APPENDIX 13

Biodiversity Assessment Report

Environmental & Social Consultants

MANGOOLA OPEN CUT
GLENCORE

MANGOOLA COAL CONTINUED OPERATIONS PROJECT

Biodiversity Assessment Report

FINAL

June 2019

MANGOOLA COAL
CONTINUED OPERATIONS PROJECT

Biodiversity Assessment Report

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Mangoola Coal Operations Pty Ltd

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Report No.	3450/R12
Date:	June 2019

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This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Executive Summary

Mangoola Coal Operations Pty Limited (Mangoola) operates the Mangoola Coal Mine and is preparing an application for development consent for the Mangoola Coal Continued Operations Project (MCCO Project). The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations.

This Biodiversity Assessment Report (BAR) has been prepared by Umwelt (Australia) Pty Limited (Umwelt) to assess the biodiversity impacts of the MCCO Project and forms part of an Environmental Impact Statement (EIS) prepared to accompany the development application for the MCCO Project. It has been prepared in accordance with the Framework for Biodiversity Assessment (FBA) (OEH 2014b) and the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014a) under Clause 27(2) of the *Biodiversity Conservation (Savings and Transitional) Regulation 2017*.

The MCCO Project will result in the removal of approximately 570 hectares (ha) of native vegetation (consisting of 196 ha of woodland and balance of derived native grassland) and fauna habitat, including four NSW listed threatened ecological communities, one of which is also listed as threatened at the Commonwealth level; White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland Critically Endangered Ecological Community.

A total of 17,718 ecosystem credits are required to offset impacts to native vegetation and fauna habitats as a result of the MCCO Project.

11 threatened species have been recorded in the MCCO Additional Project Area including five birds, four bats and two orchids. This biodiversity assessment identified that under the FBA impacts to four of these threatened species would require specific offsetting requirements, in addition to offsetting the impacts on native vegetation, being:

- large-eared pied bat (*Chalinolobus dwyeri*) – 27 credits
- southern myotis (*Myotis macropus*) – 20 credits
- Tarengo leek orchid (*Prasophyllum petilum*) – 8,983 credits
- pine donkey orchid (*Diuris tricolor*) – 17,238 credits

Mangoola has developed a biodiversity offset strategy that fully meets the offset requirements for the MCCO Project and builds on the existing offsets established by the mine. The biodiversity offset strategy for the MCCO Project includes:

- In-perpetuity conservation achieved through the retirement of biodiversity credits through the establishment of the following Stewardship Sites:
  - Mangoola Offset Site
  - Wybong Heights Offset Site
  - Mangrove Offset Site
  - Highfields Offset Site
- Restoration of up to 456 ha of native vegetation communities as part of ecological mine rehabilitation.
- Retirement of the remaining credits through either payment into the Biodiversity Conservation Fund or purchase of available credits from the credit market.

Glossary

BAR	Biodiversity Assessment Report
BBAM	BioBanking Assessment Methodology
BBCC	BioBanking Credit Calculator
BC Act	NSW *Biodiversity Conservation Act 2016*
BOMPS	Mangoola Open Cut Biodiversity Offset Management Plan and Strategy
BOPC	Biodiversity Offsets Payment Calculator
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
CMA	Catchment Management Authority Area
DECC	NSW Department of Environment and Climate Change (now OEH)
Development Footprint	The total impact zone associated with the Mangoola Coal Continued Operations Project. The Proposed Disturbance Area is referred to throughout this report as the Development Footprint according to the FBA methodology.
DoEE	Commonwealth Department of the Environment and Energy
DNG	Derived Native Grasslands
Ecosystem credit	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a Development Footprint and the gain in biodiversity values at an offset site.
EEC	Endangered Ecological Community
EP	Endangered Population
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FBA	Framework for Biodiversity Assessment
GCAA	Glencore Coal Assets Australia
GDEs	Groundwater-dependent Ecosystem
Glencore	Glencore Coal Pty Limited. Mangoola Coal Operations Pty Limited is owned by Glencore Coal Pty Limited
GIS	Geographical Information System
IBRA	Interim Biogeographic Regionalisation for Australia (Version 7)
LGA	Local Government Area
Mangoola	Mangoola Coal Operations Pty Limited (Mangoola)
Mangoola Coal Mine	Existing approved operation as per Project Approval 06_0014
Mangoola Coal Operations Pty Limited (Mangoola)	Proponent

Mangoola Coal Continued Operations (MCCO) Project	The proposed development which is assessed in this BAR relating to the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations
MCCO Project Area	Includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area
MCCO Additional Project Area	Encompasses all areas required for the MCCO Project to the immediate north of the existing operation
MOP	Mining Operations Plan
MGA	Map Grid of Australia
Mtpa	Million tonnes per annum
MNES	Matters of National Environmental Significance
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
PMST	Protected Matters Search Tool
SAT	Spot Assessment Technique
SEARs	Secretary's Environment Assessment Requirements
Species credit	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Species Profile Database.
SPRAT	EPBC Threatened Species Profiles and Threats Database
Strahler Stream Order	Classification system that gives a waterway an 'order' according to the number of tributaries associated with it.
TEC	Threatened Ecological Community
TSC Act	NSW *Threatened Species Conservation Act 1995* (now repealed)
TSPD	Threatened Species Profile Database
UHSA	Upper Hunter Strategic Assessment
Umwelt	Umwelt (Australia) Pty Limited
VIS	Vegetation Information System

Disclaimer

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	Allison Riley	26/06/2019	Allison Riley	26/06/2019

Table of Contents

Figures

Plates

Tables

Appendices

Appendix A	Threatened Species Justification
Appendix B	Survey Methods
Appendix C	Expert Report
Appendix D	Development Footprint Plot and Transect Data and Species Lists
Appendix E	Biodiversity Credit Report
Appendix F	Aquatic Ecology Assessment Report
Appendix G	Mangoola Offset Site
Appendix H	Wybong Heights Offset Site

1 Introduction

Mangoola Coal Operations Pty Limited (Mangoola) engaged Umwelt (Australia) Pty Limited (Umwelt) to complete a Biodiversity Assessment Report (BAR) for the Mangoola Coal Continued Operations Project (MCCO Project). The purpose of the assessment was to identify and assess the impacts of the MCCO Project on biodiversity values in accordance with the Framework for Biodiversity Assessment (FBA) (OEH 2014b) and the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014a).

This BAR will form part of an Environmental Impact Statement (EIS) being prepared to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project. This BAR has been prepared for the MCCO Project under the provisions of Clause 27(2) of the *Biodiversity Conservation (Savings and Transitional) Regulation 2017*.

1.1 Project Overview

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer **Figure 1.1**). Mangoola has operated the Mangoola Coal Mine under Project Approval (PA) 06_0014 since mining commenced at the site in September 2010.

The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will extend the life of the existing operation providing for ongoing employment opportunities for the Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area as shown on **Figure 1.1**.

The MCCO Project generally comprises:

- open cut mining peaking at the same rate as that currently approved (13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal) using truck and excavator mining methods
- continued operations within the existing Mangoola Coal Mine
- mining operations in a new mining area located north of the existing Mangoola Coal Mine and Wybong Road, south of Ridgelands Road and east of the 500 kilovolt (kV) Electricity Transmission Line (ETL)
- construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the proposed Additional Mining Area
- establishment of an out-of-pit overburden emplacement area
- distribution of overburden between the proposed Additional Mining Area and the existing mine in order to optimise the final landform design of the integrated operation
- realignment of a portion of Wybong Post Office Road
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet

- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to that of the existing mine
- continued ability to discharge excess water in accordance with the Hunter River Salinity Trading Scheme (HRSTS)
- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of natural landform design principles consistent with the existing site
- rehabilitation of the proposed Additional Mining Area using the same revegetation techniques as at the existing mine
- a likely construction workforce of approximately 145 persons. No change to the existing approved operational workforce
- continued use of the mine access for the existing operational mine and access to/from Wybong Road, Wybong Post Office Road and Ridgelands Road to the MCCO Project Area for construction, emergency services, ongoing operational environmental monitoring and property maintenance.

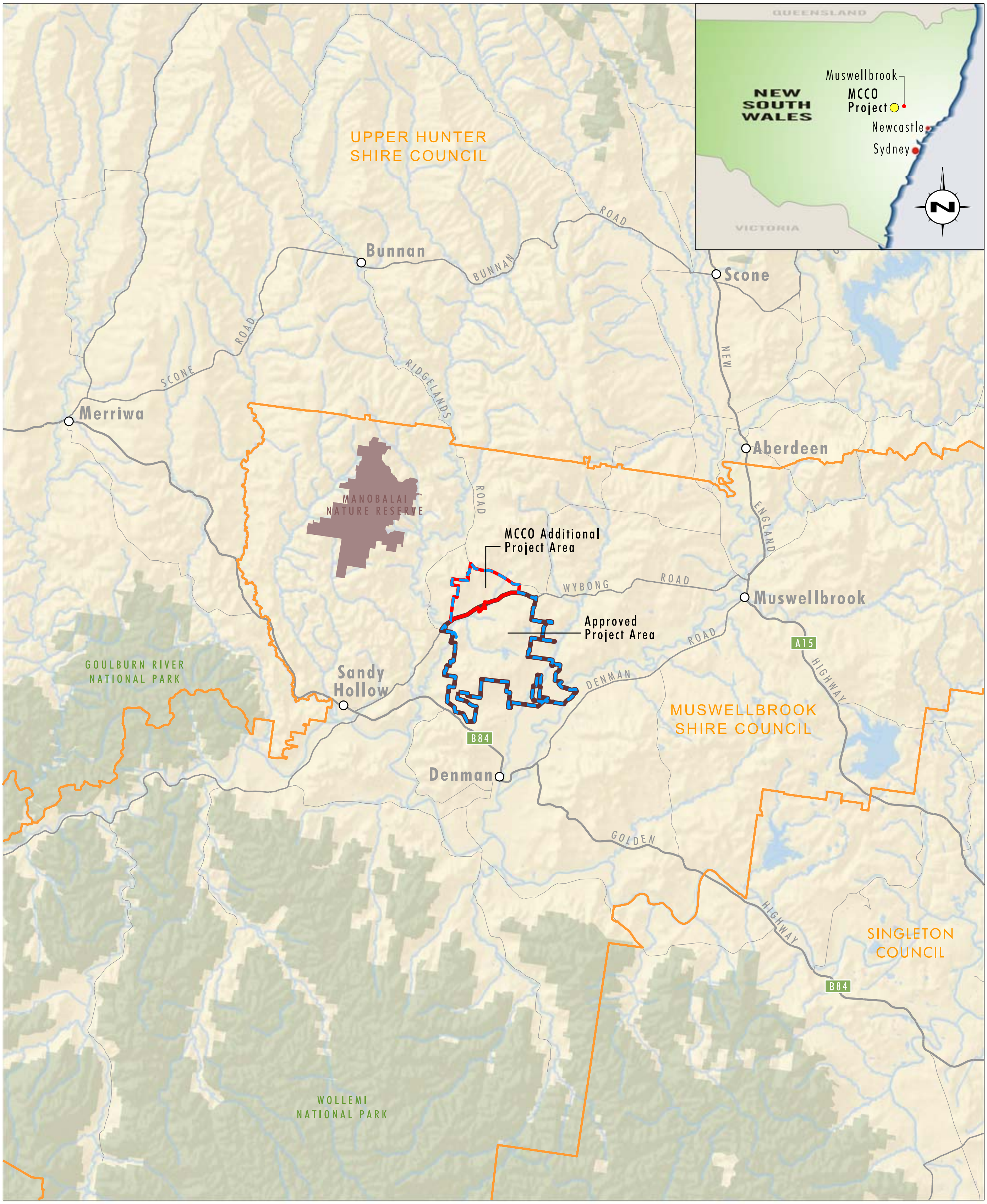
Figure 1.2 illustrates the key features of the MCCO Project.

1.2 Purpose and Scope of this Report

This report provides the findings of the Biodiversity Assessment of the MCCO Project. It addresses the specific requirements of the FBA (OEH 2014b).

Specifically, this assessment:

- describes the existing environment of the Development Footprint (refer to **Section 1.3**)
- identifies flora and fauna species and ecological communities within the Development Footprint that have the potential to be impacted by the MCCO Project
- determines the presence or likelihood of occurrence of threatened flora and fauna species and populations and Threatened Ecological Communities (TECs) listed under the *Biodiversity Conservation Act 1995* (BC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- calculates the offset requirements for ecosystem credits and species credits generated as a result of the permanent impacts of the MCCO Project in accordance with the FBA (OEH 2014b)
- provides an assessment of Matters of National Environmental Significance (MNES) under the EPBC Act, and
- describes the offset strategy to satisfy the credit requirements of the MCCO Project.



Data Source: Glencore (2018), LPI (2016)

Legend

- MCCO Project Area
- Approved Project Area
- MCCO Additional Project Area
- Local Government Area

FIGURE 1.1

Regional Locality Plan

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20181004 14.01

umwelt

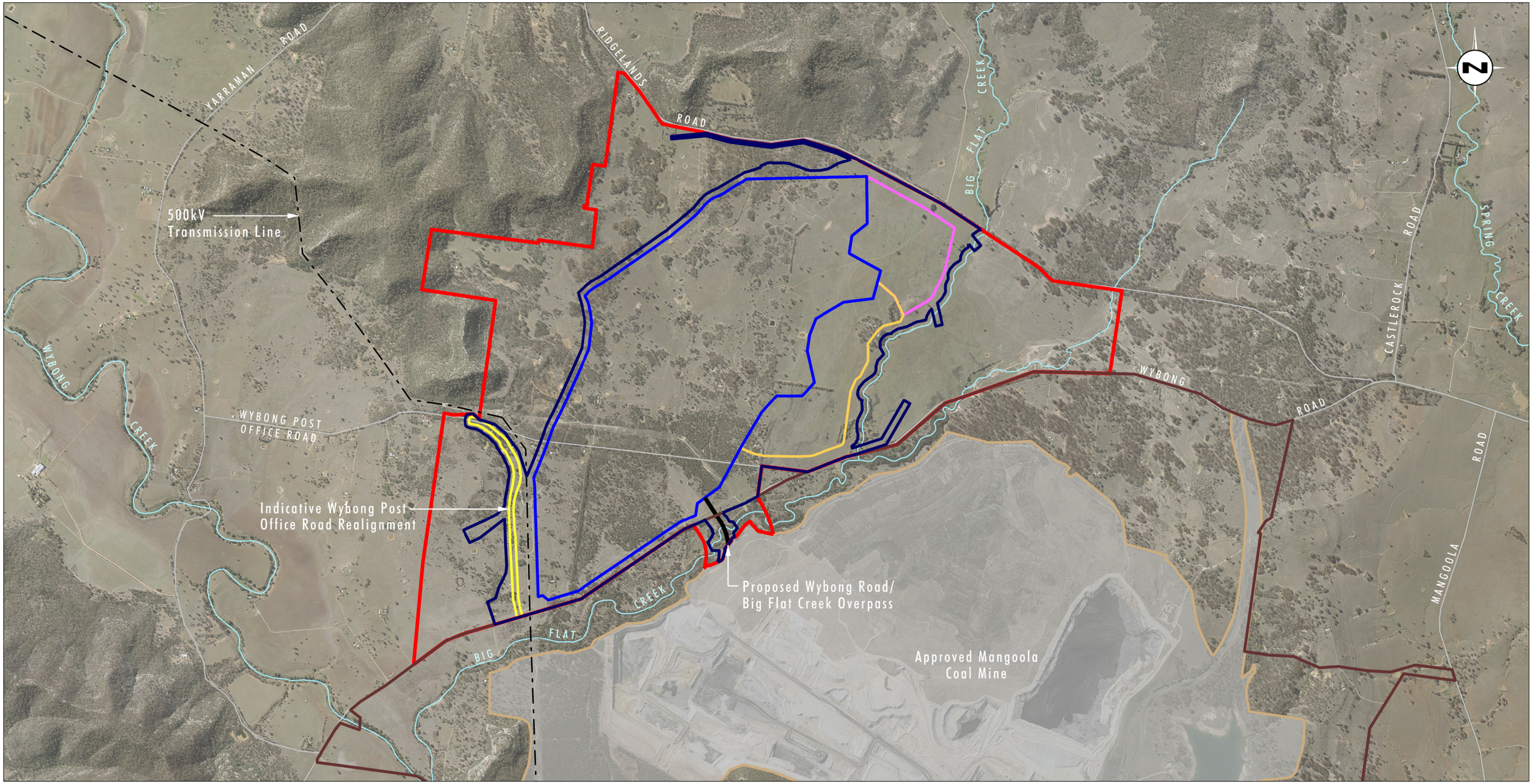

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

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Legend

- MCCO Additional Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- MCCO Proposed Additional Mining Area
- MCCO Proposed Emplacement Area
- MCCO Proposed Topsoil Stockpile Area
- Indicative Wybong Post Office Road Realignment

FIGURE 1.2

Mangoola Coal Continued Operations Project Development Footprint

File Name (A4): R12/3450_045.dgn
20190418 15.17

1.3 Development Footprint Information

The Development Footprint represents the maximum area of impact beyond the currently Approved Project Area of the existing Mangoola Coal Mine, as shown in **Figure 1.2**. The Development Footprint is also referred to as the Proposed Disturbance Area in the MCCO Project EIS, however, in this report Development Footprint is used to be consistent with FBA terminology.

The Development Footprint will be subjected to a range of disturbances as outlined in **Section 5.0**. The MCCO Additional Project Area (refer to **Figure 1.2**) was the subject of the ecological surveys to identify biodiversity values and to provide information to Mangoola to seek to minimise impacts by refining the Development Footprint. Following the completion of ecological surveys and the identification of significant biodiversity values, the Development Footprint has been refined to avoid some areas of key biodiversity value; particularly areas with threatened orchid species (refer to **Section 4.1**).

1.3.1 Location

The Development Footprint is situated approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer **Figure 1.1**) within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) bioregion and the Kerrabee IBRA subregion. Refer to **Figures 1.3** to **1.5** for the location of the Development Footprint and other relevant landscape features that pertain to this FBA assessment. Refer to **Table 1.1** for a summary of the Development Footprint's location in the landscape.

Table 1.1 Development Footprint Location in the Landscape

Mangoola Coal Continued Operations Project	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Kerrabee
Major Catchment Area	Hunter-Central Rivers
Mitchell Landscape	Central Hunter Foothills
LGA	Muswellbrook Shire Council

1.3.2 Size

The Development Footprint covers approximately 623.3 hectares (ha). For ease of reference, approximately 623 ha is used throughout much of this report.

1.3.3 Local and Regional Ecological Context

Much of the central Hunter Valley has been cleared of native vegetation, primarily for agriculture and other land uses, including mining and urban development. Similar land use patterns occur in the vicinity of the Mangoola Coal Mine and the Development Footprint, which is surrounded by agricultural land and several nearby coal mining operations. Extensive native vegetation is present to the west in Manobalai Nature Reserve, which represents a significant link between remnant patches of vegetation in the central Hunter Valley to the very large Wollemi National Park.

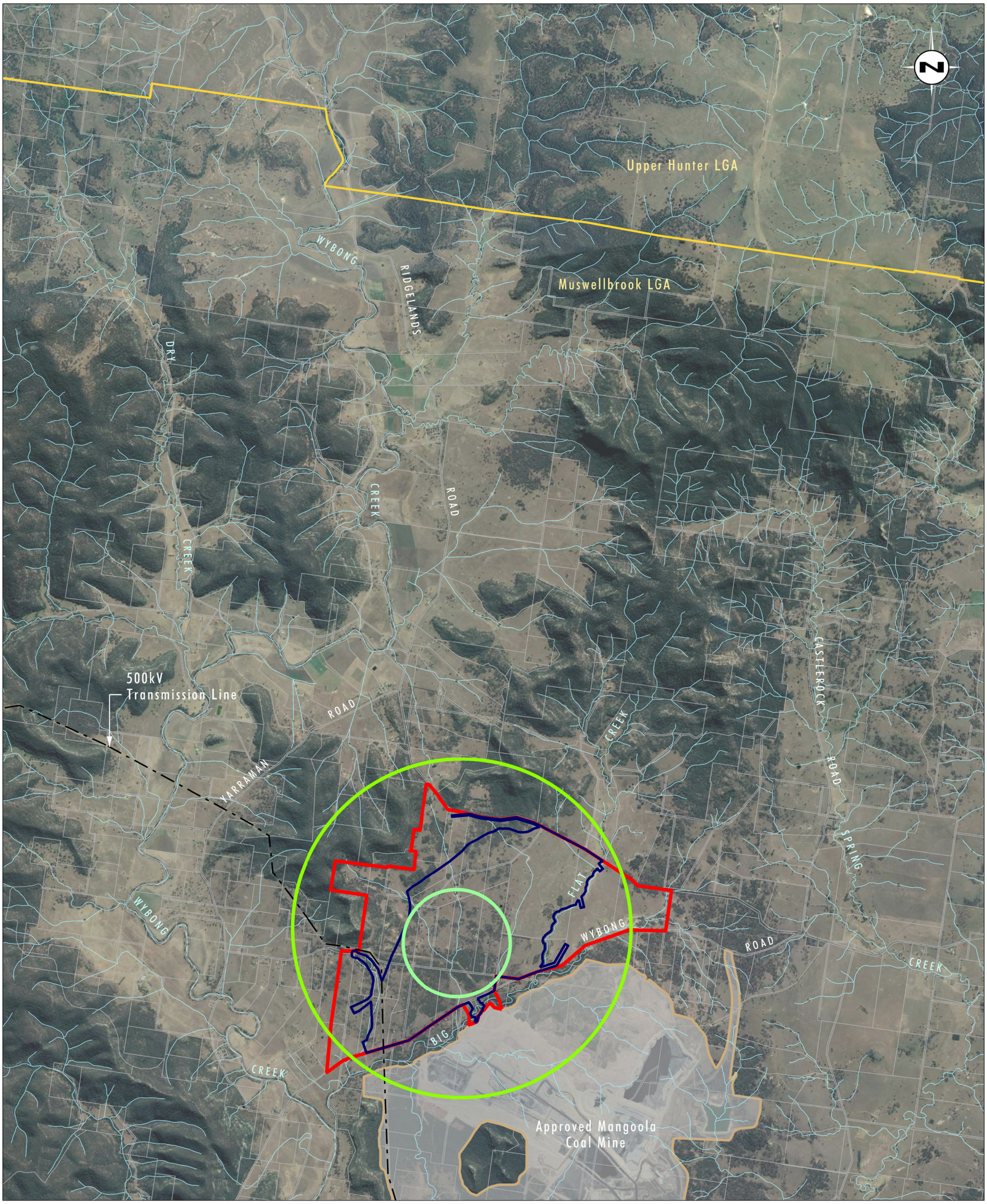

Image Source: Google Earth - Digital Globe (2018)
Data Source: Glencore (2018), LPI (2017)

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- 200 Hectare Assessment Circle
- 2000 Hectare Assessment Circle
- Local Government Area
- Drainage Line

FIGURE 1.3

Location Map
Local Government Areas

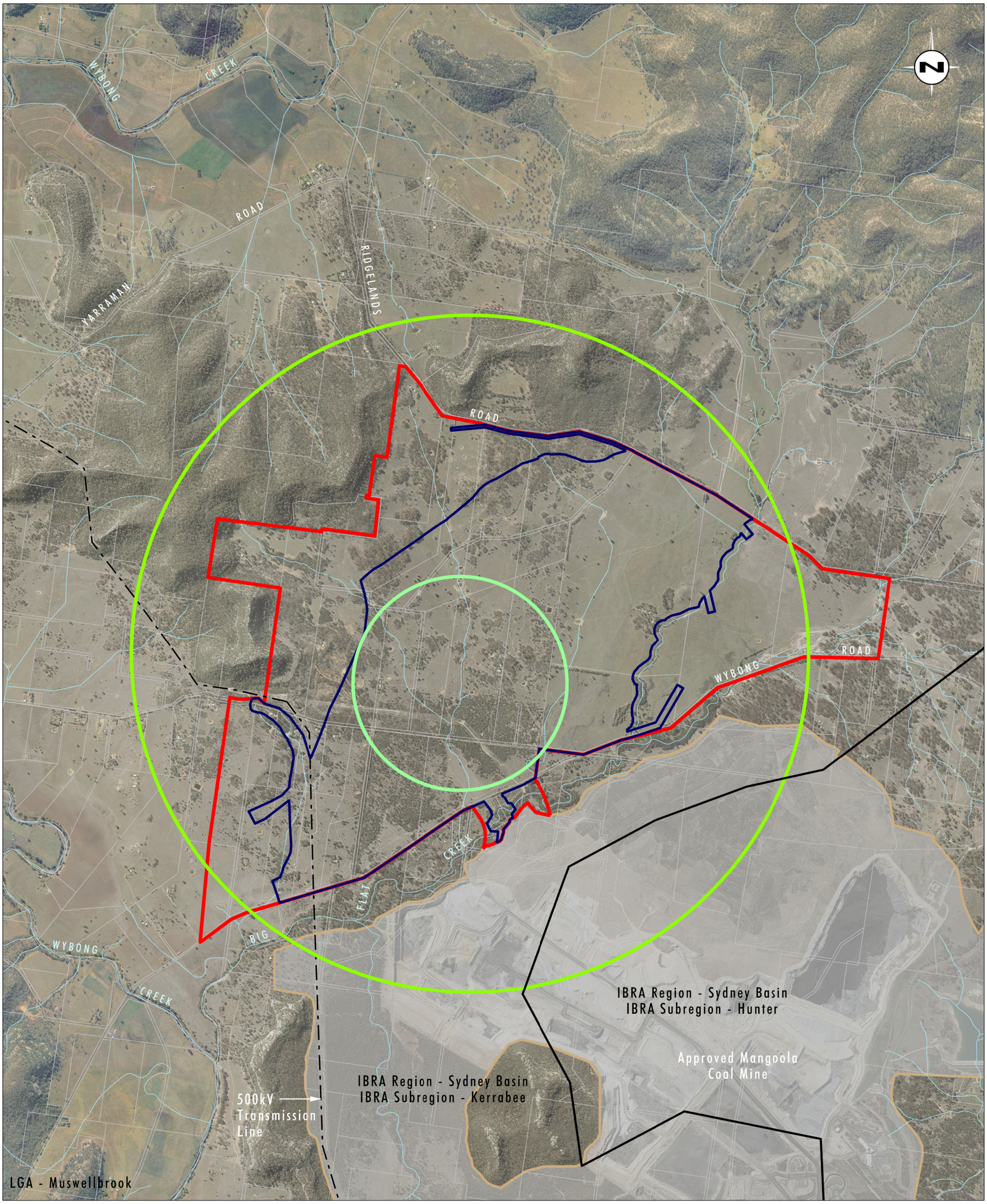

Image Source: Glencore (April 2018)
Data Source: Glencore (2018),
Australian Government Department of the Environment (2012)

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Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- 200 Hectare Assessment Circle
- 2000 Hectare Assessment Circle
- IBRA Subregions
- Drainage Line

FIGURE 1.4

Location Map
IBRA Regions/Subregions

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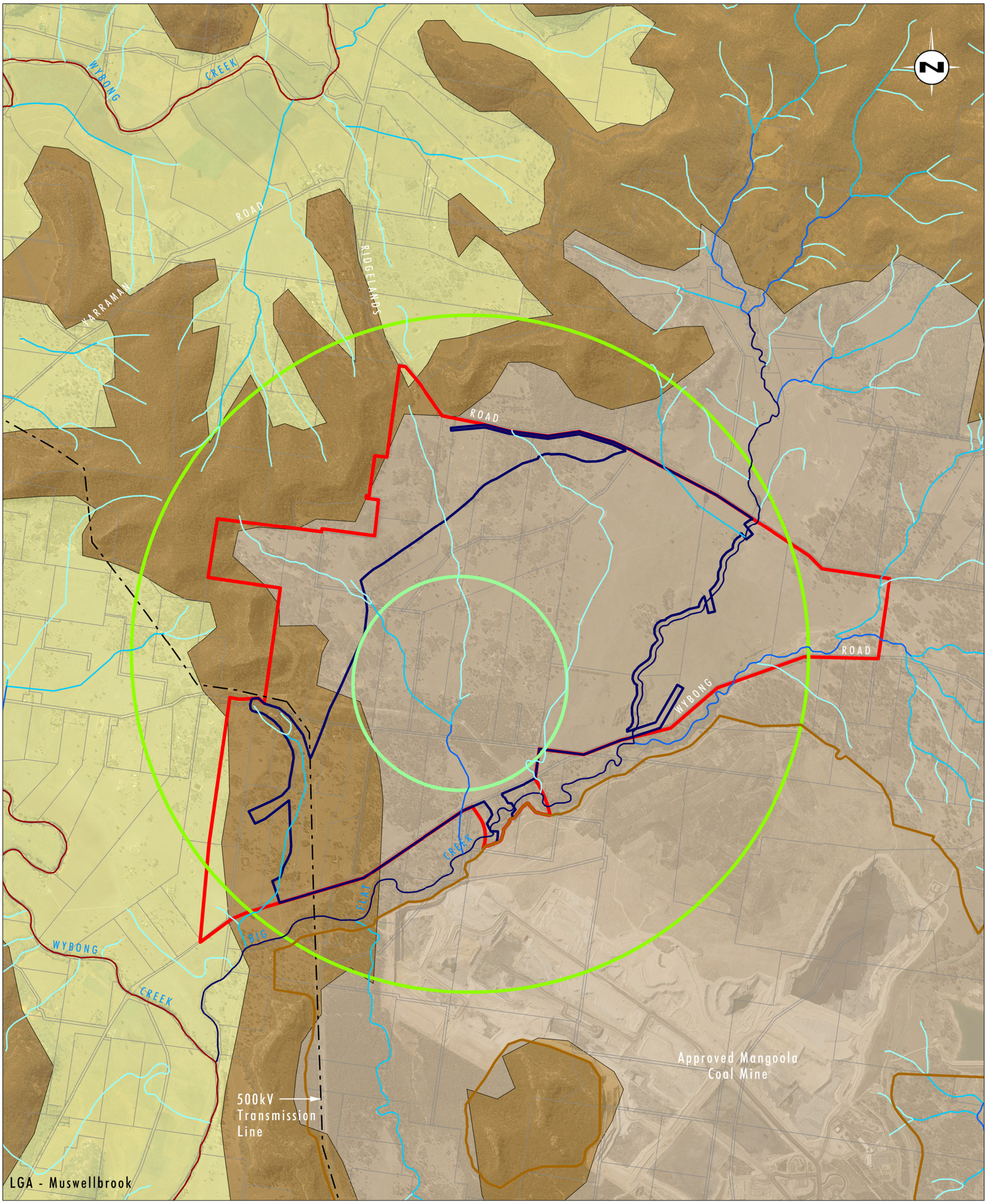

Image Source: Glencore (April 2018)
Data Source: Glencore (2018), Office of Environment and Heritage (OEH) (2017)

0 0.5 1.0 2.0km
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Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- 200 Hectare Assessment Circle
- 2000 Hectare Assessment Circle

Mitchell Landscapes:
- Central Hunter Foothills
- Lees Pinch Foothills
- Upper Hunter Channels and Floodplain

Stream Order:
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream
- 5th Order Stream
- 6th Order Stream

FIGURE 1.5

Location Map Landscape Features

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20190418 15.21

1.4 Key Resources, Policies and Documents

The following key resources, policies and documents were used during the preparation of this BAR for the MCCO Project:

- The Secretary's Environmental Assessment Requirements (SEARs) (DPE 2019)
- NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a)
- Framework for Biodiversity Assessment (OEH 2014b)
- Credit Calculator for Major Projects and BioBanking Operational Manual (OEH 2016a)
- BioBanking Assessment Methodology 2014 (OEH 2014c)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities –Working Draft (DEC 2004)
- BioBanking Credit Calculator (Major Project Assessment Type) (BBCC 2018), accessed November 2018
- BioNet Atlas of NSW Wildlife database and mapping tool (OEH 2018a), accessed November 2018
- OEH Threatened Species Profile Database (TSPD) (OEH 2018b), accessed archived datasets November 2018
- Vegetation Information System (VIS) Classification Database (OEH 2018c), accessed November 2018
- NSW Guide to Surveying Threatened Plants (OEH 2016b), and
- Department of the Environment and Energy (DoEE) Protected Matters Search Tool (DoEE 2018a), accessed November 2018a.

1.5 Use of Data from Upper Hunter Strategic Assessment

Umwelt was commissioned by Glencore in 2014 to undertake the flora and fauna surveys and prepare an ecological assessment as part of the Upper Hunter Strategic Assessment process which is a Strategic Assessment being undertaken as a joint initiative by the NSW and Commonwealth government. The resultant *UHSA – Mangoola Coal Biodiversity Certification Assessment Report* (Umwelt 2015) assessed areas that Mangoola had identified as potential areas for future mining activities. The Biodiversity Certification Assessment Report prepared for Mangoola was approved by OEH in 2015.

The MCCO Additional Project Area lies within the targeted UHSA survey area and, as a result of the extensive surveys completed for the Mangoola UHSA; this Ecological Study utilises the information from this approved assessment in relation to survey effort and identification of significant ecological features. Notwithstanding, this BAR has been prepared in accordance with the FBA with further extensive survey and addresses the SEARs issued in February 2019.

1.6 Report Preparation

This BAR was prepared by Shaun Corry (Principal Ecologist) and Brooke Weber (Ecologist), with review and technical direction from Allison Riley (NSW Ecology Manager). Field surveys have been completed by several Umwelt ecologists, primarily by Shaun Corry (Principal Ecologist), Ryan Parsons (Senior Ecologist – Botanist), Bill Wallach (Senior Ecologist), Brooke Weber (Ecologist), James Garnham (Ecologist) and Kate Riley (Ecologist). Allison Riley, Shaun Corry, Ryan Parsons and Bill Wallach are accredited under the BC Act as BioBanking Assessors and Biodiversity Assessment Method (BAM) Assessors. **Table 1.2** below outlines the details of the accredited BioBanking Assessors involved in the survey, calculations and reporting for the MCCO Project.

Table 1.2 Accredited BioBanking Assessors and their Role

Name	BioBanking Assessor ID	Role on MCCO Project
Allison Riley ***NSW Ecology Manager***	183	• Technical review and reporting
Shaun Corry ***Principal Ecologist***	238	• Field surveys and biometric data collection • Application of the BBCC • Report preparation
Ryan Parsons ***Principal Ecologist - Botanist***	113	• Field surveys and biometric data collection • Report Assistance
Bill Wallach ***Senior Ecologist***	230	• Field surveys and biometric data collection

1.6.1 Structure of the Report

The structure of the report is outlined below as per the requirements of Appendix 7 of the FBA (OEH 2014b):

- **Stage 1:**
  - Section 1 – provides the introduction to the report
  - Section 2 – outlines the methods used in the assessment
  - Section 3 - outlines the results of the field surveys and BioBanking credit calculator application
- **Stage 2:**
  - Section 4 – describes the avoidance measures implemented and minimisation of impacts as part of the MCCO Project
  - Section 5 – provides a summary of impacts in accordance with the FBA
  - Section 6 – summarises the credit requirements for the MCCO Project
- **Stage 3:**
  - Section 7 – outlines the Biodiversity Offset Strategy
- **Other sections:**
  - Section 8 – provides an assessment of MNES
  - Section 9 - provides a list of references used throughout the report and assessment.

2 Methods

The methods described herein reflect an assessment process that has spanned 5 years. At the time of preparation of this report, the MCCO Project could have formally been assessed under two different biodiversity assessment frameworks (FBA and BAM). In accordance with the transitional arrangements of the *Biodiversity Conservation (Savings and Transitional) Regulation 2017*, this assessment has been prepared in accordance with the FBA. As also noted above, the initial survey work for the Development Footprint was undertaken as part of the UHSA process. **Figure 2.1** documents the timeline and survey approach and highlights any change in the approvals pathway or timing of prominent MCCO Project deliverables and/or approvals.

OEH has previously reviewed and approved all pre-2016 ecological surveys and the results of that work as part of the *Upper Hunter Strategic Assessment – Mangoola Coal Biodiversity Certification Assessment Report* (Umwelt 2015). OEH reviewed the Mangoola Coal Biodiversity Certification Assessment Report and on 20 March 2015 provided written approval of the surveys and report confirming adequacy in accordance with the BioCertification methodology.

The MCCO Project is being assessed using the FBA and the methodologies discussed below are presented in accordance with that assessment framework. This assessment uses survey and results from the approved Mangoola UHSA report with further survey completed to reflect the refined MCCO Additional Project Area.

2.1 Landscape Features

2.1.1 Identifying Landscape Features

Landscape features within the Development Footprint and the inner and outer assessment circles were determined through reviewing aerial photography and relevant GIS layers. Landscape features that were reviewed included:

- IBRA bioregions and IBRA subregions
- Mitchell landscapes
- Rivers, streams and estuaries (using the Strahler (1952) ordering system)
- Wetlands
- Native vegetation extent, and
- State and/or Regional Biodiversity Links.

2.1.2 Determining Landscape Value

Determining the 'Landscape Value' of the Development Footprint is calculated by assessing the following:

- Per cent Native Vegetation Cover
- Connectivity Value, and
- Patch Size.

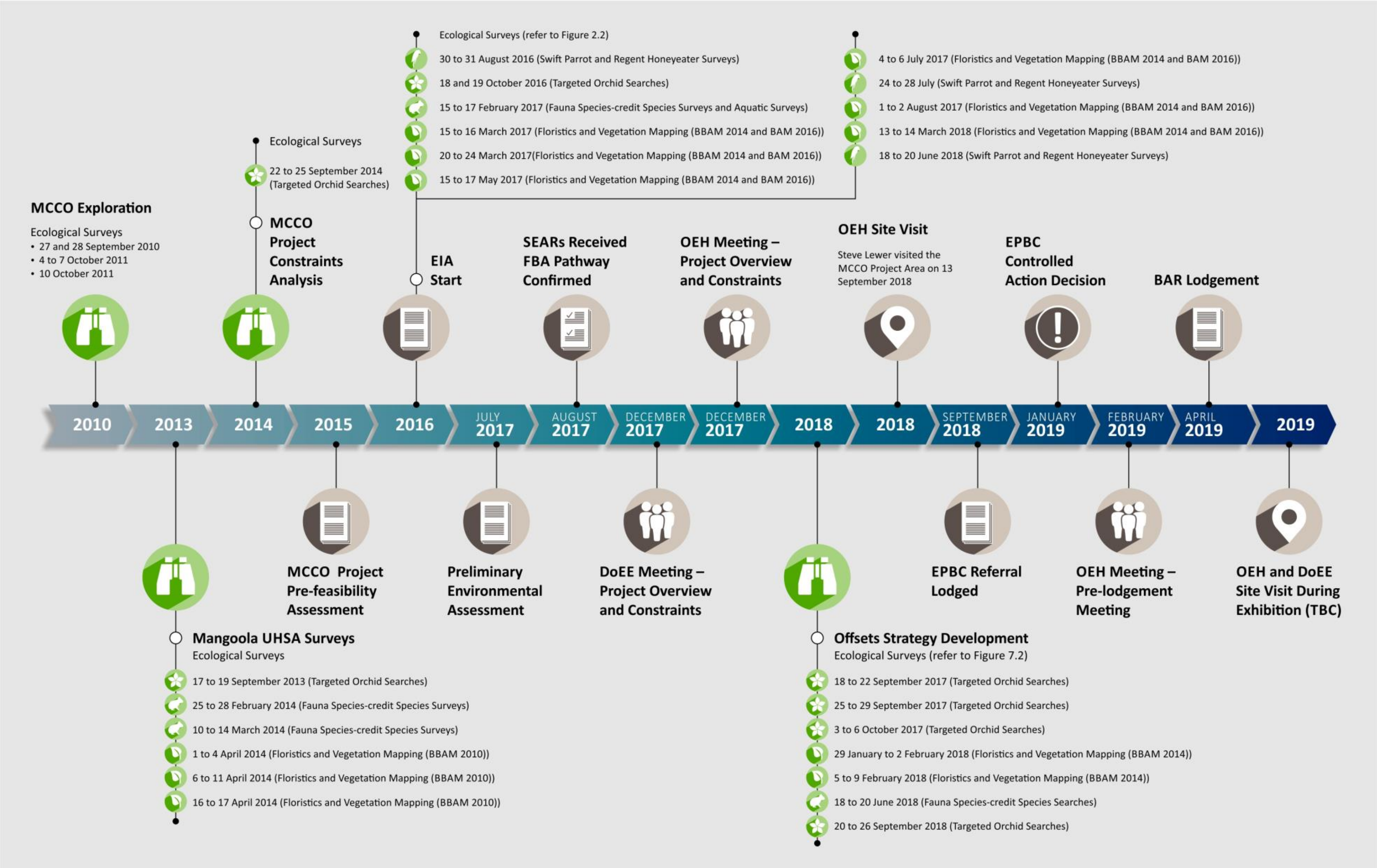

Figure 2.1 Project Timeline and Ecological Surveys and Assessment

2.2 Literature and Database Review

A review of previous documents and reports relevant to the MCCO Project was undertaken. This included regional and sub-regional vegetation mapping reports, annual monitoring reports, ecological surveys undertaken in the vicinity of the Development Footprint and also relevant ecological database searches. The information obtained was used to inform survey design, and was also used to assist in the assessment of potentially occurring ecosystem-credit and species-credit species, endangered populations (EPs) and TECs. Relevant documents included:

- Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor* and *Prasophyllum petilum*) : Expert Report Prepared for the Mangoola Coal Continued Operations Project (Bell 2018) (refer to **Section 2.5**)
- Surveys for the threatened *Diuris tricolor* and *Prasophyllum petilum* (Orchidaceae) on Glencore-owned, non-approved mining lands at Wybong, Upper Hunter Valley. April 2016. Eastcoast Flora Survey (Bell, 2016).
- Mangoola Coal Continued Operations Project EPBC Referral (Umwelt 2018)
- Mangoola Coal Continued Operations Project Preliminary Environmental Assessment (Umwelt 2017)
- Mangoola Coal Biodiversity Certification Assessment Report (Umwelt 2015)
- The Vegetation of the Central Hunter Valley, NSW (Peake 2006)
- Greater Hunter Native Vegetation Mapping (Sivertsen *et al*. 2011)
- Ecological Assessment Anvil Hill Project (Umwelt 2006)
- Ecological Assessment – Proposed Modification for Mangoola Coal Pipeline (Umwelt 2008)
- Ecological Assessment for Proposed Mine Plan Modification – Mangoola Coal (Umwelt 2010a)
- Ecological Assessment – Proposed Relocation of 500kV Electricity Transmission Line, Mangoola Coal (Umwelt 2010b)
- Ecological Assessment for Exploration Drilling Sites, Wybong NSW (Umwelt 2011a)
- Baseline Ecological Studies of Potential Biodiversity Offset Site – Wybong Heights, near Manobalai, NSW (Umwelt, 2011b)
- Baseline Ecological Studies of Potential Biodiversity Offset Site – Mangrove, Near Hollydeen, NSW (Umwelt 2012b)
- Ecology and Biology of Two Threatened Orchidaceae Prasophyllum sp. Wybong and Diuris tricolor for Conservation and Management (Vizer 2012)
- *Diuris tricolor* and *Prasophyllum* sp. Wybong at Mangoola Coal Literature Review (Vizer et al. 2012)
- Mangoola Coal Biodiversity Offset Management Plan (Umwelt 2014a)
- Mangoola Coal Mining Operations Plan 2016-2019
- Mangoola Coal Environmental Management Strategy (Mangoola 2014)
- Bionet Vegetation Classification Database (OEH 2018c), accessed November 2018

- OEH Online Search Tool (OEH 2018d) for known/predicted threatened communities in the Hunter IBRA subregion
- DoEE Protected Matters Search Tool for known/predicted EPBC Act-listed TECs, accessed November 2018.

2.3 Native Vegetation Assessment

2.3.1 Previous Floristic Survey Effort in the MCCO Additional Project Area

A wide range of field surveys have been completed within the broader Mangoola Coal land holding and specifically within portions of the Development Footprint as part of previous assessments including the Anvil Hill Project (Umwelt 2006) and the Mangoola Coal Biodiversity Certification Assessment prepared for the UHSA (Umwelt 2015).

Anvil Hill Project

Flora field surveys were carried out across 4,142 ha as part of the Ecological Assessment for the Anvil Hill Project (Umwelt 2006).

The flora surveys were undertaken between 2 September 1999 and 17 July 2001; 19 February and 16 May 2002; and between 23 March 2004 and 24 May 2005, during the following months and seasons:

- summer (December, February)
- autumn (March, April, May)
- winter (June, July), and
- spring (September, October).

The flora survey program included extensive plot-based sampling of 20 x 20 metre plots at 141 sites, and 73 km of targeted threatened flora walking transects (Umwelt 2006).

Mangoola Upper Hunter Strategic Assessment

A total of 60 plot/transects were undertaken in the Mangoola UHSA (within and adjacent to the Development Footprint), were undertaken over the following periods:

- 1 to 4 April 2014
- 6 to 11 April 2014, and
- 16 to 17 April 2014.

At each plot/transect data was recorded according to Appendix 2 of the BioBanking Assessment Methodology and Credit Calculator Operational Manual (DECC 2009). This involved setting out nested 20 x 50 metre and 20 x 20 metre plots and a 50 metre transect. Each plot was positioned at a standardised bearing (north/south and east/west, with the longer side running north/south) and the location marked from the north-east corner with a handheld GPS.

A total of 34 qualitative rapid assessments were completed across the Development Footprint. Each comprised the recording of the dominant canopy and understorey species as well as notes on the condition of the understorey in the area around the qualitative rapid assessment site.

2.3.2 Digital Aerial Photograph Interpretation

Digital imagery (aerial photographs) of the Development Footprint was viewed prior to and after vegetation survey to identify spatial patterns in vegetation, land use and landscape features. This informed field survey design and implementation, ecological assessment and vegetation community mapping of the Development Footprint.

Vegetation communities in the Development Footprint were mapped on-screen overlaying the April 2018 high resolution aerial photographs provided by Mangoola. Mapping was undertaken using the Manifold System 8.0 Enterprise Edition GIS and ESRI ArcMap 10.6. Generally the minimum mapping unit for a vegetation zone was 0.1 ha.

2.3.3 Systematic Plot/Transect Surveys

A total of 57 floristic plots and 34 rapid assessments were conducted across the MCCO Additional Project Area during the surveys undertaken for this assessment (refer to **Figure 2.2**). Of these plots and rapid assessments, 43 plots and 28 rapid assessments were conducted within the Development Footprint and were used to inform the BBCC assessment of the Development Footprint.

These surveys were undertaken over 10 separate survey periods in order to accurately sample the vegetation communities and potentially occurring threatened flora species within the Development Footprint (refer to **Figure 2.2** and **Figure 2.3**).

Floristic plot data within the Development Footprint was collected in accordance with minimum requirements under the FBA (OEH 2014a). In addition to the plot based survey work completed for the MCCO Project, extensive floristic surveys of the Mangoola area have been undertaken since 2001.

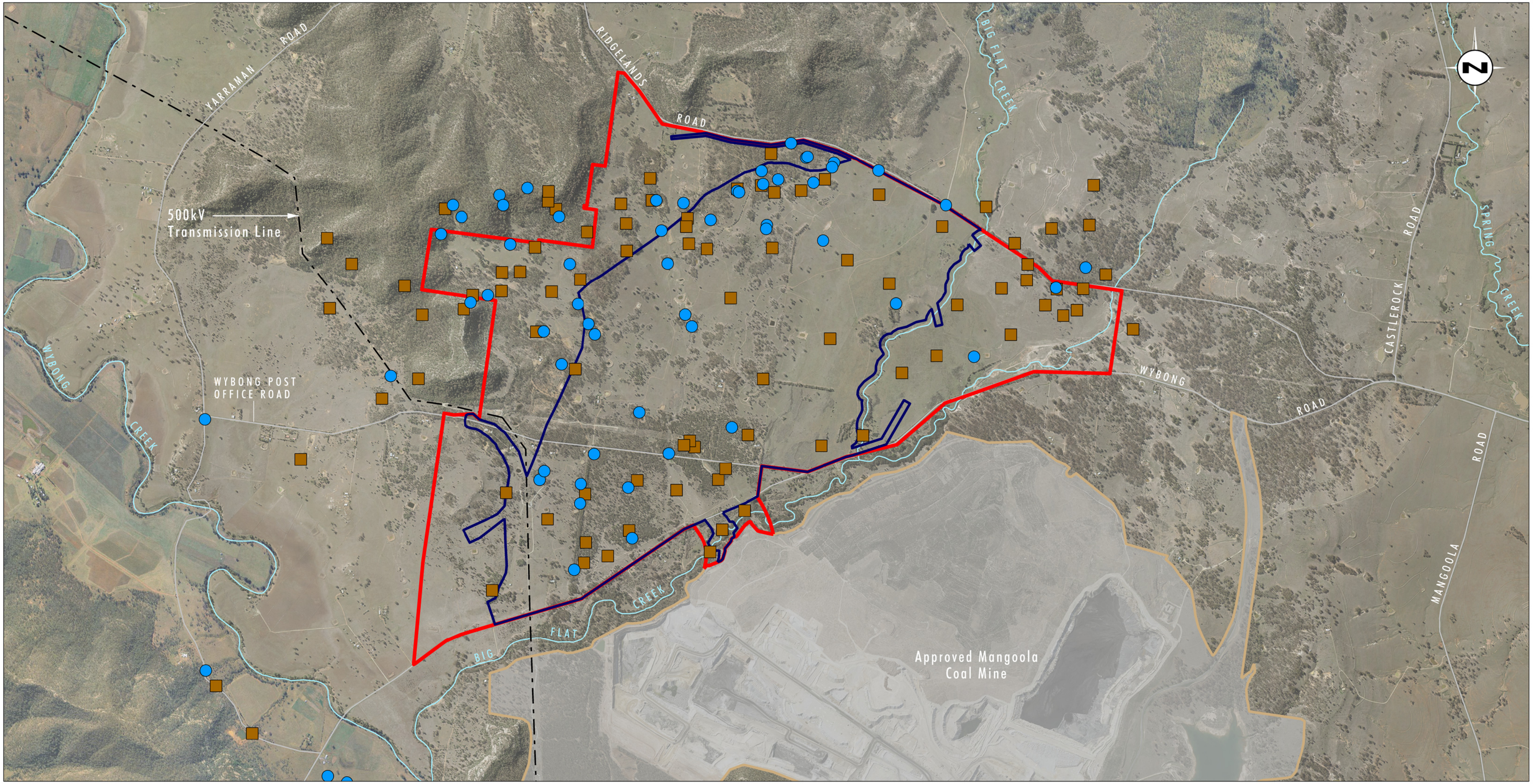

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

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1:40 000

Legend
- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Flora Plots/Transect
- Semi-quantitative Rapid Sampling Plot

FIGURE 2.2

Floristic Sampling Effort

File Name (A4): R12/3450_049.dgn
20190418 15.22

2.3.3.1 Plot/Transect Selection and Stratification of the Development Footprint

Designing an appropriate survey requires consideration of both survey methods and effort. Reference was made to the VIS Classification Database to identify Plant Community Types (PCTs), as well as reviews of other regional and local vegetation mapping and reporting (refer to **Section 2.3.1**) when designing the field survey. The PCTs were further stratified into Vegetation Zones (condition states) in accordance with the FBA (OEH 2014b) following previous field surveys of the site to determine the appropriate number of transect/plots required.

Table 2.1 below outlines the adequacy of the plot/transect flora survey with respect to the FBA Methodology (OEH 2014b) pertinent to the Development Footprint.

Table 2.1 Adequacy of Vegetation Survey in the Development Footprint

Biometric Vegetation Type (BVT)	Plant Community Type (PCT)	Area in the Development Footprint (ha)*	Number of Floristic Plots/Transects	
			Required	Completed
HU812	1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter	29.91	6	8
HU816	1602 Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter	6.3	3	3
HU817	1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter	492.74	16	19
HU821	1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter	6.46	3	3
HU906	1692 Bull Oak Grassy Woodland of the Central Hunter Valley	32.4	5	6
HU945	1731 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	2.95	3	4

*TheDevelopment Footprint is approximately 623 ha in area whereas the total area of native vegetation within the Development Footprint is approximately 570 ha. The difference of 53 ha is made up of non-native vegetation, cleared areas, roads, dams and residences.

2.3.3.2 Plot/Transect Data Collected

At each plot/transect data was recorded according to Section 5 of the FBA (OEH 2014b). At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to search the tree canopy and tree trunks for mistletoes, vines and epiphytes.

Additional details were also recorded in each quadrat, including soil texture, drainage and depth; site disturbances; physiography (position in the landscape); and vegetation structure (strata percentage covers, heights and dominant species). Photographic records were also taken at each site.

2.3.4 Qualitative Rapid Sampling

Qualitative rapid assessments were also completed during the surveys to assist with mapping areas added to the MCCO Project (refer to **Figure 2.2**). Each comprised the recording of the dominant canopy and understorey species. The qualitative rapid assessments utilised a qualitative sampling approach, as this method was designed to allow rapid collection of non-quantitative species dominance data across the Development Footprint. The data from the qualitative rapid assessments was primarily used to provide assistance in the delineation and refinement of vegetation mapping.

2.3.5 Meandering Transects

Meandering transects were walked through vegetation units across much of the Development Footprint (refer to **Figure 2.3**). Opportunistic sampling of vegetation was undertaken along these transects, particularly searches for threatened and otherwise significant species, EPs and TECs. Meandering transects enable floristic sampling across a much larger area than plot-based survey. Records along transects supplemented floristic sampling carried out in plots, however, the data collected are in the form of presence records, rather than semi-quantitative cover abundance scores.

Meandering transects provided invaluable information on spatial patterns of vegetation that informed vegetation community mapping of the Development Footprint.

2.3.6 Vegetation Mapping

Vegetation mapping was undertaken using best-practice techniques to delineate vegetation communities across the Development Footprint (refer to **Figure 2.4**). Vegetation mapping involved the following key steps:

- preliminary review of aerial photography to explore vegetation distribution patterns as dictated by change in canopy texture, tone and colour, as well as topography
- predicting the distribution of particular vegetation communities based on understanding the distribution of Biometric vegetation types (OEH 2018c) and using existing vegetation mapping completed as part of the Mangoola UHSA (Umwelt 2015)
- preparation of a draft vegetation community map based on interpretation of aerial photography and preliminary delineation of vegetation community floristics
- ground-truthing of the vegetation map based on survey effort documented in **Section 2.3.3** to **2.3.5.**
- revision of vegetation community floristic delineations based on plot data, and
- revision of the vegetation map based on ground-truthing.

Vegetation communities were delineated through the identification of repeating patterns of plant species assemblages in each of the identified strata. Communities were named in accordance with their site character, with consideration of the naming conventions of those vegetation communities identified by the VIS Classification Database (OEH 2018bc).

2.3.7 Threatened Ecological Community Delineation Techniques

Vegetation communities identified in the Development Footprint were compared to TECs listed under the Commonwealth EPBC Act and NSW BC Act and an assessment of similarity with the NSW Threatened Species Scientific Committee Final Determinations and the Commonwealth Threatened Species Scientific Committee Listing and Conservation Advice. The following approach was used:

- full-floristic quadrat assessment, rapid assessments and meandering survey to determine floristic composition and structure of each ecological community (including specific 20 x 50m plot sampling for White box – Yellow box – Blakelys Red Gum Grassy Woodland and Derived Native Grasslands CEEC)
- comparison with published species lists, including lists of 'important species' as identified on the listing advice provided by the NSW Threatened Species Scientific Committee and/or Commonwealth Threatened Species Scientific Committee
- comparison with habitat descriptions and distributions for listed TECs
- assessment using guidelines and recovery plans published by the Commonwealth DoEE and NSW OEH
- assessment against diagnostic and condition criteria, where relevant, and
- comparison with other assessments of TECs in the region.

2.3.8 Biometric Vegetation Type (BVT)/Plant Community Type (PCT) Allocation

Each of the vegetation communities described within the Development Footprint was aligned with an equivalent BVT/PCT as detailed in the Bionet Vegetation Classification Database (OEH 2018bc). For each vegetation community described in the Development Footprint, the dominant and characteristic species were entered into the online plant community identification tab and an initial list of BVTs/PCTs was generated. The profiles for each of the possible BVTs/PCTs were then interrogated and the most appropriate match assigned based on floristic, structural, soil, landform and distribution details.

Further detail regarding this allocation for individual BVTs/PCTs is outlined in **Section 3.2.1** and Umwelt's internal process regarding vegetation community mapping, PCT allocation and TEC delineation is shown on **Figure 2.4**.

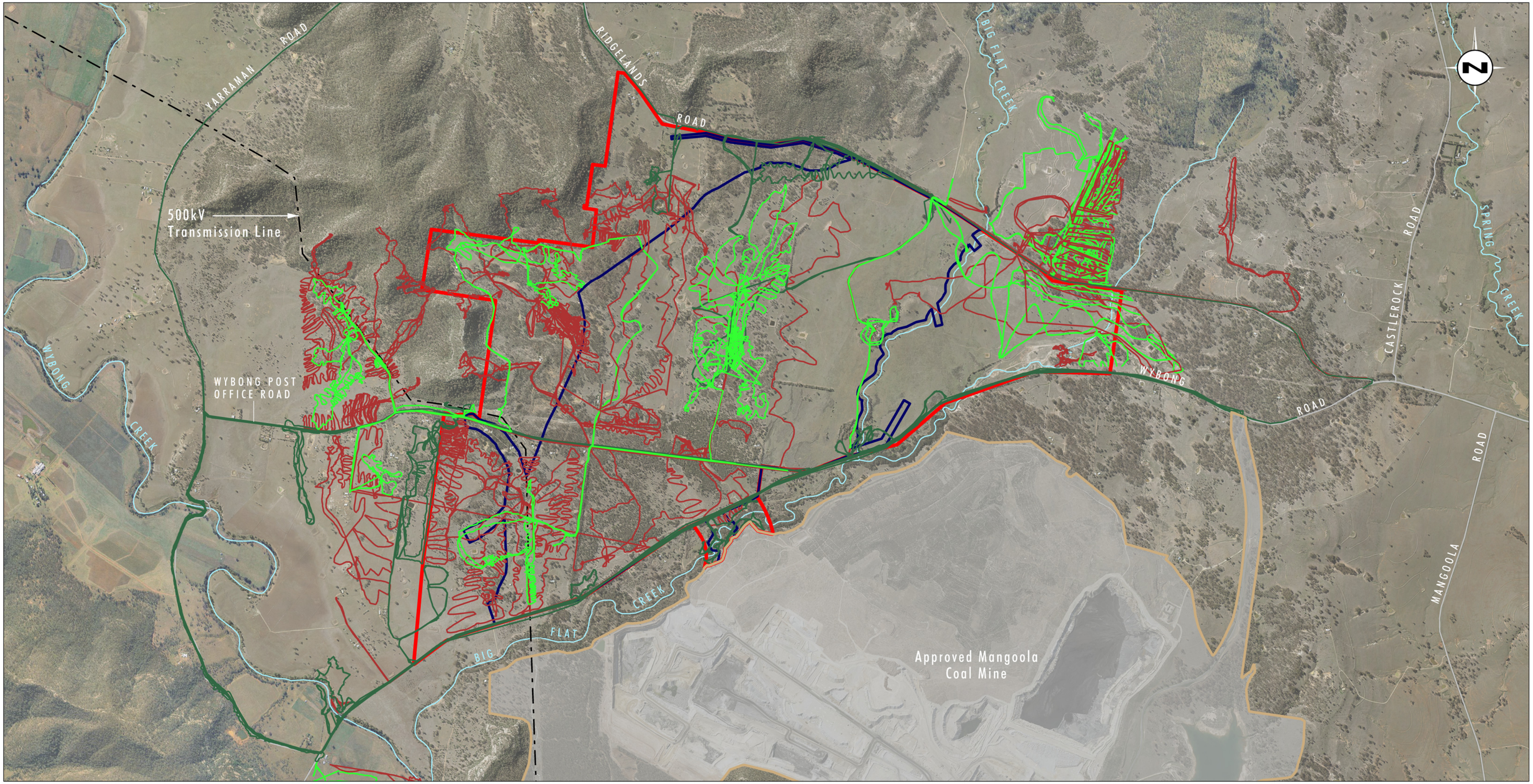

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

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1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Spring 2013 Targeted Searches
- Spring 2014 Targeted Searches
- Spring 2016 Targeted Searches

FIGURE 2.3

Targeted Species-credit Flora Transect Locations

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20190418 15.43

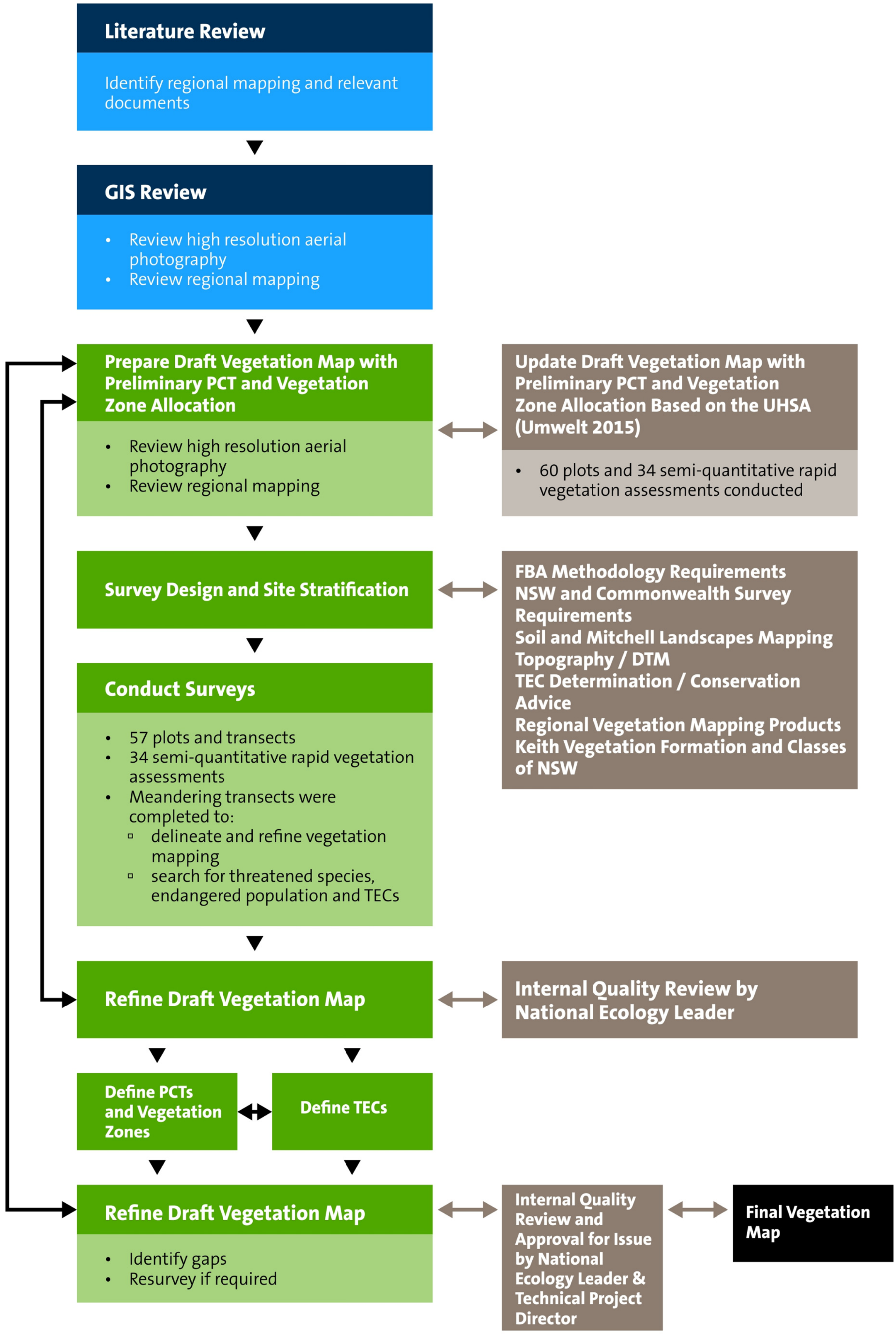

FIGURE 2.4

Vegetation Mapping and PCT Identification Process

2.4 Threatened Species Assessment

Following the literature review (refer to **Section 2.2**), a preliminary assessment using the TSPD was undertaken which provided a list of species-credit species requiring survey and the suitable survey periods for each species. The results of these database searches, literature review and TSPD review were used to design the survey requirements for species-credit species to ensure adequate surveys were undertaken as part of the FBA.

The *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DEC 2004) and Commonwealth Threatened Species Survey and Assessment Guidelines were considered when undertaking the threatened species surveys in the Development Footprint. Targeted threatened species searches undertaken beyond 2016 have also considered the *NSW Guide to Surveying Threatened Plants* (OEH 2016b).

2.4.1 Species-credit Flora Surveys

A preliminary list of threatened flora species with potential to occur in the MCCO Additional Project Area was generated during the literature review, completion of database searches and preliminary assessment using the Biodiversity Certification Credit Calculator (BBCC). The preliminary list of potentially occurring species-credit species was reviewed to remove species that did not require further assessment in the Development Footprint. Species not requiring further assessment include:

- species for which there is no suitable or poor quality habitat in the Development Footprint
- species only predicted to occur in the CMA subregion
- where an expert report states the species is unlikely to be present
- species which are vagrant species and unlikely to utilise habitat in the Development Footprint, and
- where the records of the species presence are old or have doubtful authenticity.

Appendix A outlines the species-credit species identified in the literature review that were not considered likely to occur due to lack of suitable habitat and/or absence of local records and therefore did not warrant further assessment as per Section 6.5.1.6 of the FBA (OEH 2014b). **Table 2.2** below documents the flora species-credits species specifically considered for the MCCO Project and **Figure 2.3** identifies the targeted species-credit survey locations. These species are known to occur in the local area, including the Mangoola land holdings, or could potentially occur due to the identification of potential habitat.

Table 2.2 Species-credit Flora Species Requiring Targeted Survey

Common Name *Scientific Name*	BC Act Status	EPBC Act Status	Source	Required Survey Period	Survey Technique, Timing and Location
pine donkey orchid *Diuris tricolor*	V	-	1, 2, 3	September - October	Targeted threatened orchid searches and walking transects have been undertaken by Umwelt within the Development Footprint and the wider Mangoola land holdings. Surveys have been completed in suitable habitat during September/October 2010, 2011, 2013, 2014, 2016, 2017 and 2018. Opportunistic observations undertaken throughout all Umwelt survey periods.
Tarengo leek orchid *Prasophyllum petilum*	E	CE (sp. Wybong)	1, 2, 3	September - October	Targeted threatened orchid searches and walking transects have been undertaken by Umwelt within the Development Footprint and the wider Mangoola land holding. Surveys have been completed in suitable habitat during September/October 2010, 2011, 2013, 2014, 2016, 2017 and 2018. Opportunistic observations undertaken throughout all Umwelt survey periods.
Commersonia rosea	E	E	1,2	All year	Targeted threatened flora searches and opportunistic observations were completed in suitable habitat throughout all Umwelt survey periods.
scant pomaderris *Pomaderris queenslandica*	E	-	1	All year	Targeted threatened flora searches and opportunistic observations were completed in suitable habitat throughout all Umwelt survey periods.
Denman pomaderris *Pomaderris reperta*	CE	CE	1	All year	Targeted threatened flora searches and opportunistic observations were completed in suitable habitat throughout all Umwelt survey periods.
Ozothamnus tesselatus	V	V	1	All year	Targeted threatened flora searches and opportunistic observations were completed in suitable habitat throughout all Umwelt survey periods.

Note: 1 = BioBanking Credit Calculator 2 = Bionet Atlas of NSW Wildlife 3 = Protected Matters Search Tool

Targeted surveys and transects for cryptic and seasonal species-credit flora species that are identifiable in September/October have been conducted across the Development Footprint and wider Mangoola land holdings over numerous years and seasons. The surveys within the Development Footprint were primarily undertaken between 2013 and 2016 which represented the best flowering years in the last eight years of monitoring (refer to **Figure 2.3**). In comparison, the surveys of the proposed offset areas were undertaken in 2017 and 2018 which represent the worst years for flowering in the last eight years. Specific searches for pine donkey orchid (*Diuris tricolor*) and Tarengo leek orchid (*Prasophyllum petilum*) have been undertaken across the Development Footprint (or parts thereof) over consecutive years (excluding 2012) from 2010 to 2018. Specifically, surveys were undertaken on the following dates:

- 27 and 28 September 2010
- 4 to 7 October 2011
- 10 October 2011
- 17 to 19 September 2013
- 22 to 25 September 2014
- 23 September to 9 October 2015
- 18 and 19 October 2016
- 18 to 22 September 2017
- 25 to 29 September 2017
- 3 to 6 October 2017
- 20 to 21 September 2018
- 24 to 26 September 2018.

Prior to the detailed surveys in the date periods listed above, known sites containing the orchids were used to gauge the most appropriate period, with the survey teams mobilising at the most suitable time.

The surveys listed above also included opportunistic observations of other threatened flora and species-credit flora surveys, where appropriate, and considered the following survey guidelines:

- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* – Working Draft (DEC 2004)
- Draft Survey Guidelines for Australia's Threatened Orchids (DoE 2013), and
- *NSW Guide to Surveying Threatened Plants* (OEH 2016b).

In addition to the above, targeted flora species-credit species and other opportunistic flora surveys have been undertaken across the MCCO Additional Project Area on the following occasions:

- 1 to 4 April 2014
- 6 to 11 April 2014
- 16 to 17 April 2014
- 15 to 17 February 2017

- 15 to 16 March 2017
- 20 to 24 March 2017
- 15 to 17 May 2017
- 4 to 6 July 2017
- 1 to 2 August 2017
- 9 February 2018
- 13 to 14 March 2018.

Although the intent of many of these surveys wasn't solely the identification of threatened flora species, many threatened flora species have been identified during the process and importantly these surveys have refined the knowledge of the ecological characteristics of the wider Mangoola area and assisted in defining habitat availability for threatened flora species within the Development Footprint for the MCCO Project.

2.4.2 Species-credit Fauna Surveys

A preliminary list of species-credit fauna species with potential to occur in the Development Footprint was generated during the literature review, completion of database searches and review of the TSPD. Searches of the TSPD were undertaken by the Hunter IBRA subregion and Hunter CMA region.

Species-credit fauna surveys were undertaken over several survey periods, being:

- 10 – 14 March 2014
- June, July or August of 2009 to 2018 at monitoring points surrounding the Development Footprint and 2016, 2017 and 2018 within the Development Footprint
- 15 to 17 February 2017.

Table 2.3 identifies the species-credit fauna species that were determined to potentially occur in the Development Footprint and therefore require targeted surveys and further assessment. **Appendix A** outlines the species-credit species identified in the literature review that were not considered likely to occur due to lack of suitable habitat and/or absence of local records and therefore did not warrant further assessment as per Section 6.5.1.6 of the FBA (OEH 2014b).

Targeted surveys were undertaken for the species listed in **Table 2.3** and included targeted on-ground searches in suitable habitat throughout the Development Footprint (refer to **Figure 2.5**). Surveys completed include bird and herpetological searches, remote cameras, spotlighting and call playback, Anabat echolocation surveys, State Environmental Planning Policy (SEPP) 44 - Koala Habitat Protection assessments, species-credit species habitat assessment and opportunistic observation. These methods are described in **Appendix B**.

Table 2.3 identifies the months that surveys are required according to the FBA Calculator and the TSPD. Where this is unavailable, the relevant detection periods were sought from online species profiles (OEH or Commonwealth SPRAT). The source of the threatened species/potential habitat record is also provided and was based on the outcome of the literature review described in **Section 2.2**. Sources include:

1 = BioBanking Credit Calculator (BBCC)

2 = Bionet Atlas of NSW Wildlife

3 = Protected Matters Search Tool.

2.5 Expert Report

Mangoola engaged the preparation of an expert study into the availability of suitable *Prasophyllum petilum* and *Diuris tricolor* habitat within the proposed offset areas as part of the Biodiversity Assessment for the MCCO Project. Dr Stephen Bell was approved by OEH as an expert in accordance with the requirements of the BC Act and was subsequently commissioned by Mangoola to prepare the Expert Report to determine the likely *Prasophyllum petilum* and *Diuris tricolor* population size in the proposed MCCO biodiversity offset areas.

Although the purpose of the Expert Report was prepared to define that habitat availability within the proposed offset areas, the report uses abundance data from the Development Footprint and the wider Mangoola land holdings to develop the metrics to define that habitat. These metrics have been utilised, where required, to supplement the quantification of impacts in the Development Footprint. This is further discussed in **Section 3.3.2** and **Section 7.6** and the Expert Report is provided in **Appendix C.**

Table 2.3 Species-credit Fauna Species Requiring Targeted Survey

Common Name *Scientific Name*	BC Act Listing Status	EPBC Act Listing Status	Source	Required Survey Period	Survey Technique, Timing and Location
brush-tailed phascogale ***Phascogale tapoatafa***	V	-	2	All year	Targeted remote camera surveys were undertaken at 20 locations across the wider Mangoola area with 9 cameras located in the MCCO Additional Project Area in March 2014. Cameras were set at each site for between three and four 24 hour periods. Spotlighting surveys were also undertaken across the MCCO Additional Project Area in February 2017 Opportunistic observations were recorded during all other aspects of the field survey.
koala ***Phascolarctos cinereus***	V	V	1,3	All year	Targeted surveys for signs of the presence of koalas were undertaken at 20 locations across the Development Footprint in March 2014 using the Spot Assessment Technique (SAT) and spotlighting. Searches were undertaken on and around the base of 30 trees at each survey site. Additional SAT searches and koala call playback was undertaken in February 2017. The searches focused on signs of presence including scats at the base of trees and characteristic scratches on tree trunks. Opportunistic observations were recorded during all other aspects of the field survey.
regent honeyeater ***Anthochaera phrygia***	CE	CE	1, 3	All year	Winter bird surveys targeting this species were undertaken by two ecologists during June, July or August in 2010, 2011, 2012, 2013, 2014, 2016, 2017 and 2018 comprising more than 150 person hours of survey across the Development Footprint. Opportunistic observations were recorded during all other aspects of the field survey.
southern myotis ***Myotis macropus*** **(breeding habitat)**	V	-	1	October-March	Anabat echolocation recording surveys were undertaken in February 2014. Targeted habitat searches were undertaken adjacent to creek lines with permanent, or close to permanent, water to identify any potential hollow roosting habitat in April and May 2014.

Common Name *Scientific Name*	**BC Act Listing Status**	**EPBC Act Listing Status**	**Source**	**Required Survey Period**	**Survey Technique, Timing and Location**
large-eared pied bat ***Chalinolobus dwyeri*** **(breeding habitat)**	V	V	1,2	January – March, September & October - December	Targeted microbat potential roosting habitat searches were undertaken in caves and overhangs on land adjoining the MCCO Additional Project Area during October 2013 (Umwelt 2016). Anabat echolocation recording was completed in from the 25 to 28 February 2014 (Umwelt 2016).
eastern cave bat ***Vespadelus troughtoni*** **(breeding habitat)**	V	-	2	January, November and December	Targeted microbat potential roosting habitat searches were undertaken in in caves and overhangs on land adjoining the MCCO Additional Project Area during October 2013 (Umwelt 2016). Anabat echolocation recording was completed in from the 25 to 28 February 2014 (Umwelt 2016).
little bentwing-bat ***Miniopterus australis*** **(breeding habitat)**	V		2	January, February and December	Targeted microbat potential roosting habitat searches were undertaken in in caves and overhangs on land adjoining the MCCO Additional Project Area during October 2013 (Umwelt 2016). Anabat echolocation recording was completed in from the 25 to 28 February 2014 (Umwelt 2016).
eastern bentwing-bat ***Miniopterus schreibersii oceanensis*** **(breeding habitat)**	V	-	2	January – February & November - December	Targeted microbat potential roosting habitat searches were undertaken in in caves and overhangs on land adjoining the MCCO Additional Project Area in October 2016 (Umwelt 2016). Anabat echolocation recording was completed in autumn and spring 2005 (Umwelt 2006). Opportunistic observations were recorded during all other aspects of the field survey.
brush-tailed rock-wallaby ***Petrogale penicillata***	E	E	1	All year	Targeted brush-tailed rock wallaby surveys were completed using remote cameras surveys in February, March and April 2014. The cameras were set within potential habitat areas outside of the Development Footprint for between four and ten days (Umwelt 2016).

umwelt

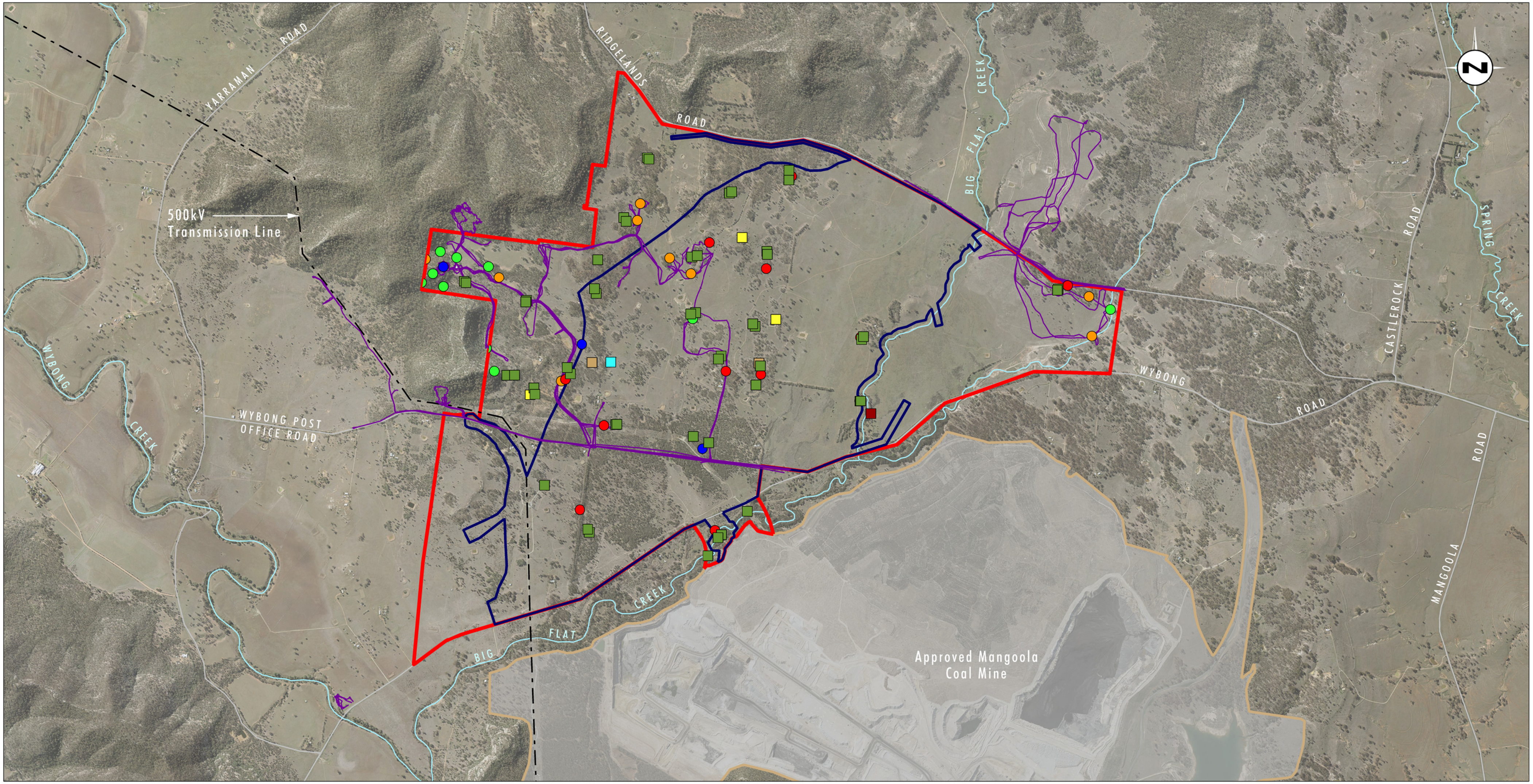

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

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Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Driving Spotlight Transects

Survey (2014-2016):
- Winter Bird Survey
- Anabat Survey
- Remote Camera
- Koala SAT Searches

Survey (2017-2018):
- Winter Bird Survey
- Call Playback
- Herpetological Survey
- Koala SAT Search
- Spotlighting Survey

FIGURE 2.5

Target Species-credit Fauna Survey Effort

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20190418 15.38

3 Results

3.1 Landscape Value

3.1.1 Soils

To determine the soils and the likely age of the parent material they are derived from, a review of detailed soil landscapes mapping undertaken as part of the MCCO Project (EMM 2018) and geological mapping was undertaken to determine whether Permian derived soils occur within the Development Footprint. The Development Footprint is situated on the edge of the Permian Singleton Coal Measures mapping with much of the surface geology being formed by the Triassic Narrabeen group (as determined both from regional geological mapping and from detailed geological investigations undertaken with the MCCO Additional Project Area). The detailed soil survey undertaken within the Development Footprint (EMM 2018) found that the soils have mostly been derived from the Triassic Narrabeen group. The Sodosol and Tenosol soils found in the Development Footprint generally support the soil landscape mapping done by Kovac and Lawrie (1991) Soil Landscapes of the Singleton 1:250,000 sheet (with some localised boundary readjustments). The alluvial influence along Wybong Creek and Big Flat Creek has also played a part in the soil formation in the Development Footprint, with alluvial derived soils in the southern portion and some alluvial influence further on the flats (EMM 2018).

The soil assessment concluded that there are no clearly Permian derived soils on site.

3.1.2 Landscape Features

The outer assessment circle is contained entirely in the Central Hunter Foothills Mitchell landscape. Landscape features that were considered in the connectivity value scores for the Development Footprint are outlined in **Table 3.1** below and are shown in **Figure 3.1**. Mitchell landscapes are shown on **Figure 1.5**.

Table 3.1 Landscape Features in the Development Footprint

Landscape Feature	Development Footprint
Mitchell Landscapes	Central Hunter Foothills
Rivers, Streams, Estuaries	4th order streams - Big Flat Creek
Wetlands	None identified
Native Vegetation	2,000 ha in the outer assessment circle 200 ha in the inner assessment circle
State or Regional Biodiversity Links	None identified

3.1.3 Landscape Value Scores

3.1.3.1 Percent Native Vegetation Cover

Table 3.2 details the percent native vegetation cover before and after the proposed disturbance in the Development Footprint and the native vegetation percent class entered into the BioBanking Calculator as per Table 9 of Appendix 4 of the FBA (OEH 2014b).

Table 3.2 Native Vegetation Cover in Assessment Circles

Assessment Circle	Pre-Development			Post-Development		
	Area of Native Veg (ha)	Native Veg Cover (%)	Native Veg Per cent Class	Area of Native Veg (ha)	Native Veg Cover (%)	Native Veg Per cent Class
Outer (2000 ha)	951	48	46-50	753	37	36-40
Inner (200 ha)	94	47	46-50	0	0	0

3.1.3.2 Connectivity Value

No state or regional significant biodiversity links were identified in the Sydney Basin IBRA Bioregion. However, the Development Footprint contains part of a Regionally significant biodiversity link in the form of a riparian buffer 20 metres either side of a 4th or 5th order stream as defined under the FBA (OEH 2014b) (refer to **Figure 3.1**).

Details of the connectivity value scores applicable for entry to the BBCC are shown in bold in **Table 3.3** below.

Table 3.3 Connectivity Value Score

Highest Category of Connecting Link	Connectivity Score	Definition	Description
Regionally Significant Biodiversity Link	**9**	An area identified by the assessor as being part of a regionally significant biodiversity link in a plan approved by the Chief Executive of OEH OR	Not identified
		A riparian buffer 20m either side of a 4th or 5th order stream OR	**Big Flat Creek**
		A riparian buffer 30m around a regionally significant wetland	Not identified

3.1.3.3 Patch Size

Table 3.4 below details the parameters that determined the Patch Size score as per Table 15 of Appendix 4 of the FBA (OEH 2014b).

Table 3.4 Patch Size Score Parameters

Mitchell Landscape	Central Hunter Foothills
Percent Native Vegetation Cleared	28%
Patch Size Class	>1001
Patch Size Score	**12**

3.1.3.4 Landscape Value Score

The landscape value score for the Development Footprint is **14.2**, as calculated by the BBCC.

3.2 Native Vegetation within the Development Footprint

3.2.1 Biometric Vegetation Types and Vegetation Zones

The vegetation communities within the Development Footprint were assigned to PCTs. PCTs were aligned with types described as part of the VIS Classification Database (OEH 2018bc). The PCTs were then categorised into 11 vegetation zones (refer to **Figure 3.2**). The composition of these vegetation zones within the Development Footprint is outlined in **Section 3.2** below and a flora species list for all plots surveyed is included in **Appendix D**. **Figure 3.3** identifies the extent of TECs within the Development Footprint.

The raw site condition attribute data for each of the vegetation zones is provided in **Appendix D**.

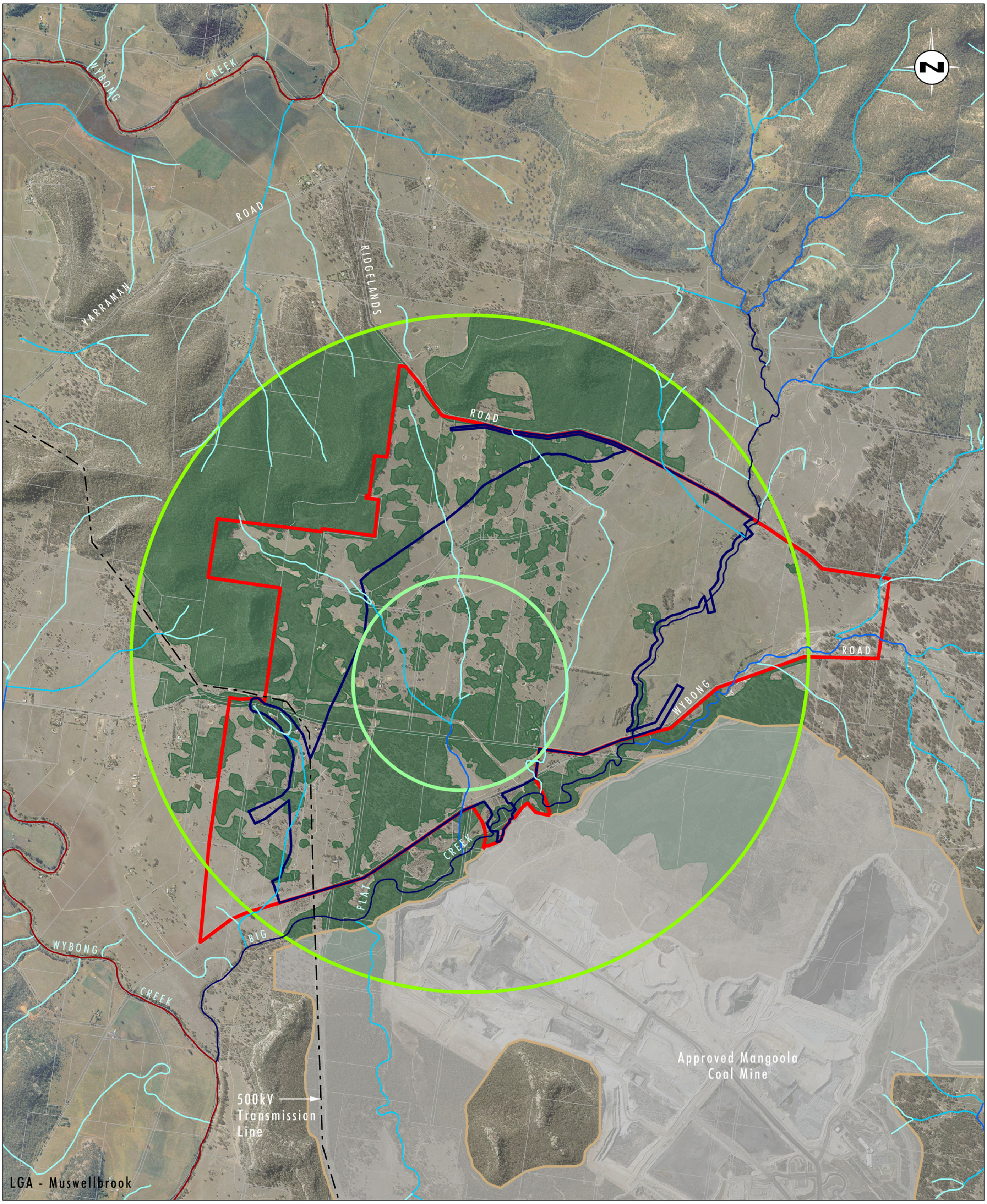

Image Source: Glencore (April 2018)
Data Source: Glencore (2018), Office of Environment and Heritage (OEH) (2017)

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1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- 200 Hectare Assessment Circle
- 2000 Hectare Assessment Circle
- Native Vegetation

Stream Order:

- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream
- 5th Order Stream
- 6th Order Stream

FIGURE 3.1

Connectivity Value

File Name (A4): R12/3450_051.dgn
20190418 15.39

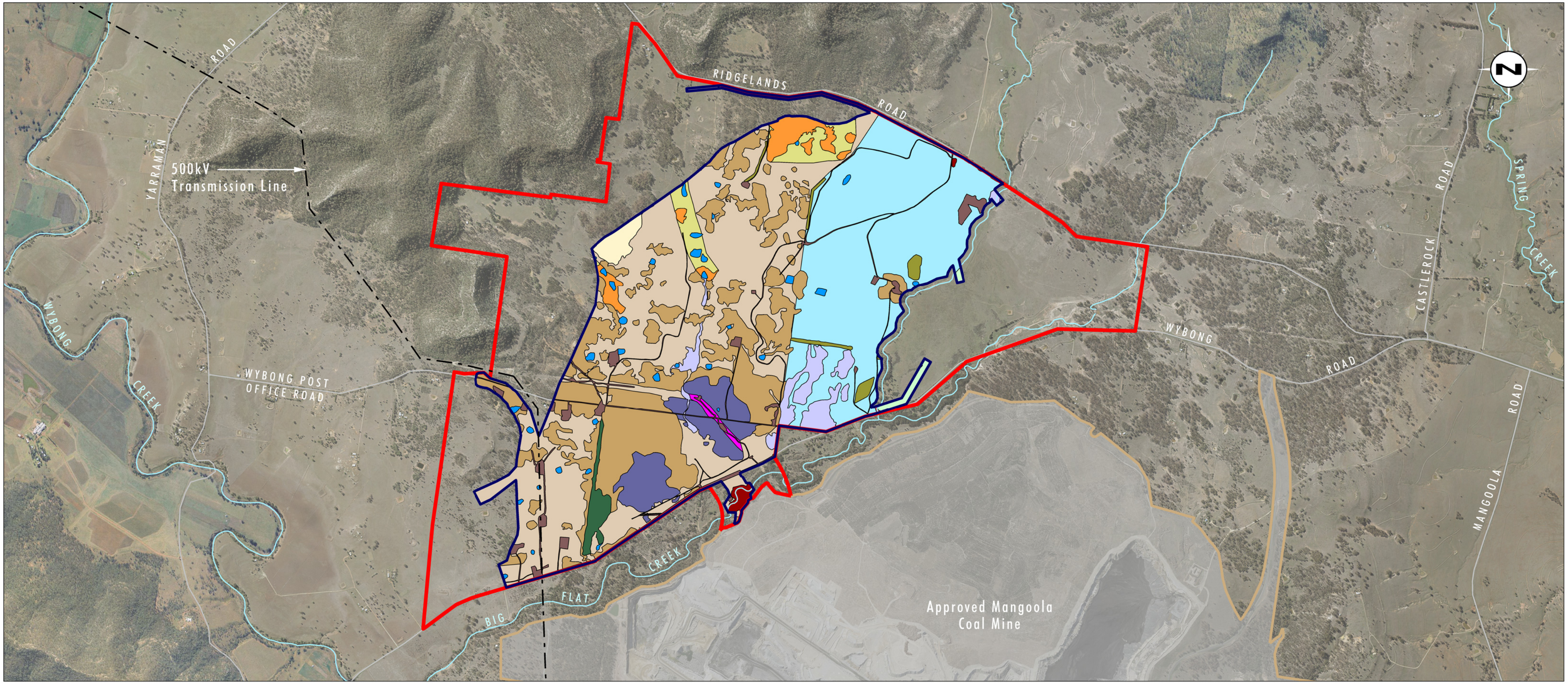

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Disturbed Land
- Exotic Rushland
- Mixed Species Revegetation Plantation
- Water Body
- Zone 1 - HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter - Moderate to Good
- Zone 2 - HU812/PCT1598 - Moderate to Good - Derived Native Grassland
- Zone 3 - HU816/PCT1602 Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good
- Zone 4 - HU817/PCT1603 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter - Moderate to Good
- Zone 5 - HU817/PCT1603 Moderate to Good - Derived Native Grassland
- Zone 6 - HU817/PCT1603 Low - Derived Native Grassland
- Zone 7 - HU821/PCT1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter - Moderate to Good
- Zone 8 - HU906/PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good
- Zone 9 - HU906/PCT1692 Moderate to Good - Derived Native Grassland
- Zone 10 - HU945/PCT1731 Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good
- Zone 11 - HU945/PCT1731 Moderate to Good Condition - Other

FIGURE 3.2

Vegetation Zones in the Development Footprint

File Name (A4): R12/3450_052.dgn
20190418 15.40

3.2.1.1 Zone 1 – HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good Condition

PCT Name	Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter	
Condition	**Moderate to Good**	
PCT Number	1598	
BVT Number	HU812	
Area (ha)	14.67	
Plots/Transects	Four	
Current Site Value Score	94.67	
Formation	Forested Wetlands	
Class	Coastal Floodplain Wetlands	
General Description	This vegetation zone occurs along the upper reaches of three unnamed tributaries to Big Flat Creek in the western portion of the Development Footprint.	
Canopy Description	This vegetation zone has a mid-dense canopy between 8 and 20 metres in height, dominated by forest red gum (*Eucalyptus tereticornis*) and possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakely's red gum (*Eucalyptus blakelyi*), with occurrences of narrow-leaved ironbark (*Eucalyptus crebra*) and rough-barked apple (*Angophora floribunda*).	
Mid-storey Description	A very sparse mid-storey is sometimes present between 2 to 6 metres in height dominated by young forest red gum (*Eucalyptus tereticornis*) and native olive (*Notelaea microcarpa* var. *microcarpa*).	
Shrub Layer Description	A very sparse shrub layer is sometime present. Shrub species recorded include coffee bush (*Breynia oblongifolia*), native olive (*Notelaea microcarpa* var. *microcarpa*), shiny-leaved canthium (*Psydrax odorata*), narrow-leaved geebung (*Persoonia linearis*), narrow-leaved orangebark (*Denhamia silvestris*) and *Melaleuca decora*.	
Ground Cover Description	This vegetation zone is characterised by a sparse to mid-dense ground layer generally less than 1 metre in height. Common forbs include yellow burr-daisy (*Calotis lappulacea*), variable glycine (*Glycine tabacina*), *Oxalis perennans*, common everlasting (*Chrysocephalum apiculatum*), wiry spurge (*Phyllanthus virgatus*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), sprawling bluebell (*Wahlenbergia gracilis*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), berry saltbush (*Einadia hastata*), whiteroot (*Pratia purpurascens*), kidney weed (*Dichondra repens*), twining glycine (*Glycine clandestina*) and austral bugle (*Ajuga australis*). Native grasses include purple wiregrass (*Aristida ramosa*), weeping grass (*Microlaena stipoides*), barbed wire grass (*Cymbopogon refractus*), open summer-grass (*Digitaria diffusa*), threeawn speargrass (*Aristida vagans*), common couch (*Cynodon dactylon*) and Browns lovegrass (*Eragrostis brownii*).	
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone and include catsear (*Hypochaeris radicata*), Paddys lucerne (*Sida rhombifolia*), cobblers pegs (*Bidens pilosa*), fireweed (*Senecio madagascariensis*), flaxleaf fleabane (*Conyza bonariensis*), common prickly pear (*Opuntia stricta*) and purpletop (*Verbena bonariensis*).	

