification. Key elements of the groundwater model remain unchanged for this assessment, including:

- the model extent, boundary conditions and internal Voronoi mesh;
- the 21 model layers that represent the hydrostratigraphic units in the area; and
- the model calibration, which achieved a Scaled Root Mean Squared Error (SRMS) of 6.1%.

A full description of the numerical groundwater model is provided in the Groundwater Technical Report on UG4 LW401-LW408 Extraction Plan (AGE, 2021).

The fractured zone (Section 4.60) is represented in the groundwater model by adjustments of the hydraulic properties to reflect the changes which occur in the developed fractured zone. Dewatering is simulated in the coal seam layers through the application of the MODFLOW drain boundary condition. The model layers above the mined coal seam have their properties adjusted at the same time (that mining occurs) to replicate the fracturing which occurs in response to longwall mining. Mining has been represented in the groundwater model based on the indicative mine schedule for the Modification. A change in the sequence of mining is unlikely to materially affect the quantum of predicted impacts but may affect the timing of impacts.

The amount that hydraulic properties are altered (within the groundwater model) depends on where in the zone of continuous fracturing the model cell is situated. Model cells immediately above the mined coal seam are altered the greatest, with a reduction in change occurring with height, within the fracture zone.

Potential impacts of the Modification have been assessed by simulating a ‘no Modification’ model run and comparing that to a model scenario which incorporates the proposed changes to the UG2 longwall layout. The no Modification’ model run includes the cumulative approved mining at the Moolarben Coal Complex, Ulan Mine Complex and Wilpinjong Coal Mine.

5.1 Groundwater Inflows

The predicted inflows to the UG2 mining area (with and without the Modification) per water year are shown on Figure 5.1.

