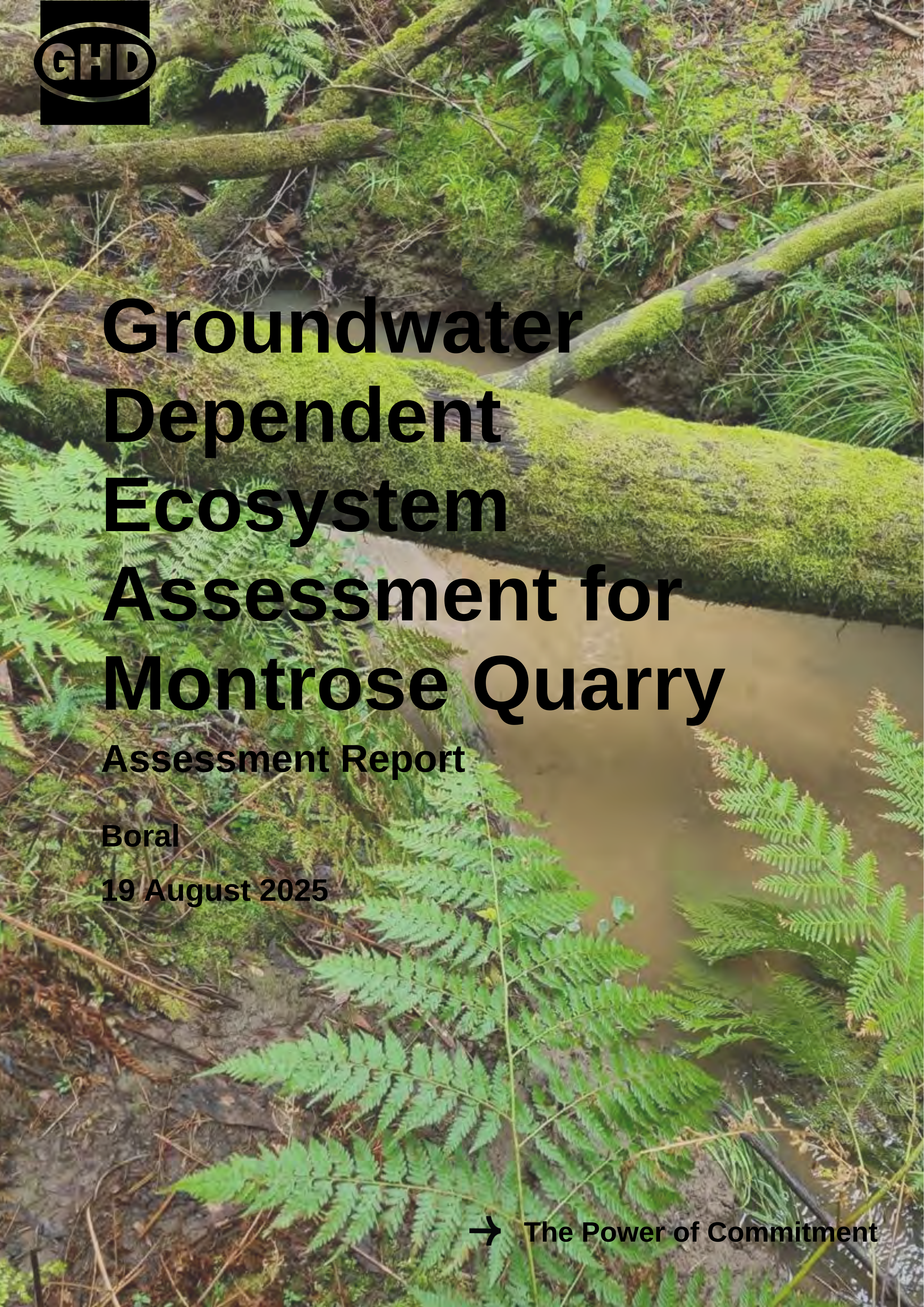


Groundwater Dependent Ecosystem Assessment for Montrose Quarry

Assessment Report

Boral

19 August 2025

→ The Power of Commitment

Project name	GDE Assessment						
Document title	Groundwater Dependent Ecosystem Assessment for Montrose Quarry | Assessment Report						
Project number	12611238						
File name	12611238-REP_Phase 3 Groundwater Dependent Ecosystem Assessment.docx						
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	P. Lind S. Bidwell	P. Lind S. Harrow		S. Harrow		04/08/2025
S4	1	P. Lind S. Bidwell	P. Lind S. Harrow		S. Harrow		14/08/2025
S4	2	P. Lind S. Bidwell	P. Lind S. Harrow		S. Harrow		19/08/2025

GHD Pty Ltd | ABN 39 008 488 373
180 Lonsdale Street, Level 9
Melbourne, Victoria 3000, Australia
T +61 3 8687 8000 | **F** +61 3 8732 7046 | **E** melmail@ghd.com | **ghd.com**

The Power of Commitment

Executive summary

GHD Pty Ltd (GHD) was engaged by Boral to undertake an assessment of Groundwater Dependent Ecosystems (GDEs) and ecological values adjacent to the Boral's Montrose quarry and to assess the level of risk associated with a proposed expansion.

Boral's Montrose quarry has a long history of operation dating back to the 1950s. The base of the quarry pit represents a local low point in the regional groundwater system, with the seepage and pooling of groundwater at the base where it intersects the water table.

To evaluate these risks, a range of ecological assessments in the vicinity of the quarry were initially completed. Their findings confirmed the presence of potential GDEs and ecological values within the study area - many of which are dependent on groundwater or sustained surface water flows. These include burrowing crayfish, riparian vegetation, and fauna reliant on that habitat. Several threatened species protected under State or Commonwealth legislation were identified as potentially present, including native flora, vegetation communities, mammals, birds, reptiles, frogs, and crustaceans.

A risk assessment was completed, taking into account findings from a range of supporting investigations. These included a site-specific Surface Water and Groundwater Assessment and a Terrestrial GDE Assessment focusing on the ecohydrological function.

The risk assessment concluded that most GDEs and ecological values face low inherent risks from projected changes to groundwater levels. For example, it was determined that trees prefer soil moisture as a source of water rather than groundwater, while other threatened water dependent floral species such as *Pteris epaleata* (Netted Brake) and *Senecio campylocarpus* (Bulging Fireweed) were not detected in the study site during targeted surveys.

There were some medium inherent risks associated with Bungalook Creek and associated aquatic values due to the loss of surface water. These included risks to Burrowing Crayfish, the health of the creek itself, and trees along the creek that are partly reliant on creek water and seepage.

These inherent risks were further reduced by modifying the discharge system as a mitigation control - specifically by relocating the existing discharge point upstream of the predicted drawdown areas to allow quarry water to be returned to Bungalook Creek, thus compensating for lost surface flow. However, a medium residual risk remains for two threatened Burrowing Crayfish species listed under the FFG Act: the Dandenong Burrowing Crayfish (*Engaeus urostrictus*) and the Foothill Burrowing Crayfish (*Engaeus victoriensis*). Risk to these species is expected to:

- Increase during active quarrying operations, then lessen during the rehabilitation phase
- Intensify in dry seasons, when creek flow is naturally reduced
- Be exacerbated by poor water quality linked to dry conditions (e.g. stagnation, eutrophication)

The reduced residual risks are dependent on the effectiveness of the relocated discharge point compensating for lost surface flow.

Monitoring recommendations are provided with regard to filling of remaining information gaps and to track changes to baseline conditions over time.

This report is subject to, and must be read in conjunction with, the limitations set out in Sections 1.3 and 1.4 and the assumptions and qualifications contained throughout the Report.

Contents

Abbreviations **vi**

Glossary **vii**

1. Introduction **1**

1.1 Background 1

1.2 Scope 1

1.3 Limitations 2

1.4 Exclusions 2

1.5 Other acknowledgements 2

2. Methods **4**

2.1 Influence of quarry expansion on groundwater and surface water 4

2.2 Preliminary assessment for presence of GDEs and ecological values 4

2.2.1 Desktop assessment - GDEs 5

2.2.2 Desktop assessment – ecological values 5

2.2.3 Preliminary site assessment 5

2.2.4 Likelihood assessment and water dependency 6

2.3 Targeted surveys to confirm presence of GDEs and ecological values 6

2.3.1 Flora and vegetation values 7

2.3.2 Terrestrial fauna values 8

2.3.3 Aquatic values 8

2.4 Development of conceptual models 8

2.5 Potential risks to GDEs and ecological values due to quarry expansion 9

3. Results **12**

3.1 Influence of quarry expansion on groundwater and surface water 12

3.1.1 Aquifer and groundwater flow system 12

3.1.2 Surface water flow system 12

3.1.3 Interactions between groundwater and surface water 13

3.1.4 Predicted changes to surface water and groundwater due to quarry expansion 15

3.2 Groundwater dependent ecosystems and ecological values 17

3.2.1 Groundwater dependent ecosystems 18

3.2.2 Aquatic fauna and habitat 19

3.2.3 Vegetation 29

3.2.4 Terrestrial fauna and habitat 42

3.2.5 Existing threatening processes 51

3.3 Risk Assessment – problem formulation 57

3.3.1 Sensitive receptors 57

3.3.2 Impact pathways 60

3.3.3 Conceptual models 60

3.4 Risk Assessment – risk analysis 64

3.4.1 Aquatic fauna and habitat 64

3.4.2 Native vegetation 66

3.4.3 Terrestrial fauna 67

3.4.4 Management controls 67

4. EE Act referral criteria **68**

5. Conclusions **72**

6.	**Recommendations**	**73**
6.1	Ecohydrological assessment	73
6.2	Refuge pools	73
6.3	Groundwater use/reliance by trees	73
6.4	Ecological monitoring	74
6.4.1	Aquatic values	74
6.4.2	Vegetation	75
7.	**References**	**76**

Table index

Table 1	Plant Functional Group definitions (modified from Casanova 2011)	viii
Table 2	Consequence criteria related to native vegetation, flora species or fauna species (Source JPR 2020)	10
Table 3	Likelihood categories (Source JPR 2020)	10
Table 4	Risk rating matrix (Source JPR 2020)	11
Table 5	Risk rating acceptability (Source JPR 2020)	11
Table 6	Water quality (in situ) results – Bungalook Creek	23
Table 7	Biological index results – Bungalook Creek	24
Table 8	Dependence of aquatic fauna listed as threatened under the FFG Act on surface water or groundwater	28
Table 9	Ecological Vegetation Classes within the study sites (recorded by EH&P and/or GHD) and descriptions	31
Table 10	Root depth and water requirements of characteristic flora species	36
Table 11	Assessment of potential risk to flora listed as threatened under the EPBC or FFG Act as a result of surface water or groundwater changes at this study site	38
Table 12	Protected flora recorded during GHD site assessment and preliminary risk assessment	41
Table 13	Preliminary assessment of potential risks to terrestrial fauna listed as threatened under the EPBC Act as a result of surface water or groundwater changes	47
Table 14	Preliminary assessment of potential risk to terrestrial fauna listed as migratory under the EPBC Act as a result of surface water and/or groundwater changes	48
Table 15	Preliminary assessment of potential risk to terrestrial fauna listed as threatened under the FFG Act as a result of surface water or groundwater changes	48
Table 16	Key and associated members of the VTWBC identified for the study area	50
Table 17	Frog species recorded during the targeted surveys	51
Table 18	Noxious weeds recorded within the study site	52
Table 19	Other environmental weeds recorded within the study site (in addition to declared noxious weeds)	52
Table 20	Pest species – non-native terrestrial and aquatic fauna	53
Table 21	Sensitive receptors considered in the risk assessment	57
Table 22	Individual and combined criteria under the EE Act and preliminary assessment of project implications	68

Figure index

Figure 1	Montrose GDE assessment study site	3
Figure 2	Stages used in the GDE assessment	4
Figure 3	Groundwater and surface water interactions showing a gaining stream (left) and a losing stream (right)	13
Figure 4	Interflow observed during site assessment of Bungalook Creek	14
Figure 5	Simulated water table drawdown at the end of the extraction period based on 95th percentile (Sourced from GHD 2023)	16
Figure 6	Bungalook Creek flow duration curve	17
Figure 7	Melbourne Water Key Values for Dandenong Creek Middle Sub-catchment (10 - 50 year targets) (Melbourne Water 2018)	18
Figure 8	Bureau of Meteorology GDE Atlas results showing potential locations of aquatic GDE (left) and terrestrial GDEs (right)	18
Figure 9	Aquatic ecological values at study site	27
Figure 10	Ecological Vegetation Class mapping along Bungalook Creek	30
Figure 11	Boral Montrose conceptual ecological model	62
Figure 12	Conceptual model of potential changes to stream flow and potential risks to ecological values	63

Appendices

Appendix A	Assessment of the presence of GDEs or ecological values with some dependence on groundwater
Appendix B	Targeted survey and baseline monitoring methods
Appendix C	Results of Baseline Vegetation Monitoring
Appendix D	Likelihood of occurrence - Threatened flora
Appendix E	Likelihood of occurrence - Threatened fauna
Appendix F	Likelihood of occurrence - Migratory fauna
Appendix G	Flora species recorded during site assessment
Appendix H	Ecological risk register

Acknowledgement of Country

GHD acknowledge the Wurundjeri Woi Wurrung people as the Traditional Owners across the lands in which this project is based. We recognise the Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation as the Registered Aboriginal Party responsible for managing Cultural Heritage on behalf of this group, which includes cultural values of land, wildlife and waterways.

Abbreviations

Abbreviation	Full term
AHD	Australian Height Datum
AMFI	Australian Macroinvertebrate Flow Index
BGL	Below ground level
CaLP Act	Catchment and Land Protection Act 1996
DCCEEW	Department of Climate Change, Energy, Environment and Water
DEECA	Department of Energy, Environment and Climate Action
EE Act	Environment Effects Act
EES	Environment Effects Statement
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EVC	Ecological Vegetation Class
FFG Act	Flora and Fauna Guarantee Act 1988
GDE	Groundwater Dependent Ecosystem
ISC	Index of Stream Condition
PMST	Predicted Matters Search Tool
VBA	Victorian Biodiversity Atlas
WoNS	Weed of National Significance

Glossary

Study site

The term **study site** refers to the area shown in Figure 1. The extent of the study site was determined based on the total area that GHD (2023) predicted to be prone to drawdown due to the quarry expansion (Figure 5), as well as additional areas outside of the predicted drawdown. The additional areas were included as the influence of the drawdown may extend to vegetation, terrestrial and aquatic values beyond the immediate drawdown areas. For example, a reduction in flow of Bungalook Creek may result in impacts to fish or other aquatic fauna that are mobile and not necessarily within the drawdown areas but have the capacity to pass through these areas during their life cycles. As such, the study site encompasses Bungalook Creek from the headwaters to the Colchester Road retarding basin, and the areas of remnant vegetation adjacent to the quarry.

Study area

The term **study area** refers to a broader region and includes all land and waterways within 10 km of the study site. The additional information from the broader study area has been used to provide context to assess the significance of existing GDEs and ecological values within the study site (e.g., whether values are part of the broader area, or whether there is the potential for impacts outside the study site). The broader study area was assessed at a desktop level only.

Groundwater-dependent ecosystems

A GDE is an ecosystem that have their species composition and natural ecological processes wholly or partially determined by groundwater (Serov et al. 2012). If the availability of groundwater to GDEs is reduced, or the quality allowed to deteriorate, these ecosystems may be impacted. GDEs can be broadly grouped into three categories:

1. Ecosystems that depend on the surface expression of groundwater:
    - Swamps and wetlands can be sites of groundwater discharge and may represent GDEs. These may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution. Tidal flats and inshore waters may also be sites of groundwater discharge.
    - Permanent or ephemeral stream systems may receive seasonal or continuous groundwater contribution to flow as baseflow. Interactions depend on the nature of the streambed and underlying aquifer, and the relative water level heads in the aquifer and the stream.
2. Ecosystems that depend on the subsurface presence of groundwater. Terrestrial vegetation such as trees and woodlands may be supported seasonally or permanently by groundwater. These may comprise shallow or deep-rooted communities that use groundwater to meet some or all their water requirements. Animals may depend on this vegetation and therefore indirectly depend on groundwater. Groundwater quality generally needs to be high to sustain vegetation growth.
3. Ecosystems that reside within a groundwater resource. These are referred to as hypogean ecosystems. Micro-organisms such as stygofauna in groundwater systems can exert a direct influence on water quality.

Native vegetation

Native vegetation is defined in the Victoria Planning Provisions as "*plants that are indigenous to Victoria, including trees, shrubs, herbs and grasses*". In the *Guidelines for the Removal, Destruction or Lopping of Native Vegetation* (DELWP 2017), native vegetation is classified into two categories, a **Patch** of vegetation or a **Scattered Tree**:

– A **Patch** of native vegetation is either:
    - An area of native vegetation where at least 25% of the total perennial understorey plant cover is native
    - Any area with three or more native canopy trees where the drip line of each tree touches the drip line of at least one other tree, forming a continuous canopy
    - Any mapped wetland included in the current wetlands map that is available on DEECA online mapping tools

– A **Scattered tree** is a native canopy tree that does not form part of a patch.

Other forms of vegetation include:

- **Planted native vegetation** that are non-indigenous native species and areas of revegetation
- **Scattered native plants** are areas of vegetation dominated by introduced species, where less than 25% of the total perennial understorey plant cover is native
- **Non-native vegetation** is vegetation that comprises introduced flora

Common and scientific names for flora follow Version 3.2.6 of the Victorian Biodiversity Atlas (VBA). Conservation status was determined in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act).

Vegetation communities

Native vegetation in Victoria is mapped in units known as Ecological Vegetation Classes (EVCs). EVCs are described according to a combination of floristic, life form and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC occurs under a common regime of ecological processes within a given biogeographic range and may contain multiple floristic communities.

Other vegetation types that may occur in Victoria include vegetation communities listed as threatened under the EPBC Act and/or the FFG Act. These have separate vegetation classification systems, each of which is also separate to the EVC classification system. As such, any single patch of native vegetation occurring within a site (or anywhere in Victoria) will be classifiable as a particular EVC and may also be separately classified as a different threatened ecological community under the EPBC Act, and/or as another vegetation community under the FFG Act.

Plant Functional Groups

Plant species were grouped into Plant Functional Groups (PFGs) with respect to their known or likely water requirements and as classified by Casanova (2011) and Doeg et al. (2012). The PFGs represent plant species that have similar water requirements and occupy a similar component of an EVC (Table 1). They may also be present across EVCs. The purpose of using the functional group approach is to identify water requirements of EVCs and identify which components (functional groups) may be impacted by groundwater drawdown.

Table 1 Plant Functional Group definitions (modified from Casanova 2011)

Functional group code	Definition	Example species
Tdr	**Terrestrial dry.** Does not require flooding and will persist in damper parts of the landscape because of localised high rainfall. Can invade or persist in riparian zones and edges of wetlands but are essentially terrestrial.	Messmate, Brown Stringybark, Prickly Moses, Silver Banksia
Tda	**Terrestrial damp.** Germinate and establish on saturated or damp ground but cannot tolerate flooding in the vegetative state. Require the soil profile to remain damp for at least several months.	Swamp Gum, Hop Goodenia, Common Bog-sedge
ATl	**Amphibious fluctuation tolerator, low-growing.** Can germinate either on saturated soil or under water and grow submerged, as long as they are exposed to air by the time they start to flower and set seed. Require or tolerate shallow flooding for ~ 3 months.	Austral Brookline, Club-sedge, Knotweed
ATe	**Amphibious fluctuation tolerator, emergent.** Emergent monocots and dicots that survive in saturated soil or shallow water but require most of their photosynthetic parts to remain above the water (emergent). Tolerate fluctuations in water depth, as well as water presence. Need water or soil moisture to be present for ~ 8-12 months of the year.	Tall Sedge, Tall Sword-sedge, Thatch Saw-sedge, Duckweed, Common Ground-fern, Austral Bracken
ATw	**Amphibious fluctuation tolerator, woody.** Consists of woody perennial species that may hold their fruits (and seeds) in the canopy and require water to be present in the root zone all year round but will germinate in shallow water or on a drying substrate.	Scented Paperbark, Swamp Paperbark
ARp	**Amphibious fluctuation responder, plastic.** Occupies similar zone to the ATl group, except they have a morphological response to water level changes such as rapid shoot elongation or a change in leaf form. Persist on damp and drying soil because of their morphological flexibility but can flower even if the site does not dry out. Occupy a slightly deeper/wet-for-longer site than the ATl group.	Creeping Cotula, River Buttercup
Se	**Perennial-emergent.** Monocotyledonous species that require permanent water in the root zone but remain emergent. Occur where water levels do not fluctuate or fluctuate with relatively little drawdown in the dry part of the year.	Cumbungi, Common Reed, Duckweed, Water-ribbons

Weeds

The "*loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants*" is a listed key threatening process under the EPBC Act. In addition, "*invasion of native vegetation by environmental weeds*" is a listed potentially threatening process under the FFG Act.

Weeds may be classified as environmental weeds and/or noxious weeds listed under the *Catchment and Land Protection Act 1994* (CaLP Act) and/or Weeds of National Significance (WoNS).

Fauna and fauna communities

As recommended by GHD (2023), this assessment includes the identification of ecological values and their potential to be dependent on groundwater (i.e., no dependence, facultative or obligatory dependence). The focus of this assessment has been on species and communities of conservation significance that are listed under Commonwealth and State legislation. However, it is acknowledged that there are several common native flora and fauna species potentially present within the study site.

Unless otherwise noted, common and scientific names for fauna follow the VBA database (Version 3.2.6). The conservation significance of fauna was determined in accordance with the EPBC Act and the FFG Act. The EPBC Act and the FFG Act also list a number of threatened fauna communities, at a national or state scale, respectively.

Fauna and fauna communities known or potentially occurring within the study area were only considered if they are listed under one or more of these Acts. For this project, **terrestrial fauna** is any fauna that occurs in the terrestrial environment that largely resides in the terrestrial environment for all or dominant life stages. **Aquatic fauna** is any fauna that occurs primarily in freshwater. Amphibians are considered terrestrial fauna, while platypus, turtles, crayfish, and other aquatic invertebrates are considered aquatic fauna.

The marine status of fauna (as indicated under the EPBC Act) was not considered because the study site is not in or near a Commonwealth marine area.

1. Introduction

1.1 Background

The Boral Pty Ltd (Boral) Montrose quarry is located on the north-western foothills of Mount Dandenong and has a long history of operation dating back to the 1950s. The base of the quarry pit is currently around 17 m AHD at the deepest point, which is more than 100 m below the surrounding ground level. Due to this, the pit represents a local low point in the regional groundwater system, with the seepage and pooling of groundwater at the base where it intersects the watertable. This water is removed via pumping and is likely to have resulted in some drawdown of the watertable towards the nearby Bungalook Creek (GHD 2023).

Boral is proposing to expand the quarry and deepen the pit by a further bench. Due to the proposed expansion GHD was commissioned to undertake a surface water and groundwater assessment to investigate the potential changes to groundwater levels and flow in Bungalook Creek, and recovery of the watertable level during rehabilitation of the quarry (GHD 2023). In part, this assessment determined that the expansion may cause local disconnection between Bungalook Creek and the underlying groundwater which could increase the loss of surface water flow due to leakage from the creek into the groundwater. Groundwater drawdowns are also predicted beneath vegetated land, including the Dr Ken Leversha Reserve adjacent to the quarry (GHD 2023).

GHD (2023) recommended that an assessment be implemented to determine whether the predicted changes in groundwater levels and flow in Bungalook Creek could result in unacceptable risks to groundwater dependent ecosystems (GDEs) and ecological values.

1.2 Scope

GHD Pty Ltd (GHD) was engaged by Boral to undertake an assessment of GDEs and ecological values adjacent to the Montrose quarry and to assess the level of risk associated with the proposed expansion. The aims of the assessment were to:

- Identify the presence of GDEs and ecological values adjacent to the quarry, and the current influence of the quarry on surface water and groundwater dynamics
- Where required, undertake targeted surveys to confirm the presence and extent of GDEs and ecological values that may be impacted by changes in surface water and groundwater dynamics
- Develop a conceptual model illustrating the interactions between surface water, groundwater, GDEs and ecological values
- Undertake a risk assessment to determine if there are unacceptable risks to any GDEs or ecological values due to changes in surface water and groundwater dynamics
- Provide recommendations on the need for any further monitoring or mitigation measures
- Determine the need to refer the quarry expansion project to the Minister of Planning, as outlined in the Victorian *Ministerial Guidelines for Assessment of Environmental Effects* under the *Environment Effects Act 1978,* for a decision on whether Boral is required to undertake an Environment Effects Statement (EES), based on the potential for ecological impacts
- Establish a baseline monitoring program including the monitoring of vegetation condition (tree health and vegetation composition) overtime

Note that following submission of a draft version of this report, our recommendation to undertake further studies of the potential reliance of trees on groundwater was implemented by Boral. EMM was engaged by Boral to undertake a study that included leaf water potential, soil matric potential and water isotope analysis. This version of our report incorporates the findings of the EMM investigation (EMM 2025), including updating the risk assessment framework and conceptual model.

In addition, since the assessment of tree health that was completed in 2023, a bushfire occurred within the study site in March 2025 that impacted many of the trees. Boral engaged GHD to re-assess tree health using the same method applied during collection of baseline condition data (see Appendix B). This report includes the updated tree health data collected in June 2025 following the bushfire.

1.3 Limitations

This report has been prepared by GHD for Boral and may only be used and relied on by Boral for the purpose agreed between GHD and Boral as set out in this report. GHD otherwise disclaims responsibility to any person other than Boral arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations stated in this section and set out in the report.

The site assessment was limited to vascular flora (ferns, conifers and flowering plants). It did not include non-vascular flora (e.g., mosses, liverworts, lichens) or fungi, except where threatened species are known or are suspected to occur, or where bryophytes comprise part of an Ecological Vegetation Class (EVC) benchmark. The assessment of terrestrial fauna was limited to vertebrates, except where threatened invertebrate species are known or suspected to occur.

The opinions, conclusions and any recommendations in this report are based on conditions encountered, observations made, and information reviewed up to the date of preparation of the report. As GHD was only present on specific dates and certain times, this report is only indicative (and not definitive) of flora and fauna present. Flora and fauna (whether in type or quantity) can also change and fluctuate at different times throughout the year (due to factors including seasonal changes, external events, or third-party intervention), and it is generally not possible to observe such changes or fluctuations where only discrete site visits have taken place. GHD has no responsibility or obligation to update this report to account for events or changes occurring after the date the report was prepared.

GHD has prepared this report based on information provided by Boral and others (including Government authorities). GHD has not independently verified or checked this information beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. GHD has not checked or verified information or conclusions contained in the *Montrose Quarry Extension. Groundwater Dependent Ecosystem Assessment: Field Summary* (EMM 2025).

1.4 Exclusions

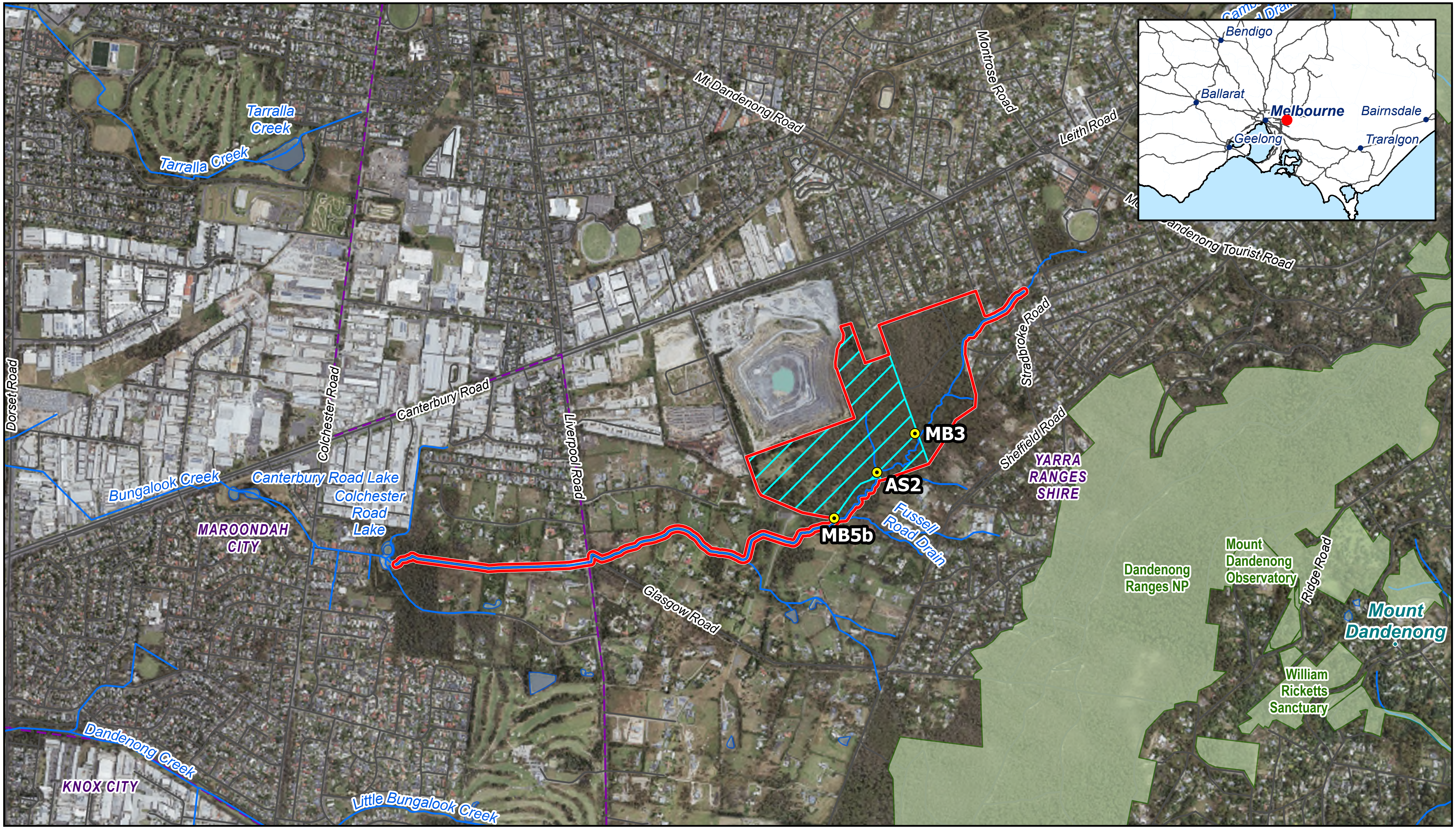
The scope of works did not include:

- Assessment of hypogean (i.e., underground) ecosystem and associated values such as stygofauna
- Determination of environmental approval requirements (other than *Environment Effects Act 1978*) or preparation of environmental approval documentation
- Targeted surveys for all possible threatened flora and/or fauna species
- The risk assessment is limited to hydrogeological and hydrological changes and does not constitute a full risk assessment for the proposed quarry upgrade (i.e., does not include other potential impacts of the upgrade not associated with groundwater/surface water changes, such as direct removal of native vegetation within the proposed quarry location)

1.5 Other acknowledgements

GHD acknowledges the assistance, advice and/or information provided by the following:

- Boral for providing access to the site and other information and reports relevant to the study site
- The Victorian Department of Energy, Environment, and Climate Action (DEECA) for access to the VBA database and NatureKit 2.0 Map Tool
- The Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) for access to its Protected Matters Search Tool (PMST) and Species Profiles database (SPRAT)
- The Bureau of Meteorology for access to the Groundwater Dependent Ecosystem Atlas
- Tarmo Raadik (Arthur Rylah Institute - DEECA) for advice regarding threatened invertebrates



Legend

- Study site
- EH & P Study area
- Groundwater Bores
- Watercourse
- Waterbody
- Parks and Reserves
- Local government area

Paper Size ISO A4

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

GHD

BORAL
Groundwater Dependent Ecosystem Investigation

Study Site

Project No. **31-12611238**
Revision No. **1**
Date **29/07/2025**

FIGURE 1

\\ghdnet\ghd\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_001_StudySite
Print date: 29 Jul 2025 - 10:44

Data source: EHP (2023); VicMap (2023); MetroMap (2023); GHD (2023). Created by: tworth

2. Methods

The Australian Government *Australian Groundwater-Dependent Ecosystems Toolbox Part 1: Assessment Framework* (Richardson et al. 2011) includes a three-stage approach to identify GDEs, determine the reliance of those ecosystems on groundwater, and determine possible changes to ecosystem state or function due to changes in the groundwater environment. Similarly, the NSW Government *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al. 2012) provides detailed methods for defining, identifying, and assessing ecological values associated with GDEs. In this assessment a modified method has been used based on these two approaches, with the main stages presented in Figure 2. The approach adopted for each of these stages is discussed in the following sections.

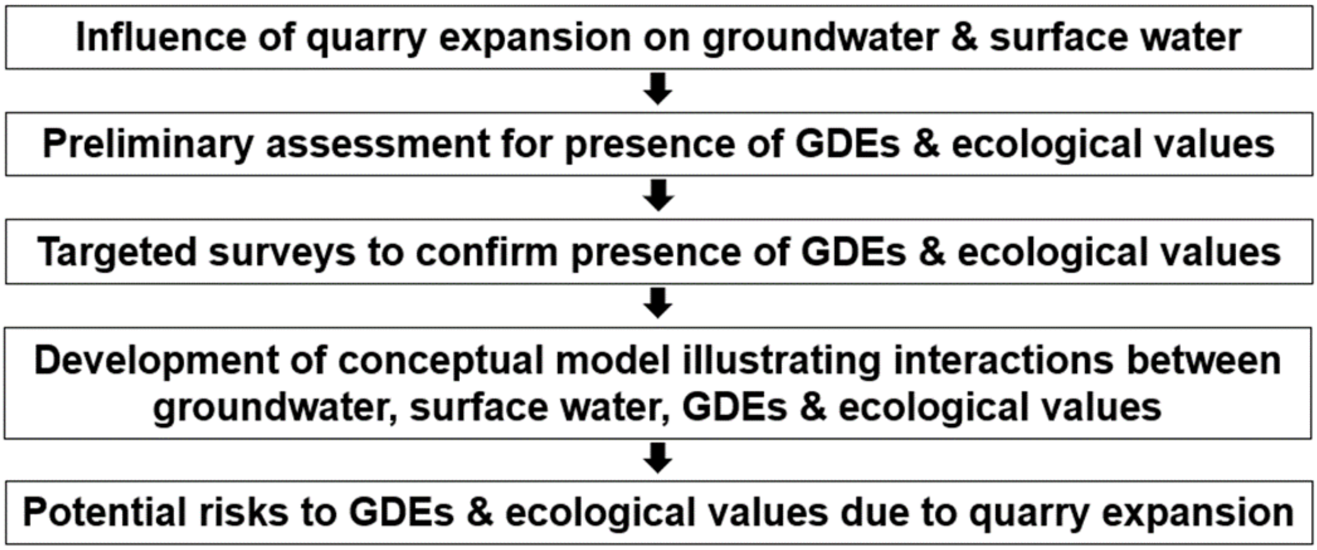


Figure 2 Stages used in the GDE assessment

2.1 Influence of quarry expansion on groundwater and surface water

The existing surface water and groundwater dynamics in the vicinity of Montrose Quarry, and predicted changes due to the quarry expansion, are detailed in the *Surface Water and Groundwater Assessment* (GHD 2023). This assessment included interactions between surface water and groundwater under existing conditions, numerical groundwater modelling to quantify the potential impacts of the expansion on groundwater and flow in Bungalook Creek, and water level recovery during rehabilitation. Findings from the GHD (2023) assessment report were considered throughout this report.

2.2 Preliminary assessment for presence of GDEs and ecological values

The preliminary assessment for the presence of GDEs and ecological values was undertaken using a desktop assessment, and a preliminary site assessment. Findings from the desktop assessment and preliminary site assessment were used to inform the need for targeted surveys of GDEs and ecological values (see Section 2.3).

2.2.1 Desktop assessment - GDEs

Richardson et al. (2011) and Serov et al. (2012) state that an initial identification of ecosystems that potentially use groundwater can be determined using landscape mapping and site-specific information. Landscape-scale mapping involves landscape/regional datasets and is based on the principle that biophysical characteristics can be used as indicators to identify potential GDEs (Richardson et al. 2011). A national example of a landscape mapping tool is the Bureau of Meteorology GDE Atlas that was developed as part of a National Water Commission project. The GDE Atlas was interrogated to determine the presence of potential GDEs in the study area.

Limitations of the GDE Atlas include that it is based upon regional information, its accuracy at a local scale is uncertain, and the coarse-scale mapping may not allow detection of small GDEs (Richardson et al. 2011; Serov et al. 2012). Due to this it should only be used as a first pass in a GDE assessment, and ground-truthing and further assessment of the defined area of interest (i.e., study site) should be undertaken by a team of specialists with geological, hydrological, and ecological expertise (Richardson et al. 2011; Serov et al. 2012). The geological and hydrological components were considered in the surface water and groundwater assessment by GHD (2023). Ground-truthing of the ecological components were undertaken during the preliminary site assessment (Section 2.2.3) and targeted surveys (Section 2.3).

2.2.2 Desktop assessment – ecological values

A desktop assessment of ecological values known or predicted to be present within the study area (10 km buffer around the study site) was undertaken and included, but not limited to, a review of the following reports, government databases and spatial datasets:

- Commonwealth EPBC Act Protected Matters Search Tool (PMST) that is maintained by the Department of Climate Change, Energy, the Environment and Water (DCCEEW 2023)
- The Victorian Biodiversity Atlas (VBA: Version 3.2.6) that is maintained by the Department of Energy, Environment and Climate Action (DEECA 2023)
- Third Benchmark of the Index of Stream Condition (ISC) Report (DEPI 2010)
- NatureKit that is maintained by DEECA (DELWP 2021) and includes:
  - Ecological Vegetation Classes (EVCs) (DEECA 2023)
  - Landcover layer
  - Aerial imagery of the study site
- Previous project reports including:
  - Biodiversity Assessment Report for the Montrose Quarry Expansion (E&HP 2022)
  - Surface Water and Groundwater Assessment - Montrose Quarry (GHD 2023)
  - Bungalook Creek Surface Water Assessment - Existing Conditions Assessment & Ecological Risk Assessment (Ecological Engineering 2007)
  - Hanson Construction Materials Pty Ltd v Head, Department of Jobs Precincts and Regions [2023] VCAT 49 decision (17 January 2023)
- Other sources of information, as listed in Section 7.

2.2.3 Preliminary site assessment

The preliminary ecological site assessment was undertaken by a range of GHD specialists (i.e., botanists, zoologists and aquatic ecologists) on 23 August 2023 to verify the accuracy of the desktop information and characterise the ecological values in the study site. This was done by:

- Confirming and mapping dominant EVCs in relevant areas not included in previous surveys (e.g., E&HP 2022)
- Describing each EVC and GDE (e.g., collating list of dominant flora species, review of water requirements of dominant flora species, and highlighting species that may be reliant on groundwater)
- Determining the presence of suitable habitat for threatened species and their likelihood of occurrence
- Recording the location of any listed ecological communities

- Assessing Bungalook Creek instream habitat and waterway structure (i.e., pool/riffle features, aquatic fauna habitat and in-channel modifications)
- Opportunistic searches for fauna and other signs of animals occupying the site (e.g., presence of tree hollows, tracks, scats, etc.)
- Collecting an inventory of incidental observations of native and non-native flora and fauna seen during the site assessment
- Recording areas of threatening processes including dieback of vegetation, major weed and/or pest animal invasions, and barriers to aquatic fauna movement
- Identifying significant weed species and infestations, including those declared under relevant state and national legislation, policy or strategy (e.g., *Catchment and Land Protection Act 1994* and National Weeds Strategy)

2.2.4 Likelihood assessment and water dependency

Based on findings from the desktop and preliminary site assessment, the likelihood of the presence of GDEs and each species or community of conservation significance occurring within the study site was assessed.

Richardson et al. (2011) and Serov et al. (2012) pose a series of questions the help determine the likelihood of an ecosystem being reliant on groundwater (see Appendix A). Some of the questions are not relevant to this assessment (e.g., those related to estuarine, marine or hypogean ecosystems), cannot be answered in a short timeframe (e.g., long-term monitoring to detect wetland seasonality), or are out of scope (e.g., chemical analysis to determine groundwater contributions to surface water). The types of questions that were considered in this assessment are aimed at answering whether there are GDEs within the study site, and whether they rely on the surface expression of groundwater or the sub-surface presence of groundwater.

The likelihood of each species or community of conservation significance under the EBPC Act or FFG Act occurring within the study site was assessed on the basis of their history of occurrence and habitat requirements. For each species or community, the presence of suitable habitat within the study site was determined, along with the approximate extent of suitable habitat within the broader context of the surrounding landscape. This was compared with how often and how recently each species or community had been recorded (if at all) within the study site or within 10 km of the study site. Resources such as the VBA database and NatureKit were used to help determine likelihood of occurrence.

Following the likelihood assessment, the groundwater and surface water dependency was determined for those species or communities that were determined to be present or possibly present. This was done to identify species or communities that may be potentially impacted by the loss of surface water flow in Bungalook Creek and/or groundwater drawdowns – either directly due to water dependency, or indirectly due to factors such as loss of habitat. Those species or communities deemed to have some degree water dependency and therefore may be impacted by the quarry expansion were considered further in this assessment.

2.3 Targeted surveys to confirm presence of GDEs and ecological values

Based on the outcomes of the desktop assessment and preliminary site assessment, a range of ecological surveys were completed to either fill existing knowledge gaps and/or establish baseline conditions. The surveys were aimed at confirming if there are GDEs and threatened species that need to be considered in future approval pathways. The surveys also allow changes in the health of ecological values (based on baseline conditions) to be tracked overtime through monitoring. Establishing baseline conditions and tracking changes overtime is important as it will allow other influences and impacts to be separated from those potential impacts associated with the quarry expansion.

The targeted surveys focussed on the vegetation communities, as well as flora and fauna of conservation significance, considered to have at least a moderate likelihood of being present in the study site and with some degree of water dependency (see Section 2.2). The results of the targeted surveys were used to update the likelihood of occurrence for those species or communities, where required. The surveys also considered existing threatening processes. A range of surveys techniques were used in the targeted surveys and baseline monitoring for vegetation and details are included in Appendix B. The ecological values surveyed are listed below.

2.3.1 Flora and vegetation values

- Ecological Vegetation Class mapping
- Vegetation composition:
  - Species richness
  - Vegetation cover
  - Water Plant Functional Groups
  - Weed cover and species richness
- Tree health
- Threatened flora:
  - Netted Brake (*Pteris epaleata*) FFG endangered
  - Floodplain Fireweed (*Senecio campylocarpus*) FFG endangered

Leaf water potential, soil matric potential and water isotope analysis

As mentioned in Section 1.2, EMM (2025) undertook an investigation of leaf water potential, soil matric potential and water isotope analysis to identify the extent of the ecohydrological function of GDEs. Further details of methods and results are contained in EMM (2025), but in summary their investigation included:

- Assessment of three mature trees for pre-dawn and midday leaf water potential (LWP) at 12 locations to assist in understanding tree water status and ability to access soil moisture. Collection of twig samples for stable isotope analysis.
- Construction of six auger holes to refusal (maximum depth achieved 3.5 m BGL) to investigate the geological and hydrogeological characteristics underlying the area.
- Undertaking soil logging/lithological descriptions and sampling at approximately 0.25–1 m interval for stable isotope analysis and measurement of soil moisture potential (SMP), also referred to as matric potential, to inform moisture availability down the soil profile.
- Sampling groundwater bores and surface water for stable isotope analysis.
- Stable isotope analysis completed by the ANU Stable Isotope Analysis Laboratory to compare the isotopic signatures of tree xylem, soil moisture, surface water, and groundwater to identify the source or sources of moisture utilised by trees.
- Interpretation of data produced from the field-based investigation and laboratory isotope data alongside scientific literature and expert advice to develop an understanding of potential casual pathway linkages between the key water effecting activities on the groundwater system and associated potential GDEs.
- Development of ecohydrological conceptual models to visually represent conclusions drawn from data interpretation and provide the basis for the risk assessment, to be included in the GDE Impact Assessment.

Leaf water potential provides an indicator of water availability and can be used to infer groundwater dependency (EMM 2025). EMM conducted pre-dawn and midday sampling of leaf water potential of canopy eucalyptus species at 12 locations within the study site. These sample sites were selected to provide representative coverage of environmental conditions, assumed depths to groundwater and GDE potential.

Soil matric potential is an indicator of the energy required to extract water from the soil. When compared with leaf water potential, this metric can indicate whether a tree may have limited water availability or has access to saturated soil indicative of groundwater (EMM 2025). EMM collected soil samples at regular depth intervals to determine soil matric potential.

Water isotope analysis can provide an indication of the source of the water that trees are utilising (EMM 2025). EMM collected water samples from surface water (Bungalook Creek), soil and groundwater sources from within the study site. The isotopic signatures of these water samples were compared to the signatures of water contained within plant xylems.

2.3.2 Terrestrial fauna values

– Threatened fauna
  - Brown Toadlet (*Pseudophryne bibronii*) FFG Act (endangered)
  - Southern Toadlet (*Pseudophryne semimarmorata*) FFG Act (endangered)

The EPBC Act-listed Swamp Skink (*Lissolepis coventryi*) (endangered) and Broad-toothed Rat (*Mastacomys fuscus mordicus*) (vulnerable), along with the FFG Act-listed Glossy Grass Skink (Pseudemoia rawlinsoni) (endangered), were also deemed possible to occur within the study site. At this stage of the project, GHD surveyed for the two FFG-listed toadlets - Brown Toadlet and Southern Toadlet - due to their greater dependency on the waterway and to assist with Boral's anticipated approvals timeline.

GHD did not survey for Broad-toothed Rat, Swamp Skink and Glossy Grass Skink at this point in time, as any impact to these species would be indirect (i.e., due to a loss of vegetation and habitat). That is, if there is only a low risk to vegetation and habitat associated with these two species, then surveys may not be required as it may be determined that risks are also low to these species. However, should the risk to vegetation and habitat be deemed high, further assessment may be required to quantify the level of risk to these species. Recommendations are provided in Section 6.4.