PCT Name	Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter
Condition	Moderate to Good
PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs. Vegetation Zone 1 is aligned with HU812/PCT1598 as it supports a reasonable proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2018c). Of the 15 flora species listed on the VIS Classification database as characteristic for HU812/PCT1598, Vegetation Zone 1 supports 10 of them (67 per cent). Although the title of HU812/PCT1598 specifies its distribution as being the Lower Hunter, a review of the VIS Classification Database (OEH 2018c) indicates that this BVT/PCT can occur in the Upper Hunter Valley and specifically in the Kerrabee IBRA subregion where the Development Footprint occurs. There are no other reasonable BVT/PCT equivalents for vegetation zone 1 according to the VIS Classification Database (OEH 2018c). HU812/PCT1598 was the BVT/PCT mapped within the Mangoola Upper Hunter Strategic Assessment (Umwelt 2014) and has been previously accepted as occurring in this locality by OEH.
BC Act Status	This vegetation zone is consistent with the *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. For further information, refer to **Section 3.2.2**.
EPBC Act Status	The portions of this vegetation zone that support intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*) are consistent with CEEC *White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland* listed under the EPBC Act. For further information refer to **Section 3.2.2**.

3.2.1.2 Zone 2 – HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good Condition Derived Native Grassland

PCT Name	Forest Red Gum grassy open forest on floodplains of the lower Hunter	
Condition	Moderate to Good –Derived Native Grassland	
PCT Number	1598	
BVT Number	HU812	
Area (ha)	15.24	
Plots/Transects	Four	
Current Site Value Score	53.33	
Formation	Forested Wetlands	
Class	Coastal Floodplain Wetlands	
General Description	This vegetation zone occurs along the upper reaches of three unnamed tributaries to Big Flat Creek in the western portion of the Development Footprint adjacent to woodland areas HU812/PCT1598 (vegetation zone 1).	
Canopy Description	Not present. In some areas regeneration of forest red gum (*Eucalyptus tereticornis*), possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*), and rough-barked apple (*Angophora floribunda*) are present in this vegetation zone.	

PCT Name	**Forest Red Gum grassy open forest on floodplains of the lower Hunter**
Condition	**Moderate to Good –Derived Native Grassland**
Mid-storey Description	Not present.
Shrub Layer Description	Not present.
Ground Cover Description	This vegetation zone is characterised by a mid-dense ground layer generally less than 1 metre in height. Common forbs include common everlasting (*Chrysocephalum apiculatum*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), bristly cloak fern (*Cheilanthes distans*) and *Juncus usitatus*. Native grasses include slender rats tail grass (*Sporobolus creber*), threeawn speargrass (*Aristida vagans*), purple wiregrass (*Aristida ramosa*), common couch (*Cynodon dactylon*), red grass (*Bothriochloa decipiens* var. *decipiens*), barbed wire grass (*Cymbopogon refractus*), paddock lovegrass (*Eragrostis leptostachya*), weeping grass (*Microlaena stipoides*), hairy panic (*Panicum effusum*) and red grass (*Bothriochloa macra*).
Introduced Species	Introduced species generally occur at low to moderate abundance in this vegetation zone and include galenia (*Galenia pubescens*), scarlet pimpernel (*Anagallis arvensis*), veined verbena (*Verbena rigida* var. *rigida*), bindyi (*Soliva sessilis*), *Romulea rosea* var. *australis*, capeweed (*Arctotheca calendula*), catsear (*Hypochaeris radicata*), Paddys lucerne (*Sida rhombifolia*) and fireweed (*Senecio madagascariensis*).
PCT Allocation	This vegetation zone has been attributed to HU812/PCT1598 based on its position in the landscape between remnant woodland patches of Zone 1 – HU812/PCT1598. Additionally this vegetation zone contains a third of the characteristic species for HU812/PCT1598, including regenerating forest red gum (*Eucalyptus tereticornis*), possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*), and rough-barked apple (*Angophora floribunda*).
BC Act Status	The portions of this vegetation zone that are likely to have previously supported possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*) are consistent with the derived native grassland form of the EEC *White Box Yellow Box Blakely's Red Gum Woodland* listed under the BC Act. For further information refer to **Section 3.2.2**.
EPBC Act Status	The portions of this vegetation zone that are likely to have previously supported intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*) are consistent with the derived native grassland form of the CEEC *White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland* listed under the EPBC Act. For further information refer to **Section 3.2.2**.

3.2.1.3 Zone 3 – HU816/PCT1602 Spotted Gum- Narrow-leaved Ironbark Shrub – Grass Open Forest of the Central and Lower Hunter – Moderate to Good Condition

PCT Name	**Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open forest of the Central and Lower Hunter**
Condition	**Moderate to Good**
PCT Number	1602
BVT Number	HU816
Area (ha)	6.3
Plots/Transects	Three
Current Site Value Score	68.23
Formation	Dry Sclerophyll Forests (Shrub/grass sub-formation)
Class	Hunter-Macleay Dry Sclerophyll Forests
General Description	This vegetation zone comprises young forest associated with lower slopes in the western portion of the Development Footprint.
Canopy Description	This vegetation zone has a mid-dense canopy between 18-22 metres in height, dominated by spotted gum (*Corymbia maculata*), with occurrences of narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*Eucalyptus moluccana*).
Mid-storey Description	A very sparse to sparse mid-storey is present between 2-8 metres in height. Dominant species include native olive (*Notelaea microcarpa* var. *microcarpa*), shiny-leaved canthium (*Psydrax odorata*), and green wattle (*Acacia deanei*).
Shrub Layer Description	A very sparse to sparse shrub layer generally less than a metre in height is present throughout this vegetation zone. Dominant species include western golden wattle (*Acacia decora*), blunt beard-heath (*Leucopogon muticus*), coffee bush (*Breynia oblongifolia*), narrow-leaved geebung (*Persoonia linearis*) and narrow-leaved orangebark (*Denhamia silvestris*).
Ground Cover Description	This vegetation zone is characterised by a diverse and sparse to mid-dense ground layer generally less than 0.5 metre in height. Common forbs include yellow burr-daisy (*Calotis lappulacea*), kidney weed (*Dichondra* sp. A), slender tick-trefoil (*Desmodium varians*), blue trumpet (*Brunoniella australis*), *Oxalis perennans*, wiry spurge (*Phyllanthus virgatus*), stinking pennywort (*Hydrocotyle laxiflora*), variable glycine (*Glycine tabacina*), slender wire lily (*Laxmannia gracilis*), slender flat-sedge (*Cyperus gracilis*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), common everlasting (*Chrysocephalum apiculatum*) and wattle matt-rush (*Lomandra filiformis*). Native grasses include weeping grass (*Microlaena stipoides* var. *stipoides*), open summer-grass (*Digitaria diffusa*), threeawn speargrass (*Aristida vagans*), bushy hedgehog grass (*Echinopogon caespitosus*), barbed wire grass (*Cymbopogon refractus*), paddock lovegrass (*Eragrostis leptostachya*), purple wiregrass (*Aristida ramosa*), red grass (*Bothriochloa macra*) and shorthair plumegrass (*Dichelachne micrantha*).
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone. Introduced species recorded in this vegetation zone include flaxleaf fleabane (*Conyza bonariensis*), catsear (*Hypochaeris radicata*), common prickly pear (*Opuntia stricta*) and *Richardia stellaris*.

PCT Name	**Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open forest of the Central and Lower Hunter**
Condition	**Moderate to Good**

PCT Allocation	In the first instance BVTs/PCTs in the Sydney Basin IBRA bioregion with the characteristic canopy species spotted gum (*Corymbia maculata*) were filtered in the VIS Classification Database (OEH 2018c). In addition to this, characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs.
	Vegetation Zone 3 is aligned with HU816/PCT1602 as it supports a high proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2018c). Of the 15 flora species listed on the database as characteristic for HU816/PCT1602, Vegetation Zone 3 supports 9 of them (60 per cent). HU816/PCT1602 is also known to occur in the Kerrabee IBRA subregion.
	Other similar BVTs/PCTs considered include:
	• HU814/PCT1600 Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter
	  ○ Ruled out as vegetation zone 3 does not contain red ironbark (*Eucalyptus fibrosa*), typically more a coastal form of Hunter Valley Spotted Gum Forest (not known from the Kerrabee IBRA sub-region) and contains a lower proportion of characteristic species (58%) compared to HU816/PCT1602.
	• HU815/PCT1601 Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter
	  ○ Ruled out as vegetation zone 3 does not contain red ironbark (*Eucalyptus fibrosa*) and contains a lower proportion of characteristic species (47%) compared to HU816/PCT1602.
	• HU818/PCT1604 Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter
	  ○ Whilst this BVT/PCT comprised a slightly higher proportion of characteristic species than HU816/PCT1602 (10 out of 14 or 71%), it is classified as a Grassy Woodland Keith formation according to the VIS Classification Database and vegetation zone 3 is a Dry Sclerophyll Forest formation.

BC Act Status	This community is consistent with the *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. For further information refer to **Section 3.2.2**.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) as it does not occur on Permian derived soils (refer to **Section 3.2.2.6.**

3.2.1.4 Zone 4 – HU817/1603 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter – Moderate to Good Condition

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter
Condition	Moderate to Good
PCT Number	1603 
BVT Number	HU817
Area (ha)	135.21
Plots/Transects	Seven
Current Site Value Score	67.19
Formation	Grassy Woodlands
Class	Coastal Valley Grassy Woodlands
General Description	This vegetation zone occurs across the lower to mid slopes within the Development Footprint.
Canopy Description	This vegetation zone has a sparse to mid-dense canopy between 8-20 metres in height, dominated by narrow-leaved ironbark (*Eucalyptus crebra*), with occurrences of grey box (*Eucalyptus moluccana*) and rough-barked apple (*Angophora floribunda*).
Mid-storey Description	A sparse mid-storey is often present between 3-8 metres in height. Dominant species include bulloak (*Allocasuarina luehmannii*) and narrow-leaved ironbark (*Eucalyptus crebra*). Black cypress pine (*Callitris endlicheri*) also occurs in the northern portion of the Development Footprint.
Shrub Layer Description	A very sparse to sparse shrub layer 1 to 2 metres in height is generally present throughout this vegetation zone. Dominant species include shiny-leaved canthium (*Psydrax odorata*), sifton bush (*Cassinia arcuata*) and native olive (*Notelaea microcarpa* var. *macrocarpa*)).
Ground Cover Description	This vegetation zone is characterised by a diverse and mid-dense to dense ground layer generally less than 1 metre in height. Common forbs include slender wire lily (*Laxmannia gracilis*), *oxalis perennans*, rock fern (*Cheilanthes sieberi* subsp. *sieberi*), slender tick-trefoil (*Desmodium varians*), variable glycine (*Glycine tabacina*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), blue trumpet (*Brunoniella australis*), yellow burr-daisy (*Calotis lappulacea*), common everlasting (*Chrysocephalum apiculatum*), native wandering Jew (*Commelina cyanea*), slender flat-sedge (*Cyperus gracilis*), kidney weed (*Dichondra repens*), berry saltbush (*Einadia hastata*), climbing saltbush (*Einadia nutans*), *Murdannia graminea*, trailing speedwell (*Veronica plebeia*) and tufted bluebell (*Wahlenbergia communis*). Native grasses include threeawn speargrass (*Aristida vagans*), purple wiregrass (*Aristida ramosa*), speargrass (*Austrostipa scabra*), barbed wire grass (*Cymbopogon refractus*), paddock lovegrass (*Eragrostis leptostachya*), open summer-grass (*Digitaria diffusa*) and slender rats tail grass (*Sporobolus creber*).
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone. Introduced species recorded in this vegetation zone include fireweed (*Senecio madagascariensis*), catsear (*Hypochaeris radicata*), common peppercress (*Lepidium africanum*) and galenia (*Galenia pubescens*).

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter
Condition	**Moderate to Good**

PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs.
	Vegetation Zone 3 is aligned with HU817/PCT1603 as it supports a high proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2017x). Of the 14 flora species listed on the database as characteristic for HU816/PCT1602, Vegetation Zone 3 supports 10 of them (71 per cent).
	Other similar BVTs/PCTs considered include:
	• HU905/PCT1691 Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
	  o Very similar to HU817/PCT1603, both of which share strong floristic similarity with vegetation zone 4. However, given the common occurrence of bulloak (*Allocasuarina luehmannii*) within vegetation zone 4, HU817/PCT1603 is considered to be a better match.
	• Other PCTs similar PCTs that were considered, however were ruled out based on lower floristic similarity (between 50 to 60 per cent) include:
	  o HU701/PCT623 Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion
	  o HU819/PCT1605 Narrow-leaved Ironbark - Native Olive shrubby open forest of the central and upper Hunter
	  o HU825/PCT1611 Narrow-leaved Ironbark - Black Cypress Pine shrub - grass woodland upper Hunter and northern Wollemi

BC Act Status	This community is consistent with the EEC *Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. For further information refer to **Section 3.2.2**.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) as it does not occur on soils derived from Permian-aged material.

3.2.1.5 Zone 5 – HU817/1603 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter – Moderate to Good Condition Derived Native Grassland

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter	
Condition	**Moderate to Good - Derived Native Grassland**	
PCT Number	1603	
BVT Number	HU817	
Area (ha)	197.49	
Plots/Transects	Six	
Current Site Value Score	28.12	
Formation	Grassy Woodlands	
Class	Coastal Valley Grassy Woodlands	
General Description	This vegetation zone occurs across the lower to mid slopes within the Development Footprint adjacent to woodland areas HU817/PCT1603 (vegetation zone 4).	
Canopy Description	Not present. Regeneration of the tree species narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*) is present in this vegetation zone.	
Mid-storey Description	Not present.	
Shrub Layer Description	Not present.	
Ground Cover Description	This vegetation zone is characterised by a diverse and mid-dense to dense ground layer generally less than 1 metre in height. Common forbs include common everlasting (*Chrysocephalum apiculatum*), common fringe-sedge (*Fimbristylis dichotoma*), wiry spurge (*Phyllanthus virgatus*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), variable glycine (*Glycine tabacina*), variable raspwort (*Haloragis heterophylla*), *Oxalis perennans*, solenogyne (*Solenogyne bellioides*) and tufted bluebell (*Wahlenbergia communis*). Native grasses include purple wiregrass (*Aristida ramosa*), red grass (*Bothriochloa macra*), threeawn speargrass (*Aristida vagans*), barbed wire grass (*Cymbopogon refractus*), paddock lovegrass (*Eragrostis leptostachya*), open summer-grass (*Digitaria diffusa*), Browns lovegrass (*Eragrostis brownii*), hairy panic (*Panicum effusum*) and slender rats tail grass (*Sporobolus creber*).	
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone. Introduced species recorded in this vegetation zone include catsear (*Hypochaeris radicata*), flaxleaf fleabane (*Conyza bonariensis*), *Romulea rosea* var. *australis* and fireweed (*Senecio madagascariensis*).	
PCT Allocation	This vegetation zone has been attributed to HU817/PCT1603 based on its position in the landscape between remnant woodland patches of Zone 4 – HU817/PCT1603. Additionally this vegetation zone contains a reasonable proportion (50 per cent) of the characteristic species for HU817/PCT1603, including regenerating narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*).	

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter
Condition	**Moderate to Good - Derived Native Grassland**
BC Act Status	This community is not consistent with any TEC listed under the BC Act.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) as it does not occur on Permian derived soils.

3.2.1.6 Zone 6 – HU817/1603 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter – Low Condition – Derived Native Grassland

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter	
Condition	**Low - Derived Native Grassland**	
PCT Number	1603	
BVT Number	HU817	
Area (ha)	160.04	
Plots/Transects	Six	
Current Site Value Score	16.67	
Formation	Grassy Woodlands	
Class	Coastal Valley Grassy Woodlands	
General Description	This vegetation zone occurs across the lower slopes within the Development Footprint adjacent to woodland areas HU817/PCT1603 (vegetation zone 4). Due to land management practices this zone is in lower condition than vegetation zone 5 HU817/PCT1603, having a reduced diversity and cover of native ground cover species.	
Canopy Description	Not present.	
Mid-storey Description	Not present.	
Shrub Layer Description	Not present.	
Ground Cover Description	This vegetation zone is characterised by a mid-dense ground layer generally less than 0.5 metres in height. Native grasses include slender rats tail grass (*Sporobolus creber*), paddock lovegrass (*Eragrostis leptostachya*), common couch (*Cynodon dactylon*) and threeawn speargrass (*Aristida vagans*). Native forbs generally occur at low abundance and include common everlasting (*Chrysocephalum apiculatum*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*) and *Oxalis perennans*.	
Introduced Species	Introduced species are abundant in this vegetation zone. Common introduced species include catsear (*Hypochaeris radicata*), common crowfoot (*Erodium cicutarium*), galenia (*Galenia pubescens*), Paddys lucerne (*Sida rhombifolia*), *Romulea rosea* var. *australis*, fireweed (*Senecio madagascariensis*), common prickly pear (*Opuntia stricta* var. *stricta*), bindyi (*Soliva sessilis*), capeweed (*Arctotheca calendula*), flaxleaf fleabane (*Conyza bonariensis*), burr medic (*Medicago polymorpha*) and *Setaria parviflora*.	

PCT Name	Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter
Condition	Low - Derived Native Grassland
PCT Allocation	This vegetation zone has been attributed to HU817/PCT1603 based on its position in the landscape between remnant woodland patches of Zone 4 – HU817/PCT1603 and the presence of several of the characteristic ground cover species for HU817/PCT1603.
BC Act Status	This community is not consistent with any TEC listed under the BC Act.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act.

3.2.1.7 Zone 7 – HU821/PCT1607 Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple shrubby woodland of the upper Hunter – Moderate to Good Condition

PCT Name	Blakelys Red Gum - Narrow-leaved Ironbark - Rough-barked Apple Shrubby Woodland of the upper Hunter	
Condition	Moderate to Good	
PCT Number	1607	
BVT Number	HU821	
Area (ha)	6.46	
Plots/Transects	Three	
Current Site Value Score	42.19	
Formation	Dry Sclerophyll Forests (Shrub/grass sub-formation)	
Class	North-west Slopes Dry Sclerophyll Woodlands	
General Description	This vegetation is confined to the flats in the southern portion of the Development Footprint. This vegetation may be a relic of past disturbance.	
Canopy Description	This vegetation zone has a sparse to mid-dense canopy between 8 20 metres in height, dominated by intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*). Other associated tree species include narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*).	
Mid-storey Description	A sparse to mid dense mid-storey is present between 2 to 15 metres in height. Dominant species include native olive (*Notelaea microcarpa* var. *microcarpa*), *Melaleuca decora* and bulloak (*Allocasuarina luehmannii*).	
Shrub Layer Description	A sparse shrub layer generally less than a metre in height is present throughout this vegetation zone. Dominant species include young bulloak (*Allocasuarina luehmannii*), shiny-leaved canthium (*Psydrax odorata*), sifton bush (*Cassinia arcuata*) and narrow-leaved orangebark (*Denhamia silvestris*).	
Ground Cover Description	This vegetation zone is characterised by a diverse and sparse to mid-dense ground layer generally less than 0.5 metre in height. Common forbs include rock fern (*Cheilanthes sieberi* subsp. *sieberi*), twining glycine (*Glycine clandestina*), variable glycine (*Glycine tabacina*), wattle matt-rush (*Lomandra filiformis* subsp. *coriacea*), yellow-burr daisy (*Calotis lappulacea*), slender tick-trefoil (*Desmodium varians*), common everlasting (*Chrysocephalum apiculatum*), native wandering Jew (*Commelina cyanea*), slender flat-sedge (*Cyperus gracilis*) and *Oxalis perennans*. Native grasses include Browns lovegrass (*Eragrostis brownii*), threeawn speargrass (*Aristida vagans*), purple wiregrass (*Aristida ramosa*), open summer-grass (*Digitaria diffusa*) and slender rats tail grass (*Sporobolus creber*).	

PCT Name	Blakelys Red Gum - Narrow-leaved Ironbark - Rough-barked Apple Shrubby Woodland of the upper Hunter
Condition	**Moderate to Good**
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone and include tiger pear (*Opuntia aurantiaca*), common prickly pear (*Opuntia stricta*) and flaxleaf fleabane (*Conyza bonariensis*).
PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs. Vegetation Zone 7 is aligned with HU821/PCT1607 as it supports a reasonable proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2018c). Of the 16 flora species listed on the database as characteristic for HU821/PCT1607, Vegetation Zone 7 supports 6 of them (40 per cent). There are no other reasonable BVT/PCT equivalents for vegetation zone 7 according to the VIS Classification Database (OEH 2018c). HU812/PCT1598 was the BVT/PCT mapped within the Mangoola Upper Hunter Strategic Assessment (Umwelt 2014) and has been previously accepted as occurring in this locality by OEH.
BC Act Status	This community is consistent with the *White Box Yellow Box Blakely's Red Gum Woodland* EEC listed under the BC Act. For further information refer to **Section 3.2.2**.
EPBC Act Status	This community is consistent with the *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* CEEC listed under the EPBC Act. For further information refer to **Section 3.2.2**

3.2.1.8 Zone 8 – HU906/PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley	
Condition	**Moderate to Good**	
PCT Number	1692	
BVT Number	HU906	
Area (ha)	30.76	
Plots/Transects	Four	
Current Site Value Score	56.25	
Formation	Grassy Woodlands	
Class	Coastal Valley Grassy Woodlands	
General Description	This vegetation zone is confined to the lower slopes and flats in the southern portion of the Development Footprint.	
Canopy Description	This vegetation zone has a mid-dense canopy between 4 to 15 metres in height, dominated by bulloak (*Allocasuarina luehmannii*).	
Mid-storey Description	A sparse mid-storey is sometimes present between 1 to 5 metres in height dominated by young bulloak (*Allocasuarina luehmannii*).	
Shrub Layer Description	A defined shrub layer is generally absent. Shrub species recorded in low abundance include native olive (*Notelaea microcarpa* var. *microcarpa*) and sifton bush (*Cassinia arcuata*).	

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley
Condition	**Moderate to Good**
Ground Cover Description	This vegetation zone is characterised by a sparse ground layer generally less than 1 metre in height. Common forbs include rock fern (*Cheilanthes sieberi* subsp. *sieberi*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), common everlasting (*Chrysocephalum apiculatum*), wattle matt-rush (*Lomandra filiformis* subsp. *coriacea*), *Zornia dyctiocarpa* var. *dyctiocarpa*, variable glycine (*Glycine tabacina*), yellow-burr daisy (*Calotis lappulacea*) and slender wire lily (*Laxmannia gracilis*). Native grasses include Browns lovegrass (*Eragrostis brownii*), red grass (*Bothriochloa macra*), barbed wire grass (*Cymbopogon refractus*), threeawn speargrass (*Aristida vagans*), open summer-grass (*Digitaria diffusa*), purple wiregrass (*Aristida ramosa*), paddock lovegrass (*Eragrostis leptostachya*) and common couch (*Cynodon dactylon*).
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone and include tiger pear (*Opuntia aurantiaca*), common prickly pear (*Opuntia stricta*) and fireweed (*Senecio madagascariensis*).
PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs. Vegetation Zone 8 is aligned with HU906/PCT1692 as it supports a high proportion of characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2017). Of the 9 flora species listed on the database as characteristic for HU906/PCT1692, Vegetation Zone 8 supports 7 of them (78 per cent). HU817/PCT1603 was also considered, however this BVT/PCT is dominated by bulloak (*Allocasuarina luehmannii*) in combination with narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*Eucalyptus moluccana*). Since these 2 eucalypt species are largely absent from Vegetation Zone 8 and bulloak (*Allocasuarina luehmannii*) generally the sole canopy species, HU906/PCT1692 is considered to be the best match.
BC Act Status	This community is not consistent with any TEC listed under the BC Act.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) as it does not occur on Permian derived soils.

3.2.1.9 Zone 9 – HU906/PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition – Derived Native Grassland

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley
Condition	**Moderate to Good – Derived Native Grassland**
PCT Number	1692
BVT Number	HU906
Area (ha)	1.64
Plots/Transects	Two
Current Site Value Score	46.88
Formation	Grassy Woodlands

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley
Condition	**Moderate to Good – Derived Native Grassland**
Class	Coastal Valley Grassy Woodlands
General Description	This vegetation zone occurs across the lower slopes and flats within the Development Footprint adjacent to woodland areas HU906/PCT1692 (vegetation zone 4).
Canopy Description	A sparse low (1-5 metres) canopy of regenerating bulloak (*Allocasuarina luehmannii*) is present in this vegetation zone.
Mid-storey Description	Not present.
Shrub Layer Description	Not present.
Ground Cover Description	This vegetation zone is characterised by a mid-dense ground layer generally less than 0.5 metre in height. Common forbs include yellow burr-daisy (*Calotis lappulacea*), slender tick-trefoil (*Desmodium varians*), variable glycine (*Glycine tabacina*), *Juncus usitatus*, ridge sida (*Sida cunninghamii*), *Oxalis perennans*, wiry spurge (*Phyllanthus virgatus*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*) and common everlasting (*Chrysocephalum apiculatum*). Native grasses include purple wiregrass (*Aristida ramosa*), barbed wire grass (*Cymbopogon refractus*), clustered lovegrass (*Eragrostis elongata*), red grass (*Bothriochloa macra*) and hairy panic (*Panicum effusum*).
Introduced Species	Introduced species generally occur at low abundance in this vegetation zone and include spear thistle (*Cirsium vulgare*), prickly lettuce (*Lactuca serriola*), common prickly pear (*Opuntia stricta*), black-berry nightshade (*Solanum nigrum*) and catsear (*Hypochaeris radicata*).
PCT Allocation	This vegetation zone has been attributed to HU906/PCT1692 based on its position in the landscape between remnant woodland patches of Zone 8 – HU906/PCT1692. Additionally this vegetation zone contains a reasonable proportion (44 per cent) of the characteristic species for HU906/PCT1692, including regenerating bulloak (*Allocasuarina luehmannii*).
BC Act Status	This community is not consistent with any TEC listed under the BC Act.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) as it does not occur on Permian derived soils.

3.2.1.10 Zone 10 – HU945/PCT1731 Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley – Moderate to Good Condition

PCT Name	Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley
Condition	**Moderate to Good**
PCT Number	1731
BVT Number	HU945
Area (ha)	2.57
Plots/Transects	Three
Current Site Value Score	66.44
Formation	Forested Wetlands

PCT Name	Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley
Condition	Moderate to Good
Class	Coastal Swamp Forests
General Description	This vegetation zone is confined to the riparian zone along Big Flat Creek.
Canopy Description	This vegetation zone has a mid-dense to dense canopy between 10 and 18 metres in height, dominated by swamp oak (*Casuarina glauca*).
Mid-storey Description	A very sparse mid-storey is sometimes present between 2 and 6 metres in height dominated by young swamp oak (*Casuarina glauca*).
Shrub Layer Description	A very sparse shrub layer is sometimes present. Shrub species recorded in low abundance include native olive (*Notelaea microcarpa* var. *microcarpa*), bead bush (*Spartothamnella juncea*), young swamp oak (*Casuarina glauca*) and the exotic species African boxthorn (*Lycium ferocissimum*).
Ground Cover Description	This vegetation zone is characterised by a mid-dense to dense ground layer generally less than 1 metre in height. Common forbs include yellow burr-daisy (*Calotis lappulacea*), kidney weed (*Dichondra repens*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*) and *Einadia* spp. Native grasses include slender bamboo grass (*Austrostipa verticillata*), common couch (*Cynodon dactylon*), threeawn speargrass (*Aristida vagans*), tall chloris (*Chloris ventricosa*), and weeping grass (*Microlaena stipoides* var. *stipoides*).
Introduced Species	Introduced species occur at moderate abundance in this vegetation zone and include panic veldtgrass (*Ehrharta erecta*), galenia (*Galenia pubescens*), greater beggars ticks (*Bidens subalternans*), common prickly pear (*Opuntia stricta*), common chickweed (*Stellaria media*), Paddys lucerne (*Sida rhombifolia*), African boxthorn (*Lycium ferocissimum*) and catsear (*Hypochaeris radicata*).
PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details were then used to further refine the candidate BVTs/PCTs. Vegetation Zone 10 is aligned with HU945/PCT1731 as it supports a reasonable proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (OEH 2018c). Of the 9 flora species listed on the VIS Classification database as characteristic for HU945/PCT1731, Vegetation Zone 10 supports 5 of them (55 per cent).
BC Act Status	This community is not consistent with the EEC Swa*mp Oak Floodplain Forest of the NSW North Coast Sydney Basin and South East Corner Bioregions* listed under the BC Act. The Scientific Committee in limiting the EEC's occurrence to 'rarely above 10 metres elevation' however this BVT occurs at an approximate elevation of 150 metres in the Development Footprint. In addition, only two species listed in the Final Determination (45 species listed in total the Final Determination) occur within this community in the Development Footprint, being swamp oak (*Casuarina glauca*) and common couch (*Cynodon dactylon*).
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act. It does not meet the key diagnostic features for the *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* EEC as it occurs at greater than 50 metres above sea level.

3.2.1.11 Zone 11 – HU945/PCT1731 Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley – Moderate to Good Condition – Rough-barked Apple Variant

PCT Name	Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley	
Condition	Moderate to Good – Rough-Barked Apple Variant	
PCT Number	1731	
BVT Number	HU945	
Area (ha)	0.38	
Plots/Transects	One	
Current Site Value Score	62.00	
Formation	Forested Wetlands	
Class	Coastal Swamp Forests	
General Description	This vegetation zone is confined to the riparian zone along Big Flat Creek and is associated with vegetation zone 11.	
Canopy Description	This vegetation zone has a sparse canopy between 12 to 15 metres in height, dominated by mature rough-barked apple (*Angophora floribunda*).	
Mid-storey Description	Not present.	
Shrub Layer Description	Not present.	
Ground Cover Description	This vegetation zone is characterised by a mid-dense ground layer generally less than 0.5 metres in height. Common forbs include common everlasting (*Chrysocephalum apiculatum*), variable glycine (*Glycine tabacina*) and *Oxalis perennans*. Native grasses purple wiregrass (*Aristida ramosa*), speargrass (*Austrostipa scabra*), slender bamboo grass (*Austrostipa verticillata*), barbed wire grass (*Cymbopogon refractus*), common couch (*Cynodon dactylon*), weeping grass (*Microlaena stipoides*), hairy panic (*Panicum effusum*) and slender rat's tail grass (*Sporobolus creber*).	
Introduced Species	Introduced species occur at moderate abundance in this vegetation zone and include fleabane (*Conyza* sp.), galenia (*Galenia pubescens*), catsear (*Hypochaeris radicata*), *Juncus acutus* subsp. *acutus*, common peppercress (*Lepidium africanum*), fireweed (*Senecio madagascariensis*) and Paddys lucerne (*Sida rhombifolia*).	
PCT Allocation	Characteristic native species of this vegetation zone were entered into the VIS Classification Database. Distribution details and descriptive attributes were then used to further refine the candidate BVTs/PCTs. Vegetation Zone 11 is difficult to assign to an appropriate BVT/PCT according to the VIS Classification database. Vegetation Zone 11 is aligned with HU945/PCT1731. Although this BVT/PCT does not contain rough-barked apple (*Angophora floribunda*) in the characteristic on the VIS Classification Database (OEH 2018c), the dominant groundcover species in this vegetation zone are characteristic of HU945/PCT1731. This vegetation zone is also associated with Big Flat Creek where Swamp Oak Forest is common, and further downstream from this vegetation zone swamp oak (*Casuarina glauca*) and rough-barked apple (*Angophora floribunda*) are growing in association. Additionally, the equivalent map unit for the Vegetation of the Central Hunter Valley (Peake 2006) lists rough-barked apple (*Angophora floribunda*) as an occasional associated species. Of the nine flora species listed on the VIS Classification database as characteristic for HU945/PCT1731, Vegetation Zone 11 supports three of them (33 per cent). In terms of the ground stratum species, Vegetation Zone 11 supports three of the six characteristic species (50 per cent) and these species are dominant in this vegetation zone.	

PCT Name	Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley
Condition	Moderate to Good – Rough-Barked Apple Variant
	Other attributes including landscape position, distribution and substrates detailed in the VIS Classification Database (OEH 2018c) were considered. Other potential BVTs/PCTs considered include: • HU713/PCT481 Rough-barked Apple - Blakely's Red Gum - Narrow-leaved Stringybark +/- Grey Gum Sandstone Riparian Grass Fern Open Forest in the Southern Brigalow Belt South Bioregion and Upper Hunter region o Ruled out as this BVT/PCT occurs as a shrubby dry sclerophyll forest, in comparison to the grassy woodland structure of vegetation zone 11. Additionally, vegetation zone contains a low number of characteristic species for HU713/PCT481. • HU907/PCT1693 Yellow Box - Rough-barked Apple grassy woodland of the upper Hunter and Liverpool Plains o Ruled out as a low number of characteristic species associated with this BVT/PCT occur in vegetation zone 11. Of the five characteristic species listed in the VIS Classification Database (OEH 2017), vegetation zone 11 contains two (comprising one canopy species and one ground layer species). • HU981/PCT1767 Rough-barked Apple grassy tall woodlands of the Brigalow Belt South o Ruled out as a low number of characteristic species associated with this BVT/PCT occur in vegetation zone 11. Of the 11 characteristic species listed in the VIS Classification Database (OEH 2017), vegetation zone 11 contains two (comprising one canopy species and one ground layer species).
BC Act Status	This community is not consistent with any TEC listed under the BC Act.
EPBC Act Status	This vegetation zone is not consistent with any TEC listed under the EPBC Act.

3.2.1.12 Cleared Land and Non-native Vegetation

All other areas not mapped as part of a vegetation zone satisfied the definition of 'cleared land'. Cleared land is land on which the native overstorey has been completely removed and there is no native mid-storey, and less than 50 per cent of the ground cover vegetation is indigenous species, or less than 10 per cent of the ground cover is present (whether dead or alive). Areas mapped as disturbed land, including exotic rushland, mixed species revegetation plantation, water bodies, dwellings and roads are all considered to meet the definition of 'cleared land'.

It should be noted that whilst the mixed plantation areas included some native species, the majority of the dominant species in the upper stratum were not locally native, thus these areas could not be aligned to an appropriate BVT. One area of mixed plantation contained planted weeping myall (*Acacia pendula*). Approximately 40 individuals were observed in this area. They were mature plants (approx. 30 years old), planted in rows with the trunks still in the plastic trunk protecters used in planting (refer to **Section 3.3.2**). Despite the age of the individuals, no evidence of reproduction was observed.

3.2.2 Threatened Ecological Communities

Five of the vegetation zones described above and mapped within the Development Footprint conform to State and Commonwealth listed TECs, comprising:

BC Act

- Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions EEC
- Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions EEC

- Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions EEC
- White Box Yellow Box Blakely's Red Gum Woodland EEC.

<u>**EPBC Act**</u>

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

Detailed analysis of the vegetation zones with respect to the NSW Threatened Species Scientific Committee Final Determinations and/or the Commonwealth Threatened Species Scientific Committee Conservation/Listing Advice is provided below in **Sections 3.2.2.1** to **3.2.2.5**.

The remaining PCTs identified in the Development Footprint do not conform to any NSW or Commonwealth TEC listings. Other TECs considered, assessed and determined not to occur in the Development Footprint are summarised in **Section 3.2.2.6.**

3.2.2.1 Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions EEC under the BC Act

Zone 1 HU812 – Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good condition is considered to conform to the *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC. This vegetation zone conforms to the Final Determination of *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (NSW Scientific Committee 2011a) with regard to the following attributes:

- occurs on the floodplain rises along a tributary to the Hunter River within the Sydney Basin Bioregion
- occurs in the Muswellbrook Local Government Area (LGA), where it has previously been recorded
- supports a reasonable proportion of species that are in the list of characteristic species for the EEC:
  - 17 out of 86 (20 per cent) native species recorded in this vegetation zone are in the EEC listing and
  - 17 out of 37 (49 per cent) species in the characteristic species list for the EEC were recorded in this vegetation zone.

3.2.2.2 Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregion EEC under the BC Act

Zone 3 HU816/PCT1602 Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter – Moderate to Good Condition is considered to conform to the *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions EEC*. This vegetation zone conforms to the Final Determination of *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC (NSW Scientific Committee 2011) with regard to the following attributes:

- occurs in the NSW Sydney Basin Bioregion
- this EEC generally occurs on Permian sediments, however vegetation zone 3 occurs on the very edge of the Permian Singleton coal measures mapping and according to the soil studies by EMM (2018) there are no clearly Permian derived soils. The soils present within vegetation zone 3 are likely to be colluvial derived from Triassic Narrabeen group from the western geology influence. It is noted in the vegetation profile for the equivalent map unit in Peake (2006) that this community 'may occur on alluvial and colluvial soils'. As such the soils present within vegetation zone 3 do not preclude the EEC from occurring within the Development Footprint.

- this vegetation zone occurs in the Muswellbrook LGA where this EEC has previously been recorded
- this vegetation zone supports a canopy dominated by the characteristic species spotted gum (*Corymbia maculata*), with occurrences of grey box (*Eucalyptus moluccana*) and narrow-leaved ironbark (*Eucalyptus crebra*)
- this vegetation zone supports a reasonable proportion of species that are in the list of characteristic species for the EEC:
    - 20 out of 66 (30 per cent) native species recorded in this vegetation zone are characteristic species in the EEC listing and
    - 20 out of 44 (45 per cent) species in the characteristic species list for the EEC were recorded in this vegetation zone.

3.2.2.3 Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions EEC under the BC Act

Zone 4 HU817/1603 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter – Moderate to Good condition is considered to conform to the *Central Hunter Grey Box - Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC. This vegetation zone conforms to the Final Determination of *Central Hunter Grey Box - Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (NSW Scientific Committee 2011), due to the following factors:

- occurs in the NSW Sydney Basin Bioregion
- this EEC generally occurs on Permian sediments, however vegetation zone 4 occurs on the very edge of the Permian Singleton coal measures mapping and according to the soil studies by EMM (2018) there are no clearly Permian derived soils. The soils present within vegetation zone 4 are likely to be colluvial derived from Triassic Narrabeen group from the western geology influence. The final determination (NSW Scientific Committee 2011) states that this EEC generally occurs on Permian sediments, this reference does not preclude the EEC from occurring within the Development Footprint on colluvial soils derived from Triassic Narrabeen
- this vegetation zone occurs in the Muswellbrook LGA where this EEC has previously been recorded
- this vegetation zone supports a canopy dominated by the characteristic species narrow-leaved ironbark (*Eucalyptus crebra*), with occurrences of grey box (*Eucalyptus moluccana*) and rough-barked apple (*Angophora floribunda*), and
- this vegetation zone supports a reasonable proportion of species that are in the list of characteristic species for the EEC:
    - 30 out of 58 (52 per cent) native species recorded in this vegetation zone are characteristic species in the EEC listing, and
    - 30 out of 38 (79 per cent) species in the characteristic species list for the EEC were recorded in this vegetation zone.

3.2.2.4 White Box Yellow Box Blakely's Red Gum Woodland EEC under the BC Act

Two vegetation zones, Zone 2 HU812 – Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good – Derived Native Grassland (only the portions of this vegetation zone that are likely to have previously supported possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*)) and Zone 7 HU821– Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter – Moderate to Good condition, are consistent with the *White Box Yellow Box Blakelys Red Gum Woodland* EEC. These vegetation zones correspond with the Final Determination of *White Box Yellow Box Blakely's Red Gum Woodland* EEC (NSW Scientific Committee 2011) with regard to the following attributes:

- both vegetation zones occur within the NSW Sydney Basin Bioregion
- both vegetation zones either currently support (vegetation zone 7) or previously supported (vegetation zone 2) a canopy dominated by intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*). The final determination for this EEC specifically identifies that intergrades between these two red gum species may occur in the Hunter Valley
- both vegetation zones support a predominantly native understorey
- supports a reasonable proportion of species that are in the list of characteristic species for the EEC:

Zone 2

- 9 out of 30 (30 per cent) native species recorded in this vegetation zone are characteristic species in the EEC listing, and
- 9 out of 95 (10 per cent) species in the characteristic species list for the EEC were recorded in this vegetation zone.

Zone 7

- 13 out of 48 (27 per cent) native species recorded in this vegetation zone are characteristic species in the EEC listing, and
- 13 out of 95 (14 per cent) species in the characteristic species list for the EEC were recorded in this vegetation zone.

3.2.2.5 White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box Gum Woodland) CEEC

Within the central to upper Hunter Valley region, Blakelys red gum (*Eucalyptus blakelyi*) commonly intergrades or hybridises with forest red gum (*Eucalyptus tereticornis*). Eucalypt samples collected during the field surveys identified individuals to Blakelys red gum, forest red gum as well hybrids of the two red gum species (*Eucalyptus blakelyi × tereticornis*). Samples of possible intergrades or hybrids between Blakelys red gum (*Eucalyptus blakelyi*) and forest red gum (*Eucalyptus tereticornis*) were confirmed by the National Herbarium of NSW. This has implications for determining whether a patch of vegetation meets the Box Gum Woodland CEEC, as discussed further below.

The Box Gum Woodland CEEC previously excluded intergrades or hybrids from the Listing Advice, however this issue became less clear following a letter from the Commonwealth Threatened Species Scientific Committee in December 2010 (DSEWPC 2010) noting that intergrades or hybrids of eucalypt species are widely accepted and that "*The opinion of the TSSC is that the presence of natural hybrids of any taxa within any ecological community currently listed under the EPBC Act does not render the areas of the ecological community in which hybrids occur ineligible for protection"*.. By employing a precautionary approach, the vegetation communities listed below are considered to conform to the Box Gum Woodland CEEC.

Under the assumption that intergrades or hybrids of these species conform to the Box Gum Woodland CEEC, the vegetation in the Development Footprint where these species are common are considered to meet the Listing Advice of Box Gum Woodland CEEC in relation to the canopy criteria.

For this BAR a number of assumptions have been made in relation to the identification of Box Gum Woodland CEEC and include the following:

- it is taken that, in relation to the canopy requirements of the Listing Advice, 'dominance or prior dominance' means that either of the CEEC canopy species, or any combination of all three, would need to collectively comprise at least 50 per cent of the treed canopy cover across the patch (.
- extant woodland and forest vegetation has been assumed for this assessment to represent natural and historic proportions of overstorey eucalypt species.

Overall, each of the identified vegetation zones are consistent with the Box Gum Woodland CEEC for the following reasons:

- occur within the NSW Sydney Basin Bioregion as listed in the Commonwealth Listing Advice (TSSC 2006)
- the overstorey comprises, or prior to clearing would have comprised, one or more of the three characteristic species, including white box (*Eucalyptus albens*), yellow box (*Eucalyptus melliodora*), Blakelys red gum (*Eucalyptus blakelyi*) or their intergrades or hybrids, as the most common overstorey species
- each patch has a predominantly native understorey where at least 50 per cent of the perennial vegetation cover in the ground layer is made up of native species
- all patches are 0.1 ha or greater in size
- all patches contain at least one 'important species' (DEH 2006b). Common important species included *Cheilanthes distans*, *Glycine tabacina*, common everlasting (*Chrysocephalum apiculatum*) and yellow burr-daisy (*Calotis lappulacea*)
- the species composition is consistent with the Commonwealth Listing Advice (TSSC 2006) and associated species list (DEH 2006b), and
- all patches contained at least 12 native understorey species (excluding grasses).

Three vegetation zones mapped within the Development Footprint are consistent with the Box Gum Woodland CEEC, including:

- Zone 1 HU812 – Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good condition (only the portions of this vegetation zone that support possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*))
- Zone 2 HU812 – Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter – Moderate to Good – Derived Native Grassland (only the portions of this vegetation zone that are likely to have previously supported possible intergrades between forest red gum (*Eucalyptus tereticornis*) and Blakelys red gum (*Eucalyptus blakelyi*), and
- Zone 7 HU821– Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter – Moderate to Good Condition.

3.2.2.6 Other TECs Considered within the Development Footprint

Other TECs listed under the BC Act and/or EPBC Act that were considered, assessed and determined not to occur within the Development Footprint include:

BC Act

- Swamp Oak Floodplain Forest of the NSW North Coast Sydney Basin and South East Corner Bioregions

  While a swamp oak BVT occurs in the Development Footprint, this EEC does not occur. The Scientific Committee documents the EEC's occurrence as 'rarely above 10 metres elevation' however this BVT occurs at an approximate elevation of 150 metres in the Development Footprint. In addition, only two species listed in the Final Determination (45 species listed in total the Final Determination) occur within this community in the Development Footprint, being swamp oak (*Casuarina glauca*) and common couch (*Cynodon dactylon*).

EPBC Act

- Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland EEC

  While a swamp oak BVT occurs in the Development Footprint, this EEC does not occur. The MCCO Additional Project Area is at an elevation greater than 50 metres above sea level and as such no vegetation community can conform to the *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* EEC.

- Weeping Myall Woodland EEC

Four small patches of weeping myall (*Acacia pendula*) have been recorded in the MCCO Additional Project Area, outside the Development Footprint. The MCCO Project will not impact these patches of weeping myall and no areas of this EEC occur within the Development Footprint.

- Central Hunter Valley Eucalypt Forest and Woodland CEEC

The referral for the MCCO Project under the EPBC Act included discussion of the absence of this CEEC from the Development Footprint with a summary of the key reasons it was determined to be absent provided below. The controlled action decision for the MCCO Project did not list this CEEC as a reason for the controlled action finding, confirming its absence from the Development Footprint.

Central Hunter Valley Eucalypt Forest and Woodland CEEC occurs in the Hunter Valley region on soils derived from Permian sedimentary bedrock (TSSC 2015). One of the key diagnostic characteristics of the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* is its occurrence on soils derived from Permian aged sediments. To determine the soils and the likely age of the parent material they are derived from, a review of detailed soil landscape mapping undertaken as part of the MCCO Project (EMM 2018) and geological mapping was undertaken to determine whether Permian derived soils occur within the Development Footprint. The Development Footprint is situated on the edge of the Permian Singleton Coal Measures mapping with much of the surface geology being formed by the Triassic Narrabeen group (as determined both from regional geological mapping and from detailed geological investigations undertaken within the MCCO Additional Project Area). The detailed soil survey undertaken within the MCCO Additional Project Area (EMM 2018) found that the soils have mostly been derived from the Triassic Narrabeen group. The Sodosol and Tenosol soils found in the MCCO Additional Project Area generally support the soil landscape mapping done by Kovac and Lawrie (1991) Soil Landscapes of the Singleton 1:250,000 sheet (with some localised boundary readjustments). The alluvial influence along Wybong Creek and Big Flat Creek has also played a part in the soil formation in the MCCO Additional Project Area, with alluvial derived soils in the southern portion of the MCCO Additional Project Area and some alluvial influence further on the flats (EMM 2018).

The soil assessment concluded that there are no clearly Permian derived soils on site.

In summary, the soil and geological investigations identified the absence of the necessary Permian derived soils in areas with floristic potential to be part of the Central Hunter Valley Eucalypt Forest and Woodland CEEC and the CEEC was found to be absent from the Development Footprint.

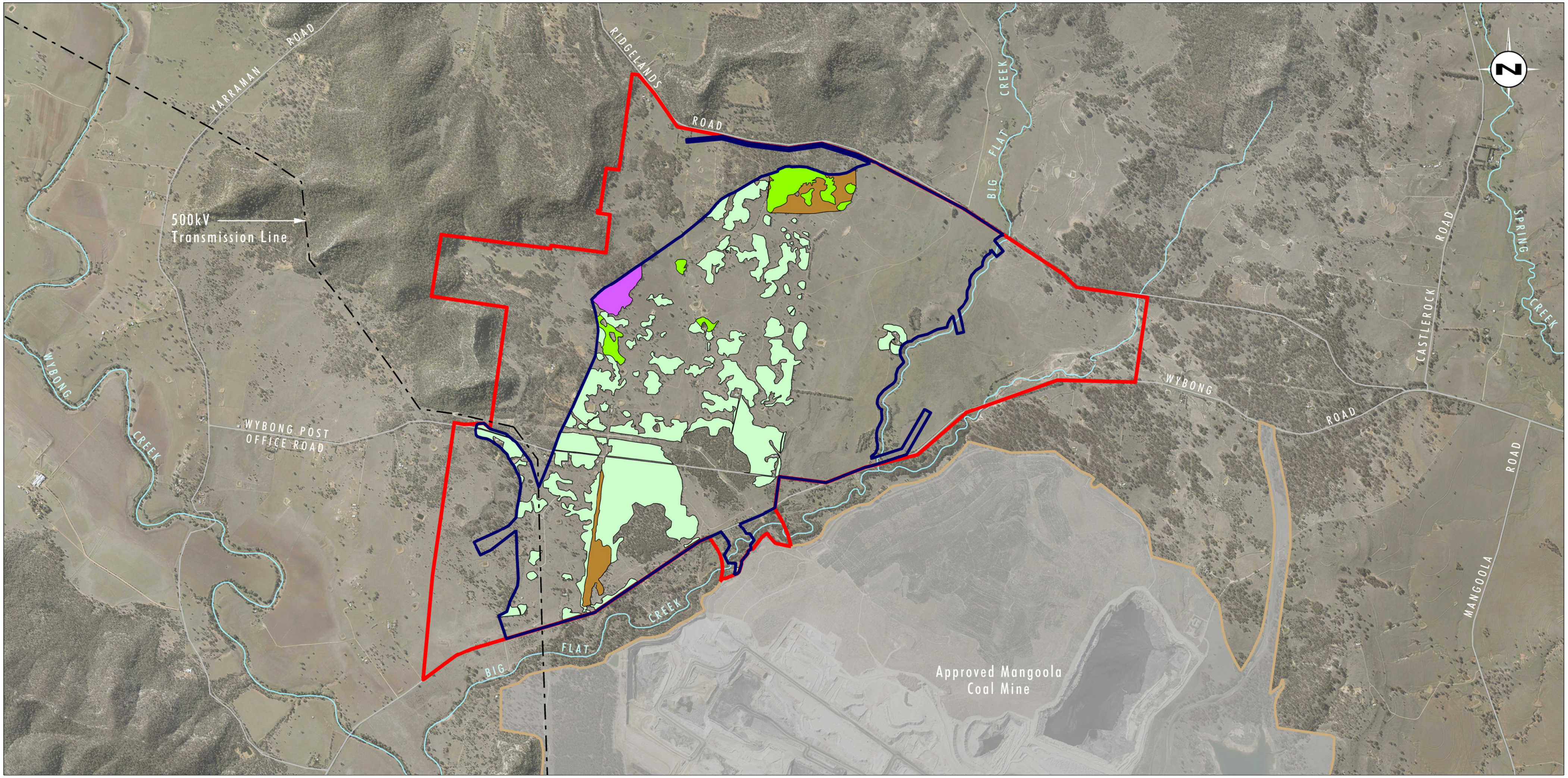

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Central Hunter Grey Box-Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions
- Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions
- Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions
- White Box Yellow Box Blakely's Red Gum Woodland

FIGURE 3.3

BC Act Listed Threatened Ecological Communities in the Development Footprint

File Name (A4): R12/3450_053.dgn
20190418 15.40

3.3 Threatened Species within the Development Footprint

3.3.1 Ecosystem-credit Species

Eight ecosystem-credit species have been recorded in the Development Footprint. These include:

- glossy black-cockatoo (*Calyptorhynchus lathami*)
- grey-crowned babbler (*Pomatostomus temporalis temporalis*)
- little lorikeet (*Glossopsitta pusilla*)
- speckled warbler (*Chthonicola sagittata*)
- varied sittella (*Daphoenositta chrysoptera*)
- squirrel glider (*Petaurus norfolcensis*)
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)
- southern myotis (*Myotis macropus*) (foraging habitat).

The BBCC predicts ecosystem-credits species and the Threatened Species Offset Multiplier of these species is used to determine the credits generated by the PCTs. The predicted species list produced by the BBCC for the MCCO Project is presented in **Appendix A**.

3.3.2 Species-credit Species

Four species-credit species were recorded within the MCCO Additional Project Area (refer to **Figure 3.4**). The species were:

- Pine donkey orchid (*Diuris tricolor*) – 1326 individuals
- Tarengo leek orchid (*Prasophyllum petilum*) – 691 individuals
- Southern myotis (*Myotis macropus*) – breeding habitat - 0.9 ha
- Large-eared pied bat (*Chalinolobus dwyeri*) – breeding habitat – 2.1 ha.

Please note that the 691 individuals of the Tarengo Leek Orchid documented above represents 634 individuals that have been recorded in the Development Footprint and 57 individuals extrapolated to occur in an area of habitat approximately 13 ha in size. Survey timing restrictions prevented formal transects being walked across the entirety of the small area of potential habitat. Instead, a single transect was walked the potential habitat area and individuals were counted from 5m on either side. Using the observed density along the single transect and the results of the Expert Report (Bell 2018) (refer to **Section 7.6**), a density of 4 plants per hectare was used to determine the final number of individuals in that area. The density estimate used to extrapolate the number of individuals in the this area of potential habitat is the upper limit of density estimates provide by Dr Stephen Bell in his Expert Report for this species and double the density used by Bell to determine the number of individuals occurring in the adjoining Mangoola Offset site.

The Development Footprint includes formerly privately owned properties and some of these properties have planted privacy screens, windrows and driveway edges which contain mixes of native and exotic tree species. Two species listed under the BC Act as forming endangered populations in the Hunter Catchment, river red gum (*Eucalyptus* camaldulensis) and weeping myall (*Acacia pendula*), were observed as planted in select areas.

River Red Gum (*Eucalyptus camaldulensis*)

Planted river red gums (*Eucalyptus camaldulensis*) were identified at two adjoining properties proximate to dwellings. At each property, the river red gums occurred in a evenly aged (young) stand of mixed eucalypts and bulloak (*Allocasuarina luehmannii*) and most of the individuals observed were connected to a separate tree species at the base (usually *Eucalyptus crebra* or Allo*casuarina luehmannii)* (refer to **Plate 3.1**). On one occasion, the river red gum was observed growing out of a 44 gallon drum. Other species planted in the area included sugar gum (*Eucalyptus cladocalyx*) and mugga ironbark (*Eucalyptus sideroxylon).*

Plate 3.1 Evidence of planted river red gums (*Eucalyptus camaldulensis*)

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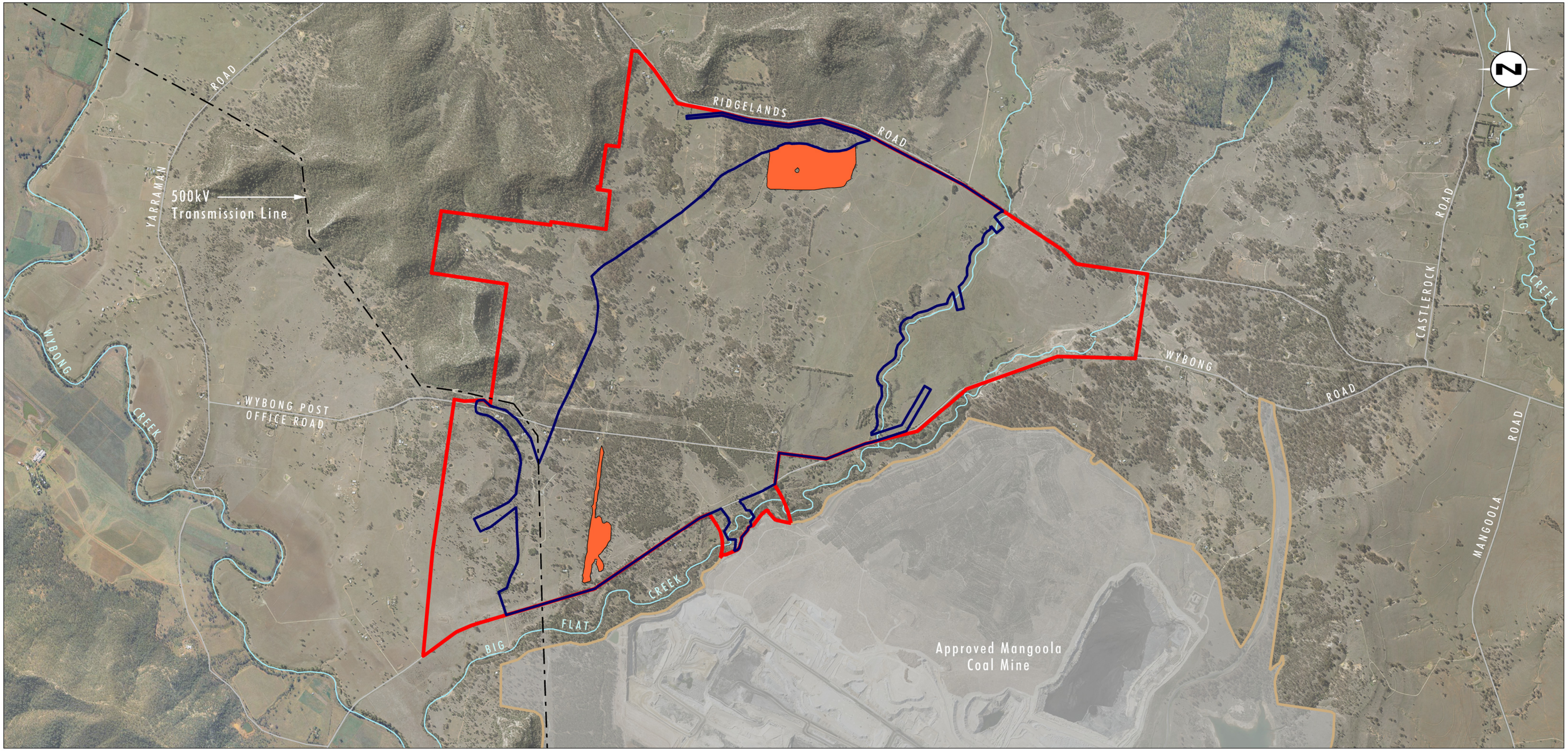

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 1.5km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- White Box Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland

FIGURE 3.4

EPBC Act listed Threatened Ecological Communities in the Development Footprint

File Name (A4): R12/3450_073.dgn
20190418 15.44

Under the BC Act, river red gums occurring within the Hunter Catchment represent an endangered population *(Eucalyptus camaldulensis* population in the Hunter catchment). The final determination (TSSC 2005) does not discuss the treatment of planted individuals within the catchment however it could be considered that planted individuals (of local provenance) occurring within the appropriate habitat types, being "*major floodplains of the Hunter and Goulburn rivers, especially in areas where water impoundment occurs after flood* " would be considered to form part of the endangered population.

The locations of the individuals within the development footprint are not in a major floodplain of the Hunter or Goulburn Rivers, occurring approximately 700 metres to the north of Big Flat Creek which is a fourth order (Strahler) stream. Big Flat Creek flows into Wybong Creek to the west of the Development Footprint and Wybong Creek adjoins the Goulburn River approximately eight kilometres south of the confluence with Big Flat Creek. The location is approximately 10 metres higher in elevation than the upper banks of Big Flat Creek. The planted river red gums are also located outside the extent of the existing 1 in 100 year and 1 in 1000 year flooding model (HEC 2019) and as such these plants would not be subjected to the regular inundation required for regular propagation.

In addition to this, as the individuals are clearly planted, there remains substantial uncertainty around the provenance of the plants. There is sufficeient morphological variation (glaucous leaf colourations) and secondary evidence (planted with non-local species) among the plants occuring within the Development Footprint to suggest that they are not all from the same provenance and not from the Hunter Catchment population. The final determination documents that the Hunter Catchment endangered population may be "genetically distinct" from the western populations and that planted individuals coming from non-local provenance "*may produce a threat to the genetic integrity of the Hunter Catchment population*".

Based on the above, the river red gum individuals occurring within the Development Footprint are not considered to form part of the *Eucalyptus camaldulensis* population in the Hunter catchment endangered population and credits have not been generated for this species.

Weeping Myall (*Acacia pendula*)

Approximately 40 individual weeping myall (*Acacia pendula*) were observed within a mixed species regeneration plantation. They were mature plants (approx. 30 years old), planted in rows with the trunks still in the plastic trunk protecters used in planting (refer to **Plate 3.2**). Despite the age of the individuals, no evidence of reproduction was observed.

Plate 3.2 Example of Planted Weeping Myall (*Acacia pendula*)

The weeping myall observed in the Disturbance Footprint has been planted with various non-local species to form a plantation. The plantation does not form a recognisable vegetation assemblage or BVT nor does it present any conservation value as a stand of apparentliy sterile mature plants. As such, the weeping myall individuals occurring within the Development Footprint are not considered to form part of the Acacia pendula population in the Hunter catchment t endangered population and credits have not been generated for this species.

No other species-credit species have been assessed as occurring within the Development Footprint. **Appendix A** outlines the species-credit species identified in the literature review and BBCC that were not considered likely to occur due to lack of suitable habitat and/or absence of local records and therefore did not warrant further assessment as per Section 6.5.1.6 of the FBA (OEH 2014b).

3.3.2.1 Species Habitat Polygons

Species habitat polygons have been prepared for all the species-credit species (or their habitats) recorded within the Development Footprint (refer to **Figure 3.5** to **3.7**).

Large-eared pied bat (*Chalinolobus dwyeri*)

No roosting habitat for this cave roosting species is present within the Development Footprint. However, several areas outside of but within 500 metres of the Development Footprint contain rocky habitat and potentially suitable breeding habitat may occur. A total of 2.1 ha of woodland/open forest habitat within 500 metres of potential breeding for this species has been mapped as breeding habitat (refer to **Figure 3.5**).

Pine donkey orchid (*Diuris tricolor*)

The 1326 individuals have been buffered by 30 metres and merged where touching to create the polygon for this species (refer to **Figure 3.6**). This species has been entered into the BBCC using count data and as such the species polygon is shown for presentation purposes and does not reflect an area of habitat.

Tarengo leek orchid (*Prasophyllum petilum*)

The 13 ha extrapolated area has been shown and the 634 individuals have been buffered by 30 metres and merged where touching to form the polygon for this species (refer to **Figure 3.7**). This species has been entered into the BBCC using count data and as such the species polygon is shown for presentation purposes and does not reflect an area of habitat.

Southern myotis (*Myotis macropus*)

Any area of woodland or forest within 200 metres of a permanent water body and that contains tree hollows may provide breeding habitat for this species. All woodland and forest vegetation containing hollow bearing trees within 200 metres either side of the sections of Big Flat Creek with permanent water, were mapped as potential breeding habitat for this species within the Development Footprint. A total of 0.9 ha of potential breeding habitat, which occurs within the 200 metre creekline buffer, has been mapped for this species within the Development Footprint.

The species polygon for southern myotis was prepared:

- using satellite imagery dated April 2018
- using the unit of measurement identified for the species in the Archived Threatened Species Profile Database (OEH 2018b)
- using guidance material published for the UHSA – Guidelines for Assessing Southern Myotis Breeding Habitat (OEH 2016).

The species polygon for southern myotis is shown on **Figure 3.5.**

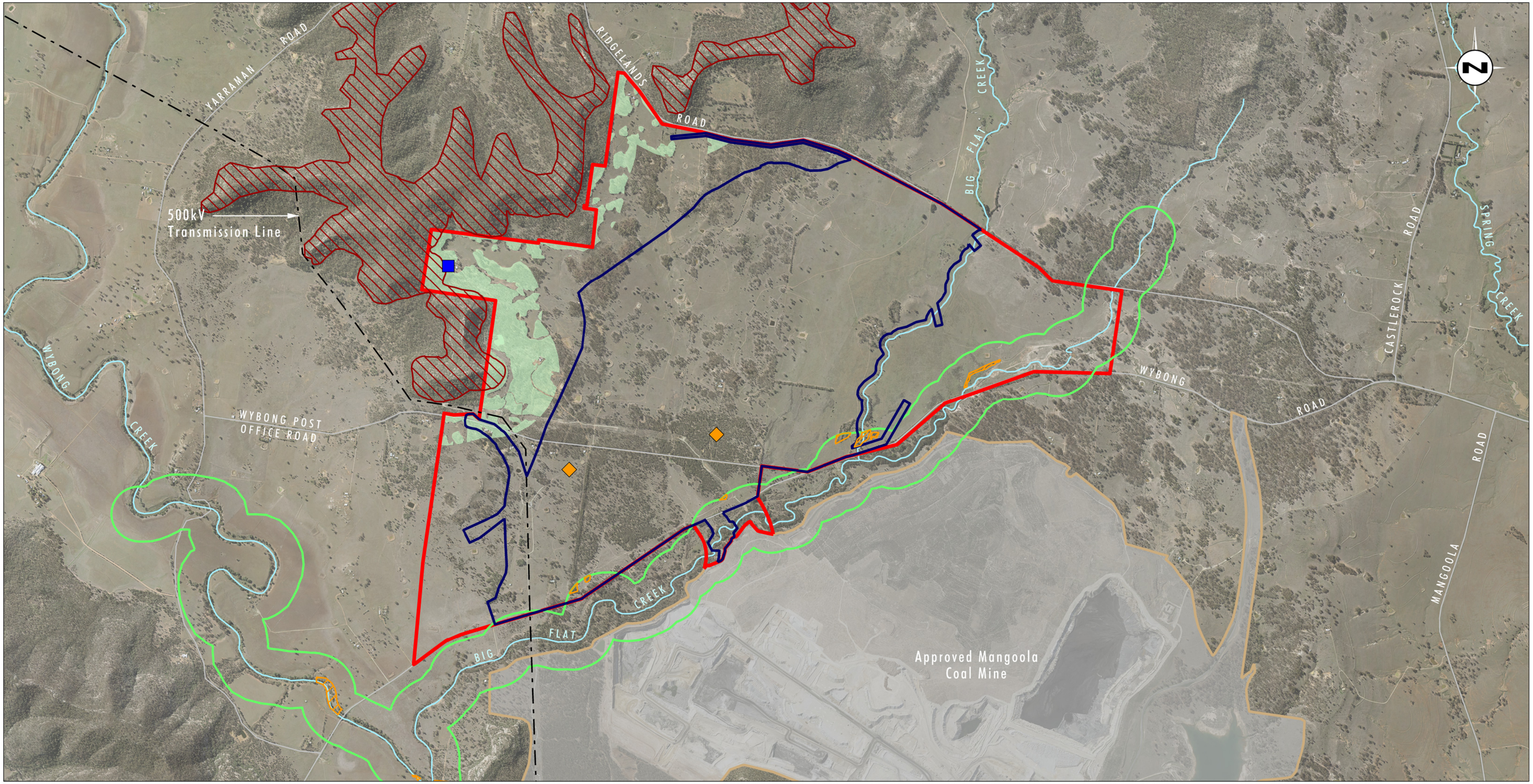

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Large-footed Myotis 200m Buffer
- Brush-tailed Rock-wallaby Potential Habitat
- Large-footed Myotis Potential Breeding Habitat
- Large-eared Pied Bat Potential Breeding Habitat
- Brush-tailed Rock-wallaby Scat Record
- Southern Myotis Echolocation Records

FIGURE 3.5

Species-credit Fauna Species Location

File Name (A4): R12/3450_057.dgn
20190418 15.42

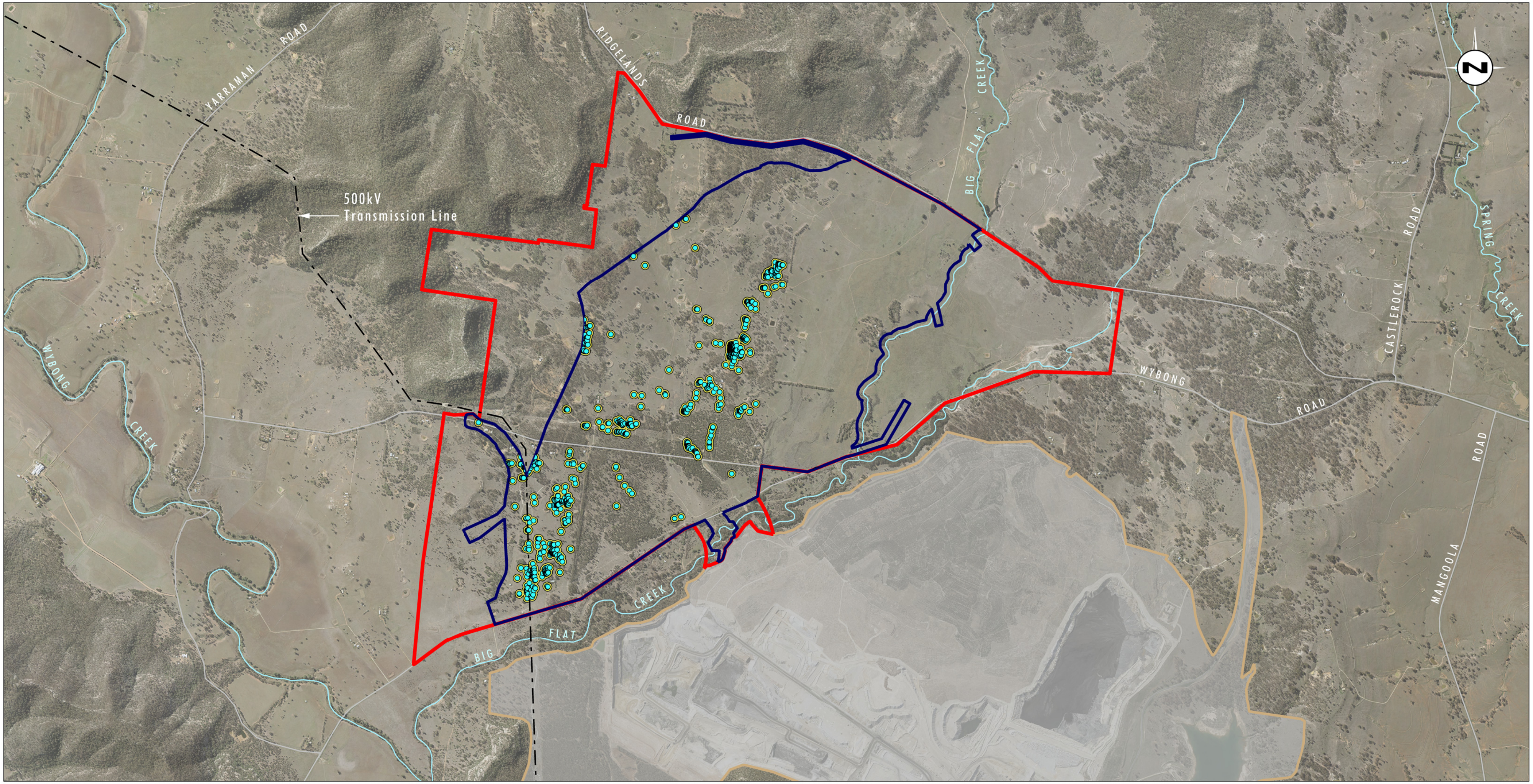

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Pine Donkey Orchid (*Diuris tricolor*) Locations
- Pine Donkey Orchid (*Diuris tricolor*) Species Polygon

FIGURE 3.6

Pine Donkey Orchid (*Diuris tricolor*) Locations and Species Polygons

File Name (A4): R12/3450_054.dgn
20190418 15.41

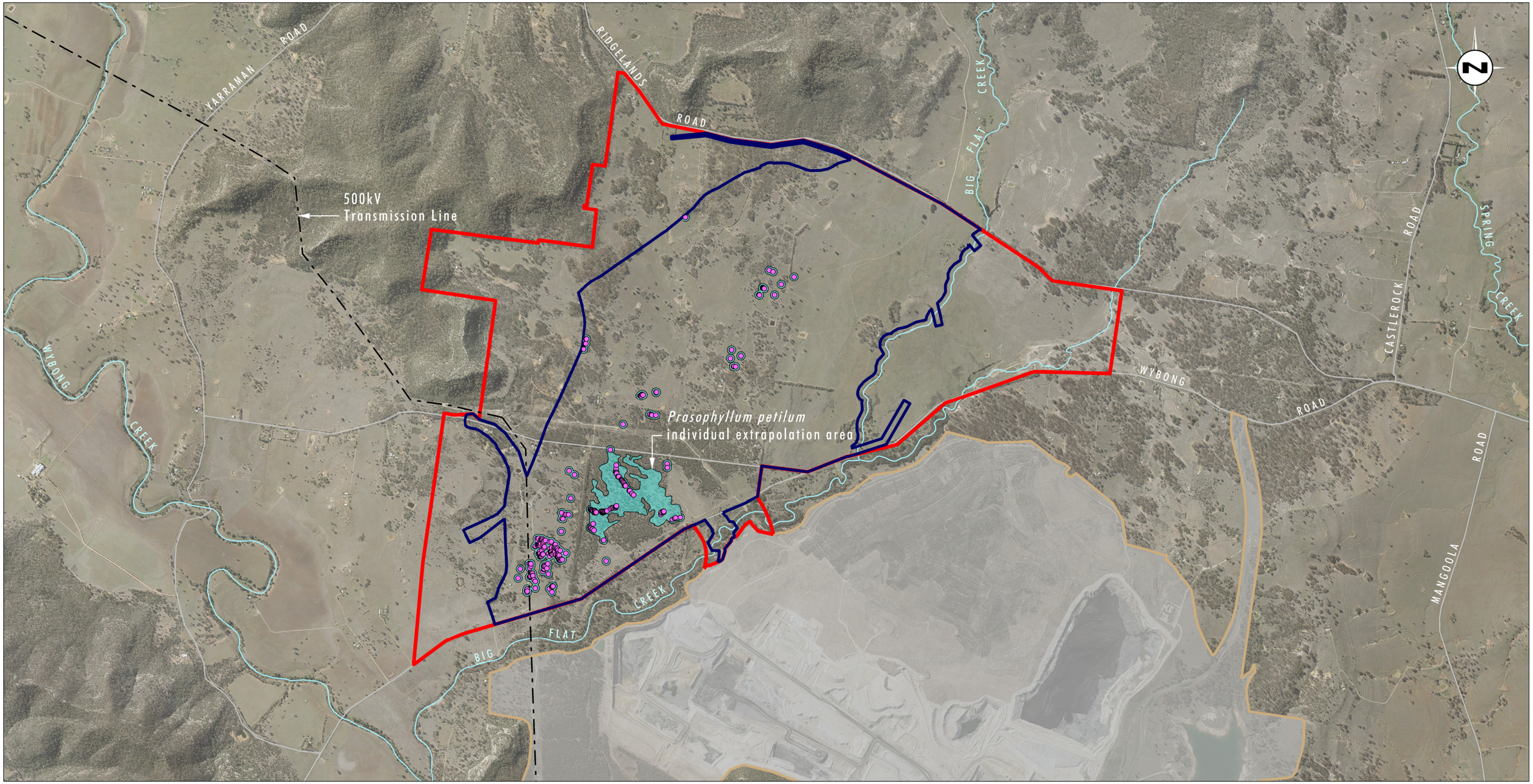

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Tarengo Leek Orchid (*Prasophyllum petilum*) Locations
- Tarengo Leek Orchid (*Prasophyllum petilum*) Species Polygon

FIGURE 3.7

Tarengo Leek Orchid (*Prasophyllum petilum*) Locations and Species Polygons

File Name (A4): R12/3450_055.dgn
20190418 15.42

4 Avoidance and Minimisation of Impacts

4.1 Avoidance and Minimisation Measures

Mangoola has sought and will continue to seek opportunities during the detailed design process to avoid and minimise impacts to biodiversity values, following the established hierarchy of avoid, minimise, mitigate and offset. Measures that have been taken to minimise impacts to vegetation arising from the MCCO Project are discussed further below.

Where impacts are unavoidable the residual impact of the MCCO Project will be offset following the NSW Biodiversity Offsets Policy for Major Projects which utilises the FBA (refer to **Section 6**).

Project Changes to Avoid and Minimise Impacts

Mangoola undertook a detailed biodiversity constraints study as part of the MCCO Project's pre-feasibility assessment to guide the development and detailed design of the MCCO Project. Through this process, alternative mining options were considered and Mangoola has sought to minimise the biodiversity impacts associated with the MCCO Project whilst maximising the economic resource recovery.

The proposed integration of the two open cut mining areas provides significant resource recovery and mining efficiency advantages, positive commercial outcomes, improved final landform outcomes and minimises environmental and social impacts to below those of other options considered, and was therefore identified as the preferred project over the other options assessed.

Avoidance of Impacts

Through the iterative design process and the modifications made to the project design, the potential biodiversity impacts of the MCCO Project have been significantly reduced. In total the changes to the physical components of the MCCO Project have resulted in an overall reduction of 401 ha to the total MCCO Additional Disturbance Area.

Due to selecting the preferred option and not proceeding with the alternative mining options and infrastructure locations, the MCCO Project was able to avoid key impacts through the reduced surface disturbance footprint and extent of proposed operations. A summary of the key physical impacts that have been avoided are provided in **Table 4.1**. In addition to these avoided physical impacts there have also been significant reductions in predicted impacts of noise and dust emissions on private receivers by deciding not to proceed with some of the alternative mine plan options.

Table 4.1 Physical Impact Reduction

Alternative MCCO Project Option	Number of Threatened Species Avoided (Individuals)	Threatened Ecological Community Avoided (ha)	Archaeological Sites Avoided	Disturbance Area Reduction (ha)
Avoided Impacts				
Additional Eastern Mining Area	76	1.8	nil	16.6
Additional Out of Pit Overburden Emplacement	56	5.7	2	74.6
Alternative Ridgelands Road Realignment	60	0.4	nil	7

Alternative MCCO Project Option	Number of Threatened Species Avoided (Individuals)	Threatened Ecological Community Avoided (ha)	Archaeological Sites Avoided	Disturbance Area Reduction (ha)
Alternative 500kV Transmission line Realignment	632	1.1	nil	33.4
Wybong Post Office Road Realignment Location	178	3.2	1	12.8
Proposed Wybong Road/Big Flat Creek Overpass Location	26	1	8	7.8
Clean Water Diversion Drains Removed	99	12.5	1	23.5
TOTAL AVOIDED IMPACTS	**1027**	**25.7**	**11**	**175.7**
Not Selected				
Additional Western Mining Area	3140	38.8	8	245.8
TOTAL NOT SELECTED	**3140**	**38.8**	**8**	**245.8**

These detailed design works are ongoing and Mangoola Coal will continue to investigate opportunities to minimise impacts as part of the ongoing design work for the MCCO Project.

The majority of the MCCO Additional Project Area comprises heavily modified vegetation in the form of grazed derived native grasslands and the MCCO Project largely avoids the highest quality remnant forest and woodland occurring on the slopes within the MCCO Additional Project Area (refer to **Figure 4.1**). Furthermore, these higher quality remnant forest and woodland areas avoided by the MCCO Project have been included in the biodiversity offsetting strategy (refer to **Section 7.0**).

4.2 Mitigation Measures

Mangoola has an existing approved NSW Biodiversity and Offset Management Plan and Strategy (BOMPS) which provides guidance for minimising the impacts of its operations on biodiversity. This existing plan will be updated in line with the NSW and Commonwealth requirements to include the MCCO Project and be applied to the new activities associated with the MCCO Project to mitigate adverse biodiversity impacts during construction and operation. This will include specific measures to manage potential impacts on fauna species in the MCCO Additional Project Area during vegetation clearing. Mitigation measures currently in place will continue to apply to the MCCO Project and will include (but not be limited to) measures that address the following direct and potential indirect impacts:

- vegetation and habitat clearing protocols
- weed control
- sediment and erosion control
- dust and noise impacts
- pathogen management.

4.3 Direct Impacts Unable to be Avoided

The development of the MCCO Project will result in direct impacts on biodiversity values within the Development Footprint. Direct impacts include the loss of native vegetation and fauna habitats as a result of clearance works and subsequent mining activity.

Table 4.2 below outlines these impacts as they were entered into the BBCC, which totals approximately 570 ha of direct impacts to native vegetation communities.

Avoidance and mitigation measures associated with minimising the impacts of these direct impacts are discussed in **Section 4.1** above.

Table 4.2 Direct Impacts of the MCCO Project on Native Biodiversity Features

Ecological Feature	Area within the Development Footprint (ha)
Biometric Vegetation Type	
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter – Moderate to Good	14.67
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter – Moderate to Good - Derived Native Grassland	15.24
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter – Moderate to Good	6.30
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Moderate to Good	135.21
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Moderate to Good – Derived Native Grassland	197.49
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Low Condition	160.04
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	6.46
HU906 Bull Oak grassy woodland of the central Hunter Valley – Moderate to Good	30.76
HU906 Bull Oak grassy woodland of the central Hunter Valley – Moderate to Good – Derived Native Grassland	1.64
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Moderate to Good	2.57
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Moderate to Good	0.38
Total	**570.76**

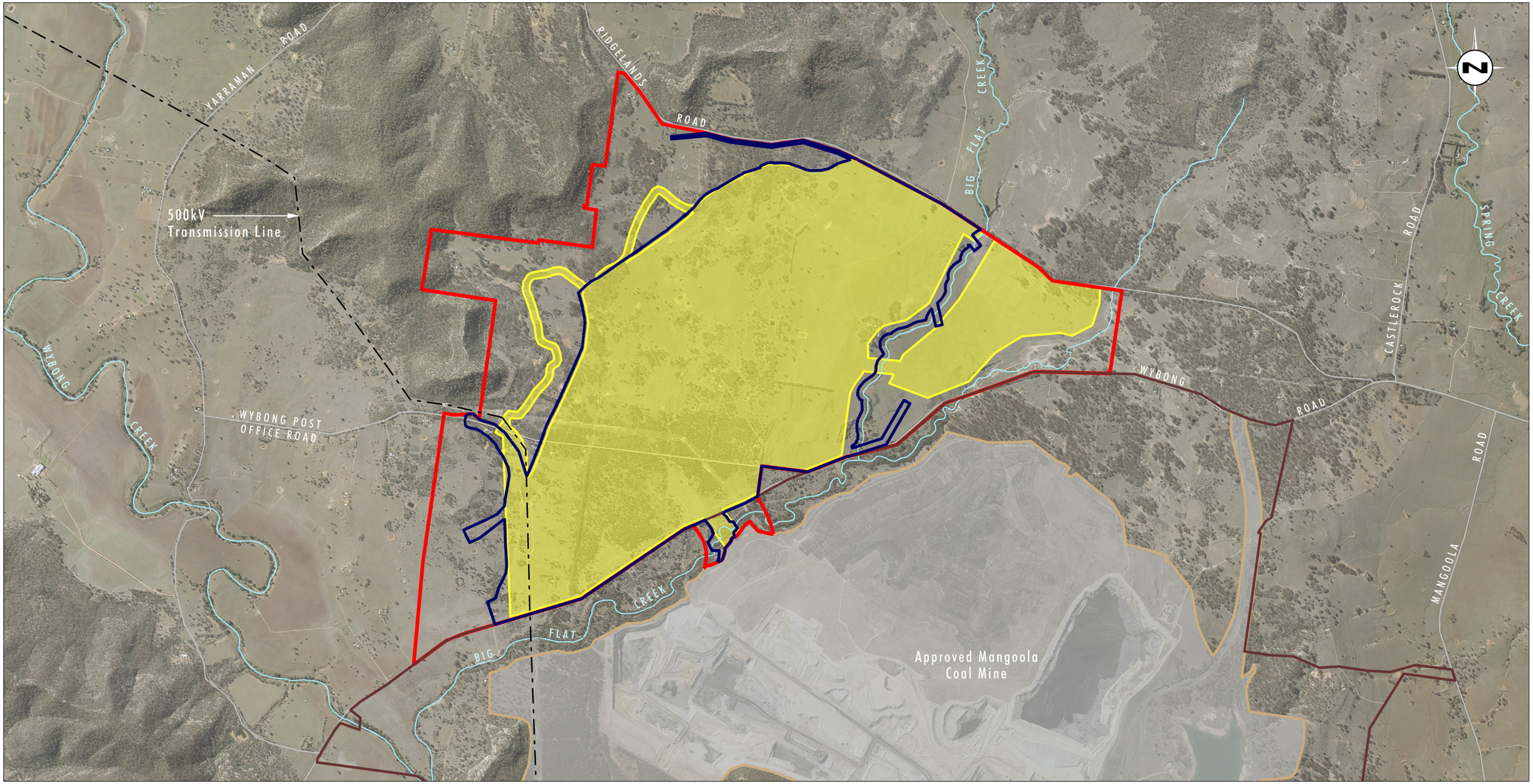

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

Legend
- MCCO Additional Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- Preliminary Development Footprint

FIGURE 4.1

Final and Preliminary Development Footprint

File Name (A4): R12/3450_067.dgn
20190418 15.44

4.4 Assessment of Indirect Impacts on Biodiversity

As required by Section 8.4 of the FBA, this section documents the potential indirect impacts of the MCCO Project on biodiversity values and documents the onsite measures to be implemented to minimise indirect impacts on biodiversity values. Whilst indirect impacts are difficult to quantify and how they affect biodiversity values or ecological processes is often complex, the following sub-sections outline a list of potential impacts and an appropriate mitigation strategy for the MCCO Project.

The MCCO Project is not expected to result in any substantial indirect impacts on the biodiversity values of surrounding lands. However, some minor indirect impacts associated with habitat connectivity, fugitive light emissions, dust, noise, groundwater changes, weeds and feral animals may occur during the MCCO Project. This is further discussed in the sections below in accordance with Section 8.4 of the FBA (OEH 2014b). Impacts to groundwater are discussed in **Section 5.6.2**.

4.4.1 Connectivity and Corridors

To an extent, the potential loss of local and regional connectivity is already factored in to the credit calculation used as part of the FBA process in that the Assessment Circle and associated Landscape Value Scores take into account the pre- and post-clearing percentage of native vegetation cover (excluding the proposed post-mine rehabilitation). It is unlikely that any further indirect impact through reduced connectivity and loss of corridors would be of any significant level. Additionally, future mine rehabilitation of the Development Footprint will re-instate connectivity at a local and regional scale in the medium to long-term.

The removal of native vegetation from within the Development Footprint could affect the ability of some local fauna species to move throughout the landscape by removing patches of native vegetation that provide a fragmented ‘stepping-stone’ corridor in a highly disturbed landscape. Isolated or fragmented areas of suitable habitat for species provide short to medium term refuges (or ‘stepping stones’ for species as they move from one area of habitat to another, travelling across unsuitable habitat areas between the ‘stepping stones’) for species as they disperse, migrate or move throughout the landscape. The loss of ‘stepping stone’ habitat areas for some species could result in an increased level of isolation of populations where species are unable or unwilling to travel across the increased distance between habitat areas.

A potential corridor of fauna movement (comprising fragmented remnant woodland and existing rehabilitation patches) currently exists between the southern portion of the Development Footprint linking woodland and forest habitats to the south with those in the east. The proposed crossing of Big Flat Creek and Wybong Road proposed as part of the MCCO Project may reduce the dispersal, migration and movement ability of some fauna species using these riparian habitats within the local area. During the planning phase for the MCCO Project it was identified that an access corridor would be required across Big Flat Creek and Wybong Road to link the two operational areas. The location where this access corridor is required includes approximately 12 ha of the originally proposed biodiversity and cultural heritage offset areas. This portion of the former offset area has been excised from the Conservation Agreements that are currently being formalised with the NSW Government.

The proposed crossing will consist of three large (3m) culverts which could allow for some movement of terrestrial fauna species such as macropods and rodents, however, it is noted that due to the size of the formation required to construct the crossing, these culverts will be quite long and it is unlikely that much, if any, movement would be facilitated. The crossing will not pose any substantial risk to flying fauna such as birds and bats. Vegetation either side of the crossing will remain intact and the crossing will be removed and rehabilitated post mining to reinstate the vegetation connection along Big Flat Creek. The crossing will remain in place for the life of the MCCO Project (that is, until approximately 2030) and will be removed after that time. Importantly, the main function of the corridor, which is to maintain gene flow across the landscape (not just species movement) is unlikely to be affected in the short or medium term while the overpass exists or in the long-term after the mining has ceased and the vegetated connection along Big Flat Creek is re-established.

