CHAPTER 10 – GROUNDWATER

STANMORE ID EXTENSION PTY LTD
ISAAC DOWNS EXTENSION PROJECT

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10. GROUNDWATER

10.1 Introduction

This chapter describes the groundwater environmental values of the Isaac Downs Extension (IDE) Project (the Project) area and surrounds, groundwater fieldwork investigations, development of conceptual groundwater and ecohydrological models, the assessment of impacts on groundwater environmental values through the development of a numerical groundwater model, and the management measures and mitigation strategies designed to protect groundwater environmental values.

The assessment of groundwater environmental values includes groundwater dependent ecosystems (GDEs) and stygofauna.

The groundwater impact assessment, including conceptual and numerical modelling was subject to an independent peer review.

The information in this chapter is primarily based on the:

- Groundwater Assessment provided in **Appendix K**
- Groundwater Assessment Peer Review provided in **Appendix L**
- Groundwater Dependent Ecosystem Assessment provided in **Appendix N**
- Stygofauna Assessment provided in **Appendix O**
- Groundwater Monitoring and Management Plan provided in **Appendix AE**
- Groundwater Dependent Ecosystem Monitoring and Management Plan provided in **Appendix AF**
- Groundwater Dependent Ecosystem Habitat Quality Monitoring Program provided in **Appendix AG**.

The Project will be integrated into Isaac Plains Complex (IPC), comprising Isaac Downs Mine (IDM) and Isaac Plains Mine (IPM). The proponent for the Project, Stanmore ID Extension Pty Ltd (ID Extension) is a wholly owned subsidiary of Stanmore Resources Ltd (Stanmore).

10.2 Regulatory Framework

10.2.1 Mineral Resource Act 1989

The *Mineral Resources Act 1989* (MR Act) entitles the holder of a mining lease to take or interfere with underground water (i.e. groundwater) as part of approved mining operations. This entitlement is termed the mining lease holder's 'underground water rights'. Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of the mining lease is entitled to use associated water for any purpose.

10.2.2 Water Act 2000

The right to take associated water comes with monitoring and reporting obligations under the MR Act and the *Water Act 2000* (Water Act). The MR Act requires that the volume of associated water taken is measured and reported. Obligations under Chapter 3 of the Water Act include undertaking baseline assessments of the groundwater regime and water supply bores, providing ongoing assessment and reporting of groundwater take, preparing underground water impact reports (UWIRs) and, where necessary, entering into make good agreements with owners of affected water supply bores.

The taking of or interfering with groundwater is regulated under the water licensing provisions of the Water Act. The Water Act specifies that a water licence is required to take or interfere with sub-artesian groundwater within areas declared as management areas or declared areas under subordinate Queensland legislation. The Project will not result in the take or interference with groundwater, other than associated water while exercising its underground water rights.

10.2.3 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) (Section 126A) provides information requirements to support a specific environmental authority (EA) application involving the exercise of underground water rights. Table 10-1 lists the requirements of Section 126A and where these are addressed by the Project's environmental impact statement (EIS).

The *Environmental Protection Regulation 2019* (EP Regulation) elaborates how the principles and objectives of the EP Act are to be implemented and enforced. The EP Regulation also defines the environmental objective and performance outcomes for Queensland's water environment, which are applicable to the Project's assessment and management of potential groundwater impacts.

Table 10-1 EP Act Section 126A Requirements

EP Act Section 126A requirement	EIS Section Reference
(1), (2) – applicable to a site-specific application involving the exercise of underground water rights on a ML, in which case the application must state:	The Project will involve the exercise of underground water rights. Rights to the take of associated water under the Water Act are described in Sections 10.2.1 and 10.2.2.
(2)(a) - any proposed exercise of underground water rights during the period in which resource activities will be carried out	10.7, 10.8
the areas in which underground water rights are proposed to be exercised	10.2.10, 10.4, 10.5
for each aquifer affected, or likely to be affected, by the exercise of underground water rights— (i) a description of the aquifer; and (ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers and surface water; and (iii) a description of the area of the aquifer where the water level is predicted to decline because of the exercise of underground water rights; and (iv) the predicted quantities of water to be taken or interfered with because of the exercise of underground water rights during the period in which resource activities are carried out;	10.5, 10.7, 10.8
the environmental values that will, or may, be affected by the exercise of underground water rights and the nature and extent of the impacts on the environmental values;	10.6, 10.7, 10.8

EP Act Section 126A requirement	EIS Section Reference
any impacts on the quality of groundwater that will, or may, happen because of the exercise of underground water rights during or after the period in which resource activities are carried out;	10.8, 10.8.3
strategies for avoiding, mitigating or managing the predicted impacts on the environmental values stated for paragraph (d) or the impacts on the quality of groundwater mentioned in paragraph (e).	10.8, 10.9

10.2.4 Water Plan (Fitzroy Basin) 2011

The Project is located within the Fitzroy River catchment which is managed under the *Water Plan (Fitzroy Basin) 2011* (Fitzroy Basin WP), which is subordinate legislation under the Water Act. The plan covers surface water (zone WQ1301) associated with Isaac River, and groundwaters (zone WQ1310 – Fitzroy Basin groundwaters). The Project is located within the Isaac Connors Groundwater Management Area (GMA) as described in the Fitzroy Basin WP. The Isaac Connors GMA is subdivided into the following groundwater units:

- Isaac Connors Groundwater Unit 1, also known as the Isaac Connors Alluvium groundwater sub-area, containing aquifers of the Quaternary alluvium.
- Isaac Connors Groundwater Unit 2, containing all sub-artesian aquifers within the Isaac Connors GMA other than the aquifers included in Isaac Connors Groundwater Unit 1.

In the Project area and surrounds, the Isaac Connors Groundwater Unit 1 is limited to the alluvium of the Isaac River channel, floodplain and associated historical Isaac River channel meanders (paleochannels). The western and southern areas of the Project occur within the Isaac Connors Groundwater Unit 1, with the northern and eastern areas outside the Isaac River floodplain being situated within the Isaac Connors Groundwater Unit 2.

The Fitzroy Basin WP requires consideration of the following potential impacts which influence environmental values:

- Lateral connectivity and interaction between the Isaac River and adjacent riverine environments, including floodplains.
- Groundwater levels required to maintain water dependent assets such as groundwater dependent ecosystems.
- Water quality deterioration.
- The effect taking, or interfering with groundwater may have on baseflow and contribution of aquifers to the flow in the watercourses.

Assessment of these potential impacts is provided in this chapter.

10.2.5 Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017

The Project is located over 160 km east of the boundary of the Great Artesian Basin (GAB). No approvals or groundwater allocations associated with the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* are applicable within the Project area.

10.2.6 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses.

The processes to identify environmental values (EVs) and to determine water quality objectives (WQOs) in Queensland waters is based on the Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (ANZG, 2018), hereafter referred to as the Australian Water Quality Guidelines. The EPP Water is supported by the Queensland Water Quality Guidelines 2009 (QWQG) (DEHP, 2013).

The relevant document for the Project, pursuant to the EPP Water, is the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), September 2011* (DEHP, 2011), hereafter referred to as the 'Isaac River Sub-basin EVs and WQOs'. The document is made pursuant to the provisions of the EPP Water. It contains EVs and WQOs for waters in the Isaac River Sub-basin, which are listed under Schedule 1 of EPP Water.

The environmental values of Isaac groundwaters, as listed in the 'Isaac River Sub-basin EVs and WQOs' is for aquatic ecosystems, irrigation, farm supply/use, stock water, drinking water, industrial use, primary recreation and cultural and spiritual values. DES (2018) reviewed the chemistry of groundwater occurring within Quaternary alluvium, Tertiary sediments and Permian fractured rock as part of a process to better define environmental values under the EPP Water. The Project occurs in Basin 130 where the Cainozoic alluvium was determined to have the highest environmental value. The Isaac River alluvium is within Isaac River alluvium zone 12 – divided into 'Isaac' and 'Isaac near stream'. The salinity indicates the groundwater is suited for stock and is reasonably suited for irrigation, although the quality is only moderate for sensitive crops because salinity may be elevated. The water may be suited for drinking and other domestic uses despite its hardness.

The Project occurs within zone 34 within the Fitzroy Basin on plan WQ1310 of the 'Isaac River Sub-basin EVs and WQOs'. WQOs are long-term goals for water quality management that protect environmental values. WQOs are provided, as statistical percentiles, for two depths (shallow < 30 m, and deep > 30 m). Zone 34 is a much larger region than the Project, encompassing a range of different geological domains, topography and climatic conditions over a spatial extent of approximately 300 km^2. The statistical percentiles of water quality data for Zone 34 WQOs will reflect these different hydrogeological environments and not wholly the specific hydrogeological conditions at the Project. Nevertheless, they provide a useful basis against which to compare the water quality data from the Project monitoring bores, and to inform interim WQOs for the Project. In addition, the 'Isaac River Sub-basin EVs and WQOs' provide WQOs for stock drinking water and short term irrigation, against which the water quality data from the Project monitoring bores has been compared.

10.2.7 Environment Protection and Biodiversity Conservation Act 1999

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) determined the Project to be a controlled action (EPBC 2025/10183). The controlled action includes 'a water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E)'. This controlling provision is relevant to the groundwater assessment.

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Developments provides scientific advice to decision makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources. The IESC assess the proposals against the Information Guidelines for Independent Expert Scientific Committee advice (IESC, 2024) on coal seam gas and large coal mining development proposals where there is a significant impact on water resources (IESC Guidelines). The core purpose of the guideline is to determine whether a coal seam gas (CSG) or large coal mining development has, or is likely to have, a significant impact on a water resource. The IESC Guidelines specify information required for groundwater studies including the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) as well as a methodology to assess uncertainty associated with groundwater modelling (Peeters and Middlemis, 2023). The groundwater assessment was specifically designed to provide the information required by these guidelines, including utilising proposed concepts for assessing model confidence that are expected in future updates to the Australian Groundwater

Modelling Guidelines (Barnett et al., 2012). **Chapter 24** provides an assessment of the significance of impacts to groundwater resources in accordance with DCCEEW significant impact guidelines 1.3[1]. **Chapter 24** provides a cross reference table identifying where the requirements of the IESC Guidelines have been addressed.

10.2.8 Environmental Objectives and Performance Outcomes

The environmental objectives and performance outcomes, based on the EP Regulation and terms of reference (ToR) for the Project's EIS, that are relevant to the groundwater assessment are provided in Table 10-2. A corresponding EIS section reference is provided in this table demonstrating how the Project meets these environmental objectives and performance outcomes.

Table 10-2 Environmental Objectives and Performance Outcomes – Groundwater

Requirement	Environmental Objectives and Performance Outcomes	EIS Reference
EP Regulations Terms of Reference	The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.	10.6, 10.7, 10.8, 10.9
Performance Outcomes		
1 Both of the following apply— a) there will be no direct or indirect release of contaminants to groundwater from the operation of the activity b) there will be no actual or potential adverse effect on groundwater from the operation of the activity.		Not applicable
2 The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.		10.6, 10.7, 10.8, 10.9
Additional Environmental Objective		
Terms of Reference	Maintenance of supply to existing users of surface and groundwater resources.	10.8.1, 10.9.1 **Chapter 8**

10.2.9 EIS Information Guidelines

The EIS assessment has been undertaken in accordance with the EIS information guideline – Water[2] and EIS information guideline – Groundwater Dependent Ecosystems[3]. The relevant EIS sections where the requirements of these guidelines have been addressed are provided in Table 10-3 and Table 10-4.

Table 10-3 EIS Information Guideline – Groundwater

Guideline Requirement	Section of EIS
Water sampling, characterisation and monitoring	10.2.10, 10.3.1, 10.3.1.8, 10.5, 10.5.2, 10.5.6

[1] https://www.dcceew.gov.au/sites/default/files/documents/significant-impact-guidelines-1-3.pdf
[2] https://www.detsi.qld.gov.au/_global/policy-register/policy-register-pdf?getdoc=5312&name=eis-tm-water-information-guide.pdf
[3] https://www.detsi.qld.gov.au/_global/policy-register/policy-register-pdf?getdoc=5301&name=eis-tm-gde-information-guide.pdf

Guideline Requirement	Section of EIS
Surface water resources	**Chapter 8** and **Chapter 9**
Water quality and environmental values	10.5, 10.5.6
Alterations to flow of water	10.7, 10.7.5, 10.7.6, 10.8.2
Water supply	**Chapter 8**
Project infrastructure	**Chapter 4**
Discharges and onsite reuse of wastewater	**Chapter 8**
Discharges to wetlands	**Chapter 12**
Release of particular contaminants to the Great Barrier Reef (GBR) catchment waters and other waters	**Chapter 8**
Bank stability and riparian vegetation	**Chapter 9**
Voids	**Chapter 5**
Acid producing material	**Chapter 7**
Avoidance and mitigation measures	10.7, 10.8, 10.9
Monitoring and corrective actions	10.9, 10.9.3, 10.9.4
Commitments and conditions	10.9, **Appendix A**, **Appendix AA**, **Appendix AC**

Table 10-4 EIS Information Guideline – Groundwater Dependent Ecosystems

Guideline Requirement	Section of EIS
Identifying GDEs and determining the spatial extent of impacts to GDEs	10.2.10, 10.3.2, 10.3.3, 10.6, 10.6.3, 10.6.4
Assess groundwater dependence	10.6.3, 10.6.4
Determine baseline ecological condition	10.6.3, 10.6.4
Assess impacts	10.7, 10.8, 10.8.5, 10.8.6
Develop avoidance and mitigation measures	10.9, 10.9.3, 10.9.4

10.2.10 Guideline - Applications for Activities with Impacts to Water

The EIS assessment has been undertaken in accordance with the Guideline - Applications for Activities with Impacts to Water (ESR/2015/1837). The relevant EIS sections where the requirements of this guideline have been addressed are provided in Table 10-5.

Table 10-5 Guideline - Applications for Activities with Impacts to Water

Guideline Requirement	Section of EIS
Project description information relevant to waters.	**Chapter 4** 10.4

Guideline Requirement	Section of EIS
Identifying environmental values of receiving waters, including topography, surface waters, wetlands, catchments (including Great Barrier Reef), water quality objectives flooding, hydrology, bores, hydrogeological features, aquifers, groundwater dependent ecosystems, water quality, groundwater levels.	**Chapter 8** **Chapter 9** 10.3, 10.4, 10.5, 10.6
Possible impacts to identified environmental values, including discharges and releases, uncontrolled releases, water infrastructure, surface water and groundwater interactions, groundwater changes, and impacts to wetlands, catchments and hydrology.	**Chapter 8** **Chapter 9** 10.7, 10.8
Proposed management practices, including management hierarchy and practices, release controls and limits, stormwater management, and managing activities near watercourses.	**Chapter 8** 10.8, 10.9
Management plans, including for stormwater, groundwater monitoring and site water management	**Chapter 8** 10.9, 10.9.3
Rehabilitation of the site	**Chapter 5**

10.3 Methodology and Fieldwork

10.3.1 Groundwater

10.3.1.1 Desktop Data

Groundwater studies have been undertaken for resource projects in the vicinity of the Project area (the Project's four mining lease application (MLA) areas), and were used to inform the Project's groundwater investigation studies and to supplement the extensive program of Project-specific groundwater data collection including the field programs described below. Relevant groundwater information was sourced from:

- Stanmore related projects:
  - the Integrated Isaac Plains project (IIPP) (Matrix+ Consultants, 2008), a discontinued project that targeted the same resource as the Project
  - IDM Groundwater Impact Assessment (AGE, 2020), which is directly relevant to the Project as the IDM area lies along the same geological strike and abuts the northern extent of the Project
  - Poitrel Mine (PTM) assessments, with PTM located immediately to the east of the Project
  - IPM East Extension Project, located to the north of IDM
  - groundwater monitoring data from the Eagle Downs project, located to the south of the Project.
- Stanmore data:
  - detailed topographic data
  - Stanmore's resource structure geological model
  - groundwater monitoring data (bore logs, drilling information, water level and quality data) for Stanmore operated bores in the vicinity of the Project.
- Public data:
  - Queensland Government registered bore database
  - Queensland Government geological mapping.

- Third party data for other nearby mines or mining projects, either publicly available or subject to data sharing agreements with Stanmore[4], for:
    - Peak Downs Mine
    - Moorvale South project
    - Caval Ridge Mine
    - Millennium Mine
    - Daunia Mine
    - Saraji Mine
    - Saraji East Mining Lease project
    - Winchester South project
    - Caval Ridge Mine Horse Pit Extension project
    - Moorvale South project
    - Olive Downs project
    - Moranbah South project.

Data from these sources has been incorporated into the regional, numerical groundwater model that supports the groundwater assessment for the Project.

10.3.1.2 Overview of Fieldwork Programs

Numerous groundwater field programs have been undertaken for the Project to inform the groundwater impact assessment. Each field program sought to build upon the previous programs and address residual gaps identified in the available information and dataset. The Project field programs have included:

- a groundwater bore census (Appendix E to **Appendix K**)
- hydrogeological drilling and bore installation campaigns (Appendix F to **Appendix K**)
- site specific hydraulic testing (Appendix F to **Appendix K**)
- geophysical testing (electrical resistivity surveys (Appendix G to **Appendix K**)
- GDE field studies (See Section 10.3.2)
- Routine and ongoing groundwater level monitoring and groundwater quality sampling.

10.3.1.3 Groundwater Bore Census

The primary objective of the bore census undertaken in November 2024 (Appendix E to **Appendix K**) was to identify and confirm existing bores (specifically bores installed from previous IIPP which were within or surrounding the Project area) that could be incorporated into the baseline groundwater monitoring network. It also served to identify landholder bores that required consideration in the groundwater assessment. The census involved a desktop review and field investigation, including groundwater level measurements and water quality sampling.

In total, 43 bores were assessed, comprising 32 monitoring bores and 11 landholder supply bores. Of the 32 monitoring bores, 16 were found to be functional, while the remaining 16 were either damaged, lost, or destroyed, often due to broken or buried PVC casings. Among the landholder bores, six were active and sampled, while five were inactive at the time of the survey.

The census informed the scope of work for the 2025 groundwater field investigation program (Appendix F to **Appendix K**). An initial groundwater level and quality monitoring event was undertaken during the groundwater bore census and data was included in the baseline groundwater dataset for the 2025 groundwater field investigation program.

10.3.1.4 Bore Drilling and Installation

A baseline groundwater monitoring program for the Project was recommended by AGE (2022), and together with the gap analysis prepared specifically for the Project, formed the foundation for the scope

[4] References to the sources of these studies and data is provided in Section 1.3 of **Appendix K**.

of work for the 2025 groundwater field investigation program. The recommendations included the installation of 19 new monitoring bores. Of these, seven were successfully installed in 2022 but remained undeveloped, requiring contractor services to airlift develop the bores in the 2025 groundwater field investigation program before being deemed suitable for baseline monitoring.

In addition, seven damaged legacy bores identified during the site bore census were recommended for rehabilitation to re-establish the integrity of the bores and widen spatial coverage of the groundwater monitoring network. Two of these legacy bores, considered key components of the monitoring network, were damaged beyond rehabilitation, and therefore, were scheduled for redrilling. Consequently, the installation of a total of 14 additional bores was completed in the 2025 groundwater field investigation program (Appendix F to **Appendix K**).

10.3.1.5 Fault Exploration Drilling and Down-hole Geophysics Survey

A component of the 2025 groundwater field investigation program was exploration drilling to delineate and characterise the Isaac Thrust Fault east of the Project area. Five exploration holes were used to identify the fault core and inform the design and installation of a subsequent groundwater monitoring bore targeting the fault (Appendix F to **Appendix K**).

Exploration drilling was conducted 1.5 km east of the Project area, where State regional geological mapping indicated the likely position of the fault. Five exploratory air-rotary chip holes were drilled southwest to northeast across geological strike of the mapped fault trace. These chip holes provided key geological information, enabling the identification of the fault's location and depth on the basis of observed structural offsets with respect to the expected stratigraphy as is present within the Project area and surrounds.

The results of this exploratory drilling combined with downhole geophysical logging informed the final design and siting of a monitoring bore targeting the Isaac Thrust Fault itself. The most hydraulically conductive zone of the fault was targeted for the monitoring bore installation, as discussed below.

Epiroc undertook downhole geophysics at all five exploration holes drilled as part of the Fault Investigation. The objective of the downhole geophysics was to support the siting and final design of the monitoring bore targeting the Isaac Thrust Fault.

Wireline geophysical techniques were employed on all drill holes, and nuclear magnetic resonance (NMR) testing was employed on three drillholes. These three drillholes were selected as they were determined to show the most significant faulting present out of the five exploration drillholes. NMR is a widely utilised method employed in the petroleum industry. Resulting data processing provides measurements of:

- porosity: total volume of rock pore space.
- permeability estimates: based on pore size distribution and fluid mobility.
- bound vs. free fluid: helps identify producible fluids vs. those bound to rock surfaces.

The NMR method provides a faster, and higher resolution method of assessing downhole hydrogeological properties than more traditional methods such as packer testing. The aim of the NMR testing was to:

- provide characterisation of Isaac Thrust Fault permeability across the vertical drillhole profile
- contrast the inferred permeabilities between the fault zone and the overlying/underlying undisturbed Rangal Coal Measures interburden
- identify any higher permeability zones for installation of a groundwater monitoring bore.

10.3.1.6 Hydraulic Testing

Groundwater hydraulic slug testing was conducted across the Project's baseline groundwater monitoring network, which comprised 33 bores (Appendix F to **Appendix K**). The testing included both rising and falling head slug tests. Prior to this campaign, slug testing was carried out in 2008 at selected existing bores as part of the IIPP.

Hydraulic testing had previously been carried out on the adjacent IDM, located north of the Project area. This earlier work was conducted by AGE (AGE, 2020), providing useful comparative data for regional hydrogeological interpretation and is included in Section 5.3 of **Appendix K**.

10.3.1.7 Electrical Resistivity Imaging Survey

Between 14 May and 26 June 2025, Marine & Earth Science conducted electrical resistivity imaging (ERI) surveys to test the resistivity of the ground cover up to 80 m below ground level (Appendix G to **Appendix K**). The primary objective of these surveys was to characterise the thickness and lateral extent of alluvial sediments along the Isaac River and Cherwell Creek, the Isaac River alluvium near the northern highwall of the Project mining area as well as the sediments underlying potential wetlands. The survey also assisted to assess the potential connectivity between shallow groundwater and alluvium, possible presence of paleochannels and occurrence and thickness of clay layer between the alluvium and underlying Permian rock. The transects were aligned with existing drilling data as best as possible in order to tie in the geophysical data with the drill hole data.

A total of six ERI transects were completed during the survey period. Two lines were positioned along the riverbeds of Isaac River and Cherwell Creek, while the remaining four were strategically located to investigate subsurface conditions adjacent to the Project's proposed mine pit (see Section 10.4.3.3 for a discussion of results).

10.3.1.8 Routine Groundwater Level and Quality Monitoring

Routine groundwater level and quality monitoring has been conducted monthly at all Project monitoring bores since March 2025 or since bore installation, following an initial monitoring event in late 2024 associated with the groundwater bore census. As new bores have been installed in ongoing drilling campaigns, these have been incorporated into the routine monitoring program, with logger installation completed.

It should be noted that some historical monitoring at bores within the Project area, including initial groundwater levels collected in 2006 as part of the IIPP, as well as routine IDM monitoring bores starting around 2021, have been incorporated into the baseline groundwater database. The bore monitoring network and data is described in Section 10.5.

10.3.2 Groundwater Dependent Ecosystems

10.3.2.1 GDE Survey Timing

GDE field surveys were completed in dry seasons, namely November 2024, with supplementary field data collected in August, September and November 2025. The timing of dry season surveys for GDEs is considered optimal for sampling of groundwater dependent vegetation as it can limit the influence of variables, such as recent rainfall recharge of soil moisture. Due to the intensive nature of the data collection process, representative areas were chosen for GDE sampling which were used as a basis for extrapolation over broader areas considered to present similar ecohydrological function. The data collection process allowed for the conceptualisation of the ecohydrological characteristics of any GDEs confirmed to be present in the Project area and their general distribution. Additional information on survey timing is provided in Section 2 of **Appendix N**.

10.3.2.2 GDE Survey Methods

The field survey included an assessment of 20 'GDE assessment areas (or sites)', all considered to represent potential GDEs from the Bureau of Meteorology GDE Atlas (BOM, 2024), as shown on Figure 10-1. At each assessment site, sampling of two to five trees for leaf water potential (LWP) was completed, with twig samples collected to analyse xylem stable isotope composition. Seven locations were subject to soil auger profiling to facilitate the collection of soil moisture potential (SMP) and stable isotope data from the soil profile. Sampling of groundwater was completed from soil auger holes when groundwater was intersected, and from monitoring bores as part of the groundwater sampling program. All methods are consistent with GDE assessment protocols detailed by Doody et al. (2019) and Richardson et al. (2011).

Four sampling events contributed to the data analyses in the assessment, as follows:

- A primary phase of biophysical and hydrochemical sampling (leaf, soil and water) occurred in November 2024.
- Additional isotopic sampling occurred in two supplementary stages, which occurred in August and September 2025.
- A subsequent phase of isotopic and biophysical sampling occurred in November 2025.

Section 4 of **Appendix N** provides a detailed description of each of the sampling methods, with summary information below.

LWP defines the work required per unit quantity of water to transport it from the moisture held in the soil to leaf stomata. In total, 70 trees were assessed for LWP across the twenty assessment sites, and ranked from extremely low to extremely high[5]. The 'extremely high' category would indicate the potential for interaction with a highly fresh groundwater source, with the degree of groundwater interaction decreasing to the 'moderate' category, which may indicate either utilisation of soil moisture from the vadose zone (the unsaturated zone, above the water table in unconfined aquifers) or interaction with saline groundwater. Categories of 'low' to 'extremely low' are considered unlikely to utilise groundwater to any degree, regardless of salinity.

SMP, which includes the matric (water availability) and osmotic (saltiness) potential, measures the energy required to extract moisture from the soil. Where measured LWP is below the standard wilting point (the maximum suction roots for crops can apply to soil/rock before a plant wilts due to a negative water supply), it indicates plant water deficit, and the tree is unlikely to be supported by a saturated water source regardless of groundwater salinity. Soil sampling was undertaken at regular intervals down the soil profile for analysis of stable isotopes of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$), and duplicate samples were retained for analysis of SMP.

Trees may utilise water from various sources including the phreatic zone (saturated zone), the vadose zone (unsaturated zone) and surface water. The stable isotopes of water, oxygen ($\delta^{18}O$), and hydrogen ($\delta^{2}H$) are valuable tools to help define terrestrial vegetation's predominant water source. The method relies on a comparison between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with stable isotope ratios found in the various sources of water, including a shallow groundwater table, potential sub-artesian aquifer water sources, rainfall or shallow soil moisture.

Radon (^{222}Radon) is a by-product of uranium decay that has a much higher concentration in groundwater than surface water. It can therefore provide an accurate indication of how much groundwater has entered surface water bodies. As radon has a half-life of 3.8 days, its concentration will decrease downstream along a river from a source of groundwater discharge. Radon sampling targeted the detection of groundwater discharge into surface waters (if any), and hence sampling included residual surface water bodies on the Isaac River, water in a State mapped high ecological significance (HES) wetland (near the confluence of Isaac River and Cherwell Creek), and groundwater in alluvial monitoring bores, a coal seam bore, a soil auger hole and river sands in the Isaac River.

10.3.2.3 GDE Data Interpretation

GDE field data interpretation followed a structured approach by filtering multiple lines of evidence to assess groundwater dependence. The biophysical measurement of LWP formed the primary assessment, followed by the adjunct comparison with SMP, with stable isotope data used to provide supplementary

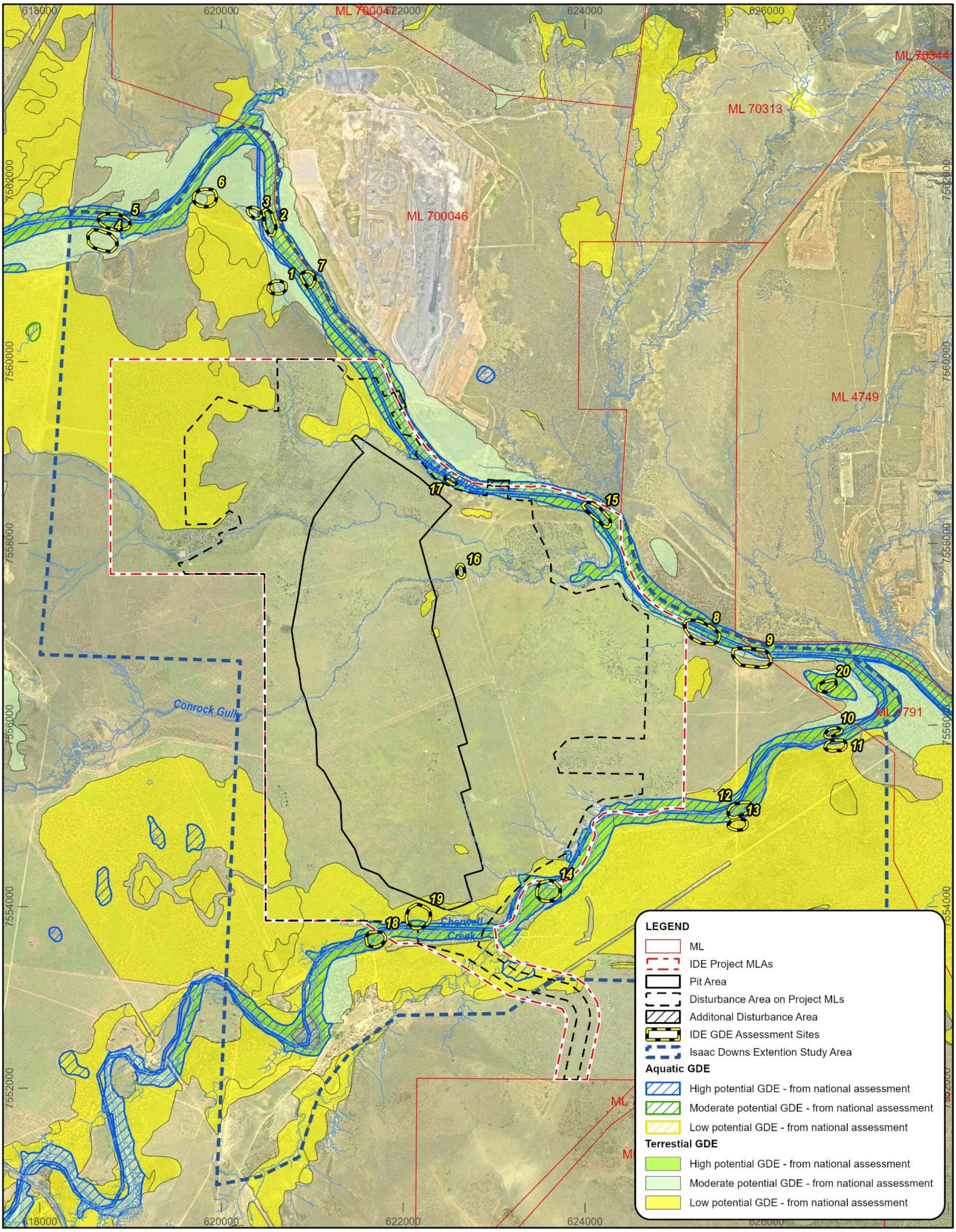
[5] LWP values are 'negative with smaller negative number (i.e. closer to zero) being the high to extremely high category) and a larger negative number (i.e. approaching or less than minus 2) being the low to extremely low category.

evidence where ambiguity remained. In addition, an overview of the depth of the groundwater table and groundwater salinity was completed as a final filter to determine the accessibility of groundwater and suitability as a source of moisture to support transpiration at each assessment locality.

Trees that demonstrate LWP values that are considerably more negative than expected ranges for the local groundwater salinity regimes are assumed not to exhibit any significant degree of groundwater dependence.

For trees where LWP was within the expected range of values for GDEs under specific local salinity regimes, soil augering allowed the direct observation of the physical features of the soil profile, as well as facilitated measurement of SMP to identify the likelihood that moisture for transpiration was being supplied from the upper soil profile, or whether deeper sources of moisture may exist. SMP analysis identifies potential sources of moisture to give context to evaluating stable isotopes.

For trees that demonstrate potential groundwater dependence from LWP measurements, stable isotope signatures from the xylem samples were compared to signatures from groundwater, surface water from residual and permanent pools, and soil moisture to provide a fingerprint for the source of moisture being utilised. Where three lines of evidence indicated utilisation of a groundwater source, the tree was generally accepted as being groundwater dependent. Where ambiguity remained in the assessment, additional features were considered, including site-specific geology, geomorphology, soil physical properties, groundwater salinity, and depth to the water table at the location to inform the final assessment of groundwater dependence for any tree or site. Radon sampling was useful for conceptualisation of groundwater and surface water interactions, and was used specifically for this purpose.



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GDE Assessment Sites

Figure | **10-1**

10.3.3 Stygofauna

A review was undertaken to search for available data and reports on stygofauna within and adjacent to the Project area, including State government data bases and studies for nearby resource projects.

Based on the desktop review, it was determined that the most appropriate approach to stygofauna sampling was to undertake a pilot survey, which typically consists of sampling a minimum of 10 bores with bore locations satisfying specific criteria for conducting stygofauna surveys.

A total of 12 groundwater bores were selected for stygofauna sampling across a study area, comprising the Project area and surrounds, two of which were found to be dry. The locations of the groundwater bores sampled within the proposed study area are shown in Figure 2 of **Appendix O**. Of the 12 bores, two were in the alluvium (alluvial aquifer), three in the regolith (two dry) and seven in the coal seams. All bores were used primarily for groundwater monitoring purposes. Bore construction dates for two bores is at least 15 years old, 2020 for two bores, 2022 for seven bores and 2025 for the one remaining bore. The bore constructed in 2025 (MBIS03) was constructed two months prior to sampling. The bores ranged from 13.5 to 180 metres deep.

Bore inspections and sampling was conducted from 20 to 22 July 2025. The bores were sampled for stygofauna in accordance with the methods defined in Queensland Environment Protection (Water) Policy 2009 – Monitoring and Sampling Manual for Biological Assessment (DES, 2018b) and following established sampling techniques defined elsewhere in Australia and overseas (i.e. the Guideline for the environmental assessment of Subterranean aquatic fauna - Sampling methods and survey considerations, DSITI[6] (2015)). The field sampling program met all the requirements for conducting a stygofauna pilot survey.

The sampling method aimed to collect between four and six replicate hauls off the bottom of each bore in order to be classified as a good sample. Overall, high quality stygofauna samples were collected from the 10 bores which held water.

Stygofauna samples were analysed in a laboratory by specialists in the field. All aquatic animals present were removed (stygofauna and non-stygofauna) and identified to Order/Family level (or lower taxonomic rank if visually possible) in accordance with DSITI (2015).

Further details on desktop and field studies for stygofauna are described in Sections 3 and 4 of **Appendix O**.

10.4 Project Setting

10.4.1 Climate, Surface Water Catchments, Topography and Land Use

The 'physical setting' for the Project, as relevant to the groundwater assessment is described in the following chapters of the EIS:

- Climate is described in **Chapter 6**.
- Topography and land use is described in **Chapter 7**.
- Watercourses, drainages and catchments are described in **Chapter 8**.

Supplementary information on the physical setting for the Project is provided in Section 3 of **Appendix K**.

10.4.2 Resource Operations and Projects

Table 10-6 provides a summary of the various resource operations and proposed projects located within the Project's region. These operations and projects form the basis for the regional numerical groundwater

[6] Fomer Department of Science, Information Technology and Innovation

model which has been used to assess the Project's impacts and cumulative impacts. Additional information on these resource operations and proposed projects is provided in Section 3.3 of **Appendix K**.

Table 10-6 Existing and Proposed Resource Operations and Projects in Project Region

Operation	Status	Type	Planned Start	Planned End	Distance from Project[1]	Target Coal Resource
IDM	Operating	Open-cut	2021	2028	1 km north	Rangal Coal Measures
IPM	Operating	Open-cut	2006	2026	10 km north	Rangal Coal Measures
Moranbah South	Proposed (on hold)	Underground – Longwall and Bord and Pillar	2045	2088	Adjacent west	Moranbah Coal Measures
Moranbah North	Operating	Underground - Longwall	1998	2033	35 km northwest	Rangal Coal Measures
Winchester South	Proposed (approved)	Open-cut	2026	2051	10 km southeast	Rangal Coal Measures, Fort Cooper Coal Measures
PTM	Operating	Open-cut	2006	2032	7 km northeast	Rangal Coal Measures
Eagle Downs	Care and Maintenance	Underground - Longwall	2029	2064	3 km south	Moranbah Coal Measures
Millennium	Operating	Open-cut	2005	2027	11 km northeast	Rangal Coal Measures
Daunia	Operating	Open-cut	2011	2034	13 km east	Rangal Coal Measures
Moorvale South	Operating	Open-cut	2021	2031	18 km southeast	Rangal Coal Measures, Fort Cooper Coal Measures
Moorvale	Operating	Open-cut	2023	2033	23 km northeast	Rangal Coal Measures
Olive Downs	Operating	Open-cut	2023	2099	21 km southeast	Rangal Coal Measures
Caval Ridge	Operating	Open-cut	2014	2037	13 km west	Moranbah Coal Measures
Peak Downs	Operating	Open-cut and underground	1972	2119	17 km southwest	Moranbah Coal Measures

Operation	Status	Type	Planned Start	Planned End	Distance from Project[1]	Target Coal Resource
Lake Vermont	Operating	Open-cut (with approved underground extension)	2008	2045	47 km SW	Rangal Coal Measures
Meadowbrook	Approved / Proposed	Open-cut and underground	2026	2050-2055	35 km SW	Rangal Coal Measures
Moranbah Gas Project	Petroleum lease (PL) 196	Coal Seam Gas	NA	NA	11 km northwest	Rangal Coal Measures, Moranbah Coal Measures
	PL 191		NA	NA	23 km northwest	
	PL 223		NA	NA	17 km northeast	
	PL 224		NA	NA	16 km northwest	
Bowen Gas Project	Exploration & Appraisal (ATP 1103)	Coal Seam Gas	2030	2060	Large exploration area with small overlap with Project Area	Rangal Coal Measures, Moranbah Coal Measures
	Production (PL 486)		NA	NA	45 km northwest	
1 Distances measured from approximate centre of mining lease or petroleum lease						

10.4.3 Geology

10.4.3.1 Overview

The regional and local geology of the Project area and surrounds is described in Section 7.3.11 of **Chapter 7**. This is supplemented by information in Section 4 of **Appendix K**, summarised below, used to inform the understanding of the hydrogeology of the Project area and surrounds.

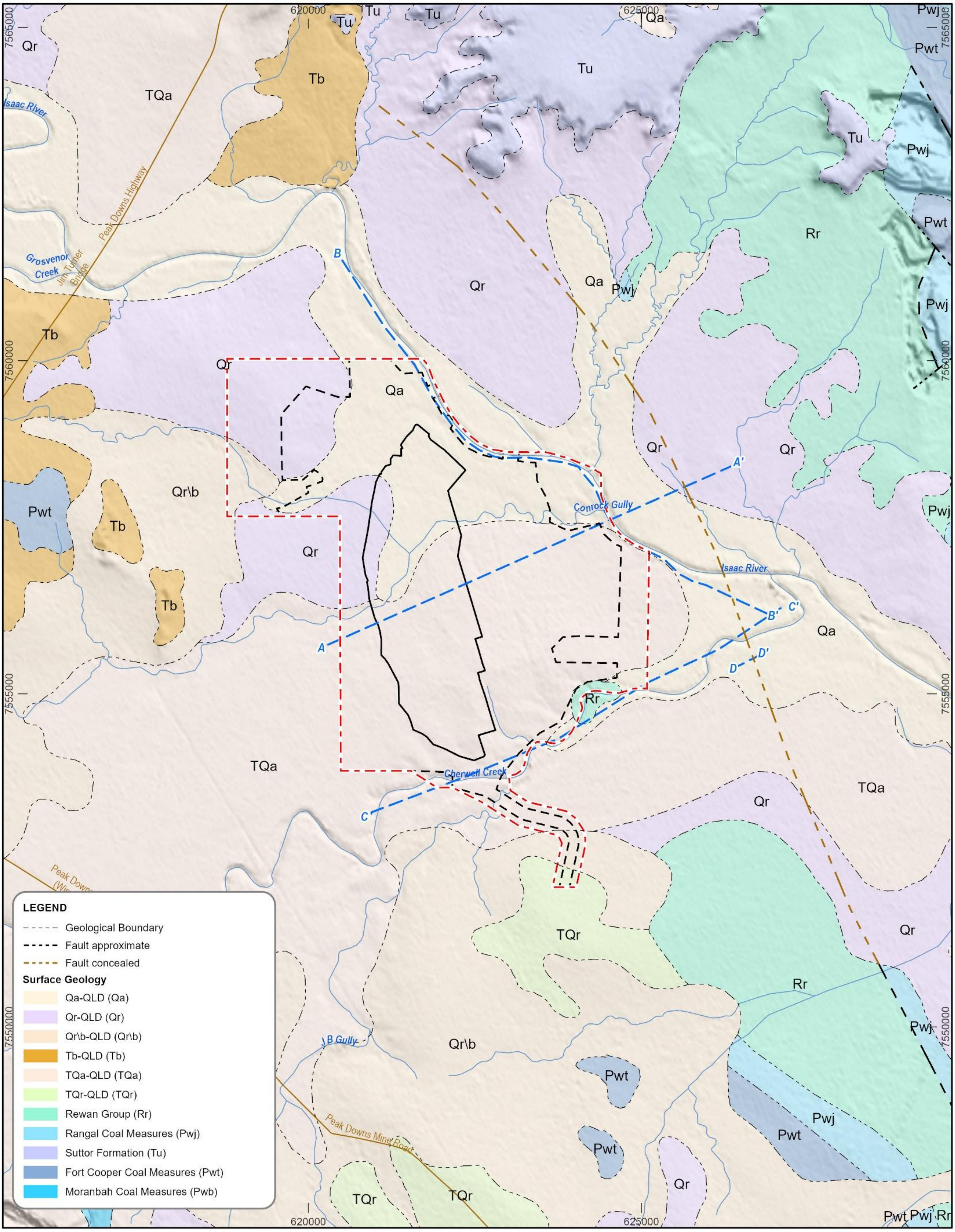
Local surface geology in the vicinity of the Project, with cover sequence extents, is shown in Figure 10-2. The local geology of the Project area is well defined through both resource exploration and groundwater drilling, with over 500 individual drillholes at and near to the Project area. Furthermore, Stanmore's extensive resource exploration and groundwater drilling at the adjoining IDM enhances the understanding of the local geology. Additional methods, including downhole geophysical surveys and ERI, have further refined the geological model of the region.

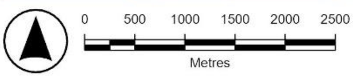
The stratigraphic profile within the Project Area and surrounds comprises three distinct units:

- Cenozoic sediments:
    - Quaternary alluvium and colluvium.
    - Tertiary Alluvium, colluvium, and Regolith that includes weathered Permian strata, and weathered Tertiary basalt in places.
- Triassic Rewan Group Strata.
- Permian Strata:
    - Rangal Coal Measures.