2.3.3 Aquatic values

– Dandenong Burrowing Crayfish (*Engaeus urostrictus*) FFG Act (critically endangered)
– Foothill Burrowing Crayfish (*Engaeus victoriensis*) FFG Act (endangered)
– Surface waters including Bungalook Creek (requirements for General Environmental Duty under the Victorian *Environment Protection Act 2017*)

2.4 Development of conceptual models

Conceptual models are tools that formalise the understanding of the major components of a given ecosystem, their interactions, and how ecosystems can be modified by external changes (Richardson et al. 2011). Ultimately, they express the relationships of *cause and effect*, and more generally *how the system works*. Generally, Richardson et al. (2011) suggest a conceptual model provides four functions:

– Clarifies the problem and ensures that the important components and the ecological interactions between them have been identified. It thus ensures that all the participants managing a given ecosystem are working from the same basic understanding as to how that system is structured and functions.
– Identifies the 'knowns' and the 'unknowns', and thus the critical knowledge gaps and where research investment needs to be focused.
– Allows predictions to be made about the likely impacts of different management interventions, and which ones can be eliminated as unlikely to be useful.
– Assists with the design of monitoring programs and selection of appropriate indicators.

A conceptual model of GDEs and ecological values within the study site was developed to illustrate potential interactions and reliance on groundwater and surface water. The model builds on the conceptual models for groundwater and surface water developed by GHD (2023). During development of the conceptual model, a range of factors were considered including:

– The presence and type of GDEs in the study site
– Key species at the study site, particularly threatened species with direct or in-direct groundwater reliance
– Ecosystem response to changes in surface water and groundwater dynamics
– Current risks that may impact GDEs and ecological values

The conceptual model was refined during a workshop with project ecologists and the surface water and groundwater project teams and then refined following EMM (2025). During the risk assessment additional conceptual models were developed illustrating predicted changes to streamflow and groundwater and subsequent potential risks to ecological values.

2.5 Potential risks to GDEs and ecological values due to quarry expansion

A risk assessment was undertaken to identify if changes in surface water and groundwater dynamics could result in unacceptable risks to GDEs and ecological values. A risk assessment framework was developed as part of the surface water and groundwater assessment undertaken by GHD (2023) which is broadly consistent with the *Australian/New Zealand Standard - Risk Management* (AS/NZS 4360:2004). This framework considered risk to changes to surface water and groundwater quality and quantity, and preliminary risks to GDE and other ecological values. For consistency, this framework was adopted to allow the previously identified risks to be put in the context of GDEs and other ecological values based on the additional work undertaken as part of this assessment. Consideration was also given to specific guidelines related to surface water and groundwater ecosystems including:

– *Guidance for environmental and human health risk assessments of wastewater discharges to surface waters* (EPA publication 1287, May 2023)
– *The Australian Government Australian Groundwater-Dependent Ecosystems Toolbox Part 1: Assessment Framework* (Richardson et al. 2011)
– *The NSW Government Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al. 2012)
– *Preparation of Work Plan and Work Plan Variations – Guidelines for Extractive Industry Projects* (JPR 2020)
– *Ministerial Guidelines for Groundwater Licensing and the Protection of High Value Groundwater Dependent Ecosystems* (DELWP 2015c)

As outlined in EPA publication 1287, there are three main phases in the risk assessment process – Problem Formulation, Risk Analysis and Risk Characterisation. These are discussed further below including how information and data generated through this project has been used in the risk assessment process.

Problem Formulation determines the focus and scope of the risk assessment, including collating of available data and information, identification of risk/impact pathways and sensitive receptors, and development of a conceptual model. The risk pathways were identified by reviewing available data and information; in particular, the surface water and groundwater assessment (GHD 2023). In addition, during the preliminary site assessments and targeted surveys additional risk pathways were considered and included existing threatening processes, weeds, pest animals and areas of tree dieback. The sensitive receptors that these pathways may impact are the GDEs and ecological values identified in this assessment and the conceptual model developed as outlined in Section 2.4. To allow for a precautionary principle to be applied, the risk assessment was based on the 'worst-case scenario' identified by GHD (2023). Background information related to the problem formulation stages of this project are initially considered in Sections 3.1 to 3.2, and summarised in Section 3.3.

Risk Analysis involves consideration of risk pathways and sensitive receptors, and the likelihood and consequence of those pathways occurring. The consequences ratings (Table 2) and likelihood ratings (Table 3) for each pathway are used to determine the risks to sensitive receptors (Table 4). The risk analysis stage of this project is included in Section 3.4.

Ultimately, **Risk Characterisation** is the evaluation and reporting of the problem formulation and risk analysis results for decision-making and risk management purposes. It uses the outcomes of the problem formulation and risk analysis to decide which risks require treatment, and the treatment priorities. In this report, the risk characterisation stage is ultimately covered in Section 5 and 6.

Table 2 Consequence criteria related to native vegetation, flora species or fauna species (Source JPR 2020)

Severity	Consequence
Critical	Damage leading to bioregional, State or national extinction of listed threatened species of native flora or fauna or vegetation community. Irreversible or long-term (years) damage or environment harm to ≥10 ha of native vegetation (not listed threatened vegetation community) or to ≥1 ha listed threatened native vegetation community. Deaths of hundreds (or more) of listed native flora or fauna species or native mammals. Contamination or other environmental damage leading to deaths of native fauna well beyond (>1 km) the boundaries of the operation.
Major	Damage leading to local extinction of listed threatened species of native flora or fauna or vegetation community. Deaths of up to ~100 listed threatened flora or fauna species or native mammals. Major damage or environment harm to 1-10 ha of native vegetation (not listed threatened vegetation community) or to <1 ha listed threatened native vegetation community that will be irreversible or take years to recover from.
Moderate	Damage leading to deaths of a small number of listed threatened flora or fauna species or native mammals. Reversible damage or environmental harm to <10 ha of non-listed native vegetation community or <1 ha of listed native vegetation community.
Minor	Damage to <1 ha of native vegetation (not listed threatened vegetation community) that can be recovered in weeks to months. Damage that affects native fauna populations but does not kill individuals or disrupt breeding or other important ecological processes.
Insignificant	Hazard event with minimal environmental impact and no noticeable effect beyond the immediate occurrence or expression of the hazard.

Table 3 Likelihood categories (Source JPR 2020)

Descriptor	Explanation
Almost Certain	The event is expected to occur in most circumstances. 90% - 100% chance of occurring
Likely	The event will probably occur in most circumstances. 70% - 90% chance of occurring
Possible	The event might occur at some time. 30% – 70% chance of occurring
Unlikely	The event could occur at some time. 5% – 30% chance of occurring
Rare	Highly unlikely, but the risk event may occur in exceptional circumstances. Less than 5% chance of occurring
Eliminated	Risk has been eliminated

Table 4 Risk rating matrix (Source JPR 2020)

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Critical**
Almost Certain	Medium	High	Very High	Very High	Very High
Likely	Medium	Medium	High	Very High	Very High
Possible	Low	Medium	Medium	High	Very High
Unlikely	Low	Low	Medium	High	High
Rare	Low	Low	Medium	Medium	High
Eliminated	Eliminated				

Once the risk rating has been established, some risks will need to have controls in place to reduce them to an acceptable level. Higher risk levels should take priority. Table 5 provides guidance on what steps need to be taken depending upon the risk rating.

Table 5 Risk rating acceptability (Source JPR 2020)

Risk level	Description
Very High	Totally unacceptable level of risk. Controls must be put in place to reduce the risk to lower levels.
High	Generally unacceptable level of risk. Controls must be put in place to reduce the risk to lower levels or seek specific guidance from the Earth Resources Regulator (ERR).
Medium	May be acceptable provided the risk has been minimised as far as reasonably practicable.
Low	Acceptable level of risk provided the risk cannot be eliminated.

3. Results

3.1 Influence of quarry expansion on groundwater and surface water

The existing surface water and groundwater conditions in the vicinity of the Montrose quarry are detailed in the *Surface Water and Groundwater Assessment* (GHD 2023). This section provides a summary of key findings of that assessment, with a focus on the current conditions that may influence GDEs and ecological values, and the potential influence of the quarry expansion. All information in this section is based on GHD (2023) unless otherwise specified.

3.1.1 Aquifer and groundwater flow system

The area around the quarry is comprised of a two-aquifer system that includes alluvial sediments associated with Bungalook Creek and other waterways, and the fractured Palaeozoic rocks that form part of the Mount Dandenong Volcanics Complex (MDVC). The alluvial sediments may have higher permeability than the underlying fractured bedrock, although the permeability and storage potential of the bedrock may have increased in areas that have been subject to faulting, shearing, or weathering.

The regional depth to groundwater is variable across the study area due to topography. Along Bungalook Creek and in the suburbs to the west of Liverpool Road, groundwater levels are less than 5 m deep but are greater than 10 m deep east and north of the quarry. These groundwater depths indicate that it is ‘possible’ that groundwater interacts with terrestrial vegetation (DELWP 2015c). As topography rises in the east and southeast towards Mount Dandenong, groundwater levels become considerably deeper and potentially exceed 50 m. The low rates of groundwater abstraction in the area means that watertable levels in the fractured rocks are predominately influenced by climate and the infiltration of rainfall.

Prior to quarry operations, the groundwater flow direction would have been towards the west/northwest and operation of the quarry would not have significantly altered the regional groundwater flow. However, dewatering of the pit creates a localised depression in the watertable towards Bungalook Creek. Despite this, Boral monitoring bores adjacent the creek indicates groundwater levels are similar to those recorded 19 years previously. This suggests that stream flow events are important to maintaining soil moisture in the alluvials and adjacent MDVC and therefore potentially maintaining GDE accessibility to water. This is despite a significant increase in the quarry pit depth over this 19-year period.

3.1.2 Surface water flow system

There are three named waterways near the quarry, the closest and most significant being the 13 km long Bungalook Creek that drains the northern slopes of Mount Dandenong (refer Figure 1). Bungalook Creek originates north-east of the quarry and generally flows in a westerly direction past the quarry, before joining with Dandenong Creek in Heathmont. Taralla Creek flows in a south-westerly direction and joins Bungalook Creek just upstream of its confluence with Dandenong Creek. Some small tributaries that drain the northwestern slopes of Mount Dandenong also join Bungalook Creek.

Ecological Associates (2007) noted that prior to urbanisation Bungalook Creek was likely to have been ephemeral. However, with increased urbanisation the creek appears to be moving towards a perennial system because of contributions from impervious areas within the catchment.

Flow in the waterways is largely driven by rainfall with higher flows in wetter years. Within a year, flow is highest from around June to October, with the lowest flows occurring from January to March. Ecological Associates (2007) suggest that during March surface runoff can fully provide the flow and that groundwater influence is not significant (and potentially non-existent). During the late summer and early autumn dry periods, flow in the creek can cease.

3.1.3 Interactions between groundwater and surface water

Interactions between groundwater and surface water are complex. Figure 3 shows a thin deposit of alluvial and colluvial sediments, which are generally laterally restricted from the present-day course of Bungalook Creek and other waterways in the study area. Where groundwater levels are above the creek, groundwater would discharge into the creek (i.e., gaining stream). Where the creek bed is above the water table, the creek may lose water to the aquifer (i.e., losing stream). However, this flow direction can change over time due to rainfall and flooding, growth of riparian vegetation (i.e., additional evapotranspiration), or potentially due to changes in groundwater levels associated with quarry operations. Adjacent to waterways, where groundwater levels may be closer to the surface, groundwater losses may also occur through evapotranspiration (i.e., riparian vegetation reduces water levels).

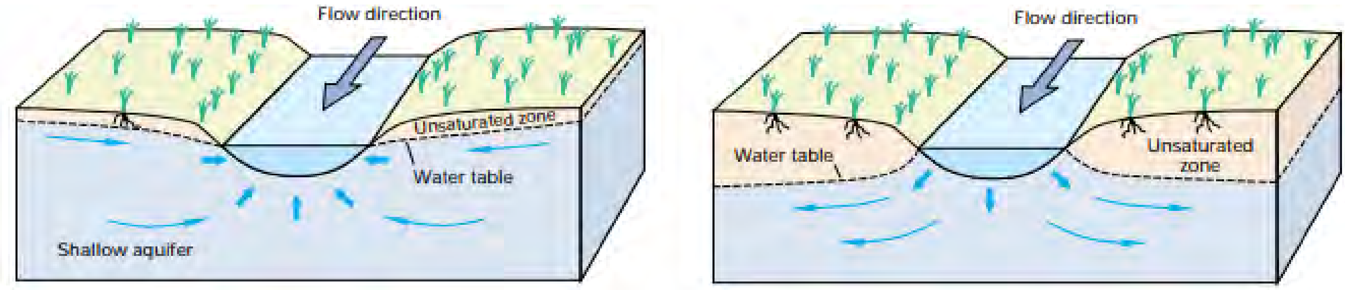


Figure 3 Groundwater and surface water interactions showing a gaining stream (left) and a losing stream (right)

Based on the above, GHD (2023) suggest surface water flows in Bungalook Creek could be derived from three sources:

- **Interflow**, which is the proportion of rainfall that infiltrates below the subsurface and moves laterally through the soil profile before discharging to the waterway. This occurs above the regional watertable (i.e., unsaturated flow).
- **Groundwater** contributions to baseflow. Baseflow is the sustained low flow in a waterway during dry weather conditions and includes contributions from groundwater (saturated flow) and interflow (unsaturated flow).
- **Stormwater** run-off or overland flow, which is the component of rainfall that flows along the ground surface and into the waterway.

The Bungalook Creek flow record from gauge 228369A at Fussell Road provide important insights into the nature of the surface water dynamics. Typically, daily flow rates range from around 0.1 ML/day to 30 ML/day, with a maximum recorded flow of around 250 ML/day. GHD (2023) describe the seasonal variability of flow in Bungalook Creek as follows:

- For most of the time, the water level in the creek (stage) is low, with <0.2 m of water above gauge zero for 90% of the time (i.e., close to the creek bed elevation). This suggests that the difference between the creek elevation and adjacent groundwater level could provide general indications of flow direction between the creek and groundwater under a typical condition.
- During wet days, the water level in the creek can rise rapidly (by 2 to 4 m) but also drains quickly. High flow events, accompanied by a rapid rise in creek level, may initially supply recharge to the water table (i.e., creek is losing). As the creek level quickly recedes, groundwater may locally discharge to the creek as baseflow where the water table is above the creek level (i.e., creek is gaining).
- During dry periods, little to no flow and stage are recorded. This means any flow accumulated from upstream (either from runoff and/or baseflow) is lost to the groundwater system before flow reaches the gauge (i.e., creek is losing).

Overall, GHD (2023) determined that Bungalook Creek is likely to be generally losing at the upstream end of the quarry adjacent to bore MB3, likely to become gaining at the downstream end adjacent to bore MB5b (see Figure 1). Between these two areas there is likely a transitional zone adjacent to bore AS2 where the elevation of the creek and groundwater levels are similar. In this transitional zone the creek is in a loosely gaining or baseflow neutral condition. Furthermore, during the targeted surveys to confirm the presence of GDEs and ecological values, evidence of interflow was also observed (Figure 4). The surveys occurred following a period of high rainfall and there was an obvious discharge of water from the bank into the creek in some areas.

Figure 4 Interflow observed during site assessment of Bungalook Creek

The information currently available suggests that flows in Bungalook Creek are derived from a combination of interflow, groundwater contributions to baseflow, and stormwater run-off or overland flow. However, the contribution to the flows would vary overtime depending on climatic conditions. For example, given the generally small difference in the groundwater level and estimated creek level in the potentially gaining areas, large increases in the creek level during wet days (in the order of 2 to 4 m) are likely to result in the creek temporarily becoming a losing system. Similarly, the lowering of the water table during extended dry periods (such as the Millennium Drought) is likely to result in the water table becoming disconnected from sections of the creek bed, leading to little to no baseflow (with zero flow recorded at the Fussell Road gauge). Despite this, the gauging data indicates that flow in Bungalook Creek is predominantly driven by stormwater run-off or overland flow and that groundwater contributions (baseflow) are small.

Although dewatering of the mine pit creates a localised depression in the water table towards Bungalook Creek, this is only temporary and limited to periods of low flow when there is insufficient leakage to top up the watertable from the creek. Overall, the magnitude and extent of drawdown from historical extraction has not been significant enough to cause major changes to the dynamics of surface water and groundwater interactions along Bungalook Creek. However, under the expansion scenario there are likely to be greater changes due to the potential for a much larger drawdown to extend towards Bungalook Creek.

3.1.4 Predicted changes to surface water and groundwater due to quarry expansion

The proposed expansion would involve widening of the quarry footprint and deepening of the pit over approximately 40 years. This will be followed by rehabilitation, which would include backfilling of the quarry, over five stages, with each typically lasting around 10 years. Dewatering would be required at least to the end of the quarry extraction period to maintain access and safe and stable working conditions. Subject to the rate of groundwater level recovery, some form of dewatering may need to continue to maintain the stability of the internal overburden dump and initial stages of the pit backfilling.

GHD (2023) determined that the maximum groundwater drawdown would occur towards the end of the quarry expansion at around year 40. Based on this, the following sections consider the drawdown during this period as it may represent the greatest risks to GDEs and ecological values. However, GHD (2023) note that the groundwater drawdown is not instantaneous but occurs over the 40-year period and the results represent the net change from a condition where the existing quarry remains in place in perpetuity (i.e., base case).

Note that GHD (2023) modelled changes in surface water and groundwater dynamics using two scenarios with Bungalook Creek receiving baseflow only, and with the creek receiving a combination of baseflow and surface flow. The latter provides a more realistic indication of water table drawdown near the creek and this scenario has been considered in this section.

3.1.4.1 Changes in groundwater level

Due to expansion of the quarry, there is potential for further watertable drawdown near Bungalook Creek. When drawdowns extend such that the groundwater level falls below the streambed, there will be no groundwater contribution to flow in the waterway. Flow may continue to occur as it could be generated from runoff within the broader catchment. However, if there is flow in the waterway but the groundwater level has been drawn down under the streambed, this will create a hydraulic gradient, causing a proportion of this flow to leak downwards and recharge the groundwater system. This in turn influences groundwater behaviour elsewhere. That is, if some flow is lost through leakage, it results in less flow further downstream being available to leak and recharge groundwater in these areas.

The drawdown predicted along Bungalook Creek by year 40 is around 10 m or less (Figure 5). It is limited to this because when the watertable is lowered below the creek level and there is sufficient surface flow, recharge to the watertable occurs from the creek. However, as described above, this recharge leads to less flow reaching the downstream section of Bungalook Creek, resulting in localised drawdown along the creek including a maximum drawdown of around 4 m along Fussell Road.

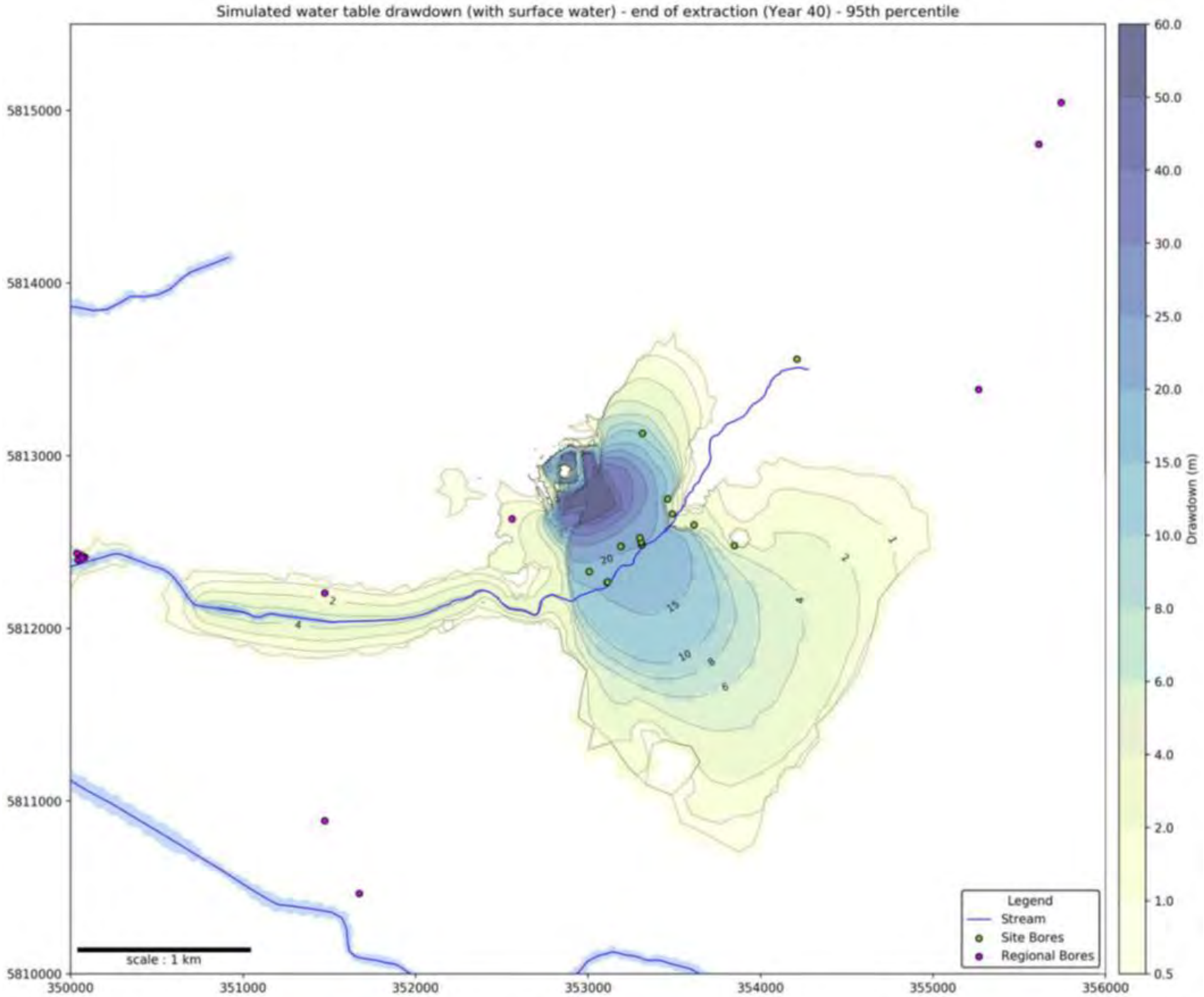


Figure 5 *Simulated water table drawdown at the end of the extraction period based on 95th percentile (Sourced from GHD 2023)*

The drawdown over time will be influenced by rainfall and a maximum drawdown of around 23 m is predicted to occur in year 35 during a dry period when total flow is limited. However, the water table is subsequently replenished by higher flow, with drawdown along Bungalook Creek generally limited to 3 to 10 m, depending on the prevalent climate and flow.

3.1.4.2 Changes in baseflow

GHD (2023) determined that during dry periods, when the total flow is less than 10 L/s, all of the flow is lost as leakage due to the expansion of the quarry and associated drawdown of the watertable. During these low flow periods, the loss of flow in the upstream section of Bungalook Creek results in localised drawdown along the downstream section. The locations of the downstream losses and localised drawdown are shown in Figure 5. A flow of 10 L/s is roughly equivalent to 0.86 ML/day and a flow duration curve for Bungalook Creek indicates that under existing conditions, there is less than 10 L/s for 43% of the time (Figure 6). Given further seepage from the creek into the groundwater is predicted following expansion of the quarry, it is likely all flow in Bungalook Creek will be lost more frequently.

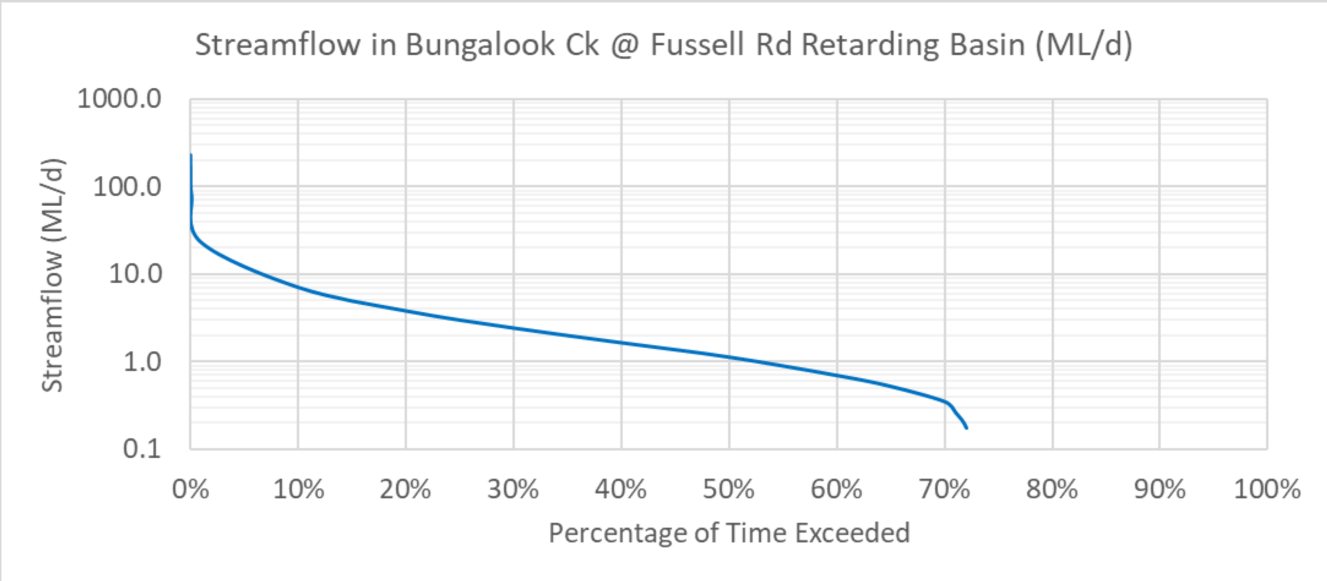


Figure 6 ***Bungalook Creek flow duration curve***

Climate change will also play a role in the surface water and groundwater dynamics in the study site. During dry periods most flow in the creek is predicted to be lost as leakage, resulting in little to no flow in downstream reaches. Even under low climate change conditions, there would be a larger magnitude of flow loss in the creek when leakage is induced due to the quarry expansion. Overall, the expansion of the quarry has the potential to exacerbate the effect of climate change on baseflow, resulting more frequent and longer periods of little to no downstream flow due to induced leakage.

3.2 Groundwater dependent ecosystems and ecological values

The study site falls within the Dandenong Creek Middle Sub-catchment under Melbourne Water's Healthy Waterways Strategy (Melbourne Water 2018). At a sub-catchment scale the following is noted regarding the current state of relevant Melbourne Water key values:

- Birds: Moderate (most expected species occur but some of these are only infrequently recorded)
- Fish: Low (few freshwater native species recorded in the catchment likely to be present)
- Frogs: High (many of the expected species of frog are found)
- Macroinvertebrates: Very low (very low likelihood of sensitive aquatic macroinvertebrate families)
- Platypus: Very low (very low likelihood that waterways will support platypus)
- Vegetation: Low (low naturalness and very low to medium uniqueness)

Figure 7 present the key values, with comment on current and predicted condition over 10-50 years. Although the data is presented at a sub-catchment level (i.e., beyond the study site), it provides context for values that require protection within the catchment and an expected trajectory based on current threats and future management actions.

Current state	Current trajectory	Target trajectory	
mod.	mod.	mod.	Birds (riparian) score is moderate, meaning most of the expected species occurred but some of these were only infrequently recorded. Despite the effects of climate change adequate investment in targeted management, such as riparian revegetation, should ensure the riparian bird score is maintained at moderate. Significant species include the powerful owl and eastern great egret.
low	mod.	mod.	Fish are currently rated as low due to lack of suitable habitat (instream and riparian). This is largely a result of extensive urbanisation, stormwater and barriers to fish movement. The increased current trajectory score is due to climate change increasing habitat suitability for common and widespread species. Improvements to riparian vegetation, stormwater and fish passage will provide suitable habitat for a wider range of species and contribute to a moderate rating in the long term. Threatened dwarf galaxias are known to occur in the sub-catchment.
high	mod.	high	Frog score is high since most of the expected species of frog were recorded. With dedicated management the score should be maintained at high.
very low	very low	very low	Macroinvertebrates score is very low due high levels of urbanisation which have impacted all the environmental conditions which support this value. While improvements to stormwater and vegetation over the long term may increase macroinvertebrates in some locations, score is unlikely to improve.
very low	very low	very low	Platypus score is very low as a result of large-scale urbanisation which has resulted in a lack of suitable instream and riparian habitat. If conditions improve and the population within the Corhanwarrabul Creek sub-catchment also improves then the population may expand back into middle Dandenong Creek in the long term.
low	very low	mod.	Vegetation is low as much of the riparian vegetation is degraded from extensive land use modification. Without management of existing threats like pest plants and animals and in the face of climate change score is likely to drop to very low. Improvements along priority reaches are expected to increase score to moderate in the long term.

Figure 7 Melbourne Water Key Values for Dandenong Creek Middle Sub-catchment (10 - 50 year targets) (Melbourne Water 2018)

This assessment has taken each of Melbourne Water's key values into consideration – in terms of their likelihood of occurrence, current state at a local scale and potential for impacts due to groundwater drawdown due to the quarry's expansion.

3.2.1 Groundwater dependent ecosystems

The Bureau of Meteorology GDE Atlas suggests that Bungalook Creek has a high potential of being a GDE, and that there are some areas of vegetation in the vicinity of the quarry with low to moderate potential of being GDEs (Figure 8).

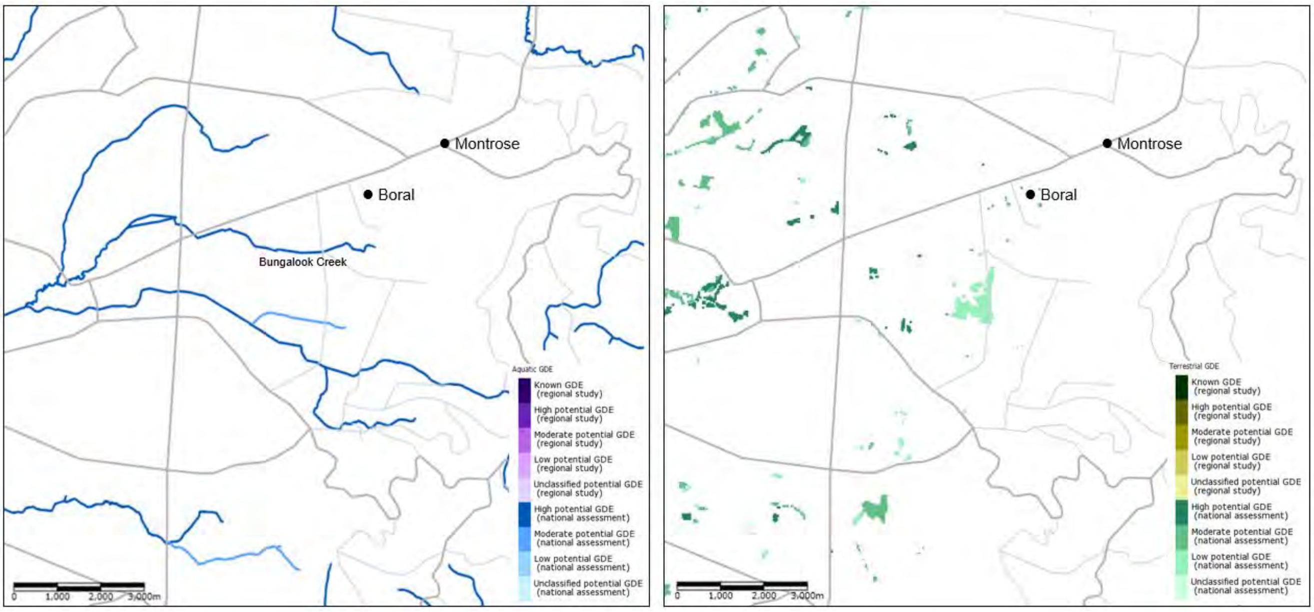


Figure 8 Bureau of Meteorology GDE Atlas results showing potential locations of aquatic GDE (left) and terrestrial GDEs (right)

Based on the definitions of GDEs outlined in Appendix A, the following types of GDEs are potentially present within the study site:

- Ecosystems that depend on the surface expression of groundwater.
  - Permanent or ephemeral stream systems that receive seasonal or continuous groundwater contribution to flow as baseflow (i.e., Bungalook Creek). Interactions depend on the nature of the streambed and underlying aquifer, and the relative water level heads in the aquifer and the stream.
- Ecosystems that depend on the subsurface presence of groundwater.
  - Terrestrial vegetation such as trees and woodlands supported seasonally or permanently by groundwater. These may comprise shallow or deep-rooted communities that use groundwater to meet some or all their water requirements. Animals may depend on this vegetation and therefore indirectly depend on groundwater.

To confirm groundwater-dependence of the creek and vegetation (and other ecological values), and to gather information required to address the questions posed in Appendix A, the following sections discuss the ecological values in the study site.

3.2.2 Aquatic fauna and habitat

3.2.2.1 Mapped wetlands

There are no wetlands mapped as a Current Wetland by DEECA on the Native Vegetation Information Management system online tool. No Ramsar sites were identified within the study area. The nearest Ramsar site is Edithvale-Seaford Wetlands which is located approximately 35 km southwest of the Boral Montrose quarry.

3.2.2.2 Aquatic habitat

The context for waterway/wetland habitat here is aquatic fauna and terrestrial fauna habitat in relation to these waterways is described in Section 3.2.2. The key waterway habitat for aquatic fauna within the study site is Bungalook Creek. Overall, the waterway was generally narrow and shallow with the substrate dominated by silt and clay. Except for isolated areas, there was little instream vegetation with many areas dominated by terrestrial weeds. However, there were some changes along the creek, predominately due to adjacent land use and the degree of urbanisation. There was no evidence of dense stands of filamentous algae, which suggests excessive nutrients are not a current issue in the waterway. Shading in areas upstream of Fussell Road would also aid in preventing algal growth.

Sites BUN01 and BUN02 (upstream reaches of Bungalook Creek)

Upstream of the Dr Ken Leversha Reserve, the waterway flows through semi-urban areas with limited riparian vegetation in some areas (Site BUN01 (Figure 9; Plate 1 & Plate 2)). There is limited instream vegetation in this area and the banks are typically weedy and degraded. There is only low value habitat for aquatic fauna. Further downstream within Dr Ken Leversha Reserve, the riparian vegetation resembles a more natural condition and there is a greater proportion of habitat complexity in the form of large woody debris and over-hanging vegetation along both banks (BUN02 (Figure 9; Plate 3 & Plate 4)). An increase in shading due to the canopy cover has contributed to an increase in moss and is expected to reduce water temperatures and associated decreases in dissolved oxygen during hotter periods. The presence of undercut banks provides further habitat complexity and overall, this area contains suitable habitat for small-bodied native fish and other aquatic fauna.

Sites BUN03 and BUN04 (adjacent to Montrose quarry)

Similar to areas within Dr Ken Leversha Reserve, Bungalook Creek adjacent to the Montrose quarry also contains a largely native riparian zone that contributes to habitat complexity (Sites BUN03 and BUN04 (Figure 9; Plate 5 - Plate 8)). However, a greater proportion of weeds are present in this area, when compared to the Dr Ken Leversha Reserve. The creek is generally narrow and mainly composed of shallow run/riffle areas although there were some deeper pool areas in several locations that may provide a drought refuge for aquatic fauna during low flow periods (Site BUN03 (Figure 9; Plate 5 & Plate 6). There were also some areas where the channel had braided (Plate 9) and at the end of Fussell Road there was a swampy area with dense stands of vegetation including Common Reeds (*Phragmites australis*) and Cumbungi (*Typha* sp.) (Plate 10). This was the only area that contained native instream vegetation that was observed between Fussell Road and the upstream extent of Bungalook Creek.

Sites BUN05 and BUN06 (between Montrose quarry and Colchester Road Retarding Basin)

Further downstream at Liverpool Road the creek entered a more developed area including residential and industrial land uses (Site BUN05 (Figure 9; Plate 11 & Plate 12)). This area of the creek was highly disturbed, with evidence of deep incision, little riparian vegetation and the banks dominated by weeds and exotic vegetation. Downstream of Liverpool Road the channel has been artificially straightened with the banks stabilised with rocks. The influence of the more urbanised area was apparent, with an increase in litter. There was little quality aquatic habitat in this area.

Prior to entering the Melbourne Water retarding basin near Colchester Road there was less understorey vegetation along the banks of Bungalook Creek and little instream habitat (Site BUN06 (Figure 9; Plate 13)). With the exception of some native trees and shrubs, most of the vegetation along the banks was terrestrial species and weeds. The retarding basin itself was dominated by dense vegetation including Common Reeds (*Phragmites australis*) and Cumbungi (*Typha* sp.).

A number of barriers to aquatic fauna passage exist within and downstream from these sites (see Section 3.2.5.4 – *Barriers to aquatic fauna passage*).

Plate 1 Bungalook Creek upstream Dr Ken Leversha Reserve (Site BUN01)

Plate 2 Bungalook Creek upstream Dr Ken Leversha Reserve (Site BUN01)

Plate 3 Bungalook Creek within Dr Ken Leversha Reserve (Site BUN02)

Plate 4 Bungalook Creek within Dr Ken Leversha Reserve (Site BUN02)

Plate 5 Pool in Bungalook Creek adjacent to Montrose quarry (Site BUN03)

Plate 6 Pool in Bungalook Creek adjacent to Montrose quarry (Site BUN03)

Plate 7 Bungalook Creek adjacent to Montrose quarry (Site BUN04)

Plate 8 Bungalook Creek adjacent to Montrose quarry (Site BUN04)

Plate 9 Braided Bungalook Creek adjacent to Montrose quarry

Plate 10 Swampy Tall Marsh habitat downstream of Montrose quarry

Plate 11 Bungalook Creek upstream from Liverpool Road (Site BUN05)

Plate 12 Bungalook Creek at Liverpool Road

Plate 13 Bungalook Creek upstream retarding basin (Site BUN06)

Plate 14 Bungalook Creek at Colchester Road retarding basin

3.2.2.3 Water quality

Water quality results are presented in Table 6. In terms of suitability of water quality to protect the integrity and biodiversity of water dependent ecosystems, the following observations were made:

– pH values at all sites were within the range specified by the Victorian Government (2021) Environment Reference Standard (ERS).
– Conductivity/salinity concentrations were elevated above the ERS objective at sites BUN01 and BUN02 – possibly an indication of groundwater or a point-source input at these localities.
– Dissolved oxygen saturation was below the ERS objective at sites BUN01 and BUN04, noting that these results may be an artefact of sample measurements being taken in the morning, when photosynthesis is lower.
– Turbidity levels were elevated above the ERS objective at sites BUN05 and BUN06 – potentially as a result of road run-off and or erosion of bare banks (e.g. see Plate 11 and Plate 13).

Table 6 Water quality (in situ) results – Bungalook Creek

Site	Temperature (ºC)	pH (pH units)	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	Turbidity (NTU)
BUN01	17.6	7.1	900	5.9	62.0	11
BUN02	17.2	7.7	607	9.0	94.2	11
BUN03	16.9	7.2	412	7.2	72.3	7
BUN04	16.8	7.2	412	6.6	67.9	10
BUN05	17.6	7.3	462	8.2	86.1	40
BUN06	17.6	7.5	406	8.4	88.0	42
ERS objective (urban segment)	n/a	≥6.4 to ≤7.9	≤500	n/a	≥70% (max 130%)	≤35 NTU

Note: red cells do not meet the ERS objective.

3.2.2.4 Waterway health assessment

The macroinvertebrate biological index results are presented in Table 7.

– SIGNAL-2 scores indicate that the macroinvertebrate community at all sites surveyed met ERS objectives – indicating a relatively high proportion of pollution-sensitive taxa remain within these reaches, when considering that the waterway is located within an urban environment.

– Likewise, the number of 'EPT' taxa generally met the ERS objective – with Site BUN02 being the only site not to meet the objective of three taxa.

– In terms of diversity, sites BUN02 and BUN06 did not meet the ERS objective but all other sites met the objective of 16 families being present.

– All sites met the objective for AUSRIVAS grading (grade B), which indicates that the families collected during the survey are generally those that would be expected within the local region, but that potential impacts on water or habitat quality have led to a loss of families.

The ERS objectives take into account that waterways within urban areas face a range of stressors (e.g. stormwater input) which are known to reduce diversity within waterways (see for example, Walsh et al. 2007).

The ERS does not include objectives for the AMFI/rheophilly index, but this index has been included to provide an understanding of how reliant the existing macroinvertebrate community is on flowing water. The sites scored between 3 and 4.6 (with the index allowing for scores of 1-10). Across all sites, the percentage of taxa that prefer flowing habitat (i.e. index >5) averaged 25% and those with less dependence on flow (index ≤5) averaged 75%. As such, the results indicate that there are some obligate flow-dependent taxa present, but that the majority of the community at the time of sampling have a preference for lower flow conditions.

Of the sites surveyed, sites BUN03 and BUN04 (in the vicinity of the Boral Montrose quarry) are considered to have the best aquatic ecosystem health, based on both sites meeting all ERS objectives, and in general, supporting higher numbers of pollution-sensitive taxa and consistently higher diversity across the two sites surveyed.

Poor habitat quality (i.e. very low water levels) likely contributed to lower scores are site BUN02. Poor habitat and existing impacts (i.e. a greater proportion of urbanisation in the local catchment, less in-stream aquatic habitat and a more degraded riparian zone) were observed at sites BUN05 and BUN06 likely contributed to lower aquatic ecosystem health in these downstream reaches.

At a sub-catchment scale, the Dandenong Creek Middle Sub-catchment is classified as being in 'Very Low' condition based on macroinvertebrates as a key value (Melbourne Water 2018). However, where habitat is less degraded, Bungalook Creek does support a relatively diverse and pollution-sensitive macroinvertebrate community that meets environmental objectives for an urban waterway.

Table 7 Biological index results – Bungalook Creek

Site	SIGNAL-2	Number Families	EPT	AUSRIVAS OE50	AUSRIVAS Band	AMFI (rheophily) index	% taxa with rheophily scores ≤5	% taxa with rheophily scores >5
BUN01	3.8	26	3	0.72	B	3.6	77	23
BUN02	4.9	12	2	0.72	B	4.6	67	33
BUN03	4.6	21	4	0.80	B	3.6	78	22
BUN04	4.3	24	4	0.72	B	3.3	76	24
BUN05	4.4	18	3	0.72	B	3.7	68	32
BUN06	3.9	14	3	0.48	B	3.0	81	19
ERS objective (urban segment)	3.2	16	3	n/a	B	n/a	n/a	n/a

Note 1: red cells do not meet the ERS objective.

Note 2: index results are based on average across duplicate samples (as per EPA 2021) or lowest grading of the duplicates for AUSRIVAS.

3.2.2.5 Fish community

Two fish species were recorded during the fish survey at Site BUN04 (Figure 9).

- *Galaxias coxii* (Climbing galaxias) (Plate 15)
- *Anguilla australis* (Short-finned eel)

Both species recorded are native and non-threatened. The reaches of Bungalook Creek surveyed therefore support native fish as water-dependent environmental values, but the fish community is characterised by low abundance and diversity – likely due to poor connectivity in the upper reaches of Bungalook Creek. Both Climbing galaxias and Short-finned eel have the capacity to navigate in-stream barriers, which have been noted within the Bungalook catchment.

No fish were observed at other sites, with very low water levels at Site BUN02 both restricting sampling access but also reducing the likelihood of fish being present due to poor connectivity and a lack of refuge pools. In terms of by-catch, large abundances of *Cherax destructor* (Freshwater yabbies) were recorded at site BUN05.

Based on field and desktop assessments there is a low likelihood of other species being present, including threatened species.

Plate 15 Galaxias coxii – Bungalook Creek, 13 December 2023

3.2.2.6 Burrowing crayfish survey

The survey focused on the potential drawdown area, as indicated by GHD (2023). Within this area (~1000 m^2) approximately 50 burrow openings were observed (Plate 16).

Two specimens of the non-threatened Central Highlands Burrowing Crayfish (*Engaeus affinis*) were recorded (Figure 9). Identification was based on a lack of sternal pores (Plate 17, left) and antennae extending beyond the carapace, presence of long bristle setae and rostrum shape (Plate 18, right).

Survey effort equated to a ~2% capture rate (two individuals ÷ (35 traps x 3 nights) x 100). Although no accurate data is available to allow for a comparison of population densities between sites, Bryant et al. (2014) recorded a capture rate of 8.8% using the same methods during studies to assess the effectiveness of Burrowing crayfish survey methods. Similar survey effort completed by GHD (unpublished data) has resulted in capture rates of 1-2%.

Burrowing crayfish are thought to be most active at the burrow entrance during the breeding season and following wet conditions (July to December). Whilst collection of more data to confirm this is warranted, surveys should coincide with these periods to maximise crayfish detectability (Bryant et al. 2012). The December surveys were carried out during optimum conditions (i.e. warm temperatures and following rainfall) and as such the survey can confirm that:

– Timing of surveys were suitable to capture Burrowing crayfish during their most active period
– The study site likely supports low abundances of Burrowing crayfish and that this survey provides an indication of baseline conditions, allowing for the survey to be repeated using the same methods, if required

Plate 16 Engaeus sp. crayfish burrows observed along Bungalook Creek

Plate 17 Central Highlands Burrowing Crayfish Engaeus affinis – Bungalook Creek, 13 December 2023

- Study Site
- Fish survey
- Recorded species
- Burrowing crayfish trapping location
- Waterbody
- Watercourse

Macroinvertebrate Survey location

Biological Index Compliance (%)

- 76 - 100%
- 51 - 75%
- 26 - 50%

Paper Size ISO A4

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

BORAL
Groundwater Dependent Ecosystem Investigation

Aquatic Surveys

Project No. 31-12611238
Revision No. 3
Date 18/07/2024

FIGURE 9

\\ghdnet\ghd\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_00X_AquaticSurveys_A4L_Rev0
Print date: 18 Jul 2024 - 11:48

Data source: VicMap (2023); GHD (2023). Created by: sblades

3.2.2.7 Aquatic fauna of conservation significance

A likelihood of occurrence assessment (Appendix E) has been completed for all threatened species which have the potential to occur within the study area. The following sections discuss results of the assessment.

***Environmental Protection and Biodiversity Conservation Act 1999* – threatened species**

Of EPBC Act listed species, none are expected to be present in the study site based on field and desktop assessments. As such, they have not been considered further in this assessment.

