BHP Mitsubishi Alliance

# Appendix H

## Groundwater Dependent Ecosystem Impact Assessment Report

# Groundwater-Dependent Ecosystem Impact Assessment

Saraji Mine Grevillea Pit Continuation Project

Technical Report

BMA

21/10/2025

# DOCUMENT CONTROL

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**DISCLAIMER**

This GDE impact assessment Technical Report was prepared according to the scope, brief and project information provided by BMA. It also relies upon documentation collected specifically for this project. All findings, conclusions or recommendations in the report are based on the information provided and collected for this project. The report is for the use of BMA only and 2rog Consulting accept no liability or responsibility for its use by other parties.

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| IESC | Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development |
| BMA | BHP Mitsubishi Alliance Coal Operations Pty Ltd |
| BOM | Bureau of Meteorology |
| cm | Centimetres |
| Cwth | Commonwealth |
| DCCEEW | Department of Climate Change, Energy, the Environment and Water *(Cwth)* |
| DES | Department of Environment and Science *(Qld) superseded* |
| DESI | Department of Environment, Science and Innovation *(Qld) superseded* |
| DETSI | Department of the Environment, Tourism, Science and Innovation *(Qld)* |
| DoR | Department of Resources *(Qld)* |
| DTW | Depth to Water |
| EA | Environmental Authority |
| EC | Electrical Conductivity |
| EP Act | *Environmental Protection Act 1994 (Qld)* |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999 (Cwth)* |
| EPC | Exploration Permit – Coal |
| FCCM | Fort Cooper Coal Measures |
| FY | Financial Year |
| GDE | Groundwater Dependent Ecosystem |
| GEM | Groundwater Dependent Ecosystem Mapping method |
| GTRE | Ground-truthed Regional Ecosystem |
| IESC | Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development |
| LWP | Leaf Water Potential |
| mbgl | Meters Below Ground Level |
| mbTOC | Meters Below Top of Casing |
| MCM | Moranbah Coal Measures |
| ML | Mining Lease |

| | |
|---|---|
| ML/d | Megalitres per day |
| MLA | Mining Lease Application |
| mm/yr | Millimetres per year |
| NDMI | Normalised Difference Moisture Index |
| NDVI | Normalised Difference Vegetation Index |
| Predicted Drawdown Extent | The area of groundwater drawdown predicted, relevant to GDEs per SLR (2025) |
| Project Area | The area encompassing ML700021 |
| Qa | Quaternary Alluvium |
| Qld | Queensland |
| RCM | Rangal Coal Measures |
| RE | Regional Ecosystem |
| REMP | Receiving Environment Monitoring Program |
| SA | Surface Area |
| SELMP | Saraji East Mining Lease Project |
| SLR | SLR Consulting |
| SMP | Soil Moisture Potential |
| spp. | Species (plural) |
| SRM | Saraji Mine |
| SWL | Standing Water Level |
| TDS | Total Dissolved Solids |
| TGDE | Terrestrial Groundwater Dependent Ecosystem |
| the Project | Grevillea Pit Continuation Project (EPBC 2023/09757) |
| TQa | Tertiary-Quaternary Alluvium |
| VWP | Vibrating Wire Piezometer |
| µS/cm | MicroSiemens per centimetre |

# 01 INTRODUCTION

## 01.1 Background

The Saraji Mine (SRM) is owned and operated by BM Alliance Coal Operations Pty Ltd (BMA), on behalf of the Central Queensland Coal Associates Joint Venture. The SRM is an open cut mine and has been in operation since 1974, operating using dragline and truck/shovel equipment, supplying hard coking (steel making) coal product for the export market. Within the SRM, a suite of pits are present (refer Table 01-1).

As a result of mine sequencing and planning, mining activities are currently scheduled to reach the limit of approved Grevillea Pit extents during FY25. BMA is proposing to extend the footprint of the existing Grevillea Pit at SRM beyond Mining Lease (ML) 1782 and into ML700021 (i.e. the Project Area). ML700021 is bordered by Spring Creek to the north and Phillips Creek to the south and is positioned directly east of ML1782 where current open-cut SRM mining operations are occurring (refer Figure 01-1).

**Table 01-1 Mine pits within SRM**

| Mine | Pit Name | Mining Lease |
|---|---|---|
| SRM | Acacia | ML1775 |
| | Bauhinia | |
| | Coolibah | |
| | Dogwood | |
| | Jacaranda | |
| | Ebony | ML1782 |
| | Hakea | |
| | Grevillea (existing approved) | |
| | **Grevillea (continuation)** | **ML700021** |

In 2017 BMA submitted an Environmental Authority (EA) amendment application under the *Environmental Protection Act 1994* (Qld) (EP Act) to authorise the continuation of Grevillea Pit into ML700021, along with an associated ML application for ML700021 in accordance with requirements under the *Mineral Resources Act 1989* (Qld). This EA amendment and ML were granted in 2018, with Surface Area (SA) rights (SA1) obtained shortly after for the purpose of coal mining. Grevillea Pit Continuation Project (the Project) will operate under the conditions of the approved EA (EPML00862313).

The Project was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) and was deemed a Controlled Action (EPBC 2023/09757) by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), with the controlling provisions of:

- Listed threatened species and communities (sections 18 and 18A).
- A water resource, in relation to unconventional gas development and large coal mining development (sections 24D and 24E).

As water resource is a controlling provision, assessment of the significance of potential impacts to groundwater-dependent ecosystems (GDEs) was undertaken and delivered as part of a Preliminary Documentation (PD) package to DCCEEW on 03/10/2024.

In response to the PD, the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC), on behalf of the regulator, have provided BMA with advice on the Project (as it relates to water resources). Specifically, the IESC have offered response to questions posed by the regulator, regarding the adequacy of the assessment of potential impacts to water resources (as a result of the Project).

This technical report presents an updated significant impact assessment to GDEs, with respect to the advice provided by the IESC, and supporting the Project's broader Commonwealth adequacy review process.

### 01.2 Purpose and scope

The purpose of this report is to conduct a significant impact assessment for potential, likely and/or known GDEs which occur within ML700021 and surrounding areas, and which may be adversely affected by the Project. Predictive groundwater modelling was initially undertaken by SLR (2024) to conceptualise groundwater resources and assess potential impacts to groundwater associated with the progression of the Project. This modelling has since been revised (SLR 2025) in response to the Project's PD adequacy review and IESC commentary. Most pertinently, the updated model has adjusted the extent and magnitude of predicted groundwater drawdown associated with the Project. The Predicted Drawdown Extent (relevant to GDEs), together with the Project Area (i.e. ML700021), forms the Assessment Area referred to within this report (refer Section 01.3 and Figure 01-1).

The scope of this report incorporates the following:

- A desktop review of information to preliminarily identify terrestrial, aquatic, and subterranean (stygofauna) GDEs that may occur within the Assessment Area (Section 02).
- Collation / evaluation of eco-hydrogeological data relevant to the identification and assessment of potential impacts to GDEs (Section 03).
- A systematic approach by which the likely presence and degree of groundwater dependence is determined for each potential GDE (Section 04), this includes:
  - Application of groundwater diagnostic criteria (Section 04.2.1).
  - Application of vegetation diagnostic criteria (Section 04.2.2).
  - Analysis of greenness and moisture indices via a remote sensing approach (Section 04.2.3, Appendix C:).

Potential impacts to GDEs are then discussed based on the results of the updated groundwater modelling (per SLR (2025)) and relevant ecological data analysis (Section 05). Section 06 provides a significant impact assessment undertaken for those GDEs identified in Section 04, with respect to direct and indirect impacts within the Assessment Area. Specifically, the assessment includes:

- Determination of the likelihood of impacts to GDEs being significant (supported by a risk analysis – refer Appendix A)
- Assessing impacts with reference to relevant guidance:
  - Independent Expert Scientific Committee (IESC) Information Guidelines Explanatory Note Assessing groundwater-dependent ecosystems (Doody, Hancock & Pritchard 2019).
  - Significant impact guidelines 1.3: Coal seam gas and large coal mining development – impacts on water resources (DCCEEW 2022).

### 01.3 Nomenclature

Several key terminologies are referred to throughout the course of this report. These are defined below:

**Project** – Grevillea Pit Continuation Project (EPBC 2023/09757) (refer Section 01.1).

**Project Area** – The area encompassing ML700021 (refer Figure 01-1).

**Predicted Drawdown Extent** – The area in which groundwater drawdown is predicted from the model (SLR 2025), and where this may potentially impact on GDEs (refer Figure 01-1).[1]

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[1] Further clarification of the Predicted Drawdown Extent (i.e. the model rationale) is provided Section 02.5.

**Assessment Area** – Includes both the **Project Area** (ML700021) and **Predicted Drawdown Extent**, as modelled by SLR (2025) (refer Figure 01-1).

**Standing water level (SWL)** – refers to the height of groundwater surface in a bore, measured from a reference point.

**Meters below ground level (mbgl)** – refer to the depth of groundwater measured from surface to water table.

**Meter below top of casing (mbTOC)** – refer to the depth of groundwater measured from the reference point of a bore's casing.

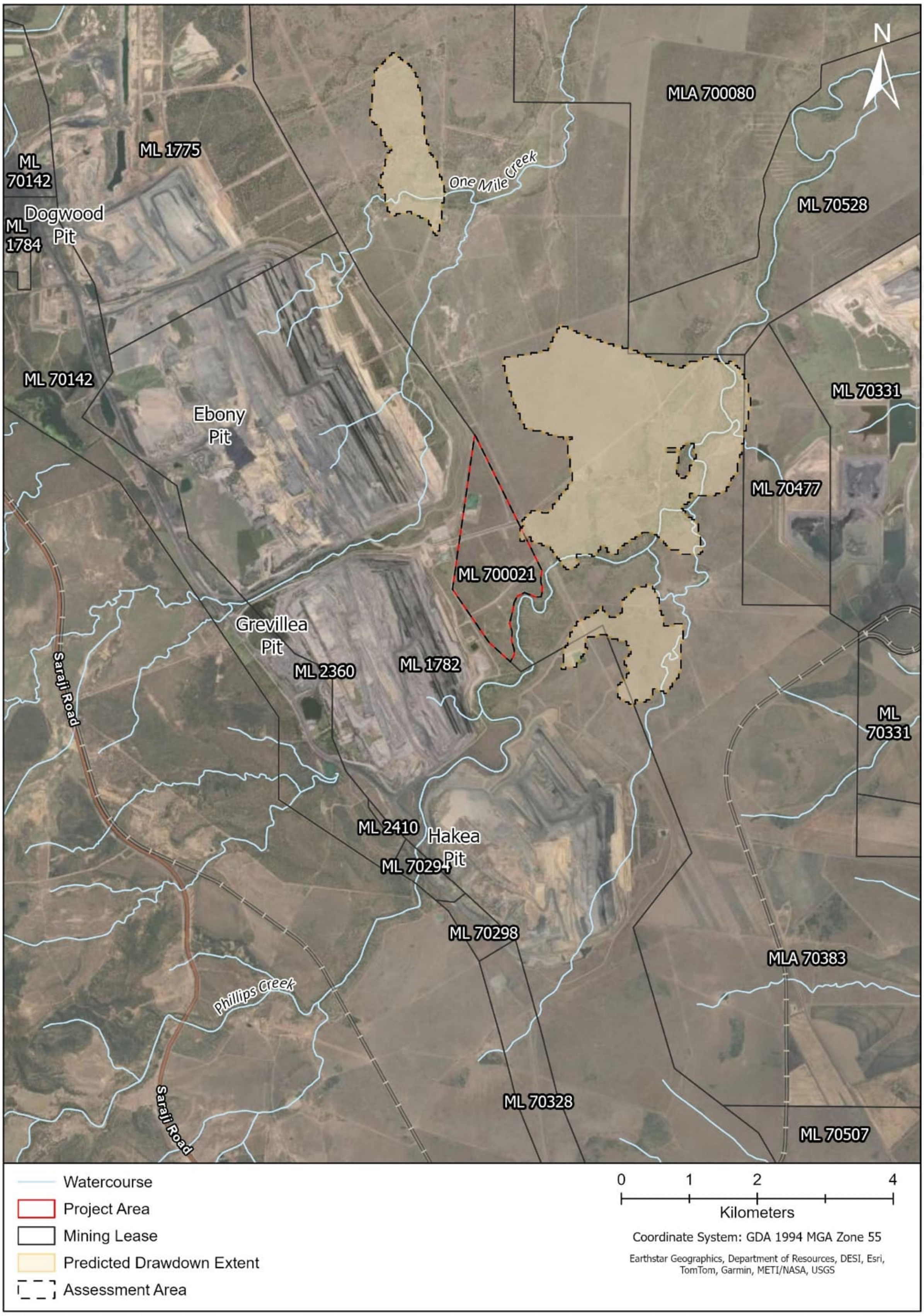


**Figure 01-1 Assessment Area (Project Area and Predicted Drawdown Extent)**

# 02 METHODS TO IDENTIFY GDE

## 02.1 Literature review

GDEs are ecosystems that require access to groundwater on a permanent or intermittent basis to meet the biological requirements of assemblages that comprise them (i.e. communities of plants and animals) and maintain their ecological processes and services (Richardson et al. 2011). Spatial and temporal variation of groundwater flow, influenced by factors such as geological formations, climate patterns, and land management practices, contribute to the formation of diverse GDEs within a landscape.

Eamus et al. (2006a) identifies three main types of GDEs:

- **Subterranean GDEs** that comprise caves or aquifers. GDEs within caves have some degree of connectivity with groundwater and typically have high moisture content and exhibit the presence of stygofauna. All aquifers are GDEs by their nature and are inhabited by micro species (i.e. stygofauna between rock formation and sediments within the aquifer).
- **Aquatic GDEs** are ecosystems that rely on the surface expression of water to maintain their processes and services. These ecosystems can be river baseflow systems (including aquatic and riparian ecosystems in or adjacent to streams and which rely on groundwater), wetlands that receive groundwater discharge, or ecosystems that rely on submarine discharge of groundwater for nutrients and/or physio-chemical attributes.
- **Terrestrial GDEs (TGDEs)** are those reliant on sub-surface presence of groundwater. In these ecosystems, vegetation uses root structures to access the capillary fringe located between the regional groundwater table and the vadose (unsaturated) zone.

The nature of an ecosystem's reliance on groundwater depends on their location within the landscape and the ecology of species within them. Trees found in riparian zones and floodplains rely heavily on consistent access to water sources, including surface flows, soil moisture, and groundwater (Kath et al. 2014). Plant species that need continuous access to groundwater have an **obligate** groundwater dependency (Eamus, et al. 2006b). These species typically succeed in areas where groundwater is readily accessible, such as the lower banks of water bodies.

Conversely, there are species that have adapted to intermittent groundwater access, typically utilising the resource during periods of flooding, when groundwater levels rise. Referred to as **facultative** groundwater-dependent species, these plants can utilise groundwater when it's available but can also survive without it (Eamus, et al. 2006a). Facultative species are typically situated on the upper banks and floodplains of water bodies, though groundwater use can vary with specific landscape / ecosystem context.

An overview of potentially groundwater-dependent species relevant to this assessment can be found from Section 03.2.2.

## 02.2 Desktop assessment

A desktop assessment was undertaken to preliminarily identify likely / potential GDEs occurring within the Predicted Drawdown Extent. Resources used to determine the presence of GDEs within the Predicted Drawdown Extent included:

- Bureau of Meteorology GDE Atlas (BOM 2024).
- State Surface Geology Mapping 1975 (DoR 2023).
- DES Potential GDE Aquifer mapping Ver 1.5 (Queensland Government 2017).
- Queensland Wetland Data (Wetland Maps) (DESI 2019).
- DES Remnant Vegetation Mapping 2021 (Ver 13.1) (DESI 2024).
- Modelled groundwater table contours (SLR 2025).
- Available bore monitoring data, within and surrounding the Assessment Area (SLR 2024, 2025; Appendix B).

## 02.3 Field studies

A suite of ecological surveys have been undertaken throughout and surrounding the Project Area. Results of these investigations have been used to inform this GDE assessment. These resources provide information on the ecology of the Project Area and surrounds, as well as the likely presence of GDEs within the Predicted Drawdown Extent. Table 02-1 summaries these reports and their relevance to this assessment.

**Table 02-1 Field studies informing this report**

| Report | Date/s | Relevance to current Project | Overlay with Project Area |
|---|---|---|---|
| Terrestrial Ecology Baseline Report (AECOM) | 2016 | Report contains information from several ecological field studies from SKM (2007 & 2010) and AECOM (2016) including the field verification and mapping of regional ecosystems and TECs within and proximal to the disturbance footprint (ML700021). Regrowth and remnant REs identified (i.e. REs 11.3.25, 11.5.3, 11.3.4) include TGDE indicator species. | Study area for 2016 surveys aligns with the Project Area (refer Figure 2, AECOM 2016). Previous ecological surveys took place on Mining Lease Application (MLA) 70383 - this large MLA encompasses the Project Area. |
| Saraji Mine Spring Creek Diversion – Stage 1 (EcoLogical) | 2018 | Report summarises ecological field surveys undertaken within and adjacent to (northwest) ML700021. Surveys included ground-truthing of REs including TGDE indicator species (i.e. REs 11.3.2, 11.3.25, 11.3.4, 11.5.3). | Study area for this work sits immediately adjacent (to the northwest) of Project Area and encompasses a section of the nearby Spring Creek (refer Figure 1, EcoLogical 2018). |
| Ecological baseline assessment Saraji Mine (BAAM) | 2021 | The report refers to ecological field surveys across the broader SRM, including pre and post wet seasons for 2020/2021. Ground truthing of regional ecosystems and threatened ecological community (TEC) assessment were undertaken with data points collected within and adjacent to ML700021 (i.e. along Phillips Creek). REs were mapped within the ML700021 and along adjacent waterways that include TGDE indicator species (i.e. REs 11.3.4 and 11.5.3). | Study area extends along the length of SRM and encompasses most of Assessment Area (refer Figure 2.1c, BAAM 2021). |
| Saraji East Mining Lease Project – GDE Report (3D Environmental) | 2023 | Report described GDE assessments across the broader area of SRM and Caval Ridge Mine. GDE assessments were undertaken in mapped high potential zones (for aquatic and terrestrial GDEs) proximal to ML700021 (i.e. Phillips Creek). Field verification and testing has identified common TGDE indicator species at sites along Phillips Creek and the identification of perched groundwater at survey sites neighbouring ML700021. Report describes standing water levels (SWLs) within monitoring bores surrounding ML700021. | Project area is within Exploration Permit - Coal (EPC) 837 and includes survey areas proximal to Assessment Area (refer Figure 13, 3D Environmental 2023). |
| Terrestrial Ecology Survey Report (Engeny) | 2025 | Report describes the most contemporary ecological field surveys undertaken within ML700021. Field surveys confirm presence of REs that contain TGDE indicator species (i.e. REs 11.5.3 and 11.3.1). | Survey area of report is equivalent to Project Area (refer Figure 1, Engeny 2025a). |

## 02.4 Remote sensing analysis

Remotely sensed data provides an additional line of evidence to identify and validate potential GDEs and the nature of their groundwater dependence. The Groundwater Dependant Ecosystem Mapping (GEM) method, endorsed by the IESC as a preferred remote sensing approach[2] (Doody et al 2019; Barron et al 2012), has been utilised to support the assessment.

The method uses satellite imagery to compare vegetation greenness and moisture in wet and dry seasons using two indices:

- NDVI (Normalised Difference Vegetation Index) – indicates vegetation greenness.
- NDMI (Normalised Difference Moisture Index) – indicates vegetation moisture content.

Appendix C provides a memorandum on the application of the approach, and the results of that analysis has been considered alongside other diagnostic criteria present in Section 04.2.

## 02.5 Groundwater modelling

SLR (2024, 2025) have undertaken regional groundwater modelling to support the implementation of the Project. Key objectives of the groundwater modelling included:

- Estimate the groundwater inflow to the Grevillea Project as a function of mine position and timing.
- Simulate and predict the extent of **groundwater level drawdown** due to the Project (of specific relevance to this report).
- Identify areas of potential environmental risk, where groundwater impact management measures may be necessary.

The model is built on a foundational regional model (HydroSimulations 2018 cited in SLR 2024) previously developed for the nearby Olive Downs Project, which was also the basis for other models developed for various mining projects in the region. The regional groundwater model has been modified with the approved and proposed mine plans for the Grevillea Pit Continuation (SLR 2024). The model's predictive period runs from 2024 until 2063.

Responding to feedback from the IESC, SLR (2025) have further refined the 2024 model to improve predictions of groundwater impacts relative to the hydrogeological conceptualisation of the local area. Per the updated model (SLR 2025), potential groundwater drawdown will manifest variously across different water bearing strata (i.e. Alluvium, tertiary sediments, coal seams – refer Section 03.1.3). With respect to this report, application of the model predictions has been limited to Alluvium and regolith layers, with GDEs considered unlikely to access groundwater in Permian hydrostratigraphic units due to the following:

- The thickness of Alluvium and regolith sediments (refer Section 03.1.2).
- Modelled depth-to-water (DTW; refer Section 03.1.3) and relative rooting depth of GDE indicator species (refer Section 04.2.2).
- Heavy clay soils in tertiary sediments restricting effective rooting depth of GDE indicator species (refer Section 04.1.3).
- A lack of vertical movement between Permian and upper layers (i.e. due to low hydraulic conductivity of interburden and presence of other aquitards) (refer Section 03).

[2] For identifying potential terrestrial groundwater dependent ecosystems (TGDEs)

Key outcomes of the updated modelling include:

- No groundwater drawdown[3] is predicted within the Quaternary Alluvium as a result of the Project.
- The maximum incremental drawdown within the regolith (due to the Project) is expected to be <1 m and will occur mostly east (~2.6 kilometres) of the Project Area; although minimal drawdown may also occur to the north (over One Mile Creek) and south (northeast of Hakea Pit) (refer Figure 01-1).

*Note – this technical report utilises the refined groundwater model (SLR 2025) as a basis for GDE impact assessment; however, references to previous work provided by SLR (2024), including the characterisation of groundwater at SRM, are maintained where appropriate and valid.*

### 02.5.1 Cumulative drawdown

The domain of the model is considered sufficiently large to capture all potential overlapping groundwater impacts from resource operations in the Bowen Basin (i.e. cumulative impacts). Predicted groundwater drawdown has been modelled with respect to both the Project and its cumulative interaction with other mining operations in the region (SLR 2025).

Cumulative drawdown within the mapped Alluvium nearby Grevillea Pit will occur in a localised and limited extent, along Phillips Creek upstream of the Project Area (refer Figure 02-1). This modelled drawdown will be <6 m (at maximum); however, based on remote sensing analysis (refer Appendix C), drawdown mostly occurs outside vegetation communities likely to function as TGDEs. No Project-related drawdown (incremental) is anticipated (SLR 2025); therefore, the Project is not considered to contribute to cumulative drawdown in the Phillips Creek alluvium.

Cumulative drawdown in regolith is expected to join Project-related drawdown across SRM and the neighbouring Peak Downs Mine (SLR 2024; 2025) (refer Figure 02-2). This drawdown zone will extend along Phillips Creek, towards the confluence with the Issac River. Cumulative drawdown of up to 5 m is predicted within the Assessment Area. However, Project-related (incremental) drawdown likely provides a negligible contribution to the currently approved mining operations; with 88.5% of the Predicted Drawdown Extent (incremental drawdown) expected to be <10 cm in the regolith[4] (refer Figure 05-1).

Considering the above, this report concerns itself with the impacts associated with the Project (i.e. incremental drawdown). As previously stated, drawdown in Permian strata is not considered within this report and no incremental drawdown has been modelled within the Alluvium. Therefore, the Predicted Drawdown Extent is defined by the maximum predicted incremental drawdown within the regolith only (refer Figure 01-1).

*Note – BMA proposes to develop and implement a dedicated* GDE Monitoring and Management Plan *(GDEMMP) to (1) validate the current assessment of GDEs present within the Assessment Area and (2) monitor and manage the condition of GDEs as the Project progresses. While the MMP will focus on GDEs relevant to the Project, condition monitoring can be used to assist in validating impact contribution to cumulative drawdown.*

[3] Maximum incremental drawdown refers to the drawdown impact associated with the Grevillea Continuation Project only and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved scenario (status quo) and the Project scenario at matching times.

[4] Predicted drawdown in the regolith is modelled across a continuous gradient between 0.01-0.53m. For the purposes of this impact assessment (refer Section 05 & 06), a conservative 1m drawdown has been applied.