4.4.2 Fugitive Light Emissions

Fugitive light emissions resulting from the MCCO Project may result in adverse impacts on adjacent habitats and, particularly nocturnal birds and bats. Behavioural changes in animals can occur in response to the physical presence of a development and include changes in foraging locations and mating behaviour (Gleeson and Gleeson 2012). This may lead to changes in species composition in the landscape, with these impacts resulting from impacts such as fugitive lighting, noise and vibration impacts. Research into the impacts of altered lighting indicates that it can trigger behavioural and physiological responses including changes in foraging behaviour, disruptions of seasonal day length trigger cues for critical behaviour, disorientation and temporary blindness and interference with predator prey relationships (OEH 2016). As per existing site practice, appropriate lighting controls to minimise impacts will continue to be implemented as part of the MCCO Project including minimisation of fugitive lighting emissions following Australian Standards. There will be no substantial change to fugitive light emission impacts on the surrounding fauna habitat given that the proposed mine operation is already is part of, and adjacent to, existing mining operations with existing lighting impacts.

4.4.3 Noise and Blasting Impacts

Noise impacts have the potential to adversely impact native species. Potential impacts include:

- noise disturbing the roosting and foraging behaviour of fauna species
- noise reducing the occupancy of areas of otherwise suitable habitat.

Noise impacts can affect fauna physiology and behaviour, particularly by causing disruption to communication including mating calls, territorial calls and alarm calls (OEH 2016). Blasting overpressure and vibration has the potential to disturb routine activities of fauna, particularly birds and bats, including disrupting breeding cycles and behaviour patterns (OEH 2016).

There will be no substantial change to noise impacts on fauna given that the proposed mine operation is part of, and adjacent to, an already existing operation with existing impacts. The same applies to vibration with the vibration impacts broadly consistent with the blasting impacts from the existing mining operations.

Any additional impacts resulting from noise emissions are not expected to be substantial for threatened species, populations and communities.

4.4.4 Air Quality Impacts

Air quality impacts have the potential to adversely impact native species from dust generating activities during ground disturbing works, including blasting, fumes (NOx emissions) from blasting and diesel exhaust emission from the operation of machinery. Potential impacts include dust covering vegetation thereby potentially reducing vegetation health and growth and increased air pollutants for native species (flora and fauna) making them more susceptible to environmental stresses.

The design of the MCCO Project will include inherent measures to minimise the potential for adverse air quality impacts. These include:

- progressive rehabilitation and stabilisation of disturbed land
- dust suppression on haul roads and other operational areas to reduce vehicle generated dust emissions
- a range of other dust control measures.

In regard to potential impacts on biodiversity, there will be no substantial change to air quality impacts given that the proposed mine is part of, and adjacent to, an already existing operation with existing impacts.

Any additional impacts resulting from dust are not expected to be of any level of significance in relation to threatened species, populations and communities.

4.4.5 Weed and Feral Animal Encroachment

Weed species could be inadvertently brought into the Development Footprint with imported materials, or could invade naturally through removal of native vegetation. The presence of weed species within the Development Footprint has the potential to decrease the value of extant vegetation to native species, particularly threatened species. Mitigation measures will be outlined in the updated Mangoola BOMPS (refer to **Section 4.2**) will be implemented to minimise the potential for weed encroachment into areas surrounding the Development Footprint. Populations of feral fauna species such as foxes, rabbits, pigs, deer, dogs and cats can increase and quickly populate new areas as a result of disturbance. Clearing, thinning of vegetation and the creation of tracks have the ability to assist the establishment and spread of feral fauna species. There will be no substantial change to impacts from weeds or feral animals, given that the proposed mine is part of, and adjacent to, an existing operation with existing impacts. Any additional impacts resulting from weeds or feral animals are not expected to be of any level of significance in relation to threatened species, populations and communities.

4.4.6 Cumulative habitat loss and vegetation clearance impacts on agricultural and mining areas of the Hunter Valley

The Development Footprint is situated in a landscape that is characterised by agricultural land and mining land. The history of land clearing, agriculture and mining development has resulted in an incremental loss of vegetation and fauna habitat surrounding the Development Footprint, and within the upper Hunter Valley more generally. The MCCO Project will result in a loss of approximately 570 ha of native woodland and forest vegetation.

It is recognised that the MCCO Project will remove vegetation and further increase fragmentation and isolation of habitats, and thus contribute to cumulative habitat loss and vegetation clearance in the locality. To address these impacts, an extensive mitigation and offsetting strategy is proposed including the provision of:

- the delineation of clearance areas to avoid unnecessary impacts and clearance of surrounding vegetation
- habitat enhancement measures such as the installation of nest boxes, salvaged hollows, fallen timber, hollow logs and rocks to supplement mine rehabilitation areas
- rehabilitation of the Development Footprint post mining as described in the EIS, and
- the implementation of a biodiversity offset strategy in accordance with the FBA, including local biodiversity offsets which include habitat regeneration areas.

4.4.7 Mitigation and Onsite Management of Indirect Impacts

Section 8.4.1.4 (f) of the FBA relates to onsite avoidance and minimisation measures required for consideration for impacts related to the operational phase of the MCCO Project. **Section 4.2** outlines the mitigation measures proposed for the MCCO Project for direct and indirect impacts including:

- implementation of clearing procedures to minimise the impacts of the clearing process and maximise the recovery of any valuable biodiversity resources (e.g. seed collection, re-use of hollow logs and hollows where appropriate)
- feral animal and noxious weed control
- fencing and access control
- management of domestic stock
- bushfire management
- water management systems that seek to minimise the potential for damage to flora and fauna and their habitats from erosion and unnatural flooding events
- control systems to minimise noise, dust, lighting and blasting impacts
- employee education and training.

Should the MCCO Project be approved, Mangoola will update the existing BOMPS in accordance with any relevant state and Commonwealth approval requirements. The MCCO Project-specific biodiversity management will guide the implementation of the mitigation steps, which are addressed in the following sections. The outcomes of biodiversity monitoring (see below) will also be used to provide for the management plan to be reviewed and adapted in response to new information.

As outlined in Section 4.2 of the FBA report, monitoring is a tool that can be used to assess and inform the ongoing improvement of management actions. The effectiveness and long-term success of mitigation actions will be evaluated against key outcomes, which necessitate regular and appropriately targeted monitoring. This will be achieved by using formal monitoring programs and due diligence assessments that periodically examine measurable changes over time and provide information on impacts and the success or otherwise of mitigation actions. The frequency and level of monitoring will be dependent on the environmental features to be assessed. The techniques proposed to be used will be documented in the proposed BOMPS and will be systematic and repeatable.

5 Impact Summary

5.1 Impacts Not Requiring Further Assessment

The Development Footprint contains approximately 53 ha of cleared land/non-native vegetation (refer to **Section 3.2.1.12**) that will be removed as a result of the MCCO Project that does not meet the definition of 'native vegetation' under the Local Land Services Act 2016 and therefore does not require further assessment in accordance with the FBA. This includes dams, roads, cleared access tracks and areas exotic vegetation.

5.2 Impacts Not Requiring Offset

Impacts on native vegetation not requiring offsets under the FBA include native vegetation that has a site value score of less than 17 and are not identified as an endangered or critically endangered ecological community, and/or associated with threatened species habitat (as represented by ecosystem credits). Six plots/transects were completed across multiple years and seasons (April 2014, April and July 2017) in Zone 6 – HU817/1603 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter – Low Condition – Derived Native Grassland with the site value achieved across the zone being 16.67, which is below the site value score of 17 that is required to generate an offset credit requirement under FBA. This grassland covers an area of approximately 160 ha and is shown on **Figure 3.2**.

5.3 Ecosystems and Threatened Species Requiring Offset

A range of PCTs, ecosystem-credit species and species-credit species were found to require offsetting for the MCCO Project as discussed in the sections below.

5.3.2 Ecosystem Credits

Table 5.1 outlines the ecosystem credits that will be generated as a result of the MCCO Project. The full BBCC Credit Calculator report is included in **Appendix E**.

Table 5.1 Plant Community Types Requiring Offset and the Total Ecosystem Credits Generated as a result of the MCCO Project

Plant Community Type	Total Area to be Impacted (ha)	Highest Threatened Species or EEC Offset Multiplier	Total Ecosystem Credits Required
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	29.91	3.0	1,874
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	6.3	3.0	369
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	492.74	3.0	13,457
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	6.46	3.0	253
HU906 Bull Oak grassy woodland of the central Hunter Valley	32.4	3.0	1,597

Plant Community Type	Total Area to be Impacted (ha)	Highest Threatened Species or EEC Offset Multiplier	Total Ecosystem Credits Required
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	2.95	3.0	168
	570.76	**-**	**17,718**

5.3.2 Species Credits

Table 5.2 outlines the species-credit species to be impacted as a result of the MCCO Project and the species credits required to offset those impacts. A full Credit Calculator report is included in **Appendix E**. Species-credit polygons for each of the species-credit species identified are shown on **Figures 3.5** to **3.7**.

Table 5.2 Species-credit Species Requiring Offset and the Species Credits Required

Common Name Scientific Name	Habitat to be Impacted (ha)	Threatened Species Offset Multiplier	Species Credits Required
Fauna			
large-eared pied bat *Chalinolobus dwyeri*	2.1	1.3	27
southern myotis *Myotis macropus*	0.9	2.2	20
Flora			
Tarengo leek orchid *Prasophyllum petilum*	691 (Individuals)	1.3	8,983
pine donkey orchid *Diuris tricolor*	1,326 (individuals)	1.3	17,238

5.4 Impacts on Biodiversity that Require Further Consideration

Under the FBA, certain impacts on biodiversity values may require further consideration by the consent authority. These are impacts that are considered to be complicated or severe and include:

- impacts on landscape features, being:
  - impacts that will reduce the width of vegetation in the riparian buffer zone bordering significant streams and rivers, important wetlands or estuarine areas (in accordance with Section 9.2.3 of the FBA), or
  - impacts that will prevent species movement along corridors that have been identified as providing significant biodiversity linkages across the state (in accordance with Section 9.2.3 of the FBA), and
- impacts on native vegetation that are likely to cause the extinction of an EEC/CEEC from an IBRA subregion or significantly reduce its viability (in accordance with Section 9.2.4 of the FBA), and
- impacts on critical habitat or on threatened species or populations that are likely to cause the extinction of a species or population from an IBRA subregion or significantly reduce its viability (in accordance with Section 9.2.5 of the FBA).

In accordance with the SEARs issued for the MCCO Project and Section 9.2.5 of the FBA (OEH 2014b), impacts on the following biodiversity values require further consideration in the BAR:

- white-flowered wax plant (*Cynanchum elegans*)
- silky pomaderris (*Pomaderris sericea*)
- smooth bush-pea (*Pultenaea glabra*)
- pink-tailed legless lizard (*Aprasia parapulchella*)
- regent honeyeater (*Anthochaera phrygia*)
- bush stone curlew (*Burhinus grallarius*).

Table 5.3 below provides further information for the white-flowered wax plant, silky pomaderris and smooth bush-pea; and **Table 5.4** provides further information for pink-tailed legless lizard, regent honeyeater and bush stone curlew.

No impacts on landscape features or native vegetation were identified as requiring any further consideration.

Table 5.3 Impacts on Threatened Species that Require Further Consideration

Details Required by Section 9.2.5 of the FBA (OEH 2014)	white-flowered wax plant *Cynanchum elegans*	silky pomaderris *Pomaderris sericea*	smooth bush-pea *Pultenaea glabra*
the size of the local population directly and indirectly impacted by the development	The white-flowered wax plant is restricted to eastern NSW from Brunswick Heads to Gerroa and has also been recorded at Mt Dangar in the upper Hunter River Valley (OEH 2018b). The nearest record of this species is located approximately 20km southwest of the Development Footprint at the Goulbourn River National Park in 1990 and another record approximately 23km south of the Development Footprint along the Martindale trail in 1997. The white-flowered wax plant has not been recorded within the Development Footprint or wider Mangoola area despite extensive surveys across many years – including annual biodiversity monitoring since 2006. This species occupies dry rainforests or wet riparian margins, habitats which don't exist within the Development Footprint for the MCCO Project. No known populations of the white-flowered wax plant are known or expected to occur within the Development Footprint and it is considered that the species is unlikely to be impacted as a result of the MCCO Project.	In NSW, silky pomaderris is known from Morton National Park near Bundanoon and from Wollemi National Park (OEH 2018b). The nearest record of this species was recorded in 1997 at Benjang Gap in Wollemi National approximately 62km southwest of the Development Footprint (OEH 2018b). Silky pomaderris has not been recorded within the Development Footprint despite extensive surveys. Targeted threatened flora surveys and opportunistic surveys have been completed in 2013, 2014, 2015, 2016 and 2017. No known populations of the silky pomaderris are known or expected to occur within the Development Footprint and it is considered that the species is unlikely to be impacted as a result of the MCCO Project.	The smooth bush-pea is only known from the Blue Mountains Local Government Area (OEH 2018b). The nearest record of this species is from 2011 in Wollemi National Park, approximately 50km south of the Development Footprint (OEH 2018b). Smooth bush-pea has not been recorded within the Development Footprint despite extensive surveys. Targeted threatened flora surveys and opportunistic surveys have been completed in 2013, 2014, 2015, 2016 and 2017. No known populations of the smooth bush-pea are known or expected occur within the Development Footprint and it is considered that the species is not likely to be impacted as a result of the MCCO Project.

Details Required by Section 9.2.5 of the FBA (OEH 2014)	**white-flowered wax plant** ***Cynanchum elegans***	**silky pomaderris** ***Pomaderris sericea***	**smooth bush-pea** ***Pultenaea glabra***
the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: **an estimate of the change in habitat available to the local population as a result of the proposed development**	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.
the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.
modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.

Details Required by Section 9.2.5 of the FBA (OEH 2014)	white-flowered wax plant *Cynanchum elegans*	silky pomaderris *Pomaderris sericea*	smooth bush-pea *Pultenaea glabra*
the likely impact on the ecology of the local population. At a minimum, address the following: breeding foraging roosting, and dispersal or movement pathways	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.
a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely that known records of the species will be fragmented or isolated as a result of the MCCO Project.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely that known records of the species will be fragmented or isolated as a result of the MCCO Project.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely that known records of the species will be fragmented or isolated as a result of the MCCO Project.
the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The nearest record of this species is located approximately 20km southwest of the Development Footprint at the Goulbourn River National Park in 1990 and another record approximately 23km south of the Development Footprint along the Martindale trail in 1997. It is unlikely that the MCCO Project will impede the ability of the white-flowered wax plant population to interact for dispersal and genetic viability or diversity.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. There are only two known records of this species within NSW, with the nearest record of this species 62km southwest of the Development Footprint (OEH 2018b). It is unlikely that the MCCO Project will impede the ability of the silky pomaderris population to interact for dispersal and genetic viability or diversity.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The smooth bush-pea is restricted to the higher Blue Mountains from the Katoomba, Hazelbrook and Mt Victoria areas (DoEE 2018). As the nearest record of this species is approximately 50km south of the Development Footprint, it is unlikely that the MCCO Project will impede the ability of the smooth bush-pea population to interact for dispersal and genetic viability or diversity.

Details Required by Section 9.2.5 of the FBA (OEH 2014)	white-flowered wax plant *Cynanchum elegans*	silky pomaderris *Pomaderris sericea*	smooth bush-pea *Pultenaea glabra*
the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population	No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.	No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.	No known populations of the smooth bush-pea occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.
the measure/s proposed to contribute to the recovery of the species in the IBRA subregion	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a). This will require the conservation of suitable land-based or non-land based offsets as outlined in this Policy. The proposed offset strategy for the proposal is discussed in **Section 7.0**. No known populations of the white-flowered wax plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a). This will require the identification of suitable land-based or non-land based offsets as outlined in this Policy. The proposed offset strategy for the proposal is discussed in **Section 7.0**. No known populations of the silky pomaderris occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a). This will require the identification of suitable land-based or non-land based offsets as outlined in this Policy. The proposed offset strategy for the proposal is discussed in **Section 7.0**. No known populations of the smooth bush-pea plant occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be removed, modified or isolated as a result of the MCCO Project.

Table 5.4 Impacts on Threatened Fauna Species that Require Further Consideration

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
the size of the local population directly and indirectly impacted by the development	In NSW, this species is only known from the Central and Southern Tablelands and South Western Slopes (TSSC 2015 & OEH 2018b). The closest record of this species is known within the Goulburn River National Park, located approximately 70km west of the Development Footprint. The preferred habitat of this species is sloping open woodland areas which are typically well-drained and containing rocky outcrops (OEH 2018b). The pink-tailed legless lizard has not been recorded within the Development Footprint despite targeted surveys across the MCCO Additional Project Area in February 2013 and 2017 (refer to **Figure 3.4**) which involved traversing rocky areas and looking under rocks. No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	The regent honeyeater primarily breeds in four known key breeding areas where the species is regularly recorded. The species is known to disperse to foraging habitats in the non-breeding season. As at 2010, the total population size is estimated at 350–400 mature individuals and this is likely to represent one single population (DoE 2015). The nearest record of this species exists approximately 15 km north west of the Development Footprint from 2011 (Umwelt 2011) and approximately 15 km east at Giants Creek in 2014 (Mick Roderick pers. comm.). This species has high breeding site fidelity and although some of the woodland habitat within the Development Footprint represents at least marginal foraging habitat, no breeding events have been recorded within the Development Footprint. A breeding site was recorded in Goulburn River National Park in 2017, approximately 80 km west of the Development Footprint and another breeding site is known from the Kurri Kurri area approximately 90 km to the southeast of the Development Footprint. The regent honeyeater has not been recorded within the Development Footprint despite targeted and appropriately timed winter bird surveys August in 2016, 2017 and 2018 (refer to	The bush stone-curlew is found throughout Australia except for central southern coast inland, the far south-east corner and Tasmania (OEH, 2017). The closest record of this species is a historic record located approximately 10km west of the Development Footprint from 1978. This species is ground-dwelling and roosts amongst fallen timber and other woody debris. Extensive transects were walked across the Development Footprint as part of flora surveys for the MCCO Project and it is likely that, if this species was to exist within the Development Footprint, it would have been recorded during these searches from 2013, 2014 and 2016. In addition to this, extensive fauna monitoring, including nocturnal surveys, have been undertaken across the wider Mangoola Coal Mine area since 2006 and this species hasn't been detected as part of those surveys. As such, no known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
		Figure 3.4). Diurnal bird surveys during winter are undertaken at fauna monitoring locations within existing Mangoola Mine offset areas, from 2008 to 2018. The species has not been recorded as part of these surveys. Whist the Development Footprint does not support breeding habitat for this species, approximately 6.3 ha of potential foraging habitat (CoA, 2016b) will be removed. Despite this, it is unlikely that any individuals within the regent honeyeater population will be directly or indirectly impacted by the MCCO Project.	
the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to: **an estimate of the change in habitat available to the local population as a result of the proposed development**	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	The species has not been recorded breeding in the Development Footprint despite targeted surveys. The Development Footprint does include vegetation containing spotted gum which is a key feed tree species for the regent honeyeater (CoA, 2016b & OEH, 2017) in the Hunter Valley, as described in the National Recovery Plan for the species. The Proposed Action may result in the loss of approximately 6.3 ha of this habitat.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	Habitat critical to the survival of the regent honeyeater includes any breeding or foraging areas where the species is likely to occur and any newly discovered breeding or foraging locations (CoA, 2016b). The species has not been recorded in the Development Footprint despite targeted surveys. The Development Footprint does include vegetation containing spotted gum which is a key feed tree species for the regent honeyeater (CoA, 2016b & OEH, 2017) in the Hunter Valley, as described in the National Recovery Plan for the species. The Proposed Action may result in the loss of approximately 6.3 ha of this habitat.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.
modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species or its habitat is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.	The regent honeyeater mainly breeds in four key sites, being the Bundarra-Barraba, Capertee Valley and Hunter Valley districts in NSW, and the Chiltern area in north-east Victoria (DoE 2016). Locally, the species has been recorded breeding in forest habitats around Mudgee approximately 80km from the Development Footprint and Kurri Kurri, NSW approximately 90 km from the Development Footprint. No breeding or nesting habitat for the regent honeyeater has been recorded within or in the vicinity of the Development Footprint and the MCCO Project will not result in the modification of habitat important to the species' life	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
		cycle. Potential habitat required for the maintenance of important life cycle processed will not be modified as a result of the MCCO Project.	
the likely impact on the ecology of the local population. At a minimum, address the following: **breeding** **foraging** **roosting, and** **dispersal or movement pathways**	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	The regent honeyeater mainly breeds in three key sites in NSW being the Bundarra-Barraba area, the Capertee Valley, and the Lower Hunter Valley (CoA, 2016b & OEH, 2017). Other breeding areas are known in the Pilliga woodlands and the Mudgee-Wollar areas of NSW. No breeding or nesting habitat for the regent honeyeater has been recorded within the Development Footprint. The MCCO Project is unlikely to affect dispersal or movement pathways for this highly mobile species. The MCCO Project will result in the removal of 6.3 ha of potential foraging habitat. The MCCO Project is unlikely to affect the ecology and biology of the population of the regent honeyeater in the locality.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.
a description of the extent to which the local population will become fragmented or isolated as a result of the proposed development	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.	The regent honeyeater has not been recorded within the Development Footprint. This species is highly dispersive and it is unlikely that the MCCO Project will create a significant change to the species dispersal capacity or create a significant barrier to the movement of the species.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project.

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
the relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. In NSW, this species is only known from the Central and Southern Tablelands and South Western Slopes (TSSC 2015 & OEH 2018b). The closest record of this species is known within the Goulbourn River National Park, located approximately 70km west of the Development Footprint. It is unlikely that the MCCO Project will impede the ability of the pink-tailed legless lizard population to interact for dispersal and genetic viability or diversity.	Seasonal movements outside breeding season in autumn and winter appear to be related to foraging resource availability (DoE 2016). The Development Footprint is not at the limit of extent of the species known range. This species is highly dispersive and it is unlikely that the MCCO Project will create a significant change to the species dispersal capacity or create a significant barrier to the movement of the species. It is unlikely that the MCCO Project will impede the ability of the regent honeyeater population to interact for dispersal and genetic viability or diversity.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. It is unlikely that the MCCO Project will impede the ability of the bush stone-curlew population to interact for dispersal and genetic viability or diversity.
the extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population	No known populations of the pink-tailed legless lizard occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.	Key threats for the regent honeyeater include habitat loss and fragmentation, habitat degradation and the species' small population size. The MCCO Project will exacerbate habitat loss and fragmentation for the species in potential foraging habitat in the Hunter Valley. The species has not been recorded utilising the habitats of the Development Footprint. This is likely to be due to the low frequency of key feed trees and the small number of individuals remaining in the population utilising other higher quality habitats in NSW.	No known populations of the bush stone-curlew occur within the Development Footprint or MCCO Additional Project Area and it is considered that the species is unlikely to be impacted, directly or indirectly, as a result of the MCCO Project. The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.

Details Required	pink-tailed legless lizard *Aprasia parapulchella*	regent honeyeater *Anthochaera phrygia*	bush stone-curlew *Burhinus grallarius*
		The MCCO Project is not expected to lead to an increase in threats and indirect impacts, which are discussed in detail in **Section 4.4**. Therefore the MCCO Project is not expected to decrease the viability of known populations of this species, occurring outside of the Development Footprint.	
the measure/s proposed to contribute to the recovery of the species in the IBRA subregion	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a) which will offset the PCTs and habitats recorded in the MCCO Additional Project Area in accordance with the FBA. The proposed offset strategy for the proposal is discussed in **Section 7.0**.	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a). This will require the conservation of suitable land-based or non-land based offsets as outlined in this Policy. The proposed offset strategy for the proposal is discussed in **Section 7.0**.	As part of the MCCO Project, a like-for-like Biodiversity Offset Strategy will be prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects (OEH 2014a). This will require the conservation of suitable land-based or non-land based offsets as outlined in this Policy. The proposed offset strategy for the MCCO Project is discussed in **Section 7.0**.

5.5 Five Part Test of Significance

Threatened species impact assessment is an integral part of environmental impact assessment. The objective of Section 5A of the EP&A Act, the assessment of significance, is to improve the standard of consideration afforded to threatened species, populations and ecological communities, and their habitats through the planning and assessment process, and to ensure that the consideration is transparent.

Although it is understood that the preparation of an assessment under the FBA was intended to supersede the requirement to prepare assessments of significance, the DPE has advised that the requirements of Section 7AA of the EP&A Act are to be considered in the BAR. The preparation of a BAR under the FBA addresses the components of Section 7AA by use of the BBCC. A summary of the requirements of Section 7AA and where they are addressed in the FBA Assessment is outlined in **Table 5.5** below.

Table 5.5 Five Part Test of Significance and the FBA

Five Part Test of Significance	Where Addressed in the FBA Process
in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	Threatened species (ecosystem-credit and species-credit) are predicted in the BBCC by the landscape features of the Development Footprint (native vegetation cover, IBRA regions, patch sizes, condition and plant community types) and assessed by the impact on these features. Impacts requiring further consideration (Section 9.2 of the FBA (OEH 2014b) identify impacts on critically endangered threatened species, impacts that may cause the extinction of a species in an IBRA subregion and impacts that significantly reduce the viability of a species.
in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity; **i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or** **ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction;**	Endangered ecological communities are predicted in the BBCC by the plant community types and biometric community types identified from the field surveys and entered into the BBCC. Impacts requiring further consideration (Section 9.2 of the FBA (OEH 2014b) are identified as impacts on any critically endangered or endangered ecological community that may cause the extinction of the EEC/CEEC in a IBRA subregion or significantly reduce the viability of an EEC/CEEC.
in relation to the habitat of a threatened species, population or ecological community: **i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and** **ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and** **iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality;**	Habitat loss is assessed in the BBCC via the 'Site Values' tab and the loss in site value score entered for each vegetation zone. Fragmentation of habitat is addressed as part of the 'Landscape Value' score including consideration of features before and after the development including per cent native vegetation cover, connectivity value and vegetation condition. The per cent cleared scores for the dominant Mitchell Landscape is also calculated in the 'Landscape Value' score. Important habitat features are identified through determining geographic and habitat features relevant for particular species-credit species and the assessment of landscape features (such as riparian buffers, important wetlands and state or regionally significant biodiversity links).

Five Part Test of Significance	Where Addressed in the FBA Process
	The extent of habitat loss is ultimately determined by the measure of ecosystem credits and species credits calculated in the BBCC.
whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),	No declared area of outstanding biodiversity value is located within the Development Footprint.
whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	Key threatening processes are not directly assessed under the FBA. In this case, the MCCO Project is likely to contribute to the following key threatening processes through the clearing of vegetation: • Clearing of native vegetation (BC Act and EPBC Acts) • Loss of hollow-bearing trees (BC Act) • Removal of dead wood and dead trees (BC Act). The MCCO Project may to contribute to the following key threatening processes through clearing of vegetation, edge effects and the operation of the MCCO Project: • Aggressive exclusion of birds by noisy miners (*Manorina melanocephala*) (BC and EPBC Acts) • Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*) (BC and EPBC Acts) • Predation by the European red fox (*Vulpes vulpes*) (BC and EPBC Acts) • Invasion of native plant communities by exotic perennial grasses (BC Act) • Invasion of native vegetation communities by African olive (*Olea europaea*) (BC Act). While the MCCO Project is considered likely to contribute to the function of the above key threatening processes, the MCCO Project as a whole, or any component of the MCCO Project would not be classified as a key threatening process.

5.6 Environmental Values not Assessed under the FBA

The FBA does not assess the direct impacts of a project that are not associated with clearing of vegetation. Examples of these impacts include, but are not limited to:

- bird and bat strike associated with wind farm developments
- vehicle strike
- subsidence and cliff falls associated with mining developments
- downstream impacts on hydrology and environmental flows on surface vegetation and groundwater dependent ecosystems, and
- impacts on karst ecosystems.

The following sections discuss impacts of the MCCO Project that are not clearing of native vegetation and that have the potential to impact on biodiversity.

5.6.1 Blasting Impacts on Rock Formations

The MCCO Project will involve blasting activities. There are some rock formations in the vicinity of the existing operations and the MCCO Project including Anvil Rock, The Book and several rock overhangs/rock shelters. The blasting assessment for the MCCO Project has assessed impacts on each of these sites and identified that the predicted impacts are well below the criteria set to avoid impacts on these rock formations. The MCCO Project is therefore not predicted to result in adverse impacts on these rock formations. As such, there is not predicted to be any impacts to threatened species, EPs or TECs as a result of blasting activities on rock formations.

5.6.2 Groundwater Dependent Ecosystems

A detailed assessment of the impact of the MCCO Project on potential GDEs is provided as part of the Groundwater Impact Assessment (GIA) (AGE 2019) and the Aquatic Impact Assessment (Umwelt 2019). A summary of the assessment outcomes is provided below based on the results of the GIA.

The MCCO Project will result in clearing of native vegetation within the Disturbance Footprint. As shown on **Figure 5.1**, this will include some woodland / forest vegetation that has access to shallow groundwater (defined as areas where groundwater was predicted to occur within 10 metres of the surface pre-mining by the groundwater model developed as part of the GIA) and was therefore identified as a potential GDE. The direct impact of clearing of this vegetation is assessed and offset in accordance with the NSW Framework for Biodiversity Assessment described in this report.

The MCCO Project will also result in drawdown of groundwater within the vicinity of the MCCO Project. With regard to GDEs, the predicted drawdowns of relevance are those in layer 1 of the groundwater model which relates to drawdown in alluvium, colluvium and regolith; and in layer 2 which relates to drawdown in shallow weathered bedrock. **Figures 5.2** and **5.3** show the areas of 1m or greater drawdown resulting from the incremental impact of mining the MCCO Additional Mining Area in these layers where potential GDEs occur. As shown on the figures, outside of the proposed Development Footprint for the MCCO Project the predicted drawdowns are 1m to 2m and occur in the vicinity of Big Flat Creek. The predicted drawdowns affect areas of:

- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley which as a riparian community is considered likely to have a moderate level of dependence on groundwater

- HU905/PCT1691 - *Eucalyptus crebra*/ *Eucalyptus moluccana* grassy woodland of the central and upper Hunter which is considered likely to have a low level of dependence on groundwater.

It is expected that Swamp Oak - Weeping Grass Grassy Riparian Forest has a moderate potential to be dependent on shallow groundwater resources during periods of reduced surface water flow. The dependence of the vegetation community on groundwater will depend on the depth of root systems and their efficiency at utilising rainfall and surface moisture.

With regard to the other potential GDEs identified in the area surrounding the MCCO Additional Project Area, the results of the GIA have shown that there are no incremental impacts due to the MCCO Project predicted on these GDEs as they are outside the predicted zone of 1m of greater groundwater drawdown in layers 1 and 2 of the groundwater model. This includes no drawdown impacts predicted on the Wybong Creek or the Wybong Creek alluvium (refer to drawdown shown on **Figure 5.2**) and no impact on the Goulburn River.

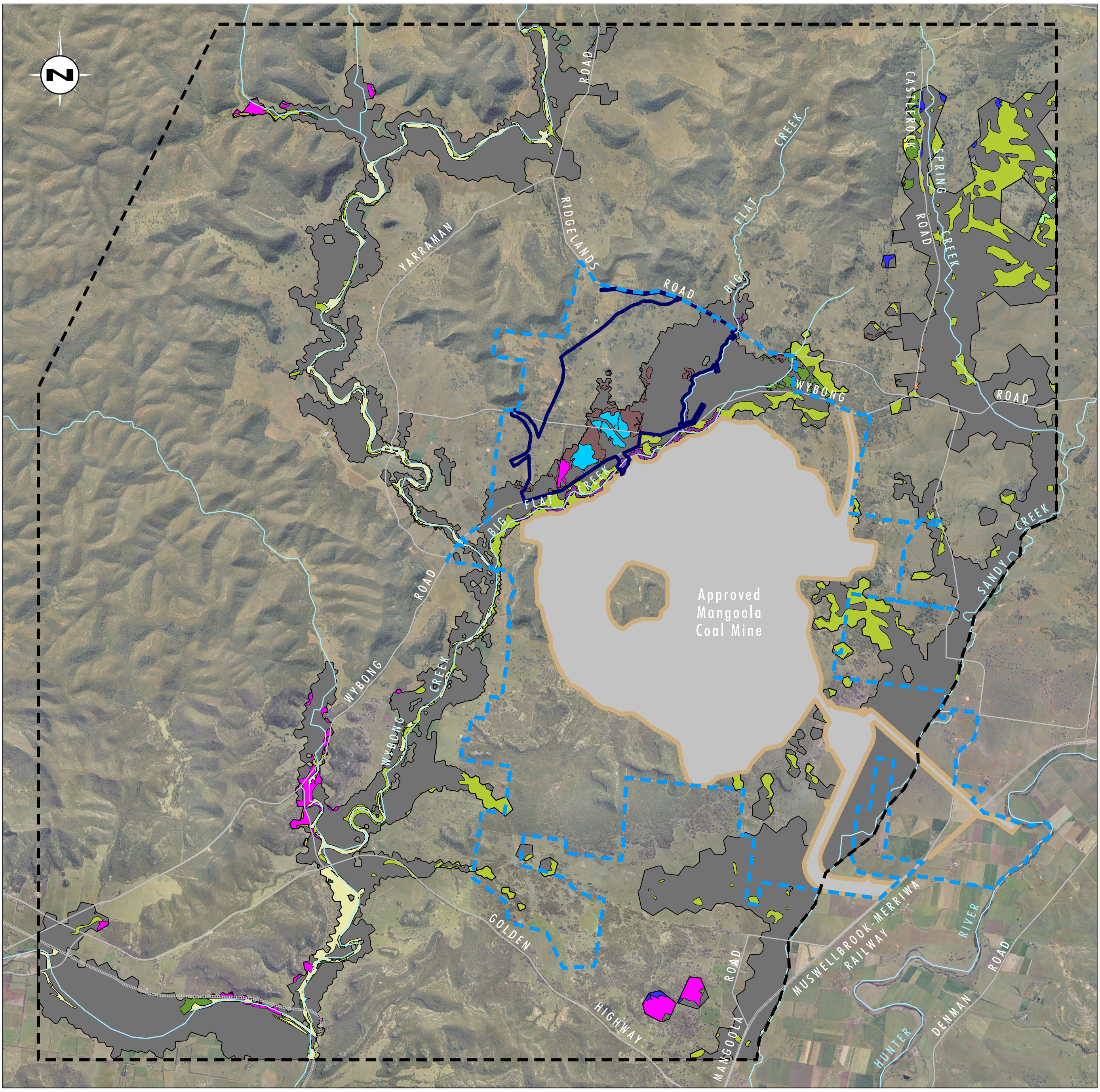

Image Source: Glencore (2018), Google Earth (2018)
Data Source: Glencore (2018), AGE (2018)

0 1.0 2.5 5.0km
1:100 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Model Extent (GDE Study Area)
- Groundwater Within 10m of Surface
- HU654/PCT1310 - White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley
- HU757/PCT1543 - Ficus rubiginosa/ Alectryon subcinereus/ Notelaea microcarpa/ dry rainforest of the Central Hunter Valley
- HU812/PCT1598 - Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter
- HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
- HU818/PCT1604 - Eucalyptus crebra/ Eucalyptus moluccana/ Corymbia maculata shrub/ grass open forest of the central and lower Hunter
- HU819/PCT1605 - Eucalyptus crebra/ Notelaea microcarpa shrubby open forest of the central and upper Hunter
- HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
- HU825/PCT1611 - Eucalyptus crebra/ Callitris endlicheri shrub/grass woodland upper Hunter and northern Wollemi
- HU826/PCT1612 - Eucalyptus crebra/ Eucalyptus punctata/ Notelaea microcarpa woodland of Central Hunter
- HU869/PCT1655 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin
- HU883/PCT1669 - Eucalyptus fibrosa/ Eucalyptus punctata/ Eucalyptus sparsifolia/ Corymbia trachyphloia shrubby open forest on sandstone ranges of the Sydney Basin
- HU884/PCT1670 - Eucalyptus sparsifolia/ Eucalyptus punctata shrubby open forest on sandstone ranges of the Sydney Basin
- HU905/PCT1691 - Eucalyptus crebra/ Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU906/PCT1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- HU928/PCT1714 - Eucalyptus camaldulensis/ Casuarina cunninghamiana grassy riparian woodland of the Hunter Valley
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 5.1

Native Woodland / Forest Vegetation Communities where Pre-mining Groundwater is within 10m of Surface

File Name (A4): R12/3450_081.dgn
20190314 15.33

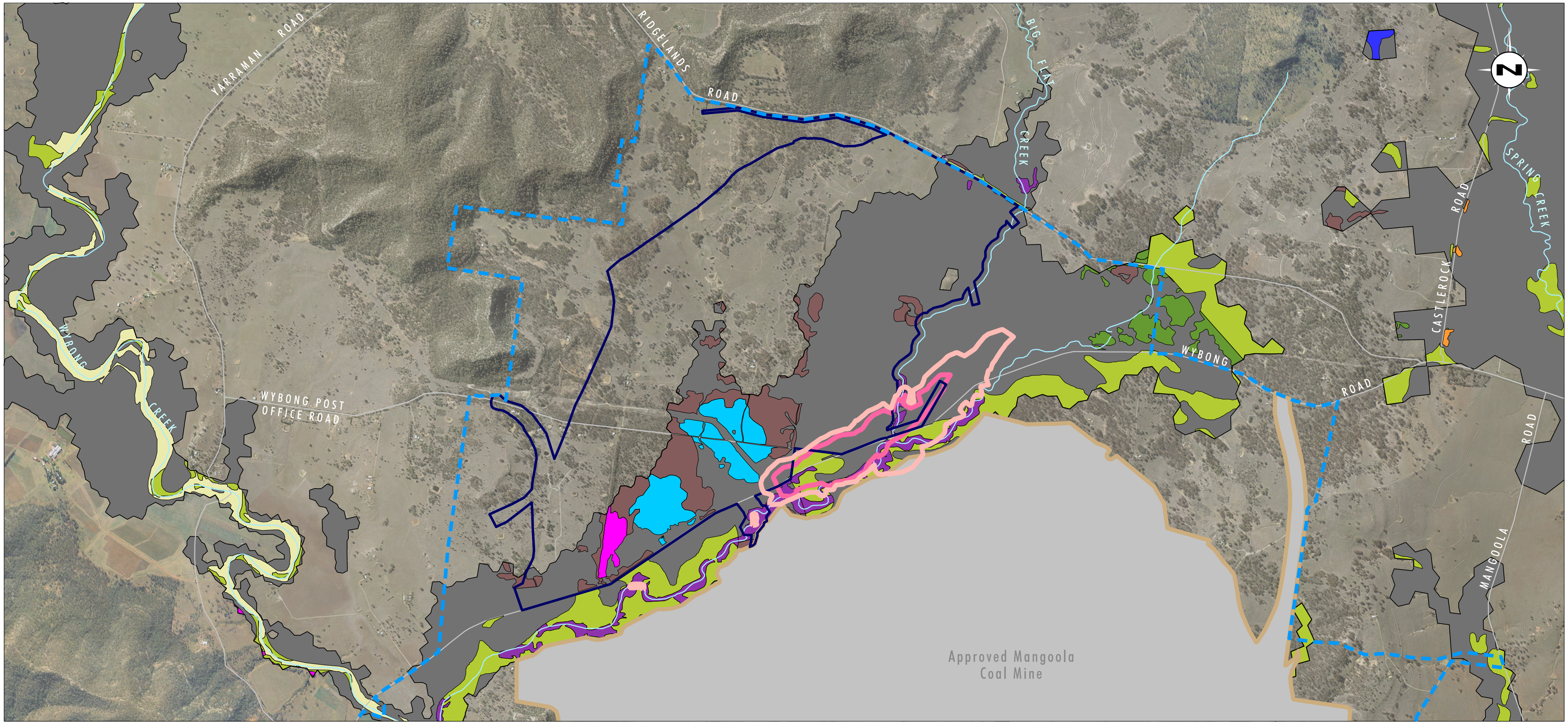

Image Source: Glencore (2018)
Data Source: Glencore (2018), AGE (2018)

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Within 10m of Surface

Groundwater Drawdown Contours Layer 1 (metres):

- Predicted Maximum Drawdown - 1m
- Predicted Maximum Drawdown - 2m

- HU654/PCT1310 - White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley
- HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
- HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
- HU826/PCT1612 - Eucalyptus crebra/ Eucalyptus punctata/ Notelaea microcarpa woodland of Central Hunter
- HU869/PCT1655 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin
- HU905/PCT1691 - Eucalyptus crebra/ Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU906/PCT1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- HU928/PCT1714 - Eucalyptus camaldulensis/ Casuarina cunninghamiana grassy riparian woodland of the Hunter Valley
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 5.2

Potential GDE's and Predicted maximum groundwater drawdown due to the MCCO Project Layer 1 (alluvium, colluvium, regolith)

File Name (A4): R12/3450_082.dgn
20190314 15.35

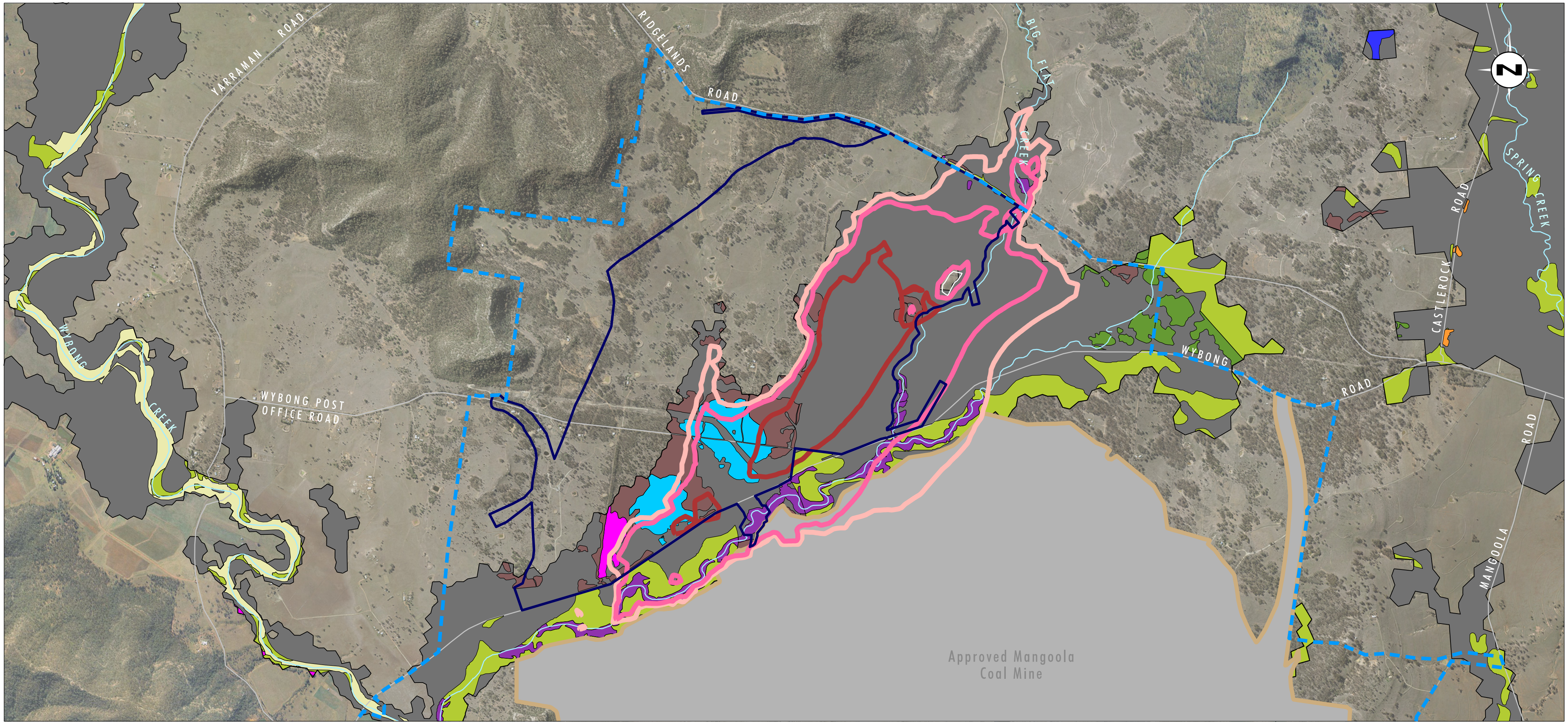

Image Source: Glencore (2018)
Data Source: Glencore (2018), AGE (2018)

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Within 10m of Surface

Groundwater Drawdown Contours Layer 1 (metres):

- Predicted Maximum Drawdown - 1m
- Predicted Maximum Drawdown - 2m
- Predicted Maximum Drawdown - 5m

- HU654/PCT1310 - White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley
- HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
- HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
- HU826/PCT1612 - Eucalyptus crebra/ Eucalyptus punctata/ Notelaea microcarpa woodland of Central Hunter
- HU869/PCT1655 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin
- HU905/PCT1691 - Eucalyptus crebra/ Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU906/PCT1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- HU928/PCT1714 - Eucalyptus camaldulensis/ Casuarina cunninghamiana grassy riparian woodland of the Hunter Valley
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

0 0.5 1.0 2.0km
1:40 000

FIGURE 5.3

Potential GDE's and Predicted maximum groundwater drawdown due to the MCCO Project Layer 2 (shallow weathered bedrock)

File Name (A4): R12/3450_083.dgn
20190314 15.38

5.6.2.1 Stygofauna

Stygofauna live in groundwater and therefore if a stygofauna community occurred in the vicinity of the site it would be considered to be a GDE.

A stygofauna assessment has been prepared for the MCCO Project to assess the potential presence of stygofauna, and if present, the impacts of the MCCO Project. The assessment was undertaken following relevant Commonwealth and NSW Government guidelines and included sampling of bores within and surrounding the MCCO Additional Project Area. The assessment report is included as part of the EIS for the MCCO Project.

No stygofauna were identified during targeted stygofauna surveys in representative bores within and surrounding the MCCO Project and the assessment found that the bedrock aquifers are unlikely to be suitable habitat because they lack a significant network of interconnected fractures for stygofauna movement. The colluvium within the MCCO Additional Project Area was also found to be generally unsuitable because it is likely to dry out periodically. The survey also included the Wybong Creek alluvium within the vicinity of the MCCO Additional Project Area. Although no stygofauna were collected from sampling within the Wybong alluvium, the stygofauna assessment found that the section of the Wybong alluvium closer to the confluence with the Goulburn River (well to the south of the MCCO Project) is potentially suitable habitat because of its hydrological connection to the Goulburn River, adequate porosity, and acceptable water quality. However, if a stygofauna community is inferred for the Wybong alluvium, then this community would be the same as the Goulburn alluvium community, since this is the source of colonisation.

In summary, there were no stygofauna communities identified in the vicinity of the MCCO Additional Project Area, however, the potential for stygofauna to occur in the lower reaches of the Wybong Creek alluvium was recognised. As discussed above, this alluvium area is not predicted to be impacted by the predicted incremental drawdown of the MCCO Project.

Further assessment of the impacts of the MCCO Project on GDEs is provided in the EIS.

5.6.3 Aquatic Ecology

The MCCO Additional Disturbance Area crosses two branches of Big Flat Creek which is a tributary of Wybong Creek. Big Flat Creek and Wybong Creek are both part of the Hunter River catchment, which is characterised by variable and unpredictable patterns of flow and water levels exacerbated by heavily cleared catchments and prevalence of agricultural land use. Big Flat Creek is ephemeral and only flows after periods of sustained rainfall. As discussed in the EIS Surface Water Assessment, the creek also has generally poor water quality (naturally occurring, not related to the existing mining operations).

The FBA does not assess impacts on aquatic biodiversity so an Aquatic Ecology Assessment has been prepared and is included in **Appendix F**.

Targeted aquatic habitat assessment and qualitative sampling was undertaken within appropriate habitats within the Development Footprint.

Impacts associated with the MCCO Project include:

- removal of riparian vegetation on the banks of Big Flat Creek will be required for the construction of the haul road crossing of the creek
- removal of snags and in-stream vegetation – predominantly non-native grasses and weed species though some small beds of sedges/reeds were noted in watercourse

- temporary obstruction of fish passage when constructing access tracks associated with either filling or removal of material from the watercourse

- potential for increased sediment load downstream of the MCCO Additional Project Area due to disturbance activities in the creek

- risk of spills and pollution associated with construction equipment working in the watercourse.

The impact of the proposal on riparian communities has been addressed through the generation of ecosystem credits, in accordance with the FBA.

While minimal fish habitat exists, at the time of construction, while unlikely there may be semi-permanent pools in the Development Footprint that may support fish. Draining and/or filling of these pools may result in adverse impacts, however, any such impacts are considered unlikely to significantly impact local fish populations.

There are minimal impacts on aquatic ecological systems associated with operation of the proposal including consideration for the potential for spills from vehicles using the crossing. No aquatic flora or fauna species listed under the *Fisheries Management Act (1995)* (FM Act) were recorded within the MCCO Additional Project Area, however potential habitat for the Darling River hardyhead (*Craterocephalus amniculus*) Endangered Population in the Hunter Catchment was identified in Wybong Creek. The MCCO Project is unlikely to result in an adverse effect on the Darling River hardyhead Endangered Population in the Hunter River catchment.

No nationally listed threatened aquatic species, TECs or aquatic migratory species are expected to occur in the watercourses within the MCCO Additional Project Area and therefore no impacts are predicted.

6 Biodiversity Credit Report

A full Biodiversity Credit Report is included in **Appendix E**. A summary of the key outcomes in provided below.

Table 6.1 below provides a summary of the ecosystem credits that require offsetting as a result of the MCCO Project.

Table 6.1 Credits Required to Offset the MCCO Project

Name	Credits Required
Ecosystem Credits	
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	1,874
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	369
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	13,457
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	253
HU906 Bull Oak grassy woodland of the central Hunter Valley	1,597
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	168
Species Credits	
Flora	
Tarengo leek orchid *Prasophyllum petilum*	8,983
pine donkey orchid *Diuris tricolor*	17,238
Fauna	
large-eared pied bat *Chalinolobus dwyeri*	27
southern myotis *Myotis macropus*	20

7 Biodiversity Offset Strategy

Mangoola is committed to delivering a biodiversity offset strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the MCCO Project. The following biodiversity offset strategy has been developed in accordance with the FBA and completely satisfies the credit requirements of the MCCO Project.

As discussed in **Section 4.0**, Mangoola has, where possible, altered the MCCO Project to avoid and minimise ecological impacts in the MCCO Project planning stage, and a range of impact mitigation strategies have been included to mitigate the impact on ecological values prior to the consideration of offsetting requirements. The final biodiversity offset strategy presented herein will meet the offset requirements for the MCCO Project identified in **Section 6.0**.

Glencore has a strong record in preparing and implementing biodiversity offset strategies that address significant biodiversity matters and adequately counterbalance impacts on them. Mangoola is committed to delivering a biodiversity offset strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the MCCO Project. The offset strategy will be implemented following the process outlined in the FBA and the final composition of the offset strategy may evolve as the MCCO Project progresses.

The proposed land-based offsets described in the sections below refer to BioBank sites as the biometric data was collected in accordance with BBAM (2014), a BioBanking credit calculator assessment was conducted to enable direct comparison to be made with the impact credits which were determined in accordance with the FBA. For ease of reference 'Offset sites' are referred to in this report although it is noted that the mechanism to secure these offset sites will likely be a Stewardship Agreement prepared in accordance with the BAM.

It is currently proposed that the biodiversity offset strategy will consist of the following:

- In-perpetuity conservation using the retirement of biodiversity credits through the establishment of the following Stewardship Agreements for:
    - Mangoola Offset Site, and
    - Wybong Heights Offset Site
- In addition to this, credits from proposed Biobank Sites currently being finalised by Glencore will be used. These credits have been created at existing offset sites using the BBAM and are currently unallocated. These credits will be retired for the MCCO Project. These include:
    - 790 credits for HU817 from the proposed Highfields BioBank Site, and
    - *Prasophyllum petilum* credits and *Diuris tricolor* credits from the proposed Mangrove BioBank Sites
- Restoration of up to 456 ha of native vegetation communities as part of ecological mine rehabilitation, and
- Payment into the Biodiversity Conservation Fund for the small number of remaining credits.

Figure 7.1 documents the process undertaken to develop the biodiversity offset strategy and outlines how each part of the package relates to the NSW *Biodiversity Offset Policy for Major Projects* and link together to fulfil the offsetting requirements of the MCCO Project. **Figure 7.2** and **Figure 7.3** show the locations of the proposed offset sites.

The sections below outline the information on the currently proposed offset package components as required in Table 22 of the FBA (OEH 2014b). Details of each of the proposed BioBank sites, their biodiversity values and credits generated (BBAM Credits) are provided in **Sections 7.1** to **7.2**. To supplement the results of the ecological surveys at the Mangoola and Mangrove BioBank Sites, Mangoola commissioned an Expert, Dr Stephen Bell, to prepare an Expert Report to document the availability of habitat for two threatened orchid species, *Prasophyllum petilum* and *Diuris tricolor*, and determine the number of each of these species present at the proposed Mangoola offset site and the proposed Mangrove BioBank site. Dr Stephen Bell was approved by OEH as an Expert in accordance with Section 6.5.2.3 of the Biodiversity Assessment Method in May 2018. The results of the Expert Report are summarised in **Section 7.6** and the Expert Report is provided in **Appendix C**.

Ecological mine rehabilitation is discussed in **Section 7.5** and payment into the Biodiversity Conservation Fund is discussed in **Section 7.6**. All proposed BioBank sites have been subject to full biometric surveys as required under the BBAM (OEH 2014c). Full details on survey effort and results for the proposed BioBank sites are included in **Appendix G** and **Appendix H.**

It is noted that retiring offsets under the FBA has been designed to be a market based system and while the currently intended offsetting arrangement are outlined in this report, Mangoola may alter the composition of the offsets to be retired as the MCCO Project progresses. All of the proposed offsets for the MCCO Project will be development in accordance with the requirements of the FBA.

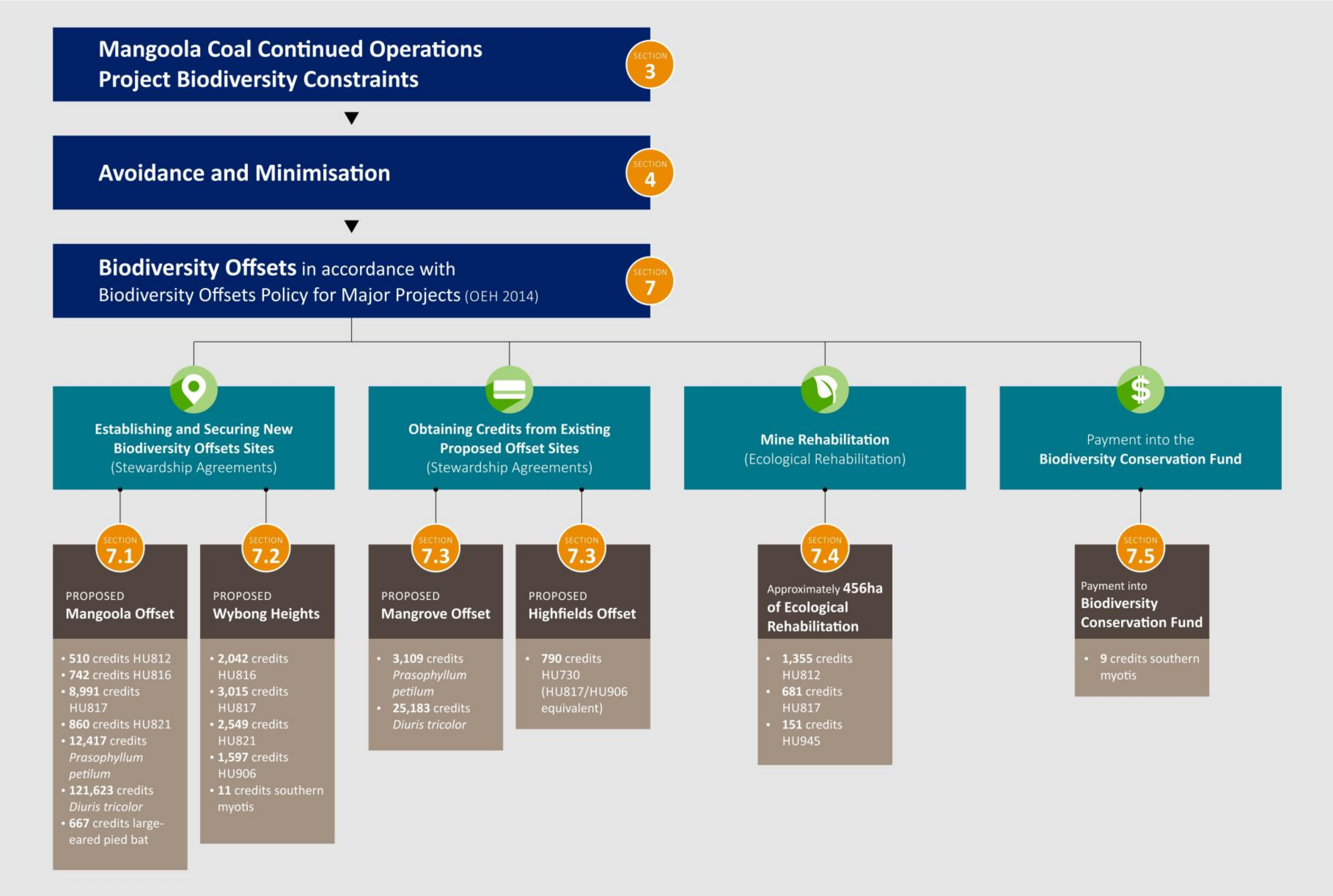

Figure 7.1 Biodiversity Offsetting Strategy Development and Outcomes

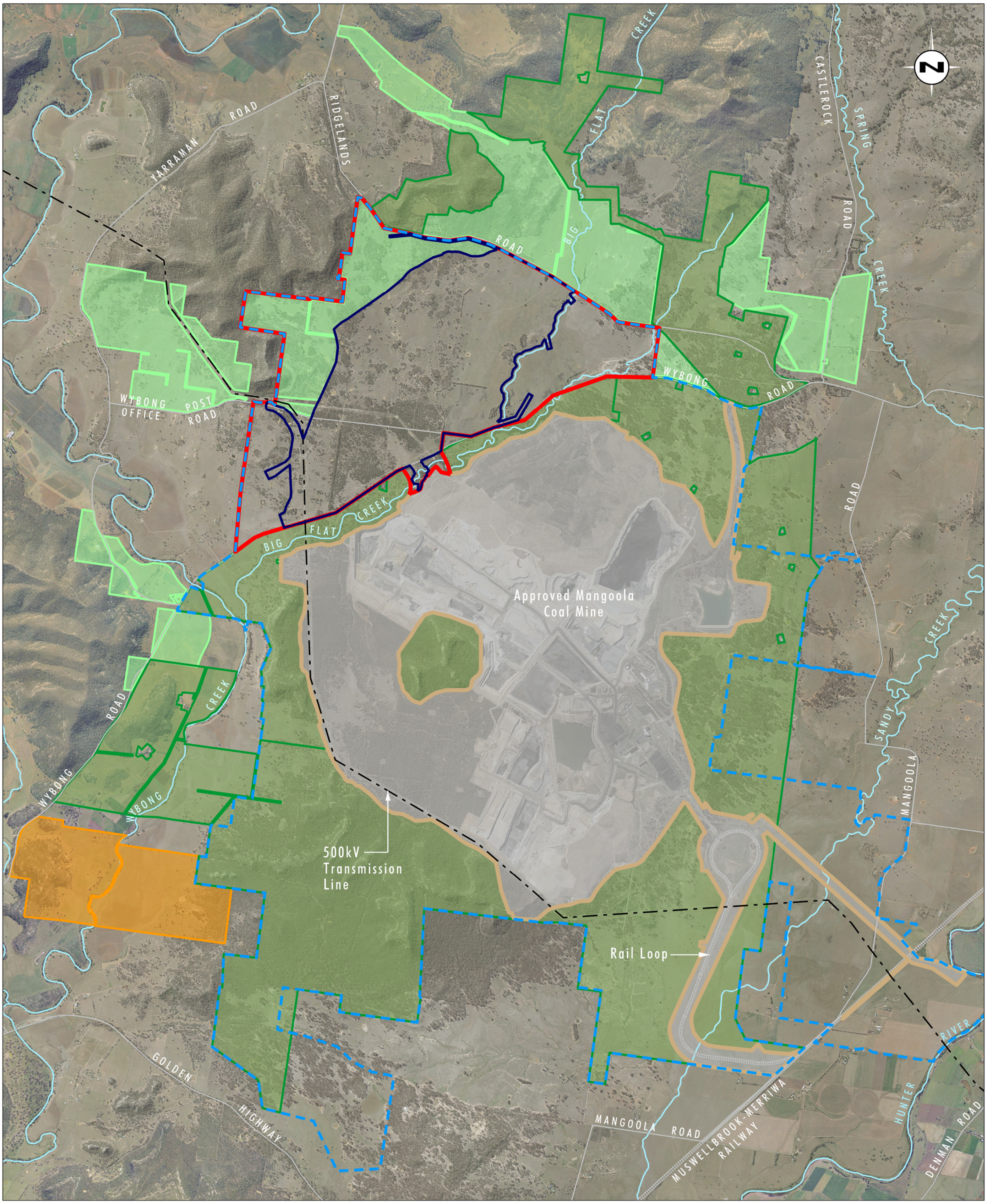

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)
Note: Offset boundaries are based on LPI cadastre

0 1.0 2.0 3.0km
1:65 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- MCCO Additional Project Area
- Existing Offsets
- Proposed Mangoola Offset Sites
- Mangrove Offset Site

FIGURE 7.2

Proposed Mangoola and Mangrove Offset Sites

File Name (A4): R12/3450_058.dgn
20190403 12.01

umwelt

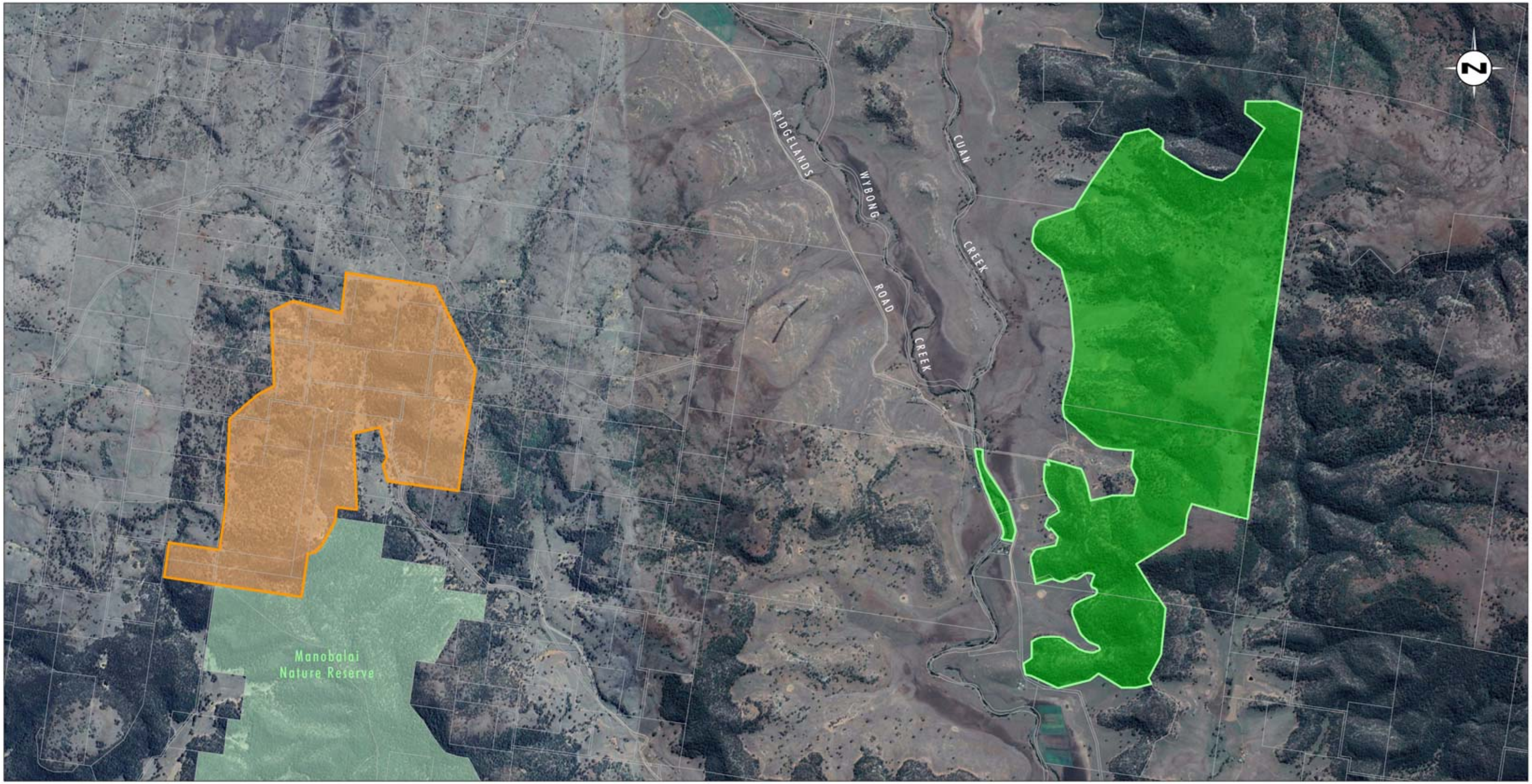

Image Source: Google Earth (Sept 2018)
Data Source: LPI (2018)
Note: Offset boundaries are based on LPI cadastre

0 0.5 1.0 2.0km
1:50 000

Legend

- Proposed Wybong Heights Offset Site
- Highfields Offset Site
- Manobalai Nature Reserve

FIGURE 7.3

Wybong Heights and Highfields Offset Sites

File Name (A4): R12/3450_059.dgn
20190402 16.24

7.1 Mangoola Offset Site

The proposed Mangoola Offset site contains the following key biodiversity features relevant to the offsetting strategy for the MCCO Project:

- 38.4 ha of HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter
- 51.5 ha of HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- 597.2 ha of HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter
- 54.6 ha of HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter
- Estimated population of 17,558 pine donkey orchid (*Diuris tricolor*)
- Estimated population of 1,780 Tarengo leek orchid (*Prasophyllum petilum*)
- Approximately 94 ha of Large-eared pied bat (*Chalinolobus dwyeri*) habitat.

7.1.1 Site Details

The proposed Mangoola Offset site is wholly owned by Mangoola Coal Operations. BioBanking surveys (BBAM 2014) were undertaken across the site to inform the credit yield (in accordance with the FBA) however it is envisaged that the Mangoola Offset site will be secured using a Stewardship agreement. All Mangoola-owned land that was deemed suitable to conserve was considered in the development of the offset package however properties were strategically selected based on suitability for the MCCO Project (similarity of PCTs) and landscape position (proximity to existing offsets) and avoided if they were high quality agricultural land (alluvial flats for example).

Table 7.1 below provides general information on the proposed Mangoola Offset site as required by Table 22 of the FBA (OEH 2014b).

Table 7.1 Mangoola Offset site Details

Mangoola Offset site	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Kerrabee
Major Catchment Area	Hunter-Central Rivers
Rivers, Creeks, etc	Wybong Creek (6th order)
Mitchell Landscape	Central Hunter Foothills
LGA	Muswellbrook Shire Council
Zoning	RU1 Primary Production
Size	Approx. 1005 ha
Land Use History	The historical land use of the proposed Mangoola Offset site has been agricultural, primarily cattle and sheep grazing,

Mangoola Offset site	
General Description	The proposed Mangoola Offset site is 1005 ha in size, with approximately 30 per cent having been previously cleared for agricultural purposes (refer to **Figure 7.2**). The site is positioned on the lower slopes sandstone escarpments with the majority of the site containing Hunter Valley floor woodland vegetation and derived native grassland. The vegetation is reasonably young and as a result the hollow-bearing tree density is generally low. The woodland vegetation within the site occurs at the interface of land which has been predominantly cleared of trees and converted to grassland for grazing purposes. The Mangoola Offset site, in part, directly adjoins large areas of native vegetation already managed by Mangoola for conservation purposes through a (pending) Conservation Agreement (refer to **Figure 7.1**).

7.1.2 Survey Effort and Methods

Surveys of the proposed Mangoola Offset site have been completed in accordance with the requirements of the BBAM (2014) and included the following methodology:

- Detailed floristic and vegetation mapping surveys in 2013 as part of the UHSA project. This included 18 systematic plot-based surveys and collection of biometric data in accordance with BBAM 2014 (OEH 2014c).
- Detailed floristic and vegetation mapping surveys in 2017. This included 28 systematic plot-based surveys and collection of biometric data in accordance with BBAM 2014 (OEH 2014c).
- Targeted *Diuris tricolor* and *Prasophyllum petilum* surveys in September and October 2014, 2015, 2016, 2017 and 2018.

Surveys of the proposed Mangoola Offset site identified five BVTs relevant to the MCCO Project in accordance with the requirements under BBAM (OEH 2014c) (refer to **Figure 7.4**).

Full details on survey effort and results for the proposed Mangoola Offset site are included in **Appendix G.**

7.1.3 Credits Generated

Table 7.2 below outlines the BVTs at the proposed Mangoola Biobank Offset Site and the ecosystem credits generated at this site. In addition, the species credits-species recorded and identified through the Expert Report and the credits they generate are also shown.

Appendix E includes a full Biodiversity Credit Report for the proposed Mangoola Offset site.

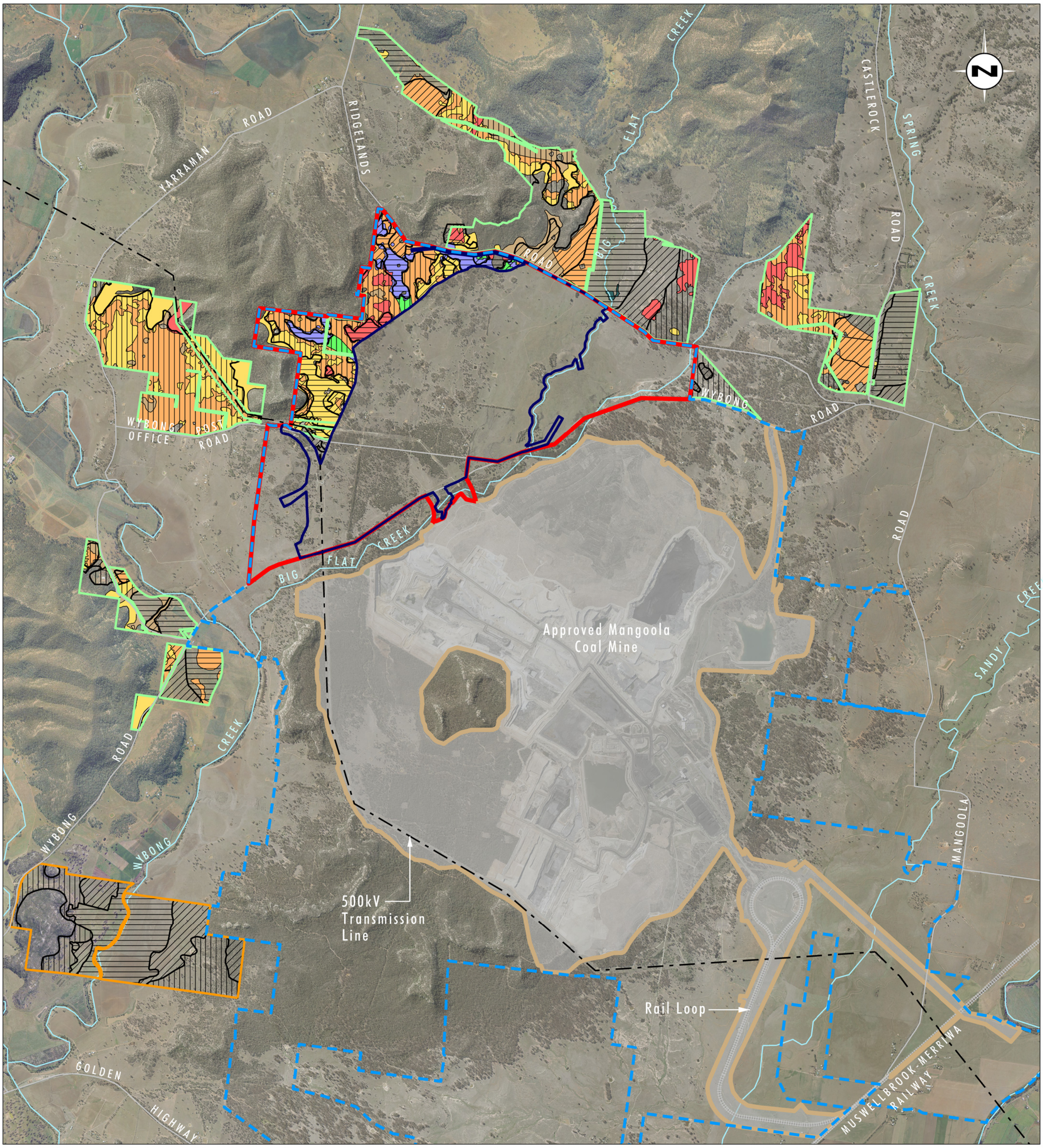

Image Source: Glencore (April 2018)
Data Source: Glencore (2018)
Note: Offset boundaries are based on LPI cadastre

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Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- Development Footprint
- MCCO Additional Project Area
- Proposed Mangoola Offset Sites
- Proposed Mangrove Offset Sites
- High *Prasophyllum petilum* Habitat Potential
- Moderate *Prasophyllum petilum* Habitat Potential
- Low *Prasophyllum petilum* Habitat Potential
- HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter - Moderate to Good
- HU812/PCT1598 - Moderate to Good - Derived Native Grassland
- HU816/PCT1602 Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good
- HU817/PCT1603 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter - Moderate to Good
- HU817/PCT1603 Moderate to Good - Derived Native Grassland
- HU821/PCT1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter - Moderate to Good
- HU869/PCT1655 Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin - Moderate to Good
- HU945 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Good

FIGURE 7.4

Mangoola Offset Site Biodiversity Features

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Table 7.2 Credits Generated at the Mangoola Offset Site

Plant Community Type *Condition Class*	Area (ha)	Credits Generated
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	38.4	510
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	51.5	742
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	583.4	8,991
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	54.6	860
HU945 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	1.1	17
large-eared pied bat	94 ha	667
pine donkey orchid (*Diuris tricolor*)(known)	7,567 ind	53,725
pine donkey orchid (*Diuris tricolor*)(Expert Report)	9,991 ind	70,936
Tarengo leek orchid (*Prasophyllum petilum*) (known)	877 ind	6,226
Tarengo leek orchid (*Prasophyllum petilum*) (Expert Report)	903 ind	6,411

7.1.4 Improvement in Site Values

There are no pre-existing conservation obligations in relation to the proposed Mangoola Offset site. This site has previously been, and could be in the future, developed for agricultural purposes under existing legislative arrangements. The economic viability of any farming on this area in the future (i.e. if not used for offsetting the impacts from the proposed MCCO Project) would benefit from an improvement in pasture quality which will significantly lower the ecological value of this land from that which presently exists.

Additional management actions have been proposed to increase the gain for one management zone of HU817. The management zone is approximately 120 ha in area and currently a derived native grassland. The management actions proposed are detailed in **Appendix G**. These include active planting of overstorey and midstorey species as well as tree hollow and fallen log augmentation.

No changes have been made to the credit gains for the other BVTs identified above with standard gain used as no additional management actions proposed.

7.2 Wybong Heights Offsets Site

Wybong Heights is a 895 ha agricultural property that contains a mix of native woodland and forest communities, derived native grasslands and improved pasture on the alluvial flats associated with Wybong Creek near Manobalai in the Upper Hunter Valley. The site adjoins the Glencore's Bulga Mine Reedy Valley Offset Site and is proximate to the Glencore Highfields and Esparanga Offsets Sites (proposed for the Wambo United Open Cut Coal Mine Project and Mount Owen Continued Operations Project, respectively) in the west. Wybong Heights contains the following key ecological features in an offsetting context under the FBA:

- 297.6 ha of HU730 White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley

- 130.6 ha of HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- 140.4 ha of HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter
- 1.5 ha of breeding habitat (tree hollows within 200 metres of Wybong Creek) for southern myotis (*Myotis macropus*)
- a riparian buffer area on one side of Wybong Creek (6th order stream) (i.e. within a strategic location).

The key biodiversity features of the Wybong Heights offset site are shown on **Figure 7.5**.

7.2.1 Site Details

The proposed Wybong Heights offset site will be committed to conservation through the establishment of a Stewardship Agreement. Wybong Heights is located approximately 15 km to the north of the Development Footprint. It comprises land owned by Glencore, located in the Manobalai area, approximately 30 km northwest of Muswellbrook, NSW (refer to **Figure 7.3**). Approximately 570 ha is proposed for the retirement of biodiversity credits as part of the MCCO Project Biodiversity Offset Strategy, with the remaining 325 ha being retained for agricultural purposes.

Table 7.3 below provides general information on the proposed Wybong Heights Offset site as required by Table 22 of the FBA (OEH 2014b).

Table 7.3 Wybong Heights Offset site Details

Wybong Heights Offset site	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Kerrabee
Major Catchment Area	Hunter-Central Rivers
Rivers, Creeks, etc	Wybong Creek (6th Order)
Mitchell Landscape	Central Hunter Foothills
LGA	Muswellbrook
Zoning	RU1 Primary Production
Size	Approximately 760 ha proposed for conservation
Land Use History	The historical land use of the Wybong Heights Offset site has been agricultural, primarily a cattle and sheep grazing enterprise. The property has been maintained as a landholding for this purpose since the late 1800s. Currently this property is maintained by Glencore and utilised for cattle grazing. Large portions of the property contain native vegetation cover (Umwelt 2011b).
General Description	Wybong Heights is a 895 ha property on the alluvial flats associated with Wybong Creek near Manobalai in the Upper Hunter Valley (refer to **Figure 7.3**). Wybong Heights contains an array of basalt, sandstone and conglomerate outcropping, primarily along the mid slopes and within the semi-regular ridgelines that line the elevated sections. These ridgelines, which form a near continuous escarpment along the majority of the elevated areas, contain numerous caves. The caves are primarily shallow to moderate depressions in the ridgelines formed by erosion over time.

Wybong Heights Offset site	
	The gullies within Wybong Heights range from gradual to steep in slope and are generally dry with few aquatic or inundation dependant flora species present. These gullies contain drainage lines which generally remain dry but would provide ephemeral creeks in times of high rainfall. There are a several small farm dams scattered on the lower slopes and upper plateaux of Wybong Heights, in areas cleared for livestock grazing. Wybong Creek also occurs within the Offset site. The alluvial flats and lower slopes trend from open grassland, to grassland with scattered trees to woodland areas, representing several different vegetation community types. The mid-slope areas tend to be dominated by forest and woodland and the upper slopes tend from open grassland to woodland areas. Wybong Heights is found on the western edge of a large scale vegetation corridor which runs along the Great Dividing Range. On a broad scale, this corridor connects the Liverpool Ranges to the north with Wollemi and Yengo National Parks to the south and Barrington Tops National Park to the east. Wybong Heights is located within the Great Eastern Ranges corridor that extends along the majority of the eastern coast of Australia and connects the Great Dividing Range and the Great Escarpment of Eastern Australia.

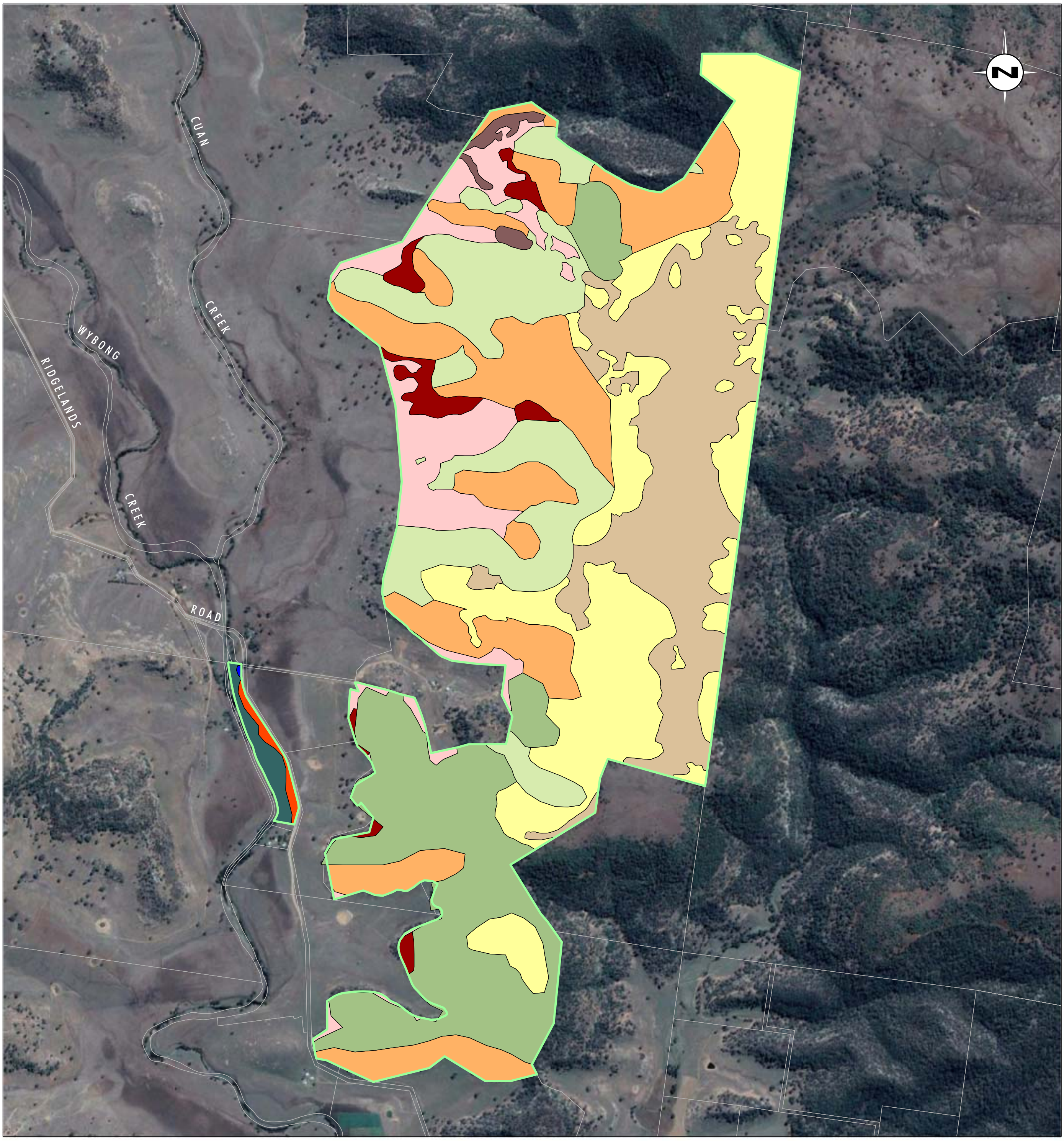

Image Source: Google Earth (Sept 2018)
Data Source: LPI (2018)
Note: Offset boundaries are based on LPI cadastre

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Legend

- Wybong Heights Offset Site
- HU599/PCT42 - River Red Gum / River Oak riparian woodland wetland in the Hunter Valley - Moderate to Good
- HU599/PCT42 - River Red Gum / River Oak riparian woodland wetland in the Hunter Valley - Moderate to Good - DNG
- HU701/PCT623 Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion - Moderate to Good
- HU701/PCT623 Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion - Moderate to Good - DNG
- HU712/PCT485 River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley– Moderate to Good
- HU714/PCT281 Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion - Moderate to Good Condition
- HU730/PCT618 White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley - Moderate to Good
- HU730/PCT618 White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley - Moderate to Good - DNG
- HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- HU821/PCT1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter - Moderate to Good
- HU868/PCT1654 Narrow-leaved Ironbark - Grey Gum shrubby open forest on sandstone ranges of the upper Hunter Valley - Moderate to Good

FIGURE 7.5

Wybong Heights Offset Site Biodiversity Features

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7.2.2 Survey Effort and Methods

Surveys of the proposed Wybong Heights Offset site been completed in accordance with the requirements of the FBA and included the following methodology:

- Detailed floristic and vegetation mapping surveys in April and May 2011 and included systematic plot-based sampling, rapid assessments and targeted threatened flora surveys and vegetation mapping (Umwelt 2011b).
- Detailed floristic sampling in accordance with BBAM (OEH 2014) in February 2017 and 2018 which included 50 floristic plots.
- Targeted surveys for southern myotis (*Myotis macropus*) habitat along Wybong Creek in August 2018.
- Detailed fauna surveys in April 2011 including hair funnel surveys, harp trapping, spotlighting, herpetological searches, bird surveys, call playback, micro-bat echolocation recording, remote camera surveys and habitat assessments (Umwelt 2011b).
- Targeted winter bird surveys in April 2011 including bird surveys and call playback targeting the regent honeyeater (*Anthochaera phrygia*) and swift parrot (*Lathamus discolor*).
- Opportunistic cave-roosting microbat surveys in April 2011 including traversing escarpment and cliff lines areas for potential caves, cracks, fissures and overhangs for potential micro-bat roosts/maternity caves (Umwelt 2011b).
- Opportunistic brush-tailed rock-wallaby (*Petrogale penicillata*) surveys in April 2011 were undertaken in areas of steep, extensive exposed rock and associated shallow caves (Umwelt 2011b).

Full details on survey effort and results for the proposed Wybong Heights Offset site are included in **Appendix H**.

7.2.3 Credits Generated

Table 7.4 below outlines the PCTs at the proposed Wybong Heights Offset site and the ecosystem credits generated at this site as required by Table 22 of the FBA (OEH 2014b). The surveys, dictated by MCCO Project timing considerations were undertaken in the summers of 2017 and 2018 during a declared drought period. **Appendix E** includes a full Biodiversity Credit Report for the proposed Wybong Heights Offset site.

Table 7.4 PCTs and Credits Generated at the Wybong Heights Offset site

Plant Community Type ***Condition Class***	**Area (ha)**	**Credits Generated**
HU730 White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley	297.4	4,612
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	133.2	2,042
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	140.4	2,549
southern myotis (*Myotis macropus*)	1.5	11

7.2.4 Improvement in Site Values

There are no pre-existing conservation obligations in relation to the proposed Wybong Heights Offset site. This site is currently grazed and has previously been, and could in the future be developed for agricultural purposes under existing legislative arrangements.

Additional management actions have been proposed to increase the gain for one management zone of HU730. The management zone is approximately 136 ha in area and currently a derived native grassland. The management actions proposed are detailed in **Appendix H**. These include active planting of overstorey and midstorey species as well as tree hollow and fallen log augmentation. No changes have been made to the credit gains for the other BVTs identified above with standard gain used as no additional management actions proposed. If additional management actions are proposed prior to the preparation of the BioBanking Agreement, the credits generated for each BVT listed in **Table 7.4** above will increase.

7.3 Credits Sourced from Existing BioBank Sites

Mangoola will source species and ecosystem credits from two proposed BioBank sites currently being established by Glencore, being the proposed Mangrove Biobank Site and the Highfields BioBank Site.

The proposed Mangrove BioBank Site is proposed for establishment for the United Wambo Coal Mine Project and adjoins other Mangoola offset sites that are protected as part of the offset for Glencore's Mangoola Mine (refer to **Figure 7.1**). The full details of the proposed offset site have been assessed by DPE and OEH as part of the assessment process for the United Wambo Coal Mine Project. The site will protect important lowland, river flat and creekline habitats, while also providing a link from the Mangoola offsets to vacant Crown land to the west, and ultimately to Manobalai Nature Reserve and Goulburn River National Park. The proposed Mangrove BioBank Site contains the following key biodiversity features relevant to the offsetting strategy for the MCCO Project:

- 3,109 credits for *Prasophyllum petilum*, and
- 25,183 credits for *Diuris tricolor*.

The 3,109 *Prasophyllum petilum* credits and the 25,183 *Diuris tricolor* credits have not been allocated to any other projects (they are not relevant to the offsetting of the United Wambo Project) and are currently available and will be committed to the MCCO Project and retired as part of the biodiversity offset strategy.

The proposed Highfields BioBank Site was also proposed for the United Wambo Project. The full details of the proposed offset site have been assessed by DPE and OEH as part of the assessment process for the United Wambo Coal Mine Project. The proposed Highfields BioBank Site contains the following key biodiversity features relevant to the offsetting strategy for the MCCO Project:

- 790 credits of HU730 - White Box x Grey Box - Red Gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley.

The 790 credits of HU730 - White Box x Grey Box - Red Gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley is a 'like for like' offset under the FBA for HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter and will be committed to the MCCO Project and retired as part of the biodiversity offset strategy. These credits have not been allocated to any other projects and are available to be allocated to the MCCO Project.

7.4 Mine Rehabilitation

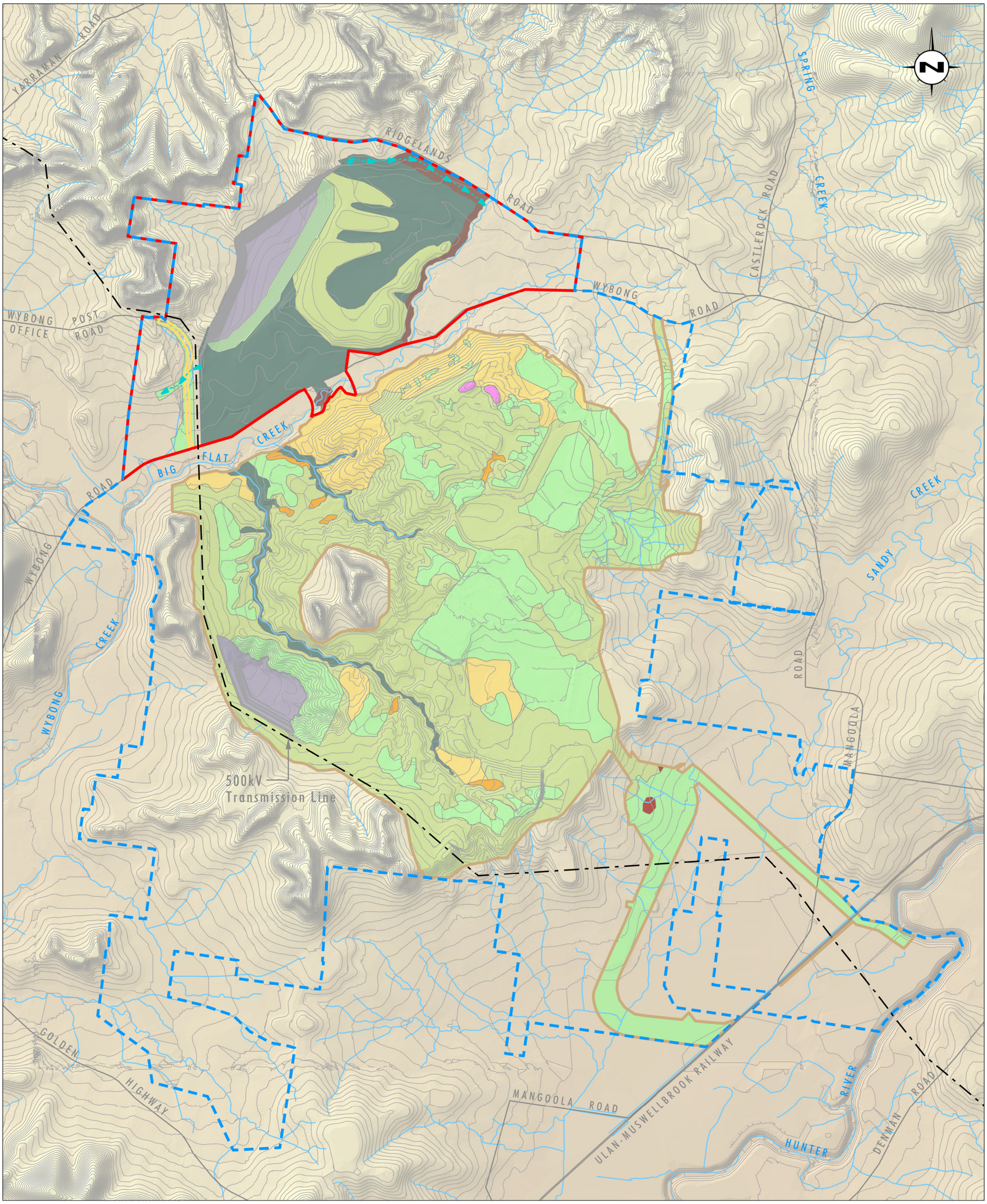
The NSW *Biodiversity Offset Policy for Major Projects* enables the use of ecological mine rehabilitation to contribute towards meeting the offset requirement of a mining project. While no theoretical limit exists for the amount that rehabilitation can contribute to the offset under the FBA (OEH 2014b), Glencore acknowledges the importance of providing a varied offset strategy that includes a combination of offset components including land-based offsets and revegetation programs and therefore proposes to use mine rehabilitation to complement other proposed land based offsets. Taking into account the existing rehabilitation commitments already attributed to Mangoola Coal Mine and may not be used for credit generation, there is approximately 456 ha of ecological rehabilitation proposed as part of the MCCO Project that is suitable for use as part of the biodiversity offset strategy.