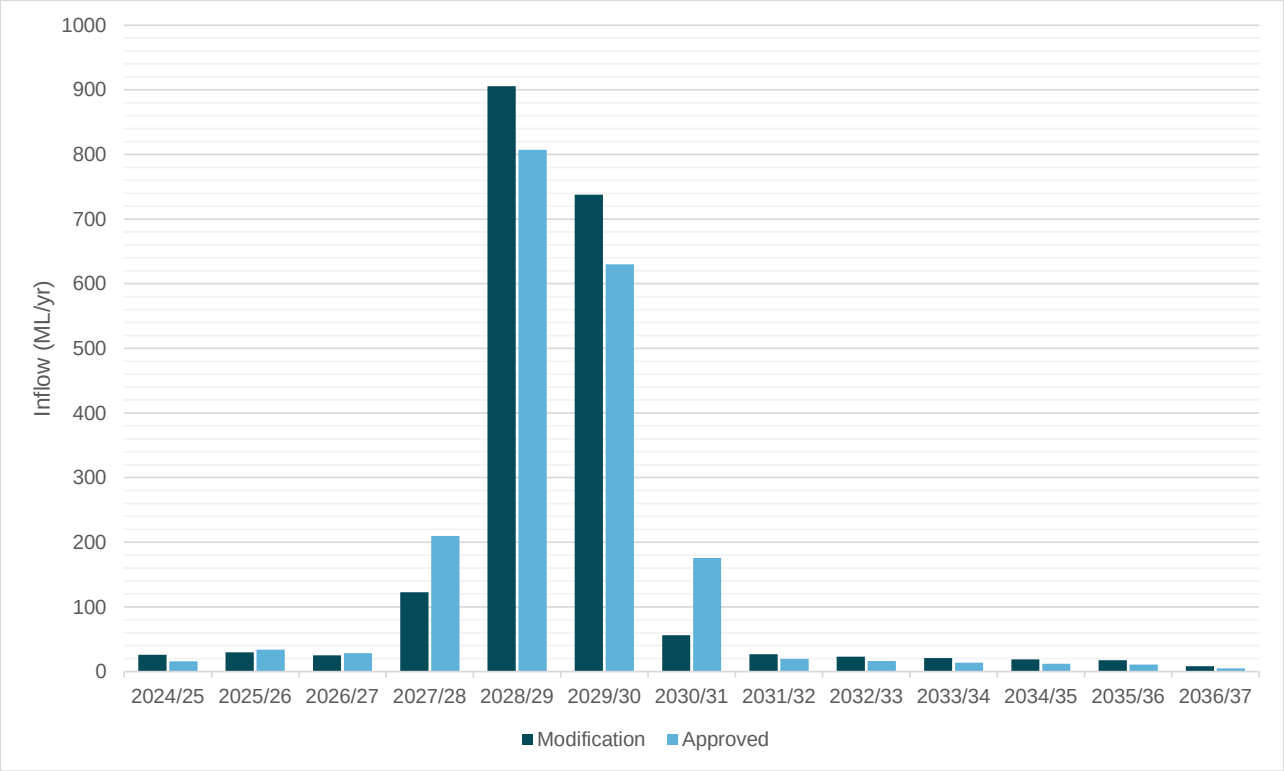
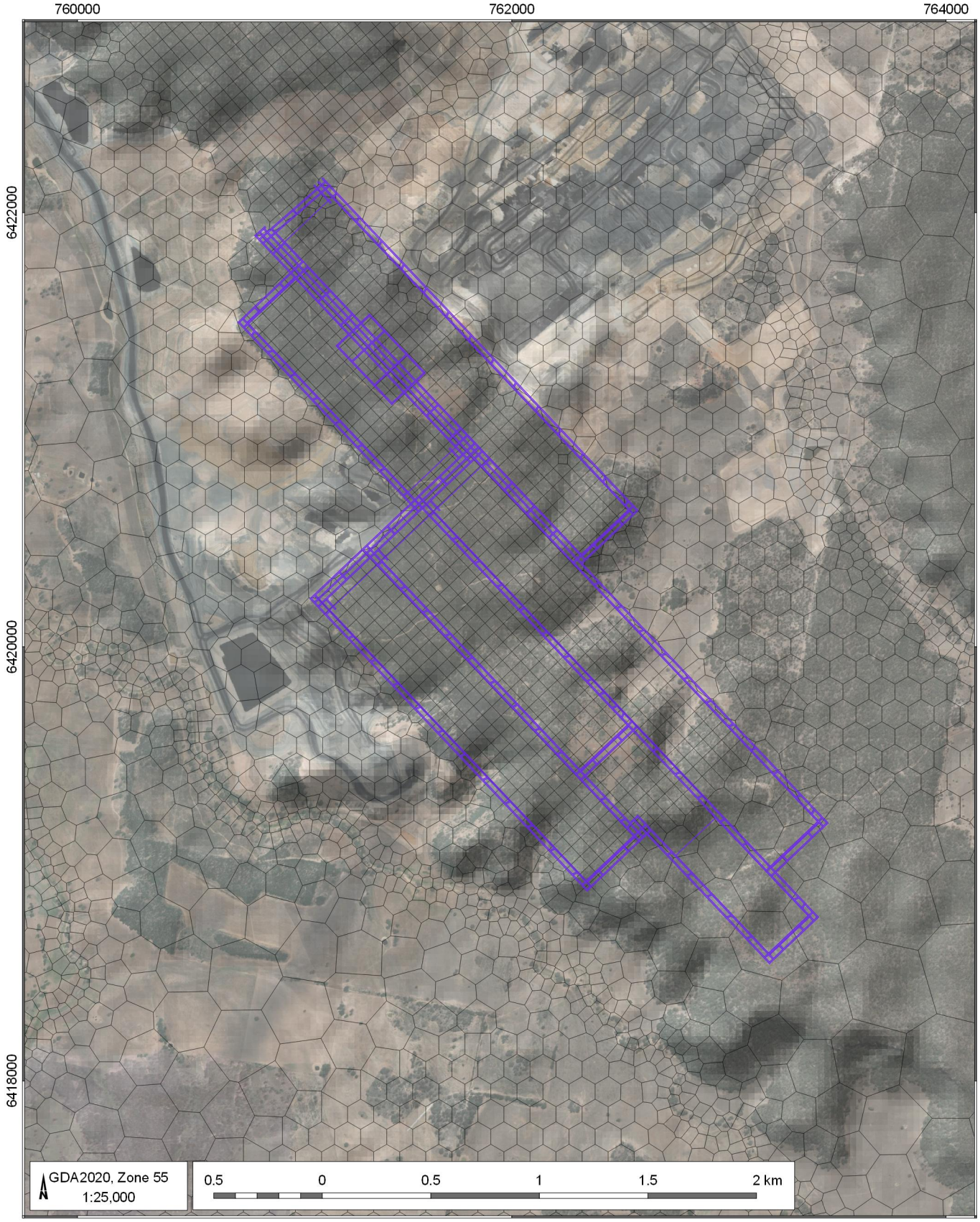