***Flora and Fauna Guarantee Act 1988* – threatened species**

Desktop assessments (see Appendix E) and field surveys indicate that one FFG Act-listed *Engaeus* (Burrowing crayfish) species has been recorded within the study area:

– *Engaeus victoriensis* (Foothill Burrowing Crayfish) (Endangered)

The results of the targeted survey cannot discount the presence of the threatened Tubercle Burrowing Crayfish or Dandenong Burrowing Crayfish from the study site due to the low capture rates during the survey and due to the overlap in the species' ranges and the suitability of habitat present. As such, the following are considered to possibly occur:

– *Engaeus urostrictus* (Dandenong Burrowing Crayfish) (Critically Endangered)
– *Engaeus tuberculatus* (Tubercle Burrowing Crayfish) (Endangered)

The three threatened species' have a small home range and would be expected to be present all year. Except for the Tubercle Burrowing Crayfish, these crayfish are considered likely to be dependent on habitats that are groundwater-dependent to some degree, depending on depth of groundwater and their burrowing ability. A preliminary assessment of dependence of each species on groundwater at this study site is presented in Table 8.

Table 8 Dependence of aquatic fauna listed as threatened under the FFG Act on surface water or groundwater

Common name	Scientific Name	FFG Act status	Dependence of species on surface water (waterways) or groundwater
Dandenong Burrowing Crayfish	*Engaeus urostrictus*	Critically Endangered	**High dependency**. A small burrowing crayfish restricted to Dandenong Ranges near headwaters of small streams (DELWP 2015). Burrow systems have tunnels which descend to the water table to a depth of around 0.5 m, allowing the crayfish to follow the rise and fall of the water table (Horwitz et al. 1985). Surface and ground water reductions arising from drought and water extractions/diversions may limit habitable area for the species (DELWP 2015).
Tubercle Burrowing Crayfish	*Engaeus tuberculatus*	Endangered	**Low dependency**. Microhabitats can be divided into flood-bed and clay-dominated hill slopes. Occupies banks and hill slopes and has burrows independent of the water table being wholly reliant on surface water runoff (Horwitz et al. 1985).
Foothill Burrowing Crayfish	*Engaeus victoriensis*	Endangered	**High dependency**. Found in large, cavernous burrows in grey, clay-dominated soils in temperate, wet sclerophyll forest at the foot of the Dandenong Ranges. Little is known about the habitat preferences of the species, so a conservative approach has been used and the dependence on surface or groundwater is considered high.

3.2.3 Vegetation

3.2.3.1 Ecological Vegetation Classes

Nine EVCs were recorded within the study site (Figure 10). Of these, three are considered potential GDEs, particularly where groundwater is relatively shallow (i.e., mid-stream of Bungalook Creek abutting the proposed quarry upgrade):

– EVC 29 Damp Forest (least concern)
– EVC 17 Riparian Scrub/Swampy Riparian Woodland Complex, which is a mix of Riparian Scrub (EVC 191) and Swampy Riparian Woodland (EVC 83)
– EVC 83 Swampy Riparian Woodland

Table 9 lists the location of the EVCs mapped within the study site and a brief description of each EVC. The dominant EVCs mid-stream are EVC 29 Damp Forest and EVC 17 Riparian Scrub/Swampy Riparian Woodland Complex, which is a mix of Riparian Scrub (EVC 191) and Swampy Riparian Woodland (EVC 83). The latter two EVCs occur intermittently and are very patchy in distribution, sometimes characteristic species of both EVCs occurring together, thus forming a complex.

3.2.3.2 Water requirements of characteristic species

The dominant flora species within each of the above-mentioned EVCs vary in root depth and water requirements. Table 10 provides an overview of dominant flora species found within the study site, their typical root depth and potential water requirements (i.e., assigned Plant Functional Group; PFG as defined in Table 1 in the Glossary). This information was then used to identify which species have higher water requirements and thus may be more reliant on current surface water and/or groundwater levels.

Deep rooted trees (e.g., Messmate and Swamp Gum) may source some water directly from the groundwater owing to their deep root systems. Trees fringing the waterway would also source water directly from surface water in Bungalook Creek but are likely to be mostly dependent on replenishment of soil moisture through seepage and rainfall in this region. Groundwater may be important during dry periods that have prolonged periods without rainfall. Groundwater use may also increase when groundwater table rises during high rainfall events.

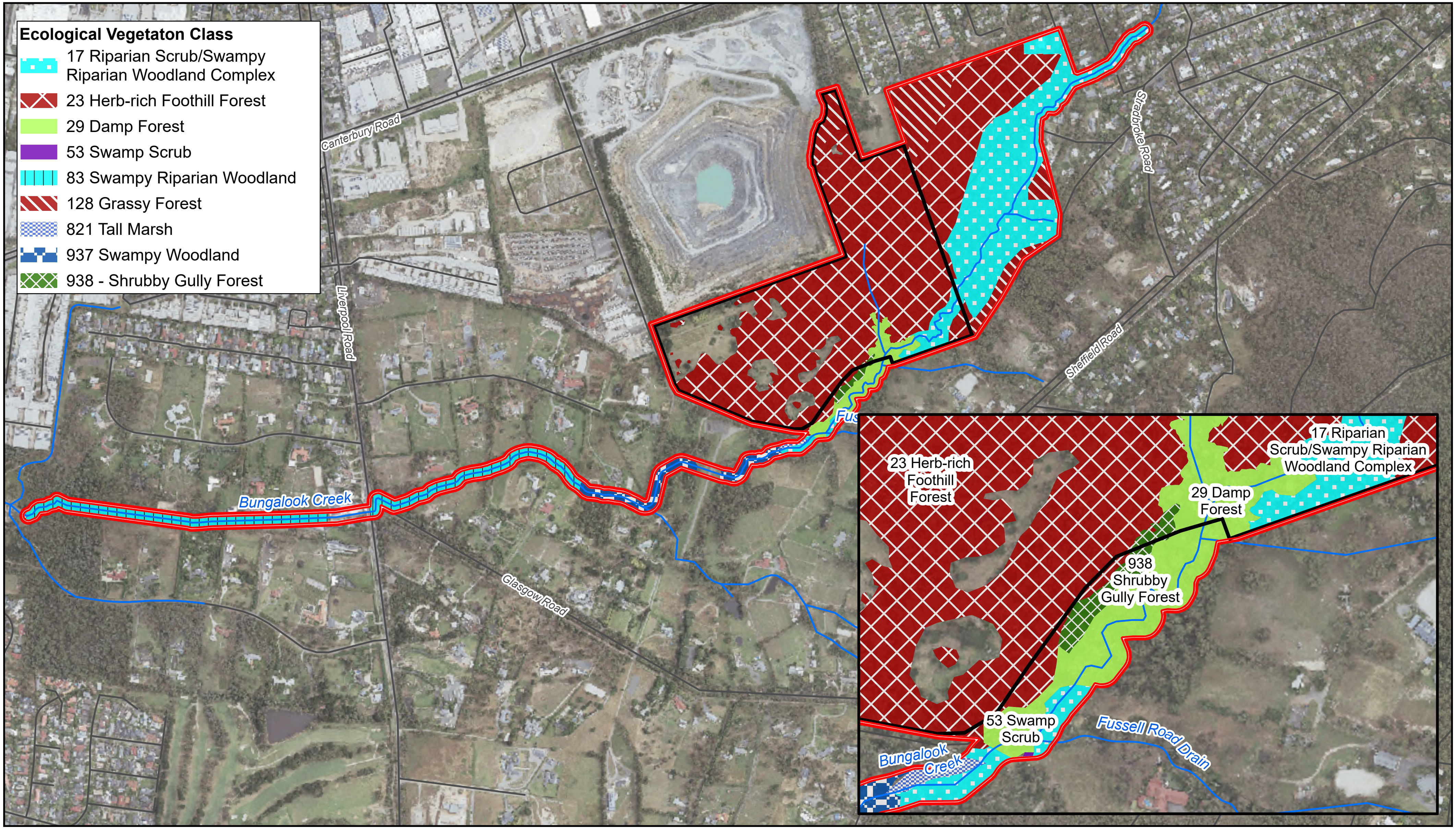
Tree Ferns and Ground-ferns require damp soil for extended periods of time (Terrestrial damp; Tda or Ate) to establish and survive. Scented Paperbark requires wet soil for long periods, and is found in wet and peaty soils, fringing swamps and streambanks (ATw). This species occurs within the study site along the streambank and surrounding pools. Reeds such as Cumbungi and Common Reed are dependent on long periods of inundation (Se) and dominate the stormwater treatment area and retarding basin within the study site.

3.2.3.3 Findings of leaf water potential, soil matric potential and water isotope analysis

EMM Consulting Pty Ltd was engaged by Boral to investigate the extent of the ecohydrological function of the terrestrial ecosystems within the Montrose Quarry Extension (EMM 2025). EMM applied three approaches to conduct this analysis: leaf water potential, soil matric potential and water isotope analysis as described in Section 2.3.1.

EMM (2025) concluded that soil moisture data indicate that vegetation is accessing available moisture within at least the top 3 m of the soil profile, rather than relying on groundwater. The isotope results also showed no isotope cluster correlation identified between the vegetation and groundwater isotopes, with the vegetation appearing to be more isotopically similar to the soil water isotope data.

Overall, EMM (2025) concluded that their analysis suggests there are no terrestrial GDEs within the study site and that the risk posed by a potential falling water table to terrestrial ecosystems is low to negligible. Their investigation focused on trees within the study site, and their findings suggest that the trees are preferencing soil moisture rather than groundwater.



Legend

- Study site
- EH & P Study area

Paper Size ISO A4

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

BORAL
Groundwater Dependent Ecosystem Investigation

Ecological Values

Project No. 31-12611238
Revision No. -
Date 29/07/2025

FIGURE 10

\\ghdnet\ghd\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_010_EcologicalValues
Print date: 29 Jul 2025 - 10:49

Data source: EHP (2023); VicMap (2023); DEECA (2023); GHD (2023). Created by: tworth

Table 9 Ecological Vegetation Classes within the study sites (recorded by EH&P and/or GHD) and descriptions

EVC	Location	Description	Photo
EVC 17 Riparian Scrub/Swampy Riparian Woodland Complex Vulnerable within the HSF bioregion. **Potential GDE**	Along Bungalook Creek – **midstream** – abutting proposed quarry expansion area	Along Bungalook Creek in the **midstream** section corresponded to Riparian Scrub/Swampy Riparian Woodland Complex, with Swampy Riparian Woodland being the dominant EVC. This EVC was dominated by *Eucalyptus obliqua* (Messmate) and *Eucalyptus ovata* (Swamp Gum) to 20 metres tall. A sub-canopy layer (understorey trees) of *Acacia melanoxylon* (Blackwood) and *Acacia dealbata* (Silver Wattle) was present. The shrub layer consisted of *Coprosma quadrifida* (Prickly Currant-bush), *Goodenia ovata* (Hop Goodenia) and *Olearia lirata* (Snowy Daisy-bush). Sedges and rushes were common in some areas, including *Gahnia radula* (Thatch Saw-sedge) and *Carex appressa* (Tall Sedge). Weeds were abundant in the ground layer and included declared noxious weeds and weeds of national significance such as *Zantedeschia aethiopica* (Arum Lily), *Asparagus asparagoides* (Bridal Creeper) and *Hedera helix* (English Ivy). Riparian Scrub areas (EVC 191) were dominated by *Melaleuca squarrosa* (Scented Paperbark) and *Leptospermum continentale* (Prickly Tea-tree). These patches were too small in scale to map as a separate EVC and were part of the understorey of Swampy Riparian Woodland.	 Sedge understorey
EVC 23 Herb-rich Foothill Forest Depleted within the HSF bioregion.	Within the proposed Quarry extension	EH&P described Herb-rich Foothill Forest within the study site as a forest to 30 metres tall with a tree canopy dominated by *Eucalyptus obliqua* (Messmate Stringybark) and occasional *Eucalyptus goniocalyx* (Bundy) and *Eucalyptus radiata* (Narrow-leaf Peppermint (EH&P 2022). The shrub layer is diverse, with dominant shrubs including *Acacia dealbata* (Silver Wattle), *Coprosma quadrifida* (Prickly Currant-bush), *Bursaria spinosa* var. *spinosa* (Sweet Bursaria) and *Leptospermum continentale* (Prickly Tea-tree). Ground layer dominated by native grasses e.g., *Austrostipa pubinodis* (Tall Spear-grass), *Microlaena stipoides* var. *stipoides* (Weeping Grass) and *Tetrarrhena juncea* (Forest Wire-grass).	 A canopy dominated by Messmate Stringybark within a patch of HrFF1 (source: Ecology and Heritage Partners, 2022)

EVC	Location	Description	Photo
EVC 29 Damp Forest Least concern within the HSF bioregion **Potential GDE**	Along Bungalook Creek – **midstream** – abutting proposed quarry expansion area	Majority of the vegetation along Bungalook Creek in the **midstream** section corresponded to Damp Forest EVC 29, although modelled EVC mapping suggests Riparian Scrub/Swampy Riparian Woodland Complex. This EVC was dominated by *Eucalyptus obliqua* (Messmate) and *Eucalyptus ovata* (Swamp Gum) to 20 metres tall. A sub-canopy layer (understorey trees) of *Acacia melanoxylon* (Blackwood) and *Acacia dealbata* (Silver Wattle) was present. The shrub layer consisted of *Coprosma quadrifida* (Prickly Currant-bush), *Goodenia ovata* (Hop Goodenia) and *Olearia lirata* (Snowy Daisy-bush). Ground ferns were abundant in, dominant species included *Pteridium esculentum* (Austral Bracken) and *Calochlaena dubia* (Common Ground-fern) forming thickets. Weeds were abundant in the ground layer and included declared noxious weeds and weeds of national significance such as *Zantedeschia aethiopica* (Arum Lily), *Asparagus asparagoides* (Bridal Creeper) and *Hedera helix* (English Ivy).	
EVC 53 Swamp Scrub	Along Bungalook Creek – **midstream** abutting the proposed quarry expansion and **downstream** at the MW stormwater retention plant	Swamp Scrub occurred as small pockets within damp areas along Bungalook Creek. Swamp Scrub was characterized by tall *Melaleuca ericifolia* (Swamp Paperbark) to 6 metres tall, forming a somewhat impenetrable thicket.	 Photo taken midstream abutting Bungalook Creek

EVC	Location	Description	Photo
EVC 83 Swampy Riparian Woodland Endangered within the HSF bioregion. **Potential GDE**		This EVC was dominated by *Eucalyptus obliqua* (Messmate) and *Eucalyptus ovata* (Swamp Gum) to 20 metres tall. A sub-canopy layer (understorey trees) of *Acacia melanoxylon* (Blackwood) and *Acacia dealbata* (Silver Wattle) was present. The shrub layer consisted of *Leptospermum continentale* (Prickly Tea-tree), *Coprosma quadrifida* (Prickly Currant-bush), *Goodenia ovata* (Hop Goodenia) and *Olearia lirata* (Snowy Daisy-bush). Ground ferns were abundant in damper/wetter areas, dominant species included *Pteridium esculentum* (Austral Bracken) and *Calochlaena dubia* (Common Ground-fern) forming thickets, with occasional tree ferns. Sedges and rushes were common in some areas, including *Gahnia radula* (Thatch Saw-sedge) and *Carex appressa* (Tall Sedge). Weeds were abundant in the ground layer and included declared noxious weeds and weeds of national significance such as *Zantedeschia aethiopica* (Arum Lily), *Asparagus asparagoides* (Bridal Creeper) and *Hedera helix* (English Ivy).	
EVC 821 Tall Marsh No bioregional conservation status within the Gippsland Plain bioregion, therefore assumed endangered. **Potential GDE**	Along Bungalook Creek – **midstream** – abutting proposed quarry expansion area within the retarding basin. Also present at the MW stormwater retarding basin. **downstream** of proposed quarry expansion	Tall Marsh was dominated by *Phragmites australis* and *Typha* spp. to 3 metres tall. These two species formed dense swards in inundated areas.	 Photo taken midstream – abutting the proposed quarry expansion along Bungalook Creek, showing Tall Marsh EVC 821 (foreground)

EVC	Location	Description	Photo
			 Photo taken downstream at MW stormwater retarding basin, showing Tall Marsh EVC 821 (foreground)
EVC 819 Potential Spike-sedge Wetland	**Midstream** – along drainage lines on private property abutting Bungalook Creek	Drainage lines on private property abutting the study site sometimes supported *Eleocharis acuta* (Spike Sedge). At the time of the GHD site assessment, this vegetation did not meet condition thresholds to be considered a patch of native vegetation under the Guidelines for the removal, destruction or lopping of native vegetation (DELWP 2017). However, there is potential for the cover of native species to increase under suitable conditions and meet the definition of a patch of native vegetation.	 Photo taken midstream on private land abutting Bungalook Creek

EVC	Location	Description	Photo
EVC 938 Shrubby Gully Forest No bioregional conservation status within the HSF bioregion, therefore assumed endangered		EH&P also mapped a patch of Shrubby Gully Forest along Bungalook Creek. According to EH&P this vegetation class was dominated by *Eucalyptus obliqua* (Messmate Stringybark) and *Eucalyptus viminalis* (Manna Gum), with an understorey of *Lepidosperma laterale* var. l*aterale* (Variable Sword-sedge) and *Pteridium esculentum* (Austral Bracken).	 Shrubby Gully Forest (source: Ecology and Heritage Partners, 2022)

Table 10 Root depth and water requirements of characteristic flora species

Life-form	Canopy trees	Understorey trees	Shrubs	Tree-ferns	Ground-ferns	Sedges	Reeds
Photo							
EVCs	Damp Forest or Riparian Scrub/ Swampy Riparian Woodland	Damp Forest or Riparian Scrub/Swampy Riparian Woodland	Riparian Scrub	Damp Forest or Riparian Scrub/Swampy Riparian Woodland	Damp Forest or Riparian Scrub/Swampy Riparian Woodland	Riparian Scrub/Swampy Riparian Woodland	Tall Marsh
Example species	*Eucalyptus obliqua* (Messmate Stringybark) *Eucalyptus camphora* (Mountain Grey-gum)	*Acacia melanoxylon* (Blackwood) *Acacia dealbata* (Silver Wattle)	*Melaleuca squarrosa* (Scented Paperbark) *Melaleuca ericifolia* (Swamp Paperbark)	*Cyathea australis* (Rough Tree-fern)	*Pteridium esculentum* (Austral Bracken) *Calochlaena dubia* (Common Ground-fern)	*Gahnia radula* (Thatch Saw-sedge) *Carex appressa* (Tall Sedge)	*Typha* sp. (Cumbungi) *Phragmites australis* (Common Reed)
Typical plant height (m)	Messmate 30 m Swamp Gum 20 m Mountain Grey-gum 20 m	Blackwood 3-45 m Silver Wattle 10-20 m up to 30 m	Scented Paperbark 2-5 m to 10 m	Rough Tree-fern to 15 m	Austral Bracken 1 m Common Ground-fern 1 m	Thatch Saw-sedge 1 m Tall sedge 1-2 m	Cumbungi 2 m Common Reed 3 m
Typical root depth (m)	5-10 m	2-5 m	0.5-3 m	0.5-1 m	<0.5 m	0.5-2 m	0.5-1 m
Plant Functional Group (PFG)	Tdr Messmate Tda Swamp Gum	Tdr/Tda Blackwood and Silver Wattle	ATw Scented Paperbark Swamp Paperbark	Tda	Tda Austral Bracken Common Ground	Ate Tall Sedge	Se Cumbungi Common Reed

3.2.3.4 Threatened ecological communities (TECs)

The PMST identified two EPBC Act-listed communities that are known, likely or may occur within 10 km of the study site:

– Natural Damp Grassland of the Victorian Coastal Plains

– White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

Neither of these TECs are present within the study site. Furthermore, no FFG-listed communities correlate with the EVCs (vegetation) observed within the study site.

3.2.3.5 Threatened flora

Seventy-one threatened flora species listed as threatened under the EPBC Act and/or the FFG Act have been recorded and/or predicted to occur within 10 km of the study site by the VBA and PMST databases (see Appendix D for full list of threatened flora). Of these species, 20 are listed under the EPBC Act and 68 are listed under the FFG Act.

A likelihood of occurrence table is provided in Appendix D and is based on the presence of suitable habitat and the number of previous records within the study area. Suitable habitat is present for one EPBC Act listed and 13 FFG Act listed flora species within the study site (Table 11), albeit limited extent of habitat is present and in some cases likelihood of occurrence is considered low.

A preliminary assessment of expected responses by each species to groundwater changes at this study site is presented in Table 11. Most of these species are terrestrial dry or damp species and thus unlikely to be dependent on direct use of groundwater. The exceptions are *Pteris epaleata* (Netted Brake) and *Senecio campylocarpus* (Bulging Fireweed), which favour seepages, stream banks and damp flats and thus have a higher water requirement. Hence, targeted surveys were conducted for these two threatened species. As individuals were not found within areas deemed suitable habitat in the study area along Bungalook Creek during the targeted surveys, these three threatened species are not considered further in the risk assessment.

The other 11 possible threatened species are somewhat dependent on maintenance of forest/woodland structure (e.g., maintenance of a tree canopy and shrub layer for shade). Therefore, if groundwater drawdown affects tree, understorey tree or shrub health, then these species could also decline (if present). It was beyond the scope of this investigation to undertake targeted surveys for these additional 11 threatened flora. However, the indirect risks to these threatened flora species due to any changes in the forest/woodland structure are considered in the risk assessment.

3.2.3.6 Protected Flora

During the site assessment, several FFG protected species were recorded, but direct or indirect risks due to groundwater drawdown to these species are considered low (Table 12).

3.2.3.7 Vegetation condition

Baseline data was collected on vegetation condition in December 2023 and following the 2025 bushfire. The results are summarised in Appendix C.

Table 11 Assessment of potential risk to flora listed as threatened under the EPBC or FFG Act as a result of surface water or groundwater changes at this study site

Scientific name	Common Name	EPBC Act status	FFG Act status	Plant Functional Group (PFG) Dependency on surface water or groundwater
Acacia stictophylla	Dandenong Range Cinnamon Wattle		Endangered	**Tdr or Tda** **Low dependency**. Common in the riparian zone on hillsides in tall forest and open woodland in the Dandenong Ranges. Direct impacts from groundwater drawdown unlikely.
Asterolasia asteriscophora subsp. *albiflora*	Emerald Star-bush	Critically endangered	Critically endangered	**Tdr or Tda** **Low dependency**. Scattered in dry woodlands, shrublands and moist to wet heathy open forests in the eastern half of the state, usually in foothill to montane district. Direct impacts from groundwater drawdown unlikely.
Caladenia oenochila	Wine-lipped Spider-orchid		Critically endangered	**Tdr** **Low dependency**. Grows in shaded situations in more mesic heathy woodlands and open forests on sand and clay loams that are fairly well drained (Backhouse and Jeanes, 1995). Direct impacts from groundwater drawdown unlikely.
Chiloglottis jeanesii	Mountain Bird-orchid		Vulnerable	**Tda** **Low dependency**. Grows in fern gullies and wet sclerophyll forests. Direct impacts from groundwater drawdown unlikely.
Correa reflexa var. *lobata*	Powelltown Correa		Endangered	**Tdr or Tda** **Low dependency**. Grows in moist, often heathy open forest. Direct impacts from groundwater drawdown unlikely.
Eucalyptus yarraensis	Yarra Gum		Critically endangered	**Tda** **Low dependency**. Moist, wet, poorly drained soils. Tolerates some inundation. Direct impacts from groundwater drawdown unlikely.
Prasophyllum lindleyanum	Green Leek Orchid		Endangered	**Tda** **Low dependency**. Occurs in more fertile soils of woodland or scrubby heath, but now localized and uncommon (Walsh & Entwisle 1996). Found mainly in open forests, woodlands, heathy woodlands and heathlands. Soils are generally sand and clay loams that may be moist for at least part of the year (Backhouse & Jeanes 1996). Direct impacts from groundwater drawdown unlikely.

Scientific name	Common Name	EPBC Act status	FFG Act status	Plant Functional Group (PFG) Dependency on surface water or groundwater
Pteris epaleata	Netted Brake		Endangered	**ATe** Although restricted in distribution in Victoria, it is often locally abundant and conspicuous, favouring seepages, stream banks and damp flats in shady forests. **Moderate dependency** (if present) if groundwater drawdown reduces seepage areas. Drawdown of seepage areas could lead to drying out of soil and consequently decline in health of plants (if species is present). In addition, if groundwater changes cause long-term decline in forest/woodland health/survival, then decline in species' habitat suitability at this site could occur. Targeted surveys in December/January did not detect this species within areas deemed suitable habitat along Bungalook Creek. Therefore, the species is considered unlikely to occur within the study site and unlikely to be impacted by changes to groundwater at the study site.
Pterostylis grandiflora	Cobra Greenhood		Endangered	**Tdr or Tda** **Low dependency**. Grows in shaded situations in open forests, often among small shrubs, grasses and bracken. Substrates are generally well-drained sand and clay loams (Backhouse & Jeanes 1995). Direct impacts from groundwater drawdown unlikely.
Pultenaea weindorferi	Swamp Bush-pea		Endangered	**Tda** **Low dependency**. Confined to swamps and drainage lines in scattered localities, often associated with *Eucalyptus cephalocarpa* (Walsh and Entwisle 1999). Direct impacts from groundwater drawdown unlikely.
Senecio campylocarpus and	Bulging Fireweed		Endangered Vulnerable	**Tda or ATi** Occurs in loam to clay soils in forest and woodland, usually in seasonally inundated areas (Ohlsen 2018). **Moderate dependency** (if present) - direct impacts from groundwater drawdown possible if groundwater contributing to inundated areas where this species is present. In addition, if groundwater changes cause long-term decline in forest/woodland health/survival, then decline in species' habitat suitability at this site could occur. Targeted surveys in December/January did not detect these species within areas deemed suitable habitat along Bungalook Creek. Therefore, the species are considered unlikely to occur within the study site and unlikely to be impacted by changes to groundwater at the study site.
Thismia rodwayi	Fairy Lanterns		Endangered	**Tda** **Low dependency**. Grows along seasonal watercourses, floodplains and depressions. Direct impacts from groundwater drawdown unlikely.

Scientific name	Common Name	EPBC Act status	FFG Act status	Plant Functional Group (PFG) Dependency on surface water or groundwater
Tmesipteris parva	Small Fork-fern		Endangered	**Tdr or Tda** **Low dependency**. On tree-ferns. Direct impacts from groundwater drawdown unlikely. Tree ferns are present but in low abundance. Therefore, likelihood of occurrence of this species is low.

Table 12 Protected flora recorded during GHD site assessment and preliminary risk assessment

Scientific Name	Common Name	Plant Functional Group and dependency on surface water or groundwater
Acacia verticillate	Hedge Wattle	**Tda** **Low dependency**. Direct impacts from groundwater drawdown unlikely.
Cassinia aculeata subsp. *aculeata*	Common Cassinia	**Tdr** **Low dependency**. Direct impacts from groundwater drawdown unlikely.
Calochlaena dubia	Common Ground-fern	**Tda** **Low dependency**. Direct impacts from groundwater drawdown possible if groundwater contributing to inundated areas where this species is present.
Cyathea australis	Rough Tree-fern	**Tda** **Low dependency**. Direct impacts from groundwater drawdown unlikely.
Epacris impressa	Common Heath	**Tdr** **Low dependency**. Direct impacts from groundwater drawdown unlikely.
Olearia lirata	Snowy Daisy-bush	**Tda** **Low dependency**. Direct impacts from groundwater drawdown unlikely.
Ozothamnus spp.	Everlasting	**Tdr** **Low dependency**. Direct impacts from groundwater drawdown unlikely.

3.2.4 Terrestrial fauna and habitat

3.2.4.1 Fauna habitat

Prior to European settlement the study site is likely to have been entirely tree-covered, with Bungalook Creek flowing through, creating some sections of swampy forest or woodland. European settlement and the changes brought about by that have changed much of the study site, such that only patches of the original habitats remain.

Three main habitat types that may support terrestrial fauna occur within the study site and its immediate surrounds: forest/woodland habitat, waterway/riparian habitat and grassland habitat. There are areas within the study site where these habitats form discrete patches, and other areas where they tend to integrate with each other. The three main habitat types in the study site are described below.

The broader landscape is also likely to influence the fauna that occurs within the study site. The landscape is dominated by urbanisation to the north and northwest, while to the west and south cleared semi-agricultural land dominates, with low-density dwellings on larger blocks. The slopes of Mount Dandenong dominate to the southeast and east. As a result of its location in the landscape, the study site is at the western edge of larger tracts of natural uncleared habitat (i.e., the Dandenong Ranges), but is partially disconnected from those larger patches. The study site is also strongly influenced by human activity in surrounding areas, with resulting habitat degradation (e.g., high cover of weeds, reduced water quality, edge effects, increased noise and lighting, likely presence of non-native animals including domestic pets). This likely influences the types of fauna that occur within the study site.

Forest/woodland habitat

The main patch of forest/woodland occurs in the Dr Ken Leversha Reserve, immediately south and east of the quarry. Bungalook Creek flows through this patch, and the patch is sloped rather than flat. The other main patch of forest/woodland is around the Melbourne Water Retarding Basin near Colchester Road, well downstream from the quarry. Between the Dr Ken Leversha Reserve and the Melbourne Water Retarding Basin, most of the forest/woodland has been cleared, leaving most of the creek with only a narrow band of riparian vegetation along each bank.

Forest/woodland in this area is characterised by an open overstorey of eucalypts (various species), a mid-storey of acacias (i.e., Black Wattle *Acacia mearnsii*), other shrubs and eucalypt recruits, and an understorey composed of grasses, shrubs, sedges or ferns (Plate 18 and Plate 19). In some areas, the understorey and mid-storey are particularly dense (Plate 20). Canopy trees were moderate to large in size (25+ m tall) with larger trees likely to be hollow bearing. Coarse woody debris (including logs) and litter were abundant in some areas. The ground level was generally damp, particularly in gullies, with many logs being moss-covered (Plate 21).

Some parts of the forest/woodland habitat had a notably weedy understorey (Plate 22), particularly along Bungalook Creek, and there were signs of dieback in some of the trees near Fussell Road (Plate 23) and evidence of disturbance and degradation in some areas (Plate 24 and Plate 25).

Large intact patches of this type of habitat are typically of high value for terrestrial fauna and would be expected to support a diverse assemblage, including threatened and migratory species. Degraded, isolated and/or fragmented patches of this habitat tend to have reduced diversity, with fewer species of conservation significance.

This habitat is likely to support a range of native birds in all of the forest structural layers including honeyeaters, wattlebirds, pardalotes, parrots, cockatoos, owls, goshawks, whistlers, thornbills, fairy-wrens and scrubwrens. Arboreal mammals such as possums and gliders are also likely to occur in the trees and shrubs in this habitat. Understorey habitats are likely to provide habitat for mammals (kangaroos, wallabies, echidna, wombat, rats, antechinus), reptiles (i.e., skinks, snakes and Lace Monitor) and frogs.

Threatened species that do or may use or visit this habitat within the study site include gliders (e.g., Southern Greater Glider, *Petauroides volans*, Yellow-bellied Glider, *Petaurus australis*), Broad-toothed Rat (*Mastacomys fuscus mordicus*), Grey Goshawk (*Accipiter novaehollandiae*), owls (e.g., Barking Owl, *Ninox connivens*, Powerful Owl, *Ninox strenua*, Sooty Owl, *Tyto tenebricosa*), Gang-gang cockatoo (*Callocephalon fimbriatum*), Blue-winged Parrot (*Neophema chrysostoma*), reptiles such as Lace Monitor (*Varanus varius*), and potentially frogs such as Southern Toadlet (*Pseudophryne semimarmorata*). Further discussion on these species is provided in Section 3.2.4.2.

Plate 18 Forest habitat with a dense understorey of ferns

Plate 19 Forest habitat with an understorey of sedges

Plate 20 Forest habitat showing the dense understorey

Plate 21 A damp gully with moss-covered logs

Plate 22 An example of weedy understorey

Plate 23 Evidence of dieback in trees

Plate 24 A degraded gully

Plate 25 Evidence of forest/woodland disturbance

Waterway/wetland habitat

The context for waterway/wetland habitat here is terrestrial fauna; obligate aquatic fauna in these waterways are described in Section 3.2.2.2.

The key waterway habitat within the study site follows Bungalook Creek. Upstream of the Dr Ken Leversha Reserve, the waterway is typically weedy and degraded and offers low value habitat for terrestrial fauna (Plate 26). Some sections through the forest/woodland habitat are of higher value but also weedy (Plate 27), while other sections are fringed by a dense native understorey that provides high value habitat for ground-dwelling fauna (Plate 28). There are more open areas where the creek forms larger pools (Plate 29), but the pools generally do not appear to be large enough to support regular visits by waterbirds such as ducks or cormorants. Downstream of the quarry, Bungalook Creek opens out into a large expanse of tall marsh in the Colchester Road Retarding Basin, with *Typha* and *Phragmites* (Plate 30 and Plate 31), and patches of Swamp Scrub habitat (Plate 32).

Through the forested sections, the waterway habitat is likely to be used by the same fauna that uses the forest habitat, with fewer species using the weedy areas and more species in the more intact native areas. The tall marsh habitat, and potentially the swamp scrub habitat, offers an opportunity for some fauna species that would not typically occur in the forested sections.

Threatened species that may use or visit waterway habitats within the study site include secretive or wading waterbirds (e.g., Lewin's Rail, *Lewinia pectoralis*, Little Egret, *Egretta garzetta nigripes*, Plumed/Intermediate Egret, *Ardea intermedia plumifera*, Eastern Great Egret, *Ardea alba modesta*, Australian Little Bittern, *Ixobrychus dubius*, Australasian Bittern, *Botaurus poiciloptilus*), reptiles such as Swamp Skink, *Lissolepis coventryi*, and Glossy Grass Skink, *Pseudemoia rawlinsoni*). Further discussion on these species is provided in Section 3.2.4.2.

Plate 26 Weedy creekline habitat upstream of Dr Ken Leversha Reserve

Plate 27 Waterway habitat through the forested section, with more weedy understorey

Plate 28 Waterway habitat through the forested section, with more intact, native understorey

Plate 29 A larger pool along Bungalook Creek

Plate 30 Tall Marsh habitat along Bungalook Creek

Plate 31 Tall Marsh habitat along Bungalook Creek

Plate 32 Swamp scrub habitat along Bungalook Creek

Grassland habitat

Grassland habitat in the study site is derived, comprising forest or woodland cleared of trees. Cleared grassy habitat dominates the agricultural and suburban land adjacent to Bungalook Creek downstream of the quarry – this habitat is generally of low value for terrestrial fauna and is used mostly by common and adaptable native and non-native species such as Australian Magpie (*Gymnorhina tibicen*) and Common Starling (*Sturnus vulgaris*).

Within and alongside the forested areas, there are also small and cleared patches which are now dominated by grassland (Plate 33 and Plate 34). Because these patches are derived and small, they tend to be of low value to the fauna that use the treed habitats that naturally occur in this area. However, because of their proximity to forest and dense understorey, these grassland patches may be used by a small number of threatened species, such as Blue-winged Parrot (*Neophema chrysostoma*), Lace Monitor (*Varanus varius*) and Glossy Grass Skink (*Pseudemoia rawlinsoni*).

Plate 33 Weedy creekline habitat upstream of Dr Ken Leversha Reserve

Plate 34 Waterway habitat through the forested section, with more weedy understorey

3.2.4.2 Fauna of conservation significance

The VBA and PMST results determined there are 71 species of native fauna documented or predicted to occur within the study area that are listed under the EPBC Act and/or the FFG Act. This included 13 mammals, 44 birds, five reptiles, three frogs and six invertebrates. The likelihood of occurrence of all threatened fauna are included in Appendix E. Of the native fauna, 16 species are listed as migratory under the EPBC Act. The likelihood of occurrence of all migratory fauna are included in Appendix F.

***Environment Protection and Biodiversity Conservation Act 1999* – conservation significant species**

Eleven EPBC Act listed species are considered likely or possible to occur within the study site (Table 13). Most of these species are forest dwellers and some are highly mobile. Generally, they are unlikely to be dependent on habitats that are groundwater dependent or at risk if there are changes in surface water and groundwater dynamics. However, species such as the Broad-toothed Rat, Pilotbird and Swamp Skink may find that their dense ground-cover habitat dries out and opens up, making it less favourable. A preliminary assessment of expected responses by each species to surface and/or groundwater changes at the study site is presented in Table 13.

Table 13 Preliminary assessment of potential risks to terrestrial fauna listed as threatened under the EPBC Act as a result of surface water or groundwater changes

Common name	Scientific Name	EPBC Act status	Dependency of species on surface water or groundwater
Southern Greater Glider	*Petauroides volans*	Endangered	**Low dependency**. Uses tall trees and forests, often in areas unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in habitat suitability could occur.
Yellow-bellied Glider	*Petaurus australis*	Vulnerable	**Low dependency**. Uses tall trees and forests, often in areas unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in habitat suitability could occur.
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	**Low dependency**. Highly mobile and uses a range of habitats, many of which are not groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then species may reduce or abandon its use of the site.
Broad-toothed Rat	*Mastacomys fuscus mordicus*	Vulnerable	**High dependency**. Relies on dense ground cover, often in damp areas. If groundwater changes cause the understorey to dry out and open up, then habitat suitability expected to decline.
Australasian Bittern	*Botaurus poiciloptilus*	Endangered	**Low dependency**. Highly mobile that occurs in low densities and uses broad range of wetland habitats. If groundwater changes cause decline in tall marsh habitat, then species may abandon its use of the site.
Gang-gang cockatoo	*Callocephalon fimbriatum*	Endangered	**Low dependency**. Uses a range of forests, often in areas that are unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in habitat suitability could occur.
Blue-winged Parrot	*Neophema chrysostoma*	Vulnerable	**Low dependency**. Highly mobile and uses a range of habitats. If groundwater changes cause loss of grassland or long-term decline in forest health/survival, then species may reduce or abandon its use of the site.
White-throated Needletail	*Hirundapus caudacutus*	Vulnerable	**Low dependency**. Predominantly aerial species. Unlikely to be associated with groundwater dependent habitats.
Pilotbird	*Pycnoptilus floccosus*	Vulnerable	**Moderate dependency**. Uses dense understorey and mid-storey in wet mountainous forests. If groundwater changes cause long-term decline in forest health/survival, particularly in the understorey, then a decline in habitat suitability could occur.
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	Vulnerable	**Low dependency**. Mobile and tends to use open drier forest/woodland habitats. Groundwater changes may cause forests to dry out and open up, which could make the site more favourable.
Swamp Skink	*Lissolepis coventryi*	Endangered	**High dependency**. Relies on dense ground cover, often in damp areas. If groundwater changes cause the understorey to dry out and open up, then habitat suitability expected to decline.

Environment Protection and Biodiversity Conservation Act 1999 – migratory species

While most of the EPBC Act migratory birds are considered unlikely to use habitat within the study site regularly or rely on the habitat, six species are considered further based on their potential to occur within the study site (Table 14).

Three of these species (Rufous Fantail, Satin Flycatcher, Black-faced Monarch) typically use a range of wet, damp and dry forest habitats in the east of Australia during the summer period. If groundwater changes cause long-term decline in forest health/survival, particularly in the mid-storey, then decline in habitat suitability for these three species could occur. The White-throated Needletail and Fork-tailed Swift are aerial specialists and may fly over the study site but are not expected to make use of terrestrial habitats.

Latham's Snipe is a regular non-breeding migrant to southeast Australia and visits freshwater wetlands or creek edges among dense vegetation cover. While conditions at the study site are not ideal for this species, the species may visit occasionally in small numbers. Latham's Snipe may find that its damp foraging habitat dries out, making it less favourable. A preliminary assessment of expected responses by each species to surface water and/or groundwater changes at the study site is presented in Table 14.

Table 14 Preliminary assessment of potential risk to terrestrial fauna listed as migratory under the EPBC Act as a result of surface water and/or groundwater changes

Common name	Scientific Name	Dependency on surface water or groundwater
Latham's Snipe	*Gallinago hardwickii*	**High dependency**. Relies on damp or wet ground for foraging. If groundwater changes cause the ground to dry out, then habitat suitability expected to decline.
White-throated Needletail	*Hirundapus caudacutus*	**Low dependency**. Predominantly aerial species. Unlikely to be associated with groundwater dependent habitats.
Fork-tailed Swift	*Apus pacificus*	**Low dependency**. Predominantly aerial species. Unlikely to be associated with groundwater dependent habitats.
Rufous Fantail	*Rhipidura rufifrons*	**Moderate dependency**. Prefers dense mid-storey in forests. If groundwater changes cause long-term decline in forest health/survival, particularly in the mid-storey, then decline in habitat suitability could occur.
Satin Flycatcher	*Myiagra cyanoleuca*	**Moderate dependency**. Prefers dense mid-storey in forests. If groundwater changes cause long-term decline in forest health/survival, particularly in the mid-storey, then decline in habitat suitability could occur.
Black-faced Monarch	*Monarcha melanopsis*	**Moderate dependency**. Prefers dense mid-storey in forests. If groundwater changes cause long-term decline in forest health/survival, particularly in the mid-storey, then decline in habitat suitability could occur.

Flora and Fauna Guarantee Act 1988 – threatened species

A total of 25 FFG Act listed species are considered likely or possible to occur within the study site. Nine of these are also listed as threatened under the EPBC Act and were considered above. The remaining 16 species are listed in Table 15.

Some of these species are forest dwellers and expected to reside in the study site, if they are present. Others are expected to be occasional visitors to habitats at the site during favourable conditions. Most are considered unlikely to be dependent on habitats that are groundwater dependent.

However, some species such as the Glossy Grass Skink, if they are present within the study site, may find that their damp ground or dense ground-cover habitat dries out and opens up, making it less favourable, if those habitats are dependent on groundwater and the groundwater level changes. Other species that may visit the site especially for its surface water (e.g., egrets) may choose not to visit if the surface water becomes unreliable or absent. A preliminary assessment of expected responses by each species to groundwater changes at this study site is presented in Table 15.

Table 15 Preliminary assessment of potential risk to terrestrial fauna listed as threatened under the FFG Act as a result of surface water or groundwater changes

Common name	Scientific Name	FFG Act status	Dependency on surface water or groundwater
Brush-tailed Phascogale	*Phascogale tapoatafa*	Vulnerable	**Low dependency**. Species uses woodlands, often in areas that are unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Eastern Bent-wing Bat	*Miniopterus orianae oceanensis*	Critically Endangered	**Low dependency**. Highly mobile species that uses a range of habitats for foraging, many of which are not groundwater dependent.
Lewin's Rail	*Lewinia pectoralis*	Vulnerable	**Low dependency**. Highly mobile species that occurs in low densities and uses wetland habitats across a broad range. If groundwater changes cause decline in Tall Marsh habitat, then this species may abandon its use of this site.

Common name	Scientific Name	FFG Act status	Dependency on surface water or groundwater
Little Egret	*Egretta garzetta nigripes*	Endangered	**Moderate dependency**. This species relies on the presence of surface water, but many of its preferred habitats are permanent water or rain fed, rather than groundwater dependent. At this site, if groundwater changes cause surface water to disappear, then habitat suitability for this species would decline.
Plumed/Intermediate Egret	*Ardea intermedia plumifera*	Critically Endangered	**Moderate dependency**. This species relies on the presence of surface water, but many of its preferred habitats are permanent water or rain fed, rather than groundwater dependent. At this site, if groundwater changes cause surface water to disappear, then habitat suitability for this species would decline.
Eastern Great Egret	*Ardea alba modesta*	Vulnerable	**Moderate dependency**. This species relies on the presence of surface water, but many of its preferred habitats are permanent water or rain fed, rather than groundwater dependent. At this site, if groundwater changes cause surface water to disappear, then habitat suitability for this species would decline.
Australian Little Bittern	*Ixobrychus dubius*	Endangered	**Low dependency**. Highly mobile species that occurs in low densities and uses wetland habitats across a broad range. If groundwater changes cause decline in Tall Marsh habitat, then this species may abandon its use of this site.
Grey Goshawk	*Accipiter novaehollandiae*	Endangered	**Low dependency**. Species uses trees and forests, potentially in areas that are groundwater-dependent, but is relatively tolerant of wet/dry, open/dense vegetation. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Little Eagle	*Hieraaetus morphnoides*	Vulnerable	**Low dependency**. Species uses a range of forested and cleared habitats, often in areas that are unlikely to be groundwater dependent.
Barking Owl	*Ninox connivens*	Critically Endangered	**Low dependency**. Species uses woodlands, often in areas that are unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Powerful Owl	*Ninox strenua*	Vulnerable	**Low dependency**. Species uses a range of forests, often in areas that are unlikely to be groundwater dependent. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Sooty Owl	*Tyto tenebricosa*	Endangered	**Low dependency**. Species uses wetter forests. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Speckled Warbler	*Pyrrholaemus sagittatus*	Endangered	**Low dependency**. Mobile species that tends to use open drier forest/woodland habitats. Groundwater changes at this site may cause forests to dry out and open up, which could make the site more favourable for this species.
Lace Monitor	*Varanus varius*	Endangered	**Low dependency**. Species uses trees and forests in wet and dry areas, and is relatively tolerant of wet/dry, open/dense vegetation. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.
Glossy Grass Skink	*Pseudemoia rawlinsoni*	Endangered	**High dependency**. This species relies on dense ground cover, often in damp areas. If groundwater changes cause the understorey to dry out and open up, then habitat suitability for this species would be expected to decline.
Jewel Beetle	*Temognatha sanguinipennis*	Endangered	**Low dependency**. Wood-boring species in woodlands and forests. If groundwater changes cause long-term decline in forest health/survival, then decline in species' habitat suitability at this site could occur.

Flora and Fauna Guarantee Act 1988 – threatened communities

One fauna community listed under the FFG Act may occur within the study site: Victorian Temperate Woodland Bird Community (VTWBC). The VBA has records of 18 'key' species and 12 'associated' species within 10 km of the study site, which suggests that this community is at least possible to occur (Table 16). However, many of the species in this community that have been recorded with the study area are considered unlikely to occur within the study site, or at least be rare visitors. This fauna community typically occurs in drier woodland habitats rather than wetter forests and is not expected to be strongly associated with groundwater-dependent habitats.

