BHP Mitsubishi Alliance

Appendix I

Groundwater Dependant Ecosystems Assessment

Groundwater Dependent Ecosystems Report

SLR Consulting Australia
Horse Pit Extension Project – Caval Ridge Mine

Level 1
30 Little Cribb Street
MILTON QLD 4064

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mail@e2mconsulting.com.au
www.e2mconsulting.com.au

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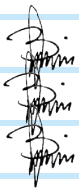

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Definitions

Term	Definition
BioCondition	A vegetation condition assessment tool, which provides a measure of how well a terrestrial ecosystem is functioning for the maintenance of biodiversity values at a local scale.
Facultative GDE species/communities	Species/Communities that have adapted to access groundwater when available, usually following floods when groundwater levels rise. These species/communities can utilise groundwater when it is available; however, will persist without (Eamus, et al., 2006).
Indicator species	Flora species dependent (partial/full) on groundwater for ongoing survival and reproduction.
Modelled groundwater table	Modelled groundwater table as described within Section 6 of the Horse Pit Extension Project Groundwater Assessment (SLR, 2021a).
Obligate GDE species/communities	Species/Communities reliant on permanent access to groundwater. Dependency can be deemed to be obligate if the groundwater is relied upon only very infrequently (6 months in every 10 – 20 years), or frequently but for short periods of time (1 month in every 12 months) (Eamus et al., 2006).
Predicted Drawdown Extent	The 1 m drawdown area identified by the revised groundwater model, incorporating updated model extents, grid refinement and site-specific information relating to the CVM. Following refinement of the groundwater modelling, results of the field survey were the adjusted to reflect the refined and detailed Predicted Drawdown Extent.
Preliminary Drawdown Area	Comprises the initial modelled 1 m drawdown extent based on preliminary groundwater impact assessment and numerical groundwater modelling used for Whitehaven Coal's Winchester South Project, located approx. 30 km east of the CVM. The Preliminary Drawdown Area was a conservative model used to assess terrestrial GDEs potentially impacted by the Project in lieu of the detailed revised groundwater model (unavailable at the time of the field surveys).
Regional Ecosystem	A vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil. Regional Ecosystems are described in the Regional Ecosystem Description Database, produced by the Queensland Herbarium.
Regulated Vegetation	Vegetation that is mapped within the regulated vegetation management map produced by DoR. The Queensland *Vegetation Management Act 1999* is applicable to regulated vegetation.
The Project	The Horse Pit Extension Project located in the northern extent of ML 1775 and ML 70403, north of the Peak Downs Highway.
Vegetation community	An identified vegetation community (i.e. structure, composition, condition and/or underlying geology) verified from a field survey. Communities may include Regional Ecosystems, remnant vegetation and/or disturbed/novel ecosystems (e.g. parkland, disturbed roadsides etc.).

Term	Definition
Watercourse	A watercourse as determined by the Department of Natural Resources, Mines and Energy (now Department of Resources) under the Queensland *Water Act 2000*.

Abbreviations

Abbreviation	Description
BMA	BM Alliance Coal Operations Pty Ltd
BOM	Bureau of Meteorology
CVM	Caval Ridge Mine
DAWE	Commonwealth Government Department of Agriculture, Water and the Environment
DES	Queensland Department of Environment and Science
DNRME	Queensland Department of Natural Resources, Mines and Energy (now Department of Resources)
DoR	Queensland Department of Resources
DTW	Depth to water
E2M	E2M Pty Ltd
EA	Environmental Authority
ETM	Enhanced Thematic Mapper (Landsat ETM)
GDE	Groundwater Dependent Ecosystem
GPS	Global Positioning System
ha	hectares
HVR	High Value Regrowth
IBRA	Interim Biogeographic Regionalisation of Australia
km	kilometres
m	metres
mbgl	Metres below ground level
ML	Mining Lease
NDMI	Normalised Differentiation Moisture Index
NVDI	Normalised Difference Vegetation Index
RE	Regional Ecosystem

Abbreviation	Description
sp.	Singular species. For example, *Eucalyptus* sp. refers to a single species of *Eucalyptus*
spp.	Multiple species. For example, *Eucalyptus* spp. refers to multiple species of *Eucalyptus*

1 Introduction

1.1 Project background

The BM Alliance Coal Operations Pty Ltd (BMA) own and operate the Caval Ridge Mine (CVM) located in the northern section of the Bowen Basin, approximately six kilometres south of Moranbah in central Queensland. The CVM has been in operation since 2014, producing and processing hard coking coal pursuant to the conditions prescribed in the EPBC Approval 2008/4417 (SEWPAC, 2011), the Environmental Authority (EA) Permit EPML00562013 (DEHP, 2020) and the Coordinator-General's Report (Queensland Government, 2010).

BMA propose to extend mining operations within one of CVM's two, open-cut pits, namely Horse Pit (the Project). The Project (Figure 1) requires:

- the extension of the current disturbance footprint towards the eastern boundary of Mining Lease (ML) 1775
- the development of enabling infrastructure (e.g. haul roads, powerlines, pipelines); and
- an out of pit dump (potentially located in the adjacent ML 70403).

An Environmental Impact Statement (EIS), published in 2009, originally catalogued the CVM baseline ecological values; however, a dataset representing the Project's current ecological values in line with contemporary government legislation is required.

1.2 Scope and objectives

E2M was engaged by SLR Consulting Australia Pty Ltd (SLR) on behalf of BMA to ground-truth mapped GDEs and conduct a baseline assessment of vegetation condition within the modelled, predicted drawdown area (herein referred to as the Predicted Drawdown Extent). The Predicted Drawdown Extent comprised the north-eastern extent of ML 1775 and adjacent properties along the Peak Downs Highway, Moranbah Access Road and Peak Downs Mine Road (excluding the Moranbah Airport) (Figure1).

The objective of the assessment was to identify and evaluate the GDE values associated with the Project and to determine whether GDEs would be significantly impacted. The assessment was undertaken in accordance with the Independent Expert Scientific Committee's (IESC) guidelines (Doody et al., 2019). Specifically, the assessment included:

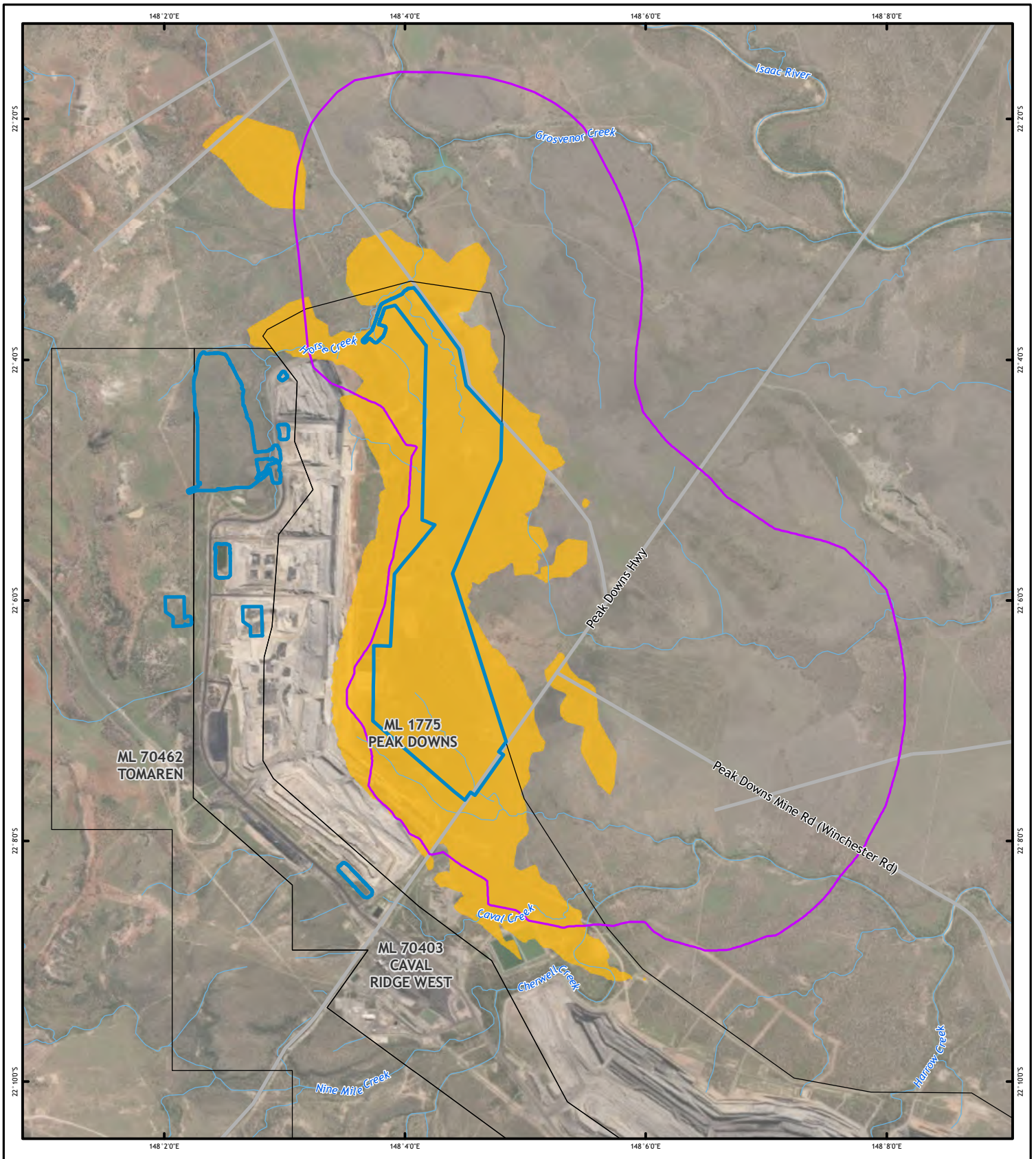
- a risk assessment to identify potential terrestrial GDEs associated with the Project through a desktop assessment, review of preliminary groundwater modelling results (herein referred to as Predicted Drawdown Extent) and literature review
- field verification of vegetation communities within potential GDE areas identified within the Predicted Drawdown Extent
- interpretation of field data in conjunction with the modelled groundwater table information to determine the likelihood of terrestrial GDEs occurring
- mapping the extent of potential terrestrial GDEs within the area and documenting the current condition of associated vegetation communities; and
- identify potential impacts of the Project on likely or possible terrestrial GDEs and assess the significance of the impact and any required management measures.

1.3 Project area overview

The CVM is situated within a modified landscape associated with a coal mining precinct in the northern Bowen Basin where resource extraction, agriculture and livestock grazing are predominant land uses. The Project is located within the Brigalow Belt bioregion, situated within the Northern Bowen Basin province. This province is characterised by undulating landscapes associated with Triassic and Permian sediments of the Bowen Basin with small areas of basalt and Tertiary sediments (Sattler & Williams, 1999). Key vegetation communities observed within this province include:

- *Acacia harpophylla* (brigalow) and *Eucalyptus cambageana* (Dawson gum) communities on clay soils
- open and shrubby woodlands of *E. crebra* (narrow-leaved ironbark) and *E. populnea* (poplar box) on shallow texture-contrast soils
- native grasslands dominated by *Dichanthium sericeum* (bluegrass) on undulating plains; and
- woodlands and open woodlands of *E. crebra* and *Corymbia* spp. on sandstone ranges.

The Project and surrounds are located within the Isaac River drainage sub-basin of the Fitzroy Basin. The Isaac River drainage sub-basin covers approximately 22,365 km^2 and encompasses the township of Moranbah, Dysart and Nebo. A number of Department of Resources (DoR) mapped watercourses traverse the Project area and surrounds. Tributaries of the Isaac River traversing the Predicted Drawdown Extent include Horse Creek (stream order 3) located in the northern extent and Cherwell Creek (stream order 6) and Caval Creek (stream order 4) located within the southern extent.



Legend

- Preliminary Drawdown Area
- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

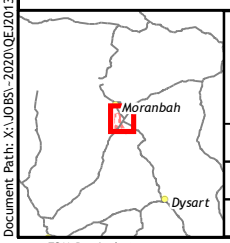
N

Scale 1:80,000 (A4)

0 1 2 3 4

Kilometres

Coordinate System: GCS GDA 1994



Notes:
Aerial Imagery: © ESRI 2020
Cadastre: © DoR 2018
Ordered Drainage: © DoR 2020
Road: © PSMA 2014

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FIGURE 1: PROJECT OVERVIEW

BMA Caval Ridge Mine

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2 Methods

Determining the extent to which terrestrial vegetation communities are groundwater dependent is complex and generally relies on a number of lines of evidence. This assessment has been based on several data sources, including existing information from Commonwealth and Queensland mapping, remote sensing data analysed using IESC recommended methods and field-based surveys. The lines of evidence and how they assisted decision making around the potential presence of GDEs is presented in Table 1.

Data gathered and analysed against each line of evidence is presented in the following sections. The results of the desktop assessment (Section 3) have assisted in the interpretation of field results (Section 4) to provide an analysis of the likelihood that vegetation communities within the Study area are groundwater dependent (Section 5).

Table 1 Data sources used for GDE assessment

Line of evidence	Data source for this study	Use in decision making
Commonwealth & state government mapping products	Bureau of Meteorology GDE Atlas Regional ecosystem mapping Map of Queensland Wetland Environmental Values (DES, 2021) Queensland Wetland Data (DES, 2021a)	Data provided at a variety of scales and used for: • Identifying wetlands and other potential GDEs • Targeting areas for field verification • Understanding surface geology and likelihood of interactions between vegetation and groundwater • All data contributes to decision making but not definitive in isolation
Remote sensing analysis	*Remote Sensing of Terrestrial GDEs: Using the GEM method* (2rog Consulting 2021)	Method recommended by IESC that may be used for: • Regional scale data that may be useful to supplement field assessments • Highlights vegetation areas that are relatively greener and wetter than surrounding areas • Selection of dry (drought) images and wet images provides contrast to identify vegetation likely to be accessing groundwater sources.
Groundwater modelling	Predicted Drawdown Extent	• Understanding predicted impact area
	Modelled Groundwater Table impact: Horse Pit Extension Project Groundwater Assessment (SLR 2021)	• Critical information about existing depth to groundwater and whether it is shallow enough for vegetation to access • Critical information to predict potential impacts (including location and scale) to any potential GDEs from drawdown
Groundwater bore data	Site groundwater data	Important inputs into groundwater models (see above)

Line of evidence	Data source for this study	Use in decision making
Vegetation types	Field surveys – this report Scientific literature (see reference below)	Critical information about vegetation communities and their ecological attributes, particularly: • Known reliance on groundwater • Likely rooting depth of key tree species

2.1 Desktop assessment and literature review

A desktop assessment was undertaken to identify potential GDEs occurring within the Predicted Drawdown Extent. The following databases were reviewed:

- Bureau of Meteorology GDE Atlas (Bureau of Meteorology, 2019)
- Regulated Vegetation Management Map as issued by the DoR and Vegetation Management Supporting Map (Department of Natural Resources, Mines and Energy, 2020)
- Detailed Surface Geology Mapping (Department of Resources, 2020)
- DES Potential GDE Aquifer mapping version 1.5 (Department of Environment and Science (DES), 2018b)
- Map of Queensland Wetland Environmental Values (DES, 2021)
- Queensland Wetland Data (WetlandMaps) (Department of Environment and Science, 2021a)
- DES Remnant Vegetation Mapping (Department of Environment and Science, 2021b)
- modelled groundwater table contours (SLR, 2021); and
- available bore monitoring data, containing historical and recent groundwater levels (measured top and base metres below ground level (mbgl)) within and surrounding the CVM.

In addition to the desktop assessment, a literature review was undertaken. The document review included:

- *Remote Sensing of Terrestrial GDEs: Using the GEM method* (2rog Consulting, 2021)
- the Independent Expert Scientific Committee's (IESC) *Information Guidelines Explanatory Note: Assessing ground-water dependent ecosystems* (Doody et al., 2019); and
- other available literature (i.e. journal articles etc.).

2.2 Field assessment

A field survey was conducted by two E2M ecologists from the 2 to 6 December 2020, to identify and characterise the presence, extent and condition of potential terrestrial GDEs vegetation communities within the Preliminary Drawdown Area (refer to Figure 1). The modelled Predicted Drawdown Extent was not available at the time of the field survey so a conservatively large area was considered for planning the field surveys. As such, the field survey aimed to verify and characterise the presence, extent and condition of potential terrestrial and aquatic GDEs within the Preliminary Drawdown Area (refer to Figure 1).

Upon finalisation of the groundwater modelling data, potential GDEs were refined to the Predicted Drawdown Extent (refer to Figure 1). As a result, not all of the proposed baseline assessment sites are located within the Predicted Drawdown Extent. While some baseline impact sites are located outside of the Predicted Drawdown Extent, potential GDE communities surveyed were considered representative of those located within the Predicted Drawdown Extent. This is due to the sites being in close proximity (<2 km) to those areas identified within the Predicted Drawdown Extent and being located within the existing CVM ML, subject to the same land use practices (i.e. natural resource extraction, no livestock grazing).

Areas targeted within the Preliminary Drawdown Area for the field assessment comprised:

- mapped terrestrial and aquatic GDEs identified by the GDE Atlas; and
- riparian, floodplain and wetland vegetation evident on aerial imagery and mapped by DoR.