Figure 5.1 Predicted inflows to the UG2 mining area (with and without the Modification)

The Modification would result in an increase in the peak inflow to the UG2 mining area of 98 megalitres per year (ML/year) in water year 2028/29. The Modification would not change the peak inflow for the Moolarben Coal Complex, which is predicted to occur during the mining of UG4, prior to longwall extraction commencing in UG2.

5.2 Incremental Drawdown / Depressurisation

Figure 5.2 to Figure 5.5 show the incremental drawdown/depressurisation due to the Modification in the key Hydrostratigraphic units.



LEGEND

- Drawdown contour (m)
- Model mesh
- UG2 Modification

Drawdown (m)

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

Moolarben (G1622F)

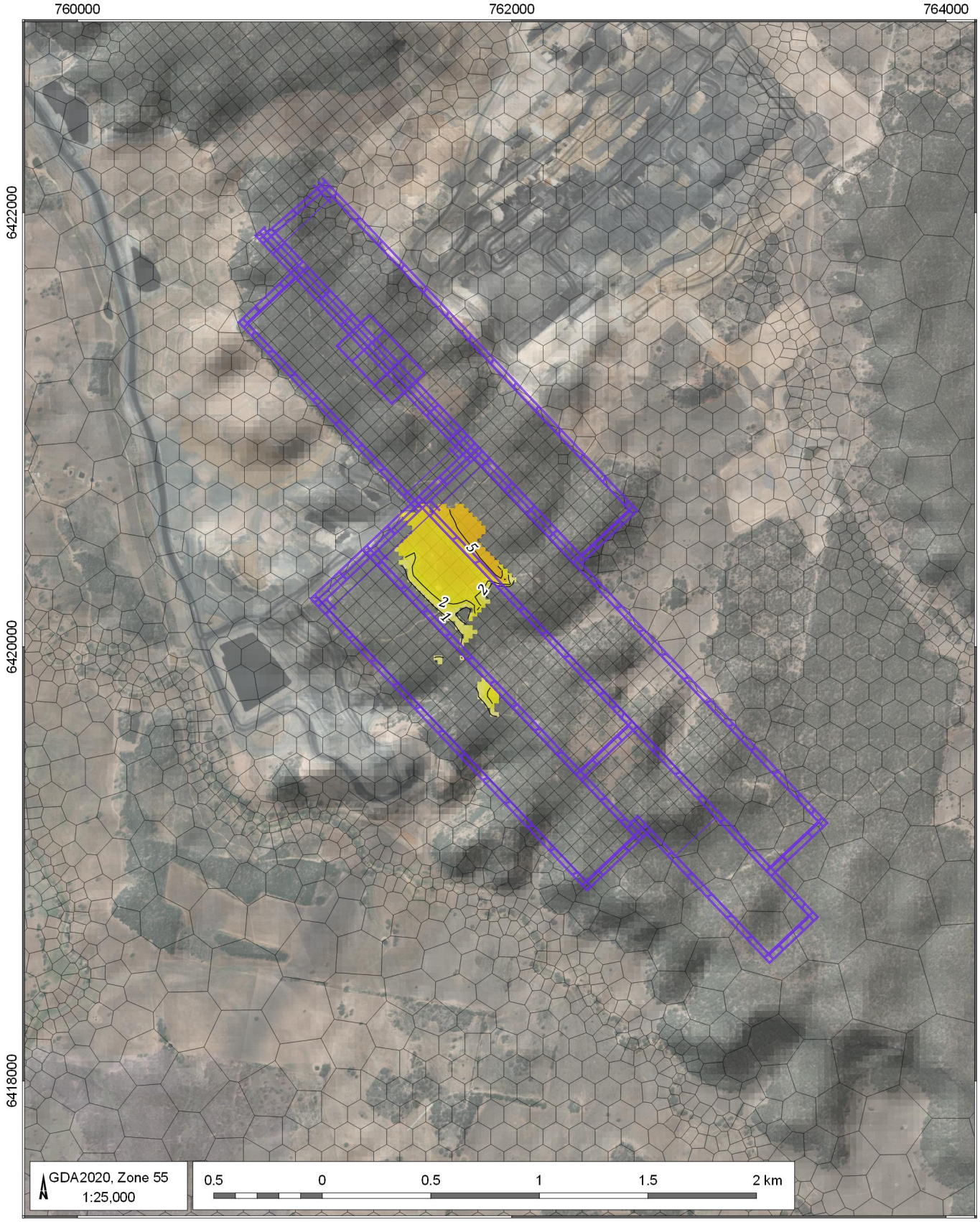
Drawdown in the alluvium/colluvium and paleochannel sediments due to UG2 Modification at end of UG2 mining