Table 16 Key and associated members of the VTWBC identified for the study area

Common name	Scientific Name	VBA recs	VBA last
Key species			
Painted Button-quail	*Turnix varia*	10	2006
Barking Owl	*Ninox connivens*	4	2004
Little Lorikeet	*Glossopsitta pusilla*	24	2020
Superb Parrot	*Polytelis swainsonii*	1	2005
Swift Parrot	*Lathamus discolor*	6	1976
Jacky Winter	*Microeca fascinans*	33	2019
Red-capped Robin	*Petroica goodenovii*	4	2000
Hooded Robin	*Melanodryas cucullata*	0	NA
Grey-crowned Babbler	*Pomatostomus temporalis*	4	1931
Western Gerygone	*Gerygone fusca*	2	1999
Speckled Warbler	*Pyrrholaemus sagittatus*	15	2000
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	13	2018
Brown-headed Honeyeater	*Melithreptus brevirostris*	118	2021
Painted Honeyeater	*Grantiella picta*	0	NA
Regent Honeyeater	*Anthochaera phrygia*	15	2009
Fuscous Honeyeater	*Lichenostomus fuscus*	2	1976
Yellow-tufted Honeyeater	*Lichenostomus melanops*	5	1980
Diamond Firetail	*Stagonopleura guttata*	2	1914
Associated species			
Square-tailed Kite	*Lophoictinia isura*	2	2018
Grey Falcon	*Falco hypoleucos*	0	NA
Powerful Owl	*Ninox strenua*	413	2022
Restless Flycatcher	*Myiagra inquieta*	67	2018
Eastern Yellow Robin	*Eopsaltria australis*	878	2022
Rufous Whistler	*Pachycephala rufiventris*	265	2021
Eastern Shrike-tit	*Falcunculus frontatus*	129	2021
Southern Whiteface	*Aphelocephala leucopsis*	0	NA
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	1	1896
White-browed Woodswallow	*Artamus superciliosus*	6	2017
Dusky Woodswallow	*Artamus cyanopterus*	98	2020
Varied Sittella	*Daphoenositta chrysoptera*	115	2021

3.2.4.3 Targeted survey results

As mentioned in Section 2.3, targeted surveys in the study site were undertaken for the following two conservation significant toadlets that are both endangered under the FFG Act:

- Brown Toadlet (*Pseudophryne bibronii*)
- Southern Toadlet (*Pseudophryne semimarmorata*)

Southern Toadlet and Brown Toadlet were not recorded during the targeted surveys. Six common frog species were either observed or heard calling during the surveys (Table 17).

Table 17 Frog species recorded during the targeted surveys

Common name	Scientific name	Record type
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	Observed/heard
Southern Bullfrog	*Limnodynastes dumerilii*	Observed/heard
Common Froglet	*Crinia signifera*	Heard
Southern Brown Tree Frog	*Litoria ewingii*	Observed/heard
Whistling Tree Frog	*Litoria verreauxii verreauxii*	Observed/heard
Victorian Smooth Froglet	*Geocrinia victoriana*	Heard

3.2.5 Existing threatening processes

Several existing threatening processes already occur within the study site that may exacerbate risks associated with the proposed quarry expansion and changes to groundwater and surface water dynamics. For example, the weed Bridal Creeper (*Asparagus asparagoides*) can form a dense canopy which smothers other vegetation, and their roots can extend to form a thick, dense mat which destroys understorey plants and reduce soil moisture (Wills 1999; CRC 2003). As such, it is important to document existing threatening processes prior to the upgrade so that any impacts associated with these processes can be separated from those that may occur due to the expansion.

3.2.5.1 Weeds

Eight species listed as noxious weeds under the *Catchment and Land Protection Act 1996* (CaLP) Act in the Port Philip and Westernport CMA region were recorded in the site assessment (Table 18). Noxious weeds are those that have or might have the potential to become a serious threat to primary production, Crown land, the environment or community health. Five of the noxious weeds are also listed as Weeds of National Significance (WoNS).

The risk rating for each weed is based on scores allocated to each weed species based on five attributes (see White et al. 2018):

- Impact on natural systems
- Area of potential distribution remaining
- Potential for invasion
- Rate of dispersal
- Range of susceptible habitat types

Species with high final scores pose a higher risk to biodiversity than species with low final scores.

Table 18 Noxious weeds recorded within the study site

Scientific Name	Common Name	WoNS	CaLP classification & risk rating
Asparagus asparagoides	Bridal Creeper	Yes	Restricted / High
Asparagus scandens	Asparagus Fern	Yes	Restricted / Very high
Chrysanthemoides monilifera	Boneseed	Yes	Regionally Controlled / Very high
Cirsium vulgare	Spear Thistle		Regionally Controlled / Moderately high
Cytisus scoparius	English Broom	Yes	Regionally Controlled / High
Rosa rubiginosa	Sweet Briar		Regionally Controlled / High
Rubus fruticosus	Blackberry	Yes	Regionally Controlled / Most species high, but ranges from potential to very high
Watsonia spp.	Watsonia		Regionally Controlled / High or very high
Regionally controlled weeds - Invasive plants usually widespread in a region. To prevent spread, ongoing control measures are required. Landowners have the responsibility to take all reasonable steps to prevent the growth and spread on their land. Restricted weeds - Includes plants that pose an unacceptable risk of spreading in this state and are a serious threat to another state or territory of Australia. Trade in these weeds and their propagules (either as plants, seeds or contaminants in other materials) is prohibited.			

Numerous species considered environmental weeds in Victoria (White et al. 2018) but not listed as noxious weeds under the CaLP Act, were also determined to be present in the study site. These are presented in Table 19.

Table 19 Other environmental weeds recorded within the study site (in addition to declared noxious weeds)

Scientific name	Common name	Risk rating
Cynodon dactylon var. *dactylon*	Couch	Moderately high
Dactylis glomerata	Cocksfoot	High
Ehrharta erecta	Panic Veldt-grass	Very high
Erigeron spp.	Fleabane	Most species moderately high
Galium aparine	Cleavers	High
Hedera helix s.l.	English Ivy	Very high
Myosotis sylvatica	Wood Forget-me-not	Very high
Oxalis pes-caprae	Soursob	Very high
Paspalum dilatatum	Paspalum	Medium
Pinus radiata	Radiata Pine	Very high
Ranunculus repens	Creeping Buttercup	Very high
Rosa rubiginosa	Sweet Briar	High
Rubus fruticosus spp. agg.	Blackberry	
Vinca major	Blue Periwinkle	High
Zantedeschia aethiopica	White Arum-lily	Very High

3.2.5.2 Pest animals

A total of 29 species of non-native terrestrial fauna have been recorded within 10 km of the study site. This includes 12 species of non-native mammal and 17 species of non-native bird (Table 20).

There were 10 aquatic non-native species, all of which are fish. Field surveys completed in December 2023 (see Appendix B) indicate that these species may be present within larger waterways such as Dandenong Creek (downstream from the study site) but are unlikely to be present in Bungalook Creek due to barriers within the sub-catchment.

Table 20 Pest species – non-native terrestrial and aquatic fauna

Mammals	Birds	Fish
Black Rat *Rattus rattus* Brown Rat *Rattus norvegicus* House Mouse *Mus musculus* European Rabbit *Oryctolagus cuniculus* European Brown Hare *Lepus europaeus* Pig (feral) *Sus scrofa* Goat (feral) *Capra hircus* Fallow Deer *Cervus dama* Sambar *Cervus unicolor* Rusa Deer *Cervus timorensis* Red Fox *Vulpes vulpes* Cat (feral) *Felis catus*	Chestnut-breasted Mannikin *Lonchura castaneothorax* European Skylark *Alauda arvensis* Domestic Goose *Anser anser* Northern Mallard *Anas platyrhynchos* Rock Dove *Columba livia* Spotted Turtle-dove *Streptopelia chinensis* European Goldfinch *Carduelis carduelis* European Greenfinch *Carduelis chloris* Common Blackbird *Turdus merula* Song Thrush *Turdus philomelos* Eurasian Tree Sparrow *Passer montanus* House Sparrow *Passer domesticus* Indian Peafowl *Pavo cristatus* Common Pheasant *Phasianus colchicus* Red-whiskered Bulbul *Pycnonotus jocosus* Common Myna *Acridotheres tristis* Common Starling *Sturnus vulgaris*	Rainbow Trout *Oncorhynchus mykiss* Chinook Salmon *Oncorhynchus tshawytscha* Brown Trout *Salmo trutta* Goldfish *Carassius auratus* European Carp *Cyprinus carpio* Roach *Rutilus rutilus* Oriental Weatherloach *Misgurnus anguillicaudatus* Eastern Gambusia *Gambusia holbrooki* Redfin *Perca fluviatilis* Tench *Tinca tinca*

3.2.5.3 Tree dieback

An area of dieback of eucalypt trees was observed near Fussell Road along Bungalook Creek. The cause of the dieback is unknown. However, it is plausible that these trees died in the last drought period (Plate 35). Upon review of aerial imagery over the last 10 years, it appears that trees died between 2015-2018.

Tree health transects were established in 2023 to collect data on tree health prior to the upgrade of the quarry. Results are presented in Appendix C. One of the transects was intentionally located within the area where trees had recently died or are showing signs of dieback (T2) to capture current condition before the upgrade of the quarry takes place. Living trees only were included in the baseline monitoring.

Plate 35 Tree dieback observed along Bungalook Creek near Fussell Road

3.2.5.4 Barriers to aquatic fauna passage

There are existing barriers to aquatic fauna passage in Bungalook Creek that would prevent access to the study site. From the headwaters of Bungalook Creek to Dandenong Creek these include:

- Colchester Road Retarding Basin
- Stormwater wetland (between Colchester and Canterbury Road) where natural flow paths are bypassed/drains present
- Areas where the creek flows underground (i.e. from Canterbury Road for a distance of ~2.5 km downstream)

Examples of drains/barriers to passage are provided in Plate 36.

Plate 36 Examples of existing drains (left, centre) and dry reach on Bungalook Creek where flows bypass natural channel and flow underground (right). Located approximately 3 km downstream from project site

3.2.5.5 Water quality

GHD (2023) state that the groundwater and surface water quality could be impacted by several pathways associated with operation of the quarry including:

– Spillage, improper handling, storage and application of hazardous materials (e.g., refuelling and maintenance of plant)
– Seepage from sumps and onsite storages
– Erosion of ground surfaces and increased sediment load in runoff after a rainfall event
– Acid sulphate soils

The Boral quarry operations are typical of quarrying practices throughout Victoria and the on-going operation of the site is not expected to alter the risk profile in terms of having an impact on groundwater or surface water quality. The site environmental controls and emergency response procedures are considered reasonable to mitigate this risk, including the use of bunding to control surface water run-off, and incident response procedures in the event of a spill or seepage. There are also contaminated sites neighbouring the quarry, and if contaminated groundwater exists at these sites, there is a risk that the plumes may be captured by the quarry dewatering. However, this is considered a low risk due to several reasons including previous management actions and natural attenuation of contaminants at these sites (GHD 2023).

The erosion of ground surfaces and increased sediment load in runoff as a result of exposed soil has the potential to impact surface water and the quality of receiving waterways. However, appropriate erosion and sediment controls and measures to reduce soil disturbance would be in place before overburden stripping begins and monitored and maintained throughout the development of the expansion area. Controls as per the EPA *Civil construction, building and demolition guide* (Publication 1834), and reestablished vegetation cover on the waterway side of the perimeter bunding would further assist to minimise offsite discharge of sediment laden run-off.

There are two main pathways for the activation of acid sulfate soil to form groundwater impacts:

– Excavation of PASS soils above the water table and their management, such as acid run-off from stockpiles and treatment areas, filling, handing of spoil from excavations
– Dewatering required as part of the construction of features below the water table

CSIRO's Atlas of Australian Acid Sulphate Soils was interrogated by GHD (2023), and the mapping indicates that the site and surrounds have an extremely low probability and very low confidence of acid sulphate soils occurring.

3.2.5.6 Climate change

Changes to climate have the potential to affect the groundwater system, primarily by altering the dynamics of recharge and evapotranspiration. Predicting potential changes to these processes by future climate variations is challenging due to their dependence on multiple climate variables and complex interactions between vegetation, soil and climate (McCallum et al., 2010).

The potential impact of climate change on groundwater was assessed by GHD (2023) by referencing the *Victorian Government's Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP 2020). The guidelines provide projections of percentage changes in key climate parameters such as average annual rainfall, potential evapotranspiration and runoff under three climate change conditions (low, medium and high impact).

GHD (2023) did not identify a significant change in the drawdowns due to the low climate change condition, which was not unexpected given the relatively small changes to recharge, evapotranspiration and streamflow. For the medium and high climate change conditions, greater drawdown is expected along Bungalook Creek and beyond. There was also a larger area of downstream drawdown for the low climate change condition compared to the medium climate condition. This is because under these drier climate change conditions, a much greater overall reduction in streamflow and recharge means the drawdown impact of the quarry becomes more pronounced. That is, there would be greater drawdowns occurring beneath the waterway, inducing greater leakage from the waterway. However, there is less flow available to leak and recharge the underlying groundwater system which results in a much broader area of impact downstream.

Overall, the expansion of the quarry has the potential to exacerbate the effect of climate change on baseflow, resulting more frequent and longer periods of little to no downstream flow due to induced leakage.

3.2.5.7 March 2025 Bushfire

In March 2025, an out-of-control bushfire started in the adjacent Ken Leversha Reserve and quickly encroached the study site. Vegetation within monitoring transects and quadrats was burnt, example photo below and is now in a phase of recovery.

3.3 Risk Assessment – problem formulation

3.3.1 Sensitive receptors

It is acknowledged that the contribution of groundwater to baseflow in Bungalook Creek and the use of groundwater by vegetation and other ecological values (either directly or indirectly) varies depending on climate. However, based on the assessment of ecological values in Section 3.2 and the definitions of GDEs outlined in Appendix A, the following types of GDEs are considered present within the study site:

– Ecosystems that depend on the surface expression of groundwater (i.e., Bungalook Creek).
– Ecosystems that depend on the subsurface presence of groundwater (i.e., terrestrial vegetation and fauna that depend on this vegetation).
– The GDEs and ecological values identified to potentially occur in the study site that have some dependency on surface water or groundwater. This includes a range of flora species and vegetation communities, and several mammals, birds, reptiles, frogs, crustaceans and fish.

Table 21 summarises sensitive environmental receptors considered in the risk assessment. Sections 3.3.1.1 to 3.3.1.3 summarise the assessment findings to date for each ecosystem component, providing the rationale for inclusion within the risk assessment.

Table 21 Sensitive receptors considered in the risk assessment

Ecosystem component	Value
Surface water	Bungalook Creek and associated native species
Aquatic fauna and habitat	**Crustaceans -** Foothill Burrowing Crayfish (*Engaeus victoriensis*) and Dandenong Burrowing Crayfish (*Engaeus urostrictus*)
	Water dependent ecosystems and species (as per EP Act 2017) – Refuge pools – Native fish – Macroinvertebrates
Vegetation	**Vegetation communities –** EVC 29 Damp Forest EVC 17 Riparian Scrub/Swampy Riparian Woodland Complex, which is a mix of Riparian Scrub (EVC 191) and Swampy Riparian Woodland (EVC 83); EVC 83 Swampy Riparian Woodland; EVC 821 Tall Marsh. **Deep rooted trees –** Such as Messmate and Swamp Gum that may source some water directly from groundwater owing to their deep root systems, particularly in shallow groundwater areas abutting the quarry. Recent leaf water potential, soil moisture potential and isotope tracing suggest trees within the study site are largely dependent on soil moisture, that is likely to be sustained by rainfall and creek flows, when creek seepage occurs. **Amphibious flora species –** Such as Tree Ferns and Ground-ferns require damp soil for extended periods of time (Ate) to establish and survive. Scented Paperbark requires wet soil for long periods, and is found in wet and peaty soils, fringing swamps and streambanks (ATw). This species occurs within the study site along the creek and surrounding pools. Reeds such as Cumbungi and Common Reed are dependent on long periods of inundation (Se). These species dominate the stormwater treatment area and retarding basins within the study site.
Terrestrial fauna	**Mammals -** Broad-toothed Rat (*Mastacomys fuscus mordicus*). **Birds -** Pilotbird (*Pycnoptilus floccosus*); Little Egret (*Egretta garzetta nigripes*); Plumed/Intermediate Egret (*Ardea intermedia plumifera*); Eastern Great Egret (*Ardea alba modesta*); Latham's Snipe (*Gallinago hardwickii*); Rufous Fantail (*Rhipidura rufifrons*); Satin Flycatcher (*Myiagra cyanoleuca*); Black-faced Monarch (*Monarcha melanopsis*). **Reptiles -** Glossy Grass Skink (*Pseudemoia rawlinsoni*); Swamp Skink (*Lissolepis coventryi*).

3.3.1.1 Aquatic fauna and habitat

3.3.1.1.1 Burrowing crayfish

The Dandenong Burrowing Crayfish has burrow systems which descend to the watertable, allowing the crayfish to follow the rise and fall of the water table (Horwitz et al. 1985) and surface and groundwater reductions arising from drought and water extractions/diversions have been identified as a risk to habitat for these species (DELWP 2015). Habitat/burrowing preferences of the Foothill Burrowing Crayfish are less well understood, so a conservative approach has been adopted, with an assumption that connection to the watertable is required.

3.3.1.1.2 Water dependent ecosystems and species (EP Act 2017)

Waterway health – water quality and macroinvertebrate communities

Under the EP Act 2017, there is an over-arching requirement to maintain:

Water quality that is suitable to protect the integrity and biodiversity of water dependent ecosystems. This integrity and biodiversity includes:

– The integrity of riparian vegetation as it contributes to the health of water dependent ecosystems and bank stability.
– Groundwater quality that does not adversely affect surface water ecosystems.
– Groundwater quality that does not adversely affect natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis to maintain their communities of organisms, ecological processes and ecosystem services. This includes wetlands, rivers and streams reliant on groundwater baseflow, some terrestrial vegetation and some estuarine and near-shore marine systems, stygofauna and troglofaunal.
– Maintenance of fish passage.

In addition, as surface and groundwater systems are connected, there is a requirement to ensure that:

– Groundwater does not affect receiving (surface) waters to the extent that the level of any indicator in the receiving waters: (a) exceeds the level of that indicator (if specified as an upper limit); or (b) is less than the level of that indicator (if specified as a lower limit), specified for surface water in the ERS (Victorian Government, 2021).

As such, indicators in this case refer to both water quality and aquatic macroinvertebrate communities, both of which have objectives in the Tables 5.8 and 5.9 of the ERS, noting that these objectives do not apply if:

– The objective is not able to be attained due to the background water quality levels of that indicator, or
– The background water quality level better protects the environmental values than the objective specified in the Table 5.7 of the ERS

This is relevant to the Boral Montrose project as existing data (see Sections 3.2.2.3 and 3.2.2.4) indicates that:

– Aquatic macroinvertebrate communities and water quality in the vicinity of the Boral Montrose site generally meet ERS objectives (depending on site and parameter) and as such are relevant environmental values within Bungalook Creek that require consideration.
– Locations upstream from the Boral Montrose site do not meet ERS objectives (depending on site and parameter).

Native fish

It is unlikely that threatened fish species inhabit Bungalook Creek and barriers to fish passage downstream of the study area are likely to be at least partly responsible for this (see Section 3.2.5.4). However, as required by the *Fisheries Act 1995*, the project must not create additional barriers to fish passage to allow for the existing native fish community to be maintained. Barriers to fish passage can be caused by physical barriers such as weirs and culverts, but also due to flow restrictions (i.e. water levels below which fish cannot pass) or water quality barriers (i.e. fish may not pass through water which has poor water quality). Activities that potentially degrade aquatic environments and habitat are also regulated under the Act - even if the affected fish are not listed under the FFG Act or EPBC Act.

Refuge pools

The site assessments determined that potential refuge pools are present in Bungalook Creek within the vicinity of Boral's Montrose quarry (see Section 3.2.2.2).

Refuge pools/habitat provide physical places where organisms (e.g., macroinvertebrates and fish) can persist during times of disturbance, such as drought or flooding (Hale 2018 cited in Shackleton et al. 2019). They can maintain populations through dry/drought periods and provide a source of organisms that can disperse throughout a waterway when reconnection is established following dry periods (Robson et al. 2008).

It is likely these pools provide an ecosystem function in the creek that is known to cease flowing, and that their importance during dry/drought periods may increase in a drying climate and/or due to groundwater drawdown. As such, they have been included as a key habitat value for the risk assessment.

3.3.1.2 Native vegetation

Sensitive receptors related to native vegetation include:

- Instream aquatic vegetation (Atw Ate), albeit limited in extent within the waterway
- Creekline fringing vegetation (trees, ground ferns, sedges - Atw Ate)
- Deep rooted trees (Tda Tdr) that can source water from creek seepage
- Deep rooted shrubs (e.g., understorey trees - Tda Tdr) that can source water from creek seepage
- Flora species dependent on shade provided by overstorey trees (e.g., ground ferns - Tda)
- Threatened flora (if present)

The ability for species to access water depends on:

- Current groundwater depth
- Species and known rooting depths
- Predicted drawdowns
- Plant Functional Group (i.e. specific water requirements for the species)
- Availability of other water sources such as creekline water and soil moisture from rainfall infiltration

In the higher topography the depth to groundwater is beyond the accessible threshold depths for mature trees. However, where the groundwater is currently shallow (especially within <10 metres of the surface), potential risks to vegetation include:

- Decline in health of deep-rooted eucalypts or understorey trees (wattles, melaleuca spp.) that may be partially reliant on groundwater as a water source.
- Drying up of seepage and inundated areas that could in turn lead to a decline in health of amphibious species such as Cumbungi, Common Reed, Scented Paperbark and Ground-ferns.
- Tree death (or decline in health) could decrease canopy cover, and a more open canopy may lead to further invasion of weeds and decline in health of understorey species dependent on tree canopy (i.e., shading and nutrient enrichment of soils).

3.3.1.3 Terrestrial fauna

For terrestrial fauna, a decrease in groundwater levels may lead to indirect risks due to a loss of suitable habitat. For example, the Broad-toothed Rat, Swamp Skink and Glossy Grass Skink rely on dense ground cover, often in damp areas, for habitat. Latham's Snipe relies on damp or wet ground for foraging while other birds (e.g., Pilotbird, Rufous Fantail, Satin Flycatcher, Black-faced Monarch) require suitable vegetation for habitat. If groundwater drawdowns reduce the health of the vegetation and habitat these species rely on, there would be a risk of impacts to these species. Furthermore, the three Egret species identified within the study site rely on the presence of surface water at some stage in their life cycles. Although many of their surface water habitats are permanent waterbodies or rain fed, an increase in seepage into the groundwater can also reduce habitat quantity and quality.

As any impacts would be indirect (i.e. due to native vegetation impacts) or due to a loss of permanent surface water habitat, the assessment has used the aquatic and native vegetation risk assessment as proxies to determine whether a risk to this ecosystem component exists.

3.3.2 Impact pathways

The following impact pathway has been considered during the risk assessment:

– Dewatering required to access lower levels of the quarry

The impact pathway caused by dewatering has the potential to lead to the following mechanisms, which may impact and result in harm to the identified sensitive receptors (Section 3.3.1):

– Groundwater level reduced from ~5 m under existing conditions to 5-15 m
– Increased seepage from Bungalook Creek, resulting in loss of surface water flow (and associated changes in water quality)

Note that a maximum drawdown of around 23 m is predicted to occur in year 35 during a dry period when total flow is limited. However, in general the drawdown predicted along Bungalook Creek will be around 10 m or less, depending on prevalent climate and flow. Furthermore, during dry periods, when the total streamflow is less than 10 L/s, all of the streamflow is lost as leakage due to the expansion of the quarry and associated drawdown of the water table. This effect is predicted to gradually occur during operation (years 1-40). During rehabilitation (over ~50 years) this effect will then be reduced, as groundwater levels recover.

As these two mechanisms are not mutually exclusive (i.e. a reduction in groundwater level can lead to increased seepage), each of the sensitive receptors have been assessed against the single impact pathway related to dewatering of the quarry listed above. Discussion has been provided in Section 3.4 of how the mechanism and impact pathway interacts with each sensitive receptor, and whether that is due to groundwater or surface water changes, or both.

3.3.3 Conceptual models

3.3.3.1 Surface water and groundwater interactions

The development of the GDE conceptual model (Figure 11) builds upon the models for groundwater and surface water developed by GHD (2023) but also incorporates the ecological values and GDEs within the study site. The model conceptualises the information detailed within this report, to provide a simple representation of GDEs within the study site under existing conditions.

The water table is likely a subdued reflection of topography, with groundwater levels ranging between 30 m BGL directly south of the quarry, to within 5 m BGL adjacent to Bungalook Creek. The model in Figure 11 focuses on the area abutting the proposed quarry upgrade where groundwater appears to be at its shallowest (approximately 2-8 m BGL) and where the predicted drawdown is expected to be greatest following expansion of the quarry. The section of Bungalook Creek of relevance to the model is located near monitoring bores AS2 (see Figure 1) and is within the reach considered a transitional zone. That is, it is the section where the elevation of the creek and groundwater levels may be similar, and the creek is in a loosely gaining or baseflow neutral condition during an average climatic season. The model also demonstrates how interactions with surface water and groundwater under different climate scenarios (i.e., average, wet and dry seasons).

Average season

– Baseflow to the creek is thought to be minimal based on measured groundwater levels, with the creek in a loosely gaining or baseflow neutral condition.
– Root water uptake by large trees likely to occur from soil water and interflow due to the infiltration of surface water runoff.
– Plant Functional Groups with higher water requirements may also be dependent on groundwater seepage (e.g., ground ferns), but likely to occur from soil water and interflow due to the infiltration of surface water runoff.
– Dandenong and Foothills Burrowing Crayfish burrows deep enough to follow and intercept water table; Tubercle Burrowing Crayfish burrows wetted by surface water runoff.
– Water quality suitable for maintenance of ecosystem values and services.
– Maintenance of refuge pools and other aquatic habitat.

– Terrestrial fauna (including frogs and birds) are dependent on current vegetation structure/habitat that would be maintained in an average season.

Dry season

– Groundwater unlikely to provide any baseflow to the creek, with increased seepage from creek into groundwater.
– Root water update by large trees likely to occur from soil water and interflow due to the infiltration of surface water runoff, when present.
– Dandenong and Foothills Burrowing Crayfish burrows not deep enough to intercept water table; Tubercle Burrowing Crayfish burrows wetted by surface water runoff, if present. Crayfish likely to adopt survival strategies such as reducing surface activity and sealing of burrows to maintain moisture.
– Water quality likely to be reduced compared to average and wet seasons, with potential for increased temperature and salinity, and reduced dissolved oxygen.
– Potential loss of refuge pools and other aquatic habitat.
– Terrestrial fauna (including frogs and birds) are dependent on current vegetation structure/habitat and changes to vegetation structure could in turn reduce habitat suitability for some terrestrial fauna species during extended dry seasons.

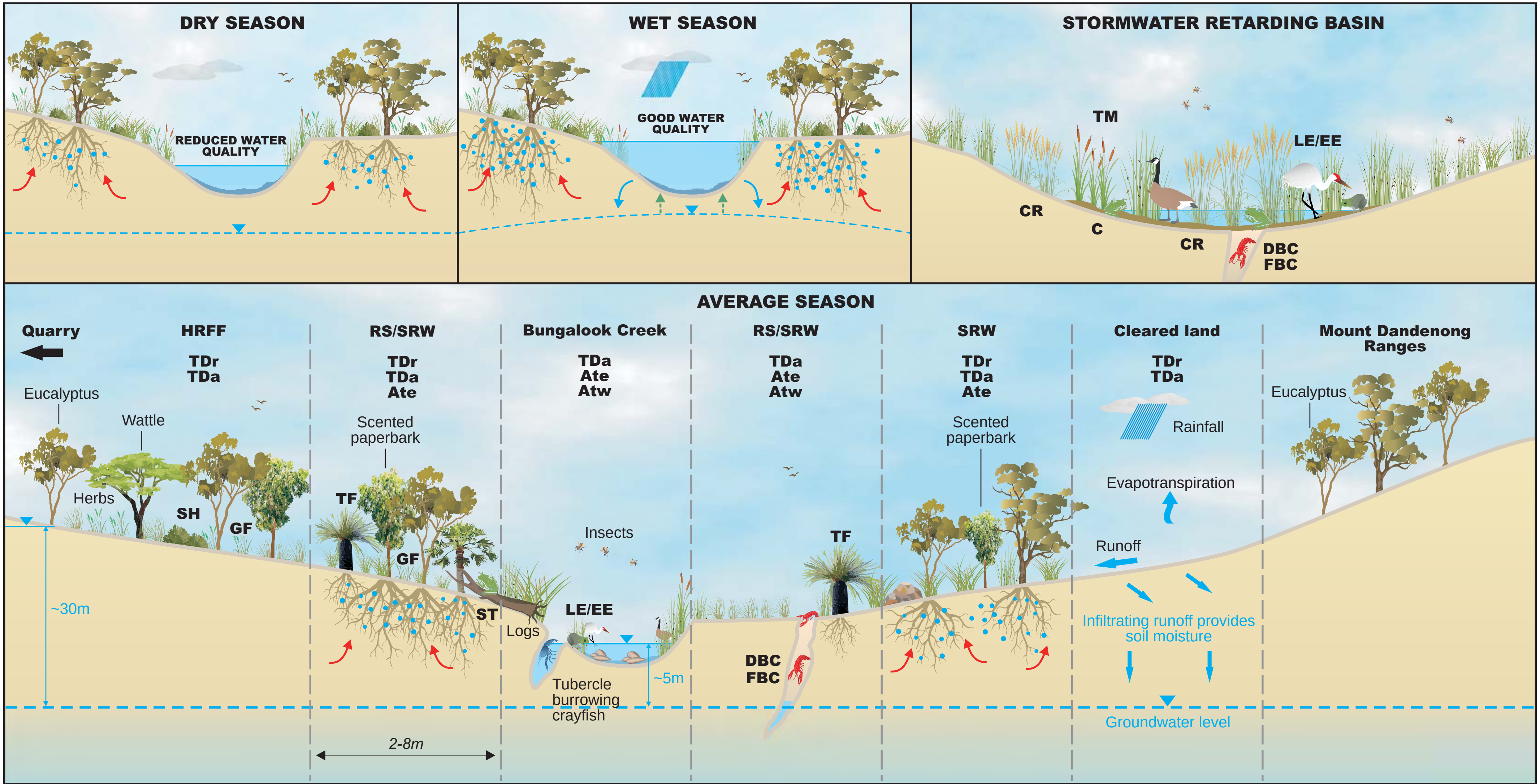
Wet season

– Potentially some contribution of groundwater to baseflow in the creek, but with majority of flow due to surface water runoff.
– During times of higher rainfall, when groundwater levels maybe even shallower, trees close to Bungalook Creek may access groundwater, however this would still likely be sourced from recent creek recharge post rainfall events.
– Root water update by large trees and other vegetation may occur at shallower depths during the wetter periods, when soil water is replenished.
– Plant Functional Groups with higher water requirements may also be dependent on groundwater seepage (e.g., ground ferns), but likely to occur from soil water and interflow due to the infiltration of surface water runoff.
– Dandenong and Foothills Burrowing Crayfish burrows deep enough to follow and intercept water table; Tubercle Burrowing Crayfish burrows wetted by surface water runoff.
– Water quality suitable for maintenance of ecosystem values and services.
– Maintenance of refuge pools and other aquatic habitat.
– Terrestrial fauna (including frogs and birds) are dependent on current vegetation structure/habitat that would be maintained in a wet season.

3.3.3.2 Changes in surface water flow

Figure 12 summarises our conceptual understanding of ecological values and predicted risks to those values based on modelled increases in the frequency and duration of cease to flow events in Bungalook Creek. Potential impacts on ecological values during expansion of the quarry are illustrated with yellow arrows.

In summary, increased cease-to-flow frequency and duration may result in temporary loss of aquatic habitat, reduction in connectivity and water quality, which could lead to decline in: ERS objectives/macroinvertebrates, reduced fish passage, burrowing crayfish habitat, refuge pools, aquatic and fringing vegetation within Bungalook Creek. Impacts are expected to be greatest at years 25-50. Impacts are likely to be temporary i.e. once quarry operation ceases and flow events increase again, connectivity and water quality fresh could facilitate recovery of ecological values.



Ecological Vegetation Class

TM	Evc 821. Tall marsh
HRFF	Evc 23. Herb-rich Foothill Forest
RS/SRW	Evc 17. Riparian scrub/swampy riparian woodland
SRW	Evc 83. Swampy riparian woodland

Plant Functional Groups

TDr	Terrestrial dry
TDa	Terrestrial damp
Ate	Amphibious fluctuation tolerator, emergent
Atw	Amphibious fluctuation tolerator, woody
Se	Perennial-emergent

Life Forms

SH	Shrub
GF	Ground fern
S	Sedges
TF	Tree fern
G	Grass

Threatened Species

ST	Southern toadlet
DBC	Dandenong burrowing crayfish
FBC	Foothills burrowing crayfish
LE/EE	Little Egret/Eastern Egret

Other Species

C	Cumbungi
CR	Common Reed Phragmites Australis

Legend

- Soil water uptake by roots
- Soil moisture
- Surface water recharge
- Groundwater contribution to baseflow

Conceptual diagram only - not to scale

GHD

Boral Montrose

Conceptual ecological model - groundwater shallowest

Project No. 12611238
Revision No. A
Date 29/07/2025

FIGURE 11

AU\Launceston\Projects\Admin\Graphics\12\611238\12611238_LST_02.cdr

180 Lonsdale Street Melbourne VIC 3000 T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

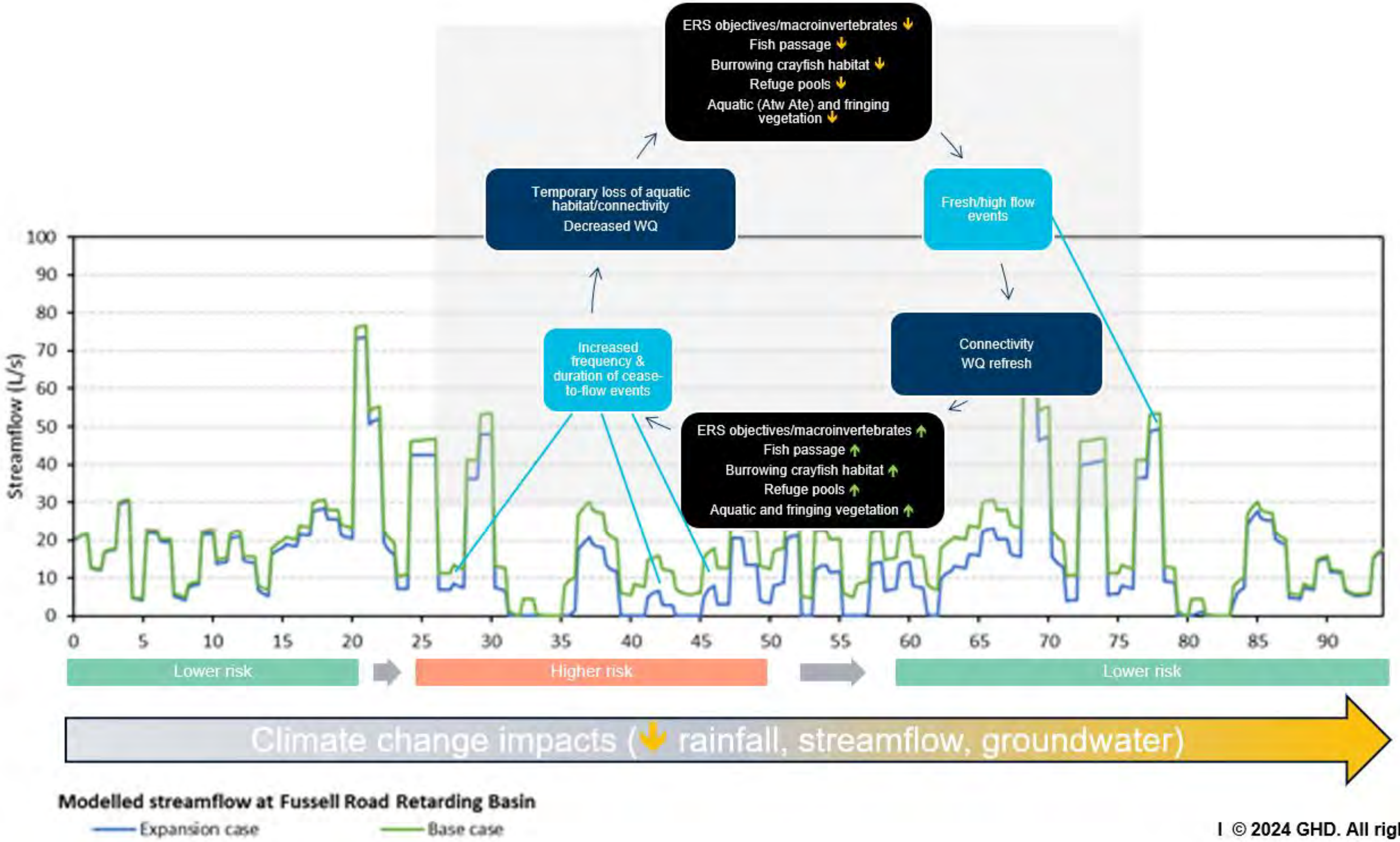


Figure 12 ***Conceptual model of potential changes to stream flow and potential risks to ecological values***

3.4 Risk Assessment – risk analysis

The results of the ecological risk assessment are presented in Appendix H. Inherent risk is defined as risk before mitigation measures are employed. Medium or low risk levels were assigned to all risk events before mitigation.

Residual risk after mitigation was reduced to low risk for all risk events except for:

– Burrowing crayfish in areas of predicted groundwater drawdown, for which the residual risk is considered medium

3.4.1 Aquatic fauna and habitat

Burrowing crayfish

Foothill Burrowing Crayfish have been recorded within Bungalook Creek by DEECA in 2011, and Dandenong Burrowing Crayfish are known to occur within the broader study area. Although not detected during the targeted survey, Dandenong Burrowing Crayfish cannot be discounted from the study site and Bungalook Creek due to the low capture rates during the survey, the overlap in the species' ranges and the suitability of habitat present.

A reduction in groundwater levels is unlikely to impact these species, based on the fact that the species is unlikely to construct burrows that would intersect groundwater under existing conditions. Dandenong Burrowing Crayfish are known to have burrow systems that descend to the water table to a depth of around 0.5 m (Horwitz et al. 1985). While the burrowing ability of Foothill Burrowing Crayfish is unknown, their burrowing ability can be inferred based on ability of other crayfish species which have groundwater or surface water dependence. Horwitz et al. (1985) observed that burrow depths can be relatively shallow (in the realm of 0.5 m). It is therefore unlikely that Foothill Burrowing Crayfish construct burrows at depths that intersect existing groundwater levels (which can be ~5 m in the modelled drawdown area).

Existing streamflow, water quality and wetting of the riparian zone (e.g. to a depth of 1 m BGL) in the vicinity of Bungalook Creek are likely to be of more importance to these species.

Based on a loss of streamflow due to seepage, the level of risk to Burrowing crayfish will:

– Increase as operation proceeds, then decrease during the rehabilitation phase
– Manifest during dry periods, when Bungalook Creek flows are low (with more seepage loss to groundwater)
– Be influenced by water quality conditions caused by dry periods (e.g. stagnation of water/eutrophication)

The level of impact is uncertain, as there are knowledge gaps in terms of Burrowing Crayfish biology – both in terms of existing distribution, their use of existing habitat and how they may react to drying conditions or a drying climate. However, in general, surface and groundwater reductions arising from drought and water extractions/diversions may limit habitable area (DELWP 2015b) at a local scale. Additional catchment inputs in downstream reaches of Bungalook Creek mean that the level of impact is not likely to extend throughout the sub-catchment.

Based on the above, the inherent risk to Burrowing Crayfish in the study site is considered medium. The discharge point from the Boral quarry is currently of downstream from where the predicted area of drawdown is likely to be greatest (GHD 2023) and where the crayfish habitat was observed during the targeted surveys. Relocating the discharge point upstream of these areas may offset increased seepage from Bungalook Creek and assist in protecting habitat for the species (see Section 3.4.4). However, the effectiveness of this remains would need to be confirmed through monitoring. As such, the residual risk to burrowing crayfish remains medium.

Native fish

The native fish community of Bungalook upstream from the Colchester Road Retarding Basin is of low diversity and abundance. Both species recorded (Short-finned eel and Climbing galaxias) have some capacity to navigate barriers and would have had to navigate numerous existing barriers in Bungalook Creek to access the upper reaches (see Section 3.2.5.4). Both fish species were recorded within the predicted drawdown area, in reaches of Bungalook Creek that were in relatively good condition for an urban waterway (in terms of in-stream and riparian habitat present).

A reduction in groundwater levels is unlikely to impact the fish community. Existing streamflow and, to some extent, connectivity in Bungalook Creek are the key drivers for the species present. Based on a loss of streamflow due to seepage, the level of risk to native fish will:

– Increase as operation proceeds, then decrease during the rehabilitation phase
– Manifest during dry periods, when Bungalook Creek flows are low
– Be influenced by water quality conditions caused by dry periods (e.g. stagnation of water/eutrophication)

The most likely consequence to native fish would be that a decrease in habitable areas may occur during dry periods (e.g. drying of pool habitats), which may also lead to a barrier effect that prevents passage along Bungalook Creek. Fish may also become isolated in drying pools, where water quality may become unsuitable.

The inherent risk to native in the study site is considered medium. Relocating the discharge point upstream of the predicted drawdown area will likely assist in protecting habitat for the species (see Section 3.4.4) and the residual risk is considered low.

Waterway health

Aquatic macroinvertebrate communities and water quality in the vicinity of the Boral Montrose site generally meet ERS objectives (depending on site and parameter). The majority of taxa collected during the initial baseline monitoring either have a mobile (i.e. flying) life stage and/or are relatively common taxa that would recolonise from upstream or downstream locations in the event of the waterway drying/ceasing to flow – which occurs under existing conditions.

A reduction in groundwater levels is unlikely to impact the macroinvertebrate community. Existing streamflow and, to some extent, connectivity in Bungalook Creek are the key drivers for the species present. Based on a loss of streamflow due to seepage, the level of risk to macroinvertebrate communities will:

– Increase as operation proceeds, then decrease during the rehabilitation phase
– Manifest during dry periods, when Bungalook Creek flows are low
– Be influenced by water quality conditions caused by dry periods (e.g. stagnation of water/eutrophication)

The most likely consequence to macroinvertebrates (and waterway health) would be that a decrease in habitable areas may occur (e.g. drying of pool habitats) and a reduction in water quality which may lower the likelihood of Bungalook Creek meeting ERS objectives, at a local scale. Although the creek ceases to flow under existing conditions, the increased seepage may prolong the dry periods or lead to additional cease to flow events, reducing the ecosystem function of the creek. Additional catchment inputs in downstream reaches of Bungalook Creek mean that the level of impact is not likely to extend throughout the sub-catchment.

The inherent risk to waterways as determined by the macroinvertebrate communities is considered medium. Relocating the discharge point upstream of the predicted drawdown area will likely assist in protecting habitat for the species (see Section 3.4.4) and the residual risk is considered low.

Refuge pools

A number of refuge pools were noted within the predicted drawdown areas during the field surveys. At this stage the importance of these pools and their water source is a knowledge gap. Under existing conditions, they are likely to provide refuge for a range of aquatic fauna in a waterway that is known to cease to flow. In a predicted drying climate, their importance may increase.

It is understood that the majority of surface water flow in Bungalook Creek is derived from surface water/stormwater run-off, with a lower proportion derived from groundwater. That said, both a reduction in groundwater levels and loss of streamflow due to seepage may lead to a reduction in refuge pool volume and water quality in these pools. This impact is most likely to occur during dry periods, with potential for a loss of habitat for aquatic fauna (as discussed previously).

The inherent risk to refuge pools is considered medium. Relocating the discharge point upstream of the predicted drawdown area will likely assist in protecting this habitat (see Section 3.4.4) and the residual risk is considered low.

3.4.2 Native vegetation

Instream aquatic vegetation (Bungalook Creek)

Reduction in baseflow and/or increased seepage from Bungalook Creek, resulting in loss of surface water flow could lead to a reduction or loss of instream and fringing vegetation (e.g. aquatic and amphibious vegetation). Aquatic and amphibious plants need shallow water for a period of three or more months (dependent on species) or soil moisture to persist. Given there is little instream vegetation within Bungalook Creek (low cover and low species richness of aquatic plants was observed in 2023), aquatic vegetation inherent risks are considered low.

Deep rooted trees/shrubs and fringing vegetation (Bungalook Creek)

It is predicted that groundwater levels will reduce from ~5 m under existing conditions to 5-15 m. Such changes to groundwater depth will lead to decrease in groundwater available for deep rooted trees and/or shrubs (understorey trees). Decreased water availability may lead to a decline in tree condition over time (i.e., reduced canopy cover and potentially tree death). Areas of existing tree dieback and stressed trees may be more at risk than trees currently in moderate/good condition.

It is not possible to quantify the extent of tree decline that may occur as result of groundwater drawdown (i.e. what percentage of trees may be affected and what percentage may die during the drawdown phase). Based on the findings of the EMM (2025) investigation, tree impacts are considered unlikely when only considering direct use of groundwater by trees (assigned a 5% – 30% chance of occurring; Table 3). However, there is a higher likelihood that the decrease in streamflow predicted to occur as a result of groundwater drawdown may impact trees along Bungalook Creek, as these trees are partly reliant on creekline water and seepage (assigned a 30-70% chance of occurring; Table 3).

With mitigation in place (see Section 3.4.4), a low residual risk to deep rooted trees that rely on surface water has been identified. However, with a drying climate, trees may become more dependent on groundwater over time, increasing the risk of tree impacts from reduction in groundwater levels.

Shade dependent flora (Tda Tdr)

Ecological Vegetation Classes such as Damp Forest have a dense understorey of shade dependent and moisture dependent ground ferns and scattered tree ferns. Tree decline (or tree death) could result in reduced canopy cover, which would reduce shade required for these ferns. A low residual risk rating has been determined for shade dependent flora.

Threatened flora

The three threatened flora species considered possible to occur and more likely to be affected by groundwater/stream flow changes were eliminated from the investigation as targeted surveys were undertaken and the species were not found within the study site (see Section 3.2.3.5).