Trimble Nomad Global Positioning System (GPS) devices were used to delineate the extent of vegetation communities within the Preliminary Drawdown Area and record flora species encountered, including GDE indicator species.

Assessments undertaken within targeted areas comprised GDE vegetation verification and, assessment of vegetation condition. The associated methods for each assessment type are detailed below.

2.2.1 Vegetation assessments of potential GDEs

A field assessment of the Preliminary Drawdown Area was conducted from 2 to 6 December 2020. Minimum daily temperatures during the field assessment ranged from 18.1˚C to 24.4˚C, with maximum temperatures between 36.2˚C to 41.3˚C[1]. No rainfall occurred over the duration of the field survey, with below average rainfall recorded in the months prior to the survey. Approximately 18.6 mm and 4.8 mm was recorded in October and November 2020 respectively, compared to the monthly average of 24 mm for October and 38.3 mm for November[1].

Vegetation surveys of potential GDE communities at targeted locations (i.e. mapped potential GDEs, floodplains and riparian areas) were conducted in accordance with the Queensland Government's *Methodology for Surveying and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner et al., 2020). Using this methodology, Quaternary vegetation surveys were carried out in alignment with the Queensland Herbarium's CORVEG database in areas identified as potential GDEs in the desktop assessment. Following finalisation of the groundwater modelling, potential GDEs considered in this assessment were refined to the Predicted Drawdown Extent.

2.2.2 Analysis of potential interaction between vegetation and groundwater

In order for vegetation to access groundwater in the subsurface, root structures need to access the capillary zone located above the groundwater level. Eamus et al (2006) suggests that groundwater existing at depths greater than 10 m has reduced importance to vegetation. While the probability of use of groundwater by vegetation is reduced at depths of 10 to 20 m, use of groundwater is likely where depth-to-water (DTW) is 0 to 10 mbgl, possible at depths of 10 to 20 mbgl and unlikely at depths greater than 20 mbgl (Eamus, Hatton, et al., 2006). This evidence makes an analysis of the potential interaction between the vegetation and groundwater within the Study area an important line of evidence in considering the likely presence of terrestrial GDEs.

[1] Based on rainfall data (from February 2012 to July 2021) recorded at Moranbah Airport weather station (weather station 34035).

A comprehensive literature review was then undertaken to identify potential GDE indicator species observed during the field survey to evaluate the species' reliance of groundwater for long-term viability. Based on information identified within the desktop assessment and literature review, as well as the modelled groundwater table data, an assessment of the likelihood of vegetation and groundwater interaction was undertaken. The likelihood of communities constituting a terrestrial GDE was determined based on the following criteria:

- **Likely interaction:** Modelled groundwater table is within adequate range (<10 mbgl) to be accessed by indicator species (i.e. canopy species).
- **Possible interaction:** Modelled groundwater table is between 10 to 23 mbgl reducing the likelihood of access to groundwater by indicator species.
- **Unlikely interaction:** Modelled groundwater table is outside of the range (>23 mbgl) to be accessed by indicator species.

2.2.3 Baseline vegetation condition assessment

2.2.3.1 BioCondition assessment

Assessment of the condition of potential GDE communities were conducted in accordance with the *BioCondition Assessment Manual* (Eyre et al., 2015). In addition to GDEs identified within the Preliminary Drawdown Area, a number of suitable control sites were also assessed during the field survey to assist within the baseline assessment. BioCondition Assessment involve the collection of in situ vegetation data, site condition and spatial context. This method is recognised within the *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems* (Doody et al., 2019) as a suitable method to assess ecological condition for GDEs comprising terrestrial vegetation.

Vegetation data was collected within a 100 m x 50 m area (including various sub-plots) for each representative vegetation community and weighted in accordance with the methods prescribed in the BioCondition Manual and compared to BioCondition benchmark values obtained from the published Brigalow Belt Bioregion benchmarks for each respective RE (Queensland Herbarium, 2019). In addition, observations regarding weed species and associated densities were also recorded.

A Trimble Nomad Global Positioning System (GPS) device was used to record the location of the mid-point (50m mark) of each BioCondition survey site.

2.2.3.2 Additional condition observations

Additional observations of vegetative condition, particularly for canopy species, was also recorded at each BioCondition site to provide further information on the current health of potential GDE indicator species. These observations aim to assist in identifying the current condition and potential changes in community health over time, such as water stress. Additional observations included:

- land use type and relative intensity
- fire history (if observed)
- canopy dieback presence: if identified, additional data collected for relevant indicator species, included:
  - epicormic index: Proportion of tree crown which is of epicormic origin
  - live crown percentage: Percentage of crown supporting live foliage
  - live crown height ratio: Height of live crown in comparison of total tree height (live and dead)

- insect herbivory; and
- mistletoe abundance.

2.3 Survey limitations

Ecological surveys have a range of inherent limitations associated with seasonal timing of the survey, variable climate conditions and species behaviour. As such, the survey conducted only represents a "snapshot" in time and may not provide a true indication of presence or absence of flora species within the site. In light of the identified limitations, precautionary principles were applied to assume presence where necessary for impact assessment purposes.

Potential GDE vegetation communities assessed as part of this report comprise terrestrial vegetation associated largely with floodplain, riparian communities and is based on available literature on root depths for identified indicator species. Assessment of subterranean GDEs and aquatic vegetation are not included as part of this assessment.

3 Desktop assessment

3.1 Literature review

3.1.1 Identification of GDEs

GDEs are those that depend on direct access to groundwater for ongoing maintenance and survival (Eamus, et al., 2006). Because of the scale and number of species that can comprise terrestrial communities, it is important to note a GDE does not imply that all species making up the community are likely to be dependent on groundwater (Eamus, et al., 2006). A community that comprises some groundwater dependent species (i.e. indicator species), is typically considered to be a community that is groundwater-dependent (Eamus, et al., 2006). As such, a GDE can comprise of flora species, such as some forb and grass species, that rely on precipitation and not directly reliant on the availability of groundwater.

There are three main types of GDE as defined by Eamus *et al.* (2006), including:

- Aquifer/cave ecosystems, occupied by stygofauna (Subterranean GDEs)
- Ecosystems dependant on the surface availability (discharge) of groundwater. These ecosystems are characterised by permanent provision of surface water (Aquatic GDEs); and
- Ecosystems dependent on access to subsurface groundwater, which includes many riparian communities (Terrestrial GDEs).

GDE communities can be determined by flora species composition and their relative dependence on groundwater for survival (Eamus, Froend, et al., 2006). Riparian and floodplain tree species are highly dependent on access to reliable water sources, including surface flows, soil moisture and groundwater (Kath et al., 2014). Particular flora species can be reliant on permanent access to groundwater and are considered to have 'obligate groundwater dependency' (Eamus, Hatton, et al., 2006). These species tend to occupy areas of the landscape that optimise access to groundwater, such as along the lower banks of waterways. Obligate species may include *Eucalyptus camaldulensis* (river red gum), *Melaleuca leucadendra* and *M. fluviatilis* (O'Grady et al., 2006; Roberts & Marston, 2000). Species with an obligate dependence on groundwater do not always require access to groundwater; however, to survive long periods of drought, access to groundwater is essential.

Other species have adapted to occasional access to groundwater, usually following floods when groundwater levels rise. These facultative groundwater dependent species can utilise groundwater when it is available; however, can survive without (Eamus, Froend, et al., 2006). Facultative groundwater dependent species are usually located on the upper banks and floodplains of waterways, such river she-oak *(Casuarina cunninghamiana*) and coolibah (*E. coolabah*) (Eamus, Hatton, et al., 2006; Roberts & Marston, 2000).

3.1.2 GDE remote sensing

2rog Consulting (2021) have undertaken a remote sensing assessment to determine the location of potential GDEs within a Study Area encompassing a number of BMA tenements in central Queensland. They applied the Groundwater-dependent Ecosystem Mapping (GEM) approach developed by the IESC (Doody et al. (2019)) to identify potential terrestrial GDEs by contrasting relative 'greenness' and 'moisture-status' of vegetation communities in wet and dry periods using remotely sensed data. The assessment utilised Landsat Enhanced Thematic Mapper (Landsat ETM) and available weather data to calculate the Normalised

Difference Vegetation Index (NDVI) and Normalised Differentiation Moisture Index (NDMI). The assessment then identifies and statistically finds clusters of similar index values to identify areas that may contain potential terrestrial GDEs.

While the approach adopted by 2rog Consulting (2021) is identified as a suitable method under the Independent Expert Scientific Committee (IESC), there are a number of limitations to this method that should be considered when interpreting the output. One of these limitations is in relation to the discrepancy of resolution of remote sensing data and the scale of the ecological features being identified (Glanville et al., 2016). Landsat remote sensing imagery are usually at moderate (~25 m) spatial resolutions (Glanville et al., 2016). As such, narrow riparian corridors and small wetland communities may not be identified using the method. The IESC's *Information Guidelines Explanatory Note: Assessing ground-water dependent ecosystems* identifies the remote-sensing method is restricted when identifying small/narrow polygons (i.e. approx. 30 m wide) that cannot be easily identified unless imagery resolution is less than 2 m (Doody et al., 2018).

Results of the GEM method did not identify any likely or possible GDEs within the Study area or immediate vicinity. However, the GEM method does identify a number of small patches of potential GDE within a 30 km radius of the Project area, many of which occur within riparian areas. An analysis of these vegetation communities was undertaken and highlighted that a number of potential GDEs include RE 11.3.2 and RE 11.3.25 (single and within mixed RE polygons), which are vegetation communities ground-truthed within the Study area which also occur within areas of shallow groundwater. This analysis indicates the GEM method is capable of identifying RE 11.3.2 and RE 11.3.25 as potential GDEs in circumstances where the vegetation has a strong greenness and wetness signal, even during dry times (indicative of groundwater use). However, this was not the case within the Study area.

The utilisation of NDVI and NDMI can also identify areas unrelated to groundwater use as well as not incorporating lags in changes of water availability and vegetation condition (Glanville et al., 2016). This approach attempts to identify GDEs as a distinct ecosystem type (i.e. areas that are greener or wetter than surrounding areas), based on the assumption that all GDEs can be identified by this characteristic alone (Glanville et al., 2016). However, groundwater dependence is just one characteristic of an ecosystem and incorporate a variety ecosystem types. As such, a threshold value for a single index is unlikely to capture the complexity of groundwater dependence by an ecosystem within a landscape (Glanville et al., 2016). While the 2rog Consulting (2021) assessment acknowledges that the model identified areas of 'potential' GDEs, as opposed to 'confirmed' GDEs. The approach does not address the potential for errors associated with false absence of terrestrial GDEs present within the area. While 2Rog (2021) identified no potential GDEs within the CVM ML, other indicative GDE mapping resources utilising remote sensing and GIS rules-based analysis (i.e. BOM GDE Atlas) have identified 'Potential' and 'Likely' GDEs within the Predicted Drawdown Extent (refer to Figure 2).

While remote sensing methods to identify GDEs can be useful in the assessment of large areas, it is important to understand the limitations of the associated method. Field-based assessments can be useful in identifying and mapping of ecosystems at a finer spatial scale (Perez Hoyos et al., 2016). Field surveys undertaken as part of this assessment aim to identify potential GDEs within the Project at a finer scale and discuss any associated impacts.

3.2 Geology overview

The Interim Biogeographic Regionalisation of Australia (IBRA) divides the Brigalow Belt bioregion into the Brigalow Belt North and Brigalow Belt South (Sattler & Williams, 1999). The geology of the Brigalow Belt North bioregion is characterised by Permian volcanics and Permian-Triassic sediments, Carboniferous and

Devonian sediments and volcanics and Cambrian/Ordovician rocks (and associated Tertiary deposits) (Department of Environment and Science (DES) 2018).

DNRME (2018) detailed surface Geology mapping identified four key geologies within the Predicted Drawdown Extent. A summary of geology units and associated land zones is provided in Table 2.

Table 2 Geology and Land Zones within the Predicted Drawdown Extent

Geology	Description	Land Zone
TQa	Tertiary and Quaternary floodplain alluvium poorly consolidated sand, silt, clay, minor gravel	3
Qr	Black soil, silt, sand and mud; residual and colluvial deposits	4/5
Tb	Mostly olivine basalt flows and some plugs; some areas of nephelinite, basanite etc	8
Pwb	Labile sandstone, siltstone, mudstone, coal and conglomerates	9

3.3 GDE Atlas and mapped vegetation communities

The National Groundwater Dependent Atlas (2016) identified 154 ha of terrestrial GDEs mapped within the Predicted Drawdown Extent. Mapped GDE areas were in association with watercourse and floodplain vegetation as well as areas containing underlying basalt, located within the southern extent in association with Cherwell and Caval creeks. A summary of the Bureau of Meteorology (BoM) GDE Atlas mapped Terrestrial GDEs within the Predicted Drawdown Extent is provided in Table 3 and depicted in Figure 2.

The Project and associated Predicted Drawdown Extent is located outside of the Potential GDE mapping available via DES. No DNRME (now DoR) mapped GDE springs are located within the Predicted Drawdown Extent or within close proximity (50 km) of the Preliminary Drawdown Area.

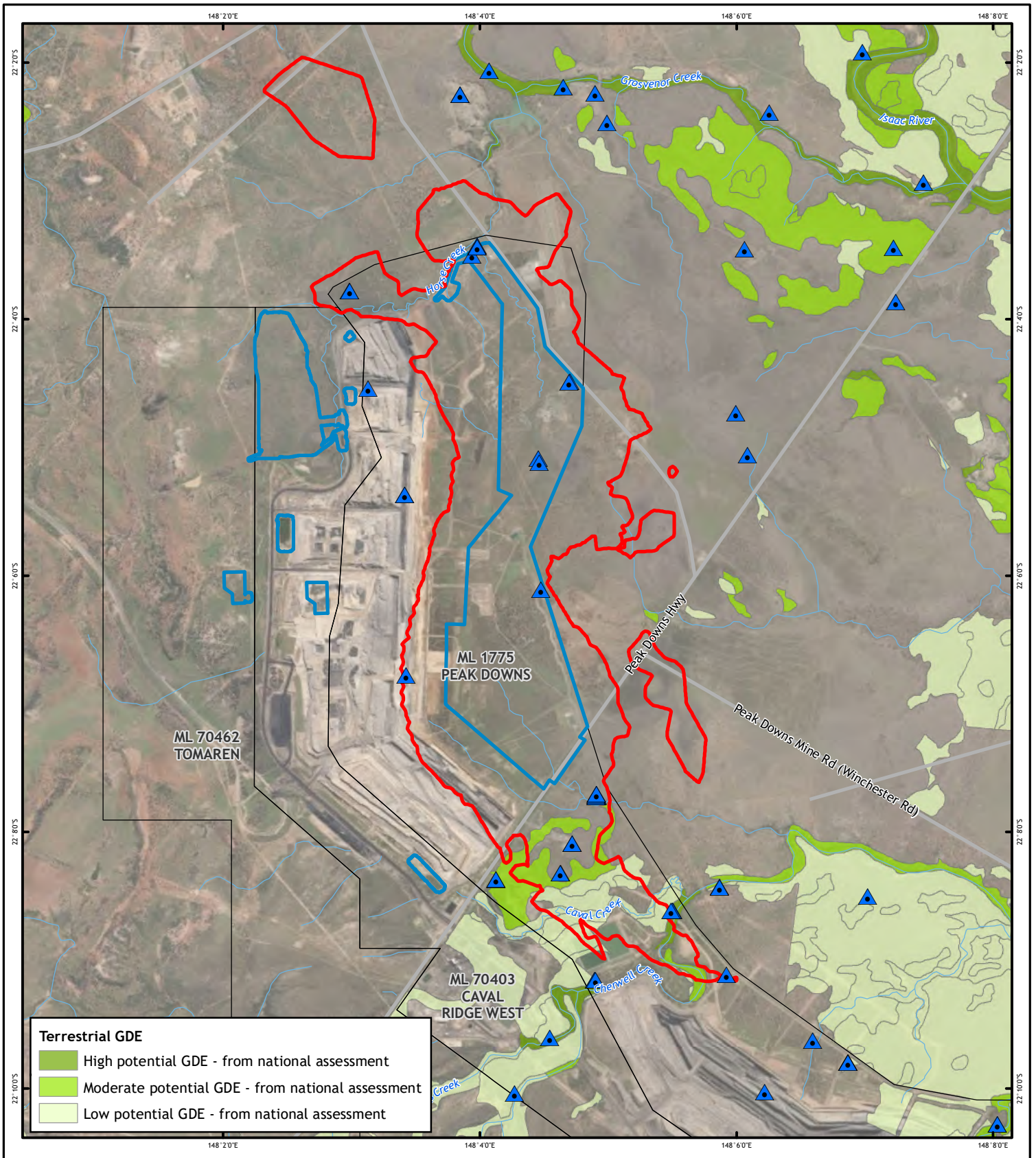
DoR mapped Regulated Vegetation intersecting the BoM GDE Atlas areas comprise eight REs. A summary of RE descriptions of within the BoM mapped terrestrial GDE areas is provided in Table 4. The DES Queensland Wetland mapping identified Riverine RE wetlands, associated with RE 11.3.25 and wetlands of general ecological significance, and a number of artificial lacustrine bodies associated with existing dams within the CVM ML (refer to Appendix A). No Ramsar or important wetlands are mapped within the Predicted Drawdown Extent. No wetlands of high ecological significance are mapped within the Predicted Drawdown Extent (refer to Appendix A).