AGE

DATE 18/11/2021

FIGURE No: **5.2**

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\G1622F_Moolarben\3_GIS\Workspaces\999_Working\drawdowns_UG2mod.qgs



LEGEND

- Drawdown contour (m)
- Model mesh
- UG2 Modification

Drawdown (m)

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

Moolarben (G1622F)

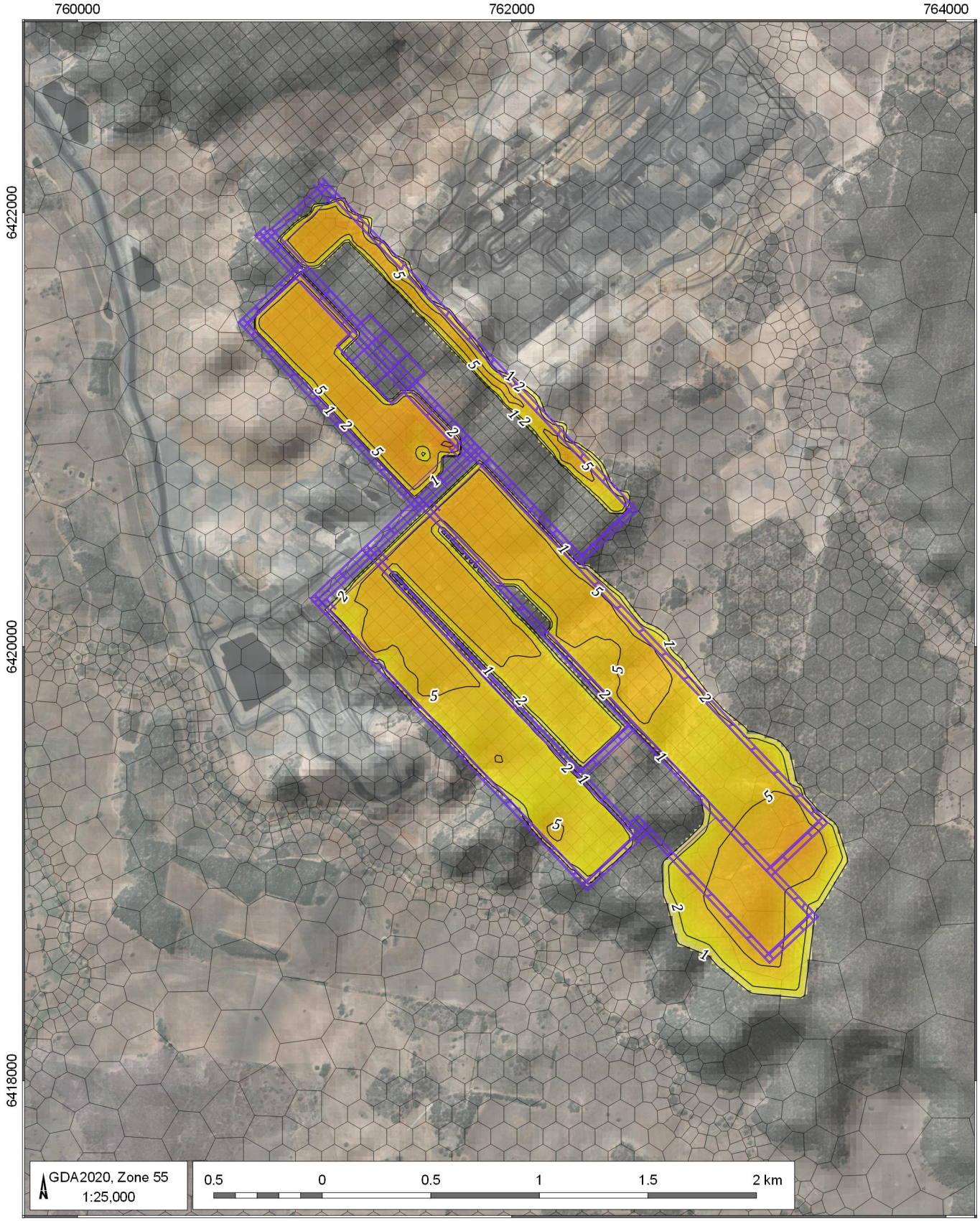
Drawdown in layer 8 (base of Triassic quartzose) due to UG2 Modification at end of UG2 mining