## Predicted Cumulative Drawdown (Alluvium & Regolith)

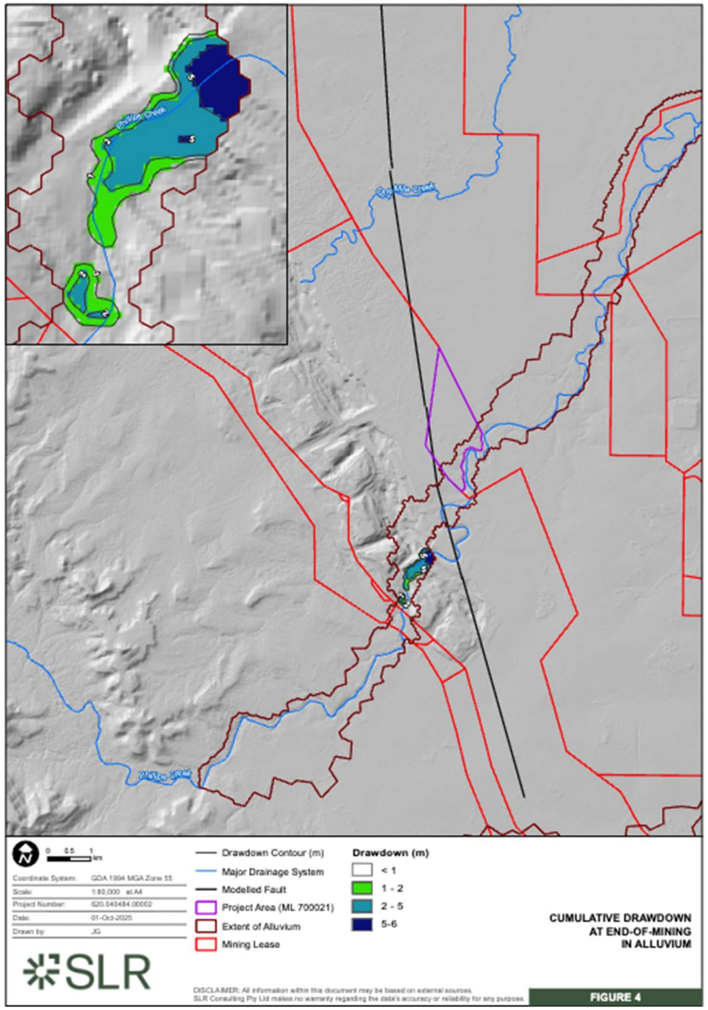


Figure 02-1 Predicted Cumulative Drawdown in Alluvium across SRM (within mapped alluvium – Figure 4 in SLR 2025)

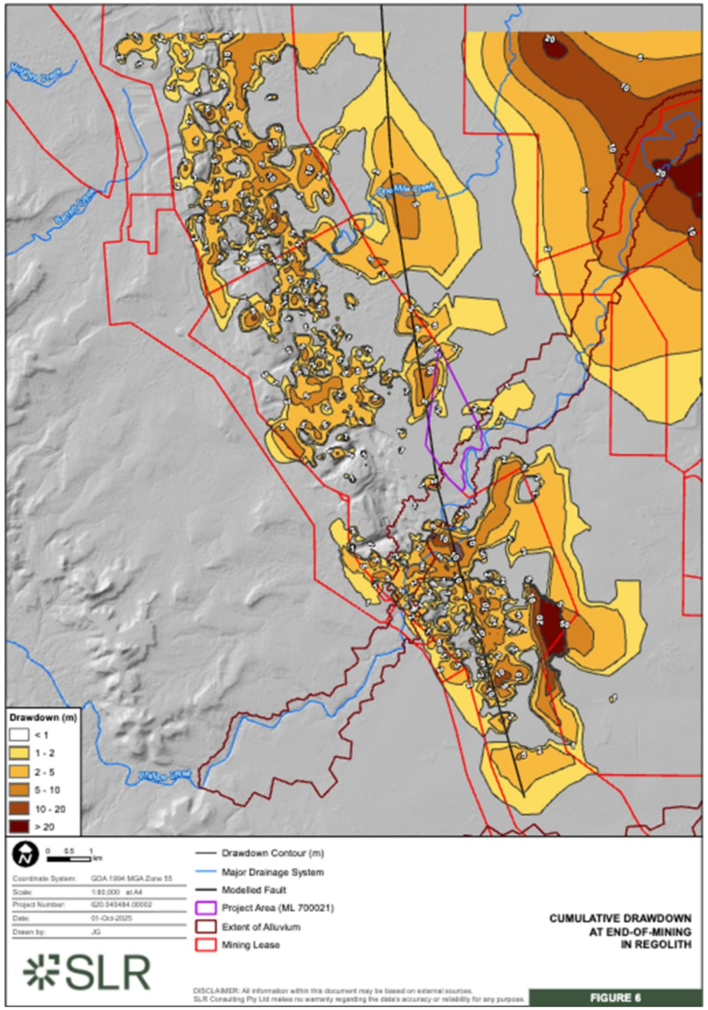


Figure 02-2 Predicted Cumulative Drawdown in Regolith across SRM (Figure 6 in SLR 2025)

# 03 ECO-HYDROGEOLOGICAL SETTING

This section provides details on information relating to the hydrology, geology, and ecology of the Assessment Area.

## 03.1 Hydrogeological setting

The Assessment Area sits in the northern portion of the Bowen Basin. The basin is Permo-Triassic aged and runs along a north-northwest to south-southeast orientation, overlapping with the Surat Basin at its southern end. A variable cover of Quaternary and Tertiary period sediment and basic volcanic rocks (basalts) is present within the Bowen Basin. Three major coal measures are present in the northern basin including the Moranbah coal measures (MCM) that underlies the Assessment Area.

### 03.1.1 Geomorphic setting

The regional geology falls within the Collinsville Shelf as defined by Dickins and Malone (1973). The Permian aged Back Creek Group is overlain by the Blackwater Group, which includes the MCM (SLR 2024). Permian aged strata are overlain by Triassic consolidated sedimentary rocks of the Rewan Group. The Permian and Triassic divisions are covered by a thin layer of Cainozoic sediments (Tertiary to Quaternary Alluvium and colluvium) (SLR 2024). The landscape of the Assessment Area (and general surrounds) is characterised by gently undulating plains and is incised by ephemeral drainage features that flow towards the Isaac River to the east (e.g. Phillips Creek, Hughes Creek) (3D Environmental 2023). Quaternary Alluvium (Qa) (clay, silt, sand and gravel) is concentrated along rivers and creeks, including that which intersect the Assessment Area (i.e. Phillips Creek). Alluvium along Phillips Creek features a localised, unconfined aquifer (sporadically water-bearing strata of permeable unconsolidated sand or gravel) (SLR 2024).

Surrounding plains are lifted by thick sequences of Pleistocene to Tertiary age cracking clay and residual silts and loams to the north of Phillips Creek (including across ML700021) (3D Environmental 2023). Tertiary-Quaternary Alluvium (TQa) is present across some of the Assessment Area.

### 03.1.2 Geological characteristics

The local geology across SRM can be described as two distinct units (SLR 2024):

- Cainozoic sediments and regolith.
- Permian coal measures.

Cainozoic sediments relevant to this GDE assessment are the clay, sand, silt and gravel comprising the Alluvium and colluvium, along with black soils, silts and muds derived from weathered basalts also present within deposits of regolith (SLR 2024). Other Cainozoic units are present more regionally (i.e. Suttor and Duaringa Formations and Tertiary Basalt), though not found within the vicinity of SRM. State (DoR 2023) Detailed Surface Geology mapping shows the Quaternary Alluvium across the Assessment Area is concentrated along Phillips Creek (refer Figure 03-1), with the corridor extending east to join the alluvial sediments associated with the Isaac River Flood Plain. Quaternary sediments associated with Phillips Creek have previously been reported to have a thickness of up to 25 m (AGE 2007 cited in 3D Environmental 2023; AECOM 2019). Current modelling of Alluvium nearby the Project Area note thickness ranges from 0.8m to 22m (SLR 2025).

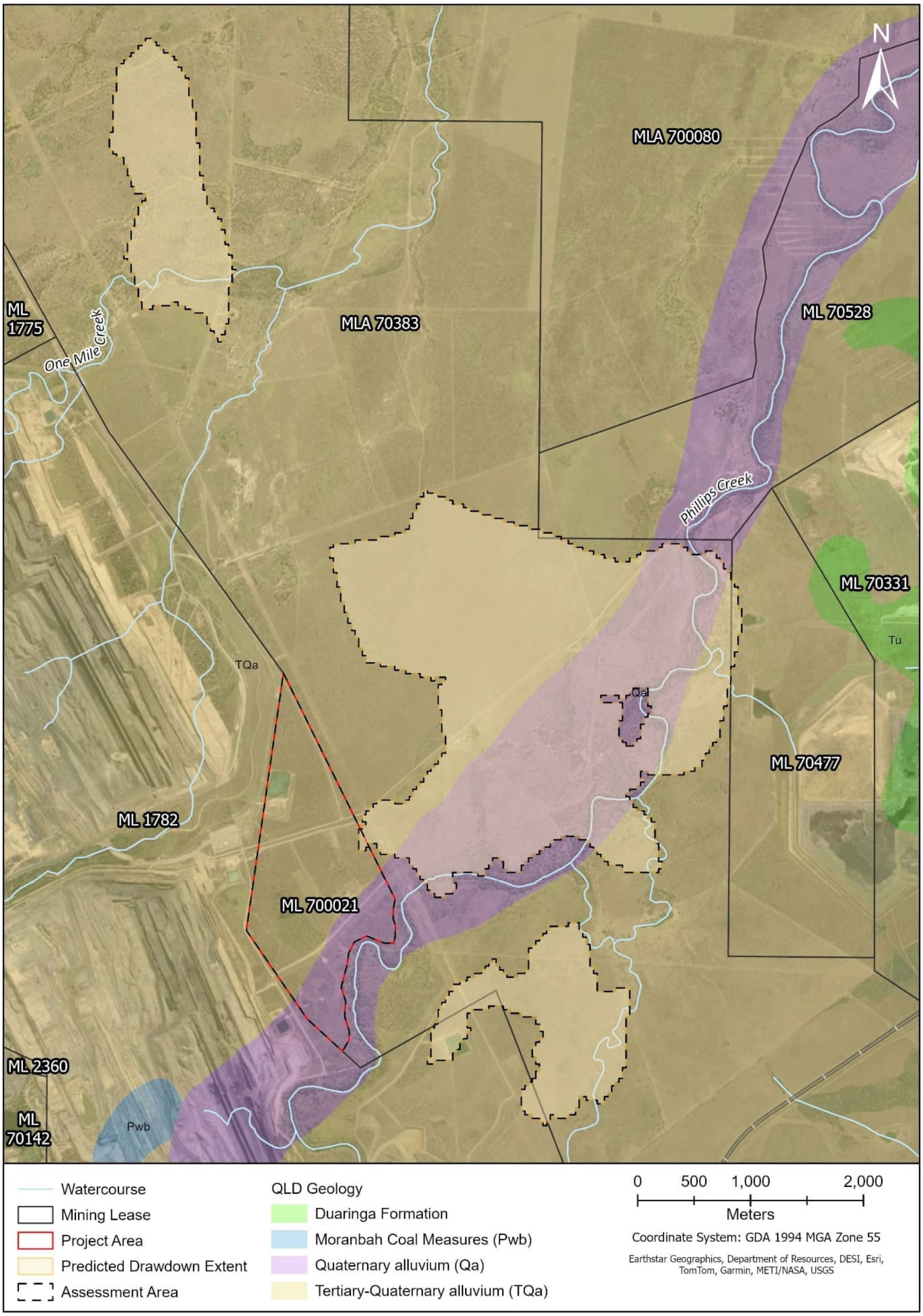


**Figure 03-1 State Surface Geology over Assessment Area**

Outside of creek lines, surface geology is Quaternary to Tertiary sediments and weathering derived regolith. TQa is present extensively across SRM (refer Figure 03-1) and the Predicted Drawdown Extent, extending eastward to the Isaac River Alluvium. Tertiary sediments have been described as being comprised of 'tight' clay which overlies a discontinuous basal unit of sand and gravel (AECOM 2019). Clay comprises the predominant unit within Tertiary sediments, with a basal sand and gravel unit (i.e. 0–3 m thick) comprised of sand and fine gravels (thought to indicate presence of a laterally discontinuous paleo-channel system (i.e. an early Phillips Creek)) (JBT 2014 cited in AECOM 2019). Tertiary sediment thickness reportedly varies from 45–57 m in the western areas of SRM (AGE 2011 cited in SLR 2024). Average thickness of the Tertiary unit in the SLR (2024) regional model layer (2) is 19.2 m (refer Table 03-1).

Further undifferentiated surficial material, including colluvium and residual deposits (Qr and Qr\b) derived from weathering of the underlying Permian strata, are also present primarily to the west of the active SRM pits. This regolith comprises clay, silt, sand, gravel and soil. For the purposes of this report, however, these sediments are grouped with present Tertiary units and termed "**regolith**", as prior groundwater study indicates they essentially function as a single hydrogeological unit (SLR 2024).

Permian coal measures are sedimentary rock found below surficial units across the SRM. The three major measures are:

- Moranbah coal measures (MCM).
- Fort Cooper coal measures (FCCM).
- Rangal coal measures (RCM).

The coal measures are comprised of coal seams and other various geologies including carbonaceous shale, mudstone and siltstone (SLR 2024). The MCM contains four primary coal seams, each consisting of multiple plies. These seams, listed in order of increasing depth, are the Q seams, P seams, Harrow Creek (H) seams, and Dysart (D) seams. Throughout SRM, these seams split and merge. The main coal seams subcrop in the western part of the SRM. FCCM and RCM do not occur within the SRM mining leases (or underlie the Assessment Area) and are not considered relevant to this report.

**Table 03-1 Regional groundwater model layers and thickness (SLR 2024)**

| Model layer | Formation | Unit | Average thickness (m) |
|---|---|---|---|
| 1 | Alluvium, colluvium, Tertiary basalt | Surface cover – Alluvium, colluvium and Tertiary basalt | 8.3 |
| 2 | Tertiary sediments, Tertiary basalt ("regolith") | Tertiary and minor Triassic Clematis group, weathered Permian, Tertiary basalt | 19.2 |
| 3 | Rewan Group | Triassic | 117.7 |
| 4 | Rangal coal measures | Leichhardt overburden | 36.6 |
| 5 | | Leichhardt seam | 4.6 |
| 6 | | Interburden | 35.6 |
| 7 | | Vermont seam | 3.8 |
| 8 | | Vermont underburden | 34.1 |
| 9 | Fort Cooper coal measures | Fort Cooper overburden | 206.6 |
| 10 | | Fort Cooper seams (combined) | 55.9 |
| 11 | | Fort Cooper underburden | 56.1 |
| 12 | Moranbah coal measures | Q Seam | 3.3 |
| 13 | | Interburden | 38.0 |

| Model layer | Formation | Unit | Average thickness (m) |
|---|---|---|---|
| 14 | | P Seam | 2.9 |
| 15 | | Interburden | 56.4 |
| 16 | | H Seam | 5.5 |
| 17 | | Interburden | 67.1 |
| 18 | | D Seam (target coal seam for SEMLP[5]) | 8.4 |
| 19 | | Base of Model - aquitard | 100.0 |

### 03.1.3 Groundwater standing water levels and water quality

Groundwater resources across SRM (and the Assessment Area) should be assessed relative to the geological layers described in Section 03.1.2. These are defined as (SLR 2024):

- Cainozoic sediments and regolith. Comprised of:
  - Quaternary Alluvium – unconfined aquifer (sporadically water-bearing strata of permeable unconsolidated sand or gravel) localised at and near to SRM along Phillips Creek, and regionally along the Isaac River where it is particularly well developed.
  - Quaternary to Tertiary sediments (regolith) – unconfined and largely unsaturated unit at SRM and in the Study Area.
- Permian coal measures. Comprised of:
  - Low permeability interburden units with aquitard properties; and
  - Coal seams that exhibit water bearing properties associated with secondary porosity through cracks and fissures.

The levels and quality of water within different strata (including depth to water (DTW) modelling) are derived via bore data across SRM. A network of sites (consisting of monitoring bores and Vibrating Wire Piezometer (VWP) arrays) have been established since 2011 (AGE 2011 cited in SLR 2024) and this is described in Table 03-2. Of the monitoring bores present within the network, 13 are located proximally or in areas relevant to the GDE assessment (refer Figure 03-2).

**Table 03-2 SRM monitoring sites and hydrogeological units (SLR 2024)**

| Layer | Hydrogeological unit | Number of sites |
|---|---|---|
| Quaternary Alluvium | Quaternary Alluvium | 17 bores |
| N/A | Fill material | 2 bores |
| Regolith | Tertiary sediments (including regolith) | 13 bores |
| Permian Sediments | FCCM | 4 bores |
| | MCM R Seam | 1 bore |
| | MCM Q Seam | 1 bore |
| | MCM P Seam | 3 bores and 2 VWP sensors |
| | MCM H Seam | 5 bores and 3 VWP sensors |
| | MCM D Seam | 6 bores and 3 VWP sensors |
| | MCM Interburden | 3 bores |
| | Back Creek Group | 2 bores |

[5] Saraji East Mining Lease Project

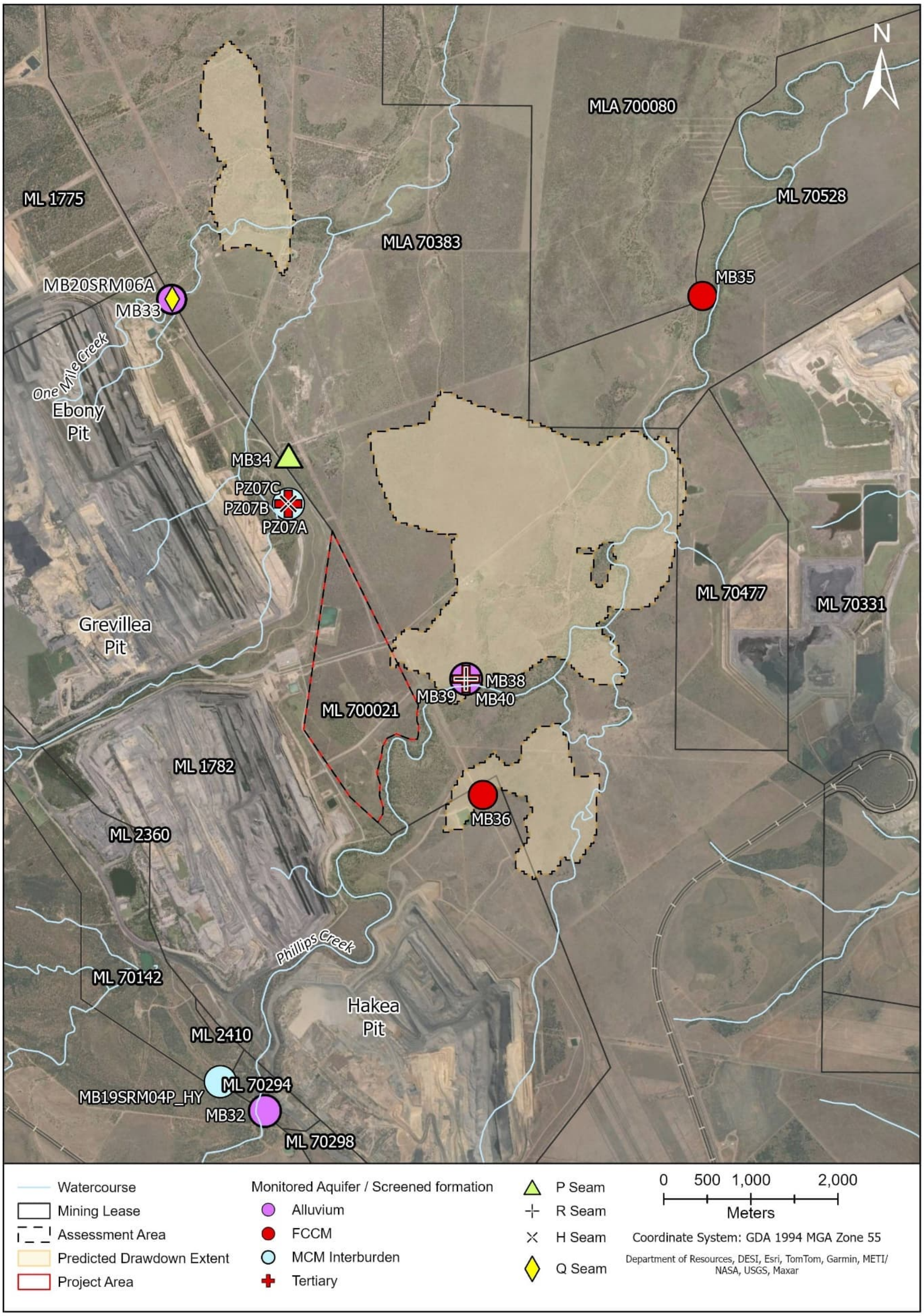


**Figure 03-2 Proximal monitoring bores**

Further details of the bores in Figure 03-2 is provided in Table 03-3, with key points including:

- There is limited information on water depth in the Alluvium along Phillips Creek, with a majority of available groundwater monitoring data for the Alluvium from the area adjacent to Hughes Creek (near Bauhinia Pit). However:
    - SWL along Phillips Creek has been recorded at 7.5 metres below ground level (mbgl) in MB32 upstream of the Assessment Area (3D Environmental 2023). Recent monitoring data (since May 2023) shows groundwater levels in MB32 between 10.5mbgl to 14mbgl (SLR 2025).
    - Hydrographic data from saturated alluvial bores elsewhere in SRM shows groundwater at variable depths, including between 3 and 11.5 mbTOC[6] at Hughes Creek, ~9-9.5 mbgl at Boomerang Creek and ~5.6 mbgl One Mile Creek (SLR 2024; refer Appendix B:).
    - Largely, Alluvium monitoring bores downstream of SRM are dry, as seen in MB38 (SLR 2025)
    - Salinity concentrations in Phillips Creek Alluvium (i.e. in MB32) are notably lower than that recorded in other alluvial screened bores.
- SWLs in regolith proximal to the Assessment Area is reflective of that across SRM (~17-24 mbgl) (SLR 2024).
- SWLs in Permian coal measures nearby the Assessment Area vary with the monitored hydrogeological unit; however, they typically exceed 17 mbgl.
- Salinity concentrations vary with layers, though are typically lower in the upper strata (with no Alluvium / Tertiary monitoring bores exceeding 2,500 microSiemens per centimetre (µS/cm)).

Data from monitoring bores proximal to the Assessment Area (as well as others further afield in SRM) suggests that groundwater in Alluvium is likely only found in isolated, deeper pockets of Alluvium that are more deeply incised into the underlying strata, indicating limited availability of groundwater resource associated within this alluvial corridor (SLR 2024, 2025; AECOM 2019). Variation in hydrograph water levels for MB32 (SLR 2024,2025; Appendix B) suggests strong climatic influence on groundwater within the Phillips Creek Alluvium (i.e. Alluvium recharged by rainfall and associated surface flows). Levels are more consistent in Tertiary sediments (i.e. MB40), reflecting a subdued effect of climate on regolith groundwater (SLR 2024).

Based on monitoring data, contours of expected DTW across SRM and within the Assessment Area, have been modelled (SLR 2025) (refer Figure 03-3). Across the Predicted Drawdown Extent, the model predicts a DTW of '≤20 m' and '20–30 m', and within the Project Area, depth rapidly increases across ML700021 (i.e. east to west) (refer Figure 03-3). Shallower DTW contours (i.e. ≤ 20 m) largely coincide with drainage features such as Phillips Creek.