Table 3 Terrestrial GDE Atlas (BoM) areas mapped within the Predicted Drawdown Extent

Mapped Terrestrial GDE potential	Geomorphology	Area (ha)	Associated REs according to DoR Regulated Vegetation
Low Potential	Dissected sandstone plateau.	88.03	11.3.2, 11.3.7, 11.3.25, 11.4.9, 11.5.3 and 11.5.9b
Moderate Potential	Dissected sandstone plateau.	61.76	11.3.25, 11.4.8, 11.4.9 and 11.8.5
High Potential	Dissected sandstone plateau.	4.54	11.3.25

Table 4 Regional Ecosystem descriptions

RE	Regional Ecosystem description
11.3.2	*Eucalyptus populnea* woodland on alluvial plains.
11.3.7	*Corymbia* spp. woodland on alluvial plains.
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
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.
11.5.9b	*Eucalyptus crebra* and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces.
11.8.5	*Eucalyptus orgadophila* open woodland on Cainozoic igneous rocks.



Legend

- Monitoring Bore
- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

N

Scale 1:75,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GCS GDA 1994

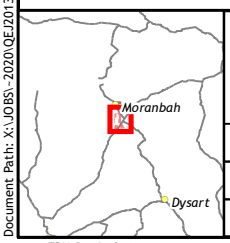


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FIGURE 2: BOM MAPPED TERRESTRIAL GDES AND MONITORING BORES

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3.4 Groundwater modelling

3.4.1 Preliminary Drawdown Area

A review of preliminary groundwater modelling was undertaken to assist with planning field surveys to identify potential GDEs. The Preliminary Drawdown Area (refer to Figure 1) comprises the initial modelled 1 m drawdown extent based on preliminary groundwater impact assessment and numerical groundwater modelling used for Whitehaven Coal's Winchester South Project, located approximately 30 km east of the CVM. The Preliminary Drawdown Area was a conservative model used to assess terrestrial GDEs potentially impacted by the Project in lieu of the detailed final groundwater model which was unavailable at the time of the field surveys.

The Predicted Drawdown Extent (refer to Figure 1) is based on 1 m drawdown area identified by the final detailed groundwater model, incorporating updated model extents, grid refinement and site-specific information relating to the CVM. The assessment of the potential interaction of vegetation with groundwater and the extent of potential GDEs was based on the detailed Predicted Drawdown Extent as well as the groundwater monitoring bore data.

3.4.2 Modelled Groundwater Table and Data

The modelled groundwater table for the Predicted Drawdown Extent (refer to Section 6 of the *Horse Pit Extension Project Groundwater Assessment* (SLR, 2021a) is depicted in Figure 3. The modelled groundwater table (SLR, 2021) identified the DTW to range from 9.8 m to >30 m across the Predicted Drawdown Extent. The groundwater table within areas along Horse Creek within the northern extent of the Predicted Drawdown Extent were found to be between 5 m to 10 m deep. The raised groundwater table associated with areas surrounding Horse Creek may be a result of historical vegetation clearing. Deep-rooted vegetation can intercept rainfall within the soil profile, reducing the rate of groundwater recharge (Scanlon et al., 2007). When the vegetation is removed, the rate of groundwater recharge can increase resulting in a rise in the groundwater table, particularly when remaining vegetation is largely shallow-rooted regrowth and grasses (Allison et al., 1990; Scanlon et al., 2007).

Areas modelled as containing groundwater 10-15 mbgl were largely associated with riparian corridors (southern extent) and the associated floodplain (northern extent), including Cherwell Creek and sections of Caval Creek (Figure 3).

The majority of the modelled groundwater table extent within the Predicted Drawdown Extent was identified to have greater than 20 m DTW (Figure 3).

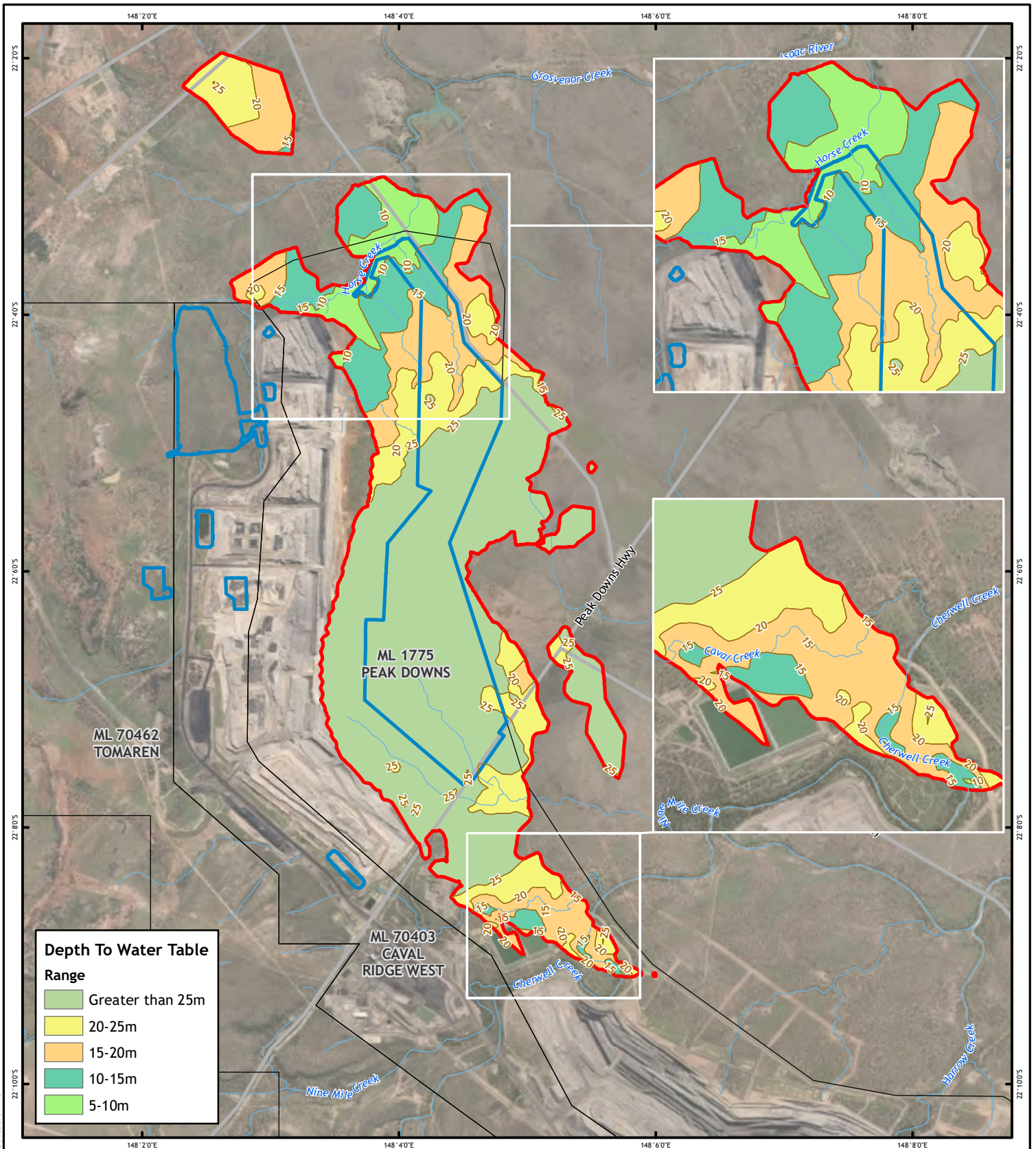
The location of monitoring bores within the CVM ML and adjacent areas are depicted in Figure 2 and summarised in Table 5. A review of the data within the Preliminary Drawdown Area and surrounds identified Tertiary-Quaternary Alluviums (TQ) range between 8 to 18.5 mbgl (base screen), with the DTW ranging from 5 to 15.5 mbgl. A number of alluvium bores within the period between June 2020 to February 2021 have been dry (Pz-07-S and MB19CVM01A).

Basalt aquifers were located at greater depths, with the top screen ranging from 16.5 to 39.5 mbgl. Monitoring bores targeting the regolith (weathered sands and sandstones) recorded base screens ranging between 13.9 to 68 mbgl with DTW around 10.9 to 14.5 mbgl.

Monitoring bores targeting the Coal seam recorded greater than 30 m DTW and are considered unlikely to be accessed by terrestrial vegetation. These have been excluded from the summary in Table 5.

Table 5 Summary of CVM monitoring bore data

Bore ID	Target aquifer	Status	Top screen (mbgl)	Base screen (mbgl)	Easting (GDA 94)	Northing (GDA 94)
Alluvium						
Pz-07-S	TQ alluvium	Active	9.0	15.0	612584	7550881
Pz-08-S		Active	9.0	15.0	611524	7549887
Pz-11-S		Active	6.0	9.0	616904	7547778
MB19CVM01A		Active	7.0	13.0	610443	7548264
MB19CVM09A		Active	15.5	18.5	612560	7550879
MB20CVM01A		Active	5.0	8.0	610028	7560466
Regolith						
Pz-12s	Sandstone/ siltstone	Active	26.8	29.8	610825	7557397
MB20CVM06T	Sand/ weathered sandstone	Active	11.8	17.8	610921	7549067
CVMVWP15_01_V1	Sand/ weathered sandstone	Active	14.5	68.0	614909	7548676
CVMMB16_01	weathered sandstone/ mudstone	Active	10.9	13.9	611257	7558498
Basalt						
Pz-02	Basalt	Decommissioned	24.0	35.0	608553	7558420
Pz-03-S	Basalt	Decommissioned	17.5	26.5	609028	7556894
Pz-06-S	Basalt	Active	22.0	31.0	611237	7551854
MB19CVM03T	Basalt	Active	29.0	35.0	610214	7551338
MB19CVM05T	Basalt/ basalt sands	Active	39.5	45.5	611082	7551428
MB19CVM07T	Basalt	Active	21.0	27.0	611578	7552537
MB20CVM04T	Basalt	Active	22.0	28.0	608307	7559829
MB20CVM02A	Basalt	Active	16.5	19.5	613209	7551216
CVMPB07_01	Basalt	Active	22.0	28.0	611565	7552523



Legend

- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

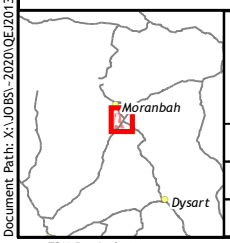
N

Scale 1:75,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GCS GDA 1994



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2	Issued for Use	PR	PW	23/08/2021
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FIGURE 3: MODELLED GROUNDWATER TABLE CONTOURS

BMA Caval Ridge Mine

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4 Field assessment results

4.1 Vegetation communities and associated indicator species

BoM mapped GDEs within the Predicted Drawdown Extent are largely associated with riparian and floodplain communities (land zone 3). Due to the lack of mapped terrestrial vegetation associated with surface expression, indicator species within the groundcover (e.g. grasses and forbs) are considered unlikely to occur in the Predicted Drawdown Extent. As such, potential GDE indicator species were restricted to canopy tree species and some subcanopy/shrub species, comprising extensive root systems, that may access groundwater levels.

Vegetation community types identified for the purpose of the terrestrial GDE assessment comprised:

- **Riparian and floodplain communities**: Vegetation located on Tertiary and Quaternary alluvium in association with watercourses and adjacent floodplains
- **Communities on sandy, depositional plains**: Vegetation located on residual and colluvial deposits comprising sands (i.e. excludes clay plains)
- **Communities on underlying basalt**: Vegetation on underlying olivine basalt flows and rock; and
- **Other**: Vegetation located on clay plains, Cainozoic duricrusts.

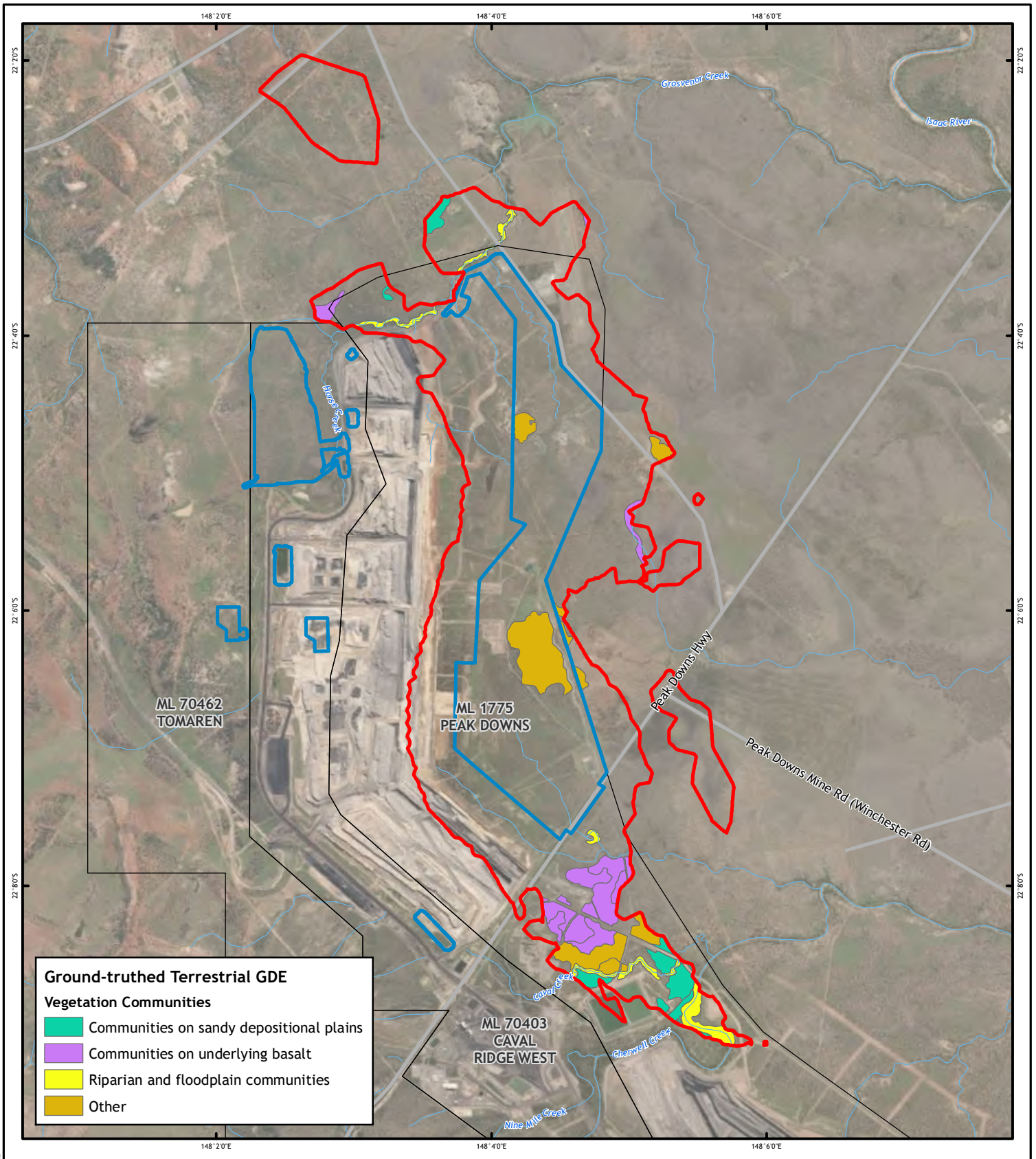
A large proportion of the vegetation within the central and northern extent of the Predicted Drawdown Extent had been subject to historical clearing processes and agricultural development. Vegetation within these areas were at various stages of regrowth or comprised highly modified environments. Due to the absence of BoM mapped GDEs and the lack of mature vegetation considered likely to access groundwater, these areas were not considered to comprise GDEs and were not included as part of the community types identified above. This is also supported by the results of the GEM method assessment.

An overview of the extent of vegetation communities identified within the Predicted Drawdown Extent is provided in Figure 4. A summary of the vegetation communities, associated REs and likely GDE indicator species identified within the Predicted Drawdown Extent is provided in Table 6.