- Fort Coper Coal Measures (at depth).
- Moranbah Coal Measures (at depth).

A geological cross-section is provided in Figure 10-3 (section A-A’ on Figure 10-2). This illustrates the overall stratigraphy and structural geology framework of the Project area and surrounds, depicting the spatial relationships between the main geological units.





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LEGEND
- Waterway
- Roads
- IDE Project MLAs
- Proposed Project Disturbance Area
- Project Pit Extent
- Hydrogeological/Geological Cross Section Line

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Project Surface Geology

Figure | 10-2

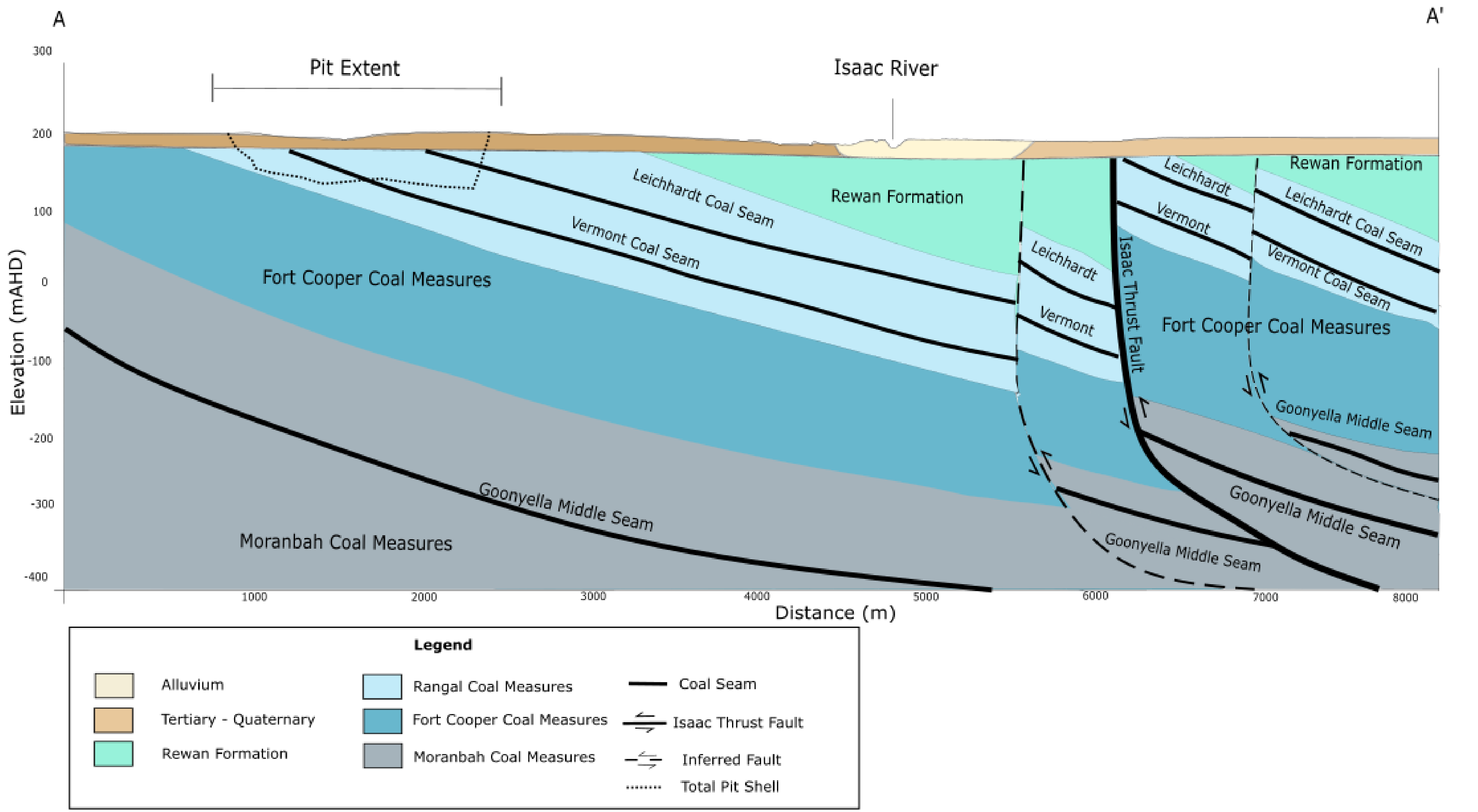


Figure 10-3 Conceptual Geological Cross Section across the Project Area and Pit

10.4.3.2 Cenozoic Sediments

Cenozoic aged (Tertiary to Quaternary) sediments within and surrounding the Project area include recent alluvium associated with the Isaac River, Cherwell Creek and other tributaries, overlying weathering derived colluvium and undifferentiated Tertiary sediments which are collectively termed Regolith in many recent studies and this groundwater assessment.

10.4.3.3 Quaternary Alluvium

Surface geology mapping (Figure 10-2) identifies Quaternary alluvium (Qa) primarily along the Isaac River, which intersects the eastern portion of the Project area. Tributaries such as Cherwell Creek, Conrock Gully, and other smaller unnamed creeks also contain mapped alluvium.

Quaternary alluvium, hereafter referred to as alluvium, in the region is generally described as a geological unit of unconsolidated sequences of clay, silt, sand, and gravel, typically less than 20 m thick (AGE, 2020). Previous studies (e.g. AGE, 2020) report that the thickest accumulations occur adjacent to the Isaac River, with locally deeper sections associated with paleochannel systems incised into bedrock (i.e. former river channels). Away from the main channel, the deposits are dominated by clay and silt derived from floodplain environments.

A series of recent geological and hydrogeological investigations at and near to the Project area have improved the characterisation and determination of the thickness of the alluvium local to the Project area. This includes data from exploration drilling, groundwater bore drilling, geophysical surveys (ERI) and groundwater investigations.

Data from these sources has been used to develop conceptual cross sections, demonstrating the shallow geological conditions along the Isaac River (Figure 10-4) and Cherwell Creek (Figure 10-5) in the vicinity of the Project (cross section locations shown on Figure 10-2).

Drill logs across the Project Area reveal that the alluvial sequences are composed of interbedded layers of clay, silt, sand, and gravel, reflecting fluvial depositional processes. Coarse sands and gravels are present near active surface drainage channels, particularly adjacent to the Isaac River, where alluvium thicknesses of 15 to 20 m have been recorded. These deposits thin progressively toward floodplain margins, where finer grained sediments such as clay and silt become more prevalent. This compositional variability is consistent with regional investigations.

Interpretation of ERI geophysical survey data, in conjunction with drillhole data, has refined the mapped extent of alluvium within and adjacent the Project area, as shown in Figure 10-6, noting that this is similar to the alluvium mapped in Figure 10-2. Alluvium extent along Cherwell Creek is more closely associated with the modern channel compared to the broader Isaac River floodplain. Near the confluence with the Isaac River, saturated alluvial sediments up to 14 m thick have been recorded. Alluvial deposits also extend along Conrock Gully within the Project area, although they are thinner (generally <10 m) than those along the Isaac River.

Several paleochannels filled with gravel and coarse sediments have been identified, up to 15 m thick. Paleochannels were identified from drillhole data and explain localised variations in alluvium thickness. ERI data confirms their presence and distribution.

The investigations and data supported a re-assessment of alluvium extent and thickness local to the Project, as shown in Figure 10-6. Where field specific data on alluvium thickness is not available (e.g. areas outside the Project area, upstream of Isaac River and Cherwell Creek), alluvium thickness is based on publicly available mapped geology and data from surrounding mines and has been iteratively interpolated for model layering using data from these mines.

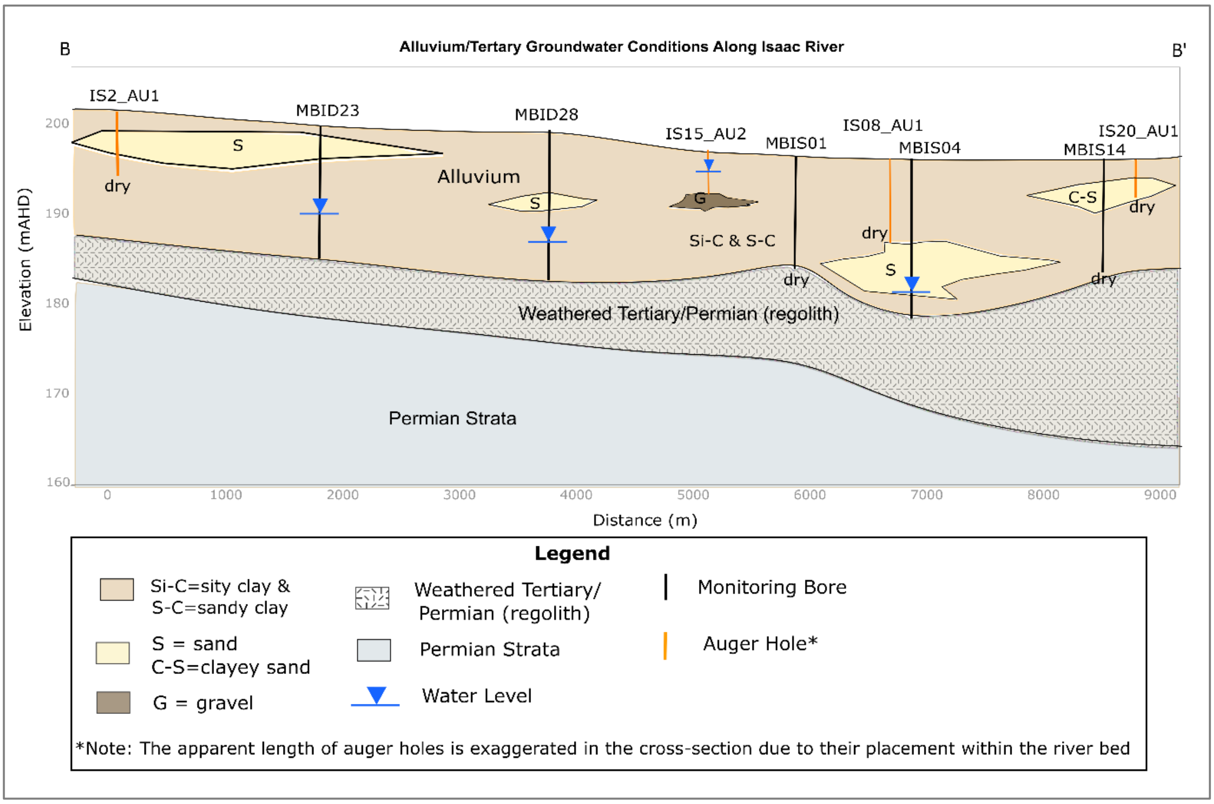


Figure 10-4 Cross Section of the Alluvium along the Isaac River

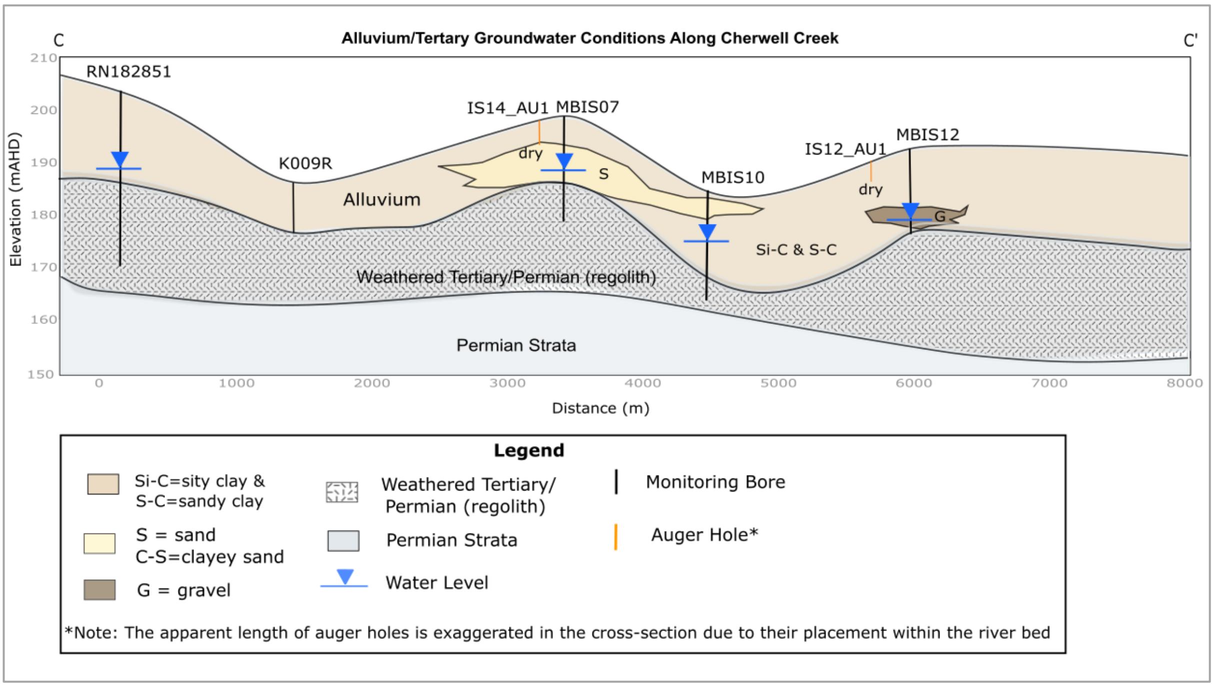


Figure 10-5 Cross Section of the Alluvium along Cherwell Creek

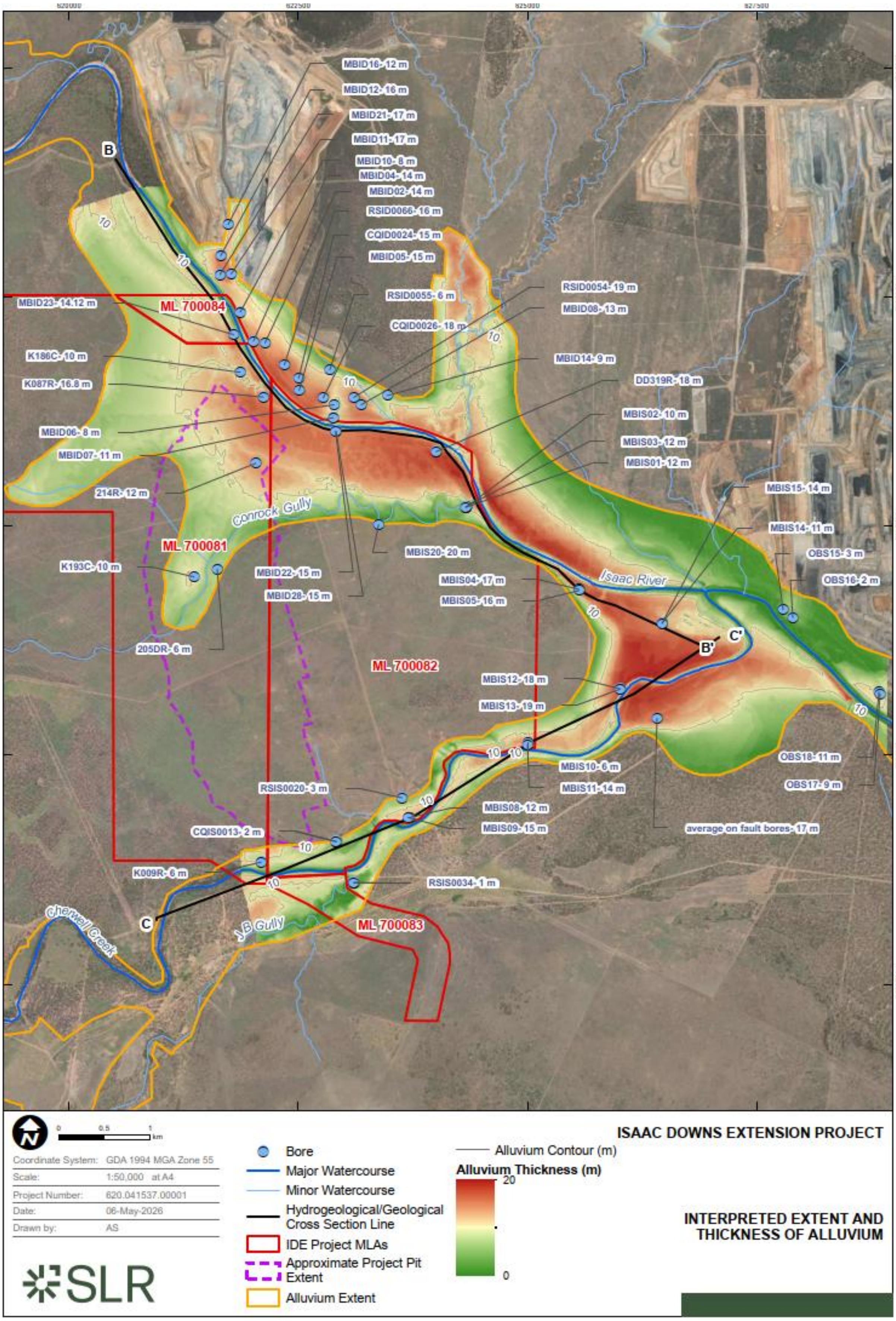


Figure 10-6 Interpreted Extent and Thickness of Alluvium

10.4.3.4 Regolith

The surface geology across the broader study area (approximately 15 km surrounding the Project area), outside of the extent of Quaternary alluvium, is dominated by Cenozoic-aged sediments (Quaternary to Tertiary) comprising a mix of colluvium and semi-consolidated, undifferentiated materials. These materials have been collectively referred to as 'regolith' in the Project's groundwater assessment and other previous investigations, given they function in a hydrogeological sense as one interconnected unit. The regolith also includes older alluvial deposits (mapped as TQa in Figure 10-2), which are widespread throughout the study area.

The regolith is lithologically heterogeneous, consisting of varying proportions of fine- to coarse-grained sand, clay, claystone and highly weathered siltstone and sandstone.

Drilling data from groundwater monitoring and exploration boreholes at and adjacent the Project area indicate that unconsolidated to semi-consolidated Tertiary sediments underlie the Quaternary alluvium to depths of approximately 20 m. These Tertiary units are predominantly composed of low strength, weathered siltstone and fine-grained sandstone. In areas dominated by colluvial processes away from drainage lines, such as at bore MBIS17 to the southeast of Cherwell Creek, the regolith includes clay, clayey sand, and mudstone.

Regionally, Tertiary basalt is also known to occur within paleovalleys incised into the underlying Permian–Triassic bedrock. However, basalt is absent from the Project area. The nearest confirmed occurrence is approximately 4 km to the west of the Project area, where it was intercepted during drilling of Moranbah South project groundwater monitoring bores MB06, MB07, and MB09C.

10.4.3.5 Triassic Rewan Group

The consolidated Triassic sedimentary strata include the Rewan Group, which dips to the east and unconformably overlies the Permian coal measures, outcropping in the east of the Project area. The Rewan Group regionally comprises Late Permian to Early Triassic strata with pebbly lithic sandstone, green to reddish brown mudstone and minor volcano lithic pebble conglomerates.

The Rewan Group is extensive over the eastern and northern parts of the Project area, outcropping and sub-cropping in a number of places. Where intersected within the Project area, the unit is generally comprised of a well consolidated pink-brown sandstone.

10.4.3.6 Permian Coal Measures (Blackwater Group)

Permian coal-bearing sedimentary rocks of the Blackwater Group form the main economic resource of the numerous mines in the study area. In increasing depth order, the major coal measures within the study area include the:

- Rangal Coal Measures (RCM).
- Fort Cooper Coal Measures (FCCM).
- Moranbah Coal Measures (MCM).

The RCM are approximately 100 m thick and dip 2 to 6 degrees to the east-northeast in the Project area. It marks the youngest of the Blackwater Group coal measures, and overlies the FCCM. The transition between the RCM and FCCM is marked by the Yarrabee Tuff, which lies between the Vermont Upper Seam and Vermont Lower Seam.

The RCM comprise light grey, cross-bedded, fine to medium grained labile and well cemented sandstones, grey siltstones, mudstones, shale and coal seams. The Leichhardt and Vermont Seams occur within the RCM and are the target for mining at the Project. The RCM are mined at nearby mines to the east and south.

The FCCM conformably underlie the RCM regionally and at the Project. Regionally, the formation has a maximum thickness of approximately 350 m and drill logs indicate the FCCM comprise lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff and tuffaceous (cherty) mudstone.

The MCM conformably underlie the FCCM. The MCM underlies the Project area, at significant depth. The unit has little direct relevance to the Project's groundwater assessment. The Goonyella Middle Seam of the MCM is the target for mining at the Moranbah South project, and the MCM is also mined at Caval Ridge, Peak Downs and Saraji mines to the west and southwest.

10.4.3.7 Structural Geology

The main regional scale fault in the vicinity of the Project is the north-northwest trending reverse Isaac Thrust Fault, which forms a wide zone of heavily fractured 'fault complex' and associated secondary northwest trending fault splays, with throws of up to 100 m. The Isaac Thrust Fault is mapped to the east of the Project area, as shown on Figure 10-2 and Figure 10-3.

Field programs to delineate to delineate and characterise the Isaac Thrust Fault (including to improve the understanding of its hydrogeological properties) are described in Section 10.3.1.5 and Section 4.2.5 of **Appendix K**. The field program provided key subsurface geological data, enabling identification of the fault's location, depth, and structural characteristics.

Faulting was evident across all five exploratory drillholes, likely due to the presence of a shallow dip angle to the fault structure (typical of reverse thrust faults) combined with a broad zone of deformation and secondary faulting associated with the main fault structure. Detailed analysis of lithology and geophysical data identified significant faulted zones/structures in three drillholes RFIS0060, RFIS0062, and RFIS0064. NMR logging at these holes provided high-resolution vertical profiles of inferred porosity and hydraulic conductivity, enabling identification of permeability contrasts across the fault zone and the relatively undisturbed RCM strata above and below the fault zone. As a result, monitoring bore MBIS19 was installed at this location, with the screen interval designed to target the most permeable zone within the fault structure as identified in the NMR data. Section 10.5.3 provides discussions of the resulting groundwater information from this bore.

Analysis of lithological data and downhole geophysical logging informed delineation of the fault core and supported a localised characterisation of the Isaac Thrust Fault. Based on the vertical displacement of coal seams and the horizontal distance between drillholes, a dip angle of approximately 5 degrees was calculated. This is consistent with regional fault geometry and confirms a southwest-directed fault throw of approximately 100 m.

10.5 Environmental Values – Hydrogeology

10.5.1 Overview

Based on the understanding of the geological setting, the hydrogeological regime of the Project area comprises the following key hydrogeological units:

- Cenozoic sediments:
  - Quaternary alluvium (i.e. alluvium) – forms the unconfined alluvial aquifer (sporadically water-bearing strata of permeable unconsolidated sand or gravel with interlayered clays and silts) localised to major ephemeral drainage lines (Isaac River and Cherwell Creek) in the Project area and in the study area.
  - Perched groundwater systems are likely to occur within the alluvium. These are discrete groundwater units sitting above the alluvial aquifer / water table, and are separated by an unsaturated zone. Downward percolation of groundwater in these perched systems is restricted by a material of localised low permeability such as a clay lens.

  - Quaternary to Tertiary non-alluvial sediments and weathered units (collectively termed ‘regolith’) – unconfined unit with variable but limited saturation and generally present at the surface within the Project area.
- Triassic Rewan Group – considered a regional scale aquitard. However, some saturated, more hydraulically conductive horizons exist within, particularly within the upper weathered zone. The Rewan Group subcrops on the eastern side of the Project area.
- Permian coal measures with:
  - low permeability interburden and overburden units with aquitard properties.
  - coal seams that exhibit water bearing properties associated with secondary porosity through cracks and fissures.

The following terminology is used in this chapter and the groundwater assessment (**Appendix K**) to distinguish between the alluvial aquifer in the alluvium and the perched groundwater systems in the alluvium:

- Bore data and numerical modelling relate to groundwater conditions within the alluvial aquifer.
- ‘Perched groundwater systems’ are referenced in the context of GDEs.
- None of the groundwater monitoring bores intersect perched systems. Therefore, all monitoring and modelling results relate solely to the alluvial aquifer.
- Perched groundwater systems associated with GDEs are described in Section 10.6.3.
- When referring to water in the alluvium, this relates to water in the alluvial aquifer, unless specifically describing the perched groundwater systems.

The coal seams within the Permian RCM are the main aquifer units in the Project area. The coal seams can be characterised as confined aquifers, with the Leichhardt and Vermont coal seams forming the main aquifer units locally. The RCM overburden and interburden act as aquitards and are typically dry, or very low yielding.

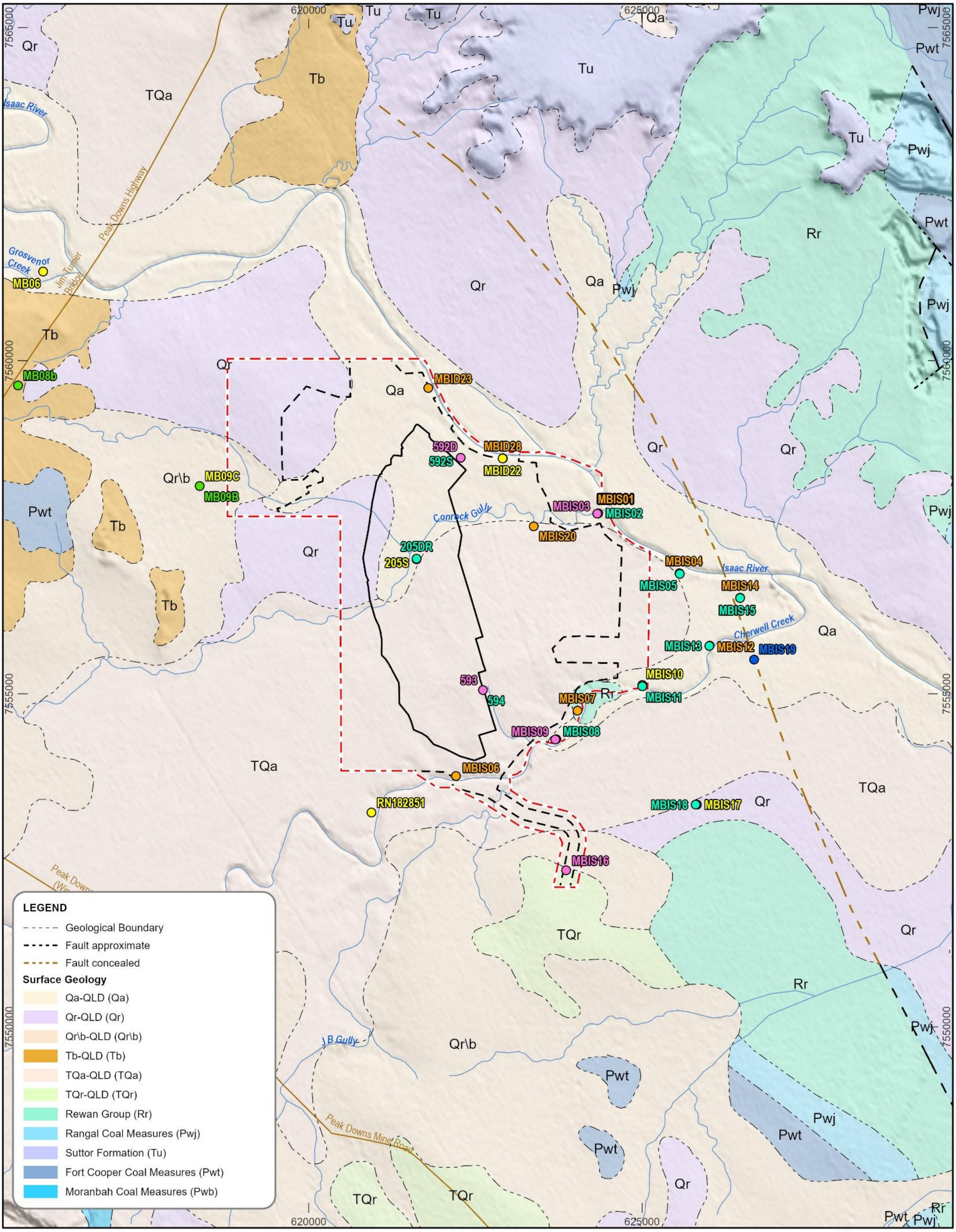
As the Project is located immediately south of IDM, along geological strike, the hydrogeology is very similar between IDM and the Project. AGE (2020) discussed the hydrogeology of IDM, and information presented therein has informed the understanding of the Project’s hydrogeology.

10.5.2 Groundwater Monitoring

10.5.2.1 Project Monitoring Network

The Project’s groundwater bore monitoring network, developed from the field programs described in Section 10.3.1 is shown in Figure 10-7. This is a comprehensive monitoring network representative of all potential aquifers. Information on each monitoring bore including depth, groundwater unit being monitored and periods over which monitoring of water quality and levels has occurred, is presented in Table 5-1 of **Appendix K**. There are 34 bores in the Project’s groundwater monitoring network:

- Nine bores targeting Quaternary alluvium (associated with either Isaac River, Cherwell Creek or Conrock Gully).
- Seven bores targeting the Regolith (colluvium, Tertiary basalts, Tertiary sediments, weathered Rewan Group and shallow highly weathered RCM overburden).
- 10 bores targeting the Leichhardt coal seam of the RCM.
- Five bores targeting the Vermont coal seam of the RCM.
- One bore targeting the core of the Isaac Thrust Fault within the RCM.
- Two bores targeting the FCCM.



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LEGEND

- Waterway
- Roads
- IDE Project MLAs
- Proposed Project Disturbance Area
- Project Pit Extent

Groundwater Monitoring Network

- Alluvium
- Regolith
- Leichhardt coal seam
- Vermont coal seam
- Fort Cooper Coal Measures
- Isaac Thrust Fault core (RCM)

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Groundwater Monitoring Network

Figure | 10-7

10.5.2.2 Other Monitoring Networks

IDM is located immediately adjacent (northwest) and along geological strike from the Project. As a result, 18 groundwater monitoring bores from IDM have been incorporated into the groundwater assessment as relevant to characterisation of the baseline setting at the Project, particularly for bores around the southern and southeastern boundary of IDM, adjoining the Project area:

- 11 bores targeting the Alluvium associated with the Isaac River.
- Three bores targeting weathered Rewan Group.
- Two bores targeting the Leichhardt Seam of the RCM.
- One bore targeting the Vermont Seam of the RCM.
- One bore screened across both the Leichhardt and Vermont seams of the RCM.

PTM is also located to the east of to the Project (northeast). Groundwater monitoring bores from PTM have been incorporated into the groundwater assessment as relevant to characterisation of the baseline setting at the Project, particularly for the eight bores around the east and southeastern boundary of PTM:

- One bore targeting the Alluvium associated with the Isaac River.
- One bore targeting both the Alluvium associated with the Isaac River and weathered Tertiary sediments (Regolith).
- Two bores targeting weathered Tertiary sediments (Regolith).
- Two bores targeting the Leichhardt Seam of the RCM.
- One bore targeting the Vermont Seam of the RCM
- One bore screened in the interburden of the RCM.

Stanmore has also entered into groundwater data sharing agreements with the owners of several neighbouring projects and mines. These agreements facilitate the exchange of groundwater data, models, and supporting documentation. Where applicable, relevant data from each participating project or mine's groundwater assessment has been integrated into the groundwater assessment.

These bores are shown in Figure 5-2 of **Appendix K**, with bore details provided in Table 5-2 of **Appendix K**.

The combination of Project monitoring bores and other monitoring bores provides a comprehensive network of over 60 bores from which information has been obtained to inform the groundwater assessment.

10.5.3 Hydraulic Properties

Section 5.3 of **Appendix K** provides detailed information on the hydraulic properties of the hydrogeological units in the Project area, which is summarised below.

10.5.3.1 Site Specific Hydraulic Conductivity Data

Groundwater hydraulic testing results are available from slug (rising and falling head) tests conducted on the Project's monitoring network bores (see Appendix F of **Appendix K**). A summary of the results are provided in Table 10-7.

Hydraulic conductivity values for the alluvium range from 0.33 to 9.68 m/day, with an average of 1.19 m/day, indicating significant variability between bores. This variability is attributed to the heterogeneous nature of floodplain deposits along the Isaac River, where differing grain sizes influence permeability.

Hydraulic conductivity values for the regolith hydrogeological unit range between 0.15 and 2.51 m/day. These bores, with screen depths less than 30 m, target highly weathered material. The mean hydraulic conductivity recorded was 0.71 m/day. This weathered transition zone in the Permian strata is expected to exhibit greater permeability and storage capacity than the underlying fresh Permian rock (RCM) due to the opening of joints and bedding planes through weathering.

The coal seams within the RCM generally exhibit higher hydraulic conductivities than the surrounding non-coal strata and are considered the primary groundwater-bearing zones within the RCM.

Bore MBIS19, installed into the Isaac Thrust Fault zone, yielded hydraulic conductivity estimates generally two orders of magnitude lower than the RCM coal seams (10^{-3} m/day). Noting that MBIS19 was installed in to the most permeable part of the fault zone inferred from NRM data, which indicates that the fault structure does not provide for a preferential groundwater flow pathway with respect to groundwater flow in the RCM.

Table 10-7 Summary of Mean Hydraulic Conductivity per Hydrogeologic Unit - Site Testing

Target Formation	Number of Bores	Number Slug tests Analysed	Minimum Hydraulic Conductivity (m/day)	Maximum Hydraulic Conductivity (m/day)	Median Hydraulic Conductivity (m/day)	Geometric Mean Hydraulic Conductivity (m/day)
Alluvium	5	48	0.33	9.68	1.33	1.19
Regolith	4	49	0.15	2.51	1.00	0.71
Leichhardt Coal Seam	10	74	0.001	30.31	0.25	0.33
Vermont Coal Seam	5	32	0.03	5.90	0.45	0.37
FCCM	2	16	0.04	0.11	0.07	0.07
Isaac Thrust Fault	1	12	0.002	0.006	0.003	0.003

10.5.3.2 Regional Hydraulic Conductivity Ranges

A significant record of aquifer hydraulic testing information is available from adjacent and nearby mines and project sites for the same hydrogeologic units that are found at the Project. Given the similar geologies, these data are considered representative of the hydraulic properties of the units at the Project.

A histogram of the spread of horizontal hydraulic conductivity from the field testing at the nearby mines and projects is presented in Figure 5-4 of **Appendix K**. The results are compared to the range of documented values for the various units in literature. The comparison shows that the field results for the hydrogeologic units within the Project area and immediate surrounds fall within the range of field data collected through other studies across the Bowen Basin. The results of the site specific testing generally fall within the range of regional and literature values for each unit, indicating the site specific dataset aligns with the regional dataset.

10.5.3.3 Faulting

A number of studies, as described in Section 5.3 of **Appendix K**, have been undertaken in the Bowen Basin to understand faulting. Faulting has been inactive within the Bowen Basin for over 140 million years, indicating that the fault zones are less likely to act as conduits to flow. Fault cores typically exhibit hydraulic conductivities one to three orders of magnitude lower than the surrounding host rock. Drill core logs from the study area and surrounding mines indicate that many fractures and faults are 'healed' with calcite and siderite, reducing the effective permeability compared to open fracture networks. Faults act as a horizontal permeability barrier to water and gas flow, with compartmentalisation evident due to the structural geology (faulting) in the Bowen Basin.

In the Project area, vertical displacement of coal seams (typically thin <4 m) often results in juxtaposition against lower permeability interburden or Rewan Group strata, creating local scale compartmentalisation. The Isaac Thrust Fault, which throws eastward by up to 100 m, contributes significantly to this compartmentalisation in a regional sense. Fault displacement and remineralisation together create hydraulic barriers that disrupt lateral groundwater flow along lithological bedding planes.

This conceptual understanding is supported by the site-specific hydraulic testing at the Project where slug test data from monitoring bore MBIS19 (which targets the Isaac Thrust Fault) recorded hydraulic conductivity values of 10^{-3} m/day, two orders of magnitude lower than the average values observed in the Leichhardt and Vermont coal seams at the Project. These results reinforce the interpretation that fault structures in the Bowen Basin, particularly the Isaac Thrust Fault, act as hydraulic barriers consistent with regional literature and observed field data.

10.5.4 Groundwater Recharge

10.5.4.1 Overview

The dominant mechanism for recharge to the groundwater system in the vicinity of the Project is via diffuse infiltration of rainfall through the soil profile and subsequent deep drainage to the underlying groundwater table. Short term sporadic recharge events to the underlying alluvium may also result from seepage of streamflow in the Isaac River and Cherwell Creek.

Section 5.4 of **Appendix K** provides detailed information on groundwater recharge, which is summarised below.

10.5.4.2 Deep Drainage

Deep drainage is defined as the downward movement of water from the soil profile beyond the root zone into the saturated groundwater system. This process occurs when infiltrated rainfall exceeds the soil water-holding capacity and is not removed through evapotranspiration or root uptake.

The Australian Water Resources Assessment Landscape model (AWRA-L), developed by the Frost, A. J., and Shokri, A. (2021) simulates the historical and projected landscape water balance for Australia and outputs estimates of surface runoff, soil moisture, evapotranspiration and deep drainage.

For the Project's groundwater assessment, monthly AWRA-L deep drainage outputs from 1985 to the end of 2025 were obtained from the Bureau of Meteorology and used as a proxy for groundwater recharge for the Project area. The AWRA-L data is not specific to a particular hydrogeologic unit. These outputs were compared against observed monthly rainfall data from the SILO database[7] for the same location.

To assess the temporal relationship between rainfall and modelled recharge from AWRA-L, a lag analysis was performed. The analysis showed that the strongest correlation between rainfall variability and deep drainage occurred when a four-month lag was applied to the deep drainage data. This pattern indicates a notable time delay between rainfall events and the eventual movement of infiltrated water to the groundwater table, which ultimately contributes to groundwater recharge.

Annual deep drainage shows a link relative to annual rainfall, with deep drainage as a percentage of rainfall ranging from less than 2% in dry years to over 12% in wetter years. That is, it is evident that the amount of rainfall that is simulated by AWRA-L to end up as deep drainage is variable (rather than a fixed percentage), and increases proportionally with increases in total annual rainfall. A long-term annual average deep drainage is calculated at 5.4% of average annual rainfall for the period 1998 to 2025.

[7] SILO is climate database facility operated by DETSI, based on data derived from the BoM.

10.5.4.3 Chloride Mass Balance

Recharge rates have been estimated using chloride mass balance (CMB) calculations. The CMB method estimates long-term mean recharge rates based on mean annual rainfall, atmospheric chloride accession, and chloride concentration in the groundwater, with the assumption of no other sources or sinks for the deposited chloride.

The CMB calculations are based on available groundwater quality results (chloride concentrations) collected from the monitoring bores in the Project monitoring network up until December 2025.

The results of the CMB analysis demonstrate calculated recharge rates generally range from 0.02 % to 4.96 % of long-term average annual rainfall, with highest recharge rates in the Isaac River alluvium and lowest recharge rates for the Leichhardt and Vermont coal seam. There is significant variability in calculated recharge rates within the alluvium, which reflects the heterogeneous nature of the alluvial sequence.

The long term average simulated deep drainage is higher than the long term average recharge rates calculated using the CMB. This is likely attributed to the scale of the data, as deep drainage is not aquifer specific and is simulated on a broad grid spacing, whereas the CMB calculation is local aquifer (and bore) specific.

10.5.5 Groundwater Distribution, Flow, Recharge and Discharge

Section 5.5 of **Appendix K** provides detailed information on groundwater distribution, flow, recharge and discharge, and is summarised below for each groundwater unit.

10.5.5.1 Alluvium

Saturation within the alluvial sediments across the study area is highly variable, suggesting that the alluvium does not form a continuous, high-yielding groundwater-bearing unit away from the immediate vicinity of the Isaac River and Cherwell Creek. Groundwater monitoring and ERI data indicate that significant saturation occurs primarily near the modern drainage channels of the Isaac River, Cherwell Creek, and at their confluence, where thicker and more permeable sediments are present. In contrast, areas further away from these channels often exhibit unsaturated or intermittently saturated conditions, reflecting the discontinuous nature of the aquifer system. This spatial variability suggests that the alluvium does not function as a single, laterally extensive groundwater-bearing unit across its mapped extent, but rather as a series of localised zones. Regionally, groundwater in the alluvium, where saturated, occurs between 10 - 12 metres below ground level (mBGL). The potential for alluvium to host groundwater is considered limited at depths shallower than this.

Within the Isaac River alluvium, bores MBIS01 (base screen 12 mBGL or 184.9), MBID03 (base screen 20 mBGL, 181.5 mAHD), MBID09 (base screen 8 mBGL, 187.8 mAHD), and MBID26 (base screen 8 mBGL, 184.4 mAHD) have all been dry since installation. MBID26, with a base of screen of 8 mBGL (184.4 mAHD) has been recorded as dry since January 2023. Other bores show a genermAHDal west to east decrease in groundwater level from approximately 192 mAHD to 183 mAHD, with some response to variation in rainfall.

In the Cherwell Creek alluvium, saturation is similarly sporadic. Project bore MBIS06 (base screen 10 mBGL, 175.5 mAHD) has remained dry since installation in November 2024, while MBIS07, monitored since May 2025, show groundwater levels between approximately 10 and 12.5 mBGL, respectively, with a subtle decline in groundwater levels of approximately 0.5 m since the start of monitoring coinciding with declining deep drainage. Groundwater level elevations decrease from southwest to northeast in the Cherwell Creek alluvium, in the direction of surface water flow.

MBIS14 (bottom of screen 12 mBGL or 184.7 mAHD), located at the confluence of Isaac River and Cherwell Creek, has been dry since installation in June 2025. This indicates that the State defined HES wetland at this location is not supported by groundwater hosted in the regional alluvium aquifer. Based on the GDE studies (see Section 10.6.3), the floor of the HES wetland is underlain by a roughly 2.5 m thick hardened clay sequence, which acts as an aquitard and contributes to perched surface water above that horizon during wetter periods.

At Conrock Gully, groundwater levels at MBID27 (May 2021 to January 2023) show limited fluctuations in response to deep drainage recharge events, with groundwater levels occurring around 12.5 mBGL (186 mAHD).

Hand-augering investigations for the GDE study, targeting the shallow alluvium along the Isaac River and Cherwell Creek, indicated that the majority of auger holes were dry (see Section 10.6.3). Only one hole, located within the Isaac River channel itself, intersected groundwater at a depth of 0.8 m below the current streambed. However, this is interpreted as a shallow perched groundwater system, derived from rainfall and surface water infiltration rather than the regional alluvial water table. The presence of an unsaturated zone beneath the streambed (besides limited perched groundwater systems) confirms that the river is a losing stream with no baseflow interaction at this location, and that the alluvial aquifer is hydraulically disconnected from the riverbed.