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[6] Meters below the Top of Casing

Table 03-3 SWL and water quality of monitoring bores proximal to Assessment Area

| ID | Monitored aquifer unit | Status | Installation year | SWL (mbgl or mbTOC[7]) | Water quality (salinity - µS/cm) | Source/s | Location |
|---|---|---|---|---|---|---|---|
| MB32 | Alluvium | Existing, Monitored | Unknown | 7.5 (3D Environmental)<br>13.2 (2020) (3D Environmental)<br>11.67 (2008) – 8.29 (2016) (AECOM 2019)<br>10.5-14 (SLR 2025) | 773-2,276 (AECOM 2019)<br><br><2,500 (3D Environmental) | SLR 2024; 3D Environmental 2023; Gauge 2016 in AECOM 2019 | Phillips Creek reference bore – located west of Hakea Pit (upstream) |
| MB38 | Alluvium | Existing, monitored | 2019 | Dry | Not Available | SLR 2024; 3D Environmental 2023 | Located east of Grevillea Pit near Phillips Creek (downstream) – co-located with MB40 & MB39 |
| MB20SRM06A | Alluvium | Existing, abandoned | 2019 | 5.65 (refer Appendix B)<br>6.10 (SLR 2024) | Not Available | SLR 2024, 2025; AECOM 2023 | Located east of Ebony Pit, along tributary of One Mile Creek |
| PZ07A | Tertiary | Existing, not actively monitored | 2011 | Not available | Not available | SLR 2024; 3D Environmental 2023; AECOM 2019 | Located immediately northeast of Grevillea Pit - co-located with PZ07C & PZ07B |
| MB40 | Tertiary | Existing, monitored | 2019 | 17.15 (Feb 2020 - AECOM)<br>17.82 (Feb 2022 – AECOM)<br>18.03 (2020-2021 Avg – 3D) | 2,230 (3D)<br>1,980 – 2,480 (AECOM 2023a) | SLR 2024; 3D Environmental 2023; AECOM 2019; AECOM 2023a | Located east of Grevillea Pit near Phillips Creek (downstream) – co-located with MB38 & MB39 |
| MB34 | P Seam | Existing, monitored | 2012 | 22.97 to 28.2 (2020-2021 Avg – 3D)<br>23.10 (2017 - AECOM | 30756 (3D)<br>23,000-35,000 (AECOM) | SLR 2024; 3D Environmental 2023; AECOM 2019 | Located northeast of Grevillea Pit (nearby Ebony Pit) |
| MB39 | R Seam | Existing, monitored | 2019 | 17.81 (2020-2021 Avg – 3D) | 9864 (3D) | SLR 2024; 3D Environmental 2023 | Located east of Grevillea Pit near Phillips Creek (downstream) – co-located with MB38 & MB40 |

[7] Reported as mbTOC by SLR (2024) and mbgl from all alternative sources

| ID | Monitored aquifer unit | Status | Installation year | SWL (mbgl or mbTOC[7]) | Water quality (salinity - µS/cm) | Source/s | Location |
|---|---|---|---|---|---|---|---|
| PZ07C | H Seam | Existing, not actively monitored | 2011 | 64.5 (AECOM) | N/A | SLR 2024; AECOM 2019 | Located immediately northeast of Grevillea Pit - co-located with PZ07B & PZ07A |
| MB33 | Q Seam | Existing, monitored | 2014 | 18.45 to 21.34 (3D Environmental) | 24,865 | 3D Environmental | Located east of Ebony Pit, along tributary of One Mile Creek |
| MB19<br>SRM04P<br>_HY | MCM Interburden | Existing, monitored | 2019 | 19.93 - 19.96 (Avg) (3D Environmental) | 6,190 (3D Environmental) | SLR 2024; 3D Environmental | Adjacent to MB32 along Phillips Creek Alluvium – West of Hakea Pit |
| PZ07B | MCM Interburden | Existing, not actively monitored | 2011 | ~11 (2012 - AECOM) | N/A | SLR 2024; AECOM 2019 | Located immediately northeast of Grevillea Pit - co-located with PZ07C & PZ07A |
| MB35 | FCCM | Existing, monitored | 2012 | 17.02 – 20.3 (Avg) (3D Environmental)<br>27.96 (2012) – 17.87 (2016) (AECOM) | 1,546 (3D Environmental)<br>1,125 – 1,340 (AECOM) | SLR 2024; 3D Environmental<br>2023; AECOM 2019 | Located northeast of Grevillea Pit along Phillips Creek Alluvium (downstream) |
| MB36 | FCCM | Existing, monitored | 2012 | 17.45 to 18.45 (2020-2021 Avg – 3D Environmental)<br>19.58 (2012) – 17.84 (2016) (AECOM) | 7,177 (3D)<br>7,500 – 10,500 (AECOM) | SLR 2024; 3D Environmental<br>2023; AECOM 2019 | Located southeast of Grevillea Pit |

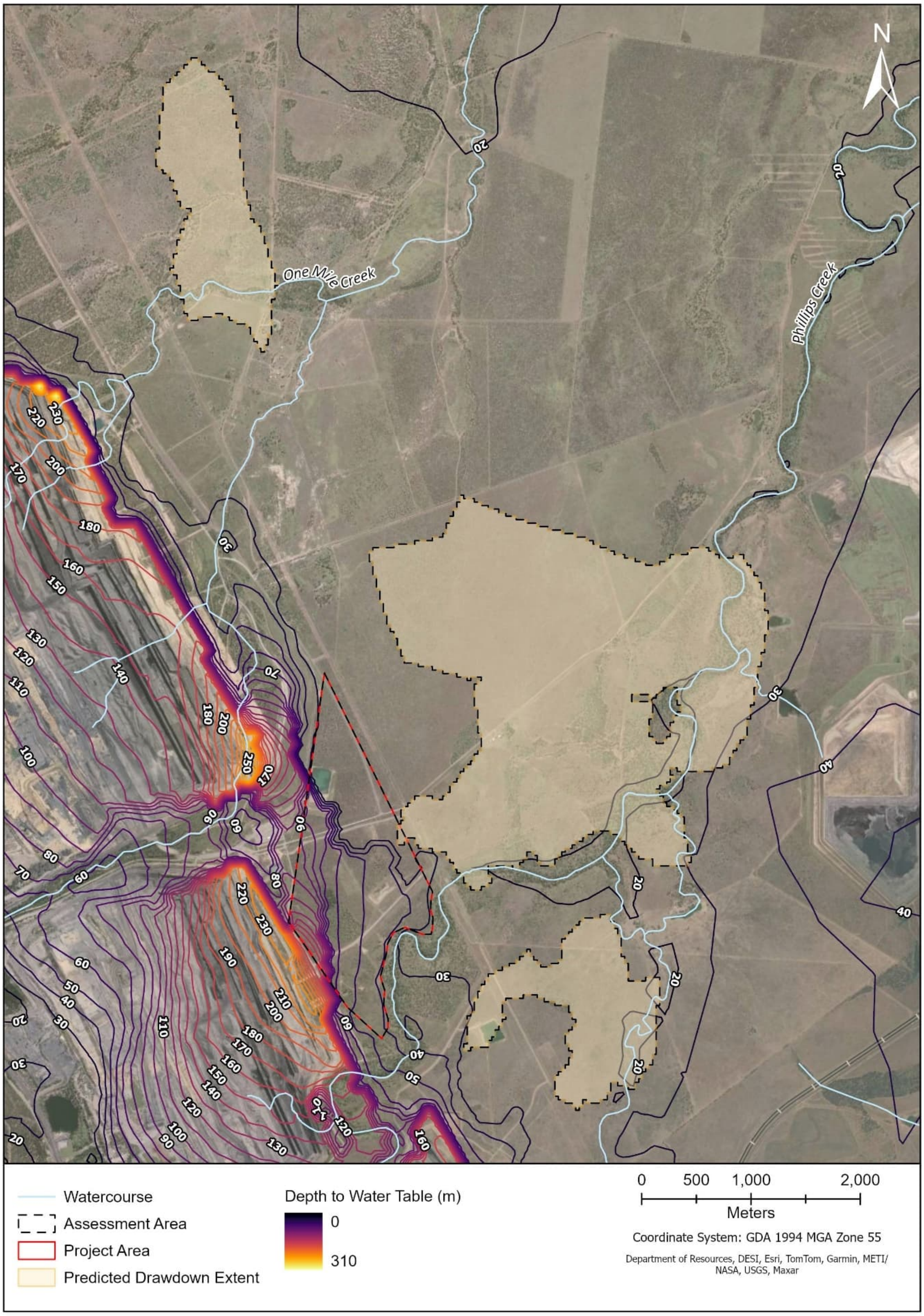



**Figure 03-3 Modelled DTW across the Assessment Area**

### 03.1.4 Groundwater recharge and discharge

Due to the spatial distribution of surficial Alluvium within the Assessment Area, and limited quantity of monitoring data, discussion of groundwater recharge and discharge within Alluvium is concentrated along Phillips Creek. Quaternary Alluvium along the creek can be characterised as an unconfined aquifer of intermittently water-bearing strata of permeable unconsolidated sand or gravel (SLR 2024, 2025). Previous investigations (AECOM 2019) and bore monitoring within this Alluvium indicates that there is limited groundwater resources present, however, and any occurrence of groundwater is likely isolated pockets that are hydrologically disconnected from the broader flood plain Alluvium (SLR 2024). Data from MB32 (the only non-dry bore in this Alluvium) demonstrates correlation between groundwater levels and precipitation levels, indicating a climatic influence on recharge in groundwater pockets (i.e. groundwater levels drop in Phillips Creek Alluvium during dry periods (SLR 2024)).

Recharge of Alluvium groundwater in Phillips Creek likely occurs via stream flow and/or flooding events, (SLR 2024). Below the Alluvium, clay barriers act as aquitards which largely prevents infiltrating surface water from moving to deeper groundwater units. SLR (2024) calculated the recharge rate of Alluvium (not in the Isaac River Channel) as 1.3 millimetres per year (mm/yr) via chloride mass balance (SLR 2021 in SLR 2024). Discharge occurs via downstream throughflow, with some potential for evapotranspiration from deeper rooted riparian vegetation growing along watercourses (particularly along the Isaac River) (SLR 2024). Landholder bore discharge is also common in the region. The Alluvium across SRM is underlain by stratigraphy with low hydraulic conductivity, such as claystone, siltstone, and sandstone (SLR 2024). This composition limits the rate of downward leakage to the underlying formations. Localised perched water tables within the Alluvium are observed where water bodies retain water throughout dry periods, though perched groundwater pockets have been recorded under dry riverbed in Phillips Creek (3D Environmental 2023). Perched water tables occur where clay layers slow the percolation of surface water (SLR 2024).

Tertiary sediments (regolith) are unconfined and comprise a largely unsaturated unit across the broader SRM (SLR 2024). Flow of groundwater within regolith is likely to be consistent with surface drainage (AECOM 2019). Slow change in the SWL at monitoring site MB40, (in response to dry and wet periods) suggests that there is a limited climate influence over the groundwater recharge in Tertiary sediments around that area of Phillips Creek (SLR 2024). Generally, material within Tertiary sediments is of low hydraulic conductivity (i.e., clay and claystone), restricting rainfall recharge. Further, vertical seepage is limited by the underlying low hydraulic conductivity of the Blackwater Group overburden (and other aquitards), meaning that Tertiary sediments effectively form a perched groundwater system above the Permian strata (SLR 2024). Recharge rate of Tertiary sediments across SRM has been previously calculated at 0.1 mm/yr (SLR 2021 in SLR 2024).

For coal measures within SRM, groundwater occurrence is mostly restricted to permeable seams, which exhibit secondary porosity through fractures and cleats (SLR 2024). Prior to mining activities in the area, recharge of Permian coal measures occurred where the seams were present at outcrop and subcrop (SLR 2024), with a calculated rate of 0.1 mm/yr (SLR 2021 in SLR 2024). However, where now exposed by mines, higher recharge can occur. Groundwater flows horizontally along coal seams, as interburden material is of low hydraulic conductivity. Discharge occurs from inflow into active mine pits and evaporation (SLR 2024).

### 03.1.5 Hydraulic characteristics

Hydraulic data from SLR (2024) indicates variable hydraulic conductivity of Alluvium, illustrative of the heterogeneous nature of alluvial sediments within the SRM region. Hydraulic conductivity in Alluvium ranges from $10^{-2}$ to almost 10 metres per day (m/day). Field data shows that conductivity results for Alluvium, Tertiary sediments, RCM and FCCM within the SRM (and surrounds) fall within the range of field data collected through other studies across the Bowen Basin (SLR 2024). Interburden/overburden testing shows a hydraulic conductivity of at least an order of magnitude less than that of coal seams at similar depths. Higher hydraulic conductivity in Permian coal measures generally declines with depth (SLR 2024).

## 03.2 Ecological setting

### 03.2.1 Regional ecosystems

To align with field data and for ease of reference, vegetation communities in the Assessment Area have been identified using the Queensland Government's regional ecosystem (RE) classification methods. These REs (including those known to contain GDE indicator species) have been ground-truthed as part of numerous field surveys (refer Section 02.3). Engeny (2024) have provided the most current ground-truthed regional ecosystem (GTRE) mapping across the Project Area with mapping in additional areas supplemented with data from other contemporary field surveys (refer Table 02-1). Notably, no EPBC Act listed ecological communities have been identified within the Assessment Area.

**Vegetation communities within the Assessment Area are typical of those within the Brigalow Belt North bioregion and include Acacia species (spp.) and/or eucalypt open forests to woodlands. REs present on Tertiary plains include Eucalyptus populnea (RE 11.5.3), Eucalyptus tereticornis (RE 11.3.4) and Acacia harpophylla (brigalow) (RE 11.4.9) woodlands. The riparian habitats that fringe Phillips Creek are predominantly comprised of RE 11.3.25, with other proximal REs including 11.5.3, 11.4.9 and 11.4.8 (3D Environmental 2023; BAAM 2021; Engeny 2025a). Table 03-4 outlines the extent**

**of REs within the Assessment Area, with the spatial distribution of ecosystems across SRM displayed in**

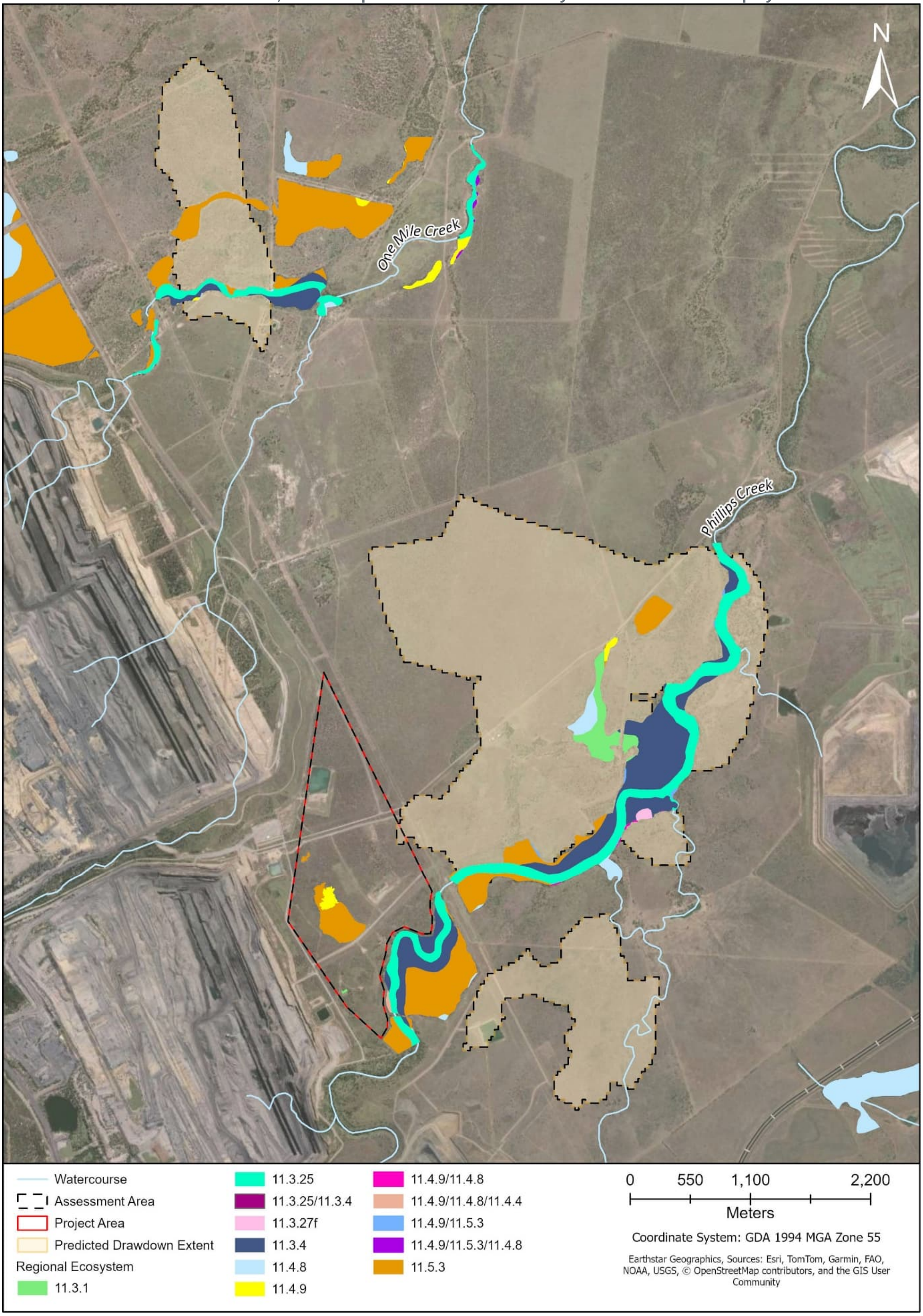


Figure 03-4[8]. Potential GDE indicator species within REs are identified in Table 03-4 and discussed in Section 03.2.2.

**Table 03-4 REs within the Assessment Area**

| Regional ecosystems | Potential GDE indicator species | Extent (ha) within Assessment Area | |
|---|---|---|---|
| | | Project Area | Predicted Drawdown Extent |
| 11.3.1 - *Acacia harpophylla* and/or *Casuarina cristata* low open forest on alluvial plains | *Acacia harpophylla* | 0.1 | 14.4 |
| 11.3.25 - *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines | *Eucalyptus camaldulensis*<br>*Eucalyptus tereticornis*<br>*Corymbia tessellaris*<br>*Corymbia clarksoniana*<br>*Casuarina cunninghamiana* | Nil | 36.3 |
| 11.3.27f - *Eucalyptus coolabah* and/or *E. tereticornis* open woodland to woodland fringing swamps. | *Eucalyptus tereticornis* | Nil | 1.2 |
| 11.3.4 - *Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains | *Eucalyptus camaldulensis*<br>*Eucalyptus tereticornis*<br>*Corymbia tessellaris*<br>*Corymbia clarksoniana* | Nil | 42.4 |
| 11.4.8 - *Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains | *Acacia harpophylla* | Nil | 5.0 |
| 11.4.9 - *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains | *Eucalyptus populnea*<br>*Acacia harpophylla* | 2.2 | 1.2 |
| 11.4.9/11.4.8 - *Acacia harpophylla* shrubby woodland AND *Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* | *Eucalyptus populnea*<br>*Acacia harpophylla* | Nil | 0.1 |
| 11.4.9/11.5.3 - *Acacia harpophylla* shrubby woodland AND *Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* woodland | *Eucalyptus populnea*<br>*Acacia harpophylla*<br>*Corymbia clarksoniana* | Nil | 0.3 |
| 11.5.3 - *Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces | *Eucalyptus populnea*<br>*Corymbia clarksoniana* | 11.7 | 23.0 |
| **TOTAL:** | | **14.0** | **123.9** |

[8] Several RE mosaics present in Figure 03-4 include several outside of the Assessment Area, which are therefore not captured under Table 03-4.

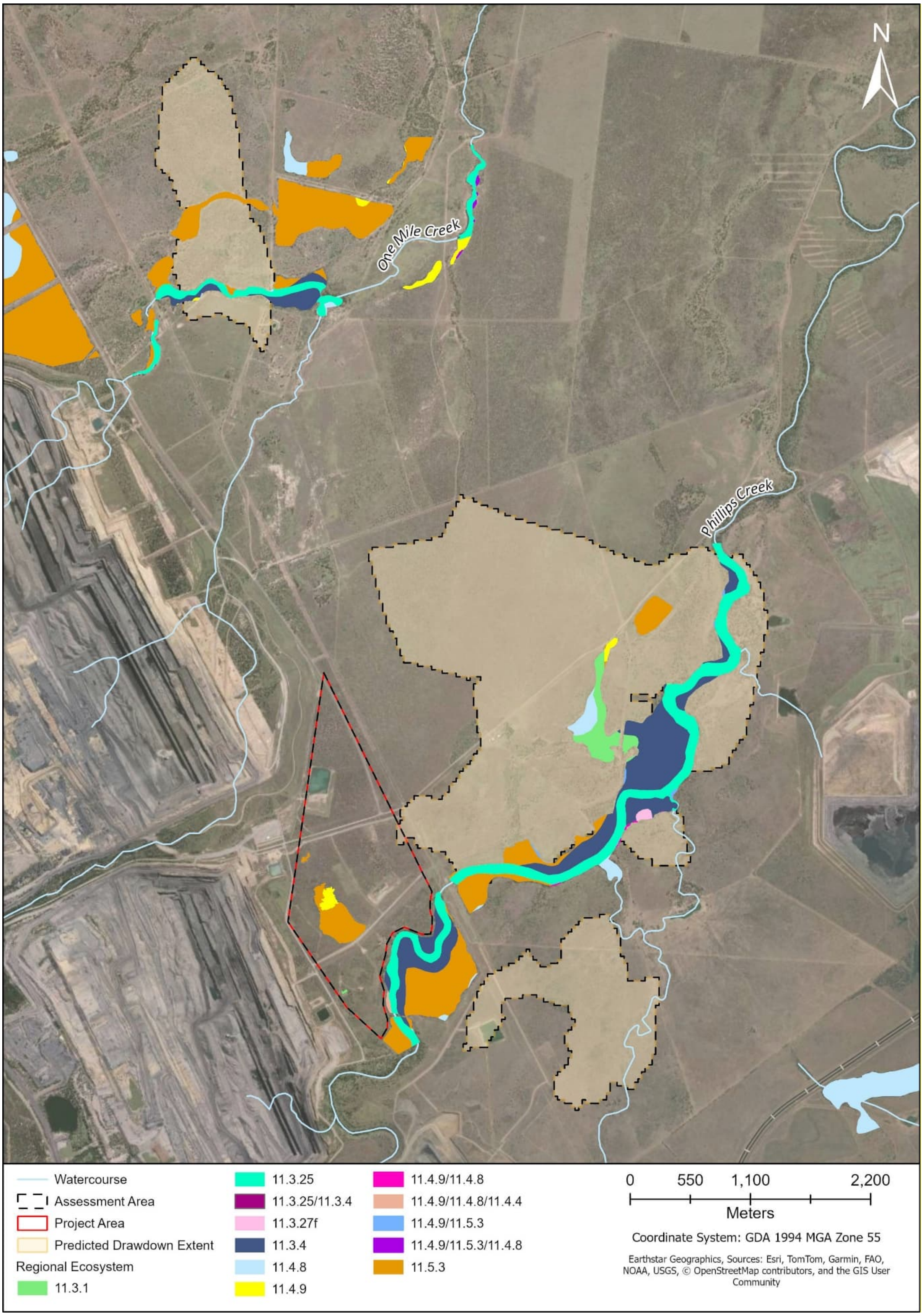



**Figure 03-4 GTREs across the Assessment Area**

### 03.2.2 GDE-indicator species

The GDE indicator species discussed in this section are derived from a review of ecological literature. The species listed do not constitute a comprehensive list of all potential TGDE indicator species which may occur in the region; however, the ecology and geology which occurs across the site and broader SRM indicates they are most relevant to this assessment. Species-specific root morphologies, land zone, soil type (e.g. alluvial vs. igneous) and detailed RE descriptions (e.g. occurs in depressions / drainage lines *vs* occurs on crests and scarps) were considered in determining potential for groundwater access / independency.

Key characteristics of these species, with respect to potential for groundwater dependency, are described below and outlined in Table 04-2.

#### 03.2.2.1 *Eucalyptus populnea*

*Eucalyptus populnea* (poplar box) are common to the region. Within the Project Area, the species occurs in open forest communities co-dominated by *E. melanophloia* and/or *Corymbia clarksoniana* (RE 11.5.3) (Engeny 2025a). *Eucalyptus populnea* is also present in a small patch of brigalow woodland (RE 11.4.9) within the Project Area as a sub-dominant species (Engeny 2025a). Large tracts of RE 11.5.3 have also been identified immediately south of Phillips Creek (AECOM 2016).

Uncertainty exists concerning the potential for *E. populnea* to act as a GDE indicator species due to variation in rooting depth (dependent on the region in which they occur). Anderson and Hodgkinson (1997) concluded that poplar box seedlings have the ability to grow down to groundwater. More recent work from Kath et al. (2014) denotes potential rooting depth of the species between 12.6–26.7 mbgl within the Condamine catchment of southern Queensland (noting that this is theoretical rooting depths based on tree condition and groundwater depth). Conversely, Fensham and Fairfax (2007) contend that *E. populnea* have a shallow rooted nature comparative to bloodwoods within Central Queensland savanna. The latter conclusion, along with the species typical presence on plains elevated above drainage lines, indicates the species has limited groundwater dependency, as is noted in previous ecological studies which overlap with the Assessment Area (i.e., 3D Environmental 2023).

#### 03.2.2.2 *Eucalyptus camaldulensis*

*Eucalyptus camaldulensis* (river red gum) is a known GDE-indicator species which exhibits deep rooting depths and may tolerate a wide variety of water regimes (Colloff 2014). River red gums are a ‘facultative phreatophyte’ (i.e. requiring groundwater intermittently throughout its life), alternating between use of surface soil moisture and groundwater during periods of extended precipitation, and exclusively tapping into groundwater during dry periods. This transition is likely facilitated by the deactivation of surface roots coupled with a heightened dependence on deeper tap roots when surface water becomes scarce. Rooting depth for the species has been reported between 7–22.6 mbgl (Burgess et al. 2000; Kath et al. 2014). The species has been identified in association with riparian ecosystems (i.e. RE 11.3.25) along Phillips Creek.

#### 03.2.2.3 *Eucalyptus tereticornis*

*Eucalyptus tereticornis* (forest red gum) are common to the region and demonstrate comparable ecological attributes to *E. camaldulensis*. The species is somewhat more adaptable and can occur within riparian and alluvial plains ecosystems (3D Environmental 2023). Forest red gums have been recorded rooting to depths of 9.3 mbgl (Kallarackal & Somen 1998). 3D Environmental (2023) note *E. tereticornis* is co-dominant within vegetation along Phillips Creek (i.e. RE 11.3.25) aside *Casuarina cunninghamiana* (river she-oak). Patches of *E. tereticornis* woodland were also identified to the north of the Project Area, adjacent to Spring Creek.

#### 03.2.2.4 *Corymbia tessellaris*

*Corymbia tessellaris* (Moreton Bay ash) occurs along Phillips Creek (in RE 11.3.25) alongside *E. camaldulensis*, with *Casuarina cunninghamiana* and *Melaleuca fluviatilis* (river tea tree) (AECOM 2016). Surveys from BAAM (2021) identified the species also present within RE 11.3.4 on alluvial plains south of Phillips Creek, forming a canopy with *E. tereticornis*. Bloodwoods are considered to invest more in deeper-reaching root architecture[9] than other eucalypt species (e.g., ironbarks, boxes) (Fensham and Fairfax 2007) and thus should be considered a facultative phreatophyte. O'Grady et al. (2006b) determined *C. tessellaris* to be capable of accessing groundwater at least 4 mbgl in a study undertaken in remnant vegetation near Mackay, Queensland.

#### 03.2.2.5 *Corymbia clarksoniana*

*Corymbia clarksoniana* (Clarkson's bloodwood) is present in remnant RE 11.5.3 within the Project Area (Engeny 2025a) and in RE 11.5.3 adjacent to Phillips Creek (BAAM 2021). As with *C. tessellaris*, the species is known to be a facultative phreatophyte and will likely utilise groundwater where they occur along riverbanks (subject to DTW and water quality). O'Grady et al. (2006b) estimated a rooting depth of 10 mbgl for *C. clarksoniana* from work in the region (i.e. Mackay area). 3D Environmental (2023) note both *Corymbia* spp. sporadically occur along the frontages of Phillips Creek, in REs 11.3.25 and 11.3.2.

#### 03.2.2.6 *Casuarina cunninghamiana*

*Casuarina cunninghamiana* (river she-oak) has been identified in the lower layers of RE 11.3.25 (immediately south of the Project Area), alongside *Corymbia tessellaris* and *Melaleuca fluviatilis* (BAAM 2021). O'Grady et al. (2006a) identified that groundwater use by river she-oaks varied with distance relative to surface flow (i.e. a facultative phreatophyte); however, when adjacent to stream channels (as is the case for the species within the Assessment Area), *Casuarina cunninghamiana* is considered to primarily rely upon river water (O'Grady et al. 2006b).

#### 03.2.2.7 *Acacia harpophylla*

*Acacia harpophylla* (brigalow) often occurs adjacent to floodplains of major drainage systems and generally occupies cracking clay soils with microrelief (i.e. gilgai). The species is described as clonal, with extensive lateral root architecture (Johnson 1964) that predominately occurs in the upper 60 centimetres (cm) of the soil profile where nutrient recycling occurs in heavy clay soils (3D Environmental 2023). Brigalow vertical rooting is characterised by suckering (shooting from lateral roots), in response to disturbance (Johnson 1964). The shallow rooting nature of the species is demonstrated via fallen trees which expose a well-developed lateral root system with little evidence of sinker roots that would have capacity to reach deeper groundwater tables (3D Environmental 2023). Notably, the species is not typically found in association with Alluvium. In the case of the Assessment Area, brigalow is present in REs 11.4.8 and 11.4.9, further up on the elevated Cainozoic clay plains and terraces.