The ecological rehabilitation discussed in **Sections 7.4.1** to **7.4.6** is conceptual only and will be refined through the development of the rehabilitation strategy. Mangoola Mine's current rehabilitation program is re-establishing 1100 ha of woodland and forest vegetation in accordance with its existing development consent and this commitment will be maintained for the MCCO Project. In addition, the MCCO Project would result in a further 456 ha of rehabilitation within the MCCO Additional Project Area.

7.4.1 Target PCTs for Ecological Rehabilitation

Table 7.5 below outlines the target PCTs for ecological rehabilitation, the natural distribution of the PCTs in relation to the MCCO development footprint, the proposed increase in site attribute scores, the area of rehabilitation and the ecosystem credits proposed to be generated using the Calculator for FBA Section 12.2: "Generating biodiversity credits for ecological rehabilitation of previously mined land" (OEH 2015). It should be noted that no species credits are currently proposed to be generated through mine rehabilitation.

The conceptual location of the mine rehabilitation is shown in **Figure 7.6**. The exact areas of ecological rehabilitation will be determined through the detailed rehabilitation planning.



Data Source: Glencore (2019)
Note: Contour interval 5m

0 1.0 2.0 3.0km
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Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Wybong Post Office Road Realignment
- Final Void
- Forest Redgum Riparian Woodland
- Grassland
- Ironbark Woodland Complex
- Paperbark Woodland
- Slaty Box Woodland
- Spotted Gum Open Forest
- Swamp Oak Forest
- Weeping Myall Woodland

FIGURE 7.6

Conceptual Ecological Mine Rehabilitation

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Table 7.5 Target PCTs for Mine Rehabilitation

Natural Distribution in Relation to the Development Footprint	Proposed Increase in Site Attribute Condition Scores	Area Proposed for Rehabilitation (ha)	Ecosystem Credits Generated
HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter			
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	• Native species richness: 1.0 • Over-storey cover: 1.0 • Mid-storey cover: 1.0 • Native ground cover (grasses): 1.0 • Native ground cover (shrubs): 1.0 • Native ground cover (other): 1.0 • Exotic plant cover: 1.0 • Number of trees with hollows: 0.5 • Over-storey regeneration: 0.5 • Total length of fallen logs: 0.5	282	1355
HU817/PCT1603 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter			
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	• Native species richness: 1.0 • Over-storey cover: 1.0 • Mid-storey cover: 1.0 • Native ground cover (grasses): 1.0 • Native ground cover (shrubs): 1.0 • Native ground cover (other): 1.0 • Exotic plant cover: 1.0 • Number of trees with hollows: 0.5 • Over-storey regeneration: 0.5 • Total length of fallen logs: 0.5	142	681
HU945/PCT1731 Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley			
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	• Native species richness: 1.0 • Over-storey cover: 1.0 • Mid-storey cover: 1.0 • Native ground cover (grasses): 1.0 • Native ground cover (shrubs): 1.0 • Native ground cover (other): 1.0 • Exotic plant cover: 1.0 • Number of trees with hollows: 0.5 • Over-storey regeneration: 0.5 • Total length of fallen logs: 0.5	32	151
	Total	**456**	**2,187**

7.4.2 Rehabilitation Objectives

Mangoola's rehabilitation objectives for the Development Footprint include the following:

- Provide for the safety of employees and the public during and following the closure of the mining operations.
- Provide a sustainable final landform that uses natural landform design principles.
- Establish similar native vegetation communities to those that will be impacted by the MCCO Project.
- Establishment of ecological rehabilitation as part of the biodiversity offset for the MCCO Project.
- Develop native vegetation corridors linking surrounding remnant vegetation areas to the southwest of the Development Footprint to existing remnants in the north

In achieving these objectives, Mangoola will also aim to:

- Comply with relevant regulatory requirements.
- Reduce the need for long term monitoring and maintenance by achieving effective rehabilitation.
- Regularly consult with the relevant stakeholders during the closure and rehabilitation planning and implementation process.

7.4.3 Preliminary Performance Indicators and Completion Criteria

Mine rehabilitation will be undertaken in accordance with the development consent and Mining Operations Plan (MOP) which will incorporate a Rehabilitation Management Plan (RMP). The MOP will detail performance measures and criteria for specific areas that are to be rehabilitated during the term of the MOP. The MOP process provides benchmarks against which performance of the rehabilitation strategy can be measured through development of completion criteria and performance indicators. The preliminary completion criteria and performance indicators that have been developed for the ecological rehabilitation will be reviewed in accordance with the MOP review timeframe to confirm that the rehabilitation areas are meeting or trending towards meeting the completion criteria. Subsequent reviews of the MOP will consider relevant updates to PCTs, benchmarks and assessment methodologies in relation to ongoing refinement of the final completion criteria.

As required in Section 12.2.1.5 of the FBA (OEH 2014b) **Table 7.6** below outlines the preliminary performance indicators and completion criteria for the rehabilitation of the PCTs proposed to be established in the Development Footprint to contribute to the offset strategy for the MCCO Project. While the values in **Table 7.6** have been guided by the Draft *Guidelines for the Ecological Rehabilitation of Recognisable and Self-sustaining Plant Communities Types* (OEH 2015b) and the Biodiversity Assessment Method (BAM) (OEH 2018bd), these are preliminary and in consideration of the ongoing changes in legislation and policy, mine rehabilitation indicators and criteria will be reviewed and modified as part of the MOP process and will consider the contemporary best practice guidance on ecological mine rehabilitation.

Table 7.6 Preliminary Performance Indicators and Completion Criteria by PCT

Attribute	Preliminary Performance Indicators (by Year 7)	Preliminary Completion Criteria (to generate credits for offset)
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter		
Site Condition	Native species richness scores are trending towards benchmark for HU812 as determined through monitoring.	Rehabilitation contains >50% of the native plant species richness benchmark (i.e. >20 native species) for species characteristic to HU812.
	Overstorey cover scores are trending towards benchmark for HU812 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native overstorey cover benchmark for species characteristic to HU812.
	Midstorey cover scores are trending towards benchmark for HU812 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native midstorey cover benchmark for species characteristic to HU812.
	Native ground cover (grasses) scores are trending towards benchmark for HUI812 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (grasses) benchmark for species characteristic to HU812.
	Native ground cover (shrubs) scores are trending towards benchmark for HU812 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (shrubs) benchmark for species characteristic to HU812.
	Native ground cover (other) scores are trending towards benchmark for HU812 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (other) benchmark for species characteristic to HU812.
	Exotic plant cover is trending towards less than 45% for total ground and midstorey cover as determined through monitoring.	Exotic plant cover is <45% for total ground and midstorey cover.
	Number of trees with hollows (i.e. natural hollows or stags salvaged from other areas and placed into rehabilitation) occur in the rehabilitation.	Rehabilitation contains hollows >25% of the number of hollow-bearing trees benchmark for HU812. This is proposed to be achieved with the installation of artificial nest boxes.
	Targeted planting of canopy species is undertaken with natural reproduction processes (seeds, fruiting) taking place.	Rehabilitation contains at least 25% of dominant overstorey species naturally regenerating (i.e. not planted or seeded).
	Fallen timber and logs occur in the rehabilitation.	Rehabilitation contains >25% of the total length of fallen log benchmark for HU812.
Vegetation Composition	Targeted planting of flora species characteristic or diagnostic of HU812 is undertaken	Rehabilitation contains at least 50% of the species characteristic or diagnostic of HU812 as outlined in the VIS (or equivalent) or in suitable local reference sites.

Attribute	Preliminary Performance Indicators (by Year 7)	Preliminary Completion Criteria (to generate credits for offset)
Vegetation Structure	Targeted planting of flora species characteristic of growth form groups for HU812 is undertaken. Growth form groups include: • Trees • Shrubs • Grasses • Forbs • Ferns and • Other species	Rehabilitation contains vegetation structure and vegetation growth forms covers within a suitable range of benchmark for HU812 (or equivalent).
Ecosystem Function	Targeted placement of functional features is undertaken including: • Leaf litter • Fallen timber and logs • Nest boxes or salvaged hollows	Rehabilitation contains leaf litter, coarse woody debris and hollows within a suitable range of benchmark for HU812.
	Targeted planting of characteristic canopy species is undertaken. Species include: • forest red gum (*Eucalyptus tereticornis*) • rough-barked apple (*Angophora floribunda*)	The following characteristic canopy species are regenerating across the rehabilitation (i.e. evidence of regeneration stems <5cm DBH): • forest red gum (*Eucalyptus tereticornis*) • rough-barked apple (*Angophora floribunda*)
	High threat weeds (OEH 2018bd) do not comprise more than 20% cover of any stratum.	High threat weeds (OEH 2018bd) do not comprise more than 10% cover of any stratum.
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter		
Site Condition	Native species richness scores are trending towards benchmark for HU817 as determined through monitoring.	Rehabilitation contains >50% of the native plant species richness benchmark (i.e. >20 native species) for species characteristic to HU817.
	Overstorey cover scores are trending towards benchmark for HU817 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native overstorey cover benchmark for species characteristic to HU817.
	Midstorey cover scores are trending towards benchmark for HU817 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native midstorey cover benchmark for species characteristic to HU817.
	Native ground cover (grasses) scores are trending towards benchmark for HUI817 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (grasses) benchmark for species characteristic to HU817.

Attribute	Preliminary Performance Indicators (by Year 7)	Preliminary Completion Criteria (to generate credits for offset)
	Native ground cover (shrubs) scores are trending towards benchmark for HU817 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (shrubs) benchmark for species characteristic to HU817.
	Native ground cover (other) scores are trending towards benchmark for HU817 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (other) benchmark for species characteristic to HU817.
	Exotic plant cover is trending towards less than 45% for total ground and midstorey cover as determined through monitoring.	Exotic plant cover is <45% for total ground and midstorey cover.
	Number of trees with hollows (i.e. natural hollows or stags salvaged from other areas and placed into rehabilitation) occur in the rehabilitation.	Rehabilitation contains hollows >25% of the number of hollow-bearing trees benchmark for HU817. This is proposed to be achieved with the installation of artificial nest boxes.
	Targeted planting of canopy species is undertaken with natural reproduction processes (seeds, fruiting) taking place.	Rehabilitation contains at least 25% of dominant overstorey species naturally regenerating (i.e. not planted or seeded).
	Fallen timber and logs occur in the rehabilitation.	Rehabilitation contains >25% of the total length of fallen log benchmark for HU817.
Vegetation Composition	Targeted planting of flora species characteristic or diagnostic of HU817 is undertaken	Rehabilitation contains at least 50% of the species characteristic or diagnostic of HU817 as outlined in the VIS (or equivalent) or in suitable local reference sites.
Vegetation Structure	Targeted planting of flora species characteristic of growth form groups for HU817 is undertaken. Growth form groups include: • Trees • Shrubs • Grasses • Forbs • Ferns and • Other species	Rehabilitation contains vegetation structure and vegetation growth forms covers within a suitable range of benchmark for HU817 (or equivalent).
Ecosystem Function	Targeted placement of functional features is undertaken including: • Leaf litter • Fallen timber and logs • Nest boxes or salvaged hollows	Rehabilitation contains leaf litter, coarse woody debris and hollows within a suitable range of benchmark for HU817.

Attribute	Preliminary Performance Indicators (by Year 7)	Preliminary Completion Criteria (to generate credits for offset)
	Targeted planting of characteristic canopy species is undertaken. Species include: • narrow-leaved ironbark (*Eucalyptus crebra*) • grey box (*Eucalyptus moluccana*)	The following characteristic canopy species are regenerating across the rehabilitation (i.e. evidence of regeneration stems <5cm DBH): • narrow-leaved ironbark (*Eucalyptus crebra*) • grey box (*Eucalyptus moluccana*)
	High threat weeds (OEH 2018bd) do not comprise more than 20% cover of any stratum.	High threat weeds (OEH 2018bd) do not comprise more than 10% cover of any stratum.
HU906 - Bull Oak grassy woodland of the central Hunter Valley		
Site Condition	Native species richness scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation contains >50% of the native plant species richness benchmark (i.e. >20 native species) for species characteristic to HU906.
	Overstorey cover scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native overstorey cover benchmark for species characteristic to HU906.
	Midstorey cover scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native midstorey cover benchmark for species characteristic to HU906.
	Native ground cover (grasses) scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (grasses) benchmark for species characteristic to HU906.
	Native ground cover (shrubs) scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (shrubs) benchmark for species characteristic to HU906.
	Native ground cover (other) scores are trending towards benchmark for HU906 as determined through monitoring.	Rehabilitation achieves between >25% and <200% of per cent native ground cover (other) benchmark for species characteristic to HU906.
	Exotic plant cover is trending towards less than 45% for total ground and midstorey cover as determined through monitoring.	Exotic plant cover is <45% for total ground and midstorey cover.
	Number of trees with hollows (i.e. natural hollows or stags salvaged from other areas and placed into rehabilitation) occur in the rehabilitation.	Rehabilitation contains hollows >25% of the number of hollow-bearing trees benchmark for HU906.
	Targeted planting of canopy species is undertaken with natural reproduction processes (seeds, fruiting) taking place.	Rehabilitation contains at least 25% of dominant overstorey species naturally regenerating (i.e. not planted or seeded).
	Fallen timber and logs occur in the rehabilitation.	Rehabilitation contains >25% of the total length of fallen log benchmark for HU906.

<table>
<tr><th>Attribute</th><th>Preliminary Performance Indicators
(by Year 7)</th><th>Preliminary Completion Criteria
(to generate credits for offset)</th></tr>
<tr><td>Vegetation Composition</td><td>Targeted planting of flora species characteristic or diagnostic of HU906 is undertaken</td><td>Rehabilitation contains at least 50% of species characteristic or diagnostic of HU906 as outlined in the VIS or in suitable local reference sites.</td></tr>
<tr><td>Vegetation Structure</td><td>Targeted planting of flora species characteristic of growth form groups for HU906 is undertaken.
Growth form groups include:
• Trees
• Shrubs
• Grasses
• Forbs
• Ferns and
• Other species</td><td>Rehabilitation contains vegetation structure and vegetation growth forms covers within a suitable range of benchmark for HU906.</td></tr>
<tr><td rowspan="3">Ecosystem Function</td><td>Targeted placement of functional features is undertaken including:
• Leaf litter
• Fallen timber and logs
• Nest boxes or salvaged hollows</td><td>Rehabilitation contains leaf litter, coarse woody debris and hollows within a suitable range of benchmark for HU906.</td></tr>
<tr><td>Targeted planting of characteristic canopy species is undertaken. Species include:
• bulloak (Allocasuarina luehmannii)</td><td>The following characteristic canopy species are regenerating across the rehabilitation (i.e. evidence of regeneration stems <5cm DBH):
• bulloak (Allocasuarina luehmannii)</td></tr>
<tr><td>High threat weeds (OEH 2018bd) do not comprise more than 20% cover of any stratum.</td><td>High threat weeds (OEH 2018bd) do not comprise more than 10% cover of any stratum.</td></tr>
</table>

7.4.4 Achievability of Ecological Mine Rehabilitation

Glencore is committed to the continual improvement of native ecosystem establishment in mine rehabilitation across all of its mine sites and believes that mine rehabilitation plays an important role in mitigating and offsetting impacts on biodiversity. Glencore has had considerable success in establishing high quality mine rehabilitation in the Hunter Valley.

Glencore has also participated in several Australian Coal Association Research Program (ACARP) projects on mine site rehabilitation. In collaboration with the University of Newcastle, Glencore has supported a research program that will lead to the most effective methods to establish dry sclerophyll and other native forest communities on rehabilitated overburden emplacements. The report *Establishing Native Vegetation – Principles and Interim Guidelines for Spoil Placement Areas and Restoration Lands* (Nussbaumer *et al.* 2012) summarises the outcomes of the University of Newcastle research programs and provides guidance for the ongoing development of ecological rehabilitation on each of Glencore's Hunter Valley operations.

Mangoola aims to develop rehabilitation of mined land that returns the site to a condition where the landforms, soils, hydrology, and flora and fauna are self-sustaining and compatible with the surrounding land uses. Rehabilitation of the overburden emplacement areas are conducted progressively over the life of mine, as an integral component of mining operations. Topsoil is managed to maximise the viability of soil biota, with topsoil management measures including varying stripping depths for different soil types, incorporation of mulched vegetation material into the topsoil resource, limiting topsoil storage stockpiles to a maximum of three metres in height and minimising any compaction of stockpiles or where possible topsoil is direct placed onto shaped overburden. Mangoola continues to implement a natural landform design process in all final rehabilitation which assists in the creation of a self-sustaining post-mining rehabilitated landform that is compatible with surrounding land and provides habitat for the suite of flora and fauna species encountered in the Mangoola local area prior to mining.

Plates 7.1 and **7.2** show examples of the current Mangoola Mine rehabilitation areas.

Plate 7.1 **Aerial view of rehabilitation in North Pit area**

Plate 7.2 Open woodland rehabilitation in North Pit area

Umwelt, supported by funding from the Australian Coal Association Research Program (ACARP) and with the assistance of Glencore and Mangoola, and other coal mining businesses, is currently conducting a research project that is focussing on the proven success or the success potential of ecological mine rehabilitation. The project is titled “Establishing Self-sustaining Ecological Mine Rehabilitation that Achieves Recognised Ecological Communities.” Previous investigations conducted by Umwelt in the Hunter Valley found that rehabilitation programs were meeting the benchmark of, or progressing strongly towards, critically endangered ecological community listings under the EPBC Act even though this was not the objective of the rehabilitation when planted. This included investigations at the Mangoola Mine. The current research project aims to determine if ecological mine rehabilitation can form recognisable ecological communities and if it can be self-sustaining, in accordance with emerging government policy and guidelines. In particular, the project aims to determine whether ecological mine rehabilitation has, or can be, established and maintained to meet recognised PCTs and BC Act and EPBC Act listed TECs. The research project also aims to develop a set of principles to inform the establishment of appropriate rehabilitation objectives, monitoring methods, performance criteria and completion criteria for the establishment of recognisable and self-sustaining ecological communities.

Glencore is a key supporting partner to the research project and, further to this, Mangoola has been selected to form the primary part of the ecological case study, which is an integral aspect of the research project. Mangoola was chosen due to its commitment to rehabilitate specific vegetation communities and, most importantly, due to the high quality rehabilitation it has established as part of its post-mining landform establishment. This is further supported by the strong baseline and monitoring dataset that has been maintained by Umwelt and Mangoola throughout the mine’s rehabilitation history. Mangoola has been actively participating in the research project by supplying data and other valuable information as well as supporting the site visits and fieldwork required by the project.

7.4.5 Contingency Measures

Mangoola has a high degree of confidence in its ability to deliver ecological mine rehabilitation based on the success it has had in delivering high quality rehabilitation at the mine to date. Government policy also facilitates the use of ecological rehabilitation as an offset, encouraging mining companies to focus on delivering high quality rehabilitation. For some projects where Glencore has proposed ecological rehabilitation some stakeholders have asked about contingency measures should the intended rehabilitation quality not be achieved. While Mangoola believes that it can deliver the required standard of rehabilitation, should unforeseen circumstances affect rehabilitation outcomes the following contingency measures will be available:

- implement management measures to improve the rehabilitation to achieve the required standards (e.g. additional plantings etc.)
- replace the credits generated by the proposed rehabilitation with credits generated by Mangoola securing further land based offsets
- replace the credits generated by the proposed rehabilitation with credits purchased on the credit market (if available)
- replace the credits generated by the proposed rehabilitation by paying into the NSW Biodiversity Conservation Fund.

7.4.6 Long-term Security of Mine Rehabilitation

As required in the FBA (OEH 2014b) and the NSW *Biodiversity Offset Policy for Major Projects*, a security bond will be required in order to ensure that the cost of rehabilitation will be met by the proponent. The monetary amount is to be sufficient to cover the cost of undertaking the works to achieve self-sustaining and recognisable PCTs as outlined in **Table 7.6** above.

Following the completion of the rehabilitation and achievement of the criteria set out in **Table 7.6**, the ongoing land use for the area of mine rehabilitation will be targeted for native vegetation conservation to provide ongoing protection and management of the biodiversity values of the local area.

7.4.7 Monitoring Requirements

Mangoola has an existing rehabilitation monitoring program in place which will be continued as part of the MCCO Project. The monitoring program will be refined to address the specific monitoring requirements for the proposed ecological rehabilitation and will be detailed in the MOP. Broadly, the monitoring program will include:

- ***Initial establishment inspections*** – within approximately three months of each rehabilitation campaign to provide early identification of potential issues to minimise harm to the establishing rehabilitation. Examples of these issues include: erosion that has occurred due to storm events, failure of drainage structures and a lack of germination or establishment of ground cover.
- ***Routine general inspections*** – to be undertaken at least annually until it can be demonstrated that completion criteria has been met. Parameters may include growing media conditions, the presence and extent of erosion, the stability of drainage and sediment control structures, revegetation germination rates, plant health, species density and diversity, presence of colonising fauna (e.g. ants, foraging birds), control of unauthorised access, effectiveness of habitat augmentation features and presence and/or impact of feral animals and weeds.

- ***Ecosystem development monitoring*** - to evaluate the progress of rehabilitation towards achieving the rehabilitation completion criteria outlined in **Table 7.6**, including a focus on composition, function and structure. The monitoring program will also include non-mined areas for reference (analogue) sites.

7.5 Payment into the Biodiversity Conservation Fund

Payment in the now operational Biodiversity Conservation Fund is considered a 'like for like' option under the FBA. Mangoola propose to pay into the Biodiversity Conservation Fund for southern myotis (*Myotis macropus*) credits that couldn't be secured at the Offset sites or proposed BioBank sites or through the credit market. A total of nine (9) southern myotis credits will be purchased to relinquish the residual credit liability for that species.

The payment amount will be generated using the Biodiversity Offsets Payment Calculator (BOPC) post determination of the MCCO Project. The BOPC generates payments based on BAM credits so an FBA credit equivalency will be calculated following the process prescribed by OEH to determine the final value of the payment.

7.6 Expert Report – *Prasophyllum petilum*

Mangoola commissioned an independent study into the availability of suitable *Prasophyllum petilum* and *Diuris tricolor* habitat within the proposed offset areas as part of the Biodiversity Assessment for the MCCO Project. Detailed biodiversity surveys conducted in the proposed biodiversity offset areas had determined that suitable potential habitat for *Prasophyllum petilum* and *Diuris tricolor* is present, however drought conditions during 2017 and 2018 meant that flowering of the threatened orchid species was heavily constrained, hampering the ability to undertake appropriate targeted surveys for these orchid species.

Dr Stephen Bell was approved by OEH as an expert in accordance with the requirements of the BC Act (refer to **Appendix C**) and was subsequently commissioned by Mangoola to prepare the Expert Report to determine the likely *Prasophyllum petilum* and *Diuris tricolor* population size in the proposed Mangoola Offset site and the proposed Mangrove BioBank site.

Local weather conditions are known to be highly influential in determining flowering and therefore detectability, of *Prasophyllum petilum* and *Diuris tricolor*. Dr Stephen Bell of East Coast Flora surveys has undertaken an analysis of rainfall and correlations with flowering of *Prasophyllum petilum* at Mangoola. The following is an excerpt from Dr Stephen Bell's Expert Report (Bell,2018) in relation to the detectability of *Prasophyllum petilum* and *Diuris tricolor* and rainfall:

> *As a rule of thumb, dry winters in the Hunter Valley generally result in below average flowering in terrestrial orchids. Low rainfall in the three months leading up to flowering place individual orchids under stress, meaning that flowering may be postponed for that season for all but the most robust individuals. Because of this trait, terrestrial orchids have been described of as 'time-travellers' (Brundrett 2016), encapsulating the uncertainty in determining their presence in any given area.*
>
> *The unpredictability of orchid flowering from year-to-year has been highlighted over the eight year translocation project of Diuris tricolor and Prasophyllum petilum that has been undertaken at Mangoola Coal (Bell in prep. 1, 2; also reported annually in reports to Mangoola Coal). Over the course of eight years of monitoring, the June-to-August pre-flowering rainfall in approximately half of them has been above average, and half has been below average. Dry years have been reflected in low rates of detection within recipient plots, while wetter years have shown an increase in detection (Figure 3). There are of course other factors contributing to the extent of orchid detection observed (expanded upon in Bell in prep 2), but there is a clear trend associated with winter rainfall. Of the nine recipient plots, all displayed lower detection rates in the drought year of 2017, following three seasons of above average winter falls. Results obtained for the 2018 surveys showed a continuing decline in detection despite marginally better rainfall. A similar downward trend was observed for the five recipient plots (n=440) established within mine rehabilitation, monitored over 2-3 years since 2015.*

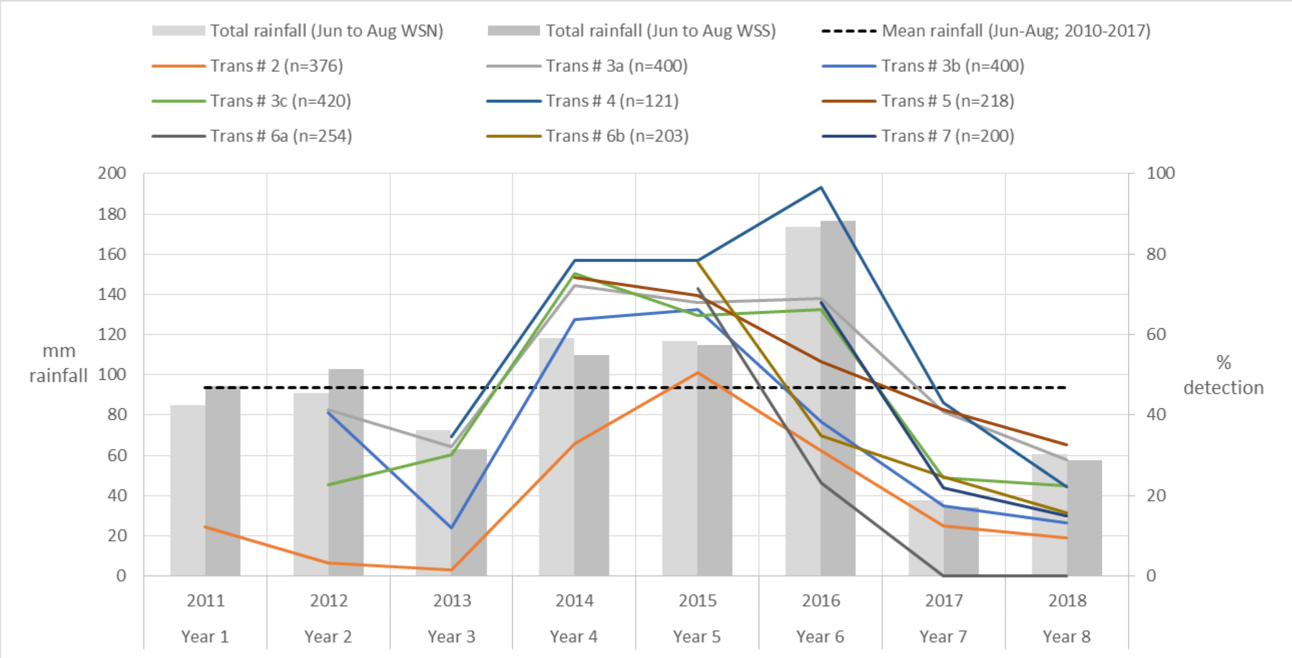

Figure 7.7 Excerpt from Bell (2018) Rainfall received (with 3-month average, June to August) and orchid detection during the course of monitoring across nine recipient plots within derived grassland, over a period of three to eight years (n=2,592 orchids)

The surveys within the Development Footprint were primarily undertaken between 2013 and 2016 which represented the best flowering years in the last eight years of monitoring (refer to **Figure 7.7**). In comparison, the surveys of the proposed offset areas were undertaken in 2017 and 2018 which represent the worst years for flowering in the last eight years. In order to determine the likely population size of *Prasophyllum petilum* and *Diuris tricolor* in the proposed biodiversity offset areas, Dr Bell undertook a detailed analysis of the habitat and conditions within each of the proposed offset areas.

The Expert Report considers a range of habitat features, using the biophysical attributes documented at locations where the orchids are known to occur, to determine the likelihood of individuals occurring in the offset areas. In addition, Dr Stephen Bell also examined the relative densities of *Prasophyllum* and *Diuris* individuals across the entire Mangoola land holding (using information from Bell 2016) to estimate the likely population size within the proposed offset sites. Following field inspections on 31 July and 4 October 2018, Dr Bell used data collected then and existing floristic plot data to construct a map of orchid habitat quality across the proposed offsets. This resulted in the designation of 514 ha of high quality habitat, 265 ha of moderate quality, and 330 ha of low quality. The balance (181 ha) was considered to comprise negligible orchid habitat. Combining the areas of high and moderate quality habitat, 779 ha of the total 1290 ha combined offsets provide suitable habitat for *Diuris* and *Prasophyllum*. This represents 60% of the total proposed Mangoola Offset site. Using existing point record data on orchid occurrence (n=11,006 *Diuris*; n=3,606 *Prasophyllum*), representative densities of orchids were then calculated across eight different areas surveyed in previous years to determine appropriate lower and upper bounds for the expected population size within the proposed offsets. This analysis resulted in a range of 2 to 74 *Diuris* per hectare and 2 to 4 *Prasophyllum* per hectare. Extrapolating these densities across the mapped high and moderate quality habitat within the proposed offset areas, the expected population size for *Diuris* likely falls within the range of 1,530 to 45,000 individuals, and for *Prasophyllum* 1,530 to 2,530 individuals.

In order to provide more definitive estimates of both species that could be used in credit calculations, two different multipliers were used (median density from previous surveys for high/moderate quality habitat; lowest density for low quality habitat) to calculate the expected number of individuals across the combined offset area. Following this process the Expert Report identified that 21,304 *Diuris* and 2,218 *Prasophyllum* are expected to be present. This analysis was based on a combination of known records and predicted records. Therefore, in addition to the 904 *Prasophyllum petilum* individuals and 9,030 *Diuris tricolor* individuals currently known to occur within the proposed offsets, the Expert Report predicts a further 1,314 *Prasophyllum petilum* and 12,045 *Diuris tricolor* individuals to occur. The Expert Report is included as **Appendix C**. In accordance with the FBA, an expert report can be prepared to determine species presence within an offset site and the numbers presented in Dr Bell's Expert Report (Bell 2018) have been used in the credit calculations presented in **Sections 7.7** and **7.8.**

7.7 Summary of Available Credits

Table 7.7 below provides a summary of the ecosystem and species credits available at each of the proposed offset sites, mine rehabilitation and use of the fund that comprise the MCCO Project Biodiversity Offset Strategy.

Table 7.7 Summary of Offset Package

PCT / Species	Area (ha)	Credits
Mangoola Offset site		
HU812 - Forest Red Gum grassy open forest on floodplains of the lower Hunter	37.4	510
HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	51.5	742
HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	583.4	8,991
HU821 - Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the Hunter	54.6	860
HU945 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	1.1	17
pine donkey orchid (*Diuris tricolor*)(known)	7,493 ind	53,200
pine donkey orchid (*Diuris tricolor*)(Expert Report)	9,637 ind	68,423
Tarengo leek orchid (*Prasophyllum petilum*) (known)	877 ind	6,226
Tarengo leek orchid (*Prasophyllum petilum*) (Expert Report)	872 ind	6,191
large-eared pied bat	94 ha	667
Wybong Heights Offset site		
HU730 - White Box x Grey Box - Red Gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley	297.6	4,612
HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	133.2	2,042
HU821 - Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	140.4	2,549
southern myotis (*Myotis macropus*)	1.5	11

PCT / Species	Area (ha)	Credits
Highfields BioBank Site		
HU730 - White Box x Grey Box - Red Gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley	69	790
Mangrove BioBank Site		
pine donkey orchid (*Diuris tricolor*) (known)	1,463 ind	10,387
pine donkey orchid (*Diuris tricolor*) (Expert Report)	2,084 ind	14,796
Tarengo leek orchid (*Prasophyllum petilum*) (known)	27 ind	191
Tarengo leek orchid (*Prasophyllum petilum*) (Expert Report)	411 ind	2,918
Mine Ecological Rehabilitation (456 ha)		
HU812 - Forest Red Gum Grassy Open Forest	282*	1364*
HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest	142*	681*
HU945– Swamp Oak - Weeping Grass Grassy Riparian Forest	32*	151*
Biodiversity Offsets Payment Fund		
Southern Myotis	NA	9

Like for like offset option for HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter
*Approximate areas of rehabilitation and associated credits. Will be confirmed following the retirement of all other available credits

7.8 Overall Offsetting Outcome

The overall offsetting outcome for the MCCO Project is summarised in **Table 7.8**. All offset methods proposed are in accordance with the FBA and are considered 'like for like' in accordance with the NSW *Biodiversity Offset Policy for Major Projects*. Under the 'like for like' rules, impacts on vegetation are to be offset with vegetation that is in the same locality as the impact and is:

- the same plant community type (vegetation in NSW is divided into around 1500 plant community types), or
- a plant community type in the same vegetation class (vegetation in NSW is divided into 99 vegetation classes) that has undergone a similar or greater amount of clearing since European inhabitation.

Under the FBA, impacts on HU817 and HU906 can use HU730 as a like for like option and HU730 has been used in the preparation of the current offsetting strategy.

Table 7.8 Summary of Credits Required by the MCCO Project and Credits Available for Offsetting

BVT/PCT/Species Credit	Credits Required	Offset Credits Available	Is Credit Requirement Met?
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	1,874	1,874	Yes
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	369	2,784	Yes

BVT/PCT/Species Credit	Credits Required	Offset Credits Available	Is Credit Requirement Met?
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	13,457	13,477	Yes
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	253	3,409	Yes
HU906 Bull Oak grassy woodland of the central Hunter Valley	1,597	1,597	Yes
HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	168	168	Yes
Tarengo leek orchid (*Prasophyllum petilum*)	8,983	15,526	Yes
pine donkey orchid (*Diuris tricolor*)	17,238	146,806	Yes
large-eared pied bat (*Chalinolobus dwyeri*)	27	667	Yes
southern myotis (*Myotis macropus*)	20	11	Yes (fund for 9 credits)

8 Matters of National Environmental Significance

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister for the Environment and Energy is required for any action that may have a significant impact on matters of national environmental significance (MNES). These matters are:

- listed threatened species and communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- World Heritage properties
- National Heritage places
- nuclear actions, and
- a water resource, in relation to coal seam gas development and large coal mining development.

Those aspects of the MCCO Project requiring approval under the EPBC Act were referred to DoEE in October 2018 to determine whether or not the MCCO Project was a controlled action, thereby requiring approval of the Commonwealth Minister for the Environment and Energy. Detailed assessments of significance were prepared for the following ecological MNES considered to have the potential to occur or be impacted by the MCCO Project:

Critically Endangered or Endangered Ecological Communities

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

Critically Endangered and Endangered Species

- Tarengo leek orchid (*Prasophyllum petilum*)
- swift parrot (*Lathamus discolor*)
- regent honeyeater (*Anthochaera phrygia*), and
- spotted-tailed quoll (*Dasyurus maculatus maculatus*) (SE mainland population).

Vulnerable Species

- brush-tailed rock wallaby (*Petrogale penicillata*)
- koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT)
- large-eared pied bat (*Chalinolobus dwyeri*), and
- grey-headed flying-fox (*Pteropus poliocephalus*).

No other MNES (relating to biodiversity) are likely to be significantly impacted as a result of the MCCO Project. Subsequent alterations to the MCCO Project boundaries since the preparation of the EPBC Referral have resulted in impact area reductions and no new impacts are applicable to other MNES.

On 21 January 2019, DoEE confirmed the MCCO Project was a controlled action for impacts on threatened species and communities and water related MNES. Specifically, DoEE considered the MCCO Project is likely to have a significant impact on:

- White Box – Yellow Box – Blakelys Red Gum Woodland and Derived Native Grasslands
- *Prasophyllum* sp. Wybong
- Regent honeyeater.

In addition, DoEE also considers the MCCO Project may result in a significant impact on:

- Swift parrot
- Grey-headed flying fox.

Under the bilateral agreement, the SEARs for the MCCO Project were reissued to include the assessment requirements from DoEE. A report has been prepared to satisfy the requirements relating to MNES and is appended to the EIS (refer to Appendix 24).

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APPENDIX A

Threatened Species Justification

Appendix A - Threatened Species Assessment Justification

Table A1 below lists the flora and fauna species-credit species that were identified during database searches, a literature review and an assessment using the BioBanking Credit Calculator that are considered unlikely to occur due to lack of suitable habitat and/or absence of local records. **Table A1** provides an individual description of why each of the species was excluded from further assessment within the Development Footprint as per Section 6.5.1.6 of the FBA (OEH 2014b). In many cases, the seasonal survey requirements for these species were adequately covered during the species-credit flora and fauna species surveys outlined in **Section 2.3**.

Habitat and record information is derived from the BioNet Atlas of NSW Wildlife (OEH 2018ba), OEH threatened species profiles (OEH 2018bb), and DoEE SPRAT profiles (DoEE 2018b), unless otherwise noted.

1	BioBanking Credit Calculator
2	BioNet Atlas of NSW Wildlife
3	Protected Matters Search Tool
CE	Critically Endangered
E	Endangered
V	Vulnerable

Table A1 – Threatened Species Assessment Justification

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Flora Species				
Acacia dangarensis	E	-	1	This species is confined to the summit and surrounding slopes of Mount Dangar south of Merriwa, within Goulburn River National Park. It occurs in pure stands or as a co-dominant tree in sclerophyll woodland on the edge of dry rainforest on basalt and basalt colluvium. Despite extensive seasonal surveys, this species was not recorded within the Development Footprint, and it is considered unlikely that potential habitat exists for this species within the Development Footprint, or in the immediate locality. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
Commersonia procumbens	V	V	1,2	*Commersonia procumbens* is endemic to NSW and it confined to the Dubbo, Mendooran and Gilandra region, and also in Pilliga and Nymagee areas (PlantNet, 2018). Despite extensive seasonal surveys, this species was not recorded within the Development Footprint, and it is considered unlikely that potential habitat exists for this species within the Development Footprint, or in the immediate locality. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Commersonia rosea	E	E	1,2	The Sandy Hollow commersonia is known from six populations in the vicinity of Sandy Hollow in the upper Hunter Valley in New South Wales (Wilkins & Witlock, 2011). Four populations are located within an 8 km radius of Sandy Hollow (including one within the Mangoola land holdings) one population occurs several kilometres to the south-east of Sandy Hollow and one population occurs 80 km to the west in Goulburn River National Park (TSSC, 2008). The species is estimated to have a total population size of about 300 individuals (Copeland, 2006, pers. comm., cited in TSSC, 2008) with an extent of occurrence of 2000 km^2 (TSSC, 2008). The record of this species at Mangoola is located on a rocky hilltop, south of the Approved Disturbance Area in one of the existing conservation agreement areas. The Sandy Hollow commersonia occurs on skeletal sandy soils in scrub or heath with scattered emergent eucalypts namely, narrow-leaved ironbark (*Eucalyptus crebra*), black cypress pine (*Callitris endlicheri*) or *E. caleyi* subsp. *caleyi* (TSSC, 2008; Wilkins & Whitlock, 2011; OEH 2018). The species is likely a fire-ephemeral and requires a suitable fire regime to germinate and produce flowers and seed (Bell, 2006, pers. comm., cited in TSSC, 2008). Vegetation assemblages within the MCCO Additional Project Area do not meet the known habitat requirements for the species, however the species was targeted during floristic surveys due to the proximity of known records. The species was not identified in the MCCO Additional Project Area and the MCCO Additional Project Area does not provide potential habitat for this species. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Denman pomaderris *Pomaderris reperta*	CE	CE	2,3	The Denman pomaderris is endemic to the Wybong area. The species occurs in narrow-leaved ironbark (*Eucalyptus crebra*) and Blakely's red gum (*E. blakelyi*) woodland (NSW SC, 2002), with small-fruited mock-olive (*Notelaea macrocarpa*) and black sheoak (*Allocasuarina littoralis*) subdominant (OEH, 2013). The species is known to occur in the Mangoola biodiversity offset areas to the south of the MCCO Additional Project Area, occurring in Ironbark Woodland Complex, Sheltered Grey Gum Woodland and Tall Mixed Shrubland on the Lees Pinch soil landscape. These communities and soil sandscapes do not occur in the MCCO Additional Project Area. Vegetation assemblages within the MCCO Additional Project Area do not meet the known habitat requirements for the species, however the species was targeted during floristic surveys due to the proximity of known records and was not found. The MCCO Additional Project Area does not provide potential habitat for this species. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
large-leafed monotaxis *Monotaxis macrophylla*	E	-	1	This species is not known from the central Hunter Valley area. This species only appears to be detectable following fire events and is known to grow on rocky ridges and hillsides. The nearest record of this species is over 50 km to the south of the Development Footprint in Wollemi National Park. Floristic surveys and targeted threatened flora walking transects undertaken during the detection period of this species (June-Nov) did not record this species in the Development Footprint. Furthermore, the Development Footprint does not contain suitable rocky habitat for this species. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
leafless tongue orchid *Cryptostylis hunteriana*	V	V	3	Targeted threatened flora searches were completed in suitable habitat during February 2009, February 2013 and November 2016 surveys. This species was not recorded within the Development Footprint despite extensive survey effort by Umwelt throughout the entire area across multiple surveys and years. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Mount Vincent mint-bush *Prostanthera stricta*	V	V	1	This species occurs as an understorey species within open forest or tall open forests or in heath or scrub vegetation communities along cliff edges and has been recorded from Mt Vincent to Genowlan Mountain and at Dingo Creek and Widden and Baerami Valleys in the Upper Hunter (OEH 2018b). This species was not recorded within the Development Footprint despite extensive survey effort by Umwelt throughout the Development Footprint across multiple surveys and years. The closest confirmed record of this species occurs approximately 20 km south-west of the Development Footprint (OEH 2018a). There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
Ozothamnus tesselatus	V	V	2,3	This species was formerly restricted to a few locations north of Rylstone. However in 2003 it was recorded in Ravensworth State Forest, approximately 30 km from the MCCO Additional Project Area. The species is poorly defined and it is known to occur in eucalypt woodlands and forests. The species has been previously recorded at Mangoola Mine, in eucalypt forest. Targeted searches were undertaken for *Ozothamnus tesselatus* within the MCCO Additional Project Area due to the proximity of records and the relatively undefined nature of the preferred habitat for the species. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
scant pomaderris *Pomaderris queenslandica*	E	-	1,2	Scant pomaderris is found in sheltered woodlands or moist eucalypt forests (OEH 2018b). This species has a widely scattered distribution in northeast NSW and Queensland however is not a common species. In NSW records are known from the New England Tablelands and North West Slopes (OEH 2018b). This species was not recorded within the Development Footprint despite extensive survey effort by Umwelt throughout the entire area across multiple surveys and years. The closest confirmed record of this species occurs approximately 16km south of the Development Footprint and is generally known to occur around Denman and in the Goulburn River National Park (OEH 2018a). There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Senecio linearifolius subsp. *dangarensis*	E	-	1	This species is restricted to a single known population at Mount Dangar in Goulburn River National Park where it has been recorded growing on an open scree slope and in woodland and rainforest communities on basalt (OEH 2018b). Despite extensive seasonal surveys, this species was not recorded within the Development Footprint, and it is considered unlikely that potential habitat exists for this species within the Development Footprint, or in the immediate locality. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
silky pomaderris *Pomaderris sericea*	E	V	-	Targeted surveys for the silky pomaderris were undertaken in April and September 2017. Despite extensive seasonal surveys, this species was not recorded within the Development Footprint, and it is considered unlikely that potential habitat exists for this species within the Development Footprint, or in the immediate locality. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
weeping myall population in the Hunter catchment	E	CE	1,2,3	Weeping myall individuals that would conform to the endangered population have been identified within the MCCO Additional Project Area (outside the Development Footprint). The MCCO Project has avoided all known locations of the species and therefore there will be no impacts on the endangered population and no species credits have been generated for this species.
White-flowered Wax Plant *Cynanchum elegans*	E	E	1	This species was not recorded within the Development Footprint despite extensive survey effort by Umwelt throughout the entire area across multiple surveys and years. Targeted surveys for the white-flowered wax plant were undertaken in April and September 2017. This species is usually found on the margins of dry rainforest and is restricted to Wollongong, NSW, north to southeast Queensland and west to Mt Danger (DoEE 2018b). The closest confirmed record of this species occurs approximately 20 km south-west of the Development Footprint (OEH 2018a). Despite extensive seasonal surveys, this species was not recorded within the Development Footprint, and it is considered unlikely that potential habitat exists for this species within the Development Footprint, or in the immediate locality. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
Fauna Species (Species-credit)				
brush-tailed rock-wallaby *Petrogale penicillata*	E	V	1,2,3	This species occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges. A scat was recorded within the MCCO Additional Project Area (outside the Development Footprint) in 2014 (OEH 2018a). Diurnal surveys undertaken for this species have not identified this species in the Development Footprint. The Development Footprint does not contain suitable rocky escarpment habitat suitable for this species however it has not been detected following many years of ecological surveys in the locality.
Eastern Pygmy-possum *Cercartetus nanus*	V	-	1	This species has been recorded in intact habitats in the adjacent Wollemi National Park and more recently near Rothbury to the southeast of the Development Footprint. The closest record occurs approximately 10km south of the Development Footprint in Wollemi National Park. While potentially suitable habitat was identified for the species occurs within the Development Footprint, this species was not recorded within this area despite extensive survey effort by Umwelt throughout the entire area across multiple surveys and years. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.
Koala *Phascolarctos cinereus*	V	V	1,2,3	The koala was not recorded within the Development Footprint during the targeted SAT or spotlighting surveys and few preferred feed trees were recorded within the MCCO Additional Project Area. There are no known records of this species occurring within the Development Footprint. The closest record of the species occurs approximately 6km to the south of the Development Footprint. Given the scattered nature of the eucalypt woodlands in the Development Footprint and lack of primary koala feed trees in the Hunter-Central Rivers CMA (DECC 2008), it is unlikely this species uses these habitats on a long-term basis. There is no potential that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

Common Name *Scientific Name*	BC Act	EPBC Act	^Source	Reason Targeted Surveys and Further Assessment Were Not Required
pale-headed snake *Hoplocephalus bitorquatus*	V	-	1	The pale-headed snake has a patchy distribution with known records in NSW from Mungindi and Quambone on the Darling Riverine Plains and from the north coast from Queensland to Sydney (OEH 2018b). This species occurs in dry eucalypt forests and woodlands, cypress forests and less frequently in rainforests or moist eucalypt forests (OEH 2018b). This species was not recorded within the Development Footprint despite extensive survey effort by Umwelt throughout the entire area across multiple surveys and years. In addition, it hasn't been recorded during the extensive fauna monitoring program that has been undertaken at Mangoola since 2006. The nearest record is from Tucker's Creek, approximately 95km southeast from the Development Footprint (OEH 2018a). This species is unlikely to be impacted by the MCCO Project and no species credits have been generated for this species.
regent honeyeater *Anthochaera phrygia*	CE	CE	1,3	This species has not been recorded within the Development Footprint despite targeted winter bird surveys since 2010 (Umwelt 2010a). The nearest record of this species exists approximately 16 km north west of the Development Footprint from 1996 and approximately 20 km east at Muswellbrook in 1905. While the MCCO Project will likely exacerbate habitat loss and fragmentation for the species in potential foraging habitat in the wider Hunter Valley, the species has not been recorded utilising the habitats of the Development Footprint. This is likely to be due to the low frequency of key feed trees (DoE 2016) and the small number of individuals remaining in the population utilising other higher quality habitats in NSW. It is unlikely that this species would be impacted by the MCCO Project and no species credits have been generated for this species.

^ Source
1 = BioBanking Credit Calculator
2 = Bionet Atlas of NSW Wildlife
3 = Protected Matters Search Tool

A full fauna species list from the surveys undertaken is included in **Appendix D**. **Table A2** below outlines the predicted ecosystem-credit species predicted to occur by the BioBanking Credit Calculator and whether they were recorded within the Development Footprint or the wider MCCO area during the surveys undertaken for this assessment or previous surveys (as shown on **Figure 3.4**). It also includes ecosystem species that were not predicted by the BioBanking Credit Calculator, however were recorded as part of surveys of the Development Footprint or wider MCCO Additional Project Area.

Table A2 - Ecosystem-credit Species Predicted to occur by the BBCC or Previously Recorded

Species Name	BC Act	EPBC Act	Threatened Species Offset Multiplier	Predicted by the BBCC	Previously Recorded	
					Development Footprint	MCCO Additional Project Area
barking owl *Ninox connivens*	V	-	3.0	Yes	No	No
black-chinned honeyeater *Melithreptus gularis* subsp. *gularis*	V	-	1.3	Yes	No	No
brown treecreeper *Climacteris picumnus* subsp. *victoriae*	V	-	2.0	Yes	No	Yes
eastern false pipistrelle *Falsistrellus tasmaniensis*	V	-	2.2	Yes	No	No
eastern freetail-bat *Mormopterus norfolkensis*	V	-	2.2	Yes	No	Yes
flame robin *Petroica phoenicea*	V	-	1.3	Yes	No	No
gang-gang cockatoo *Callocephalon fimbriatum*	V	-	2.0	Yes	No	No
glossy black-cockatoo *Calyptorhynchus lathami*	V	-	1.8	Yes	Yes	Yes
greater broad-nosed bat *Scoteanax rueppellii*	V	-	2.2	Yes	No	Yes
grey-crowned babbler *Pomatostomus temporalis* subsp. *temporalis*	V	-	1.3	Yes	Yes	Yes
hooded robin *Melanodryas cucullata* subsp. *cucullata*	V	-	1.7	Yes	No	Yes
little eagle *Hieraaetus morphnoides*	V	-	1.4	Yes	No	Yes
little lorikeet	V	-	1.8	Yes	Yes	Yes

Species Name	BC Act	EPBC Act	Threatened Species Offset Multiplier	Predicted by the BBCC	Previously Recorded	
					Development Footprint	MCCO Additional Project Area
Glossopsitta pusilla						
masked owl *Tyto novaehollandiae*	V	-	3	Yes	No	No
painted honeyeater *Grantiella picta*	V	V	1.3	Yes	No	No
powerful owl *Ninox strenua*	V	-	3.0	Yes	No	No
scarlet robin *Petroica boodang*	V	-	1.3	Yes	No	No
speckled warbler *Chthonicola sagittata*	V	-	2.6	Yes	Yes	Yes
spotted harrier *Circus assimilis*	V	-	1.4	Yes	No	Yes
spotted-tailed quoll *Dasyurus maculatus*	V	E	2.6	Yes	No	No
square-tailed kite *Lophoictinia isura*	V	-	1.4	Yes	No	No
swift parrot *Lathamus discolor*	E	CE	1.3	Yes	No	Yes
turquoise parrot *Neophema pulchella*	V	-	1.8	Yes	No	No
varied sittella *Daphoenositta chrysoptera*	V	-	1.3	Yes	Yes	Yes
yellow-bellied sheathtail-bat *Saccolaimus flaviventris*	V	-	2.2	Yes	Yes	Yes
speckled warbler *Chthonicola sagittata*	V	-	2.6	No	Yes	Yes

APPENDIX B

Survey Methods

Appendix B - Species-credit Fauna Surveys

Umwelt was commissioned by GCAA in 2014 to undertake the flora and fauna surveys and prepare an ecological assessment for the *UHSA – Mangoola Coal Biodiversity Certification Assessment Report* (Umwelt 2015) for areas that Mangoola identified as potential areas for future mining activities. The Biodiversity Certification Assessment Report prepared for Mangoola was approved by OEH in 2015.

The MCCO Additional Project Area lies within the targeted UHSA survey area and, as a result of the extensive surveys completed for the Mangoola UHSA; this Ecological Study utilises the information from this approved assessment in relation to survey effort and identification of significant ecological features. Notwithstanding, this BAR has been prepared in accordance with the FBA and addresses the Secretary's Environmental Assessment Requirements (SEARs) issued in February 2019.

Table A1 identifies the species-credit species that were predicted to occur in the UHSA project area and that required survey. The list of species not requiring further assessment was identified in Appendix 2 of the *UHSA – Mangoola Coal Biodiversity Certification Assessment Report* (Umwelt 2015). Review of the predicted species against the survey undertaken as part of the UHSA was conducted during the MCCO Project pre-feasibility assessment in 2016 to identify any gaps in survey requirements and to ensure that additional species that were not assessed as part of the UHSA were captured. This gap analysis identified the regent honeyeater as requiring additional survey as it changed from an ecosystem-credit species in the UHSA to a species-credit species under the FBA following approval of the *UHSA – Mangoola Coal Biodiversity Certification Assessment Report* (Umwelt 2015). Additional survey was conducted for the regent honeyeater, as discussed below.

Section 1.1 details the fauna survey methods employed during the UHSA surveys and **Section 1.2** details the additional surveys undertaken as part of the MCCO Project to meet the requirements of the FBA and the SEARs. The extent of species-credit fauna surveys undertaken in the MCCO Additional Project Area is shown on **Figure 2.3**.

UHSA Survey Methodology

Threatened fauna species surveys were undertaken from 25 to 28 February 2014 and focussed on surveying for all species credit fauna species with potential to occur in the UHSA project area (refer to Table A1). A survey during February allowed all species listed in Table A1 to be searched for during the appropriate seasons.

Table B1 – List of Mangoola UHSA Species-credit Fauna Species Determined to Require Surveys

Common Name	Scientific Name	Status		Month												Source Codes
		BC Act	EPBC Act	J	F	M	A	M	J	J	A	S	O	N	D	
Birds																
Anthochaera phrygia	Regent Honeyeater	CE	CE													1
Mammals																
Phascolarctos cinereus	Koala	V	V													1, 2, 3
Petrogale penicillata	Brush-tailed rock-wallaby	E	V													1, 2, 3
phascogale tapoatafa	brush- tailed phascogale	V														1, 2, 3
Chalinolobus dwyeri	large-eared pied bat (breeding habitat)	V	V													1, 2, 3, 4
Miniopterus australis	little bentwing-bat (breeding habitat)	V														2
Miniopterus schreibersii oceanensis	eastern bentwing-bat (breeding habitat)	V														1, 2, 4
Vespadelus troughtoni	eastern cave bat (breeding habitat)	V														1, 2, 4
Myotis macropus	southern (breeding habitat)	V														1, 2, 4

Shaded cell = month that survey is required according to the Biodiversity Certification Credit Calculator or a BioBanking report exported for the Hunter-Central Rivers CMA from the online OEH Atlas of NSW Wildlife.
1 = Biodiversity Certification Credit Calculator
2 = Atlas of NSW Wildlife
3 = Commonwealth Protected Matters Search Tool (PMST)
4 = Previous nearby ecological surveys including Umwelt 2006, Umwelt 2011 and Umwelt 2012.
V = Vulnerable
E = Endangered

UHSA Surveys

Targeted surveys for species-credit fauna species comprised spotlighting surveys, remote camera surveys, Anabat echolocation recording, koala Spot Assessment Technique (SAT) searches, targeted pink-tailed worm lizard searches and targeted habitat searches.

Spotlighting Surveys

Driving spotlighting surveys targeting the koala were undertaken in areas of appropriate habitat between the hours of 8 pm and midnight using 30 watt Lightforce hand-held spotlights. The surveys were undertaken over two nights with approximately four person hours completed each night. Areas targeted for spotlighting primarily comprised woodland patches dominated by eucalypt species.

Remote Camera Surveys

The brush-tailed rock-wallaby was targeted using remote camera surveys at 14 locations across the UHSA project area in February, March and April 2014. An additional 13 remote cameras were set throughout the remaining UHSA project area. Bushnell Trophy Cam HD cameras were used for the remote camera surveys. At each site, a remote camera was mounted approximately one metre above the ground on a tree trunk and positioned towards a bait station containing tuna flakes or oats and honey. In potential brush-tailed rock-wallaby habitat areas cameras were positioned along potential tracks or facing rock platform areas where brush-tailed rock-wallabies may occur. Cameras were set to take three photos in quick succession when movement was detected. Remote cameras were set at each site for between 4 and 10 days resulting in a total of 168 camera days/nights of survey. The locations of the remote cameras are shown on **Figure 2.3**.

Targeted remote camera surveys targeting Brush- tailed Phascogale were also undertaken at 20 locations across the wider Mangoola area with 9 cameras located in the MCCO Additional Project Area in March 2014. Cameras were set at each site for between three and four 24 hour periods.

Anabat Echolocation Recording

Threatened micro-bat surveys were undertaken at 12 locations across the UHSA project area during February 2014. Calls were recorded using Anabat SD1 and Anabat SD2 devices (hereafter referred to as an 'Anabat'). At each site, the Anabat was positioned at an approximate 30 degree angle and 1 metre above the ground in a waterproof housing.

Each detector was positioned towards potential micro-bat flight paths or over water-bodies to increase the likelihood of detecting micro-bat species. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. At each location, the Anabat recorded for between one and two entire nights, resulting in a total of 17 nights of recording. Recordings of bat calls were analysed by Glenn Hoye of Fly By Night Bat Surveys Pty Ltd (a recognised expert in the identification of micro-bat calls). The echolocation calls of species were identified to one of three confidence levels:

- confident
- probable and
- possible.

All three levels of confidence were treated as positive identifications for the purposes of this ecological assessment. The locations of the micro-bat echolocation surveys are shown on **Figure 2.3** of the main text.

Koala SAT Searches

Searches for signs of the presence of koalas were undertaken at 20 locations across the UHSA project area in February 2014 using the Spot Assessment Technique (SAT). Searches were undertaken on and around the base of 30 trees at each survey site. These searches focused on signs of presence including scats left at the base of trees and characteristic scratches on tree trunks. The location of the 20 koala SAT searches are shown on **Figure 2.3**.

Targeted Pink-tailed Worm Lizard Searches

Targeted searches for pink-tailed worm lizard were undertaken in February 2013 at six locations (refer to **Figure 2.5**. The searches targeted areas of potential habitat within the UHSA project area. A total of 7.25 person hours of pink-tailed worm-lizard searches were undertaken. The searches involved traversing rocky areas and looking under rocks.

Targeted Habitat Searches

Targeted microbat potential roosting habitat searches were undertaken in in caves and overhangs on land adjoining the MCCO Additional Project Area during October 2013 for large- eared pied bat, eastern cave bat and little bentwing- bat. Targeted habitat searches were also undertaken adjacent to creek lines with permanent, or close to permanent, water to identify any potential hollow roosting habitat (hollow bearing trees) for the southern myotis (*Myotis macropus*) in February 2014. Areas of woodland within 200 metres of permanent, or close to permanent, water bodies containing hollow bearing trees were recorded.

Habitat searches for grey-headed flying-fox camp sites in woodland and forest habitats were undertaken opportunistically across the UHSA project area in February, March and April 2014.

Additional MCCO Project BBAM Surveys

As part of the finalisation of the ecological pre-feasibility assessment conducted by Glencore in 2015/2016, a gap analysis was undertaken to determine the range of seasonal surveys that would be required as part of a project development application during 2017/18. The gap analysis identified the requirement for additional targeted species surveys during spring (October) and summer (either December or February).

Appropriately-timed surveys are important to achieve sufficient survey effort in accordance with a range of survey guidelines and policy requirements. Under the BioBanking methodology (which underpins the FBA and UHSA), any species-credit species potentially occurring in the study area would require targeted surveys. Targeted species-credit species surveys were then conducted across the MCCO Project pre-feasibility study area in suitable habitat. All components of the MCCO Project that fell outside the area covered by the Mangoola UHSA project area required detailed survey and assessment.

In accordance with the BioBanking threatened species survey guidelines, the following species-credit species were identified as requiring additional survey within the MCCO Additional Project area during spring 2016 and summer 2017:

Winter

- regent honeyeater (*Anthochaera phrygia*)
- swift parrot (*Lathamus discolour*)

Spring

- large-eared pied bat (*Chalinolobus dwyeri*) – breeding habitat component only
- little bentwing-bat (*Miniopterus australis*) – breeding habitat component only
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) – breeding habitat component only
- large-footed myotis (*Myotis macropus*) – breeding habitat component only
- eastern cave bat (*Vespadelus troughtoni*) – breeding habitat component only
- pine donkey orchid (*Diuris tricolor*)
- Bodalla pomaderris (*Pomaderris bodalla*)
- Large-leafed Monotaxis (*Monotaxis macrophylla*)
- Tarengo leek orchid (*Prasophyllum petilum*)

It is noted that the threatened bat species listed above can be surveyed between October and March, however in order to maximise survey efficiency, surveys were undertaken during the spring (October) survey period, rather than the summer survey period.

Summer

- pink-tailed legless lizard (*Aprasia parapulchella*)
- *Cymbidium canaliculatum* – endangered population
- white-flowered wax plant (*Cynanchum elegans*)
- river red gum (*Eucalyptus camaldulensis*) – endangered population
- Camfield's stringybark (*Eucalyptus camfieldii*)
- Singleton mallee (*Eucalyptus castrensis*)
- slaty red gum (*Eucalyptus glaucina*)
- Pokolbin mallee (*Eucalyptus pumila*)
- stephen's banded snake (*Hoplochephalus stephensii*)
- *Leionema lamprophyllum* subsp. *obovatum* – endangered population
- green and golden bell frog (*Litoria aurea*) *Ozothamnus tesselatus*
- eastern osprey (*Pandion cristatus*)
- tall knotweed (*Persicaria elatior*)
- brush-tailed phascogale (*Phascogale tapoatafa*)

- koala (*Phascolarctos cinereus*)
- black flying-fox (*Pteropus alecto*)
- grey-headed flying-fox (*Pteropus poliocephalus*)
- scant Pomaderris (*Pomaderris queenslandica*)
- Denman pomaderris (*Pomaderris reperta*)
- *Commersonia rosea*
- Singleton mintbush (*Prostanthera cineolifera*)
- Wollemi mint-bush (*Prostanthera cryptandroides* subsp. *cryptandroides*)
- Austral toadflax (*Thesium australe*).

Winter Surveys

The regent honeyeater (*Anthochaera phrygia*) and the swift parrot (*Lathamus discolor*), both listed as critically endangered under the EPBC Act, have been recorded in the region but they have not been recorded within the MCCO Additional Project Area despite targeted survey. The regent honeyeater and swift parrot are considered to have potential to occur in areas of appropriate winter-flowering eucalypt habitat, as defined for the national recovery plans for the species.

Targeted surveys for the regent honeyeater and swift parrot were undertaken by two ecologists during June, July or August in 2010, 2011, 2012, 2013, 2014, 2016, 2017 and 2018 comprising more than 150 person hours of survey across the Development Footprint.

Surveys began with a period of quiet listening for approximately 5 minutes. Regent honeyeater and swift parrot calls were played using a 15 watt directional loud hailer for approximately four minutes, followed by a listening period of five minutes between species calls. Following call playback sessions, bird surveys were conducted at each site for a minimum of 30 minutes totalling one person hour of survey per site. This involved walking a meandering transect and recording the number of any bird species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. Opportunistic observations were also undertaken throughout the survey.

Opportunistic observations were recorded during all other aspects of the field survey.

The winter bird surveys targeted areas of better quality habitat resources for both species and were timed to coincide with the known presence of the species in the Hunter Valley.

Spring Surveys

Spring surveys consisted of two days of survey across the MCCO Additional Project Area in October 2017. The surveys consisted of walking meandering transect surveys throughout the MCCO Additional Project Area for the purposes of threatened flora searches.

It should be noted that the *NSW Guide to Surveying Threatened Plants* was released by OEH in February 2016. This document was released to guide assessors to identify the minimum standards to use when surveying for threatened plants under the BioBanking, FBA and BioCertification methodologies. The guide acknowledges the impractically of undertaking detailed searches over larger areas of potential habitat and therefore the targeted surveys for threatened flora species focussed on likely habitat areas only.

Summer Surveys

Summer surveys consisted of two days and two nights of survey across the MCCO Additional Project Area in February 2017. Diurnal surveys walking parallel transects and meandering surveys throughout the MCCO Additional Project Area targeting habitat for potentially occurring threatened flora species, and threatened fauna species habitat (e.g. outcrops for basking brush-tailed rock wallabies). Diurnal searches for the pink-tailed worm-lizard (*Aprasia parapulchella*) and Stephen's banded snake (*Hoplocephalus stephensii*) were conducted by traversing rocky areas and looking under rocks for individuals or their traces (e.g. shed skins) during diurnal surveys. Searches for Stephen's banded snake were also conducted during spotlighting.

Additional Koala SAT searches and koala call playback was undertaken in February 2017. The searches focused on signs of presence including scats at the base of trees and characteristic scratches on tree trunks.

Spotlighting surveys were undertaken across the MCCO Additional Project area in February 2017 targeting brush- tailed phascogale and koala.

Opportunistic observations were recorded during all other aspects of the field survey.

APPENDIX C

Expert Report

Expert Report

Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor* & *Prasophyllum petilum*):

Mangoola Coal Continued Operations Project

June 2019

Final Report

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SUMMARY

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW. Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 (as modified) since mining commenced at the site in September 2010. The Mangoola Coal Continued Operations Project (MCCO Project) will allow for the continuation of mining at Mangoola into a new mining area to the immediate north of the existing operations. The MCCO Project will mine an additional 50Mt of coal, and utilise the existing infrastructure and equipment at Mangoola Coal Mine to extend the life of the existing operation, providing for ongoing employment opportunities for the existing Mangoola workforce.

With the endorsement of the Office of Environment and Heritage (OEH), I have been engaged by Umwelt Australia Pty Ltd (Umwelt) on behalf of Mangoola Coal Operations Pty Limited (Mangoola) to complete an expert review in relation to two threatened orchids (*Diuris tricolor* and *Prasophyllum petilum*), to be incorporated into an impact assessment for the MCCO Project. The expert review is as required and in accordance with Section 6.5.2.3 of the NSW Governments Biodiversity Assessment Method, and will form part of an Environmental Impact Statement being prepared by Umwelt, aiming to support an application for development consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

The MCCO Project, if approved, will result in the removal of both *Diuris tricolor* and *Prasophyllum petilum*. Completed surveys by Umwelt show that 1,325 *Diuris* and 634 *Prasophyllum* will be directly impacted upon by proposed activities, and additional lands are consequently required to offset this impact ('proposed offset lands'). Based on targeted field surveys completed by myself in 2015, and Umwelt staff in 2016 and 2017, a minimum of 9,030 *Diuris* and 904 *Prasophyllum* individuals are known to be present within the proposed 1290 ha offset lands. Results obtained during 2017 surveys of the proposed offsets were poor due to drought conditions, hence the need for this expert report.

Following field inspections on 31 July and 4 October 2018, I used data collected then and existing floristic plot data to construct a map of orchid habitat quality across the proposed offsets. This resulted in the designation of 514 ha of high quality habitat, 265 ha of moderate quality, and 330 ha of low quality. The balance (181 ha) was considered to comprise negligible orchid habitat. Combining the areas of high and moderate quality habitat, **779 ha of the total 1290 ha combined offsets provide suitable habitat for *Diuris* and *Prasophyllum*.** This represents 60% of the total proposed offset lands. Using existing point record data on orchid occurrence (n=11,006 *Diuris*; n=3,606 *Prasophyllum*), I then calculated representative densities of orchids across eight different areas surveyed in previous years to determine appropriate lower and upper bounds for the expected population size within the proposed offsets. This analysis resulted in a range of 2 to 74 *Diuris* per hectare and 2 to 4 *Prasophyllum* per hectare. Extrapolating these densities across the mapped high and moderate quality habitat within the proposed offset areas, the **expected population size for *Diuris* likely falls within the range of 1,530 to 45,000 individuals, and for *Prasophyllum* 1,530 to 2,530 individuals**.

In order to provide more definitive estimates of both species that can be used in credit calculations, I used two different multipliers (median density from previous surveys for high/moderate quality habitat; lowest density for low quality habitat) to calculate the expected number of individuals across the combined offset area. Following this process, 21,304 *Diuris* and 2,218 *Prasophyllum* are expected to be present. Allowing for the 9,914 orchids already recorded in previous surveys, the proposed offset lands can be expected to support **an additional 12,294 *Diuris* and 1,314 *Prasophyllum***.

Table of Contents

1. Introduction

1.1 Background

1. I have been engaged by Umwelt Australia Pty Ltd (Umwelt) on behalf of Mangoola Coal Operations Pty Limited (Mangoola) to complete an expert review in relation to two threatened orchids (*Diuris tricolor* and *Prasophyllum petilum*), to be incorporated into an impact assessment for the Mangoola Coal Continued Operations Project (MCCO Project). The expert review is as required and in accordance with Section 6.5.2.3 of the NSW Governments Biodiversity Assessment Method (OEH 2017). It will form part of an Environmental Impact Statement being prepared by Umwelt, which aims to support an application for development consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

2. As part of my brief, I have been asked to examine search effort and existing orchid records against environmental and floristic data from proposed offset lands (the Subject Area) to assess the likely population size of both species within these lands. Collectively, these offset lands occupy 1290 hectares (ha), and lie in close proximity to the existing Mangoola operations. My assessment is required as drought conditions within the Subject Area in recent years may have restricted overall counts of the total orchid population size, leading to the perception that proposed offset lands supported fewer individuals than may be expected. In addition to the review and analysis of available data, a two day inspection of the offset lands has also been undertaken (on 31 July and 4 October 2018).

1.2 Project Overview

3. Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (Figure 1). Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 (as modified) since mining commenced at the site in September 2010.

4. The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will mine an additional 50Mt of coal, and utilise the existing infrastructure and equipment at Mangoola Coal Mine to extend the life of the existing operation, providing for ongoing employment opportunities for the existing Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area.

5. The MCCO Project generally comprises:

   - open cut mining at up to the same rate as that currently approved [13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal] using truck and excavator mining methods.
   - mining operations in a new mining area located north of the existing Mangoola Coal Mine on Wybong Road, south of Ridgelands Road and east of the 500 kV Electricity Transmission Line (ETL).
   - construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the proposed Additional Mining Area.

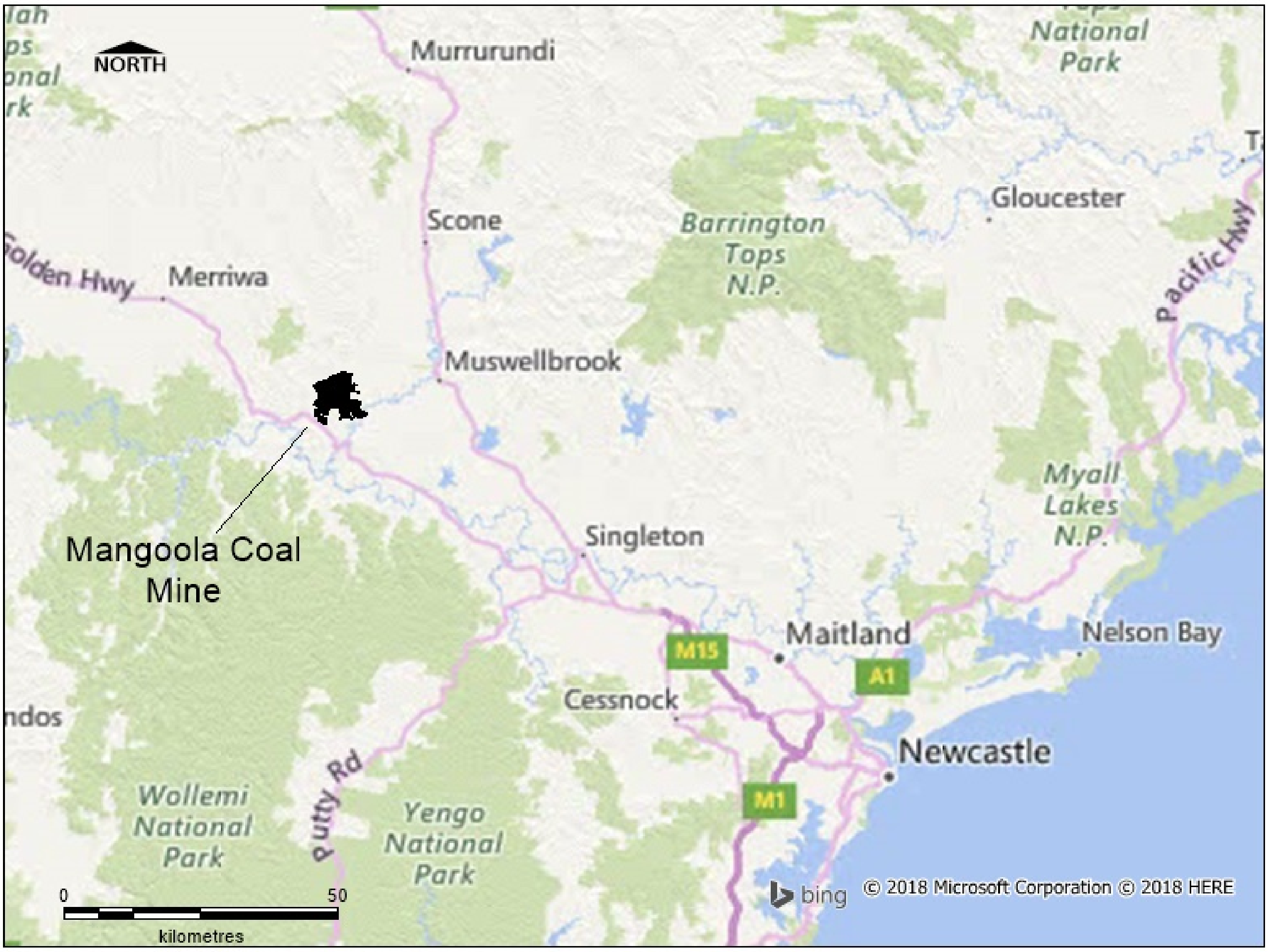

Figure 1 Location of Mangoola Coal Mine.

- establishment of an out-of-pit overburden emplacement area.
- distribution of overburden between the proposed Additional Mining Area and the existing mine in order to optimise the final landform design of the integrated operation.
- realignment of a portion of Wybong Post Office Road.
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet.
- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to that of the existing mine.
- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of micro-relief consistent with the existing site.
- rehabilitation of the proposed Additional Mining Area using the same revegetation techniques as at the existing mine.
- a likely construction workforce of approximately 145 persons. No change to the existing approved operational workforce.

- Continued use of the mine access for the existing operational mine and access to/from Wybong Road, Wybong Post Office Road or Ridgelands Road to the MCCO Additional Project Area for construction, emergency services and ongoing operational environmental monitoring.

6. The focus of my report is on the 1290 ha of proposed offset lands lying largely to the immediate north and south-west of the existing Mangoola operations (Figure 2). For contextual reasons, however, I have also assessed known orchid records and habitat data from the wider Mangoola lands. To assist in later discussions, I have broken up the 1290 ha proposed offset lands into five separate parcels of land (Table 1).

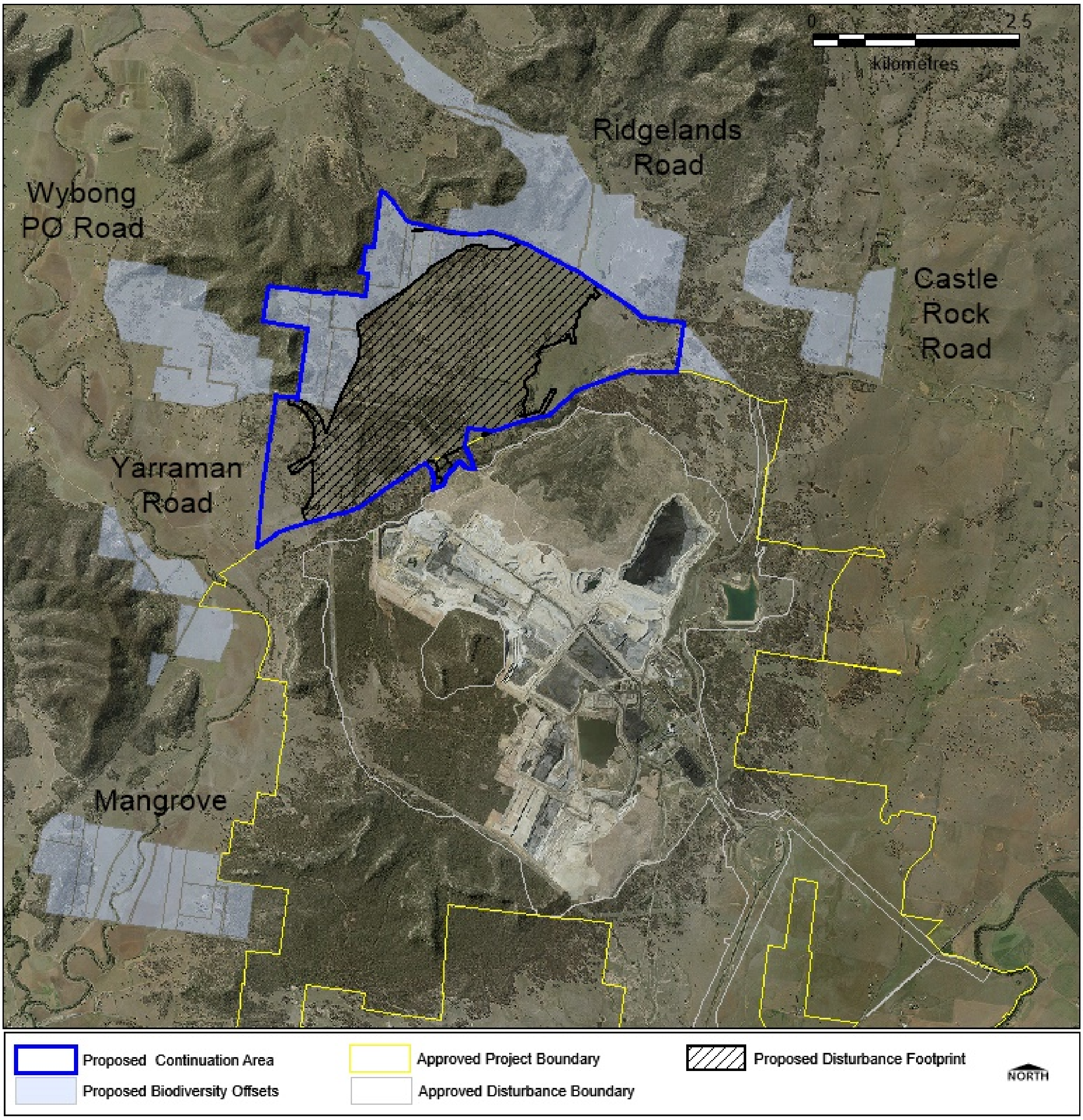

Figure 2 **Proposed biodiversity offset areas (the Subject Area).**

Table 1 Land parcels comprising the proposed Biodiversity Offset Lands.

Land Parcel	Size (ha)	Details
Ridgelands Road	563	three parcels of land immediately north and south of Ridgelands Road
Mangrove	259	immediately west of Wybong Road, adjoining approved project boundary
Wybong PO Road	208	immediately north of Wybong PO Road, and west to upper Yarraman Road
Castle Rock Road	156	two parcels of land either side of Castle Rock Road near its intersection with Wybong Road
Yarraman Road	104	five parcels of land either side of Yarraman Road and Wybong Road, at their intersection
Total	1,290	

1.3 Report Criteria & Structure

7. As detailed in the Biodiversity Assessment Method (OEH 2017), an expert report is required to address the following criteria, and these form the basis of the structure of this report:

a. identify the relevant species or population (see Section 2);
b. provide a justification for the use of an expert report (see Section 3);
c. indicate and justify the likelihood of presence of the species or population and prepare a species polygon showing the location and area of the species polygon (see Section 4);
d. estimate the number of individuals or area of habitat (as identified in the Credit Calculator) for the development site (see Section 5);
e. include the information considered in relation to the determination made in the report (see Section 6), and;
f. identify the expert and provide evidence of their credentials (see Section 7).

1.4 OEH Approval to Prepare Expert Report

8. I have been approved to prepare this expert report by the relevant officers at the Newcastle Office of Environmental and Heritage (OEH), as shown in Appendix 1.

2. Criterion (a) - The Relevant Species

2.1 Legal Status

9. *Diuris tricolor* and *Prasophyllum petilum* are both threatened species included in relevant State, Territory and Commonwealth legislation. *Diuris tricolor* is listed both as vulnerable in NSW and as an endangered population in the Muswellbrook local government area under the *Biodiversity Conservation Act 2016* (BC Act), while *Prasophyllum petilum* is listed as endangered in NSW (BC Act), the ACT (*Nature Conservation Act 2014*) and the Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*, EPBC Act).

10. In recent years, there has been some taxonomic confusion over the identity of *Prasophyllum* plants growing in the upper Hunter (Wybong) area. Following an informal review of these plants by NSW orchid taxonomists in the past decade, these plants were placed in synonymy with the more widespread *Prasophyllum petilum* (see PlantNet[1]), a finding also supported by other orchid experts elsewhere in Australia (e.g. Backhouse et al 2016a) and OEH (see Appendix 1). As a consequence, *Prasophyllum* sp. Wybong (C. Phelps ORG5269) is now an accepted synonym of *Prasophyllum petilum*, but remains listed as critically endangered on the EPBC Act.

2.2 Distribution and Known Populations

11. *Diuris tricolor* and *Prasophyllum petilum* (Figure 3) are present and co-occur in the Hunter Valley region of New South Wales (NSW), but the two species also occupy considerably wider geographical ranges throughout eastern Australia.

2.2.1 Diuris tricolor

12. *Diuris tricolor* (Pine Donkey Orchid) is a widespread terrestrial orchid, occurring on the western slopes and plains and tablelands of NSW, and also in the Moreton and Darling Downs districts of Queensland (Stanley & Ross 1989; Jones 1993). Populations of *Diuris tricolor* in the upper Hunter Valley around Denman and Muswellbrook (including at Mangoola Coal) form the eastern extent of an east-west trending meta-population extending along the Goulburn River valley to Mudgee (Figure 4). Records exist for this species at ~20 km intervals along this 200 km extent, suggesting that some exchange of genetic material is likely to be occurring with more westerly stands. A single, small disjunct population of *Diuris tricolor* has also recently been discovered at North Rothbury (noted in Bell 2017), and represents the most easterly population known within New South Wales.

13. Elsewhere in New South Wales, *Diuris tricolor* is extensive across the north, central and south western slopes, and extends into south-eastern Queensland. A single record from the Hume region of Victoria suggests that the species is very rare in that state, and indeed Backhouse et al (2016b) indicate that it is known from just three plants.

[1] http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Prasophyllum~petilum

Figure 3 ***Diuris tricolor* (left) and *Prasophyllum petilum* (right), photographed *in situ* at Mangoola.**

2.2.2 Prasophyllum petilum

14. *Prasophyllum petilum* (Tarengo Leek Orchid) occupies a smaller distributional range, with most records from the Australian Capital Territory (ACT) but with outliers in the Kandos, Denman, Premer and Inverell districts on the tablelands and western slopes of NSW. Until recently, Hunter Valley plants were considered a distinct taxon, *Prasophyllum* sp. 'Wybong' (C.Phelps ORG 5269), but are now placed in synonymy with *P. petilum* by NSW taxonomic authorities. Additionally, Backhouse et al (2016a) do not include *Prasophyllum* sp. 'Wybong' in their comprehensive list of Australian orchid taxa, despite the inclusion of three other un-named taxa with close affinities to *P. petilum*, therefore supporting the NSW concept of synonymy in this group.

15. Relative to the Wybong district the next nearest populations of *Prasophyllum petilum* occur near Kandos, some 140 km to the south-west, and Premer 190 km to the north-west (Figure 5). Hunter Valley populations of *Prasophyllum* are consequently isolated from all others, and opportunities for genetic exchange are minimal. Note that Jeanes (2015) considers Victorian populations of *Prasophyllum* to represent a different taxon, implying that *Prasophyllum petilum* is endemic to New South Wales. This view is also supported by Backhouse et al (2016a).

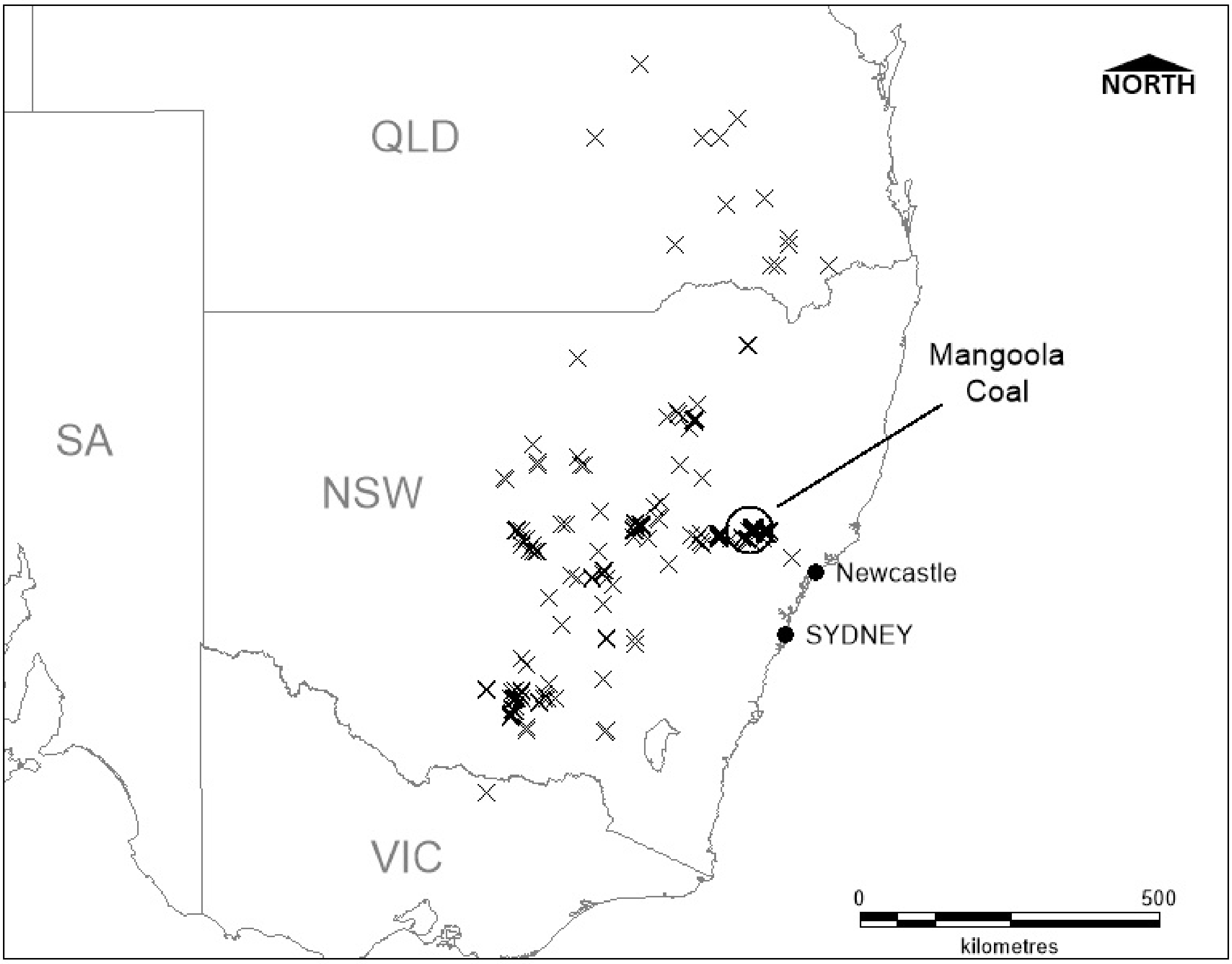

Figure 4 **Distribution of *Diuris tricolor* (X) across eastern Australia, shown relative to populations at Mangoola Coal.** Data is sourced from Australia's Virtual Herbarium and the NSW Wildlife Atlas database (OEH).

2.3 Habitat

2.3.1 Diuris tricolor

16. Most texts dealing with *Diuris tricolor* document favoured habitat as grassy *Callitris* woodlands (eg: Jones 1993; Burrows 1999; Bishop 2000), although in Queensland it is 'eucalypt open forest' (Stanley & Ross 1989). In a study of remnant vegetation stands in the South Western Slopes of New South Wales, Burrows (1999) recorded *Diuris tricolor* at several sites, but all within *Callitris glaucophylla* dominated vegetation.

17. Anecdotal evidence and unpublished data from subpopulations of *Diuris* in the Hunter Valley suggest that it occurs most commonly within grassy woodlands and grasslands derived from former Ironbark (*Eucalyptus crebra*) and Box (*E. moluccana*) woodlands. Herd and Herd (2005), for example, reported a single flowering specimen near Wybong as being in 'grassland/open woodland', and Abel Ecology (2005) also recorded this species in grassland at nearby Bell's Lane.