AGE

DATE 18/11/2021

FIGURE No: **5.3**

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\G1622F_Moolarben\3_GIS\Workspaces\999_Working\drawdowns_UG2mod.qgs



LEGEND

- Drawdown contour (m)
- Model mesh
- UG2 Modification

Drawdown (m)

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

Moolarben (G1622F)

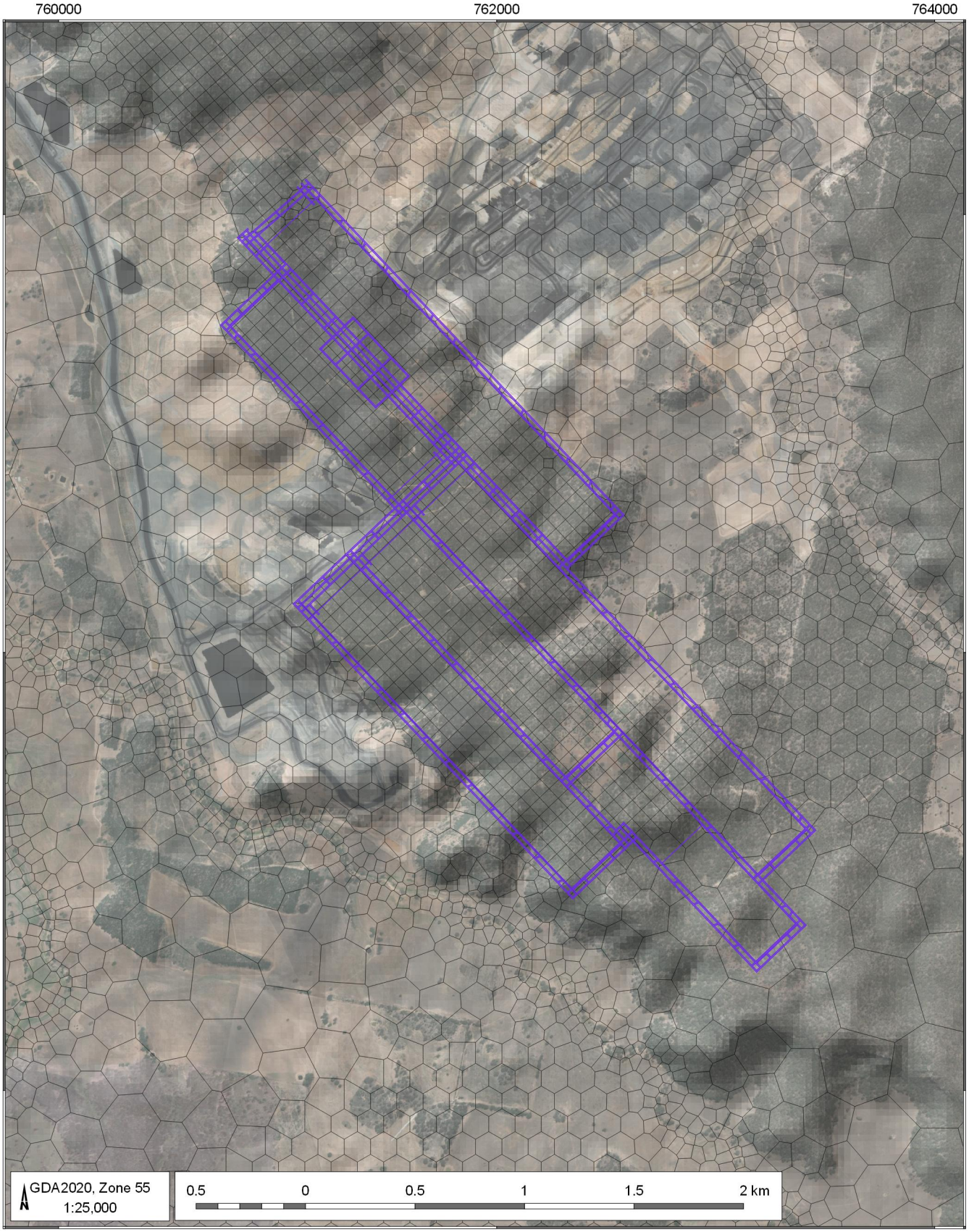
Drawdown in layer 15 (base of Permian overburden) due to UG2 Modification at end of UG2 mining