Table 6 Summary of regional ecosystems occurring in the study area

RE	Description	Potential GDE indicator species
Riparian and floodplain communities		
11.3.1	*Acacia harpophylla* woodlands occurring along riparian corridors.. Other associated species include *Lysiphyllum carronii* and *Atalaya hemiglauca*.	-
11.3.2	*Eucalyptus populnea* woodlands occurring on floodplains.	*Eucalyptus populnea*
11.3.25	*Eucalyptus camaldulensis* woodlands occurring along riparian corridors. Associated species include *E. populnea*, *Melaleuca fluviatilis*, *Casuarina cunninghamiana*, *Lysiphyllum hookeri* and *Acacia salicina*.	*Eucalyptus camaldulensis* *Eucalyptus populnea* *Melaleuca fluviatilis* *Casuarina cunninghamiana*

RE	Description	Potential GDE indicator species
Communities on sandy, depositional plains		
11.5.3	*Eucalyptus populnea* woodlands occurring on sandy, depositional plains with associated species *Acacia salicina* and A. *excelsa*.	*Eucalyptus populnea*
Communities on underlying basalt		
11.8.5	*Eucalyptus orgadophila* open-woodland occurring on underlying basalt flows with associated species *Corymbia dallachiana* and *Acacia salicina*.	-
11.8.11	Natural grasslands occurring on underlying basalt flows.	-
Other communities		
11.4.8	*Acacia harpophylla* and *Eucalyptus cambageana* woodlands occurring on clay plains. Other associated species include *Lysiphyllum carronii* and *Atalaya hemiglauca*.	-
11.4.9	*Acacia harpophylla* woodlands occurring on clay plains. Other associated species include *Lysiphyllum carronii* and *Atalaya hemiglauca*.	-
11.7.1	*Acacia harpophylla* woodlands occurring on lateritic soils. Other associated canopy species include *E. thozetiana*, *Acacia catenulata* and *Atalaya hemiglauca*.	-



Legend

- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

N

Scale 1:70,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GCS GDA 1994

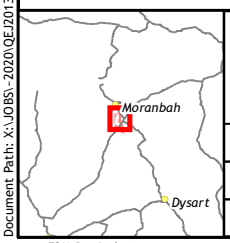


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FIGURE 4: VEGETATION COMMUNITIES WITHIN THE PREDICTED DRAWDOWN EXTENT

BMA Caval Ridge Mine

Map Number	Job Number	Rev
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4.2 Baseline condition assessment

4.2.1 BioCondition assessment

Prolonged changes in groundwater levels can result in impacts to terrestrial GDE communities, including differences in canopy condition (including leaf mortality and dieback), recruitment, species composition and resilience (Kath et al., 2014; Sommer & Froend, 2011). Determination of groundwater depth thresholds and associated time periods triggering (irreversible) changes in community condition are relatively uncertain. Furthermore, contributing factors associated with modification of hydrological conditions from surrounding land uses, climatic influences (e.g. drought) and soil nutrients can also result in changes in condition and overall resilience for a particular community (Kath et al., 2014; Overton et al., 2006).

In order to evaluate vegetation condition prior to disturbance, a baseline assessment of vegetation condition (i.e. BioCondition Assessment) was undertaken within GDEs within the Preliminary Drawdown Area. A total of seven BioCondition sites were undertaken within the Predicted Drawdown Extent with an additional eight sites assessed within similar GDEs within the greater landscape (control sites)(Figure 5). A summary of BioCondition scores for identified 'likely' and 'possible' GDEs and associated RE are provided in Table 7. BioCondition site scores for each site are provided in Appendix B.

Biocondition assessments of vegetation associated with the identified potential GDEs were generally of moderate condition, with scores ranging from 5 to 7 of the maximum BioCondition score (10). Sites were generally characterised by vegetation height, cover and diversity consistent with benchmark sites. BioCondition scores within HVR vegetation were generally of lower condition. Site condition attributes contributing to a decrease in Habitat Quality scores included:

- low native grass and native forb species richness and cover, potentially due to the introduction of exotic pasture species and the conditions at the time of the survey ('dry season' conditions)
- high non-native plant cover, particularly from non-native grasses and forbs, including C*enchrus ciliaris** (buffel grass), *Megathyrsus maximus** (guinea grass), *Portulaca oleracea** (pigweed) and *Parthenium hysterophorus** (parthenium); and
- selective clearing, thinning and dieback of large trees which resulted in low large tree densities within some sites.

Table 7 GDE BioCondition summary for impact and control sites

RE	Vegetation type	Assessment Unit	Number of sites sampled	BioCondition Score
Impact sites				
11.3.2	Remnant	A1	2*	5.06
11.3.25	Remnant	A2a	2	6.59
	HVR	A2b	1	5.13
11.5.3	Remnant	A3	2	6.68
Control sites				
11.3.2	Remnant	C1	1	5.56

RE	Vegetation type	Assessment Unit	Number of sites sampled	BioCondition Score
11.3.25	Remnant	C2U (upstream)	3	6.33
		C2D (downstream)	2	6.78
11.5.3	Remnant	C3	2	6.94

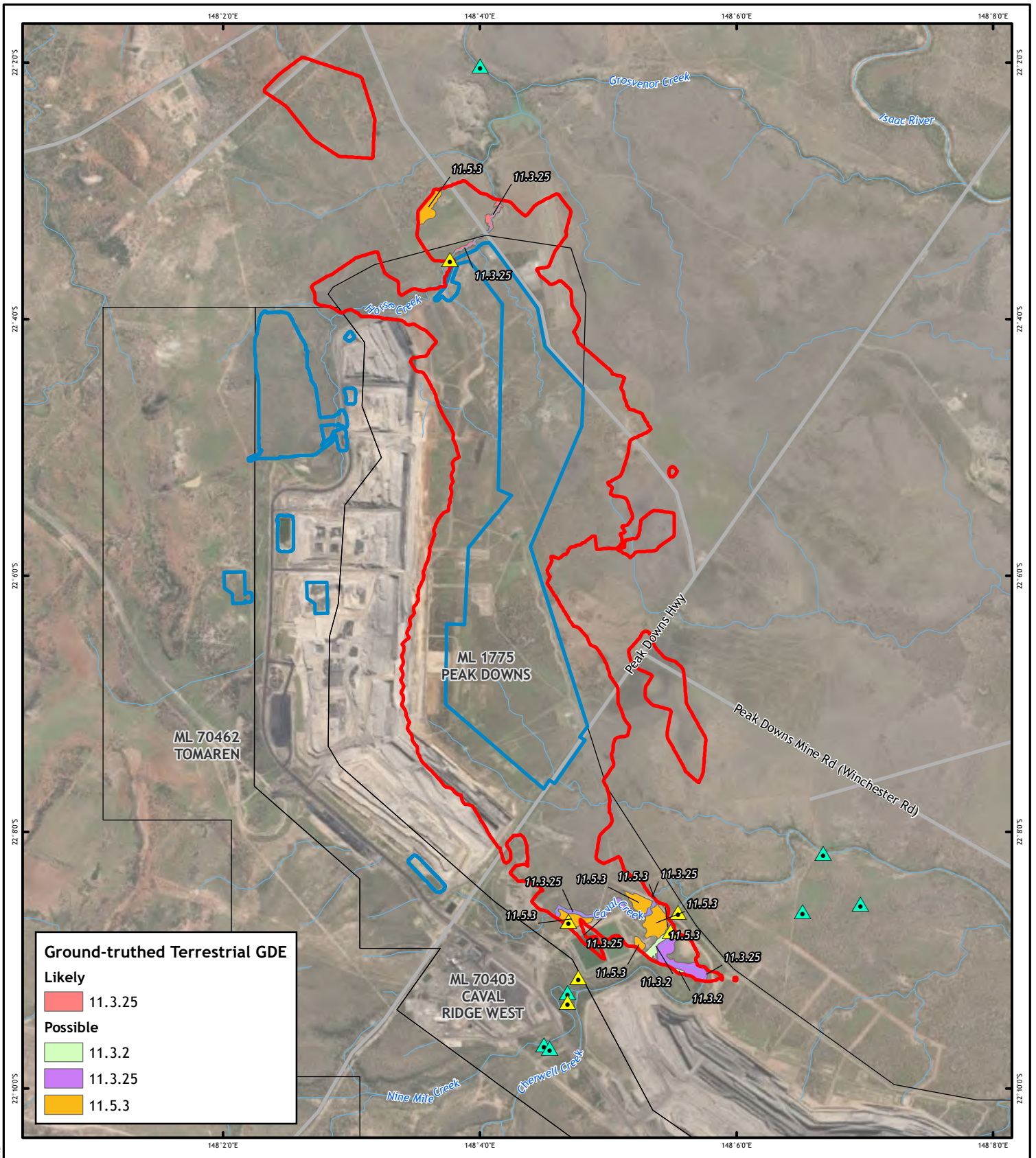
* BioCondition Site located outside of the Predicted Drawdown Extent but within the CVM ML and are considered representative of vegetation within the drawdown area.

4.2.2 Additional condition observations

In addition to climate conditions (e.g. extended drought), disease and high-intensity grazing, canopy dieback can be an indication of water stress resulting from the retreat of ground water below the effective root zone of canopy trees or at a rate faster than the roots can grow (Kath et al. 2014). Evidence of minor canopy dieback was observed in isolated individuals at the majority of impact and control sites, potentially attributed to natural causes (e.g. storm damage). Assessment of mature canopy trees within the plots typically contained greater than 85% live crown cover. Epicormic growth was generally very low to absent (0-5%) on canopy trees assessed (Image 1a). Larger areas of canopy dieback were observed in remnant RE 11.5.3 located east of the CVM. These areas were in proximity to control site (T10), with little live cover or epicormic regrowth observed (Image 1b).

Abundance of mistletoes, evidence of insect damage and herbivory was largely absent from all BioCondition locations at the time of the survey.

Image 1: a) Epicormic regrowth on *E. populnea*; and b) larger areas of canopy dieback observed in proximity to Control site within RE 11.5.3 (right)



Legend

Baseline Location

Site Type

- Control
- Impact

- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

N

Scale 1:75,000 (A4)

0 1 2 3

Kilometres

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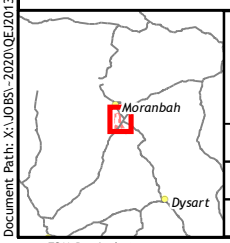

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FIGURE 5: BASELINE CONDITION ASSESSMENT LOCATIONS

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5 Assessment of Potential GDEs

The potential for vegetation communities occurring within the Predicted Drawdown Extent to be GDEs has been determined based on the potential for the root structure of vegetation to access groundwater. In order to do this, the potential rooting depth of potential GDE indicator species within each community has been compared to the existing modelled groundwater depth. Associated REs with each vegetation community and the modelled groundwater table contours used to assist in the GDE likelihood assessment is shown in Figure 6.

5.1 Vegetation communities

5.1.1 Riparian and floodplain communities

Potential GDE indicator species occurring within REs 11.3.2 and 11.3.25 consist of *Eucalyptus camaldulensis* and *E. populnea*. While the maximum rooting depths in *E. camaldulensis* and *E. populnea* are relatively unknown, a number of studies have identified critical groundwater depths that can assist determining an approximate limit to root growth for the species (Kath et al 2014). Horner et al. (2009) identified evidence of mortality of *E. camaldulensis* on floodplains of the Murray River when groundwater depths reached thresholds of 12 to 15 m deep. Similarly, modelling by Kath et al. (2014) identified correlation between decreased tree condition when groundwater depths reached thresholds of between 12 and 23 m for *E. camaldulensis* and between 13 and 27 m for *E. populnea* on the Condamine floodplain. Naumburg et al. (2005) found groundwater decline can inhibit tree roots from accessing available moisture, contributing to water stress and impacting tree condition, particularly during extended drought conditions (Kath et al., 2014).

Based on these studies, it has been assumed that the root zone of *Eucalyptus camaldulensis* and *E. populnea* is up to approximately 23 m deep. Therefore, areas of REs 11.3.2 and 11.3.25 that occur where the DTW is between 5 and 23 mbgl are considered to be potential terrestrial GDEs (Figure 6).

Areas of HVR and remnant RE 11.3.25 along Horse Creek are modelled with a DTW between 5 to 10 mbgl (Figure 6). Due to the proximity to the groundwater table, this community is considered likely to be a GDE. Furthermore, as the root depths associated species are within the threshold identified by previous studies, coupled with the existing modelled DTW, areas containing RE 11.3.25 are considered to be facultative, utilising groundwater when available however not dependent on access for ongoing persistence.

The modelled groundwater table for areas of RE 11.3.2 located within the floodplain of Cherwell Creek and Caval Creek were identified to be around 15 to 25 mbgl (Figure 6). As these areas are also within the threshold of the root depths identified by previous studies RE 11.3.2 is also considered a possible GDE (facultative).

Rooting depths for other common tree species within floodplain vegetation was also limited. Studies undertaken by O'Grady et al. (2006) within the Daly River in the Northern Territory noted *Casuarina cunninghamiana*, was relatively opportunistic, accessing groundwater at low elevations and relying on soil water at higher elevations in the landscape. O'Grady et al. (2006) also found *Melaleuca* species fringing riparian corridors to be accessing groundwater, however, are likely to be facultative as opposed to obligate.

Areas comprising remnant and HVR RE 11.3.1, dominated by *Acacia harpophylla*, were also observed in association with Caval and Horse creeks. While identified as a species likely to be a GDE under the IESC

Consultation Draft (refer to Doody et al., 2018), the species typically has a horizontal root system and is considered unlikely to be dependent on access to groundwater for long-term survival (DES, 2017).

5.1.2 Communities on sandy, depositional plains

As previously discussed, *E. populnea*, the dominant species in RE 11.5.3, is considered a facultative GDE species, capable of roots reaching depths of 13 to 27 m (Kath et al., 2014). A review of modelled groundwater table identified the DTW for areas of RE 11.5.3 to range between 15 to 25 mbgl. As groundwater depths are likely to be greater than 10 mbgl, associated communities (i.e. RE 11.5.3) are considered to be possible GDEs (facultative). Areas of RE 11.5.3 with a DTW greater than 20 m are considered unlikely to be a terrestrial GDE.

5.1.3 Communities on underlying basalt

Woodland communities occurring on underlying basalt flows (RE 11.8.5) are dominated by *E. orgadophila* and *C. dallachiana* which may be facultative groundwater users depending on the depth of the basalt deposits and groundwater levels. However, the modelled groundwater table contours indicate DTW for these communities is greater than 20 mbgl, reducing the likelihood of access and dependence on groundwater. As such, RE 11.8.5 is considered unlikely to be a GDE.

As discussed in section 4.1, due to the lack of surface expression of groundwater, areas of the grassland RE 11.8.11 are considered unlikely to be a GDE.

5.1.4 Other communities

Rooting depths for other common tree species within floodplain vegetation was also limited. *Acacia harpophylla* has a horizontal root system (DES, 2017) and is considered unlikely to be dependent on access to groundwater for long-term survival. Although *E. populnea* is identified as a GDE indicator species, it is considered facultative, capable of surviving on soil moisture and overland flows. Due to the geological characteristics of deep, clay plains, joints and fractures within underlying rock are typically filled with clay sediments, reducing the water-holding potential (Helm et al., 2009). As such, communities situated on clay plains within the Predicted Drawdown Extent are considered unlikely to be dependent on groundwater.

5.2 Summary of terrestrial GDEs

The extent of vegetation communities consider likely and possible terrestrial GDEs within the Predicted Drawdown Extent is depicted in Figure 7. In summary, of the vegetation communities assessed as part of the field survey, only small areas of riparian vegetation, comprising remnant and HVR RE 11.3.25 within the northern extent of the Predicted Drawdown Extent were considered likely to be a terrestrial GDE (Figure 7). Other remnant and HVR communities comprising RE 11.5.3, 11.3.2 and 11.3.25 within the southern extent of the Predicted Drawdown Extent were considered possible terrestrial GDEs, with DTW between 10 to 25 mbgl (Figure 6).

Based on available literature and current modelled groundwater table, all of the likely and possible terrestrial GDEs identified are considered to comprise facultative GDE species, utilising groundwater when available however not dependent on access for ongoing persistence.

The conclusion that vegetation in the study area uses groundwater facultatively is supported by the results of the GEM method assessment. The GEM method assessment did not identify any likely GDEs in the study area, meaning the vegetation did not produce a strong 'green or wet' signature relative to other

vegetation communities in the region, even when wet and dry image responses were contrasted. Importantly, the dry period used in the GEM method assessment was during 2019, when rainfall in the Bowen Basin was approximately half the annual average (BoM 2021). This suggests that the target area vegetation was not accessing groundwater during this prolonged drought period.