Figure 5-13 of **Appendix K** illustrates the interpreted alluvial potentiometric surface for the end of 2025. Groundwater flow within the Isaac River alluvium is directed to the southeast, consistent with the surface water flow. Groundwater elevations along Cherwell Creek exhibit a similar pattern, reflecting both surface water flow and local topography.

Recharge to the alluvium is considered to be mostly by infiltration from short lived stream flow or flooding (losing streams as demonstrated in Section 10.5.5.4), with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow subsurface.

The calculated CMB recharge estimates as a percentage of long term average annual rainfall ranged from 0.02% to 4.69% for the Isaac River alluvium. For the Cherwell Creek alluvium, three samples from two bores were analysed, showing recharge estimates between 0.33% and 0.89% of long term average annual rainfall.

Geological logs in in the alluvial sediments indicate the alluvium is underlain by low hydraulic conductivity strata, including claystones, siltstones (with only pockets of coarser grained sand). These layers restrict the rate of downward leakage to underlying formations and contribute to the overall low recharge percentage. Slight differences in recharge between the Cherwell Creek and Isaac River alluvium are primarily influenced by variations in river size, sediment characteristics, and hydrological connectivity. The Isaac River alluvium occurs as a larger river system with drill logs indicating larger floodplains and coarser sediments, which promote higher infiltration and more variable recharge rates. In contrast, Cherwell Creek is a smaller tributary with finer-grained sediments limiting infiltration from surface and lower recharge estimates.

Following significant rainfall and flood alluvial groundwater levels may rise, causing temporary discharge from the perched groundwater system as interflow contributions back into the Isaac River. The alluvial groundwater system has not been recorded to rise above stream bed elevations over the monitoring period. Groundwater discharge from the alluvium at the Project also occurs through the use of privately-owned bores within the region.

Some limited local-scale discharge from the alluvium to active mine pits may occur in the study area, where saturated alluvium is intersected by mining pits.

Localised perched groundwater systems within the alluvium (i.e. above and disconnected from the alluvial aquifer considered to form the alluvial aquifer) are evident where surface waterbodies continue to hold water at times during dry periods (e.g. pools in the Isaac River and floodplain wetlands occur where clay layers slow the percolation of surface water (see Section 10.6.3)).

10.5.5.2 Regolith

Across the Project area, the colluvial material, Tertiary sediments, weathered Triassic strata and weathered Permian strata (< 30 m deep), collectively referred to as the Regolith, generally form the water table aquifer where saturated overlying alluvium is not present. Groundwater within the Regolith (where it is present) typically occurs at depths between 9 to 14 mBGL within the clayey sand and weathered horizons of Tertiary and Permian-aged sediments.

Bores MBID22, MBID06A, MBID07, MBID25A target the weathered Rewan Group strata. Groundwater levels in MBIS22 fluctuate by approximately 10 m in the monitoring record, likely in response to pumping for livestock water supply from a nearby landholder bore located about 5 m away. Similarly, bore MBID07, situated just northeast of MBIS22, exhibits comparable fluctuations, which are also attributed to landholder pumping activities. In contrast, historical data from MBID25 show relatively stable water levels around 183 mAHD, although a notable decline of 10 m was observed at the end of 2021.

Shallow bores within the upper weathered parts of the RCM are included with the Regolith. Recent monitoring at bores targeting the upper weathered RCM interburden shows groundwater levels ranging between 184 and 195 mAHD.

Groundwater flow within the Regolith, where it is saturated, is generally towards the south-southeast, following regional topographic gradients and the drainage direction of the Isaac River and Cherwell Creek.

The calculated CMB recharge estimates as a percentage of long term average annual rainfall ranged from a minimum of 0.03% to a maximum of 2.83%. Recharge to the Tertiary sediments and weathered strata (Regolith) is restricted by the presence of low hydraulic conductivity material (clays) which limit rainfall infiltration.

Regionally, groundwater discharge within the Regolith may occur primarily via evapotranspiration (which includes components of evaporation through the soil profile, and transpiration from terrestrial vegetation). However, transpiration from terrestrial vegetation appears unlikely in the Project area, as the GDE assessment did not identify any terrestrial groundwater-dependent ecosystems beyond the immediate vicinity of creek lines (see Section 10.6.3). There may be some limited local-scale discharge from the Regolith to active mine pits where saturated Regolith is intersected. Vertical seepage from the Regolith to deeper formations is expected to be limited by the underlying low hydraulic conductivity Rewan Group (where present) and other aquitards, such that the Regolith effectively forms a perched groundwater system above the Permian strata.

10.5.5.3 Permian Coal Measures

Groundwater within the Permian coal measures is confined and sub-artesian. Within the Leichhardt coal seam, groundwater levels generally range from approximately 179 to 191 mAHD (approximately 11 to 23 BGL) across the Project area and surrounds. Most bores with long-term (pre-2022) monitoring data show relatively stable groundwater levels, with gradual declines of up to 2 to 3 m over the monitoring period, likely reflecting the influence of nearby mining activities at IDM. More recent data from newly installed bores at the Project, further east-southeast from IDM, indicate subtle short-term fluctuations of 1–2 m, which appear to correspond with rainfall events.

Groundwater levels from bores targeting the Vermont coal seam indicate groundwater levels are between 186 and 189 mAHD (12 to 25 mBGL) and are generally stable over the monitoring record, with only minor fluctuations in response to rainfall. An exception is observed at MBIS16 in the south of the Project area, where groundwater levels are affected by an actively pumping landholder bore located approximately 10 m south of MBIS16, resulting in localised drawdown.

Historical data from Matrix+ Consultants (2008) give an insight to historical pre-mining groundwater levels recorded in 2006 within the IIPP area, which overlapped directly with the Project area. This historical data provides a comparison to more recent pre-mining groundwater levels. Bores 205S, 205DR, 592S and 592D record deeper groundwater levels in 2025 compared to those observed in 2006, with these declines likely attributed to the cumulative impacts of mining activities in and around the Project area. In contrast, bores 593 and 594 show shallower water levels in 2025 relative to 2006, which may possibly be attributed to historical landholder abstraction in the vicinity of these bores 593 and 594 which has now ceased.

The interpreted Permian coal measures potentiometric surface for the end-2025 shows that groundwater flow direction is consistent with regional topographic trends, with a localised inward gradient towards the active pits at IDM and PTM.

Recharge to the Permian coal measures occurs where the coal seams of the unit subcrop. Due to the low hydraulic conductivity of the interburden material, groundwater largely flows along the bedding plane of the coal seams. CMB recharge estimates for the Leichhardt coal seam were derived from 94 samples collected across 11 bores. The calculated recharge as a percentage of long term average annual rainfall ranged from 0.02% to 1.59%. For the combined Leichhardt and Vermont coal seams, 38 samples from a single bore were analysed, showing recharge estimates between 0.03% and 0.09% of long term average annual rainfall. Recharge estimates for the Vermont coal seam were based on 17 samples collected from five bores. The calculated recharge as a percentage of long term average annual rainfall ranged from 0.04% to 0.24%. For the Fort Cooper Coal Measures, eight samples from two bores were analysed, showing recharge estimates between 0.20% and 1.32% of long term average annual rainfall.

Recharge within the Permian formations is generally low because these units occur at significant depths and are overlain by thick interburden sequences composed of sandstone and siltstone, that have very low hydraulic conductivity, which restricts vertical water movement from the surface to the coal seams. The combination of depth and low-permeability barriers means that rainfall infiltration rarely reaches these formations, and recharge is limited to slow, localised processes such as leakage through fractures or faults. The limited correlation with deep drainage also supports this finding.

Groundwater discharge occurs predominantly via evaporation from pit faces in mining operations at neighbouring mines.

10.5.5.4 Vertical Connectivity and Hydraulic Gradient Between Aquifers

The Project's monitoring network includes several locations where two or more bores are installed at the same site, each screened in different aquifer units. These 'paired' bores enable direct comparison of groundwater levels between overlying and underlying aquifers, providing valuable insights into hydraulic connectivity and potential vertical flow gradients within the stacked aquifer system.

Figure 5-21 of **Appendix K** presents a series of graphs illustrating groundwater level trends observed in these paired bores across the Project area and surrounds. Overall, the data indicate that vertical hydraulic connectivity between the alluvium, Leichhardt coal seam, and Vermont coal seam is limited. This supports the conceptualisation of these aquifers as hydraulically distinct, with minimal potential for significant vertical groundwater movement under current conditions. Furthermore, groundwater levels within the alluvium and the Leichhardt and Vermont coal seams are below the stream bed elevations of the Isaac River and Cherwell Creek, indicating there is no potential for RCM groundwater discharge into these surface water features.

10.5.6 Groundwater Quality

10.5.6.1 Groundwater Types

Summary statistics for all monitoring bores, across the parameters assessed, are presented in Appendix A of **Appendix K**.

The proportions of major anions and cations were used to determine the hydrochemical facies of groundwaters sampled at the Project (as well as relevant groundwater sampled at IDM and PTM). The anion-cation balance, pH and electrical conductivity (EC) of historical data from all bores listed in Section 10.5.2 is displayed on the Durov diagrams in Figure 5-22 to Figure 5-25 of **Appendix K** for the alluvium, Regolith, Permian RCM and FCCM. Overall, groundwater quality shows a high degree of variability both between hydrostratigraphic units and among individual bores within the same unit.

Groundwater quality for majority of the monitoring bores screened within the alluvium indicates a sodium (Na) - chlorine (Cl) water type, with pH values ranging from weakly acidic to weakly alkaline. While some bores have a mixed water type with higher ratios of magnesium and bicarbonate. This chemistry is consistent with processes such as ion exchange on clays and the dissolution of saline or evaporitic material, which commonly influence groundwater in alluvial settings. In contrast, bores upstream along the Isaac River show a Na- magnesium (Mg) - calcium (Ca) water type and slightly lower EC, which reflects fresher groundwater with shorter residence times and stronger interaction with the surrounding sediments and rocks.

Monitoring bores within the Regolith include those installed into both Tertiary sediments/basalt, weathered Rewan Group and shallow weathered RCM overburden. The dominant water types are Na-Mg-Cl, with some Na-Mg- bicarbonate (HCO_3). Na-Mg waters usually form when silicate minerals like feldspars and pyroxenes break down, releasing sodium and magnesium into solution, which can occur as a result of weathering. The Na-HCO_3 water type points to ion exchange processes and carbonate inputs, with bicarbonate coming from both carbonate dissolution and carbon dioxide (CO_2) from soils.

In the shallow zones, some samples have higher salinity as EC, showing an evaporitic signature where salts are concentrating through evaporation. The pH is neutral to moderately alkaline, which is typical where carbonate reactions help buffer acidity.

Monitoring bores screened within the RCM mainly record Na-Cl type waters, with minor increases in carbonate (CO_3) and Mg. The dominance of Na-Cl waters likely reflects the influence of evaporite dissolution and long-term water–rock interaction in the coal-bearing formation. Salinity across the RCM varies widely, from brackish to highly saline, indicating compartmentalisation of the groundwater system. Groundwater pH also varies considerably, ranging from slightly acidic to strongly alkaline.

In the FCCM, monitoring bores consistently record strongly Na-Cl type waters, with minor contributions of HCO_3. The waters are generally slightly alkaline. The dominance of Na-Cl-HCO_3 suggests significant rock–water interaction and long residence times, allowing minerals to dissolve and release their ions into solution.

10.5.6.2 Salinity

Salinity is a key constraint to water management and groundwater use by receptors and can be described by total dissolved solid (TDS) concentrations. Figure 10-8 presents the TDS data associated with groundwaters screened in the various hydrostratigraphic units for Project monitoring bores.

The graph shows that available data for the alluvium indicates a large range in salinity, with TDS ranging from fresh to highly saline. Fresher salinities are considered indicative of relatively recent local recharge, whereas more saline areas of alluvium are considered indicative of relatively long groundwater residence times and significant evapo-concentration. These results indicate that groundwater in the alluvium is not well interconnected but rather somewhat isolated across the formation. It also indicates that some areas receive significant recharge from surface water whereas other areas experience a comparative lack of freshwater recharge, an increase in evapoconcentration, and longer groundwater residence times.

Groundwater from bores in the Regolith ranges from brackish to highly saline. Bores that screen the Leichhardt and Vermont coal seams of the RCM generally have higher salinities, recording groundwater ranging from brackish to highly saline. The FCCM have salinities in groundwater ranging from brackish to highly saline.

For the purposes of the void hydrogeochemical study (**Appendix M, Chapter 5**), a subset of the Project groundwater quality dataset was used to represent more localised conditions around the void as source terms for the modelling. This subset focuses on bores targeting non-coal interburden that will surround the spoil, as well as selected bores targeting coal seams near the void. Median field EC values were 3,492 µS/cm for the non-coal interburden and 11,216 µS/cm for the coal seams.

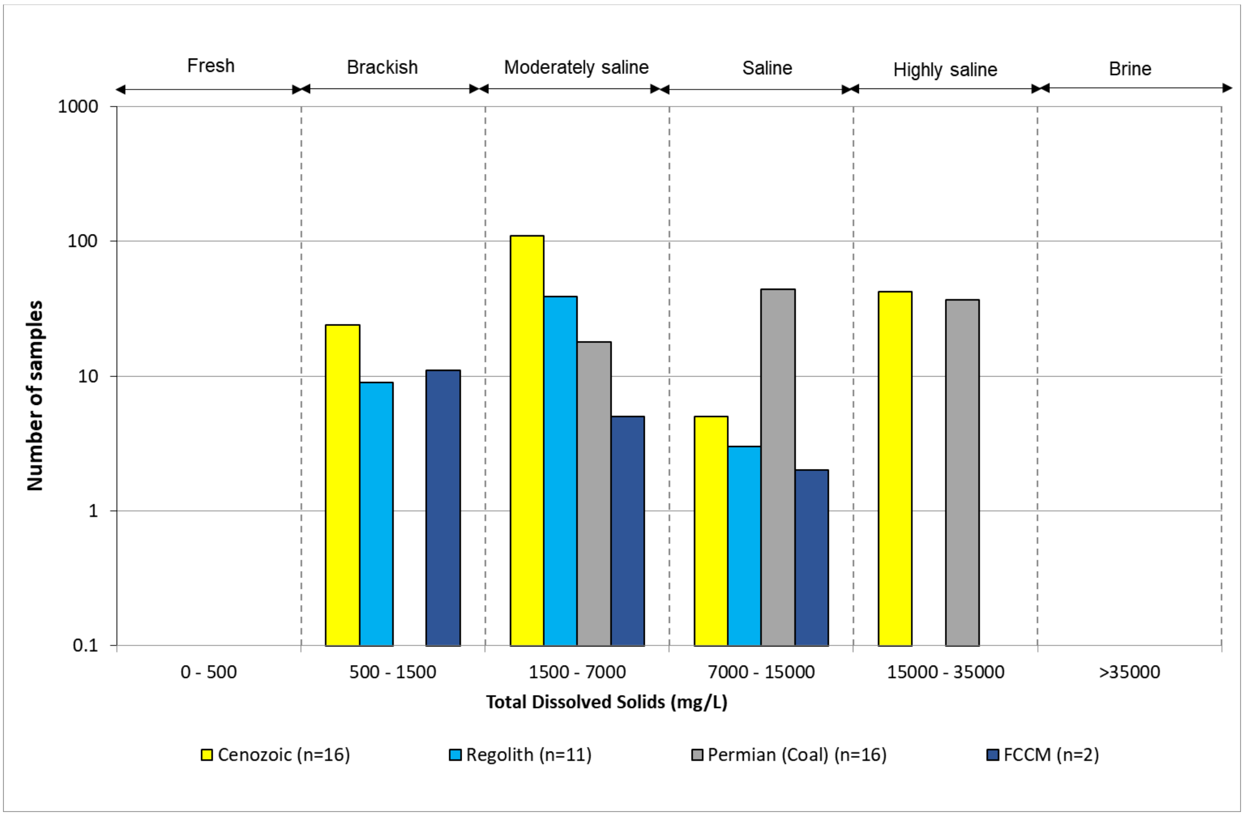


Figure 10-8 Salinity Ranking by Groundwater Unit

10.5.6.3 Water Quality Objectives

WQOs are scheduled under the EPP Water for Isaac Groundwaters of the Isaac River Sub-basin of the Fitzroy Basin WP (WQ1310), as relevant to identified EVs.

WQOs has been defined in terms of:

- Australian Drinking Water Guidelines (ADWG) (NHMRC and NRMMC, 2011), despite there be no evidence that groundwater is utilised as drinking water supply (Table 10-8).
- Aquatic ecosystem protection for moderately disturbed system (ANZG, 2018) (95% protection) (Table 10-8).
- Isaac River Sub-basin EVs and WQOs for stock and irrigation (DEHP, 2011) (Table 10-8).
- Fitzroy Basin Groundwater Water Quality Objectives: Aquatic ecosystems (Zone 34) (DEHP, 2011) (Table 10-9).

Table 10-8 Water Quality Objectives for Isaac River Sub-basin Environmental Values

Water Quality Indicator	Unit	ADWG Guidelines		Isaac River Sub-basin EVs		
		Health	Aesthetic	Irrigation	Stock	Aquatic 95%
pH	-		6.5 to 8.5			6.5 to 8.5
Aluminium	mg/L		0.2		5	0.055
Calcium	mg/L				1000	
Chloride	mg/L		250			
Magnesium	mg/L				2000	
Manganese	mg/L	0.5	0.1	10		1.9
Sodium	mg/L		180			
Sulfate	mg/L				1000	
Zinc	mg/L		3			0.008
Arsenic	mg/L	0.01		2	0.5	0.024
Cadmium	mg/L	0.002			0.01	0.0002
Chromium	mg/L	0.05			1	0.001
Cobalt	mg/L			0.1	1	
Copper	mg/L	2	1		1	0.0014
Lead	mg/L	0.01			0.1	0.0034
Mercury	mg/L	0.001			0.002	0.0006
Nickel	mg/L	0.02			1	0.011
Selenium	mg/L	0.01			0.02	0.005
Silver	mg/L	0.1				0.05

Table 10-9 Isaac River Sub-basin Zone 34 WQOs for Groundwater Resources (Aquatic Ecosystem Protection)

Water Quality Indicator	Unit	Shallow Groundwater (<30m)			Deep Groundwater (<30m)		
Percentile	-	*20th*	*50th*	*80th*	*20th*	*50th*	*80th*
EC	µS/cm	498	2150	8910	3419	6100	16000
Hardness as CaCO3	mg/L	163	674	2228	359	919	3208
pH	-	7.1	7.75	8.1	7.4	7.8	8.03
Alkalinity	mg/L	154	435	752	156	275	536
Ca	mg/L	18	84	215	46	145	442
Mg	mg/L	27	108	389	35	115	491
Na	mg/L	135	747	1500	480	1100	2565
Cl	mg/L	171	1309	3185	753	1900	5905
SO4	mg/L	12	140	318	25	138	398

Water Quality Indicator	Unit	Shallow Groundwater (<30m)			Deep Groundwater (<30m)		
HCO3	mg/L	187	536	878	188	330	650
NO3	mg/L	0	0.95	5.3	0.01	2.15	14.92
SiO2	mg/L	21	36	52	16	25	36
F	mg/L	0.1	0.28	0.5	0.02	0.155	0.4
Fe	mg/L	0	0.03	0.14	0	0.05	0.246
Mn	mg/L	0	0.01	0.16	0	0.05	0.291
Zn	mg/L	0	0.015	0.06	0.01	0.025	0.317
Cu	mg/L	0	0.01	0.03	0.017	0.03	0.03

In order to understand the possible utilisation of groundwater resources within and proximal to the Project area, available Project groundwater quality data (80th percentile of available dataset at each bore) have been compared to various WQOs. Where groundwater quality analysis results exceed a particular WQO for a particular EV, it is considered indicative that the groundwater may be unsuitable for supporting that particular EV.

A comparison of these WQOs to the 80th percentile of available historical water quality data for the monitoring bores are presented as Appendix A of **Appendix K**.

Groundwater within the alluvial and regolith Project bores generally exceeds the WQO criteria for aquatic ecosystem protection (shallow groundwaters <30 m) for zinc, manganese, pH, and total alkalinity. Bores also exceed the aquatic ecosystem WQO criteria for cadmium, copper, mercury and selenium. However, bores MBIS05 and MBID07 targeting the alluvium along the Isaac River show no exceedances of WQO criteria. This difference may be attributed to the hydrogeological heterogeneity of the alluvium, which likely results in shorter groundwater residence times and a greater influx of recharged fresher water at these locations. Overall, the comparison suggests that alluvial and regolith groundwater typically exceeds one or more WQO criteria for aquatic ecosystem protection but is generally suitable for supporting stock watering and irrigation.

Groundwater in the Permian strata units, including the Leichhardt and Vermont coal seams, consistently exceeds multiple WQO criteria across all scheduled EVs. Key exceedances include pH, EC, and many major ions and dissolved metals such as manganese, chromium, iron, and zinc. A similar exceedance pattern is observed in groundwater from the FCCM. These results indicate that groundwater in the Permian coal measures is generally unsuitable to support any of the scheduled EVs.

10.6 Environmental Values – Groundwater Receptors

10.6.1 Overview

The potential groundwater receptors identified through Project related studies are:

- landholder groundwater bores utilised primarily for stock watering, with some bores utilised for water supply to a quarry to the west of the Project
- GDEs
- stygofauna.

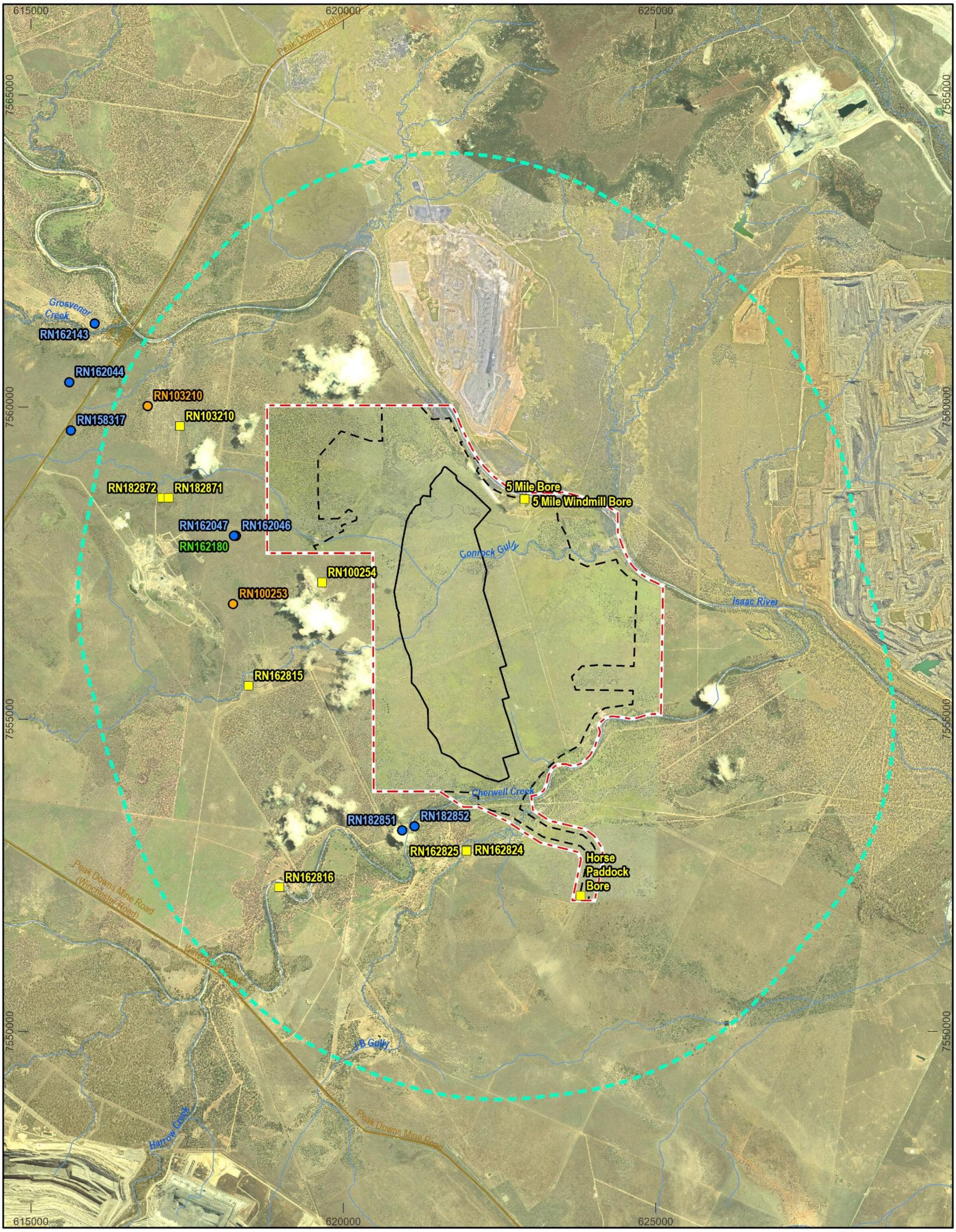
These potential groundwater receptors are described in the following sections.

10.6.2 Landholder Bores

A search of the State's registered groundwater bore database was carried out for registered bores within 5 km of the Project area, with these shown in Figure 10-9. A subsequent bore census was conducted (Appendix E of **Appendix K**). The bore census confirmed a total of 11 landholder supply bores within 5 km of the Project area. Of these, six were active supply bores, while the remaining five were inactive and not equipped with pumps at the time of the survey. Details of the 11 landholder bores are provided in Table 5-7 of **Appendix K**. Figure 10-9 shows all registered bores inspected during the census, including the 11 landholder bores. Non-landholder bores, associated with groundwater monitoring by other resource companies), RN162143 (MB06), RN158317 (MB08b), RN162046 (MB09B), RN162047 (MB09C) and RN182851 formed part of the baseline monitoring network for the Project. Other non-landholder bores shown in Figure 10-9 are historical monitoring bores.

Bores RN162815 (unknown aquifer), RN103210 (Permian coal measures), and the 5 Mile Windmill Bore (weathered Triassic / regolith) are stock supply bores, each supplying one or more storage tanks or cattle troughs. Measured flow rates at these bores during the site visit ranged from 0.05 to 0.25 L/s. The Horse Paddock Bore was not operational at the time of inspection, and the landholder was unable to activate the pump. No information regarding the pumping schedules of the stock supply bores was available from the landholder.

Bores RN182871 and RN182872 are active supply bores for a small basalt quarry just west of the Project area and drilled to 60 mBGL and 80 mBGL, respectively, indicating a likely groundwater source within the FCCM. Both are equipped with steel headworks and electro-submersible pumps. However, no depth or source aquifer information is available. These bores reportedly operate at rates of 0.2 and 0.3 L/s, respectively, for approximately 8 hours per day. Bore RN182871, drilled in October 2024, is more recent than RN182872, and the quarry manager reported elevated iron precipitate in this bore.



0 500 1000 1500 2000 2500

Metres

Datum:	GDA2020 Zone 55
Scale:	See Scale Bar
Date:	28/05/2026 8:07 AM
Drawn:	Minserve
Source:	SLR
File:	20260527 Bores Map.aprx

DISCLAIMER: Third party data sources are used in this map compilation. Minserve makes no warranty regarding this data's accuracy or currency.

LEGEND

- Waterway
- Roads
- IDE Project MLAs
- Proposed Project Disturbance Area
- Project Pit Extent
- Proposed Project Pit 5km Buffer
- Landholder Bore

Registered Bore

- Monitoring
- Monitoring (VWP)
- Supply

stanmore

ISAAC DOWNS EXTENSION

Registered and Landholder Bores

Figure | **10-9**

10.6.3 Groundwater Dependent Ecosystems

10.6.3.1 Ecological Characteristics of GDE Species and Communities

As GDEs define a continuum between groundwater and surface ecology, Section 3 of **Appendix N** provides a description of both biotic factors and abiotic controls, enabling linkages to be drawn to assist in the assessment of risks to GDE function.

Field mapped regional ecosystems (REs) (see **Chapter 11**) were used to understand the vegetation within and surrounding the Project area, including threatened ecological communities (TECs).

Species sampled in the GDE survey include the four eucalypts associated exclusively with RE11.3.25, namely river red gum (*Eucalyptus camaldulensis),* forest red gum (*Eucalyptus tereticornis*), poplar box (*Eucalyptus populnea*), and coolabah (*Eucalyptus coolabah*), plus *Melaleuca fluviatilis*. The sampling of river and forest red gum occurred in all habitats that fringed watercourses (RE11.3.25) and wetlands (RE11.3.27b), while poplar box formed more laterally extensive habitats on elevated terraces. Brigalow (*Acacia harpophylla*) and coolabah (*Eucalyptus coolabah*) generally formed discrete patches, often mixing on the fringes of ephemeral watercourses.

A detailed description of the potential for various tree species to be GDEs is provided in Section 3 of **Appendix N**, and summarises as:

- All eucalyptus species are potential groundwater users, with varying degrees of adaptations or limitations. River red gum is a well-studied species known to have deep sinker roots, hypothesised to grow down towards zones of higher water supply, and the species mixes with forest red gum along the river frontage.
- Brigalow's shallow rooting habit is evident with the tendency of mature trees to topple because of churning in the upper soil profile with fallen trees universally exposing a well-developed lateral root system with little evidence for development of deeper sinker roots that would have capacity to propagate to deeper groundwater tables. Brigalow is not considered to represent groundwater dependent vegetation.
- Based on observations of matted tree roots concentrated in wet sands within river channel deposits, it is expected that melaleuca species will utilise mostly surface water, with the capacity to utilise residual moisture in river channel deposits as surface water recedes.
- Native grassland communities (i.e. RE11.8.11) are not considered in the GDE assessment as the shallow root system of native grasses precludes any likelihood of groundwater dependence.

Chapter 12 identifies that the Project area and surrounds does not support aquatic GDEs, due the ephemeral nature of the drainage systems and lack of persistent groundwater-supported pools in these systems.

10.6.3.2 Hydrogeological Setting

Section 10.5 describes the hydrogeological setting for the Project that has informed the GDE assessment, including the data from groundwater monitoring bores, as detailed in Section 3.2 of **Appendix N**. Key findings, as relevant to the GDE assessment include:

- The Isaac River alluvium is typically formed by thick, fluvial sand deposits which host a seasonally sustained unconfined groundwater table. Recharge to the alluvium is mostly from stream flow or flooding (i.e. a losing stream), with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow subsurface. Alluvium along Cherwell Creek is closely aligned with the modern creek channel, compared to the broader extent of alluvium associated with the Isaac River.
- The unconfined aquifer within the alluvium is referred to as the 'alluvial aquifer'.

- Perched groundwater systems are likely to occur within the alluvium. These are discrete groundwater units sitting above the alluvial aquifer / water table, and are separated by an unsaturated zone.

Chapter 8 and **Chapter 9** provide a description of the surface waters catchments, and the hydrology and geomorphology of waterways, respectively, within and surrounding the Project area. Vegetation in the Project area and surrounds, including potential GDEs, will also rely on surface water flows.

10.6.3.3 GDE Assessment Findings - Leaf Water Potential

Figure 10-10 shows the average and range of LWP values reported for each of the 20 assessment areas, separated by key vegetation types and / or location. The black line approximates 'standard wilting point' where trees are moisture-limited and unlikely to be utilising groundwater. Low to very low moisture availability indicates vegetation that is utilising soil moisture sources in the vadose zone. High to moderate moisture availability suggests that riparian vegetation is utilising a brackish groundwater source. Very high moisture availability suggest the possible use of a fresh groundwater source.

Sites along the Isaac River vary from very low to very high moisture availability. Sites along Cherwell Creek have mostly low to very low moisture availability. The HES wetland demonstrated high to very high moisture availability. Brigalow and poplar box sites have considerably more negative LWP values in the low to extremely low range. Based on LWP values alone, this suggests that brigalow and poplar box habitats are moisture-limited and unlikely to be utilising groundwater.

Additional detail on LWP findings is provided in Section 5.1 of **Appendix N**.

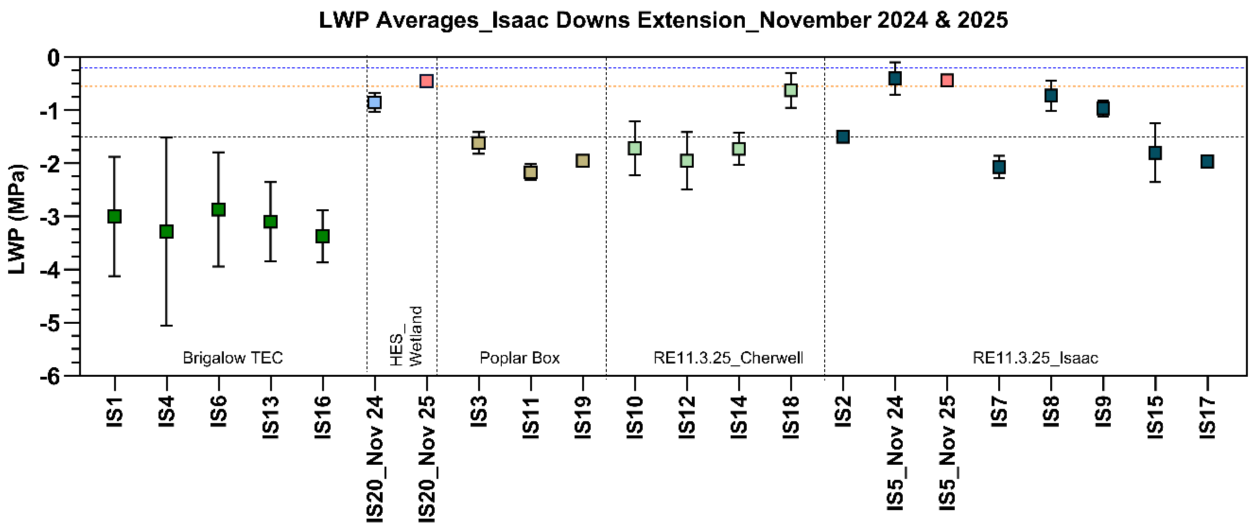


Figure 10-10 LWP for GDE Assessment Sites – Ranges and Averages

10.6.3.4 GDE Assessment Findings - Soil Auger Sampling

Seven auger profiles were completed in November 2024 assessment, plus an additional two auger samples in November 2025. These targeted riparian landforms associated with the Isaac River and Cherwell Creek, as well as the HES wetland.

Results from the Isaac River indicate that that soil moisture from the vadose zone can account for the reported LWP values at these sites, and the presence of shallow groundwater is not necessary to account for any measured high LWP values.

Results from Cherwell Creek indicate that LWP values can be readily accounted for by the moisture availability in the vadose zone, supporting the inference that groundwater is not contributing to the moisture sources.

Results from the HES wetland indicate that SMP values overlap with LWP values below deeper than 3 mBGL, which provides direct evidence that soil moisture within the sand provided the source of moisture for deep-rooted vegetation in November 2024, with no evidence for significant groundwater usage. In November 2025, the entire soil profile was potentially contributing to tree moisture sources.

Additional detail on soils auger and SMP results is provided in Section 5.2 of **Appendix N**.

10.6.3.5 GDE Assessment Findings - Stable Isotopes

An analysis of stable isotope data collected from soils, twig xylem, groundwater and surface water was used to inform vegetation groundwater dependence.

For Isaac River GDE assessment sites, the lack of overlap between isotopic clusters formed by twig xylem and groundwater indicates that groundwater was not a significant source of moisture for riparian trees. However, the twig xylem values tend to lie consistently between the soil and surface water values, indicating that both sources likely contribute moisture to riparian vegetation. At one site xylem isotopes were substantially lighter, reflecting the influence of the isotopically light perched groundwater unit.

For Cherwell Creek GDE assessment sites, the lack of overlap between isotopic clusters formed by twig xylem and groundwater indicates that groundwater was not a significant source of moisture for riparian trees.

For the HES wetland GDE assessment sites, twig xylem isotope values form clusters that are distinct from the groundwater clusters, and limited overlap with the soil isotope values. The lack of overlap between isotopic clusters formed by twig xylem and groundwater indicates that groundwater was not a significant source of moisture for riparian trees in November 2024. SMP and isotope sampling in November 2025 provide strong evidence that moisture was derived from the soil profile, with possible minor contribution from small quantities of groundwater perched above the basement contact.

Additional detail on the results from stable isotope analysis is provided in Section 5.3 of **Appendix N**.

10.6.3.6 GDE Assessment Findings - Radon Analysis

Radon concentrations in the river sand, riverbanks, and residual surface waters form a distinct cluster, with radon concentrations and EC values lower than those in the alluvial monitoring bores.

Additional detail on the results from radon analysis is provided in Section 5.4 of **Appendix N**.

10.6.3.7 Summary of Results

GDE data analysis demonstrates the following:

- Combined application of LWP and SMP measurements demonstrates riparian vegetation (RE11.3.25) fringing both the Isaac River and Cherwell Creek, was utilising soil moisture in the unsaturated portion of the soil profile to support transpiration at the time of the November 2024 assessment. The stable isotope composition of tree xylem is substantially enriched and distinct from other sources, possibly influenced by surface water usage where this is available. Isotopic data from one site on the Isaac River (IS5) in November 2025 indicates increased use of water in the perched groundwater unit by riparian vegetation, though soil moisture and surface water remained the dominant moisture sources.
- Similarly, deep-rooted woody vegetation both within and fringing the HES wetland (Site IS20) was utilising moisture sourced from the vadose zone in November 2024, preferably utilising moisture from an unsaturated interval of sand that formed a 3 m thick massive sequence above weathered basement rock. When sampled in November 2025, the soil profile carried substantially more

moisture, and wetland trees were using moisture held throughout the soil profile, including the potential use of small volumes of groundwater, attributed to surface infiltration, that was perched in sand above weathered Permian sediments.

- For the Poplar Box (RE11.5.3) and Brigalow threatened ecological community (TEC) habitats (RE11.3.1 and 11.4.9), the highly negative LWP measurements confirm that trees are utilising moisture tightly bound to soil grains within the vadose zone, and not groundwater.

Despite the lack of demonstrated groundwater use at the time of the November 2024 assessment for any habitats within and surrounding the Project area, the saturation of soil profiles and seasonal perching of groundwater above impervious strata and the regional water table is likely to occur during wetter climatic periods following moisture recharge by rainfall and surface flows. Increased volumes of groundwater from the perched groundwater unit (as distinct from the deeper alluvial aquifer) were demonstrated during sampling in November 2025, intersected in auger profiles at sites IS5 and IS20 in a lower terrace of the Isaac River and the HES wetland, respectively. Although seasonal in nature, and being discharged through evapotranspiration as the climate dries, the accumulation of groundwater (in the perched groundwater unit) in the root zone of woody vegetation is consistent with the definition of a 'terrestrial' GDE. Where groundwater use occurs, it is restricted to the immediate riverbanks where trees interact directly with perched groundwater unit, and not with the deeper alluvial aquifer.

Sandy soils facilitate the rapid infiltration of rainfall and surface flows, while also having the capacity to store and transmit groundwater, typically found within the channel and stream banks of the Isaac River and Cherwell Creek. The thick sandy interval lying below the HES wetland will be variably saturated during wet seasons through downward leakage of surface waters. The pervasive intense iron oxide staining evident in the thick sand interval suggests sustained wetting and moisture infiltration rather than prolonged saturation which would result in iron dissolution (Taylor and Eggleton, 2001). Perching of small volumes of groundwater at the base of the sandy interval was confirmed during November 2025 auger sampling, though groundwater perching only occurs following significant surface pondage and associated leakage. Perched groundwater in this wetland is not associated with the deeper alluvial aquifer.

Radon sampling provided additional context to the partitioning of groundwater with the alluvium, particularly the differentiation of the alluvial aquifer and the perched groundwater unit. Surface water was abundant in the Isaac River, consistent with ponding in the HES wetland in August 2025. Surface water from this sampling event is rainfall-derived on account of its low radon concentration and low EC. Most isolated residual pools sampled in the Isaac River in November 2025 had more elevated radon concentrations, consistent with groundwater in the perched groundwater unit (both in the river sand and the riverbank). The increased radon concentrations in November 2025 suggest that the residual waterbodies in the Isaac River are a surface expression of the perched groundwater unit, encompassing groundwater in the river sand and riverbank. The perched groundwater unit is distinct from the alluvial aquifer sampled in monitoring bores, and groundwater from the perched unit slowly leaks into the alluvial aquifer, providing a source of recharge to it. Data from stable isotopes suggests that leakage is diffuse and slow, with the first evidence of groundwater influx from the perched groundwater unit to the alluvial aquifer taking several months.

10.6.3.8 Ecohydrological Conceptual Site Models

Ecohydrological conceptual models for potential GDEs, as represented by terrestrial vegetation along the Isaac River and the HES wetland, are provided in Figure 10-11 for the dry season, Figure 10-12 for the wet season and Figure 10-13 for post wet season. These models have been developed based on the findings from GDE field studies for the Project.

The dry season model (Figure 10-11) demonstrates the partitioning of the perched groundwater unit and the alluvial aquifer, the slow leakage of groundwater from the perched groundwater unit to the alluvial aquifer, plus the use of the perched groundwater unit by fringing riparian vegetation. The hydrological function of the lower reaches of Cherwell Creek mimics the Isaac River, except for shorter flow duration and more rapid discharge of water from the river sand. Further upstream (westward) in Cherwell Creek the alluvium shallows.

The wet season conceptualisation (Figure 10-12) demonstrates recharge of the perched groundwater unit hosted in recent/active alluvia on the inner banks of the Isaac River. Flooding drives surface water into the riverbanks during seasonal 'wet-ups' and associated flooding, creating a bulge in the perched groundwater table. This 'bank storage' is utilised by the bulk of the riparian vegetation fringing the Isaac River channel and the lower reaches of Cherwell Creek, with the degree of utilisation diminishing in trees positioned progressively higher upslope along the riverbanks. The seasonal bank storage has a weak unsaturated hydraulic linkage to the deeper alluvial aquifer. However, it predominantly discharges back into the river as surface flows subside or depletion occurs through evapotranspiration. The discharge of bank storage back into the river, as surface flows subside, extends the period of river flow and sustains water levels in the river sand in the post wet season (Figure 10-13). The persistence of surface pools depends on climatic variables and fluvial processes that form channel hollows to expose the perched groundwater unit. However, the residual pools are spatially restricted and rapidly diminish in size and extent as the perched groundwater unit discharges during dry climatic periods.

Data for the HES wetland indicates that it has formed on a river paleochannel, where the sand is moist to wet, depending on rainfall recharge. Small volumes of groundwater seasonally perch in the sand above the basement contact with weathered Permian sediments, where they may contribute to moisture use by deep-rooted wetland vegetation. The 2.5 m thick sequence of clay that forms the wetland floor limits surface water infiltration, facilitating surface water accumulation during the wet season. Wet season ponding of surface water in the HES wetland is also responsible for the most substantial moisture recharge of the wetland soil profile and associated perched groundwater.

Evapotranspiration regulates discharge from the perched groundwater units associated with both the Isaac River and the HES wetland during drying cycles. As perched groundwater depletes seasonally, reliance on soil moisture to support transpiration increases.

The GDE field assessment for the Project did not detected the current periodic use of groundwater from the regional alluvial groundwater table (as distinct from the perched groundwater unit) by woody riparian vegetation.