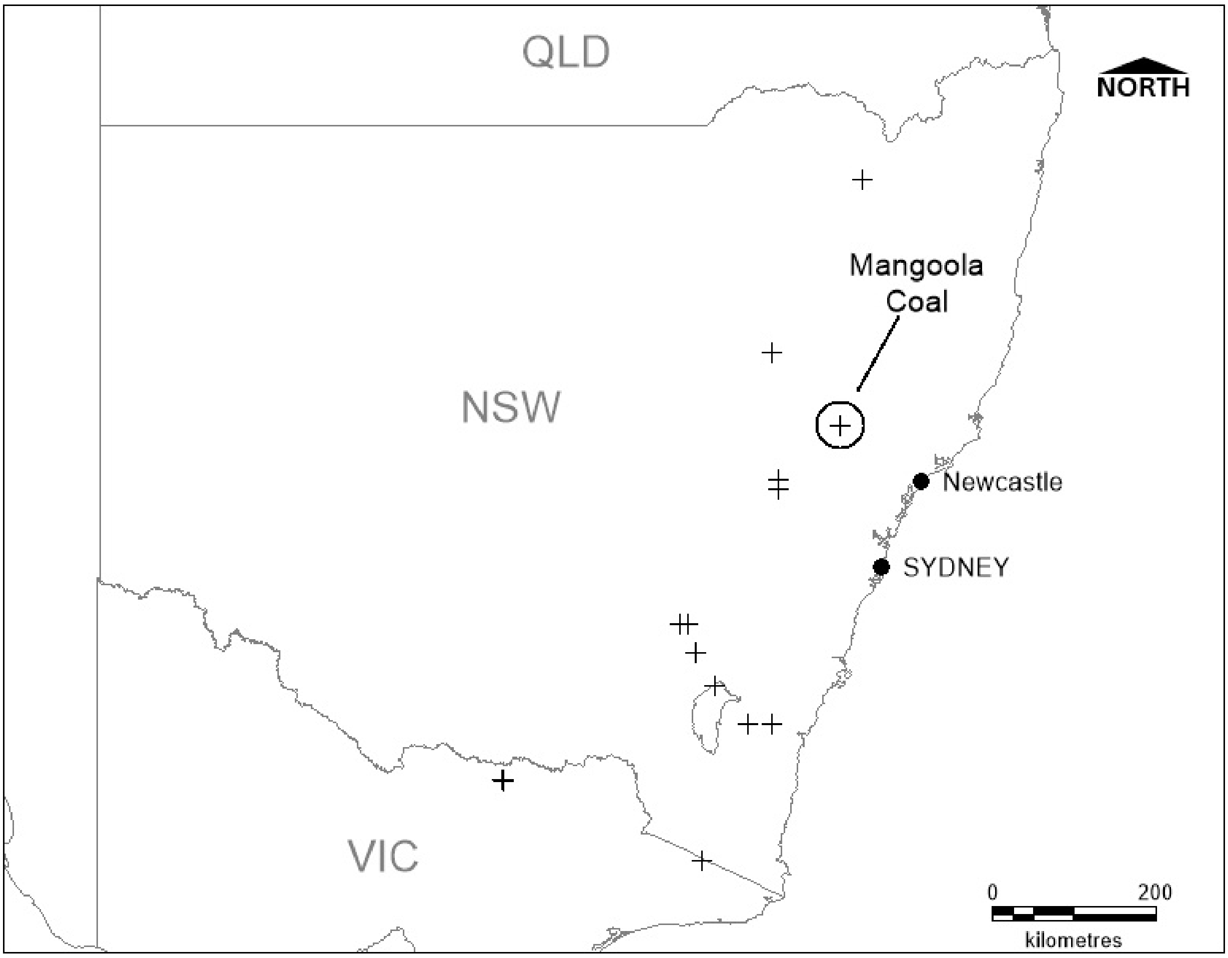

Figure 5 **Distribution of *Prasophyllum petilum* (+) across eastern Australia, shown relative to populations at Mangoola Coal.** Data is sourced from Australia's Virtual Herbarium and the NSW Wildlife Atlas database (OEH). Note that Victorian records purportedly represent a different taxon (Jeanes 2015).

2.3.2 Prasophyllum petilum

18. Information on the habitat of *Prasophyllum petilum* throughout its range is brief but documents variable associations. When describing the species, Jones (1991) reported the known habitat at that time (the type locality only, in the ACT) as being "moist grassy patches in sparse woodland developed on fertile soils", while Bishop (2000) describes it as remnant *Themeda* grassland on silty clay loams.

19. The national recovery plan for this species (DECCW 2010) provides more detail on floristic associations at the five known sites for which it was written, mostly on the Southern and Central Tablelands of NSW. At Captains Flat cemetery, grassy woodland dominated by *Eucalyptus pauciflora* and *Eucalyptus aggregata*, with a patchy shrub layer of *Hakea microcarpa*, *Acacia dealbata* and *Leptospermum brevipes* and a ground layer of *Poa sieberiana, Themeda australis* and *Schoenus apogon*, is documented. At Hall and Ilford cemeteries, habitat includes grassy woodland of *Eucalyptus blakelyi* and *Eucalyptus melliodora*, over *Poa sieberiana* and *Themeda australis* at Hall but *Themeda australis* and *Sorghum leiocladum* at Ilford. The Tarengo TSR site supports natural grassland of *Bothriochloa macra, Pentapogon quadrifidus, Austrodanthonia* spp., *Themeda australis, Schoenus apogon, Drosera peltata, Sebaea ovata* and *Haloragis*

heterophylla on a treeless grassy plain, while at Steves TSR *Prasophyllum* occurs in a treeless frost hollow, surrounded by *Eucalyptus pauciflora*.

20. Notes associated with collections included in Australia's Virtual Herbarium indicate that most southern records of *Prasophyllum petilum* occur in grasslands dominated by *Themeda australis, Bothriochloa* spp. and *Danthonia* spp, with associated forbs of *Bulbine* sp., *Dichopogon* sp., *Wurmbea* sp., *Swainsonia* sp., *Pimelea curviflora*, *Chrysocephalum* sp., *Ajuga australis*, *Craspedia* sp., *Stackhousia monogyna*, *Eryngium* sp., *Burchardia* sp., *Arthropodium* sp., and *Juncus* sp. Northern records occur in grassland of *Aristida* sp., *Themeda australis* and *Stackhousia monogyna*.

21. With the exception of populations on the North Western Slopes, these habitats are very different to those where *Prasophyllum petilum* occurs in the Hunter Valley. In this region plants occur most commonly in grasslands derived from former Ironbark (*Eucalyptus crebra*) and Box (*E. moluccana*) woodlands, dominated by species such as *Cymbopogon refractus, Aristida ramosa, Dichanthium sericeum* and *Chloris ventricosa* (further detailed in Section 2.3.3).

2.3.3 At Mangoola Coal

22. A floristic analysis of derived grasslands undertaken at Mangoola Coal by me between 2009 and 2011 found that *Diuris tricolor* and *Prasophyllum petilum* occurred within three of seventeen grassland types, in descending order of importance (Bell 2012):

- *Aristida*/ *Cymbopogon* Grassland (Unit 2);
- *Bothriochloa biloba*/ *Carthamnus*/ *Danthonia* Grassland (Unit 4);
- *Dichanthium*/ *Sporobolus*/ *Chloris* Grassland (Unit 1a).

Both species were also present in three woodland communities, those characterised by *Eucalyptus crebra, Eucalyptus dawsonii* or *Allocasuarina luehmannii*. Combined, the three derived grassland habitats defined encompassed a significantly large proportion of the grasslands included in that study (84% of 1069 ha). Detailed floristic composition of each of these key grassland communities are replicated in Appendix 2.

23. The knowledge gained from this floristic analysis of grassland types within the Mangoola area, comprising 168 plots sampled over a 2000 ha study area, has been incorporated into my assessments of suitable orchid habitat discussed later in this report.

2.4 Ecology

2.4.1 Flowering & Orchid Detection

24. As a rule of thumb, dry winters in the Hunter Valley generally result in below average flowering in terrestrial orchids. Low rainfall in the three months leading up to flowering place individual orchids under stress, meaning that flowering may be postponed for that season for all but the most robust individuals. Because of this trait, terrestrial orchids have been described of as 'time-travellers' (Brundrett 2016), encapsulating the uncertainty in determining their presence in any given area.

25. The unpredictability of orchid flowering from year-to-year has been highlighted over the eight year translocation project of *Diuris tricolor* and *Prasophyllum petilum* that has been undertaken at Mangoola Coal (Bell in press; Bell in prep.; also reported annually in reports to Mangoola

Coal). Over the course of eight years of monitoring, the June-to-August pre-flowering rainfall in approximately half of them has been above average, and half has been below average. Dry years have been reflected in low rates of detection within recipient plots, while wetter years have shown an increase in detection (Figure 6). There are of course other factors contributing to the extent of orchid detection observed (expanded upon in Bell in prep.), but there is a clear trend associated with winter rainfall. Of the nine recipient plots, all displayed lower detection rates in the drought year of 2017, following three seasons of above average winter falls. Results obtained for the 2018 surveys showed a continuing decline in detection despite marginally better rainfall. A similar downward trend was observed for the five recipient plots (n=440) established within mine rehabilitation, monitored over 2-3 years since 2015 (not presented here).

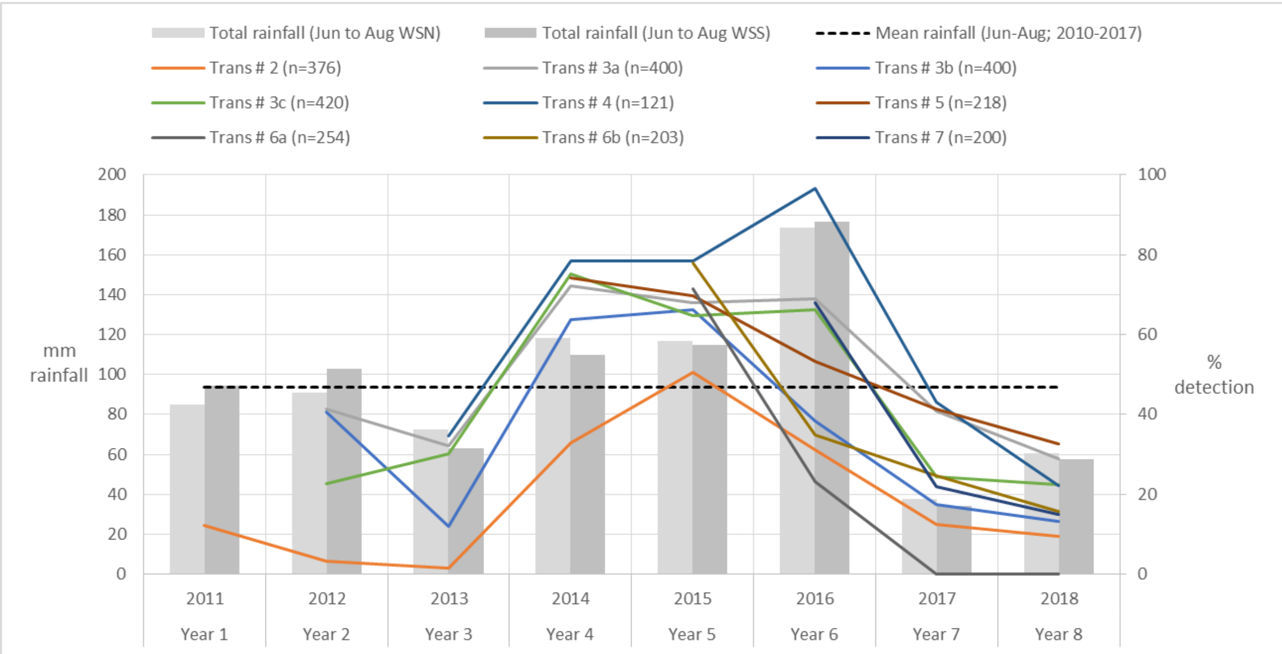

Figure 6 **Rainfall received (with 3-month average, June to August) and orchid detection during the course of monitoring across nine recipient plots within derived grassland, over a period of three to eight years (n=2,592 orchids).** Rainfall data from Mangoola Coal weather stations north (WSN) and south (WSS), shown relative to the Subject Area in Figure 7.

26. Vizer (2013) investigated a range of aspects of the ecology and biology of *Diuris tricolor* and *Prasophyllum petilum* at Mangoola Coal. He found peak flowering to occur from mid- to late-September, but that less than 20 % of plants would be flowering on any particular day at this time. This implies that a 'one-off' survey, even if conducted on the day of peak flowering, would likely overlook more than 80 % of individuals in that population. Capsule production was also found during this study to occur in less than 3 % of plants for both species, with herbivory identified as an important limiting factor in seed production.

27. For *Prasophyllum petilum*, Wilson et al. (2016) analysed annual monitoring data over a 25 year period from the largest known population on the southern tablelands of NSW, and identified the incidence of frost (nights ≤ -4°C) as being instrumental in preventing flowering in any one season. Frost damage to emerging plant parts prior to reaching flowering stage prevents detection during monitoring surveys, influencing annual counts. Warm winters are

consequently of benefit to the orchids in this population, although it is unknown if the same applies to the Hunter Valley population.

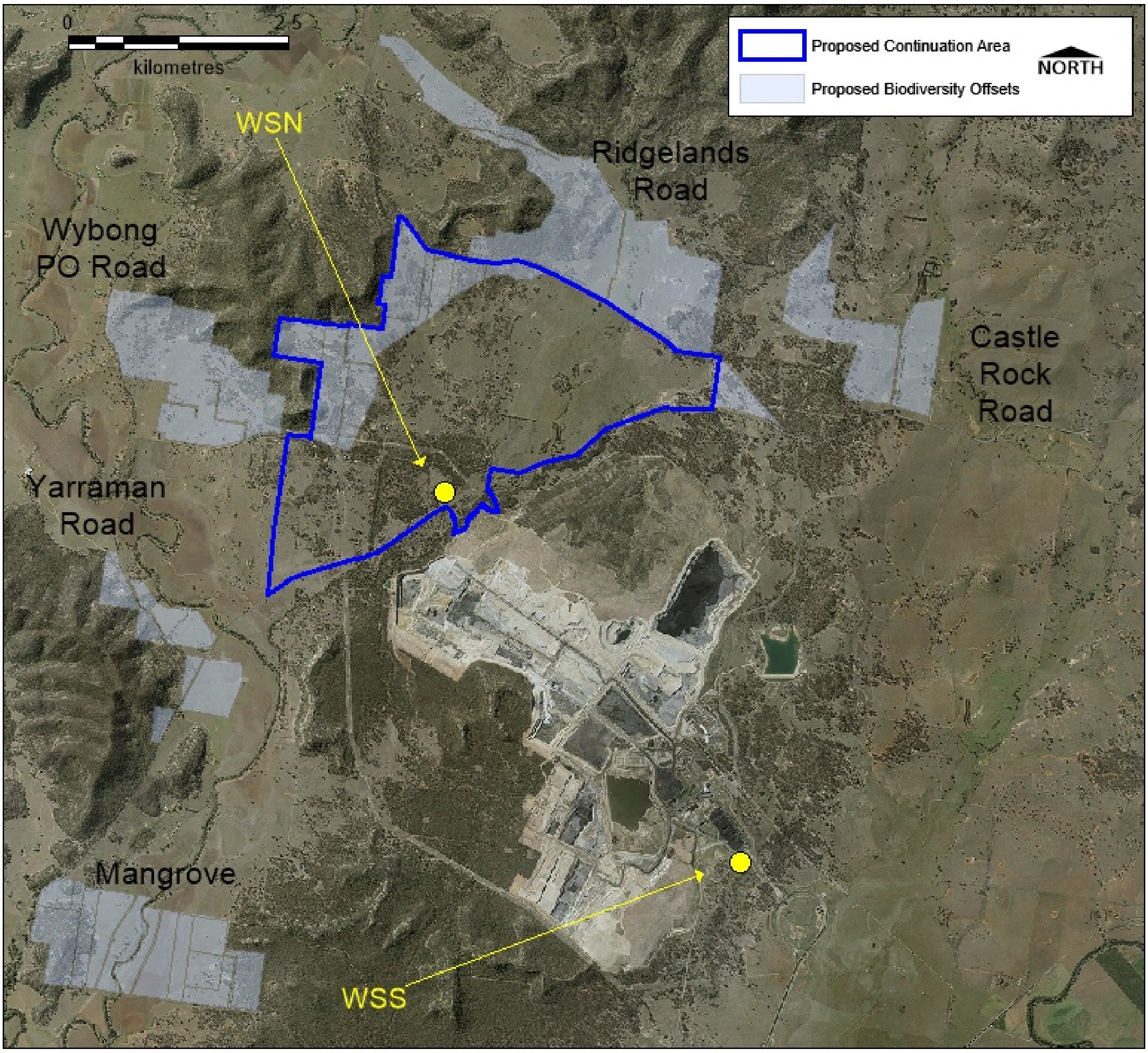

Figure 7 Location of Mangoola Coal weather station north (WSN) and south (WSS), relative to the Subject Area.

2.4.2 Mycorrhizal Fungi

28. Orchid presence in any area is dependent on the availability of co-occurring mycorrhizal fungi present within the soil, and different fungi are required by different orchid species. Indeed, Weston et al (2005) noted a high degree of specificity between a particular species of orchid and their associated species of mycorrhiza, but that there are also commonalities between and within genera. For *Diuris*, they indicate that the *Tulasnella* genus is important, while for *Prasophyllum* it is *Ceratobasidium*.

29. At Mangoola, seed-baiting techniques were used by Vizer (2013) in an attempt to map the distribution of mycorrhizal fungi, finding that the distribution of *Diuris* was actually more restricted than the relevant fungi. This implies that there may be extensive suitable habitat,

complete with mycorrhizal fungi, within a wider area than is currently known to support the species. Mycorrhizal seed-baiting for *Prasophyllum* was not successful in the study of Vizer (2013), which is not unusual for this genus. There was some doubt, however, if the specific mycorrhiza required for this species was correctly isolated, reflected in poor germination of seed under laboratory conditions. Further research on the fungi associated with *Prasophyllum* is required.

2.4.3 Pollination and Capsule Development

30. Pollination in both *Diuris* and *Prasophyllum* (and most other orchids) is enacted by insects. Many orchids rely on mimicry to trick unsuspecting insects, either by the development of flowers that appear identical to those of co-occurring species in their habitat (food mimicry), or by individual flowers resembling the females of certain insects (sexual mimicry). Other species offer a nectivorous reward and lure pollinators by scent. Most *Diuris* mimic co-occurring species of pea to attract pollinators, and for *D. tricolor* at Mangoola this is likely to be *Templetonia stenophylla* or *Daviesia genistifolia* (pers. obs.; Vizer 2013). *Prasophyllum* employ a different strategy to attract pollinators, using nectar and scent. Weston et al (2005) indicate that the pollinators of *Diuris* are likely to be various colletid bees from the *Trichocolletes* and *Leioproctus* genera, while colletid and halictid bees, ichneumonid, tiphiid, scoliid and sphecid wasps, syrphid flies, and beetles are the likely pollinators of *Prasophyllum*.

31. Once pollination has been enacted, the development of seed capsules progresses over the following weeks. Based on observations made at translocation sites at Mangoola over several years (e.g. Bell 2016a), capsule development is unhindered and many individual orchids have produced seed. Fruit:Flower ratios of around 30% were achieved in a pilot study of capsule production for both target species (Bell 2013). Evidently, despite the level of historical and current-day disturbance to the Mangoola landscapes, the necessary pollinators persist in the area.

2.4.4 Translocation

32. Two papers are currently in press or in preparation that detail experiences with the translocation of more than 3000 *Diuris tricolor* and *Prasophyllum petilum* at Mangoola Coal (Bell in press; Bell in prep.). No translocation studies into either of these two species have been published in the literature, although some on the related *Diuris fragrantissima* and *Diuris behrii* have (Dilley 2007; Nevill 2008; Smith et al 2009; and see Reiter et al 2016 for other genera). No other Australian orchid translocation study has monitored the emergence and flowering of over 3000 individual orchids, and globally the largest study involved only 700 individuals (Reiter et al 2016).

3. Criterion (b) – Justification for an Expert Report

33. Targeted surveys for *Diuris tricolor* and *Prasophyllum petilum* undertaken by staff from Umwelt (Australia) during the 2017 flowering season resulted in very low detections (136 *Diuris* and 0 *Prasophyllum*). As advised by Shaun Corry (Umwelt), four teams of observers were utilised for surveys over a three week period (18 September – 6 October 2017), involving eight ecologists with ecological survey experience ranging from 2 to 10 years. Survey timing was governed by the flowering progress of reference populations of both species from within the wider Mangoola area. Each two-person team was led by an ecologist with at least 6 years survey experience, with a colleague generally with less experience (2-9 years). All teams and staff were briefed on the identification of both orchid species prior to survey, and in the case of the cryptic *Prasophyllum petilum* flowering individuals (from within translocation sites) were viewed by all surveyors to confirm familiarity. Two *Prasophyllum* individuals were also monitored twice weekly from early September to guide the commencement of targeted surveys.

34. As highlighted in Section 2.4.1 above, the June to August period in 2017 was exceptionally dry at Mangoola Coal (the lowest for at least consecutive seven years). In addition, with a single exception (March 2017) the preceding eleven months prior to flowering also received well below average rainfall (Figure 8), meaning that all plants, including terrestrial orchids, had been under severe water stress for a prolonged period of time. Moisture in the soil following the exceptionally wet March 2017 could not be maintained over the autumn and winter periods. Most orchid species will not emerge to flower during stressful periods, or if leaves are produced at this time then flower stalks may not form. Given the drought conditions experienced throughout most of 2017, and in particular during the June-August period prior to flowering, there is clear justification for the preparation of this expert report rather than reliance on collected survey data which may fail to detect numerous viable individuals. Evidence from studies of translocated orchids over a period of eight years at Mangoola clearly show the trend between winter rainfall and orchid detection.

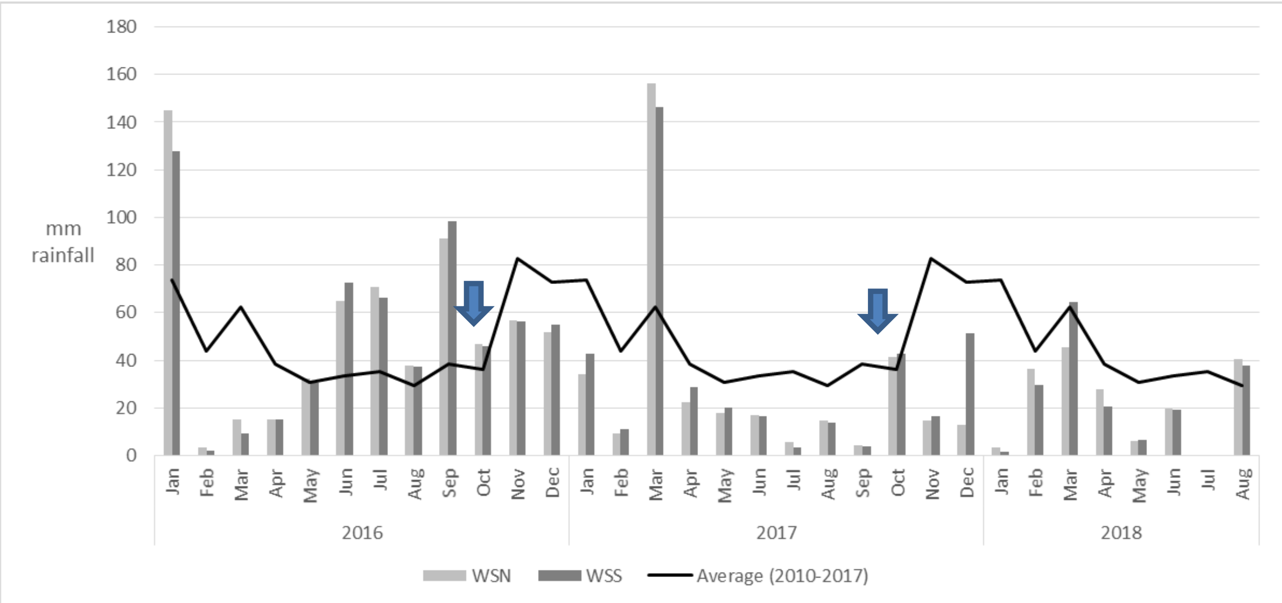

Figure 8 **Rainfall received for the 2016 and 2017 calendar years (and up to August 2018) at Mangoola Coal weather stations north (WSN) and south (WSS), showing the prolonged period of below-average rainfall from November 2016 to December 2017. Arrows show approximate orchid flowering times for both years, allowing comparison of winter rainfalls.**

35. Additionally, pressure from herbivory during drought periods escalates considerably (Duncan et al 2005), not only from vertebrate grazers such as macropods and rabbits, but also invertebrates including grasshoppers and caterpillars (Light & MacConnaill 2011; Vizer 2013). Bird species too are known to selectively feed on orchid species, with White-winged Choughs for example extracting orchids out of the ground to consume tubers (Duncan et al 2005; Faast & Facelli 2009). Any vegetation present during dry times will be the focus of herbivore browsing, meaning a reduction in the time orchids will be present above ground and hence reduced detection rates during survey. Desiccation through heat and wind in periods of drought will also reduce above-ground periods of flowering orchids.

4. Criterion (c) – Likelihood of Species Presence in the Subject Area

4.1 Land-use History of the Subject Area

36. Umwelt (2006a) provides a brief overview of the land use history of the locality in and around the Subject Area, as part of the original environmental assessment of the Mangoola mine. They indicate that by at least 1930 substantial clearing of vast areas had already taken place, primarily for grazing purposes.

37. A more detailed historical study (Umwelt 2006b) summarises the early settlement of the Wybong district, commencing with its first reporting by Henry Dangar in 1824. By the late nineteenth century, large estates dominated the Wybong landscape, including those named *Yarraman*, *Callatoota*, *Pickering*, *Milgara* and *Bundaraga*. The majority of lands within these large estates were largely cleared of woody vegetation to support various agricultural industries, including dairying, horse and sheep grazing, and cultivation on the better soils. From the mid twentieth century, regrowth of native vegetation has occurred sporadically within the Subject Area depending on land use and tenure, which in recent years has accelerated following ownership by Mangoola Coal. All parts of the Subject Area, with the exception of the rugged sandsone hills, have undergone some level of clearing associated with agricultural industries since European occupation.

4.2 Existing Orchid Records within the Subject Area

38. Based on the results of targeted field surveys undertaken within and surrounding the current Mangoola Coal lease area over several years, both *Diuris tricolor* and *Prasophyllum petilum* are known and expected to occur within the Subject Area. A review of all location data of both species revealed a total of 4,631 point records (4,236 *Diuris*, 395 *Prasophyllum*) from within the Subject Area. Based on collection notes associated with these data, this represents 9,030 *Diuris* and 904 *Prasophyllum* individuals. The actual number of orchids present in the Subject Area is likely to be considerably higher than this, given earlier suggestions that less than one half of all orchids present are likely to be detected in any targeted survey, due to separation distances between walked transects and variable flower emergence over the season (Bell & Copeland 2010). This is particularly so for *Prasophyllum*, given its small stature and small, indistinct flowers. Additionally, Vizer (2013) found that more than 80% of individuals were likely to be overlooked in any single-day survey of an orchid population, even if conducted at peak flowering.

39. Figure 9 shows the extent of orchids recorded across the Subject Area and proposed continuation area since 2009. Clearly, the Wybong PO Road offset supports the largest number of orchid records (4,948), followed by Ridgelands Road (2,895), Mangrove (1,490), Yarraman Road (577) and Castle Rock Road (24).

40. The number of orchid records revealed in any targeted search will always be a reflection of the extent of search effort for these species. As discussed elsewhere, the likelihood of detecting the target orchid species will be contingent on suitable growing and flowering conditions. Figure 10 summarises the extent of search effort expended within the Subject Area between 2015 and 2017. These searches were undertaken by myself at the Wybong PO Road offset and part of Yarraman Road offset in 2015, and Umwelt staff at all other offsets during the 2016 and

2017 flowering seasons. All surveys were timed to coincide with flowering in nearby reference populations.

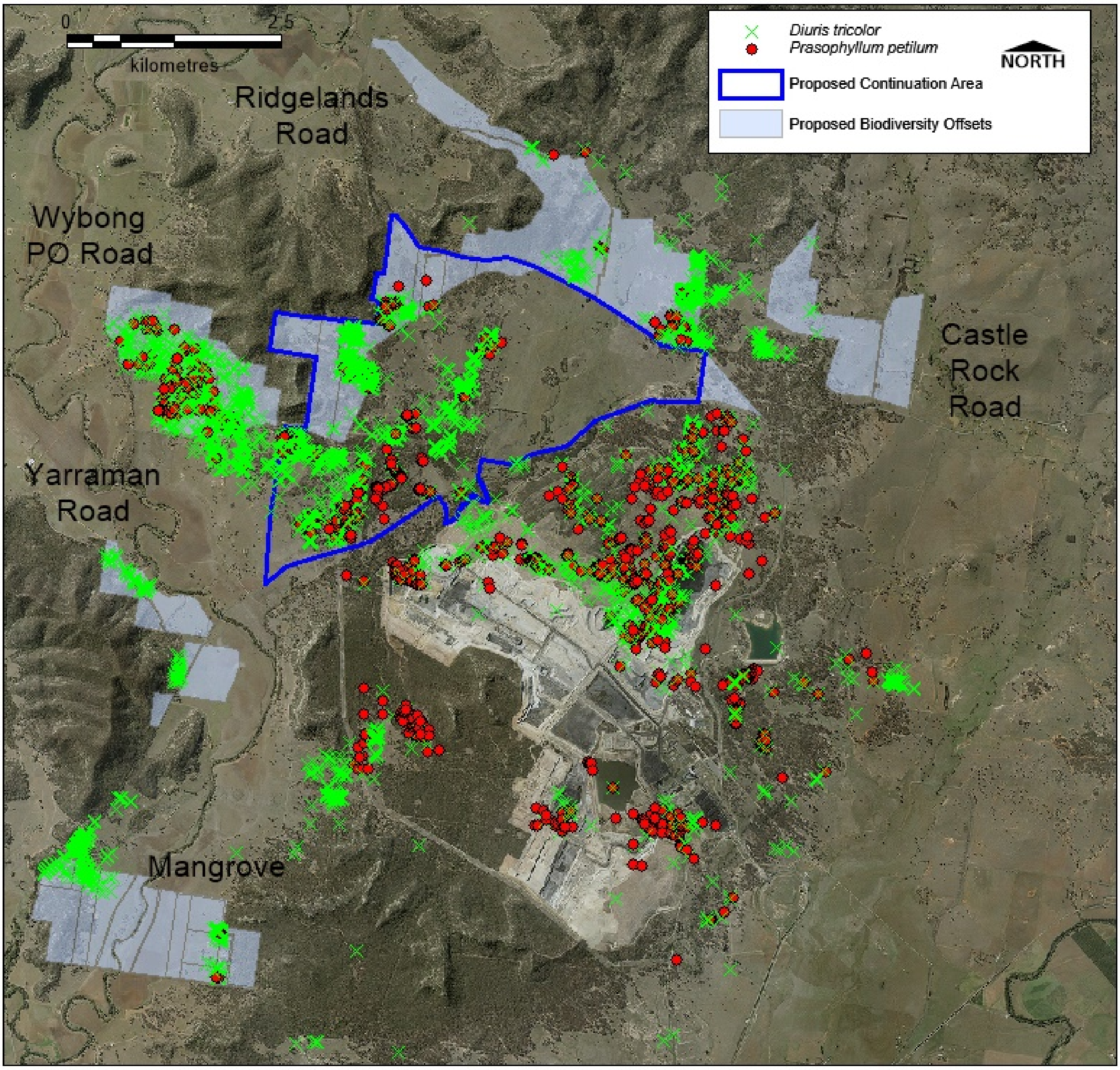

Figure 9 **Distribution of *Diuris* and *Prasophyllum* across the proposed offset and continuation areas, 2009 – 2017.**

4.3 Analysis of Floristic Data from within the Subject Area

41. Understanding the floristic patterns in the Subject Area is important in gaining an impression of how suitable the lands are to supporting one or both of the target orchid species. Although 2017 was a very dry year, examining floristic data collected during this time can still be compared with other data from the wider Mangoola area where both orchids are known to occur.

42. Three phases of plot data collection have been undertaken by Umwelt within the Subject Area and the proposed continuation. Fifty (50) plots have been sampled within the proposed

continuation area in 2017, while twenty-eight (28) plots have been sampled from proposed offset areas in 2017 and 2018. Additionally, plot data from the same areas were also collected in 2014 (20 plots; 18 within offsets, 2 in continuation area) as part of Upper Hunter Strategic Assessment (UHSA) surveys (Figure 11).

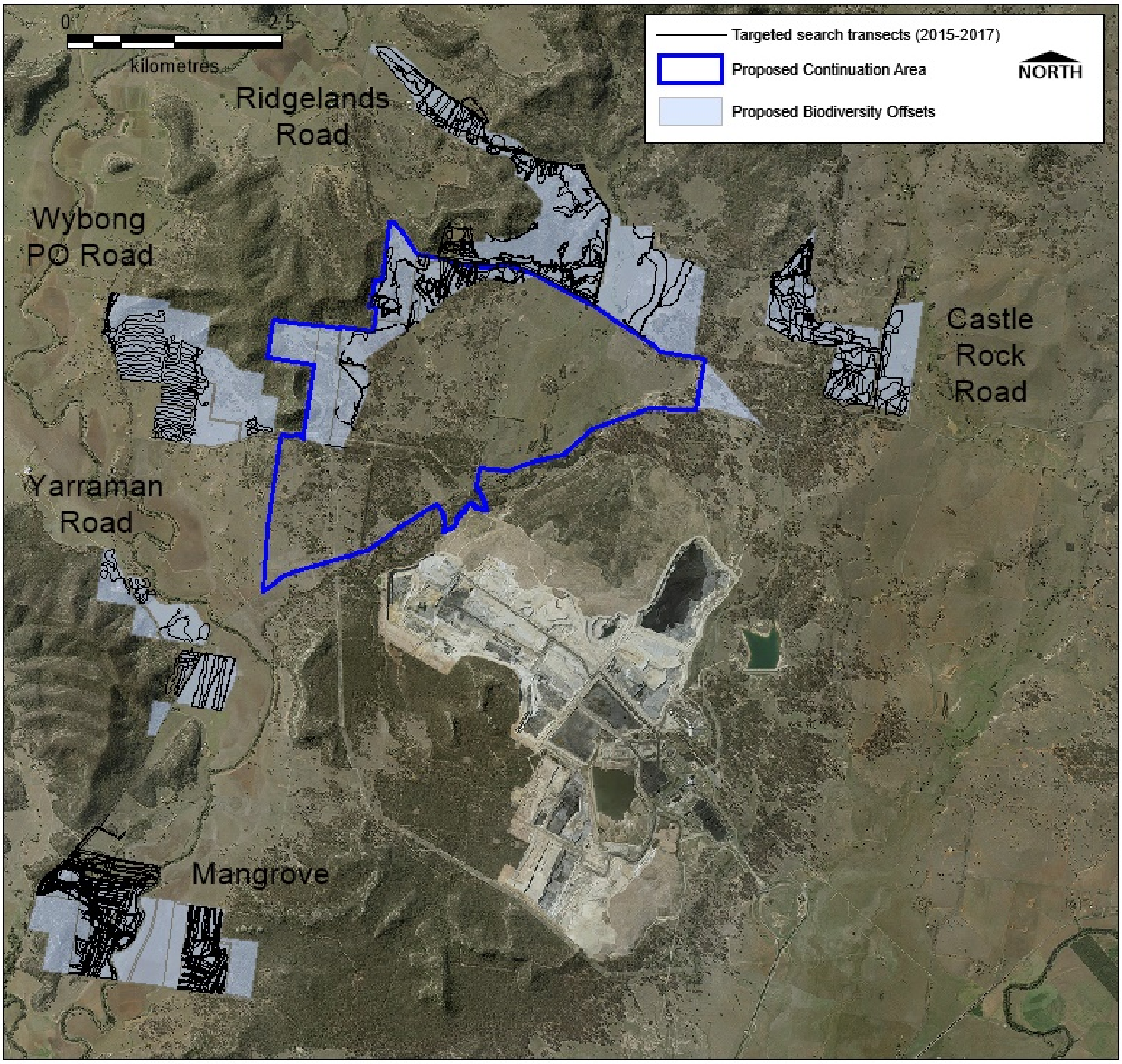

Figure 10 **Extent of targeted survey for *Diuris* and *Prasophyllum* across the proposed offset areas, 2015 – 2017.**

43. In total, the proposed continuation area has seen 52 plots sampled, while the proposed offset areas have had 47 plots (total survey effort = 99 plots). Some offsets (e.g. Castle Rock Rd, parts of Yarraman Rd and Ridgelands Rd) have had no plot sampling to date; assessment of these has been guided by my own field inspection (see Section 4.5). Plot data collected by Umwelt from the Mangrove offset was not available at the time of data analysis, so assessment is based entirely on my field inspection undertaken on 4 October 2018.

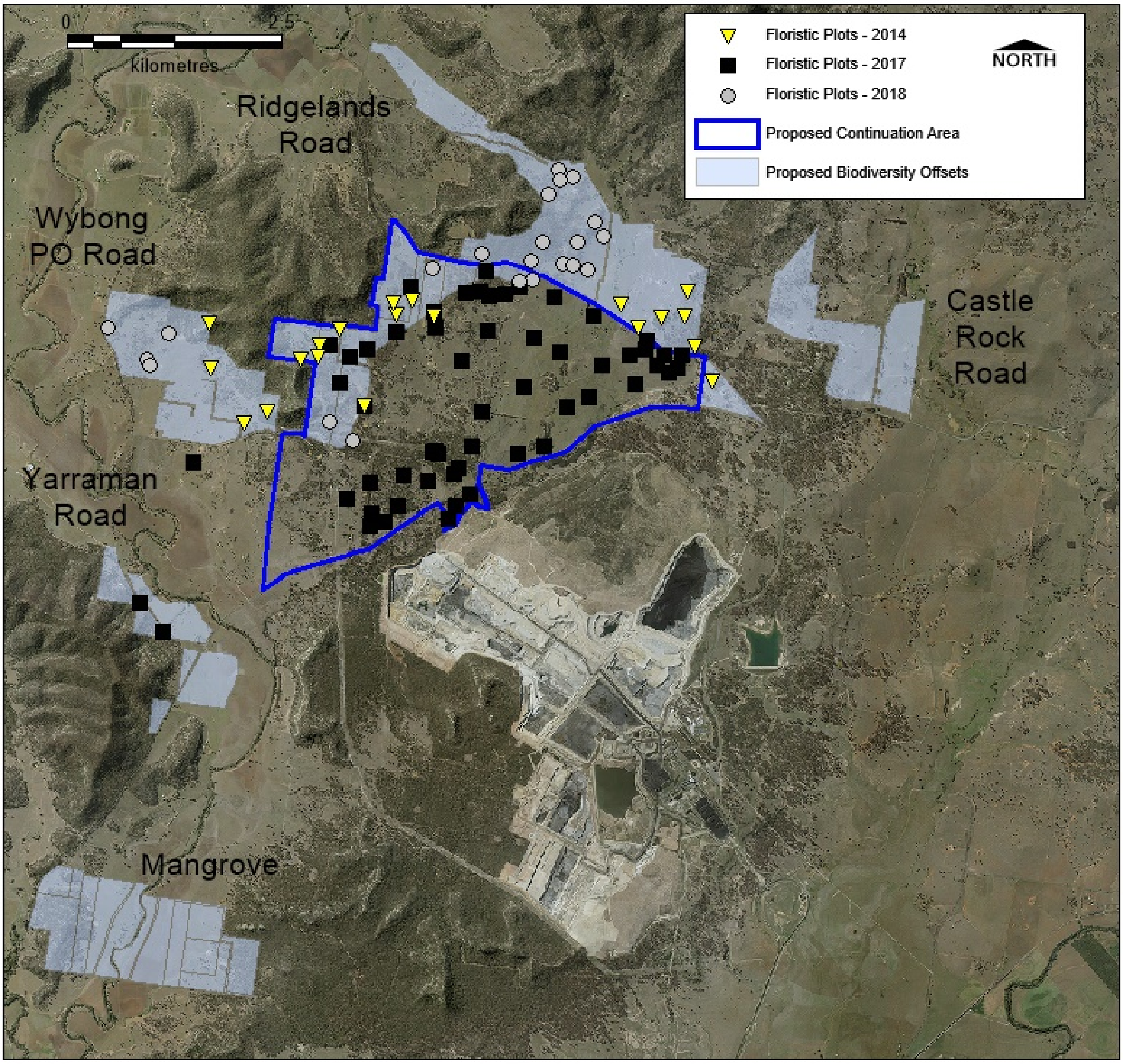

Figure 11 Distribution of floristic plot data (n=99) collected by Umwelt across the proposed offset and continuation areas, 2014 – 2018.

44. Apart from 30 plots collected in March 2017, all plots assessed during the 2017-2018 period have been surveyed in very dry periods when the rainfall received has been well below average (Figure 12). Given the very dry January to February period of 2017, commencing surveys in March after some decent falls (c. 37mm at the commencement of surveys on 20 March) was appropriate. However, all remaining plots sampled in Winter 2017 and Summer 2017-18 occurred following prolonged drought conditions (unavoidable under the circumstances), hence floristic diversity is not expected to be high.

45. Conversely, all of the 20 plots sampled as part of the UHSA in 2014 occurred in Autumn (April) following a 3-month period of above-average rainfall (Figure 13), where it may be expected that floristic diversity would be high.

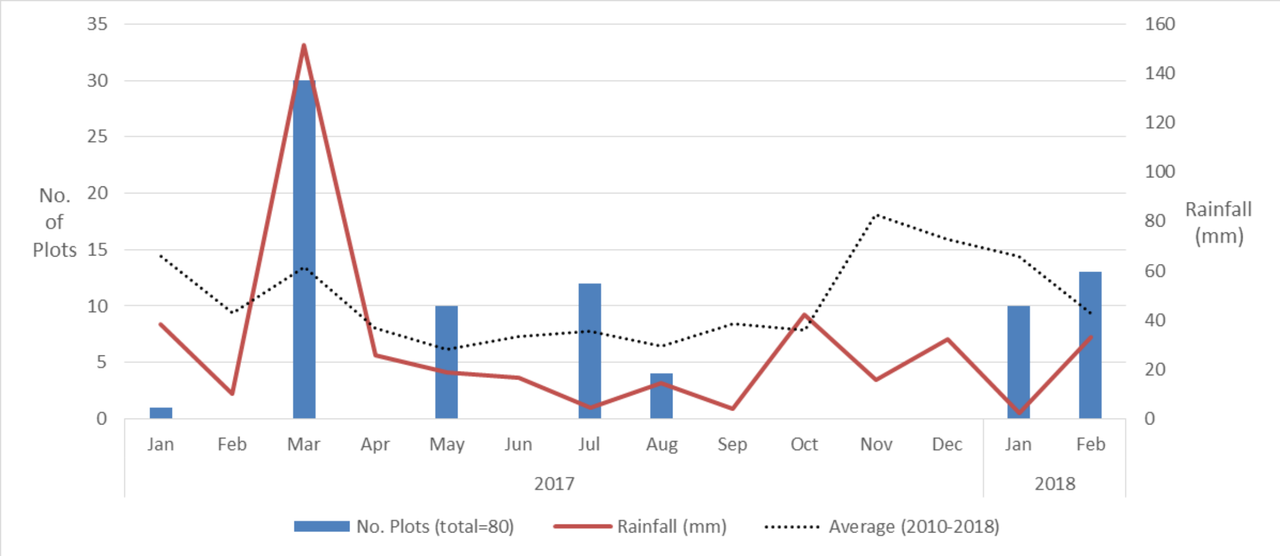

Figure 12 Timing of floristic plot data collection across 2017-2018, shown with rainfall received and the 8-year average. Rainfall data is averaged from the Mangoola Coal weather stations north (WSN) and south (WSS).

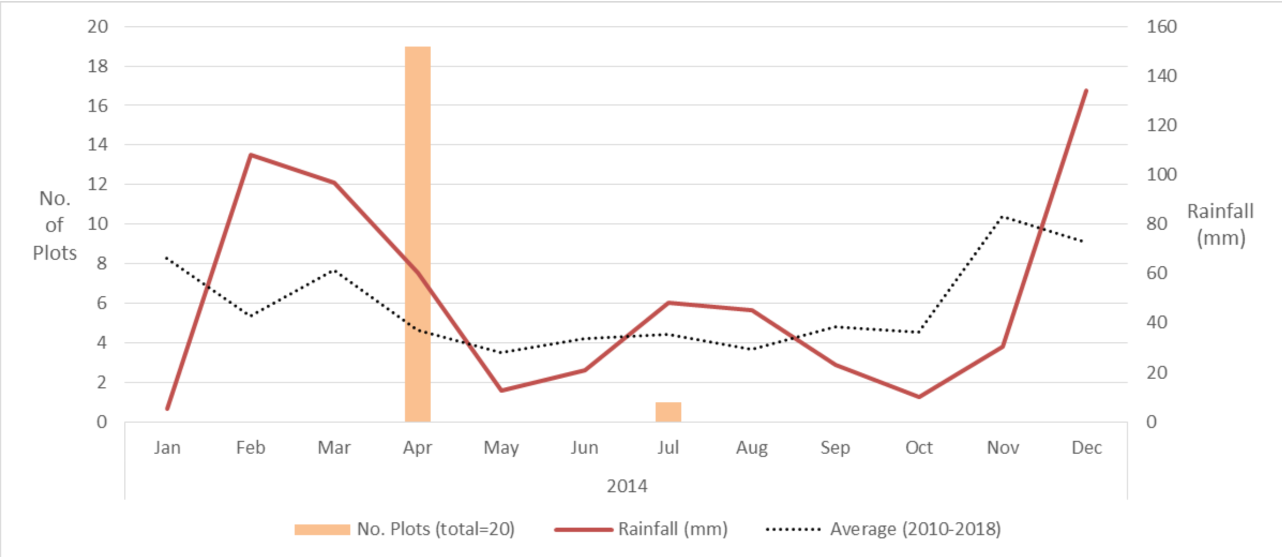

Figure 13 Timing of floristic plot data collection during UHSA surveys in 2014, shown with rainfall received and the 8-year average. Rainfall data is averaged from the Mangoola Coal weather stations north (WSN) and south (WSS).

4.3.1 Dataset 1: Proposed Continuation Area

46. In total, 47 floristic plots were sampled within the proposed continuation area by Umwelt in 2017, together with three additional plots in 2018. Five field staff collected this data (Ryan Parsons, Kate Riley, Amy Nelson, Brooke Weber, James Garnham), with between 3 and 12 years of experience in undertaking floristic surveys. Thirty-eight of the 50 plots (76%) were led by one observer of 6 years of experience, assisted by two ecologists of 3 or 5 years of experience. The remaining 12 plots (24%) were sampled by a lead ecologist of 12 years' experience, assisted by ecologists of 3 or 6 years of experience.

47. As shown in Figure 12 above, these floristic plots were sampled predominantly in the Autumn and Winter of 2017, with the bulk of them (33 plots, 66%) collected in Autumn (20-24 March & 15-16 May 2017) during the very wet month of March. Of the remaining data, 13 plots (26%) were collected in Winter (4-6 July & 1-2 August 2017) and 4 plots (8%) were collected in late Summer (12 January 2017 & 29-30 January 2018), all under drought conditions. All data collected followed the BBAM methodology of OEH (2017), which entails recording all vascular plant species in 20 x 20m plots, and applying actual percentage cover and abundance counts for each taxon.

48. Approximately 50% of all flora observations within the supplied dataset are forbs or herbs, followed by grasses (17%), shrubs (13%), trees (6%), sedges (4%), graminoids (3%), vines (2%), small trees and mistletoes (both 1%), and ferns and orchids (both <1%) (Figure 14). This break down of species diversity is typical of derived grassland habitats in the upper Hunter Valley, and despite the Autumn-Winter period of sampling has captured a representative snapshot of the areas floral biodiversity.

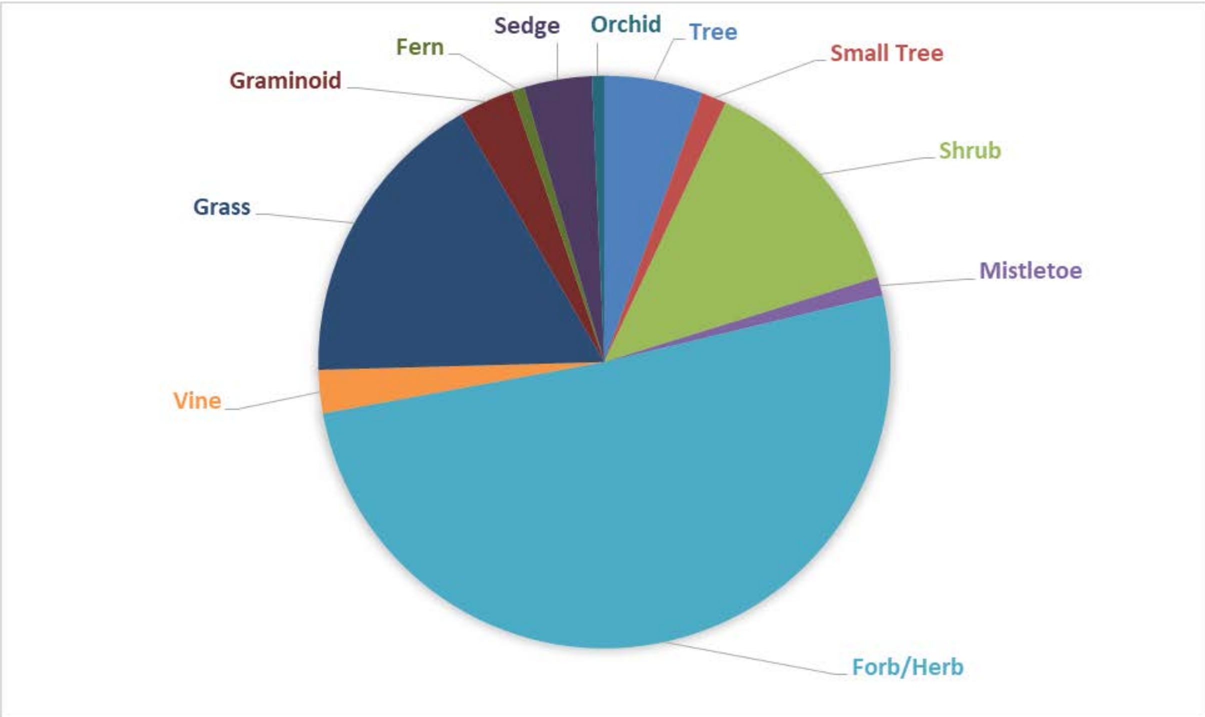

Figure 14 Relative proportion of major habit classes within the supplied floristic dataset of 57 plots comprising Dataset 1, sampled in 2017 (n=287).

49. Seventy-five (75) percent of the species included in the supplied dataset are native species, suggesting that although weed species form a common component of the sampled data there is sufficient native biodiversity to potentially support populations of *Diuris tricolor* and/or *Prasophyllum petilum*.

4.3.2 Dataset 2: Proposed Biodiversity Offset Areas (2018)

50. Twenty (20) floristic plots were sampled in the proposed offset areas by Umwelt in late January/early February 2018, with an additional three (3) within the proposed continuation

area at the same time. Two field staff (Kate Riley, James Garnham) collected this data, with 6 and 3 years of experience in undertaking floristic surveys at that time.

51. All 23 floristic plots were sampled in the late Summer of 2018. This period coincided with prolonged drought following c. 9 months of below average rainfall (see Figure 12 above). As a consequence, it may be expected that species diversity will be low in this dataset, but as noted previously under the circumstances this was unavoidable. A total diversity of 108 native and 39 weed species (147 total) were represented in the data, the relatively low weed count potentially due to the dry conditions.

52. The breakdown of species habit within this dataset is shown in Figure 15. Seventy-three (73) percent of all taxa are native, and twenty-seven (27) percent are weeds.

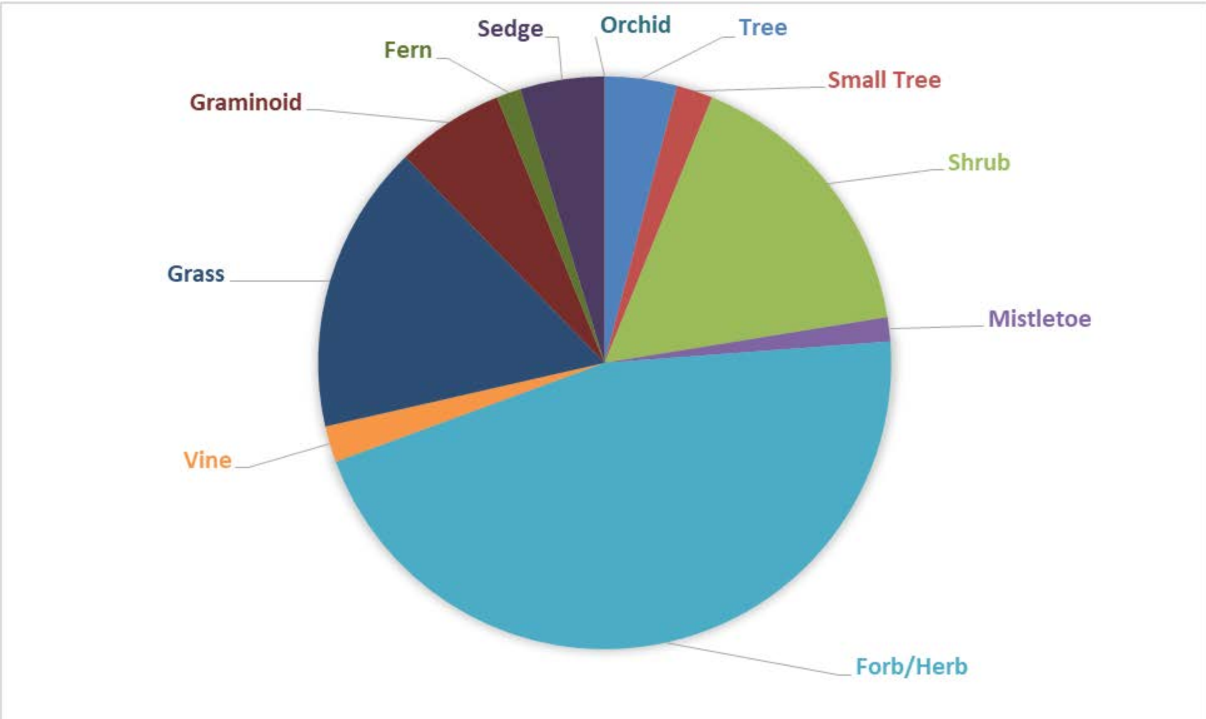

Figure 15 Relative proportion of major habit classes within the supplied floristic dataset of 23 plots comprising Dataset 2, sampled in 2018 (n=147).

4.3.3 Dataset 3: Proposed Biodiversity Offset Areas (UHSA)

53. Twenty (20) floristic plots were sampled in the proposed offset areas by Umwelt in April 2014, as part of the Upper Hunter Strategic Assessments (UHSA) initiative. Two field staff (Kate Riley, Bill Wallach) collected this data, with 2 and 4 years of experience in undertaking floristic surveys at that time.

54. Figure 16 shows the breakdown of habit classes for this 2014 dataset. Eighty-four (84) percent of all taxa in this dataset are native, while sixteen (16) percent are weeds.

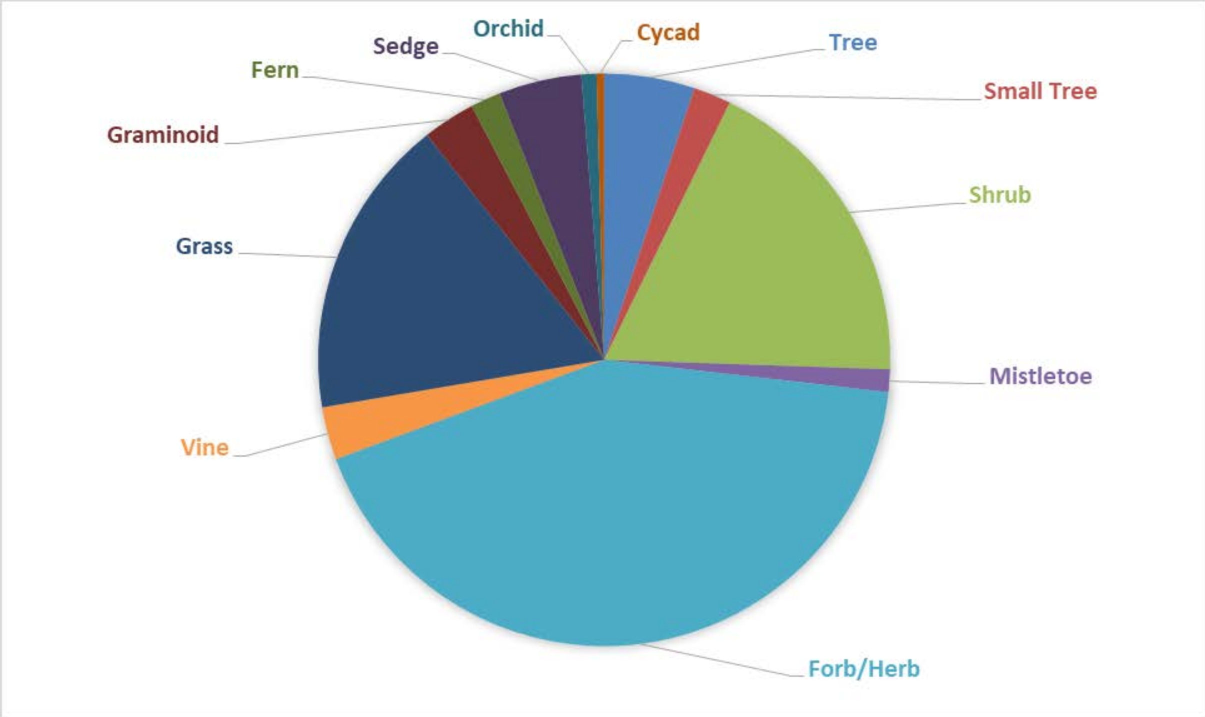

Figure 16 Relative proportion of major habit classes within the supplied floristic dataset of 20 plots comprising Dataset 3, sampled in 2014 (n=234).

4.3.4 Combined Continuation Area and Offsets Data

55. I combined the supplied floristic datasets from the proposed continuation area (Dataset 1, 47 plots) with that from the proposed offset areas (Dataset 2, 23 plots) and earlier data collected as part of the UHSA process (Dataset 3, 20 plots) to enable a complete overview of the habitats present in both the proposed continuation and offsets areas. This provided a total dataset of 99 plots (one plot was common to both Dataset 2 & 3). The combined dataset allowed a numerical analysis to be undertaken which could examine both areas equally, acknowledging the differing dates and observers involved, and the different data collection methods.

56. Prior to analysis, I converted all cover abundance data to a common scale (Braun-Blanquet 1-6), following the same transformation rules used by OEH (Native Vegetation Information Science Branch) in their analysis of new and legacy plot data. I also reviewed the taxonomy of the combined dataset and made a few minor changes to clean up species entries where, for example, the same taxon was entered under two or more different names. Some of these changes were based on my own knowledge of plant species presence at Mangoola obtained from working in the area since 2007. Appendix 3 summarises the changes I made to the dataset prior to analysis.

57. Weed species were included in the analysis dataset, because in long-disturbed habitats such as around Mangoola this group of species play an important role in delineating different vegetation types. The level of weed species present can also impact on the quality of suitable orchid habitat. It was noted that weed species were prevalent across all three datasets, irrespective of the recent history of rainfall relative to survey dates (although abundance was low during drought).

58. Some species included in Dataset 3 contained a cover abundance value of 9, which fell outside of the 1-6 cover scale used for this dataset. I was advised by Umwelt (R. Parsons) that these represented species occurrences that were observed outside of plot boundaries, so I have consequently removed these from analysis.

59. With this cleaned dataset, I used Primer (Clarke & Gorley 2006) to examine the floristic patterns and identify floristic groups which may represent vegetation communities across the area. The delineation of floristic groups was undertaken acknowledging the potential influence of different observers and levels of experience, survey times, seasonal impacts and the data transformation process, but nevertheless provides a solid overview of the habitats present. I used the SIMPROF routine in combination with the CLUSTER module to identify statistically significant splits in the dataset ($p<0.01$). This provided a cluster diagram where sites supporting similar floristic combinations and cover values were grouped and linked to their most similar neighbours. I also ran the MDS routine with a minimum stress level of 0.01 and 25 restarts to produce an ordination plot of the same data (Figure 17). Clustering of similar sample plots (communities) can be better appreciated across this two-dimensional ordination space than in a cluster diagram. The stress level of 0.24 shown in Figure 17 is an indication of the difficulty in which all data can be accommodated within two-dimensions. In general, a stress level of <0.2 is considered acceptable in these sorts of analyses, but increases in line with complexities associated with multiple observers and seasons.

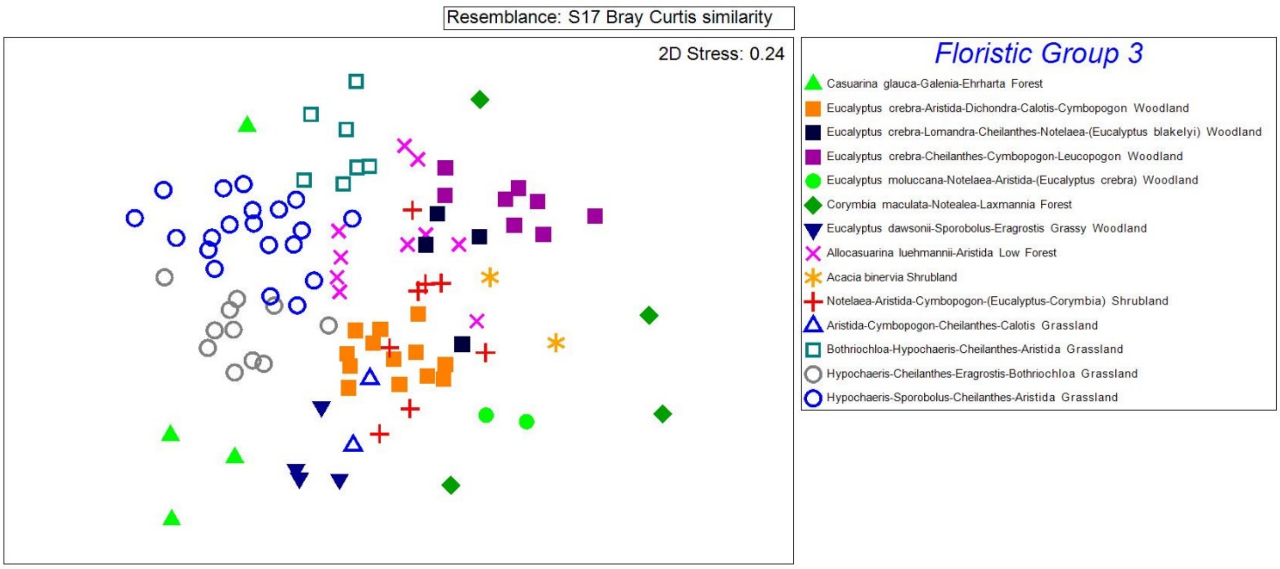

Figure 17 nMDS ordination of the supplied floristic dataset of 99 plot samples from the proposed extension area (see Table 3 for further details).

60. Analysis of this combined dataset revealed fourteen (14) significant splits which for the current review have been accepted as different communities or habitats. These groups provide insights into the extent of potential orchid habitat within the proposed continuation and offset areas. The fourteen defined groups are summarised in Table 3, while Appendix 4 contains more detailed floristic information. Of these fourteen, ten can be considered to provide potential habitat for *Diuris* and *Prasophyllum*, based on knowledge of the habitats in which they occur across the Mangoola area, and the previous analysis discussed earlier in Section 2.3.3.

Table 3 Summary of floristic groups from numerical analysis of 99 plots.

Structure	Floristic Group	Notes	Orchid Habitat
Riparian Forest	1. *Casuarina glauca – Galenia – Ehrharta* Forest	Along riparian zones and adjacent areas. High incidence of weed species.	no
Woodland / Forest	2. *Eucalyptus crebra – Aristida – Dichondra – Calotis – Cymbopogon* Woodland		yes
	3. *Eucalyptus crebra – Lomandra – Cheilanthes – Notelaea* - (*Eucalyptus blakelyi*) Woodland		yes
	4. *Eucalyptus crebra – Cheilanthes – Cymbopogon - Leucopogon* Woodland		yes
	5. *Eucalyptus moluccana – Notelaea – Aristida* - (*Eucalyptus crebra*) Woodland		yes
	6. *Corymbia maculata – Notealea - Laxmannia* Forest	Restricted areas, often on conglomerate	no
	7. *Eucalyptus dawsonii – Sporobolus - Eragrostis* Grassy Woodland	Across low lying plains	yes
Low forest	8. *Allocasuarina luehmannii - Aristida* Low Forest	Regrowth following previous clearing	no
Shrubland	9. *Acacia binervia* Shrubland	Elevated areas on sandstone	no
	10. *Notelaea – Aristida – Cymbopogon* - (*Eucalyptus-Corymbia*) Shrubland		yes
Grassland	11. *Aristida – Cymbopogon – Cheilanthes - Calotis* Grassland		yes
	12. *Hypochaeris – Sporobolus – Cheilanthes - Aristida* Grassland		yes
	13. *Hypochaeris – Cheilanthes – Eragrostis - Bothriochloa* Grassland		yes
	14. *Bothriochloa – Hypochaeris – Cheilanthes - Aristida* Grassland		yes

61. The geographical distribution of sample plots that comprise the ten floristic groups providing orchid habitat are shown in Figure 18. In the absence of more accurate vegetation community mapping, this provides an indication of the geographical spread of potentially suitable habitat for the two target orchid species. From this dataset, the bulk of lands within both the proposed continuation area and the proposed offset lands appear to provide good orchid habitat.

4.4 Analysis of Soil Data within the Subject Area

62. No detailed soil sampling program has been undertaken across the Subject Area and the surrounding lands. Soil landscape mapping is available (Kovac & Lawrie 1991), but is provided at 1:250,000 scale and is of little use for high resolution investigations. Nevertheless, the 1:250k soil landscape mapping shows the Subject Area to predominantly support solodic soils from the Sandy Hollow (sy; 648 ha or 50% of Subject Area) and Wappinguy (wp; 478 ha or 37%)

landscapes, with a small proportion of shallow soils from the Lees Pinch (lp; 120 ha or 9%) landscape, and alluvial soils from the Wollombi (wo: 45 ha or 4%) landscape (Figure 19). These landscapes (with the exclusion of Wollombi) are consistent with the surrounding lands that are known to support populations of *Diuris tricolor* and *Prasophyllum petilum*, with the addition of some areas of the Castle Rock and Growee soil landscapes (solodic soils) (further discussed below).

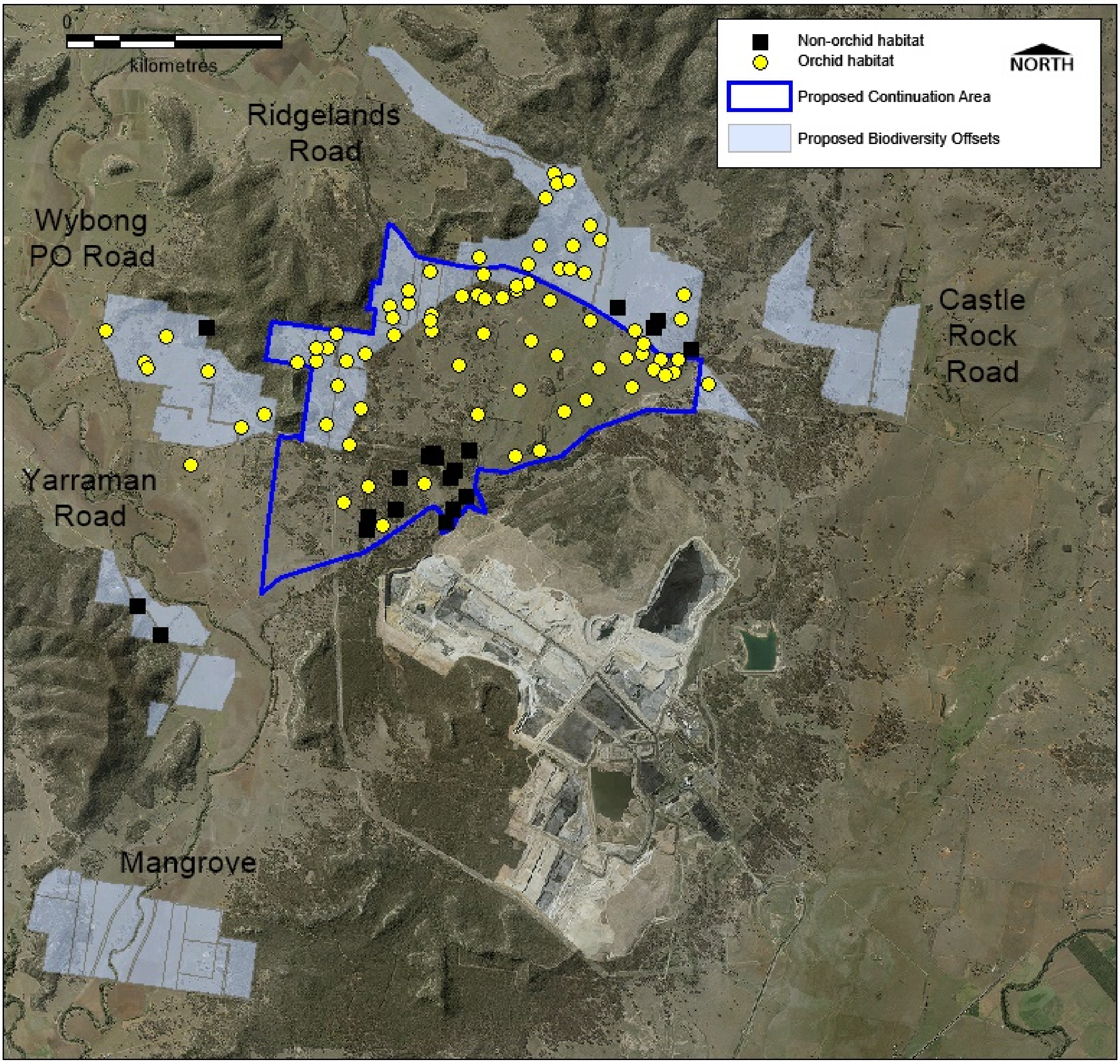

Figure 18 Potential orchid habitat as indicated by floristic plot data (n=99) collected by Umwelt across the proposed offset and continuation areas, 2014 – 2018.

63. Using the combined records collated during the wider Mangoola orchid survey project (Bell 2016b) and results from the most recent 2017 surveys conducted by Umwelt (Australia), an analysis of occurrence across mapped soil landscapes (Kovak & Lawrie 1991) has been undertaken to assist in defining occupied habitat. This is of course contingent on the amount of search effort and timing of surveys that has been extended across all landscapes in the area,

but nevertheless provides a sound basis on which to assess likely occurrence in the Subject Area.

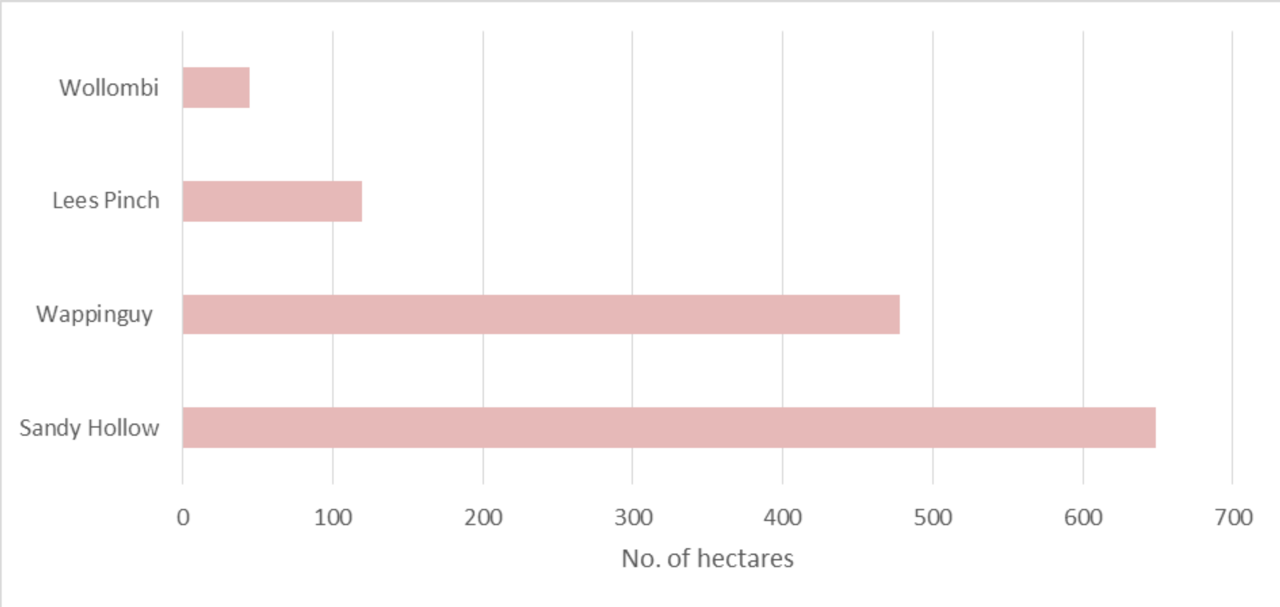

Figure 19 Extent (hectares) of soil landscapes across the proposed offset lands.

64. As detailed in Bell (2016b), up until and including the 2015 flowering season, a combined total of 8548 *Diuris* and 1812 *Prasophyllum* were recorded across all Mangoola Coal-instigated surveys since 2009. The poor flowering season in 2017 resulted in only 136 additional *Diuris* records detected by Umwelt (Australia), but no *Prasophyllum*. In total, 8684 *Diuris* and 1812 *Prasophyllum* have been detected over a ten year period, over several thousand km of search transects. No orchid surveys were completed during the 2016 flowering period. Note also that from the supplied 2017 Umwelt data, 85 records of *Diuris tricolor* from the 2017 flowering season were from a location near Jerrys Plains, some 30km to the south-east of Mangoola, occurring on the Jerrys Plains soil landscape. These records have been excluded from the current analyses, leaving a total of 136 *Diuris* recorded during 2017 surveys.

65. Figure 20 summarises the relative distribution of orchid records across the six soil landscapes in which they have been recorded. The majority of occurrences are on the Wappinguy and Sandy Hollow landscapes, which both support solodic soils. These two landscapes are also the primary soil landscapes present within the Subject Area (84% of the total area). Based on existing records, *Diuris* more-or-less equally occur on Wappinguy and Sandy Hollow soils, while *Prasophyllum* shows a strong preference for Sandy Hollow soils, with Wappinguy and Castle Rock soils also important for this species. Minor occurrences on Lees Pinch, Growee and Dartbrook soil landscapes may be an artefact of the poor resolution of soils mapping (1:250k scale).

66. Limited more detailed soil analysis has also been undertaken in part of the Mangoola lands. Bell (2016a) outlines the results of the soil sampling program undertaken across areas of naturally occurring *Diuris* and *Prasophyllum* habitat (control) and sites where translocated populations had been newly established at Mangoola Coal. During that study, involving soil

analysis from four different locations, soil pH was found to be slightly acidic and between 5.5 and 7.2, total nitrogen ranged from 470 to 1150 mg/kg, total phosphorous from 98 to 200 mg/kg, and total organic matter from 1.1 to 2.4%. Moisture content was low at the time of sampling (30 October 2015), ranging from 5.7 to 13.9%, and followed a five month period of mostly below average rainfall.

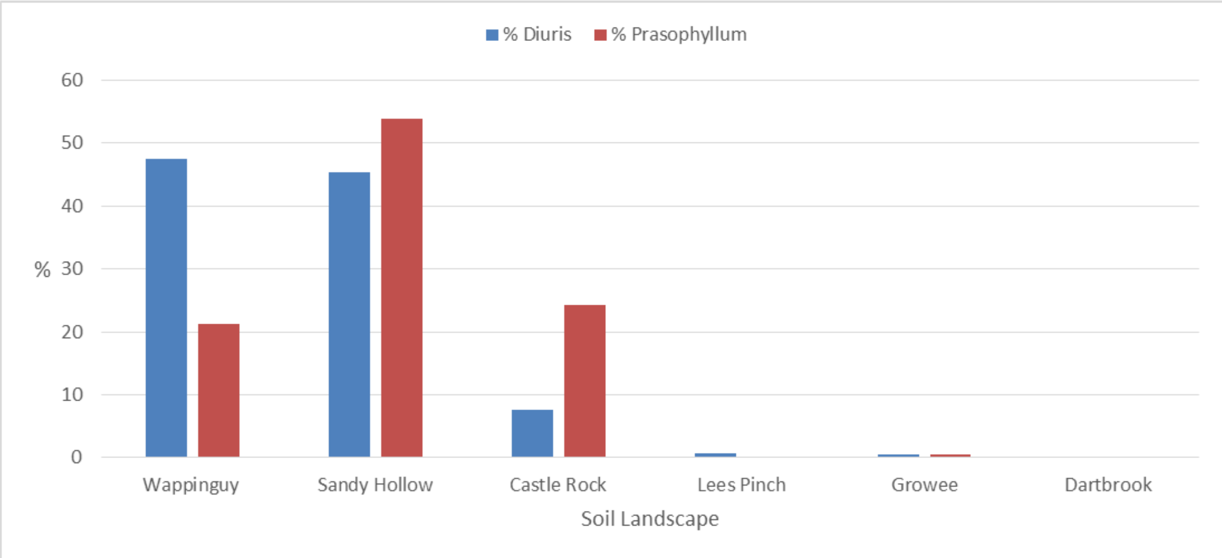

Figure 20 Relative proportion of known orchid presence (2009 – 2017) across six soil landscapes (n=8684 *Diuris*; 1812 *Prasophyllum*).

67. Compared to soils data from the Subject Area, there is a good correlation between known locations of *Diuris* and *Prasophyllum* in the wider Mangoola area with soil landscapes (Figure 21). For *Diuris*, almost all known records (93%) occur on the Wappinguy and Sandy Hollow soil landscapes (both well represented in proposed offsets), while the most important landscapes for *Prasophyllum* are Sandy Hollow, Castlerock and Wappinguy (99%). There are no areas of the Castle Rock landscape present in the proposed offset lands, but this is a rare unit shown in Kovak & Lawrie (1991) for only three areas: one within the current Mangoola approval area, but the other two some distance to the east in the Elderslie and Pokolbin localities. Apart from this anomaly, there is a strong match between known soil preferences and the landscapes contained in the proposed offsets.

4.5 Field Inspection of the Subject Area

68. I inspected most parcels of land that comprise the proposed offsets on 31 July 2018, in the company of Ryan Parsons (Umwelt). I did not inspect the Wybong PO Road offset and parts of the Yarraman Road offset as I have previously surveyed those in 2015 and was familiar with their attributes and the orchid populations residing there. Additionally, I inspected the Mangrove property on 4 October 2018, after this parcel of land was added to the project brief.

Field inspection on 31 July and 4 October generally involved traversing large portions of each offset in vehicle, periodically stopping to record data on habitat and to take photographs. An assessment on the likelihood of the two target orchid species being present, together with a GPS location, was recorded on a mobile device for later use in GIS. Notes were also made on the perceived level of grazing history at each of 98 sites across the offsets, and how this may influence the presence of a residing orchid population.

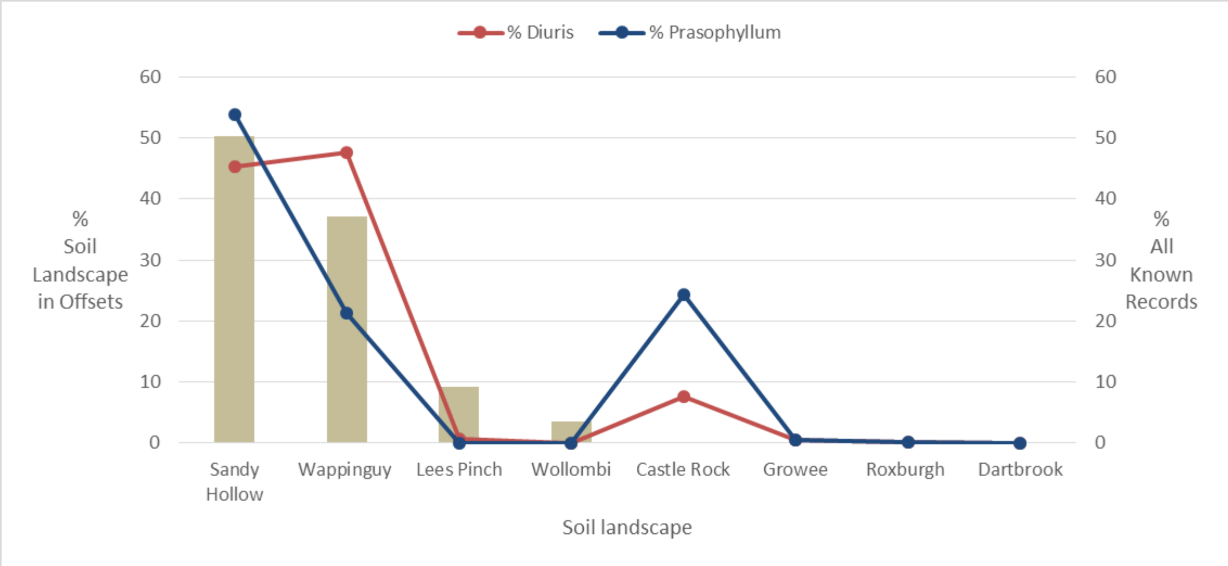

Figure 21 Correlation between known orchid presence (2009 – 2017) and soil landscapes present within the proposed offsets (n=8684 *Diuris*; 1812 *Prasophyllum*).

69. On the GIS, I created maps of likely orchid habitat quality based on my field observations and the floristic plot data supplied by Umwelt, so that estimates of the number of hectares anticipated to support a viable orchid population could be calculated. My field notes and the Umwelt floristic plot data were overlain as point locations across the study area, and these were used to guide the creation of habitat quality maps. Additional guidance was provided by aerial imagery to refine boundaries between areas of differing quality, such as where clearly distinct photopatterns were evident along fenced paddock boundaries.

70. I constructed four classes of potential orchid habitat based on field point data and GIS analysis:

- **high** (dominance of native grasses and forbs, relatively undisturbed ground, little evidence of heavy agricultural grazing, orchids known to be present)
- **moderate** (dominance of native grasses and forbs but with obvious weed species, some observable ground disturbance, evidence of recent agricultural grazing)
- **low** (dominance by weed species although natives still present, obvious ground disturbance, evidence of high intensity agricultural grazing, past or present cropping)
- **none** (forested habitats, typically on sandstone, or areas with high ground disturbance)

Note that these four classes of orchid habitat were equally applicable to *Diuris* and *Prasophyllum*, as in my experience surveying these species since 2009 both co-occur in very similar habitat (*viz*. derived native grasslands). At the micro-scale, *Prasophyllum* tends to occur at the wetter end of the occupancy spectrum where *Diuris* is often absent, however both occur across dryer and intermediate grassland types. In any case, these observed trends have not been validated through testing of soil moisture levels hence should be considered a working hypothesis only. Despite this, I investigated whether or not there were suitable GIS environmental layers that may attempt to replicate these micro-scale trends, however none were available.

71. The distribution of these four mapped potential orchid habitats were as shown in Figure 22 and Table 4. Note that Figure 22 is based on my own field observations and interpretation of aerial imagery and not the existing vegetation community mapping of Umwelt, nor of soil landscape mapping. Representative photographs, taken under drought conditions during field inspections in July 2018, of the three levels of potential orchid habitat are shown in Figure 23 to Figure 25. A few areas were considered to be particularly suitable for *Prasophyllum* due to the presence of moss on the ground surface, indicative of better moisture retention (e.g. Figure 26). During the October 2018 inspection of the proposed Mangrove offset, plentiful *Diuris* were observed flowering in the eastern and western sections considered to represent high quality habitat, and scattered *Diuris* were also detected in western parts of the moderate quality habitat.

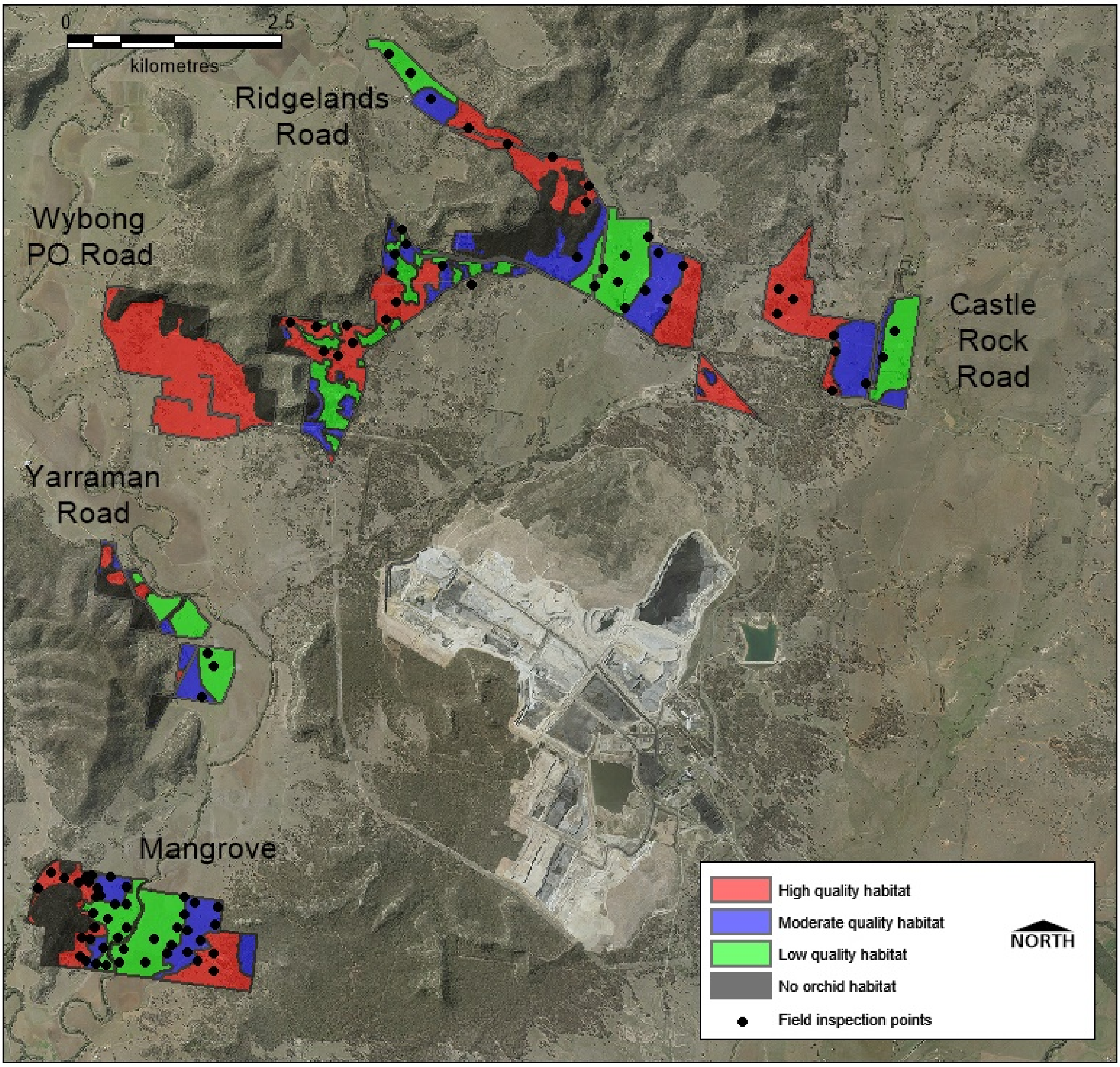

Figure 22 **Orchid habitat quality across the proposed offset lands, based on field inspection, existing floristic plot data and known orchid locations.**

Table 4 Extent of potential and actual orchid habitat across all offsets.

	No. hectares				
Offset	**High**	**Moderate**	**Low**	**None**	**Total (ha)**
Mangrove	76	58	85	40	259
Castle Rock Rd	66	50	40	0	156
Yarraman Rd	12	25	45	22	104
Wybong PO Rd	169	0	0	39	208
Ridgelands Rd	191	132	160	80	563
Total (ha)	**514**	**265**	**330**	**181**	**1290**

Figure 23 Example of low quality orchid habitat (Castle Rock Road offset), July 2018.

Figure 24 Example of moderate quality orchid habitat (Castle Rock Road offset), July 2018.

Figure 25 Example of high quality orchid habitat (Ridgelands Road offset), July 2018.

Figure 26 Example of high quality *Prasophyllum* habitat supporting live moss (Ridgelands Road offset), expected to support a range of native forbs and orchids during wetter periods, July 2018.

5. Criterion (d) – Size of Population or Habitat

72. In order to estimate the potential size of the orchid populations within the proposed offsets, I examined various patches of high quality habitat where population size has been tallied previously during wetter years to calculate an estimate of orchid density (Table 5). For earlier targeted searches (2010 & 2011) I also calculated orchid densities against search effort area irrespective of habitat quality (these lands have now been mined). I performed these calculations across several different geographical and habitat types to establish some lower and upper bounds for an estimate of expected population size within the proposed offsets. Densities calculated should be considered a minimum in each case, as many point records did not contain a count of individuals so were assumed to only represent one individual.

Table 5 Orchid density from previous counts in better years.

			Diuris		*Prasophyllum*	
Offset	**Size (ha)**	**Year**	**No.**	**Density (/ha)**	**No.**	**Density (/ha)**
Yarraman Rd (part)	3	2015	222	74	0	0
Yarraman Rd (part)	4	2015	157	39	0	0
Ridgelands Rd (part)	27	2014	1148	43	61	2
Ridgelands Rd (part)	29	2014	272	9	65	2
Ridgelands Rd (part)	35	2014	989	28	110	3
Wybong PO Rd	168	2014/15	4266	25	626	4
existing mine (south)	460	2011	649	2	722	2
existing mine (north)	764	2010	3303	4	2022	3
Density range	-	-	-	**2 to 74 / ha**	-	**2 to 4 / ha**

73. Based on previous searches conducted between 2010 and 2015, the density of *Diuris* detection ranges dramatically from 2 individuals/hectare in 2011 (below average rainfall Jun-Aug; see Figure 6) to 74 individuals/hectare in 2015 (above average rainfall). For *Prasophyllum* detection, the considerably more restricted range varies from 2 individuals/hectare in 2011 (below average rainfall) to just 4 individuals/hectare in 2014/15 (above average rainfall). As noted elsewhere, *Prasophyllum* detection is considerably more difficult than *Diuris* due to the small stature and insignificant flowers of this species when compared to *Diuris*, and consequently I suspect that many *Prasophyllum* individuals were overlooked during these targeted surveys.

74. Given that my assessment of the proposed 1290 ha offset lands comprise a total of 514 ha of **high quality habitat** (see Table 4), it follows that these habitats alone would be expected to support many thousands of individuals of both *Diuris* and *Prasophyllum*. More specifically, using the ranges indicated in Table 5 it can be expected that between 1000 and 38,000 *Diuris*, and between 1000 and 2000 *Prasophyllum* are likely to be present across the combined high quality offset areas. Again, I expect these numbers to be an under-estimate of the true population size due to difficulties of detection (particularly for *Prasophyllum*), separation distances between survey transects, the staged nature of flowering across each season, and variation in climate (principally winter rainfall) from year to year.

75. Additionally, the 265 ha of **moderate orchid habitat** shown in Figure 20 and Table 4 can also be expected to support between 530 and 7,000 individuals of *Diuris* and around 530 *Prasophyllum*. These estimates have used the lower bound figure of 2 individuals/hectare shown in Table 5 for both species, but the median of scores shown in Table 5 to be more

reflective of the moderate habitat quality status. Note that for *Prasophyllum*, the median and lower figure are equal (both 2). Combined across the high and moderate quality classes within the proposed offsets, a minimum of 1,500 *Diuris* and *Prasophyllum* may be expected to be present, with perhaps as many as 45,000 *Diuris* and 2,500 *Prasophyllum*. Table 6 summarises these expected ranges.

Table 6 Expected population size ranges of *Diuris* and *Prasophyllum* within proposed offset lands.

		Diuris		***Prasophyllum***	
Assessed Offset Habitat	**ha**	**Lower**	**Upper**	**Lower**	**Upper**
High quality habitat	514	1000	38,000	1000	2000
Moderate quality habitat	265	530	7000	530	530
Total	**779**	**1530**	**45,000**	**1530**	**2530**

76. Some of the proposed offset lands have already been surveyed for orchids during non-drought years, particularly in 2014 and 2015. These surveys resulted in the detection of 9,030 *Diuris* (well exceeding my lower estimate of 1,530 individuals) and 904 *Prasophyllum* individuals (just over half of my lower estimate). If we deduct these totals from the overall predicted upper bounds population size shown in Table 6, this leaves approximately 36,000 *Diuris* and 1,600 *Prasophyllum* additionally expected within the offsets. Lower bounds would stand at 9,030 for *Diuris* (assuming the unlikely scenario that no further individuals are present than those already detected in 2014 and 2015), and 626 *Prasophyllum* (a deduction of 904 from 1,530).