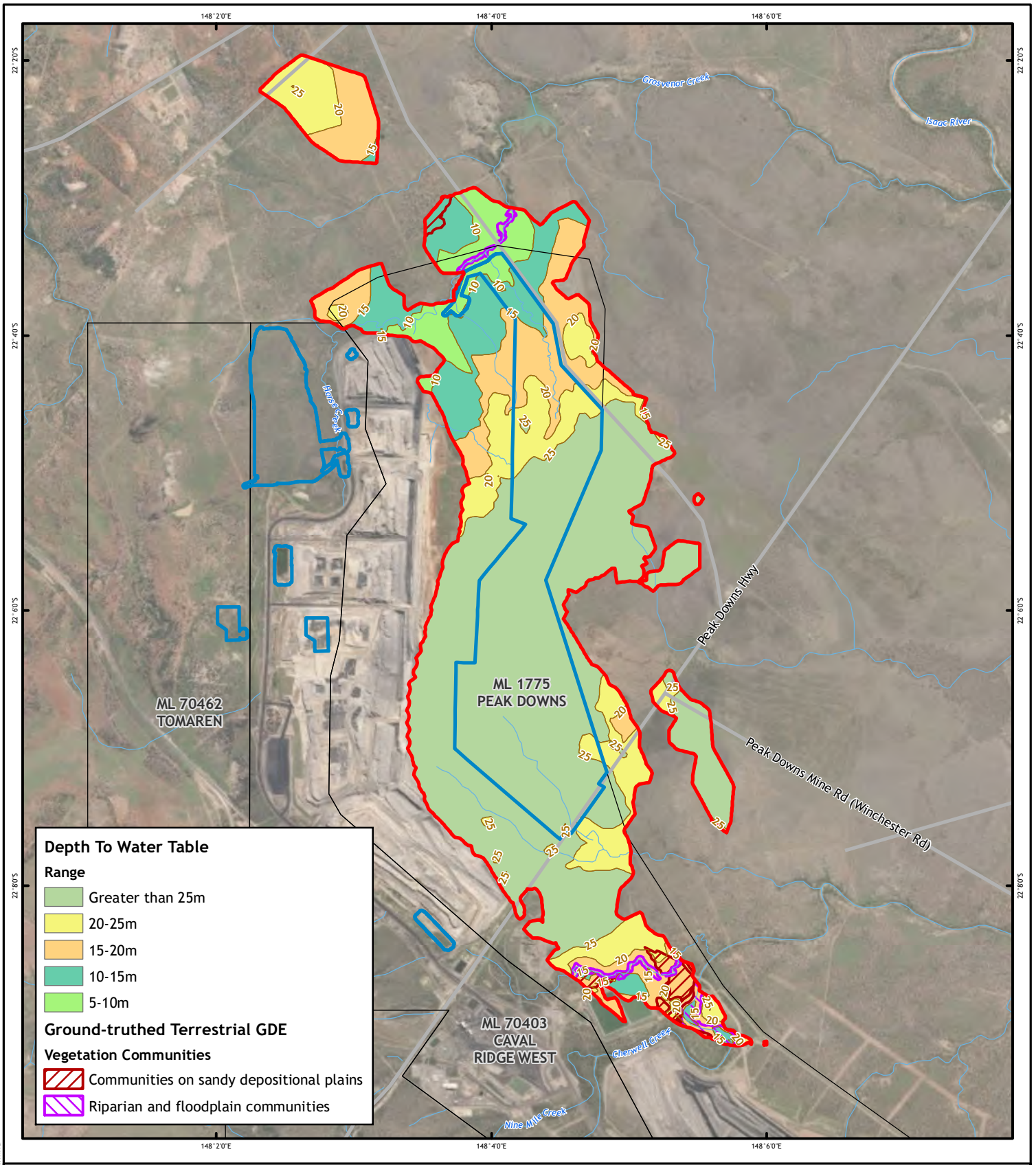
All other vegetation within the Predicted Drawdown Extent were considered unlikely to be groundwater dependent.

A summary of vegetation communities (i.e. RE) identified as potential terrestrial GDEs, associated indicator species observed and justification is provided in Table 8. Likelihood was assessed in accordance with the criteria defined in Section 2.2.2.

In total, 6.21 ha of likely terrestrial GDEs and 64.88 ha of possible terrestrial were identified within the Predicted Drawdown Extent.

Table 8 Summary of potential terrestrial GDEs

GDE indicator species	Area (ha)	GDE likelihood and justification
E. populnea	0.78 HVR 3.85 Remnant	**Possible GDE (facultative)** • mapped as low potential by GDE Atlas • field assessment identified one GDE indicator species (i.e. *E. populnea*) dominated the community • modelled DTW for the community to be between 15-25 mbgl = possible GDE
E. camaldulensis *E. populnea* *Melaleuca fluviatilis* *Casuarina cunninghamiana*	6.21 HVR 26.50 Remnant	**Likely / Possible GDE (facultative)** • mapped high and moderate potential by GDE Atlas • field assessment identified potential GDE indicator species (e.g. *E. camaldulensis* and *E. populnea*) occurring within the community • modelled DTW for 6.21 ha within the northern extent of the Predicted Drawdown Extent between 5 to 10 mbgl = likely GDE • modelled DTW for 26.5ha within the southern extent between 15 to 20 mbgl = possible GDE
E. populnea	9.28 HVR 28.52 Remnant	**Possible GDE (facultative)** • mapped low potential by GDE Atlas • field assessment identified one GDE indicator species (i.e. *E. populnea*) dominated the community • modelled DTW for 34.06 ha of the community between 15 to 25 mbgl = possible GDE • other areas of the community located where >20 m DTW = unlikely GDE.



Legend

- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

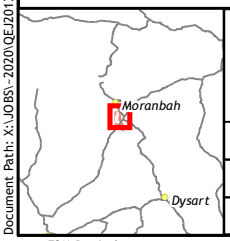
N

Scale 1:70,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GCS GDA 1994



Notes:
Aerial Imagery: © ESRI 2020
Cadastre: © DoR 2018
Ordered Drainage: © DoR 2020
Road: © PSMA 2014
Water Table Contours: © SLR 21/07/2021

Rev	Description	Drawn	Approved	Date
2	Issued for Use	PR	PW	23/08/2021
1	Issued for Use	PR	PW	09/08/2021

FIGURE 6A: GDE LIKELIHOOD OF OCCURRENCE ASSESSMENT

BMA Caval Ridge Mine

Map Number	Job Number	Rev
1 of 2	QEJ20130	2

Document Path: X:\JOBS\-2020\QEJ20130\GIS\QEJ20130_GDE_Occurrence_a.mxd

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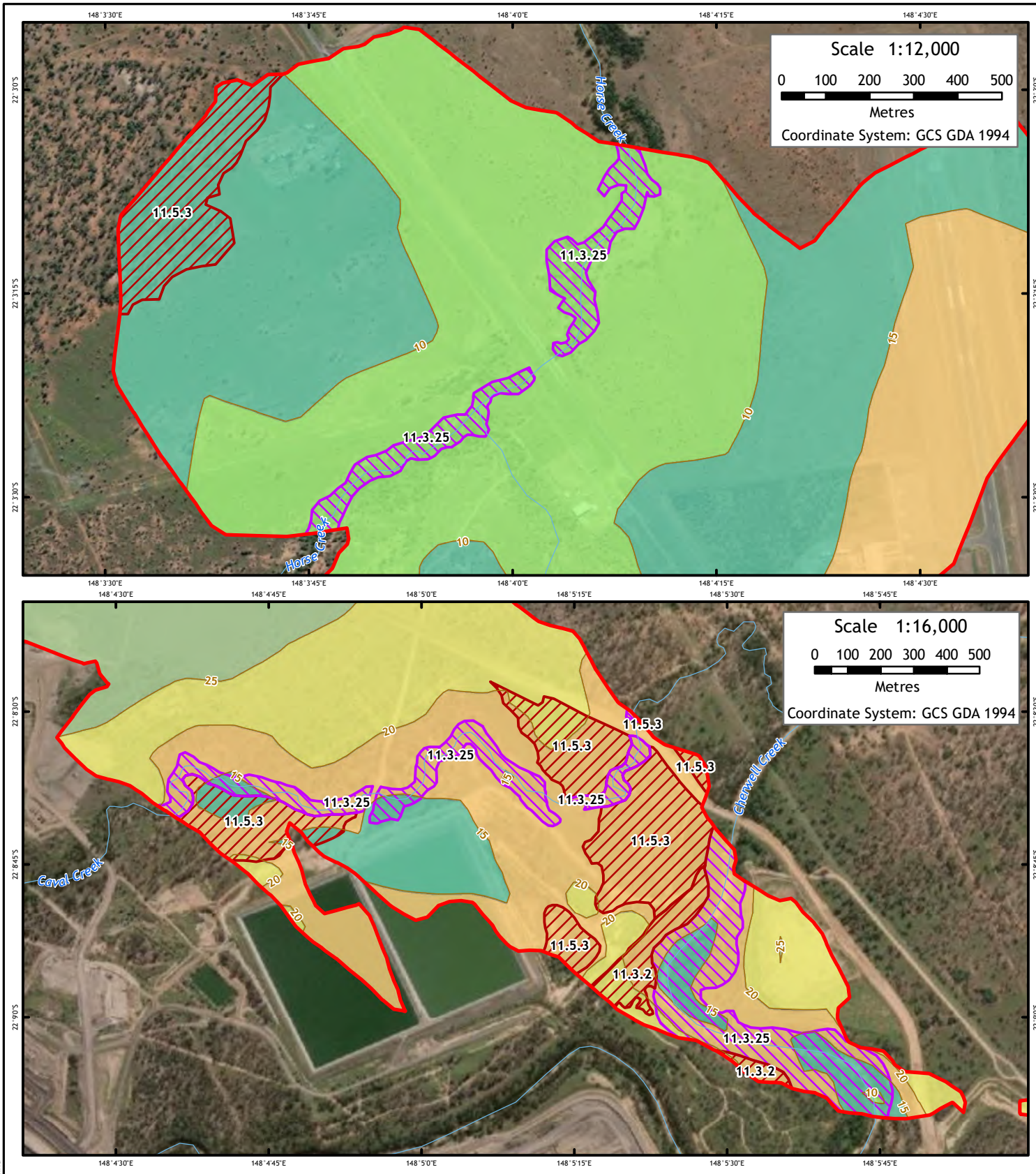
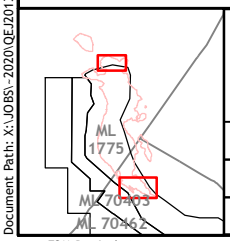


Legend

- Predicted Drawdown Extent
- **Ground-truthed Terrestrial GDE**
  - **Vegetation Communities**
    - Communities on sandy depositional plains
    - Riparian and floodplain communities
- **Depth To Water Table Range**
  - Greater than 25m
  - 20-25m
  - 15-20m
  - 10-15m
  - 5-10m

N



Notes:
Water Table Contours: © SLR 21/07/2021

Rev	Description	Drawn	Approved	Date
2	Issued for Use	PR	PW	23/08/2021
1	Issued for Use	PR	PW	09/08/2021

FIGURE 6B: GDE LIKELIHOOD OF OCCURRENCE ASSESSMENT

BMA Caval Ridge Mine

Map Number	Job Number	Rev
2 of 2	QEJ20130	2

Document Path: X:\JOBS\-2020\QEJ20130\GIS\QEJ20130_GDE_Occurrence_b.mxd

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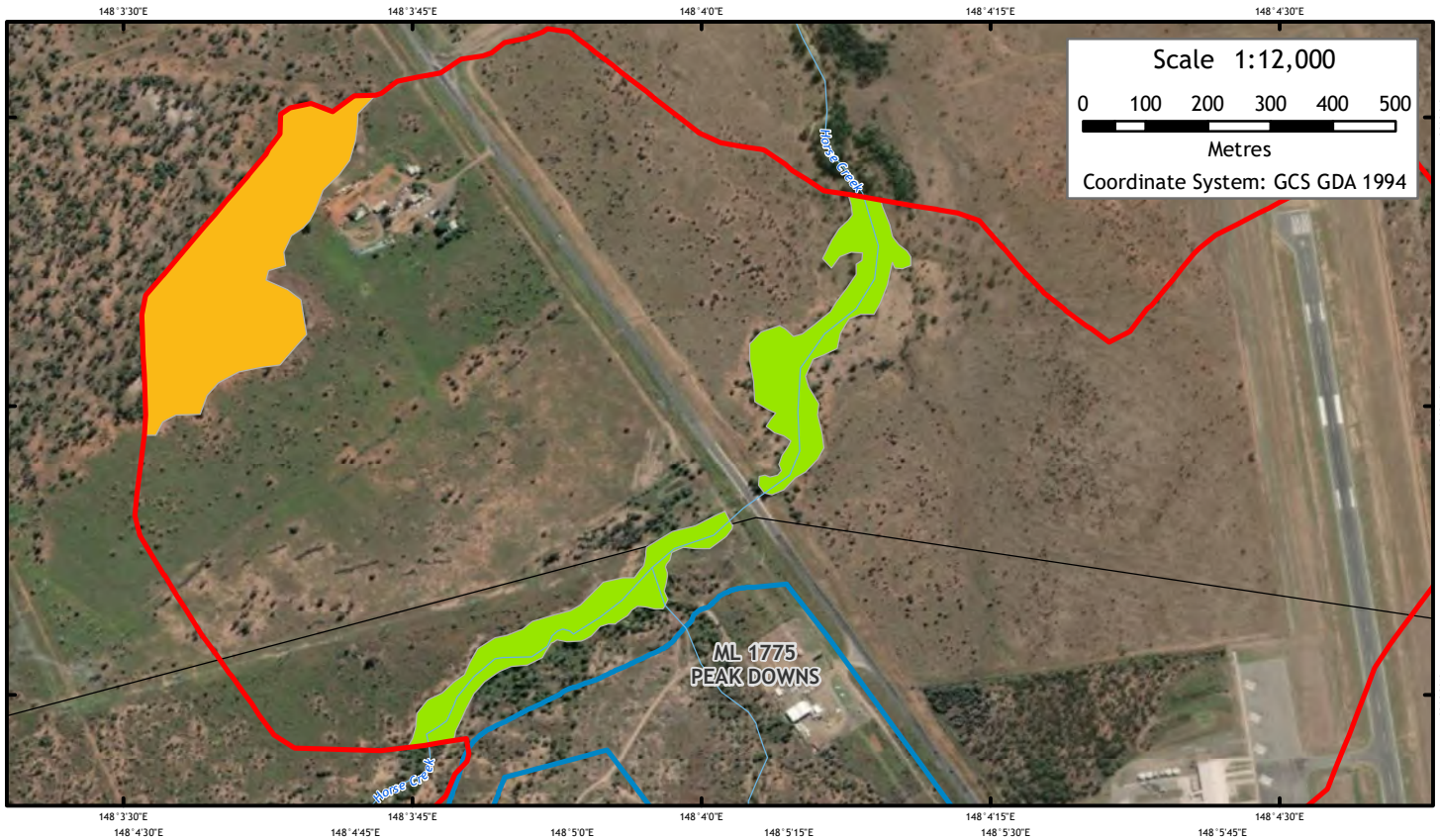
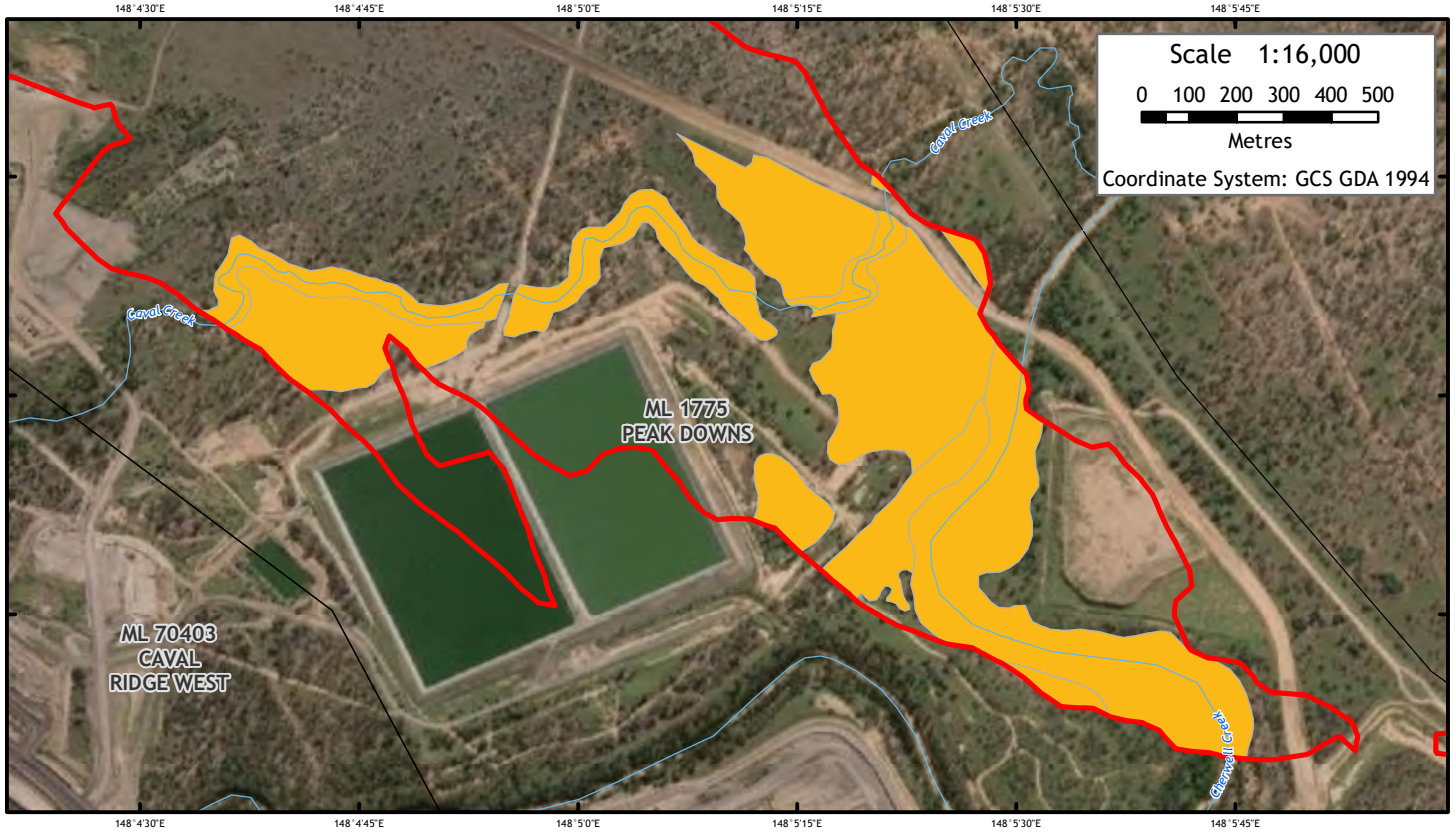




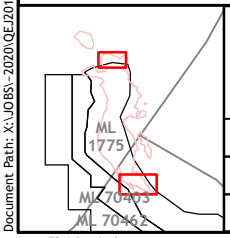
Legend

- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

Ground-truthed Terrestrial GDE

- Likely
- Possible

N



Notes:
Aerial Imagery: © ESRI 2020
Water Table Contours: © SLR 21/07/2021

Rev	Description	Drawn	Approved	Date
2	Issued for Use	PR	PW	23/08/2021
1	Issued for Use	PR	PW	09/08/2021

FIGURE 7: GROUND-TRUTHED TERRESTRIAL GDES

BMA Caval Ridge Mine

Map Number	Job Number	Rev
1 of 1	QEJ20130	2

Document Path: X:\JOBS\-2020\QEJ20130\GIS\QEJ20130_GT_TGDE_split.mxd

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6 Potential ecological impacts and proposed mitigation measures

The Project has largely avoided the direct clearing of possible and likely terrestrial GDE vegetation communities identified within the Predicted Drawdown Extent.