IDM, which adjoins the Project, is required to implement a GDE monitoring and management plan (GDEMMP) as a condition of its Commonwealth approval EPBC 2019/8413. The IDM GDEMMP Baseline Assessment (3d Environmental, 2023) concluded that periodic use of small quantities of groundwater from the regional alluvial groundwater table (as distinct from the perched groundwater unit) by woody riparian vegetation (RE11.3.25) occurs, particularly where this groundwater is <10 mBGL. Nevertheless, there remains a very low likelihood of sporadic use of groundwater from the deeper alluvial aquifer based on the data for the Project. Any use of alluvial aquifer water by riparian vegetation is not widespread and extensive. Immersion of the riparian tree root zone in a seasonally fluctuating perched groundwater unit will occur during seasonal flow events, where it is associated with bank recharge and storage, implying that groundwater dependence on the perched groundwater unit is seasonal. Away from the river, groundwater usage is restricted by the shallow rooting depth of vegetation, increased aquifer salinity, and increased depth of the regolith groundwater unit. The most significant control on groundwater dependence across the study area is a lack of well-developed alluvial deposits, except for the relatively narrow Isaac River floodplain and thin slivers of alluvium attenuating upstream along the larger tributary streams (e.g., Cherwell Creek). The lack of significant alluvium away from the Isaac River channel means that, away from the drainage channels, the base of the regolith or coal seams hosts the shallowest groundwater sources.

10.6.3.9 Mapped Extent of GDEs

GDE field data for the Project indicates groundwater partitioning in the alluvium, with a perched groundwater unit directly linked to recharge from Isaac River surface flows, and a deeper alluvial aquifer linked through an unsaturated connection. Riparian vegetation on the Isaac River uses groundwater from the perched groundwater unit seasonally (when recharged). However, it shifts to predominantly using soil moisture when the perched groundwater unit dries. There was no evidence for vegetation use of the deeper alluvial aquifer. Reaches of Cherwell Creek within the Project area lack development of the perched groundwater unit, and riparian vegetation persists primarily due to its use of soil moisture.

Riparian vegetation associated with a mapped HES wetland demonstrated groundwater perched at the base of a thick sandy soil interval (paleochannel) following wet-season recharge, then discharged through transpiration during drier periods, after which transpiration is sustained solely by soil moisture. The HES wetland does not rely on water in the deeper alluvial aquifer.

In summary, the local extent of GDEs within and surrounding the Project area is restricted to the margins of the Isaac River, attenuating upstream along Cherwell Creek. The likelihood of GDEs along Cherwell Creek pinches out upstream due to shallowing of the sedimentary basement toward the west, associated with a thinning of the alluvium. Additional terrestrial GDE areas may coincide with the HES wetland near the confluence of the Isaac River and Cherwell Creek.

Based on the fieldwork findings, data from GDE studies at IDM (3d Environmental, 2020) and the ecohydrological conceptualisation for GDEs, the extent of GDEs within and surrounding the Project area is shown in Figure 10-14.

Figure 10-14 shows the location of riverine (Type 1) and wetland (Type 2) GDEs within and surrounding the Project area. Type 3 GDEs represent areas that have extended water availability through drier seasonal periods, as identified in the IDM GDE assessment (3d Environmental, 2020).

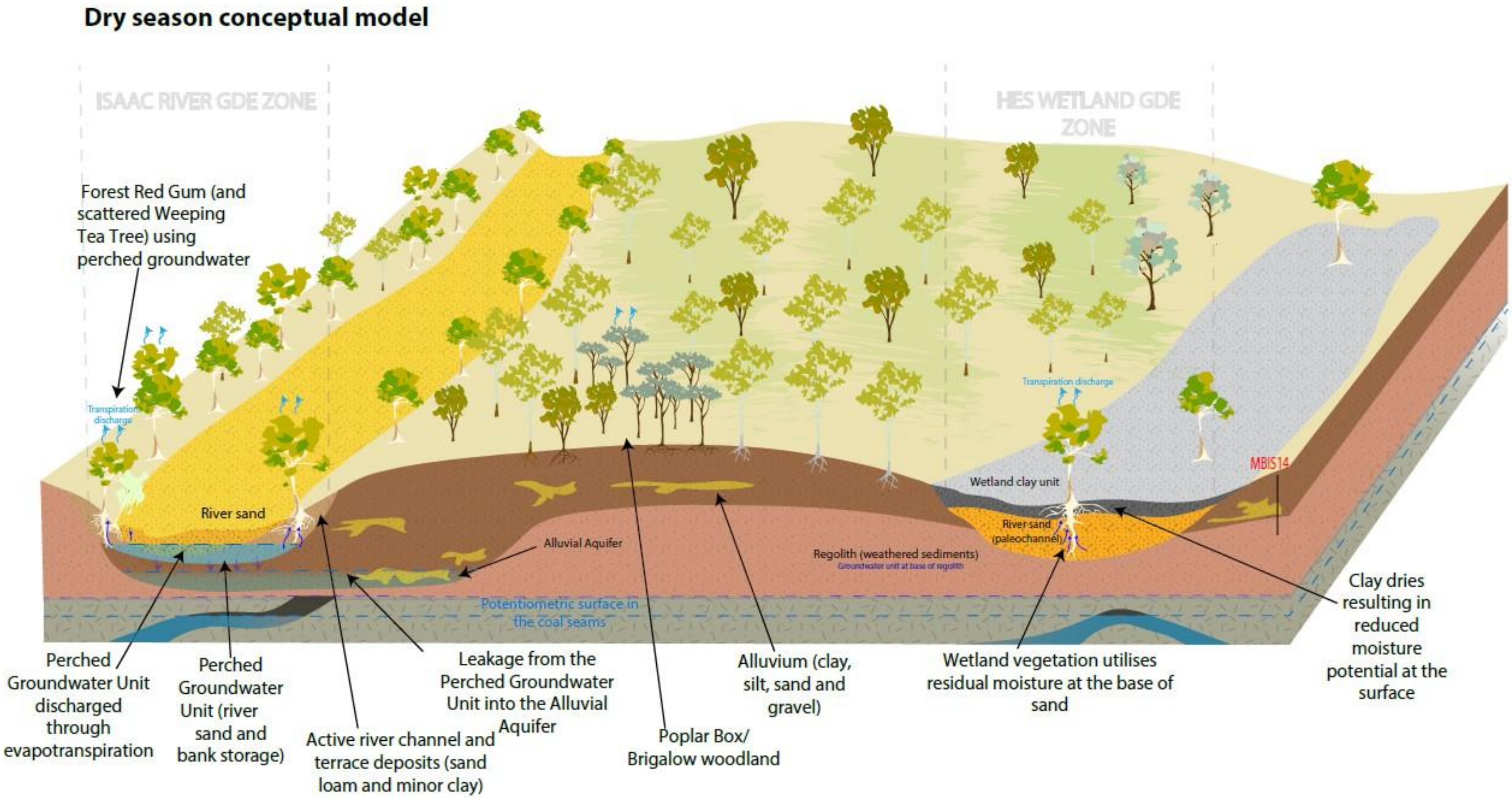


Figure 10-11 Conceptual Ecohydrological Model – Dry Season

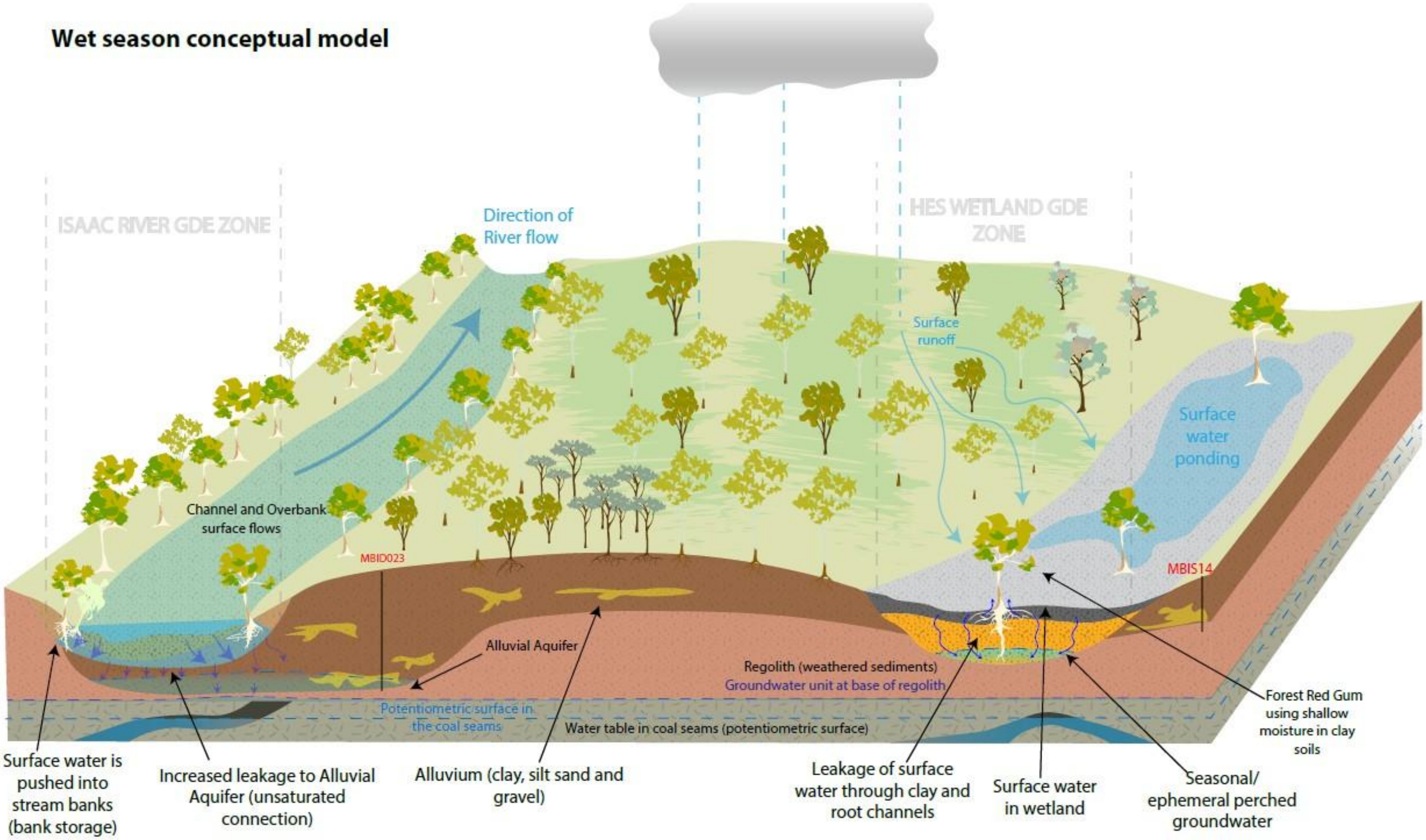


Figure 10-12 Conceptual Ecohydrological Model – Wet Season

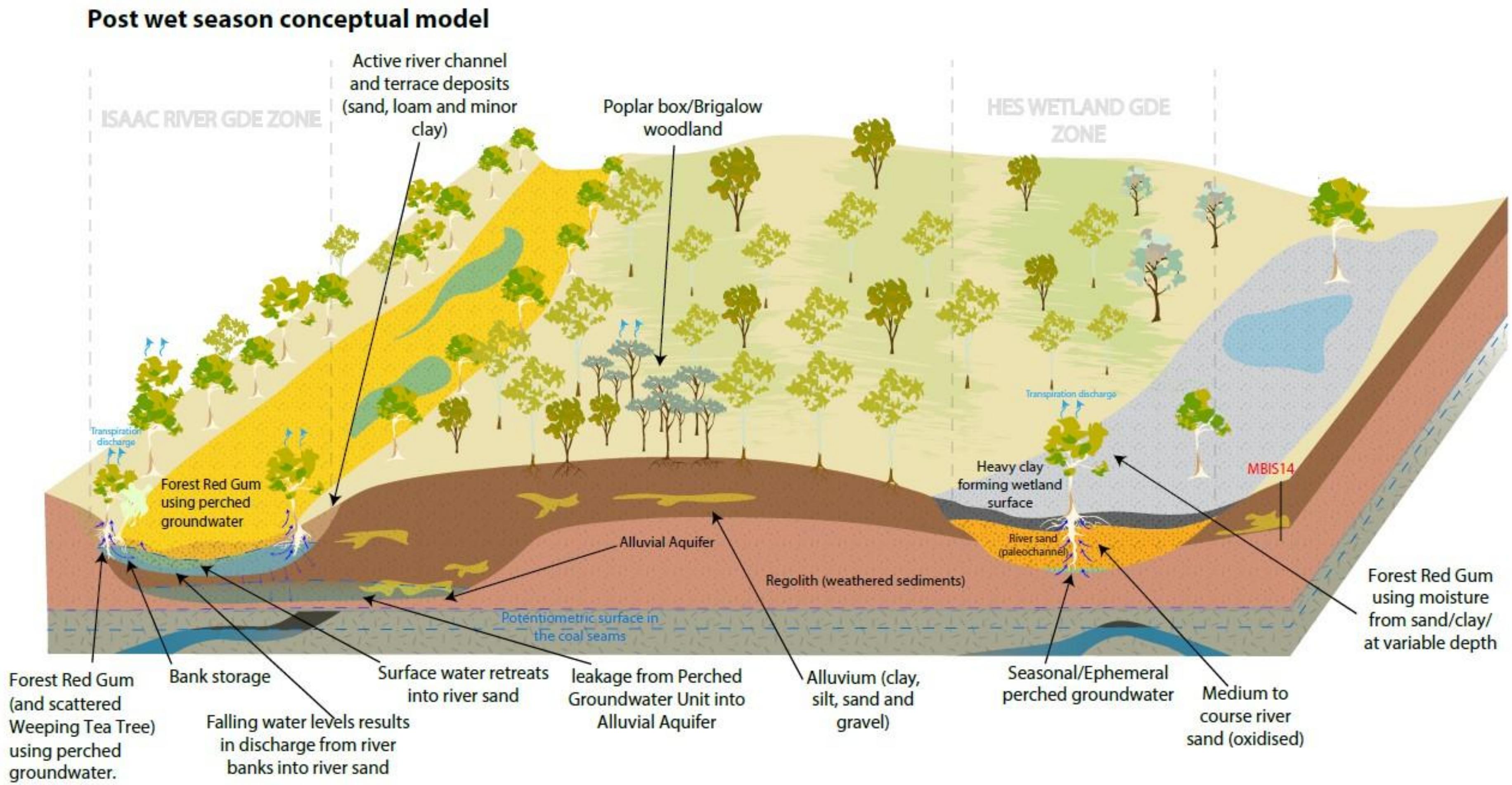
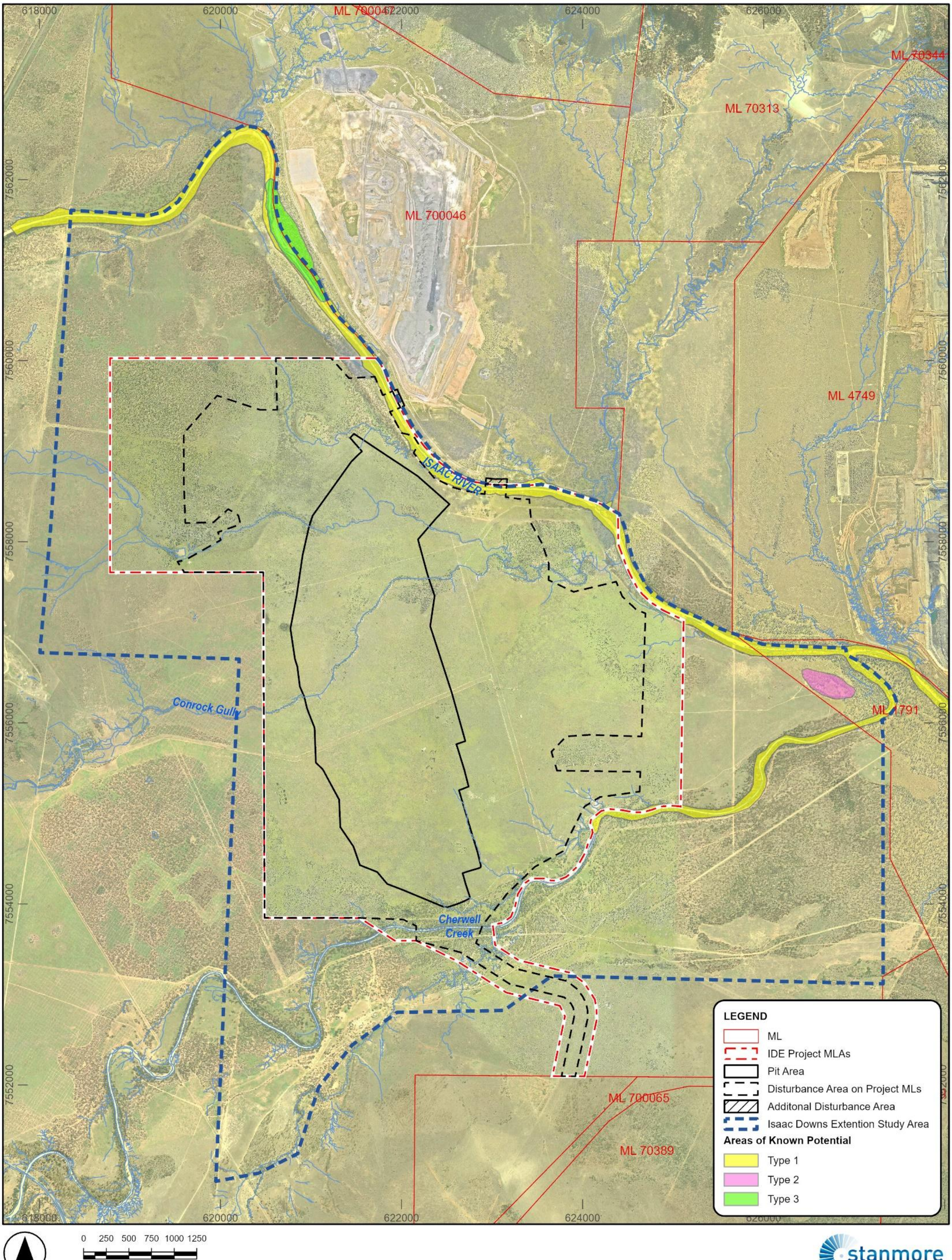


Figure 10-13 Conceptual Ecohydrological Model – Post Wet Season



Datum:	GDA2020 Zone 55
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ISAAC DOWNS EXTENSION

GDE Areas

Figure | **10-14**

10.6.4 Stygofauna

10.6.4.1 Desktop Data

Stygofauna are aquatic subterranean animals that are found throughout Australian aquifers. The term stygofauna encompasses a variety of different types of organisms that are found in groundwater, and includes animals that are obligate, groundwater-adapted organisms (stygobionts), and those that are not specifically groundwater-adapted but are able to survive the harsh conditions in aquifers (stygoxenes).

A synthesis was undertaken across Australia by Hose et al. 2015, which summarised the key findings from 12 studies from the Bowen Basin. These studies identified stygofauna assemblages in alluvial aquifers that contain common stygobionts such as copepods, amphipods and syncarids, and to a lesser extent also from basalt aquifers and coal seams. In the Bowen Basin stygofauna were recorded where standing water level was between 1.4 and 45 m below ground level and from groundwaters with electrical conductivity ranging from 342 – 9,975 µS/cm, pH from 6.39 – 10.27 and dissolved oxygen from 0.93 – 6.54 mg/L.

A review of the Queensland Subterranean Aquatic Fauna Database identified 48 bores that had been sampled within a 50 kilometre radius of the Project's stygofauna study area. Several stygobionts, and likely stybionts, were recorded from 13 of the bores, with all but one bore intersecting the alluvium (that bore intersected basalt).

Several, more recent, stygofauna assessments have been conducted for environmental impact assessments in the vicinity of the Project. An assessment of two bores sampled for the Olive Downs South Project recorded no stygofauna. However, it was noted that suitable conditions existed in the bores to support stygofauna. Of 10 bores sampled for the Isaac Downs EIS, two stygoxenes were recorded but no stygobites (frc environmental 2019). Initial stygofauna sampling for the Winchester South Project EIS detected no stygofauna. However, two taxon (Bathynellidae and Candonidae – an ostracod) were recorded during supplementary surveys (ESP 2022).

Section 2 of **Appendix O** provides additional context about stygofauna, their ecological requirements and diversity.

10.6.4.2 Stygofauna Field Data

Abundance of stygofauna typically decreases with increasing EC above 5,000 µS/cm. EC recorded from bores in the stygofauna study area ranged from 1,570 – 23,140 µS/cm, with only 3 bores (MBID23, MBID28 and MBIS10) consistent within the preferred range for stygofauna. Stygofauna have been recorded from groundwater with pH range of 3.5 to 10.3, but diversity is highest between 6.5 and 7.5. The pH of groundwater from the stygofauna study area ranged from 6.9 – 8.9 and thus aligned with the range known to support stygofauna communities.

Stygofauna were recorded from three bores, MBID23, MBID28 and MBIS03, all of which are located immediately adjacent to the Isaac River. MBID23 and MBID28 are screened in the alluvial aquifer of the alluvium. The recording of stygofauna in bore MBIS03 (screened in the coal seam at 170 – 180 mBGL) is considered out of character with the historical sampling across the region due to the depth and strata. Further, the water quality recorded from this bore was not optimal for a diverse stygofauna assemblage and reflective of the extremes from which they have been recorded. In consideration of this bore having been installed only two months prior to sampling, it is likely that the stygofauna were not being recorded from the aquifer that the bore was slotted in and rather entered the bore from the alluvial aquifer during construction. This is supported by the similar taxa composition but lower abundance than bore MBID23. Therefore, the alluvial aquifer in the vicinity of the Isaac River is considered to be the primary location for stygofauna assemblages within and surrounding the Project area.

Stygofauna specimens were recorded from the three bores across five higher taxonomic groups, with nine taxa groups when considered at the lowest level of identification. Of these taxonomic groups only three taxa were considered to be true stygobionts (obligate stygofauna), two as possibly stygobiont with the remaining taxa considered likely to be stygoxenes (facultative stygofauna not reliant on groundwater).

These results show a relatively diverse stygofauna assemblage within the alluvial aquifer adjacent to the Isaac River. This finding is due partially to the level of identification being lower than historical sampling across the region and in line with the DSITI (2015) sampling guidelines. At a taxonomic level, comparable with historical reporting and studies across the region, these results are consistent with those that have previously been recorded. The same taxonomic groups are the most commonly recorded across Queensland.

Additional details on the stygofauna identified during field sampling are provided in Section 6 of **Appendix O**.

10.6.4.3 Status under Commonwealth and State legislation

Stygofauna have no conservation listings at the Queensland level. At the Commonwealth level there are numerous stygofauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, all are confined to the Pilbara region in Western Australia. Stygofauna communities associated with Great Artesian Springs are also listed as endangered under the EPBC Act. However, the Project area is outside the Great Artesian Basin. Therefore, there are no species of stygofauna that occur in or surrounding the Project area that are Matters of National or State Environmental Significance.

10.7 Groundwater Modelling

10.7.1 Conceptual Hydrogeological Model

A conceptual hydrogeological model of the groundwater regime has been developed based on hydrogeological information obtained for the Project area and surrounds (see Section 10.5), as well as information from the GDE assessment (see Section 10.6.3). The conceptual model is shown in Figure 10-15. The conceptual model builds upon the groundwater conceptualisation presented in the groundwater assessments for other surrounding projects that occur in the same hydrogeologic environment (e.g. IDM, PTM and Winchester South project), and overall is consistent with those other conceptualisations. That is, no information has come to light through Project specific studies that would suggest that the Project area is hydrogeologically unique to any of these surrounding mine or project sites.

The key geology and hydrogeology relevant to the Project are described in Section 10.4.3 and Section 10.5, respectively.

Where present, the alluvial aquifer is disconnected from the riverbed elevation. Spatially, the alluvial aquifer is locally variably saturated and drilling results close to the Project have indicated it is dry and/or comprised only of clay in several locations, with groundwater hosted only in the deeper coarser grained intersections of alluvium that are likely representative of incised paleochannels.

Shallow perched groundwater systems occur locally within recent channel sands and bank deposits, typically within 1–2 m of the ground surface. These perched systems are transient, seasonally recharged during flow and flood events, and are hydraulically disconnected from the deeper alluvial aquifer. Perched groundwater is facultatively accessed by riparian vegetation, predominantly River Red Gum, fringing the Isaac River and lower reaches of Cherwell Creek. Away from the immediate proximity of the river channel, the alluvial aquifer occurs at depth generally between 10 and 12 mBGL and not accessible by terrestrial vegetation. Groundwater levels within the alluvial aquifer and the Leichhardt and Vermont coal seams are all below the stream bed elevations of the Isaac River and Cherwell Creek, indicating there is no potential for groundwater discharge into these surface water features.

Regionally, groundwater flow within the alluvial aquifer is a subdued reflection of topography, with groundwater flowing in a southeasterly direction consistent with the alignment of the Isaac River and northeasterly along Cherwell Creek. Groundwater levels within the alluvium are also highest close to the main surface water features, indicating losing conditions from the surface water features to the underlying alluvium aquifer during flow periods. Over 50% of flow events are shorter than 10 days, highlighting that most flow events are relatively brief. Recharge to the unconsolidated sediments is primarily from stream flow losses or flooding (i.e. losing streams), with direct infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow sub surface.

Hydraulic connection between the Cenozoic unconsolidated sediments (including alluvium) and the underlying formations is limited to areas where relatively high hydraulic conductivity units (e.g. coal seams) subcrop beneath the unconsolidated sediments, although the weathering horizon at the interface of the Permian and overlying Cenozoic units may reduce this connectivity. General downwards recharge to deeper units is limited by the low hydraulic conductivity (confining) coal measure interburden sequences. Water quality in the Cenozoic sediments (including alluvium) ranges from brackish to highly saline and is indicated to be unsuitable for aquatic ecosystem protection. However, it is considered suitable for stock watering and irrigation.

The Triassic aged Rewan Group, present across the eastern extent of the Project area is considered a regional scale aquitard, though it still contains some saturated horizons. Due to its typically fined grained nature, the Rewan Group generally exhibits a low vertical hydraulic conductivity, resulting in limited hydraulic connection between the unit and the underlying/overlying units. However, local permeability testing indicates hydraulic conductivity values may be higher in the upper weathered zone of the unit.

In the Permian aged coal measures strata, groundwater is encountered mainly in the coal seams, and only occasionally in the sandstone/siltstone units. As with the rest of the Bowen Basin, the coal seams are the main groundwater bearing units within the Permian sequences, with low hydraulic conductivity interburden generally confining the individual seams. Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures. Vertical movement of groundwater (including recharge) is limited by the confining interburden layers, meaning that groundwater flow is primarily horizontal through the seams with recharge only occurring at subcrop where the overlying strata permits. Regionally, groundwater within the Permian coal measures flows in a southeasterly direction with local flow towards the active mining areas proximal to the Project.

The Permian coal measures within and surrounding the Project area have undergone extensive deformation, including folding and faulting. The main northwest-southeast trending fault is the Isaac Thrust Fault. Faults significantly compartmentalise the Permian groundwater system, particularly the major northwest-southeast trending faults. Hydraulic testing of faults at sites near to the Project area indicate that faulting zones tested are not pathways for preferential flow but rather act as hydraulic barriers. Testing of the Isaac Thrust Fault immediately east of the Project has supported the previous findings that the fault zone is ‘healed’ by mineralisation and the fault does not provide a higher permeability pathway for groundwater flow in the Permian coal measures, with hydraulic conductivity values several orders of magnitude lower than the coal seams.

Recharge to the Permian coal measures occurs where the unit subcrops. Due to the low hydraulic conductivity of the interburden material, groundwater largely flows horizontally, along the bedding plane of the coal seams. Groundwater discharge occurs predominantly via evaporation from pit faces in mining operations. Water quality in the Permian units ranges from brackish to highly saline and is indicated to be generally unsuitable to be used for stock watering, irrigation, and aquatic ecosystem protection.

During mining, excavation of open-cut pits and depressurisation of the coal seams will create strong localised hydraulic sinks, resulting in a change of natural hydraulic gradients in the vicinity of mining area. Groundwater flow will become directed toward the pit from the surrounding coal seams, and regolith. This inward flow regime causes localised drawdown and depressurisation. However, the extent of these changes is constrained by the low permeability interburden. In the alluvial aquifer, the conceptual model indicates that changes to groundwater flow direction will be minimal. The discontinuous nature of the alluvial aquifer, combined with its weak hydraulic connectivity to deeper units, means that regional flow directions (aligned to drainage) are largely maintained.

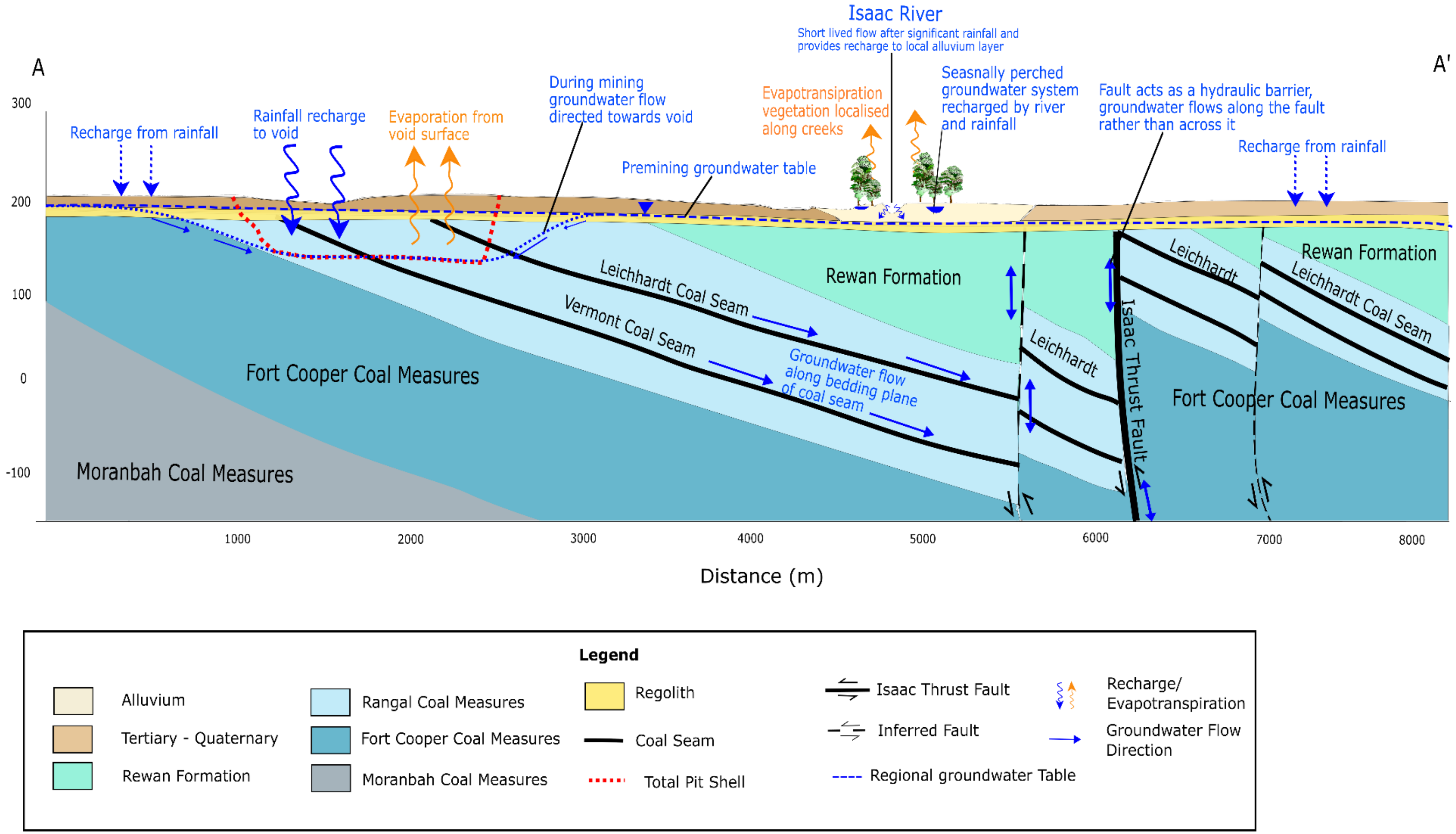


Figure 10-15 Conceptual Hydrogeological Model of the Project Groundwater System

10.7.2 Numerical Groundwater Model

10.7.2.1 Overview

This section provides a summary of the design and development of the numerical groundwater model used to support the groundwater assessment. The design and development of the Central Bowen Basin regional numerical groundwater model (CBB Model) is provided in Appendix I of **Appendix K**. The Project's groundwater modelling calibration and prediction report (Appendix H of **Appendix K**) presents the Project specific scenarios, updates, and results derived from the established CBB model. In this way, the CBB model informs and underpins the Project's numerical groundwater model, with the core model architecture remaining consistent and only targeted refinements and scenario applications varying between the two models.

10.7.2.2 Central Bowen Basin Regional Numerical Groundwater Model

The CBB model was adopted for assessing the Project's impact on groundwater (Appendix I of **Appendix K**). This is a regional scale model that has been developed as part of data share agreements between some mining operators within the model domain. The CBB model is based upon information owned by different operators and supplied for use in the model development, calibration, and prediction of future groundwater conditions that account for cumulative impacts. The model mesh boundary conditions and 'approved' operations (i.e. all existing resource operations and proposed projects, as identified in Section 10.4.2) are shown in Figure 10-16. Over time, the CBB model has been enhanced to reflect improved geological and hydrogeological understanding. Updates have included domain extension to incorporate additional mining areas, mesh refinements around key mine areas, the incorporation of additional mine footprints, revised modelling packages, expanded calibration datasets, and an updated calibration method. The primary objective of the CBB model is to provide a consistent tool for assessing potential hydrogeological impacts associated with mining activities across the central Bowen Basin (i.e. within the model domain).

Appendix I of **Appendix K** provides information on CBB model construction and development such as model software codes, model extent and mesh design, model layers, hydrogeological parameterisation, model stresses and boundary conditions, model calibration and model limitations. The CBB model provides a comprehensive and well established model basis for assessing cumulative impacts from resource operations in the Bowen Basin.

The CBB model that has been subject to multiple independent peer reviews, as well as State and Commonwealth regulator reviews as part of groundwater assessments for other projects.

10.7.2.3 Project's Numerical Groundwater Model

The Project's numerical groundwater model is described in Appendix H of **Appendix K**, and summarised in Section 7 of **Appendix K**. This includes model objectives and design, model calibration, model predictions, sensitivity and uncertainty analysis, and model performance and limitations. Information from the numerical groundwater model is provided below.

The model was deemed appropriate for the purposes of the Project for the following reasons:

- Adoption of the MODFLOW-USG code in the existing model allows for sufficient refinement of the model grid around the Project's proposed mining activities, such that the limitations of a CBB model in terms of the grid design are mitigated.
- The model incorporates the Project's geologic model with model layer representation consistent with the geologic model.
- The stochastic model is calibrated using an extensive regional dataset, including data collected at IDM and other neighbouring mines. Calibration targets were selected from the regional dataset

based on monitoring locations that are within or proximal to the Project, and the model realisation with the best fit to these targets was selected for the Project assessment.

- The model incorporates regional influences that may interact with the groundwater system (and model predictions) post-closure, including operations at the IDM and PTM that are considered likely to interact with the Project voids given their proximity.
- The version of the model adopted for the Project is the latest update to the CBB model.

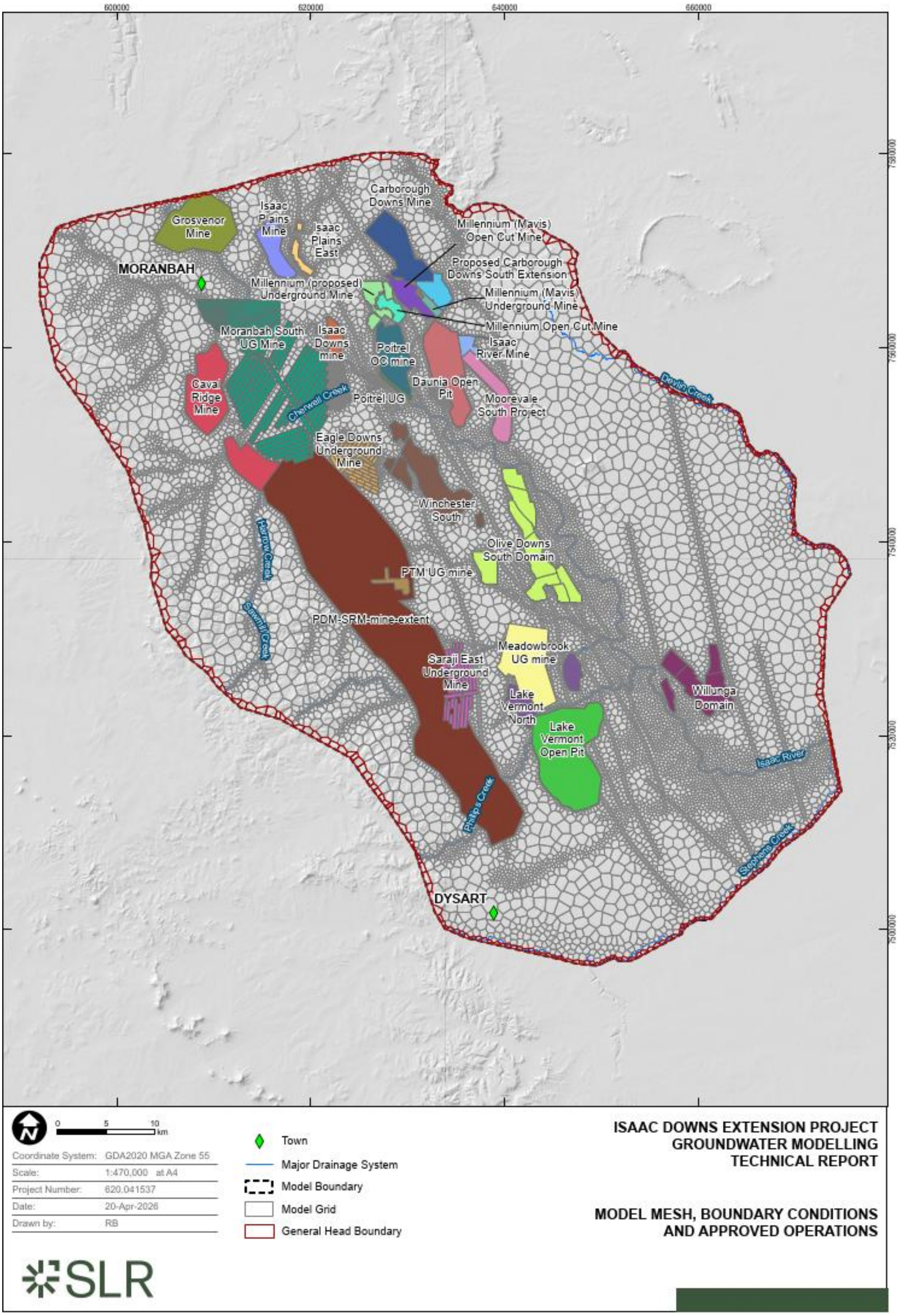


Figure 10-16 Model Mesh, Boundary Conditions and Approved Operations

10.7.2.4 Model Objectives

Numerical modelling was undertaken in support of the groundwater assessment for the Project to assess the potential impacts due to mining on the local groundwater regime. The objectives of the predictive modelling were to:

- Predict groundwater levels during the lifecycle of the Project (operation and closure) and the extent of groundwater drawdown/depressurisation due to mining at the Project and cumulatively with existing mines and proposed resource projects, including those at IPC.
- Predict changes in groundwater levels at identified groundwater receptors (see Section 10.6), during operations and closure, due to mining at the Project and cumulatively with existing and proposed resource projects.
- Predict induced changes in water budgets including groundwater fluxes to and from alluvial sediments during Project mining operations and mine closure (via the use of zone budgets).
- Predict potential changes in surface water flow due to Project mining operations (i.e. the reduction in baseflow to, or induced leakage from, watercourses).
- Identify where groundwater impact mitigation/control measures may be required for the Project.
- Estimate direct water take (groundwater removed during mining) and final void inflows (groundwater fluxes to the final void post mining) of the Project.
- Estimate post-mining recovery conditions.

The predictions are required to assess potential groundwater from the Project only (i.e. incremental) and cumulatively.

10.7.2.5 Model Design

Modelling software (i.e. MODFLOW-USG), and its suitability for use for the Project, as well as model layering to represent different hydrogeological units, is described in Section 7.3 of **Appendix K**.

10.7.2.6 Model Calibration

Model calibration was performed using a Sequential Monte Carlo approach, which incrementally refines parameter distributions through a series of resampling and adjustment steps. Model calibration is described in detail in Section 1.2 of Appendix H of **Appendix K**, and summarised in Section 7.4 of **Appendix K**.

10.7.2.7 Model Performance and Limitations

The groundwater modelling has been conducted in accordance with the Australian groundwater modelling guidelines (Barnett et al., 2012) and the MDBC Groundwater Flow Modelling Guideline (MDBC, 2001). These are mostly generic guides and do not include specific guidelines on special applications, such as open cut mine modelling.

The model confidence level (Class 1, Class 2 or Class 3 in order of increasing confidence) based on the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) was previously widely used in the industry. The latest version of the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023) introduces a new concept on how model confidence can be assessed. The document also indicates that this change will follow in the next iteration of the Australian Groundwater Modelling Guidelines and the new concept for assessing model confidence is hence applied for this groundwater model.

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are:

- Usable -- Relevant to the decision-making process, providing information about the uncertainty in conceptualisations and modelling simulations in a way that allows decision-makers to understand the effects of uncertainty on project objectives and the effects of potential bias. The relevant Quantities of Interests in this context are the groundwater inflows and drawdowns to assess licensing, site water management and drawdown impacts.

- Reliable -- Demonstrate that the range of model outcomes is consistent with the system knowledge and honours historical observations and provides objective evidence that uncertainties affecting decision-critical predictions of impacts on aquifer resources and dependent systems are not underestimated. The calibration performance was deemed acceptable.
- Feasible -- Trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the Project. This study is an update of an earlier model, which shows that there are several model revisions therefore mitigating budget and time trade-offs. Updated technical datasets are included in the most recent revision. The model has been peer reviewed for each revision. The model builds and associated review process are deemed commensurate with the Project related risk to the groundwater environment.

In order to assess these three points above, the four sources of scientific uncertainty (structural, parametrisation, measurement error, predictions) have been qualitatively assessed with regards key aspects of the groundwater model, as presented in Table 7-2 of **Appendix K**. Overall, the model is considered 'fit for purpose' to achieve the model objectives.

10.7.3 Peer Review

10.7.3.1 Overview

An independent technical peer review of the groundwater impact assessment and the associated numerical groundwater modelling has been undertaken by Manewell Groundwater, and is provided in **Appendix L**.