77. Therefore, my estimate of the number of orchids likely to be present within the proposed offset lands, following the logic outlined in the above paragraphs relating to density of detection in previous years and extent of moderate-to-high quality habitat, stands at:

- between 9,030 and 36,000 *Diuris* (moderate to high habitat only)
- between 626 and 1,600 *Prasophyllum* (moderate to high habitat only)

78. In addition to these expected orchids, there will also be a number of both species likely within areas designated as low quality habitat (330 ha), but this number is difficult to quantify due to variations in past and current disturbances, weed densities or floristic associations.

79. To settle on a single expected figure for the quantum of both *Diuris* and *Prasophyllum* within the proposed offset lands (to be incorporated as I understand in the calculation of species credits), I have used two separate metrics to predict orchid density across high/moderate quality habitat and low quality habitat. For **high/moderate habitat** (combined for this purpose as distinctions between the two are heavily rainfall- and disturbance history-related), I used the median density score for each species from the eight previous count areas shown in Table 5 as an appropriate multiplier. I have selected median as the preferred measure of central tendancy, as it is not influenced greatly by outliers in a dataset and it accommodates skewed datasets better than does the mean. As it turns out, the median in the orchid density dataset is identical to the mean score for *Prasophyllum* (both 2), and only slightly lower than the mean score for *Diuris* (26.5 vs 28). For **low quality habitat**, I have taken the lowest density score of *Diuris* and *Prasophyllum* from Table 5 to use as an appropriate multiplier (but ignoring the zero returns attained for the two Yarraman Road survey areas), using the assumption that very few orchids can be expected in these lands but that some are likely.

80. Table 7 summarises the final expected density of *Diuris* and *Prasophyllum* for the proposed offset lands across high/moderate and low quality habitat (non-orchid habitat, such as the sandstone ridges, have not been considered), and incorporates data and observations on orchid presence, habitat quality and preferred floristic associations gathered over several years of survey. In total, **21,304 *Diuris*** and **2,218 *Prasophyllum*** are expected to be present there.

Table 7 Expected density of *Diuris* and *Prasophyllum* within proposed offset lands. See text for explanation of multiplier selection.

		Diuris			***Prasophyllum***		
		Multiplier			**Multiplier**		
Habitat Quality	**Extent (ha)**	Median Density	Minimum Density	Expected Density	Median Density	Minimum Density	Expected Density
High/Moderate	779	26.5	-	20,644	2	-	1,558
Low	330	-	2	660	-	2	660
Total	**1109**		***Diuris* =**	**21,304**		***Prasophyllum* =**	**2,218**

81. Allowing for the 9,914 orchids already recorded, the proposed offset lands can be expected to support **an additional 12,294 *Diuris* and 1,314 *Prasophyllum***.

6. Criterion (e) – Documents & Data Reviewed

82. I have been provided with following reports and datasets from Umwelt (Australia) Pty Ltd to assist in this review:

- spatial GIS files showing orchid survey search tracks for the 2017 flowering season.
- an email from Umwelt detailing the dates of field survey during the 2017 flowering season, together with the names and years of ecological experience of team members.
- a spreadsheet detailing weather observation collected from two weather stations at Mangoola Coal, spanning the period 2010 to May 2018 (and some minor updates). The location of these weather stations are shown on Figure 2.
- two digital photographs of flowering *Prasophyllum petilum*, taken within one of my translocation sites in the Spring of 2017 and used for reference purposes for their field surveys.
- vegetation survey plot data from the proposed continuation area and biodiversity offset areas, various projects.
- spatial GIS files of proposed extension and biodiversity offset areas.

Other published and unpublished reports and papers that form part of this report have been cited in the normal way, with publication details contained in Section 9. Floristic data analyses undertaken by me as part of this report are based solely on that collected by Umwelt (Australia) from the Mangoola Coal site.

7. Criterion (f) – Expert Credentials

83. Under the requirements of the Biodiversity Assessment Method, an expert report can be prepared by an endorsed person in the place of undertaking field survey. This report must include information on the credentials of the expert, including the following:

a. *the expert's qualifications such as relevant degrees, post graduate qualifications*;

I possess three degrees in the science field: a Bachelor of Science (1988), Bachelor of Science (Honours) (1990) and a Doctor of Philosophy (Vegetation Science) (2013).

b. *the expert's history of experience in the ecological research and survey method, for the relevant species*;

In regard to the threatened orchid species that are the subject of this expert report (*Diuris tricolor, Prasophyllum petilum*), I have been surveying and monitoring both of these species over nine consecutive years at the Mangoola site, including the annual monitoring of over 3000 translocated specimens since 2010. In addition, I have searched for and monitored other populations of *Diuris tricolor* at separate sites in the Muswellbrook and Singleton local government areas, at one of these sites for five consecutive years. Methods used for all of these studies have incorporated systematic open-ended transect surveys in appropriate habitat, using GPS devices to record tracks searched and orchids located. Separation distances between adjacent search transects vary in relation to quality of habitat and visibility. Search times have only occurred when other known reference populations have been in flower.

c. *a resume detailing projects pertaining to the survey of the relevant species (including the locations and dates of the work) over the previous 10 years*;

My full Curriculum Vitae are appended as Appendix 5 to this report. In relation to the relevant species that are the subject of this report (*Diuris tricolor, Prasophyllum petilum*), the following projects pertain to survey for these (2009 to 2018):

- Bell, S.A.J., Murray, M., & Sims, R. (2018) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2017 Results*. Unpublished Report to Bulga Surface Operations (Glencore). March 2018. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2018) *Monitoring of translocated threatened orchids (*Diuris tricolor, Prasophyllum petilum*) at Mangoola Coal: 2017 Results*. Unpublished Report to Mangoola Coal. February 2018.
- Bell, S.A.J. (2017) *Targeted survey for the threatened* Diuris tricolor *at Persoonia Park, North Rothbury, Hunter Valley*. Unpublished Report to Office of Environment & Heritage. November 2017. Eastcoast Flora Survey.
- Bell, S.A.J. & Murray, M. (2017) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2016 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2017. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2017) *Targeted Orchid Survey: Addendum to Pre-clearance Surveys, Borehole Explorations Areas, Rix's Creek North Mine*. Unpublished Report to Rix's Creek Pty Limited. October 2017. Eastcoast Flora Survey.

- Bell, S.A.J. & Murray, M. (2016) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2015 Results*. Unpublished Report to Bulga Surface Operations (Glencore). May 2016. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. & Murray, M. (2015) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2014 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2015. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. & Driscoll, C (2014) *Assessment and mapping of vegetation in the Bylong Valley: Authorisations 287 & 342*. Unpublished Final Report to Hansen Bailey Pty Ltd. Eastcoast Flora Survey. December 2014.
- Bell, S.A.J. (2013) *Monitoring of translocated threatened orchids (*Diuris tricolor, Prasophyllum *sp. Wybong C.Phelps ORG5269) at Mangoola Coal: 2013 Results*. Unpublished Report to Mangoola Coal. November 2013. Eastcoast Flora Survey.
- Bell, S.A.J. & Murray, M. (2013) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA*. Unpublished Report to Bulga Surface Operations (Glencore). November 2013. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2013) *Monitoring of translocated threatened orchids (*Diuris tricolor, Prasophyllum *sp. Wybong C.Phelps ORG5269) at Mangoola Coal: Status Report 2012*. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, January 2013.
- Bell, S.A.J. & Carty, A. (2012) *Vegetation mapping of the Singleton Military Area*. Unpublished report to Commonwealth Department of Defence. Eastcoast Flora Survey & SKM, March 2012.
- Bell, S.A.J. (2012) *Targeted terrestrial orchid surveys at Mangoola Coal, Upper Hunter Valley: Spring 2011*. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, January 2012.
- Bell, S.A.J. & Copeland, L. (2010) *Targeted terrestrial orchid surveys at Mangoola Coal, Upper Hunter Valley: Spring 2010*. Unpublished Report to Mangoola Coal, October 2010. Eastcoast Flora Survey.
- Bell, S.A.J. & Copeland, L. (2010) *A strategy for the translocation of threatened terrestrial orchids at Mangoola Coal, Upper Hunter Valley*. Unpublished Report to Mangoola Coal, September 2010. Eastcoast Flora Survey.
- Bell, S.A.J. & Copeland, L. (2009) *Targeted terrestrial orchid survey, Mangoola, Upper Hunter Valley*. Spring 2009. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, November 2009.
- Bell, S.A.J. (2009) *Targeted terrestrial orchid survey of the ex-Nipol property, near Denman, Upper Hunter Valley*. Unpublished report to Mangoola Coal. Eastcoast Flora Survey, November 2009.

d. *their employer's name and period of employment (where relevant)*;

I am the principal and owner of *Eastcoast Flora Survey*, established in the Hunter Valley in October 1996, and spanning a continual period of dedicated flora consulting of over 21 years. Since 2014, I have also been a Conjoint Fellow at the University of Newcastle, in the School of Environmental and Life Sciences.

e. *relevant peer reviewed publications*;

No publications to date specifically addressing *Diuris tricolor* or *Prasophyllum petilum* (these are currently in press or preparation), however several dealing with other threatened orchid species (e.g. *Cryptostylis hunteriana*: Bell 2001a, de Lacey et al 2012a,b, de Lacey et al 2013;

Thelymitra adorata: Bell et al 2005) and non-orchid threatened taxa (e.g. *Acacia dangarensis*: Bell & Elliott 2013; *Acacia pendula*: Bell et al 2007, Bell & Driscoll 2014, Bell & Driscoll 2016; *Acacia wollarensis*: Bell & Driscoll 2017, Bell & Kodela 2018; *Angophora inopina*: Bell 2004; *Banksia conferta*: Bell 2017; *Commersonia rosea*: Bell & Copeland 2004, Bell & Holzinger 2015; *Dracophyllum macranthum*: Bell & Sims submitted; *Eucalyptus expressa*: Bell & Nicolle 2012; *Hibbertia procumbens*: Bell 2002, Bell & Driscoll 2005; *Leionema lamprophyllum* subsp. *fractum*: Bell & Walsh 2015; *Monotaxis macrophylla*: Bell & Holzinger 2015), together with those examining a range of significant and threatened species in sandstone habitats of the Hunter Valley (23 taxa; Bell 2001b) and those present in Wollemi National Park (87 taxa; Bell 2008). I am also the lead author on an *in press* book manuscript with CSIRO Publications detailing some of the endemic plant species of the Hunter Region on behalf of the University of Newcastle, many of which are threatened species.

f. *evidence that the person is a well-known authority on the relevant species to which the survey relates*.

I have been surveying and monitoring the two target species for over 9 years in the Hunter Valley, and am acutely aware of their habitat requirements and variability in flowering from year to year. Additionally, Dr Lachlan Copeland (EcoLogical Australia & orchid taxonomist) has endorsed me as a recognised authority on the field ecology of *Diuris tricolor* and *Prasophyllum petilum* (see letter appended in Appendix 6).

8. Conclusion

84. The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will utilise the existing infrastructure, emplacement areas and equipment at Mangoola Coal Mine, and will extend the life of the existing operation providing for ongoing employment opportunities for the existing Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area.

85. The MCCO Project, if approved, will result in the removal of two threatened orchid species, *Diuris tricolor* and *Prasophyllum petilum*. Completed surveys in the project area by Umwelt show that 1,325 *Diuris* and 634 *Prasophyllum* will be directly impacted upon by proposed activities, and additional lands are consequently required to offset this impact.

86. Five separate parcels of land (Mangrove, Castle Rock Road, Ridgelands Road, Wybong PO Road, Yarraman Road) are proposed as offsets, comprising a total of 1290 ha. These offsets are located to the north and west of existing operations, and comprise various habitats including grasslands, woodlands and forests. I have inspected these properties and assessed the potential for the provision of habitat for the two target species.

87. I have undertaken survey and monitoring of *Diuris* and *Prasophyllum* at Mangoola since 2010, and as a consequence have a solid understanding of the occupied habitat of both species in this locality. Through annual monitoring of translocation sites, where the fate of individual orchids has been followed for several years, detection rates have been shown to reflect rainfall received in the three months to September (Jun-Aug) each year. The last two flowering seasons (2017 & 2018) were exceptionally dry at Mangoola, with the area receiving as little as one third of the average for this 3-month pre-flowering period. The poor survey results obtained during targeted searches in 2017 reflected the dry winter (and indeed the previous two consecutive dry years), and justifies the need for this expert report.

88. If required as part of an offsets package for the MCCO Project, the possibility of translocating orchids out of the proposed continuation area should be considered. Translocation of both orchid species has been shown to be successful over a period of eight years at Mangoola, and will provide an added management action for the conservation of these species. According to the review of Reiter et al (2016), the translocation project at Mangoola, involving over 3,000 individual orchids, is the largest known attempt involving orchids within Australia (highest reported is 400 individuals) and the world (700 individuals). Scientific papers outlining the translocation project are currently in press or preparation (Bell in press; Bell in prep.).

89. Based on targeted field surveys completed by myself in 2015, and Umwelt staff in 2016 and 2017, a minimum of 9,030 *Diuris* and 904 *Prasophyllum* individuals are known to be present within the proposed offset lands. Results obtained during 2017 surveys were poor due to drought conditions.

90. In addition to my two day field inspection of the proposed offset lands, I examined floristic plot data collected by Umwelt staff to help inform my opinion on the suitability or otherwise for the target orchids. Ninety-nine plots were supplied for this purpose (collected between 2014 and 2018, and covering both the proposed offset and continuation areas), and after examining survey times in relation to rainfall, assessing relative proportions of key plant habits and weed species, and rationalising taxonomy and cover abundance values these data were considered representative and adequate for analysis purposes. I subsequently ran a numerical

classification of these data to identify the main floristic groups (communities) present, delineating fourteen communities. Four of these were grasslands, eight were woodlands or forests, and two were shrublands. Of the fourteen, I determined that ten would provide potential habitat for *Diuris* and *Prasophyllum*, based on my own experiences with habitat occupied by these species at Mangoola in previous years.

91. I also examined the available soil landscape information (a surrogate for soil, otherwise not available) for the proposed offset and continuation areas, and compared it to other areas at Mangoola where the two orchid species occur. Over a ten year period, point records for 8,684 *Diuris* and 1,812 *Prasophyllum* have been collated, and these were used to intersect soil landscape units. Based on these records, *Diuris* more-or-less equally occur on Wappinguy and Sandy Hollow soil landscapes, while *Prasophyllum* shows a strong preference for the Sandy Hollow soil landscape, with Wappinguy and Castle Rock landscapes also important for this species. Minor occurrences on Lees Pinch, Growee and Dartbrook soil landscapes may be an artefact of the poor resolution of soils mapping (1:250k scale).

92. The primary soil landscapes present within the proposed offset lands were found to be the Wappinguy and Sandy Hollow landscapes (a combined total of 87% of all offsets), which corresponds well to the analysis of known point records noted above. For *Diuris*, almost all known records (93%) occur on the Wappinguy and Sandy Hollow soil landscapes (both well represented in proposed offsets), while the most important landscapes for *Prasophyllum* are Sandy Hollow, Castlerock and Wappinguy (99%). There is a strong match between known soil preferences and the landscapes contained in the proposed offsets.

93. Following my field inspections on 31 July and 4 October 2018, I used data collected then and existing floristic plot data to construct a map of orchid habitat quality across the proposed offsets. This resulted in the designation of 514 ha of high quality habitat, 265 ha of moderate quality, and 330 ha of low quality. The balance (181 ha) was considered to comprise negligible orchid habitat. Combining the areas of high and moderate quality habitat, 779 ha of the total 1290 ha combined offsets provide good quality habitat for *Diuris* and *Prasophyllum*. This represents 60% of the total proposed offset lands.

94. Using existing point record data on orchid occurrence (n=11,006 *Diuris*; n=3,606 *Prasophyllum*), I calculated representative densities of orchids across eight different areas surveyed in previous years to determine appropriate lower and upper bounds for the expected population size within the proposed offsets. This analysis resulted in a range of 2 to 74 *Diuris* per hectare and 2 to 4 *Prasophyllum* per hectare. Extrapolating these densities across the mapped high and moderate quality habitat within the proposed offset areas, the expected population size for *Diuris* likely falls within the range of 1,530 to 45,000 individuals, and for *Prasophyllum* 1,530 to 2,530 individuals.

95. Given the fact that some of the proposed offset lands have already been surveyed for orchids in previous years, I deducted these 9,030 *Diuris* and 904 *Prasophyllum* individuals from the above ranges to determine population sizes in lands yet to be sampled during wetter climatic conditions. This resulted in the adjusted expected population sizes of between 9,030 and 36,000 *Diuris* (assuming the unlikely scenario that no further individuals are present than those already detected in 2014 and 2015), and between 626 and 1,600 *Prasophyllum*.

96. In order to provide more definitive estimates of both species that can be used in credit calculations, I used two different multipliers (median density from previous surveys for high/moderate quality habitat; lowest density for low quality habitat) to calculate the expected

number of individuals across the combined offset area. Following this process, 21,304 *Diuris* and 2,218 *Prasophyllum* are expected to be present. Allowing for the 9,914 orchids already recorded, the proposed offset lands can be expected to support **an additional 12,294 *Diuris* and 1,314 *Prasophyllum***.

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Appendix 1 – Letter of Approval from OEH

NSW GOVERNMENT | Office of Environment & Heritage

DOC18/211176-1

Mr Shaun Corry
Senior Ecologist
Umwelt (Australia) Pty Ltd
scorry@umwelt.com.au

Dear Shaun

Recognition of Dr Stephen Bell as an expert for *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong')

Thank you for your e-mail of the 9 April 2018 in which you request that Dr Stephen Bell be recognised as an expert for *Diuris tricolor* (Pine Donkey Orchid) and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong') (Tarengo Leek Orchid) for the Mangoola Coal Continued Operations project.

The Office of Environment and Heritage (OEH) has reviewed the information provided by you in support of this request. OEH is satisfied that Dr Stephen Bell satisfies the definition of species expert for *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong'), in accordance with Section 6.5.2.3. of the Biodiversity Assessment Method.

Please note that this formal recognition of Dr Stephen Bell as an expert only applies to *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong').

If you require any further information regarding this matter, please contact Steven Cox, Senior Team Leader, Planning Hunter Central Coast, on 4927 3140.

Yours sincerely

Sharon Molloy 14/5/2018

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Appendix 2 – Floristic Composition of Grassland Habitat (Bell 2012)

The derivation of diagnostic species for each defined floristic group has been defined using the SIMPER routine in *Primer* on available full floristic plot data. SIMPER analysis provides the relative contributions of each species to the Bray-Curtis similarity within each of the defined vegetation communities. Only those species contributing to a total cumulative contribution of 99% of the average similarity (i.e. the value shown at the top of each floristic table) for each community are listed. These species can be described of as *typical* of that community, and have a consistently large presence within the data as reflected in the ratio of their contribution to the standard deviation (the Sim/SD field in each table) across the within-group similarities (the average similarity). Key canopy species are highlighted.

In the tables:

- Average similarity — is the within-group similarity for all pairs of sample plots comprising the community. Higher average similarity indicates a better defined community.
- Av.Abund — is the average cover abundance of that species within sample plots comprising the community
- Av.Sim — is the average similarity (contribution) made by each species to the within-group similarity (the overall average similarity).
- Sim/SD — is the ratio of average similarity to standard deviation for each species across all pairs of samples. A high ratio represents a good discriminating species. At least three samples are required for this ratio to be calculated (not available for four communities).
- Contrib % — is the percentage contribution of each species to the overall average similarity for the community.
- Cum.% — is the cumulative percentage contribution of each species, up to a maximum of 99%.

Unit 1a: Dichanthium/ Sporobolus/ Chloris Grassland - Key Diagnostic Species [based on 63 plots]:

Group 1a: Dichanthium/ Sporobolus/ Chloris Average similarity: 45.72					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Dichanthium sericeum subsp. sericeum	2.92	2.68	1.09	5.87	12.92
Senecio madagascariensis *	1.89	2.58	3.58	5.64	18.56
Sporobulus creber	2.02	2.22	1.79	4.87	23.42
Anagallis arvensis *	1.75	2.13	1.86	4.66	28.09
Chrysocephalum semipapposum	1.71	1.92	1.48	4.20	32.29
Centaurium tenuiflorum *	1.67	1.88	1.40	4.10	36.39
Bothriochloa decipiens var. decipiens	2.02	1.82	1.06	3.98	40.37
Glycine tabacina	1.56	1.78	1.47	3.90	44.27
Chloris truncata	1.79	1.41	0.93	3.09	47.36

*Gamochaeta americana **	1.38	1.38	1.04	3.02	50.39
*Cyclospermum leptophyllum **	1.35	1.22	1.19	2.67	53.05
Fimbristylis dichotoma	1.30	1.21	0.88	2.66	55.71
Aristida ramosa var. ramosa	1.52	1.21	0.89	2.64	58.35
Vittadinia muelleri	1.41	1.20	0.84	2.63	60.99
Cheilanthes sieberi subsp. sieberi	1.27	1.12	0.86	2.44	63.43
Dichelachne micrantha	1.59	1.09	0.76	2.38	65.80
*Vulpia muralis **	1.38	1.05	0.77	2.30	68.10
*Hypochaeris radicata **	1.21	0.90	0.73	1.97	70.08
*Trifolium arvense **	0.97	0.83	0.93	1.81	71.88
*Petrorhagia dubia **	1.08	0.81	0.73	1.78	73.66
Asperula conferta	1.06	0.78	0.68	1.70	75.36
Plantago debilis	1.03	0.77	0.67	1.69	77.05
*Hypochaeris microcephala var. albiflora **	1.00	0.74	0.62	1.61	78.66
Dichondra repens	0.94	0.61	0.64	1.33	80.00
Oxalis perenans	0.94	0.61	0.61	1.33	81.33
*Carthamnus lanatus **	0.81	0.39	0.50	0.86	82.19
*Briza minor **	0.76	0.38	0.46	0.84	83.02
Eulalia aurea	0.92	0.37	0.36	0.81	83.83
Wahlenbergia communis	0.62	0.35	0.54	0.77	84.61
Convolvulus erubescens	0.62	0.35	0.49	0.76	85.36
Cymbopogon refractus	0.63	0.31	0.46	0.68	86.04
Daucus glochidiatus	0.65	0.31	0.40	0.67	86.71
Sida corrugata	0.65	0.31	0.39	0.67	87.38
Austrodanthonia tenuior	0.65	0.30	0.36	0.65	88.03
*Polycarpon tetraphyllum **	0.62	0.28	0.39	0.62	88.65
Triptilodiscus pygmaeus	0.62	0.28	0.33	0.62	89.27
Calocephalus citreus	0.78	0.27	0.33	0.58	89.85
Brunoniella australis	0.57	0.23	0.31	0.51	90.36

Unit 2: Aristida/ Cymbopogon Grassland - Key Diagnostic Species [based on 44 plots]:

Group 2: Aristida/ Cymbopogon Average similarity: 39.82					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Aristida ramosa var. ramosa	3.43	4.60	2.17	11.55	11.55
*Linum trigynum **	2.18	3.01	2.04	7.56	19.11
Cheilanthes sieberi subsp. sieberi	2.07	2.84	2.01	7.14	26.25
*Anagallis arvensis **	1.70	2.42	1.73	6.09	32.34
*Senecio madagascariensis **	1.66	2.32	1.65	5.84	38.18
Aristida vagans	1.95	1.83	0.90	4.60	42.78
*Hypochaeris radicata **	1.75	1.77	1.00	4.44	47.22
Cymbopogon refractus	1.48	1.73	1.19	4.35	51.58
Glycine tabacina	1.14	1.32	1.25	3.32	54.90
Bothriochloa decipiens var. decipiens	1.43	1.23	0.69	3.08	57.98
*Vulpia muralis **	1.27	1.20	0.97	3.02	61.00
Sporobulus creber	1.14	0.99	0.68	2.48	63.48

Briza minor *	1.07	0.96	0.79	2.41	65.89
Chrysocephalum apiculatum	1.02	0.81	0.54	2.03	67.92
Triptilodiscus pygmaeus	0.84	0.58	0.50	1.47	69.39
Vittadinia muelleri	0.93	0.58	0.44	1.45	70.83
Dichondra repens	0.77	0.54	0.53	1.35	72.18
Gamochaeta americana *	0.80	0.53	0.52	1.34	73.52
Dichelachne micrantha	0.82	0.52	0.49	1.31	74.83
Taraxacum officionale *	0.80	0.50	0.43	1.26	76.08
Lomandra confertifolia subsp. pallida	0.75	0.48	0.53	1.21	77.30
Tolpis barbata *	0.77	0.46	0.44	1.16	78.46
Lachnagrostis filiformis	0.75	0.44	0.39	1.10	79.56
Centaurium tenuiflorum *	0.70	0.41	0.41	1.03	80.59
Oxalis perenans	0.68	0.39	0.41	0.97	81.56
Richardia stellaris *	0.66	0.38	0.41	0.94	82.51
Chrysocephalum semipapposum	0.77	0.37	0.38	0.94	83.44
Fimbristylis dichotoma	0.68	0.37	0.37	0.93	84.38
Cyclospermum leptophyllum *	0.66	0.36	0.44	0.90	85.27
Petrorhagia dubia *	0.68	0.35	0.37	0.88	86.15
Asperula conferta	0.59	0.31	0.35	0.77	86.93
Sida corrugata	0.57	0.30	0.39	0.75	87.67
Linaria pelisseriana *	0.57	0.25	0.33	0.64	88.31
Glycine clandestina	0.41	0.23	0.41	0.58	88.89
Murdannia graminea	0.50	0.21	0.31	0.53	89.42
Centaurium erythraea *	0.50	0.20	0.25	0.50	89.92

Unit 4: Bothriochloa biloba/ Carthamnus/ Danthonia Grassland - Key Diagnostic Species [based on 7 plots]:

Group 4: Bothriochloa biloba/ Carthamnus/ Danthonia Average similarity: 50.03					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Bothriochloa biloba	5.14	13.03	5.61	26.04	26.04
Carthamnus lanatus *	2.57	6.41	2.45	12.82	38.86
Chloris truncata	1.86	4.86	4.58	9.72	48.57
Austrodanthonia tenuior	2.14	4.54	1.32	9.08	57.65
Einadia nutans subsp. linifolia	1.71	4.16	3.83	8.31	65.97
Lolium perenne *	1.57	3.31	1.35	6.61	72.58
Austrostipa aristiglumis	1.57	2.20	0.74	4.40	76.97
Vittadinia cuneata var. cuneata	0.86	1.55	0.90	3.11	80.08
Oxalis perenans	1.14	1.34	0.62	2.68	82.76
Senecio madagascariensis *	0.86	1.22	0.92	2.43	85.19
Sporobulus creber	1.00	1.07	0.59	2.13	87.32
Medicago truncatula *	0.86	0.95	0.60	1.90	89.22
Carex inversa	0.86	0.92	0.58	1.84	91.05

Appendix 3 – Taxonomic Review of Datasets

Summary of taxonomic changes made to supplied dataset prior to analysis.

Taxon Form 1 (No. plots)	Taxon Form 2 (No. plots)	Adopted Name (justification)
Acacia deanei (3)	*Acacia deanei* subsp. *deanei* (1)	*Acacia deanei* (weight of numbers)
Austrostipa scabra (19)	*Austrostipa scabra* subsp. *falcata* (8)	*Austrostipa scabra* (weight of numbers)
Bossiaea prostrata (2)	*Bossiaea* spp. (2)	Bossiaea prostrata (only Bossiaea present at MC)
Brachychiton populneus (3)	*Brachychiton populneus* subsp. *populneus* (7)	*Brachychiton populneus* subsp. *populneus* (only subp. present at MC)
Brachychiton spp. (1)	*Brachychiton populneus* subsp. *populneus* (7)	*Brachychiton populneus* subsp. *populneus* (only subp. present at MC)
Brachyscome ciliaris (1)	*Brachyscome ciliaris* var. *ciliaris* (2)	*Brachyscome ciliaris* (more than one var. present at MC)
Bursaria spinosa (8)	*Bursaria spinosa* subsp. *spinosa* (2)	*Bursaria spinosa* (weight of numbers)
Cheilanthes sieberi (6)	*Cheilanthes sieberi* subsp. *sieberi* (89)	*Cheilanthes sieberi* subsp. *sieberi* (only subsp. present at MC)
Dendrophthoe spp. (1)	*Dendrophthoe vitellina* (1)	*Dendrophthoe vitellina* (only spp. present at MC)
Denhamia spp. (5)	-	*Denhamia silvestris* (only spp. present at MC)
Dodonaea spp. (1)	*Dodonaea viscosa* (7)	*Dodonaea viscosa* (most likely spp. at MC)
Einadia nutans (10)	*Einadia nutans* subsp. *linifolia* (1)	*Einadia nutans* (weight of numbers)
Einadia nutans (10)	*Einadia nutans* subsp. *nutans* (8)	*Einadia nutans* (weight of numbers)
Eriochloa pseudoacrotricha (3)	*Eriochloa* spp. (1)	*Eriochloa pseudoacrotricha* (most likely spp. at MC)
Eucalyptus blakelyi (3)	*Eucalyptus blakelyi* <--> *tereticornis* (16)	*Eucalyptus blakelyi* (most likely identity)
Evolvulus alsinoides (9)	*Evolvolus alsinoides* var. *decumbens* (5)	*Evolvulus alsinoides* var. *decumbens* (only var. at MC)

Taxon Form 1 (No. plots)	Taxon Form 2 (No. plots)	Adopted Name (justification)
Haloragis heterophylla (12)	*Haloragis* spp. (1)	*Haloragis heterophylla* (most likely spp. at MC)
Lomandra filiformis (32)	*Lomandra filiformis* subsp. *coriacea* (14)	*Lomandra filiformis* (weight of numbers)
Lomandra filiformis (32)	*Lomandra filiformis* subsp. *filiformis* (3)	*Lomandra filiformis* (weight of numbers)
Maireana microcarpa (1)	-	*Maireana microphylla* (likely typo during data entry)
Maireana microphylla (8)	*Maireana* spp. (2)	*Maireana microphylla* (likely spp.)
Microlaena stipoides (13)	*Microlaena stipoides* var. *stipoides* (16)	*Microlaena stipoides* var. *stipoides* (most likely var. at MC)
Notelaea microcarpa (46)	*Notelaea microcarpa* var. *microcarpa* (14)	*Notelaea microcarpa* var. *microcarpa* (only var. present at MC)
Oenothera sp. (1)	*Oenothera stricta* subsp. *stricta* (6)	*Oenothera stricta* subsp. *stricta* (weight of numbers, most likely spp)
Opercularia diphylla (3)	*Opercularia* spp. (1)	Opercularia diphylla (most likely spp.)
Opuntia stricta (32)	*Opuntia stricta* var. *stricta* (21)	*Opuntia stricta* var. *stricta* (only var. present at MC)
Ozothamnus diosmifolius (1)	*Ozothamnus* spp. (1)	*Ozothamnus diosmifolius* (most likely spp. at MC)
Psydrax odorata (35)	*Psydrax* spp. (3)	*Psydrax odorata* (only spp. present at MC)
Rostellularia adscendens (1)	*Rostellularia adscendens* var. *adscendens* (1)	*Rostellularia adscendens* var. *adscendens* (most likely var. at MC)
Setaria parviflora (13)	*Setaria* spp. (1)	*Setaria parviflora* (weight of numbers)
Vittadinia cuneata (6)	*Vittadinia cuneata* var. *cuneata* (1)	*Vittadinia cuneata* var. *cuneata* (most likely var. at MC)
Xanthorrhoea johnsonii (1)	*Xanthorrhoea* spp. (4)	*Xanthorrhoea johnsonii* (only spp. at MC)

MC = Mangoola Coal

Appendix 4 – Floristic Composition of Delineated Groups (Umwelt data)

The derivation of diagnostic species for each defined floristic group has been defined using the SIMPER routine in *Primer* on available full floristic plot data. SIMPER analysis provides the relative contributions of each species to the Bray-Curtis similarity within each of the defined vegetation communities. Only those species contributing to a total cumulative contribution of 99% of the average similarity (i.e. the value shown at the top of each floristic table) for each community are listed. These species can be described of as *typical* of that community, and have a consistently large presence within the data as reflected in the ratio of their contribution to the standard deviation (the Sim/SD field in each table) across the within-group similarities (the average similarity). Key canopy species are highlighted.

In the tables:

- Average similarity — is the within-group similarity for all pairs of sample plots comprising the community. Higher average similarity indicates a better defined community.
- Av.Abund — is the average cover abundance of that species within sample plots comprising the community
- Av.Sim — is the average similarity (contribution) made by each species to the within-group similarity (the overall average similarity).
- Sim/SD — is the ratio of average similarity to standard deviation for each species across all pairs of samples. A high ratio represents a good discriminating species. At least three samples are required for this ratio to be calculated (not available for four communities).
- Contrib % — is the percentage contribution of each species to the overall average similarity for the community.
- Cum.% — is the cumulative percentage contribution of each species, up to a maximum of 99%.

1. Casuarina glauca-Galenia-Ehrharta Forest

Average similarity: 34.36

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Casuarina glauca	4.25	7.6	6.3	22.11	22.11
Galenia pubescens	2.75	4.06	7.05	11.81	33.92
Ehrharta erecta	2.75	3.12	0.9	9.09	43.01
Austrostipa verticillata	1.5	2.08	0.9	6.06	49.07
Cynodon dactylon	1.5	2.08	0.9	6.06	55.13
Microlaena stipoides var. stipoides	1.75	1.65	0.91	4.81	59.94
Sida rhombifolia	1.5	1.65	0.91	4.81	64.75
Stellaria media	1.75	1.65	0.91	4.81	69.56
Spartothamnella juncea	1.25	1.43	0.77	4.16	73.72
Lycium ferocissimum	1.5	1.2	0.88	3.5	77.22
Hypochaeris radicata	1.5	1.1	0.82	3.2	80.42

Bidens subalternans	1.25	1.09	0.84	3.16	83.57
Cheilanthes sieberi subsp. sieberi	1	0.78	0.41	2.26	85.83
Aristida vagans	1	0.72	0.41	2.09	87.92
Einadia hastata	1	0.65	0.41	1.9	89.82
Dichondra repens	1	0.59	0.41	1.72	91.54
Glycine tabacina	1	0.52	0.41	1.5	93.04
Senecio madagascariensis	1	0.52	0.41	1.5	94.54
Calotis lappulacea	0.75	0.36	0.41	1.04	95.59
Opuntia stricta var. stricta	0.75	0.36	0.41	1.04	96.63
Chloris ventricosa	0.5	0.29	0.41	0.86	97.49
Einadia spp.	0.75	0.29	0.41	0.86	98.35
Notelaea microcarpa var. microcarpa	0.75	0.29	0.41	0.86	99.2

2. Eucalyptus crebra-Aristida-Dichondra-Calotis-Cymbopogon Woodland

Average similarity: 44.41

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dichondra repens	2	1.87	2.23	4.21	4.21
Calotis lappulacea	1.85	1.81	2.25	4.07	8.28
Aristida vagans	2	1.76	1.88	3.97	12.25
Desmodium varians	1.77	1.71	1.97	3.85	16.1
Cymbopogon refractus	2	1.62	1.47	3.65	19.75
Microlaena stipoides var. stipoides	1.85	1.56	1.49	3.52	23.26
Cheilanthes sieberi subsp. sieberi	1.92	1.51	1.5	3.41	26.67
Glycine tabacina	1.85	1.51	1.5	3.39	30.06
Oxalis perennans	1.77	1.5	1.51	3.38	33.44
Phyllanthus virgatus	1.62	1.45	1.68	3.27	36.71
Eucalyptus crebra	2.23	1.36	0.81	3.06	39.77
Aristida ramosa	1.69	1.29	1.14	2.9	42.67
Digitaria diffusa	1.69	1.25	1.13	2.81	45.48
Laxmannia gracilis	1.46	1.14	1.28	2.58	48.06
Notelaea microcarpa var. microcarpa	1.69	1.12	1.08	2.52	50.59
Cyperus gracilis	1.46	1.11	1.08	2.49	53.08
Senecio madagascariensis	1.38	1.06	1.34	2.39	55.47
Austrostipa scabra	1.54	1.01	1.04	2.28	57.76
Eragrostis leptostachya	1.54	0.98	0.91	2.21	59.97
Wahlenbergia communis	1.46	0.98	1.05	2.21	62.18
Psydrax odorata	1.38	0.96	1.38	2.17	64.35
Glycine clandestina	1.31	0.88	0.85	1.99	66.34
Chrysocephalum apiculatum	1.54	0.82	0.72	1.84	68.17
Sporobolus creber	1.31	0.76	0.74	1.72	69.89
Eulalia aurea	1.31	0.76	0.86	1.72	71.61
Brunoniella australis	1.23	0.7	0.7	1.57	73.18
Lomandra filiformis	1.15	0.67	0.68	1.52	74.7
Sida subspicata	1.15	0.65	0.71	1.45	76.15
Eragrostis brownii	1.08	0.63	0.67	1.43	77.58

Panicum effusum	1.08	0.6	0.6	1.34	78.92
Sida corrugata	1.08	0.51	0.56	1.16	80.08
Einadia nutans	1	0.5	0.58	1.12	81.19
Sida rhombifolia	0.92	0.46	0.69	1.04	82.24
Veronica plebeia	0.92	0.45	0.57	1.01	83.25
Hypochaeris radicata	1.08	0.43	0.48	0.96	84.21
Bothriochloa macra	1.15	0.42	0.48	0.94	85.15
Zornia dyctiocarpa var. dyctiocarpa	0.92	0.41	0.55	0.93	86.08
Einadia hastata	0.92	0.39	0.48	0.89	86.97
Cassinia arcuata	0.85	0.31	0.56	0.7	87.67
Stackhousia viminea	0.77	0.29	0.44	0.65	88.32
Fimbristylis dichotoma	0.77	0.28	0.38	0.62	88.94
Richardia stellaris	0.85	0.27	0.46	0.61	89.55
Allocasuarina gymnanthera	0.85	0.26	0.45	0.59	90.14
Opuntia stricta var. stricta	0.69	0.25	0.45	0.57	90.71
Glossocardia bidens	0.54	0.22	0.48	0.49	91.2
Evolvulus alsinoides var. decumbens	0.69	0.2	0.36	0.45	91.64
Murdannia graminea	0.62	0.17	0.29	0.38	92.02
Breynia oblongifolia	0.69	0.17	0.36	0.37	92.39
Digitaria brownii	0.69	0.16	0.28	0.36	92.76
Bidens pilosa	0.62	0.15	0.37	0.35	93.1
Leucopogon muticus	0.69	0.15	0.29	0.34	93.45
Paspalidium distans	0.62	0.15	0.29	0.34	93.79
Cheilanthes distans	0.62	0.14	0.29	0.32	94.11
Eucalyptus tereticornis	0.85	0.13	0.2	0.3	94.4
Galenia pubescens	0.54	0.13	0.27	0.28	94.69
Chloris truncata	0.62	0.13	0.26	0.28	94.97
Ajuga australis	0.54	0.12	0.27	0.27	95.25
Maytenus silvestris	0.54	0.12	0.27	0.26	95.51
Commelina cyanea	0.54	0.12	0.28	0.26	95.77
Paronychia brasiliana	0.54	0.11	0.27	0.26	96.03
Lomandra multiflora subsp. multiflora	0.54	0.11	0.27	0.24	96.27
Lepidium africanum	0.46	0.1	0.27	0.23	96.5
Anagallis arvensis	0.46	0.09	0.26	0.21	96.71
Vittadinia cuneata var. cuneata	0.46	0.09	0.27	0.2	96.91
Chrysocephalum semipapposum	0.46	0.08	0.2	0.19	97.1
Dianella spp.	0.31	0.08	0.28	0.18	97.27
Digitaria divaricatissima	0.46	0.07	0.2	0.16	97.44
Myoporum montanum	0.31	0.07	0.29	0.16	97.6
Spartothamnella juncea	0.38	0.06	0.18	0.13	97.73
Vittadinia spp.	0.38	0.05	0.19	0.12	97.85
Hypericum gramineum	0.38	0.05	0.18	0.12	97.97
Allocasuarina luehmannii	0.46	0.05	0.19	0.12	98.09
Dodonaea viscosa	0.38	0.05	0.18	0.12	98.21
Angophora floribunda	0.46	0.05	0.18	0.12	98.32

Maireana microphylla	0.31	0.05	0.2	0.11	98.43
Wahlenbergia gracilis	0.31	0.05	0.2	0.1	98.54
Pratia purpurascens	0.38	0.05	0.19	0.1	98.64
Cyperus brevifolius	0.23	0.04	0.2	0.1	98.74
Conyza bonariensis	0.31	0.04	0.2	0.1	98.84
Solanum nigrum	0.23	0.04	0.2	0.1	98.94
Sonchus oleraceus	0.31	0.04	0.2	0.09	99.02

3. Eucalyptus crebra-Lomandra-Cheilanthes-Notelaea-(Eucalyptus blakelyi) Woodland

Average similarity: 39.61

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Lomandra filiformis	2.5	3.93	4.32	9.93	9.93
Cheilanthes sieberi subsp. sieberi	2	3.61	20.23	9.12	19.04
Einadia hastata	2	3.61	20.23	9.12	28.16
Eucalyptus crebra	2.5	3.55	1.92	8.97	37.13
Notelaea microcarpa var. microcarpa	2.25	3.01	2.05	7.6	44.72
Opuntia stricta var. stricta	1.75	2.71	2.69	6.84	51.57
Lomandra multiflora subsp. multiflora	1.75	2.7	2.78	6.82	58.39
Aristida vagans	2.25	2.05	0.87	5.17	63.56
Chrysocephalum apiculatum	1.5	1.88	0.91	4.74	68.3
Senecio madagascariensis	1.25	1.26	0.81	3.18	71.47
Eragrostis brownii	1.25	1.18	0.8	2.97	74.44
Breynia oblongifolia	1	0.94	0.91	2.37	76.81
Eucalyptus blakelyi	1.75	0.89	0.41	2.25	79.06
Amyema miquelii	1	0.87	0.91	2.2	81.27
Maytenus silvestris	0.75	0.87	0.91	2.2	83.47
Allocasuarina luehmannii	1.5	0.85	0.41	2.14	85.61
Cheilanthes distans	1	0.64	0.41	1.62	87.23
Cymbopogon refractus	1	0.64	0.41	1.62	88.85
Cynodon dactylon	1.25	0.61	0.41	1.53	90.38
Juncus spp.	1	0.61	0.41	1.53	91.91
Digitaria spp.	1	0.57	0.41	1.45	93.36
Persoonia linearis	0.5	0.31	0.41	0.79	94.15
Brachychiton populneus subsp. populneus	0.5	0.3	0.41	0.75	94.91
Psydrax odorata	1	0.3	0.41	0.75	95.66
Sporobolus creber	0.75	0.3	0.41	0.75	96.41
Gahnia aspera	0.75	0.29	0.41	0.73	97.13
Galenia pubescens	0.75	0.29	0.41	0.73	97.86
Calotis lappulacea	0.5	0.28	0.41	0.71	98.57
Commelina cyanea	0.75	0.28	0.41	0.71	99.29

4. Eucalyptus crebra-Cheilanthes-Cymbopogon-Leucopogon Woodland

Average similarity: 49.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%

Cheilanthes sieberi subsp. sieberi	2	4.89	9.63	9.89	9.89
Cymbopogon refractus	2.14	4.89	9.63	9.89	19.78
Eucalyptus crebra	2.43	4.46	3.14	9.02	28.81
Leucopogon muticus	2.29	4.08	1.41	8.24	37.05
Chrysocephalum apiculatum	1.71	3.44	1.52	6.95	43.99
Lomandra filiformis	1.86	3.44	1.52	6.95	50.94
Sida subspicata	1.71	3.39	1.52	6.85	57.79
Notelaea microcarpa var. microcarpa	1.86	3.17	2.54	6.4	64.19
Psydrax odorata	1.43	2.4	1.36	4.86	69.05
Laxmannia gracilis	1.43	2.3	0.92	4.65	73.69
Cheilanthes distans	1.43	2.26	0.92	4.56	78.25
Allocasuarina gymnanthera	1.57	1.63	0.6	3.3	81.55
Aristida spp.	1.43	1.56	0.6	3.15	84.7
Callitris endlicheri	1.14	0.91	0.52	1.84	86.54
Styphelia triflora	0.86	0.76	0.59	1.55	88.09
Stackhousia viminea	0.86	0.72	0.4	1.45	89.54
Opuntia stricta var. stricta	0.71	0.69	0.62	1.39	90.93
Lissanthe strigosa	0.86	0.65	0.4	1.31	92.23
Melichrus urceolatus	0.86	0.65	0.4	1.31	93.54
Austrostipa spp.	1	0.64	0.4	1.3	94.85
Allocasuarina verticillata	0.57	0.38	0.4	0.76	95.61
Alphitonia excelsa	0.43	0.37	0.4	0.75	96.36
Aristida ramosa	0.86	0.37	0.22	0.75	97.11
Cynodon dactylon	0.57	0.25	0.22	0.5	97.61
Panicum spp.	0.57	0.22	0.22	0.45	98.06
Austrostipa scabra	0.57	0.21	0.22	0.43	98.49
Phyllanthus virgatus	0.57	0.2	0.22	0.41	98.9
Xanthorrhoea johnsonii	0.57	0.2	0.22	0.4	99.3

5. Eucalyptus moluccana-Notelaea-Aristida-(Eucalyptus crebra) Woodland

Average similarity: 43.22

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Notelaea microcarpa var. microcarpa	4	4.02	#######	9.3	9.3
Eucalyptus moluccana	3	3.02	#######	6.98	16.28
Aristida ramosa	2	2.01	#######	4.65	20.93
Bidens pilosa	2	2.01	#######	4.65	25.58
Brunoniella australis	2.5	2.01	#######	4.65	30.23
Callitris endlicheri	2.5	2.01	#######	4.65	34.88
Cheilanthes distans	2.5	2.01	#######	4.65	39.53
Cheilanthes sieberi subsp. sieberi	2	2.01	#######	4.65	44.19
Desmodium varians	2	2.01	#######	4.65	48.84
Dichondra repens	2	2.01	#######	4.65	53.49
Eucalyptus crebra	2	2.01	#######	4.65	58.14
Hibiscus sturtii var. sturtii	2.5	2.01	#######	4.65	62.79
Maytenus silvestris	2	2.01	#######	4.65	67.44

Phyllanthus virgatus	2	2.01	#######	4.65	72.09
Psydrax odorata	2	2.01	#######	4.65	76.74
Sida subspicata	2.5	2.01	#######	4.65	81.4
Spartothamnella juncea	2.5	2.01	#######	4.65	86.05
Commelina cyanea	1.5	1.01	#######	2.33	88.37
Cyperus gracilis	1.5	1.01	#######	2.33	90.7
Einadia hastata	1.5	1.01	#######	2.33	93.02
Glossocardia bidens	1.5	1.01	#######	2.33	95.35
Opuntia stricta var. stricta	1.5	1.01	#######	2.33	97.67
Vittadinia cuneata var. cuneata	1	1.01	#######	2.33	100

6. Corymbia maculata-Notealea-Laxmannia Forest

Average similarity: 20.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Corymbia maculata	2.5	3.61	0.88	17.84	17.84
Laxmannia gracilis	1.5	3.28	3.62	16.21	34.05
Notelaea microcarpa var. microcarpa	1.75	3.27	3.79	16.16	50.2
Cynodon dactylon	1.25	2.35	0.87	11.59	61.79
Einadia nutans	1.25	1.83	0.9	9.06	70.85
Einadia hastata	1.5	1.79	0.87	8.83	79.68
Aristida ramosa	1	1.36	0.41	6.72	86.4
Commelina cyanea	1	0.7	0.41	3.47	89.87
Bursaria spinosa	1	0.68	0.41	3.36	93.23
Senecio madagascariensis	0.75	0.68	0.41	3.36	96.59
Opuntia stricta var. stricta	0.75	0.35	0.41	1.73	98.32
Psydrax odorata	1	0.34	0.41	1.68	100

7. Eucalyptus dawsonii-Sporobolus-Eragrostis Grassy Woodland

Average similarity: 40.99

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Eucalyptus dawsonii	4	5.6	4.55	13.65	13.65
Cyperus gracilis	2	2.8	4.55	6.83	20.48
Eragrostis leptostachya	2	2.8	4.55	6.83	27.31
Sporobolus creber	2	2.8	4.55	6.83	34.13
Brunoniella australis	1.5	1.63	0.9	3.99	38.12
Alternanthera denticulata	1.5	1.57	4.42	3.84	41.96
Commelina cyanea	1.5	1.45	0.87	3.54	45.5
Sida corrugata	1.5	1.45	0.87	3.54	49.04
Einadia hastata	1.5	1.28	0.89	3.13	52.17
Einadia nutans	1.5	1.28	0.89	3.13	55.3
Austrostipa scabra	1.5	1.23	0.9	2.99	58.29
Chloris truncata	1.5	1.23	0.9	2.99	61.29
Chrysocephalum apiculatum	1.5	1.23	0.9	2.99	64.28
Fimbristylis dichotoma	1.5	1.23	0.9	2.99	67.28
Wahlenbergia communis	1.5	1.23	0.9	2.99	70.27

Galenia pubescens	1.5	1.08	0.83	2.62	72.9
Glycine tabacina	1.25	1.08	0.83	2.62	75.52
Glycine clandestina	1.25	0.94	0.84	2.28	77.8
Dichondra repens	1	0.61	0.9	1.5	79.3
Senecio madagascariensis	1	0.61	0.9	1.5	80.8
Cynodon dactylon	1	0.52	0.41	1.26	82.06
Eremophila debilis	1	0.52	0.41	1.26	83.32
Rytidosperma spp.	1	0.52	0.41	1.26	84.58
Aristida vagans	1	0.42	0.41	1.02	85.6
Lomandra multiflora subsp. multiflora	1	0.42	0.41	1.02	86.62
Panicum effusum	1	0.42	0.41	1.02	87.65
Aristida ramosa	1	0.4	0.41	0.97	88.61
Bothriochloa macra	1	0.4	0.41	0.97	89.58
Chamaesyce drummondii	1	0.4	0.41	0.97	90.55
Digitaria diffusa	1	0.35	0.41	0.85	91.4
Maireana microphylla	1	0.35	0.41	0.85	92.25
Maireana spp.	1	0.35	0.41	0.85	93.09
Plantago lanceolata	1	0.35	0.41	0.85	93.94
Polygonum aviculare	1	0.35	0.41	0.85	94.79
Richardia stellaris	1	0.35	0.41	0.85	95.63
Sida rhombifolia	1	0.35	0.41	0.85	96.48
Laxmannia gracilis	0.75	0.26	0.41	0.63	97.11
Myoporum montanum	0.75	0.24	0.41	0.59	97.7
Phyllanthus virgatus	0.75	0.2	0.41	0.48	98.18
Solenogyne bellioides	0.75	0.2	0.41	0.48	98.67
Stackhousia viminea	0.75	0.2	0.41	0.48	99.15

8. Allocasuarina luehmannii-Aristida Low Forest

Average similarity: 38.01

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Allocasuarina luehmannii	3.1	5.78	1.72	15.22	15.22
Aristida ramosa	2.2	3.89	1.82	10.24	25.46
Cheilanthes sieberi subsp. sieberi	1.9	3.51	1.84	9.22	34.68
Lomandra filiformis	1.6	3.07	1.23	8.08	42.76
Chrysocephalum apiculatum	1.8	2.69	1.62	7.07	49.83
Aristida vagans	1.4	1.82	0.84	4.79	54.62
Digitaria diffusa	1.5	1.73	0.87	4.55	59.17
Cymbopogon refractus	1.4	1.72	1.11	4.53	63.69
Eragrostis brownii	1.2	1.46	0.69	3.84	67.53
Lomandra multiflora subsp. multiflora	0.9	1.1	0.89	2.9	70.43
Oxalis perennans	1	0.95	0.61	2.51	72.94
Zornia dyctiocarpa var. dyctiocarpa	0.8	0.81	0.66	2.12	75.06
Opuntia stricta var. stricta	0.7	0.79	0.68	2.08	77.15
Cassinia arcuata	1.1	0.69	0.48	1.81	78.95
Bothriochloa macra	0.8	0.63	0.51	1.65	80.61

Panicum effusum	0.8	0.56	0.49	1.47	82.08
Phyllanthus virgatus	0.7	0.52	0.51	1.38	83.46
Hypochaeris radicata	0.8	0.47	0.39	1.23	84.69
Glycine tabacina	0.6	0.46	0.52	1.21	85.9
Eragrostis leptostachya	0.6	0.39	0.26	1.04	86.93
Opuntia aurantiaca	0.4	0.38	0.38	1	87.94
Sporobolus creber	0.7	0.36	0.37	0.96	88.9
Eucalyptus crebra	0.8	0.35	0.26	0.93	89.82
Amyema miquelii	0.5	0.32	0.39	0.83	90.66
Commelina cyanea	0.4	0.31	0.38	0.8	91.46
Murdannia graminea	0.4	0.28	0.38	0.74	92.2
Brunoniella australis	0.5	0.2	0.23	0.53	92.73
Arthropodium spp.	0.3	0.18	0.26	0.48	93.21
Conyza bonariensis	0.5	0.17	0.24	0.44	93.64
Laxmannia gracilis	0.5	0.16	0.25	0.42	94.07
Notelaea microcarpa var. microcarpa	0.3	0.16	0.26	0.42	94.49
Eucalyptus blakelyi	0.6	0.16	0.15	0.42	94.92
Einadia hastata	0.4	0.15	0.26	0.4	95.31
Calotis lappulacea	0.5	0.15	0.25	0.39	95.7
Glycine clandestina	0.4	0.14	0.26	0.37	96.07
Senecio madagascariensis	0.4	0.14	0.26	0.37	96.43
Evolvulus alsinoides var. decumbens	0.4	0.12	0.26	0.33	96.76
Sida cunninghamii	0.4	0.12	0.26	0.32	97.08
Phyllanthus hirtellus	0.4	0.11	0.15	0.3	97.38
Eulalia aurea	0.5	0.08	0.15	0.22	97.6
Digitaria spp.	0.4	0.08	0.15	0.2	97.8
Eragrostis elongata	0.4	0.07	0.15	0.19	97.99
Setaria parviflora	0.4	0.07	0.15	0.19	98.18
Chamaesyce drummondii	0.2	0.06	0.15	0.15	98.33
Euchiton sphaericus	0.2	0.05	0.15	0.14	98.47
Rytidosperma spp.	0.3	0.05	0.15	0.14	98.62
Allocasuarina gymnanthera	0.3	0.05	0.15	0.13	98.75
Fimbristylis dichotoma	0.3	0.05	0.15	0.12	98.87
Cassinia aculeata	0.2	0.05	0.15	0.12	98.99
Einadia nutans	0.3	0.05	0.15	0.12	99.11

9. Acacia binervia Shrubland

Average similarity: 41.44

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Acacia binervia	3.5	5.41	#######	13.04	13.04
Amyema spp.	2.5	3.6	#######	8.7	21.74
Cheilanthes distans	2	3.6	#######	8.7	30.43
Cheilanthes sieberi subsp. sieberi	2	3.6	#######	8.7	39.13
Cyperus spp.	2	3.6	#######	8.7	47.83
Einadia hastata	2	3.6	#######	8.7	56.52

Eragrostis leptostachya	2	3.6	#######	8.7	65.22
Oxalis perennans	2	3.6	#######	8.7	73.91
Phyllanthus virgatus	2	3.6	#######	8.7	82.61
Evolvulus alsinoides var. decumbens	1.5	1.8	#######	4.35	86.96
Leucopogon muticus	1.5	1.8	#######	4.35	91.3
Notelaea microcarpa var. microcarpa	1	1.8	#######	4.35	95.65
Opuntia stricta var. stricta	1.5	1.8	#######	4.35	100

10. Notelaea-Aristida-Cymbopogon-(Eucalyptus-Corymbia) Shrubland

Average similarity: 41.77

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Notelaea microcarpa var. microcarpa	2.75	3.9	4.42	9.35	9.35
Cheilanthes sieberi subsp. sieberi	2	3.08	11.17	7.37	16.72
Aristida vagans	2.13	2.57	1.57	6.16	22.88
Cymbopogon refractus	1.88	2.32	1.67	5.56	28.44
Hypochaeris radicata	1.5	1.86	2.86	4.46	32.9
Maytenus silvestris	1.38	1.7	3.58	4.07	36.97
Phyllanthus virgatus	1.25	1.37	1.41	3.29	40.25
Digitaria diffusa	1.38	1.32	0.97	3.16	43.41
Glycine tabacina	1.38	1.3	0.99	3.12	46.53
Breynia oblongifolia	1.38	1.28	1.5	3.07	49.61
Chrysocephalum apiculatum	1.25	1.22	0.92	2.93	52.54
Carex appressa	1.5	1.22	0.88	2.92	55.46
Cyperus gracilis	1.25	1.11	0.93	2.65	58.11
Dichondra repens	1.38	1.08	0.73	2.58	60.69
Leucopogon muticus	1.25	0.94	0.67	2.25	62.95
Lomandra filiformis	1.13	0.94	0.68	2.25	65.19
Psydrax odorata	1	0.91	1.01	2.19	67.38
Opuntia stricta var. stricta	1	0.85	0.98	2.04	69.42
Aristida ramosa	1.38	0.84	0.5	2.01	71.43
Microlaena stipoides var. stipoides	1.25	0.84	0.68	2.01	73.44
Eucalyptus blakelyi	1.63	0.83	0.43	1.98	75.42
Oxalis perennans	1	0.71	0.67	1.71	77.13
Corymbia maculata	1.5	0.64	0.34	1.53	78.66
Eucalyptus crebra	1	0.61	0.7	1.45	80.11
Desmodium varians	0.75	0.58	0.73	1.39	81.5
Einadia hastata	0.88	0.57	0.7	1.37	82.87
Hydrocotyle laxiflora	0.75	0.51	0.73	1.23	84.1
Commelina cyanea	0.88	0.49	0.47	1.16	85.26
Eragrostis leptostachya	0.88	0.48	0.47	1.16	86.42
Sida rhombifolia	1	0.45	0.48	1.09	87.5
Lomandra multiflora subsp. multiflora	0.75	0.38	0.49	0.92	88.42
Brachychiton populneus subsp. populneus	0.75	0.38	0.47	0.92	89.34
Dichondra sp. A	0.75	0.38	0.48	0.9	90.25
Cassinia arcuata	0.75	0.37	0.49	0.87	91.12

Gahnia aspera	0.63	0.36	0.51	0.85	91.97
Bidens pilosa	0.75	0.35	0.49	0.84	92.81
Laxmannia gracilis	0.63	0.22	0.32	0.53	93.34
Calotis lappulacea	0.63	0.21	0.32	0.51	93.85
Pratia purpurascens	0.63	0.2	0.32	0.47	94.33
Verbena bonariensis	0.63	0.2	0.32	0.47	94.8
Anagallis arvensis	0.5	0.18	0.34	0.42	95.22
Gomphocarpus fruticosus	0.38	0.18	0.34	0.42	95.64
Persoonia linearis	0.38	0.16	0.34	0.38	96.03
Senecio madagascariensis	0.5	0.16	0.34	0.37	96.4
Rumex brownii	0.5	0.15	0.34	0.36	96.76
Conyza bonariensis	0.38	0.15	0.34	0.36	97.12
Lomandra longifolia	0.5	0.15	0.34	0.36	97.47
Echinopogon caespitosus	0.63	0.11	0.19	0.26	97.73
Acetosella vulgaris	0.5	0.1	0.19	0.23	97.96
Euchiton spp.	0.38	0.06	0.19	0.15	98.1
Allocasuarina gymnanthera	0.38	0.06	0.19	0.14	98.24
Angophora floribunda	0.25	0.06	0.19	0.14	98.38
Veronica plebeia	0.25	0.06	0.19	0.14	98.52
Eucalyptus tereticornis	0.63	0.05	0.19	0.13	98.65
Sida cunninghamii	0.25	0.05	0.19	0.13	98.77
Dianella spp.	0.25	0.05	0.19	0.13	98.9
Wahlenbergia gracilis	0.25	0.05	0.19	0.13	99.03

11. Aristida-Cymbopogon-Cheilanthes-Calotis Grassland

Average similarity: 39.06

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Aristida vagans	3	4.69	#######	12	12
Calotis lappulacea	2.5	3.13	#######	8	20
Chamaesyce drummondii	2	3.13	#######	8	28
Cheilanthes sieberi subsp. sieberi	2.5	3.13	#######	8	36
Cymbopogon refractus	2.5	3.13	#######	8	44
Digitaria diffusa	2	3.13	#######	8	52
Einadia nutans	2	3.13	#######	8	60
Eucalyptus punctata	2	3.13	#######	8	68
Fimbristylis dichotoma	2	3.13	#######	8	76
Glycine tabacina	2.5	3.13	#######	8	84
Galenia pubescens	1	1.56	#######	4	88
Haloragis heterophylla	1.5	1.56	#######	4	92
Phyllanthus virgatus	2	1.56	#######	4	96
Sida subspicata	1.5	1.56	#######	4	100

12. Hypochaeris-Sporobolus-Cheilanthes-Aristida Grassland

Average similarity: 37.48

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**

Hypochaeris radicata	2.45	4.54	2.36	12.11	12.11
Sporobolus creber	1.85	3.25	1.52	8.67	20.77
Cheilanthes sieberi subsp. sieberi	1.95	3.14	1.51	8.37	29.14
Senecio madagascariensis	1.65	3.03	1.89	8.09	37.23
Chrysocephalum apiculatum	1.4	2.03	0.9	5.41	42.64
Aristida vagans	1.6	1.87	0.81	5	47.64
Bothriochloa macra	1.6	1.83	0.91	4.88	52.52
Aristida ramosa	1.7	1.79	0.74	4.78	57.3
Romulea rosea var. australis	1.4	1.78	0.81	4.75	62.05
Cymbopogon refractus	1.45	1.68	0.81	4.48	66.52
Galenia pubescens	1.1	1.29	0.61	3.44	69.97
Panicum effusum	1.05	1.07	0.68	2.86	72.83
Cynodon dactylon	1.15	1.04	0.47	2.77	75.6
Sida rhombifolia	1	0.99	0.59	2.64	78.24
Anagallis arvensis	0.9	0.76	0.48	2.04	80.28
Eragrostis leptostachya	0.95	0.75	0.47	1.99	82.27
Arctotheca calendula	0.85	0.71	0.41	1.89	84.16
Opuntia stricta var. stricta	0.65	0.59	0.52	1.59	85.75
Eragrostis brownii	0.75	0.5	0.39	1.34	87.09
Eulalia aurea	0.7	0.38	0.35	1.01	88.09
Verbena rigida var. rigida	0.65	0.37	0.33	0.98	89.07
Oxalis perennans	0.65	0.3	0.34	0.81	89.88
Cyperus aggregatus	0.6	0.28	0.29	0.76	90.63
Soliva sessilis	0.5	0.25	0.23	0.68	91.31
Medicago polymorpha	0.55	0.25	0.23	0.67	91.98
Conyza spp.	0.4	0.21	0.28	0.55	92.53
Conyza bonariensis	0.45	0.2	0.26	0.52	93.05
Erodium cicutarium	0.55	0.2	0.18	0.52	93.57
Austrostipa spp.	0.45	0.14	0.18	0.39	93.96
Fimbristylis dichotoma	0.5	0.14	0.22	0.38	94.34
Parentucellia latifolia	0.4	0.14	0.18	0.37	94.72
Echium plantagineum	0.4	0.14	0.18	0.37	95.09
Lomandra filiformis	0.4	0.13	0.18	0.35	95.44
Austrostipa scabra	0.45	0.13	0.18	0.34	95.78
Phyllanthus virgatus	0.4	0.12	0.22	0.31	96.09
Sida subspicata	0.4	0.12	0.18	0.31	96.4
Arthropodium spp.	0.35	0.09	0.17	0.23	96.63
Oenothera stricta subsp. stricta	0.35	0.08	0.17	0.2	96.83
Trifolium repens	0.3	0.07	0.12	0.19	97.02
Briza minor	0.3	0.07	0.13	0.18	97.2
Eucalyptus crebra	0.2	0.07	0.18	0.18	97.37
Cotula spp.	0.3	0.07	0.13	0.17	97.55
Glycine tabacina	0.2	0.06	0.18	0.17	97.72
Microlaena stipoides var. stipoides	0.3	0.06	0.12	0.17	97.88
Paronychia brasiliana	0.25	0.06	0.18	0.16	98.04

Hyparrhenia hirta	0.3	0.06	0.13	0.16	98.2
Eragrostis spp.	0.25	0.05	0.12	0.13	98.33
Juncus spp.	0.2	0.04	0.13	0.1	98.43
Notelaea microcarpa var. microcarpa	0.15	0.04	0.13	0.1	98.53
Lomandra multiflora subsp. multiflora	0.25	0.04	0.12	0.1	98.62
Setaria parviflora	0.2	0.04	0.13	0.09	98.72
Verbena bonariensis	0.2	0.03	0.13	0.09	98.81
Zornia dyctiocarpa var. dyctiocarpa	0.25	0.03	0.12	0.08	98.89
Facelis retusa	0.25	0.03	0.07	0.07	98.96
Chondrilla juncea	0.2	0.03	0.07	0.07	99.03

13. Hypochaeris-Cheilanthes-Eragrostis-Bothriochloa Grassland

Average similarity: 38.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hypochaeris radicata	2.27	4.07	5.33	10.46	10.46
Cheilanthes sieberi subsp. sieberi	2	3.95	8.39	10.16	20.62
Eragrostis leptostachya	2	3.24	1.99	8.33	28.95
Bothriochloa macra	1.82	2.58	1.33	6.62	35.58
Phyllanthus virgatus	1.64	2.47	1.35	6.35	41.93
Aristida vagans	2	2.39	0.94	6.14	48.07
Conyza bonariensis	1.55	2.31	1.25	5.94	54.01
Fimbristylis dichotoma	1.45	1.96	1	5.04	59.05
Cynodon dactylon	1.73	1.93	0.89	4.95	64
Sporobolus creber	1.55	1.48	0.76	3.81	67.81
Aristida ramosa	1.18	1.13	0.61	2.9	70.71
Digitaria diffusa	1.18	1.07	0.6	2.75	73.45
Chrysocephalum apiculatum	1.18	1.03	0.6	2.66	76.11
Galenia pubescens	1	0.89	0.57	2.29	78.4
Setaria parviflora	0.91	0.75	0.46	1.94	80.34
Glycine tabacina	0.91	0.68	0.46	1.75	82.09
Lactuca saligna	0.82	0.62	0.44	1.59	83.69
Chamaesyce drummondii	0.91	0.61	0.47	1.58	85.26
Digitaria spp.	0.73	0.45	0.35	1.15	86.42
Paspalum dilatatum	0.73	0.43	0.34	1.1	87.52
Enteropogon acicularis	0.82	0.39	0.35	0.99	88.51
Solenogyne bellioides	0.73	0.38	0.35	0.98	89.49
Opuntia stricta var. stricta	0.55	0.37	0.46	0.94	90.43
Glycine clandestina	0.64	0.32	0.33	0.81	91.24
Convolvulus erubescens	0.64	0.28	0.32	0.72	91.96
Panicum effusum	0.64	0.24	0.24	0.63	92.59
Chondrilla juncea	0.55	0.23	0.24	0.59	93.18
Oxalis perennans	0.55	0.22	0.24	0.57	93.75
Haloragis heterophylla	0.55	0.21	0.24	0.55	94.3
Digitaria divaricatissima	0.55	0.21	0.24	0.55	94.85
Wahlenbergia communis	0.55	0.19	0.24	0.48	95.33

Cyperus gracilis	0.55	0.18	0.24	0.47	95.79
Rumex brownii	0.45	0.14	0.23	0.37	96.16
Sida cunninghamii	0.55	0.14	0.23	0.36	96.52
Richardia stellaris	0.45	0.13	0.23	0.33	96.86
Desmodium varians	0.45	0.13	0.22	0.33	97.19
Cyperus spp.	0.36	0.09	0.13	0.23	97.42
Oxalis pes-caprae	0.36	0.09	0.13	0.23	97.65
Juncus spp.	0.36	0.08	0.13	0.19	97.84
Chloris truncata	0.36	0.07	0.13	0.17	98.01
Sida rhombifolia	0.36	0.07	0.13	0.17	98.19
Vittadinia muelleri	0.36	0.07	0.13	0.17	98.36
Plantago lanceolata	0.36	0.06	0.13	0.17	98.52
Romulea rosea var. australis	0.36	0.06	0.13	0.16	98.68
Austrostipa scabra	0.36	0.06	0.13	0.16	98.83
Gomphrena celosioides	0.36	0.06	0.13	0.14	98.98
Plantago debilis	0.36	0.06	0.13	0.14	99.12

14. Bothriochloa-Hypochaeris-Cheilanthes-Aristida Grassland

Average similarity: 45.27

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Bothriochloa spp.	2.71	5.92	4.68	13.07	13.07
Cheilanthes sieberi subsp. sieberi	2	4.78	16.31	10.56	23.62
Hypochaeris radicata	2	4.78	16.31	10.56	34.18
Aristida vagans	2.14	3.46	0.93	7.65	41.82
Lomandra filiformis	1.86	3.39	1.53	7.48	49.3
Cynodon dactylon	1.86	2.67	0.89	5.9	55.21
Laxmannia gracilis	1.43	2.29	0.93	5.05	60.26
Verbena rigida var. rigida	1.43	2.25	0.93	4.98	65.23
Phyllanthus virgatus	1.29	1.8	0.86	3.98	69.21
Linum trigynum	1.29	1.77	0.86	3.9	73.11
Aristida ramosa	1.57	1.7	0.6	3.76	76.87
Cymbopogon refractus	1.29	1.35	0.62	2.98	79.85
Eragrostis brownii	1.14	1.31	0.62	2.89	82.75
Senecio madagascariensis	0.86	0.79	0.59	1.76	84.5
Romulea rosea var. australis	0.86	0.72	0.4	1.58	86.08
Chrysocephalum apiculatum	0.86	0.67	0.4	1.48	87.57
Austrostipa spp.	0.86	0.66	0.4	1.46	89.03
Stackhousia viminea	0.86	0.66	0.4	1.46	90.49
Conyza spp.	0.57	0.66	0.62	1.45	91.94
Sida subspicata	0.86	0.65	0.4	1.43	93.36
Anagallis arvensis	0.71	0.44	0.38	0.96	94.33
Zornia dyctiocarpa var. dyctiocarpa	0.71	0.43	0.37	0.94	95.27
Bromus spp.	0.57	0.24	0.22	0.53	95.8
Allocasuarina luehmannii	0.71	0.23	0.22	0.51	96.31
Chloris ventricosa	0.57	0.23	0.22	0.51	96.83

Hyparrhenia hirta	0.71	0.23	0.22	0.51	97.34
Oenothera stricta subsp. stricta	0.57	0.22	0.22	0.48	97.82
Petrorhagia nanteuilii	0.57	0.22	0.22	0.48	98.31
Opuntia stricta var. stricta	0.57	0.2	0.22	0.45	98.76
Chondrilla juncea	0.43	0.12	0.22	0.26	99.02

Appendix 5 – Resume: Dr Stephen Bell

CONTACT DETAILS

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https://www.researchgate.net/profile/Stephen_Bell10

PRÉCIS

Stephen has been involved in native vegetation survey, classification and mapping in the Greater Sydney and Hunter Regions since 1990. During this time, he has undertaken comprehensive surveys for the National Parks and Wildlife Service in over 30 conservation reserves, and has been contracted to the NSW Office of Environment & Heritage as Senior Botanist and Team Leader for several large scale regional projects within the Sydney Basin bioregion. Under contract to local Councils, Stephen has co-ordinated and completed LGA-wide vegetation classification and mapping projects for Wyong, Gosford, Cessnock, Pittwater and Lake Macquarie LGAs, and has assisted in similar mapping projects for Blue Mountains LGA. Stephen has also completed several studies on Threatened Ecological Communities and threatened plant species, and published the results of some of these in the scientific literature.

On behalf of the Ecological Society of Australia, Stephen was the ecological expert on the Hunter Regional Vegetation Committee (2003), and from 2017 represents that organization on the NSW Threatened Species Scientific Committee (administering the *Biodiversity Conservation Act 2016*). Stephen was also a past member of the Hunter Threatened Flora Recovery Team, a founding member of the Hunter Rare Plants Committee (a sub-committee of the Hunter Region Botanic Gardens), and since 2014 has been a member of the Office of Environment & Heritage Species Technical Group which oversees management and expenditure of threatened species throughout NSW via its *Saving our Species* initiative. He is also often called upon by Government for advice regarding the significance of vegetation communities and plant species within the northern Sydney Basin bioregion, and has sat on numerous expert panels in this regard. Stephen has been called upon as an Expert Witness for several cases heard in the NSW Land and Environment Court, where his knowledge on the vegetation of the Sydney Basin bioregion has been used to argue contentious land-use decisions.

Stephen has published several scientific papers on various aspects of the vegetation of the Sydney Basin, including classifications of vegetation within conservation reserves, threatened and rare plant species, and the description of new plant taxa. Stephen has completed over 4500 standard full floristic sampling plots within the Sydney Basin, which are stored and used in vegetation classification analyses. Other skills include extensive multivariate data analysis experience, and GIS mapping. Stephen's PhD thesis, completed on a part-time basis through the University of Newcastle, presented improvements in the recognition, identification and classification of restricted and significant vegetation communities, such as Threatened Ecological Communities (TECs).

In October 1996, Stephen established *Eastcoast Flora Survey*, a specialist botanical consultancy providing high quality services to government and the private sector. Since June 2014, Stephen has been a Conjoint Fellow in the School of Environmental & Life Sciences at the University of Newcastle (NSW), seeking to raise the output of ecological research on plants and vegetation within the Hunter region.

ACADEMIC QUALIFICATIONS

Doctor of Philosophy (PhD), 2013	*Defining and mapping rare vegetation communities: Improving techniques to assist land-use planning and conservation* (University of Newcastle)
Bachelor of Science (Honours), 1991	*Effects of the weed Scotch Broom on bird communities in open forests on Barrington Tops* (University of Newcastle)
Bachelor of Science, 1989	*Majors in Geography and Biology* (University of Newcastle)

EMPLOYMENT HISTORY

University of Newcastle	Conjoint Fellow (Plant Sciences Group)	June 2014 - Present
Eastcoast Flora Survey	Consultant Botanist (Principal)	Oct. 1996 - Present
Ecotone Ecological Consultants Pty Ltd	Manager - Flora Studies	Jan. 1996 - Oct. 1996
Private Ecological Consultant	Sole trader	Jan. 1991 - Dec. 1995
NSW National Parks and Wildlife Service	Project Officer	Sept. 1993 - Jan. 1994
University of Newcastle, Geography Dept.	Field Tutor (Scientific)	July 1993 - Aug. 1993
NSW National Parks and Wildlife Service	Project Officer	Jan. 1993 - June 1993
University of NSW, School of Biol. Sciences	Research Assistant (Bird ecology)	Sept. 1992 - Jan. 1993
NSW National Parks and Wildlife Service	Technical Officer (Scientific)	Jan. 1992 - June 1992
RZ Mines (Newcastle)	Environmental Research Officer	Oct. 1990 - Dec. 1991
Wayne Perry & Associates P/L	Environmental Officer (Casual)	June 1990 - Oct. 1990

RESEARCH INTERESTS

- Vegetation classification and mapping, at local and regional scales
- Definition and mapping of rare and threatened vegetation communities
- Restoration of threatened grassy woodlands from derived grasslands
- Improving data sampling methods for monitoring and classification
- Re-constructing vegetation distribution using information from historical botanical explorers
- Population ecology and habitat of rare and threatened plants
- Taxonomy and significance of Hunter Region plants

MINISTERIAL APPOINTMENTS

- Committee Member, NSW Threatened Species Scientific Committee (July 2017-present)
- Committee Member, NSW Species Technical Group, Flora (*Save Our Species Program*) (2014-present)
- *Ecological Society of Australia* representative on the Hunter Regional Vegetation Committee (2001-2003)

CONFERENCE & WORKSHOP PRESENTATIONS

- Best Practice Mine Rehabilitation Conference, September 2014, Singleton, NSW; The Tom Farrell Institute for the Environment, University of Newcastle: "*Effective Biodiversity Offsets: Improving planning, valuation and monitoring practice*" (with Martin Fallding).
- Plant Identification for Flora of the Hunter Valley, 7th - 8th April 2014, Kurri Kurri, Australian Network for Plant Conservation: "*Introduction to the flora of the Hunter Valley - history, diversity and ecology*".
- HOTSPOTS Fire Project: Awabakal and Worimi Fire Forum, 27th July 2011, Williamtown, Never Never Resources: "*Vegetation of the Worimi Conservation Lands*".
- HOTSPOTS Fire Project: Wanaruah Fire Forum, 17th – 19th August 2010, Sandy Hollow, Upper Hunter Valley, Nature Conservation Council: "*Vegetation of Wanaruah Lands, Sandy Hollow*".
- Coastal Groundwater Dependent Ecosystems Workshop, 3rd – 4th September 2009, South West Rocks, NSW (Geoscience Australia): "*Surveying, classifying and mapping vegetation on the Tomago Sandbeds*".
- Vegetation Management and Biodiversity Conservation in the Hunter Region, May 2000, Singleton, NSW (Hunter Environment Lobby Inc.): "*An evaluation of vegetation survey and threatened plant species listings in the Hunter Region*"

PROFESSIONAL MEMBERSHIPS

- Ecological Society of Australia (ESA)
- Australian Network for Plant Conservation Inc. (ANPC)
- International Association for Vegetation Science (IAVS)
- International Association for Vegetation Science Vegetation Classification Working Group (IAVS VCWG)
- Australasian Native Orchid Society Inc. (ANOS)
- Australasian Systematic Botany Society (ASBS)

PUBLICATION REVIEWER

- *Diversity* (MDPI, Switzerland)
- *Journal of Vegetation Science* (International Association for Vegetation Science)
- *Phytocoenologia* (International Association for Vegetation Science)
- *Resources* (MDPI, Switzerland)
- *Sustainability* (MDPI, Switzerland)
- *Telopea* (National Herbarium of New South Wales)

PUBLICATIONS (PEER REVIEWED)

Bell, S.A.J. (in prep) Experiences in translocating threatened terrestrial orchids (*Diuris tricolor* and *Prasophyllum petilum*) into non-mined and post-mined lands in the upper Hunter Valley of New South Wales, Australia. *Austral Ecology* (in prep).

Bell, S.A.J. & Nicolle, D. (in prep) Taxonomic clarification of an unusual, disjunct, mallee-form population of *Eucalyptus dealbata* (Myrtaceae) from the Hunter Valley of New South Wales, with comparative notes on other populations in the Sydney Basin bioregion. *Telopea* (in prep).

DeLacey, C., Bell, S., Chamberlain, S., & Bossard, K. (in review) Prediction of and realised habitat for a cryptic plant species: the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls. *Cunninghamia* (in review)

Bell, S.A.J. (2019) *Macrozamia flexuosa* C. Moore (Zamiaceae): a review of distribution, habitat and conservation status of an endemic cycad from the Hunter Region of New South Wales. *Cunninghamia* 19: 7-27.

Bell, S.A.J. (2018) Fate of a rare flowering event in a population of the endangered *Acacia pendula* (Weeping Myall) from the Hunter Valley of New South Wales. *Cunninghamia* 18: 79-88.

Bell, S.A.J. & Driscoll, C. (2017) *Acacia wollarensis* (Fabaceae, Mimosoideae sect. Botrycephalae), a distinctive new species endemic to the Hunter Valley of New South Wales, Australia. *Telopea* 20: 125-136.

Bell, S.A.J. & Driscoll, C. (2016) Hunter Valley Weeping Myall Woodland – is it really definable and defendable with and without Weeping Myall (*Acacia pendula*)? *Cunninghamia* 16: 15-30.

Bell, S.A.J. & Walsh, N. (2015) *Leionema lamprophyllum* subsp. *fractum* (Rutaceae); a new and highly restricted taxon from the Hunter Valley of New South Wales. *Telopea* 18: 505-512.

Bell, S.A.J. & Driscoll, C. (2014) *Acacia pendula* (Weeping Myall) in the Hunter Valley of New South Wales: early explorers' journals, database records and habitat assessments raise doubts over naturally occurring populations. *Cunninghamia* 14: 179-200.

Bell, S.A.J. & Nicolle, D. (2012) *Eucalyptus expressa* (Myrtaceae): a new and distinctive species from the sandstone ranges north-west of Sydney, New South Wales. *Telopea* 14: 69-76.

Bell, S.A.J. & Stables, M. (2012) Floristic variability, distribution and an extension of range for the endangered Pittwater Spotted Gum Forest, Central Coast, New South Wales. *Cunninghamia* 12(2): 143-152.

Bell, S.A.J. (2009) Vegetation and floristics of Columbey National Park, lower Hunter Valley, New South Wales. *Cunninghamia* 11(2): 241-275.

Bell, S.A.J. (2008) Rare or threatened vascular plant species of Wollemi National Park, central eastern New South Wales. *Cunninghamia* 10(3): 331-371.

Bell, S., Branwhite, B., & Driscoll, C. (2005) *Thelymitra 'adorata'* (Orchidaceae): population size and habitat of a highly restricted terrestrial orchid from the Central Coast of New South Wales. *The Orchadian* 15(1): 6-10.

Bell, S.A.J. (2004) Distribution and habitat of the vulnerable tree species, *Angophora inopina* (Myrtaceae), on the Central Coast of New South Wales. *Cunninghamia* 8(4): 477-484.

Bell, S.A.J. (2004) Vegetation of Werakata National Park, Hunter Valley, New South Wales. *Cunninghamia* 8(3): 331-347.

Bell, S.A.J. & Copeland, L.M. (2004) *Commersonia rosea* (Malvaceae *s.l.*: Lasiopetaleae): a new, rare fire-ephemeral species from the upper Hunter Valley, New South Wales. *Telopea* 10(2): 581-587.

Bell, S.A.J. (2002) Habitat of the endangered *Hibbertia procumbens* (Labill.) DC (Dilleniaceae) from the Central Coast of New South Wales. *Victorian Naturalist* 119(2): 69-74.

Bell, S.A.J. (2001) Notes on population size and habitat of the vulnerable *Cryptostylis hunteriana* Nicholls (Orchidaceae) from the Central Coast of New South Wales. *Cunninghamia* 7(2): 195-204.

Bell, S.A.J. (2001). Notes on the distribution and conservation status of some restricted plant species from sandstone environments of the upper Hunter Valley, New South Wales. *Cunninghamia* 7(1): 77-88.

Bell, S. (2000) An evaluation of vegetation survey and threatened plant species listings in the Hunter Region. Pp. 19-34 IN *Vegetation Management and Biodiversity Conservation in the Hunter Region - Where to from here?* Ed. by M.Fallding. Proceedings of the Public Workshop. Hunter Environment Lobby. Singleton, 12 May 2000.

PUBLICATIONS (OTHERS)

Bell, S. (in press) Translocation 'success' is all about detection: experiences with two threatened orchids from the Hunter Valley of NSW. *Australasian Plant Conservation* (in press).

Bell, S. (2018) The responsibilities of ecological consultants in disseminating outcomes from threatened species surveys: a call to arms. *Australasian Plant Conservation* 27:3-6.

Bell, S. & Sims, R. (2018) Extensive populations of *Dracophyllum macranthum* (Ericaceae) in Coorabakh NP suggest a review of threat status. *Australasian Plant Conservation* 27: 11-14.

Bell S.A.J. & Kodela P.G. (2018) *Acacia wollarensis*. In: *Flora of Australia*. Australian Biological Resources Study, Department of the Environment and Energy, Canberra. https://profiles.ala.org.au/opus/foa/profile/Acacia%20wollarensis

Bell, S. (2017) New insights into the ecology of the critically endangered *Banksia conferta* (Proteaceae) from the mid-north coast of NSW. *Australasian Plant Conservation* 26(1): 15-18.

Bell, S. & Holzinger, B. (2015) Wildfire reveals new populations of the endangered *Commersonia rosea* and *Monotaxis macrophylla* in northern Wollemi National Park, NSW. *Australasian Plant Conservation* 23: 2-4.

Bell, S. & Elliott, M. (2013) Preliminary results suggest fire is required to maintain *Acacia dangarensis*, a threatened single-population endemic from the Hunter Valley of NSW. *Australasian Plant Conservation* 22(1): 9-10.

de Lacey, C, Bell, S, Chamberlain, S. & Bossard, K. (2013) Finding the leafless tongue orchid *'Cryptostylis hunteriana'* Nicholls. *Nature New South Wales* Vol. 57 (1) Autumn 2013: 24-25. [online]

de Lacey, C., Bell, S., & Chamberlain, S. (2012) Habitat of the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls throughout its known Australian distribution. *Australasian Plant Conservation* 20(4): 23-25.

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Bell, S.A.J. (2010) Defining and mapping an endangered ecological community within Lake Macquarie Local Government Area, New South Wales. *Australasian Plant Conservation* 18(3): 18-19.

Bell, S., Peake, T. & Driscoll, C. (2007) Dealing with taxonomic uncertainty in Weeping Myall *Acacia pendula* from the Hunter catchment, New South Wales. *Australasian Plant Conservation*. 16(1): 14-15.

Bell, S. & Driscoll, C. (2005) New records of the endangered *Hibbertia procumbens* from the Central Coast of NSW. *Australasian Plant Conservation* 13(4): 24-25.

Bell, S.A.J., Parsons, J., & Meldrum, R. (2005) Towards the protection and management of hanging swamps on the Somersby Plateau, Central Coast, New South Wales. *Australasian Plant Conservation* 13(3): 10-11.

Bell, S. (2003) Another new and highly restricted mallee from the Hunter Valley, *Eucalyptus castrensis*. *Hunter Flora* 11: 2.

Peake, T., Bell, S., Tame, T., Simpson, J., & Curran, T. (2003) *The Hunter Rare Plants Database: Identification and listing of regionally significant flora for the Hunter Region, New South Wales*. Poster Presentation at the Ecological Society of Australia Annual Conference 2003, Armidale NSW.

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Bell, S.A.J. (2018) *Baseline demography of a significant new population of the Critically Endangered* Banksia conferta *(Proteaceae), Coorabakh National Park, NSW*. Unpublished Report to NSW Office of Environment & Heritage. June 2018. Eastcoast Flora Survey. Final Report.

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Bell, S.A.J. (2017) *Targeted survey for the threatened* Diuris tricolor *at Persoonia Park, North Rothbury, Hunter Valley.* Unpublished Report to Office of Environment & Heritage. November 2017. Eastcoast Flora Survey.

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Bell, S.A.J. (2017) *Vegetation and floristics of the Huntlee Offset Lands, Hunter Valley, NSW: 1. Cedar Creek (Cessnock LGA).* Unpublished Report to NSW Office of Environment and Heritage. October 2017.

Bell, S.A.J. (2017) *Baseline monitoring and survey of the Critically Endangered* Pomaderris reperta *(Rhamnaceae) and Vulnerable* Lasiopetalum longistamineum *(Malvaceae), Upper Hunter Valley, New South Wales*. Unpublished Report to NSW Office of Environment and Heritage. October 2017.

Bell, S.A.J. (2017) *Field Validation of Wetlands Mapping on the Central Coast of New South Wales*. Unpublished Report to NSW Office of Environment and Heritage.

Bell, S.A.J. (2017) *Mt Dangar Multi-species Saving our Species Project: Year 1 (2016-2017) Summary Report.* Unpublished Report to NSW National Parks and Wildlife Service. June 2017.

Bell, S.A.J. (2017) *Monitoring of the Critically Endangered* Banksia conferta *(Proteaceae) at Coorabakh National Park, NSW*. Unpublished Report to NSW Office of Environment and Heritage.

Bell S.A.J. (2016) *Monitoring of the endangered* Pterostylis gibbosa *(Orchidaceae) at Milbrodale, Hunter Valley, NSW*. Unpublished Report to NSW Office of Environment and Heritage.

Bell S.A.J. (2016) *Distribution and condition of the threatened* Melaleuca biconvexa *(Myrtaceae) on the Central Coast of NSW*. Unpublished Report to NSW Office of Environment and Heritage.

Bell, S.A.J. (2016) *Additional notes on distribution and fragmentation of Warkworth Sands Woodland, from the Hunter Valley of New South Wales*. Unpublished Report to Department of Environment, Ecological Communities Section, Protected Species & Communities Branch, Canberra. April 2016.

Bell, S.A.J. (2016) *An assessment of the vegetation occurring on coastal sands at Pelican Flats, Lake Macquarie LGA*. Lake Macquarie Research Grant Project 2004/2005-01.

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Bell, S.A.J. (2016) *Volume 2: Vegetation Community Profiles, Lake Macquarie Local Government Area. Working Draft v2*. Unpublished Report to Lake Macquarie City Council. March 2016. Eastcoast Flora Survey.

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Bell, S.A.J. (2015) *Review of Offset Multipliers (Tg values) for Selected Threatened Species*. Unpublished Report to NSW Office of Environment and Heritage. November 2015. Eastcoast Flora Survey.

Bell, S.A.J. (2015) *Distribution, habitat and conservation status of* Macrozamia flexuosa *(Zamiaceae) in Lake Macquarie LGA and the lower Hunter Valley of New South Wales*. Lake Macquarie Research Grant Project 1999/2000-02.

Bell, S.A.J. (2015) *External Review: Draft Threatened Plant Survey Guidelines*. Unpublished Report to Office of Environment & Heritage, NSW Department of Premier and Cabinet. May 2015. Eastcoast Flora Survey.

Bell, S.A.J. (2015) *Lower Hunter Spotted Gum-Ironbark Forest: Verification Survey, Proposed Newcastle Inner City Bypass (Rankin Park to Jesmond), Newcastle LGA*. Unpublished Report to Roads and Maritime Services. March 2015. Eastcoast Flora Survey.

Bell, S.A.J. (2014) *Tablelands Snow Gum TEC: Field Survey & Classification Analysis, Southern Tablelands, New South Wales. Tallaganda & Badja State Forest Trial Areas*. Unpublished DRAFT Report to NSW Office of Environment & Heritage. Eastcoast Flora Survey. November 2014.

Bell, S.A.J. (2014) *Preliminary data analysis of Slaty Gum (*Eucalyptus dawsonii*) Forests & Woodlands in the Hunter Valley*. Unpublished Report to Department of Environment, Ecological Communities Section, Protected Species & Communities Branch, Canberra. August 2014. Prepared as part of deliberations emanating from the Expert Panel assessing the proposed Central Hunter Valley Eucalyptus Forest and Woodland Complex endangered ecological community.

Bell, S.A.J. (2014) *Submission on Warkworth Sands Woodland EEC: Warkworth / Mt Thorley Continuation Project*. Unpublished Submission to NSW Department of Planning and Environment. Eastcoast Flora Survey. July 2014.

Bell, S.A.J. (2013) *Ecological studies on* Acacia dangarensis*: Baseline data to inform management*. Unpublished Report to NSW Office of Environment & Heritage, Mudgee. October 2013. Eastcoast Flora Survey.

Bell, S.A.J. (2013) *Assessment of Alluvial Riparian Blackbutt Forest in Wyong LGA against River Flat Eucalypt Forest EEC*. Unpublished Report to Wyong Shire Council. June 2013. Eastcoast Flora Survey.

Bell, S.A.J. (2013) *A strategy for monitoring revegetation of rehabilitation after coal mining, Ravensowrth Operations, Hunter Valley*. Unpublished Report to Ravensworth Operations, Xstrata Coal, April 2013. Eastcoast Flora Survey.

Bell, S.A.J. (2013) *Summary Report of Baseline* Pomaderris reperta *Monitoring Data, Mangoola Coal*. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey.