Potential impacts to potential terrestrial GDE vegetation community values identified within the Predicted Drawdown Extent include:

- groundwater drawdown and
- changes in groundwater quality.
- reduced surface water quality through erosion and sedimentation.

The following sections outline the potential ecological impacts which have been identified based on the ecological values assessment and associated mitigation measures recommended for implementation to reduce these impacts.

6.1 Potential groundwater drawdown

The areas of likely and possible terrestrial GDEs within the Predicted Drawdown Extent are associated with riparian corridors and floodplains containing REs 11.3.2 and 11.3.25, as well as some areas of sandy plains comprising RE 11.5.3 (Figure 7). All likely and possible GDEs identified are considered to be facultative based on the depth of the existing groundwater contours as well as the results of the GEM mapping. While these communities may access groundwater during prolonged periods of drought, canopy species are likely to utilise surface flows following periods of rain rather than rely solely on groundwater.

Modelled groundwater drawdown has indicated drawdown extending approximately 4 km south towards Cherwell Creek and approximately 2 km north along Horse Creek (Figure 8). A summary of the extents of likely and possible GDEs within the modelled 1 m, 2 m, 5 m, 10 m, 20 m and 50 m drawdown extents is provided in Table 9.

Table 10 shows the extent to which the predicted drawdown would increase the depth to groundwater beyond the threshold of root depths (as reported in literature review) for the identified indicator species. Overall, the results identify 1.81 ha of likely GDE and 36.92 ha of possible GDE to be within the area of potential impact. This includes patches of RE 11.3.2, 11.3.25 and 11.5.3, all vegetation communities considered to be facultative with vegetative condition and persistence largely attributed to surface flows as opposed to access to groundwater. Based on the limited extent and facultative nature the impacts of groundwater drawdown on these areas is not considered to be significant.

Table 9 Summary of predicted drawdown impacts to GDEs

Current depth to groundwater	Modelled drawdown extent	Predicted depth to groundwater	Potential impacts to likely GDE	Potential impacts to possible GDE
5 – 10 mgbl	2 m	7 – 12 mbgl	No – water table remains within 23 m rooting depth	
	5 m	10 – 15 mbgl	No – water table remains within 23 m rooting depth	
	10 m	15 – 20 mbgl	No – water table remains within 23 m rooting depth	

Current depth to groundwater	Modelled drawdown extent	Predicted depth to groundwater	Potential impacts to likely GDE	Potential impacts to possible GDE
	20 m	25 - 30 mbgl	0.63 ha of vegetation potentially affected	-
	50 m	55 - 60 mbgl	1.18 ha of vegetation potentially affected	-
10 - 15 mgbl	2 m	12 - 17 mbgl	No likely GDEs occur within this existing depth to groundwater	No - water table remains within 23 m rooting depth
	5 m	15 - 20 mbgl		No - water table remains within 23 m rooting depth
	10 m	20 - 25 mbgl		1.0 ha of vegetation potentially affected
	20 m	30 - 35 mbgl		0.06 ha of vegetation potentially affected
	50 m	60 - 65 mbgl		-
15 - 20 mgbl	2 m	17 - 22 mbgl	No likely GDEs occur within this existing depth to groundwater	No - water table remains within 23 m rooting depth
	5 m	20 - 25 mbgl		15.06 ha of vegetation potentially affected
	10 m	25 - 30 mbgl		10.93 ha of vegetation potentially affected
	20 m	35 - 40 mbgl		6.22 ha of vegetation potentially affected
	50 m	65 - 70 mbgl		-
20 - 25 mgbl	2 m	22 - 27 mbgl	No likely GDEs occur within this existing depth to groundwater	1.54 ha of vegetation potentially affected
	5 m	25 - 30 mbgl		1.32 ha of vegetation potentially affected
	10 m	20 - 35 mbgl		0.63 ha of vegetation potentially affected
	20 m	40 - 45 mbgl		0.17 ha of vegetation potentially affected
	50 m	70 - 75 mbgl		-

6.2 Reduced surface water quality through erosion and sedimentation.

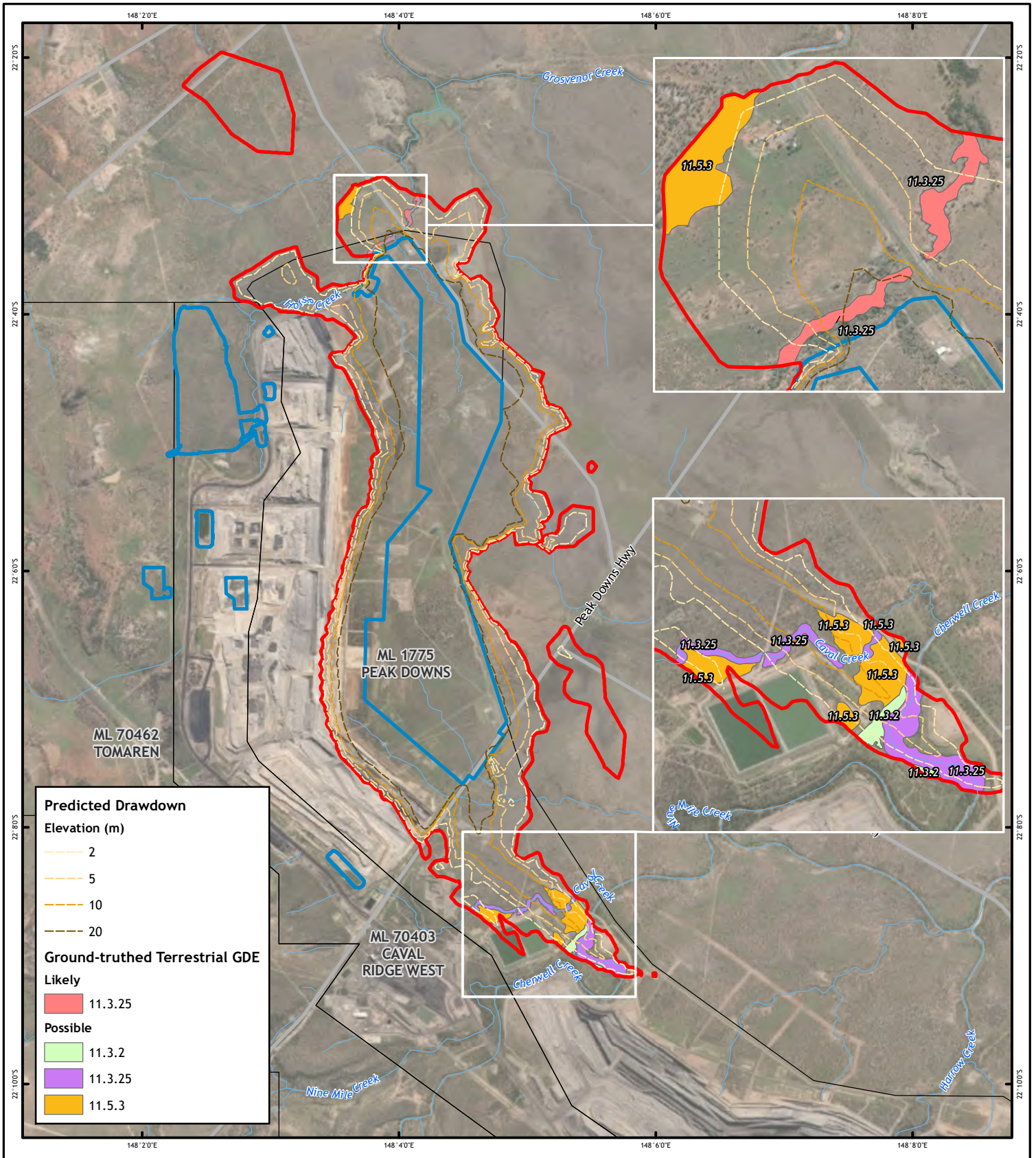
Where vegetation clearing occurs on floodplains and near drainage lines, erosion can lead to sedimentation of waterways, potentially degrading downstream aquatic and riparian habitats, some of which have been identified by this study as possible or likely terrestrial GDEs. Where necessary, erosions and sediment control measures in accordance with the existing BMA Erosion and Sediment Control guideline and EA conditions for CVM will be implemented at the Project site. To manage the potential for decreased water quality during construction and operation, the following mitigation measures will be implemented:

- appropriate erosion and sediment control measures will be established as required to reduce the amount of runoff from disturbed areas in accordance with industry standards and guidelines
- bunding and appropriate storage of fuels and other hazardous and flammable materials will be undertaken in accordance with AS1940:2004, and where practical, will be located away from any waterbodies
- oil spill recovery equipment will be available when working adjacent to drainage channels with the ability to discharge off site. Spill kits will be located with construction crews conducting activities with the potential for significant spills. CVM existing SOP for spill management will be utilised
- refuelling locations and handling of fuels shall be undertaken away from waterbodies
- construction of the haul road crossing will occur over the dry season to minimise soil disturbance on adjacent waterways
- as soon as practical, disturbed areas will be rehabilitated to reduce the amount of exposed soils
- the existing Mine Water Management Plan (MWMP) will be amended progressively as required to incorporate modified and new water management infrastructure following construction
- sediment dams, pit water storage and other water management structures (e.g. bunds and drains) will be designed and operated in accordance with BMA's standards and within the current framework specified in the existing site MWMP
- disturbed areas within the Project site will be diverted to sediment dams for treatment, and possible reuse for dust suppression and process water requirements. This will maximise their storage capacity to reduce the risk of off-site discharges
- fuel, dangerous goods and, hazardous chemicals will be managed as outlined by current standards, guidelines and in compliance with statutory requirements
- the existing Standard Operating Procedure for spills and emergency response procedures will continue to be utilised. Spill recovery and containment equipment will be available when working adjacent to sensitive drainage paths and within other areas, such as workshops; and
- The road crossing of the Horse Creek diversion will be managed in accordance with the measures outlined above for construction and operations. In addition to these, the erection of temporary waterway barriers during construction of any road crossings will include the provision to transfer flows from upstream of the works to the downstream channel without passing though the disturbed construction site.

6.3 Groundwater quality

Leaks, spills and improper disposal of wastes, including waste rock can lead to the leaching of compounds into the groundwater following rainfall events. Contamination of groundwater can impact the condition and health of terrestrial GDEs. Conditions of the existing CVM EA will be implemented for Project activities. To minimise potential impacts on groundwater quality, existing mitigation measures required by the EA conditions should continue to be implemented, including:

- Implement annual monitoring of groundwater quality to identify trends and changes over time; and
- fuel, dangerous goods and, hazardous chemicals will be managed as outlined by current standards, guidelines and in compliance with statutory requirements.



Legend

- Road
- Watercourse
- Predicted Drawdown Extent
- Project Footprint
- Mining Lease

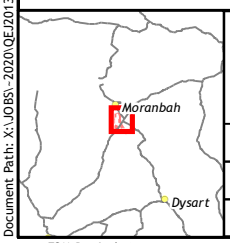
N

Scale 1:75,000 (A4)

0 1 2 3

Kilometres

Coordinate System: GCS GDA 1994



Notes:
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2	Issued for Use	PR	PW	23/08/2021
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FIGURE 8: PREDICTED GROUNDWATER DRAWDOWN

BMA Caval Ridge Mine

Map Number	Job Number	Rev
1 of 1	QEJ20130	2

Document Path: X:\JOBS\-2020\QEJ20130\GIS\QEJ20130_Predicted_GDE.mxd

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7 Conclusion

This report documents the assessment undertaken to determine the likely presence of terrestrial groundwater dependent vegetation that may be impacted by the Project. The GDE Atlas maps terrestrial GDEs within the Predicted Drawdown Extent as low potential (88.04 ha) and moderate potential (61.76 ha), with minor areas of high potential (4.54 ha). This mapping in conjunction with vegetation community mapping guided survey design and literature review.

Assessments of vegetation communities within the Predicted Drawdown Extent identified approximately 6.21 ha of vegetation communities considered likely terrestrial GDE (riparian communities RE 11.3.25) associated with Horse Creek. Vegetation considered possible terrestrial GDE, totalling 64.88 ha, associated with riparian corridors, floodplains and sandy plains were also identified within the southern extent in association with Caval Creek and Cherwell Creek.

Interpretation of the modelled groundwater drawdown data showed 1.81 ha of likely GDE along Horse Creek that is expected to be subject a DTW increase beyond the threshold of indicator species root depths (12-23 m). An additional 36.92 ha of possible GDE vegetation is also expected to be subject to a DTW increase beyond the threshold of indicator species root depths.

While the indicator species in vegetation communities within the area of likely GDE and possible GDE may experience an increase in depth to the groundwater, these communities are considered to be facultative. Facultative vegetation access groundwater when it is available rather than relying on it for survival. The conclusion that vegetation in the Predicted Drawdown Extent uses groundwater facultatively is further supported by the results of the GEM method assessment. The GEM method assessment did not identify any likely GDEs in the Predicted Drawdown Area.

Due to the facultative nature of these vegetation communities, likelihood and scale of impact (i.e. area), the Project is considered unlikely to result in a significant impact to vegetation communities that may access groundwater.

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Appendix A Desktop search results

WetlandMaps Report

For selected area of interest

Current as at 04/06/2021

Environmental Reports - General Information

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is ot present within the Area of Interest(AOI) (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the mapping of water bodies and wetland regional ecosystems across Queensland. The Queensland wetland mapping was produced using existing information including water body mapping derived from Landsat satellite imagery, regional ecosystem mapping, topographic data, and a springs database. The result is a consistent wetland map for the whole of Queensland.

Ancillary data, such as higher resolution imagery (for example SPOT and aerial photographs), other vegetation and wetland mapping, geology, soil and land system mapping was also used in attributing and assessing the derived Queensland Wetlands Program wetland mapping products.

The wetland mapping was done in accordance with a detailed peer reviewed methodology which included quality assurance measures for all steps in the process. For more detailed information on how the Queensland Wetlands Program wetland mapping was produced, please see the Wetland Mapping and Classification Methodology.

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Summary Information

The following table provides an overview of the area of interest.

Table 1. Area of interest details

Size (ha)	18,597.44
Local Government(s)	Isaac Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Northern Bowen Basin
Catchment(s)	Fitzroy
Drainage sub-basin	Isaac River

NRM Regions

The following NRM region(s) are in the area of interest:

Fitzroy Basin Association

Water Resource Plan Boundaries

The following Water Resource Plan(s) are in the area of interest:

Fitzroy Basin

Learn more about how Wetlands are mapped in Queensland:

Queensland Wetlands Mapping Definitions

Wetlands are areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 metres. To be a wetland the area must have one or more of the following attributes:

- at least periodically the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
- the substratum is not soil and is saturated with water, or covered by water at some time.

Examples under this definition **include**:

- those areas shown as a river, stream, creek, swamp, lake, marsh, waterhole, wetland, billabong, pool or spring on the latest Sunmap 1:25,000, 1:50,000, 1:100,000 or 1:250,000 topographic map
- areas defined as wetlands on local or regional maps prepared with the aim of mapping wetlands
- wetland regional ecosystems (REs) as defined by the Queensland Herbarium (Environmental Protection Agency 2005a)
- areas containing recognised hydrophytes as provided by the Queensland Herbarium
- saturated parts of the riparian zone
- artificial wetlands such as farm dams
- water bodies not connected to rivers or flowing water such as billabongs and rock pools.

Examples under this definition **exclude**:

- areas that may be covered by water but are not wetlands according to the definition
- floodplains that are intermittently covered by flowing water but do not meet the hydrophytes and soil criteria
- riparian zone above the saturation level.

Wetland Systems

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water.

Palustrine wetlands are primarily vegetated non-channel environments of less than 8 hectares. They include billabongs, swamps, bogs, springs, soaks etc, and have more than 30% emergent vegetation.

Lacustrine wetlands are large, open, water-dominated systems (for example, lakes) larger than 8ha. This definition also applies to modified systems (for example, dams), which are similar to lacustrine systems (for example, deep, standing or slow-moving waters).

Marine wetlands include the area of ocean from the coastline or estuary, extending to the jurisdictional limits of Queensland waters (3 nautical mile limit). This definition differs from that in Ramsar, as it includes waters deeper than 6m below the lowest astronomical tide.

Estuarine wetlands are those with oceanic water sometimes diluted with freshwater run-off from the land.

Subterranean wetlands are wetlands occurring below the surface of the ground and that are fed by groundwater i.e. caves and aquifers. These wetlands provide water to groundwater dependent ecosystems.