The other 11 threatened flora considered possible to occur are at lower risk to changes in groundwater/streamflow as those species are likely to continue to persist (if present) based on: i) lower water requirements ii) indirect impacts are likely to be low in extent e.g. tree decline/death may result in reduced canopy cover, which may lead to changes in understorey composition. Whilst such changes may be considered a change in habitat quality, it is considered unlikely this would result in significant decline of a threatened species population if present. The residual risk is considered low.

Recovery period (post operation)

Once operation ceases, groundwater levels are predicted to recover to pre-upgrade levels over time. Deep-rooted tree condition may then improve (canopy cover increase). However, some trees may be of too poor condition to recover. Increased canopy cover may facilitate growth and recruitment of shade dependent understorey vegetation (e.g., ground ferns). For these reasons, impacts to trees and understorey could be temporary, acknowledging that recovery may be over years or perhaps decades.

3.4.3 Terrestrial fauna

As mentioned in Section 3.3.1.3 any impacts to terrestrial fauna would be indirect (i.e. due to native vegetation impacts) or due to a loss of permanent surface water habitat. As such, the assessment has used the aquatic and native vegetation risk assessment as proxies to determine whether a risk to this ecosystem component exists.

For terrestrial fauna, a decrease in groundwater levels may lead to indirect risks due to a loss of suitable habitat. For example, the Broad-toothed Rat, Swamp Skink and Glossy Grass Skink rely on dense ground cover, often in damp areas, for habitat. Latham's Snipe relies on damp or wet ground for foraging while other birds (e.g., Pilotbird, Rufous Fantail, Satin Flycatcher, Black-faced Monarch) require groundwater to maintain suitable vegetation for habitat. If groundwater drawdowns reduce the health of the vegetation and habitat these species rely on, there would be a risk of impacts to these species. Furthermore, the three Egret species identified within the study site rely on the presence of surface water at some stage in their life cycles. Although many of their surface water habitats are permanent waterbodies or rain fed, an increase in seepage into the groundwater can also reduce habitat quantity and quality.

The outcomes of the risk assessment for vegetation that may be used as habitat for the threatened terrestrial fauna species (i.e., shade and moisture dependent understorey vegetation) determined that there is a low residual risk. Furthermore, the loss of surface water flow due to seepage into the groundwater has also been identified as a low residual risk following the implementation of management controls (see Section 3.4.4). Consequently, there is also a low residual risk to the terrestrial fauna species that utilise this vegetation as habitat.

3.4.4 Management controls

The assessment of risks indicates that impacts are most likely to occur due to increased streamflow seepage during dry/low flow periods and that the extent of impact is likely to be localised for each of the sensitive receptors. To assess the residual risk, the following management control has been included within the assessment following discussion with Boral on controls which are feasible and reasonably practicable:

– Relocation of existing discharge point upstream of the predicted drawdown area

As discussed in GHD (2023), a potential management control would be the relocation of the existing discharge point further upstream of the predicted drawdown area subject to Melbourne Water/EPA Victoria approvals. This control assumes that discharge water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS).

Under existing EPA Victoria licence conditions this would allow for up to 0.86 ML/d of water to be discharged into the creek. Relocation of the discharge point would allow for extra flows to be added to the creek, providing maintenance flows to support sensitive receptors where a loss of surface water has been identified as a risk. GHD (2023) provide discussion on this management control and note that a large portion of flows may pass downstream as the rate of leakage into groundwater would be expected to be lower than the rate in which the flow is routed downstream indicating that the flows would predominantly benefit surface water values, rather than groundwater recharge.

Under existing conditions, it is known the creek is intermittent, with low and cease-to-flow periods most likely in late summer (GHD 2023). An increase in the frequency of and/or duration of these events is likely to occur during the expansion period. Given that relocation of the discharge point would aim to counteract the increased seepage/reduction in streamflow it is recommended that a hydrological/water balance assessment is completed to provide greater certainty and maximum benefit by using this management control (see Section 6.1). This assessment should consider:

1. The capacity for Boral to harvest water prior to discharge
2. Ability to provide a surface water flow that maintain or improve ecological values, with consideration given to aspects of the flow regime such as the timing or magnitude of flows.

4. EE Act referral criteria

The *Environment Effects Act 1978* provides for environmental impact assessment of proposed project works capable of having a significant effect on the environment. In Victoria an assessment does not confer approval of a project, rather it informs decision makers when considering project approvals. The Act relies on the referral of proposed projects to the Minister administering the Act for a decision on whether a project proponent is required to undertake an environment effects statement (EES). For the purposes of the Act, the environment is broadly defined and encompasses all physical, biological, social, spiritual and economic systems, processes and attributes.

The individual and combined referral criteria shown in Table 22 assist in identifying the significance of a project's potential effects in a regional or state context and inform whether a referral is required. Proponents are encouraged to undertake a thorough self-assessment against the referral criteria. The identification of potential significant effects, and subsequent requirement for referral, does not mean that an assessment will necessarily be required.

We understand Boral has engaged EMM to undertake a self-assessment under the EE Act and prepare a referral for the broader project. Table 22 provides a preliminary assessment of environmental effects relevant to this GDE investigation only.

Table 22 Individual and combined criteria under the EE Act and preliminary assessment of project implications

Referral criteria	Relevance to project
Individual Criteria (new)	
Potential removal, destruction or lopping of 10 hectares or more of native vegetation, that consists of, or comprises a combination of: – An ecological vegetation class (EVC) classified as endangered; or – An EVC that is classified as vulnerable (with a condition score of 0.5 or more) or rare (with a condition score of 0.6 or more) – That is not authorised for removal under an approved forest management plan or fire protection plan.	Threshold unlikely to be triggered. Direct impacts to native vegetation include: – Removal of 8.662 hectares of native vegetation (Herb-rich Foothill Forest EVC 23), most of which is located within the Highland Southern falls bioregion and considered a least concern EVC (EHP 2022). Indirect impacts to vegetation associated with predicted groundwater drawdown and increased seepage from the creekline into groundwater include: – Decline in tree health and possibly tree death which may lead to changes in understorey vegetation over time in EVCs with least concern, vulnerable or endangered bioregional conservation status. Impacts would not result in destruction of these EVCs, and vegetation is likely to recover once operation ceases and groundwater levels rise. – These indirect impacts would not constitute destruction of 10 hectares or more of an endangered, vulnerable or rare EVC.
Potential clearing of an area determined as 'critical habitat' under the Flora and Fauna Guarantee Act 1988.	Threshold unlikely to be triggered. The study site does not support an area declared as 'critical habitat' under the FFG Act.
Potential for loss of a significant proportion (e.g. 1 percent or greater) of known remaining habitat or population of a threatened species within Victoria	Threshold unlikely to be triggered. **Threatened flora** There is suitable habitat within the study site for 13 threatened flora species. Two of these species occur along streambanks. Targeted surveys did not detect these two species within the study site. Potential impacts to these species (if present) are limited to changes in quality of habitat. It is unlikely that such habitat changes and localised impacts would constitute the loss of a significant proportion of remaining habitat for threatened flora. **Threatened fauna** FFG-listed Burrowing Crayfish – although remaining distribution has not been precisely quantified, it is unlikely that the localised impact would constitute the loss of a significant proportion of remaining habitat.

Referral criteria	Relevance to project
	Terrestrial fauna The outcomes of the risk assessment for vegetation that may be used as habitat for the threatened terrestrial fauna species (i.e., shade and moisture dependent understorey vegetation) determined that there is a low risk. Furthermore, the loss of surface water flow due to seepage into the groundwater has also been identified as a low risk. Consequently, there is also a low risk to the threatened terrestrial fauna species that utilise this vegetation as habitat (section 3.3.1.3).
Potential for long-term change to the ecological character of a wetland listed under the Ramsar Convention or in A Directory of Important Wetlands in Australia.	Threshold unlikely to be triggered. The study site is not located within or near a Ramsar listed wetland. The nearest Ramsar site is Edithvale-Seaford Wetlands which is located approximately 35 km southwest of the Boral Montrose quarry.
Potential for extensive or major effects on the use and environmental values of water resources due to changes in water quality, water availability, stream flows, water system function, or regional groundwater levels, or the health or biodiversity of aquatic, estuarine or marine ecosystems, over the long term.	Threshold unlikely to be triggered. **Aquatic ecosystem values** With mitigation and monitoring measures implemented, it is unlikely that major effects would occur to aquatic ecosystem values (i.e., Bungalook Creek health and fish communities) over the long-term. Impacts to these values are likely to be localised, with management controls and monitoring recommended to mitigate and manage these local impacts. However, there is potential for impacts to FFG Act listed Burrowing Crayfish with the risk level deemed medium. Although a medium risk has been identified for FFG listed Burrowing Crayfish (see Section 3.4.1), this is a conservative approach as their current distribution, use of existing habitat and how they may react to drying conditions or a drying climate are unknown, as is the effectiveness of the relocated discharge as a mitigation measure. This will be confirmed through monitoring and if required adaptive management (see Section 6), so the threshold is unlikely to be triggered. **Native vegetation values** Decreased streamflow and water availability associated with groundwater drawdown during expansion and operation of the quarry may lead to a decline in tree condition over time (i.e., reduced canopy cover and potentially tree death). However, an investigation by EMM has demonstrated trees within the study site have a low reliance on groundwater currently (EMM 2025). Risk to deep-rooted trees was determined to be low – i.e. increased seepage from the creekline to groundwater may reduce available water for trees aligning the creekline. With mitigation and monitoring measures implemented, it is unlikely that major effects would occur. **Terrestrial fauna** The outcomes of the risk assessment for vegetation that may be used as habitat for the threatened terrestrial fauna species (i.e., shade and moisture dependent understorey vegetation) determined that there is a low risk. Furthermore, the loss of surface water flow due to seepage into the groundwater has also been identified as a low risk. Consequently, there is also a low risk to the threatened terrestrial fauna species that utilise this vegetation as habitat (Section 3.3.1.3).
Potential for extensive or major effects to human health or the environment, or displacement of residents, from pollution or waste emitted to air, land, water or groundwater.	Not addressed in this investigation – Boral to investigate
– Potential for greenhouse gas emissions exceeding 200,000 tonnes of carbon dioxide equivalent per annum (direct and indirect) attributable to the operation of the facility.	Not addressed in this investigation – Boral to investigate

Referral criteria	Relevance to project
Combination Criteria	
Potential removal, destruction or lopping of 10 hectares or more of native vegetation, unless it is authorised for removal under an approved forest management plan or fire protection plan.	Threshold unlikely to be triggered. Direct impacts to native vegetation include: – Removal of 8.662 hectares of native vegetation (Herb-rich Foothill Forest EVC 23), most of which is located within the Highland Southern falls bioregion and considered a least concern EVC (EH&P 2022) Combined with indirect impacts to vegetation associated with predicted groundwater drawdown and decreased streamflow: – Decline in tree health along the creekline and possibly tree death which may lead to changes in native vegetation structure and composition over time. Impacts would not result in destruction of these EVCs and vegetation is likely to recover once operation ceases and groundwater levels rise again. Given impacts would not lead to "destruction" of native vegetation, impacts could be considered partial loss (e.g. reduction in canopy cover/loss of some trees).
Matters listed under the *Flora and Fauna Guarantee Act 1988*: – Potential loss of a significant area of a listed ecological community; or – Potential loss of a genetically important population of an endangered or threatened species (listed or nominated for listing), including from loss or fragmentation of habitats; or – Potentially significant effects on habitat values of a wetland supporting migratory bird species.	Threshold unlikely to be triggered. No FFG listed communities occur within the study site. **Threatened flora** There is suitable habitat within the study site for 13 threatened flora species. Two species were discounted as targeted surveys did not detect these species. None of the remaining 11 species are directly reliant on groundwater or streamflow. As such potential impacts to these species (if present) is limited to changes in quality of habitat. It is unlikely that such habitat changes and localised impacts would constitute the loss of a significant proportion of remaining habitat for threatened flora. **Threatened aquatic/terrestrial fauna** Burrowing Crayfish – although remaining distribution has not been precisely quantified, it is unlikely that the localised impact would constitute the loss of a significant proportion of remaining habitat. However, there is potential for impacts to FFG Act listed Burrowing Crayfish with the risk level deemed medium. If FFG listed species are present, the local population is likely to be genetically important as *Engaeus* species tend to exhibit high endemism and low genetic variability due to its extremely restricted range and isolated populations. Although a medium risk has been identified for FFG listed Burrowing Crayfish (see Section 3.4.1), this is a conservative approach as their current distribution, use of existing habitat and how they may react to drying conditions or a drying climate, and the effectiveness of the relocated discharge as a mitigation measure are yet to be confirmed. This will be confirmed through monitoring and if required adaptive management (see Section 6), so the threshold is unlikely to be triggered. **Threatened terrestrial fauna** The outcomes of the risk assessment for vegetation that may be used as habitat for the threatened terrestrial fauna species (i.e., shade and moisture dependent understorey vegetation) determined that there is a low risk. Furthermore, the loss of surface water flow due to seepage into the groundwater has also been identified as a low risk. Consequently, there is also a low risk to the threatened terrestrial fauna species that utilise this vegetation as habitat (section 3.3.1.3).
Potential for extensive or major effects on landscape values of regional importance, especially: – Where recognised by a planning scheme overlay; – Declared as a distinctive area and landscape under the Planning and Environment Act 1987; or – Within or adjoining land reserved under the National Parks Act 1975.	Not addressed in this investigation.

Referral criteria	Relevance to project
Potential extensive or major effects on land stability, acid sulphate soils or highly erodible soils over the short or long term	Not addressed in this investigation
Potential for extensive or major effects on social or economic well-being due to direct or indirect displacement of non-residential land use activities.	Not addressed in this investigation
Potential for significant effects on the amenity of a substantial number of residents, due to extensive or major, long-term changes in visual, noise and traffic conditions.	Not addressed in this investigation
Potential for extensive or major effects on Aboriginal cultural heritage values protected under the Aboriginal Heritage Act 2006.	Not addressed in this investigation
Potential for extensive or major effects on cultural heritage places and sites listed on the Victorian Heritage Register or the Victorian Heritage Inventory under the Heritage Act 2017	Not addressed in this investigation
Potential for extensive displacement of residents or severance of residents' access to their community resources.	Not addressed in this investigation

5. Conclusions

Boral's Montrose Quarry has operated since the 1950s, forming a significant feature within the local groundwater system. The quarry pit sits at a regional low point, where groundwater seeps and pools at its base upon intersecting the water table. To manage this, groundwater is actively pumped out - likely contributing to a drawdown effect in the nearby Bungalook Creek.

With the proposed expansion of quarry operations, further groundwater drawdown is anticipated along Bungalook Creek. This may intensify surface water seepage from the creek, increasing the frequency of low-flow and cease-to-flow events. Such changes pose potential risks to groundwater-dependent ecosystems (GDEs) and ecological values reliant on either groundwater or surface water flows in the creek.

To evaluate these risks, Boral commissioned GHD to conduct an ecological assessment surrounding the quarry. Their findings confirmed the presence of GDEs and ecological values within the study area - many of which are dependent on groundwater or sustained surface water flows. These include burrowing crayfish, riparian vegetation, and fauna reliant on that habitat. Several threatened species protected under State or Commonwealth legislation were identified as potentially present, including native flora, vegetation communities, mammals, birds, reptiles, frogs, and crustaceans.

The assessment concluded that most GDEs and ecological values face low inherent risks from projected changes to groundwater levels. For example, it was determined that trees prefer soil moisture as a source of water rather than groundwater, while other threatened water dependent floral species such as *Pteris epaleata* (Netted Brake) and *Senecio campylocarpus* (Bulging Fireweed) were not detected in the study site during targeted surveys. However, there were some medium inherent risks associated with Bungalook Creek and associated aquatic values due to the loss of surface water. These included risks to Burrowing Crayfish, the health of the creek itself, and trees along the creek that are partly reliant on creek water and seepage.

These inherent risks were further reduced by modifying the discharge system - specifically by relocating the existing discharge point upstream of the predicted drawdown areas to allow quarry water to be returned to Bungalook Creek, thus compensating for lost surface flow. However, a medium residual risk remains for two threatened Burrowing Crayfish species listed under the FFG Act: the Dandenong Burrowing Crayfish (*Engaeus urostrictus*) and the Foothill Burrowing Crayfish (*Engaeus victoriensis*). Risk to these species is expected to:

– Increase during active quarrying operations, then lessen during the rehabilitation phase
– Intensify in dry seasons, when creek flow is naturally reduced
– Be exacerbated by poor water quality linked to dry conditions (e.g. stagnation, eutrophication)

The reduced residual risks are dependent on the effectiveness of the relocated discharge point compensating for lost surface flow. To support the effectiveness of this management control, the following sections of this report identify management opportunities and targeted monitoring associated with the proposed project.

6. Recommendations

Recommendations related to mitigation measures and ecological monitoring are provided in the following sections.

6.1 Ecohydrological assessment

A hydrological/water balance assessment is recommended to assess the benefits that relocation of the licenced discharge point may have. The *Surface Water and Groundwater Assessment* (GHD 2023) developed a water balance, primarily for informing the rehabilitation planning. While it includes the operational period and indicative net dewatering volumes, a plan for how this volume can be extracted and diverted to the creek was not developed.

Ongoing monitoring of surface flows and groundwater levels along Bungalook Creek is recommended to improve the understanding of interactions between the surface water and groundwater systems, and to assess the potential effectiveness of this management control. Details of the recommended surface water monitoring are included in Appendix M of the *Surface Water and Groundwater Assessment* (GHD 2023). Depending on the findings of monitoring, a further hydrological assessment may become necessary to evaluate the ability of the relocated discharge to maintain or benefit the sensitive receptors identified in this assessment in terms of timing or magnitude of flows.

6.2 Refuge pools

Potential refuge pools were observed during field surveys. It can be assumed that they provide an ecosystem function in a waterway that is known to cease flowing. Their importance during dry/drought periods may increase in a drying climate and/or due to groundwater drawdown. Direct monitoring of refuge pools is not recommended as part of this project as it is assumed that they will be maintained by the relocated discharge. However, surface water volumes should be monitored to ensure suitable flows are discharged into the creek to maintain the refuge pools. Details of the recommended surface water monitoring are included in Appendix M of the *Surface Water and Groundwater Assessment* (GHD 2023).

6.3 Groundwater use/reliance by trees

Riparian and floodplain tree species tend to be mesic and highly dependent on access to reliable water sources including in-stream surface water, soil moisture and shallow groundwater (Kath et al. 2014). Such species may be poorly adapted to cope with moisture deficit; hence, their condition tends to be closely related to their hydrological status (Kath et al. 2014).

The literature reflects two models of ecological response to groundwater decline in riparian and floodplain tree species: (i) a linear response, where tree condition declines across a gradient of groundwater depths (e.g. Cunningham et al. 2011; González et al. 2012); or (ii) a threshold response, where tree condition remains relatively stable until groundwater depth declines below a particular level, after which tree condition declines rapidly (e.g. Horton et al. 2001; Cooper et al. 2003).

There is a paucity of data and literature on groundwater depth thresholds of trees. No specific research could be sourced on the dominant eucalypt species found at Bungalook Creek and groundwater interactions (Swamp Gum and Messmate). Some studies in arid zones of Australia have suggested species such as River Red-gum groundwater depth thresholds range from 12-26 metres, beyond which canopy condition declines rapidly (Kath et al. 2014). Noting critical groundwater depths may represent a functional physiological limit to root growth for some species.

To gain a better understanding of sources of water used by trees and their reliance on groundwater at the Bungalook Creek study site, hydrological tracer studies were completed by EMM (2025). Stable hydrogen and oxygen isotope technology is a new technique for exploring the source of water in plants. The Stable Isotope Analysis (δ2H/δ18O) technique has been used by others to identify the sources of water used by trees, including studies by CSIRO in Australia. By comparing the isotopic composition of water in the tree's xylem with potential water sources, researchers can determine the proportion of water uptake from each source (Liu et al. 2021). The study by EMM (2025) was undertaken to fill this information gap identified by GHD in our earlier version of this report regarding site-specific data on reliance of trees on groundwater as one of their sources of water. As mentioned previously, the study concluded that trees along Bungalook Creek are predominantly relying on soil moisture and creekline water, replenished by rainfall and seepage. There is evidence from the hydrogeological modelling that demonstrates streamflow will be reduced under a drying climate and because of expansion of the quarry. Given the trees at this location are reliant on rainfall and stream seepage, monitoring tree health is recommended (See Section 6.4.2).

It is not possible to quantify the extent of tree decline that may occur as result of groundwater drawdown (i.e. what percentage of trees may be affected and what percentage may die during the drawdown phase). Based on the findings of the EMM investigation, tree impacts are considered unlikely when only considering direct use of groundwater by trees (assigned a 5% – 30% chance of occurring; Table 3). However, there is a higher likelihood that the decrease in streamflow predicted to occur as a result of groundwater drawdown may impact trees along Bungalook Creek, as these trees are partly reliant on creekline water and seepage (assigned a 30-70% chance of occurring; Table 3).

6.4 Ecological monitoring

The surveys undertaken as part of this project have established baseline conditions for several ecological values (including changes in the vegetation following the 2025 bushfire). Additional monitoring would confirm the level of risks identified in this report, by allowing changes in those values to be assessed overtime. Furthermore, additional monitoring of burrowing crayfish may determine that threatened species are not present in the study site, thereby reducing the identified risks.

Once the information gaps are filled, the ecological monitoring should be included as a component of the surface and groundwater Trigger Action Response Plan (TARP) developed by GHD (2023), which may also be used to guide flow releases from the relocated discharge point, if required.

6.4.1 Aquatic values

Burrowing Crayfish

It has been established that Burrowing Crayfish are present within the predicted drawdown area, but December 2023 surveys did not record any threatened crayfish species. Previous records indicate presence of threatened Burrowing Crayfish within Bungalook Creek and the local region. It is therefore recommended that additional surveys are completed to provide greater certainty on the presence of Burrowing Crayfish within the predicted drawdown area. Methods as per those described in Appendix B should be followed.

Waterway health (macroinvertebrates)

It is recommended that further baseline monitoring is completed periodically to provide an understanding of seasonal variation in waterway health (e.g. to understand how waterway health changes during dry/drought or following high flow periods). Gathering this information will provide Boral with evidence of how waterway health varies under existing conditions or during the early stages of operation, when surface water impacts are likely to be lower. The results could then be used to assess whether changes in groundwater or surface water levels in later stages of operation are having an ecological impact.

6.4.2 Vegetation

Baseline vegetation monitoring was established in 2023 to monitor:

– Tree health (three transects with 30 live trees in each transect)
– Vegetation composition within EVCs fringing Bungalook Creek and in existing shallow groundwater areas (groundwater at depth <10 metres)

Tree health monitoring was repeated in June 2025 because a bushfire impacted the study site in March 2025. We recommend Boral continue to monitor tree health and vegetation composition over time, e.g. every two years. Refer to recommended monitoring methods in Appendix B for guidance.

7. References

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Backhouse, G., Jackson, J. and O'Connor, J. (2008). *National Recovery Plan for the Australian Grayling* Prototroctes maraena. Department of Sustainability and Environment, Melbourne

Baggiano, O. (2012). *The Murray-Darling turtles: gene flow and population persistence in dryland rivers*. PhD Thesis, School of Environment, Griffith University

Barmuta, L. A., Chessman, B. C. and Hart, B. T. (1998) *Interpreting the outputs from AUSRIVAS*. Land and Water Resources Research and Development Corporation: Canberra. Occasional Paper 02/98

Bino, G., Kingsford, R. T., Archer, M., Connolly, J. H., Day, J., Dias, K., Goldney, D., Gongora, J., Grant, T., Griffiths, J., Hawke, T., Klamt, M., Lunney, D., Mijangos, L., Munks, S., Sherwin, W., Serena, M., Temple-Smith, P., Thomas, J., Whittington, C. (2019). The platypus: evolutionary history, biology, and an uncertain future. *Journal of Mammalogy*, 100(2), 308–327

Booth, D. T. (2010). The natural history of nesting in two Australian freshwater turtles. *Australian Zoologist* 35, 198–203

Bower, D., Hutchinson, M. and Georges, A. (2012). Movement and habitat use of Australia's largest snake-necked turtle: Implications for water management. *Journal of Zoology* 287, 76–80

Bryant, A. G. (1993). An evaluation of the habitat characteristics of pools used by platypus (*Ornithorhynchus anatinus)* in the upper Macquarie River system, New South Wales. B.Appl.Sc. (Honours) thesis, Charles Sturt University, Bathurst, New South Wales, Australia

Bryant, D., Crowther, D. and Papas, P. (2012). Improving survey methods and understanding the effects of fire on burrowing and spiny crayfish in the Bunyip and South Gippsland catchments. Department of Sustainability and Environment, Heidelberg, Victoria

Bryant, D., Crowther, D. and Papas, P. (2014). *Engaeus* Erichson (Decapoda: Parastacidae) capture using two versions of a Norrocky trap. Australian Zoologist 1 January 2014

Cann, J. (1998). *Australian Freshwater Turtles*. Beaumont Publishing, Singapore

Cassanova, M. T. (2011). Using water plant functional groups to investigate environmental water requirements. *Freshwater Biology* 56, 2637–2652

CFE (2023). Identification and Ecology of Australian Freshwater Invertebrates. Centre for Freshwater Ecosystems, Latrobe University interactive guide. Available at: https://www.mdfrc.org.au/bugguide/index.htm

Chessman, B. C. (1978). *Ecological studies of freshwater turtles in southwestern Australia*. PhD thesis, Department of Zoology, Monash University

Chessman, B. (2003). *SIGNAL 2 - A Scoring System for Macroinvertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra

Chessman, B. C., Metzeling, L., & Robinson, D. P. (2022). Development of a flow-sensitive macroinvertebrate index for Australian rivers. River Research and Applications, 38(5), 846–862. https://doi.org/10.1002/rra.3950

Clifton, C., Cossens, B. and McAuley, C. (2007). *A Framework for assessing the environmental water requirements of groundwater dependent ecosystems*, report prepared for Land and Water Australia

Cooper, D.J., D'amico, D.R., Scott, M.L., 2003. Physiological and morphological response patterns of Populus deltoides to alluvial groundwater pumping. Environmental Management: 31, 215–226

CRC for Australian Weed Management (2003). Bridal creeper (*Asparagus asparagoides*) Weed Management Guide. Available at http://www.weeds.crc.org.au/documents/wmg_bridal_creeper.pdf

Cunningham, S.C, Thomson, J.R, Mac Nally, R., Read, J., Baker, P.J. (2011). Groundwater change forecasts widespread forest dieback across an extensive floodplain system. Freshwater Biology: 56, 1494-1508

DCCEEW (2018). What are the ecological impacts of groundwater drawdown? Department of Environment and Energy Fact sheet (now DCCEEW)

DEECA (2018). Bioregions and EVC benchmarks. Available on-line at https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks [accessed August 2023]

DEECA (2023a). Victorian Biodiversity Atlas. Available on-line at: https://www.environment.vic.gov.au/biodiversity/victorian-biodiversity-atlas [accessed August 2023]

DELWP (2015a). *Action Statement No. 261. White Star-bush Asterolasia asteriscophora* subsp. albiflora

DELWP (2015b). *Dandenong Burrowing Crayfish Engaeus urostrictus Action Statement No. 264*. The State of Victoria Department of Environment, Land, Water and Planning

DELWP (2015c). *Ministerial guidelines for groundwater licensing and the protection of high value groundwater dependent ecosystems*. The State of Victoria Department of Environment, Land, Water and Planning

Department of Environment and Heritage Protection (2012). *Pictures worth a thousand words: A guide to pictorial conceptual modelling*, Queensland Wetlands Program, Queensland Government, Brisbane

DEPI (2010). *Index of Stream Condition - Third Benchmark of Victorian River Condition*. Department of Primary Industries, State Government of Victoria

Doeg, T., Muller, K., Nicol, J. and Van Larrhoven, J. (2012). *Environmental Water Requirements of Groundwater Dependant Ecosystems in the Musgrave and Southern Basins Prescribed Wells Areas on the Eyre Peninsula*. DFW Technical Report 2012/16, Government of South Australia, Department of Water: Adelaide

E&HP (2022). *Biodiversity Assessment Report for the Montrose Quarry Expansion*. Report by Ecology and Heritage Partners for Boral Resources (Vic) Pty Limited

Ellem, B. A., Bryant, A. and O’Connor, A. (1998). Statistical Modelling of Platypus, *Ornithorhynchus anatinus*, Habitat Preferences Using Generalised Linear Models. *Australian Mammalogy* 20(2), 281-285

EMM (2025). *Montrose Quarry Extension. Groundwater Dependent Ecosystem Assessment.* Report prepared by EMM for Boral Resources (Vic) Pty Ltd June 2025.

EPA (2004). *Biological objectives for rivers and streams – ecosystem protection*. Publication Number ISBN 793.2, March 2004. Environment Protection Authority, Melbourne. Publication Number 793.1, June 2003. State Government of Victoria

EPA (2021). *Rapid Bioassessment Methodology for Rivers and Streams*. Publication Number 604.2, April 2021. Environment Protection Authority, Melbourne

GHD (2023). *Surface Water and Groundwater Assessment Montrose Quarry*. Report by GHD for Boral Resources (Vic) Pty Limited

Glanville K. Sheldon F. Butler D and Capon S. (2023). Effects and significance of groundwater for vegetation: A systematic review. Science of the Total Environment 875

González, E., González-Sanchis, M., Comín, F.A., Muller, E., (2012). Hydrologic thresholds for riparian forest conservation in a regulated large Mediterranean river. River Res. Appl: 28, 71–80

Goodwin, C., and Hopkins, C. (2005). *More Turtles: Murray River Protection Manual*. Riverland Animal Plant Control Board

Horton, J.L., Kolb, T.E., Hart, S.C., (2001). Physiological response to groundwater depth varies among species and with river flow regulation. Ecol. Appl: 11, 1046–1059

Horwitz P.H.J. (1990). A Taxonomic Revision of Species in the Freshwater Crayfish Genus Engaeus Erichson (Decapoda : Parastacidae). Invertebrate Taxonomy 4(3), 427-614

Horwitz, P. H. J., Richardson, A. M. M. and Boulton, A. (1985). The burrow habitat of two sympatric species of land crayfish, *Engaeus urostrictus* and *E. tuberculatus* (Decapoda: Parastacidae). *Victorian Naturalist* 102 (6): 188-197

JPR (2020). *Preparation of Work Plan and Work Plan Variations – Guidelines for Extractive Industry Projects.* Department of Jobs, Precincts and Regions, Victorian Government, Melbourne VIC

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

Klunzinger, M., Walker, K.F. & Jones, H. A. (2014). *Hyridella narracanensis*. The IUCN Red List of Threatened Species 2014: e.T189387A58526464. https://dx.doi.org/10.2305/IUCN.UK.2014-3.RLTS.T189387A58526464.en. Accessed on 26 March 2024

Koch, N., S. Munks, M. Utesch, P. Davies, and P. McIntosh. (2006). The platypus *Ornithorhynchus anatinus* in headwater streams, and effects of pre-Code forest clear felling, in the South Esk River catchment, Tasmania, Australia. *Australian Zoologist* 33, 458–473

Liu, Z., Liu, Q., Wei, Z. & Yu, X. (2021). Partitioning tree water usage into storage and transpiration in a mixed forest. Forest Ecosystems. Vol 8, article 72

Macgregor, J. (2015). Corrigendum to novel use of in-stream microchip readers to monitor wild platypuses. *Pacific Conservation Biology 21*, 101

McCallum, J. L., Crosbie, R. S., Walker, G. R. and Dawes, W. R. (2010). Impacts of climate change on groundwater in Australia: a sensitivity analysis of recharge. *Hydrogeology Journal* 18, 1625–1638

Melbourne Water (2018) Co-Designed Catchment Program for the Dandenong Catchment Region – October 2018 - Version 1

Milione, M., and Harding, E. (2009). Habitat use by platypus (*Ornithorhynchus anatinus*) in a modified Australian Wet Tropics catchment, north-eastern Queensland. *Australian Mammalogy* 31, 35–46

Petrov, K., Stricker, H., Van Dyke, J. U., Stockfeld, G., West, P. and Spencer, R. J. (2018). Nesting habitat of the broad-shelled turtle (*Chelodina expansa*). *Australian Journal of Zoology* 66, 4

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

Robson, B.J., Chester, E.T., Mitchell, B.D. and Matthews, T.G. (2008). Identification and management of refuges for aquatic organisms, Waterlines report, National Water Commission, Canberra

Rohweder, D. (1992). *Management of platypus in the Richmond River catchment, northern New South Wales*. B.AS. (Hons) thesis, University of New England, Northern Rivers, Lismore, New South Wales, Australia

Rohweder, D. A. and Baverstock, P. R. (1999). Distribution of platypus *Ornithorhynchus anatinus* in the Richmond River catchment, northern New South Wales. *Australian Zoologist* 31, 30–37

SAC (2022a). Preliminary Recommendation on a Nomination for Listing *Hyridella depressa* Depressed Freshwater Mussel. Flora and Fauna Guarantee – Scientific Advisory Committee

SAC (2022b). Preliminary Recommendation on a Nomination for Listing *Hyridella narracanensis* Narracan Corrugatged Mussel. Flora and Fauna Guarantee – Scientific Advisory Committee

Saddlier, S. and Hammer, M. (2010). National Recovery Plan for the Yarra Pygmy Perch (*Nannoperca obscura*). Department of Sustainability and Environment, Melbourne

Saddlier, S., Koehn J. D. and Hammer, M. P. (2013). Let's not forget the small fishes: conservation of two threatened species of pygmy perch in south-eastern Australia. *Marine and Freshwater Research* 64(9), 874-86

SCFFA (1997). 'Australian code of electrofishing practice.' (Standing Committee for Fisheries and Aquaculture, NSW Fisheries: Pyrmont, N.S.W.)

Serena, M., Williams, G. A. and Swinnerton, M. (2001). Ecology and conservation of platypus in the Barwon River catchment: I. Results of population surveys, summer 2001. Report to Corangamite Catchment Management Authority. Australian Platypus Conservancy, Whittlesea

Serov, P., Kuginis, L., Williams, J. and May, P. (2012). *Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*. NSW Department of Primary Industries, Office of Water, Sydney

Shackleton, M. E., Bond, N. R. & Crook, D. A. (2019). Review & synthesis of drought refuge habitat knowledge and management. Report for the Victorian Environmental Water Holder prepared by Centre for Freshwater Ecosystems.

Simpson J., Norris R., Barmuta L. and Blackman P. (1997). Australian River Assessment System. National River Health Program Predictive Model Manual (1st Draft). http://ausrivas.canberra.edu.au/ausrivas/

Souter, N. J., Cunningham, S. C., Little, S. and Wallace, T. A. (2012). Ground-based survey methods for The Living Murray assessment of condition of river red gum and black box populations

Spencer, R. J. (2000). *The Murray Turtle, Emydura macquarii: Population Dynamics, Nesting Ecology and Impact of the Introduced Red Fox, Vulpes vulpes*. PhD thesis, School of Biological Sciences, University of Sydney

Standards Australia, (2004). *Australian/New Zealand Standard: AS4360* - Risk Management. Retrieved from http://www.saiglobal.com

Tomlinson, M. (2011). Ecological Water Requirements of Groundwater Systems: a knowledge and policy review, Waterlines Occasional Paper, National Water Commission

Turnbull (1998). Distribution of the Platypus (*Ornithorhynchus anatinus*) in the Bombala River Catchment, South-Eastern New South Wales. *Australian Mammalogy* 20(2), 251-256

Van Dyke, J. U., Spencer, R. J., Thompson, M. B., Chessman, B., Howard, K. and Georges, A. (2019). Conservation implications of turtle declines in Australia's Murray River system. *Scientific Reports* 9, 1-12

Victorian Government (2021) *Environment Protection Act 2017 Environment Reference Standard.* Victorian Government Gazette No. S 245 by Authority of Victorian Government Printer

Walsh, C.J.; Waller, K.A.; Gehling, J. & MacNally, R. (2007). Riverine invertebrate assemblages are degraded more by catchment urbanisation than by riparian deforestation. Freshwater Biology, 52, 574–587

White, M., Cheal, D., Carr, G. W., Adair, R., Blood, K. and Meagher, D. (2018). *Advisory list of environmental weeds in Victoria*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 287. Department of Environment, Land, Water and Planning, Heidelberg, Victoria

Wills, E. (1999). Biological control of bridal creeper with the bridal creeper leafhopper. Department of Primary Industries, Victoria, Information Notes Series. Available at http://www.dpi.vic.gov.au

Appendices

Appendix A

Assessment of the presence of GDEs or ecological values with some dependence on groundwater

Table A1 Responses to example questions to help determine likelihood of an ecosystem reliance on groundwater (Source from Richardson et al. 2011 and Serov et al. 2012)

<table>
<tr><th colspan="2">All GDE types</th></tr>
<tr><td colspan="2">- Is the ecosystem identical or similar to another that is known to be groundwater dependent? Comparisons to known GDEs were not made as part of this assessment.
- Does the community contain species known to require permanent saturation? Yes, there are vegetation, terrestrial and aquatic species that require permanent saturation.
- Is the distribution of the ecosystem consistently associated with known areas of groundwater discharge? Groundwater discharge only provides a small proportion of flow in the waterways but changes in groundwater levels will influence habitat availability.
- Is the distribution of the ecosystem typically confined to locations where groundwater is known or expected to be shallow? Some areas of vegetation are restricted to shallow groundwater areas.
- Does expert opinion indicate that the ecosystem(s) is groundwater dependent? Yes, based on this assessment groundwater is important for maintaining ecosystem processes and services, either directly through the provision of water, or indirectly due to increased seepage of surface water associated with groundwater drawdown.</td></tr>
<tr><th>GDEs reliant on the surface expression of groundwater</th><th>GDEs reliant on the sub-surface presence of groundwater</th></tr>
<tr><td>- Does a stream/river continue to flow all year? No, but changes in groundwater levels will influence flow and habitat availability.
- Does the volume of flow in a stream/river increase downstream in the absence of inflow from a tributary? Not determined in this assessment.
- Is groundwater discharged to the surface for significant periods of time each year at critical times during the lifetime of the dominant vegetation type? No, but changes in groundwater levels will influence habitat availability.
- Is the vegetation associated with surface discharge of groundwater different (e.g., species composition or structure) to vegetation nearby that is not thought to access groundwater? Vegetation communities varied depending on groundwater levels and surface water.
- Is the stream or sections of the stream known to be gaining, i.e., receiving water from groundwater discharge where surrounding groundwater levels are higher than the stream bed or there is groundwater upwelling? Varies along the stream length and is also dependent on rainfall.
- Is the stream bed composed of course grained unconsolidated sediments such as sand or gravel? Yes.
- Is the aquatic invertebrate community within the surface water composed of long lived, short range endemic species? Yes, in part.</td><td>- Is groundwater or the capillary fringe above the water table within the rooting depth of any vegetation? Yes, in some areas where the groundwater depth is less than 5 m (i.e., along Bungalook Creek).
- Is the vegetation associated with surface discharge of groundwater different (e.g., species composition or structure) to vegetation nearby that is not thought to access groundwater? Yes, vegetation varied according to groundwater levels and surface water.
- Does the vegetation in a particular community occur along streams? Yes.
- Is the flora or fauna community composed of species known to require permanent saturation and are not obviously fed by surface water? Yes.
- Is the vegetation community known to function as a refuge for more mobile fauna during drought? Yes, several fauna species depend on the habitat provided by dense understorey vegetation likely resulting from presence of groundwater.
- Are seasonal changes in groundwater depth larger than can be accounted for by the sum of lateral flows and percolation to depth? Not determined in this assessment.
- Is the aquifer highly porous and composed of unconsolidated sediments (e.g., gravels, sand), or if consolidated (solid rock), is the rock matrix fractured? Yes, rock matrix is fractured and overlaid with alluvial sediments.</td></tr>
</table>

Appendix B

Targeted survey and baseline monitoring methods

Permits

All botanical site work was undertaken in accordance with GHD's Permit to take Protected Flora under the *Flora and Fauna Guarantee Act 1988* (FFG Act - Permit No. 10011043). All zoological site work was undertaken in accordance with GHD's Scientific Procedures Fieldwork License (No. SPF20067) and *Wildlife Act 1975* Research Permit (No. 100010378). Aquatic surveys were undertaken in accordance with FFG Act 1988 Authorisation to take Protected Fish (No. 10010160) and *Fisheries Act 1995* General Research Permit (No. RP1347).

Aquatic ecology values

Aquatic ecology surveys and assessments were completed from 11 to 14 December 2023 at six sites. An outline of the approach to the components monitored are included below and Table B1 provides a summary of the assessments completed at each site.

Table B1 Aquatic ecology survey summary

Site	Location	Waterway health	Fish (electrofishing)	Fish (bait traps)	Burrowing crayfish
BUN01	Tandara Court	✓			
BUN02	Dr Ken Leversha Reserve	✓	✓ (200 m surveyed)	✓	
BUN03	Adjacent to Boral Montrose quarry	✓			
BUN04	Adjacent to Boral Montrose quarry	✓	✓ (400 m surveyed)	✓	✓
BUN05	Upstream from Liverpool Road	✓			
BUN06	Upstream from Colchester Road Retarding Basin	✓	✓ (200 m surveyed)	✓	

Hydrology and weather conditions during aquatic ecology assessment

Weather conditions (temperature and rainfall) and Bungalook Creek flow conditions prior to and during the survey event are presented in Figure B1.

In summary, and of relevance to the surveys completed:

- **Rainfall:** 15.4 mm in the seven days preceding the surveys. The mean monthly rainfall between December 2015-2023 was 77 mm.
  - This indicates that a rainfall event occurred in the week leading up to the surveys, but that it would not be considered outside monthly mean rainfall for the area.
- **Waterway flow:** 2.1 ML/day in the seven days preceding the surveys and 1.9 ML/day during the surveys. The average daily waterway flow between December 2015-2023 was 2.4 ML/day.
  - This indicates that waterway flow in the seven days prior to the surveys had likely increased due to the rainfall event but that the magnitude of the increase was small, within the long-term average flow of the creek, and had stabilised during the surveys.
- **Air temperature:** Average maximum daily temperature (measured at 9 am) during the surveys was 25.4°C. The average maximum daily temperature for December 2015-2023 was 21.8°C, 95^{th} percentile was 24°C and highest was 25.6°C.
  - This indicates that air temperatures during the surveys were high relative to historical records – close to the highest on record for December between 2015 and 2023.

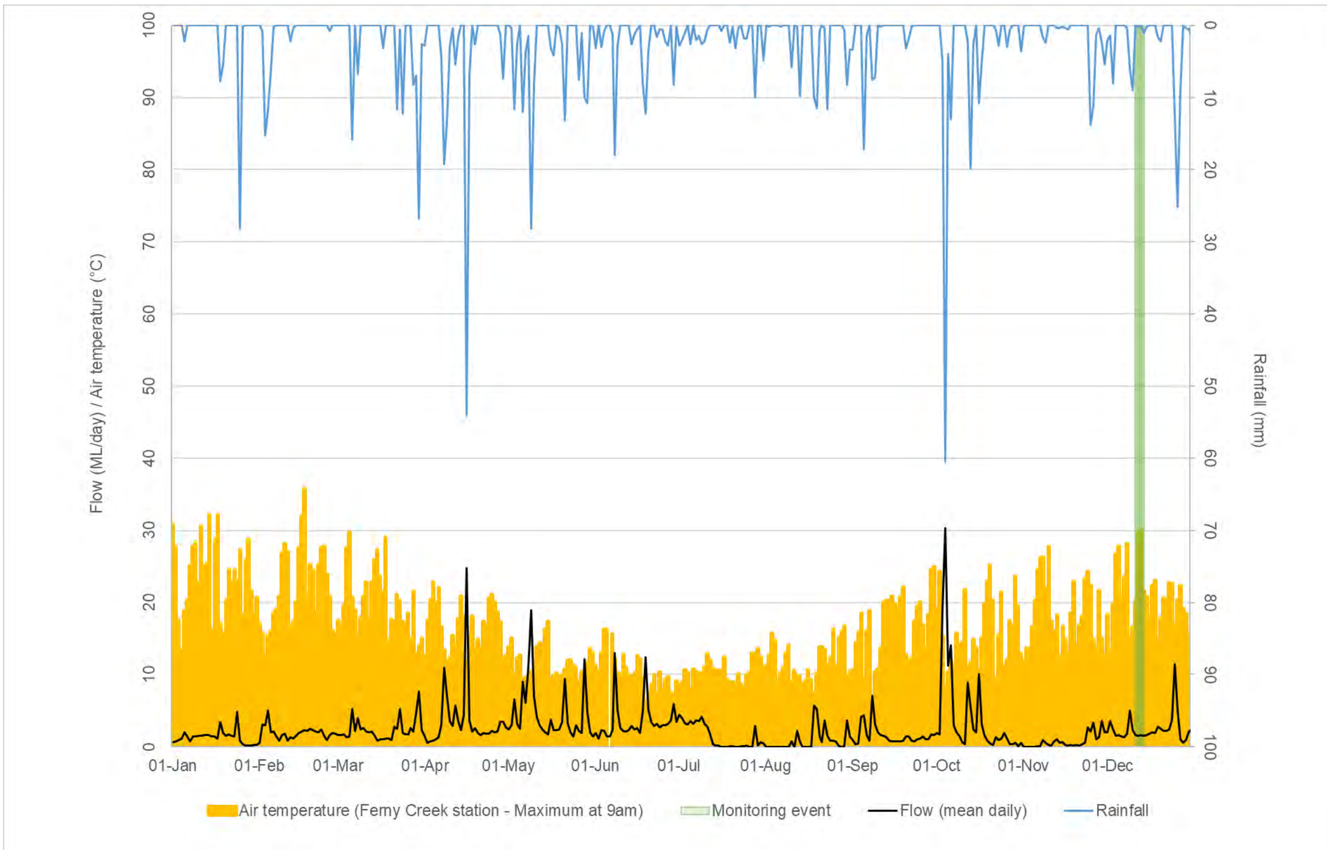


Figure B1 ***Site hydrology and weather conditions – 2023***

Waterway health

Macroinvertebrate monitoring

Macroinvertebrates were monitored at all six sites in Bungalook Creek using the protocol outlined in the *Guideline for Environmental Management (GEM) - Rapid Bioassessment Methodology for Rivers and Streams* (EPA 2021) to provide an understanding of waterway health.