AGE

DATE 18/11/2021

FIGURE No: **5.4**

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\G1622F_Moolarben\3_GIS\Workspaces\999_Working\drawdowns_UG2mod.qgs



LEGEND

- Drawdown contour (m)
- Model mesh
- UG2 Modification

Drawdown (m)

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

Moolarben (G1622F)

Drawdown in layer 18 (Ulan Seam WS2) due to UG2 Modification at end of UG2 mining

AGE

DATE 18/11/2021

FIGURE No: **5.5**

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\G1622F_Moolarben\3_GIS\Workspaces\999_Working\drawdowns_UG2mod.qgs

The incremental drawdown/depressurisation maps demonstrate that:

- there is no additional drawdown expected within the alluvium/colluvium, paleochannel sediments, or Ulan Seam as a result of the Modification (Figure 5.2 and Figure 5.5). This is consistent with the conceptual model (Section 4.7) which describes the Ulan Seam as already impacted by the adjacent operations;
- there is minimal additional drawdown expected within the Triassic Quartzose sediments as a result of the Modification. Additional drawdown is expected to be less than 2 metres, and confined to within the approved UG2 mining area (Figure 5.3);
- there is minimal additional drawdown expected within the Permian Overburden as a result of the Modification. Maximum additional drawdown occurs at the south-eastern end, where the Modification effectively extends beyond the approved mine plan (i.e. extended UG2 mining area). Approximately 5 m of additional drawdown is expected within the Permian Overburden, and is largely focussed over the extended UG2 mining area (Figure 5.4);
- an additional 1 m of groundwater drawdown within the Permian Overburden is not expected beyond 500 m from the extended UG2 mining area (Figure 5.4); and
- minor additional drawdown within the Permian Overburden (i.e. up to approximately 5 m) is expected to occur over the approved UG2 mining area and extended UG2 mining area, due to a combination of longwall panel alignment changes, and an associated increase in fracture height, due to the minor increase in panel widths (Figure 5.4).

It should be noted that these figures only show the areas where additional drawdown is expected to occur due to changes in UG2, and do not show areas where a reduction in drawdown is expected to occur (i.e. due to panel alignment changes).