It is understood that brigalow has previously been considered a potential GDE indicator species by DCCEEW. In this instance, established literature and site eco-hydrogeology would indicate this is not the case within the Assessment Area. This is due to the species' relative positioning in the landscape, and the estimated DTW below their associated REs (refer Section 04.2.1). However, brigalow will be considered a potential GDE indicator species in this report as a matter of prudence.

### 03.2.3 Mapped GDEs

National GDE mapping is undertaken by the Bureau of Meteorology (BOM) and is available to view via the BOM GDE Atlas (2024). The GDE Atlas classifies ecosystems based on the potential for dependence on groundwater through desktop collation of multiple lines of scientific evidence. Included in this dataset are the three identified GDE classifications (per Eamus 2006a):

- **Subterranean GDEs** – comprise caves or aquifers.
- **Aquatic GDEs** – rely on the surface expression of groundwater to maintain ecological function.
- **TGDEs** – reliant on sub-surface presence of groundwater.

High and moderate potential aquatic GDEs (nationally assessed – BOM 2024) are identified within the Assessment Area, primarily in association with drainage line REs (i.e. 11.3.25) and a patch of RE 11.3.27b. High potential TGDEs (nationally assessed) are also mapped along the Alluvium of Phillips Creek with moderate and low potential for TGDEs on elevated plains and along One Mile Creek (within the Predicted

[9] Though no specific rooting depth is noted

Drawdown Extent). No subterranean GDEs are mapped locally in the Assessment Area. Figure 03-5 provides an overview of the BOM GDE mapping across the Assessment Area.

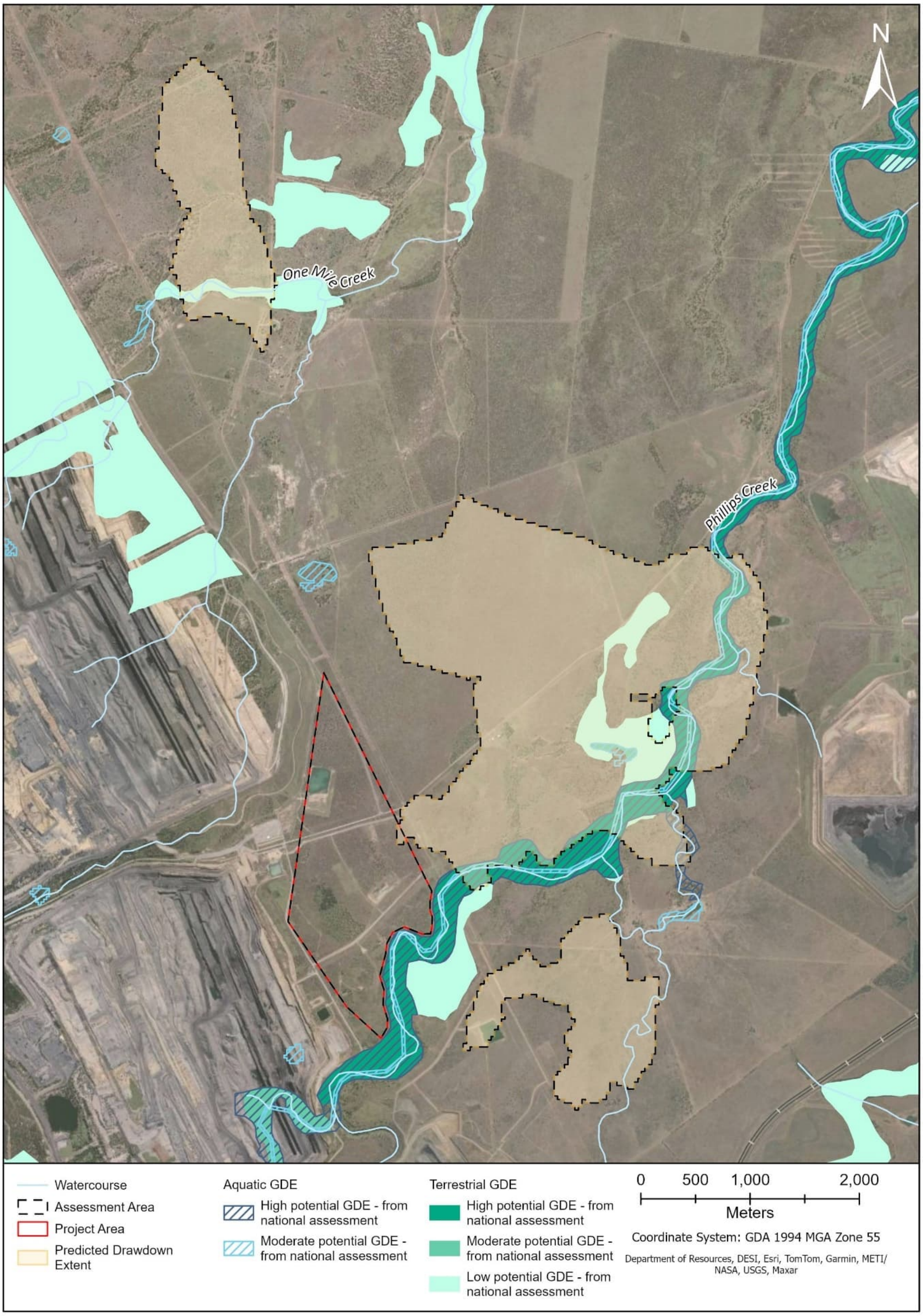



**Figure 03-5 BOM National GDE mapping across Assessment Area**

# 04 RESULTS OF GDE IDENTIFICATION

## 04.1 GDE potential

### 04.1.1 Subterranean GDEs (including stygofauna)

No known subterranean GDEs have been identified within the Assessment Area via the BOM GDE Atlas (refer Figure 03-5). Bore monitoring from within Tertiary and Permian units during 2011 (to support the adjacent Saraji East Mining Lease Project – SEMLP) detected no stygofauna (ISEA 2011a&b cited in SLR 2024). Previous studies from the broader SRM and within the Bowen Basin have provided no indication that stygofauna are present in coal seams across the region (AECOM 2023b).

Studies suggest that stygofauna preferentially occur in groundwater where salinities <5,000 µS/cm (refer Appendix Table 7 in Doody et al. 2019), and where stygofauna have been detected in the Bowen Basin, they occurred within shallow (<29 mbgl), unconsolidated sediments (i.e. Alluvium), with salinities below 2,000 µS/cm and pH levels of 6.5–8.5 (AECOM 2023b). Considering the brackish to saline nature of groundwater in deeper strata (with exclusion to that in MB40, refer Table 03-3) in the Assessment Area, it is likely that stygofauna are not present in these units. Alluvial groundwater typically provides more favourable environments for stygofauna, though contemporary investigation of this biota is absent within the Assessment Area. Investigations by Glanville et al. (2016) show a greater diversity of stygofauna in Alluvium, than other lithologies in Queensland. The authors report that five families of stygofauna are present in the Isaac-Comet Downs sub-bioregion (within which lies the Assessment Area) (Glanville et al. 2016).

Nonetheless, the limited presence, hydrological disconnection and surface recharge of the Phillip’s Creek Alluvium (refer Section 03.1.3 and 03.1.4) would suggest it is unlikely that stygofauna are present in groundwater pockets found in the Assessment Area. To confirm this conclusion, BMA proposes to undertake a stygofauna pilot survey. This is to be delivered as part of a broader GDE Monitoring and Management Plan (GDEMMP) (refer Section 05.6.1). The survey will be consistent with the Subterranean Aquatic Fauna Assessment Guidelines (DSITI 2015) and relevant standards for water quality and groundwater sampling. Sampling conducted as part of the pilot survey will occur in at least two seasons, and at least three months apart. If stygofauna are identified during the pilot survey/s, long-term monitoring and management of stygofauna will be detailed under the GDEMMP. Prior to Project commencement, the proponent proposes to submit a report presenting the findings of the pilot survey to the Commonwealth. This will include information on the distribution, diversity and abundance of stygofauna in the Assessment Area, if / where they have been identified. Ongoing reporting requirements will be detailed within the GDEMMP, dependent on the results of the pilot survey.

*Noting the limited groundwater resources across the Alluvium, the stygofauna pilot survey will utilise existing saturated monitoring bores relevant to the Assessment Area in the first instance.*

### 04.1.2 Aquatic GDEs

The BOM GDE Atlas (refer Figure 03-5) maps high and moderate potential aquatic GDEs along the length of Phillips Creek, including within the Assessment Area. However, the waterways across the Assessment Area are known ephemeral systems with seasonal surface recharge. Recent work from 3D Environmental (2023) notes that there is no indication that Phillips Creek represents an aquatic GDE. Aquatic ecology studies by FRC environmental (2018 cited in SLR 2024) note that there are no aquatic GDEs within the SRM or surrounds. Wetland ecosystems are limited in the Assessment Area (i.e. RE 11.3.27f); though are present in SRM (e.g. at Boomerang Creek – outside of the Assessment Area). These ecosystems do not exhibit hydrological connectivity between surface waters and groundwater (3D Environmental 2023). Baseline ecological surveys from SKM in 2007 & 2010 (FRC environmental 2018 cited in SLR 2024) also denote that natural aquatic habitats typically comprise shallow and small disconnected pools.

Considering the above, it is unlikely that aquatic GDEs occur within the Assessment Area.

### 04.1.3 Terrestrial GDEs

TGDEs have been mapped (per the BOM GDE Atlas; refer Figure 03-5) across various parts of SRM. Within the Assessment Area, high and moderate potential TGDEs are mapped primarily in association within Phillips Creek. Low potential TGDEs are also mapped under the Atlas where the Assessment Area coincides with One Mile Creek (refer Figure 03-5), and in association of RE 11.5.3 adjacent to Phillips Creek.

AECOM (2019 cited in SLR 2024, p. 80) reviewed the GDE Atlas assessment for SRM and concluded: "*areas mapped as having moderate potential for terrestrial GDEs in the GDE Atlas are considered to have low potential for terrestrial GDEs when considered in conjunction with site-specific groundwater data*" (relative to the GDE criteria posed by Eamus et al. 2006a).

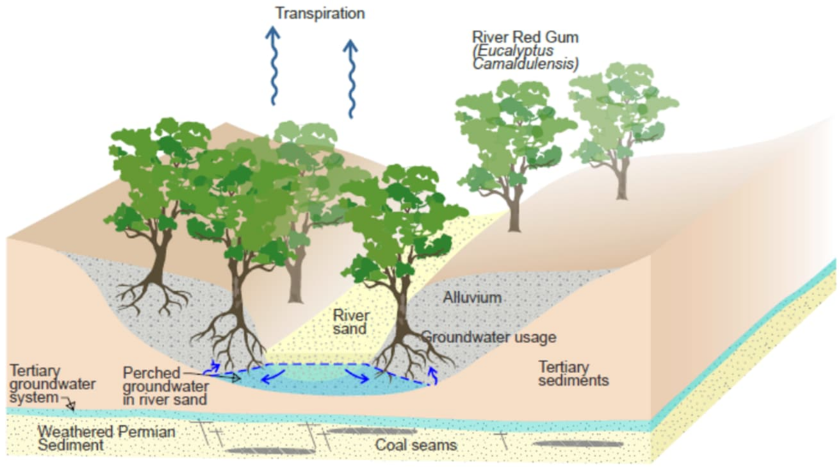
#### 04.1.3.1 Phillips Creek

Field investigation (3D Environmental 2023) suggest vegetation communities along Phillips Creek function as TGDEs in certain areas (consistent with 'high potential' mapping of TGDEs along the watercourse – refer Figure 03-5). 3D Environmental (2023) described the presence of perched aquifers within alluvial sediments, which are likely to provide intermittent access of groundwater to some species. Falling within the Assessment Area, one of the survey sites (site 2) intersected groundwater from an auger hole placed within the sandy substrate of the riverbed, at a depth of 1.15 mbgl (3D Environmental 2023).

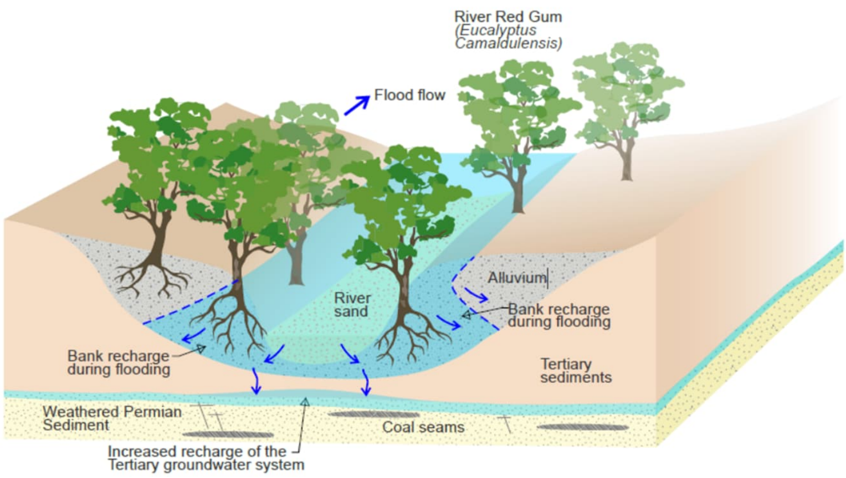
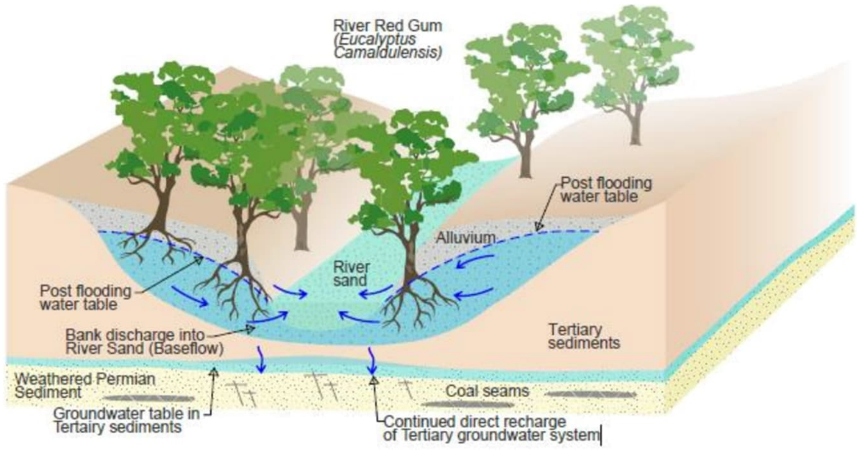
Where Phillips Creek is deeply incised, and where GDE indicator species sit sufficiently deep within the channel, some vegetation is thought to potentially access deeper groundwater resources within Tertiary sediments (3D Environmental 2023). Areas of thinner alluvial strata may facilitate access to the regolith for some indicator species; although modelled DTW (refer Figure 03-3) likely precludes its use.

Based on their field data, 3D Environmental (2023) have developed an eco-hydrogeological conceptualisation of a TGDE system within Phillips Creek (refer Table 04-1). This conceptualisation shows a seasonally variable system, which, post flooding, contains perched alluvial groundwater in deeper pockets of Alluvium, with underlying clay layers likely slowing the percolation of surface water (SLR 2024). The conceptualisation is consistent with conclusions drawn from monitoring bore data (refer Section 03.1.3) and remote sensing analysis of wetness and greenness indices across SRM (refer Section 04.2.3 and Appendix C:).

**Table 04-1 Phillips Creek TGDE conceptualisations**

| Flow Conditions | Phillips Creek eco-hydrogeological conceptualisation[10] |
|---|---|
| Dry Season |  |

[10] Refer Section 5.2 in 3D Environmental (2023)

| Flow Conditions | Phillips Creek eco-hydrogeological conceptualisation[10] |
|---|---|
| Wet Season Flood |  |
| Post Flooding Baseflow |  |

### 04.1.3.2 Additional Areas

Vegetation communities along One Mile Creek may sit above accessible groundwater resources. AECOM (2023) describes the presence of shallow alluvial sands above clay at monitoring bore MB20SRM06A, with groundwater identified approximately 5.65 mbgl in 2019. Although, field assessments from 3D Environmental (2023) concluded that these communities fail to meet necessary hydrological criteria (for TGDEs), with species moisture requirements supported within the unsaturated portion of the soil profile. This conclusion is supported by the analysis presented in Appendix C:. Outside of sandy Alluviums, the presence of heavy clay soils suggests that any species potentially capable of reaching the water table (~20 m in Tertiary sediments) are unlikely to do so due to these types of clays likely reducing effective rooting depth (Dupuy et al., 2005; Wilson & Taylor 2012).

## 04.2 Identification of potential TGDEs

To accurately identify potential TGDEs within the Assessment Area, a systematic approach (described here and depicted in Figure 04-1) is used. The approach builds upon information within the Australian groundwater-dependent ecosystems toolbox (Richardson et al. 2011), the Information guidelines for proponents preparing coal seam gas and large coal mining development proposals (IESC 2018) and its associated explanatory note on assessing GDEs (Doody, et al. 2019), as well as information obtained through direct communication with industry experts.

Diagnostic criteria that are understood to be limiting factors for the use of groundwater by terrestrial ecosystems include:

- Depth to water (DTW).
- Groundwater quality.

As a first step in the applied approach, DTW across the Assessment Area is determined. For a TGDE to be possible, groundwater must be accessible to the roots of species within the ecosystem. An estimated threshold for maximum groundwater depth at ≤ 30 mbgl[11]. Eamus et al. (2006a) has suggested that groundwater existing at depths greater than 10 mbgl has reduced importance to vegetation and that use is unlikely at depths greater than 20 mbgl (Eamus et al. 2006b). However, this criterion has been set at a purposefully high threshold in order to capture the potential for species to deviate from maximum reported / theorised rooting depths. Where groundwater depth is ≥ 30 mbgl, ecosystems are excluded from TGDE consideration (i.e. TGDEs are unlikely). Where DTW is ≤ 30 mbgl, TGDEs are considered possible.

Water quality is the second element with the defined approach. Salinity (measured as electrical conductivity) is generally considered a strong limiting factor for the presence of TGDEs. Relevant GDE indicator species (identified in Section 03.2.2) are thought to have varying tolerances for salinity (refer Table 04-2). An upper tolerance limit of 55,000 µS/m[12] has been set. This high value is, similar to rooting depth, purposefully conservative to capture any potential variation in reported tolerance levels. Salinity should be reconsidered with respect to the specific vegetation / community present in the Assessment Area; however, as a diagnostic criterion, any levels ≤ 55,000 µS/m does not initially exclude the potential for TGDE status.

Following DTW and water quality, mapping and review of ecosystems present with the Assessment Area should be undertaken, with specific analysis of the physiology of species (within the vegetation communities) with respect to the prior limiting factors (i.e. can species in present ecosystems access and use (tolerate) groundwater). Where REs, communities and/or species are deemed unlikely to use groundwater (e.g. established rooting depth of indicator species does not reach DTW (refer Table 04-2)) this refines the mapping of TGDEs. The best available (contemporary and fine scale) vegetation mapping and data should be used where available. Where site-scale data does not exist, regional data at the highest resolution available should be used.

As a final step, the satellite imagery analysis, consistent with the IESC-endorsed GEM method is to be utilised. Multi-spectral indices such as NDVI and NDMI are ideal to track changes in vegetation (Doody et al. 2019). TGDEs are expected to remain (relatively) green and moist during dry conditions, when rainfall is minimal. Data from the analysis is used to categorise likelihood of groundwater dependence where previous diagnostic criteria support its conclusions.

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[11] Note – groundwater depth and salinity thresholds are purposefully conservative and are set in order to capture the range of potential variation in species morphology and biology across a broad scale of environs. The approach is designed to review criteria with species-specific information collated at the site-scale.

[12] Set by specific *Eucalyptus largiflorens* individuals (T. Doody 2022, pers comm., 21 Feb) – not all species will be able to utilise water with salinity close to this limit. Eamus (2006b) has identified that many tree species show poor tolerance to salinities above 1,000 µS/m, though notes that certain species (e.g. *Casuarina cunninghamiana, Eucalyptus camaldulensis*) are often recognised as 'salt tolerant'. Mensforth (1994) notes that groundwater salinity up to 40,000 us/cm did not prevent utilisation of water by *E. camaldulensis* on the Murray River floodplain.

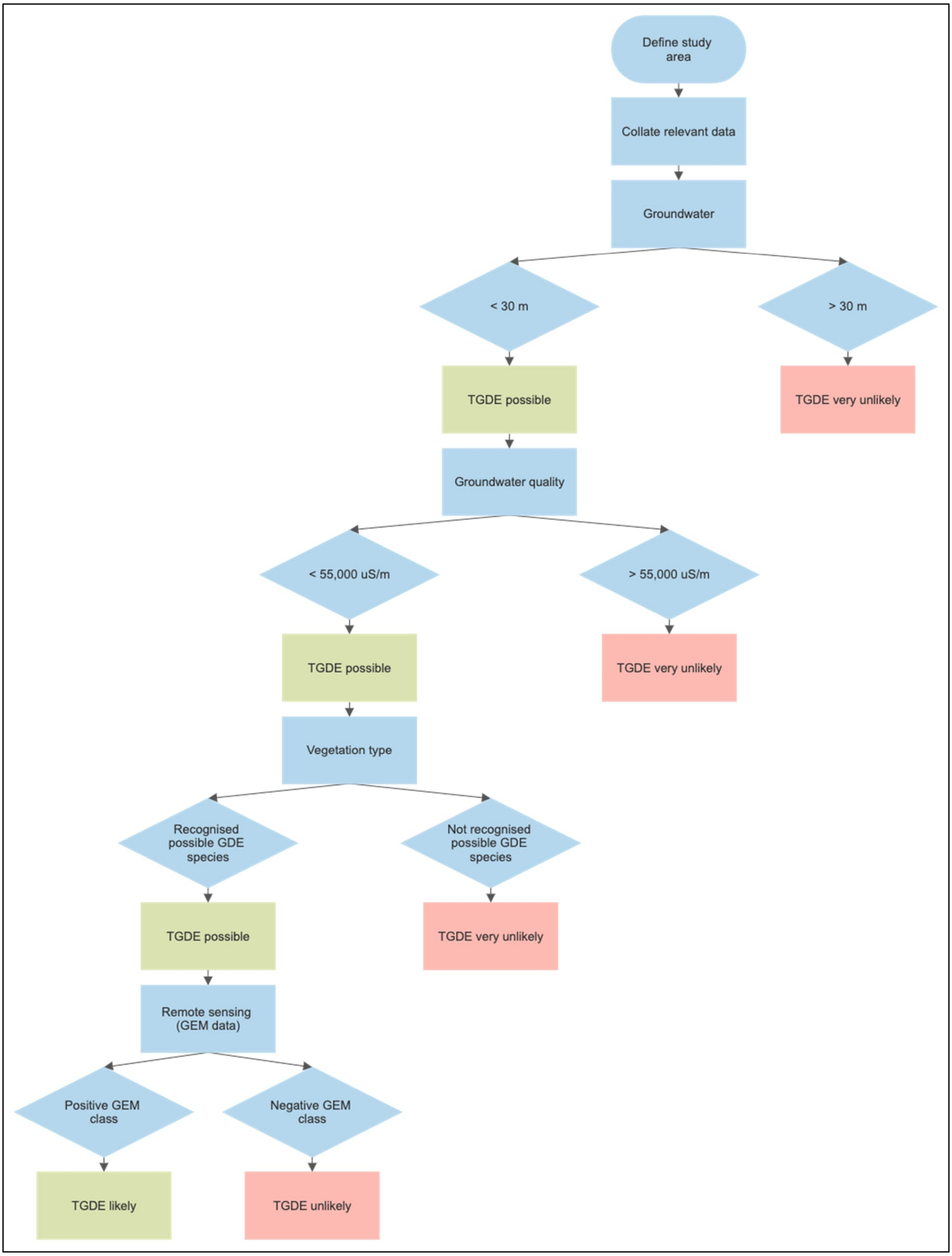


**Figure 04-1 Systematic approach to TGDE identification**

### 04.2.1 Groundwater diagnostic criteria

As modelled by SLR (2025), DTW within the Predicted Drawdown Extent is largely between 20–30 m, with shallower contours (i.e. ≤20 m) present in association with Phillips Creek and its tributaries. Across the Project Area, DTW extends from 20-30 m up to a depth of >250 m with the mining pit. Figure 04-2 displays the DTW model contours and identified REs within the Assessment Area. REs occur within the Project Area, though this is beyond where DTW contours sit ≥ 30 mbgl, therefore, TGDEs are not considered likely to occur in the Project Area as DTW is too great. As depth contours indicate DTW of 20 m within the Predicted Drawdown Extent, this criterion is met and TGDEs may be present. Field data from 3D Environmental (2023) shows that DTW sits shallower within the channel incision of Phillips Creek (which is >8 m), indicated by the presence of groundwater during auger sampling in the Phillips Creek Alluvium.

Groundwater within and adjacent to the Alluvium of Phillips Creek likely occurs within unconfined aquifers which may bear water in response to seasonal flood events (refer Section 04.1.3). Variable areas of perched groundwater sit in pockets of fluvial sands below the creek bed and move laterally into terraces. The discontinuity of groundwater along the Phillips Creek Alluvium is indicated by dry bores and further auger sampling elsewhere within the main drainage line (3D Environmental 2023; SLR 2024). Infiltration into alluvial terraces returns after recharge as low volume seepage / baseflow (3D Environmental 2023). Some hydraulic connectivity exists between the Alluvium along Phillips Creek and the groundwater within regolith (3D Environmental 2023), though the rate of recharge is restricted by the presence of clay and claystone within the strata (SLR 2024) (refer Section 03.1.4). The presence of perched groundwater along the river Alluvium likely occurs in association with areas of underlying clay, which prevents the downward percolation of groundwater (SLR 2024). Groundwater within the deeper Permian coal measures is confined by the presence of aquitards (i.e. interburden and overburden units), hydraulically limiting connectivity between Tertiary sediments and Permian strata (SLR 2024).