The technical review process was staged, involving numerous presentations, conversations and checkpoints at the model build, calibration, and prediction stages, between the groundwater modellers and the peer reviewer. The groundwater reporting process was iterative, undergoing numerous reviews to ensure technical competency.

This review was undertaken in accordance with the principles and guidelines outlined in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). The technical review incorporates the latest guidance on best practices for uncertainty analysis methods as presented in Uncertainty analysis - Guidance for groundwater modelling within a risk management framework (Peeters and Middlemis, 2023). The technical review is also based on a combination of professional expertise and modelling methodology, together with the model appraisal checklist provided in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and principles outlined by the Groundwater Modelling and Decision Support Initiative (Doherty and Moore, 2021).

The technical peer review consults the following federal regulatory guidelines to assess the sufficiency of the groundwater impact assessment and confirm compliance:

- Information guidelines for proponents preparing coal seam gas and large coal mining development proposals, issued by the Independent Expert Scientific Committee of the Commonwealth of Australia (IESC, 2024).
- Significant impact guidelines 1.3, issued by the Department of the Environment and Energy of the Commonwealth of Australia.

10.7.3.2 Peer Review Findings

The peer review assessed the groundwater impact assessment and the associated numerical groundwater modelling against the criteria described as follows, with findings, as summarised:

The model level classification is 'Class 2-3', which is reliable for use with major approvals projects.

The peer review applied a newer concept for assessing model confidence, in accordance with the 2023 IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023). This involved an assessment of the four sources of uncertainty (structural, parameterisation, measurement error, predictions). Overall, the review found that the model is useable and reliable, with some areas for improvement in future phases of modelling, that would aim to further reduce predictive uncertainty upon the onset of mine dewatering.

The peer review distilled the key guiding principles from Doherty and Moore (2021) into checklist items to ensure the model is not overly complex, and the model is a useful tool that appropriately assesses the Project's impacts. Overall, the review found that the model serves as a blunt but suitable decision support tool.

The Compliance Checklist from the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) was used to judge whether a model is fit for purpose, and describes 10 questions which cover the essential aspects that any groundwater model needs to satisfy, independent of model objectives or confidence-level classification. The results conclude that the groundwater model is 'fit for purpose', where the primary purpose is to develop upon an existing model that is reasonably well calibrated to historical groundwater levels, drawdown, flow changes, and landholder impact. The model is a suitable tool for decision support where the purpose is to provide predictions on potential impacts due to mining caused by the Project.

The peer review of the model found the following:

- The groundwater conceptualisation is generally consistent with the model objectives, which are focused on predicting Project-related and cumulative effects on groundwater levels, groundwater users, alluvial aquifers, river/baseflow systems, mine inflows and post-mining recovery. The disconnected nature of the Isaac River alluvium and deeper groundwater system is well described and presented. The conceptualisation is fit for purpose, with future improvement possible.
- The model extent and mesh design is fit for purpose.
- The modelling report presents model-wide average layer thicknesses.
- The model timing is fit for purpose. The use of annual predictive stress periods during mining is reasonable for an open-cut coal assessment at the model's scale.
- The representation of low volume groundwater extraction by private users is unlikely to materially affect the predictions given the objective of assessing mining-induced impacts.
- The mining approach adopted in the model is acceptable and well documented.
- The model calibration is fit for purpose. Head and head change statistics are at acceptable levels, and key impact trends are generally replicated. The main limitation is that some local head responses and recharge signatures are difficult to reproduce with a regional model and simplified recharge/surface water representation. This is expected and is appropriately carried through into uncertainty analysis.
- The model water balance appears numerically stable and within acceptable error thresholds.
- The likelihood of landholder bore groundwater level impacts, and duration they are affected are suitably presented, with future monitoring required to validate results.
- The uncertainty analysis appears fit for purpose.
- This review concurs with the findings that the final void is predicted to remain a long-term groundwater sink and is unlikely to become a groundwater source for the migration of contaminants.
- Model limitations are adequately recognised, and do not prevent the model from being used for the stated objectives. They do, however, support the need for continued monitoring and future model updates.

The peer review of the groundwater impact assessment and associated reporting found that the report is fit for purpose and written to a high standard. Figures, hydrographs, prediction plots and uncertainty outputs are clear and useful. Key assessment requirements have been considered and presented. The assessment addresses the key State and federal requirements, including Project description, conceptualisation, groundwater systems, surface water-groundwater interaction, water-dependent assets, risk assessment, cumulative impacts, uncertainty and monitoring.

10.7.3.3 Conclusion

The review determined that the groundwater modelling meets professional industry standards. The conceptual model is appropriate and supported by sufficient Project-specific and regional data. The use of the CBB Model is appropriate due to the significant potential cumulative impacts.

The model is fit for purpose, which is to produce a calibrated groundwater model and predict groundwater inflows, drawdown, and flow changes. The ensemble of predictive models is suitable for use as a decision support tool to predict future impacts due to the Project.

This review determined that the model and groundwater impact assessment are suitable for supporting the Project's EIS.

10.7.4 Model Predictions – Drawdown

10.7.4.1 Overview

The predictive groundwater modelling was conducted to assess the potential groundwater impacts of the Project. As such, predictive modelling was used to simulate the Project as well as mining at other approved and foreseeable mines within the model domain (see Section 10.4.2).

The predictive model has been set up to simulate Project mining activities from the end of calibration (2025) through to the end of operations (2043), after which the post-mining period begins for the Project. The predictive recovery starts from the end of mining at the Project (2043) up to 2519. Predictive models have been developed for three model scenarios:

- Null run – no mining within the region.
- Approved - all approved and foreseeable mining operations within the model domain that are likely to have model prediction effects, excluding the Project.
- Proposed – all approved and foreseeable mining with the addition of the proposed Project.

Project only (i.e. incremental impacts) are calculated as the difference between the 'Proposed scenario' model and the 'Approved scenario' model.

Cumulative impacts are calculated as the difference between the 'Proposed scenario' model and the 'Null run' model.

The process of mining reduces groundwater levels and pressures in surrounding geological units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and the nature and extent of the extractive activities and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within unconfined aquifers, including the water table (i.e. the upper surface of the saturated zone where pore water pressure equals atmospheric pressure).

Depressurisation and drawdown are greatest at the working coal-face and reduce with distance from the Project.

This chapter provides a selection of drawdown figures for different aquifer units. Section 8 of **Appendix K** provides additional drawdown figures, as referenced below.

10.7.4.2 Maximum Incremental Drawdown

The maximum incremental drawdown represents the maximum drawdown recorded at each model cell at any time over the model simulation duration time from the start of the calibration period (1960) to the end of recovery (2519). Predicted incremental drawdown figures show where maximum drawdown impacts are predicted to exceed 1 m as a result of the Project.

As shown in Figure 10-17, no incremental drawdown impacts exceeding 1 m are predicted for the alluvium as a result of the proposed Project (as shown by the absence of drawdown contours).

The predicted maximum incremental drawdown within the regolith is less than 2m and is shown in Figure 10-18. The incremental drawdown extent within the regolith is confined to a small area directly south of the Project area.

The coal seams of the Rangal Coal Measures are the primary groundwater bearing strata targeted by mining at the Project and experience drawdowns as a direct result of mining at the Project. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents.

Figure 10-19 and Figure 8-5 of **Appendix K** show the predicted maximum incremental drawdown for the Leichhardt and Vermont seams in the Rangal Coal Measures. These occur along the western margin of the Project pit area in both seams, with the Leichhardt seam exhibiting the highest magnitudes adjacent to the mined areas. In the Vermont seam, the footprint of drawdown extends further north and south relative to the Leichhardt seam.

Figure 8-1 of **Appendix K** shows that the predicted maximum incremental water table drawdown is concentrated around the Project mining area. The small areas of drawdown shown to the west of the Project area are the result of numerical effects within the model and do not represent any physical depressurisation beyond the Project.

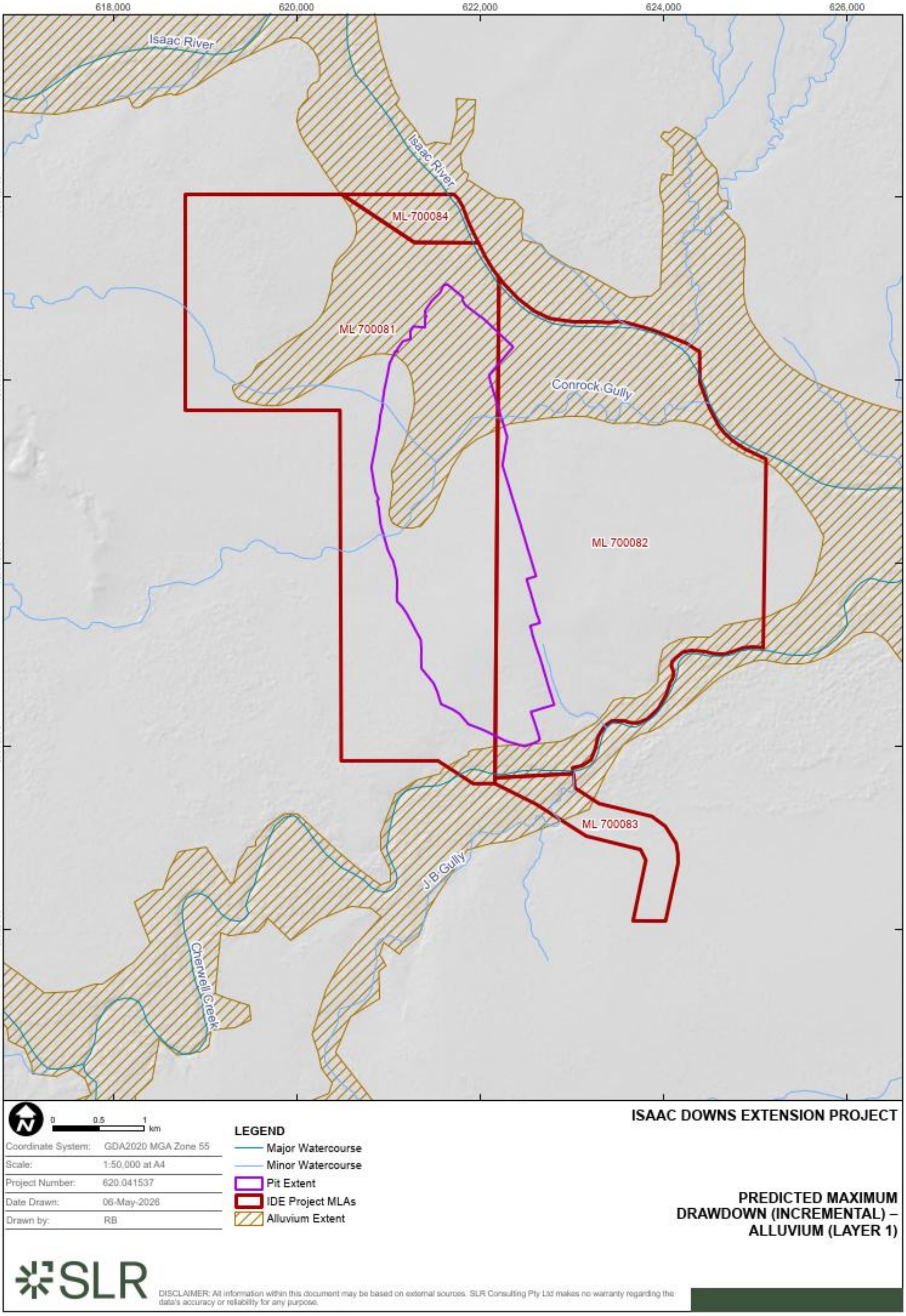


Figure 10-17 Predicted Maximum Drawdown (Incremental) – Alluvium

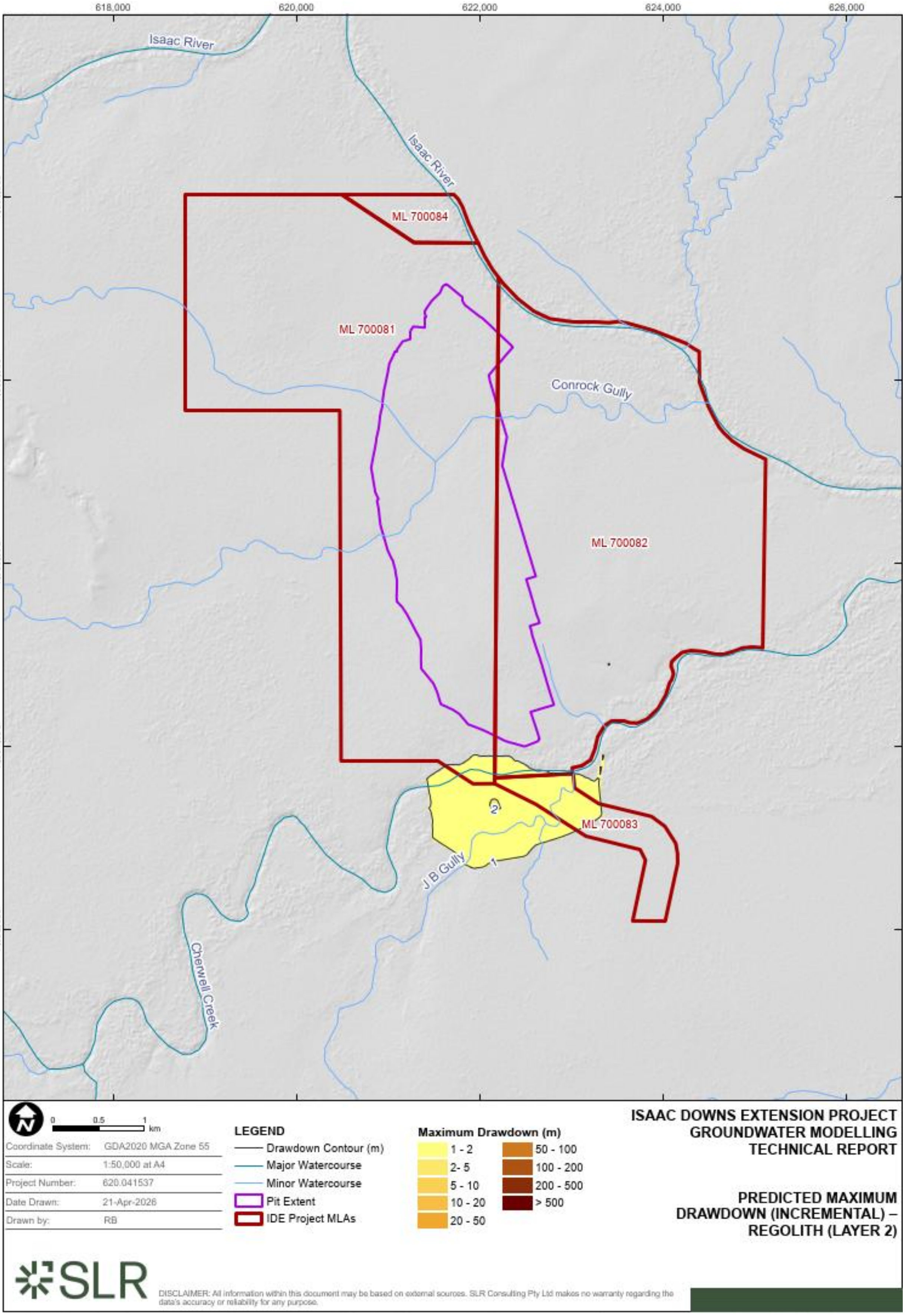


Figure 10-18 Predicted Maximum Drawdown (Incremental) – Regolith

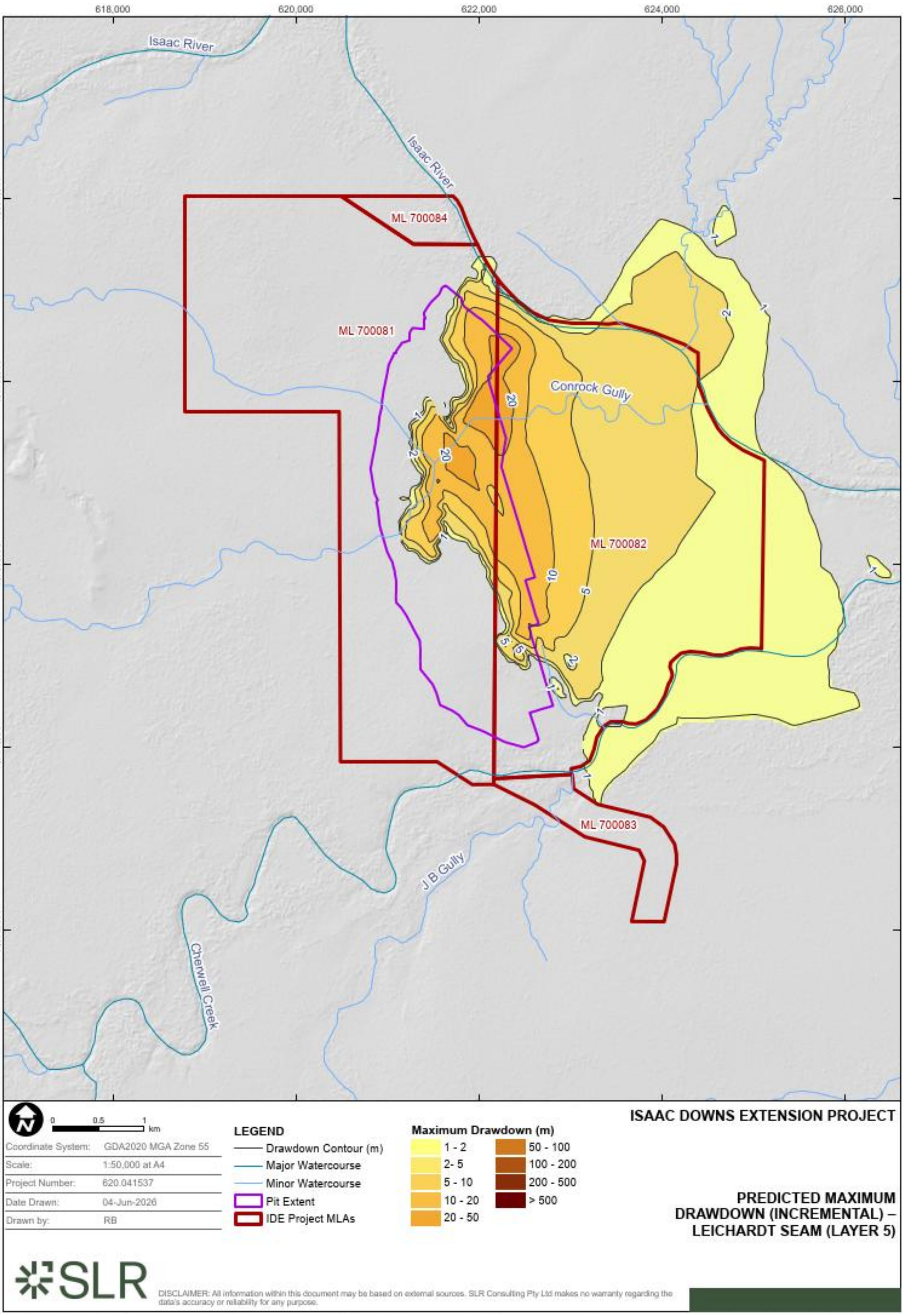


Figure 10-19 Predicted Maximum Drawdown (Incremental) – Leichardt Seam

10.7.4.3 Maximum Cumulative Drawdown

The predicted maximum cumulative drawdowns are obtained by calculating the maximum difference in heads from the start of the calibration period (1960) to the end of recovery (2519). Maximum cumulative drawdown is shown in:

- Figure 10-20 for the alluvium
- Figure 10-21 for the regolith
- Figure 10-22 for the Leichhardt Seam
- Figure 8-6 of **Appendix K** for the water table
- Figure 8-10 of **Appendix K** for Vermont Seam.

The results indicate that cumulative drawdown increases with depth, with the most pronounced depressurisation occurring within the mined coal seams, particularly the Vermont Seam. Shallower units exhibit broader but lower-magnitude drawdown patterns.

The spatial extent of cumulative drawdown reflects the combined influence of long-term mining activities within the Project area and neighbouring operations.

In the deeper coal seams, drawdown extends beyond the immediate Project footprint, indicating cumulative hydraulic interaction between adjacent mining areas.

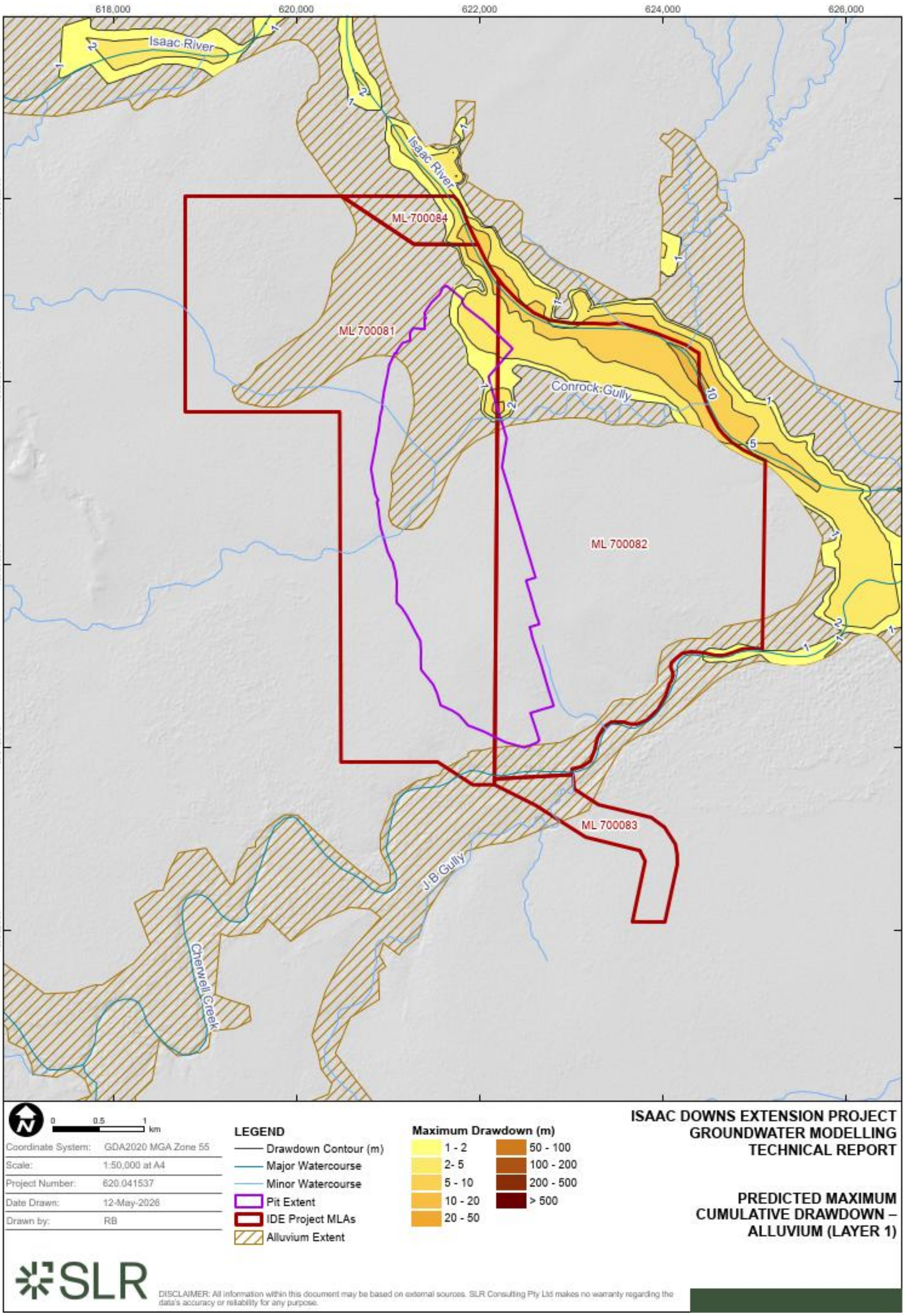


Figure 10-20 Predicted Maximum Drawdown (Cumulative) – Alluvium

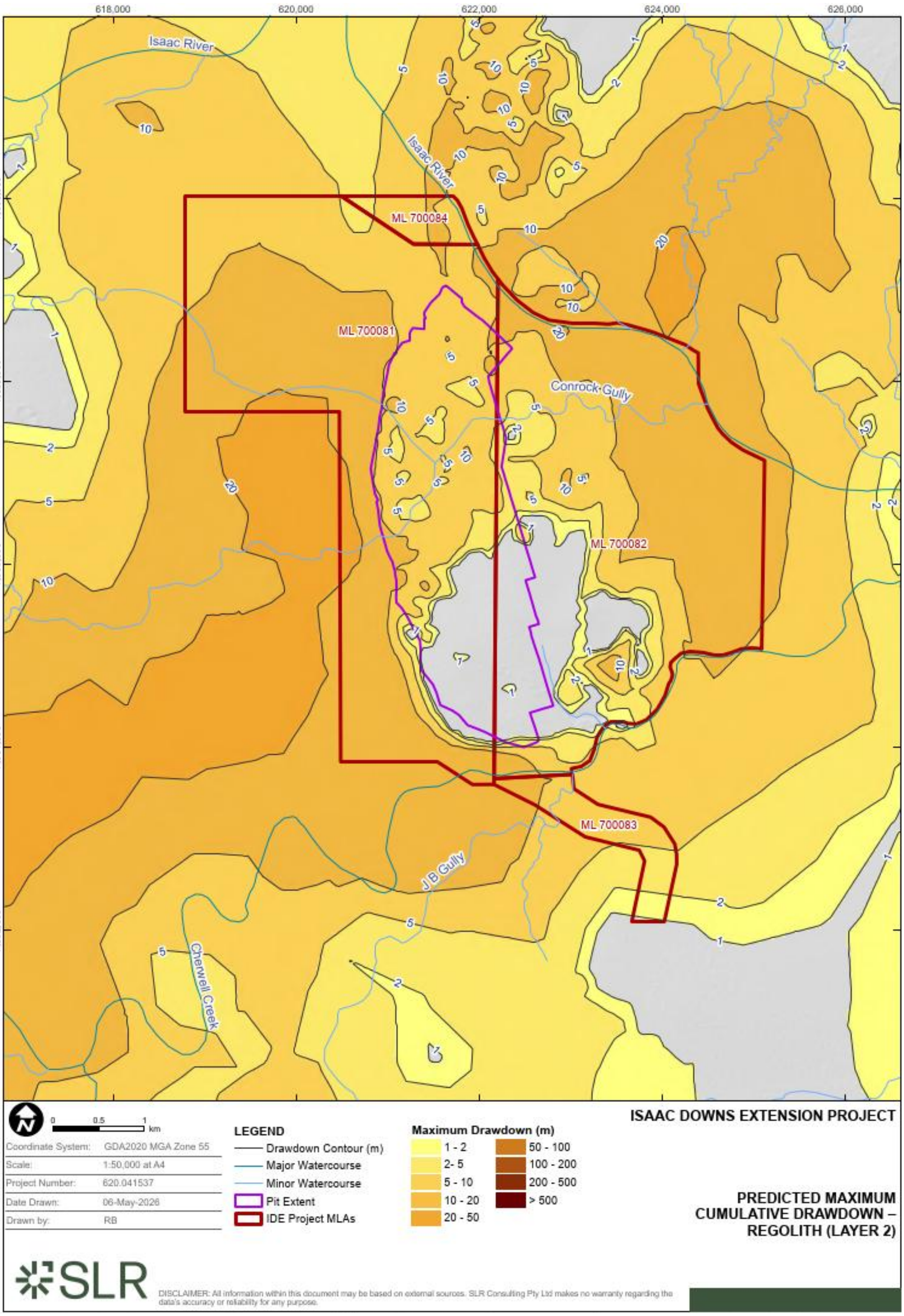


Figure 10-21 Predicted Maximum Drawdown (Cumulative) – Regolith

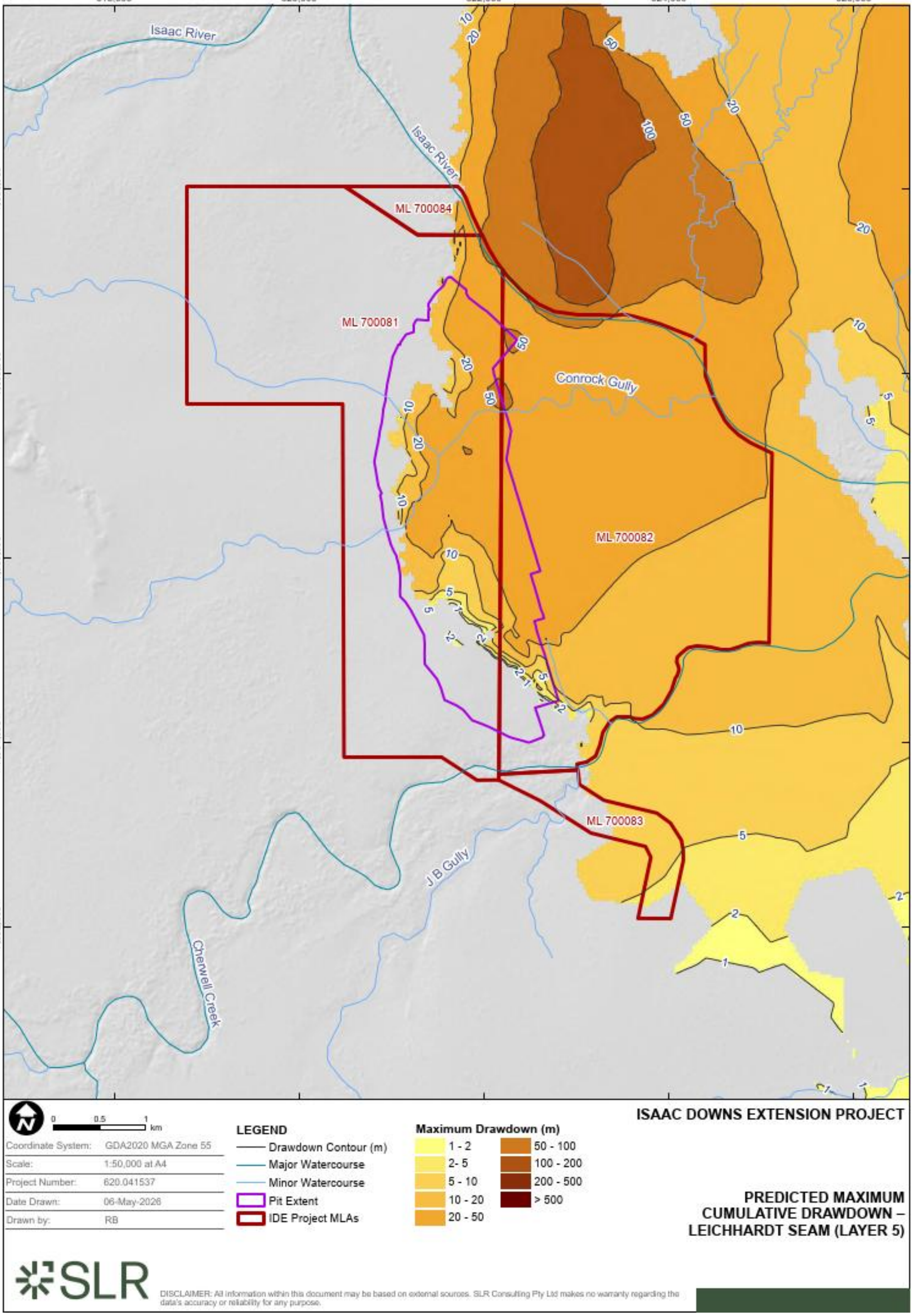


Figure 10-22 Predicted Maximum Drawdown (Cumulative) – Leichardt Seam

10.7.4.4 Residual Incremental Drawdown

The residual incremental drawdown is the drawdown at the end of the recovery period, due to the Project only. It is calculated for the last stress period of the simulation (i.e. at post mining equilibrium).

The residual incremental drawdown figures (Figure 10-23 and Figure 8-11 to Figure 8-15 of **Appendix K**) show where maximum drawdown impacts are predicted to exceed 1 m.

As shown in Figure 10-23, no incremental drawdown impacts exceeding 1 m are predicted for the alluvium as a result of the Project (as shown by the absence of drawdown contours).

Figure 8-13 of **Appendix K** shows that residual drawdown within the regolith (Layer 2) is limited in extent and confined to areas immediately to the south of the Project mining footprint at post-recovery, indicating minimal long-term impacts to the regolith following recovery.

Figure 8-14 and Figure 8-15 show that impacts are strongly concentrated around the Project mining area, with the largest magnitudes occurring in the Leichhardt and Vermont seams.

Comparison of the maximum incremental drawdown (Section 10.7.4.2) and residual incremental drawdown results indicates that drawdown magnitudes are substantially reduced by the end of the recovery period. Maximum drawdown occurs during active mining and represents the peak Project-related response across the model period, whereas residual drawdown represents the remaining incremental change at post-mining equilibrium and is lower in magnitude and more spatially confined.

For the Project, residual incremental drawdown is largely confined to areas immediately surrounding the mining footprint, with no widespread drawdown persisting beyond the Project area at post-recovery. This indicates a high degree of groundwater recovery following cessation of mining, with only small residual drawdown remaining within the deeper mined seams.

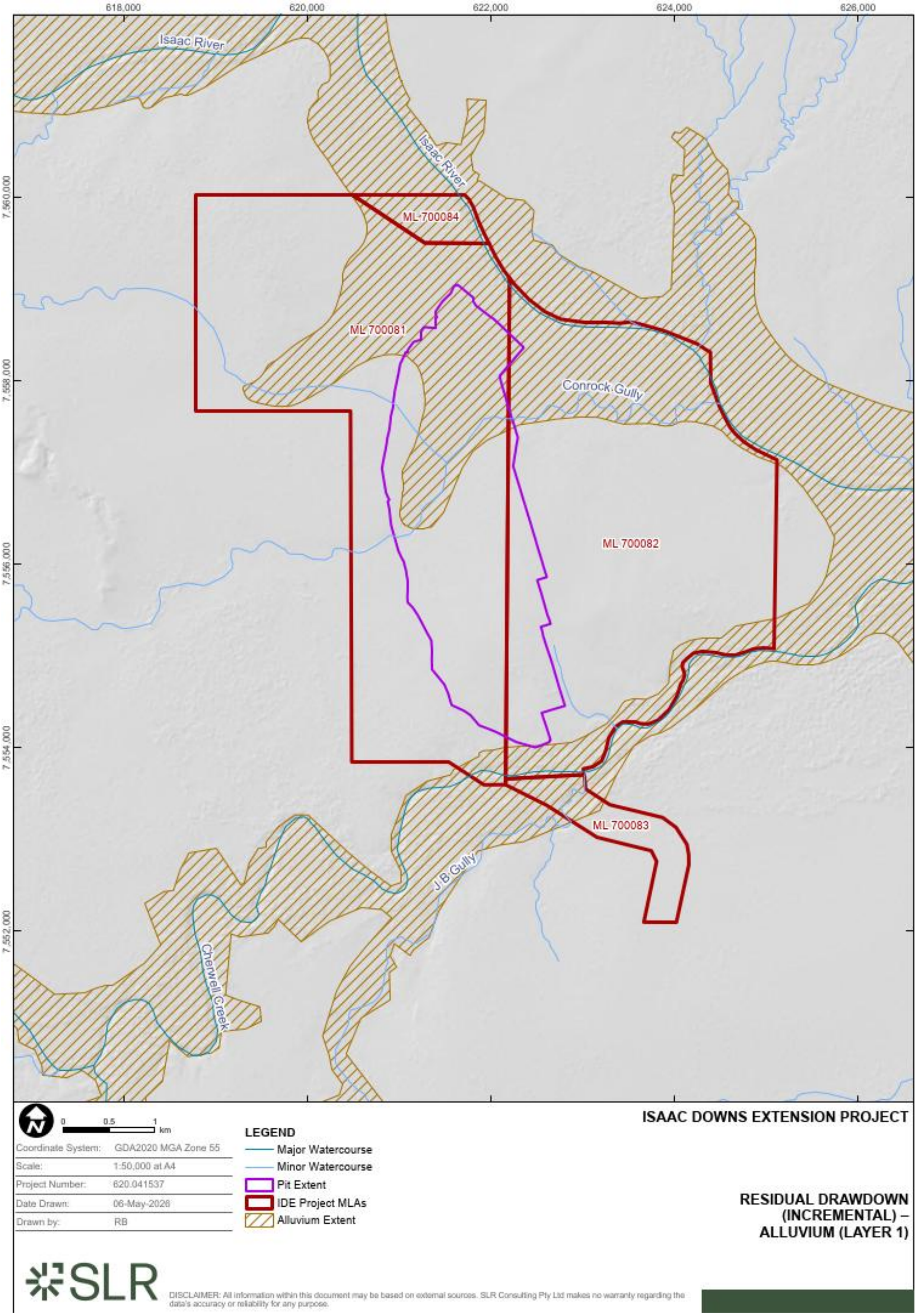


Figure 10-23 Residual Incremental Drawdown – Alluvium

10.7.4.5 Residual Cumulative Drawdown

The residual cumulative drawdown is calculated for the last stress period of the simulation, representing post-mining equilibrium conditions.

The residual cumulative drawdown figures (Figure 10-24 and Figure 8-16 to Figure 8-20 of **Appendix K**) show where cumulative drawdown impacts are predicted to exceed 1 m, for the last stress period of the simulation.

The residual cumulative drawdown for the alluvium (Figure 10-24) indicates that all drawdown within this layer arises from other existing and foreseeable mining operations rather than from the Project. This is consistent with the residual incremental drawdown results, which show no Project-only drawdown impacts exceeding 1 m in the alluvium. Accordingly, cumulative drawdown patterns within the alluvium predominantly reflect regional groundwater conditions and post-mining equilibrium responses associated with neighbouring mines, rather than Project-related effects.

A comparison of residual cumulative drawdown in the alluvium (Figure 10-24) and maximum cumulative drawdown in the alluvium (Figure 10-20) shows that cumulative drawdown is less for the post-mining equilibrium conditions.

Residual drawdown (cumulative) is shown across the water table, alluvium, regolith, and coal measures, with spatial patterns influenced by the location and extent of multiple mining operations. While drawdown magnitudes generally decrease with distance from the Project mining area, cumulative drawdown increases or persists in some areas further away, corresponding to the presence of other active or historical mines within the region.

In the deeper coal measures, particularly the Leichhardt and Vermont seams, cumulative drawdown reflects long-term groundwater responses to mining activities that extend beyond individual mine boundaries. These patterns indicate hydraulic interaction between mining areas and represent post-mining equilibrium conditions shaped by the combined influence of the Project and neighbouring operations.

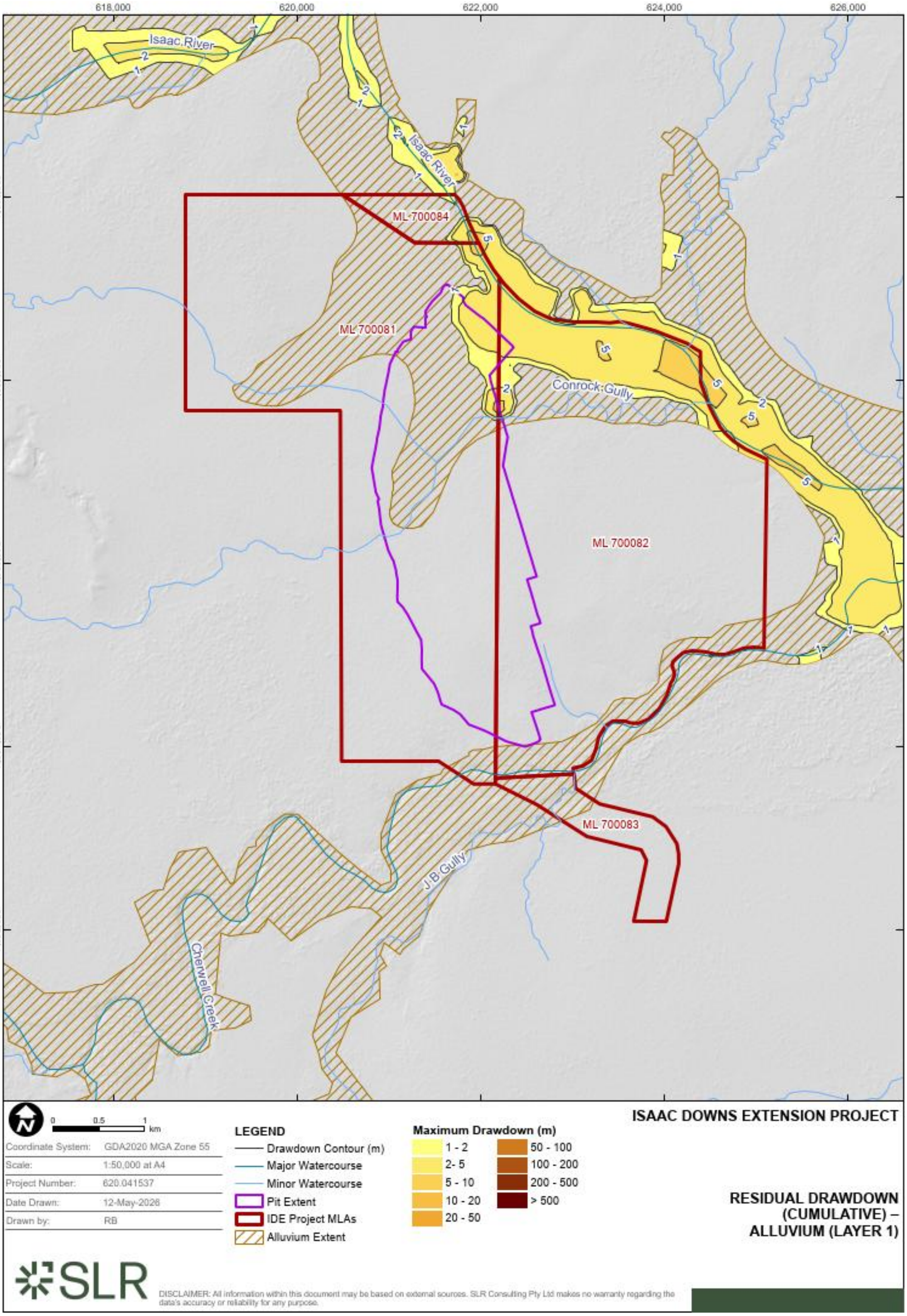


Figure 10-24 Residual Cumulative Drawdown – Alluvium

10.7.5 Model Predictions – Groundwater Interception

10.7.5.1 Operations

The predicted groundwater inflows to the Project's mine pit during operations (2029 – 2043) are presented in Figure 10-25.