5.3 Water Licensing

Mining of UG2 (incorporating the Modification) would result in a direct take of groundwater from the Sydney Basin-North Coast Groundwater Source, which is regulated under the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* (Figure 3.1). Mine dewatering at the Moolarben Coal Complex also has an indirect impact on two further water sources that are regulated under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* (Figure 3.2).

The subsidence and fracturing associated with longwall mining will provide increased connection to overlying and underlying strata, and the hydraulic gradients will result in the flow of groundwater towards the mine area. This flow results in indirect take from the surrounding strata.

The amount of intercepted incidental water take from surrounding groundwater sources has been determined by comparison of two model scenarios, one representing pre-mining conditions (the null model) and the other representing the mining activity of the UG2 mining area (incorporating the Modification). Using this process, a third model run removing the simulation of dewatering for the extended UG2 mining area was undertaken to isolate the influence and contribution of those panels.

The estimated water take from the various water sources is summarised in Table 5.1 below.

Table 5.1 Predicted Water Take

Water Source	UG2 Peak Take (ML/year)	Moolarben Peak Take (ML/year)	Incremental change due to the Modification (ML/year)
Sydney Basin-North Coast Groundwater Source	784.2	4,453.7	0.0
Upper Goulburn River Water Source	0.1	25.4	0.0
Wollar Creek Water Source	0.0	184.3	0.0

5.4 Groundwater Dependent Assets

There are no privately-owned bores in the vicinity of the UG2 mining area that would be affected by the Modification.

A review of potential impacts to GDEs indicates:

- The Drip is located over 10 km from the UG2 mining area and would be unaffected by the Modification;
- the nearest 'high priority' GDE listed in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* is the Wappinguy Spring, which is located approximately 28 km north from the Goulburn River at its closest point and would be unaffected by the Modification; and
- vegetation mapped by Niche in the extended UG2 mining area are not considered to be groundwater dependent and would, therefore, be unaffected by the incremental increase in drawdown that would occur at depth as a result of the Modification.

5.5 Interception of Baseflow

Impacts to the baseflow of drainage lines within the Upper Goulburn River Water Source and Wollar Creek Water Source were assessed by comparing the 'no Modification' model scenario against the Modification model scenario, which incorporated the proposed changes to the longwall layout in the approved UG2 mining area. The Modification model scenario predicts indistinguishable baseflow impacts when compared to the 'no Modification' model scenario.

5.6 Groundwater Quality

Within the UG2 mining area, the quality of groundwater inflows will be controlled by the groundwater quality within the strata above and around the mine workings and fracture zone, from which inflows will originate. It is therefore anticipated that groundwater quality within the UG2 mining area will remain in line with baseline data, with no change in the beneficial use of water within the Permian coal measures during or following mining.

The minor drawdown changes (Section 5.2) would lead to very minor changes in hydraulic gradients, and consequently there is no mechanism for changes in the beneficial use regarding groundwater quality.

5.7 Minimal Impact Considerations

The AIP establishes minimal impact considerations for 'highly productive' and 'less productive' groundwater. There is no mapped 'highly productive' groundwater in the vicinity of the Moolarben Coal Complex (Sections 3.2 and 4.1).

The results described in Sections 5.1 to 5.6 demonstrate that the potential impacts of the Modification would remain within the Level 1 minimal impact considerations in the AIP.

5.8 EPBC Considerations

The Moolarben Coal Complex is already approved to operate under Approval Decisions EPBC 2007/3297, 2013/6926, 2008/4444 and 2017/7974. Accordingly, consideration of potential impacts on MNES is focused on the incremental impacts of the Modification.

5.8.1 Hydrological Characteristics

Section 5.3 of the Significant Impact Guidelines for Water Resources (DotE, 2013) provide the following guidance on potential impacts of an action on hydrological characteristics:

> *A significant impact on the hydrological characteristics of a water resource may occur where there are, as a result of the action:*
>
> *a) changes in the water quantity, including the timing of variations in water quantity.*
> *b) changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence).*
> *c) changes in the area or extent of a water resource where these changes are of sufficient scale or intensity as to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes.*

Groundwater modelling indicates the Modification would result in:

- no additional drawdown expected within the alluvium/colluvium, paleochannel sediments or Ulan Seam;
- minimal additional drawdown expected within the Triassic Quartzose sediments, which are confined to within the approved UG2 mining area;
- approximately 5 m of additional drawdown within the Permian Overburden, but which is largely focussed over the extended UG2 mining area;
- less than an additional 1 m of groundwater drawdown in the Permian Overburden beyond 500 m (from the extended UG2 mining area); and
- negligible changes to baseflow to surface water drainages.