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Bell, S.A.J. & Carty, A. (2012) *Vegetation mapping of the Singleton Military Area*. Unpublished report to Commonwealth Department of Defence. Eastcoast Flora Survey & SKM, March 2012.

Bell, S.A.J. (2011) *Implementing the NSW Vegetation Classification and Assessment (VCA) Scheme in the Hunter-Central Rivers Region: Attribution of Priority Vegetation Types*. Unpublished Database to Hunter-Central Rivers Catchment Management Authority. Eastcoast Flora Survey.

Bell, S.A.J. (2011) *Review of Greater Hunter Vegetation Mapping: Version 0.1*. Unpublished Report to Office of Environment & Heritage, Department of Premier & Cabinet. August 2011. Eastcoast Flora Survey.

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Appendix 6 – Endorsement: Dr Lachlan Copeland

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5th April, 2018

Reference for orchid expertise of Dr Stephen Bell

To whom it may concern

This letter serves to introduce Dr Stephen Bell of Eastcoast Flora Survey as worthy to fill the role of 'expert' for matters concerning the threatened terrestrial orchids *Diuris tricolor* and *Prasophyllum petilum*. I myself have an extensive knowledge of the orchid flora of New South Wales, Victoria and Queensland gained over several decades of field survey. With Gary Backhouse, Robert Bates and Andrew Brown, I have co-authored the "Checklist of the Orchids of Australia including its Island Territories". In separate publications I have also described 15 new orchid species. I am personally very familiar with *Diuris tricolor* and *Prasophyllum petilum* from throughout their known distributional ranges, and have worked with Stephen on these two species previously.

Stephen has a wealth of experience and professional ability in botany and threatened species management, having worked in the consultancy field since the mid 1990's. In 1996, he established Eastcoast Flora Survey, a small consultancy focusing on vegetation surveys, classification, mapping and threatened species research and management. Over a 20 year period, Stephen has shown himself to be dedicated to presenting an accurate portrayal of the distribution and abundance of native plant species, particularly threatened plant species and ecological communities. He has researched a number of threatened plant species, including several orchids, and has published regularly in the scientific literature on these. In the past, I have personally approached Stephen on numerous occasions to discuss the distribution, abundance and threats of a wide variety of threatened plant species including several orchid taxa.

I first worked with Stephen on surveys for *Diuris* and *Prasophyllum* in the upper Hunter Valley in 2009, and since that time I am aware that he has undertaken annual surveys for these species across a number of offset and development sites, including overseeing and conducting a large translocation program at one mine site requiring detailed monitoring of individual plants, and the monitoring of natural populations elsewhere. Over a nine year period of surveying and monitoring for these species, Stephen is clearly highly regarded as an expert for these taxa in the Hunter Valley. I believe that Stephen would have personally seen more individuals of these two species and know their ecology more intimately than anyone else.

Given the experience detailed above, I have no hesitation in recommending Stephen as an expert in any matters concerning *Diuris tricolor* and *Prasophyllum petilum*, particularly with regard to habitats and status within the Hunter Valley of NSW.

Yours sincerely

Lachlan Copeland

Dr Lachlan Copeland
Senior Botanist,
Eco Logical Australia

APPENDIX D

Development Footprint Plot and Transect Data and Species Lists

Plot and Transect Data

The following plot and transect data was collected from surveys of the Development Footprint. It includes the ten site attributes that are recorded in each Biometric plot and transect as per Table 2 of the FBA (OEH 2014b). This data is assessed against benchmark data for PCTs and then entered into the BioBanking Credit Calculator (Major Project type) to assess the site value of each PCT in the Development Footprint.

The following abbreviations or symbols are used in the list:

NPS	native plant species
NOC	native overstorey cover
NMC	native midstorey cover
NGCG	native ground cover (grasses)
NGCS	native ground cover (shrubs)
NGCO	native ground cover (other)
EPC	exotic plant cover
NTH	number of trees with hollows
OR	overstorey regeneration, and
FL	total length of fallen logs.

Plot Name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone
Zone 1: HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter - Moderate to Good													
M005_Q	31	46	15	24	0	42	16	0	1	71	279797	6428985	56
M031_Q	35	13	0	70	6	34	0	0	1	14	280742	6429661	56
M038_Q	43	39.5	8.5	50	24	8	0	2	1	12	281547	6429609	56
M042_Q	12	0	0	78	0	30	50	0	1	0	278206	6427623	56
M044_Q	32	25	15.5	38	12	24	10	1	1	25	281618	6429842	56
Zone 2: HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter – Derived Native Grassland													
M039_Q	11	0	0	82	8	36	34	0	1	0	281642	6429559	56
M040_Q	12	0	0	82	0	52	24	0	1	0	281835	6429572	56
M041_Q	10	0	0	88	0	30	32	0	1	0	282009	6429653	56
M046_Q	11	0	0	68	0	14	52	0	1	0	280027	6428840	56
Zone 3: HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter - Moderate to Good													
M004_Q	23	17	4	50	0	46	2	0	1	23	279915	6428549	56
M006_Q	37	30	13	62	14	30	0	0	1	10	280235	6428928	56
M007_Q	41	41	5	12	2	14	0	0	1	63	280572	6429136	56
Zone 4: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Moderate to Good													
M008_Q	25	23.5	3.5	26	6	30	0	0	0	0	280648	6427471	56
M023_Q	40	7.7	4.5	60	8	36	40	0	1	6	281627	6429158	56
M024_Q	52	14	10.7	52	0	48	22	0	1	33	281374	6429585	56
M026_Q	36	8.2	0.5	56	4	54	10	0	1	3.5	281560	6428208	56
MQ17	36	2.3	2	50	0	24	0	0	1	3	283884	6428860	56
MQ37	32	13.5	10	76	28	10	8	1	1	36	280198	6428279	56
MQ5	28	12.5	5.5	62	4	34	0	0	1	2	281451	6427800	56

Zone 5: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland													
M011_Q	16	0	0	80	0	32	4	0	1	0	279997	6427187	56
M012_Q	22	0	0	78	0	32	4	0	1	0	280932	6427400	56
M025_Q	26	0	0	86	0	68	28	0	1	3.5	281326	6428793	56
M030_Q	26	0	0	100	0	32	22	0	1	5	281011	6429372	56
M045_Q	15	0	0	92	0	22	26	0	1	0	281021	6429188	56
MQ7	27	0	0	98	0	80	2	0	1	0	280435	6426921	56
Zone 6: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland (Low)													
M043_Q	7	0	0	76	0	32	54	0	0	0	281983	6427721	56
M020_Q	20	0	0	96	0	12	24	0	0	0	282401	6429543	56
M035_Q	5	0	0	80	2	28	70	0	0	0	282858	6429313	56
M036_Q	6	0	0	86	0	2	60	0	0	0	282172	6429070	56
M037_Q	9	0	0	56	0	8	90	0	1	0	282047	6428499	56
MQ44	14	0	0	90	0	30	42	0	0	0	282475	6428898	56
Zone 7: HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter – Moderate to Good													
M010_Q	19	9.5	2.5	36	6	46	0	0	1	12	280276	6427019	56
M029_Q	30	8	5	34	6	56	6	0	1	24	280270	6427372	56
MQ6	19	13.5	8.5	54	8	24	0	0	1	0	280262	6426872	56
Zone 8: HU906 Bull Oak grassy woodland of the central Hunter Valley – Moderate to Good													
M003_Q	15	35.5	9.5	6	12	18	4	0	1	22	281289	6427556	56
M009_Q	10	33.5	0	0	14	12	0	0	0	7	280589	6427105	56
MQ3	21	12.5	8	4	2	4	0	0	1	105	280985	6427725	56
MQ4	28	0	3.5	44	12	46	22	0	1	83	281027	6427757	56
Zone 9: HU906 Bull Oak grassy woodland of the central Hunter Valley – Derived Native Grassland													
M001_Q	30	9	0	62	20	32	2	0	1	148	281062	6427712	56
M002_Q	25	13.5	0	44	34	18	2	0	1	281	281237	6427477	56

Zone 10: HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Moderate to Good													
M027_Q	19	16.5	1.8	20	2	48	62	1	1	14.5	281265	6427111	56
M028_Q	20	12.5	8	38	6	14	70	2	1	16	281177	6426950	56
VCA9	10	3.6	9.8	4	0	12	44	0	1	0	281427	6427251	56
Zone 11: HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Variant													
M047_Q	13	25	0	76	0	6	6	3	1	11	282284.7	6427797	56
M044_Q	32	25	15.5	38	12	24	10	1	1	25	281618	6429842	56
Zone 2: HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter – Derived Native Grassland													
M039_Q	11	0	0	82	8	36	34	0	1	0	281642	6429559	56
M040_Q	12	0	0	82	0	52	24	0	1	0	281835	6429572	56
M041_Q	10	0	0	88	0	30	32	0	1	0	282009	6429653	56
M046_Q	11	0	0	68	0	14	52	0	1	0	280027	6428840	56
Zone 3: HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter - Moderate to Good													
M004_Q	23	17	4	50	0	46	2	0	1	23	279915	6428549	56
M006_Q	37	30	13	62	14	30	0	0	1	10	280235	6428928	56
M007_Q	41	41	5	12	2	14	0	0	1	63	280572	6429136	56
Zone 4: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Moderate to Good													
M008_Q	25	23.5	3.5	26	6	30	0	0	0	0	280648	6427471	56
M023_Q	40	7.7	4.5	60	8	36	40	0	1	6	281627	6429158	56
M024_Q	52	14	10.7	52	0	48	22	0	1	33	281374	6429585	56
M026_Q	36	8.2	0.5	56	4	54	10	0	1	3.5	281560	6428208	56
MQ17	36	2.3	2	50	0	24	0	0	1	3	283884	6428860	56
MQ37	32	13.5	10	76	28	10	8	1	1	36	280198	6428279	56
MQ5	28	12.5	5.5	62	4	34	0	0	1	2	281451	6427800	56

Zone 5: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland												
M011_Q	16	0	0	80	0	32	4	0	1	0	279997	6427187	56
M012_Q	22	0	0	78	0	32	4	0	1	0	280932	6427400	56
M025_Q	26	0	0	86	0	68	28	0	1	3.5	281326	6428793	56
M030_Q	26	0	0	100	0	32	22	0	1	5	281011	6429372	56
M045_Q	15	0	0	92	0	22	26	0	1	0	281021	6429188	56
MQ7	27	0	0	98	0	80	2	0	1	0	280435	6426921	56
Zone 6: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland (Low)												
M043_Q	7	0	0	76	0	32	54	0	0	0	281983	6427721	56
M020_Q	20	0	0	96	0	12	24	0	0	0	282401	6429543	56
M035_Q	5	0	0	80	2	28	70	0	0	0	282858	6429313	56
M036_Q	6	0	0	86	0	2	60	0	0	0	282172	6429070	56
M037_Q	9	0	0	56	0	8	90	0	1	0	282047	6428499	56
MQ44	14	0	0	90	0	30	42	0	0	0	282475	6428898	56
Zone 7: HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter – Moderate to Good												
M010_Q	19	9.5	2.5	36	6	46	0	0	1	12	280276	6427019	56
M029_Q	30	8	5	34	6	56	6	0	1	24	280270	6427372	56
MQ6	19	13.5	8.5	54	8	24	0	0	1	0	280262	6426872	56
Zone 8: HU906 Bull Oak grassy woodland of the central Hunter Valley – Moderate to Good												
M003_Q	15	35.5	9.5	6	12	18	4	0	1	22	281289	6427556	56
M009_Q	10	33.5	0	0	14	12	0	0	0	7	280589	6427105	56
MQ3	21	12.5	8	4	2	4	0	0	1	105	280985	6427725	56
MQ4	28	0	3.5	44	12	46	22	0	1	83	281027	6427757	56
Zone 9: HU906 Bull Oak grassy woodland of the central Hunter Valley – Derived Native Grassland												
M001_Q	30	9	0	62	20	32	2	0	1	148	281062	6427712	56
M002_Q	25	13.5	0	44	34	18	2	0	1	281	281237	6427477	56

Plot Name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone
Zone 1: HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter - Moderate to Good													
M005_Q	31	46	15	24	0	42	16	0	1	71	279797	6428985	56
M031_Q	35	13	0	70	6	34	0	0	1	14	280742	6429661	56
M038_Q	43	39.5	8.5	50	24	8	0	2	1	12	281547	6429609	56
M042_Q	12	0	0	78	0	30	50	0	1	0	278206	6427623	56
M044_Q	32	25	15.5	38	12	24	10	1	1	25	281618	6429842	56
Zone 2: HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter – Derived Native Grassland													
M039_Q	11	0	0	82	8	36	34	0	1	0	281642	6429559	56
M040_Q	12	0	0	82	0	52	24	0	1	0	281835	6429572	56
M041_Q	10	0	0	88	0	30	32	0	1	0	282009	6429653	56
M046_Q	11	0	0	68	0	14	52	0	1	0	280027	6428840	56
Zone 3: HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter - Moderate to Good													
M004_Q	23	17	4	50	0	46	2	0	1	23	279915	6428549	56
M006_Q	37	30	13	62	14	30	0	0	1	10	280235	6428928	56
M007_Q	41	41	5	12	2	14	0	0	1	63	280572	6429136	56
Zone 4: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Moderate to Good													
M008_Q	25	23.5	3.5	26	6	30	0	0	0	0	280648	6427471	56
M023_Q	40	7.7	4.5	60	8	36	40	0	1	6	281627	6429158	56
M024_Q	52	14	10.7	52	0	48	22	0	1	33	281374	6429585	56
M026_Q	36	8.2	0.5	56	4	54	10	0	1	3.5	281560	6428208	56
MQ17	36	2.3	2	50	0	24	0	0	1	3	283884	6428860	56
MQ37	32	13.5	10	76	28	10	8	1	1	36	280198	6428279	56
MQ5	28	12.5	5.5	62	4	34	0	0	1	2	281451	6427800	56

Zone 5: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland												
M011_Q	16	0	0	80	0	32	4	0	1	0	279997	6427187	56
M012_Q	22	0	0	78	0	32	4	0	1	0	280932	6427400	56
M025_Q	26	0	0	86	0	68	28	0	1	3.5	281326	6428793	56
M030_Q	26	0	0	100	0	32	22	0	1	5	281011	6429372	56
M045_Q	15	0	0	92	0	22	26	0	1	0	281021	6429188	56
MQ7	27	0	0	98	0	80	2	0	1	0	280435	6426921	56
Zone 6: HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter – Derived Native Grassland (Low)												
M043_Q	7	0	0	76	0	32	54	0	0	0	281983	6427721	56
M020_Q	20	0	0	96	0	12	24	0	0	0	282401	6429543	56
M035_Q	5	0	0	80	2	28	70	0	0	0	282858	6429313	56
M036_Q	6	0	0	86	0	2	60	0	0	0	282172	6429070	56
M037_Q	9	0	0	56	0	8	90	0	1	0	282047	6428499	56
MQ44	14	0	0	90	0	30	42	0	0	0	282475	6428898	56
Zone 7: HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter – Moderate to Good												
M010_Q	19	9.5	2.5	36	6	46	0	0	1	12	280276	6427019	56
M029_Q	30	8	5	34	6	56	6	0	1	24	280270	6427372	56
MQ6	19	13.5	8.5	54	8	24	0	0	1	0	280262	6426872	56
Zone 8: HU906 Bull Oak grassy woodland of the central Hunter Valley – Moderate to Good												
M003_Q	15	35.5	9.5	6	12	18	4	0	1	22	281289	6427556	56
M009_Q	10	33.5	0	0	14	12	0	0	0	7	280589	6427105	56
MQ3	21	12.5	8	4	2	4	0	0	1	105	280985	6427725	56
MQ4	28	0	3.5	44	12	46	22	0	1	83	281027	6427757	56
Zone 9: HU906 Bull Oak grassy woodland of the central Hunter Valley – Derived Native Grassland												
M001_Q	30	9	0	62	20	32	2	0	1	148	281062	6427712	56
M002_Q	25	13.5	0	44	34	18	2	0	1	281	281237	6427477	56

Zone 10: HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Moderate to Good													
M027_Q	19	16.5	1.8	20	2	48	62	1	1	14.5	281265	6427111	56
M028_Q	20	12.5	8	38	6	14	70	2	1	16	281177	6426950	56
VCA9	10	3.6	9.8	4	0	12	44	0	1	0	281427	6427251	56
Zone 11: HU945 Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley – Variant													
M047_Q	13	25	0	76	0	6	6	3	1	11	282284.7	6427797	56

Flora Species List

The following list was developed from the systematic plot and transect surveys of the Development Footprint and surrounds by Umwelt as outlined in **Section 2.2.3**. It includes all species of vascular plants observed during these surveys. It is acknowledged that the list is not comprehensive, as not all species are readily detected at any one time of the year. Many species flower only during restricted periods of the year, and some flower only once in several years. In the absence of flowering material, many of these species cannot be identified, or even detected.

Names of classes and families follow a modified Cronquist (1981) System.

Any species that could not be identified to the lowest taxonomic level are denoted in the following manner:

sp.	specimens that are identified to genus level only.

The following abbreviations or symbols are used in the list:

AR	denotes abundance rating according to BBAM 2014
C	cover measure according to BBAM 2014
asterisk (*)	denotes species non-native species
subsp.	subspecies and
var.	variety.

All vascular plants recorded or collected were identified using keys and nomenclature in Harden (1992, 1993, 2000 and 2002) and Wheeler *et al.* (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from PlantNET (Botanic Gardens Trust 2017), the on-line plant name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 and 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Coniferopsida pines																																																														
Cupressaceae	*Callitris endlicheri*	black cypress pine									2	2	X							X					4			3				2										3	3											3								
Cycadopsida cycads																																																														
Zamiaceae	*Macrozamia reducta*																														2	2																						1								
Zamiaceae	*Macrozamia spiralis*																													1													2																			
Filicopsida (Ferns)																																																																
Adiantaceae	*Adiantum aethiopicum*	common maidenhair																												3	3										3			1																			
Adiantaceae	*Adiantum hispidulum*	rough maidenhair																																							1																						
Adiantaceae	*Cheilanthes distans*	bristly cloak fern	2	3								2	2			1							2		2			3				2									2										1		2	3								
Adiantaceae	*Cheilanthes sieberi* subsp. *sieberi*	rock fern	3	2	2	3	3	3	2	2	2	2	2		2		1		1		2	3	3	2	3	2	3	3	3	2	2	3		3	2	2	2	2	3	2	3	2	2	3	2	3	2	2	2	3	3	1	2	2			2			3		
Adiantaceae	*Pellaea nana*	dwarf sickle fern																												2	1																															
Aspleniaceae	*Asplenium flabellifolia*	necklace fern																												2	3										2			2												2							
Blechnaceae	*Doodia caudata*	small rasp fern																												1																																
Marsileaceae	*Marsilea drummondii*	common nardoo																				X																																								
Ophioglossaceae	*Ophioglossum lusitanicum*	adders tongue																																	2		2				2									2							1			1		
Magnoliopsida (Flowering Plants) – Liliidae (Monocots)																																																														
Anthericaceae	*Arthropodium milleflorum*	pale vanilla-lily										1																		1	3													2												1							
Anthericaceae	*Laxmannia gracilis*	slender wire lily	2	3	1	2		2			1								1	2			2						1					1				1									2	2					2		2							
Anthericaceae	*Tricoryne elatior*	yellow autumn-lily																						1																																						
Commelinaceae	*Commelina cyanea*	native wandering Jew	3	2	1		2			1		2	2							2		2	2		2			1		2	2	2		3				2	2			2		2				1						1	2	2						
Commelinaceae	*Murdannia graminea*			2	1	2	2	2	1		2									2		3		1		2								2					2					2		2			1								2			1		
Cyperaceae	*Carex appressa*	tall sedge	1							2												1	2	2					2																												1					
Cyperaceae	*Carex* sp.								1									2	1	1	1														3		2																									
Cyperaceae	**Cyperus aggregatus*					1	1			1						2						1				2	2												1								1					2									2	
Cyperaceae	**Cyperus brevifolius*																																														1	1					1			1		2				
Cyperaceae	*Cyperus fulvus*	sticky sedge																														1																			1											
Cyperaceae	*Cyperus gracilis*	slender flat-sedge	2	2	1					2		2	1	2	2	2		2	3			1	2	1	2	2		2	2	2	2	2	2					2	2	2	1	2					2	2			2		2	1		2	2				1	2
Cyperaceae	*Cyperus* sp.																																										1									2										
Cyperaceae	*Eleocharis* sp.	spike-rush, spike-sedge																																																		2										
Cyperaceae	*Fimbristylis dichotoma*	common fringe-sedge	2	2	2	3	3	2	2		2							2	2		2	2		1	2	2	3		2			2		2	3	2	2	2			2			2	1	3	2		2	3	2		2			2	2		2	2	2	
Cyperaceae	*Gahnia aspera*	rough saw-sedge																										1														2	2											X								

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Cyperaceae	*Lepidosperma laterale*	variable sword-sedge																				1																		1			1												1							
Cyperaceae	*Scleria mackaviensis*											2																2																																		
Hypoxidaceae	*Hypoxis hygrometrica*	golden weather-grass		1		1		2	2	1	1											1				2								1	3		1		2					1																		
Juncaceae	*Juncus homalocaulis*									1																																																				
Juncaceae	*Juncus mollis*																																													2																
Juncaceae	*Juncus* sp.	a rush								1																								1			1																									
Lomandraceae	*Lomandra confertifolia*	mat-rush															2																																													
Lomandraceae	*Lomandra filiformis*		1								2															2			1					1							2							3	2													
Lomandraceae	*Lomandra filiformis* subsp. *coriacea*	wattle mat-rush						2																																																						
Lomandraceae	*Lomandra filiformis* subsp. *filiformis*			1			2																																								1															
Lomandraceae	*Lomandra glauca*	pale mat-rush			2								1				1																			1																										
Lomandraceae	*Lomandra longifolia*	spiny-headed mat-rush								1								2																						2																						
Lomandraceae	*Lomandra multiflora* subsp. *multiflora*	many-flowered mat-rush			3	1						2							2		3		1	2	1														1										1		1											
Lomandraceae	*Lomandra* sp.	mat-rush											2	2																																								2								
Luzuriagaceae	*Eustrephus latifolius*	wombat berry																												2										2																						
Luzuriagaceae	*Geitonoplesium cymosum*	scrambling lily																																						2																						
Orchidaceae	*Acianthus* sp.	mosquito orchid																																						2			2																			
Orchidaceae	*Chiloglottis* sp.																																							2																						
Orchidaceae	***Cymbidium canaliculatum***	**tiger orchid**										**X**																																																		
Orchidaceae	*Dendrobium speciosum*	rock lily																													2												X																			
Orchidaceae	*Eriochilus cucullatus*	parsons bands																					1																										2													
Orchidaceae	*Pterostylis* sp.	greenhood																										1		2	2									2			2																			
Phormiaceae	*Dianella caerulea*	blue flax-lily																												2																																
Phormiaceae	*Dianella caerulea* var. *producta*																														2									1			2											2	2							
Phormiaceae	*Dianella revoluta*	blueberry lily																1														2																														
Phormiaceae	*Dianella* sp.									1												1	1																																		1					
Poaceae	*Aristida leptopoda*	white speargrass																																																								2				
Poaceae	*Aristida personata*								2																																				3																	
Poaceae	*Aristida queenslandica*									2																																																				
Poaceae	*Aristida ramosa*	purple wiregrass	2	3	3	3	2	3			2	2	1	3						2			3		3		3		2			2		2			2		3		2					3		3	3	2	3	1		2		2				2	3	
Poaceae	*Aristida vagans*	threeawn speargrass	3	2		3	3	3			2						2	3	2		3	3	2	2	3	2		3	2							2		3	3								3	3			2		2				3					

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Poaceae	*Austrostipa bigeniculata*	yanganbil														2					3																																1										
Poaceae	*Austrostipa scabra*	speargrass		2							1	1																													3																				2	
Poaceae	*Austrostipa scabra* subsp. *falcata*	rough speargrass																					2		3			3	1					1		2									2	3		2		2	2		2			2						
Poaceae	*Austrostipa verticillata*	slender bamboo grass										2			3			1	2							1																						2																	
Poaceae	*Bothriochloa biloba*	lobed bluegrass															4	4																			3																		3	4	3						2	3		2	
Poaceae	*Bothriochloa macra*	red grass			2	3	2		3	1		2						3			2		3		3	2	3		2								3	3	3	3			2			4	3		3			2	4		3			2	2		3	2	3	3
Poaceae	*Brachyachne ciliaris*	hairy native couch																																											2																	
Poaceae	*Chloris divaricata* var. *divaricata*	slender chloris															2	2		2																											2		2			3		3				2		2			2	3
Poaceae	**Chloris* sp.																																		3																											
Poaceae	*Chloris truncata*	windmill grass		3	2				2			2		3	3	2	3			2	2		1		2	3		3				2	2		2	2	3	3			2	2					3	2								2			3	3		2
Poaceae	*Chloris ventricosa*	tall chloris				2																																								2						2						2						
Poaceae	*Cleistochloa rigida*													2																																										3							
Poaceae	*Cymbopogon refractus*	barbed wire grass	3	4	1			1	2	2	3	2		3	3		2	3			2	3	3	2	2	3	3		3					2				3	3							2		2	2	3		2		3				3	2		2	3	
Poaceae	*Cynodon dactylon*	common couch														3					2																										2	3				4		3											
Poaceae	*Dactyloctenium radulans*	button grass																																																2												
Poaceae	*Dichanthium sericeum*	Queensland bluegrass							2						1		4	4	2																	3												3								3						4			2	2
Poaceae	*Dichelachne crinita*	longhair plumegrass		2																																																											
Poaceae	*Dichelachne micrantha*	shorthair plumegrass																																														2															
Poaceae	*Digitaria brownii*	cotton panic grass				3																	2		2										3		1	3					2				3	2	2		2			3	1	2					2		
Poaceae	*Digitaria diffusa*	open summer-grass	3	2		2		2		2			2						2	2	2	2	2	2	2	2	2		2			3		2				2	2	3	2		3				2	3	2		1		3	3			2	2	2			
Poaceae	*Digitaria divaricatissima*	umbrella grass	2					1	2					1			2		2		1		2				3						1									2	2		2			5			2			2		2				
Poaceae	*Digitaria ramularis*	finger panic grass																													3	2																													
Poaceae	*Echinochloa colona*	awnless barnyard grass																																	2																										
Poaceae	*Echinopogon ovatus*	forest hedgehog grass		1																			3							2									1									2															
Poaceae	*Echinopogon* sp.	a hedgehog grass								2				1														1																																			
Poaceae	*Elymus scaber*	common wheatgrass																																		1											1														
Poaceae	*Enneapogon gracilis*	slender nineawn										2													2		2	2													1												2									
Poaceae	*Eragrostis alveiformis*					2	3																													3		2							2	2					3		3				2					2	
Poaceae	*Eragrostis brownii*	Browns	3	3	2	3		3	3		2		2									3			2				2			2		3							1					2	2	2	2	2			2	2			2			3	2	

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
		lovegrass																																																											
Poaceae	**Eragrostis cilianensis*	stinkgrass																						2																																						
Poaceae	**Eragrostis curvula*	African lovegrass							2																																																					
Poaceae	*Eragrostis falcata*	sickle lovegrass																									2	2																																				
Poaceae	*Eragrostis leptostachya*	paddock lovegrass	3		2	2		1		1		1							3				3	2	2	3	2		2						2	2	2	2	2		2	2			2						3	3				2	2	2				
Poaceae	*Eragrostis* sp.	a lovegrass														2	2	1																																												
Poaceae	*Eriochloa pseudoacrotricha*	early spring grass				1			2							2																			2		2				1				3					1	2								2			
Poaceae	*Eulalia aurea*	silky browntop	2	2		3	2	2	3		1			2			2	1				2	2			2	2							2				2	3								3		3				2				3		3	4		
Poaceae	*Imperata cylindrica*	blady grass								2																																																				
Poaceae	*Microlaena stipoides* var. *stipoides*	weeping grass	2	3						2	2				2				3	2	2		2	3	3	2		2	3	3	2	2	2	3				3	2	2	3	3	2			2		2	2					3			2					
Poaceae	**Panicum antidotale*	giant panic grass																																																		2										
Poaceae	*Panicum effusum*	hairy panic	1			2			2		2	2	2				2									1	2					2		1			2				2			4			2					2	2									
Poaceae	**Panicum miliaceum*	French millet										2																																																		
Poaceae	*Panicum queenslandicum*	Yadbila grass												2		2																																														
Poaceae	*Panicum simile*	two-colour panic																																																2												
Poaceae	*Panicum* sp.	panicum							3																																																					
Poaceae	*Paspalidium distans*											2	2	2		2	2						2		2							1			2																3	3	2									
Poaceae	**Paspalum dilatatum*	paspalum								1							2	2																											2		2				1						1	2				
Poaceae	*Poa* sp.																	1																																												
Poaceae	*Rytidosperma bipartitum*	wallaby grass		3					2		1			2	2																				2	2														2	3					2		2				
Poaceae	*Rytidosperma fulvum*	wallaby grass															2						2		2													2										2												2	2	3
Poaceae	*Rytidosperma monticola*	mountain wallaby grass																												1													2																			
Poaceae	*Rytidosperma racemosum* var. *obtusatum*	a wallaby grass																										1																																		
Poaceae	*Rytidosperma setaceum*	small-flowered wallaby-grass																													2																															
Poaceae	*Rytidosperma* sp.															3															2														2		2		2			3										
Poaceae	*Rytidosperma tenuius*	a wallaby grass																2																																												
Poaceae	**Setaria parviflora*					1			2	2										1						2									2											3																
Poaceae	*Sporobolus caroli*	fairy grass																																																X		2									2	2
Poaceae	*Sporobolus creber*	slender rats tail grass	2			2		1	3		2			3		2	2		1				2		2	2	3							2	2		2	2			2			2	3	3	3			2	2	3				2		3		3	2	3
Poaceae	*Themeda australis*	kangaroo grass									1																																																			
Poaceae	*Tripogon loliiformis*	fiveminute							1																		1								1		3																								1	

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
		grass																																																											
Poaceae	**Urochloa panicoides*	urochloa grass	1													1		2																																												
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	Johnsons grass tree																														2											2												2							
Xanthorrhoeaceae	*Xanthorrhoea* sp.									X			X																																																	
Magnoliopsida (Flowering Plants) – Magnoliidae (Dicots)																																																															
Acanthaceae	*Brunoniella australis*	blue trumpet		2	2	2	2				2	2		3			1	1	1		2		3	1	3					2		2						2							2		2	2				2	1	3		2					3	1
Acanthaceae	*Rostellularia adscendens*	pink tongues												1				2																																			3									
Aizoaceae	**Galenia pubescens*	galenia				1				2					3	3			2		1	1											3	3				2						2	2	3				1	3	2				1	1			1		
Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		1												2			2			2	1		1			2							3	1	2	1										1		X						1					1	2
Amaranthaceae	**Gomphrena celosioides*	gomphrena weed							2							2																			2			2												2		2									1	
Amaranthaceae	*Ptilotus nobilis*	yellowtails																																																		2										
Anacardiaceae	**Schinus areira*	pepper tree															X	2																																												
Apiaceae	*Centella asiatica*	Indian pennywort																2																																												
Apiaceae	*Hydrocotyle laxiflora*	stinking pennywort								1							2							2		2															2																					
Apocynaceae	**Gomphocarpus fruticosus*	narrow-leaved cotton bush	X														2																								2																1	1				
Asteraceae	**Arctotheca calendula*	capeweed																																																2												
Asteraceae	**Aster subulatus*	wild aster				2			2						1																		2																													
Asteraceae	**Bidens pilosa*	cobblers pegs								2	1	2	2		1									1					2			2	3																				3	2								
Asteraceae	**Bidens subalternans*	greater beggars ticks	2							1		1																		2			2	1																			1									
Asteraceae	*Brachycome ciliaris*	variable daisy																																	2																											
Asteraceae	*Brachycome ciliaris* var. *ciliaris*													2																													2												1							
Asteraceae	*Brachyscome ciliaris*	variable daisy														2																																		2		2				2					2	
Asteraceae	*Brachyscome* sp.																														2																															
Asteraceae	*Brachyscome ciliaris* var. *ciliaris*	variable daisy																																													1															
Asteraceae	*Brachyscome curvicarpa*															2																													2																	3
Asteraceae	*Calocephalus citreus*	lemon beauty-heads							2					1																															3											1					1	1
Asteraceae	*Calotis lappulacea*	yellow burr-daisy		2		3	1	1			2	2	2		3				2		2	3	2		3			3	2			2					2				2	2		2			2					1	2		1		1		1		1	
Asteraceae	*Calotis scabiosifolia* var. *scabiosifolia*																																																									2				
Asteraceae	**Carthamus lanatus*	saffron thistle														1																																			2	2										
Asteraceae	*Cassinia arcuata*	sifton bush	2	2	1	3	3	1	X	2	1								3		X	1	1	1		2								2			2		2			1					1		5								2					
Asteraceae	*Cassinia cunninghamii*																								3																																					

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Asteraceae	*Cassinia* sp.																																								1																					
Asteraceae	*Centipeda cunninghamii*	common sneezeweed																																			1														1										
Asteraceae	**Chondrilla juncea*	skeleton weed																																							2																	2			
Asteraceae	*Chrysocephalum apiculatum*	common everlasting		2	2	3	3	2	3		2			2	2		2	2	2			2	2	1	2	3	3	3	2			2		1	4	2	4	3	3		3			2	3	3	3		1	3	2	2	3			2	2	2		3	3	2
Asteraceae	**Cirsium vulgare*	spear thistle				2											3	1															2	1						1				2		1					2								2			
Asteraceae	**Conyza bonariensis*	flaxleaf fleabane	2			2			1	1																			1				2	1				1						2	1					2	2											
Asteraceae	*Cymbonotus lawsonianus*															1		1																											2					2								3				
Asteraceae	*Epaltes australis*	spreading nut-heads				1	1															2																	2																							
Asteraceae	*Euchiton involucratus*	star cudweed								2																																																				
Asteraceae	**Euchiton japonicus*																													1										1																						
Asteraceae	*Glossocardia bidens*	cobblers tack		1							1	2	2								1		1						1								2										1	1						1							2	2
Asteraceae	**Hypochaeris microcephala* var. *albiflora*	white flatweed																	2																																											
Asteraceae	**Hypochaeris radicata*	catsear				2		1	2	2								2						2		2	3		3		1		3	2	2						2			3	2	3				2							2			2		
Asteraceae	*Lagenophora gracilis*	slender lagenophora																	1				2					2		1													1																			
Asteraceae	*Olearia elliptica*	sticky daisy-bush																																														X														
Asteraceae	**Schkuhria pinnata*															1																																		1	1											
Asteraceae	*Senecio hispidulus*	hill fireweed																													1												1																			
Asteraceae	**Senecio madagascariensis*	fireweed	1		2	3			3	1				1	2		2	2		2		1				2	2		2			2	2	2			2	2			2	2	2	3	2		2	1	1	2	2		2			1	1	1	1	2		2
Asteraceae	*Sigesbeckia orientalis*																																																				2									
Asteraceae	*Sigesbeckia orientalis* subsp. *orientalis*	Indian weed																														1																														
Asteraceae	*Solenogyne bellioides*	solengyne		2					2																1										2		2	1			1	2														1				1	2	1
Asteraceae	**Soliva sessilis*	bindyi																								2									2																											
Asteraceae	**Sonchus oleraceus*	common sowthistle							1							2		1					1				1			1		1	2										1			1					2	2							2			
Asteraceae	**Taraxacum officinale*	dandelion																1																																												
Asteraceae	*Vernonia cinerea*			2									1		2									1																2		2	1																			
Asteraceae	*Vittadinia cervicularis*		2	2																																																										
Asteraceae	*Vittadinia cuneata*	a fuzzweed		1								1			2			1					1		2			2				1				1						2	2		2		2						2	1				2	1		2	2
Asteraceae	*Vittadinia cuneata* var. *cuneata*	a fuzzweed																																			2				1																					
Asteraceae	*Vittadinia muelleri*	a fuzzweed				X			3			2																																																		

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Asteraceae	*Vittadinia pustulata*	fuzzweed											1																						1						2				2							2						2			2	
Asteraceae	*Vittadinia* sp.	fuzzweed					1				1					1	1	1																																												
Asteraceae	**Xanthium spinosum*	Bathurst burr																																																			X									
Bignoniaceae	*Pandorea pandorana*	wonga wonga vine																						1						X	2									2			2																			
Boraginaceae	*Cynoglossum australe*																												2	2		1								1																						
Boraginaceae	*Cynoglossum suaveolens*	sweet hounds-tongue	2																																																											
Brassicaceae	**Brassica rapa*																																											2																		
Brassicaceae	**Brassica* sp.	brassica																																																		2										
Brassicaceae	**Lepidium africanum*	common peppercress	2											2	1	2									1	1			1				2	2										2							1											
Cactaceae	**Opuntia aurantiaca*	tiger pear	3		1									2	2	2														1																				2										1	1	2
Cactaceae	**Opuntia humifusa*	creeping pear		3	X									1									1													2																										
Cactaceae	**Opuntia stricta* var. *stricta*	common prickly pear	2	2	1				X	1	2	2			2	2	2	1	1	1		1	1		1	1		1	1	2	2							2	2	1		1	2		X				1		1		2	1	2			1				
Campanulaceae	*Wahlenbergia communis*	tufted bluebell	2	2	1	3		2	2	1	1	2		2			2	2	2				2		2	1	2	1	2						2	1	1				1						3					2	2			2		2		2	2	
Campanulaceae	*Wahlenbergia gracilis*	sprawling bluebell																2						1																								1			2						2				2	3
Campanulaceae	*Wahlenbergia littoricola*	bluebell																					2																																							
Campanulaceae	*Wahlenbergia luteola*	bluebell																	2											2	2														2									1							2	
Campanulaceae	*Wahlenbergia planiflora*	bluebell														2																																														
Campanulaceae	*Wahlenbergia* sp.	bluebell																											1	1																													3			
Campanulaceae	*Wahlenbergia stricta*	tall bluebell																																										2																		
Caryophyllaceae	**Paronychia brasiliana*	Chilean whitlow wort								1																2	2		2				2					2			2																					
Caryophyllaceae	**Spergula* sp.					1																																																								
Caryophyllaceae	**Spergularia rubra*	sandspurry																																		1																				2					1	2
Caryophyllaceae	**Stellaria media*	common chickweed																1												2	2		3																													
Caryophyllaceae	*Stellaria pungens*	prickly starwort																													1																															
Casuarinaceae	*Allocasuarina gymnanthera*			1							2												2		2			1											2										2				3									
Casuarinaceae	*Allocasuarina littoralis*	black she-oak	2																																																											
Casuarinaceae	*Allocasuarina luehmannii*	bulloak			4	3	3	3	1																	3								2							2												3	2			3					
Casuarinaceae	*Allocasuarina* sp.																	2																																												
Casuarinaceae	*Allocasuarina torulosa*	forest oak																																						3														3								
Casuarinaceae	*Allocasuarina verticillata*	drooping sheoak																														X																														
Casuarinaceae	*Casuarina glauca*	swamp oak																															4																													

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Celastraceae	*Maytenus silvestris*	narrow-leaved orangebark								1		2											2	2	3				2	1												3	1											2	1							
Chenopodiaceae	*Atriplex semibaccata*	creeping saltbush																																																		2										
Chenopodiaceae	*Chenopodium cristatum*	crested goosefoot											2																			2	3	2					1			2	1					1					1									
Chenopodiaceae	*Chenopodium glaucum*																		1																																											
Chenopodiaceae	*Chenopodium* sp.	goosefoot, crumbweed																															3	2																												
Chenopodiaceae	*Chenopodium truncatum*								3																																																					
Chenopodiaceae	*Einadia hastata*	berry saltbush	1	2	2	1				2		2	2		3					3			2		2			2	2	2	2		2	2		1		1	2			2						2						1	2							
Chenopodiaceae	*Einadia nutans* subsp. *linifolia*	climbing saltbush																																				2																								
Chenopodiaceae	*Einadia nutans* subsp. *nutans*	climbing saltbush						2			1			2	2	2			2	3	2	2			2	2		1						1	2			2			2		1										2									
Chenopodiaceae	*Einadia polygonoides*	knotweed goosefoot	1													2																													1								2			1						
Chenopodiaceae	*Einadia trigonos*	fishweed																								2						2																												1		
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush												2	1	2			2																																	1										
Chenopodiaceae	*Maireana decalvans*	black cotton bush																																																		2										
Chenopodiaceae	*Maireana enchylaenoides*	wingless fissure-weed														2	2																		2	1	2	1																					1		1	2
Chenopodiaceae	*Maireana microcarpa*																																															2				2										
Chenopodiaceae	*Maireana microphylla*	small-leaf bluebush													3	1			2							2									2		2	1									1			3	2									1		1
Chenopodiaceae	*Sclerolaena birchii*	galvinized burr														2																																				2						2				
Clusiaceae	*Hypericum gramineum*	small St Johns wort																					1		2					2	1												2																			
Convolvulaceae	*Convolvulus erubescens*	pink bindweed														2	1																		2		2				1											1						1			1	
Convolvulaceae	*Dichondra repens*	kidney weed	3	2	2				1	2	2	2			2		2	2	2		2		3	3	2	2		2	3	2	2	2		2						2		2	2		1		2	2					2	2		1	2	2				2
Convolvulaceae	*Evolvulus alsinoides* var. *decumbens*						1					1	2									2	1		1			1				2												1			2						2				2					
Crassulaceae	*Crassula sieberiana*	Australian stonecrop							2																																																					
Crassulaceae	*Crassula sieberiana* subsp. *sieberiana*																														2	1																														
Dilleniaceae	*Hibbertia acicularis*																								2							3																														
Dilleniaceae	*Hibbertia obtusifolia*	hoary guinea flower											2																1			3										2																				
Dilleniaceae	*Hibbertia* sp.			2		1					X																	2			1																															
Ericaceae	*Leucopogon muticus*	blunt beard-heath		1							2		2										3		2			3	2			2							2			2													2							
Ericaceae	*Melichrus urceolatus*	urn heath									X																		3																								1									
Ericaceae	*Styphelia triflora*	pink five-corners		1																			1																																							

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Euphorbiaceae	*Chamaesyce drummondii*	caustic weed	2		1	1	2		2		2		2	1		1					2	2						1				2		1	2	2		2				2			1		2									2			2		1	2
Euphorbiaceae	*Euphorbia planiticola*	plains spurge										2																																																		
Euphorbiaceae	*Euphorbia tannensis* subsp. *eremophila*																																																					2								
Fabaceae (Caesalpinioideae)	*Senna artemisioides*											3																																																		
Fabaceae (Caesalpinioideae)	*Senna barclayana*	smooth senna																																																	1			2								
Fabaceae (Faboideae)	*Bossiaea prostrata*																																															X														
Fabaceae (Faboideae)	*Cullen tenax*	emu-foot																																																								1				
Fabaceae (Faboideae)	*Daviesia ulicifolia*	gorse bitter pea	1	2																																																			2							
Fabaceae (Faboideae)	*Desmodium brachypodum*	large tick-trefoil		2								2													3					2		2																														
Fabaceae (Faboideae)	*Desmodium gunnii*	slender tick-trefoil											2		1													2		2										1			1											2								
Fabaceae (Faboideae)	*Desmodium rhytidophyllum*																						1					1																																		
Fabaceae (Faboideae)	*Desmodium varians*	slender tick-trefoil	2	1		1					2	2	2								2		2	2		2		2	2			2		2		1		1			1	1					2	2						2								
Fabaceae (Faboideae)	*Glycine canescens*	silky glycine				1																																																								
Fabaceae (Faboideae)	*Glycine clandestina*	twining glycine						1		1									1				1			1		2	2	2		2				2					2							2					2			1	2					
Fabaceae (Faboideae)	*Glycine microphylla*	small-leaf glycine		1																			2		1																	2				3																
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine	3	3	2	2	2		2	2	2			3	2	2	3	3	2		2	3	3	2	2	2		2	2				2	1	2	2	1	2	3		2			2	3	2	3				2	2	2	2		1	2	2			2	2
Fabaceae (Faboideae)	*Hardenbergia violacea*	false sarsaparilla		1																										1																																
Fabaceae (Faboideae)	*Hovea lanceolata*												1					1										1															1												2							
Fabaceae (Faboideae)	*Hovea* sp.																																									1																				
Fabaceae (Faboideae)	*Lotus* sp.																	1																																												
Fabaceae (Faboideae)	**Medicago polymorpha*	burr medic																																										3																		
Fabaceae (Faboideae)	**Medicago* sp.	a medic														2	2	1																											2						2	2						2	3			
Fabaceae (Faboideae)	*Podolobium ilicifolium*	prickly shaggy pea																													1																															
Fabaceae (Faboideae)	*Pultenaea microphylla*	a bush pea		1																																																										
Fabaceae (Faboideae)	*Rhynchosia minima*																	3																																								1				
Fabaceae (Faboideae)	*Templetonia stenophylla*	leafy templetonia			1									1				1																																												
Fabaceae (Faboideae)	**Trifolium repens*	white clover																																																2												

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Fabaceae (Faboideae)	**Trifolium* sp.	a clover																																										2																			
Fabaceae (Faboideae)	*Zornia dyctiocarpa*		2			2	2	2			2								1				1			2	1		1										1		2														2					
Fabaceae (Mimosoideae)	*Acacia binervia*	coast myall																								2																																				
Fabaceae (Mimosoideae)	*Acacia deanei* subsp. *deanei*	Deanes wattle										3																																																		
Fabaceae (Mimosoideae)	*Acacia decora*	western golden wattle																3																																			2									
Fabaceae (Mimosoideae)	*Acacia falcata*		2																						X																														3							
Fabaceae (Mimosoideae)	*Acacia gunnii*	ploughshare wattle																																																				1								
Fabaceae (Mimosoideae)	*Acacia paradoxa*	kangaroo thorn																			1																																									
Fabaceae (Mimosoideae)	*Acacia pendula*	weeping myall														3																																				4										
Fabaceae (Mimosoideae)	*Acacia piligera*																											2																																				
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	prickly Moses											1																																									3								
Fabaceae (Mimosoideae)	*Acacia uncinata*	gold-dust wattle											X																			3																						3	2							
Fabaceae (Mimosoideae)	*Neptunia gracilis f. gracilis*	sensitive plant												2		2	3	1																																								2	3			
Geraniaceae	**Erodium* sp.	crowfoot															1																		1										2							1										
Geraniaceae	*Geranium* sp.																																																								1					
Goodeniaceae	*Goodenia macbarronii*	narrow goodenia		1																		1																																								
Goodeniaceae	*Goodenia ovata*	hop goodenia																													2																															
Goodeniaceae	*Goodenia pinnatifida*	scrambled eggs																																	1		2								1																	
Goodeniaceae	*Goodenia* sp.			1										1			1						2																									X														2
Haloragaceae	*Gonocarpus* sp.	raspwort																														1																														
Haloragaceae	*Haloragis heterophylla*	variable raspwort				1		1	2	2	2											2		1																																	1					
Haloragaceae	*Haloragis* sp.	a raspwort																			1																																									
Lamiaceae	*Ajuga australis*	austral bugle	3	2																																					1																					
Lamiaceae	*Mentha satureioides*	native pennyroyal														1	2																																													
Lamiaceae	*Scutellaria humilis*	dwarf skullcap	2															2																																												
Lamiaceae	*Spartothamnella juncea*	bead bush	1									2																2		1		1								2	2	2	2											3								
Lamiaceae	*Teucrium* sp. A																X																																													
Lobeliaceae	*Pratia purpurascens*	whiteroot								2								2					2							3									2	3		3	3																			
Loranthaceae	*Amyema cambagei*	needle-leaf mistletoe																															1																													
Loranthaceae	*Amyema gaudichaudii*		1																																																											

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Loranthaceae	*Amyema miquelii*	box mistletoe	1				1												2																			1										1														
Loranthaceae	*Amyema quandang*	grey mistletoe																																																					1							
Loranthaceae	*Amyema* sp.	mistletoe																					1																																							
Loranthaceae	*Lysiana exocarpi* subsp. *tenuis*							1																																																						
Malvaceae	*Abutilon oxycarpum*	straggly lantern-bush										2			2																	2																														
Malvaceae	*Hibiscus sturtii* var. *sturtii*	hill hibiscus										2																1																										3								
Malvaceae	**Malva parviflora*	small-flowered mallow														2																	1																													
Malvaceae	**Modiola caroliniana*	red-flowered mallow														1																													1																	
Malvaceae	*Sida corrugata*	corrugated sida		1		2					2			3	2		2	1					1		1										2	1	2				2				2			2		2						2			1		2	2
Malvaceae	*Sida cunninghamii*	ridge sida														2																			2		2															2						2			1	1
Malvaceae	**Sida rhombifolia*	Paddys lucerne				1				3					3	2	2	1				2		2		2	2		1				2		2						2			3	1	2	1			2	3	2	1					1		1		
Malvaceae	*Sida* sp.															1			1																																											
Malvaceae	*Sida subspicata*		2	1		1	1				1	2									1	2	2		3	2		3	2			4					1		2		2			3		3		2			2		2	3			2					
Meliaceae	*Melia azedarach*	white cedar								1																																																				
Moraceae	*Ficus rubiginosa*	Port Jackson fig																																									X											X								
Myoporaceae	*Eremophila debilis*	amulla		1										2	1				2		2																	1										1														
Myoporaceae	*Myoporum montanum*	western boobialla				1																	1									2																								1						
Myoporaceae	*Myoporum* sp.	boobialla																							2																																					
Myrsinaceae	*Anagallis arvensis*	scarlet pimpernel				1										1	2				1		1	1		2	2	1							2		2							2	2					2	2		1					2	2	2		
Myrtaceae	*Angophora floribunda*	rough-barked apple					X											X											3					3					2		2								2													
Myrtaceae	*Corymbia maculata*	spotted gum											3							3				4						3	3	2								4		X	3					3						3	3							
Myrtaceae	*Eucalyptus blakelyi*	Blakelys red gum																																					1																							
Myrtaceae	*Eucalyptus* prob. *blakelyi* x *tereticornis*							3		4												3																																								
Myrtaceae	*Eucalyptus crebra*	narrow-leaved ironbark	2	3		1	3			2	4	2			4				4	X				X	4	4		3	3	3		3							4	X	4	3						X	2				4	2			3			X		
Myrtaceae	*Eucalyptus dawsonii*	slaty box												4			X				3														2	4	3										4		5							4				X	3	3
Myrtaceae	*Eucalyptus moluccana*	grey box		X								3			1		X	3				X								X						X		4	2															3						X		
Myrtaceae	*Eucalyptus punctata*	grey gum		2																	2	2						2		3	3	X								2			3												3							
Myrtaceae	*Eucalyptus sparsifolia*	narrow-leaved stringybark																													3	X																							3							
Myrtaceae	*Eucalyptus tereticornis*	forest red gum	4																				4																		3																					
Myrtaceae	*Melaleuca decora*		2																																																											
Nyctaginaceae	*Boerhavia dominii*	tarvine										2				2																				1																									2	

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Oleaceae	*Notelaea longifolia*	large mock-olive																							2																																					
Oleaceae	*Notelaea microcarpa* var. *microcarpa*	native olive	1	3		1	X			3	3	4	3					3	2	1		1	3	3	3	3		3	2	4	3	3		3					3	3	3	4	3					X					2	4	3		1					
Onagraceae	**Oenothera stricta*																										1																	1																		
Oxalidaceae	*Oxalis perennans*		2			1			2		2			2	2	2	2		2			2	3		2		3		2					2					2		2	2	2	3		2						2	2					1	2			2
Oxalidaceae	*Oxalis* sp.							1				1						2			2					2						2			2		1													2	3								1			
Phyllanthaceae	*Breynia oblongifolia*	coffee bush								2			1										1	2				2	3	2	1									1		1	2												1							
Phyllanthaceae	*Phyllanthus virgatus*	wiry spurge	2	2				2	2		2	2	2	2	1		2	1	2		1	3	2	1	2	2	1	2	1			2		1	2		2	2	2		2				2		2	2					1	2		1	1			2	2	2
Phytolaccaceae	**Phytolacca octandra*	inkweed																															2																													
Pittosporaceae	*Bursaria spinosa*	native blackthorn											2										2							3	3									3			4												2	2							
Plantaginaceae	*Plantago debilis*	shade plantain												1	1															2	3												2																			
Plantaginaceae	**Plantago lanceolata*	lambs tongues								2						2	2	2								1								1							2				1								1					2	2			
Plantaginaceae	*Veronica plebeia*	trailing speedwell						1			1															2		1												1		1					2															
Polygonaceae	**Acetosella vulgaris*	sheep sorrel								2																			2				2																													
Polygonaceae	*Persicaria hydropiper*	water pepper																															2																													
Polygonaceae	**Polygonum aviculare*	wireweed														2																												1	2																	
Polygonaceae	*Rumex brownii*	swamp dock				1				1														2		2			2	1						1		1						1													1			2		
Polygonaceae	*Rumex* sp.	dock																																				1												1											
Polypodiaceae	*Dictymia brownii*	strap fern																																																3											
Polypodiaceae	*Pyrrosia rupestris*	rock felt fern																													2																														
Portulacaceae	*Calandrinia* sp.	a purslane																				2										2																1							2							
Portulacaceae	*Portulaca oleracea*	pigweed														2																		1			2								2					1	2	2										
Proteaceae	*Persoonia linearis*	narrow-leaved geebung									1														1															X			X												3							
Ranunculaceae	*Clematis glycinoides*	headache vine																											3													2																			
Ranunculaceae	*Clematis* sp.																						1								2									2																						
Rhamnaceae	*Alphitonia excelsa*	red ash											X												1			2											1																							
Rhamnaceae	*Pomaderris elliptica*											2																																																		
Rhamnaceae	*Pomaderris lanigera*	woolly pomaderris																																																			3								
Rhamnaceae	*Pomaderris* sp.																										1																																		
Rosaceae	**Rubus fruticosus* sp. agg.	blackberry complex																															2																													
Rubiaceae	*Asperula conferta*	common woodruff							2								2	2																	2	2		2							1												1	2				
Rubiaceae	*Galium leptogonium*																										1		1													1																			
Rubiaceae	*Galium* sp.																													2																														
Rubiaceae	*Opercularia diphylla*	stinkweed	1	1	1	2																																									2						1					2		2	

Family	Scientific Name	Common Name	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7	MQ8	MQ9	MQ10	MQ11	MQ12	MQ13	MQ14	MQ15	MQ16	MQ17	MQ18	MQ19	MQ20	MQ21	MQ22	MQ23	MQ24	MQ25	MQ26	MQ27	MQ28	MQ29	MQ30	MQ31	MQ32	MQ33	MQ34	MQ35	MQ36	MQ37	MQ38	MQ39	MQ40	MQ41	MQ42	MQ43	MQ44	MQ45	MQ46	MQ47	MQ48	MQ49	MQ50	MQ51	MQ52	MQ53	MQ54	MQ55	MQ56	MQ57	MQ58	MQ59	MQ60
Rubiaceae	*Opercularia* sp.																		2																																									
Rubiaceae	*Pomax umbellata*	pomax											2																												2													2						2	2
Rubiaceae	*Psydrax odorata*	shiny-leaved canthium		2							1	2											3	2	3	3						2							1			2					2	1					2	2	3							
Rubiaceae	**Richardia stellaris*				1	1			1		1								2			2	2			1	1		1								2	2			2						3															
Rutaceae	*Correa reflexa*	native Fuchsia																												2	2									1		1	2											1								
Santalaceae	*Santalum lanceolatum*	northern sandalwood																																																			2								
Sapindaceae	*Dodonaea triangularis*	hopbush																																																			3								
Sapindaceae	*Dodonaea viscosa*	sticky hop-bush								2																																																		
Solanaceae	**Lycium ferocissimum*	African boxthorn													3	2			1														2																		2	2	2										
Solanaceae	*Solanum americanum*	glossy nightshade																											1																															
Solanaceae	*Solanum brownii*	violet nightshade										2													2			2		1	1	1								1		1	1												2							
Solanaceae	*Solanum cinereum*	Narrawa burr																														2																													
Solanaceae	**Solanum nigrum*	black-berry nightshade																														2	1																		1						1					
Solanaceae	*Solanum prinophyllum*	forest nightshade											1											1																																						
Solanaceae	**Solanum radicans*	cusmayllo																														2																													
Solanaceae	*Solanum* sp.			1																											1																														
Stackhousiaceae	*Stackhousia viminea*	slender stackhousia				1					1						1	1					1		1	1																					2		1					2		1						
Sterculiaceae	*Brachychiton populneus* subsp. *populneus*	kurrajong								1							X	1					2	2	2				1																								X		1							
Thymelaeaceae	*Pimelea latifolia* subsp. *elliptifolia*																						1		1					1	2	1										1	2					2														
Ulmaceae	*Trema tomentosa*	native peach																																				4																						
Urticaceae	*Urtica* sp.																															1																													
Verbenaceae	**Verbena bonariensis*	purpletop								2								2																																	2							2				
Verbenaceae	**Verbena officinalis*	common verbena																																																							1				

Fauna Species List

The following list was developed from surveys of the MCCO Additional Project Area. This species list was compiled from species data recorded during field surveys undertaken by Umwelt in 2017.

The following abbreviations or symbols are used in the list:

asterisk (*)	Denotes species not indigenous to Australia
subsp.	Subspecies
V	Vulnerable under Schedule 2 of the Biodiversity Conservation (BC) Act 2016;
E	Endangered under Schedule 1 of the BC Act.

Birds recorded were identified using descriptions in Slater *et al.* (2009) and the scientific and common name nomenclature of BirdLife International Taxonomic Checklist (2017) (formerly Birds Australia). Reptiles recorded were identified using keys and descriptions in Cogger (2014), Swan *et al.* (2004), Weigel (1990) and Wilson and Swan (2003) and the scientific and common name nomenclature of Cogger (2014).

Amphibians recorded were identified using keys and descriptions in Cogger (2014), Robinson (1998), Anstis (2013) and Barker *et al.* (1995) and the scientific and common name nomenclature of Cogger (2014). Mammals recorded were identified using keys and descriptions in Strahan (2002), Van Dyck, D. and Strahan, R. (2008) and Menkhorst and Knight (2010) and the scientific and common name nomenclature of Strahan (2002) and Van Dyck, D. and Strahan, R. (2008) for non-bat species.

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
BIRDS			
Acanthizidae			
Acanthiza chrysorrhoa	yellow-rumped thornbill		
Acanthiza nana	yellow thornbill		
Acanthiza reguloides	buff-rumped thornbill		
Chthonicola sagittata	speckled warbler	V	
Gerygone albogularis	white-throated gerygone		
Smicrornis brevirostris	weebill		
Accipitridae			
Aquila audax	wedge-tailed eagle		
Circus assimilis	spotted harrier	V	
Elanus axillaris	black-shouldered kite		
Aegothelidae			
Aegotheles cristatus	Australian owlet-nightjar		
Anatidae			
Chenonetta jubata	wood duck		
Artamidae			
Cracticus nigrogularis	pied butcherbird		

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
Cracticus torquatus	grey butcherbird		
Gymnorhina tibicen	Australian magpie		
Strepera graculina	pied currawong		
Cacatuidae			
Cacatua galerita	sulphur-crested cockatoo		
Cacatua roseicapillus	galah		
Calyptorhynchus lathami	glossy black-cockatoo	V	
Campephagidae			
Coracina novaehollandiae	black-faced cuckoo-shrike		
Lalage tricolor	white-winged triller		
Charadriidae			
Vanellus miles	masked lapwing		
Climacteridae			
Climacteris picumnus victoriae	brown treecreeper (eastern subspecies)	V	
Corombates leucophaea	white-throated treecreeper		
Columbidae			
Ocyphaps lophotes	crested pigeon		
Corcoracidae			
Corcorax melanorhamphos	white-winged chough		
Corvidae			
Corvus coronoides	Australian raven		
Cuculidae			
Chalcites lucidus	shining bronze-cuckoo		
Cacomantis flabelliformis	fan-tailed cuckoo		
Dicruridae			
Grallina cyanoleuca	magpie-lark		
Rhipidura fuliginosa	grey fantail		
Rhipidura leucophrys	willie wagtail		
Estrildidae			
Taeniopygia bichenovii	double-barred finch		
Falconidae			
Falco cenchroides	nankeen kestrel		
Falco longipennis	Australian hobby		
Falco peregrinus	peregrine falcon		
Halcyonidae			
Dacelo novaeguineae	laughing kookaburra		
Todiramphus macleayii	forest kingfisher		
Hirundinidae			
Hirundo neoxena	welcome swallow		

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
Hirundo nigricans	tree martin		
Maluridae			
Malurus cyaneus	superb fairy-wren		
Meliphagidae			
Acanthorhynchus tenuirostris	eastern spinebill		
Lichenostomus chrysops	yellow-faced honeyeater		
Lichenostomus penicillatus	white-plumed honeyeater		
Manorina melanocephala	noisy miner		
Melithreptus brevirostris	brown-headed honeyeater		
Plectorhyncha lanceolata	striped honeyeater		
Philemon corniculatus	noisy friarbird		
Meropidae			
Merops ornatus	rainbow bee-eater		
Monarchidae			
Grallina cyanoleuca	magpie-lark		
Nectariniidae			
Dicaeum hirundinaceum	mistletoebird		
Neosittidae			
Daphoenositta chrysoptera	varied sittella	V	
Pachycephalidae			
Colluricincla harmonica	grey shrike-thrush		
Pachycephala pectoralis	golden whistler		
Pachycephala rufiventris	rufous whistler		
Pardalotidae			
Pardalotus punctatus	spotted pardalote		
Pardalotus striatus	striated pardalote		
Petroicidae			
Eopsaltria australis	eastern yellow robin		
Melanodryas cucullata cucullata	hooded robin (south-eastern form)		
Microeca leucophaea	jacky winter		
Petroica goodenovii	red-capped robin		
Petroica rosea	rose robin		
Phasianidae			
Coturnix ypsilophora	brown quail		
Chenonetta jubata	Australian wood duck		
Anas gracilis	grey teal		
Anas superciliosa	Pacific black duck		
Podargidae			
Podargus strigoides	tawny frogmouth		

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
Podicipedidae			
Tachybaptus novaehollandiae	Australasian grebe		
Pomatostomidae			
Pomatostomus temporalis temporalis	grey-crowned babbler (eastern subsp.)	V	
Psittacidae			
Alisterus scapularis	Australian king-parrot		
Platycercus eximius	eastern rosella		
Psephotus haematonotus	red-rumped parrot		
Trichoglossus haematodus	rainbow lorikeet		
Rhipiduridae			
Rhipidura albiscapa	grey fantail		
Rhipidura leucophrys	willie wagtail		
Sturnidae			
*Sturnus vulgaris**	common starling		
Zosteropidae			
Zosterops lateralis	silvereye		
MAMMALS			
Bovidae			
Bos taurus	cow		
**Capra hircus*	goat		
Canidae			
**Canis familiaris*	dog (scats)		
**Vulpes vulpes*	fox		
Cervidae			
**Cervus timorensis*	rusa deer		
Emballonuridae			
Saccolaimus flaviventris	yellow-bellied sheathtail-bat	V	
Felidae			
**Felis catus*	cat		
Leporidae			
**Oryctolagus cuniculus*	rabbit		
Macropodidae			
Macropus giganteus	eastern grey kangaroo		
Macropus robustus	common wallaroo		
Macropus rufogriseus	red-necked wallaby		
Wallabia bicolor	swamp wallaby		
Molossidae			
Mormopterus norfolkensis	east coast freetail-bat	V	
Mormopterus planiceps	southern freetail-bat		

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
Nyctinomus australis	white-striped freetail-bat		
Muridae			
**Rattus rattus*	black rat		
Petauridae			
Petaurus norfolcensis	squirrel glider	V	
Phalangeridae			
Trichosurus vulpecula	common brushtail possum		
Pseudocheiridae			
Pseudocheirus peregrinus	common ringtail possum		
Pteropodidae			
Pteropus poliocephalis	grey-headed flying-fox	V	V
Rhinolophidae			
Rhinolophus megaphyllus	eastern horseshoe-bat		
Tachyglossidae			
Tachyglossus aculeatus	short-beaked echidna		
Suidae			
**Sus scrofa*	pig		
Vespertilionidae			
Chalinolobus dwyeri	large-eared pied bat	V	V
Chalinolobus gouldii	Gould's wattled bat		
Chalinolobus morio	chocolate wattled bat		
Falsistrellus tasmaniensis	eastern false pipistrelle	V	
Myotis macropus	large-footed myotis	V	
Scotorepens balstoni	inland broad-nosed bat		
Scotorepens orion	eastern broad-nosed bat		
Vespadelus vulturnus	little forest bat		
Vombatidae			
Vombatus ursinus	common wombat		
Amphibians			
Hylidae			
Litoria latopalmata	broad-palmed frog		
Litoria peronii	Perons tree frog		
Myobatrachidae			
Crinia signifera	brown froglet		
Limnodynastes tasmaniensis	spotted marsh frog		
REPTILES			
Agamidae			
Amphibolurus muricatus	jacky lizard		
Pogona barbata	eastern bearded dragon		

Scientific Name	Common Name	Conservation Status	
		BC Act	EPBC Act
Elapidae			
Vermicella annulata	bandy bandy		
Gekkonidae			
Diplodactylus vittatus	stone gecko		
Underwoodisaurus milii	thick-tailed gecko		
Scincidae			
Carlia tetradactyla	southern rainbow skink		
Cryptoblepharus virgatus	cream-striped shinning-skink		
Ctenotus taeniolatus	copper-tailed skink		
Egernia modesta			
Egernia striolata	tree skink		
Egernia whitii	Whites skink		
Lampropholis guichenoti	garden skink		

APPENDIX E

Biodiversity Credit Report

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 5/04/2019 Time: 10:02:59AM Calculator version: v4.0

Major Project details

Proposal ID:	238/2017/4592MP
Proposal name:	MCCOP
Proposal address:	Mangoola Mangoola
Proponent name:	Glencore
Proponent address:	Mangoola Mangoola NSW
Proponent phone:	0488220095
Assessor name:	Shaun Corry
Assessor address:	75 York Street Teralba NSW 2284
Assessor phone:	4950 5322
Assessor accreditation:	238

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter	6.46	253.00
Bull Oak grassy woodland of the central Hunter Valley	32.40	1,597.00
Forest Red Gum grassy open forest on floodplains of the lower Hunter	29.91	1,874.00
Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	492.74	13,457.36
Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	6.30	369.00
Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	2.95	168.00
Total	570.76	17,718

Credit profiles

1. Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, (HU817)

Number of ecosystem credits created	13,457
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, (HU817) Weeping Myall - Coobah - Scrub Wilga shrubland of the Hunter Valley, (HU652) White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley, (HU730) Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter, (HU905)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

2. Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, (HU817)

Number of ecosystem credits created	0
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Weeping Myall - Coobah - Scrub Wilga shrubland of the Hunter Valley, (HU652) White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley, (HU730) Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, (HU817) Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter, (HU905)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

3. Bull Oak grassy woodland of the central Hunter Valley, (HU906)

Number of ecosystem credits created	1,597
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Bull Oak grassy woodland of the central Hunter Valley, (HU906) Weeping Myall - Coobah - Scrub Wilga shrubland of the Hunter Valley, (HU652) White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley, (HU730) Grey Gum - Forest Red Gum - Yellow Box grassy tall open forest on mid-slopes of the Hunter Valley - North Coast escarpment, (HU691) Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion, (HU701) Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter, (HU817) Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter, (HU818) Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter, (HU905) Blakely's Red Gum - Rough-barked Apple shrubby woodland of central and upper Hunter, (HU910)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

4. Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter, (HU816)

Number of ecosystem credits created	369
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter, (HU816) Melaleuca decora low forest of the central Hunter Valley, Sydney Basin Bioregion, (HU564) Slaty Red Gum grassy woodland on hinterland foothills of the southern North Coast, (HU619) Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast, (HU802) Spotted Gum - Broad-leaved Mahogany - Grey Gum grass - shrub open forest on Coastal Lowlands of the Central Coast, (HU803) Spotted Gum - Broad-leaved Mahogany - Red Ironbark shrubby open forest, (HU804) Spotted Gum - Red Ironbark - Grey Gum shrub - grass open forest of the Lower Hunter, (HU806) Red Ironbark - Spotted Gum - Prickly-leaved Paperbark shrubby open forest of the Lower Hunter, (HU807) Spotted Gum - Red Ironbark - Narrow-leaved Ironbark - Grey Box shrub-grass open forest of the lower Hunter, (HU814) Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter, (HU815) Grey Box - Grey Gum - Rough-barked Apple - Blakely's Red Gum grassy open forest of the central Hunter, (HU822)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

5. Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter, (HU821)

Number of ecosystem credits created	253
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter, (HU821) White Box - Silvertop Stringybark +/- White Cypress Pine grass shrub open forest of the southern Nandewar Bioregion and New England Tableland Bioregion, (HU729) White Box - Sticky Daisy Bush - Bead Bush shrubby woodland with semi - evergreen vine thicket elements of the Central Hunter Valley, (HU800)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

6. Forest Red Gum grassy open forest on floodplains of the lower Hunter, (HU812)

Number of ecosystem credits created	1,874
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Forest Red Gum grassy open forest on floodplains of the lower Hunter, (HU812) Coastal floodplain sedgelands, rushlands, and forblands of the North Coast, (HU532) Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion, (HU635) Parramatta red gum - Fern-leaved banksia - Melaleuca sieberi swamp woodland of the Tomaree Peninsula, (HU865) Prickly-leaved Paperbark - Flax-leaved Paperbark swamp forest on poorly drained soils of the Central Coast, (HU929) Cabbage Gum - Forest Red Gum - Flax-leaved Paperbark Floodplain Forest of the Central Coast, (HU934) Swamp Oak - Sea Rush - Baumea juncea swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU941) Swamp Oak - Prickly Paperbark - Tall Sedge swamp forest on coastal lowlands of the Central Coast and Lower North Coast, (HU942) Grey Gum - Red Gum - Paperbark shrubby open forest on coastal lowlands of the Northern Sydney Basin and Lower North Coast, (HU963)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

7. Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945)

Number of ecosystem credits created	168
IBRA sub-region	Kerrabee - Hunter/Central Rivers

Offset options - Plant Community types	Offset options - IBRA sub-regions
Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley, (HU945) Swamp Mahogany swamp forest on coastal lowlands of the NSW North Coast Bioregion and northern Sydney Basin Bioregion, (HU633) Prickly-leaved Paperbark forest on coastal lowlands of the Central Coast and Lower North Coast, (HU930) Broad-leaved Paperbark - Swamp Mahogany - Swamp Oak - Saw Sedge swamp forest of the Central Coast and Lower North Coast, (HU931) Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast, (HU932) Paperbarks - Woollybutt swamp forest on coastal lowlands of the Central Coast, (HU933) Melaleuca biconvexa - Swamp Mahogany - Cabbage Palm swamp forest of the Central Coast, (HU937) Swamp paperbark - Baumea juncea swamp shrubland on coastal lowlands of the Central Coast and Lower North Coast, (HU944)	Kerrabee - Hunter/Central Rivers and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Large-eared Pied Bat	Chalinolobus dwyeri	2.10	27
Southern Myotis	Myotis macropus	0.90	20
Pine Donkey Orchid	Diuris tricolor	0.00	17,238
Pine Donkey Orchid	Diuris tricolor	1,326.00	17,238
Prasophyllum sp. Wybong	Prasophyllum sp. Wybong	691.00	8,983

APPENDIX F

Aquatic Ecology Assessment Report

MANGOOLA COAL CONTINUED OPERATIONS PROJECT

Aquatic Ecology Assessment

FINAL

June 2019

MANGOOLA COAL CONTINUED OPERATIONS PROJECT

Aquatic Ecology Assessment

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Mangoola Coal Operations Pty Ltd

Project Director:	Allison Riley
Project Manager:	Shaun Corry
Report No.	3450/R13/Final
Date:	June 2019

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This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	Allison Riley	25/06/2019	Allison Riley	25/06/2019

Executive Summary

This aquatic ecology assessment for the Mangoola Coal Continued Operations (MCCO) Project has been prepared based on a combination of field investigations and a review of available aerial photographs, topographic maps, databases, literature, policies and guidelines. The MCCO Project includes an infrastructure crossing of one named watercourse, being Big Flat Creek (fourth order at this location), with a number of minor un-named first and second order tributaries occurring within the MCCO Additional Project Area and will be impacted by mining activities. Wybong Creek (sixth order) is located downstream of the MCCO Additional Project Area. While Big Flat Creek is a fourth order stream, it is ephemeral and is characterised by variable and unpredictable patterns of flow including periods of no flow, has poor water quality and has heavily cleared catchments with agricultural and mining land uses.

Waterways were classified in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013) and un-named tributaries occurring within the MCCO Additional Project Area have been classified as having an un-recognised habitat sensitivity type (ie not sensitive) and are not considered as a watercourse for fish passage. Big Flat Creek was classified as Class 3 minimal key fish habitats and Type 3 minimal habitat sensitive and Wybong Creek was assessed as Class 1 – Major key fish habitat, with Type 1 - high habitat sensitivity.

One threatened species and one endangered fish population listed under the *Fisheries Management Act 1994* potentially occur in ecosystems downstream of the MCCO Additional Project Area, being the southern purple spotted gudgeon (*Mogurnda adspersa*) and the Darling River hardyhead Endangered Population. Neither the Darling River hardyhead Endangered Population or the southern purple spotted gudgeon are expected to occur in the MCCO Additional Project Area, and the predicted surface water and groundwater impacts of the MCCO Project are not predicted to adversely affect potential habitat for these species. No nationally listed threatened aquatic species, endangered populations, Threatened Ecological Communities (TEC) or aquatic migratory species are expected to occur in the watercourses within or adjacent to the MCCO Additional Project Area.

Vegetation mapping for the area of investigation has been overlaid with pre-mining modelled groundwater occurring within 10m of the surface to further refine the location of potential Groundwater Dependent Ecosystems (GDEs) in the area of investigation. Of the 16 vegetation communities occurring in areas of shallow groundwater only four communities were identified as having a moderate potential for being dependent on groundwater; two being riparian communities and two being floodplain communities.

The results of the groundwater assessment (AGE2019) concluded that MCCO Project is not expected to have an adverse effect on downstream groundwater resources such that aquatic biodiversity, stygofauna or terrestrial biodiversity associated with GDEs are adversely impacted.

Surface water impacts associated with the MCCO Project are not predicted to result in adverse surface water impacts on Big Flat Creek or in the downstream environments of Wybong Creek and the Goulburn River (HEC 2019) such that would result in adverse impacts on aquatic ecology values in these streams.

Overall, no aquatic biodiversity is anticipated to be adversely impacted due to the MCCO Project.

Glossary

ABL	Above sea level
AL	Assessment lease
BAR	Biodiversity Assessment Report
BFC	Big Flat Creek
CEEC	Critically endangered ecological community
DECC	NSW Department of Environment and Climate Change (now OEH)
DPI	NSW Department of Primary Industries
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EL	Exploration Lease
EP	Endangered population
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ETL	Electricity Transmission Line
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994*
GCAA	Glencore Coal Assets Australia
GDE	Groundwater Dependent Ecosystem
Ha	Hectare
HRSTS	Hunter River Salinity Trading Scheme
Km	Kilometres
kV	Kilovolt
LGA	Local Government Area
LPI	Land and Property Information
Mangoola	Mangoola Coal Operations Pty Limited
MCCO Project	Mangoola Coal Continued Operations Project
MNES	Matters of national environmental significance
Mtpa	Million tonnes per annum
OEH	Office of Environment and Heritage
PA	Project Approval
PMST	Protected Matters Search Tool
ROM	Run of mine

SEPP	State Environmental Planning Policy
SSD	State Significant Development
SSI	State Significant Infrastructure
TEC	Threatened ecological community
the Regulation	*Environmental Planning and Assessment Regulation 2000*
Umwelt	Umwelt (Australia) Pty Limited

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

Mangoola Coal Operations Pty Limited (Mangoola) engaged Umwelt (Australia) Pty Limited (Umwelt) to complete an Aquatic Ecology Assessment for the Mangoola Coal Continued Operations Project (MCCO Project). The purpose of the assessment was to identify and assess the impacts of the MCCO Project on aquatic biodiversity values in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013).

This Assessment forms part of an Environmental Impact Statement (EIS) being prepared to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

1.1 Project Overview

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer **Figure 1.1**). Mangoola has operated the Mangoola Coal Mine under Project Approval (PA) 06_0014 since mining commenced at the site in September 2010.

The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will extend the life of the existing operation providing for ongoing employment opportunities for the Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area as shown on **Figure 1.1**.

The MCCO Project generally comprises:

- open cut mining peaking at the same rate as that currently approved (13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal) using truck and excavator mining methods
- continued operations within the existing Mangoola Coal Mine
- mining operations in a new mining area located north of the existing Mangoola Coal Mine and Wybong Road, south of Ridgelands Road and east of the 500 kilovolt (kV) Electricity Transmission Line (ETL)
- construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the proposed Additional Mining Area
- establishment of an out-of-pit overburden emplacement area
- distribution of overburden between the proposed Additional Mining Area and the existing mine in order to optimise the final landform design of the integrated operation
- realignment of a portion of Wybong Post Office Road
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet
- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to that of the existing mine

- continued ability to discharge excess water in accordance with the Hunter River Salinity Trading Scheme (HRSTS)
- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of natural landform design principles consistent with the existing site
- rehabilitation of the proposed Additional Mining Area using the same revegetation techniques as at the existing mine
- a likely construction workforce of approximately 145 persons. No change to the existing approved operational workforce
- continued use of the mine access for the existing operational mine and access to/from Wybong Road, Wybong Post Office Road and Ridgelands Road to the MCCO Project Area for construction, emergency services, ongoing operational environmental monitoring and property maintenance.

Figure 1.2 illustrates the key features of the MCCO Project.

1.2 The MCCO Additional Project Area

The MCCO Additional Project Area occupies approximately 623 hectares (ha) and is located north and north-west of the existing Mangoola Coal mine operation. This area occurs within the Muswellbrook Shire Local Government Area (LGA) and within the Hunter River catchment area. This assessment is particularly focused on where the MCCO Additional Project Area overlays or is near to mapped watercourses. The MCCO Additional Project Area is shown on **Figure 1.2**.

The topography of the MCCO Additional Project Area is characterised by lower slopes, giving way to undulating hills and rocky outcrops to the north and west. Lower topographic areas are associated with drainage lines feeding Big Flat Creek to the south. A dominant topographical feature in the surrounding landscape is the series of undulating wooded hills which occur outside and to the north and west of the MCCO Additional Project Area. These hills rise to a maximum height of approximately 360 m Australian Height Datum (AHD) and are elevated approximately 200 m above the surrounding area.

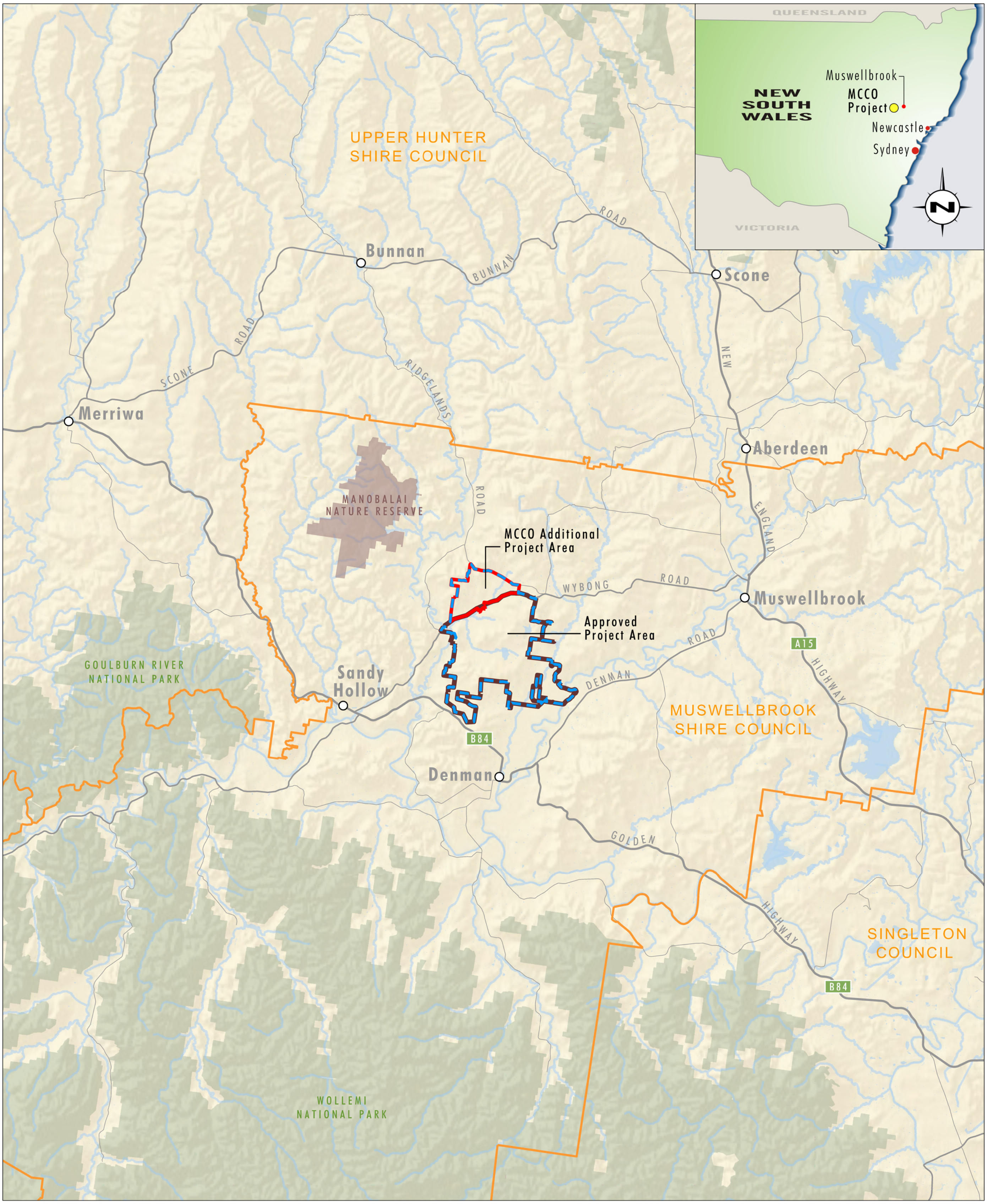
The MCCO Additional Project Area primarily lies within the catchment of Big Flat Creek with small sections extending into the Wybong Creek catchment. Big Flat Creek flows to Wybong Creek which is located approximately 600 m to the west of the MCCO Additional Project Area and is part of the upper catchment of the Hunter River (refer **Figure 1.2**). With regard to Big Flat Creek there is no mapped alluvium within the disturbance footprint associated with the proposed additional mining area. The nearest defined alluvial deposits are located to the west and are associated with Wybong Creek. Big Flat Creek overlies a shallow colluvium sourced from the weathered conglomerates, sandstones, siltstones, and tuffs.

1.3 Purpose and Scope of this Report

This report provides the results of the Aquatic Ecology Assessment of the MCCO Project. It addresses the specific requirements of the SEARs and the submission from the Department of Primary Industries (DPI) in relation to aquatic ecology, as summarised in **Table 1.1**.

Specifically, this assessment:

- describes the existing aquatic environment in terms of ecological values, including type and condition of aquatic habitats and groundwater dependent ecosystems (GDE)
- determines the presence or likelihood of occurrence of threatened species, populations and Endangered Ecological Communities (EECs) as listed under the *Fisheries Management Act 1994* (FM Act)
- determines the presence or likelihood of occurrence of matters of national environmental significance (MNES) as listed under the *Environment Biodiversity and Conservation Act 1999* (EPBC Act), relevant to the aquatic environment
- identifies threatened fish species, populations and ecological communities within the MCCO Project Area that have the potential to be impacted by the MCCO Project, and
- assesses the impact of the MCCO Project on aquatic species and ecosystems, and GDEs.



Data Source: Glencore (2018), LPI (2016)

0 5 10 20km
1:400 000

Legend

- MCCO Project Area
- Approved Project Area
- MCCO Additional Project Area
- Local Government Area

FIGURE 1.1

Regional Locality Plan

File Name (A4): R13/3450_075.dgn
20181004 14.01

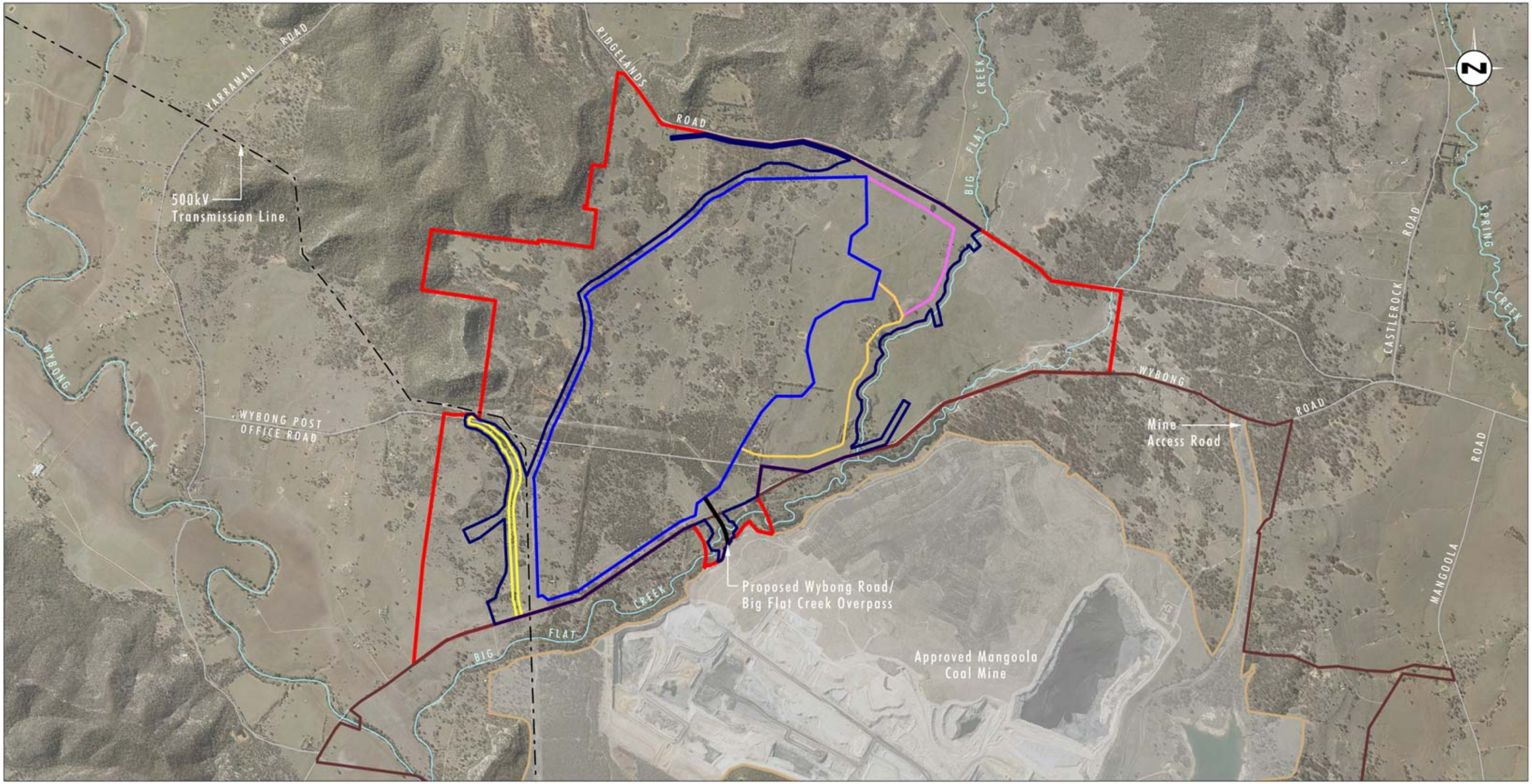


Image Source: Glencore (April 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Additional Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Proposed Additional Mining Area
- Proposed Emplacement Area
- Proposed Topsoil Stockpile Area
- Wybong Post Office Road Realignment

FIGURE 1.2

Mangoola Coal Continued Operations Project

File Name (A4): R13/3450_076.dgn
20190402 13.40

Table 1.1 Relevant SEARs

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
DPE SEARs – Biodiversity	
An assessment of the likely biodiversity impacts of the development, paying particular attention to threatened species, populations and ecological communities and groundwater dependent ecosystems, and having regard to the Framework for Biodiversity Assessment and Biobanking Assessment Methodology.	This report addresses impact on aquatic ecology. Refer to the BAR for other biodiversity impacts.
Department of Primary Industries	
Waterway Crossings DPI Fisheries need to be consulted with regards to the crossing methodology and site specific mitigation measures for replacement of culverts and bridges in watercourses that are considered to be Key Fish Habitat. The design and construction of bridges, culverts, and temporary access tracks across all waterways should be undertaken in accordance with the Department's Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013). The replacement of waterway crossings needs to ensure that the works are undertaken with minimal impact on the aquatic environment within the immediate vicinity of the proposed works. The environmental assessment should provide details on methods of dredging, duration and timing of works, and the proposed mitigation measures to protect riparian and aquatic habitat. Another concern is the requirement to avoid temporary waterway crossings for heavy machinery wherever possible. DPI Fisheries should be consulted with regards to any temporary measures that will result in blocking fish passage. This includes coffer dams, temporary access tracks or redirecting flows whilst works are conducted.	Section 4

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
Groundwater Dependent Ecosystems The Assessment must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: • Identify any potential impacts on GDEs as a result of the Project including: o the effect of the Project on the recharge to groundwater systems o the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections, and o the effect on the function of GDEs (habitat, groundwater levels, connectivity). • Provide safeguard measures for any GDEs.	Section 3.4 and Section 4.2 Refer also to the GDE assessment in the EIS.
Guidelines: • NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002) • Risk Assessment Guidelines for Groundwater Dependent Ecosystems (DPI 2012) • Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013).	This report

1.4 Legislative Context

1.4.1 NSW Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (the Regulation) provide the framework for development assessment in NSW. The EP&A Act and the Regulation include provisions to ensure that the potential environmental impacts of a development are considered in the decision making process prior to proceeding to construction. This report considers the impacts of the MCCO Project on aquatic ecology.

1.4.2 NSW Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) provides for the conservation, protection and management of fisheries, aquatic systems and habitats in NSW. The FM Act establishes mechanisms for:

- the listing of threatened species, populations and ecological communities or key threatening processes
- the declaration of critical habitat, and
- consideration and assessment of threatened species impacts in the development assessment process.

Section 3.3 of this report identifies threatened species, populations and communities with potential to occur in the MCCO Additional Project Area and **Section 4.3** of this report assesses likely impacts of the MCCO Project in accordance with section 5A of the EP&A Act.

Division 3 of the FM Act provides for the conservation of the biodiversity of fish and aquatic vegetation and protection of fish habitat though management of dredging and reclamation works. Upgrades of waterway structures such as bridges or culverts and the upgrade or construction of waterway crossings would require 'dredging' (excavation of water land or removal of material from water land) or 'reclamation' (using material to fill/reclaim or depositing material to construct anything other than water land). **Section 3** of this report describes aquatic habitats and **Section 4** describes the impacts of the proposed works within the waterways.

Any construction of waterway structures and/or crossings will need to consider fish habitat class and the use of an appropriately designed structure that does not obstruct fish passage. **Section 3.1** of this report describes fish habitat class and **Section 4** identifies the potential impacts and design requirements for structures for waterways.