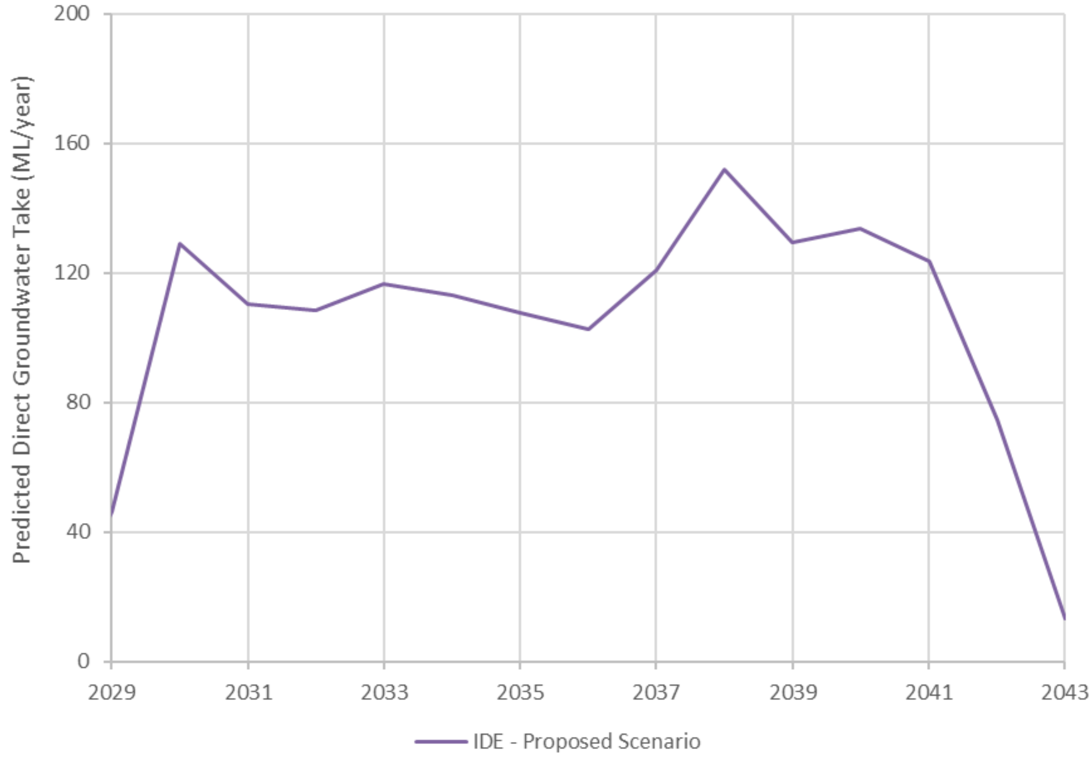


Figure 10-25 Mine Groundwater Inflows – Active Mining

10.7.5.2 Closure – Residual Void

The final predicted groundwater inflows to the residual void are shown on Figure 10-26, with inflows partitioned between those that flow into the residual void through spoil, and those that flow into the residual void through surrounding natural geological formations. This shows that almost all inflows are through spoil. Spoil materials are significantly more permeable and loosely compacted than the natural geological formations, providing preferential pathways for groundwater movement. As a result, groundwater is expected to enter the void predominantly through spoil.

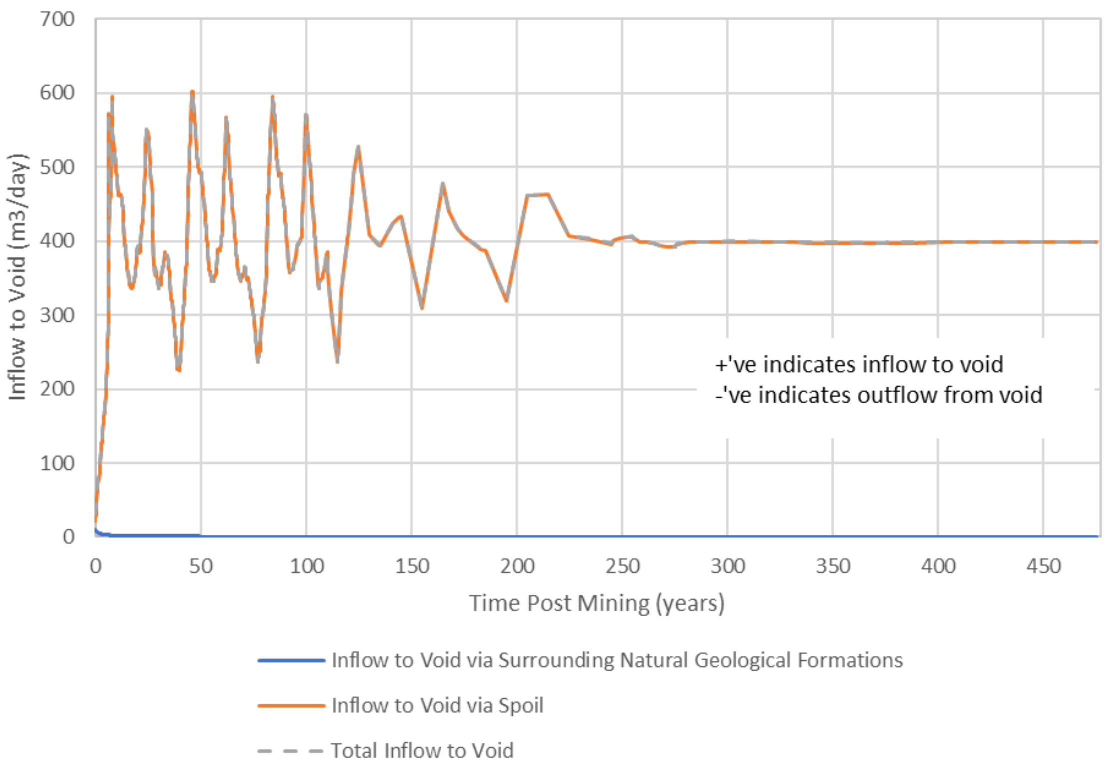


Figure 10-26 Predicted Residual Void Groundwater Inflows – Project Void

10.7.6 Model Predictions - Incidental Water Impacts

10.7.6.1 Influence on Alluvial Aquifer - Operations

The predicted incremental change in groundwater take from the alluvial aquifer due to the Project was calculated by comparing the net alluvium fluxes in the 'Proposed scenario' against the 'Approved scenario', with results shown in Figure 10-27. This shows that between the commencement of Project mining in 2029 and the end of mining in 2043, there is a predicted overall loss of water from the alluvial aquifer that is attributable to the Project of between approximately 0 and 34.5 ML/year. This represents a negligible reduction in the context of regional surface water flows; for example, compared to the mean daily flow of 430 ML/d in the Isaac River at Deverill, this equates to approximately 0.02% of annual flow.

The predicted cumulative alluvium net flux, is shown in Figure 8-24 of **Appendix K**. This shows that between 2029 and the end of Project mining in 2043, there is a predicted overall cumulative loss of water from the alluvial aquifer of between approximately 470 and 700 ML/year. This represents the net water flux associated with the alluvium across the entire regional-scale numerical model extent. As this is a cumulative prediction, the general trends in increasing and decreasing rates of loss of water from the alluvium cannot be attributed to the Project but to all mining operations represented in the model.

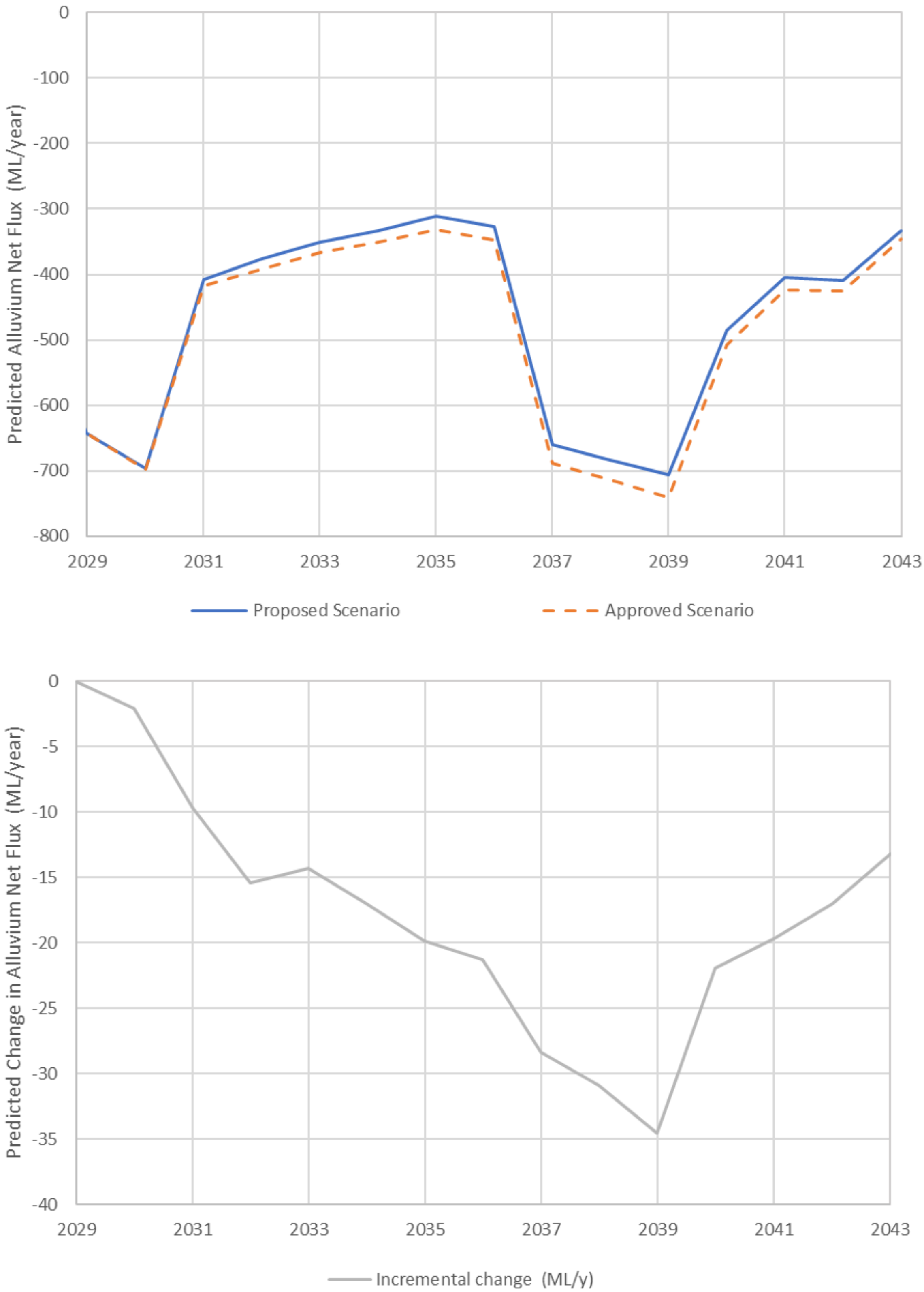


Figure 10-27 Incremental (Project) Predicted Alluvium Net Flux (top) and Change in Alluvium Net Flux (bottom)

10.7.6.2 Influence on Alluvial Aquifer – Post Mining

The predicted change in incremental (i.e. Project) alluvium net flux is shown on Figure 10-28.

The incremental net flux time series shows that post-mining variations are minor and do not exhibit any sustained increase in alluvium water loss attributable to the Project. Overall, the post-mining results demonstrate that Project-related impacts on alluvium water take are short-term, with no ongoing Project-specific increase in alluvium loss following mine closure.

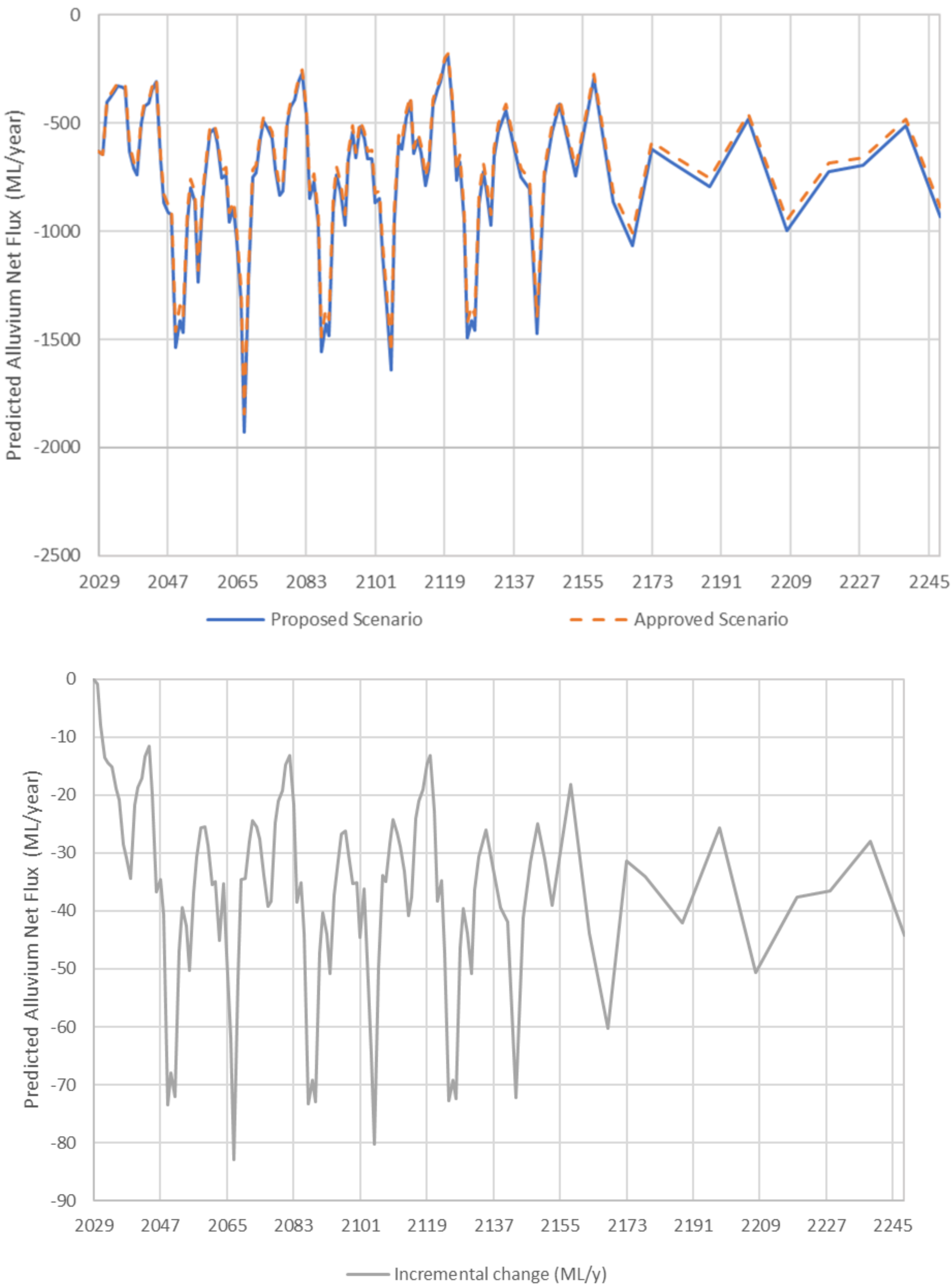


Figure 10-28 Predicted Alluvium Net Flux (top) and Change in Alluvium Net Flux (bottom) – Post Mining

10.7.6.3 Loss of Flow in Stream - Operations

Mining activities can result in a change in gradient from the aquifer into the watercourse, thereby reducing the rate at which baseflow occurs. The predicted change in net flux to the Isaac River, under both incremental and cumulative conditions, is shown in Figure 10-29.

This shows that between 2029 and the end of Project mining in 2043, there is no net flux in water moving in or out of the Isaac River that is attributable to the Project. The maximum cumulative net loss of water from the river is approximately 84 ML/year under a simulated future flow condition in 2030. This represents the net water flux associated with the River across the entire regional scale numerical model extent. As the Project does not result in a net flux of water to/from the River all fluxes are attributed all other mining operations represented in the model.

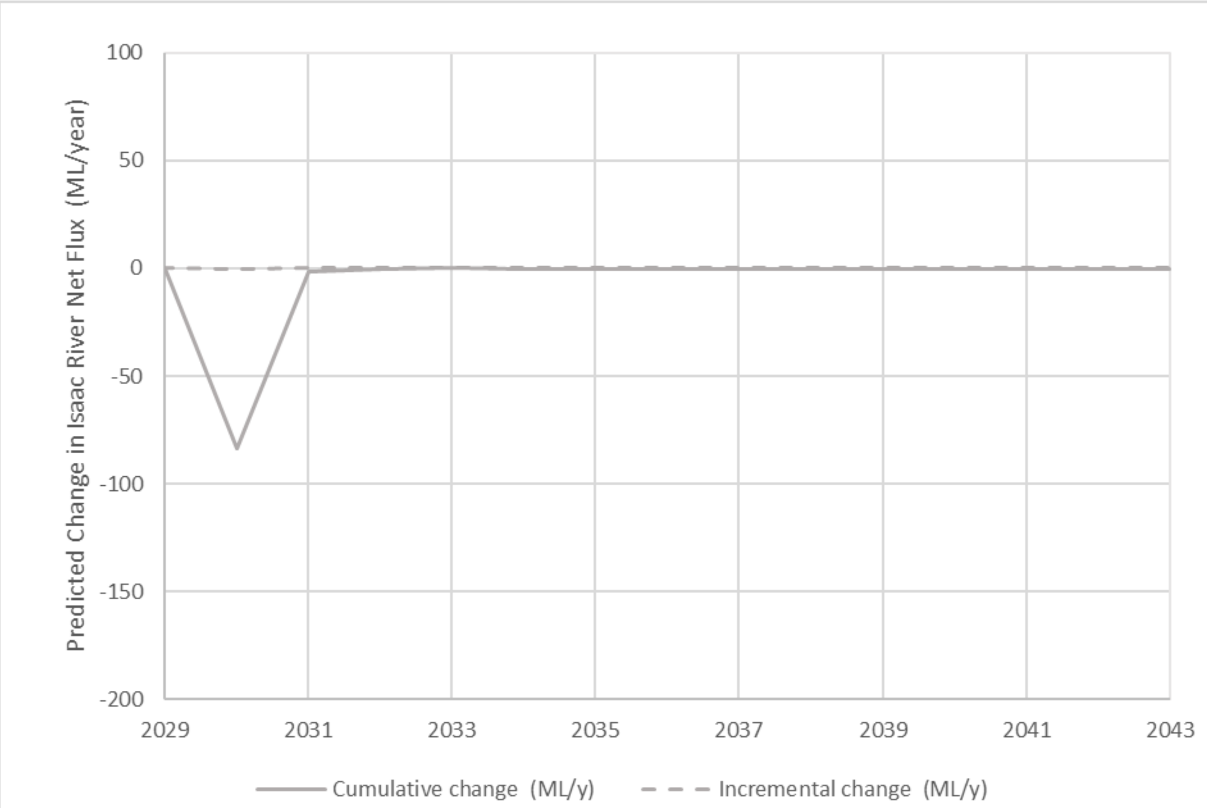


Figure 10-29 Predicted Reduction in River Baseflow (Incremental and Cumulative)

10.7.6.4 Loss of Flow in Stream – Post Mining

The predicted incremental (Project only) change in net flux and the predicted cumulative net flux of water moving in or out of the Isaac River for the post mining period are shown in Figure 10-30. This shows that both incremental and cumulative net fluxes to the Isaac River stabilise, with no ongoing Project-specific loss of river baseflow predicted during the post-mining period. The incremental net flux demonstrates that the Project has no impact on River flux.

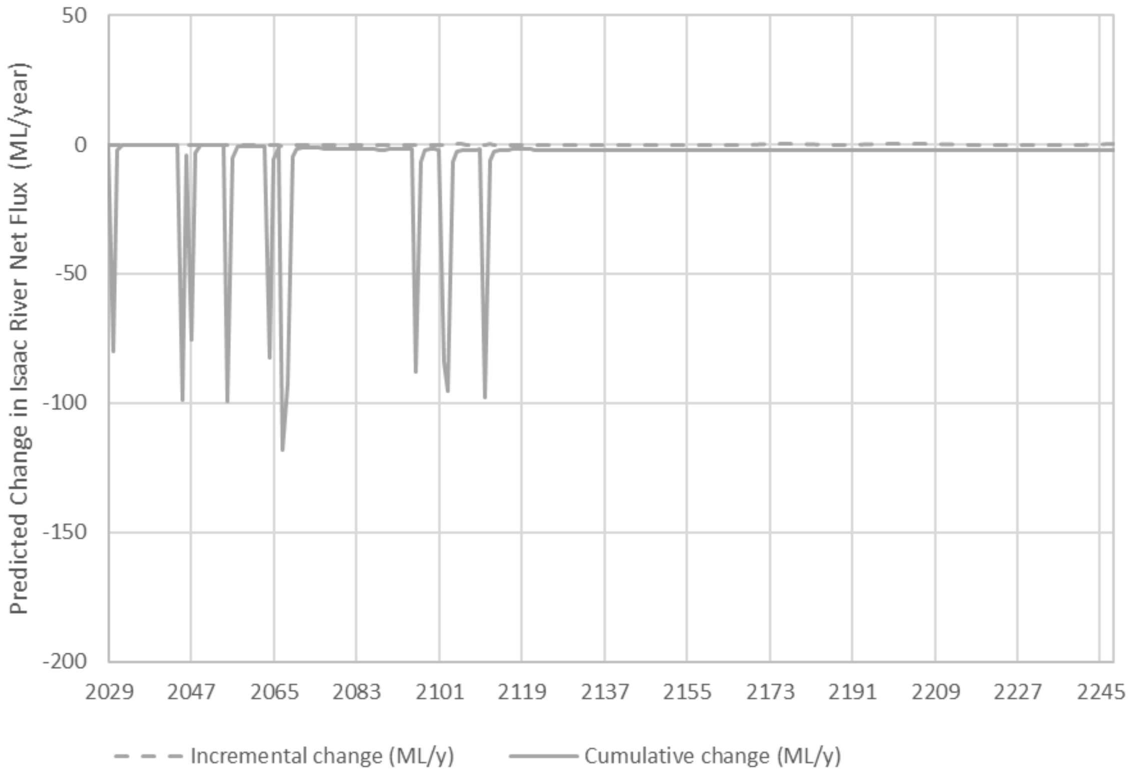


Figure 10-30 Predicted Reduction in River Baseflow (Incremental and Cumulative) – Post Mining

10.7.7 Model Predictions – Landholder Bores

Landholder bore locations are shown in Figure 10-9. The groundwater model was used to predict incremental and cumulative drawdown at landholder bores, with results discussed in Section 10.8.1

10.7.8 Model Predictions - Flow Path Simulation

An analysis of the water movement within the final landform was undertaken to simulate and assess the movement and fate of water particles through the groundwater system post mining. A number of particles were placed on the final landform and within the residual void in the recovery groundwater model and the model was used to simulate particle pathways along the groundwater flow field during recovery (i.e. 475 years).

The particles were placed at the surface of the model and released at the start of the post-mining simulation, with the movement of the particles then recorded during the post-mining simulation. Figure 10-31 shows the predicted movement of water particles in the 475-year recovery simulation of the final landform. The colours along the predicted particle flow paths provides the model layer the particle was simulated to be moving through, with the green to red scale classification representing particles moving from shallow to deep model layers.

The colour changes along the paths indicate that particles situated within the shallower saturated layers at the beginning of the post-mining simulation generally move progressively toward deeper layers over the post-mining period. The flow path analysis indicates the particles generally move toward the void lake, with many of the particles terminating in the void lake. Particles that move into the void during the post-mining simulation remain within the void for the duration of the simulation. Particles starting in the void themselves remain within the void for the duration of the simulation.

A series of particles starting outside the of the void are noted to travel outside the Project area, to the northeast in the direction of IDM. Particle tracking results indicate that migration is confined to the Rangal Coal Measures, and the flux direction is likely attributable to nearby mining operations (i.e. IDM) controlling drawdown and flow direction within the Rangal Coal Measures and terminates in the adjacent IDM void. The migration terminates in the adjacent void with no loss to regional groundwater.

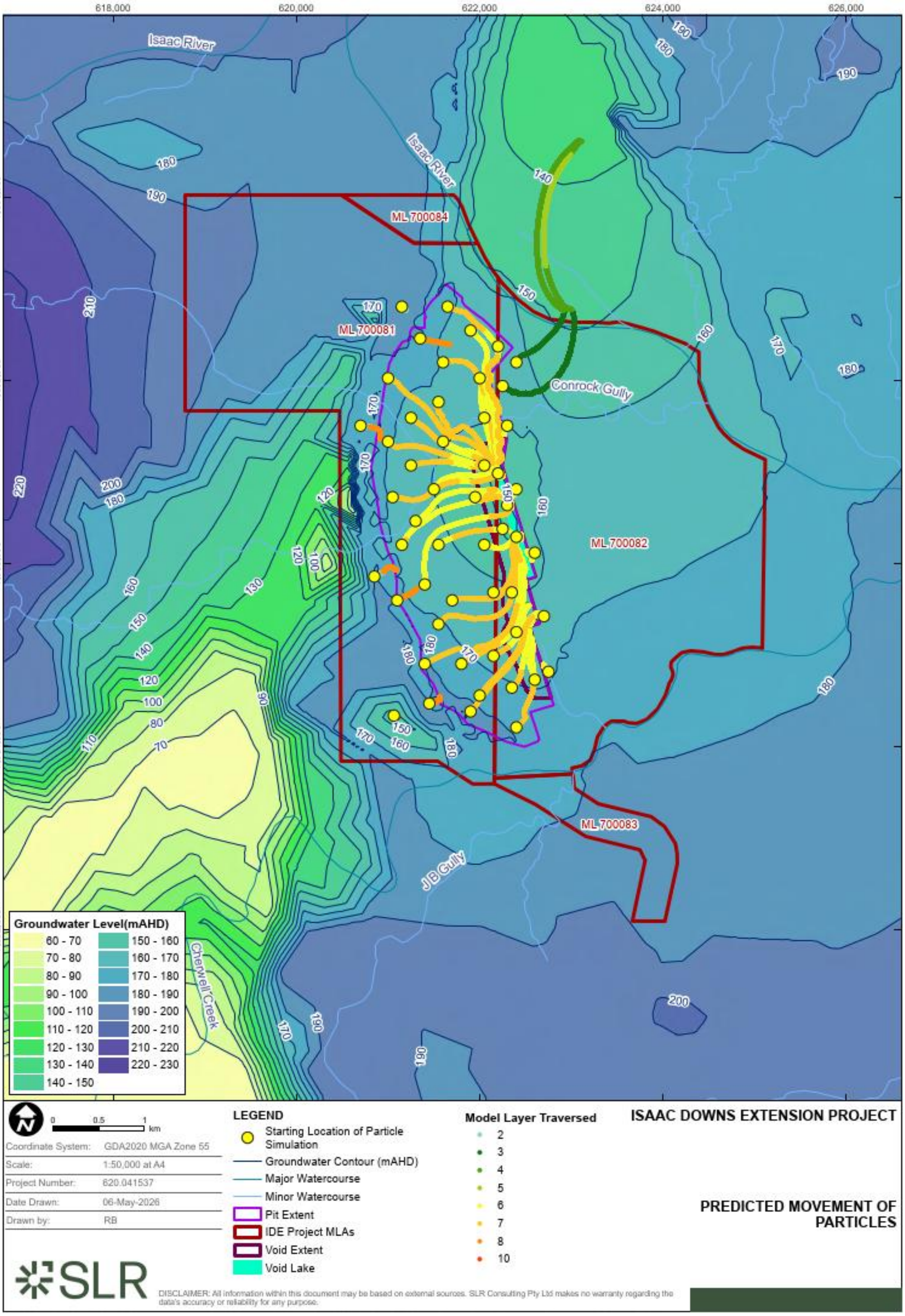


Figure 10-31 Predicted Movement of Particles

10.7.9 Sensitivity Analysis

Sensitivity analysis was undertaken to quantify how model calibration performance and model predictions respond to variations in input parameters, providing insight into model behaviour and uncertainty. Comparing calibration and prediction sensitivity allows for distinguishing between parameters that are constrained during calibration, and parameters that drive predictive uncertainty, which may or may not overlap. Such insights support decision-making in model refinement, data collection prioritisation, and risk-based scenario analysis. Details are presented in Appendix H of **Appendix K**. The sensitivity analysis identified that majority of the parameters are 'Type I - Type III' parameters. Types I-III parameters have an insignificant impact on model predictions or conditioned by calibration. Sensitivity analysis identified a limited amount of 'Type IV' parameters, which are parameters that are sensitive for the prediction but not the calibration. The uncertainty analysis covers the associated uncertainty from those parameters. The sensitivity analysis also highlighted several parameters that contribute to predictive uncertainty. A distinction was made between 'weak' and 'strong' Type IV parameters, with strong Type IV likely to be key contributors of prediction uncertainty. Prediction uncertainty was quantified for the quantities of interest.

10.7.10 Uncertainty Analysis

10.7.10.1 Overview

A Type 3 Monte Carlo uncertainty analysis was undertaken to estimate the uncertainty in the future impacts predicted by the model. Details are presented in Appendix H of **Appendix K**. This method operates by using the calibrated model realisations, executing the model independently for each realisation, and then aggregating the results for statistical analysis.

Calibrated realisations have been assigned a likelihood value as part of the sequential Monte Carlo calibration. As such, the quantities of interest (i.e. drawdown, mine groundwater inflow (active mining), alluvium take and river baseflow loss) are weighted for each realisation based on the normalised likelihood for this realisation. The statistical analysis is therefore performed on weighted predictions where realisations with a greater likelihood are given a higher weight. Results are presented as weighted percentiles for each quantity of interest.

The 109 calibrated realisations with the highest likelihood were selected for the uncertainty analysis. The predictions included in the uncertainty analysis were:

- Maximum Drawdown – the base case of the drawdown curve is plotting between the 67th and 95th percentile, meaning being at the upper end of the ensembles.
- Mine inflows (active mining) – the base case prediction mostly follows the 33-66th percentile interval, with inflows at later times being in the higher percentiles.
- Alluvium water take – the base case is conservative, following the 95th percentile of the ensemble. This gives certainty that the prediction for this quantity of interest is covering 95th percentile of cases, and the take might be lower than predicted.
- Loss of stream flow – very small range of the ensemble results, meaning the predictions have a high level of certainty.

Due to the long model run times and the number of realisations required for the uncertainty analysis, the assessment was limited to 200 years of post-mining conditions, by which time the final void lake level is expected to have reached equilibrium.

10.7.10.2 Uncertainty of Drawdown

To illustrate the level of uncertainty in the extent of predicted mine induced drawdown (1 m contours), the calibrated prediction model maximum drawdown (incremental and cumulative) and the 50th percentile maximum drawdown extent were compared to the maximum drawdown extent for the 5th and 95th percentiles. In addition, residual drawdown (incremental and cumulative) was assessed. Overall, the results indicate that the most likely estimate (MLE) (i.e. the parameter set that results in the highest likelihood, also otherwise known as the best calibrated model realisation) 1 m contour fits in between the median and the 95th percentile of the ensemble for the Regolith (Layer 2), the Leichhardt seam (Layer 5) and the Vermont seam (Layer 7). As mentioned in Section 8.1, no incremental drawdown exceeding 1 m is predicted for the MLE in the alluvium (Layer 1) as a result of the Project. This means that the MLE results presented in Section 10.7.4 are thus unlikely to underestimate drawdown.

10.7.10.3 Uncertainty of Mine Groundwater Inflows

The uncertainty of mine groundwater inflow (active mining) into the Project pit (active take) from the start of Project mining (2029) to the end of mining (2043), is shown for the incremental (Project only) scenario in Figure 9-1 of **Appendix K.** The figures show the predicted mine groundwater inflows (active mining) for the MLE model and different weighted percentiles prediction ranges.

The predicted uncertainty in mine groundwater inflows (active mining) is up to 0.45 ML/d deviation from the median for the incremental scenario. Overall, the results indicate that the MLE model is representative of the 33rd – 67th percentile range from 2029 to 2036 and the 67th – 95th percentile range from 2036 to 2043 for the estimated mine groundwater inflows (active mining). The MLE results presented in Section 10.7.5 are thus unlikely to underestimate mine inflows.

10.7.10.4 Uncertainty in Alluvium Water Take

The uncertainty in alluvium water take from the start of the predictive model (2029) to post mining equilibrium (2249), is shown for the incremental (Project only) scenario (Figure 9-2 of **Appendix K**) and the cumulative scenario (Figure 9-3 of **Appendix K**). The figures show the predicted alluvium take for the MLE model and different weighted percentiles prediction ranges.

Negative values indicate a reduction in alluvium take, while positive values indicate an increase in alluvium take. The MLE model is representative of the 5th percentile to 33rd percentile for the incremental and cumulative alluvium take. The MLE results presented in Section 10.7.6 are thus unlikely to underestimate alluvium take.

10.7.10.5 Uncertainty in River Baseflow Loss

The uncertainty of stream baseflow loss from the start of the predictive model (2029) to post mining equilibrium (2249), is shown for the incremental (Project only) scenario (Figure 9-4 of **Appendix K**) and the cumulative scenario (Figure 9-5 of **Appendix K**). The figures show the predicted stream baseflow loss for the MLE model and different weighted percentiles prediction ranges. Overall, the MLE model is representative of the median for the active mining period and of the 5th percentile to 33rd percentile for the post-mining period. The MLE results presented in Section 10.7.6 are thus unlikely to underestimate river baseflow loss.

10.7.11 Climate Change

Consideration has been given to the potential influence of long-term climate change on groundwater recharge process and associated impacts. Climate change projections for the Project area indicate a modest reduction in annual rainfall and an increase in evapotranspiration. Under the SSP3-7.0 high-emissions scenario, annual rainfall is projected to reduce by approximately 10% by 2090, while potential evapotranspiration is projected to increase by approximately 12% (Queensland Government, 2024). These changes are expected to reduce effective recharge non-linearly, because recharge is controlled by rainfall intensity, event frequency, soil moisture conditions and evapotranspiration losses. The predictive uncertainty assessment includes varying recharge rates by up to an order of magnitude. As a result, potential future climate change to rainfall is covered within the range of recharge rates as modelled for uncertainty analysis for the impact assessment.

10.8 Assessment of Impacts

10.8.1 Landholder Bores

Landholder bores are described and shown in Section 10.6.2.

Chapter 3 of the Water Act provides bore drawdown threshold triggers of 2 m for unconsolidated aquifers, and 5 m for consolidated aquifers, to aid in the assessment of impacts to third party bore users. These criteria have been adopted for the assessment.

Table 10-10 presents the MLE maximum predicted incremental drawdown at each bore, along with the approximate timeframes in which these peaks are expected to occur. In addition, Table 10-10 includes the 95th percentile drawdown from the uncertainty analysis, representing a conservative, high-end estimate of groundwater decline that exceeds most modelled outcomes. The periods during which 95th percent drawdown is predicted to exceed the relevant Water Act thresholds is also presented.

Model results indicate that the MLE maximum incremental drawdown does not exceed the 2 m or 5 m Water Act thresholds at any landholder bore. The uncertainty analysis shows that, for most bores, predicted drawdown remains within the 2 m and 5 m envelopes, except at 5 Mile Bore and 5 Mile Windmill Bore. At these bores, the 95th percentile drawdown marginally exceeds 5 m, suggesting exceedance is possible at these locations under conservative assumptions.

Mining is scheduled to commence in 2028 and conclude in 2043, followed by a modelled recovery period from 2044 to 2519. For the majority of landholder bores, maximum incremental drawdown occurs after mining has ceased, typically during the recovery period.

Overall, groundwater impacts are predicted to be limited, with drawdown remaining below regulatory thresholds for the MLE maximum drawdown prediction. The likelihood of widespread exceedances of drawdown thresholds at landholder bores due to the Project is low.

Table 10-10 Drawdown Impact on Landholder Bores

Year	Assumed Formation[1]	Longitude (GDA2020)	Latitude (GDA2020)	Bore Depth (m)[2]	Incremental			
					MLE Maximum Drawdown (m)	95th Percentile Drawdown (m)	Timing of Maximum Incremental Drawdown	Timing of Threshold Exceedance (2 m / 5 m)[2,3]
5 Mile Bore	Regolith	148.191184	-22.073753	36.3	<0.1	5.22	2050-2059	2044
5 Mile Windmill	Regolith	148.191223	-22.073762	36.3	<0.1	5.22	2050-2059	2044
Horse Paddock	Vermont Underburden	148.148627	-22.101058	85	0.59	2.33	2050-2059	NA
RN100254	Fort Cooper Underburden	148.135004	-22.073990	>150	0.35	4.23	2050-2059	NA
RN103210	Fort Cooper Overburden	148.136002	-22.073983	65.53	0.36	1.42	2050-2059	NA
RN162815	Fort Cooper Seams	148.200391	-22.131091	59	1.04	2.5	2170-2179	NA
RN162816	Fort Cooper Seams	148.137663	-22.063565	45	0.23	1.39	2120-2129	NA
RN162824	Regolith	148.159903	-22.086046	15	0.91	1.28	2280-2289	NA
RN162825	Fort Cooper Seams	148.182672	-22.124599	40.83	1.43	2.37	2160-2169	NA
RN182871	Fort Cooper Overburden	148.153633	-22.130199	60	0.29	1.44	2040-2049	NA
RN182872	Fort Cooper Overburden	148.182634	-22.124725	50	1.27	1.44	2040-2049	NA

Note:

1 Bores assigned to definitive geological unit and model layers based on known geology bore depth.

2. Chapter 3 of the Water Act 2000 specified drawdown threshold triggers of 2 m for unconsolidated aquifers and 5 m for consolidated aquifers.

3. 'NA'= No exceedance to the Chapter 3 of the Water Act 2000 specified drawdown threshold triggers.

10.8.2 Surface Drainage

The Isaac River is the major drainage feature of the region. It forms the northern boundary of the Project area and flows from west-northwest to southeast.

A natural hydraulic gradient exists between the Isaac River and the associated alluvium that results in seepage from the Isaac River to the alluvium (i.e. a losing system). The change in alluvial aquifer groundwater levels induced by mining does not have the potential to increase the hydraulic gradient between the Isaac River and associated alluvium. Consequently, the model does not predict that the average rate of seepage from the Isaac River to the alluvium will increase over the life of the Project, and therefore, the Project does not result in any loss of baseflow to the Isaac River and there are no other predicted groundwater-related impacts to surface drainage as a result of the Project.

10.8.3 Groundwater Quality

This section describes the potential sources and pathways for groundwater quality changes associated with the Project.

10.8.3.1 Spoil

Spoil emplacement at the Project will occur both within the mined void (in-pit backfill) and at designated out-of-pit spoil dump landforms, including the southwest and east out-of-pit dumps. The geochemical properties and environmental risk associated with spoil across all dump areas has been assessed in **Appendix F**, with results summarised in **Chapter 7**.

The spoil geochemical assessment demonstrated that spoil materials proposed for both in-pit and out-of-pit dumps are overwhelmingly non-acid forming, with low total sulphur concentrations and a strong excess of acid neutralising capacity. Leach testing showed that seepage from spoil is expected to be neutral to alkaline, with low salinity and very low dissolved metal concentrations, typically at or near laboratory detection limits.

For out-of-pit spoil dumps, it was concluded that the low contaminant source strength of spoil, combined with landform design and internal attenuation within the spoil mass, results in a low risk of groundwater quality impacts. No sustained acid generation or metalliferous drainage is expected from these landforms post-closure.

For in-pit spoil dump, interaction between groundwater and backfilled spoil is similarly characterised by neutral to alkaline seepage chemistry. Minor quantities of waste coal that are potentially incorporated within the in-pit spoil dump will be diluted and encapsulated by large volumes of non-acid forming spoil, ensuring groundwater quality is not adversely affected.

Based on the geochemical characteristics and assessed seepage behaviour of both in-pit and out-of-pit spoil, **Appendix F** concluded that spoil emplacements present a low risk to groundwater quality during operations and post-closure.

10.8.3.2 Final Void

The final predicted groundwater inflows to the residual void from the groundwater model is shown in Figure 10-26. The results show that over time all flow is inwards towards the void and there is no outwards flux from the void. This means that the residual void functions as a long-term groundwater sink, limiting the potential for off-site groundwater quality impacts.

Water within the final void would evaporate from the final void water body surface and draw in groundwater from the surrounding strata and runoff from the final void catchment areas. A final void water balance has been prepared for the Project (see **Appendix I** and **Chapter 5**). This shows that the water level remains well below the surface of void, there is no risk of the lake spilling to surface waters, and water quality in the void remains suitable for a range of post mining land uses, including livestock watering and algae production. Irrespective of the water quality in the void, the final void water body would not pose a risk to the surrounding groundwater regime as the final void would remain as a groundwater sink.

The geochemical risks associated with the post-mining residual void, including groundwater interaction with exposed highwall and floor materials has been assessed in **Appendix F**, with results summarised in **Chapter 7**. The assessment concluded that water quality within the residual void will be influenced by neutral to alkaline groundwater inflows and spoil interaction, with limited potential for metal mobilisation. Therefore, the residual void was assessed as posing a low risk to surrounding groundwater resources.

10.8.3.3 Workshops and Storage – Leaks or Spills

All workshop and fuel/chemical storage areas (i.e. at the go-line area) at the Project will be developed and managed in accordance with current Australian Standards, as described in Section 10.9.2. This includes refuelling areas and chemical storage areas designed with adequate bunding and equipped for spill clean-up. These controls represent standard practice and are a legislated requirement at mining operations for preventing the contamination of groundwater. Therefore, there is low risk for groundwater contamination to occur as a result of fuel/chemical storage and handling.

10.8.3.4 Blasting

Blasting activities have the potential to release metals, metalloids and ammonia associated with chemical reactions during the blasting process. During mining, the inward hydraulic flow gradients to the open cut voids would inhibit the potential for any outflow of potential contaminants. Post-mining, model results indicate that the residual void continues to form a hydraulic sink such that there is no discharge offsite to the surrounding groundwater environment.

10.8.4 Aquifer Physical Integrity and Hydraulic Properties

The process of open pit mining proposed at the Project will result in the removal of the aquifer and aquitard units within the mine pit footprints.

Given the diversion will be less than 2m deep, the diversion will not interact with groundwater aquifers which are typically 10 – 20 mBGL.

It is considered that there is no potential for any other impacts to the physical integrity of any of the identified aquifer and aquitard units, since there is no mechanism for physical impacts to the geology to propagate away from the open pits (for example, as might occur associated with underground mining subsidence). As a result, there would in turn be no potential for impacts to the hydraulic properties of the identified aquifer and aquitard units outside of the open pit footprints.

10.8.5 Groundwater Dependent Ecosystems

10.8.5.1 Overview of Potential Impacts

The following potential impacts on GDEs have been assessed, as per the methodology from Richardson et al. (2011):

- Clearing of GDEs (Section 10.8.5.2)
- Partial or total loss or reduction in pressure of the aquifer being utilised by GDEs (Section 10.8.5.3).
- Changes to the interaction between surface flows and aquifers being utilised by a GDE (Section 10.8.5.4).
- Change in chemical composition or quality of an aquifer detrimentally impacting the health of a GDE (Section 10.8.5.5).

- Sedimentation of surface flows responsible for aquifer recharge (Section 10.8.5.5).
- Cumulative impacts (Section 10.8.5.6).