Methodology and Wetland Classification: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/wetland-background/

Links and support

Other sites that deliver wetland related information include:

Wetland*Summary* tool: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/

Queensland Spatial Catalogue: http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Queensland Globe: https://qldglobe.information.qld.gov.au/

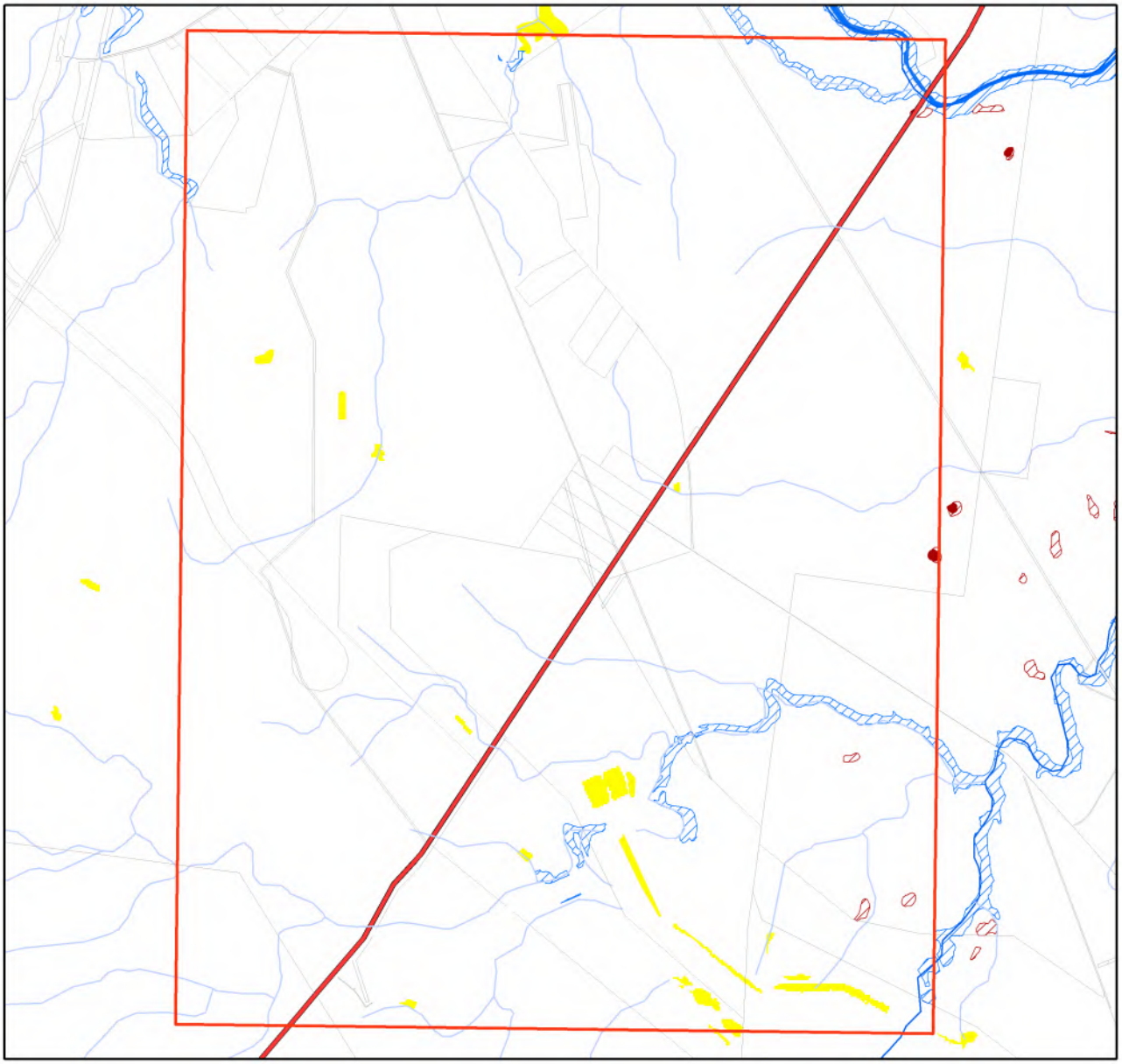
Environmental reports online: https://environment.ehp.qld.gov.au/report-request/environment/

Wetland on-line education modules: https://wetlandinfo.des.qld.gov.au/wetlands/resources/training/

Regional Ecosystem Mapping information: : https://www.qld.gov.au/environment/plants-animals/plants/herbarium/mapping-ecosystems

Aquatic Conservation Assessments: : https://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Groundwater Dependant Ecosystems information: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/groundwater-dependent/



Legend

- polygon
- Springs
- Dams and weirs
- Towns
- Highways
- Roads
- Cadastral boundaries
- Sub-basin

Wetland Mapping

Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51_80% wetland (mosaic units)

Riverine System Drainage Lines

- Major
- Minor

Queensland Wetland Map

Queensland Government

Australian Government

Queensland Wetlands Program

N

0 950 1900 2850 3800 4750 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

This map was produced by the Queensland Wetlands Program, Department of Environment and Science, June 2021.

For further information contact: wetlands@des.qld.gov.au

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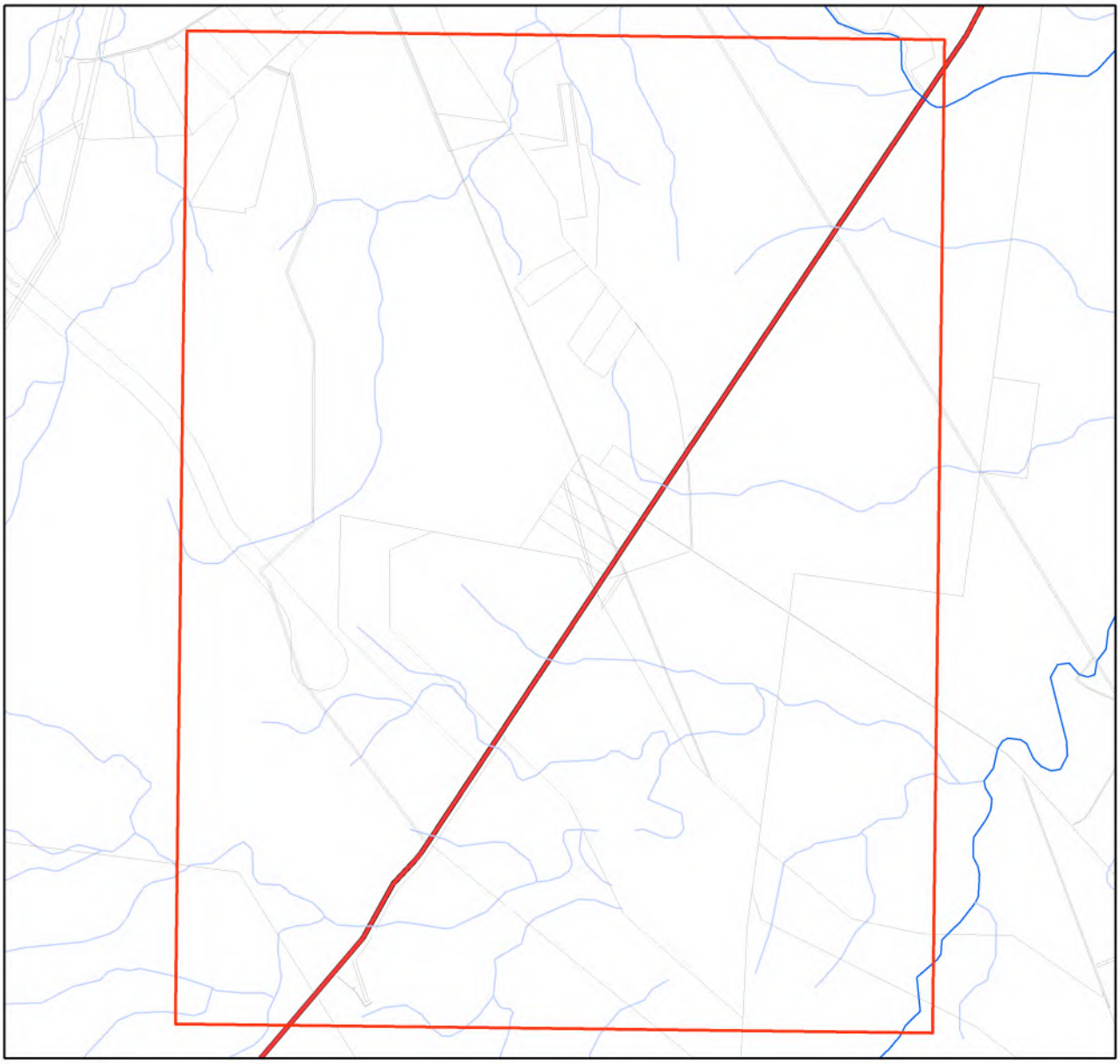

Queensland Wetlands of Importance Map

Legend

- polygon
- Towns
- Cadastral boundaries
- Highways
- Roads
- Sub-basin
- Directory of Important Wetlands
- Ramsar Wetlands

Riverine System Drainage Lines

- Major
- Minor

Queensland Government

Australian Government

Queensland Wetlands Program

N

0 950 1900 2850 3800 4750 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

This map was produced by the Queensland Wetlands Program, Department of Environment and Science, June 2021.

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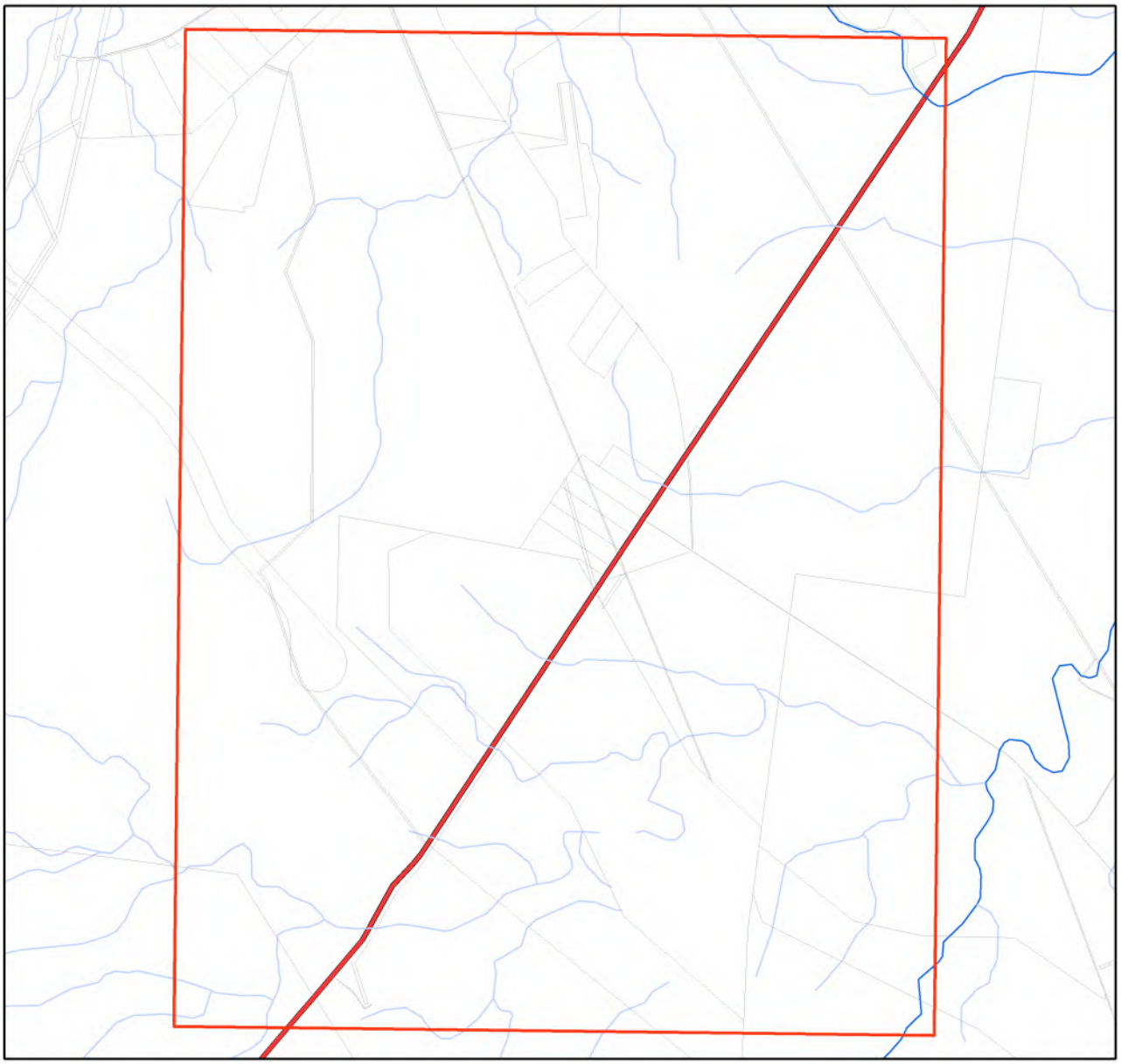

Legend

- polygon
- Towns
- Cadastral boundaries
- Highways
- Roads
- Sub-basin

Riverine System Drainage Lines

- Major
- Minor

Protected Areas

- National Park
- National Park (Scientific)
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve

Marine Parks

- General Use Zone
- Habitat Protection Zone
- Estuarine Conservation Zone
- Conservation Park Zone
- Buffer Zone
- Scientific Research Zone
- Marine National Park Zone
- Preservation Zone

Queensland Protected Area Map

Queensland Government
Australian Government

Queensland Wetlands Program

N

0 950 1900 2850 3800 4750 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

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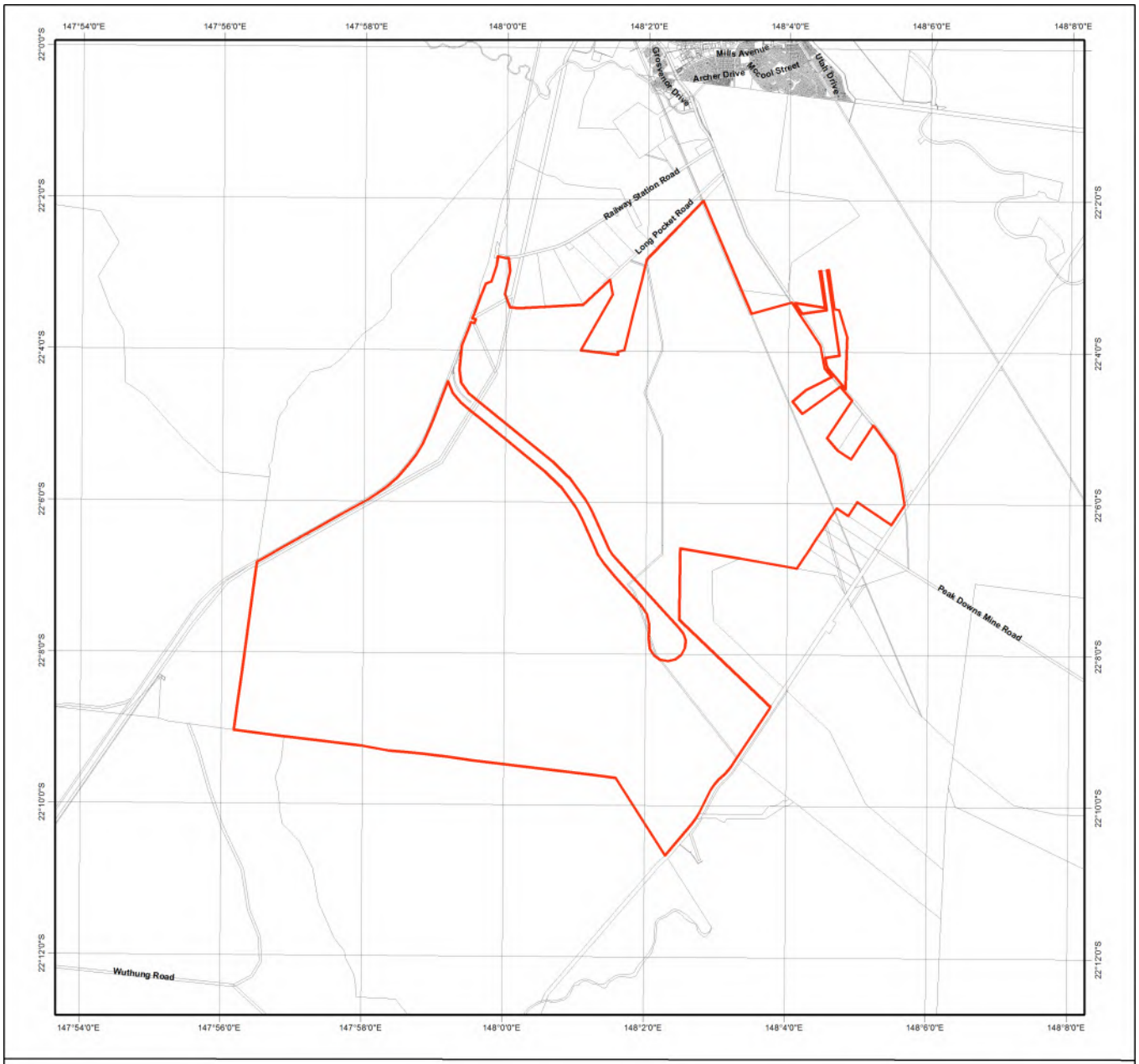
Wetland habitat types in the AOI. Total area: 1574.21ha