Macroinvertebrates were collected from edge habitats using the Rapid Bioassessment (RBA) methodology (EPA 2021). Edge habitats were sampled by sweeping a 250 µm mesh net with a 30 cm x 30 cm opening through the water column and aquatic habitat. A total distance of 10 m per site was sampled although the distance was not always continuous to encompass all microhabitats at each site. All sites were assessed for the presence of riffle habitats, but riffles were insufficient or absent at all sites. As such, two sweep samples from edge habitats were collected from each site.

Following collection, the macroinvertebrate samples were live-picked in the field (EPA 2021) with the overall aim to collect as many different families as possible. On return to the laboratory, samples were processed under a stereo microscope, with most individuals identified to family level taxonomic resolution. The exceptions were Chironomidae (midge fly larvae) identified to sub-family, and Oligochaeta (worms) and Acarina (mites) identified to class which is consistent with RBA methodology (EPA 2021).

The aquatic habitat characteristics at each site were also assessed using the standard EPA (2021) habitat assessment criteria and recorded using ArcGIS Survey123.

Macroinvertebrate data analysis

The Victorian Government (2021) Environment Reference Standard (ERS) identifies environmental quality objectives for biological indices for rivers and streams based on macroinvertebrates. Biological indices provide context regarding current ecological conditions but are not necessarily sensitive to minor impacts and are rarely used in isolation (ANZG 2018). For example, the use of multivariate statistical analysis may be used to support the biological indices. That said, for the purposes of establishing a monitoring program that can define baseline waterway health based on a single sampling event, the comparison of indices to environmental quality objectives is sufficient and can be repeated as needed in the future using the same methods and sites.

The following indices, that have relevant ERS objectives, have been calculated for each site based on the average of the two samples collected:

– **AUSRIVAS Band:** The AUSRIVAS predictive model generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress (Simpson et. al. 1997). The ratio of the observed number of families divided by the expected number of families (O/E) is calculated and allocated to Bands as listed below:
  - Band X, where O/E is richer than reference
  - Band A, where O/E is similar to reference
  - Band B, where O/E is poorer than reference
  - Band C, where O/E is much poorer than reference
  - Band D, where O/E is far poorer than reference
– **Number of Families:** The number of macroinvertebrate families can reasonably indicate ecological condition with waterways in better condition generally having more families. This is calculated by summing the total number of families with respect to the taxonomic resolution outlined in EPA (2021).
– **SIGNAL2:** In general, SIGNAL2 (Stream Invertebrate Grade Number – Average Level) score is a family-level pollution index based on the known tolerances of macroinvertebrate families to pollutants with a gradient from 1 (indicating a pollution tolerant community) to 10 (indicating a pollution sensitive community) (Chessman 2003). SIGNAL scores for a site are calculated by averaging the scores for each macroinvertebrate family present. Sites with ‘good’ water quality (e.g., low conductivity, turbidity, and nutrients and high dissolved oxygen) tend to have higher SIGNAL2 scores and sites with low SIGNAL2 scores may indicate several kinds of physical or chemical impacts (Chessman 2003).

In addition to the above indices, the **Australian Macroinvertebrate Flow Index (AMFI)** was also calculated. The AMFI is based on velocity preferences of numerous Australian macroinvertebrate families, with a gradient from 0 (preference for zero or very slow flow) to 10 (preference for fast flow) (Chessman et al. 2022). This is combined with the strength of the relationship (the strongest indicators of velocity being taxa occurring exclusively in fast-water or taxa occurring exclusively in zero or slow-water). Conversely, the weakest velocity indicators are taxa with equivalent proportional occurrence in both fast-water and slow-water (i.e., those with the mid-range value of 5).

There is no ERS objective for AMFI. However, all the above indices can be used as a diagnostic tool of waterway health for future monitoring in relation to the quarry expansion. For example, SIGNAL2 tends to be a reflection of water quality, AUSRIVAS outputs are more related to habitat quality (Barmuta 1998) and AMFI is likely to respond mainly to hydrological variation (Chessman et al. 2022). As such, the relative changes in the indices could potentially be used to infer those components of waterway health that have been influenced by changes in groundwater and surface water dynamics.

Water quality

In situ water quality recordings included water temperature, dissolved oxygen, pH, electrical conductivity, turbidity and alkalinity. Recordings of temperature, dissolved oxygen, pH and electrical conductivity were made using a YSI water quality multiprobe. Turbidity was recorded using a Merc Turbiquant 1100IR turbidity meter. Alkalinity was assessed using a HACH Alkalinity Titration Kit.

Water quality data were compared to the Victorian Government (2021) ERS objectives for the Urban (Highly modified) segment comprising the areas within the urban growth boundary for Metropolitan Melbourne (as shown on the metropolitan fringe planning schemes set out in section 46AA of the *Planning and Environment Act 1987*).

It is important to note that a single measurement cannot reflect annual variation, which is the focus of ERS objectives. However, the objectives do provide a general guide for comparison of waterway health at the time of the survey. Comparisons to the objectives ideally require a minimum of 11 data points collected monthly over 12 months (Victorian Government 2021).

Fish

Fish were surveyed at three sites on Bungalook Creek using bait traps and an E-Fish backpack electrofisher. Electrofishing was conducted by a suitably qualified senior electrofisher operator in accordance with the Australian Code of Electrofishing Practice (SCFFA 1997). Single-pass electrofishing was completed for between 200-400 m per site, with a power-on time of approximately five minutes per site. Level of effort depended on water levels and the ability to access aquatic habitat. At each site up to six unbaited bait traps were deployed overnight with the number of bait traps set dependent on available habitat. Soak times for the bait traps varied between 15 and 20 hours per site. All fish were released at the point of capture.

Burrowing crayfish

Burrowing Crayfish (*Engaeus* sp.) burrows were observed during the preliminary site assessment. As such, trapping surveys were undertaken in the area where the greatest potential drawdown was predicted by GHD (2023). Over three consecutive nights, 35 Norrocky traps (modified after Bryant et al. 2012 – Figure B2) were deployed and retrieved the following morning. Burrows that showed signs of recent crayfish activity, in the form of fresh ejecta around the mouths of burrows, were prioritised. Captured Crayfish were identified in the field, photographed, and the associated burrow location documented. The captured specimens were returned to their original burrows. Identification was completed using keys provided by Horwitz (1990). Capture rates were calculated by dividing the number of Burrowing Crayfish captured by the number of traps set and expressed as a percentage.

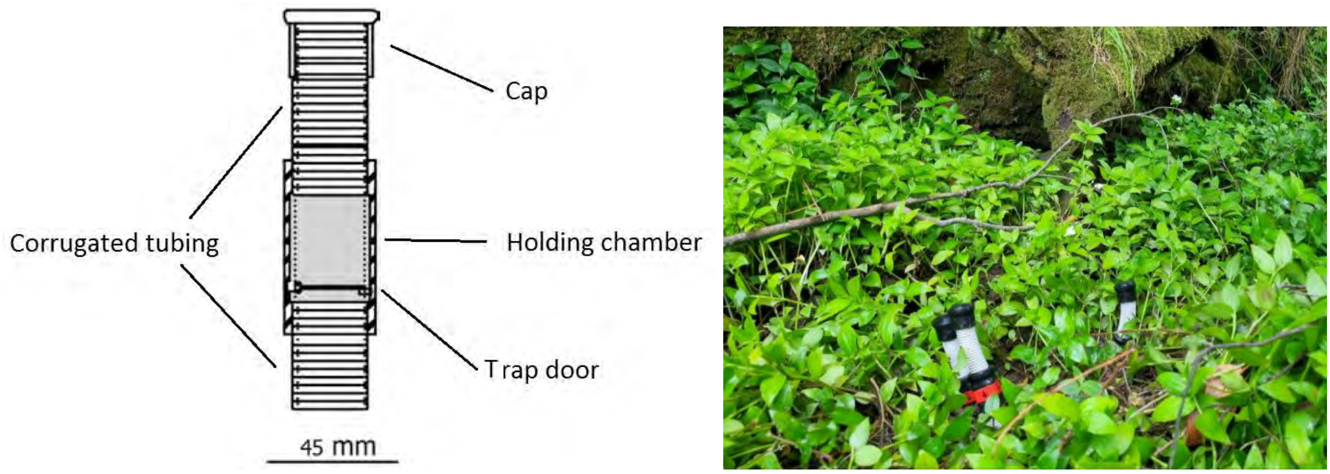


Figure B2 Modified Norrocky trap design and placement adjacent to Bungalook Creek

Vegetation

Mapping of Ecological Vegetation Classes

Field assessments were undertaken to refine the EVC mapping. Polygons for each EVC were captured in the field using ArcGIS fieldmaps, and their presence confirmed by comparing to the DEECA (2018) EVC benchmarks for the bioregion. Baseline data was collated on vegetation composition and tree health using the following methods.

Vegetation composition - transects

A transect approach with nested 20 x 20 m quadrats was applied to capture floristic data in each EVC (see Figure B3). Three transects were established perpendicular to Bungalook Creek, running in an east-west direction, at the following locations:

– One transect at the area of tree dieback observed during the preliminary site assessment
– Two transects at the area where groundwater levels are shallower

Transects were established as close at practical to the existing bores for measuring groundwater depth. A total of 10 quadrats were surveyed, with three to four quadrats established along each transect at intervals based on changes in EVC and/or vegetation condition. A permanent wooden peg was placed on the eastern centre point of each quadrat, so that quadrat locations can be located in the future. Photos were taken of the vegetation at each wooden peg (midpoint on the eastern edge of each quadrat looking South, West and North). At each quadrat the following data was collected:

– Flora species
– Origin (native or introduced)
– Foliage cover (<1%, <5%, then estimated to nearest 10% cover increments)
– Cover of litter, bare ground, bryophytes and lichens, logs, rocks
– Flora species were classified by Plant Functional Group (as defined in Table 1) and life-form. Conservation status and threat status of flora species was noted. Weeds were classified as woody, herbaceous (not grasses) or grasses, annual or perennial.

Tree health surveys

Tree health transects ran parallel to the creek with the centre point aligning with the above vegetation transects. The tree health assessments were based on the *Living Murray Method for assessing River Red Gum Health* (Souter et al. 2012). Thirty trees in each transect were tagged (metal tree tags) and assessed, equating to 90 trees in total. Tree locations were recorded using GPS and species of tree was noted. Tree locations are shown in Figure B3. Measurements included assigning categories for crown extent (%), crown density (%), epicormic growth, new tip growth and reproductive behaviour to each tree (see Table B2).

Table B2 Condition indicators for crown extent and crown density

Score	Description	% assessable crown (extent/density)
0	None	0
1	Minimal	1-10%
2	Sparse	11-20%
3	Sparse-medium	21-40%
4	Medium	41-60%
5	Medium-Major	61-80%
6	Major	81-90%
7	Maximum	91-100%

Table B3 Condition indicators for new tip growth, epicormic growth and leaf die off

Score	Description	Definition
0	Absent	Response not visible
1	Scarce	Response present but not readily visible
2	Common	Response is clearly visible
3	Abundant	Response dominates appearance of the tree

Table B4 Categories for assessing tree dominance

Category	Description
Dominant	Tree with a crown extending above the general canopy, receiving full light from above and partly from the sides; a larger than average tree in the stand
Codominant	Tree with crown forming part of the general canopy, receiving full light from above but comparatively little from the sides
Subdominant	Tree shorter than the previous classes, but with a crown extending into the canopy of Codominant trees, receiving little light from above but none from the sides
Suppressed	Tree with crown density entirely below the canopy, receives no direct light from above or from the sides

Table B5 Category scale for reporting extent of reproduction

Score	Description	Definition
0	Absent	Reproductive behaviour is not visible
1	Scarce	Reproductive behaviour is present but not readily visible
2	Common	Reproductive behaviour is clearly visible
3	Abundant	Reproductive behaviour dominates the appearance of the tree

Targeted surveys for threatened flora

Targeted surveys were conducted for the following two threatened flora species within suitable habitat during November to December 2023 and January 2024:

– *Pteris epaleata* (Netted Brake)

– *Senecio campylocarpus* (Bulging Fireweed)

Targeted searches were undertaken by two Botanists at 5-10 metre intervals along transects within areas deemed suitable habitat.

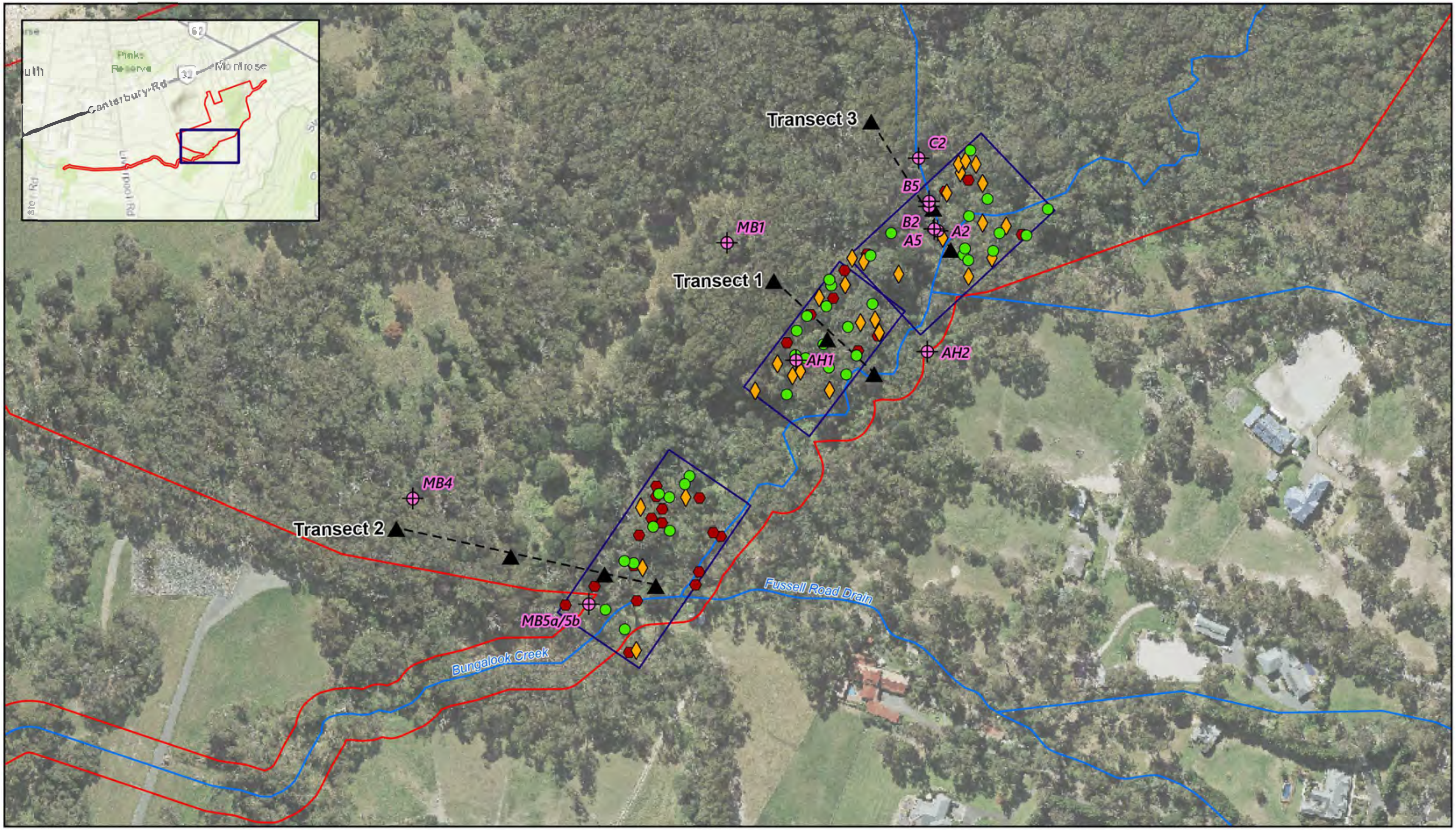
Targeted surveys for threatened (terrestrial) fauna

Suitable habitat for Southern Toadlet and Brown Toadlet was identified during the preliminary site assessment within the grassy floodplain areas of Bungalook Creek and the gullies and woodlands of the study site. A habitat assessment was also undertaken on 18 April 2024, prior to night surveys, to identify potential calling habitat to direct survey efforts. This habitat assessment determined that surveys should focus on the gullies within the study site and adjacent reserve, as well as along Bungalook Creek and a small dam in the south-west of the study site.

Targeted surveys consisted of three nights of auditory surveys on 18 and 23 April 2024 and 13 May 2024. Targeted surveys were conducted in accordance with the preliminary survey guidelines for *Pseudophryne* species (De Angelis and Cleeland 2023).

Surveys commenced from sunset (approximately 6 pm) and consisted of two GHD ecologists listening for frog calls while traversing the study site and the adjacent Dr Ken Leversha Reserve. At regular intervals of approximately 150 metres, ecologists spent five minutes listening for frog calls, followed by 2.5 minutes of call play-back of both species in an attempt to elicit vocal responses.

Survey nights were chosen based on the weather conditions considered optimal for detecting toadlets, including ambient night temperatures above 11°C, limited wind and heavy rain and with rainfall forecast within 24-48 hours prior to the survey. Before each survey, footwear was treated with a chemical disinfection to avoid the possible spread of diseases, such as Chytrid (Murray et al. 2011).



Legend	
Study site	Watercourse
Monitoring bore	**Crown extent %**
Vegetation quadrat	Poor
Vegetation transect	Moderate
Tree assessment search area	Healthy

Paper Size ISO A4

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

GHD

BORAL
Groundwater Dependent Ecosystem Investigation

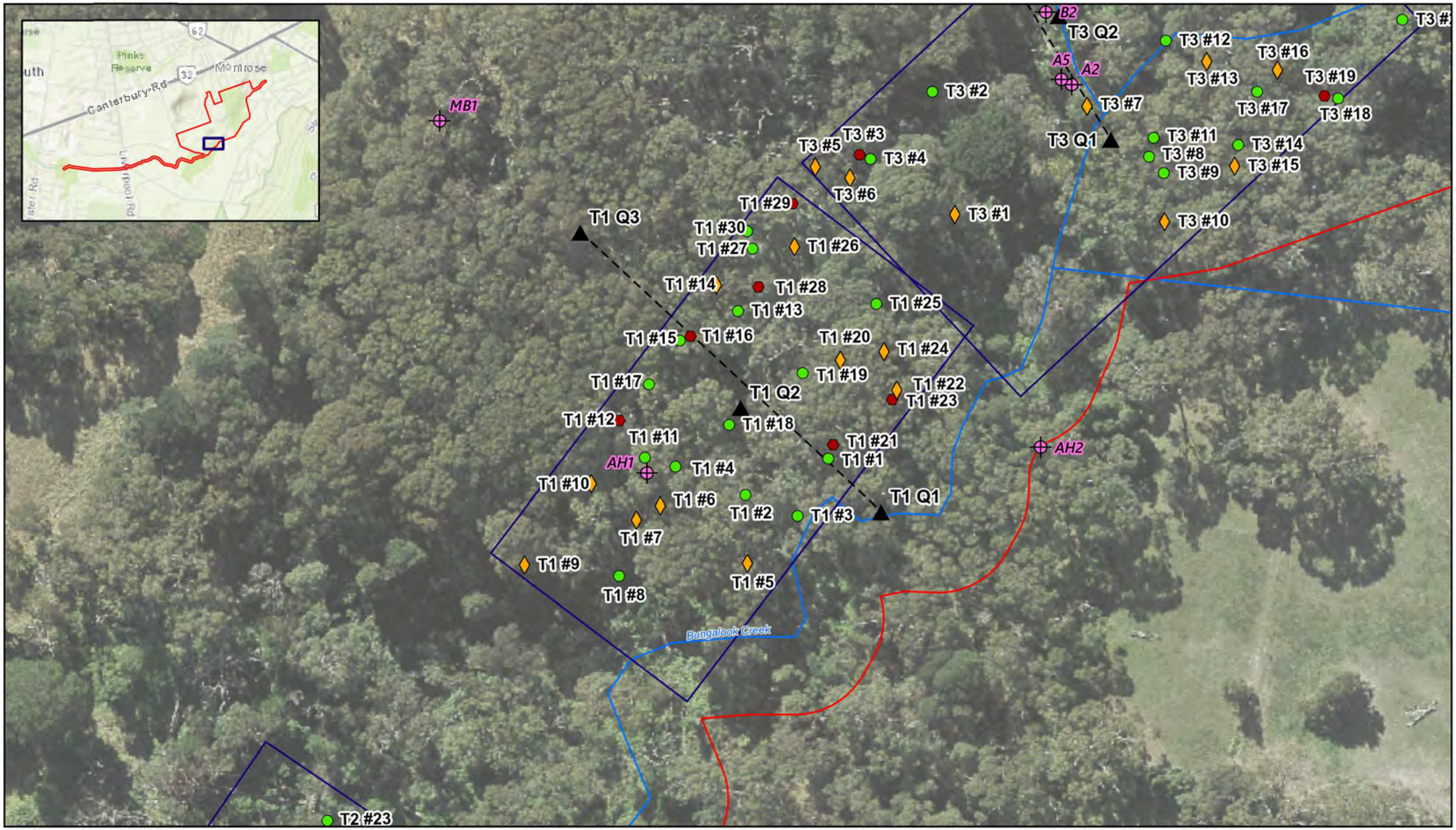
Vegetation & Tree Health Assessment - Overview

Project No. 31-12611238
Revision No. -
Date 8/04/2024

FIGURE B3.1

N:\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_03_VegTreeAssessment_Series
Print date: 08 Apr 2024 - 21:13

Data source: VicMap (2023); GHD (2023). Created by: sblades



Study site
Monitoring bore
Vegetation quadrat
Vegetation transect
Tree assessment search area

Watercourse

Crown extent %

Poor
Moderate
Healthy

Paper Size ISO A4

0 10 20 30 40

Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

GHD

BORAL
Groundwater Dependent Ecosystem Investigation

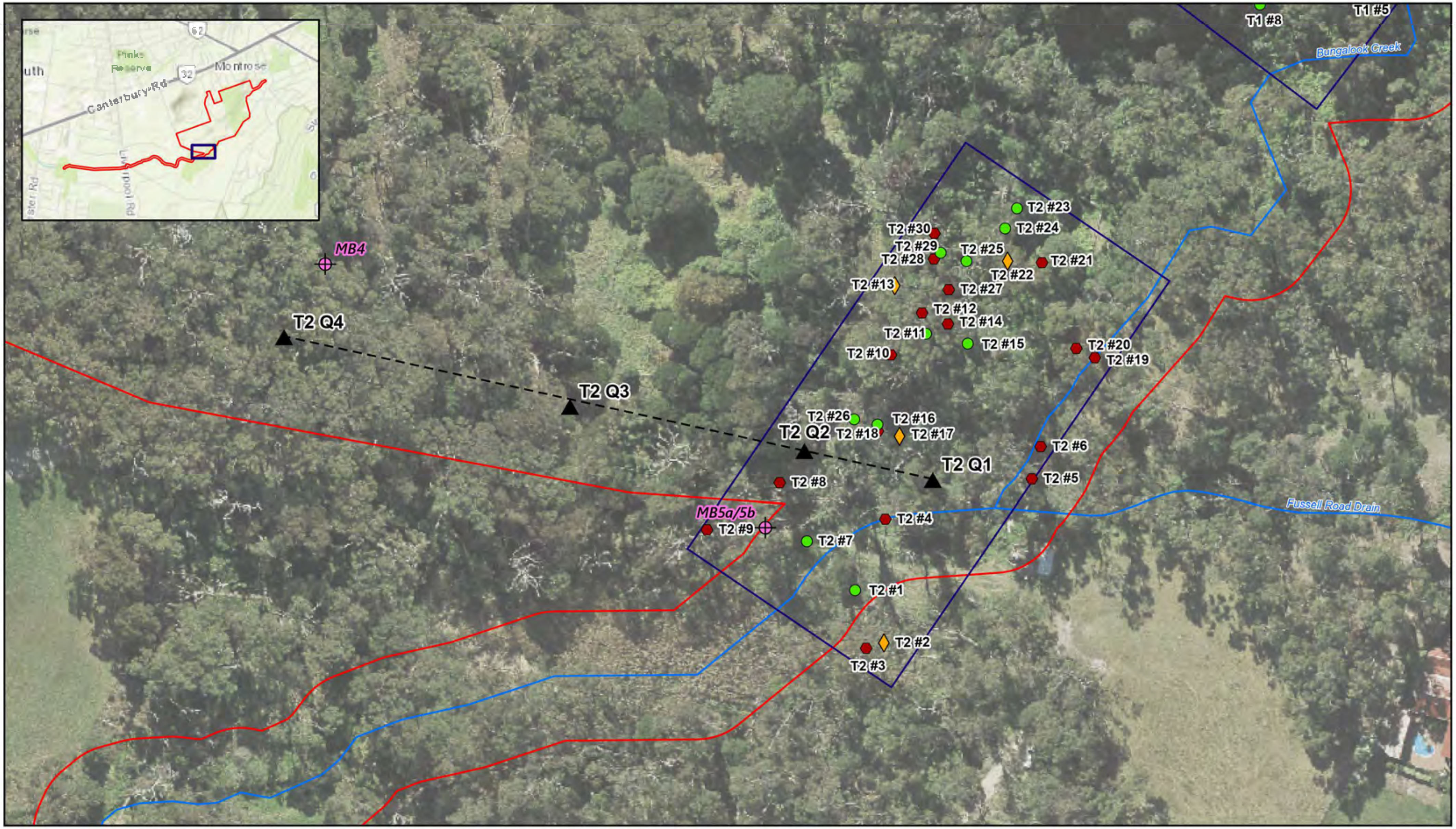
Vegetation & Tree Health Assessment - Transect 1

Project No. 31-12611238
Revision No. -
Date 8/04/2024

FIGURE B3.2

N:\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_03_VegTreeAssessment_Series
Print date: 08 Apr 2024 - 21:14

Data source: VicMap (2023), GHD (2023). Created by: sblades



Study site
Monitoring bore
Vegetation quadrat
Vegetation transect
Tree assessment search area

Watercourse

Crown extent %
- Poor
- Moderate
- Healthy

Paper Size ISO A4

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

GHD

BORAL
Groundwater Dependent Ecosystem Investigation

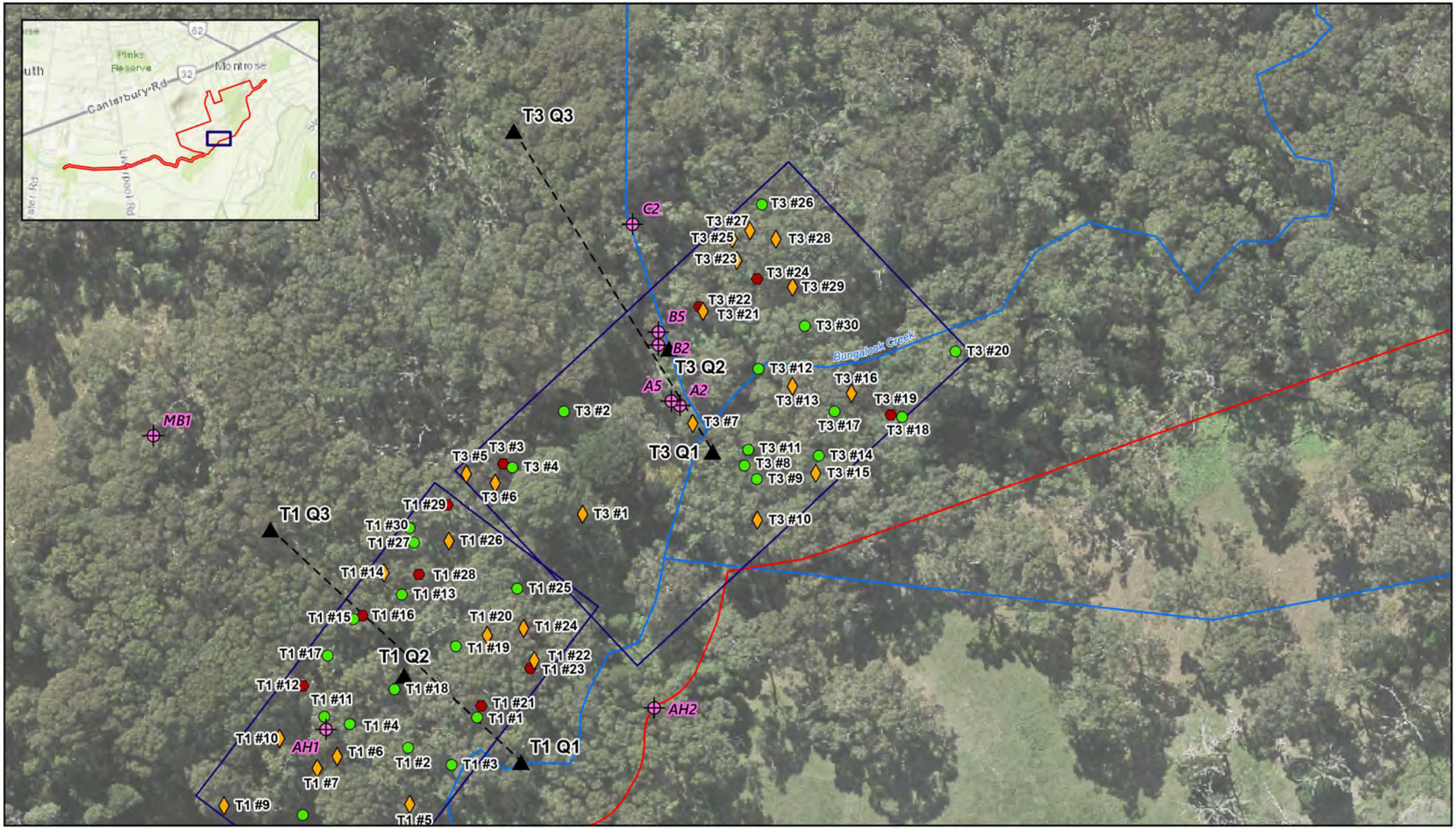
Vegetation & Tree Health Assessment - Transect 2

Project No. 31-12611238
Revision No. -
Date 8/04/2024

FIGURE B3.3

N:\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_03_VegTreeAssessment_Series
Print date: 08 Apr 2024 - 21:14

Data source: VicMap (2023); GHD (2023). Created by: sblades



Study site
Monitoring bore
Vegetation quadrat
Vegetation transect
Tree assessment search area

Watercourse

Crown extent %

Poor
Moderate
Healthy

Paper Size ISO A4

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

BORAL
Groundwater Dependent Ecosystem Investigation

Vegetation & Tree Health Assessment - Transect 3

Project No. 31-12611238
Revision No. -
Date 8/04/2024

FIGURE B3.4

Data source: VicMap (2023), GHD (2023). Created by: sblades

N:\AU\Melbourne\Projects\31\12611238\GIS\Maps\Working\12611238_GDEassessment_Fieldmaps_and_Mapping.aprx - 12611238_03_VegTreeAssessment_Series
Print date: 08 Apr 2024 - 21:14

Appendix C

Results of Baseline Vegetation Monitoring

Tree health – 2023 prior to bushfire

Three tree transects were established along Bungalook Creek to monitor current/baseline tree health prior to the upgrade of the Quarry (Figure B3). One of the transects was intentionally located within an area where trees had recently died or are showing signs of dieback (T2) to capture current condition. Living trees only were included in the baseline monitoring. Crown extent of trees in T2 were typically lower (% crown extent) than trees in T1 or T3 (Figure C1), with 53% of trees in T2 scoring ≤ 40% crown extent present (2023). Epicormic growth was more prevalent on trees in T2 than T1 or T3 (Figure C3), a common stress response in eucalypts. Crown density (%) scores were similar across the three transects (Figure C2). Majority of trees are *Eucalyptus obliqua* (Messmate), with *Eucalyptus ovata* (Swamp Gum) common also. Majority of trees were classified as codominant trees, with crown forming part of the general canopy, receiving full light from above but comparatively little from the sides.

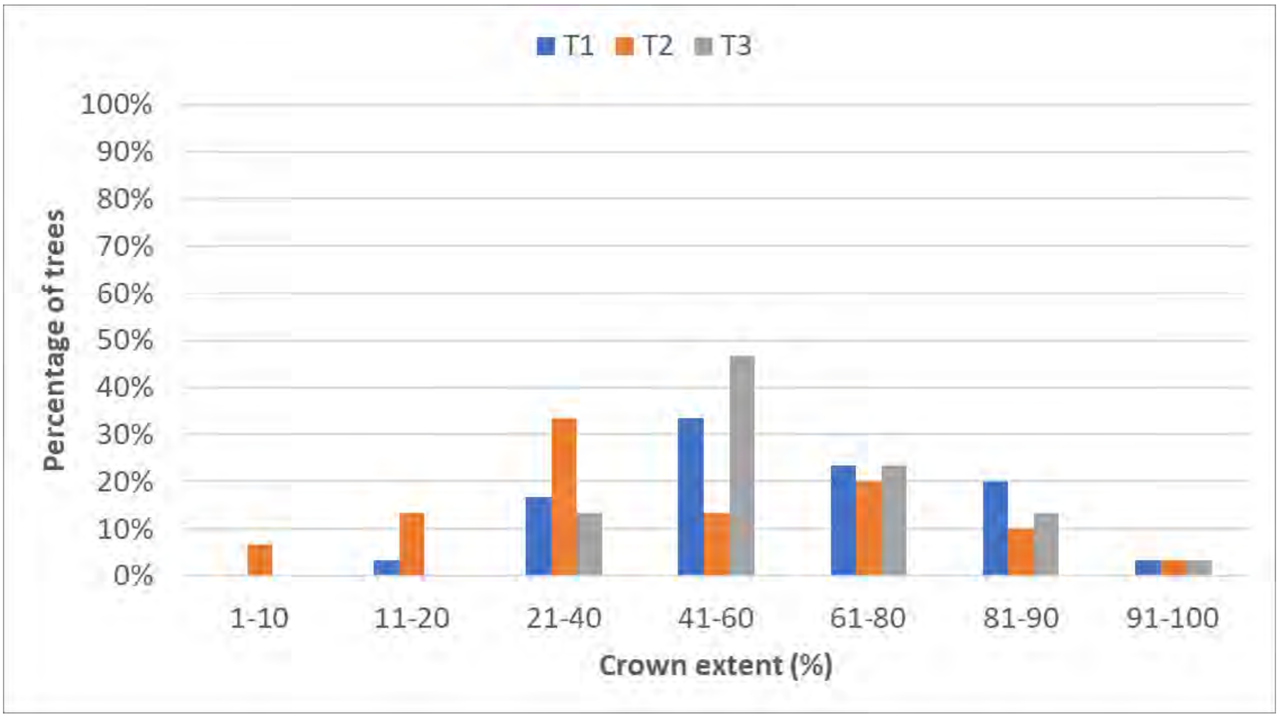


Figure C1 ***Percentage of trees in each crown extent category at Bungalook Creek by transect***

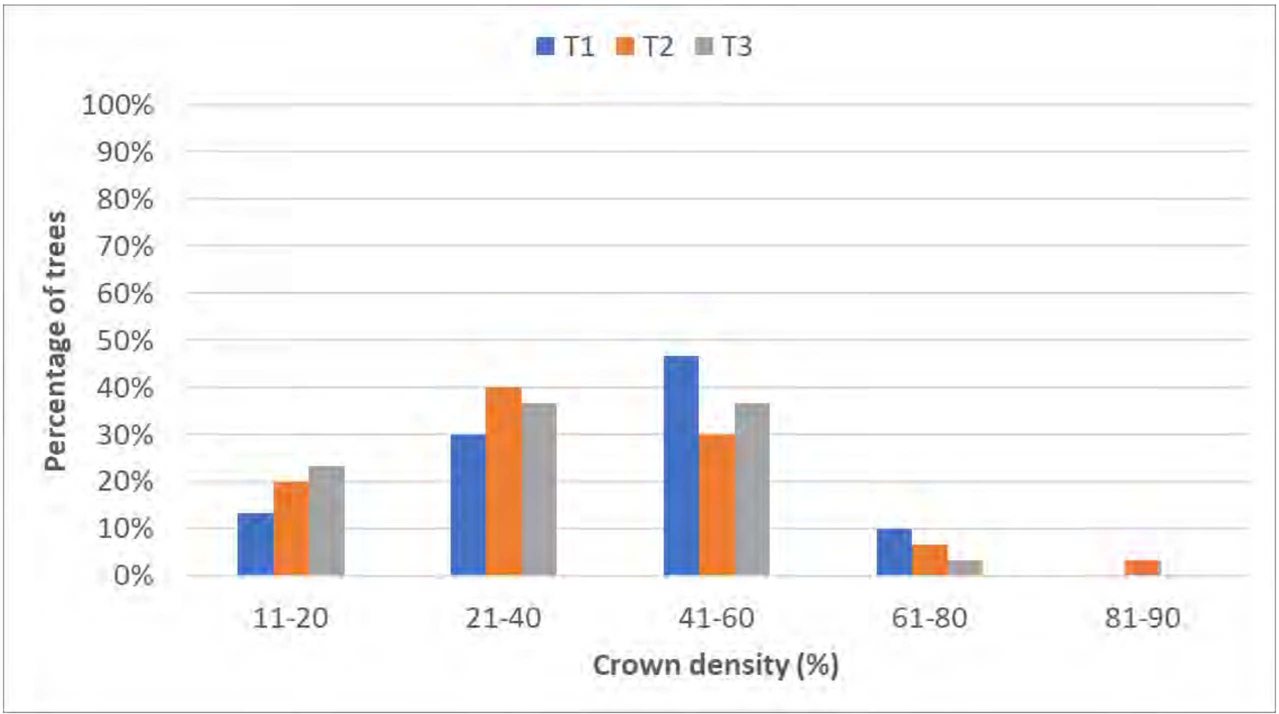


Figure C2 ***Percentage of trees in each crown density category at Bungalook Creek by transect***

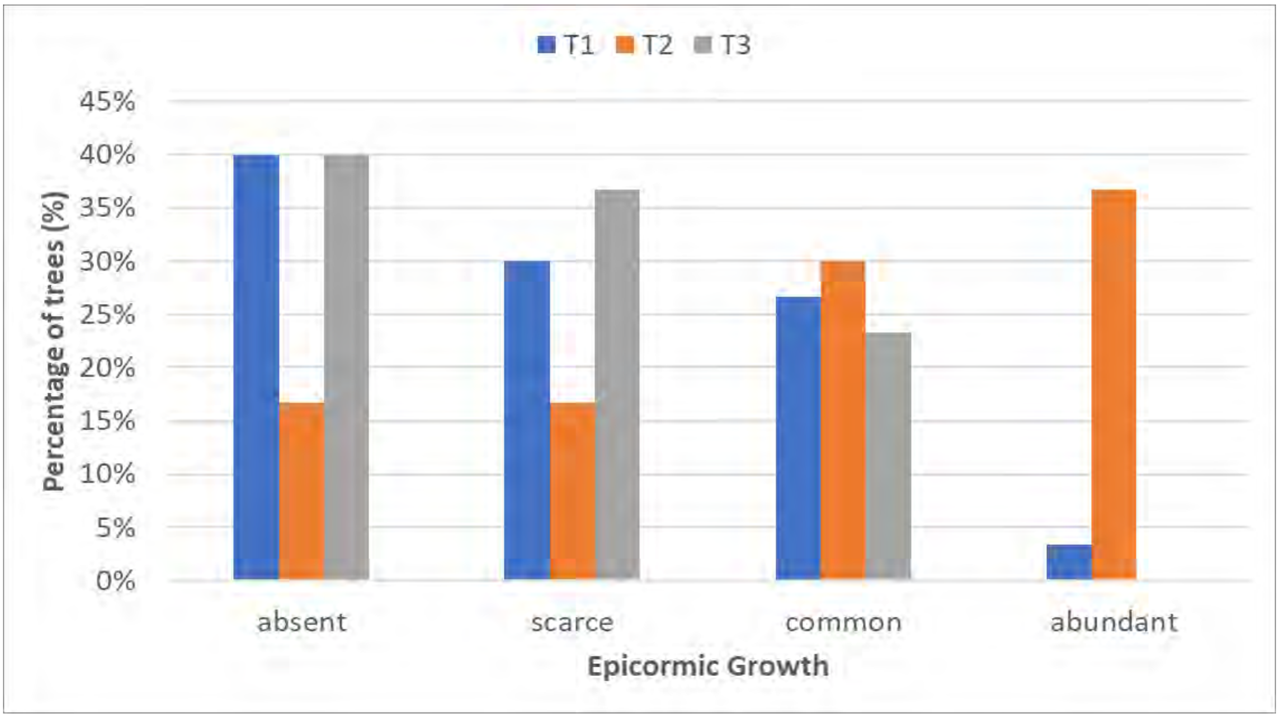


Figure C3 *Percentage of trees in each epicormic growth category at Bungalook Creek by transect*

Tree health – 2025 post bushfire

In March 2025, a bushfire impacted the study site. Therefore, follow-up monitoring of tree health was conducted in June 2025, mainly to understand percentage of trees that were impacted by the bushfire. Ten percent of trees were killed by the March 2025 bushfire or not yet showing signs of recovery in June 2025. Overall, tree health declined across the three transects, mostly likely the result of the bushfire, with many trees showing reduction in canopy extent and canopy density, scorched or dead leaves.