While there is no prediction of Project related groundwater drawdown in the alluvial aquifer, cumulative impacts may affect alluvial groundwater levels. However, the partitioning of groundwater in the alluvium between the perched groundwater unit and the alluvial aquifer limits the potential for propagation of drawdown impacts into the perched groundwater unit that supports GDEs. Figure 10-32 shows a pre-mining (all mining activity) GDE function in the Isaac River adjacent to the north section of the proposed mining pit (Figure 7-2 of **Appendix N** provides the indicative cross-section location). There is a separation through an unsaturated connection between the perched groundwater unit on which GDEs rely, and the alluvial aquifer on which drawdown impacts may occur. The mining operations model (Figure 10-33) shows cumulative drawdown impacts on the alluvial aquifer, which have not influenced groundwater levels in the perched groundwater unit due to partitioning and hydraulic separation. Cumulative drawdown on the regolith groundwater unit is also evident, though it has no impact on GDEs. In the operations model, groundwater in the coal seams drains into the mine pit for management within the mine water management system (refer to **Chapter 8**).

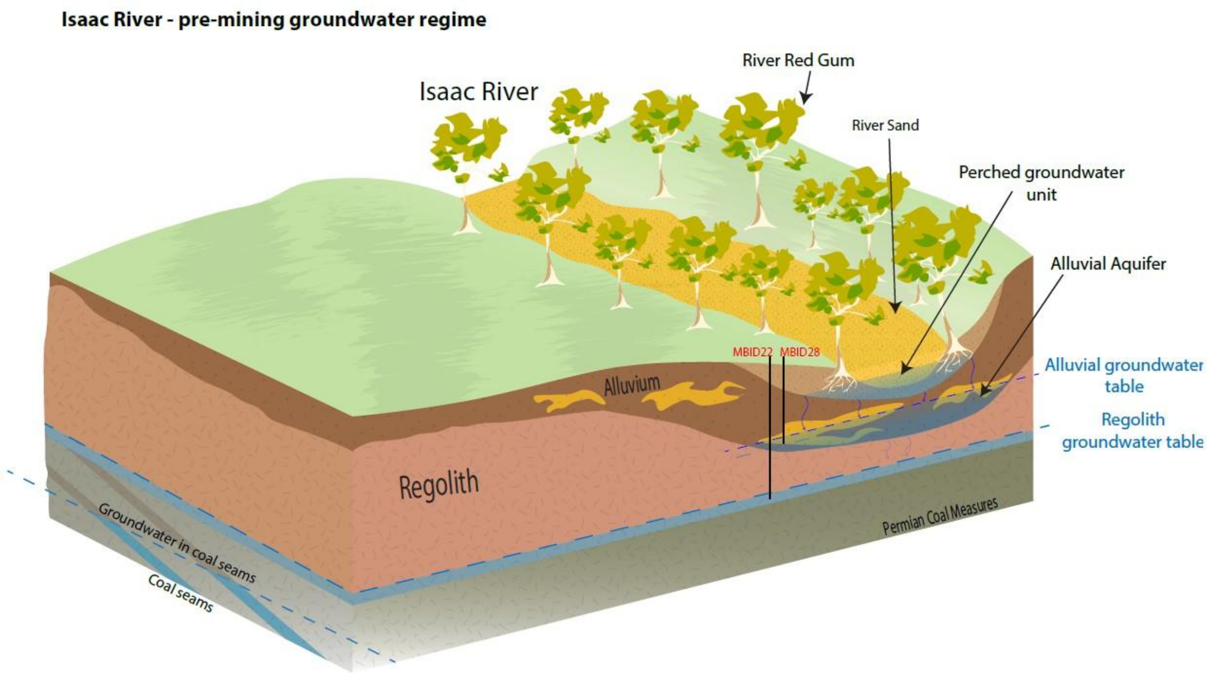


Figure 10-32 Pre-Mining Groundwater Regime

Isaac River - Operational model with maximum cumulative draw down.

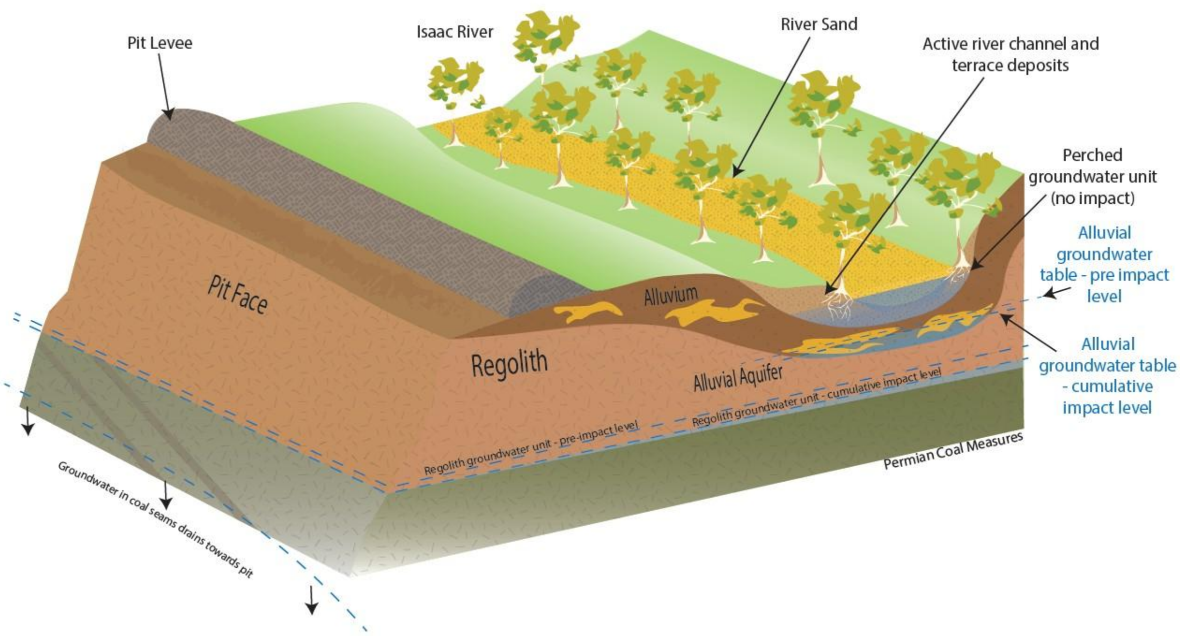


Figure 10-33 Mining Operations – Maximum Cumulative Drawdown

10.8.5.2 Clearing of GDEs

The proposed disturbance area for the Project intersects approximately 6.8 ha of localised parts of mapped GDE areas (see Figure 7-1 of **Appendix N**). These areas are mapped as RE 11.3.25 and are included in the assessment of impacts to terrestrial ecology (see **Chapter 11**), including identification of significant residual impacts to areas that require biodiversity offsets:

- The proposed Isaac River bridge crossing has a nominated 200 m wide construction corridor which, if it were all to be cleared, would impact 2.47 ha of groundwater dependent riparian vegetation fringing the Isaac River. However, this construction corridor width has been nominated to allow some flexibility in detailed design and it is likely that the disturbance in this area will be reduced.
- The proposed clearing for the dragline walk route to cross the Isaac River has a nominal 250 m wide construction corridor which, if it were all to be cleared, would impact 2.78 ha of groundwater dependent vegetation. However, this construction corridor has been nominated to allow some flexibility in detailed design and it is likely that the disturbance in this area will be reduced.
- Clearing of a maximum of 1.58 ha of groundwater dependent vegetation may be associated with the tie in point of the diversion of Conrock Gully and the Isaac River. However, this disturbance area allows for some flexibility in the construction of this tie in point, and is likely that the disturbance in this area will be reduced.

The nominated post mining land use for these locations in the PRCP (see **Appendix AB**) is riparian vegetation which would ultimately aim to achieve a similar ecosystem to that which existed pre-mining. Mapped GDEs, as shown in Figure 10-14, do not intersect with potential vegetation clearance associated with the bridge crossing of Cherwell Creek.

10.8.5.3 Aquifer Depressurisation

As per Section 10.7.4.2, there is no drawdown greater than 1 m attributable to the Project (i.e. the ‘incremental drawdown’) in the alluvial aquifer. The perched groundwater system is reliant on water from surface flows and hence is not subject to drawdown associated with mining projects.

While modelling predicts minor areas of groundwater drawdown within the Regolith layer, the GDE assessment found that groundwater in the Regolith is unlikely to support GDEs within and surrounding the Project area, and the predicted drawdown is outside the mapped GDE area.

10.8.5.4 Surface Flow Changes

The perched groundwater unit, which supports GDEs along the Isaac River and lower Cherwell Creek is hosted in active river channel and terrace deposits that interact directly with channel and overbank flows. Compared to the alluvial aquifer, the perched groundwater unit is also subject to much more rapid recharge and discharge. Project-related changes to surface flow volume and duration could influence recharge of the perched groundwater unit and affect the integrity of GDEs reliant on it.

The hydrology assessment (refer to **Chapter 9**) provides comprehensive descriptions of potential changes to the surface flow regimes of the Isaac River and Cherwell Creek, including from the Isaac River levee (and to a much lesser extent a levee plug along Cherwell Creek), the diversion of Conrock Gully, and infrastructure crossings of watercourses.

Detailed hydraulic and hydrology modelling for a range of annual exceedance probability (AEP) events has been completed for the Project for the operational and closure periods, inclusive of all Project structures and landforms with the potential to alter hydrology and geomorphology (Sections 9.4 and 9.5 of **Chapter 9**). The design of infrastructure with the potential to alter hydrology and geomorphology has been undertaken to minimise impacts (e.g. locating the Isaac River levee approximately 100–400 m from the high bank; bridge designs with minimal interference with flows; and a temporary dragline crossing). In addition, hydraulic and hydrology modelling has been completed for five cross sections through the Isaac River and adjoining floodplain upstream, adjacent and downstream of the Project, with the five cross sections representing areas of potential ecological value, containing REs, TECs, and GDEs. This modelling has identified:

- The Project will have negligible impact on hydrology and geomorphology (e.g. flood levels, velocity, bed shear stress and stream power) for more frequent flood events (e.g. 10% AEP or 1:10 year flood event)
- The Project will have negligible to minor impact on hydrology and geomorphology for less frequent flood events (e.g. 1% AEP or 1:100-year flood event) during operations.
- Post mining, with the decommissioning and rehabilitation of the crossing infrastructure and the Isaac River levee, and restoration of the associated floodplain, the Project will have negligible impact on hydrology and geomorphology.
- The Project will result in almost no change in the duration for which flood events will occur (less than 1 hour change in duration for all AEP events), as measured at the nominated cross section locations.

Based on these findings, it is expected that the Project will have a negligible impact on the landforms that host GDEs and the surface water flows that recharge the groundwater resources upon which the GDEs rely, and therefore, impacts to floodplain vegetation, riparian habitat, and vegetation condition from changes to hydrology, hydraulics, or geomorphology are expected to be negligible.

10.8.5.5 Water Quality Changes or Sedimentation

Groundwater predictive modelling identifies a permanent cone of depression around the mining void into which potentially saline groundwater flows from coal seams and regolith will be directed during and post mining (see Section 10.7.8). This will facilitate the direct drainage of groundwater into the mining void, where discharge capture will be controlled via the mine water management system during operations; and post mining the void will act as a groundwater sink.

Mine affected water will be captured within one of three proposed containment storages (see Section 8.4 of **Chapter 8**). The controlled release of mine affected water will occur under approved release conditions, based on flows and water quality, which are designed to protect downstream environmental values (see Section 8.7.2 of **Chapter 8**). There will be no predicted uncontrolled releases of mine affected from the Project (see Section 8.7.2 of **Chapter 8**).

Recharge to the perched groundwater unit that supports GDEs occurs during river channel flows associated with high-volume flood events with a substantial dilution factor and is unlikely that controlled releases of mine affected water would impact water quality within the perched groundwater unit to a degree that would compromise GDE health.

Surface water runoff from disturbed mining areas will carry sediment, requiring capture and management to prevent environmental harm. Section 8.4 of **Chapter 8** describes the design of sediment management systems for the Project. The Project's erosion and sediment control plan (ESCP) (see **Appendix AD**) will manage sediment captured in runoff, adopting the three cornerstones of erosion and sediment control:

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of clean and sediment water through the area of concern.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, nondispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion), or from windborne particles.

The Project will implement a combination of these control measures to effectively manage sediment and erosion at the site. When managed under the ESCP, there is an extremely low risk that excess sediment from disturbed mining areas will impact groundwater dependent vegetation.

10.8.5.6 Cumulative Impacts

Cumulative groundwater impacts are described in Section 10.7.4.3. Figure 10-20 shows the cumulative groundwater drawdown modelling for the alluvial layer (layer 1), indicating drawdown of 1 to 5 m directly adjacent to Project. As described in Section 10.8.5.3, the Project does not contribute to drawdown in the alluvial layer and hence drawdown in this layer is attributable to other mines in the local and regional area. While cumulative drawdown in the regolith is more extensive, based on the assessment that vegetation does not demonstrate dependence on the regolith (see Section 10.6.3), drawdown of the regolith is not expected to affect water availability to GDEs.

While other mining operations have the potential to impact GDEs on the Isaac River and associated local catchments, there are no reports of GDE impacts from existing mining operations. IDM implemented a GDEMMP in 2020 (3d Environmental, 2020b), specifically to monitor the impact of mining operations on GDEs fringing the Isaac River. To date, the monitoring at IDM has not identified any impacts to the health or function of GDEs associated with the Isaac River from operations. The outcomes of the IDM GDE monitoring support the findings of the Project's GDE assessment. In addition, the GDE assessment completed for the Winchester South project (3d Environmental 2023c) concluded a similar GDE function to areas assessed for the IDM and the Project, with groundwater-dependence restricted to the immediate riparian fringe of Isaac River and an associated floodplain wetland, and a GDE risk assessment for the Poitrel mine predicted no adverse impacts to GDEs.

Based on groundwater modelling (see Section 10.7), the Project does not further contribute to the cumulative impact of groundwater drawdown in the alluvial aquifer. Other local and regional mines or future projects will be subject to their own approval requirements for the management of GDEs, which will complement the proposed management of GDEs for the Project, as described in Section 10.9.3.4.

10.8.6 Stygofauna

10.8.6.1 Overview of Potential Impacts

Potential impacts to stygofauna could occur through:

- changes in groundwater quality associated with:
    - accidental leaks or spills of hydrocarbons and other chemicals from infrastructure areas or mining equipment.
    - seepage from spoil dumps or the void lake to groundwater.
- drawdown in aquifers associated with stygofauna.

10.8.6.2 Leaks or Spills

Any leaks or spills would be highly localised (e.g. at the Project's go-line area), and controls will be implemented to prevent or remediate any spills or leaks (see Section 10.9.2). Whilst hydrocarbons and chemicals can impact aquatic fauna at relatively low concentrations, it is unlikely that localised spills or leaks in active mining areas would interact with aquifers in which stygofauna may be present.

10.8.6.3 Seepage – Spoil and Void

As described in Section 10.8.3, the risk to groundwater quality from seepage from spoil or the void is low. As a result, the risk to the aquifers and stygofauna communities from changes to groundwater quality from seepage is low. The implementation of the groundwater monitoring and management plan (GMMP) (see Section 10.9.3) will identify if there are changes to groundwater quality that exceed trigger levels for investigation.

10.8.6.4 Changes in Groundwater Levels

Stygofauna within and surrounding the Project area have been identified in the alluvial aquifer in the alluvium adjacent the Isaac River. Modelled maximum groundwater drawdown in the alluvium as a result of the Project (i.e. incremental drawdown) and cumulatively with all other existing and proposed resource project, is described in Section 10.7.4.2 and Section 10.7.4.3, respectively. There are no incremental (i.e. Project only) drawdown impacts exceeding 1 m predicted for the alluvium. Cumulative drawdown in the alluvium ranges from 1 to 10 m, with this almost entirely due to the influence of other projects.

Therefore, the Project has a negligible contribution to drawdown in the alluvium, and as a result, has a negligible contribution to any potential impacts on stygofauna in the alluvium.

At the taxonomic level available for other studies across the region, the stygofauna assemblages identified in the Project's assessment are not unique. Localised cumulative impacts to the alluvium represent a relatively small portion of the available habitat. Therefore, the Project is considered unlikely to impact the long term survival and persistence of these communities.

As a result of the findings of a low risk of impacts to stygofauna from drawdown from the Project, no stygofauna specific management measures are proposed. However, the GMMP (see Section 10.9.3) will be implemented and will identify if there are changes to groundwater levels that are not within the predictions of the Project's groundwater modelling.

10.9 Management and Mitigation Measures

10.9.1 Landholder Bores

In accordance with Chapter 3 of the Water Act, mining proponents are required to identify, monitor and review impacts on underground water resulting from the exercise of underground water rights. This includes the preparation and ongoing review of groundwater impact predictions and affected area mapping to confirm whether actual groundwater behaviour is consistent with that predicted. Groundwater monitoring undertaken for the Project provides the primary mechanism to identify any divergence between predicted and observed drawdown, including the potential for impacts to occur beyond those anticipated at groundwater users (landholder bores). Where groundwater drawdown attributable to mining activities is predicted or observed to exceed relevant bore trigger thresholds at a landholder bore, the Water Act requires the proponent to assess the bore and, where applicable, enter into a make good agreement with the bore owner to mitigate the impact on water supply.

Based on the potential impacts on landholder bores described in Section 10.8.1, the incremental drawdown is not predicted to exceed the Water Act trigger for unconsolidated aquifers at any bores, with a low likelihood of exceedance at only two bores (5 Mile Bore and 5 Mile Windmill Bore), reflecting their close proximity to the Project and shallow screened intervals. The proponent will enter a make good agreement with the landholder as required.

Possible landholder bore impact mitigation measures that may be applied as part of a make good agreement include:

- refurbishment of an existing groundwater bore
- installation of a new groundwater bore
- establishment of an alternative water supply arrangement
- use of another mutually agreed form of mitigation.

10.9.2 Management of Leaks or Spills

Facilities at the go line for the storage of fuels and minor maintenance requirements will be constructed and bunded in accordance with the relevant Australian Standard specifications, including but not limited to the provisions of AS 3780:2008 – The storage and handling of corrosive substances, AS 1940:2004 – The storage and handling of flammable and combustible liquids (AS 1940), AS 3833:2007 – Storage and handling of mixed classes of dangerous goods in packaged and intermediate bulk containers.

Under the IPC Safety Health Management System, hazardous substances Safe Operating Procedures (SOP) will be in place at these operations. A register will be maintained on site for all chemicals. Where appropriate, material safety data sheets will be kept in storage areas or available for on-line access, as required.

Fuel storage areas are a potential source of hydrocarbons, and fuel storage areas will be constructed and bunded in accordance with the relevant specifications of AS1940. Fuel storage areas will be inspected regularly, with repair and maintenance work completed as required. Bunds filled with stormwater will be drained or pumped out by a licensed contractor as soon as practicable to maintain the bund volume.

A waste oil system will collect all waste oils for transfer offsite or recycling onsite, so that waste oils are not released to the environment. Lubricants will be stored in a bunded concrete area with a sump to collect any spills.

All runoff from areas with potential contaminants will pass through water management controls such as an oily water separator or sediment trap before entering the mine affected water management system.

Incident reporting and the management of spills will be undertaken in accordance with the site operational incident reporting forms and procedures. A spill response protocol will be developed and implemented. Spills management procedures will be designed to contain and remediate any spills of fuels or chemicals to prevent impacts to surface waters. Spill kits will be available close to areas where fuel, oils and/or chemicals are being regularly used or stored.

Specific waste bins and bunding will be used to isolate waste liquids, chemicals and hazardous wastes.

Hazardous liquid wastes awaiting disposal, such as hydrocarbons and oils, will be stored appropriately in accordance with AS1940:2004 'The storage and handling of flammable and combustible liquids'.

All areas containing potential contaminants or hazardous wastes will be protected from flooding by levees with flood protection for a 0.1% AEP (1:1,000 year) flood event. Hence, they will have a negligible risk of releasing contaminants during flood events.

With the implementation of these mitigation and management measures, the risk to the groundwater quality from leaks or spills is very low.

10.9.3 Groundwater Monitoring and Management Plan

10.9.3.1 Overview

A GMMP has been prepared for the Project (see **Appendix AE**). The GMMP describes the groundwater monitoring regime for the Project and associated groundwater impact limits and triggers for further assessment and groundwater impact management during the life of the Project. This section describes, based on the GMMP, the proposed groundwater monitoring network, including proposed water-level drawdown triggers and groundwater-quality limits for the defined compliance bores.

10.9.3.2 Groundwater Monitoring Network

A groundwater monitoring network has been established for the Project, as described in Section 10.5.2. This monitoring contains sufficient monitoring points in terms of spatial coverage of monitoring across all formations of interest to describe pre-mining groundwater conditions and monitor potential changes in the groundwater environment during the Project's construction, operations and rehabilitation phases.

The groundwater monitoring network includes defined compliance and interpretation bores as shown in Table 10-11. Compliance bores are bores that have impact criteria thresholds established in the GMMP, whereas interpretation bores are bores primarily intended to provide for background monitoring data outside of the potential mining impact area, that would support the assessment of an exceedance of a limit or trigger at a compliance bore. Bores 205S, 205DR 593, 594, 592s, 592D, which are currently being monitored, are located within the footprint of the pit and will be mined out, and therefore, are not included in the Project's GMMP monitoring network, but will be monitored for interpretation purposes until removed.

Figure 10-34 presents the proposed GMMP groundwater monitoring network for each aquifer, classifying bores as either compliance or interpretation for each relevant aquifer unit.

10.9.3.3 Monitoring Regime – Baseline and During Mining

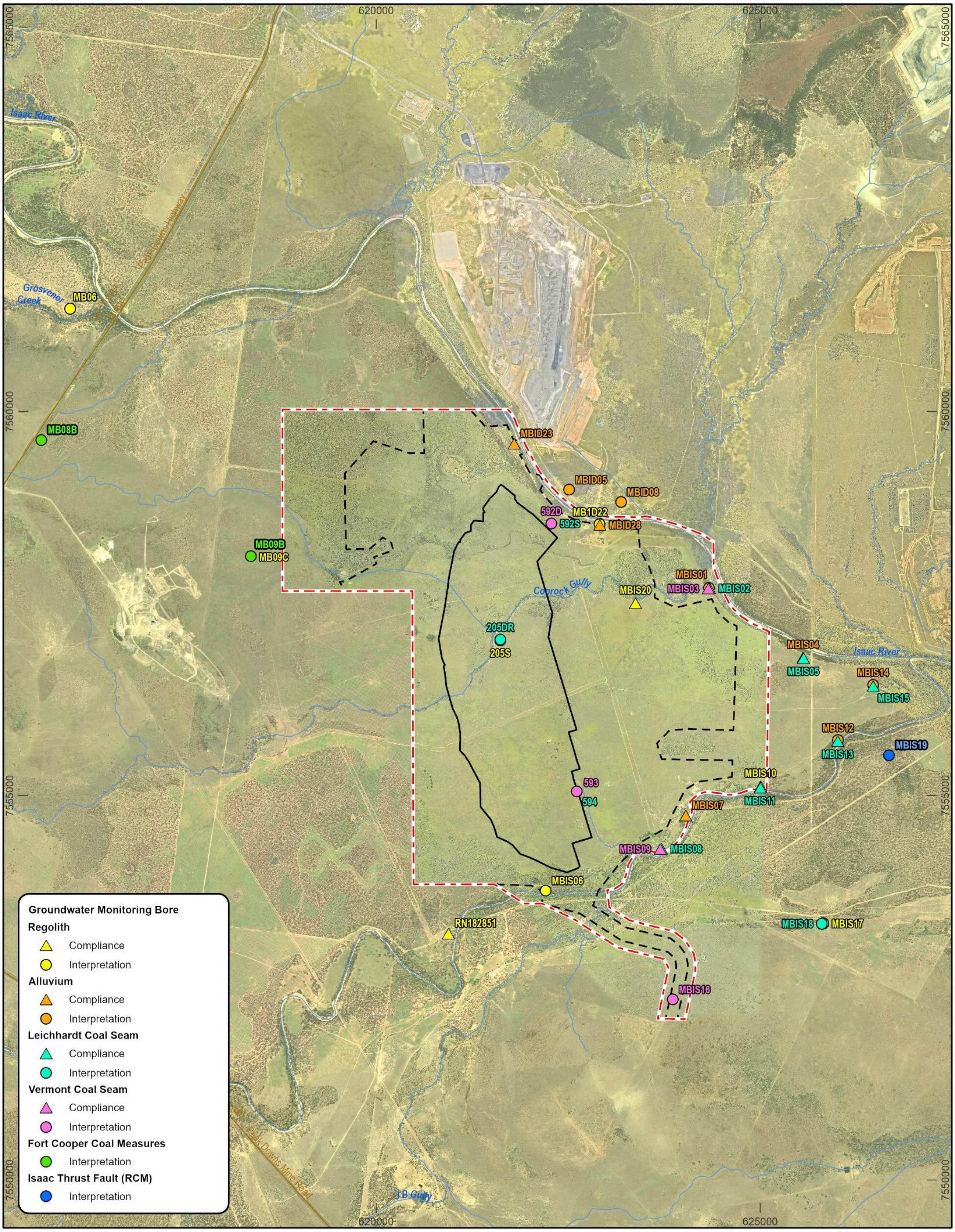
Routine monitoring includes groundwater level and quality monitoring. Routine monitoring prior to the commencement of the mining operation (i.e. baseline period) which is ongoing, will provide for continued assessment and characterisation of the pre-mining groundwater system, including quantification of pre-mining variability. Continuing to capture data to quantify pre-mining variability is important on the context of allowing the Project to distinguish any future Project related impacts from inherent natural variability, or variability from other mining operations, later during the Project's operational and rehabilitation phases. The baseline monitoring program will continue until active mining commences, at which point the operational regime will be implemented.

Routine monitoring during the mining operation will provide early warning of any variation in the response of the groundwater system to that predicted by the groundwater modelling. This will enable the proponent to undertake mitigation measures, as required, to minimise any potential groundwater related impacts, such as to surrounding groundwater users and the environment (e.g. through the implementation of make-good measures).

Table 10-11 Project GMMP Monitoring Network

Bore	Total depth (mBGL)	Aquifer	Proposed GMMP Bore	Rationale
MBIS01	22	Alluvium	Interpretation	These bores are installed to the base of the alluvium. Recorded as dry since installation. Considered unsuitable as compliance bores but will continue to be monitored as interpretation bores.
MBIS14	11	Alluvium	Interpretation	
MBID23	14	Alluvium	Compliance	Shallow groundwater monitoring along Isaac River north of the pit.
MBID28	16	Alluvium	Compliance	Shallow groundwater monitoring along Isaac River northeast of the pit.
MBIS04	19	Alluvium	Compliance	Shallow groundwater monitoring along Isaac River.
MBIS07	19	Alluvium	Compliance	Shallow groundwater monitoring along Cherwell Creek southeast of the pit.
MBIS12	20	Alluvium	Interpretation	Shallow groundwater monitoring along Cherwell Creek.
MBID05	18	Alluvium	Interpretation	These form part of the IDM monitoring network and included as interpretation bores to provide shallow groundwater monitoring north of the Isaac River.
MBID08	17	Alluvium	Interpretation	
MBIS20	22	Regolith	Compliance	Shallow groundwater monitoring along Conrock Gully east of the pit.
MBIS06	12.4	Regolith	Interpretation	These bores are installed to regolith and are intermittently dry with a recent prolonged dry spell. As it is likely that there will be frequently no or insufficient water to sample (i.e. the regolith in this area is dry) they are considered unsuitable as compliance bores but will continue to be monitored as interpretation bores.
MBIS17	23	Regolith	Interpretation	
MB06	23	Regolith	Interpretation	Located more than 5 km to the northwest and upgradient of the pit shell. Not anticipated to be impacted by Project mining related drawdown .
MB09C	15	Regolith	Interpretation	Located over 1km to the east and upgradient of the pit shell. Not anticipated to be significantly impacted by Project mining related drawdown.
MBID22	37	Regolith	Interpretation	Shallow groundwater monitoring along Isaac River northeast of the pit. Groundwater levels are influenced by nearby actively pumping landholder bore. Bore is blocked and unsuitable for sampling.
RN182851	35	Regolith	Compliance	Mining impact south of the pit.

Bore	Total depth (mBGL)	Aquifer	Proposed GMMP Bore	Rationale
MBIS10	24.15	Regolith	Compliance	Located 2km to the southeast of the pit shell in a potential zone of Project drawdown.
MBIS02	138	Leichhardt coal seam	Compliance	Mining impacts northeast of the pit.
MBIS05	155	Leichhardt coal seam	Compliance	Mining Impacts east of the pit.
MBIS08	50	Leichhardt coal seam	Compliance	Mining impacts south of the pit.
MBIS11	94	Leichhardt coal seam	Compliance	Located 2km to the southeast of the pit shell in a potential zone of Project drawdown.
MBIS13	153	Leichhardt coal seam	Compliance	Located 2km to the east of the pit shell in a potential zone of Project drawdown.
MBIS15	52	Leichhardt coal seam	Compliance	Shallow groundwater monitoring along Isaac River and HSE Wetland. The bore is located more than 2 km to the east of the pit shell.
MBIS18	150	Leichhardt coal seam	Interpretation	Located over 2 km to the southeast of the pit shell outside of Project MLAs.
MBIS03	181	Vermont coal seam	Compliance	Mining impacts northeast of the pit
MBIS09	96.41	Vermont coal seam	Compliance	Mining impacts south of the pit.
MBIS16	69.19	Vermont coal seam	Interpretation	Located over 2 km to the south of the pit shell.
MBIS19	86	Isaac Thrust Fault core (RCM)	Interpretation	Monitoring on the Isaac Thrust Fault southeast of the pit outside of Project MLAs.
MB08b	84.2	Fort Cooper Coal Measures	Interpretation	Located more than 2 km to the northwest and upgradient of the pit shell. Not anticipated to be significantly impacted by Project mining related drawdown.
MB09B	36	Fort Cooper Coal Measures	Interpretation	Located over 1km to the east and upgradient of the pit shell. Not anticipated to be significantly impacted by Project mining related drawdown.



0 500 1000 1500 2000 2500

Metres

Datum:	GDA2020 Zone 55
Scale:	See Scale Bar
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Source:	SLR
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DISCLAIMER: Third party data sources are used in this map compilation. Minserve makes no warranty regarding this data's accuracy or currency.

LEGEND

- Waterway
- Roads
- IDE Project MLAs
- Proposed Project Disturbance Area
- Project Pit Extent

stanmore

ISAAC DOWNS EXTENSION

Project GMMP Monitoring Network

Figure | **10-34**

10.9.3.4 Groundwater Level Triggers

The development of groundwater level triggers involves two key components, the calculation of 'reference level' values based on statistical analysis of the available groundwater level monitoring dataset and the derivation of 'groundwater level trigger thresholds' informed by numerical groundwater modelling. The groundwater level values for each bore are calculated as follows:

- Reference level is the bore specific groundwater level that all future groundwater level measurements will be compared to for the purpose of calculating actual groundwater drawdown. The reference level is derived on the basis of historic groundwater level monitoring data.
- Level trigger threshold is the derived from the predictive groundwater modelling at each bore location, such that an exceedance of the level trigger threshold represents greater groundwater level impact than predicted by modelling.
- Trigger level elevation is calculated by subtracting the level trigger thresholds from the reference levels at each bore.

The time series plots and analysis for each compliance bore reveals that groundwater levels are highly variable, primarily driven by natural causes (i.e. climate variability and response to rainfall). Furthermore, the relatively large range between the maximum and minimum groundwater levels highlights that groundwater level change compliance criteria need to appropriately recognise the significant variability in groundwater levels. Therefore, it is proposed to adopt the 20th percentile of the baseline dataset summary statistics as the reference level values, similar to the approach proposed within DES (2021) for establishing statistically appropriate groundwater quality triggers. Adoption of the 20th percentile allows consideration of the historic variability in groundwater levels when proposing a bore specific groundwater level that will be compared to model predictions for compliance purposes.

Level trigger thresholds have been based on the following criteria:

- Based on the maximum predicted cumulative drawdown for each bore. Drawdown values are derived from the best-calibrated model realisation at each bore location, within the relevant model layer, over the life of the mine.
- Where the proposed level trigger threshold would result in a level trigger elevation below the base of the model layer, then the level trigger threshold has been limited to drawdown to the base of the model layer.

The proposed reference level values, level trigger threshold and trigger level elevation for the compliance bores are presented in Table 10-12.

Table 10-12 Groundwater Level Trigger Thresholds

Proposed Compliance Bore	Formation monitored	Designation	Reference level (mAHD)	Level Trigger Threshold (m)	Trigger Level Elevation (mAHD)
MBID23	Alluvium	Compliance	186.03	1.50[1]	184.5
MBID28	Alluvium	Compliance	187.27	3.47[1]	183.8
MBIS04	Alluvium	Compliance	184.89	4.28[1]	180.6
MBIS07	Alluvium	Compliance	na		
MBIS20	Regolith	Compliance	186.56	7.60[1]	179.0
RN182851	Regolith	Compliance	194.77	13.38	181.4
MBIS10	Regolith	Compliance	170.44	9.64	160.8
MBIS02	Leichhardt coal seam	Compliance	186.67	25.86	160.8

Proposed Compliance Bore	Formation monitored	Designation	Reference level (mAHD)	Level Trigger Threshold (m)	Trigger Level Elevation (mAHD)
MBIS05	Leichhardt coal seam	Compliance	184.74	15.50	169.2
MBIS08	Leichhardt coal seam	Compliance	190.35	10.31	180.0
MBIS11	Leichhardt coal seam	Compliance	185.54	13.08	172.5
MBIS13	Leichhardt coal seam	Compliance	182.93	12.82	170.1
MBIS15	Leichhardt coal seam	Compliance	183.02	3.05	180.0
MBIS03	Vermont coal seam	Compliance	187.18	28.03	159.2
MBIS09	Vermont coal seam	Compliance	188.73	13.74	175.0

1. Maximum drawdown limited to base of model layer.

Note: MBIS07 has not been given a water level trigger as the water level trigger elevation falls below the screen of the bore. MBIS07 is used for groundwater quality compliance only

10.9.3.5 Groundwater Quality Limits

Groundwater quality limits for compliance bores have been established in accordance with the DES (2021) guideline 'Using monitoring data to assess groundwater quality and potential environmental impacts'. The general approach detailed in DES (2021), to use or derive site specific groundwater quality limits, is as follows:

- Determine summary statistics (i.e. 20th, 50th, 80th and 95th percentiles) for each bore and each indicator using all available validated data.
- Identify relevant default guidelines and WQOs (see Section 10.5.6.3).
- Determine whether the site-specific groundwater guidelines are more appropriate than existing default guidelines and WQOs through the following:
  - Compare the 20th (for pH lower guideline) and 80th percentile of the dataset to the relevant guidelines. DES (2021) states that where multiple EVs (with associated water quality guidelines) have been identified for an area of interest, groundwater quality should be managed to comply with the most conservative water quality guideline so that the most sensitive EV is protected.
  - Where insufficient data is available to derive a trigger value (e.g. fewer than 8 samples or where more than 15% of results were reported at the limit of reporting), the relevant ANZG 2018 guideline value, or other available guideline value (where ANZG 2018 value is not available) has been adopted as an interim limit.
  - Determine appropriate site-specific limits. The limits are appropriate if they are sufficiently conservative to measure whether an environmental impact could occur, but do not result in false non-compliances.
  - If the 80th percentile aligns closely with the default guideline or WQO, the default guideline WQO value should be adopted.

  - If the 80th percentile is substantially lower than the default guideline WQO, a site specific value may be adopted. However, for toxicants, the default guideline may still apply where it is more conservative.
  - If no default guideline WQO exists, the 80th percentile may be used as a site specific guideline, subject to regulatory acceptance.
  - If the 80th percentile exceeds the default guideline WQO, a site specific value may be adopted where it better reflects local hydrochemical conditions.

Groundwater monitoring data analysis for the Project has included all sampling events to the end of 2025, noting that some bores have less than 8 samples. Therefore, interim trigger values have been developed based on consideration of the available data and default guideline WQO values. Additionally, some bores with fewer than eight data points show two or more exceedances of the ANZG 2018 guideline values, which have been adopted as interim trigger criteria. In these cases, 'TBA' has been included in Table 10-14 as it is proposed that these trigger values be reassessed once additional data become available to ensure they are representative of meaningful hydrochemical conditions.

The monitoring bore network will continue to be monitored and final 'limits' will be developed when a sufficient number of representative samples have been obtained from each bore.

The analytes for which groundwater quality limits have been developed, were based on the potential impacts of the Project (noting that groundwater quality impacts are unlikely, as described in Section 10.8.3), and their relevance to protect identified EVs.

Table 10-13 provides the groundwater quality parameters proposed for monitoring, whether the parameters require limits or are for reference / interpretation purposes only, and justification for the parameter selection.

The following parameters will be monitored as part of the GDEMMP (Section 10.9.4) at bores relevant to the GDEMMP for the context of vegetation health.

- salinity
- dissolved oxygen
- pH
- nitrogen
- phosphorous
- organic carbon.

The proposed groundwater quality limits for each bore for each parameter, based on the methodology described above, are provided in Table 10-14. Based on this methodology and the statistical data analysis, site specific values have been proposed for some parameters for two bores, MBID23 and MBID28.

Table 10-13 Proposed Parameters for Groundwater Quality Limits

Parameter	Limit required	Justification
Physiochemical parameters		
pH	Yes	Standard parameter, identified in DEHP (2011) and ANZG (2018) for the relevant EVs
EC	Yes	Standard parameter, identified in DEHP (2011)
TDS	No	Standard parameter, identified in ANZG (2018) for the stock watering (cattle) EV.
Metal and metalloids (Dissolved)		
Aluminium	Yes	Identified in ANZG (2018) for the relevant EV's
Arsenic	Yes	Identified in ANZG (2018) for the relevant EV's

Parameter	Limit required	Justification
Boron	Yes	Identified in ANZG (2018) for the irrigation EV
Cadmium	Yes	Identified in ANZG (2018) for the relevant EVs
Chromium	Yes	Identified in ANZG (2018) for the relevant EVs
Cobalt	Yes	Identified in ANZG (2018) for the irrigation EV
Copper	Yes	Identified in DEHP (2011) and in ANZG (2018) for the relevant EVs
Iron	Yes	Identified in DEHP (2011)
Lead	Yes	Identified in ANZG (2018) for the relevant EVs
Manganese	Yes	Identified in DEHP (2011) and in ANZG (2018) for the relevant EVs
Mercury	Yes	Identified in ANZG (2018) for the relevant EVs
Molybdenum	Yes	Identified in ANZG (2018) for irrigation EV
Nickel	Yes	Identified in ANZG (2018) for the relevant EVs
Uranium	Yes	Identified in ANZG (2018) for the relevant EVs
Silver	Yes	Identified in ANZG (2018) for the relevant EVs
Zinc	Yes	Identified in DEHP (2011) and in ANZG (2018) for the relevant EVs
Major Ions		
Sulphate	Yes	Identified in DEHP (2011) and in ANZG (2018) for stock watering (cattle) EV
Calcium	No	Identified in DEHP (2011) and in ANZG (2018) for stock watering (cattle) EV
Magnesium	No	Identified in DEHP (2011) and in ANZG (2018) for stock watering (cattle) EV
Potassium	No	To be monitored for interpretative purposes only, not identified in any relevant guideline for the relevant EVs
Carbonate	No	To be monitored for interpretative purposes only, not identified in any relevant guideline for the relevant EVs
Bicarbonate	No	To be monitored for interpretative purposes only, not identified in any relevant guideline for the relevant EVs
Sodium	No	Identified in DEHP (2011) and in ANZG (2018) for stock watering (cattle) EV
Chloride	No	Identified in DEHP (2011) and in ANZG (2018) for stock watering (cattle) EV
Non-Metallic Elements		
Nitrate	Yes	Identified in DEHP (2011)

Table 10-14 Interim Groundwater Quality Limits for Compliance Bores

Analyte	pH (Field)	EC (Lab)	SO4	[1]NO_3 as N	Ag	Al	As	B	Cd	Co	Cu	Cr	Fe	Hg	Mo	Mn	Ni	Pb	U	Zn
Unit	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MBID23	6.5 to 8.5[a]	8910[d]	318[d]	3.26[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.784[e]	0.0006[a]	0.1[b]	1.788[e]	0.014[a]	0.0034[a]	0.0158[e]	0.06[d]
MBID28	6.38 to 6.85[e]	8910[d]	318[d]	3.26[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0062[a]	0.001[a]	0.784[e]	0.0006[a]	0.1[b]	1.83[e]	0.011[a]	0.0034[a]	0.004[b]	0.3214[e]
MBIS04	6.5 to 8.5[a]	8910[d]	318[d]	3.26[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	TBA	0.0006[a]	0.1[b]	TBA	0.011[a]	0.0034[a]	0.002[b]	TBA
MBIS07	6.5 to 8.5[a]	8910[d]	318[d]	3.26[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.14[d]	0.0006[a]	0.1[b]	TBA	0.011[a]	0.0034[a]	0.002[b]	0.008[c]
MBIS20	6.5 to 8.5[a]	8910[d]	TBA	3.26[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	TBA	TBA	TBA	TBA	0.14[d]	0.0006[a]	0.1[b]	TBA	0.011[a]	0.0034[a]	0.002[b]	TBA
RN182851	6.5 to 8.5[a]	16000[d]	TBA	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	TBA	0.0006[a]	0.1[b]	TBA	0.011[a]	0.0034[a]	0.002[b]	TBA
MBIS10	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	0.002[b]	TBA
MBIS02	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	TBA	0.011[a]	0.0034[a]	0.002[b]	TBA
MBIS05	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	TBA	TBA
MBIS08	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	TBA	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	0.002[b]	0.008[c]
MBIS11	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	0.291[d]	TBA	0.0034[a]	0.002[b]	TBA
MBIS13	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	0.002[b]	TBA
MBIS15	6.5 to 8.5[a]	TBA	TBA	1.12[d]	0.05[a]	0.055[a]	0.024[a]	TBA	0.0002[a]	0.1[b]	TBA	TBA	TBA	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	TBA	TBA
MBIS03	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	0.246[d]	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	0.002[b]	0.008[c]
MBIS09	6.5 to 8.5[a]	16000[d]	398[d]	1.12[d]	0.05[a]	0.055[a]	0.024[a]	0.5[b]	0.0002[a]	0.1[b]	0.0014[a]	0.001[a]	TBA	0.0006[a]	0.1[b]	0.291[d]	0.011[a]	0.0034[a]	0.002[b]	TBA

1. Guideline values reported as NO3 values have been converted to NO_3 as N to align with the sampling results.
a. Aquatic Ecosystem (95% Protection) (ANZG, 2018)
b. Irrigation (Fitzroy Basin WQO)
c. Stock (Fitzroy basin WQO)
d. Lower Isaac River (zone 34) (DEHP, 2011)
e. Site specific 80th percentile values.