Alluvial groundwater may potentially occur within One Mile Creek, with groundwater previously intersected by bore MB20SRM06A (refer Appendix B). However, the soil profile of the creek has previously been assessed by 3D Environmental (2023) within the Assessment Area and presents a largely uniform clayey sand in the top 2 m. Analysis of Leaf Water Potential (LWP) indicates high water availability, although additional analyses (Soil Moisture Potential (SMP) and Stable Isotope) support a conclusion that vegetation along this drainage feature are being supported within the unsaturated portion of the soil profile. Outside of the Alluvium groundwater resources lower strata likely sit between 20-30 mbgl (refer Figure 04-2), with associated monitoring bore data (MB33) indicating previous SWL of 18.45-21.34 mbgl (3D Environmental 2023).

Groundwater quality within the Assessment Area is not likely to preclude the presence of TGDEs. Salinity levels present within monitoring bores proximal to the Assessment Area does not exceed the defined threshold of 55,000 µS/m (refer Table 03-3). Data from MB40 (Tertiary sediment monitoring bore) shows a measurement of 2,480 µS/m in 2023. No data is available from adjacent Alluvium bore MB38; however, SLR (2024) describe salinity levels within the SRM Alluvium as fresh to saline, measuring an average TDS of 556 milligrams per litre (mg/L) (~1,010 µS/m), reflective of surface water recharge. No other prohibitive contaminants (i.e. that would affect water quality) have been identified within monitoring bores adjacent to the Assessment Area.

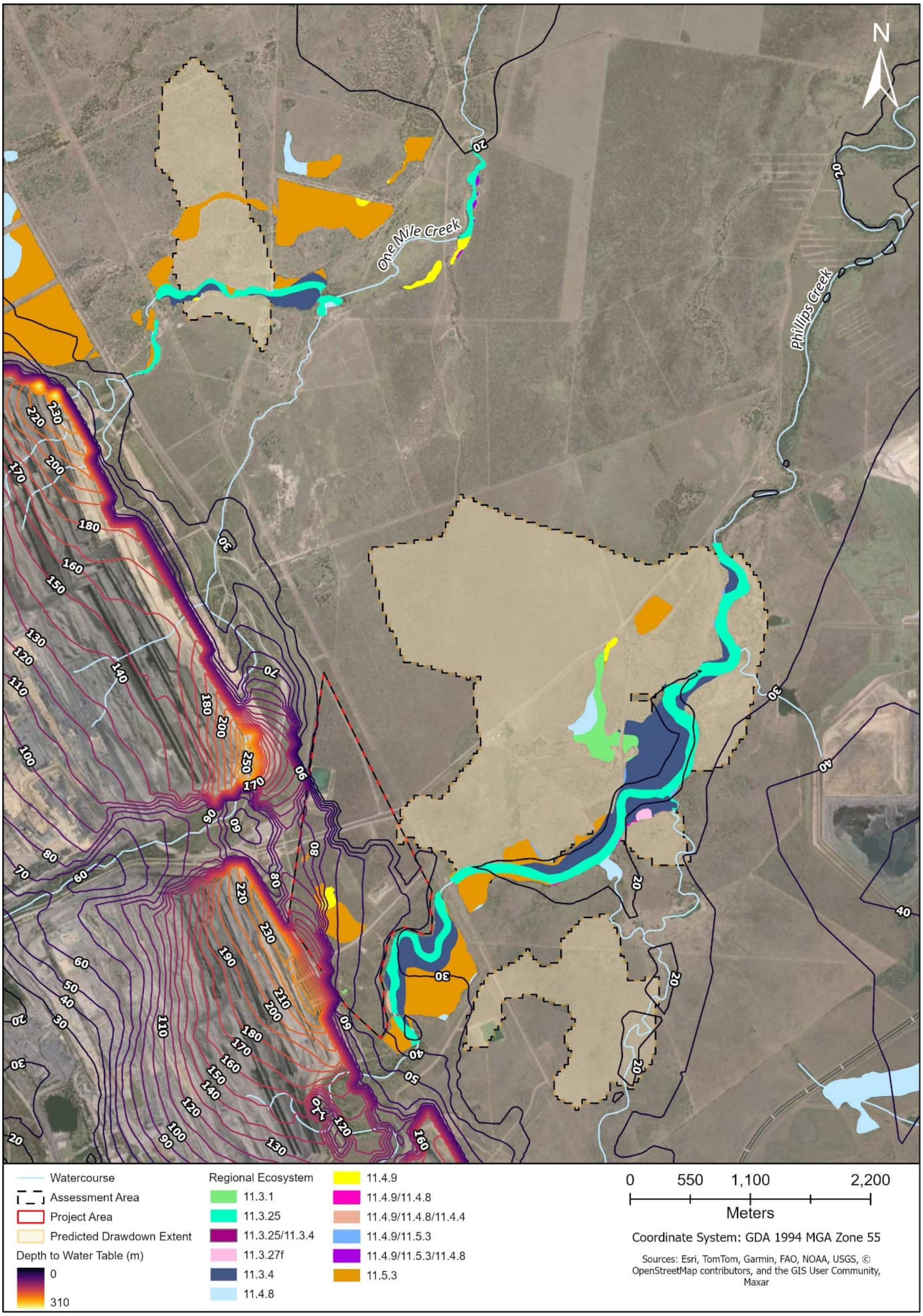


**Figure 04-2 Modelled DTW and REs across the Assessment Areas**

### 04.2.2 Vegetation criteria

REs have been ground-truthed within the Assessment Area. These include:

- 11.3.1 – *Acacia harpophylla* and/or *Casuarina cristata* low open forest on alluvial plains.
- 11.3.25 – *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
- 11.3.27f – Eucalyptus coolabah and/or E. tereticornis open woodland to woodland fringing swamps.
- 11.3.4 - Eucalyptus tereticornis and/or Eucalyptus spp. woodland on alluvial plains.
- 11.4.8 – *Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains.
- 11.4.9 – *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains.
- 11.5.3 – *Eucalyptus populnea +/- E. melanophloia +/- Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces.

Outside the Project Area RE 11.3.25 occurs within the Predicted Drawdown Extent, in association with Phillips Creek, its tributaries, and along One Mile Creek (refer Figure 04-2). Several GDE indicator species are present within this RE including *Eucalyptus camaldulensis, E. tereticornis*, *Corymbia tessellaris, C. clarksoniana* and *Casuarina cunninghamiana*. Adjacent to RE 11.3.25 (and further up on surrounding Tertiary plains), REs 11.3.4, 11.5.3 and of RE 11.4.8 are present. These communities contain GDE indicator species such as *Eucalyptus camaldulensis, E. tereticornis*, *E. populnea*, *Acacia harpophylla, Corymbia clarksoniana* and *C. tessellaris.* Eucalypt woodland with shallow ephemeral depressions (11.3.27f) also sits within the Predicted Drawdown Extent. The majority of the Predicted Drawdown Extent is non-remnant and is not likely to comprise TGDEs.

Key GDE indicator species are present within GTREs, as identified previously in Table 03-4 and summarised in Section 03.2.2. These species include:

- *Eucalyptus camaldulensis.*
- *Eucalyptus populnea.*
- *Eucalyptus tereticornis.*
- *Corymbia tessellaris.*
- *Corymbia clarksoniana.*
- *Casuarina cunninghamiana.*
- *Acacia harpophylla.*

Table 04-2 details species-specific rooting depths and salinity tolerance (derived from scientific literature) to assess the likelihood of TGDE function. Salinity tolerance levels (4,000-8,000 μS/m for most species and 2,000-4,000 μS/m for *Corymbia* spp.) suggest that water quality in the Alluvium won't prevent species from using perched alluvial groundwater. Variable salinity in regolith may impact species utilisation of deeper groundwater resources; though the primary limiting factor is DTW, at 20 mbgl. Whilst some present species are known to invest in deeper tap roots (e.g. *Corymbia clarksoniana*), only *E. camaldulensis* (and *E. populnea* – theorised; Kath et al. 2014) are considered to have sufficient potential rooting depths to access groundwater at this depth (refer Table 04-2).

3D Environmental (2023) notes, however, that perched groundwater exists within the Alluvium of the creek bed, being present at ~1.15 m below the bed. Phillips Creek's channel depth (> 8 m from bed to bank) indicates that alluvial groundwater pockets at 9–10 mbgl (from creek bank) are potentially present. Consequently, indicator species in riparian communities of Phillips Creek (e.g. RE 11.3.25) may access perched groundwater at <10 m depth (from creek bank), with species rooting below the creek bank having a reduced distance to access alluvial groundwater. The eco-hydrological conceptualisation suggests that GDE-indicator species along Phillips Creek are likely using groundwater on a facultative basis wherever tree roots can penetrate to the capillary fringe. Analysis of auger sample at One Mile Creek indicates that the same communities (e.g. RE 11.3.25) do not function as TGDEs, as moisture requirements of vegetation are being supported within the unsaturated portion of the soil profile (3D Environmental 2023) (refer Section 04.2.1).

Per state surface geology (refer Figure 03-1), the Quaternary Alluvium along Phillips Creek may stretch several hundred meters across, meaning REs adjacent to the riparian zone (i.e. RE 11.3.25) may also potentially sit above this stratum. However, groundwater is less likely to be accessible outside the riparian zone due to the need to root deeper, and potentially laterally, to reach isolated groundwater pockets.

In Tertiary sediments, heavy clays and DTW (i.e. 20 m) reduce the likelihood of TGDEs, as the effective rooting depth of GDE indicator species is restricted. Two species, *Eucalyptus camaldulensis and E. populnea,* have theorised rooting depths (refer Table 04-2) beyond the mapped DTW (refer Figure 04-2).

It is possible that *Eucalyptus camaldulensis* (where it is found along the banks of Phillips Creek) exhibits a dimorphic root architecture consisting of shallower lateral roots and deeper tap or sinker roots (accessing groundwater resources in Alluvium and/or regolith). The species has been known to invest in both extensive lateral roots and tap roots to reach water tables (up to 20 m) (Bacon et al. 1993; Burgess et al. 2001; Steggles et al. 2017). The species may access water from multiple aquifers occurring at varying depths, and other parts of the soil profile, thus maintaining transpiration during dry periods (Verma et al. 2014).

*Eucalyptus populnea* is also hypothetically capable of rooting to depths of 26 m (Kath et al. 2014). However, the species typically occurs on elevated terraces and plains in the Assessment Area and surrounds. As mentioned, heavy clay aquitards likely restrict root access and limit hydraulic connectivity between strata (3D Environmental 2023). It is possible that, where the species occurs close to Phillips Creek (i.e. in riparian zone adjacent RE – i.e. RE 11.5.3), *E. populnea* may access alluvial groundwater on a facultative basis. The remote sensing analysis presented in Section 04.2.3 would, however, suggest the extent of relevant RE type/s (for *E. populnea* i.e. RE 11.5.3) likely functioning as a TGDE is highly limited (refer Appendix C).

**Table 04-2 Key diagnostic criteria for GDE indicator species**

| GDE-indicator species | Salinity tolerance (µS/cm) | Rooting depth (mbgl)[13] | Phreatophyte | REs in the Assessment Area |
|---|---|---|---|---|
| *Acacia harpophylla*<br>Brigalow | - | 3[14] | Facultative | 11.3.1, 11.4.8, 11.4.9 |
| *Eucalyptus camaldulensis*<br>River red gum | 4,000–8,000[15] | 7 – 22.6 | Facultative | 11.3.25, 11.3.4 |
| *Eucalyptus populnea*<br>Poplar box | - | 12.6 – 26.7 | Facultative | 11.4.9, 11.5.3 |
| *Eucalyptus tereticornis*<br>Forest red gum | 4,000–40,000[16] | 9.3 | Facultative | 11.3.25, 11.3.27f, 11.3.4 |
| *Corymbia clarksoniana*<br>Clarkson's bloodwood | 1,500–4,000 based on other *Corymbia* spp.[17] | 10 | Facultative | 11.3.25, 11.3.4 |
| *Corymbia tessellaris* | | 4 | Facultative | 11.3.25, 11.3.4 |

13 Refer to Section 03.2.2

14 Per Coaldrake (1967). As described in Section 03.2.2.7, most of the root mass of the species occurs within the upper soil profile. Little evidence for deep rooting is noted within SRM (3D Environmental 2023).

15 Per Marcar and Crawford (2004)

16 Upper limit taken from Mensforth et al. (1994)

17 Sun & Dickinson (1995)

| GDE-indicator species | Salinity tolerance (µS/cm) | Rooting depth (mbgl)[13] | Phreatophyte | REs in the Assessment Area |
|---|---|---|---|---|
| Moreton Bay ash | | | | |
| *Casuarina cunninghamiana*<br>River she-oak | 4,000–5,000[18] | - | Facultative | 11.3.25 |

### 04.2.3 Remote sensing analysis

The GEM method was applied across the Assessment Area (refer Appendix C). The method utilised existing base information combined with high resolution satellite imagery (Sentinel). Specifically, the method:

- Collated existing mapping and associated spatial and textual data (identified REs and contextual information).
- Collated and prepared relevant seasonal satellite imagery over 1-5 years (i.e. wet and dry).
- Derived NDVI and NDMI indices for each relevant satellite image, resulting in four mean index layers ranging from -1 to 1.
- Used a process of data classification to produce a single TGDE layer based on set threshold values, with three resultant categories:
    - Likely TGDE – *persistent greenness and higher moisture values through dry seasons.*
    - Potential TGDE – *persistent greenness and higher moisture values through wet seasons.*
    - Unlikely TGDE – *thresholds not met*.
- Compared method outputs with mapped REs across the Assessment Area, which include potential GDE indicator species.

This method has provided an output of the extent to which REs present in the Assessment Area are likely, and potential TGDEs (refer Table 04-3). Consistent with the information discussed in Section 04 and the description of the eco-hydrogeological setting (refer Section 03), the analysis suggested that TGDEs most likely exist in isolated pockets along the Phillips Creek Alluvium (refer Figure 2 in Appendix C). Likely and potential TGDEs most predominately appear to occur in RE 11.3.25 (as field investigations would support), although some areas embedded within REs adjacent to Phillips Creek have also been identified as potential / likely TGDEs. The differentiation in classification of TGDEs indicates where groundwater is seasonally available, accessible and utilised by vegetation communities in the Assessment Area (i.e. likely TGDEs utilise, and potentially rely on, groundwater during dry periods comparative to potential TGDEs).

This information is considered collectively alongside additional diagnostic criteria in Section 04.2.4 below.

**Table 04-3 Results of remote sensing criteria consistent with mapped REs**

| RE Code | RE Description | Likely TGDE (ha) | Potential TGDE (ha) | Total (ha) |
|---|---|---|---|---|
| 11.3.25 | *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines | 1.0 | 10.9 | 11.9 |
| 11.3.27f | *Eucalyptus coolabah* and/or *E. tereticornis* open woodland to woodland fringing swamps | - | 0.2 | 0.2 |
| 11.3.4 | *Eucalyptus tereticornis* and/or *Eucalyptus spp*. woodland on alluvial plains | 0.1 | 3.5 | 3.5 |
| 11.5.3 | *Eucalyptus populnea* and / or *E. melanophloia* and / or *Corymbia clarksoniana* woodland | <0.1 | 0.3 | 0.4 |
| **TOTAL:** | | **1.1** | **15.0** | **16.1** |

[18] Van der Moezel et al. (1989)

### 04.2.4 Likely / potential TGDEs requiring assessment

Considering the information presented across Section 04.2 the following has been determined:

- Likely TGDEs exist in association with the riparian zone of Phillips Creek (in RE 11.3.25) and limited extents of REs immediately adjacent – consistent with classification by remote sensing criteria.
- REs outside the Phillips Creek riparian zone (noting the above exclusions) are less likely to function as TGDEs, factoring the modelled DTW across the Assessment Area, the limited rooting depth for known GDE indicator species, and the presence of heavy clay soil restricting deep root architecture.
- REs present within the Project Area are not considered to function as TGDEs due to the excessive DTW.

Table 04-4 tabulates the area associated with identified likely and potential TGDEs in the Assessment Area, noting that relevant DTW contours include modelled Alluvium at 2–10 mbgl, and regolith at ≤20 mbgl and 20–30 mbgl, while water quality (μS/cm) for these strata are 1,010[19] (Alluvium) and 1,940–2,480 (regolith). TGDE likelihood is further depicted in Figure 04-3 (based on GTREs).

**Table 04-4 Tabulation of likely, potential and unlikely TGDEs in the Assessment Area**

| RE | GDE indicator species present | TGDE likelihood | Area (ha) |
|---|---|---|---|
| 11.3.1 | *Acacia harpophylla* | Unlikely | 14.5 |
| 11.3.25 | *Eucalyptus camaldulensis*<br>*Eucalyptus tereticornis*<br>*Corymbia tessellaris*<br>*Corymbia clarksoniana*<br>*Casuarina cunninghamiana* | Likely | 1.0 |
| | | Potential | 10.9 |
| | | Unlikely | 24.4 |
| 11.3.27f | *Eucalyptus tereticornis* | Potential | 0.2 |
| | | Unlikely | 1.0 |
| 11.3.4 | *Eucalyptus camaldulensis*<br>*Eucalyptus tereticornis*<br>*Corymbia tessellaris*<br>*Corymbia clarksoniana* | Likely | 0.1 |
| | | Potential | 3.5 |
| | | Unlikely | 38.9 |
| 11.4.8 | *Acacia harpophylla* | Unlikely | 5.0 |
| 11.4.9 | *Eucalyptus populnea*<br>*Acacia harpophylla* | Unlikely | 3.4 |
| 11.4.9/11.4.8 | *Eucalyptus populnea*<br>*Acacia harpophylla* | Unlikely | 0.1 |
| 11.4.9/11.5.3 | *Eucalyptus populnea*<br>*Acacia harpophylla*<br>*Corymbia clarksoniana* | Unlikely | 0.3 |
| 11.5.3 | *Eucalyptus populnea*<br>*Corymbia clarksoniana* | Likely | <0.1 |
| | | Potential | 0.3 |
| | | Unlikely | 34.3 |
| **TOTAL:** | | | 137.9 |

[19] Average per SLR 2024

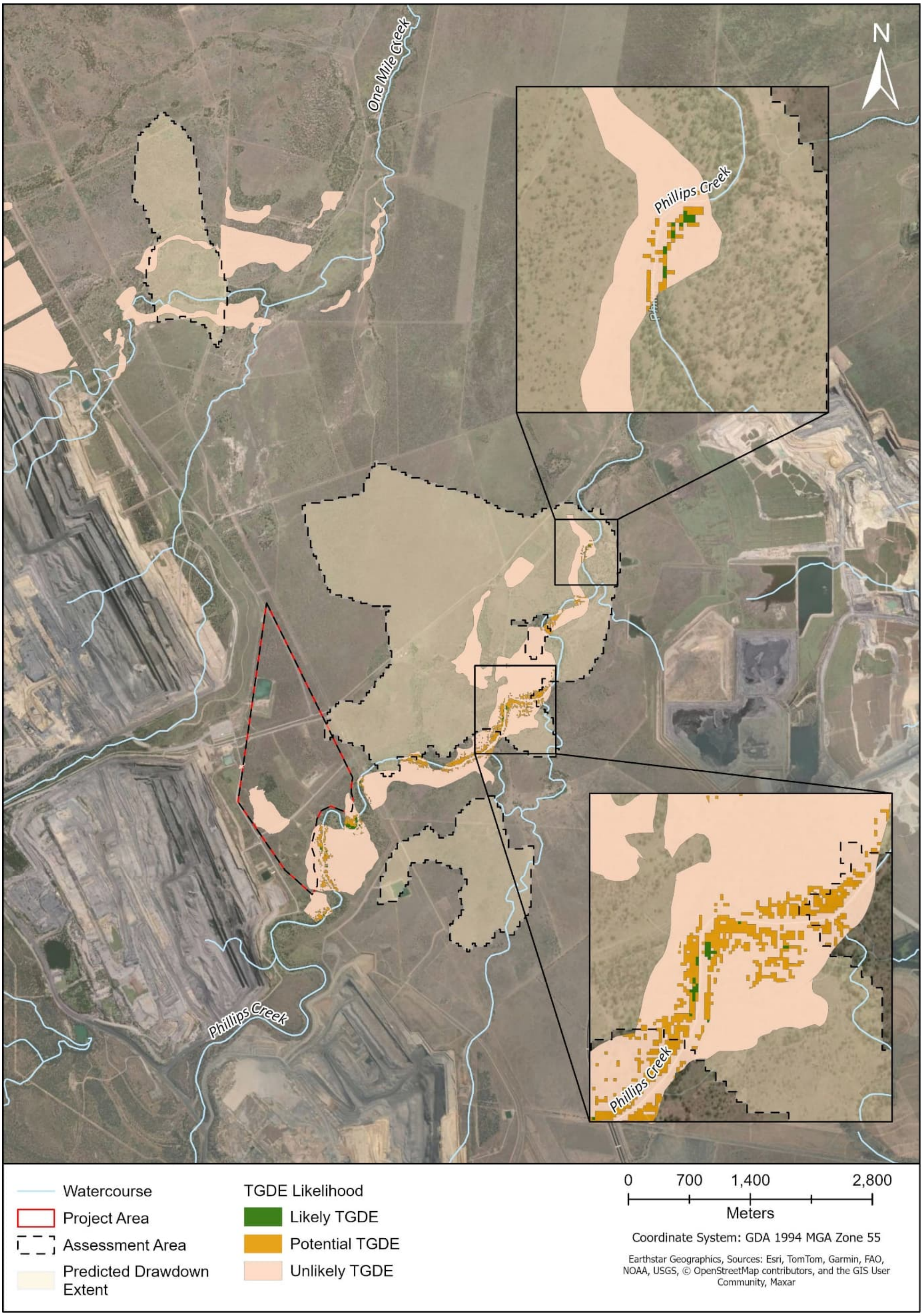


**Figure 04-3 TGDEs within the Assessment Area**

# 05 POTENTIAL IMPACTS AND MANAGEMENT

## 05.1 Potential impacts – overview

Potential impacts to likely TGDEs within the Assessment Area as a result of the Project are related to:

- Direct disturbance – clearing of GDE vegetation (i.e. within the Project Area).
- Groundwater drawdown – reduced access to water at the root depth for some species within the vegetation communities which occur within the Predicted Drawdown Extent.
- Changes in groundwater quality – for example, if there is a spill event that leads to contamination of groundwater.
- Changes in surface water hydrology / quality – noting the facultative nature of indicator species identified, an event that leads to a deterioration of surface water quality (e.g. via erosion and sedimentation), or altered reduced access to surface water, also has potential to impact TGDEs.

A formal risk assessment, detailing the likelihood of an impact occurring and the consequence associated with each impact to TGDEs has been provided in Appendix A. Based on the risk assessment outcomes, residual risk rating is ‘Low’ or ‘Insignificant’ following application of appropriate management and mitigation measures. It should be noted that for most impact pathways, GDE monitoring requires active management (including monitoring) from which mitigation measures can be adapted if impacts to GDEs are identified and are either directly or indirectly attributable to the Project.

## 05.2 Direct disturbance / clearing

Direct clearing will remove remnant and high-value regrowth vegetation (14 ha total) within the Project Area. Present vegetation communities (REs 11.3.1, 11.4.9 and 11.5.3) contain known GDE indicator species including *Eucalyptus populnea* and *Corymbia clarksoniana.* However, modelled DTW and mapped GTREs within the Project Area demonstrates that no REs (with present indicator species) are present where DTW is ≤ 30mbgl (refer Figure 04-2). Thus, these communities are not considered to function as TGDEs. As no TGDEs are present, no potential impacts are identified. This impact pathway is not considered further.

Impacts associated with the loss of these communities (i.e. where vegetation comprises habitat for Matters of National Environmental Significance (MNES)) is dealt with separately in the Terrestrial Ecology Survey & Impact Assessment Report (Engeny 2025).

## 05.3 Groundwater drawdown

The mining process reduces water levels in surrounding groundwater units due to interception of groundwater in the mined geology. To understand potential impacts, it is necessary to identify the quantity of drawdown and if it is likely to impact the maintenance of ecosystem function of the TGDE (i.e. impact to a supporting service, Section 5.2.1 of the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources* (DoE 2013)). Determining this requires an assessment of whether the predicted drawdown reduces the accessibility of the water from the root zone of an applicable TGDE.

A drawdown of any magnitude has potential to impact TGDEs differently based on the species present, the standing level of groundwater and the extent to which drawdown will move groundwater beyond the zone in which it is accessible to vegetation. This sub-section focuses on understanding whether the predicted drawdown reduces the accessibility of the water from the root zone for the applicable TGDE indicator species. To consider the risk of impact several criteria have been applied (refer Table 05-1). These criteria are discussed with respect to the rate of drawdown and seasonal variation in groundwater availability.

**Table 05-1: Risk of impact criteria**

| Drawdown depth | Risk of impact to TGDE[20] | Next steps |
|---|---|---|
| Groundwater level remains above root zone at maximum drawdown | No – TGDE unlikely to be impacted by drawdown; access to groundwater is maintained | Continue Project with appropriate mitigation measures |
| Groundwater level remains within 1 m above root zone at maximum drawdown | Potential – TGDE may be impacted by drawdown; access to groundwater may be affected | Implement adaptive monitoring over time to determine whether potential impacts arise |
| Groundwater level is below root zone at maximum drawdown | Yes – TGDE likely to be impacted by drawdown; access to groundwater is compromised | Implement appropriate measures to address impacts. This may include further avoidance or mitigation and/or offsets |

The results of the groundwater model (SLR 2025) model show that no incremental drawdown is predicted for the Quaternary Alluvium as a result of the Project. The Predicted Drawdown Extent shown in Figure 05-1 is the predicted Project-related drawdown within regolith (i.e. Tertiary and unconsolidated Quaternary sediments). The drawdown model (SLR 2025) indicates incremental drawdown in regolith is <1 m[21] (refer Figure 05-1).