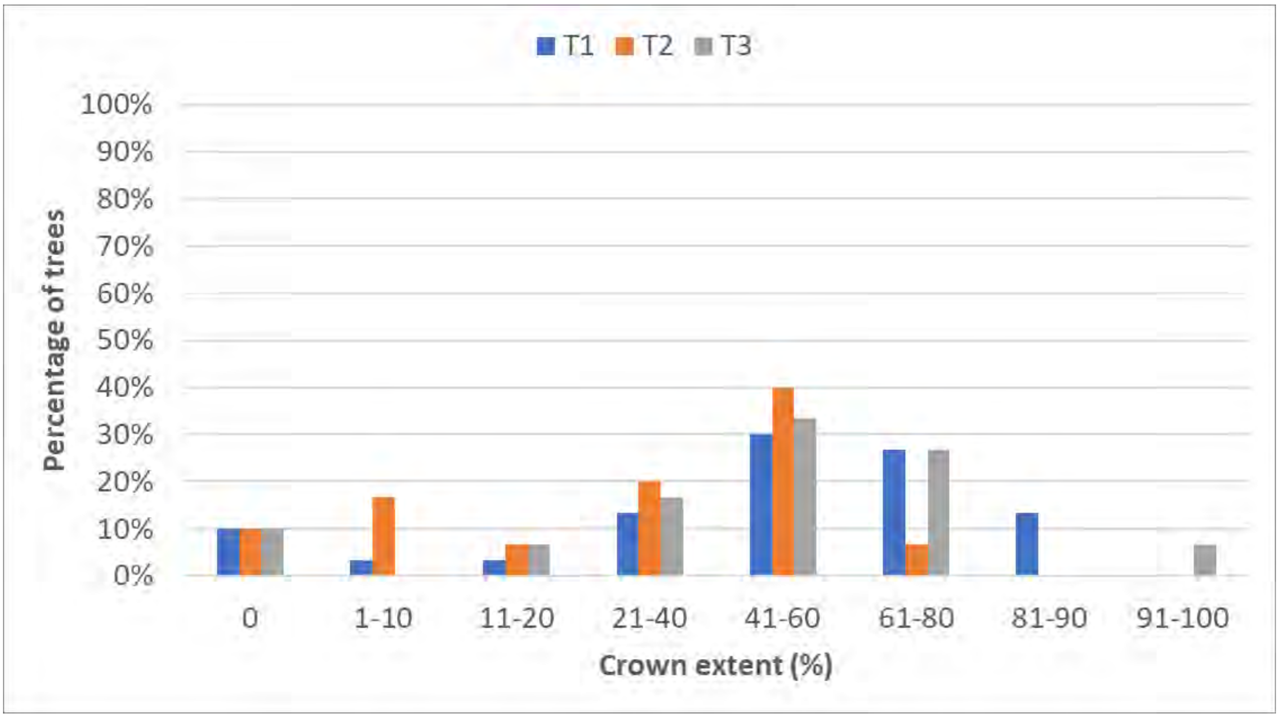


Figure C4 Percentage of trees in each crown extent category at Bungalook Creek by transect in 2025 post bushfire

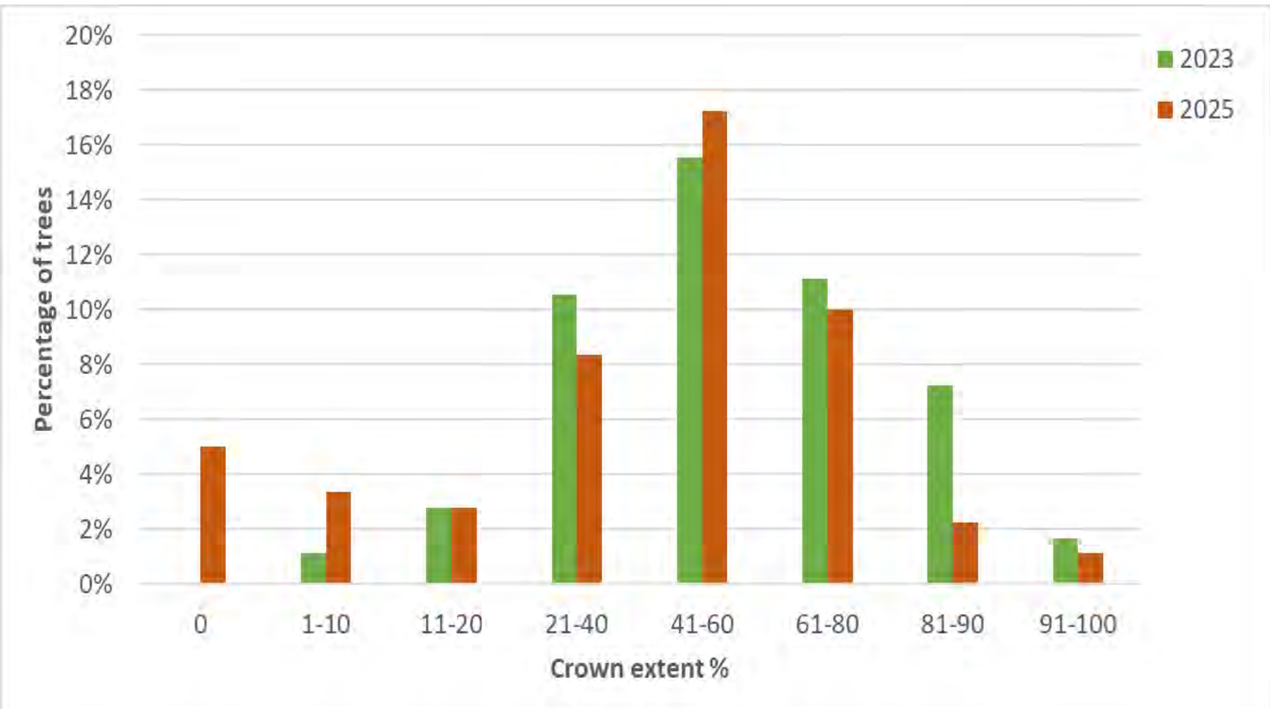


Figure C5 Comparison of percentage of trees in each crown extent category at Bungalook Creek between 2023 (pre bushfire) and 2025 (post bushfire)

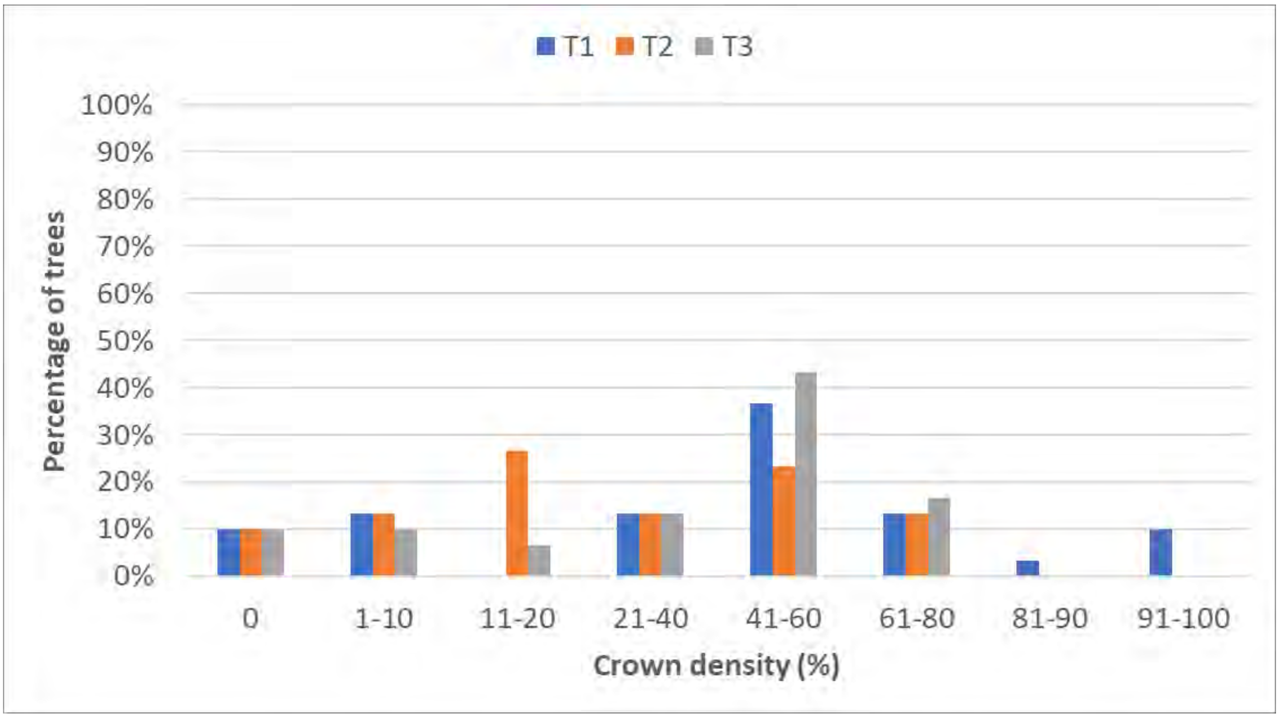


Figure C6 *Percentage of trees in each crown density category at Bungalook Creek by transect in 2025 post bushfire*

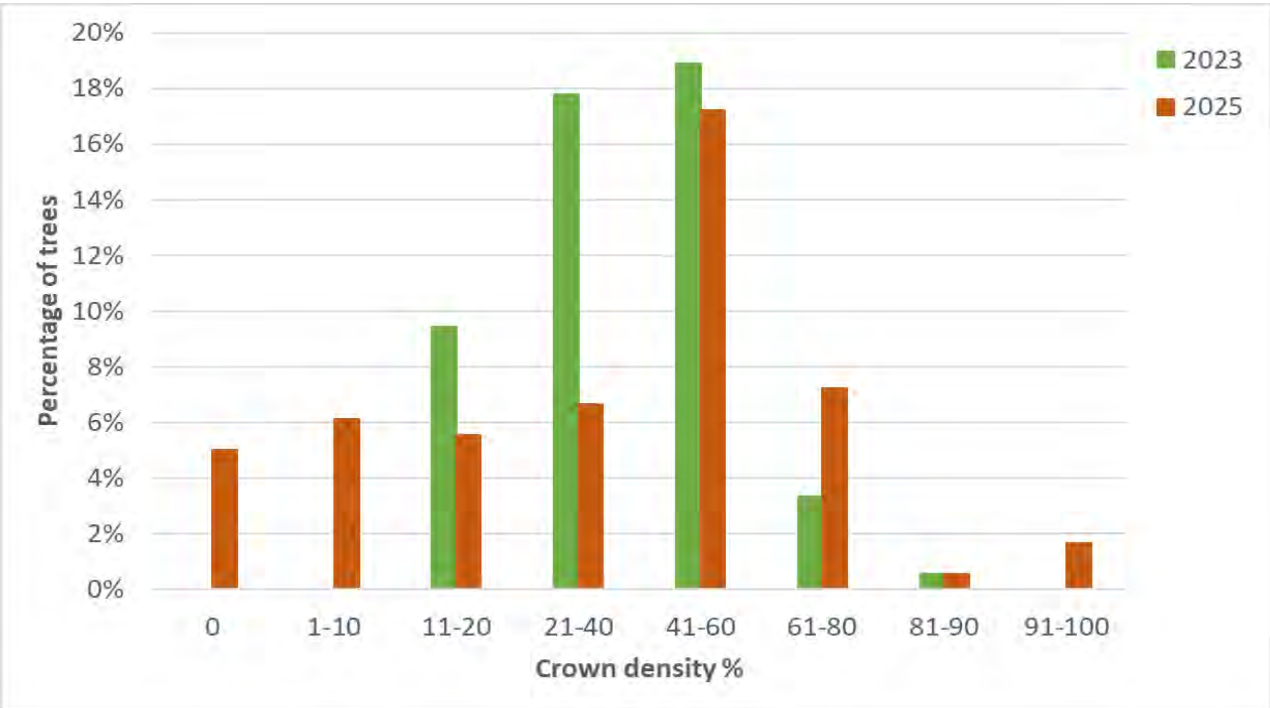


Figure C7 *Comparison of percentage of trees in each crown density category at Bungalook Creek between 2023 (pre bushfire) and 2025 (post bushfire)*

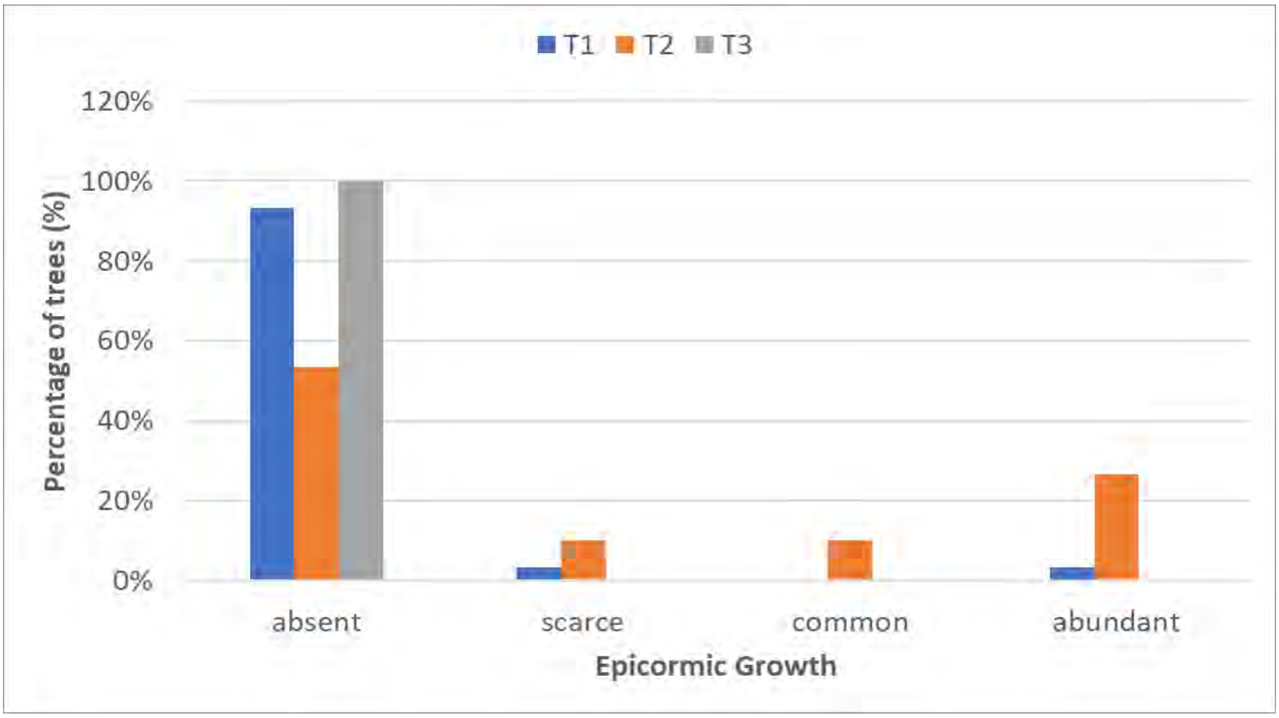


Figure C8 *Percentage of trees in each epicormic growth category at Bungalook Creek by transect in 2025 post bushfire*

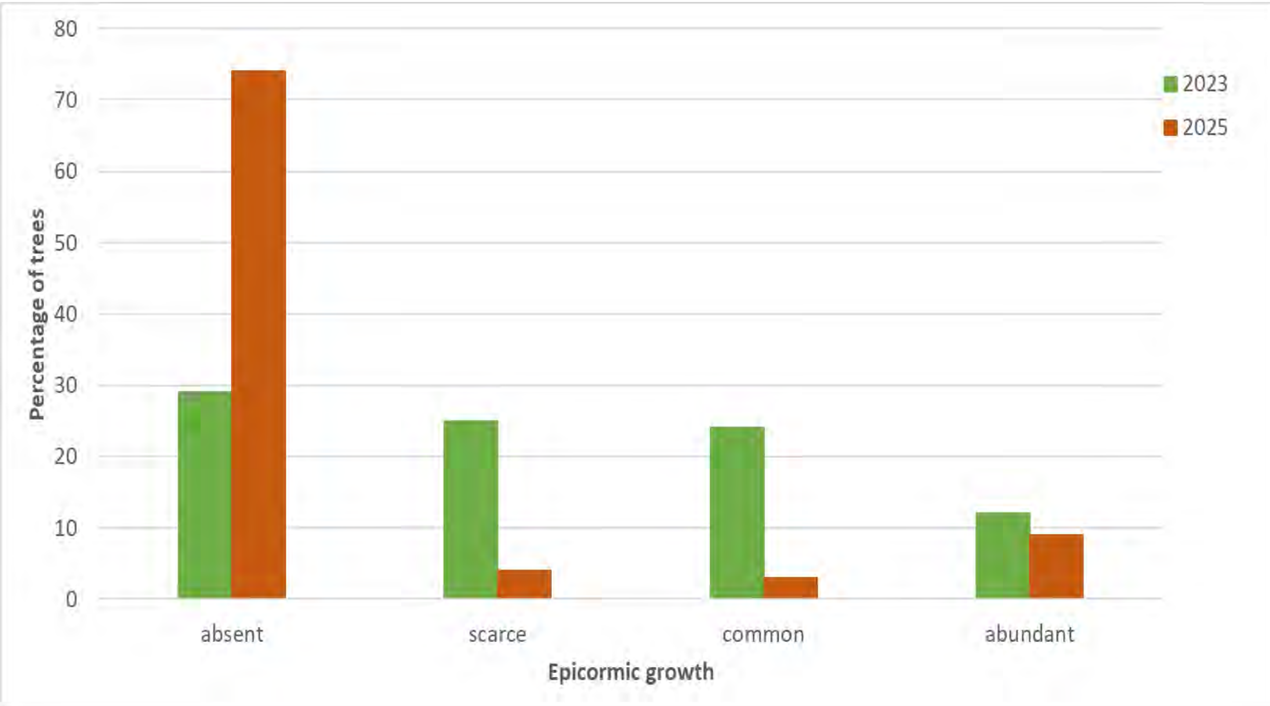


Figure C9 *Comparison of percentage of trees in each crown density category at Bungalook Creek in 2023 pre bushfire and 2025 post bushfire*

Floristic composition – 2023 prior to bushfire

The results of the flora quadrat monitoring from 2023 are presented below and the location of the quadrats are illustrated in Figure B3. Flora composition was not monitored in June 2025, as understorey vegetation had not yet shown much sign of recovery.

Species richness

Mean flora species richness was 37 flora species across the 10 quadrats, with mean native species=26 and mean non-native=11 species (Figure C4).

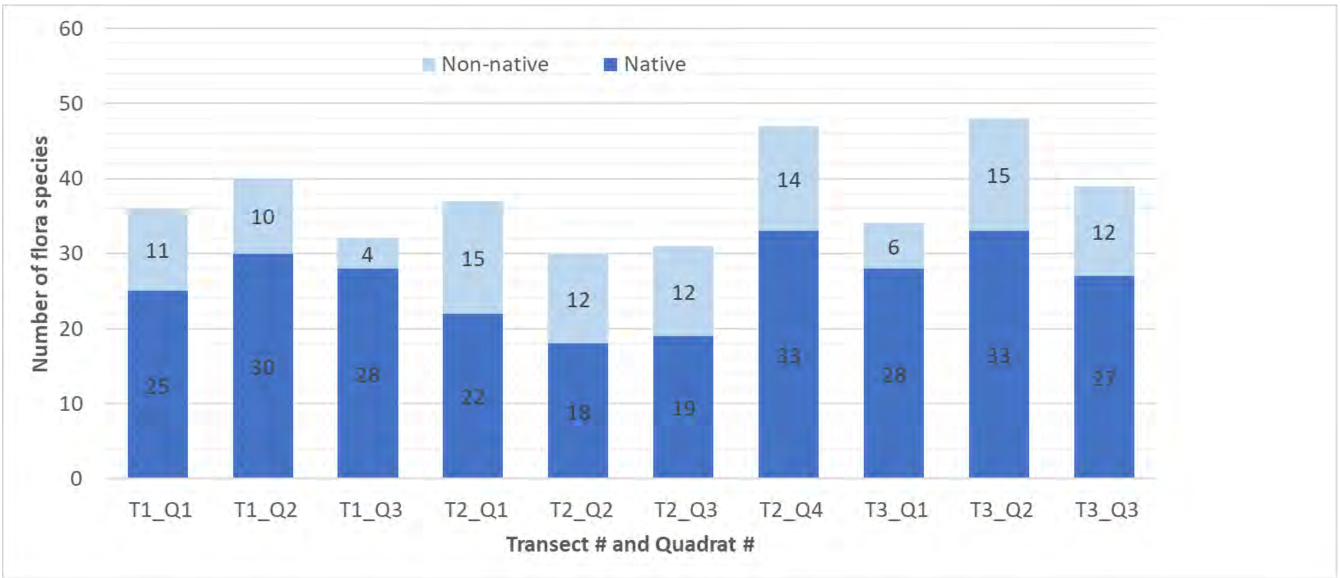


Figure C10 ***Number of native and non-native flora species recorded in each quadrat 2023***

Vegetation cover

Understorey vegetation cover was high, typically 60-80% cover. Medium shrubs and ground-ferns were the most abundant life-forms.

Weeds

Weeds were common in all quadrats, with 6-15 weed species present within 20 x 20 m quadrats. Weed cover ranged from 5-40% cover, most cover attributed to the presence of *Pittosporum undulatum.* Although native to Victoria *P. undulatum* is considered naturalised in the Montrose region and thus was assigned weed status. Other weed species with moderate cover included *Anthoxanthum odoratum* (Sweet Vernal-grass).

Appendix D

Likelihood of occurrence - Threatened flora

Likelihood of occurrence criteria:

Not all of the threatened species identified during this assessment are equally likely to occur in the project site, due to the geographic location or context of the site, or the habitat type and condition. For each species, the likelihood of occurrence was evaluated using the following rationale:

PRESENT – Species known to occur within the site

POSSIBLE – Potentially suitable habitat occurs within study site and species' known range encompasses the study site. Species recorded historically in the 10-km search area (Study Area), and generally within the last 30 years.

UNLIKELY – Species' known range encompasses the study site, but suitable habitat does not occur within study site, or occurs within study site but with generally low quality and quantity. Species recorded historically in the Study Area but generally not within the last 30 years.

HIGHLY UNLIKELY – No historical records of the species and/or no suitable habitat in the Study Area

Key: L – Listed EN / en – Endangered. VU / vu – Vulnerable. cr – Critically Endangered. Rx – Regionally Extinct

Species that are considered as near threatened or data deficient on the DELWP Advisory Lists only and not also listed as threatened on one of either the FFG Act or EPBC Act threatened species lists, were not considered.

Table D1 Likelihood of occurrence of threatened flora recorded and/or predicted to occur within the study area

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Abrodictyum caudatum	Jungle Bristle-fern		en	2	2015	VBA	A rare fern of rainforests in far East Gippsland, the Beenak area and Wilsons Promontory. It grows on the trunks of tree-ferns, particularly *Cyathea australis*.	Unlikely – no suitable habitat (i.e. rainforest) within the study site.
Acacia boormanii	Snowy River Wattle		en #	3	2011	VBA	Restricted mostly to open-forest on rocky slopes and along banks of the Snowy River and its tributaries, with outlying populations at Mt Typo and Gapsted in the Myrtleford area.	Unlikely – no suitable habitat (i.e. rocky slopes) within the study site. If present would be a garden escape as study site is outside normal distribution for this species.
Acacia decora	Western Silver Wattle		en	4	2011	VBA	Widespread in Queensland and New South Wales, but in Victoria known only from around Dookie and Thoona (west of Wangaratta) and near Wodonga. Restricted to roadside and railway remnants of open woodland.	Not applicable – study site is outside normal distribution for this species.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Acacia glandulicarpa	Hairy-pod Wattle	VU	en	1	2009	VBA	Restricted in Victoria to the far mid-west (Nhill-Dimboola area) where occurring in woodland and mallee communities.	Not applicable – study site is outside normal distribution for this species.
Acacia howittii	Sticky Wattle		vu #	7	2020	VBA	Confined to eastern Victoria from the upper Macalister River area near Mt Howitt south to near Yarram and east to near Tabberabbera; collections from near Daylesford and Melbourne are presumably of cultivated origin (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution for this species.
Acacia sporadica	Pale Hickory-wattle		cr	1	2003	VBA	Endemic to Victoria where it is known from three disjunct locations (Taradale, Howqua, and Carboor). At each of these sites plants occur in grassy, dry Eucalyptus woodland or forest on shallow soils.	Not applicable – study site is outside normal distribution for this species.
Acacia stictophylla	Dandenong Wattle		en	47	2023	VBA	Restricted to the Dandenong Ranges where it is often locally common in the riparian zone on hillsides in tall forest and open woodland.	**Possible** – suitable habitat is present within the study site and numerous records within the study area.
Acacia williamsonii	Whirrakee Wattle		vu	1	2009	VBA	Restricted to north-central Victoria, where occurring from Inglewood to Rushworth, and particularly common in the Whipstick Forest near Bendigo where growing on stony gravel or clay-loam in open Eucalyptus forest and mallee open scrub (Walsh and Entwisle, 1996).	Not applicable – study site is outside normal distribution for this species.
Amphibromus fluitans	River Swamp Wallaby-grass	VU				PMST	Apparently confined to permanent swamps principally along the Murray River Between Wodonga and Echuca, uncommon to rare in the south probably due to alteration of habitat (Walsh and Entwisle 1994).	Unlikely – no suitable habitat within study site and not recorded within study area.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Asterolasia asteriscophora subsp. *albiflora*	White Star-bush	CR	cr	9	2019	VBA, PMST	Scattered in dry woodlands, shrublands and moist to wet heathy open-forests in the eastern half of the state, usually in foothill to montane districts (Walsh & Entwisle 1996). Shrubby Foothill Forest occurs on ridges and southern and eastern slopes in moderately fertile, well drained soils (mostly loam and clay loam), with an average annual rainfall of 700-1100 mm (DSE 2004). Damp Forest occurs on well-developed soils, on a variety of aspects and extending from sea level to montane elevations (DSE 2004).	**Possible** – suitable habitat is present within the study site and previous records within the study area.
Austrostipa rudis subsp. *australis*	Veined Spear-grass		en	6	2017	VBA	Uncommon, mostly in cool areas of moderate altitude, in open-forest on sandy or sandstone derived soils (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site
Beyeria lanceolata	Pinkwood		en	8	2017	VBA	Apart from an isolated occurrence in the Dandenong Ranges, confined in Victoria to East Gippsland where usually found in gullies, often in rocky situations.	Unlikely – no suitable habitat within study site and only one record within study area.
Billardiera scandens s.s.	Velvet Apple-berry		en	15	2009	VBA	Apparently uncommon in Victoria, occurring chiefly in dry open-forests and woodlands in the north-east, with isolated occurrences near Eltham, Mt. Macedon, Hurstbridge, Eildon and Orbost (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site
Botrychium australe	Austral Moonwort		cr	2	1909	VBA	Rare in lowland forest to subalpine grassland in eastern Victoria (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site and not recorded within study area since 1909.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Burnettia cuneata	Lizard Orchid		en	1	1921	VBA	Widespread but sporadic across cooler, higher-rainfall parts of southern Victoria. Almost entirely confined to moist peaty soils around the margins of swamps and watercourses in tall, closed scrublands dominated by *Melaleuca squarrosa* (Scented Paperbark). Sites are often under water during winter but are usually damp rather than wet during flowering season (Backhouse and Jeanes 1995)	Unlikely – although suitable habitat may be present within the study site, this species has not been recorded within the study area since 1921. However, it is noted this species usually emerges post fire and surveys within appropriate conditions may not have occurred within the study area.
Caladenia flavovirens	Christmas Spider-orchid		cr	8	1980	VBA	Scattered across southern Victoria, where found primarily in coastal and hinterland areas but extending into foothills of the ranges. Generally, frequents open forests and woodlands, where it grows among grasses and other low herbaceous vegetation often slopes facing north and west. Grows in drier sand or clay loams that are well drained (Backhouse and Jeanes 1995).	Unlikely – although suitable habitat may be present within the study site, this species has not been recorded within the study area since 1980.
Caladenia oenochila	Wine-lipped Spider-orchid		cr	23	2021	VBA	Currently recorded mainly from the foothills of the ranges to the north and east of Melbourne, with isolated occurrences in western parts of the state. Grows in shaded situations in more mesic heathy woodlands and open forests on sand and clay loams that are fairly well drained (Backhouse and Jeanes, 1995).	**Possible** – suitable habitat is present within the study site and previous records within the study area.
Caladenia sp. aff. venusta (Kilsyth South)	Kilsyth South Spider-orchid	CR	cr	3	2004	VBA, PMST	Endemic to Victoria where currently known from a small reserve near Kilsyth (outer eastern suburb of Melbourne) in heathy open forest on well-drained clay loam.	Unlikely – no suitable habitat within study site.
Caladenia vulgaris	Slender Pink-fingers		vu	2	1998	VBA	Known with certainty only from the Anglesea district with unconfirmed records from south-western Victoria. Grows primarily in heathlands and heathy woodlands on well-drained sandy soils (Backhouse and Jeanes 1995).	Unlikely – no suitable habitat within study site.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Carex alsophila	Forest Sedge		en	6	2010	VBA	Endemic in Victoria, occurring in mountain gullies and swamps between Alexandra and Erica (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site.
Chiloglottis jeanesii	Mountain Bird-orchid		vu	26	2018	VBA	Localised in mountainous regions east of Melbourne (e.g. Dandenong Ranges, Toorongo, Baw Baw National Park) where sometimes locally common in fern gullies and wet sclerophyll forests.	**Possible** – suitable habitat is present within the study site and previous records within the study area.
Correa reflexa var. *lobata*	Powelltown Correa		en	12	2022	VBA	Endemic in Victoria, where locally common in moist, often heathy open-forest from the Dandenong Ranges to near Powelltown, with an isolated occurrence at Cranbourne (Walsh and Entwisle 1999).	**Possible** – suitable habitat is present within the study site and previous records within the study area.
Corybas aconitiflorus	Spurred Helmet-orchid		en	3	2006	VBA	Localized and uncommon in Victoria (Healesville and Tonimbuk areas, Corner Inlet, Gippsland Lakes area, Marlo). Colonies grow in sheltered positions, often on damp sand under ferns or shrubs (Walsh & Entwisle 1994).	Unlikely – no suitable habitat within study site.
Corybas grumulus	Mountain Helmet-orchid		en	5	2017	VBA	Found in mountain forests of eastern Victoria, often in fern gullies and wet sclerophyll forests growing in rich mountain loam or on rotting logs or tree fern trunks.	Unlikely – no suitable habitat within study site.
Corymbia maculata	Spotted Gum		vu #	15	2019	VBA	Occurring naturally north-west of Orbost (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution for this species.
Craspedia canens	Grey Billy-buttons		cr	8	1973	VBA	Known in Victoria only from grasslands (often bordering swamps) at low altitude between c Traralgon and Cranbourne (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site and not recorded since 1973 within the study area.
Cyathea cunninghamii	Slender Tree-fern		cr	32	2013	VBA	Of limited distribution in Victoria and confined to deep gullies in wet forests (e.g., Otway Range, Dandenong Ranges, Tarra-Bulga National Park, Wilsons Promontory, Mt Drummer in the far east) and seldom common (Walsh and Entwisle 1994)	Unlikely = although tree ferns are present within the study site, this species occurs in deep gullies in wet forests – which the study area does not support such habitat.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Dianella amoena	Matted Flax-lily	EN	cr	4	2016	VBA, PMST	Grasslands and grassy woodlands (Walsh & Entwisle 1994).	Unlikely – no suitable habitat within study site
Diuris behrii	Golden Cowslips		en	3	1943	VBA	Locally common in grassland and open woodland around Derrinallum, Stawell and the Grampians (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site
Diuris punctata var. *punctata*	Purple Diuris		en	1	1924	VBA	Formerly widespread throughout the fertile lowlands of Victoria. Now restricted to a few relatively isolated sites (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within study site and not recorded within study area since 1924.
Eucalyptus crenulata	Silver Gum	EN	en			PMST	Confined to Swampy sites in foothills just north and south of the Great dividing range, near Buxton, Narbethong and Yarra Glen, where it forms hybrids with E. ovata (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution of this species. If present would be planted or garden escapes.
Eucalyptus fulgens	Green Scentbark		en	7	2015	VBA	Occurs east from Healesville and Woori Yallock to the Latrobe Valley near Driffield (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution of this species. If present would be planted or garden escapes.
Eucalyptus globulus subsp. *globulus*	Southern Blue-gum		en #	3	2017	VBA	Occurs in Victoria in the area south of the Strzelecki Range (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution of this species. If present would be planted or garden escapes.
Eucalyptus strzeleckii	Strzelecki Gum	VU	cr			PMST	Apparently endemic, confined to across the western section of Strzelecki Range, from Neerim South in the north, south to Foster, Favours ridges, slopes and streambanks and deep fertile soils (Walsh & Entwisle 1996).	Unlikely – no records within study area.
Eucalyptus yarraensis	Yarra Gum		cr	24	2022	VBA	Endemic in Victoria extending west from Glengarry to Melbourne and north-west to Daylesford and Ararat (Walsh & Entwisle 1996).	**Possible** – suitable habitat is present and many records within the study area.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Euphrasia collina subsp. *muelleri*	Purple Eyebright	EN	en	2	1905	VBA	Endemic in Victoria. Formerly widespread in lowland to montane central and Western Victoria, but now exceedingly rare through habitat destruction, surviving in heathland and heathy woodland on the Mornington Peninsula and near Jamieson (Walsh & Entwistle 1996).	Unlikely – no suitable habitat within study site and not recorded within study area since 1905.
Gentianella polysperes	Early Forest-gentian		en	4	1906	VBA	Scattered through the State, usually in hilly country, e.g. Dandenong Ranges and foothills, Mt Sugarloaf, Mt Macedon (but apparently now rare at these localities), ascending to subalpine areas (e.g. Snowy Range, Mt Benambra, Mt Delusion) in the eastern ranges. Supposedly also collected from the Curdies River near Warrnambool. Commonly occurring in light forest or woodland communities.	Unlikely – although suitable habitat is present within the study site, this species has not been recorded within the study area since 1906.
Geranium solanderi var. *solanderi* s.s.	Austral Crane's-bill		en	1	22/10/1897	VBA	An uncommon species of damp to dryish, usually sheltered sites in grassy woodlands, often along drainage lines or in seepage areas (Walsh & Entwisle 1996).	Unlikely – although suitable habitat is present within the study site, this species has not been recorded within the study area since 1897.
Glossostigma cleistanthum	Small-flower Mud-mat		en	2	2009	VBA	Apparently uncommon, but possibly overlooked, in Victoria. Collected from temporary pools on granite outcrops, clayey soils of the Murray River floodplain, and margins of subalpine bogs.	Unlikely – no suitable habitat within the study site.
Glycine latrobeana	Clover Glycine	VU	vu	1	1980	VBA, PMST	Widespread but of sporadic occurrence and rarely encountered. Grows mainly in grasslands and grassy woodlands. (Walsh and Entwisle 1996).	Unlikely – no suitable habitat within the study site.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Grevillea parvula	Genoa Grevillea		en #	1	2000	VBA	Also south-east NSW where it is more common. In Victoria, *Grevillea parvula* is restricted to the East Gippsland region (e.g. Wallagaraugh and Genoa Rivers, Mt Kaye). Sparingly established at Monbulk, in the Dandenong Ranges, and north of Branxholme, in western Victoria. *Grevillea parvula* has the broadest altitudinal range among the members of the *G. victoriae* species complex, from near sea level to over 1100 metres above sea level in south-east New South Wales. Often grows in riparian sites, but also in woodland and open forest.	Not applicable – study site is outside normal distribution for this species.
Isolepis wakefieldiana	Tufted Club-sedge		en	1	1907	VBA	Scattered in cooler parts of the state; apparently uncommon, but possibly overlooked due to its superficial similarity to *I. inundata* (Walsh and Entwisle 1994).	Unlikely – not recorded within study area since 1907.
Lastreopsis hispida	Bristly Shield-fern		en	5	2000	VBA	Grows in wet forests. Locally common in Otway Ranges, but rare outside this location (Walsh and Entwistle 1994)	Unlikely – no suitable habitat within the study site.
Lepidium aschersonii	Spiny Peppercress	VU	en			PMST	Mostly on heavy clay soil near salt lakes on volcanic plain, but with outlying records from near lake Omeo (Walsh & Entwisle 1996).	Unlikely – no suitable habitat within the study site and no records within study area.
Levenhookia sonderi	Slender Stylewort		en	1	1948	VBA	Apparently endemic in Victoria, in seasonally damp ground and drying swamps in lowland areas, mostly in the south-west (Walsh & Entwisle 1996).	Unlikely – although suitable habitat is present (damp ground), this species has not been recorded within the study area since 1948.
Melaleuca armillaris subsp. *armillaris*	Giant Honey-myrtle		en #	11	2019	VBA	Mainly confined to near coastal sandy heaths, scrubs, slightly raised above saltmarsh, riparian scrubs, rocky coastlines and foothill outcrops eastwards from about Marlo. Occurrences to the west are naturalized (Walsh & Entwisle 1996).	Not applicable – study site is outside normal distribution for this species.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Orthrosanthus multiflorus	Morning Flag		en	2	2007	VBA	Very rare in Victoria where known only from heathland communities near Cape Nelson and Port Campbell.	Unlikely – no suitable habitat within the study site.
Platylobium infecundum	Famine Flat-pea		cr	2	2014	VBA	Only known from a few locations in ranges east of Melbourne, growing in heathy forest and woodland.	Unlikely – no suitable habitat within the study site.
Platylobium reflexum	Victorian Flat-pea		en	2	1945	VBA	Common in tall wet forest in ranges east of Melbourne and the in the Otways.	Unlikely – no suitable habitat within the study site and not recorded within study area since 1945.
Pomaderris vacciniifolia	Round-leaf Pomaderris	CR	cr			PMST	Endemic in moist forest and scrubs in the upper catchment of the Yarra, Plenty and Yea rivers (Walsh and Entwisle 1999).	Unlikely – no suitable habitat within the study site and not recorded within study area.
Prasophyllum colemaniarum	Lilac Leek-orchid	VU				PMST	Known with certainty only by the type collection (1922) from grassy woodland near Bayswater, probably now extinct.	Unlikely – no suitable habitat within the study site and not recorded within study area.
Prasophyllum frenchii	Maroon Leek-orchid	EN	en	5	1990	VBA, PMST	Grows mostly in or near coastal swamps, rarely more than 10 km inland (Walsh & Entwisle 1994). Widespread across southern Victoria but of disjunct occurrence and with a single record from the eastern Goldfields. Found mostly as loose colonies in grasslands, heathlands and grassy woodlands on moderately rich sandy and black clay loams (Backhouse & Jeanes, 1995). UPDATE 2019: Widespread across southern Victoria, but rare. Occurs in grassland, heathland and open forest on well-drained or water-retentive sand or clay loams.	Unlikely – no suitable habitat within the study site and not recorded within study area since 1990.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Prasophyllum lindleyanum	Green Leek-orchid		en	8	2007	VBA	Occurs in more fertile soils of woodland or scrubby heath, but now localized and uncommon (Walsh & Entwisle 1996). Scattered mainly across southern Victoria but with several isolated occurrences in the Eastern Highlands and the western Goldfields. Found mainly in open forests, woodlands, heathy woodlands and heathlands. Soils are generally sand and clay loams that may be moist for at least part of the year (Backhouse & Jeanes, 1996).	**Possible** – suitable habitat is present within the study site and previous records within the study area.
Prasophyllum spicatum	Dense Leek-orchid	VU	cr			PMST	Widespread but sporadic across Victoria, growing in heath and heathy woodland (Jeanes and Backhouse 2006) Update 2019: Localised across southern Victoria in coastal heathland and near-coastal heathy forest on sandy soils.	Unlikely – no suitable habitat within the study site and not recorded within study area.
Pteris epaleata	Netted Brake		en	13	2000	VBA	Although restricted in distribution in Victoria, it is often locally abundant and conspicuous, favouring seepages, stream banks and damp flats in shady forests (e.g., Beech Forest in the Otway Range, Dandenong Ranges where rare, Wilsons Promontory, etc.).	**Possible** – suitable habitat is present within the study site and numerous previous records within study area. Reduced to **unlikely** after targeted surveys in 2024.
Pterostylis chlorogramma	Green-striped Greenhood	VU	en			PMST	Occurs across southern Victoria, growing in heathy Woodland. Recorded for few locations, but probably more widespread than current records suggest (Jeanes and Backhouse 2006).	Unlikely – no suitable habitat within the study site and not recorded within study area.
Pterostylis clivosa	Red-tip Greenhood		en	2	2006	VBA	Widespread across southern Victoria on slopes and ridges in drier open forests and woodlands on well-drained soils.	Unlikely – no suitable habitat within the study site and not recorded within study area.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Pterostylis cucullata	Leafy Greenhood	VU	en			PMST	Widely distributed but disjunct, mostly occurring in small groups in coastal areas, rarely inland (Walsh and Entwisle 1999). Widespread across southern Victoria, and extending into montane areas of the Eastern Highlands and East Gippsland. Grows in closed scrublands on the landward slopes, swales and tops of coastal sand dunes. Also grows in open forests on moist slopes, on seasonally inundated inland river flats, and in other riparian habitats. On the coast it grows in deep, well-drained sandy loams while inland it favours heavier sandy loams (Backhouse & Jeanes 1995). Update 2019 Widely distributed but disjunct, mostly occurring in small groups in coastal areas, sometimes near inland watercourses (Jones 1994).	Unlikely – limited suitable habitat within the study site and not recorded within study area.
Pterostylis grandiflora	Cobra Greenhood		en	3	1980	VBA	Grows in shaded situations in open forests, often among small shrubs, grasses and bracken. Substrates are generally well-drained sand and clay loams (Backhouse & Jeanes 1995).	**Possible** – suitable habitat is present within the study site but not recorded within study area since 1980.
Pterostylis X ingens	Sharp Greenhood		vu	1	1927	VBA	Grows in moist areas of open forest (Walsh & Entwisle 1996). Widespread across southern Victoria, and with a few records north of the Great Dividing Range, but of disjunct occurrence. Favours open forests where it grows in moist soils around swamps and near watercourses. Substrates are usually heavier peaty sand and clay loams (Backhouse & Jeanes, 1996).	Unlikely – although suitable habitat is present within the study site, this species has not been recorded within the study area since 1927.
Pultenaea weindorferi	Swamp Bush-pea		en	25	2013	VBA	Confined to swamps and drainage lines in scattered localities, often associated with *Eucalyptus cephalocarpa* (Walsh and Entwisle 1999).	**Possible** – suitable habitat is present within the study site and numerous records within the study area.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Ripogonum album	White Supplejack		en	1	2003	VBA	Rare in Victoria, confined to the lower catchments of the Snowy, Brodribb, Bemm, Cann and Wingan Rivers and the Howe Range. Typically associated with rainforest dominated by *Acmena smithii* or *Tristaniopsis laurina*.	Unlikely – no suitable habitat (e.g., rainforest) within study site.
Senecio campylocarpus	Floodplain Fireweed		en	3	2015	VBA	In Victoria mostly throughout central Victoria and in the north-east in loam to clay soils in forest and woodland, usually in seasonally inundated area (Ohlsen 2018).	**Possible** – suitable habitat is present within the study site and records within the study area. Reduced to **unlikely** after targeted surveys in 2024.
Senecio macrocarpus	Large-fruit Fireweed	VU	cr			PMST	Largely confined to Themeda grasslands on loamy clay soils derived from basalt near Melbourne, west to Skipton area. Also known from auriferous ground near Stawell (Walsh and Entwisle 1999).	Unlikely – no suitable habitat within the study site and not recorded within study area.
Senecio psilocarpus	Swamp Fireweed	VU				PMST	Rare in Victoria, restricted to a herb-rich few winter-wet swamps south and west from c. Ballarat, growing on volcanic clays or peat soils (Walsh and Entwisle 1999).	Unlikely – no suitable habitat within the study site and not recorded within study area.
Thesium australe	Austral Toadflax	VU	en			PMST	Apparently confined to the drier north-west of the State where it grows along seasonal watercourses, floodplains and depressions (Walsh & Entwisle 1996).	Unlikely – although suitable habitat is present within the study site (e.g., seasonal watercourses), there are no previous records within the study area.
Thismia rodwayi	Fairy Lanterns		en	3	2000	VBA	Restricted to damp humus and leaf litter in deeply shaded tall forests and fern gullies (Walsh and Entwisle 1999).	**Possible** - suitable habitat is present within the study site and records within the study area.
Tmesipteris ovata	Oval Fork-fern		en	1	01/01/1853	VBA	Not common in Victoria, localized in wet forest near Gembrook and Emerald, Morwell National Park, Wilsons Promontory and East Gippsland.	Unlikely – no suitable habitat within the study site and not recorded within study area since 1853.

Scientific Name	Common Name	EPBC Status	FFG Status	Count	Last Record	Source	Habitat description	Likelihood of occurrence
Tmesipteris parva	Small Fork-fern		en	5	2015	VBA	On tree-ferns, occurring between Gembrook and Warburton and in east and south Gippsland	**Possible** - suitable habitat is present within the study site and records within the study area.
Xerochrysum palustre	Swamp Everlasting	VU	cr	6	2018	VBA, PMST	Occurs in lowland swamps, usually on black cracking clay soils (Walsh and Entwisle 1999).	Unlikely – no suitable habitat within the study site.