Wetland Class	Habitat type	Area (ha)
	Coastal/ Sub-coastal floodplain tree swamps (Melaleuca and Eucalypt)	773.87
	Coastal/ Sub-Coastal non-floodplain tree swamps (Melaleuca and Eucalypt)	467.58
Riverine	Riverine	192.83
Lacustrine	Artificial/ highly modified wetlands (dams, ring tanks, irrigation channel	123.99
Palustrine	Coastal/ Sub-Coastal non-floodplain tree swamps (Melaleuca and Eucalypt)	10.95
Palustrine	Coastal/ Sub-coastal floodplain grass, sedge and herb swamps	2.66
Palustrine	Coastal/ Sub-coastal floodplain tree swamps (Melaleuca and Eucalypt)	2.33

Queensland wetland habitat typology: Major wetland habitat types for wetland conceptual models and wetland management profiles

Wetland name	Conceptual model	Wetland profile
Mangrove Wetlands	Not developed	Mangrove Wetlands
Saltmarsh Wetlands	Not developed	Saltmarsh Wetlands
Coastal and subcoastal saline swamps of all substrates, water regimes, topographic types and vegetation communities	Coastal and subcoastal saline swamps	Coastal grass-sedge wetlands
Coastal and subcoastal non-floodplain tree swamps (Melaleuca and Eucalypt) of all substrates and water regimes	Coastal and subcoastal non-floodplain tree swamps - melaleuca and eucalypt	Coastal and subcoastal tree swamps
Coastal and subcoastal non-floodplain wet heath swamps of all substrates and water regimes	Coastal and subcoastal non-floodplain wet heath swamps	Coastal and subcoastal wet heath swamps
Coastal and subcoastal non-floodplain grass, sedge and herb swamps of all substrates and water regimes	Coastal and subcoastal non-floodplain grass, sedge and herb swamps	Coastal grass-sedge wetlands
Coastal and subcoastal spring swamps of all substrates, water types, water regimes and vegetation communities	Coastal and subcoastal spring swamps	Great Artesian Basin spring wetlands
Coastal and subcoastal floodplain tree swamps - melaleuca and eucalypt of all substrates and water regimes	Coastal and subcoastal floodplain tree swamps - melaleuca and eucalypt	Coastal and subcoastal tree swamps
Coastal and subcoastal floodplain wet heath swamps of all substrates and water regimes	Coastal and subcoastal floodplain wet heath swamps	Coastal and subcoastal wet heath swamps
Coastal and subcoastal floodplain, grass, sedge herb swamps of all substrates and water regimes	Coastal and subcoastal floodplain grass, sedge, herb swamps	Coastal grass-sedge wetlands
Coastal and subcoastal tree swamps - palm of all substrates, topographic types and water regimes	Coastal and subcoastal floodplain tree swamps - palm	Coastal Palm Swamps
Coastal and subcoastal Floodplain Lakes of all substrates, water types and water regimes	Coastal and subcoastal Floodplain Lakes	Coastal and subcoastal floodplain lakes and non-floodplain soil lakes
Coastal and subcoastal non-floodplain rock lakes of all water types and water regimes	Coastal and subcoastal non-floodplain rock lakes	Coastal and subcoastal non-floodplain rock lakes

Wetland name	Conceptual model	Wetland profile
Coastal and subcoastal non-floodplain sand lakes (window) of all water types and water regimes	Coastal and subcoastal non-floodplain sand lakes - window	Coastal non-floodplain sand lakes
Coastal and subcoastal non-floodplain sand lakes (perched) of all water types and water regimes	Coastal and subcoastal non-floodplain sand lakes - perched	Coastal non-floodplain sand lakes
Coastal and subcoastal non-floodplain soil lakes of all water types and water regimes	Coastal and subcoastal non-floodplain soil lakes	Coastal and subcoastal floodplain lakes and non-floodplain soil lakes
Arid and semi-arid saline swamps of all substrates, water regimes, topographic types and vegetation communities	Arid and semi-arid saline swamps	Semi-arid swamps
Arid and semi-arid fresh tree swamps of all substrates, and water regimes and topographic types	Arid and semi-arid tree swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid lignum swamps of all substrates, and water regimes and topographic types	Arid and semi-arid lignum swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid grass, sedge, herb swamps of all substrates, water regimes and topographic types	Arid and semi-arid grass, sedge, herb swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain tree swamps of all substrates and water regimes	Arid and semi-arid non-floodplain tree swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain lignum swamps of all substrates and water regimes	Arid and semi-arid non-floodplain lignum swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain grass, sedge, herb swamps of all substrates and water regimes	Arid and semi-arid non-floodplain grass, sedge, herb swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid, non-floodplain swamps - springs of all substrates, water regimes and vegetation communities	Arid and semi-arid spring swamps	Great Artesian Basin spring wetlands
Arid and semi-arid, saline lakes of all substrates, topographic types and water regimes	Arid and semi-arid saline lakes	Arid and semi-arid lakes
Arid and semi-arid, floodplain lakes of all, substrates and water regimes	Arid and semi-arid floodplain lakes	Arid and semi-arid lakes
Arid and semi-arid, non-floodplain Lakes of all substrates and water regimes	Arid and semi-arid non-floodplain lakes	Arid and semi-arid lakes
Arid/ semi-arid, non-floodplain (clay pans) lakes of all substrates and water regimes	Arid and semi-arid fresh non-floodplain lakes (clay pans)	Arid and semi-arid lakes
Arid and semi-arid, Permanent Lakes permanently inundated lakes of all substrates, water types, topographic types and vegetation communities	Arid and semi-arid permanent lakes	Arid and semi-arid lakes



Map of Great Barrier Reef Wetland Protection Areas

- Selected Lot and Plan
- Cadastral Boundary
- Wetland in a wetland protection area
- Great Barrier Reef wetland protection area

N

Note:
This map shows the location of wetland protection areas which are defined under the Environmental Protection Regulation 2008. Within wetland protection areas, certain types of development involving high impact earthworks are made assessable under Schedule 3 of the Sustainable Planning Regulation 2009.

The Department of State Development, Manufacturing, Infrastructure and Planning is the State Assessment Referral Agency (SARA) under Schedule 7 of the Sustainable Planning Regulation 2009 for assessable development involving high impact earthworks within wetland protection areas. The Department of Environment and Science is a technical agency.

The policy outcome and assessment criteria for assessing these applications are described in the State Development Assessment Provisions (SDAP) *State Code 9 : Great Barrier Reef Wetland Protection Areas.*

This map is produced at a scale relevant to the size of the lot on plan identified and should be printed at A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Science, email planning.support@des.qld.gov.au.

0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

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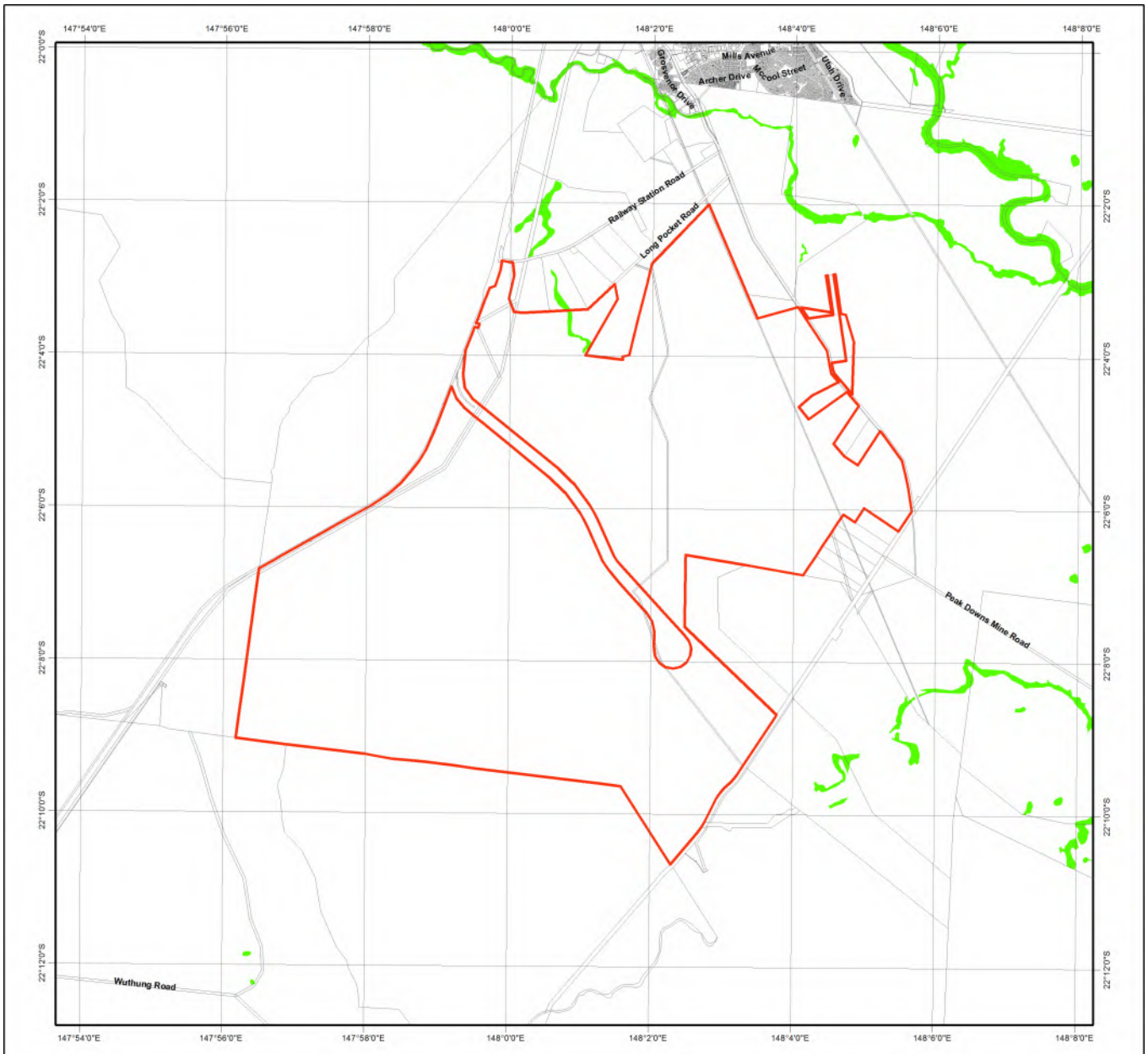

Map of Queensland Wetland Environmental Values

Selected Lot and Plan

Cadastral Boundary

High ecological values waters management intent

Wetlands assessed under section 7

GBR wetland of high ecological significance

Wetland of high ecological significance

Wetland of general ecological significance

N

Note:
This map shows the location of wetlands on the Map of Queensland Wetland Environmental Values under the Environmental Protection (Wetland and Water Biodiversity) Policy 2019. The map also shows high ecological value waters management intent under Schedule 2 of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019.

Wetlands are assessed for ecological significance using the environmental values for wetlands in section 7 of the Environmental Protection (Wetland and Water Biodiversity) Policy 2019. Wetlands are considered either High Ecological Significance (HES) or of General Ecological Significance (GES) for the purposes of the environmental values.

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0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

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Appendix B BioCondition Scores

Horse Pit Terrestrial GDE Baseline

AU
A1
A2a
A2b
A3
C1
C2D
C2U
C3
C4
(blank)

Assessment Unit	C2D			A2a		
Site	A2			A4		
Regional ecosystem	11.3.25			11.3.25		
Broad condition state	Remnant			Remnant		
Biocondition attribute	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**
Recruitment of woody perennial species (%)		100	5		100	5
Native plant species richness - trees (No.)	4	3	2.5	4	4	5
Native plant species richness - shrubs (No.)	2	6	5	2	6	5
Native plant species richness - grasses (No.)	8	5	2.5	8	2	2.5
Native plant species richness - forbs (No.)	12	2	0	12	2	0
Tree emergent height (m)	na	0		na	0	
Tree canopy height (m)	23	18	5	23	20	5
Tree sub-canopy height (m)	na	0		na	0	
Tree height - average			5			5
Tree emergent cover (%)	na	0		na	0	
Tree canopy cover (%)	22	31.8	5	22	31	5
Tree sub-canopy cover (%)	na	0		na	0	
Tree cover - average			5			5
Native shrub canopy cover (%)	1	19.6	3	1	4.5	3
Native perennial grass cover (%)	12	10	3	12	3	1
Organic litter (%)	15	41	3	15	52	3
Large trees/ha - total	21	14	10	21	20	10
Coarse woody debris (m/ha)	375	210	5	375	530	5
Non-native plant cover (%)	0	20	5	0	18	5
Maximum site-based score			80			80
Site-based BioCondition score (out of 10)			**6.75**			**6.8125**

Assessment Unit (AU)	**C2D**	**A2a**	**A2b**	**A3**	**C3**	**C2U**
AU BioCondition Score	6.78125	6.59375	5.125	6.6875	6.9375	6.33333333
AU Area						
AU Weighted BioCondition Score						

A2b			A3			A3			A2a		
B11			B2			B39			B43		
11.3.25			11.5.3			11.5.3			11.3.25		
HVR			Remnant			Remnant			Remnant		
Benchmark	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**
	60	3		75	5		50	3		100	5
4	5	5	6	5	2.5	6	2	2.5	4	5	5
2	4	5	6	6	5	6	10	5	2	3	5
8	5	2.5	6	5	2.5	6	4	2.5	8	3	2.5
12	9	2.5	10	9	5	10	5	2.5	12	4	2.5
na	0		na	0		na	0		na	0	
23	16	3	16	14	5	16	15	5	23	24	5
na	0		7	4	3	7	4	3	na	0	
		3			4			4			5
na	0		na	0		na	0		na	0	
22	16	5	20	15	5	20	8	2	22	58	3
na	11		3	10	3	3	10	3	na	30	
		5			4			2.5			3
1	0	0	3	5	5	3	29	3	1	0	0
12	9	3	19	21	5	19	5	1	12	1	0
15	28	5	20	35	5	20	25	5	15	33	3
21	4	5	10	16	15	10	2	5	21	28	15
375	110	2	314	350	5	314	430	5	375	270	5
0	60	0	0	45	3	0	55	0	0	60	0
		80			80			80			80
		5.125			**8.25**			**5.125**			**6.375**

A1	**C1**
5.0625	5.5625

C3			C2U			C2U			A1		
B44			B45			B46			B47		
11.5.3			11.3.25			11.3.25			11.3.2		
Remnant			Remnant			Remnant			Remnant		
Benchmark	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**
	75	5		75	5		60	3		100	5
6	4	2.5	4	4	5	4	6	5	2	2	5
6	5	2.5	2	6	5	2	3	5	2	3	5
6	6	5	8	2	2.5	8	2	2.5	9	0	0
10	9	5	12	3	2.5	12	3	2.5	17	3	0
na	0		na	0		na	0		na	0	
16	17	5	23	19	5	23	22	5	18	14	5
7	5	5	na	0		na	0		na	0	
		5			5			5			5
na	0		na	0		na	0		na	0	
20	51	3	22	76	3	22	70	3	40	17	2
3	9	3	na	8		na	5		na	13.5	
		3			3			3			2
3	3	5	1	0	0	1	0	0	2	0	0
19	28	5	12	2	1	12	3	1	35	0	0
20	42	3	15	32	3	15	31	3	30	29	5
10	20	15	21	4	5	21	32	15	22	0	0
314	280	5	375	700	5	375	550	5	307	380	5
0	20	5	0	65	0	0	60	0	0	78	0
		80			80			80			80
		8.25			**5.25**			**6.25**			**4**

A1			C2U			C3			C1		
B48			C2			T10			T12		
11.3.2			11.3.25			11.5.3			11.3.2		
Remnant			Remnant			Remnant			Remnant		
Benchmark	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**	**Benchmark**	**Value**	**Score**
	100	5		50	3		33	3		50	3
2	4	5	4	5	5	6	3	2.5	2	3	5
2	3	5	2	7	5	6	4	2.5	2	3	5
9	6	2.5	8	4	2.5	6	1	0	9	3	2.5
17	6	2.5	12	5	2.5	10	0	0	17	1	0
na	0		na	0		na	0		na	0	
18	16	5	23	18	5	16	16	5	18	14	5
na	0		na	0		7	6	5	na	0	
		5			5			5			5
na	0		na	0		na	0		na	0	
40	25	5	22	37.5	5	20	12.6	5	40	19	2
na	5.5		na	0		3	2.4	5	na	0	
		5			5			5			2
2	0.5	3	1	7.9	3	3	1.3	3	2	5.6	3
35	8	1	12	3	1	19	4	1	35	7	1
30	26	5	15	33	3	20	18	5	30	33	5
22	10	5	21	22	15	10	8	10	22	10	5
307	220	5	375	480	5	314	280	5	307	280	5
0	60	0	0	20	5	0	35	3	0	35	3
		80			80			80			80
		6.125			**7.5**			**5.625**			**5.5625**

C2D		
T9/A		
11.3.25		
Remnant		
Benchmark	**Value**	**Score**
	50	3
4	4	5
2	7	5
8	2	2.5
12	1	0
na	0	
23	20	5
na	0	
		5
na	0	
22	22.8	5
na	0	
		5
1	13.1	3
12	7	3
15	23	5
21	18	10
375	420	5
0	25	3
		80
		6.8125