### 05.3.1 Alluvium

Section 04.2.4 identified 1.1 ha of likely TGDEs in the Predicted Drawdown Extent. Indicator species identified within these REs (11.3.25, 11.3.4 & 11.5.3)[22] include:

- *Eucalyptus camaldulensis.*
- *Eucalyptus tereticornis.*
- *Corymbia tessellaris.*
- *Corymbia clarksoniana.*
- *Casuarina cunninghamiana.*

The estimated maximum rooting depth of these species' ranges between ~4–22.6 m (refer Table 04-2). As discussed in Section 04.2.1, field investigation has identified alluvial groundwater resources at ~1.15 m below the surface of the creek bed in Phillips Creek and estimated bank height at approximately 8 m (or greater than) (3D Environmental 2023). Within the banks of Phillips Creek, it is likely that any of the aforementioned species might use alluvial groundwater where available (noting the lack of certainty around the rooting depth of *Casuarina cunninghamiana*). It has therefore been assumed that DTW is ~2–10 m (creek bed to the top of the creek bank) within Phillips Creek Alluvium. Notably, however, alluvial thickness varies along Phillips Creek, and pockets of groundwater are likely to be found where this stratum is thicker and incised into lower sediments (SLR 2024). Most indicator species present in RE 11.3.25 / RE 11.3.4 are considered to have insufficient rooting depth (refer Table 04-2) to access groundwater in lower layers, noting the modelled DTW (refer Figure 04-2) and relevant monitoring bore data (refer Table 03-3). Exceptions to this include *E. camaldulensis* and *Eucalyptus populnea* (see below).

As no drawdown is predicted within Quaternary Alluvium (SLR 2024, 2025), no drawdown impacts are expected on TGDEs accessing alluvial groundwater.

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[20] The risk of impact to TGDEs in the event of drawdown is likely to be seasonally dependent. For example, minor drawdown during drought may have an amplified drying effect on vegetation accessing groundwater compared to wetter periods. However, 'next steps' (i.e. adaptive monitoring and management) continue to be relevant in addressing this risk and subsequent potential for impacts.

[21] Predicted drawdown in the regolith is modelled across a continuous gradient between 0.01-0.53 m; 88.5% of drawdown extent in the regolith is expected to be <10 cm. In order to make a conservative estimate of impact, a predicted drawdown of 1 m has been applied.

[22] <0.1 ha of RE 11.5.3 was classified as likely TGDE under the remote sensing analysis.

### 05.3.2 Regolith

*Eucalyptus camaldulensis* may potentially utilise groundwater in regolith from within the banks of Phillips Creek (within RE 11.3.25), as the species is known to invest in deep sinker roots to reach greater water supply (Bren et al. 1986 cited in 3D Environmental 2023). A negligible area of RE 11.5.3 (<0.1 ha) has also been mapped as likely TGDE adjacent to the riparian zone. Theoretically *E. Populnea* present within this area may also root to regolith groundwater. However, the capacity for any individual trees to reach groundwater in the regolith is likely to be restricted by the heavy clay soil profile present in Tertiary sediments. DTW in regolith within the creek is modelled at ≤ 20 m (at shallowest contour) (SLR 2025). Monitoring bores in these sediments indicate some variability of DTW, (refer Section 03.1.3) although not to the degree of enabling additional GDE indicator species access to groundwater resources in the regolith. A drawdown of <1 m (refer Figure 05-1) in the regolith would not lower the groundwater below *E. camaldulensis* or *E. populnea's* maximum theorised rooting depths (refer Table 05-2), where groundwater exists <20 m. Where modelled DTW is up to 30m, drawdown may potentially move the capillary fringe of groundwater beyond maximum species rooting depths.

The rate of drawdown must also be considered alongside magnitude. Phreatophytes will set their maximum rooting depth at the capillary fringe of a seasonally consistent water table. Where drawdown occurs over a short time period (i.e. weeks to months), GDE species may be impacted as the capillary fringe of groundwater rapidly retracts from established roots, leaving them unsaturated. Where other sources of water are unavailable, phreatophytes may need to spend energy redistributing root mass outside of regular seasonal responses.

In response to pit development associated with the Project, groundwater drawdown in the regolith is likely to occur very slowly. The Blackwater Group overburden and other aquitards exhibit low hydraulic connectivity to such a degree that the Tertiary sediments effectively form a perched groundwater system above the Permian strata (SLR 2024); this limits the rate of drawdown leakage to lower strata (as with the Alluvium). Prior trends in Tertiary groundwater levels do not show large variability either seasonally, or across multiple years, despite ongoing mining operations across SRM (refer hydrograph in Figure 24 in SLR 2024). Monitoring bores within the regolith indicate a relatively stable SWL, with MB40 (refer Figure 03-2) having only declined by approximately half a meter between 2020-2022 due to drier than average conditions (SLR 2024). However, it should be noted that previous investigations from AECOM (2019) have seen some monitoring bores sampled in 2011 become dry as a result of drawdown from regional operations, with limited recharge via rainfall.

Table 05-2 provides an overview of potential impacts to TGDE indicator species in the Assessment Area and Table 05-3 summarises the risk of impact from drawdown to TGDEs.

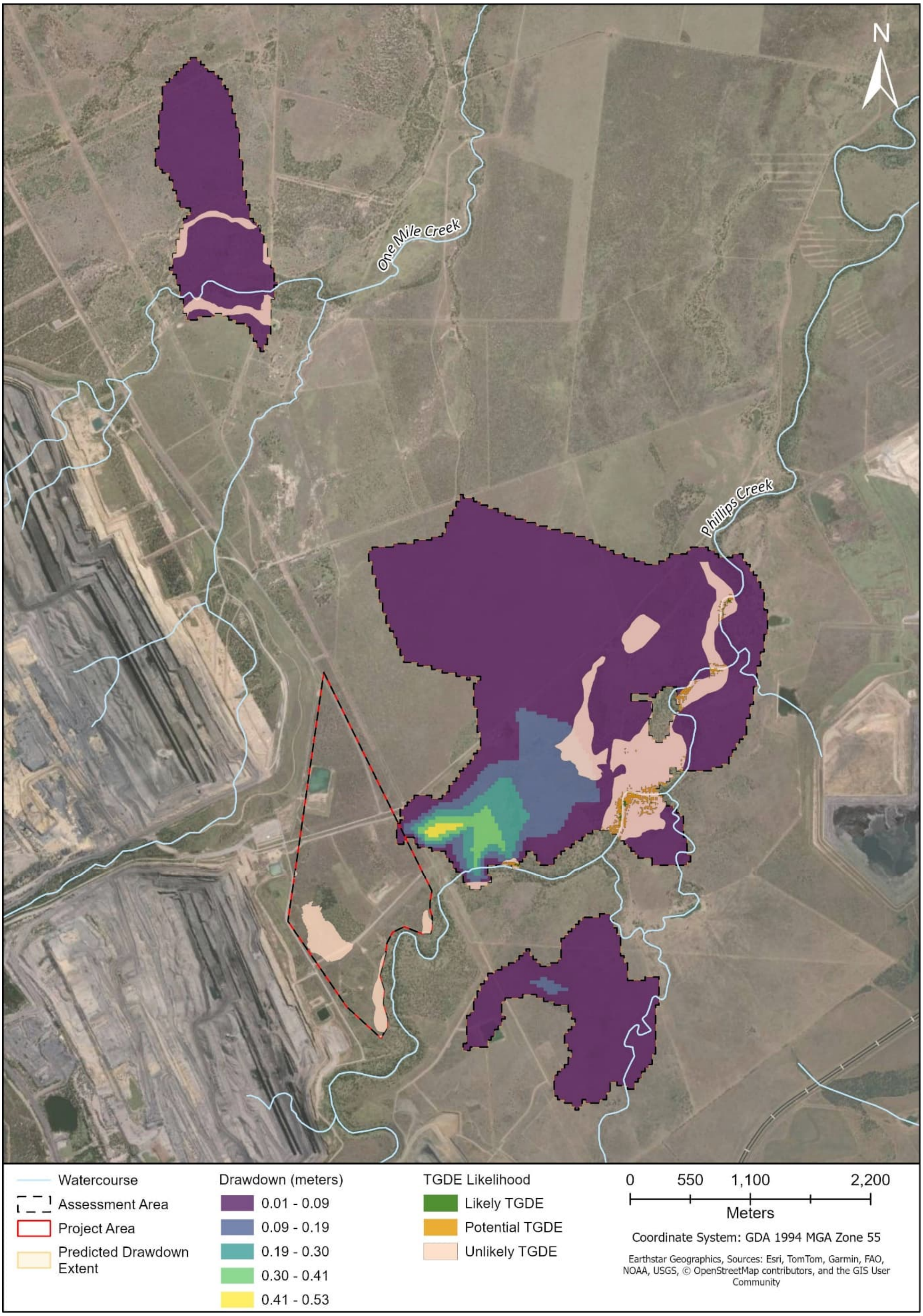



**Figure 05-1 Likely TGDEs intersecting with the Predicted Drawdown Extent (regolith)**

**Table 05-2 Potential impacts to GDE indicator species from drawdown within the Predicted Drawdown Extent**

| GDE indicator species in RE 11.3.25 | Rooting depth (mbgl) | Groundwater level prior to drawdown (mbgl) | Drawdown (m) | Potential Impact? |
|---|---|---|---|---|
| *Eucalyptus camaldulensis*<br>River red gum | 7–22.6 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| | | ≤ 20 (Regolith) | <1 | Unlikely– maximum depth of groundwater after drawdown is 21 mbgl, which is within theorised rooting depth. Rate of drawdown likely very slow |
| | | 20-30 (Regolith) | <1 | Possible – where water table is set close to maximum rooting depth, drawdown may move capillary fringe beyond access. |
| *Eucalyptus populnea*<br>Poplar box | 12.6 – 26.7 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| | | ≤ 20 (Regolith) | <1 | Unlikely– maximum depth of groundwater after drawdown is 21 mbgl, which is within theorised rooting depth. Rate of drawdown likely very slow |
| | | 20-30 (Regolith) | <1 | Possible – where water table is set close to maximum rooting depth, drawdown may move capillary fringe beyond access. |
| *Eucalyptus tereticornis*<br>Forest red gum | 9 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| *Corymbia clarksoniana*<br>Clarkson's bloodwood | 10 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| *Corymbia tessellaris*<br>Moreton Bay ash | 4 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| *Casuarina cunninghamiana*<br>River she-oak | - | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |
| *Acacia harpophylla*<br>Brigalow | 3 | 2–10 (Alluvium) | 0 | No – no drawdown predicted in Alluvium |

Table 05-3 Risk of impact due to drawdown

| Layer | Current DTW (mbgl) | Modelled drawdown[23] (m) | New maximum predicted DTW (m) | Potential impacts to likely TGDE |
|---|---|---|---|---|
| Alluvium | 2–10[24] | 0 | 2–10 | No – access to groundwater is maintained |
| Regolith | ≤ 20 | 0–1 | 21 | No – access to groundwater is maintained |
| | 20–30 | 0–1 | 21–31 | Possible |

The above considered, no reduction in accessibility of the water from the root zone for TGDEs is thought likely to occur for species accessing groundwater in the Alluvium, or where DTW is ≤ 20 within regolith.

Impacts from groundwater drawdown are possible where species access water resources in the regolith, close to maximum theorised rooting depths (between 20–30 mbgl).

## 05.4 Changes in groundwater quality

Determining the impact of changes in groundwater quality is undertaken by identifying if there will there be any changes in groundwater quality that impact the ability of the groundwater to sustain TGDEs. The primary limiting factor for groundwater quality to sustain TGDEs is salinity.

A basic impact assessment framework for salinity changes has been applied to determine the potential for impact and associated actions (refer Table 05-4). Salinity tolerance levels for indicator species have been previously outlined in Table 04-2.

Table 05-4 Assessment of changes in salinity

| Salinity level | Potential Impact? | Next steps |
|---|---|---|
| Salinity is predicted to remain within the tolerance range for the target species | No – TGDE unlikely to be impacted by changes in groundwater quality | Continue Project with appropriate mitigation measures |
| Salinity is predicted to exceed the tolerance range for the target species | Potential – TGDE may be impacted by changes in groundwater quality | Implement adaptive monitoring over time to determine whether potential impacts arise |

The assessment of groundwater drawdown identified that during mining, a cone of depression will develop around the pit footprint due to incidental pit dewatering. This will result in localised groundwater flow towards the pit, limiting potential for impact on surrounding groundwater including the existing groundwater quality (SLR 2024, 2025). Further considerations, including the hydraulic disconnection between Permian and upper (i.e. regolith / Alluvium) strata, and recharge via surface flows / precipitation (3D Environmental; SLR 2024, 2025), indicates that no potential impacts from salinity change exists for TGDEs within the Assessment Area.

Potential impacts on groundwater quality may exist where leaks, spills and improper disposal of wastes, including waste rock, leads to the leaching of compounds into the groundwater following rainfall events. Contamination of groundwater can impact the condition and health of TGDEs as they access this water source in the root zone. These potential impacts are, however, also considered unlikely to occur, with appropriate mitigation and monitoring outlined within the EA and the Fitzroy Regional Receiving Environment Monitoring Program (FRREMP)

[23] Per SLR 2024
[24] Relative to species position within creek line

The above considered, no changes in groundwater quality (that will impact the ability of the groundwater to sustain TGDEs) are likely to occur, nor are potential impacts to likely TGDEs.

### 05.5 Changes in surface water

Other considerations pertaining to potential impacts from the Project may include:

- The relationship between groundwater and subsoil moisture (i.e. water held in riverbanks).
- Impacts to TGDEs from changes to surface water hydrology or quality, as a result of:
    - Alteration of natural environment and topography due to mining operations.
    - Controlled release of mine affected water (i.e. MAW).
    - Uncontrolled release of contaminants.
    - Erosion and sedimentation of waterways.

In some areas rainfall associated recharge and water storage within subsurface soils from rainfall infiltration may also be potentially reduced, either directly due to surface water diversion of runoff affecting infiltration and/or via groundwater drawdown increasing the rate and direction of water infiltration into underlying sediments; known as enhanced leakage. In the context of the Project, the main drainage feature is Phillips Creek, which flows into the Isaac River (the major watercourse within the region). Flow in Phillips Creek will be maintained over the Project lifetime (i.e. no alteration to pathway / diversion), with only a minor reduction (<0.3%) in potential run-off area in the downstream catchment (i.e. due to cut out of ML700021 over the course of Grevillea Pit continuation) (Engeny 2025b). Streamflow volumes (annual and monthly) and daily flow duration are to be reduced by 0.29% immediately adjacent to the Project area, lessening to 0.23% towards to the Issac River confluence. Loss of streamflow will have negligible impact on flow volumes and duration characteristics in Phillips Creek (as well as One Mile / Boomerang Creeks) (Engeny 2025b).

Groundwater recharge in Phillips Creek alluvial deposits associated with seasonal flooding conditions are not likely to change as a result of the Project. 3D Environmental (2023) identified that trees within Phillips Creek utilise surface water, water from soil moisture (at a range of depths in the unsaturated portion of the soil profile – indicated by isotopic samples) and from within alluvial groundwater sources across varying sites. The continuation of established surfaces flows will ensure replenishment of soil moisture within the unsaturated zone around Alluvium; groundwater perched in Alluvium and the movement of water into Tertiary groundwater system during flood conditions (where Tertiary sediments are (semi-)permeable).

Controlled released of MAW presents another potential impact pathway. Releases are expected to occur at an incrementally increased volume as a result of the Project (Engeny 2025b). However, strict release conditions, ongoing monitoring (per the FRREMP) and specific downstream triggers are expected to manage risk to surface water associated with MAW. Uncontrolled releases of contaminants presents a potential impact pathway, particularly during precipitation events. Leaks or spills of hydrocarbons, chemicals, treated water, and spread of coal dust, has the potential to reduce surface water quality. Release of contaminants is, however, unlikely to occur where mitigation measures are applied as per established standards and guidelines (refer Section 05.6).

As no vegetation clearing will occur on floodplains and/or near drainage lines, no project-specific impacts from erosion and/or sedimentation are considered likely to occur. Regardless, the Project will apply appropriate mitigation measures per the Erosion and Sedimentation Control Plan (ESC Plan), as required by the Project's EA conditions.

The above considered, no change in surface hydrology is likely to occur outside of the Project Area (i.e. where the pit is to be dug), nor are potential impacts to likely TGDEs.

### 05.6 Management Measures

The SRM currently operates in accordance with EA EPML00862313, which was amended in 2017 to include the area associated with the Project. The operation and performance management of the proposed action will be managed in accordance with this EA approval, which covers groundwater and surface water domains. Specifically, the mitigation and management measures for impacts to water resources will continue to be implemented as required by the EA.

To minimise potential impact on groundwater and surface water, existing mitigation measures outlined in the EA conditions will continue to be implemented for the Project, including:

- Monitoring of groundwater quality to identify trends and over time – Condition I4.
- Fuel, dangerous good and hazardous chemical will be managed by current standards and guidelines – Condition E14.
- Implementation of appropriate water management and erosion control – Conditions F33 – F41.
- Implementation of Receiving Environment Monitoring Program - Condition F20.
- Release of mine affected water only from specified release points and ongoing monitoring of any releases – Condition F2, F3 and F4.
- Ongoing monitoring of receiving environment – Condition F18.

The existing management measures will be reviewed and updated as required to ensure relevancy and timeliness for detecting any marked changes to groundwater due to the Project. Adaptive management will be undertaken where actual impacts to groundwater levels or groundwater quality differ from predicted impacts (see below).

### 05.6.1 GDE Monitoring and Management Plan

In addition to management conditions under the EA, BMA will develop and deliver a GDEMMP specific to the Project. The objective of the GDEMMP will be to validate conclusions of the significant impact assessment, noting that no significant impacts to likely GDEs are expected to be associated with the Project itself (refer Section 06). The scope of the GDEMMP will primarily pertain to TGDEs (identified within this assessment) and will require:

- Collection of baseline (prior to Project commencement) and ongoing monitoring of vegetation condition (as a proxy of ecosystem function) data at sites of likely TGDEs within the Predicted Drawdown Extent, and across control sites.
- Collation of supporting data (e.g. SWL, quality) from additional sources including the:
  - SRM Groundwater Management and Monitoring Plan (GMMP); and the
  - FRREMP.
- Analysis of data against established trigger thresholds (to detect change in ecological function and/or community health).
- Investigations, and application of adaptive management procedures in the unlikely event that trigger threshold are met.
- Reviews and updates to the MMP, where necessary. This includes a process to extend the monitoring intervals and/or cease implementation of the MMP subject to certain criteria being met (e.g. additional evidence that GDEs are limited in extent and that impacts from groundwater drawdown are not realised).

In addition to TGDEs, the GDEMMP will provide additional information to validate the current assessment of subterranean GDEs relevant to the Project (i.e. stygofauna). The GDEMMP will detail the process for delivering a pilot survey for stygofauna within the Assessment Area (refer Section 04.1.1). If stygofauna are identified, monitoring will continue, with management protocols being updated within the GDEMMP. Where the pilot survey confirms the current assessment of stygofauna occurrence, no further management or monitoring will be undertaken.

# 06 SIGNIFICANT IMPACT ASSESSMENT

The 'water trigger' is a provision under the *Environment Protection and Biodiversity Conservation Amendment Act 2013* (Cwth). As a result of this amendment, under the EPBC Act, an action which involves a CSG or a large coal mining development requires approval from the Australian Government Environment Minister (the Minister) if the action has, will have, or is likely to have a significant impact on a water resource. Water resources are defined as:

- Surface water or groundwater
- A watercourse, lake, wetland or aquifer (whether or not it currently has water in it)
- And includes all aspects of the water resource (including water, organisms and other components and ecosystems that contribute to the physical state and environmental value of the water resource) (as per the *Water Act 2007* (Cwth)).

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the water resource, which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.

The Significant Impact Guidelines 1.3 – Impacts on water resources (DCCEEW 2022) provide overarching guidance on determining whether an action which involves a coal seam gas or a large coal mining development will or is likely to have a significant impact on a water resource. An action is likely to have a significant impact on a water resource if …

> *… there is a real or not remote chance or possibility that it will directly or indirectly result in a change to:*
>
> - *the hydrology of a water resource*
> - *the water quality of a water resource*
>
> *that is of sufficient scale or intensity as to reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes, or to create a material risk of such reduction in utility occurring.*

The 'value' the water resource is a key component in determining whether the impacts of a proposed action are likely to be significant. In relation to TGDEs, the value is linked to the environment, which is itself considered to be a 'third party user' of the water resource (DCCEEW 2022). The main utility of the TGDE to the environment is that of 'supporting services' e.g. the maintenance of ecosystem function. The ecosystem function of a water resource includes the ecosystem components, processes and benefits of services that characterise the water resource, including support for the biological diversity of species composition of the water resource.

GDEs fall under the cursor of water resources as they comprise both ecosystems and organisms that contribute to the environmental value of groundwater. Changes in the hydrological characteristics of a water resource (i.e. quantity, quality, connection, flow) need to be considered when assessing significant impact on the value of a water resources (e.g. how it maintains function of a GDE).

This section will assess the significance of any potential impacts to likely GDEs (Section 04) with regard to impact criteria outlined the Significant Impact Guidelines 1.3 (DCCEEW 2022), and with respect to impact pathways identified as relevant within Section 05 (i.e. groundwater depth, groundwater quality and surface hydrology).

## 06.1 Stygofauna

As described in Section 04.1.1, current evidence would suggest stygofauna are not present within the Assessment Area, and as such, impacts to these GDEs will not occur. Confirmation of this conclusion will be determined via a pilot survey detailed within the associated GDEMMP (refer Section 05.6.1). If identified as present, monitoring actions will continue, and management protocols implemented via GDEMMP.

## 06.2 TGDEs

### 06.2.1 Groundwater drawdown

Within the Assessment Area, likely TGDEs occur along the riparian zone of Phillips Creek (RE 11.3.25) and adjacent woodlands (RE 11.3.4 and RE 11.5.3). The total sum of likely TGDEs in the Assessment Area is 1.1 ha. Potential TGDEs are also mapped within RE 11.3.25, and to a more limited extent in areas of REs immediately adjacent to Phillips Creek (refer Table 04-4).

#### 06.2.1.1 Alluvium

Research indicates that GDE indicator species present within Phillips Creek may root to ≤ 10 mbgl (with the exception of *Eucalyptus camaldulensis*) (refer Table 04-2). Some species (e.g. bloodwoods) are noted to invest in deeper root architecture; however, edaphic controls, notably the presence of heavy clay soil, likely reduces the ability of species to develop tap roots below the sandy substrate and Alluvium. Considering this, and DTW in lower strata, it is expected that GDE indicator species (with the exception of *E. camaldulensis* and *E. populnea* – see below) are exclusively utilising groundwater resources from the Alluvium. As no drawdown is modelled in this layer (SLR 2025), no impacts are expected to species / communities exclusively using this groundwater resource (refer Table 05-2 and Table 05-3).

#### 06.2.1.2 Regolith

Due to theorised maximum rooting depths of *Eucalyptus camaldulensis (*7–22.6 mbgl) and *E. populnea* (12.6–26.7 mbgl), these species may potentially access groundwater in the regolith. REs within the Assessment Area, in which *E. populnea* is present, includes RE 11.5.3. The extent of RE 11.5.3 considered likely to function as a TGDE is negligible (<0.1 ha) and is therefore not considered at risk of significant impacts.

*E. camaldulensis* may be present in REs 11.3.25 and 11.3.4, with areas of both ecosystems mapped as likely (and some potential) TGDEs. Where likely TGDEs occur, modelled drawdown is <1 m (and largely in the range of 0.01-0.09 m). This magnitude of drawdown is unlikely to impact *E. camaldulensis* (refer Table 05-3), unless where DTW sits at the current edge of the species' maximum rooting depth (i.e. drawdown would move the capillary fringe of groundwater beyond theorised rooting depth). Modelled DTW contours of 20–30 m does coincide with REs containing *E. camaldulensis.* However, any potential impact is unlikely to be significant considering the following:

- Limited extent of REs 11.3.25 and 11.3.4 showing persistent greenness and moistness during dry periods (refer Appendix C).
- Species are unlikely to be rooting to maximum theorised depth, with groundwater resources also available via shallower aquifers (i.e. Alluvium groundwater).
    - There is the possibility that individual trees exhibit a dimorphic root architecture, and potentially access water within alluvial and regolith aquifers, as well as via soil moisture – reducing value of groundwater access in the regolith (noting no groundwater drawdown in Alluvium).
- The rate of drawdown in regolith is likely to be slow, given the presence of aquitards which limit the hydraulic connectivity with Permian strata (i.e. where more significant scales of drawdown may occur).
- *E. camaldulensis* is adaptable to intermittent availability of groundwater (i.e. facultative phreatophyte), with Doody et al. (2015) demonstrating that soil moisture alone can sustain individuals for six years before a decline in tree health becomes evident.

- The species also has the capacity to self-regulate and adjust their transpiration rates to match the average flood return interval (Colloff 2014 cited in 3D Environmental 2023); although strong seasonal variation is not necessarily present within regolith groundwater.
- Monitoring bores set within the Tertiary sediments of SRM also suggest that the SWL of the strata is relatively stable, with no significant variation in recent years (refer Section 05.3).

As the magnitude and rate of drawdown will not inhibit GDE indicator species' ability to access groundwater, the ecological function of GDE indicator species is not anticipated to be impacted. Consequently, the contribution of GDE indicator species to the wider ecosystem (i.e. the riparian zones associated with RE 11.3.25) will also not be impacted and there is no anticipated change to the functionality of the ecosystem as a result of groundwater drawdown. There will be no significant impacts to likely TGDEs as a result of groundwater drawdown.