Appendix E

Likelihood of occurrence - Threatened fauna

Table E1 Likelihood of occurrence of threatened terrestrial fauna recorded and/or predicted to occur within the study area

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Mammals								
Spot-tailed Quoll	*Dasyurus maculatus maculatus*	EN	E	VBA, PMST	3	1980	Preference for mature wet forest habitat that has been less disturbed by logging. Also occurs in wet sclerophyll forests, lowland forests, open and closed eucalypt woodlands, inland riparian and River Red-gum forests Woodlands, subalpine woodlands and coastal heathlands.	Unlikely. Few historical records and species now very rare in this part of Victoria. Potentially suitable habitat present.
Eastern Quoll	*Dasyurus viverrinus*	EN	EX	VBA	1	1880	Extinct in Victoria. Occurs in eastern Tas, open forest, woodlands, grasslands and alpine heaths. From 0-1000 m.	Unlikely. Considered extinct in Victoria.
Brush-tailed Phascogale	*Phascogale tapoatafa*		V	VBA	1	2017	Prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabits heath, swamps, rainforest and wet sclerophyll forest. Agile climber foraging preferentially in rough barked trees of 25 cm DBH or greater.	**Possible**. Only one historical record, but easily missed species and potentially suitable habitat present. Uncommon resident or visitor, if present.
Swamp Antechinus	*Antechinus minimus maritimus*	VU	V	PMST	0	NA	Wet areas with dense closed ground cover. Typically in wet heath, heathy woodland, sedgeland and dense tussock grassland, usually at low elevation.	Unlikely. No historical records and habitats unlikely to be suitable.
Southern Brown Bandicoot	*Isoodon obesulus obesulus*	EN	E	VBA, PMST	11	2018	Typically occurs in heathland, shrubland, heathy forest and woodland, and coastal scrub habitat across southern Victoria. Survival with foxes requires dense understorey vegetation.	Unlikely. A few historical records in the area, but habitats unlikely to be suitable and species now rare in Melbourne area.
Southern Greater Glider	*Petauroides volans*	EN	E	VBA, PMST	55	2022	Eucalypt-dominated low open forests on coast, tall forests and low woodland.	**Possible**. Numerous historical records, and potentially suitable habitat present. Common resident, if present.
Yellow-bellied Glider	*Petaurus australis*	VU	E	VBA, PMST	38	2021	Tall forest, coastal gullies, creek flats and forest mixed with woodland.	**Possible**. Numerous historical records, and potentially suitable habitat present. Uncommon resident, if present.
Long-nosed Potoroo	*Potorous tridactylus trisulcatus*	VU	V	PMST	0	NA	Uses a range of habitats from dense heathy woodland and coastal woodland to open forests, typically dominated by eucalypts. Six populations occur in certain parts of Victoria.	Unlikely. No historical records and habitats unlikely to be suitable.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Grey-headed Flying-fox	*Pteropus poliocephalus*	VU	V	VBA, PMST	14	2021	Densely vegetated flowering and fruiting trees, mainly east of Melbourne. Roosts in dense gullies. Uses a wide range of habitats in Victoria, from lowland rainforest and coastal Stringybark forests to agricultural land and suburban gardens. Established colonies known in Melbourne, Geelong, Bendigo and Mallacoota.	**Possible**. Historical records, and potentially suitable habitat present. Occasional foraging visitor, if present.
Eastern Bent-wing Bat	*Miniopterus orianae oceanensis*		CE	VBA	2	1974	Typically a cave roosting and breeding species. May occur anywhere within flying distance of suitable caves or equivalent structures (e.g., under dark bridges). Forages above canopy.	**Possible**. Only two historical records, but potentially suitable foraging habitat present. Occasional foraging visitor, if present.
Broad-toothed Rat	*Mastacomys fuscus mordicus*	VU	V	VBA, PMST	28	1994	Wet sedges and grasslands in forested areas, from alpine areas to sea level.	**Possible**. Numerous historical records, and potentially suitable habitat present. Uncommon resident, if present.
New Holland Mouse	*Pseudomys novaehollandiae*	VU	E	PMST	0	NA	Fire dependent. Inhabits a variety of habitats along the coast of south-eastern Australia, including coastal heath, sclerophyll forest, heathy woodland and coastal scrub habitats, usually with a high density of leguminous ground plants.	Unlikely. No historical records and habitats unlikely to be suitable.
Smoky Mouse	*Pseudomys fumeus*	EN	E	PMST	0	NA	Dry heathy forest on ridges. Coastal and sub-alpine heath.	Unlikely. No historical records and habitats unlikely to be suitable.
Birds								
King Quail	*Synoicus chinensis*		E	VBA	1	1981	Dense heaths and grasslands.	Unlikely. Generally rare species. Habitats unlikely to be suitable.
Lewin's Rail	*Lewinia pectoralis*		V	VBA	2	2018	Densely vegetated wetlands including wetlands, farm dams, swamps, saline lakes and river flats. Usually forages for a variety of aquatic plants and invertebrates around the water's edge in shallow water and close to cover.	**Possible**. Only two historical records, but easily missed species and potentially suitable habitat present. Uncommon resident or visitor, if present.
Caspian Tern	*Hydroprogne caspia*		V	VBA	2	2000	Coastal areas and large inland wetlands and rivers. Exposed ocean beaches, sheltered coastal bays, harbours, lagoons, inlets, estuaries, usually with sandy or muddy margins. Breeds in a variety of coastal habitats including banks, ridges and beaches of sand and shell, often in open or among low or sparse vegetation.	Unlikely. Few historical records and habitats unlikely to be suitable.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Eastern Curlew	*Numenius madagascariensis*	CR	CE	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Coastal. Sheltered coastal habitats, usually with large sand flats or intertidal mudflats with seagrass, estuaries, open sandy beaches. Occasionally on coastal rock platforms.	Unlikely. No historical records and no suitable habitat.
Common Sandpiper	*Actitis hypoleucos*		V	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Uses a wide variety of coastal and inland wetlands with muddy margins, including lakes, rivers, sewage ponds.	Unlikely. No historical records and no suitable habitat.
Common Greenshank	*Tringa nebularia*		E	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Coastal mudflats, estuaries, salt marshes, mangroves, lakes and swamps.	Unlikely. No historical records and no suitable habitat.
Curlew Sandpiper	*Calidris ferruginea*	CR	CE	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Regular visitor to Victoria. Occurs in a variety of wetland habitats with fringing mudflats including bays, coastal lagoons, lakes, swamps, creeks, inundated grasslands, saltmarshes and artificial wetlands.	Unlikely. No historical records and no suitable habitat.
Australian Painted Snipe	*Rostratula australis*	EN	CE	VBA, PMST	1	2007	Generally in shallow, terrestrial freshwater wetlands with rank, emergent tussocks of grass, sedges and rushes. Occurs in well vegetated lakes, swamps, inundated pasture, saltmarsh and dams. Fresh to saline water. May use riverine forest.	Unlikely. Generally rare species. Habitats unlikely to be suitable.
Little Egret	*Egretta garzetta nigripes*		E	VBA	6	2019	Uses wide range of wetlands, mudflats, estuaries. Typically prefers shallows of wetlands for foraging. Occasionally in small waterways or wet grassland areas.	**Possible**. Only a few historical records, but potentially suitable habitat present. Occasional foraging visitor, if present.
Plumed/Intermediate Egret	*Ardea intermedia plumifera*		CE	VBA	18	2021	Wetlands, river margins, mudflats and estuaries. Breeds in flooded or fringing trees alongside wetlands. Forages more widely.	**Possible**. Historical records, and potentially suitable habitat present. Occasional foraging visitor, if present.
Eastern Great Egret	*Ardea alba modesta*		V	VBA	49	2019	Saltwater and freshwater wetlands, lakes, dams, river margins, estuaries and mudflats.	**Possible**. Historical records, and potentially suitable habitat present. Occasional foraging visitor, if present.
Australian Little Bittern	*Ixobrychus dubius*		E	VBA	1	1894	Dense tall vegetation in swamps and wetlands.	**Possible**. Only one historical record, but cryptic species, difficult to detect. Potentially suitable habitat present. Rare foraging or breeding visitor, if present.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Australasian Bittern	*Botaurus poiciloptilus*	EN	CE	VBA, PMST	1	1988	Wetlands with tall, dense vegetation in permanent freshwater habitats, particularly when dominated by sedges, rushes and reeds. Also uses rice paddocks in north.	**Possible**. Only one historical record, but cryptic species, difficult to detect. Potentially suitable habitat present. Rare foraging or breeding visitor, if present.
Magpie Goose	*Anseranas semipalmata*		V	VBA	1	1994	Seasonal wetlands and flooded fields. Aquatic and terrestrial habitat, mostly in wetlands on flood plains. Historically occurred in SE Australia, but extinct in Victoria by early 1900s. Re-introduction attempts have had mixed results.	Unlikely. No suitable habitat.
Australasian Shoveler	*Spatula rhynchotis*		V	VBA	50	2019	Filter-feeding duck. Well vegetated larger wetlands, dams and lakes.	Unlikely. Historical records in the area, but habitats unlikely to be suitable.
Freckled Duck	*Stictonetta naevosa*		E	VBA	7	2019	Filter-feeding duck. Well vegetated shallow wetlands.	Unlikely. Historical records, but habitats unlikely to be suitable.
Hardhead	*Aythya australis*		V	VBA	141	2021	Diving duck. Deep permanent wetlands, dams, lakes and slow-flowing rivers. Also occurs in brackish wetlands and water storage ponds. Occasionally in estuarine and littoral habitats such as saltpans, coastal lagoons and sheltered inshore waters.	Unlikely. Historical records in the area, but habitats unlikely to be suitable.
Blue-billed Duck	*Oxyura australis*		V	VBA	123	2022	Diving duck. Deep open water in wetlands, dams, lakes and slow-flowing rivers.	Unlikely. Historical records in the area, but habitats unlikely to be suitable.
Musk Duck	*Biziura lobata*		V	VBA	16	2019	Diving duck. Deep open water in wetlands, dams, lakes and slow-flowing rivers.	Unlikely. Historical records in the area, but habitats unlikely to be suitable.
Grey Goshawk	*Accipiter novaehollandiae*		E	VBA	34	2022	Woodlands, forests and riparian habitats, mainly in wetter areas.	**Possible**. Numerous historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
Little Eagle	*Hieraaetus morphnoides*		V	VBA	18	2020	Widespread over diverse habitats across most of Australia, from coastal to inland forest, woodland, open scrub and tree-lined watercourses. Most abundant where open country mixes with wooded or forested hills.	**Possible**. Historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		E	VBA	9	2019	Coastal, marine and inland. Estuaries, beaches, large wetlands, including deep freshwater swamps, lakes, reservoirs, billabongs and rivers. Uses tall trees in or near water for breeding.	Unlikely. Historical records, but habitats unlikely to be suitable.
Square-tailed Kite	*Lophoictinia isura*		V	VBA	2	2018	Woodland and open forest in drier areas. Flies low and effortlessly just above the canopy hunting for nestlings.	Unlikely. Few historical records and habitats unlikely to be suitable.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Grey Falcon	*Falco hypoleucos*	VU	V	PMST	0	NA	Inland wooded watercourses and woodland. Generally rare.	Unlikely. No historical records and habitats unlikely to be suitable.
Black Falcon	*Falco subniger*		CE	VBA	2	2018	Grassy woodlands. Also found along tree-lined watercourses and in isolated woodlands, mainly in arid and semi-arid areas. It roosts in trees at night and often on power poles by day.	Unlikely. Few historical records and habitats unlikely to be suitable.
Barking Owl	*Ninox connivens*		CE	VBA	4	2004	Open woodlands and the edges of forests, often adjacent to farmland. Usually found in habitats dominated by eucalyptus, particularly red gum. Prefers woodlands and forests with a high density of large trees and particularly sites with hollows. Roost sites often near waterways or wetlands.	**Possible**. Only a few historical records, but potentially suitable habitat present. Occasional foraging or nesting visitor, if present.
Powerful Owl	*Ninox strenua*		V	VBA	413	2022	Open forests and woodlands, as well as along sheltered gullies in wet forests with dense understoreys. Especially along watercourses. Sometimes found in open areas near forests such as farmland, parks and suburban areas, as well as in remnant bushland patches. Needs old-growth trees and large hollows to nest.	**Possible**. Historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
Sooty Owl	*Tyto tenebricosa*		E	VBA	204	2021	Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests. Roosts by day in the hollow of a tall forest tree or in heavy vegetation; hunts by night for small ground mammals or tree-dwelling mammals.	**Possible**. Historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
Gang-gang cockatoo	*Callocephalon fimbriatum*	EN	E	VBA, PMST	191	2021	Tends to frequent tall forests and woodlands with dense shrubby understoreys in the mountains during the summer breeding period. In winter, tends to move to lower altitudes into drier, more open forests and woodlands. Often seen by roadsides and in parks and gardens of urban areas. Requires tall trees for nest hollows.	**Possible**. Historical records, and potentially suitable habitat present. Common foraging and potentially nesting visitor, if present.
Superb Parrot	*Polytelis swainsonii*	VU	E	VBA	1	2005	Open woodland and riverine forest. Nests in eucalypt hollows.	Unlikely. Site lies outside species' normal distributional range.
Blue-winged Parrot	*Neophema chrysostoma*	VU		VBA, PMST	28	2020	Inhabits a range of habitats from coastal, sub-coastal and inland areas, through to semi-arid zones. Tends to favour grasslands and grassy woodlands and often found near wetlands both near the coast and in semi-arid zones. Breeds in Tasmania, coastal south-eastern South Australia and southern Victoria.	**Possible**. Numerous historical records, and potentially suitable habitat present. Uncommon foraging and potentially nesting visitor, if present.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Swift Parrot	*Lathamus discolor*	CR	CE	VBA, PMST	6	1976	Winter migrant to Victoria (and other parts of SE Australia) from breeding areas in Tasmania. In Victoria, prefers dry, open eucalypt forests and woodlands, especially Box Ironbark Forest in north-central Victoria. Occasionally recorded in urban parks, gardens, street trees and golf courses with flowering ornamental trees and shrubs.	Unlikely. A few old historical records, but habitats unlikely to be favoured.
White-throated Needletail	*Hirundapus caudacutus*	VU	V	VBA, PMST	75	2021	Almost exclusively aerial within Australia, occurring over most types of habitat, particularly wooded areas. Less often seen over open farm paddocks but has been recorded in vineyards flying between the rows of trees.	**Possible**. Numerous historical records, and potentially suitable habitat present. Likely as uncommon flyover visitor.
Hooded Robin	*Melanodryas cucullata*	EN	V	PMST	0	NA	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses. Often perches on low dead stumps and fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey.	Unlikely. No historical records and habitats unlikely to be suitable.
Grey-crowned Babbler	*Pomatostomus temporalis*		V	VBA	4	1931	Well-structured open woodlands, mainly in drier areas.	Unlikely. Few historical records and species now considered extinct in this part of Victoria.
Southern Whiteface	*Aphelocephala leucopsis*	VU		PMST	0	NA	Inhabits a wide range of open woodlands and shrublands where there is an understorey of grasses or shrubs, or both. These areas are usually in habitats dominated by acacias or eucalypts on ranges, foothills and lowlands, and plains.	Unlikely. No historical records and habitats unlikely to be suitable.
Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*		V	VBA	3	2002	Heathlands, woodlands and forests with a dense, shrubby understorey. From coast to mountains. Shy species that typically forages on or near the ground and therefore requires habitat with suitable structure.	Unlikely. Few historical records and habitats unlikely to be suitable.
Speckled Warbler	*Pyrrholaemus sagittatus*		E	VBA	15	2000	Woodlands. Generally absent from very wet and very dry areas.	**Possible**. Historical records, and potentially suitable habitat present. Occasional visitor, if present.
Pilotbird	*Pycnoptilus floccosus*	VU	V	VBA, PMST	34	2018	Wet eucalypt and temperate rainforest, alpine and coastal woodland in dense undergrowth with abundant debris.	**Possible**. Numerous historical records, and potentially suitable habitat present. Rare resident or visitor, if present.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	VU		VBA, PMST	13	2018	Forests and woodlands, mainly in drier areas. Threatened sub-species victoriae occurs mainly on southern watershed of Great Dividing Range, and along a narrow intergrade on the northern and western slopes, in a rough line from the Grampians, through Maryborough and to Albury. Non-threatened sub-species picumnus occurs mainly inland of the same line.	**Possible**. Historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
Painted Honeyeater	*Grantiella picta*	VU	V	PMST	0	NA	Dry open forests and woodlands, strongly associated with mistletoe (including mistletoe in Acacia).	Unlikely. No historical records. Generally rare and nomadic species - may be a rare visitor in favourable conditions.
Regent Honeyeater	*Anthochaera phrygia*	CR	CE	VBA, PMST	15	2009	Open forests and woodlands. Generally absent from very wet and very dry areas. Dry woodlands and forests dominated by Box Ironbark eucalypts. May be restricted to the Chiltern-Mt Pilot National Park (NE Victoria) following population decline and range contraction.	Unlikely. Historical records, but species now rare in Melbourne area.
Helmeted Honeyeater	*Lichenostomus melanops cassidix*	CR	CE	VBA	3	1994	Occurs in streamside habitat of mountain swamp gum woodland. Rarely found far from water.	Unlikely. Few historical records and site lies outside species' currently used distributional range. Potentially suitable habitat present.
Diamond Firetail	*Stagonopleura guttata*	VU	V	VBA, PMST	2	1914	Occurs in eucalypt, acacia or casuarina woodlands, open forests and other lightly timbered habitats, including farmland and grassland with scattered trees. Prefers areas with relatively low tree density (including few large logs and litter cover) but a high grass cover. Generally absent from very wet and very dry areas.	Unlikely. Few historical records and habitats unlikely to be suitable.
Reptiles								
Striped Legless Lizard	*Delma impar*	VU	E	PMST	0	NA	Native grasslands and grassy woodlands, where soil is little disturbed. Also some non-native grasslands in areas where native grasslands persist.	Unlikely. No historical records and no suitable habitat.
Lace Monitor	*Varanus varius*		E	VBA	23	2022	Partly arboreal. Occurs in well-timbered areas, from dry woodland to southern temperate forests. Lays eggs in hollows.	**Possible**. Historical records, and potentially suitable habitat present. Uncommon resident or visitor, if present.
Swamp Skink	*Lissolepis coventryi*	EN	E	VBA, PMST	6	2001	Swamp scrub habitat in cool, temperate, low-lying areas, including wetlands, river margins, lakes, swamp margins and estuarine areas with a dense shrub layer, particularly in near-coastal areas across southern Victoria. Often associated with stands of paperbark and tea-tree, usually in heathy or scrubby areas.	**Possible**. Only a few historical records, but potentially suitable habitat present. Uncommon resident, if present.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Mountain Skink	*Liopholis montana*	EN	E	PMST	0	NA	Occupies areas of granite in tall open forest and heath in southern highlands. Colonies occupy burrow networks beneath rocks.	Unlikely. No historical records and no suitable habitat.
Glossy Grass Skink	*Pseudemoia rawlinsoni*		E	VBA	5	2015	Swamp and lake edges, saltmarshes, boggy creeks with dense vegetation.	**Possible**. Only a few historical records, but easily missed species and potentially suitable habitat present. Uncommon resident, if present.
Frogs								
Brown Toadlet	*Pseudophryne bibronii*		E	VBA	1	1943	Damp watercourses in woodland and open forest, where sufficient litter occurs. May breed in seemingly dry habitats that later flood with autumnal rain.	Unlikely. Only one old historical record, but potentially suitable habitat present. However, study area outside of expected species distribution. Rare resident, if present. Not detected in targeted surveys.
Southern Toadlet	*Pseudophryne semimarmorata*		E	VBA	6	1988	Moist soaks, depressions, dams and watercourses in woodland and open forest and heathlands, with sufficient litter or other ground cover. Adults shelter beneath leaf litter and other debris. Eggs and tadpoles develop in depressions that flood following autumn rains.	Unlikely. Only a few historical records, but potentially suitable habitat present. Uncommon resident, if present. Not detected in targeted surveys.
Growling Grass Frog	*Litoria raniformis*	VU	V	VBA, PMST	6	1990	Requires a matrix of well-connected permanent and semi-permanent waterbodies, including open vegetated wetlands, flooded paddocks, drains, farm dams and river pools, generally containing abundant submerged and emergent vegetation with little shade. Within lowland grasslands, woodlands and open forests.	Unlikely. Historical records, but habitats unlikely to be suitable.
Invertebrates								
Jewel Beetle	*Temognatha sanguinipennis*		E	VBA	1	1970	Wood-boring grubs, where larvae often feed in the phloem, immediately under the bark. Adults are moderately large beetles that are nectar/pollen feeders and can travel significant distances between widely separated plant populations.	**Possible**. Only one old historical record, but potentially suitable habitat present. Uncommon resident, if present.
Eltham Copper	*Paralucia pyrodiscus lucida*	EN	E	PMST	0	NA	Open forest, various eucalypt woodlands with native shrub understorey, herbs and grasses. Species has close symbiotic association with ants Notoncus genus and Sweet Bursaria (Bursaria spinosa).	Unlikely. No historical records and limited suitable habitat.
Small Ant Blue Butterfly	*Acrodipsas myrmecophila*		E	VBA	6	1942	Grassy open woodlands; hilltops.	Unlikely. A few old historical records, but habitats unlikely to be suitable.

Common name	Scientific Name	EPBC	FFG	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Yellow Ochre Butterfly	*Trapezites luteus luteus*		E	VBA	28	1953	Eucalypt woodland, cypress pine, open woodland and grassland on drier slopes and tablelands on and inland of the Great Dividing Range. Prefers open grassy areas.	Unlikely. Old historical records in the area, but habitats unlikely to be suitable.
Two-spotted Grass-skipper Butterfly	*Pasma tasmanica*		E	VBA	41	1949	Tall open eucalypt forest and subalpine woodland. Montane areas of Great Dividing Range. Riparian open forest at sea level in coastal NSW.	Unlikely. Old historical records in the area, but habitats unlikely to be suitable.
Golden Sun Moth	*Synemon plana*	VU	V	PMST	0	NA	Native grasslands and grassy woodlands, particularly where Austrodanthonia (Rytidosperma) dominant. Now recognised to occur also in exotic grasslands dominated by Chilean Needle Grass.	Unlikely. No historical records and no suitable habitat.

Table E2 Likelihood of occurrence of threatened aquatic fauna recorded and/or predicted to occur within the study area

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Crayfish								
Dandenong Burrowing Crayfish	*Engaeus urostrictus*		cr	32	2021	VBA	A small burrowing crayfish restricted to Dandenong Ranges with all known locations near headwaters of small streams (DELWP 2015). Occurs in riparian zones characterised by sandy soil flats adjacent to small, slow-flowing headwater streams with high organic content (DELWP 2015). Burrow systems have tunnels which descend to the water table to a depth of around 0.5 m, allowing the crayfish to follow the rise and fall of the water table (Horwitz et al. 1985).	**Possible** – Recent records within Study Area. Not captured during targeted survey, but suitable habitat present, *Engaeus* burrows observed during site assessment and recent records within 10km of the site.
Foothill Burrowing Crayfish	*Engaeus victoriensis*		en	14	2011	VBA	Large cavernous burrows in grey, clay-dominated soils in temperate, wet sclerophyll forest at the foot of the Dandenong Ranges.	**Present** – Recorded at Montrose in upper reaches of Bungalook Creek.
Tubercle Burrowing Crayfish	*Engaeus tuberculatus*		en	21	2022	VBA	Wet sclerophyll forest dominated by *E. regnans* and with abundant ferns at ground level. Microhabitats can be divided into flood-bed and clay-dominated hill slopes. Occupies banks and hill slopes and has burrows independent of the water table being wholly reliant on surface water runoff (Horwitz et al. 1985).	**Possible** – Recent records within Study Area. Not captured during targeted survey, but suitable habitat present, *Engaeus* burrows observed during site assessment and recent records within 10km of the site.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Fish								
Australian Grayling	*Prototroctes maraena*	VU	en	1	1979	VBA, PMST	A diadromous species which spends most of its life in freshwater habitats, typically rivers and streams with cool, clear waters and gravel substrates, but occasionally also in turbid waters (Backhouse et al. 2008). Juveniles inhabit estuaries and coastal seas (Backhouse et al. 2008).	Unlikely – Not recorded in Study Area in last 33 years. Some suitable habitat in Bungalook Creek but of low quality and multiple barriers to fish passage (in the form of undergrounded sections of the waterway) would prevent migration into the creek. Not recorded during 2023 fish survey.
Trout Cod	*Maccullochella macquariensis*	EN	en	1	1970	VBA	Inhabit a large (60 - 100 m wide), deep (>3 m) flowing river section with a sand, silt and clay substrate that contains abundant snags and woody debris. Trout Cod are often angled from within, under or adjacent to snags, branch piles, and steep clay banks, usually in areas of relatively fast current	Highly unlikely – No suitable habitat within Bungalook Creek and no credible records within Study Area. Not recorded during 2023 fish survey.
Murray Cod	*Maccullochella peelii peelii*	VU	en	1	1970	VBA, PMST	Small clear, rocky, upland streams with riffle and pool structure on the upper western slopes of the Great Dividing Range to large, meandering, slow flowing, often silty rivers in the alluvial lowland reaches of the Murray-Darling Basin.	Highly unlikely – No suitable habitat within Bungalook Creek and no credible records within Study Area. Not recorded during 2023 fish survey.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Macquarie Perch	*Macquaria australasica*	EN	en	1	1760	VBA, PMST	Deep, rocky holes with considerable cover and flowing water over unsilted cobble and gravel substrate.	Highly unlikely – No suitable habitat within Bungalook Creek and no credible records within Study Area. Not recorded during 2023 fish survey.
Yarra Pygmy Perch	*Nannoperca obscura*	VU	vu			PMST	Typically occurs in lakes, ponds and slow-flowing rivers with large amounts of aquatic vegetation, particularly emergent macrophytes, and large woody debris (Saddlier and Hammer 2010; Sadlier et al. 2013). Prefers small-medium sized and relatively shallow (1-2 m) freshwater streams with moderate to high flow (Sadlier et al. 2013).	Highly Unlikely – No suitable habitat within Bungalook Creek and no historical records within Study Area. Not recorded during 2023 fish survey.
Eastern Dwarf Galaxias	*Galaxiella pusilla*	VU	en			PMST	Relatively shallow still or slow flowing waterbodies, including streams, wetlands, drains, that often are ephemeral and partially dry up over summer. Typically requires abundant marginal and aquatic vegetation.	Highly Unlikely - No records within Study Area, barriers to fish passage present and waterway does not support abundant aquatic vegetation. Not recorded during 2023 fish survey.
Invertebrates								
Caddisfly	*Plectrotarsus gravenhorstii*		en	1	1943	VBA	Little is known of its life history or habitat requirements, but it is known to inhabit shallow and densely-vegetated waterways and swamps in its nymph stage.	Unlikely - Species recorded historically in the Study Area but not within the last 30 years.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Depressed Mussel	*Hyridella (Hyridella) depressa*		en	1	1994	VBA	A shallow burrower in silty sand/mud in streams and rivers found in upper reaches of streams to the lowlands and a range of flow regimes (SAC 2022a). Has been recorded from burrows extending to 20 metres (CFE 2023).	Highly Unlikely – Does not exist west of the Mitchell River system in Victoria. Records from 1994 are incorrect and should be *Hyridella drapeta* (pers comm. T. Raadik, DEECA, 2023).
Narracan Corrugated Mussel	*Hyridella narracanensis*		en	7	2015	VBA	A small bivalve up to 60 mm with a distribution restricted to certain rivers and streams in Victoria, north-eastern Tasmania and the south-east corner of South Australia (SAC 2022b). Two Victorian populations remain- the Olinda Creek (Yarra catchment) and the Curdies River. Found in permanent freshwater rivers and streams with stable flow regimes, well-shaded by overhanging vegetation, over shallow clear water with sandy, compacted substrata with low organic content (Klunzinger et al., 2014; SAC 2022b). Likely to be obligate parasites on the gills and fins of freshwater fish, and the viability of mussel populations is thereby dependent on the availability of hosts. The parasitic phase is the primary means for dispersal, as the adults are sedentary and have very little capacity for large-scale movement other than by being entrained by floods.	Unlikely – the very small catchment area ($3km^2$) and conditions observed at visited sites indicate a low likelihood of moderate flow in the upper reaches of Bungalook Creek. The creek supports a very low fish abundance due to existing barriers, limiting likelihood of successful reproduction/ dispersal opportunities.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Dandenong Freshwater Amphipod	*Austrogammarus australis*		cr	55	2021	VBA	Dandenong Mountain Ranges, Victoria Australia in upland cool freshwater streams with intact riparian vegetation and canopy cover of more than 75%.	Unlikely - Last known records within undisturbed forested areas of upper reaches of Olinda and Dandenong Creek. Intolerant of urbanisation impacts, which have led to its restricted distribution.
Sherbrooke Amphipod	*Austrogammarus haasei*		en	10	2011	VBA	Freshwater streams with intact riparian vegetation.	Unlikely - Last known records within undisturbed forested areas of Monbulk and Sassafras Creek. Intolerant of urbanisation impacts, which have led to its restricted distribution.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Mammals and reptiles								
Platypus	*Ornithorhynchus anatinus*		vu	112	2021	VBA	Endemic to eastern mainland Australia, Tasmania and King Island, with a small introduced population on Kangaroo Island. Widely distributed in creeks, rivers, shallow lakes, wetlands, and their riparian margins, in agricultural land, urban areas, and natural environments (Bino et al., 2019). In eastern Australian rivers, the mid and lower reaches are generally more favoured than upper reaches (Serena et al., 2001; Turnbull 1998; Rohweder and Baverstock 1999; Koch et al. 2006; Macgregor 2015). Preferred habitat tends to include consolidated earth banks with a riparian zone composed of large trees, fringing vegetation that overhangs the stream channel, wide streams with depths 1 to 3 metres containing pools with organic matter, coarse woody debris and coarse substrates (Rohweder 1992; Bryant 1993; Ellem et al. 1998; Serena et al. 2001; Milione and Harding 2009).	Unlikely – No suitable habitat within Bungalook Creek.

Common name	Scientific Name	EPBC	FFG	Count	Last Record	Source	Preferred habitat in Victoria	Likelihood of Occurrence
Broad-shelled Turtle	*Chelodina expansa*		en	1	2012	VBA	Occupies a range of habitats including main river channels, backwaters, swamps, lagoons and connecting inlets (Bower et al. 2012; Van Dyke et al. 2019). Depend on permanent water bodies and seldom emerge, apart from the breeding season (Baggiano 2012; Bower et al. 2012). Females may travel up to 300m from water to nest (Booth 2010; Petrov et al. 2018) on banks, away from vegetation and hard structures (such as rocks) and above the high-water mark (Goodwin and Hopkins 2005). Females tend to occupy discreet home ranges, but males move up to 25km, possibly to find breeding females (Bower et al. 2012).	Unlikely – No suitable habitat within Bungalook Creek.
Murray River Turtle	*Emydura macquarii*		cr	4	2016	VBA	Generally restricted to permanent water close to or with direct connections to the main channel of rivers, or permanent habitat linked to rivers (Chessman 1978; Cann 1998; Van Dyke et al. 2019; Spencer 2000). May travel up to 300m from water to nest (Booth 2010; Petrov et al. 2018). Prefer to nest on banks, away from vegetation and hard structures (such as rocks) and above the high-water mark (Goodwin and Hopkins 2005).	Unlikely – No suitable habitat within Bungalook Creek.

Appendix F

Likelihood of occurrence - Migratory fauna

Table F1 Likelihood of occurrence of migratory fauna recorded and/or predicted to occur within the study area

Common name	Scientific Name	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Caspian Tern	*Hydroprogne caspia*	VBA	2	2000	Coastal areas and large inland wetlands and rivers. Exposed ocean beaches, sheltered coastal bays, harbours, lagoons, inlets, estuaries, usually with sandy or muddy margins. Breeds in a variety of coastal habitats including banks, ridges and beaches of sand and shell, often in open or among low or sparse vegetation.	Unlikely. Few historical records and habitats unlikely to be suitable.
Eastern Curlew	*Numenius madagascariensis*	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Coastal. Sheltered coastal habitats, usually with large sand flats or intertidal mudflats with seagrass, estuaries, open sandy beaches. Occasionally on coastal rock platforms.	Unlikely. No historical records and no suitable habitat.
Common Sandpiper	*Actitis hypoleucos*	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Uses a wide variety of coastal and inland wetlands with muddy margins, including lakes, rivers, sewage ponds.	Unlikely. No historical records and no suitable habitat.
Common Greenshank	*Tringa nebularia*	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Coastal mudflats, estuaries, salt marshes, mangroves, lakes and swamps.	Unlikely. No historical records and no suitable habitat.
Curlew Sandpiper	*Calidris ferruginea*	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Regular visitor to Victoria. Occurs in a variety of wetland habitats with fringing mudflats including bays, coastal lagoons, lakes, swamps, creeks, inundated grasslands, saltmarshes and artificial wetlands.	Unlikely. No historical records and no suitable habitat.
Sharp-tailed Sandpiper	*Calidris acuminata*	VBA, PMST	1	1985	Non-breeding migrant to Australia during the austral summer. Regular visitor to Victoria. Prefers muddy edges of shallow fresh or brackish wetlands with inundated or emergent low vegetation.	Unlikely. Few historical records and habitats unlikely to be suitable.
Pectoral Sandpiper	*Calidris melanotos*	PMST	0	NA	Non-breeding migrant to Australia during the austral summer. Occurs in a variety of wetland habitats with fringing mudflats including bays, coastal lagoons, lakes, swamps, creeks, inundated grasslands, saltmarshes and artificial wetlands. Mostly recorded from Port Phillip Bay and Murray River region.	Unlikely. No historical records and no suitable habitat.

Common name	Scientific Name	Source	VBA recs	VBA last	Preferred habitat in Victoria	Likelihood of Occurrence
Latham's Snipe	*Gallinago hardwickii*	VBA, PMST	80	2020	Non-breeding migrant to Australia during the austral summer. Uses a wide variety of permanent and ephemeral wetlands, generally freshwater wetlands with cover. Also recorded along creeks, rivers and floodplains. Forages in soft mud at edge of wetlands and roosts in a variety of vegetation around wetlands including tussock grasslands, reeds and rushes, tea-tree scrub, woodlands and forests.	**Possible**. Numerous historical records, and potentially suitable habitat present.
Glossy Ibis	*Plegadis falcinellus*	VBA	1	2020	Wetlands, dams, flooded fields, mudflats, mangroves.	Unlikely. Few historical records and habitats unlikely to be suitable.
Osprey	*Pandion haliaetus*	PMST	0	NA	Found on the coast and in terrestrial wetlands of tropical and temperate Australia and off-shore islands, occasionally ranging inland along rivers. Uncommon in Victoria.	Unlikely. No historical records and no suitable habitat.
White-throated Needletail	*Hirundapus caudacutus*	VBA, PMST	75	2021	Almost exclusively aerial within Australia, occurring over most types of habitat, particularly wooded areas. Less often seen over open farm paddocks but has been recorded in vineyards flying between the rows of trees.	**Possible**. Numerous historical records, and potentially suitable habitat present. Likely as flyover visitor.
Fork-tailed Swift	*Apus pacificus*	VBA, PMST	8	1982	Aerial species, occurring over a wide range of environments, predominantly over open country but sometimes over forests and urban landscapes.	**Possible**. Historical records, and potentially suitable habitat present. May be occasional flyover visitor.
Rufous Fantail	*Rhipidura rufifrons*	VBA, PMST	194	2022	Wet woodlands and sclerophyll forests, temperate rainforests, gullies dominated by Eucalypts.	**Possible**. Numerous historical records, and potentially suitable habitat present.
Satin Flycatcher	*Myiagra cyanoleuca*	VBA, PMST	71	2021	Uncommon summer migrant in forests, particularly densely vegetated gullies.	**Possible**. Numerous historical records, and potentially suitable habitat present.
Black-faced Monarch	*Monarcha melanopsis*	VBA, PMST	4	2006	Summer migrant to rainforests, forests, denser woodlands and densely vegetated gullies.	**Possible**. Few historical records, but potentially suitable habitat present.
Yellow Wagtail	*Motacilla flava*	PMST	0	NA	Migrates from northern hemisphere. Uses open grassy and waterside habitats in wintering grounds, occasionally in Australia, and in migration. Breeds on Arctic tundra from Alaska to Russia. Ground-dwelling. Often seen near water. Rarely sighted in Australia; most sightings in coastal and northern Australia.	Unlikely. No historical records and no suitable habitat.

Appendix G

Flora species recorded during site assessment

Key to table	
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
CR	Critically Endangered
EN	Endangered
VU	Vulnerable
FFG	*Flora and Fauna Guarantee Act 1988*
cr	Critically Endangered
en	Endangered
vu	Vulnerable
Other	
Non-native	species not native to Australia
*	species recorded, but not directly using habitat within study site (i.e., fly over, in nearby habitat)
+	Evidence of species presence
#	Native but some stands may be alien
P	Protected under the FFG Act
Restricted	Listed as a Restricted weed in the East Gippsland CMA under CaLP Act
Controlled	Listed as Controlled weed in the East Gippsland CMA under CaLP Act
WoNS	Weed of National Significance
Planted	Planted – Species represented by planted (not remnant) individuals

Table G1 Flora species recorded during the preliminary site assessment (phase 1)

Scientific Name	Common Name	FFG Status	Threat status
Indigenous species			
Acacia dealbata	Silver Wattle		
Acacia melanoxylon	Blackwood		
Acacia paradoxa	Hedge Wattle		
Acacia verticillata	Prickly Moses	P	
Acaena novae-zelandiae	Bidgee-widgee		
Billardiera mutabilis	Common Apple-berry		
Bursaria spinosa subsp. spinosa	Sweet Bursaria		
Calochlaena dubia	Common Ground-fern		
Carex appressa	Tall Sedge		
Cassinia aculeata subsp. aculeata	Common Cassinia	P	
Cassytha pubescens s.s.	Downy Dodder-laurel		
Clematis aristata	Mountain Clematis		
Coprosma hirtella	Rough Coprosma		
Coprosma quadrifida	Prickly Currant-bush		
Cyathea australis	Rough Tree-fern		
Dianella revoluta s.l.	Black-anther Flax-lily		
Dianella tasmanica	Tasman Flax-lily		
Dichondra repens	Kidney-weed		
Eleocharis acuta	Common Spike-sedge		

Scientific Name	Common Name	FFG Status	Threat status
Epacris impressa	Common Heath		
Eucalyptus obliqua	Messmate Stringybark		
Eucalyptus ovata	Swamp Gum		
Eucalyptus radiata s.l.	Narrow-leaf Peppermint		
Eucalyptus viminalis subsp. viminalis	Manna Gum		
Exocarpos cupressiformis	Cherry Ballart		
Gahnia radula	Thatch Saw-sedge		
Geranium potentilloides	Soft Crane's-bill		
Gonocarpus tetragynus	Common Raspwort		
Goodenia ovata	Hop Goodenia		
Hackelia latifolia	Forest Hound's-tongue		
Juncus spp.	Rush		
Lemna disperma	Common Duckweed		
Lepidosperma elatius	Tall Sword-sedge		
Leptospermum continentale	Prickly Tea-tree		
Lomandra longifolia	Spiny-headed Mat-rush		
Melaleuca squarrosa	Scented Paperbark		
Microlaena stipoides var. stipoides	Weeping Grass		
Olearia lirata	Snowy Daisy-bush	P	
Ozothamnus spp.	Everlasting	P	
Pandorea pandorea	Wonga Vine		
Phragmites australis	Common Reed		
Pteridium esculentum subsp. esculentum	Austral Bracken		
Schoenus apogon	Common Bog-sedge		
Senecio minimus	Shrubby Fireweed	P	
Senecio spp.	Groundsel	P	
Sigesbeckia orientalis subsp. orientalis	Indian Weed		
Tetrarrhena juncea	Forest Wire-grass		
Typha domingensis	Narrow-leaf Cumbungi		
Viola hederacea sensu Willis (1973)	Ivy-leaf Violet		
Grevillea rosmarinifolia	Rosemary Grevillea		
Melaleuca ericifolia	Swamp Paperbark		
Pittosporum undulatum	Sweet Pittosporum		
Introduced species			
Adiantum aethiopicum	Common Maidenhair		#
Asparagus asparagoides	Bridal Creeper		WoNS Restricted
Asparagus scandens	Asparagus Fern		WoNS Restricted
Chrysanthemoides monilifera	Boneseed		Regionally Controlled / Very high
Cirsium vulgare	Spear Thistle		Regionally Controlled / Moderately high
Cynodon dactylon var. dactylon	Couch		Moderately high

Scientific Name	Common Name	FFG Status	Threat status
Cytisus scoparius	English Broom		Regionally Controlled / High
Dactylis glomerata	Cocksfoot		High
Ehrharta erecta	Panic Veldt-grass		Very high
Erigeron spp.	Fleabane		Most species moderately high
Galium aparine	Cleavers		High
Hedera helix s.l.	English Ivy		Very high
Myosotis sylvatica	Wood Forget-me-not		Very high
Oxalis pes-caprae	Soursob		Very high
Paspalum dilatatum	Paspalum		Medium
Pinus radiata	Radiata Pine		Very high
Ranunculus repens	Creeping Buttercup		Very high
Rosa rubiginosa	Sweet Briar		Regionally Controlled / High
Rubus fruticosus	Blackberry		Regionally Controlled / Most species high, but ranges from potential to very high
Vinca major	Blue Periwinkle		High
Zantedeschia aethiopica	White Arum-lily		Very High
Watsonia spp.	Watsonia		Regionally Controlled / High or very high

Appendix H

Ecological risk register

Appendix H - Ecological Risk Register

Risk ID	Ecosystem component	Pathway / Risk Event	Potential receptors or risk entities				Inherent Risk				Residual Risk			Monitoring
			Details of sensitive receptor	Location / proximity	Resultant harm	Supporting evidence	Likelihood	Consequence	Risk Level	Treatment measures / existing controls	Likelihood	Consequence	Risk Level	Aspect to be monitored
AQ-1	Aquatic	Dewatering required to access lower levels of the quarry	Threatened species - Burrowing Crayfish	Potentially present within modelled drawdown area	Crayfish cannot access groundwater following drawdown resulting in a loss of habitat Potential for loss of surface water flow and interflow, loss of habitat Potential for reduced water quality in Bungalook Creek due to loss of surface water flow (e.g. reduced dissolved oxygen, concentration of salts, nutrients and other contaminants)	Surveys did not detect threatened Crayfish but historical records suggest they may be present in study site and area of predicted drawdown. Known to burrow to water table. Changes in groundwater levels from ~5m under existing conditions to 10-15m. Limited information regarding response by Burrowing Crayfish species to drawdown over the long-term. Waterway known to cease-to-flow under existing conditions. Reduced streamflow and wetting of riparian zone (e.g. to a depth of 1m BGL) in vicinity of creek likely to be important to the species. Burrowing crayfish likely to rely on wetting due to surface water flows, rather than groundwater. At flows <10 L/s all surface water flow predicted to be lost due to seepage. Surface water flows likely to be reduced during low flow periods. Creek does not meet ERS for conductivity, dissolved oxygen and turbidity, on occasion. Also likely to experience water quality issues during low flow periods.	**Possible**	**Moderate**	**Medium**	Relocation of existing discharge point to return of seepage water to Bungalook Creek (this will mostly aid streamflow and soil moisture rather than baseflow). Assumes that source water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS). Carry out hydrological assessment to determine suitable timing and volume of releases to maintain sensitive receptors.	**Unlikely**	**Moderate**	**Medium**	Periodic monitoring to establish baseline/presence of threatened burrowing crayfish. If burrowing crayfish confirmed as declining despite return of seepage water to Bungalook Ck, refine discharge regime. Inclusion of monitoring as a response to SW/GW TARP trigger and to inform discharge regime.
AQ-2	Aquatic	Dewatering required to access lower levels of the quarry	Water dependent ecosystems and species (EP Act 2017) - Native fish	Throughout Bungalook Creek	Increased seepage from Bungalook Creek, when streamflow is <10L/sec which leads to a loss of surface water flows. Loss of habitat or connectivity for native fish, resulting in barriers to fish passage. Potential for reduced water quality in Bungalook Creek due to loss of surface water flow (e.g. reduced dissolved oxygen, concentration of salts, nutrients and other contaminants).	Surveys indicate low abundance, low diversity but native fish are present. Both species present have the ability to navigate barriers, which are already present within the Bungalook Creek sub-catchment. Waterway known to cease-to-flow under existing conditions. Creek does not meet ERS for conductivity, dissolved oxygen and turbidity, on occasion. Also likely to experience water quality issues during low flow periods.	**Possible**	**Minor**	**Medium**	Relocation of existing discharge point to return of seepage water to Bungalook Creek (this will mostly aid streamflow and soil moisture rather than baseflow). Assumes that source water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS). Carry out hydrological assessment to determine suitable timing and volume of releases to maintain sensitive receptors.	**Unlikely**	**Minor**	**Low**	If ecological health is confirmed as declining (i.e. through macroinvertebrate or refuge pool monitoring) despite return of seepage water to Bungalook Ck, refine discharge regime. Inclusion of monitoring as a response to SW/GW TARP trigger and to inform discharge regime.
AQ-3	Aquatic	Dewatering required to access lower levels of the quarry	Water dependent ecosystems and species (EP Act 2017) - Macroinvertebrates	Throughout Bungalook Creek	Increased seepage from Bungalook Creek, when streamflow is <10L/sec which leads to a loss of surface water flows. Loss of habitat or connectivity for macroinvertebrates due to cease-to-flow. Potential for reduced water quality in Bungalook Creek due to loss of surface water flow (e.g. reduced dissolved oxygen, concentration of salts, nutrients and other contaminants).	Surveys indicate relatively healthy waterway for an urban environment, meeting ERS objectives. Waterway known to cease-to-flow under existing conditions. Known response of key aquatic values to drying flow regime (i.e. macroinvertebrates likely to recolonise). - Flows in Bungalook Creek likely dominated by streamflow, i.e. run-off rather than groundwater contributions. This is confirmed by groundwater level response in nearby Boral monitoring bores. Creek does not meet ERS for conductivity, dissolved oxygen and turbidity, on occasion. Also likely to experience water quality issues during low flow periods.	**Possible**	**Minor**	**Medium**	Relocation of existing discharge point to return of seepage water to Bungalook Creek (this will mostly aid streamflow and soil moisture rather than baseflow). Assumes that source water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS). Carry out hydrological assessment to determine suitable timing and volume of releases to maintain sensitive receptors.	**Unlikely**	**Minor**	**Low**	Periodic monitoring of macroinvertebrate communities to capture seasonal/climatic variation. If ecological health is confirmed as declining despite return of seepage water to Bungalook Ck, refine discharge regime. Inclusion of monitoring as a response to SW/GW TARP trigger and to inform discharge regime.
AQ-6	Aquatic	Dewatering required to access lower levels of the quarry	Water dependent ecosystems and species (EP Act 2017) - Refuge pools	Noted within modelled drawdown	Increased seepage from Bungalook Creek, when streamflow is <10L/sec which leads to a loss of surface water flows. Loss of refuge pools. Potential for reduced water quality in Bungalook Creek due to loss of surface water flow (e.g. reduced dissolved oxygen, concentration of salts, nutrients and other contaminants).	Surveys indicate likely presence of refuge pools. Given that the waterway is known to experience cease-to-flow periods under existing conditions it is likely that these pools provide refuge for aquatic species which would recolonise the waterway when flows return. Creek does not meet ERS for conductivity, dissolved oxygen and turbidity, on occasion. Also likely to experience water quality issues during low flow periods.	**Possible**	**Minor**	**Medium**	Relocation of existing discharge point to return of seepage water to Bungalook Creek (this will mostly aid streamflow and soil moisture rather than baseflow). Assumes that source water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS). Carry out hydrological assessment to determine suitable timing and volume of releases to maintain sensitive receptors.	**Unlikely**	**Minor**	**Low**	Mapping and monitoring of refuge pools to establish baseline conditions and inclusion of monitoring as a response to SW/GW TARP trigger. If habitat loss (i.e. refuge pools) is confirmed despite return of seepage water to Bungalook Ck, refine discharge regime. Inclusion of monitoring as a response to SW/GW TARP trigger and to inform discharge regime.
VEG-1	Vegetation	Dewatering required to access lower levels of the quarry leads to reduction in baseflow to Bungalook Creek	Instream aquatic and amphibious vegetation.	Throughout Bungalook Creek	Reduction instream and fringing vegetation - reduction in cover and/or species richness.	Soil moisture is likely predominantly recharged by rainfall infiltration. However, around the creek areas, surface water recharge is also possible (EMM 2025). During times of higher rainfall, when groundwater levels maybe even shallower, trees close to Bungalook Creek may access groundwater, however this would still likely be sourced from recent creek recharge post rainfall events (EMM 2025).	**Unlikely**	**Minor**	**Low**		**Unlikely**	**Minor**	**Low**	

Risk ID	Ecosystem component	Pathway / Risk Event	Potential receptors or risk entities				Inherent Risk				Residual Risk			Monitoring
			Details of sensitive receptor	Location / proximity	Resultant harm	Supporting evidence	Likelihood	Consequence	Risk Level	Treatment measures / existing controls	Likelihood	Consequence	Risk Level	Aspect to be monitored
VEG-2	Vegetation	Dewatering required to access lower levels of the quarry leads to reduction in baseflow to Bungalook Creek	Deep rooted trees along Bungalook Creek that use creekline water.	Throughout Bungalook Creek	Decline in tree health, including death of some trees e.g. trees starting in poor condition.	Soil moisture is likely predominantly recharged by rainfall infiltration. However, around the creek areas, surface water recharge is also possible (EMM 2025). During times of higher rainfall, when groundwater levels maybe even shallower, trees close to Bungalook Creek may access groundwater, however this would still likely be sourced from recent creek recharge post rainfall events (EMM 2025).	**Possible**	**Moderate**	**Medium**	Return of seepage water to Bungalook Creek (this will mostly aid streamflow and soil moisture rather than baseflow). Assumes that source water quality would need to have sufficient treatment to comply with the water quality objectives to maintain downstream environmental values (as defined by the ERS).	**Unlikely**	**Minor**	**Low**	Tree health. Inclusion of monitoring as a response to SW/GW TARP trigger and to inform discharge regime.
VEG-3	Vegetation	Dewatering required to access lower levels of the quarry results in groundwater level reduced from ~5m under existing conditions to 10-15m	Deep rooted trees currently accessing groundwater as one of their sources of water.	Damp Forest and Riparian EVCs	Decline in tree health, including death of some trees e.g. trees starting in poor condition.	EMM (2025) vegetation assessment indicates vegetation not accessing groundwater and are preferentially utilising the higher nutrient soil moisture that is predominantly recharged by rainfall.	**Unlikely**	**Minor**	**Low**		**Unlikely**	**minor**	**Low**	Tree health
VEG-4	Vegetation	Decline in tree health, including death of some trees.	Shade dependent and moisture dependent understorey vegetation, especially ground ferns	Damp Forest and Riparian EVCs	Reduction in vegetation cover and species richness in understorey.	EMM (2025) vegetation assessment indicates vegetation not accessing groundwater and are preferentially utilising the higher nutrient soil moisture that is predominantly recharged by rainfall.	**Unlikely**	**Minor**	**Low**		**Unlikely**	**Minor**	**Low**	Vegetation composition
VEG-5	Vegetation	Decline in tree health, including death of some trees.	Threatened flora species	Damp Forest and Riparian EVCs	Reduction in quality of habitat.	EMM (2025) vegetation assessment indicates vegetation not accessing groundwater and are preferentially utilising the higher nutrient soil moisture that is predominantly recharged by rainfall.	**Unlikely**	**Minor**	**Low**		**Unlikely**	**Minor**	**Low**	Vegetation composition
TF-1	Terrestrial fauna	Decline in vegetation habitat	Shade dependent and moisture dependent understorey vegetation, especially ground ferns and sedges used by threatened species for habitat	Damp Forest and Riparian EVCs	Reduction in vegetation cover and species richness in understorey.	EMM (2025) vegetation assessment indicates vegetation not accessing groundwater and are preferentially utilising the higher nutrient soil moisture that is predominantly recharged by rainfall.	**Unlikely**	**Minor**	**Low**		**Unlikely**	**Minor**	**Low**	Vegetation composition