10.9.3.6 Exceedance Investigations

The level trigger threshold is used to establish a level of drawdown in the draft EA (**Appendix AA**) and draft PRCP schedule (**Appendix AC**) that, if exceeded, would require an investigation.

A groundwater quality limit exceedance is identified where a bore-specific groundwater quality limit is exceeded on three consecutive sampling occasions. A groundwater level trigger exceedance is identified where measured groundwater levels at a bore indicate drawdown greater than the level trigger threshold.

An investigation into exceedances of groundwater level triggers or groundwater quality limits will involve determination of whether the exceedance is a result of:

- mining activities authorised under this environmental authority
- seasonal/natural variation
- neighbouring land use resulting in groundwater impacts
- any other potential cause.

Investigations will consider relevant monitoring data, groundwater flow conditions, baseline information, site activities, natural conditions and bore integrity.

Where an exceedance is determined to be caused by the Project’s mining activities, then a further investigation will be undertaken to determine whether environmental harm has occurred or may occur, and the extent thereof. If the investigation determines that environmental harm has occurred, or may occur, the following actions will be taken after completing the investigation:

- implementation of measures as soon as reasonably practicable to reduce environmental harm including potential environmental harm
- development of long-term mitigation measures to address any existing groundwater contamination and prevent recurrence of groundwater contamination which is implemented in a reasonable time period
- if environmental harm has occurred as a result of groundwater drawdown exceedances:
    - determine any actions required to reduce the potential for environmental harm
    - determine any mitigation measures required to limit the drawdown in the affected groundwater resource.

10.9.3.7 Monitoring Regime – Post-Mining

The GMMP will continue during the post mining period until relinquishment of Project’s MLs, except where additional requirements are identified through implementation of the PRCP schedule. As part of the post mining phase, the monitoring program will also include additional monitoring for the void lake as follows:

- Void water level - quarterly survey consistent with the frequency of groundwater level monitoring at groundwater bores.
- Void water quality – quarterly sampling consistent with the frequency and parameter suite for groundwater quality monitoring at groundwater bores.

10.9.3.8 Quality Assurance / Quality Control

The quality assurance and quality control procedures that will be adopted for the Project’s GMMP are described in Section 6 of **Appendix AE**.

10.9.3.9 Reporting, Review and Improvement Process

During the life of Project operations, data collected through the GMMP will be used to assess the Project’s impact on groundwater resources, and if deemed necessary update and refine the numerical groundwater model and its predictions of future impacts. These outcomes will in turn be used to review and improve the GMMP through a continual reporting, review and improvement process as described in Section 8 of **Appendix AE**. In summary this includes:

- An annual groundwater monitoring report, assessing the results of monitoring and a review of the conceptual and numerical groundwater models.
- Periodic review of the GMMP, with the GMMP modified to reflect updated conditions or improved knowledge.
- Maintenance of the monitoring bores, with installation of new or replacement bores as required.

10.9.4 Groundwater Dependent Ecosystems

10.9.4.1 Disturbance Area Management

As identified in Section 10.8.5.2, there are approximately 6.8 ha of mapped GDEs within the proposed disturbance area, associated with the bridge crossing of the Isaac River, dragline walk route crossing of the Isaac River and tie in point of the Conrock Gully diversion with the Isaac River. The proposed design, construction and rehabilitation methodologies for this infrastructure are described in Section 4.12 and Section 4.14 of **Chapter 4**. In all instances the actual disturbance width needed for construction is likely to be less than the nominated disturbance area, which has been done to allow some flexibility in location during the detailed design phase. Nevertheless, all disturbance within the proposed disturbance area has been considered a direct impact in the terrestrial ecology assessment (see Section 11.5.2 of **Chapter 11**), with all GDE areas also mapped as habitat for listed threatened species, and as a result, have been assessed as likely to be significantly impacted. Hence all GDEs in the proposed disturbance area are included in the areas requiring biodiversity offsets (see **Chapter 13**).

Furthermore, all impacted GDE areas will be subject to rehabilitation with a post mining land use of riparian vegetation, as per the PRCP (see **Appendix AB**). In the case of the Isaac River bridge, rehabilitation will occur following completion of operations, with localised rehabilitation around construction areas that are not part of the operational area. For the temporary dragline crossing, rehabilitation will be staged with an interim rehabilitation stage between the pre-mining and post-mining dragline walks, and a final rehabilitation stage following operations. For the diversion tie-in point, rehabilitation will commence following diversion construction, which is early in the mine life.

10.9.4.2 Water Management

The Projects water management systems are described in detail in **Chapter 8**. These systems are design to protect downstream environmental values, including GDEs with dependence of surface water flows.

The water management strategy involves separating mine affected water, sediment water, and clean water, and applying appropriate management to each water type. Mine affected water (MAW) will be collected in the pit and transferred to the primary MAW dam. Two smaller MAW dams will collect runoff from the ROM pads, which will then be pumped to the primary MAW dam. MAW will be used for either dust suppression or piped to IDM or IPM if in excess. Alternatively, MAW will be released in a controlled manner to the Isaac River based on flows and water quality in the receiving environment to protect downstream water quality. MAW releases to the Isaac River will be specified and controlled by the Project's EA.

Sediment water, which is primarily runoff from overburden dumps before and during the rehabilitation stages, will be captured in sediment dams, which will be designed in accordance with relevant engineering standards to allow sediment settlement before water release. Water from sediment water storages will be used preferentially for dust suppression. In contrast, clean water from upgradient of the mining activities will be diverted around the mining activities into the Isaac River, Cherwell Creek and Conrock Gully diversion.

As demonstrated in **Chapter 9**, the design of levee and diversion infrastructure will have a negligible to minor impact on hydrology and geomorphology and hence this serves to mitigate potential impacts on GDEs with dependence of surface water flows.

10.9.4.3 Groundwater Monitoring and Management

A GMMP has been prepared for the Project and is described in Section 10.9.3. The GMMP demonstrates that a comprehensive groundwater monitoring network will be maintained throughout the Project life. Monitoring covers all the major groundwater units, including the alluvial aquifer, regolith, and coal seams. The primary purpose of the groundwater monitoring network will be to enable the detection and distinction of natural groundwater fluctuations from groundwater-level impacts associated with the de-watering of aquifers impacted by the Project.

10.9.4.4 Groundwater Dependent Ecosystem Monitoring and Management

10.9.4.4.1 Overview

A GDEMMP has been prepared for the Project (**Appendix AF**). This section summarises the key aspects of the GDEMMP, with details provided in **Appendix AF**. The GDEMMP presents a monitoring and management measures that are specific, measurable, achievable, reasonable / relevant and time specific.

The GDEMMP addresses and manages any uncertainties associated with the potential impacts of the Project on GDEs, through the development of consistently applied monitoring actions, analysis and reporting of data trends, and development of ‘early warning’ triggers to identify if a decline in GDE health occurs. Corrective actions are described and will be implemented when statistically significant impacts on GDE function caused by Project activities are detected.

The IDM GDEMMP (3d Environmental, 2020b), and subsequent monitoring and assessments for IDM provide the basis for the methods proposed within the Project’s GDEMMP. It is intended that IDM and Project GDEMMPs be complementary, monitoring the potential cumulative impacts associated with proposed and existing mining operations.

This GDEMMP provides a framework for the management and monitoring of GDEs associated with the Isaac River, Cherwell Creek and HES wetland including areas both within the area of predicted groundwater drawdown, and more broadly throughout the watercourse frontage, upstream and downstream from the Project area. A sequential approach to monitoring and management has been applied which allows for adaptive implementation of monitoring and management protocols reliant on results of prior assessment activities. The major components of the GDEMMP are:

- Apply monitoring and assessment techniques that support development of an environmental baseline for GDE function commencing prior to operations, including upstream and downstream control sites for GDE monitoring.
- Produce a statistically robust multi-parameter dataset that can be used to validate perturbations in GDE function that fall beyond thresholds of natural seasonal variation.
- Allow a flexible approach to monitoring which is subject to ongoing review and allows methods to be adapted based on results of lead-up monitoring and data analysis.
- Utilise biophysical and ecological parameters to establish an appropriate ecological trigger threshold, applied to indicate requirement for further investigation or corrective action.
- Develop a suite of management actions and corrective measures which can be applied if a breach of trigger threshold is identified.

The GDEMMP has been separated into two stages:

1. Two years of intensive data collection during which investigative thresholds will be defined.
2. The period after 2 years, comprising the remainder of operations and the post mining period, which will utilise data collected in the initial two years to re-assess the thresholds.

The thresholds for impact are linked to vegetation health and provide a comparison between the control and impact sites. Should the established thresholds be exceeded, this will trigger an investigation that will make use of other monitoring data on the bio-physical function of vegetation, groundwater, and surface water to determine the cause of a threshold exceedance. If drawdown of the groundwater table is found to be the cause of the threshold exceedance, then mitigation measures will be implemented, and the effect of mitigation measures monitored. If mitigation measures are not effective, habitat quality data from the GDE Habitat Quality Monitoring Program (Section 10.9.4.6) will be used to assess whether there is a significant residual impact to habitat for listed species requiring biodiversity offsets.

10.9.4.4.2 Monitoring and Analysis Techniques

Section 8 of **Appendix AF** provides a detailed description of the following monitoring methods, which were also used for the Project's GDE field surveys (see Sections 10.3.2 and 10.6.3):

- leaf area index (LAI)
- LWP
- SMP
- normalised difference vegetation index (NDVI) image capture
- stable isotope assessment of twig xylem, soil, surface water, and groundwater.

These methods will complement ongoing groundwater and surface water monitoring.

Statistical analysis will need to consider interactions between multiple datasets to establish baseline conditions and allow identification of statistically significant deviations from these conditions that may be associated with Project mining activities. The most critical interactions will be between biotic health (typically measured in LAI, LWP, and NDVI) and abiotic factors such as groundwater levels and salinity. Statistical tests applied to analysis of data will depend on whether datasets are normally distributed and may include bivariate analysis of two datasets (e.g. NDVI and LAI) applying a Pearson or Spearman Correlation. 'T-tests' will be applied to identify significant differences in mean values between sampling localities. More complex statistical analysis may be applied if investigative actions are required including multivariate analysis of variance (PERMANOVA) to interacting datasets.

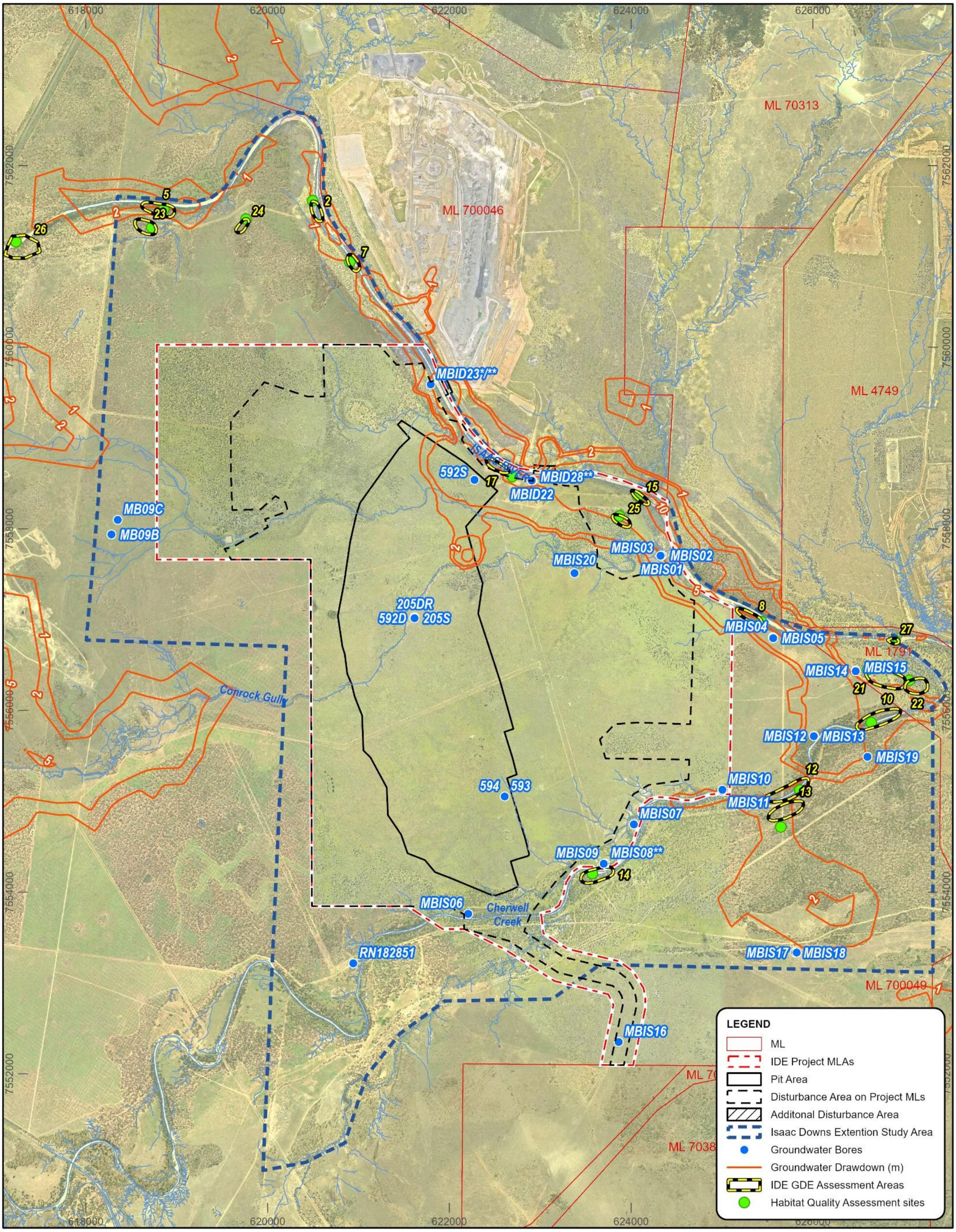
The overriding purpose of the data collection and subsequent statistical analysis is to provide representation of natural variation in the system applied to both biotic factors and abiotic controls and allow appropriate trigger thresholds to be proposed.

10.9.4.4.3 GDE Assessment Sites

The proposed GDEMMP assessment sites are shown in Figure 10-35. The assessment sites cover:

- Isaac River alluvium and riparian fringe (RE 11.3.25) (8 sites including an upstream and downstream control site)
- Cherwell Creek alluvium and riparian fringe (RE 11.3.25) (3 sites)
- HES Wetland (RE 11.3.27b) (1 site)
- Poplar Box TEC (RE 11.5.3), noting that this is not an identified GDE (2 sites)
- Brigalow TEC (RE 11.3.1 and RE 11.4.9), noting that this is not an identified GDE (3 sites).

Data collection will occur across all assessment sites, including the riverine and wetland GDEs, with upstream and downstream control sites positioned outside the modelled cumulative drawdown extent of the alluvial aquifer, as far as practical. Sites have been selected with consideration of related/nearby groundwater monitoring bores and terrestrial habitat quality sites, as shown in Figure 10-35. Where possible, sample points for base the GDE assessment (Figure 10-1) and GDEMMP utilise the same assessment sites, particularly trees, to maintain dataset continuity. Table 8-2 of **Appendix AF** provides a detailed analysis of the GDE assessment sites, and nearby groundwater monitoring bores and habitat quality monitoring locations, demonstrating the integration of these monitoring programs.



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stanmore

ISAAC DOWNS EXTENSION

GDEMMP Assessment Sites

Figure | 10-35

10.9.4.4.4 Monitoring Phases, Reporting and Review

Reporting will be prepared at the completion of each monitoring event describing the findings of monitoring.

Bi-annual baseline monitoring (four events covering two wet seasons and two dry seasons) will be undertaken for a two-year period, commencing November 2025 (dry season), and then planned for early / mid 2026 (wet season), late 2026 (dry season) and early / mid 2027 (wet season). At the completion of four baseline monitoring events, a consolidated report will be prepared which provides a synopsis of the data collected, including correlations between parameters and statistical analysis (where possible) of seasonal ecological function.

The aim of the four-event intensive data collection period is to determine the range of natural seasonal variation in the measured parameters, particularly LWP and LAI which are fundamental indicators of plant stress. These parameters can be correlated to the NDVI signature, which will allow future monitoring to be undertaken remotely at an 'on demand' basis, supplemented with field assessment.

Following completion of the baseline monitoring program, NDVI will be captured on an annual basis during the height of dry season (nominally October/November) to support ongoing monitoring of GDE health. NDVI threshold values will be calculated from correlations to LAI established during the baseline assessment and annually checked for statistically significant threshold exceedance events that affect the impact site, in the absence of similar affects at the control site. The NDVI capture will be supplemented with field assessment measuring LAI and LWP at dedicated monitoring localities including control and impact sites on a two-yearly basis, at the peak of the dry season (typically October to November).

A monitoring event that includes field assessment of monitoring parameters will be undertaken to coincide with completion of mining at the Project. Follow up field survey periods will occur two, four and six years after operations. Capture of NDVI datasets will be completed on an annual basis for the approximate six-year period. Considering the impact of groundwater drawdown on vegetation health can take several years to manifest, a period of six years, or until rehabilitation is successfully completed, should be a sufficient to capture any trend for declining vegetative health that is the result of Project mining activity.

10.9.4.4.5 Triggers for Investigative Action

LAI is proposed as the primary monitoring parameter. A decrease in LAI is an initial indicator of vegetative stress. LAI is a precursor to more intensive impacts to habitat values. LAI varies on a seasonal basis dependent on water availability.

Following the outcomes of the IDM Baseline Assessment Review (3d Environmental, 2023), a preliminary threshold of the 20th percentile of the relevant LAI values is proposed as a preliminary threshold indicator of vegetative stress for the GDEMMP, to be confirmed during the two year baseline monitoring period. NDVI is to be used as a supplementary measure to support investigative actions.

Figure 10-36 details the process and decision framework from initial data collection through to corrective actions in the case that a threshold breach can be linked to Project activity. The initial two years of the assessment covers wet and dry season surveys, to provide a baseline against which future vegetation condition trends can be assessed. At each stage, decision pathways are provided when threshold breaches are identified, including requirements for investigative action and corrective measures where causal factors can be linked to mining activity. Corrective actions, including potential requirement for biodiversity offsets, are discussed in Section 10.9.4.5.

Following the two-year baseline assessment, statistical correlation between various assessment parameters will be drawn, particularly the relationship between LAI and NDVI to allow ongoing monitoring to be completed remotely on an annual basis, and trigger thresholds to be adapted. The full suite of parameters collected during the baseline assessment period, with their relevance, intended application in both the baseline assessment and longer-term monitoring program is provided in Table 10-1 of **Appendix AF**. However, NDVI may be proposed as the primary method for detecting changes in vegetation condition if the correlation between LAI and NDVI is robust. Following the two-year baseline assessment period, subsequent field data collection will be completed in the dry season to determine if the condition threshold is exceeded and, if exceeded, trigger the flow chart process in Figure 10-36 for investigation, mitigation (corrective action) and / or offsets.

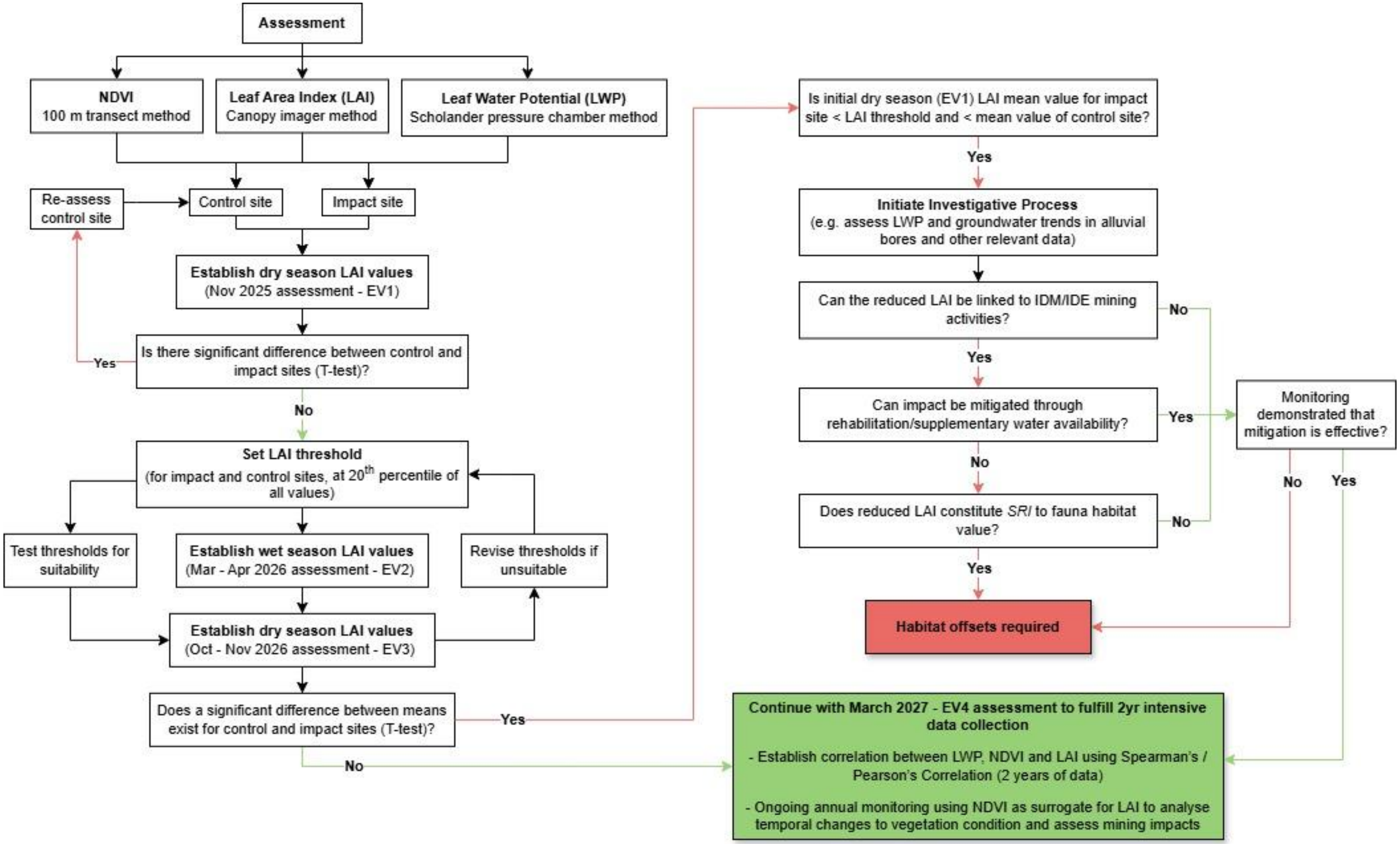

Figure 10-36 GDE Monitoring, Assessment and Decision Process

10.9.4.5 Potential Corrective Actions and Adaptative Management Measures

Section 11 of **Appendix AF** describes the potential corrective actions should GDE monitoring and data analysis detect a statistically defined decline in GDE health. These actions are:

- Restoration of tree water supply through direct injection or infiltration of surface waters.
- Infill planting.

Direct injection is likely to be practical for localised areas where impacts are detected in scattered trees or scattered groups of trees rather than application in broader scale impact mitigation. This method may be particularly suitable for any unexpected impacts to the HES Wetland habitat, where the deep sand layer below the wetland habitat provides a suitable substrate to capture, hold and attenuate any injected water.

It may be possible to restore water supply in critical portions of the tree root zone through enhancing natural infiltration involving flooding a shallow trench with suitable water.

Infill planting is recommended using River red gum (*Eucalyptus camaldulensis*) and forest red gum (*Eucalyptus tereticornis*), which are ecologically adaptable. Small scale trials may commence in areas subject to initial Project disturbance of GDEs (e.g. Isaac River crossings), through planting of forest red gum seedlings into existing canopy gaps. This will require some maintenance through drier periods until seedlings have established. Trials do not need to be extensive and should focus on the capacity of the species to survive, through planting of scattered trees into existing canopy gaps.

Corrective actions, should they be required, will be monitored using the monitoring methods described in the GDEMMP. Infill planting will be monitored on a regular basis during establishment (e.g. monthly then annually).

10.9.4.6 Groundwater Dependent Ecosystem Habitat Quality Monitoring Program

10.9.4.6.1 Overview

The GDE Habitat Quality Monitoring Program (GDEHQMP) (**Appendix AG**) has been prepared to complement the GDEMMP (Section 10.9.4.4). The GDEHQMP utilises information from the terrestrial ecology assessment (**Appendix P**, **Chapter 11**) to determine the habitat types for matters of national environmental significance (MNES) and matters of state environmental significance (MSES) that may be linked to GDEs.

The purpose of the GDEHQMP is to identify if potential changes to GDE health (as determined by the GDEMMP) result in a decline in habitat quality that are likely to result in a significant impact on MNES and MSES associated with GDEs. The GDEHQMP describes the following:

- A monitoring methodology to assess habitat quality within identified GDEs and, as a precautionary measure, surrounding vegetation types that are not identified as GDEs.
- The establishment of baseline ecological condition within these vegetation communities prior to Project activities impacting groundwater (e.g. overburden removal).
- Procedures for ongoing monitoring of habitat quality within these vegetation communities during the Project to detect changes over time and assess the effectiveness of management measures, as described in the GDEMMP.
- A definition of trigger thresholds for habitat quality changes, and indicators of vegetation stress, which will trigger further assessment of the likelihood of significant impacts to MNES and MSES.

10.9.4.6.2 GDEs and Associated MNES and MSES

Based on the mapping of GDEs (see Figure 10-14) and terrestrial ecology mapping (see **Chapter 11**), the REs associated with GDEs are:

- RE11.3.25 (wet eucalypt woodlands on alluvial plains and drainage lines), found along the riparian fringe of the Isaac River and Cherwell Creek
- RE11.3.27b (ephemeral wetlands), found at the HES wetland.

Based on the terrestrial ecology assessment (**Chapter 11**), the MNES and MSES that are associated with these REs are described in Table 10-15, and shown in Map 3 and Map 4 of **Appendix AG**, respectively.

In addition to the MNES and MSES shown to be associated with GDEs, monitoring will also occur in other vegetation types and habitats that formed part of the GDE assessment, namely:

- Brigalow TEC (also Prescribed REs that are an endangered or of concern RE)
- Poplar Box TEC (also Prescribed REs that are an endangered or of concern RE)
- Ornamental Snake habitat.

Table 10-15 GDEs, REs and Associated MNES and MSES

RE	Vegetation Community	Associated MNES Values (Map 3 Appendix AG)	Associated MSES Values (Map 4 Appendix AG)
11.3.25	Wet eucalypt woodlands on alluvial plains and drainage lines	Squatter Pigeon habitat, Koala habitat, Greater Glider habitat	Prescribed RE within the defined distance from the defining banks of a relevant management watercourse map, Essential Habitat and Protected Wildlife Habitat (the same as MNES species)
11.3.27b	Ephemeral wetlands	Squatter Pigeon habitat, Koala habitat, Greater Glider habitat, Australian Painted Snipe habitat, Common Greenshank habitat, and Sharp-tailed Sandpiper habitat	Prescribed RE that intersects with an area shown as a wetland on the vegetation management wetlands map, HES wetland, Essential Habitat and Protected Wildlife Habitat (the same as MNES species)

10.9.4.6.3 Monitoring Program

The GDEHQMP comprises the baseline assessment period prior to Project activities impacting groundwater, and ongoing monitoring to assess changes in GDE health and habitat quality during operations and closure.

The monitoring methodology will utilise the same habitat quality scoring methodologies that informed terrestrial and offset assessments for the Project, undertaken in accordance with Commonwealth and State guidelines (see Section 2.1.1 and Section 2.3.1 of **Appendix AG**). The methodology will include assessment of site-based attributes, site-context attributes and species stocking rates. These components will be used to calculate habitat quality scores for relevant MNES and MSES habitat values and to provide a consistent basis for assessing changes in habitat quality over time. This habitat quality scoring methodology has been selected as it provides quantitative measures of vegetation composition, structure and ecological function, while also incorporating species-specific habitat characteristics. This enables an assessment of the capacity of GDE habitats to support MNES and MSES values.

The habitat quality scoring methodology supports consistency with the approach used to inform determinations of whether impacts to MNES and MSES associated with GDEs are determined to be significant. As such, the habitat quality scores derived through the GDEHQMP may be used to support future assessment of Project-related impacts and, where required, subsequent biodiversity offset calculations.

The proposed GDEHQMP monitoring sites are shown in Figure 10-35, and were selected for consistency with the GDEMMP monitoring sites. This allows for the results from the two monitoring programs to be used in conjunction for interpretation of findings. There are 17 permanent habitat quality monitoring sites, comprising impact and control sites, to enable the detection of changes in habitat quality and to distinguish potential Project-related impacts from broader regional changes (e.g. drought) not attributable to the Project. The monitoring sites are located in all vegetation communities and habitat types identified in Section 10.9.4.6.2.

The baseline assessment will occur biannually (wet season and dry season) for at least 2 years, and will derive average habitat quality scores for each monitoring site and relevant MNES and MSES values. These scores will establish the baseline condition against which future ongoing monitoring results can be compared. The ongoing monitoring program will occur biennially (every two years), during the dry and wet seasons.

10.9.4.6.4 Thresholds and Actions

The nominated threshold criteria for GDEs linked to MNES and MSES values represents a substantial reduction in habitat quality and serves as a trigger for assessment of the likelihood of significant impacts and potential offset requirements.

The threshold criteria is linked to habitat quality scoring (out of 10), where a decline in score of more than two points relative to the site's baseline score represents a material change in ecological condition beyond expected short-term seasonal variation. This decline is considered to represent a potentially significant decline in vegetation community or habitat condition. When the threshold is exceeded, this will trigger additional investigation into whether the decline in score is a result of Project activities, the likelihood of significant impacts to MNES and MSES (where the decline in score is Project related) and whether offsets are required to compensate for significant impacts.

Where threshold criteria are exceeded, a staged response will be implemented to verify the monitoring result, determine the likely cause of the change, and identify the appropriate management response, including:

- Verification of monitoring results.
- Assessment of the likely cause (i.e. whether related to Project impacts to groundwater) and correlation with results on GDE health from the GDEMMP. Additional field verification may be undertaken to confirm the observed change and determine any changes in species stocking rates.
- Implementation of management and mitigation measures, as per the GDEMMP.
- Assessment of whether there are residual significant impacts to MNES and MSES, in accordance with Commonwealth and State Guidelines, following the implementation of mitigation measures.
- Determination of offset requirements, utilising habitat quality scoring data collected during monitoring.

10.9.4.6.5 Adaptive Management, Reporting and Reviews

The threshold criteria for the GDEHQMP may be refined during baseline surveys or through ongoing management in response to monitoring outcomes and the identification of any additional information needs. Where changes are required to the methodology and threshold criteria, the GDEHQMP will be reviewed and updated as required.

Upon completion of the baseline monitoring surveys, a baseline GDE habitat quality assessment report will be prepared. This report will document the baseline habitat quality condition, summarise seasonal variation during the baseline period, and present the habitat quality scores assigned to each monitoring site. This report will also identify any relevant trends, limitations or data gaps and confirm the baseline condition against which future monitoring results will be compared. The findings will be used to support the refinement of habitat quality thresholds.

The findings from ongoing monitoring will be compiled and reported, with monitoring outcomes assessed against the baseline scores and established threshold criteria. Where there are threshold exceedances this will trigger the actions described above.

The GDEHQMP will be reviewed every five years, or sooner if there are changes to the GDEMMP, approval conditions, reporting obligations or Project activities.

10.9.4.7 Assessment of Residual Risk to GDEs

Section 7.5 of **Appendix N** provides an assessment of the risk of Project impacts to GDEs (as per Section 10.8.2) before and after monitoring and management measures (as per Section 10.9.3.4). The risk assessment combines the likelihood of the potential impact event with the magnitude (or consequence) the impact event. The significance of risks is described as:

- High significance: Complete destruction of a GDE in terms of complete loss of keystone species and conversion to an alternate degraded ecological state. Impacts are irreversible and the only feasible option for mitigation is an environmental offset under relevant environmental policy and legislation.
- Moderate significance: Degradation of a GDE to an extent such that 25% or more keystone species are affected by the action. Impacts will be reversible only with mitigation.
- Low significance: Impacts are short in duration and reversible without mitigation required.
- Insignificant: Impacts are undetectable when assessed against a relevant ecological baseline.

Based on the risk assessment outcomes the residual or mitigated risk ranking is low for direct clearing and low to insignificant for other impact mechanisms. This is a function of the small area of direct impact, the low likelihood of other potential impacts from the Project and the implementation of proposed management measures should impacts be detected.

10.10 Conclusion

A groundwater assessment was undertaken for the Project, including identifying groundwater environmental values of the Project area and surrounds, undertaking groundwater fieldwork investigations, developing conceptual groundwater and ecohydrological models, assessing impacts on groundwater values through the development of a numerical groundwater model, and determining management measures and mitigation strategies to protect groundwater values.

Groundwater values were determined through a comprehensive fieldwork program, supported by geological and desktop data from other local and regional resource projects. The field program comprised:

- installation of a Project bore network comprising 34 bores in all potential aquifer units
- collection and utilisation of data from surrounding bore networks at nearby resource projects, including historical data from an additional 26 bores
- a bore census of all landholder bores with potential to be impacted by the Project
- routine groundwater level and quality monitoring at bores in the monitoring network, including the use of loggers
- hydraulic testing of bores
- drilling to identify the Isaac Thrust Fault, with associated geophysical testing and bore installation to assess hydraulic conductivity across the fault
- electrical resistivity imaging along the Isaac River and Cherwell Creek to determine the extent and thickness of the alluvium.

Based on the understanding of the fieldwork, desktop data and geological setting, the hydrogeological regime of the Project area comprises the following key hydrogeological units:

- Cenozoic sediments:
  - Quaternary alluvium – forms the unconfined alluvial aquifer localised to major ephemeral drainage lines (i.e. Isaac River and Cherwell Creek).
  - Perched groundwater systems are likely to occur within the alluvium. These are discrete groundwater units sitting above the Quaternary alluvial aquifer / water table, and are separated by an unsaturated zone.
  - Quaternary to Tertiary non-alluvial sediments and weathered units (collectively termed 'regolith') – unconfined unit with variable but limited saturation and generally present at the surface within the Project area.
- Triassic Rewan Group – considered a regional scale aquitard.
- Permian coal measures with:
  - low permeability interburden and overburden units with aquitard properties.
  - coal seam aquifers.

Groundwater data allowed for the characterisation of hydraulic properties, recharge, flow, discharge and quality. Water quality in the Cenozoic sediments (including alluvium) ranges from brackish to highly saline and is likely to be unsuitable for aquatic ecosystem protection. However, the water quality is considered suitable for stock watering and irrigation in some areas. Water quality in the Permian units ranges from brackish to highly saline and is generally unsuitable to be used for stock watering, irrigation, and aquatic ecosystem protection. Water quality objectives were defined for the various groundwater units based on State and Commonwealth guidelines.

The potential groundwater receptors in the vicinity of the Project are landholder bores, GDEs and stygofauna.

Multiple lines of evidence, including measurements of LWP and SMP, stable isotopes, radon, and physical observations, were applied to assess the groundwater dependence of vegetation across multiple assessment areas within and surrounding the Project area. This data was complemented by data on site-specific geology, geomorphology, soil physical properties, and groundwater.

A conceptual hydrogeological model of the groundwater regime was developed based on hydrogeological information obtained for the Project area and surrounds.

Where present, the alluvial aquifer is disconnected from the riverbed elevation. Spatially, the alluvial aquifer is locally variably saturated and is dry and/or comprised only of clay in several locations. Shallow perched groundwater systems occur locally within recent channel sands and bank deposits, typically within 1–2 m of the ground surface. These perched systems are transient, seasonally recharged during flow and flood events, and are hydraulically disconnected from the deeper alluvial aquifer.

In the Permian coal measures, groundwater is encountered mainly in the coal seams and are the main aquifer units in the Project area. The Permian coal measures at and surrounding the Project have undergone extensive deformation. The main northwest-southeast trending fault is the Isaac Thrust Fault, with testing confirming that the fault does not provide a higher permeability pathway for groundwater flow in the Permian coal measures.

An ecohydrological model was developed based on fieldwork and an understanding of groundwater and surface water environments, which resulted in the identification of GDEs along the Isaac River, lower portions of Cherwell Creek near confluence with the Isaac River, and the HES wetland. Riparian vegetation fringing the Isaac River and lower reaches of Cherwell Creek utilises a discontinuous and seasonally variable perched groundwater system that is associated with active alluvial deposits, including fluvial sands, riverbanks, and river terraces, extending laterally from the main river channel underneath the riverbanks in some locations to support riparian terrestrial GDEs. Field data indicates that GDEs rely on this perched groundwater system rather than deeper alluvial aquifer. Recharge of the perched groundwater unit occurs through surface flows fed by seasonal rainfall events, which leak into the alluvial aquifer via a weak unsaturated hydraulic connection. The HES wetland is maintained by infiltration of seasonally ponded wetland surface water, with perched groundwater discharge driven by transpiration. The HES wetland is not connected with the deeper alluvial aquifer.

A stygofauna pilot survey was completed across bores in all aquifer units in accordance with relevant State and Commonwealth guidelines. The alluvial aquifer in the vicinity of the Isaac River is considered to be the primary location for stygofauna assemblages within and surrounding the Project area. At a taxonomic level, comparable with historical reporting and studies across the region, the identified stygofauna are same taxonomic groups that are the most commonly recorded across Queensland.

During mining, excavation of open-cut pits and depressurisation of the coal seams will create localised hydraulic sinks, resulting in a change of natural hydraulic gradients in the vicinity of mining area. Groundwater flow will be directed toward the pit from the surrounding coal seams, and regolith. This inward flow regime causes localised drawdown and depressurisation. However, the extent of these changes is constrained by the low permeability interburden. The discontinuous nature of the alluvial aquifer, combined with its weak hydraulic connectivity to deeper units, means that regional flow directions (aligned to drainage) will be largely maintained.

A numerical groundwater model was developed for the Project. An existing regional scale groundwater model informs and underpins the Project’s numerical groundwater model, with the core model architecture remaining consistent, with targeted refinements and scenario applications for the Project. Groundwater modelling included model calibration, model predictions, and sensitivity and uncertainty analysis.

An independent technical peer review of the numerical groundwater modelling was undertaken. This review determined that the model is fit for purpose, which is to produce a calibrated groundwater model and predict groundwater inflows, drawdown, and flow changes, with models suitable for predicting impacts from the Project.

Numerical modelling was used to predict Project only (incremental) impacts and cumulative impacts with other resource projects during and post mining.

No incremental drawdown impacts exceeding 1 m are predicted for the alluvium as a result of the Project. The predicted maximum incremental drawdown is less than 2 m within the regolith, and is confined to a small area directly south of the Project area. The coal seams of the Rangal Coal Measures experience drawdowns as a result of mining at the Project, with these occurring along the western margin of the pit area in both seams.

Cumulative drawdown increases with depth, with the most pronounced depressurisation occurring within the mined coal seams. Shallower units exhibit broader but lower-magnitude cumulative drawdown patterns. The spatial extent of cumulative drawdown reflects the combined influence of long-term mining activities within the Project area and nearby resource operations.

Post mining drawdown magnitudes are substantially reduced compared to maximum drawdown, typically during mining. For the Project, residual incremental drawdown is largely confined to areas immediately surrounding the pit area, with no widespread drawdown persisting beyond the Project area. This indicates a high degree of groundwater recovery following cessation of mining.

The perched groundwater system is not subject to drawdown from the Project or other resource projects. As GDEs demonstrate a reliance on the perched groundwater system rather than the deeper alluvial aquifer, groundwater drawdown associated with the Project or other resource projects (i.e. cumulative drawdown) is unlikely to impacts GDEs. This is borne out by GDE monitoring results for IDM since 2020 along the Isaac River, where there has been no decline in GDE health.

The Project has a negligible contribution to drawdown in the alluvium, and as a result, has a negligible contribution to any potential impacts on stygofauna in the alluvium. At the taxonomic level available for other studies across the region, the stygofauna assemblages identified in the Project's assessment are not unique. Localised cumulative impacts to the alluvium represent a relatively small portion of the available habitat. Therefore, the Project is considered unlikely to impact the long term survival and persistence of stygofauna communities.

Modelling identified that the Project would result in a negligible loss of water from the alluvial aquifer during and post mining. A natural hydraulic gradient exists between the Isaac River and the associated alluvium that results in seepage from the Isaac River to the alluvium (i.e. a losing system). The change in alluvial aquifer groundwater levels induced by mining does not have the potential to increase the hydraulic gradient between the Isaac River and associated alluvium. Consequently, the model does not predict that the average rate of seepage from the Isaac River to the alluvium will increase over the life of the Project, and therefore, the Project does not result in any loss of baseflow to the Isaac River and there are no other predicted groundwater-related impacts to surface drainage as a result of the Project.

Model results demonstrate that the residual void remains a long-term groundwater sink, limiting the potential for off-site groundwater quality impacts.

Groundwater modelling at each landholder bore demonstrates that drawdown at all bores for the most likely model predictions will not exceed a 2m drawdown threshold. Monitoring will be undertaken at landholder bores, and the proponent will enter a make good agreement if drawdown at these bores exceeds the relevant threshold.

Based on the geochemical characteristics and assessed seepage behaviour of in-pit and out-of-pit spoil, seepage from spoil emplacements presents a low risk to groundwater quality during operations and post-closure. Further groundwater quality is unlikely to be impacted by the Project due to the inward hydraulic flow towards the pit area during mining and residual void post mining. Controls will be implemented to manage any localised spills of hydrocarbons or chemicals.

The design of the Project's surface water management systems will protect downstream environmental values and hence minimise any impact on GDEs. Changes to hydrology and geomorphology from the Project are expected to have negligible impact on GDEs. Approximately 6.8 ha of GDEs occur in the Project disturbance area. However, the actual extent of clearing in these areas is likely to be less; and all impacts to GDEs in the disturbance area will be subject to biodiversity offsets and will be rehabilitated to a riparian ecosystem.

A GMMP has been developed to detect changes in groundwater levels and quality, and establish groundwater quality limits, groundwater level triggers and investigation procedures should limits or triggers be exceeded. The GMMP comprises a comprehensive bore network within and surrounding the Project area in all aquifer units, with bores for monitoring compliance and bores for interpretation of background conditions.

Despite the findings of low potential for impacts to GDEs, the proponent has developed a comprehensive GDEMMP, which is designed to monitor and detect changes in GDE health that may be attributable to Project activities. Should the Project impact GDE health than corrective actions are proposed, and if there is still a significant impact to GDEs, as measured by changes in habitat quality to listed species that utilise the identified GDEs, then biodiversity offsets will be provided. The GDE assessment determined that the residual (post mitigation) risk of the Project's potential impacts on GDEs was insignificant to low.

The Project groundwater assessment demonstrates that the Project is unlikely to have a significant impact on groundwater EVs and receptors. Nevertheless, a comprehensive suite of monitoring and management is proposed. With these monitoring and management measures in place the environmental objectives and performance outcomes, as they relate to groundwater, are expected to be achieved.

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