## 06.3 Changes in groundwater quality

As described in Section 05.4, no changes to groundwater quality are expected as a result of the Project. Limited hydraulic connectivity exists between Permian and upper layers due to presence of aquitards (i.e. interburden / overburden). A downward cone of depression from pit dewatering will develop, meaning that localised groundwater will flow towards the pit, limiting potential for impact on surrounding groundwater quality (i.e. changes in salinity) including those used by TGDEs (i.e. perched groundwater in Phillips Creek Alluvium) (SLR 2024). Perched Alluvium aquifers potentially used by TGDEs are recharged via precipitation and surface flow. Where appropriate mitigation measures are implemented (refer Section 05.6), no contamination of surface flows is likely to occur from the Project. Prevention of contamination (e.g. spills / leaks) of water resources associated with the Project is described within established standards and guidelines.

As no changes in groundwater quality are predicted, there is no anticipated change to the functionality of likely TGDEs. Consequently, there will be no significant impacts to likely TGDEs as a result of changes in groundwater quality.

## 06.4 Changes in surface water

As described in Section 05.5, the SLR model has predicted negligible change in net flow in Phillips Creek (SLR 2024, 2025). No changes will occur to creek hydrology[25], excepting the minor reduction in available run-off area along creek catchment / tributaries (i.e. cut out of ML700021 over the course of the Project). Factors of sedimentation and erosion along Phillips Creek will be controlled via appropriate control measures under the SRM ESC Plan, as per Condition F33 in the EA. Additionally, controlled / uncontrolled releases will be mitigated via measures in established standards and guidelines.

As no changes to surface water hydrology / quality are anticipated, there will be no impact to the functionality of TGDEs within the Assessment Area. Consequently, there will be no significant impacts to TGDEs as a result of changes to surface water hydrology / quality.

[25] Noting the previous Spring Creek to Phillips Creek Diversion

# 07 CONCLUSION

This report has outlined the process undertaken to identify the likely presence of GDEs within the Assessment Area that may be impacted by the Project, and to determine the significance of any impacts to the GDEs in accordance with the Significant impact guidelines 1.3: Coal seam gas and large coal mining development – impacts on water resources (DCCEEW 2022).

Neither subterranean nor aquatic GDEs were identified as being likely to occur within the Assessment Area (though the former's assessment will be validated via implementation of a forthcoming survey program embedded within and delivered under the proposed GDEMMP). Through the identification and assessment of DTW, groundwater quality and plant physiology, vegetation mapping and application of appropriate remote sensing criteria, TGDEs were identified as likely and potentially occurring within the Assessment Area.

Specifically, likely TGDEs were identified in association with vegetation communities along and adjacent to Phillips Creek. TGDEs were considered unlikely outside of Alluvium, as restrictions on the rooting depth of indicator species, and a restrictive stratum (i.e. tight / heavy clay) likely prevents access to groundwater sources at modelled depth). No TGDEs were identified within the Project Area, and as such there is no direct clearing of TGDEs. The potential impact mechanisms associated with TGDEs are limited to changes in groundwater depth and quality, and changes to surface water hydrology and quality.

An assessment of the potential impacts of groundwater drawdown was completed, which identified that impacts to TGDEs are largely unlikely to occur, due to the following:

- No drawdown is predicted to occur within the Alluvium layer, meaning groundwater access is maintained for GDE indicator species in likely TGDEs
- Minor drawdown of <1 m is predicted for the regolith layer; however, majority of GDE indicator species are not likely to access groundwater in this stratum, nor rely on it.
    - The relevant exception to this is *Eucalyptus camaldulensis* which has the potential to access the groundwater in the regolith due to the species theorised maximum rooting depth[26]. Where drawdown may move DTW beyond the species maximum potential rooting depth, impacts to this species (and the likely TGDEs it occurs within) may be possible. However, any impact due to Project associated drawdown is unlikely to be significant as:
        - Limited extent of REs that likely function as TGDEs.
        - Minor magnitude of drawdown.
        - Slow rate of drawdown.
        - Access to groundwater is likely to be maintained (where DTW is <20 m).
        - Facultative nature of *E. camaldulensis.*

In regard to other impact mechanisms, there is no predicted change in groundwater quality or surface water quality or hydrology and as such, no predicted impacts to TGDEs from these mechanisms. To minimise potential impacts on groundwater and surface water, existing mitigation measures outlined in EA EPML00862313 conditions will continue to be implemented for the Project. Specifically, the mitigation and management measures for impacts to water resources will continue to be implemented as required by the EA. Furthermore, the proponent has volunteered to implement a GDEMMP to monitor and adaptively manage vegetation communities that likely access and utilise groundwater.

In consideration of the limited extent of TGDEs, the minor or negligible nature of impacts and the ongoing implementation of mitigation and management measures, there are no significant impacts predicted to occur to TGDEs as a result of the Project.

[26] *Eucalyptus populnea* is not mentioned here due to negligible presence of likely TGDEs in associated RE 11.5.3.

# REFERENCES


2rog Consulting [2rog] (2022). *Terrestrial Groundwater-Dependent Ecosystem Assessment Guidelines.* Supporting Document. Prepared for BHP.

3D Environmental (2023). *Saraji East Mining Lease Project Groundwater Dependent Ecosystem Assessment.* Prepared for AECOM Australia Pty Ltd.

AECOM (2016). *Terrestrial Ecology Baseline Report.* Prepared for BM Alliance Coal Operations Pty Ltd.

AECOM (2019). *Saraji East Mining Lease Project Groundwater Technical Report*. Report Ref: 60507031.

AECOM (2023a). *Saraji East Mining Lease Project Environmental Impact Statement – Chapter Nine Groundwater.* Prepared for BM Alliance Coal Operations Pty Ltd.

AECOM (2023b). *Saraji East Mining Lease Project Environmental Impact Statement – Groundwater Technical Report*. Prepared for BM Alliance Coal Operations Pty Ltd.

Anderson, V.J. & Hodgkinson, K.C. (1997). Grass-mediated capture of resource flows and the maintenance of banded mulga in a semi-arid woodland, *Australian Journal of Botany*, 45 (2), 331-42.

BAAM Ecological Consultants [BAAM] (2021). *Ecological Baseline Assessment Saraji Mine.* Prepared for BM Alliance Coal Operations Pty Ltd.

Bacon, P.E., Stone, C., Binns, D.L., Leslie, D.J. & Edwards, D.W. (1993). Relationships between water availability and Eucalyptus camaldulensis growth in a riparian forest. *Journal of Hydrology*. 150(2): 541-561.

Burgess, S. S. O., Adams, M. A., Turner, N. C., White, D. A. & Ong, C. K. (2001). Tree Roots: Conduits for Deep Recharge of Soil Water. *Oecologia*. 126(2): 158–165.

Burgess, S.S.O., Pate, J.S., Adams, M.A. & Dawson, T.E. (2000). Seasonal water acquisition and redistribution in the Australian woody phreatophyte, Banksia prionotes. *Annals of Botany*. 85(2): 215-224.

Bureau of Meteorology [BoM] (2024). *Groundwater Dependent Ecosystems Atlas*. http://www.bom.gov.au/water/groundwater/gde/map.shtml

Coaldrake, J.E. (1967). Depth of ploughing in relation to depth of suckering and soil type in the control of root suckers of brigalow (*Acacia harpophylla*). *Australian Journal of Experimental Agriculture.* 7: 523-527.

Colloff M. (2014). *Ecology and History of the River Red Gum.* CSIRO Publishing. Collingwood, Victoria.

Department of Climate Change, Energy, the Environment and Water [DCCEEW] (2022). Significant impact guidelines 1.3 Coal seam gas and large coal mining developments — impacts on water resources. https://www.dcceew.gov.au/sites/default/files/documents/significant-impact-guidelines-1-3.pdf

Department of Environment, Science and Innovation [DESI] (2019). *WetlandMaps - Interactive Maps and Wetlands Data in Queensland.* https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/get-mapping-help/wetland-maps/

Department of Environment, Science and Innovation [DESI] (2024). *Remnant vegetation cover - 2021 – Queensland*. https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={F5CF90D6-5881-4D8F-9581-D8F55D25F9CE}

Department of Science, Information Technology and Innovation [DSITI] (2015). Guideline for the Environmental Assessment of Subterranean Aquatic Fauna. Queensland Government.

https://www.publications.qld.gov.au/dataset/f7e68ccd-8c13-422f-bd46-1b391500423f/resource/ba880910-5117-433a-b90d-2c131874a8e6/download/guideline-subterranean-aquatic-fauna.pdf

Department of Resources [DoR] (2023). *State surface geology 1975 – Queensland.* https://www.data.qld.gov.au/dataset/queensland-geology-series/resource/30ef74c6-f88b-4ac9-9a1c-8181ef5b4ea0

Dickins, J. M. & Malone, E. J. (1973). Geology of the Bowen Basin, Queensland. Bureau of Mineral Resources. *Geology and Geophysics.* 130.

Doody, T., Colloff, M., Davies, M., Koul, V., Benyon, R., & Nagler, P. (2015). Quantifying water requirements of riparian river red gum (*Eucalyptus camaldulensis*) in the Murray–Darling Basin, Australia – implications for the management of environmental flows. *Ecohydrology.* 8(8): 1471-1487.

Doody, T.M., Hancock, P.J. & Pritchard, J.L. (2019). *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems.* Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia.

Dupuy, L., Fourcaud, T. & Stokes, A. (2005). A numerical investigation into the influence of soil type and root architecture on tree anchorage. *Plant Soil.* 278(1):119–134.

Eamus, D., Froend, R., Hose, G., & Murray, B., (2006a). A Functional Methodology for Determining the Groundwater Regime Needed to Maintain Health of Groundwater Dependent Vegetation. *Australian Journal of Botany*. 54: 97–114.

Eamus, D., Hatton, T., Cook, P., & Colvin, C. (2006b). Echohydrology, Vegetation Function, *Water and Resource Management.* ISBN: 9780643094093. CSIRO Publishing.

EcoLogical Australia. (2018). *Saraji Mine Spring Creek Diversion – Stage 1. Ecological Assessment.* Prepared for BHP.

Engeny (2025a). *BHP Grevillea Pit Terrestrial Ecology Survey Report*. Prepared for and on behalf of BHP.

Engeny (2025b). *Saraji Mine Grevillea Pit Continuation Project. Surface Water Assessment.* Prepared for and on behalf of BHP.

Fensham, R. J. & Fairfax, R. J. (2007). Drought-related tree death of savanna eucalypts: Species susceptibility, soil conditions and root architecture. *Journal of vegetation science*, 18(1): 71–80.

Johnson, R.W. (1964). *Ecology and control of Brigalow in Queensland*. Queensland Department of primary Industries. 1-92.

Kallarackal, K. & Somen, C. K. (1998). *Water relations and rooting depth of selected eucalypt species.* KFRI Research Report No. 136. Kerala Forest Research Institute, Peechi, Thrissur.

Kath, J., Reardon-Smith, K., Brocque, A.F. Le., Dyer, F.J., Dafny, E., Fritz, L., & Batterham, M. (2014). Groundwater decline and tree change in floodplain landscapes: Identifying non-linear threshold responses in canopy condition. *Global Ecology and Conservation*. 2: 148–160.

Marcar, N.E., Crawford, D.F. (2004). *Trees for saline landscapes*. Canberra. Rural Industries Research and Development Corporation, Australia.

Mensforth, L.J., Thorburn, P.J., Tyreman, S.D. & Walker, G.R. (1994). Sources of water used by riparian Eucalyptus camaldulensis overlying highly saline groundwater. *Oecologia.* 100:21-28.

O'Grady, A., Eamus, D., Cook, P., & Lamontagne, S., (2006a). Groundwater use by riparian vegetation in the wet-dry tropics of northern Australia. *Australian Journal of Botany*. 54(2): 145–154.

O'Grady, A., Cook, P., Howe, P. & Werren, G. (2006b). Groundwater use by dominant tree species in tropical remnant vegetation communities. *Australian journal of botany*. 54(2): 155.

Queensland Government (2017). *Potential groundwater dependent ecosystem aquifer mapping background.* https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/potential-aquifer-background/

Richardson, S., Irvine, E., Froend, R., Boon, P., Barber, S. & Bonneville, B. (2011). Australian groundwater-dependent ecosystem toolbox part 1: assessment framework. Waterlines report, National Water Commission. Commonwealth of Australia.

Roberts, J. & Marston, F. (2000). *Water Regime of Wetland and Floodplain Plants in the Murray-Darling Basin: A Source Book of Ecological Knowledge.* CSIRO Land and Water. Technical Report 30/00.

SLR (2024). *Saraji Mine Grevillea Pit Continuation Project. Groundwater Assessment*. Prepared on Behalf of BHP Mitsubishi Alliance (BMA).

SLR (2025). Saraji Mine Grevillea Pit Continuation Project – Groundwater Impact Assessment IESC Advice Response. Prepared on Behalf of BHP Mitsubishi Alliance (BMA).

Steggles, E.K., Holland, K.L., Chittleborough, D.J., Doudle, S.L.., Watling, J.R. & Facelli, J.M. (2017). The potential for deep groundwater use by *Acacia papyrocarpa* (Western myall) in a water-limited environment. *Ecohydrology*. 10(1).

Sun, D. & Dickinson, G.R. (1995). Survival and Growth Responses of a Number of Australian Tree Species Planted on a Saline Site in Tropical north Australia. *Journal of Applied Ecology.* 32(4), pp. 817-826.

Van der Moezel, P.G., Walton, C.S., Pearce-Pinto, G.V.N. & Bell, D.T. (1989). Screening for salinity and waterlogging tolerance in five *Casuarina* species. *Landscape and Urban Planning.* (17)4, pp. 331-337

Verma, P., Loheide (2nd), S., Eamus, D., & Daly, E. (2014). Root water compensation sustains transpiration rates in an Australian woodland. *Advances in Water Resources*.*74*: 91-101.

Wilson, P.R. & Taylor, P.M. (2012). *Land Zones of Queensland.* Queensland Herbarium. Queensland Department of Science, Information Technology, Innovation and the Arts.

# APPENDIX A: RISK ASSESSMENT

A risk assessment has been undertaken to identify the potential impacts of the Project on GDEs with a greater environmental risk and to determine where assessment and management controls should be focused. Through undertaking a risk assessment, proposed measures can be evaluated as to their expected or predicted effectiveness.

The risk assessment was undertaken using a systematic risk-based approach based on international best practice standards, including:

- AS/NZS ISO 31000:2009: Risk management – Principles and Guidelines (Standard).
- HB 158:2010: Delivering assurance based on ISO 31000:2009 Risk management – Principles and Guidelines (Handbook).
- HB 203:2012: Managing environment-related risk (Handbook).
- HB 436:2004: Risk Management Guidelines Companion to AS/NZS 4360:2004 (Handbook).

The risk assessments were conducted collaboratively between 2rog Consulting and BMA to identify the objectives, scope and risk criteria for the Project. The scope of the risk assessment included all activities directly related to the construction, operation and decommissioning of the Project, where they may interact with and/or impact GDEs.

The risk ratings were determined for each combination of environmental receptor (i.e. GDE) and Project activity, using the definitions of consequence (Table A1) and likelihood (Table A2) detailed below and applying the risk matrix (Table A3). These have been adapted from the matrix used by 3D Environmental (2023).

**Table A1: Consequence assessment**

| Consequence rating | | Description |
|---|---|---|
| 5 | Severe | Irreversible impact to >50% of mature GDE indicator species that cannot be mitigated. Vegetation is converted from remnant to non-remnant status. Offsets required. |
| 4 | High | Significant harm (loss of 20–50% of mature GDE indicator species). Impact is reversible although a significant lag (>20 years) in return to pre-disturbance condition occurs. Vegetation is converted from remnant to non-remnant status. Offsets likely required. |
| 3 | Moderate | Plant stress linked to mining activity that results in the reduction in volume and duration of groundwater supporting a GDE system that does not result in more than 25% dieback of mature GDE indicator species. Impact is reversible with mitigation. |
| 2 | Low | Plant stress linked to mining activity that results in the reduction in volume and duration of groundwater supporting a GDE system that does not result in more than 5% dieback of mature GDE indicator species. Impact localised and reversible with mitigation. |
| 1 | Negligible | No impact identifiable above baseline conditions. |

**Table A2: Likelihood assessment**

| Likelihood / probability | | Basis of rating |
|---|---|---|
| A | Highly likely | Expected to occur with open-cut mining operations of this scale |
| B | Likely | Will probably occur in most circumstances with open-cut mining operations of this scale |
| C | Possible | Could occur at some time (but not often) with open-cut mining operations of this scale |
| D | Unlikely | Occurrence improbable with open-cut mining operations of this scale |
| E | Rare | No precedent with open-cut mining operations of this scale |

Table A3: Risk matrix

| | | Consequence | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| | | | Negligible | Low | Moderate | High | Severe |
| Likelihood | A | Highly likely | Low | Intermediate | High | Extreme | Extreme |
| | B | Likely | Low | Low | Intermediate | High | Extreme |
| | C | Possible | Insignificant | Low | Intermediate | High | High |
| | D | Unlikely | Insignificant | Insignificant | Low | Intermediate | High |
| | E | Rare | Insignificant | Insignificant | Insignificant | Low | Intermediate |

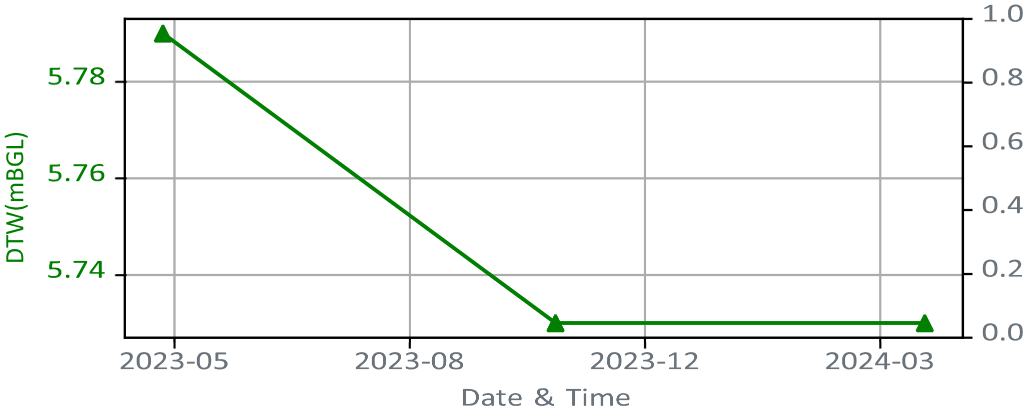
**Table A4: Risk assessment**

| Impact and risk description | Context | Initial risk rating | | | Mitigation measures | Residual risk rating | | |
|---|---|---|---|---|---|---|---|---|
| | | Likelihood | Consequence | Result | | Likelihood | Consequence | Result |
| Groundwater drawdown associated with aquifers potentially being utilised by GDEs | No drawdown in perched Alluvium aquifers (i.e. those most probable to be utilised by likely TGDEs) is anticipated to occur. The probability of TGDEs in the assessment area accessing groundwater from the regolith, wherein minimal drawdown is expected to occur, is low but possible. Further, hydraulic connectivity between Alluvium perched aquifers and the regolith is also deemed to be low. Therefore, any impacts associated with drawdown in the regolith are unlikely to be of significance. | Likely | Low | Low | • Mitigation and management measures for potential impacts to groundwater and surface water levels and quality prescribed by the EA EPML00862313 will continue to be adhered to (see Section 05.6)<br>• Monitoring and adaptive management of GDEs will be implemented, consistent with the associated GDEMMP. | Likely | Negligible | Low |
| Reduced groundwater quality of aquifers potentially being utilised by GDEs | Due to a lack of hydraulic connectivity between the Permian, regolith and Alluvium strata, and recharge to Alluvium primarily occurs via Phillips Creek flows and/or rainfall events, potential altered salinity of groundwater resources as a result of the Project is unlikely.<br>Potential impacts from Project activities on groundwater quality exist in the form of leaks, spills and improper disposal of waste rock and subsequent leaching of compounds. | Unlikely | Low | Insignificant | • Mitigation and management measures for potential impacts to groundwater and surface water levels and quality prescribed by the EA EPML00862313 will continue to be adhered to (see Section 05.6), including monitoring of groundwater quality to identify trends over time.<br>• Potential impacts associated with leaks, spills and improper disposal of wastes, including waste rock, leading to leaching of compounds into groundwater, are unlikely to occur with the appropriate mitigation measures as required by the EA EPML00862313.<br>• Fuel, dangerous goods and hazardous chemicals will be managed by current standards and guidelines.<br>• Mine affected water will only be released from specified release points, abide conditioned water quality and will incorporate ongoing monitoring of those releases.<br>• The current REMP will be continued.<br>• Monitoring and adaptive management of GDEs will be implemented, consistent with the associated GDEMMP. | Rare | Low | Insignificant |

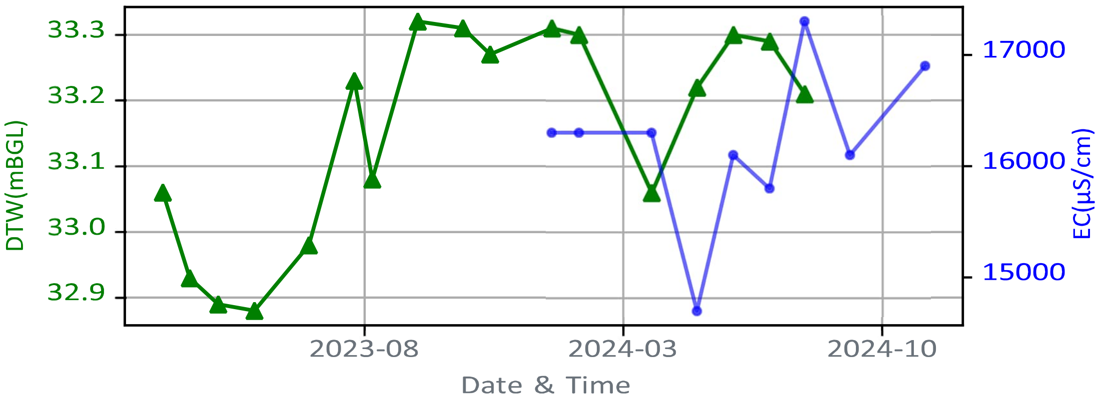
| Impact and risk description | Context | Initial risk rating | | | Mitigation measures | Residual risk rating | | |
|---|---|---|---|---|---|---|---|---|
| | | Likelihood | Consequence | Result | | Likelihood | Consequence | Result |
| Changes in surface water quality which (a) interact with aquifers potentially being utilised by GDEs, or (b) aid in sustaining likely GDEs | Perched Alluvium aquifers along Phillips Creek recharge via surface flows and rainfall. No changes in creek hydrology are anticipated to occur as a result of the Project.<br>Potential impacts from Project activities on surface water quality exist in the form of sedimentation and erosion, leaks, spills and improper disposal of waste rock and subsequent leaching of compounds. | Possible | Low | Low | • Mitigation and management measures for potential impacts to groundwater and surface water levels and quality prescribed by the EA EPML00862313 will continue to be adhered to (see Section 05.6).<br>• Potential impacts associated with leaks, spills and improper disposal of wastes, including waste rock, leading to contamination of surface flows, are unlikely to occur with the appropriate mitigation measures as required by the EA EPML00862313.<br>• Fuel, dangerous goods and hazardous chemicals will be managed by current standards and guidelines and in compliance with statutory guidelines.<br>• Mine affected water will only be released from specified release points and will incorporate ongoing monitoring of those releases.<br>• The current REMP will be continued.<br>• Erosion and Sediment Control Plan will be implemented as stipulated by the EA conditions.<br>• Monitoring and adaptive management of GDEs will be implemented, consistent with the associated GDEMMP. | Rare | Low | Insignificant |
| Changes to surface flows affecting groundwater recharge of aquifers potentially being utilised by GDEs | Perched Alluvium aquifers along Phillips Creek recharge via surface flows and rainfall. A reduction in available run-off within the creek catchment (directly corresponding to the ML700021 and proposed mining activities therein) may result in a negligible reduction in water flow in Phillips Creek downstream of the Project Area (i.e. <0.01 ML/day). | Unlikely | Low | Insignificant | • Existing hydrological function of watercourses will be maintained, allowing recharge of associated aquifers – modelling pertaining to Phillips Creek, which, along with rainfall events, are thought to recharge perched Alluvium aquifers likely supporting TGDEs, suggests minimal reductions in flow, if at all, resulting from the Project.<br>• Mitigation and management measures for potential impacts to groundwater and surface water levels and quality prescribed by the EA EPML00862313 will continue to be adhered to (see Section 05.6).<br>• The current REMP will be continued.<br>• Monitoring and adaptive management of GDEs will be implemented, consistent with the associated GDEMMP. | Rare | Low | Insignificant |