Accordingly, it is unlikely that the Modification would result directly or indirectly in a substantial change in the hydrology of groundwater resources.

5.8.2 Water Quality

Section 5.4 of the Significant Impact Guidelines for Water Resources (DotE, 2013) provide the following guidance on potential impacts of an action on water quality:

> *A significant impact on a water resource may occur where, as a result of the action:*
>
> *a) there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:*
>
> *i. creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality*
> *ii. substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality*
> *iii. causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment*
> *iv. seriously affects the habitat or lifecycle of a native species dependent on a water resource, or*
> *v. causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful vi. to the ecosystem function of the water resource, or*
>
> *b) there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives), or*
> *c) high quality water is released into an ecosystem which is adapted to a lower quality of water.*

As discussed in Section 5.6, the Modification would not have a significant impact on groundwater quality.

5.8.3 Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources (DotE, 2013) require 'controlled actions' to be:

> *Considered with other developments, whether past, present or reasonably foreseeable developments.*

Potential cumulative impacts of the approved Moolarben Coal Complex, Ulan Mine Complex and Wilpinjong Coal Mine have been considered in various previous groundwater assessments (Section 2). Given the Modification would have negligible incremental impacts on the groundwater system, its contribution to any cumulative groundwater impacts is also considered to be negligible.

5.8.4 Consideration of Potential for Significant Impact

Based on the review presented, the Modification would not result in significant changes to the quantity or quality of water available to third party users or the environment. Accordingly, the Modification would not have a significant impact on water resources.

6 Conclusion

The Modification would comprise a number of minor amendments to the approved UG2 longwall layout, including the extension in length of LW 201 and LW 202.

This Groundwater Review has considered the incremental impacts of the Modification, relative to the approved Moolarben Coal Complex. The potential for the Modification to affect the surrounding groundwater system is limited by the proximity of the UG2 mining area to the existing OC2, OC3 and OC4 open cut mining areas and the UG1 underground mining area.

The potential impacts of the Modification are summarised as follows:

- the Modification would result in an increase in the peak inflow to the UG2 mining area of 98 ML/year in 2028/29, however this would be within the maximum predicted peak inflow for the Moolarben Coal Complex;
- the Modification would not change the maximum water licensing requirements for the approved Moolarben Coal Complex;
- no additional drawdown is predicted within surrounding alluvium/colluvium, the paleochannel sediments or the Ulan Seam;
- minimal additional drawdown is predicted within the Triassic Quartzose sediments, which are confined to within the approved UG2 mining area;
- approximately 5 m of additional drawdown within the Permian Overburden, but this is largely focussed over the extended UG2 mining area;
- less than an additional 1 m of groundwater drawdown in the Permian Overburden beyond 500 m (from the extended UG2 mining area);
- negligible changes to baseflow to surface water drainages;
- no impact to water supply works as there are no privately-owned bores in the vicinity of the UG2 mining area;
- no impact to The Drip, which is located over 10 km from the UG2 mining area;
- no impact to the nearest 'high priority' GDE listed in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* which is the Wappinguy Spring (located approximately 28 km north of the Goulburn River);
- vegetation mapped by Niche in the extended UG2 mining area is not considered to be groundwater dependent and would, therefore, be unaffected by the minor incremental increase in drawdown that would occur as a result of the Modification;
- the potential impacts of the Modification would remain within the Level 1 minimal impact considerations in the AIP; and
- the Modification would not have a significant impact on water resources.

In consideration of the above, the existing groundwater monitoring and management measures outlined in the approved Water Management Plan (MCO, 2020) are considered suitable for the Moolarben Coal Complex (incorporating the Modification).

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