# APPENDIX B: HYDROGRAPHS

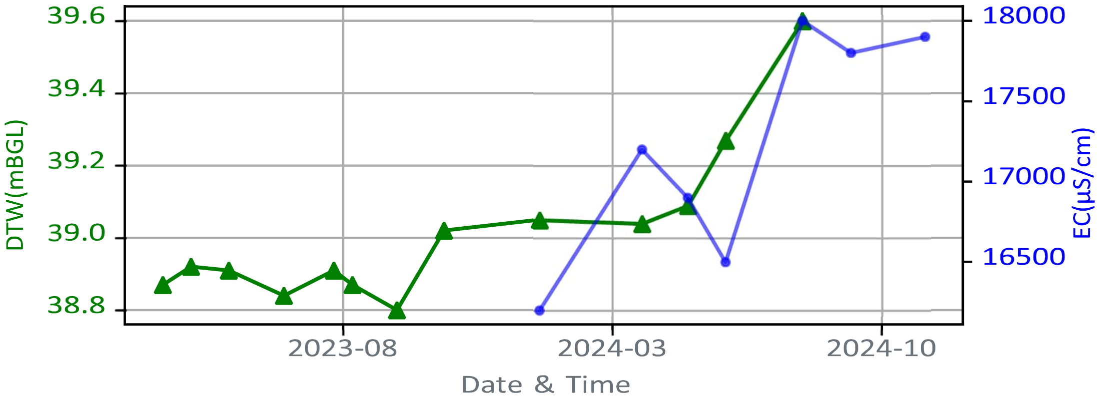
### B.1: SRM-2013MP06



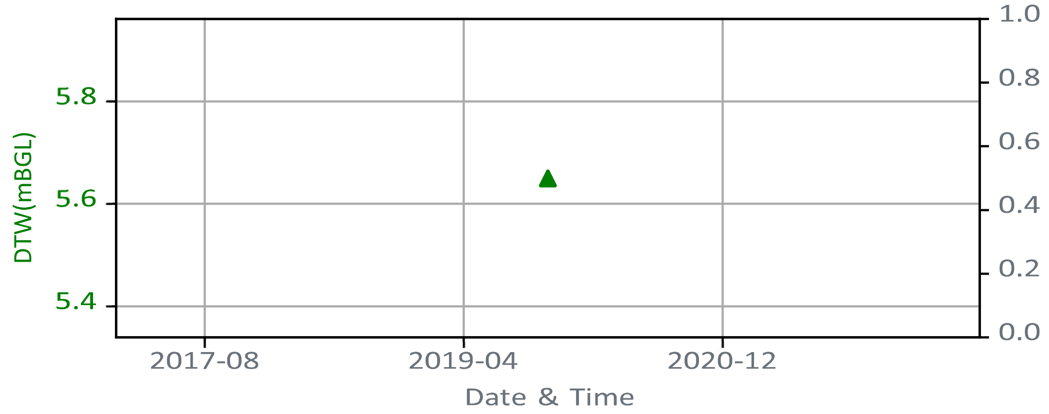

### B.2: SRM-MB14_03



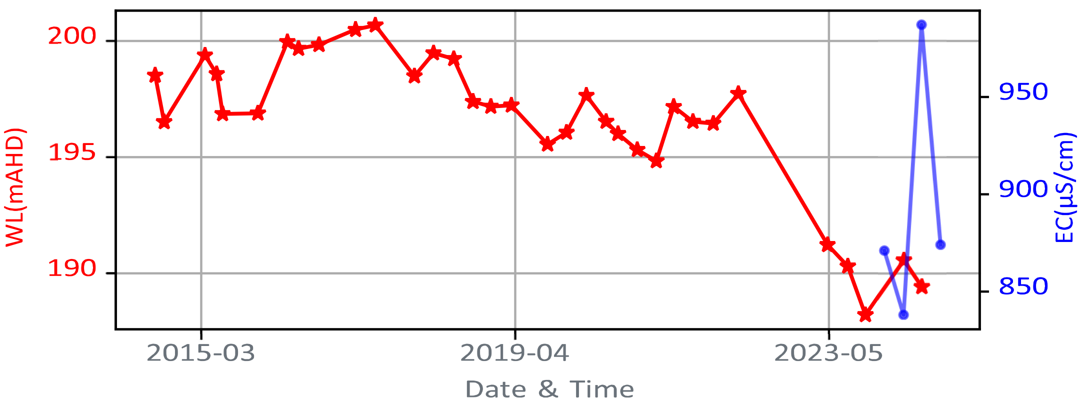

### B.3: SRM-MB15_02



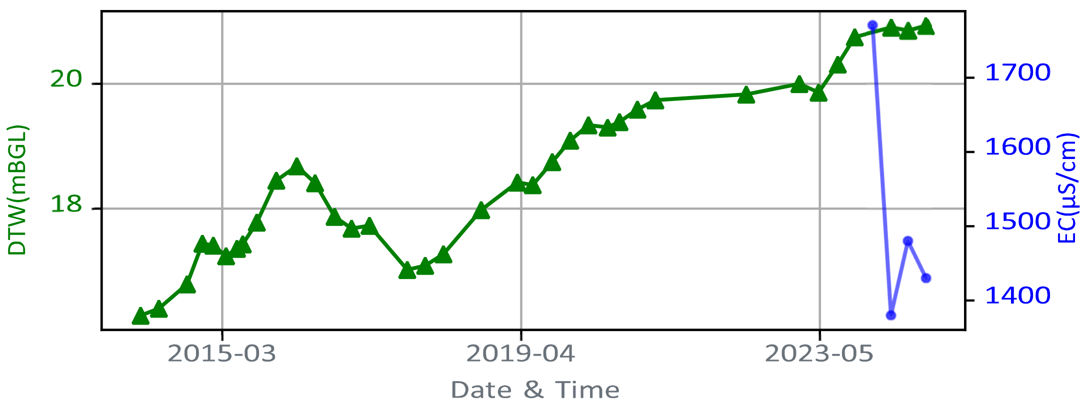
**B.4: SRM-MB20SRM04A SRM-MB20SRM06A**



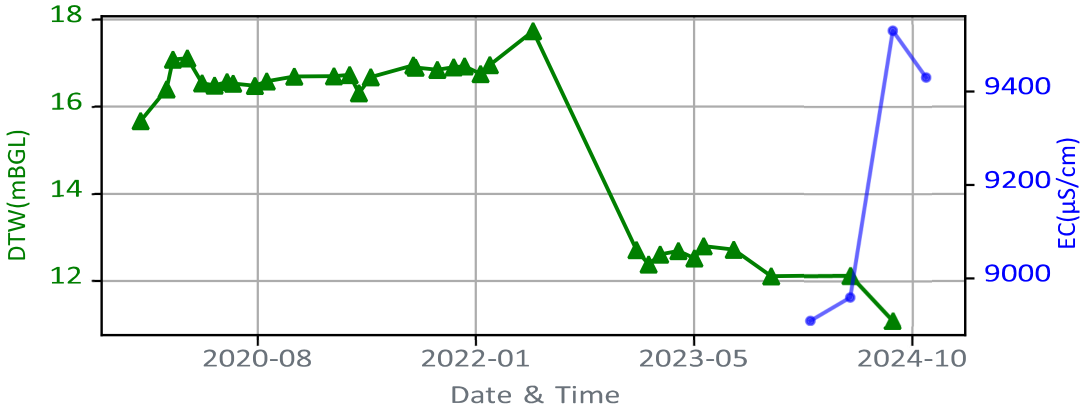

**B.5: SRM-MB32**



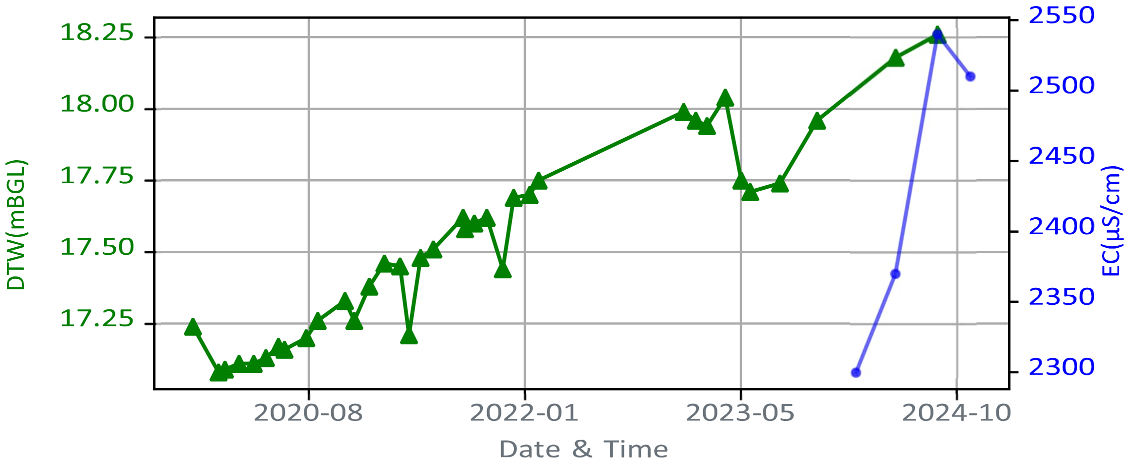

**B.6: SRM-MB35**



### B.7: SRM-MB39




### B.8: SRM-MB40



# APPENDIX C: REMOTE SENSING ANALYSIS

# Remote Sensing Terrestrial Groundwater Dependant Ecosystems

*Saraji Mine Grevillea Pit Continuation Project*

# INTRODUCTION

BMA engaged 2rog Consulting to assess the distribution and seasonal behaviour of terrestrial groundwater dependent ecosystems (TGDEs) in the area surrounding the proposed continuation of the Grevillea Pit at Saraji Mine.

To support existing information, a remote sensing approach was used to:

- Confirm the presence of TGDEs near the project area, especially along Phillips Creek
- Examine seasonal variation in groundwater use by associated vegetation communities.

# METHODS

The Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC), identifies the Groundwater Dependant Ecosystem Mapping (GEM) method as a preferred remote sensing approach for identifying potential terrestrial groundwater dependent ecosystems (TGDEs) (Doody et al 2019; Barron et al 2012).

The GEM method uses satellite imagery to compare vegetation greenness and moisture in wet and dry seasons using two indices:

- NDVI (Normalised Difference Vegetation Index) – indicates vegetation greenness
- NDMI (Normalised Difference Moisture Index) – indicates vegetation moisture content.

Vegetation that remains both green and moist during dry conditions, when rainfall is minimal, is considered a strong indicator of groundwater dependence.

This study applied the GEM method to determine areas of likely TGDEs, as well as incorporating wet season data to understand the effect of seasonality on associated vegetation communities.

### Image selection

Sentinel-2 satellite imagery was selected due to its high spatial resolution (10 m) and radiometric correction. Imagery was chosen to match distinct wet (January–April) and dry (October–December) seasons, using rainfall data from Moranbah Airport to confirm timing[27] (Appendix A). Five years of imagery (2020–2024) accessed from the Copernicus Data Space Ecosystem Browser[28] were reviewed (Table 1).

**Table 5: Sentinel - 2 image dates used for analysis**

| Year | Wet image date | Dry image date |
|---|---|---|
| 2020 | 21/3/2020 | 16/11/2020 |
| 2021 | 10/4/2021 | 17/10/2021 |
| 2022 | 15/4/2022 | 6/12/2022 |
| 2023 | 30/1/2023 | 16/11/2023 |
| 2024 | 24/4/2024 | 10/11/2024 |

### Image processing

Two indices were derived from each image:

- **Normalised Difference Vegetation Index** (NDVI) – representing vegetation greenness and density (Equation 1)

[27] http://www.bom.gov.au/climate/data/
[28] https://dataspace.copernicus.eu/browser/

- **Normalised Difference Moisture Index** (NDMI) – representing vegetation water content (Equation 2)

**Equation 1**

$$NDVI = \frac{Near\ Infrared - Red}{Near\ Infrared + Red}$$

**Equation 2**

$$NDMI = \frac{Near\ Infrared - Shortwave\ Infrared}{Near\ Infrared + Shortwave\ Infrared}$$

These indices each create a new value range with a maximum range of -1 to 1.

The indices were then averaged separately for wet and dry seasons. The resulting four index layers were:

- NDVI Dry Mean
- NDMI Dry Mean
- NDVI Wet Mean
- NDMI Wet Mean.

**Data classification**

The index layers were reclassified using threshold values based on literature and refined to reflect local site conditions. This process identified vegetation that is consistently green and moist:

- NDVI – vegetation classified as “green”
- NDMI – vegetation classified as “moist”.

Both wet and dry season imagery were used, with a focus on dry season conditions. Vegetation that remains green and moist during periods of low rainfall is more likely to be groundwater dependent.

Following standard practice (Fildes et al. 2023), initial threshold values were derived from statistical analysis of the index layers. These were then adjusted for local conditions and applied consistently across the study area to classify vegetation with persistent greenness and moisture for both wet and dry periods.

To identify areas of potential TGDEs:

- Reclassified NDVI and NDMI layers for the dry season were multiplied to create a binary raster
- Cells where both thresholds were met (value = 1) were flagged as potential TGDEs
- The same process was repeated for wet season imagery.

The wet and dry season binary rasters were then combined to produce a single TGDE layer, with three categories:

- Likely TGDE - *persistent greenness and higher moisture values through dry seasons*
- Possible TGDE - *persistent greenness and higher moisture values through wet seasons associated with Likely TGDE*
- Unlikely TGDE – *thresholds not met.*

The output was refined to exclude non-vegetated areas and limited to within the study boundary. Regional Ecosystems (RE)[29] overlapping with the potential TGDE areas were identified and the corresponding areas were calculated and summarised.

[29] qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions

# RESULTS

Using the refined GEM method, five wet-season and five dry-season Sentinel-2 images were processed to generate NDVI and NDMI values. These values were then averaged separately for the wet and dry periods to produce seasonal mean layers for each index.

Each averaged index layer was classified using a binary approach:

- 0 = below threshold
- 1 = threshold met or exceeded.

The following threshold values were applied (Figure 1):

- NDVI wet Mean ≥0.4 (green)
- NDVI Dry Mean ≥ 0.26 (green)
- NDMI Dry Mean ≥ 0.05 (moist)
- NDMI Wet Mean ≥ 0.1 (moist).

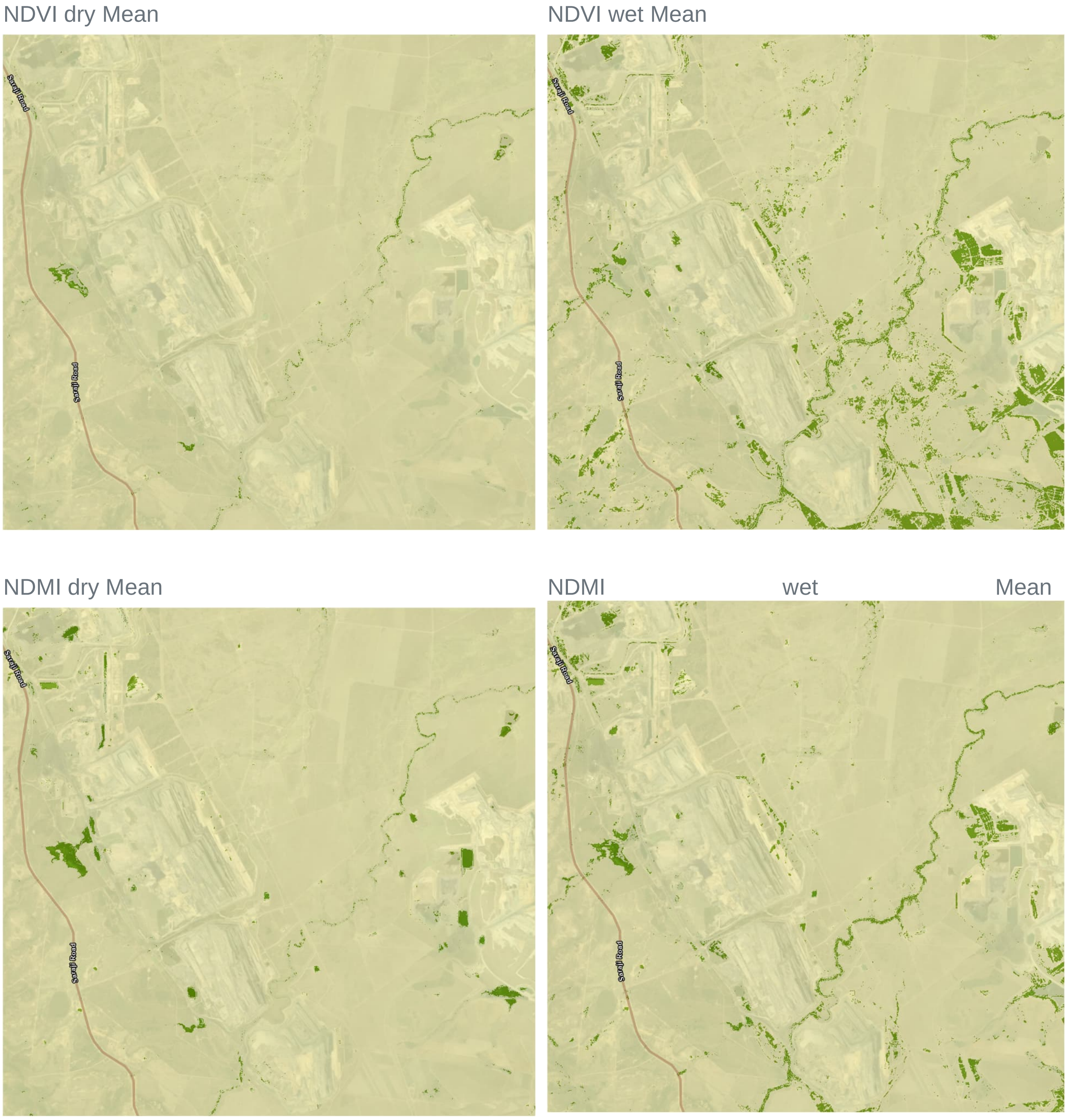



**Figure 5: Classified output for seasonal NDVI and NDMI - potential TGDE in green and non-TGDE in yellow**

The combined NDVI and NDMI layers for both wet and dry seasonal means were used to identify areas of potential TGDE. These were then merged and refined to produce a single layer showing the mapped extent of potential TGDE occurrence (Figure 2).

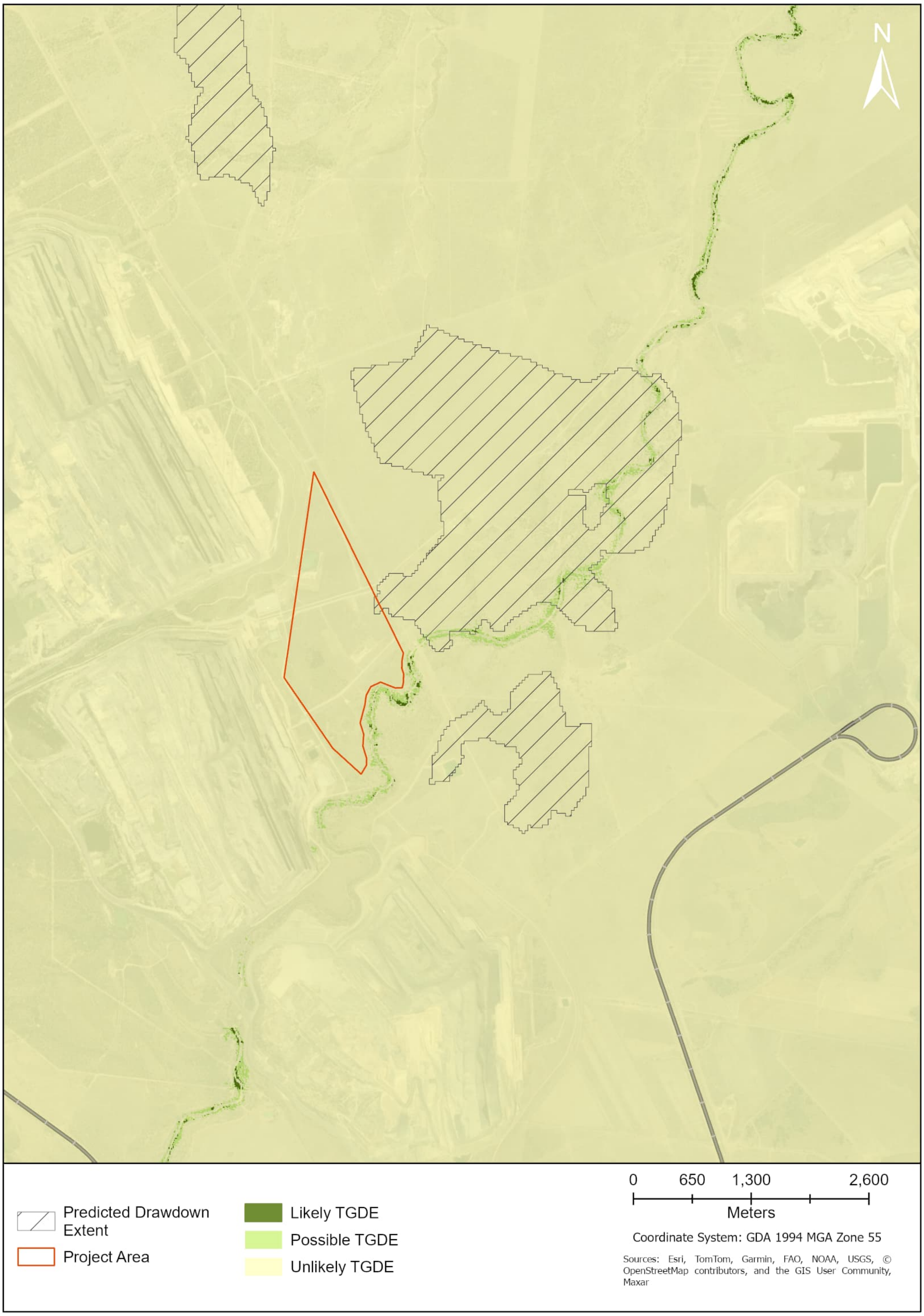



**Figure 6: Potential TGDE in the study area**

### Comparison with relevant Regional Ecosystem data

The TGDE extent was compared with the mapped REs to identify the range of RE types. Four RE types were identified within potential TGDE areas across the Assessment Area, summarised in Table 2. The total mapped TGDE area was 16.1 hectares.

**Table 6: Regional Ecosystems identified within potential TGDE areas**

| RE Code | RE Description | Likely TGDE (ha) | Possible TGDE (ha) | Total (ha) |
|---|---|---|---|---|
| 11.3.25 | *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines | 1.0 | 10.9 | 11.9 |
| 11.3.27f | *Eucalyptus coolabah* and/or *E. tereticornis* open woodland to woodland fringing swamps | - | 0.2 | 0.2 |
| 11.3.4 | *Eucalyptus tereticornis* and/or *Eucalyptus spp*. woodland on alluvial plains | 0.1 | 3.5 | 3.5 |
| 11.5.3 | *Eucalyptus populnea* and / or *E. melanophloia* and / or *Corymbia clarksoniana* woodland | <0.1 | 0.3 | 0.4 |
| **Total** | | **1.1** | **15.0** | **16.1** |

# FINDINGS

The remote sensing assessment successfully applied the GEM method using Sentinel-2 imagery to identify potential TGDE areas within the study area. These areas are characterised by vegetation that remains green and moist during dry periods, indicating likely reliance on groundwater.

The method was also extended to include a secondary group of areas that showed persistent greenness and moisture during wet seasons only. While less certain, these areas may also support TGDE vegetation, particularly where they are associated with the core dry-season TGDE areas.

### Limitations

There are a number of limitations that are present when using a desktop assessment and remotely sensed data. Primarily these include:

- NDVI and NDMI offer indirect evidence only – they can't confirm groundwater use
- Results may be influenced by irrigation or surface water
- The method doesn't differentiate natural from artificial vegetation
- Image quality, vegetation type, and local conditions can affect results
- Field validation or groundwater mapping would improve confidence.

# REFERENCES

Barron OV, Emelyanova I, Van Niel TG, Pollock D and Hodgson G (2012). Mapping groundwater-dependent ecosystems using remote sensing measures of vegetation and moisture dynamics. *Hydrological Processes*, 28(2): 372–385.

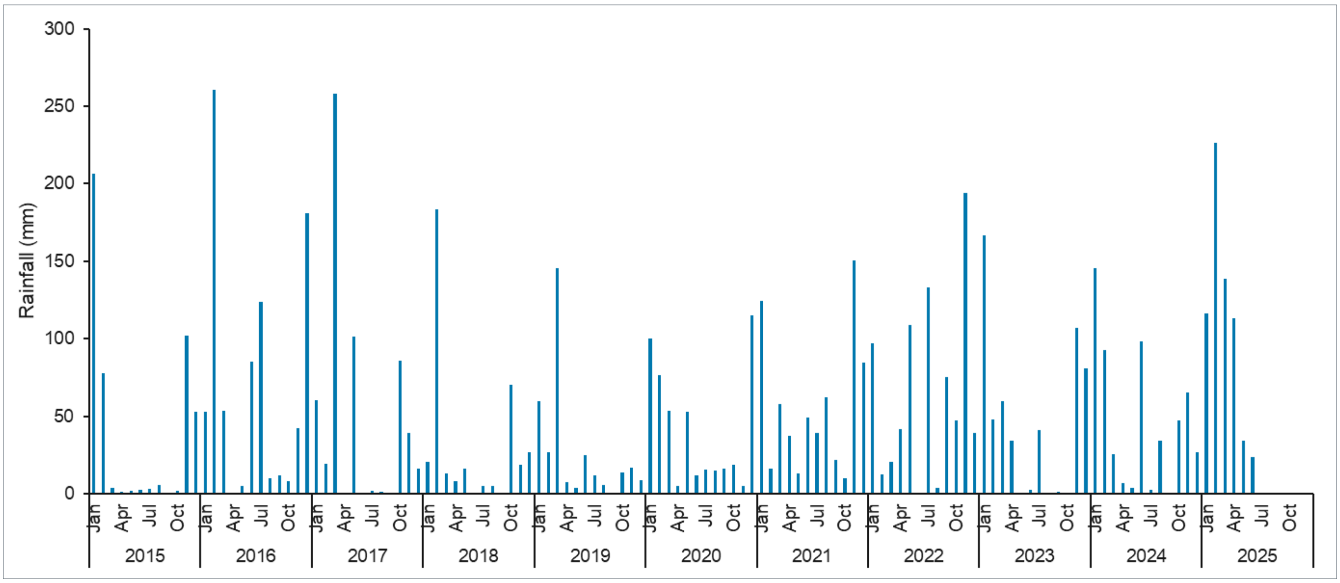
Doody TM, Hancock PJ, Pritchard JL (2019). Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2019.

Fildes SG, Doody TM, Bruce D, Clark IF & Batelaan O (2023) Mapping groundwater dependent ecosystem potential in a semi-arid environment using a remote sensing-based multiple-lines-of-evidence approach, *International Journal of Digital Earth*, 16:1, 375-406, DOI: 10.1080/17538947.2023.2176557

## C.1: Appendix A: Rainfall Data

MORANBAH AIRPORT – Monthly rainfall (mm)

Station Number: 034035 · State: QLD · Opened: 2012 · Status: Open · Latitude: 22.06°S · Longitude: 148.08°E · Elevation: 232m



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