1.4.3 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Environment Biodiversity and Conservation Act 1999* (EPBC Act) is the primary piece of Federal legislation relating to the environment. Under the EPBC Act any 'action' that is, has, or is likely to have, a significant impact on a MNES requires approval from the Commonwealth Minister for the Environment. An 'action' is defined as a project, development, undertaking, activity (or series of activities), or alteration of any of these. These matters are:

- listed threatened species and communities
- migratory species protected under international agreements

- Ramsar wetlands of international importance
- the Commonwealth marine environment
- World Heritage properties
- National Heritage places
- Great Barrier Reef Marine Park
- nuclear actions and
- a water resource, in relation to coal seam gas development and large coal mining development.

A Referral was submitted to the DoEE in October 2017 and the MCCO Project was determined to be a 'controlled action' on 22 January 2019. The controlling provisions do not include any identified potential impacts to listed aquatic species or communities, however, an assessment of the impact of the proposal on aquatic MNES is provided in **Section 4.4**.

2.0 Assessment Methodology

2.1 Literature and Database Review

A desktop review of previous documents and reports relevant to the MCCO Project was undertaken. The following ecological database searches were undertaken to determine whether threatened species or aquatic communities had been previously identified in the local area:

- a 10 kilometre buffer search from the MCCO Additional Project Area on the Commonwealth Department of the Environment and Energy Protected Matters Search Tool (DoEE 2018 – accessed November 2018)
- a search of the Muswellbrook LGA using the DPIs Threatened species distribution maps (DPI 2018).

Relevant documents included:

- Mangoola Coal Stream Health Monitoring Program – Autumn and Spring 2017 (Biosis 2018)
- Mangoola Coal Stream Health Monitoring Program – Autumn and Spring 2018 (Biosis 2019)
- Key Fish Habitat mapping for Muswellbrook LGAs as prepared by DPI
- Online publications and determinations for threatened fish, endangered populations and ecological communities as listed under the FM Act and the EPBC Act.

The information obtained was used to assist in the description of ecological context, assessment of potentially occurring threatened species, endangered populations (EPs) and Threatened Ecological Communities (TECs).

2.2 Stream Order Mapping

In characterising the watercourses in the MCCO Additional Project Area, consideration has to be given to the Strahler ordering system, as described in *NSW Government Gazette no. 37* on 24 March 2006.

The Strahler ordering system is a hierarchical numbering system based on the degree of branching within a watercourse and provides an indication of the complexity of a creek system. The methodology used is as follows:

- at its origin, a watercourse is numbered as first order. The watercourse remains first order until it joins another watercourse
- if the watercourse joins another first order watercourse, downstream of the confluence is deemed second order. The confluence of two watercourses with a similar order results in the order increasing by one, so that two second order streams joining will result in a third order stream, and so on, moving downstream
- where a watercourse of a higher order joins with a lower order watercourse, downstream of the confluence remains at the higher order.

The Strahler stream orders have been assigned to Land and Property Information (LPI) natural drainage line layer, based on the Strahler number algorithm. Stream orders are shown on **Figure 2.1**.

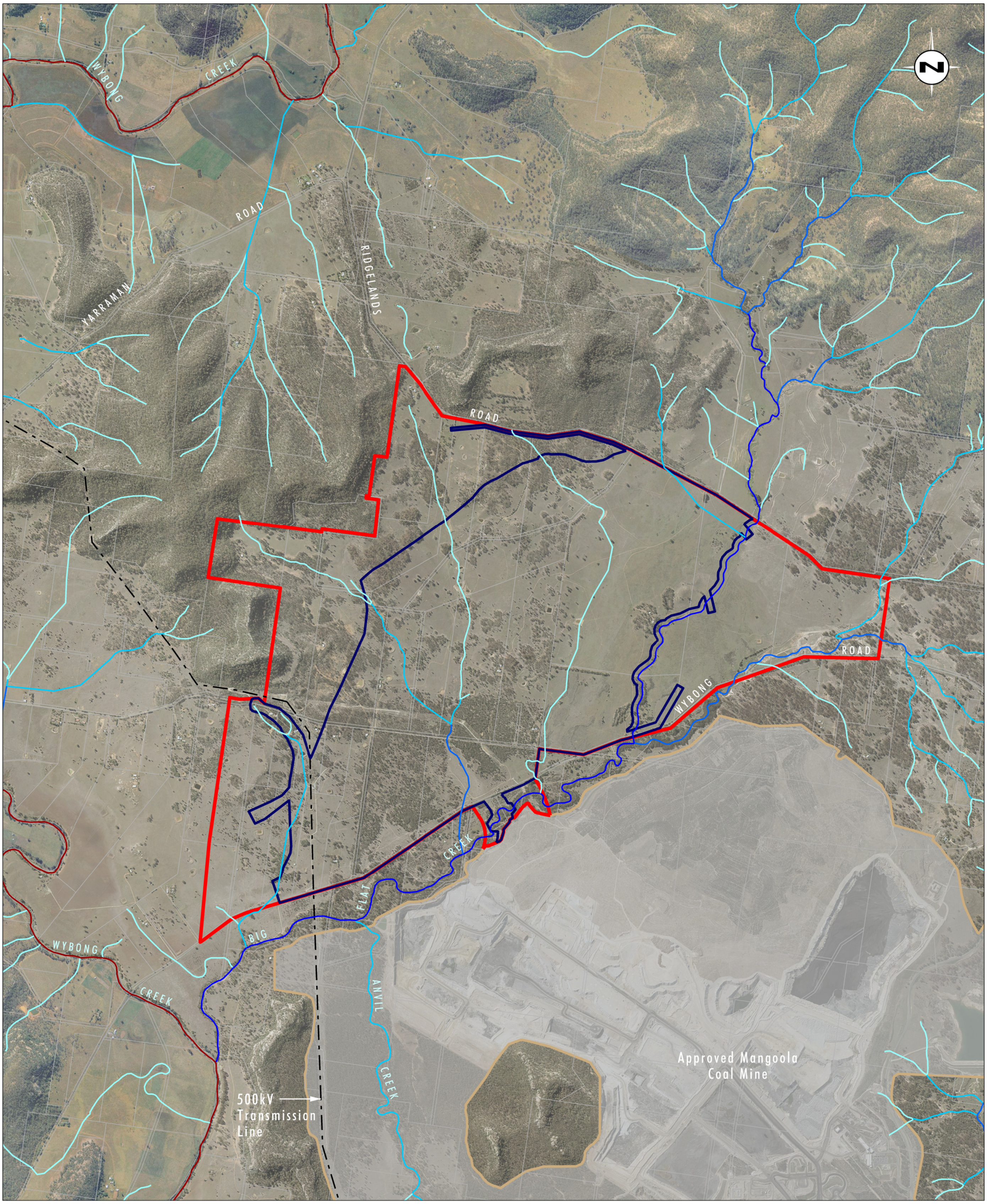


Image Source: Glencore (April 2018)
Data Source: Glencore (2018), Office of Environment and Heritage (OEH) (2017)

0 0.5 1.0 2.0km
1:40 000

Legend

MCCO Additional Project Area
MCCO Additional Disturbance Area
Approved Mangoola Coal Mine Disturbance Area

Stream Order:
1st Order Stream
2nd Order Stream
3rd Order Stream
4th Order Stream
5th Order Stream
6th Order Stream

FIGURE 2.1

Strahler Stream Orders

File Name (A4): R13/3450_077.dgn
20190418 13.36

2.3 Aquatic Habitat Mapping

Preliminary mapping of the broad scale aquatic habitats within the MCCO Additional Project Area was undertaken using recent aerial photography (April 2018) in conjunction with topographic maps prior to field surveys. Topographic maps were used to gain a broad understanding of catchment characteristics including adjacent land use, elevation, access routes, distance from source and location of barriers to fish passage, such as dams and weirs.

An assessment of the aquatic habitat characteristics of watercourses within the MCCO Additional Project Area was undertaken in July 2017, and indicators of stream condition were also noted. The aquatic habitat characteristics were recorded using standard recording sheets (adapted from those developed for the AUSRIVAS sampling protocol available as a web resource (AUSRIVAS 2007).

Some of the habitat features and stream condition indicators assessed included:

- characteristics of bed substrate
- presence of in-stream woody debris
- presence of gravel beds
- presence of drought and flood refuge areas
- depth of water
- width of channel
- presence of pool, riffle and edge habitats
- height of bank and evidence of erosion
- channel geomorphology
- evidence of sediment deposition
- degree of bank erosion
- the presence of natural or artificial barriers to fish passage upstream and downstream
- colour and clarity of water, and any visual evidence of water quality
- characteristics of in-stream, riparian and floodplain vegetation.

Detailed assessments were undertaken at sixteen locations along Big Flat Creek, upstream and adjacent to the MCCO Additional Project Area. The sampling locations are shown on **Figure 2.2**.

2.4 Stream Health Monitoring Program

Biosis was engaged by Mangoola to undertake twice-annual stream health monitoring to fulfil the requirements of the Mangoola Open Cut Surface Water Monitoring Plan (SWMP). As part of the SWMP, a stream health monitoring program was developed to facilitate compliance with the development consents and Environment Protection Licences associated with the mine's operation and enable monitoring of stream health and identification of changes that may be the result of mining activities. The initial stream health assessment was undertaken in November 2004 (Tuft 2007), and Biosis was engaged in 2009 to establish and conduct biannual stream health monitoring surveys to date (Biosis 2019).

The stream health monitoring program encompasses ten potential impact sites (monitoring sites) across four major waterways that traverse the Mangoola Open Cut site - Big Flat Creek, Wybong Creek, Anvil Creek and Sandy Creek. The program also established eight control sites in 2013 with catchments similar to the monitoring sites to differentiate potential mining impacts from environmentally driven variations due to natural processes. The control sites are located across four waterways - Cuan Creek, Wybong Creek (upstream of the mine site), Unnamed Creek 1 and Unnamed Creek 2. The location of the monitoring sites is shown on **Figure 2.3**.

Annual stream health monitoring in undertaken for Big Flat Creek, Wybong Creek and Sandy Creek and includes the monitoring of macroinvertebrate assemblages and riparian vegetation, with the monitoring program described in the Plan for Surface Water Monitoring (Mangoola Coal Operations 2018). The monitoring is undertaken bi-annually in autumn and spring in accordance with a recognised system such as AUSRIVAS and Stream Invertebrate Grade Number – Average Level (SIGNAL). The Stream Health Monitoring Program assesses macroinvertebrate community structures, water quality, channel stability and overall catchment-riparian health through:

- NSW AUSRIVAS and SIGNAL2 sampling and analyses
- HABSCORE assessments
- physical and chemical multiparameter water testing.

The SIGNAL2 method (Stream Invertebrate Grade Number Average Level version 2) assigns each macroinvertebrate group a number representative of that group's pollution tolerance, which is then used to calculate the overall water quality of the site. Combined with a HABSCORE assessment that evaluates physical habitat structure and availability, these methods provide a thorough assessment of the relative ecological health at a monitoring site. HABSCORE has the additional benefit of providing a measure of relative stream health even when a sample site is dry and AUSRIVAS sampling is not possible. These data are further useful in evaluating the effectiveness of water quality protection measures and impact mitigation implemented throughout the Mangoola Open Cut site, and detecting impacts to ecological values and water quality as a result of mining operations.

Barbour et al. (1999) describe HABSCORE as a 'visually based habitat assessment that evaluates the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community'. HABSCORE assessments are based on the presence and condition of the following habitat characteristics:

- pool substrate characterisation
- pool variability
- channel flow status

- bank vegetation (score for each bank)
- bank stability (score for each bank)
- width of riparian zone (score for each bank)
- epifaunal substrate / available cover.

These characteristics provide an indicator of the quality of the waterway even when there is insufficient water for AUSRIVAS assessments. HABSCORE categories are derived from the sum of scores divided by the maximum possible score for the characters assessed and range from 'Poor' to 'Optimal' condition, and are described by Barbour et al (1999) as follows:

- **Optimal**: watercourses that contain numerous large, permanent pools and generally have flow connectivity except during prolonged drought. They provide extensive and diverse aquatic habitat for aquatic flora and fauna.
- **Suboptimal**: watercourses that contain some larger permanent and semi-permanent refuge pools, which would persist through prolonged drought although, become greatly reduced in extent. These watercourses should support a relatively diverse array of aquatic biota including some fish, freshwater crayfish and aquatic macroinvertebrates. There may also be some aquatic plant species present.
- **Marginal**: watercourses that contain some small semi-permanent refuge pools which are unlikely to persist through prolonged drought. Flow connectivity would only occur during and following significant rainfall. These pools may provide habitat for some aquatic species including aquatic macroinvertebrates and freshwater crayfish.
- **Poor**: water courses or drainages that only flow during and immediately after significant rainfall. Permanent or semi-permanent pools that could provide refuge for aquatic biota during prolonged dry weather are absent.

The results and conclusions of the annual stream health monitoring have been used to inform this aquatic ecology assessment and are discussed in **Section 3.1.2**.

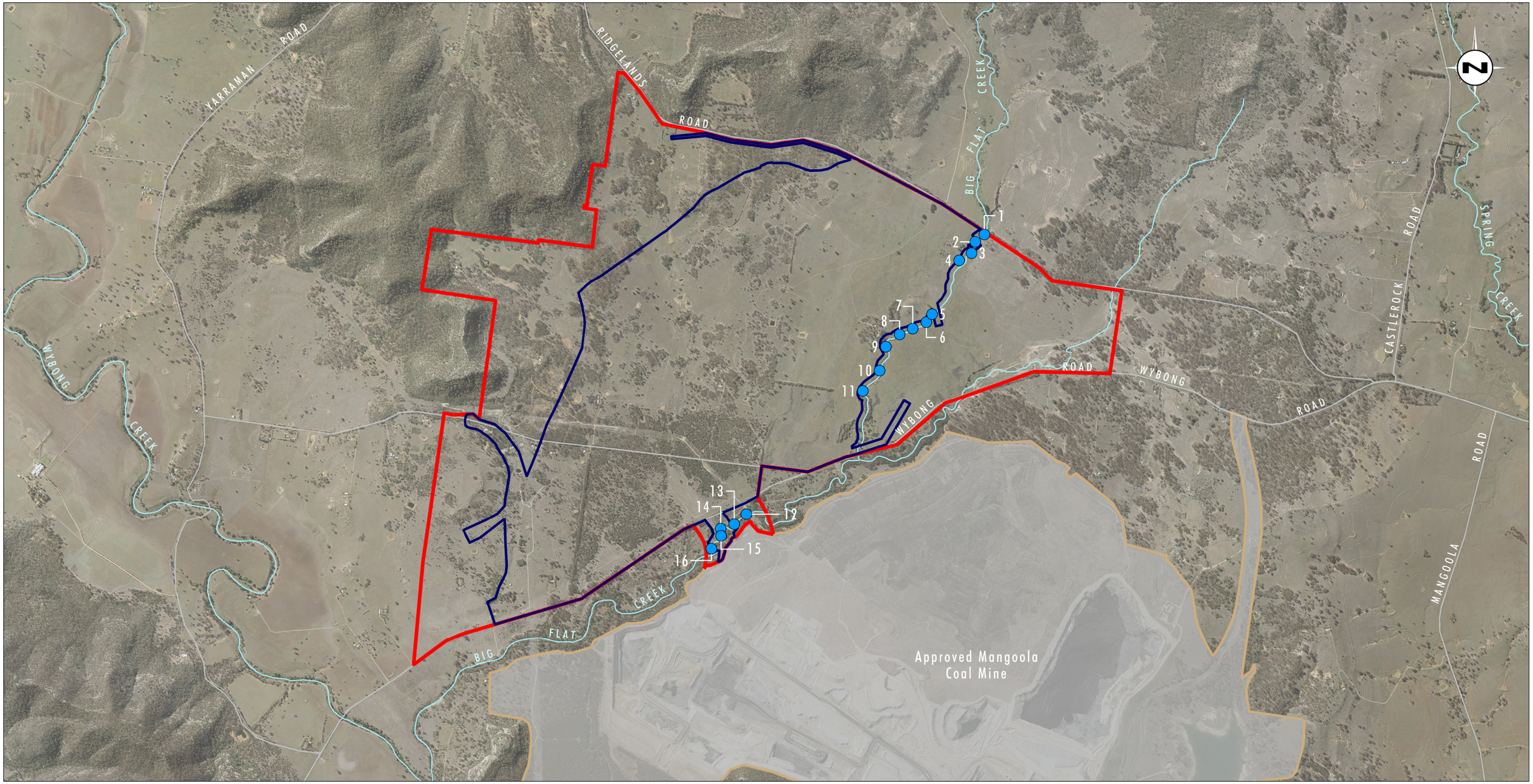


Image Source: Glencore (2018)
Data Source: Glencore (2018)

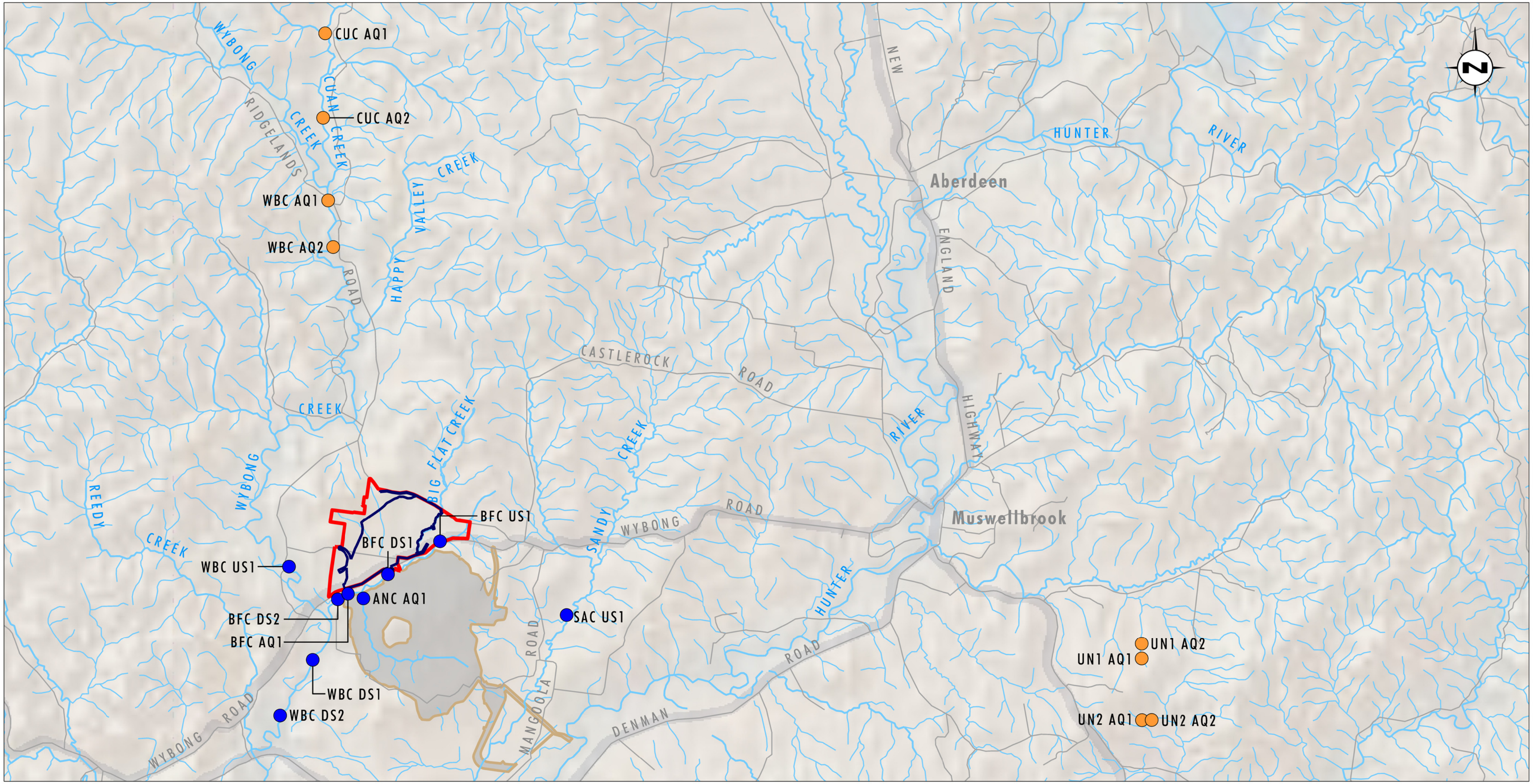
Legend

- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Approved Mangoola Coal Mine Disturbance Area
- Aquatic Habitat Assessment Location

FIGURE 2.2

Aquatic Habitat Assessment Locations

File Name (A4): R3/3450_037.dgn
20190402 13.43



Data Source: Glencore (2018), LPI (2013), BIOSIS (2019)

0 2.5 5.0 10.0km
1:200 000

Legend

- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Approved Mangoola Coal Mine Disturbance Area
- Aquatic Monitoring Site
- Aquatic Monitoring Control Site

FIGURE 2.3

Monitoring and Control Sites (BIOSIS 2019)

File Name (A4): R13/3450_078.dgn
20190418 13.49

3.0 Results

The MCCO Additional Project Area has been used extensively for agriculture since the 1800s and is comprised of rolling grazing land and patches of native woodland. An analysis of historical aerial photography indicates that most of the area had been cleared by the 1950s. To the north and east are areas of Mangoola owned grazing land and existing biodiversity offset areas and to the north-west and west forested Crown land and private grazing properties.

The main drainage feature in the vicinity of the MCCO Additional Project Area is Wybong Creek which is located outside of and to the west of the MCCO Additional Project Area (refer to **Figure 1.2**). Wybong Creek flows into the Goulburn River approximately 10 km south-west of the MCCO Additional Project Area. The Goulburn River is a major tributary of the Hunter River and the Wybong Creek confluence is approximately 16 km upstream of the Goulburn River/Hunter River confluence. The main stream channel of Wybong Creek downstream of the MCCO Additional Project Area is approximately 30 m wide and contains an alluvial base with a meandering low flow channel. Flow in Wybong Creek is recorded at a nearby NSW DPIs - Water gauging station (GS 210040). The record indicates that flow is effectively perennial with no flow recorded on approximately three per cent of days in the record.

The MCCO Additional Project Area is principally drained by Big Flat Creek and its tributaries (refer to **Figure 2.1**). Big Flat Creek joins Wybong Creek south-west of the MCCO Additional Project Area. The main channel of Big Flat Creek parallels Wybong Road and separates the MCCO Additional Project Area from the existing approved Mangoola Coal Mine. The main northern leg of Big Flat Creek rises in hills to the north-east of the MCCO Additional Project Area. The main stream channel of Big Flat Creek is typically between 3 m and 15 m wide. The reaches of Big Flat Creek within and upstream of the MCCO Additional Project Area have been disturbed by past agricultural activity, including the presence of 'farm dams'. Flow in Big Flat Creek is ephemeral and salinity values, measured upstream of existing operations, are considered high for a natural stream, with a long term average electrical conductivity value of more than 11,000 µs/cm and total dissolved solids of above 6,500 mg/L.

Big Flat Creek has an estimated total catchment area of 40.8 km^2 (based on the impact of the existing area of the approved Mangoola Coal mine), while Wybong Creek has an estimated total catchment area of 795 km^2.

A number of small un-named drainage lines traverse the MCCO Additional Project Area from north to south and drain into Big Flat Creek to the south of the MCCO Additional Project Area. As shown on **Figure 2.1**, these drainage lines are first and second order streams.

Hydrogeology

The coal measures and overlying bedrock form porous and fractured rock aquifers. The groundwater regime within and surrounding the MCCO Additional Project Area has been identified to include the following zones where groundwater occurs:

- weathered zone – in some areas springs from weathered material can occur following periods of high rainfall, depleting during extended dry periods - water is fresh to saline
- conglomerate - where intergranular matrix storage is significant - water quality is generally saline particularly in the Big Flat Creek area, and
- coal seams within coal cleats and joints, which are generally confined above and below by low permeability interburden aquitards – water quality is generally brackish to saline.

The remaining interburden materials are hydrogeologically 'tight' and therefore low yielding.

As the pre-mining water table is above the base of the proposed mining area, mining will intercept groundwater. The existing Mangoola Coal Mine first intercepted groundwater in 2014. The groundwater responses observed from mining at the approved Mangoola Coal Mine assist with understanding the potential impacts that could result from the MCCO Project.

The Wybong Creek alluvium, approximately 1 km to the west of the MCCO Additional Project Area is classified under the *NSW Aquifer Interference Policy* as a 'highly productive' alluvial aquifer. Highly productive groundwater sources are those with:

- a total dissolved solids concentration of less than 1,500 mg/L, and
- contain water supply works that can yield water at a rate greater than 5 L/s.

The Wybong Creek alluvium will not be mined, with an approximately 1,000 m buffer maintained between the MCCO Additional Project Area and the Wybong Creek alluvium, however, there is predicted to be a small passive groundwater take as the Permian strata become depressurised through mining and less groundwater flows into the alluvium.

The Sandy Creek alluvium is located within the south-east of the MCCO Additional Project Area and is also classified as a highly productive aquifer. However, as the coal measures being mined within the MCCO Additional Project Area dip to the west and subcrop before reaching the Sandy Creek alluvium, there is limited potential for propagation of impacts from the MCCO Project to impact on the Sandy Creek alluvium.

Big Flat Creek is ephemeral in nature with little or no flow during extended dry periods. The creek overlies a thin colluvium and investigations have determined it has no associated alluvium.

3.1 Watercourse Description and Classification

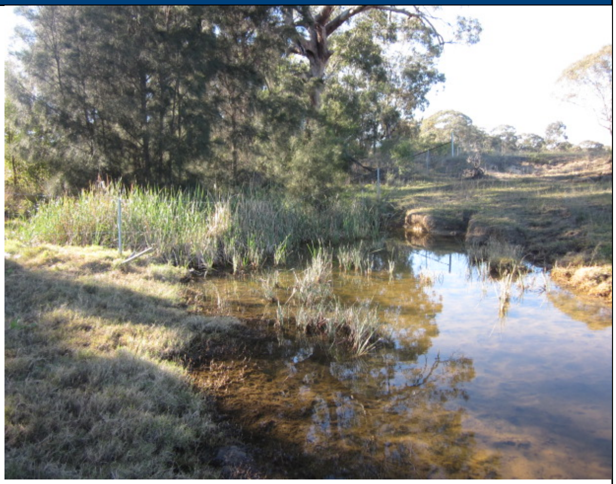
As noted in **Section 1.2**, the MCCO Project Area falls within the Hunter River catchment area. Big Flat Creek flows from the north-east through the MCCO Additional Project Area, and along the southern boundary before joining Wybong Creek to the south-west. The sixteen aquatic habitat assessment locations surveyed as part of the MCCO Project are shown on **Figure 2.2** and the stream monitoring sites sampled annually in accordance with the Plan for Surface Water Monitoring (Mangoola Coal Operations 2018) are shown on **Figure 2.3**.

3.1.1 Results of Big Flat Creek Aquatic Habitat Investigation

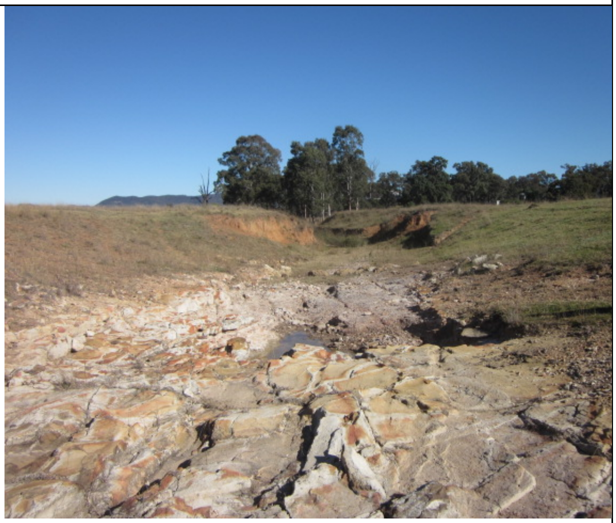
Sites beginning from the northern boundary of the MCCO Additional Project Area (AQ1-AQ11 – refer to **Figure 2.2**) are deeply eroded and largely dry, with evidence of cattle disturbance visible in many places. Minimal riparian vegetation is present, and in-channel vegetation is dominated by the weed sharp rush (*Juncus acutus subsp. acutus*), couch grass (*Cynodon dactylon*) and kikuyu grass (*Pennisetum clandestinum*). An exposed sandstone bedrock riffle occurs at AQ7, with minimal water pooling at the base. Some modifications to the watercourse occur at AQ5 and AQ9, where concrete and gortex erosion controls and concrete rubble crossings are present.

Along the MCCO Additional Project Area boundary (AQ12-AQ16) Big Flat Creek supports generally well developed riparian vegetation dominated by swamp oak (*Casuarina glauca*), sharp rush (*Juncus acutus* subsp. *acutus*) , bullrush (*Typha orientalis*) and weeping grass (*Microlaena stipoides*). Instream aquatic habitats present include occasional pool/riffle sequences and woody debris and detritus. Pools are interconnected with no obvious flow (at the time of inspection), and generally high turbidity within the water column. No fish were observed at any of the aquatic habitat assessment locations during the survey. Notable habitat features of aquatic habitat assessment locations sites are shown in **Table 3.1**.

Table 3.1 Riparian Vegetation and aquatic habitat features recorded at aquatic habitat assessment locations along Big Flat Creek

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
1	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha* sp.), swamp oak (*Casuarina glauca*), native juncus (*Juncus sp*), couch (*Cynodon dactylon*). Pool with 40cm - 50cm water depth. No sandy or stone beds or riffles identified. Evidence of cattle disturbance.	
2	Riparian vegetation absent. Weeds predominate, including Sharp rush (*Juncus acutus*), kikuyu (*Pennisetum clandestinum*) Deeply eroded pool, to approximately 1m depth. Very poor aquatic habitat.	

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
3	Riparian vegetation absent. Weeds predominate, including Sharp rush (*Juncus acutus*), kikuyu (*Pennisetum clandestinum*) Minor sandy riffles between shallow pools. Evidence of cattle disturbance. Very poor aquatic habitat.	
4	No riparian vegetation, shallow swale dominated by pasture grasses. Weeds predominate, including sharp rush (*Juncus acutus*), kikuyu (*Pennisetum clandestinum*) Very poor aquatic habitat.	
5	Erosion stabilisation works evident at this location, with pooled water at base of concreate structure. Riparian and aquatic vegetation and habitat absent.	

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
6	Flow control structure evident constructed from concrete and rock. No native riparian or instream aquatic vegetation recorded. The introduced sharp rush (*Juncus acutus*) was commonly recorded. Very poor aquatic habitat.	
7	No native riparian or instream aquatic vegetation recorded. Large area of exposed sandstone bedrock. Very small pools evident.	
8	Narrow band of riparian vegetation recorded, dominated by forest redgum (*Eucalyptus tereticornis*). In-channel vegetation dominated by sharp rush (*Juncus acutus*) and couch (*Cynodon dactylon*). No water or additional aquatic micro-habitats recorded.	

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
9	No native riparian or instream aquatic vegetation recorded. The introduced sharp rush (*Juncus acutus*) and blackberry (*Rubus fruticosus*) was commonly recorded. Aquatic habitat identified as poor.	
10	No riparian vegetation however, rough-barked apple (*Angophora floribunda*) occasionally recorded in proximity to the Creek. Small, shallow pools and limited aquatic habitat present, with sharp rush (*Juncus acutus*) the dominant species recorded.	
11	No native riparian or instream aquatic vegetation recorded. The introduced sharp rush (*Juncus acutus*) was commonly recorded. Small, shallow pools and limited aquatic habitat present.	

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
12	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha* sp.), swamp oak (*Casuarina glauca*), sharp rush (*Juncus acutus*) and *Ehrharta erecta* Snags and overhanging, exposed tree roots identified at this sampling location. Deeply incised banks. Minor areas of gravel riffles recorded at this sampling location.	
13	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha* sp.), swamp oak (*Casuarina glauca*), native juncus (*Juncus sp*), couch (*Cynodon dactylon*) and weeping grass (*Microlaena stipoides* var. *stipoides*). Moderate variety of aquatic micro-habitats identified including the presence of woody debris, slight gravel bars and riffles. Aquatic habitat identified as poor.	
14	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha* sp.), swamp oak (*Casuarina glauca*), native juncus (*Juncus sp*), couch (*Cynodon dactylon*). Signs of dieback identified in in-channel swamp oak. Shallow, turbid pools evident with silty bed sediments predominating.	

Assessment Locations	Riparian Vegetation and Aquatic Habitat Features	Photos
15	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha* sp.), swamp oak (*Casuarina glauca*), native juncus (*Juncus sp*), couch (*Cynodon dactylon*). Signs of dieback identified in in-channel swamp oak. Deep pool identified (greater than 1m deep), with some turbidity evident. Snags and overhanging, exposed tree roots identified at this sampling location.	
16	Riparian vegetation consistent with Swamp Oak Forest. Instream and aquatic vegetation dominated by Bullrush (*Typha sp*.), swamp oak (*Casuarina glauca*), native juncus (*Juncus sp*.), couch (*Cynodon dactylon*). Small pools of water evident. Deeply incised channel upstream of sampling location. Snags and overhanging, exposed tree roots identified at this sampling location.	

3.1.2 Outcomes of Annual Stream Monitoring Program (Biosis 2019)

As part of the monitoring program, stream health criteria have been established for major waterways identified as being potentially subject to impacts associated with mining activities. One site was identified as not conforming with the stream health criteria, however these results were not considered indicative of impacts associated with mining. These results were identified as being caused by broader catchment conditions following an extended low rainfall period, with a sustained drought period experienced throughout the region during the survey period.

Monitoring sites and control sites overall have remained in a relatively stable but poor condition since the stream health monitoring project commenced in 2009, and no significant difference has been observed between monitoring sites and the control sites. A number of sites were dry at the time of survey, a result of the prolonged dry conditions within the region. Water was found only at the larger waterways, such as Wybong Creek and Cuan Creek where water levels and flows were still highly reduced.

HABSCORE assessments during 2018 surveys indicated a decrease in habitat quality in comparison to the 2017 monitoring period across the monitoring and control sites, a result of dry conditions continuing through the 2018 survey period. The HABSCORE results were comparable between autumn and spring 2018. The AUSRIVAS and SIGNAL2 analyses showed that while sites have been in poor condition since the commencement of baseline monitoring, the macroinvertebrate assemblages are relatively stable. Year to year fluctuations in these metrics are observed across both monitoring and control sites and therefore likely associated with changes in water availability and environmental conditions.

The Draft 2018 Mangoola Coal Stream Health Monitoring Report (Biosis 2019) is included as **Appendix A**.

3.1.3 Key Fish Habitat Classification and Sensitivity Analysis

Key fish habitat mapping has been prepared by Fisheries Ecosystems Branch of NSW DPI for LGAs across NSW. The intent of the mapping was to recognise key fish habitat that are important to the sustainability of recreational and commercial fishing industries, maintenance of fish populations and the survival and recovery of threatened aquatic species. The definition includes most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank but excluding first and second order streams that only flow for a short period following rain and farm dams on these streams (NSW DPI).

The key fish habitat map output for the Muswellbrook LGA was reviewed and is provided in **Figure 3.1**. Both Wybong Creek and Big Flat Creek have been mapped as key fish habitat.

For the purposes of the application of the FM Act, NSW DPI has developed a classification scheme for the sensitivity of key fish habitat, to define the importance of habitat for the survival of fish and the ability of the habitat to withstand disturbance. Key fish habitat is defined in DPI (2013) as:

- Type 1 Highly sensitive key fish habitat including freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants
- Type 2 Moderately sensitive key fish habitat including:
  - freshwater habitats and brackish wetlands, lake and lagoons other than those defined in Type 1 and
  - weir pools and dams up to full supply level where the weir or dam is across a natural waterway; or
- Type 3 Minimally sensitive key fish habitat including:
  - coastal and freshwater habitats not included in Type 1 or 2
  - ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

It is noted that for the purposes of the *Policy and Guidelines for Fish Habitat Conservation and Management* that first and second order streams on gaining streams are not considered key fish habitat (DPI 2013). Accordingly, the habitat sensitivity type of the two watercourses in the adjacent area has been assessed and is identified in **Table 3.2**.

The functionality of the watercourse as fish habitat has been defined by NSW DPI (DPI 2013) to assess impacts of activities on fish habitat, in conjunction with habitat sensitivity, and to make management recommendations to minimise the impact of watercourse crossing structures on fish passage. Waterways are classified by NSW DPI (DPI 2013) for fish passage as:

- Class 1 major key fish habitat including marine or estuarine waterway or permanently flowing or flooded freshwater waterway (eg river or major creek), habitat of a threatened or protected fish species or 'critical habitat' or

- Class 2 moderate key fish habitat including non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pool or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and 2 habitats present or

- Class 3 minimal key fish habitat including named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeing areas for aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats or

- Class 4 Unlikely key fish habitat including waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (eg dry gullies or shallow floodplain depressions with no aquatic flora present).

The classification of the watercourses within and in proximity to the MCCO Additional Project Area for fish passage has been assessed in accordance with NSW DPI (DPI 2013) and is identified in **Table 3.2**.

Within the vicinity of the MCCO Additional Project Area Big Flat Creek generally has intermittent flow following rain events, and minimal native aquatic vegetation. While some semi-permanent pools occur along the MCCO Additional Project Area boundary, it is considered unlikely fish habitat due to its largely ephemeral nature and has been classified as Type 3 Class 3 minimally sensitive fish habitat. Wybong Creek has been assessed as Type 1 Class 1 highly sensitive fish habitat due to the perennial nature of the Creek, presence of in-stream gravel beds, abundance of large woody snags, and presence of native aquatic plants.

Un-named watercourses in the MCCO Additional Project Area do not contain sufficient habitat complexity to provide habitat for fish and other aquatic vertebrate species. As a result, they are classified as Class 4 – Unlikely fish habitat and they are not mapped a key fish habitat by DPI (refer to **Figure 3.1**).

Table 3.2 Habitat Sensitivity Analysis of Watercourses in the Project Area and Surrounding Landscape

Watercourse	Strahler Order	Habitat Sensitivity Type	Classification of Watercourse for Fish Passage	Key Fish Habitat Mapping
Un-named watercourses within the MCCO Additional Project Area	First Order	No – not recognised	Class 4 - Unlikely	Not mapped as key fish habitat.
Wybong Creek	Sixth Order	Type 1 – High	Class 1 – Major	Tributary of Hunter River, mapped as key fish habitat
Big Flat Creek	Fourth Order	Type 3 – Minimal	Class 3 – Minimal	Tributary of Wybong Creek, mapped as key fish habitat

umwelt

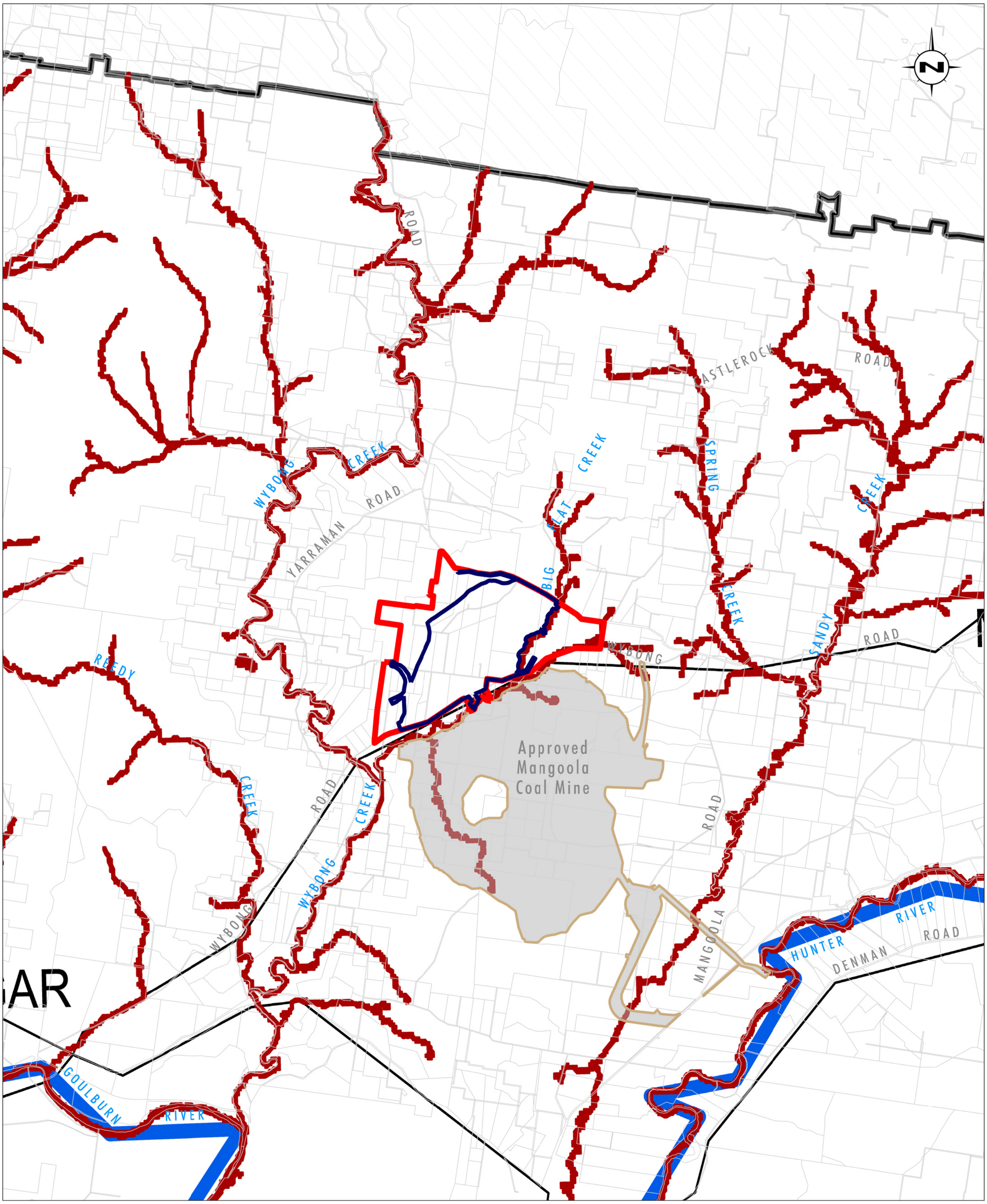


Image Source: Australian Geoscience, NSW DPI, NSW DECC and NSW LPI
Data Source: Glencore (2018)

0 2.0 4.0 6.0km
1:120 000

Legend

- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Approved Mangoola Coal Mine Disturbance Area
- Key Fish Habitat
- Major River

FIGURE 3.1

Muswellbrook Key Fish Habitat Map

3.2 Sensitive Aquatic Habitat Characteristics

3.2.1 Big Flat Creek

The Surface Water Assessment (HEC 2019) assesses the condition and surface water characteristics of Big Flat Creek and its tributaries, and identified ephemeral watercourses which have been impacted by past land clearing, construction of on-stream farm storage dams and road crossings. HEC (2019) found the condition of the streams to be variable over relatively short reaches ranging from ill-defined shallow swales and drainage depressions to well-defined deeply incised channels with overbank areas. The channel form appeared to reflect the stream characteristics such as:

- the size of the upstream catchment
- the local stream gradient
- the density of riparian and instream vegetation
- local surface geology, and
- associated anthropogenic land use disturbance.

HEC (2019) identified the streams as noticeably degraded in some sections and of higher quality in other less disturbed areas. The primary determinant of stream condition appeared to be riparian vegetation. At its closest point to the MCCO Additional Project Area, Big Flat Creek generally comprised a discontinuous swale with no defined bed or banks and vegetation consisting predominately of degraded pasture. Within the MCCO Additional Project Area, tributaries generally comprised small swales/depressions with denuded vegetation in the upper reaches and channels in the lower reaches with active erosion.

Upstream of the confluence with Tributary 1, the main arm of Big Flat Creek comprises a fourth order stream which flows through grazing paddocks. The creek generally comprises a discontinuous shallow swale profile (refer to AQ4 in **Table 3.1**). Instream and riparian vegetation were predominately degraded pasture and isolated stands of regrowth trees. The presence of several on-stream dams and a road crossing (Ridgelands Road) has resulted in localised erosion and changes to the original channel form.

Downstream of the Wybong Road crossing and the confluence with Tributary 1 the riparian vegetation in the stream was significantly denser than in upper reaches with increased sinuosity which may be influenced by the additional catchment inflow from Tributary 1. Near the confluence with Tributary 2, there were significant exposures of rock in the channel and banks which appear to control the flow through this reach of the creek (refer to AQ7 in **Table 3.1**).

Downstream of the Tributary 2 inflow the creek channel comprised a more defined, mature form with defined bed and banks, pools and riffles and floodplain features (refer to AQ15 in **Table 3.1**). There were some areas of active rilling and severe undercutting of the bank toe on the steeper banks associated with the large bends near the downstream end of the creek.

Big Flat Creek has naturally high salinity and water quality which exceeds the guideline trigger values (ANZECC, 2000) for protection of aquatic ecosystems in south-eastern Australian upland rivers. In the order of 90% of the samples in Big Flat Creek exceed the trigger values for EC and 40-60% (depending on location) exceed for total dissolved solids (TDS) and turbidity and PH trigger values are exceeded 50-60% of the time. These results indicate that the natural water quality in Big Flat Creek is generally poor.

3.2.2 Wybong Creek

Wybong Creek is a sixth order stream, which has been mapped as key fish habitat by NSW DPI and assessed as highly sensitive habitat and class 1 major fish habitat.

Water quality in Wybong Creek is much better than water quality measured in Big Flat Creek, however there are still exceedances of the trigger values for many water quality parameters such as Electrical Conductivity (EC) which is exceeded in 96% of samples, however the values were found to be lower than in Big Flat Creek. The water quality assessment completed by HEC (2019) identified Wybong Creek as a degraded system due to land use practices however water quality was better than in Big Flat Creek which is poor.

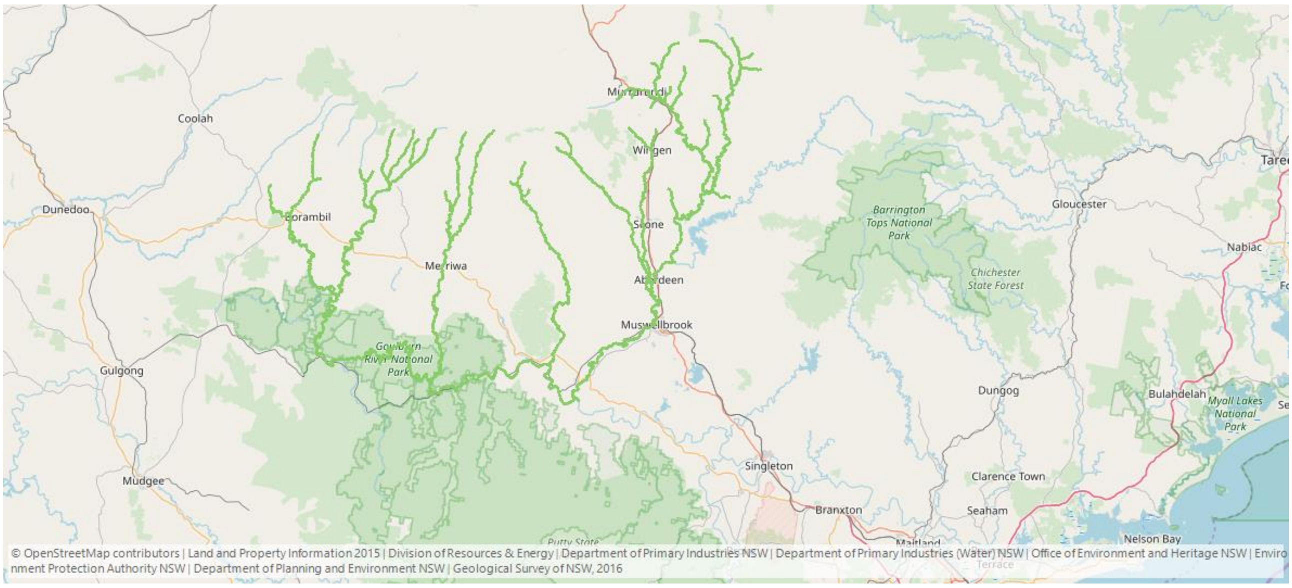
3.3 Threatened Aquatic Species and Communities

The biodiversity survey and assessment undertaken for the MCCO Project and review of previous studies and regional assessments did not identify any NSW or Commonwealth listed threatened aquatic species within, or in the vicinity of the MCCO Additional Project Area.

The following aquatic species and populations are known to occur in the Hunter River catchment.

Darling River hardyhead (*Craterocephalus amniculus*) Endangered Population

The Hunter River catchment provides habitat for the Darling River hardyhead (*Craterocephalus amniculus*) Endangered Population listed under the FM Act. Searches of the NSW DPI freshwater threatened species distribution maps listed this species as potentially occurring in Wybong Creek (refer to **Figure 3.2**).



Source: SEED access February 2019

Figure 3.2 Indicative Distribution of the Darling River hardyhead in Hunter River NSW Department of Primary Industries 2015

Darling River hardyhead (*Craterocephalus amniculus*) is predicted to occur in Wybong Creek (refer to **Figure 3.2**). The population of this species has presumably always been uncommon in the Hunter catchment as it has only ever been reported from nine widely dispersed sites. The most recent records of the species in the Hunter catchment are from the Krui River to the west of the Project Area in September 2002 and from the Hunter River at Dartbrook in September 2003 (DPI 2014b). Records are known from slow flowing, clear, shallow waters or in aquatic vegetation at the edge of such waters (DPI 2014c). The species has also been recorded from the edge of fast flowing habitats such as the runs at the head of pools (DPI 2014c). The Darling River hardyhead is unlikely to utilise the marginal aquatic habitats identified in the MCCO Additional Disturbance Area or Big Flat Creek, however it may occur in the downstream habitats of Wybong Creek.

Southern purple spotted gudgeon (*Mogurnda adspersa*)

The southern purple spotted gudgeon (*Mogurnda adspersa*), listed as endangered under the FM Act, is reported in the Fish Communities and Threatened Species Distributions of NSW (DPI 2016) to occur in the Hunter River Catchment, specifically in Goorangoola Creek, a tributary of the Glennies Creek broadly located approximately 50km to the east of the MCCO Additional Disturbance Area (refer to **Figure 3.3**). More prominently, the species is known from the Murray-Darling Basin and north of the Clarence River (DPI 2017). This species is a common aquarium fish and there is a possibility that the Goorangoola Creek population is introduced (MPR 2011).

Southern purple spotted gudgeon are a benthic species that can be found in a variety of habitat types such as rivers, creeks and billabongs with slow-moving or still waters or in streams with low turbidity. Cover in the form of aquatic vegetation, overhanging vegetation from river banks, leaf litter, rocks or snags are important for the species (DPE 2017).

The indicative distribution of the southern purple spotted gudgeon (*Mogurnda adspersa*) includes Wybong Creek, however the species is unlikely to utilise the marginal habitats of the MCCO Additional Project Area or Big Flat Creek more broadly.

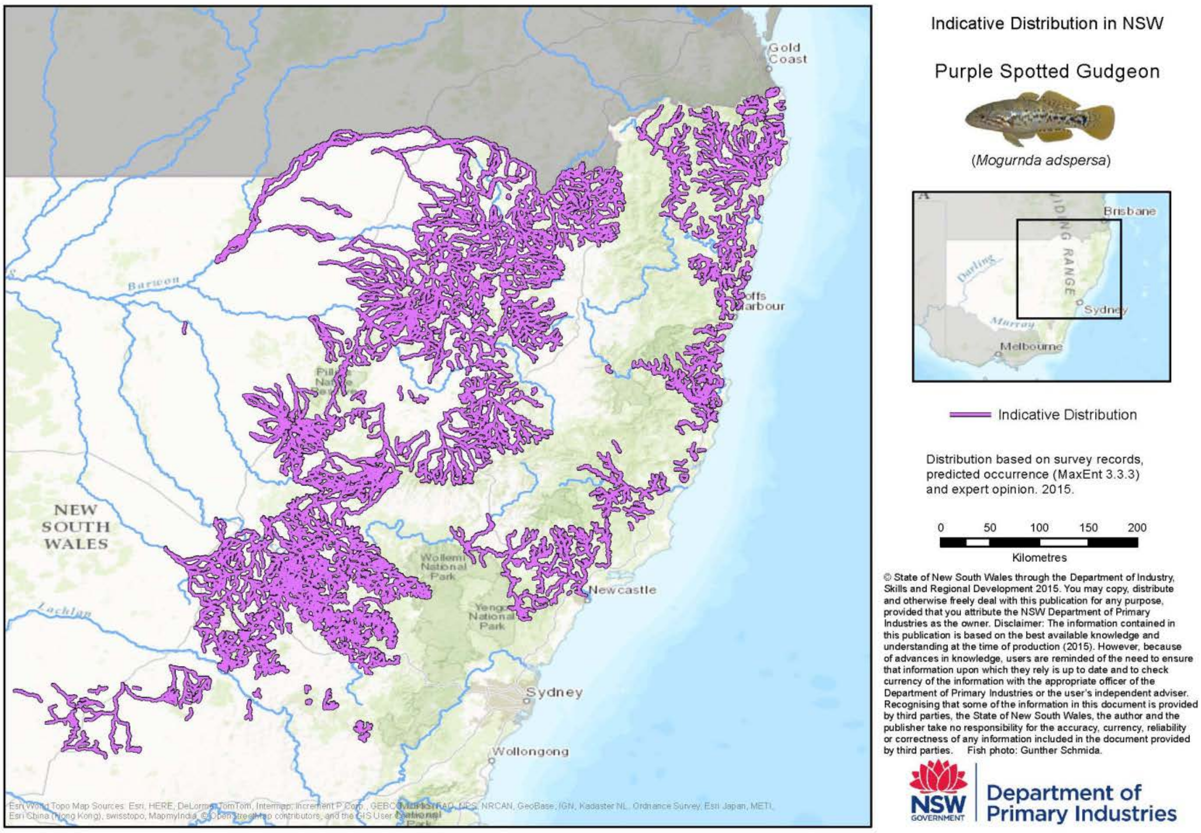


Figure 3.3 Indicative distribution of the southern purple spotted gudgeon in River NSW Department of Primary Industries 2015

No other aquatic threatened species, communities or populations listed under the FM Act are considered to have the potential to occur in, or in the vicinity of the MCCO Additional Project Area.

There are no NSW or Commonwealth listed aquatic ecological communities known to occur in the Hunter Catchment.

3.4 Groundwater Dependent Ecosystems

This section characterises the potential GDEs within and surrounding the MCCO Additional Project Area and the extent to which these GDEs are likely to be reliant on groundwater. The assessment approach for identifying and mapping GDEs is included in the EIS main text. The results of this assessment are outlined below.

The Commonwealth Government has established the National Atlas of Groundwater Dependent Ecosystems (the GDE Atlas) based on current knowledge of GDEs throughout Australia. The GDE Atlas provides an inventory of known and potential GDEs across Australia.

The GDE Atlas identified Wybong Creek as having moderate potential for being a 'river' type aquatic GDE. A small section of the Goulburn River, south of its confluence with Wybong Creek, is identified as having a low potential for being a 'river' type aquatic GDE. No aquatic GDEs were recorded in the MCCO Additional Project Area.

The GDE Atlas identified a range of woodland and forest vegetation in the area of investigation as having potential to be GDEs. These areas where further analysed using the process outlined below.

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) has developed the 'Draft Assessing Groundwater-Dependent Ecosystems: IESC Information Guidelines Explanatory Note' (Draft Explanatory Note) (Doody, Hancock and Pritchard, 2018). The Draft Explanatory Note describes GDEs as complex dynamic 'natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services' (Richardson et al., 2011 – in Doody, Hancock and Pritchard, 2018). They may be 100% dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas (Doody, Hancock and Pritchard, 2018).

The Draft Explanatory Note states that terrestrial vegetation located in areas with shallow groundwater (less than 10 m from the surface) are likely to be GDEs as they can often quite easily reach and extract groundwater. This does not necessarily mean that these native terrestrial vegetation communities are highly groundwater dependent, as they may only access groundwater intermittently or to fulfil part of their water requirements.

Vegetation mapping for the area of investigation has been overlaid with pre-mining modelled groundwater occurring within 10m of the surface to further refine the location of potential GDEs in the area of investigation (refer to **Figure 3.4**).

As shown on **Figure 3.4**, 16 plant community types (PCTs) have been mapped in locations where groundwater may occur within 10m of the surface. While all of these native woodland / forest vegetation communities may at times access groundwater, a review of each of these PCTs has been undertaken to identify those with a higher potential to be dependent on groundwater based on their position in the landscape (e.g. floodplain or riparian) and floristics, along with consideration of the findings of regional mapping discussed in Section 6.10 of the EIS main text.

These potential GDEs are listed in **Figure 3.3**.

Table 3.3 PCTs in areas of shallow groundwater and likely level of groundwater dependence

Plant Community Type	Likely Level of Groundwater Dependence
HU654/PCT1310 - White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley, Brigalow Belt South Bioregion	Low
HU757/PCT1543 - *Ficus rubiginosa/ Alectryon subcinereus/ Notelaea microcarpa/* dry rainforest of the Central Hunter Valley	Low
HU812/PCT1598 - Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter	Moderate
HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Low
HU818/PCT1604 - *Eucalyptus crebra/ Eucalyptus moluccana/ Corymbia maculata* shrub/ grass open forest of the central and lower Hunter	Low

Plant Community Type	Likely Level of Groundwater Dependence
HU819/PCT1605 - *Eucalyptus crebra/ Notelaea microcarpa* shrubby open forest of the central and upper Hunter	Low
HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter	Moderate
HU825/PCT1611 - *Eucalyptus crebra/ Callitris endlicheri* shrub/ grass woodland upper Hunter and northern Wollemi	Low
HU826/PCT1612 - *Eucalyptus crebra/ Eucalyptus punctata/ Notelaea microcarpa* woodland of Central Hunter	Low
HU869/PCT1655 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin	Low
HU883/PCT1669 - *Eucalyptus fibrosa/ Eucalyptus punctata/ Eucalyptus sparsifolia/ Corymbia trachyphloia* shrubby open forest on sandstone ranges of the Sydney Basin	Low
HU884/PCT1670 - *Eucalyptus sparsifolia/ Eucalyptus punctata* shrubby open forest on sandstone ranges of the Sydney Basin	Low
HU905/PCT1691 - *Eucalyptus crebra/ Eucalyptus moluccana* grassy woodland of the central and upper Hunter	Low
HU906/PCT1692 - Bull Oak Grassy Woodland of the Central Hunter Valley	Low
HU928/PCT1714 - *Eucalyptus camaldulensis/ Casuarina cunninghamiana* grassy riparian woodland of the Hunter Valley	High
HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley	Moderate

The review of the PCTs provided in **Table 3.3** indicates that while there is the potential for each of the vegetation communities listed to access groundwater from time to time based on pre-mining shallow groundwater in these areas, the majority of the communities are considered likely to have a low dependence on groundwater. This assessed likely low level of groundwater dependence is based on the location of these communities in the landscape and their floristics.

Three communities were identified as having a moderate potential for being dependent on groundwater; two being riparian communities and one being a floodplain community. One community, being *Eucalyptus camaldulensis* / *Casuarina cunninghamiana* grassy riparian woodland of the Hunter Valley was considered to have a higher potential level of groundwater dependence due to its occurrence in the Wybong Creek alluvium which is known to have a more substantial groundwater resource.

As discussed above, assessments of likely groundwater dependence does not mean that these communities will source all their water requirements from groundwater, however, it is considered likely that groundwater makes a contribution to their water requirements (particularly for trees which have deeper root systems). The moderate and high rated ecosystems are expected to be more dependent on groundwater than the low ranked ecosystems.

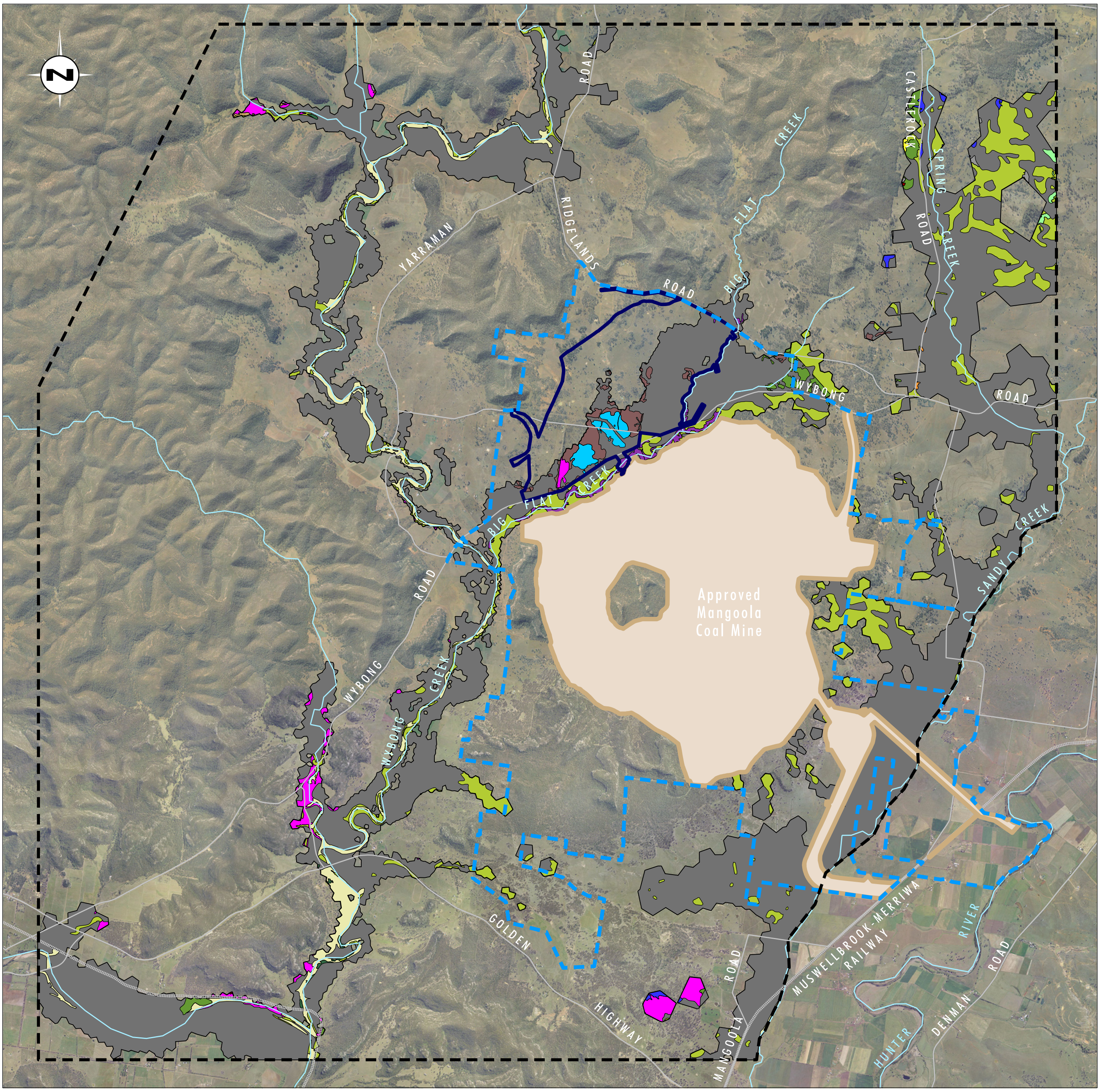


Image Source: Glencore (2018), Google Earth (2018)
Data Source: Glencore (2018), AGE (2018)

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Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Model Extent (GDE Study Area)
- Groundwater Within 10m of Surface
- HU654/PCT1310 - White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley
- HU757/PCT1543 - Ficus rubiginosa/ Alectryon subcinereus/ Notelaea microcarpa/ dry rainforest of the Central Hunter Valley
- HU812/PCT1598 - Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter
- HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
- HU818/PCT1604 - Eucalyptus crebra/ Eucalyptus moluccana/ Corymbia maculata shrub/ grass open forest of the central and lower Hunter
- HU819/PCT1605 - Eucalyptus crebra/ Notelaea microcarpa shrubby open forest of the central and upper Hunter
- HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
- HU825/PCT1611 - Eucalyptus crebra/ Callitris endlicheri shrub/grass woodland upper Hunter and northern Wollemi
- HU826/PCT1612 - Eucalyptus crebra/ Eucalyptus punctata/ Notelaea microcarpa woodland of Central Hunter
- HU869/PCT1655 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin
- HU883/PCT1669 - Eucalyptus fibrosa/ Eucalyptus punctata/ Eucalyptus sparsifolia/ Corymbia trachyphloia shrubby open forest on sandstone ranges of the Sydney Basin
- HU884/PCT1670 - Eucalyptus sparsifolia/ Eucalyptus punctata shrubby open forest on sandstone ranges of the Sydney Basin
- HU905/PCT1691 - Eucalyptus crebra/ Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU906/PCT1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- HU928/PCT1714 - Eucalyptus camaldulensis/ Casuarina cunninghamiana grassy riparian woodland of the Hunter Valley
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 3.4

Native Woodland / Forest Vegetation Communities where Pre-mining Groundwater is within 10m of Surface

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20190123 16.14

3.4.1.1 Stygofauna

Stygofauna live in groundwater and therefore if a stygofauna community occurred in the vicinity of the site it would be considered to be a GDE.

A stygofauna assessment has been prepared for the MCCO Project to assess the potential presence of stygofauna, and if present, the impacts of the MCCO Project. The assessment has been undertaken following relevant Commonwealth and NSW Government guidelines and included sampling of bores within and surrounding the MCCO Additional Project Area. A summary of the key findings of the Stygofauna Assessment is provided in this section and the full report is provided in Appendix 14 of the EIS.

No stygofauna were identified during stygofauna surveys and the assessment found that the bedrock aquifers are unlikely to be suitable habitat because they lack a significant network of interconnected fractures for stygofauna movement. The colluvium within the MCCO Project Area was also found to be generally unsuitable because it is likely to dry out periodically. The survey also included the Wybong Creek alluvium within the vicinity of the MCCO Project Area. Although no stygofauna were collected from the Wybong alluvium, the stygofauna assessment found that the section of the Wybong alluvium closer to the confluence with the Goulburn River (well to the south of the MCCO Project) is a potentially suitable habitat because of its hydrological connection to the Goulburn River, adequate porosity, and acceptable water quality. However, if a stygofauna community is inferred for the Wybong alluvium, then this community would be the same as the Goulburn alluvium community, since this is the source of colonisation.

In summary, there were no stygofauna communities identified in the vicinity of the MCCO Additional Project Area, however, the potential for stygofauna to occur in the lower reaches of the Wybong Creek alluvium was recognised.

4.0 Impact Assessment

Potential impacts associated with the MCCO Project that could affect aquatic ecosystems include:

- direct impact to Big Flat Creek where the proposed haul road crosses the Creek. The overpass construction will have an overall width of approximately 150 m including the haul road and light vehicle road, underpass, culvert structures as well as temporary erosion and sediment control works. Post mining, the crossing will be removed and Big Flat Creek will be rehabilitated
- removal of riparian vegetation on the banks of Big Flat Creek within the proposed disturbance footprint will be required for the construction of watercourse crossing structures
- removal of snags and in-stream vegetation for the construction of the watercourse crossing – predominantly non-native grasses and weed species though some small beds of sedges/reeds were noted in Big Flat Creek
- temporary obstruction of fish passage when constructing access tracks associated with either filling or removal of material from the watercourse
- potential for increased sediment load downstream of the MCCO Additional Project Area
- risk of spills and pollution associated with construction equipment working in and in the vicinity of the watercourse
- changes to water quality in Big Flat Creek and downstream environments such as Wybong Creek
- changes to the extent and duration of flooding and flow velocities
- while minimal fish habitat exists, at the time of construction there may be semi-permanent pools in the impact footprint that may support fish. Draining and/or filling of these pools may kill any fish present.

The direct impact of the MCCO Project on riparian vegetation has been assessed in the BAR (refer to Umwelt 2019), in accordance with the Framework for Biodiversity Assessment. Further assessment of the loss of riparian vegetation is therefore not required in this report.

4.1 Surface Water Impacts

4.1.1 Flooding Impacts

HEC (2019) has undertaken an assessment of flooding impacts resulting from the MCCO Project, the outcome of which indicates that flooding impacts are localised to Big Flat Creek. The Surface Water Assessment predicts some relatively small changes to flood levels, flows and velocities in sections of Big Flat Creek due to the MCCO Project. These changes are largely associated with the proposed flood levee to prevent ingress of flood flows into the mining area in larger flood events and the haul road crossing of Big Flat Creek. The key areas of predicted flow changes are at the outlet of the proposed culverts and near their inlet. Therefore, erosion protection is proposed as part of the design to prevent erosion and associated impacts. The Surface Water Assessment found that other areas of predicted velocity increase appear to be localised, generally small.

The assessment concluded that there would be no downstream flooding impacts to Wybong Creek and no cumulative flooding impacts beyond those forecast for the MCCO Project. The extent of predicted flooding impacts are shown in the EIS and Surface Water Assessment (HEC, 2019).

4.1.2 Water Quality Impacts

In terms of water quality impacts, as is currently approved, the MCCO Project proposes to discharge surplus water from the water management system in accordance with EPL limits and consistent with the provisions of the HRSTS. With these measures in place and considering the management of cumulative salt loads to the Hunter River system under the HRSTS, discharges of water from the MCCO Project are not considered likely to result in significant cumulative impacts to downstream waters.

The risk to downstream waters in Big Flat Creek and Wybong Creek associated with sediment laden water are mitigated by the design of the MCCO Project's water management system which has been designed in accordance with criteria established by the NSW Government specifically for sediment control at mining and quarrying operations. By managing sediment laden water and mine water within the MCCO Project water management system and, based on flood modelling predictions of small, localised increases in flood flow velocities and associated scour potential in Big Flat Creek, it is not anticipated that water quality in downstream watercourses will be adversely impacted by the MCCO Project. The MCCO Project is therefore considered to have a low potential to contribute to cumulative impacts on water quality in downstream watercourses (HEC 2019).

4.1.3 Flow Impacts

The MCCO Additional Project Area (including the currently approved Mangoola Mine operations) will result in reduced catchment area and hence catchment yield in Big Flat Creek and Wybong Creek (of which Big Flat Creek is a tributary). This would result in reduced flow (surface flow and baseflow) which is discussed in greater detail below.

In the context of flows in Wybong Creek, the changes predicted are very small. The Surface Water Assessment (HEC 2019) concluded that the flow changes in Wybong Creek would represent a small and likely indiscernible impact to flow.

In regard to Big Flat Creek, at its largest extent, the proposed mining operations will mean that 53% of the pre-mine catchment area of Big Flat Creek would be captured in the water management system. This would effectively result in a similar magnitude of loss of flows in Big Flat Creek noting that Big Flat Creek is ephemeral and the flows are currently intermittent. The impact reduces to 14% once the mine is rehabilitated (ie by 2030). Once rehabilitated, the change in prevalence of zero flow days in the creek is estimated to increase from approximately 26.5% of days to 28.3% of days.

In terms of the loss of baseflow into Big Flat Creek and Wybong Creek:

- the MCCO Project has no effect on baseflow in Big Flat Creek as the approved groundwater impacts of the existing mine have already disconnected the creek from the shallow groundwater in the vicinity of the mine and there is no predicted additional effect as a result of the MCCO Project

- the effect of the MCCO Project on baseflow in Wybong Creek is very small and '*represents a small and likely indiscernible impact to flow in Wybong Creek*' (HEC 2019).

4.2 Impacts on Groundwater

The local hydrogeology has already been impacted by mining at the approved Mangoola Coal Mine. The impacts result from a change in the hydraulic conductivity during and post mining, and depressurisation of the coal measures and Permian and Triassic aged sandstones and conglomerates through the removal of aquifer material.

The Wybong Creek alluvium will not be mined, with an approximately 1,000 m buffer maintained between the proposed additional mining area and the Wybong Creek alluvium, however, there is the potential for passive groundwater take as the Permian and Triassic strata become depressurised through mining and less groundwater flows into the alluvium.

The Sandy Creek alluvium is located within the south-east of the MCCO Additional Project Area and is also classified as a highly productive aquifer. However, as the coal measures being mined within the MCCO Additional Project Area dip to the west and subcrop before reaching the Sandy Creek alluvium, there is limited potential for propagation of impacts from the MCCO Project to impact on the Sandy Creek alluvium and no impacts are predicted.

Big Flat Creek is ephemeral in nature with little or no flow during extended dry periods. The creek overlies a thin colluvium and investigations have determined it has no associated alluvium and therefore potential groundwater impacts are negligible.

4.2.1 Impacts on GDEs

Based on the review of available information and field surveys, **Table 4.1** summarises the potential GDEs found to require further consideration for the MCCO Project described in **Section 3.4**.

Table 4.1 Potential GDEs identified in the MCCO Project Affectation Area

GDE
Aquatic
Wybong Creek - River GDE
Goulburn River - River GDE
Terrestrial
Native woodland / forest vegetation in areas with shallow groundwater (<10 metres from surface) and a likely low level of groundwater dependence due to their topographic location and floristics.
Native woodland / forest vegetation in areas with shallow groundwater (<10 metres from surface) and a likely moderate level of groundwater dependence. These were riparian and floodplain communities and included: • HU812/PCT1598 - Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter • HU821/PCT1607 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter • HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley.

GDE
Native woodland / forest vegetation in areas with shallow groundwater (<10 metres) and a likely high level of groundwater dependence being: • HU928/PCT1714 - *Eucalyptus camaldulensis* / *Casuarina cunninghamiana* grassy riparian woodland of the Hunter Valley

The MCCO Project will result in clearing of native vegetation within the MCCO Additional Disturbance Area. As shown on **Figure 4.1** and **Figure 4.2** this will include some woodland / forest vegetation that has access to shallow groundwater and was therefore identified as a potential GDE. The direct impact of clearing of this vegetation has been assessed and will be offset in accordance with the NSW Framework for Biodiversity Assessment, as described in the Biodiversity Assessment Report (Umwelt 2019).

The MCCO Project will also result in drawdown of groundwater within the vicinity of the MCCO Project. With regard to GDEs, the predicted drawdowns of relevance are those in layer 1 of the groundwater model which relates to drawdown in alluvium, colluvium and regolith; and in layer 2 which relates to drawdown in shallow weathered bedrock. Beyond these layers, vegetative GDEs are not expected to be influenced due to the depth of the groundwater which is not too deep to be accessed by terrestrial vegetation. **Figure 4.1** and **Figure 4.2** show the areas of 1m or greater drawdown resulting from mining of the MCCO Additional Project Area in these layers where potential GDEs occur. As shown on the figures, outside of the MCCO Additional Project Area the predicted drawdowns are 1m to 2m and occur in the vicinity of Big Flat Creek. The predicted drawdowns affect areas of:

- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley which as a riparian community is considered likely to have a moderate level of dependence on groundwater

- HU905/PCT1691 - *Eucalyptus crebra*/ *Eucalyptus moluccana* grassy woodland of the central and upper Hunter which is considered likely to have a low level of dependence on groundwater.

It is expected that Swamp Oak - Weeping Grass Grassy Riparian Forest has a moderate potential to be dependent on shallow groundwater resources during periods of reduced surface water flow. The dependence of the vegetation community on groundwater will depend on the depth of root systems and their efficiency at utilising rainfall and surface moisture.

Mangoola Coal Mine undertake annual ecosystem monitoring for one potential GDE location along Big Flat Creek. The site is coincident with an area also identified as having moderate potential to support GDEs during the plant community mapping. The purpose of the annual mapping is to identify if there are any observable negative impacts on the flora that can be attributed to groundwater depressurisation caused by mining. The 2017 ecological monitoring report for the site notes that although the vegetation may have been partially groundwater dependent until mid-2014, when the water table was drawn down below the root zone, floristic monitoring in 2017 did not observe any dieback that was likely to be associated with de-watering or lack of access to groundwater as a result of mining. The report also comments that the site appeared to be in a good state of health, and that additional floristic monitoring along other sections of Big Flat Creek did not identify areas of unexplained dieback likely to be associated with changes to groundwater, even considering the drought conditions.

With regard to the other potential GDEs identified in the area of investigation for GDE impacts, the results of the groundwater assessment have shown that there are no incremental impacts due to the MCCO Project predicted on these GDEs as they are outside the predicted zone of 1m or greater groundwater drawdown in layers 1 and 2 of the groundwater model. This includes no drawdown impacts predicted on the Wybong Creek or the Wybong Creek alluvium (refer to drawdown shown on **Figure 4.1** and **Figure 4.2**) and no impact on the Goulburn River.

Based on the above assessment findings, the MCCO Project is not expected to have an adverse effect on downstream groundwater resources such that aquatic biodiversity, stygofauna or terrestrial biodiversity associated with GDEs are adversely impacted.

4.3 Threatened Species, Endangered Populations and TECs Assessed Under the FM Act 1994

The *Fisheries Management Act 1994* (FM Act) provides for the conservation, protection and management of fisheries, aquatic systems and habitats in NSW. The FM Act establishes mechanisms for:

- the listing of threatened species, populations and ecological communities or key threatening processes
- the declaration of critical habitat
- consideration and assessment of threatened species impacts in the development assessment process.

No FM Act listed threatened aquatic flora or fauna species were recorded within the MCCO Additional Project Area, however potential habitat for the Darling River hardyhead (*Craterocephalus amniculus*) Endangered Population in the Hunter Catchment and the southern purple spotted gudgeon (*Mogurnda adspersa*) was identified in Wybong Creek to the west of the MCCO Additional Project Area. As discussed above, the MCCO Project is predicted to result in a small and likely indiscernible impact to flow in Wybong Creek and no water quality impacts are predicted. Therefore, there is negligible potential for impacting the aquatic ecology of Wybong Creek.

An assessment of significance is provided in **Table 4.2** which concludes that the MCCO Project is unlikely to result in a significant impact on an endangered population of the Darling River hardyhead or the purple spotted gudgeon.

No additional threatened aquatic species, populations or EECs have potential to occur within the MCCO Additional Project Area.

The surface water and groundwater impacts associated with the MCCO project are not expected to result in an adverse impact on threatened species, endangered populations or ecological communities listed under the FM Act.

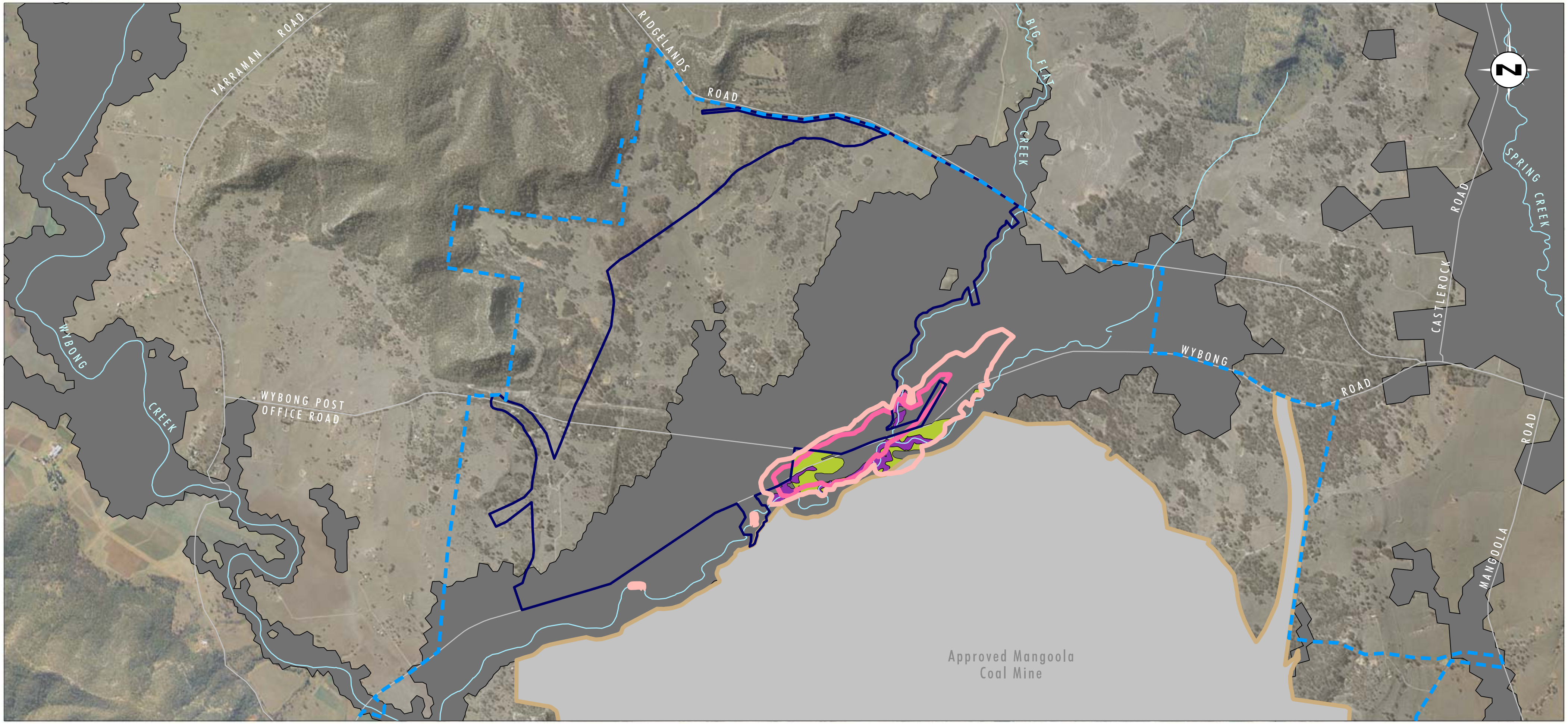

Image Source: Glencore (2018)
Data Source: Glencore (2019), AGE (2018)

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Within 10m of Surface
- HU905/PCT1691 - Eucalyptus crebra / Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

Groundwater Drawdown Contours Layer 1 (metres):
- Predicted Maximum Drawdown - 1m
- Predicted Maximum Drawdown - 2m

FIGURE 4.1

Potential GDE's and Predicted maximum groundwater drawdown due to the MCCO Project Layer 1 (alluvium, colluvium, regolith)

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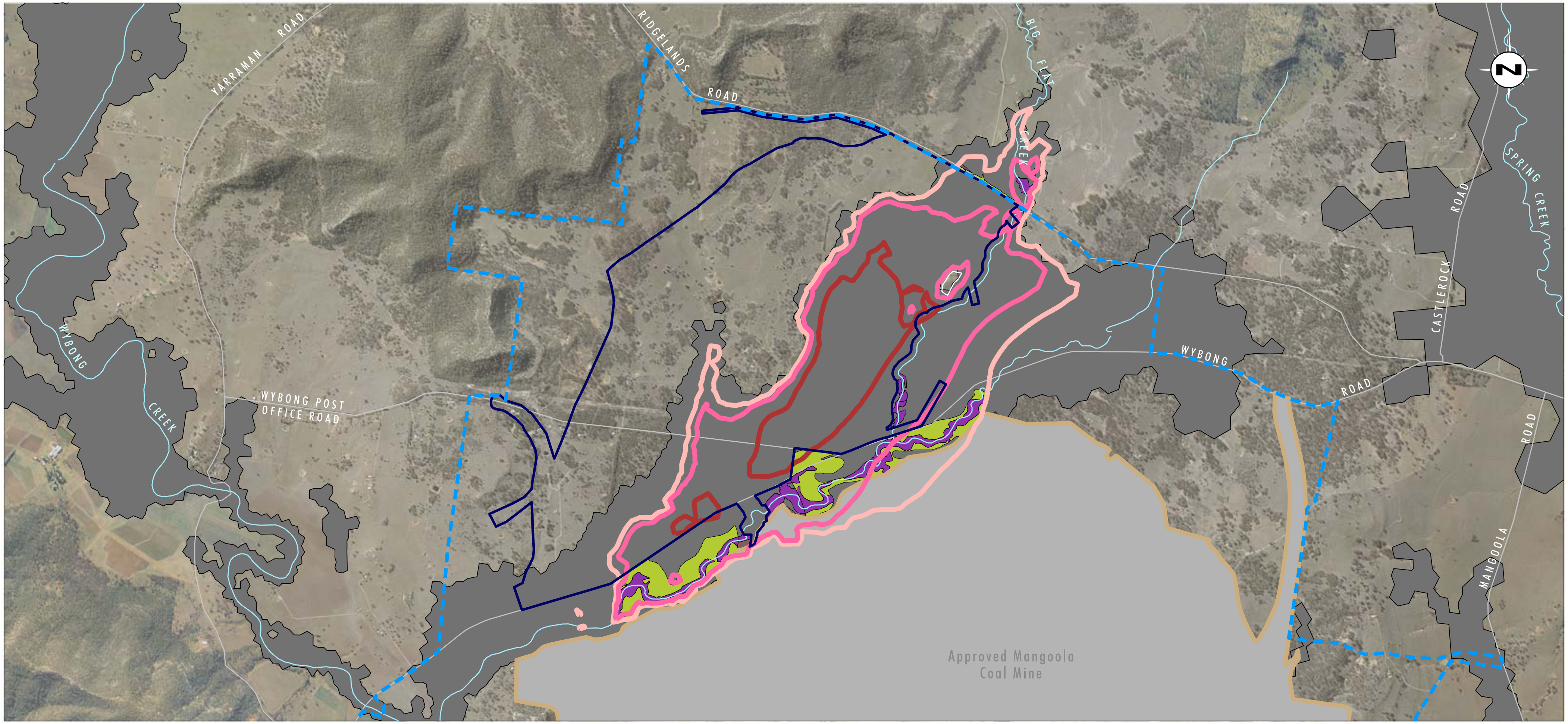

Image Source: Glencore (2018)
Data Source: Glencore (2019), AGE (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Disturbance Area
- Groundwater Within 10m of Surface
- HU817/PCT1603 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter
- HU905/PCT1691 - Eucalyptus crebra/ Eucalyptus moluccana grassy woodland of the central and upper Hunter
- HU945/PCT1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley

Groundwater Drawdown Contours Layer 1 (metres):

- Predicted Maximum Drawdown - 1m
- Predicted Maximum Drawdown - 2m
- Predicted Maximum Drawdown - 5m

FIGURE 4.2

Potential GDE's and Predicted maximum groundwater drawdown due to the MCCO Project Layer 2 (shallow weathered bedrock)

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Table 4.2 Seven Part Test of Significance for matters listed under the FM Act

Darling River hardyhead (*Craterocephalus amniculus*), Endangered population	Southern purple spotted gudgeon (*Mogurnda adspersa*), Endangered species
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	
Not applicable.	The southern purple spotted gudgeon (*Mogurnda adspersa*) has been mapped as on the DPI's broad scale freshwater threatened species distribution map (DPI 2018) as having the potential to occur 3.9 km to the west of the MCCO Additional Disturbance Area within Reedy Creek and 9.3 km to the east of the MCCO Project Area within the Hunter River. The MCCO Project will not result in direct impacts to aquatic habitats in Wybong Creek and groundwater and surface water impacts are expected to be negligible (refer to **Sections 4.1** and **4.2**). There are no known records of this species within the vicinity of the MCCO Additional Disturbance Area and the closest known record of this species is located in Goorangoola Creek; approximately 50 km east of the MCCO Additional Disturbance Area. Therefore the MCCO Project is unlikely to have an adverse effect on the life cycle of the southern purple spotted gudgeon.

Darling River hardyhead (*Craterocephalus amniculus*), Endangered population	Southern purple spotted gudgeon (*Mogurnda adspersa*), Endangered species
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	
Darling River hardyhead (*Craterocephalus amniculus*) is predicted to occur in Wybong Creek, approximately 1.5 km west of the MCCO Additional Disturbance Area. While Big Flat Creek is a tributary of Wybong Creek, the MCCO Project is unlikely to have an adverse impact on the life cycle of the endangered population of the Darling River hardyhead as there are no known records of this species within the vicinity of the MCCO Additional Disturbance Area and the closest known record of this species in the Hunter catchment are from the Krui River to the west of the MCCO Additional Disturbance Area in 2002 and from the Hunter River at Dartbrook in 2003 (DPI 2014). The MCCO Project will not result in direct impacts to aquatic habitats in Wybong Creek and groundwater and surface water impacts are expected to be negligible (refer to **Sections 4.1** and **4.2**) and therefore the MCCO Project is unlikely to have an adverse effect on the life cycle of the Darling River hardyhead (*Craterocephalus amniculus*) EP in the Hunter River catchment.	Not applicable.
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; and ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction;	
Not applicable.	Not applicable.

Darling River hardyhead (*Craterocephalus amniculus*), Endangered population	Southern purple spotted gudgeon (*Mogurnda adspersa*), Endangered species
(d) in relation to the habitat of a threatened species, population or ecological community: i. the extent to which habitat is likely to be removed or modified as a result of the action proposed; ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality;	
In accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013), the Big Flat Creek constitutes Type 3 minimally sensitive fish habitat and un-named tributaries in the MCCO Additional Project Area comprise Class 4 unlikely key fish habitat. The Darling River hardyhead has not been recorded within MCCO Additional Disturbance Area and Big Flat Creek is not considered important habitat for this threatened species.	In accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013), the Big Flat Creek constitutes Type 3 minimally sensitive fish habitat and un-named tributaries in the MCCO Additional Project Area comprise Class 4 unlikely key fish habitat. The southern purple spotted gudgeon has not been recorded within MCCO Additional Disturbance Area and Big Flat Creek is not considered important habitat for this threatened species.
(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);	
No critical habitat has been identified in the MCCO Additional Disturbance Area.	No critical habitat has been identified in the MCCO Additional Disturbance Area.
(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan; and	
Not applicable.	Not applicable.
(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
Not applicable.	Not applicable.

4.4 Matters of National Significance Assessed Under the Commonwealth EPBC Act

Under the EPBC Act, the approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on MNES. Aquatic MNES predicted to occur within the MCCO Additional Project Area and a 10 kilometre buffer are discussed in **Section 3.3**.

No nationally listed threatened aquatic species, endangered populations, TECs or aquatic migratory species are expected to occur in the watercourses within or adjacent to the MCCO Additional Project Area and therefore no adverse impacts to aquatic ecology are predicted. Accordingly an assessment of the impact of the MCCO Project on matters of national significance is not required.

5.0 Impact Avoidance and Mitigation Measures

5.1 Impact Avoidance Measures

As part of the design of the MCCO Project, adapting the design to minimise impacts and the extent of the disturbance footprint were key design considerations. There were two key design changes that reduced the impact of the MCCO Project on aquatic ecology being:

- removal of an initially proposed second out of pit overburden emplacement area. This emplacement area would have required a second crossing over Big Flat Creek impacting an additional area of aquatic habitat and riparian corridor
- refining the location and minimising the footprint of the haul road overpass over Big Flat Creek to reduce impacts. This included avoiding impacts on threatened flora and fauna species, seeking to minimise the area of vegetation impacted and reducing the overall construction disturbance footprint.

There were also a number of refinements made during the design process to the proposed water management system for the MCCO Project. The water management system design is a key driver for the avoidance of impacts of the MCCO Project on aquatic ecology.

5.2 Construction Phase Impact Mitigation

A range of general mitigation measures are proposed to be employed within the MCCO Additional Project Area during the construction phase of the MCCO Project to minimise impacts to aquatic ecological values, including:

- employee education including inductions for staff, contractors and visitors to the site to inform relevant personnel of the relevant controls to be implemented to minimise impacts on aquatic ecosystems (e.g. erosion and sediment controls, clearing controls, water management controls, pollution controls)
- the extent of works within the Big Flat Creek riparian corridor will be clearly marked so that areas of ecological value outside the proposed disturbance area are not impacted.

To minimise impacts on water quality, erosion and sedimentation associated with spills and/or construction activities in the watercourse, works within or adjacent to the watercourse will be undertaken in accordance with an updated Water Management Plan which will include specific requirements to address the following:

- works within the riparian zone will seek to minimise the extent of clearing of riparian vegetation, where possible, and minimise disturbance
- designs for works within or near watercourses will provide for the retention of natural functions and maintenance of fish passage in accordance with *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003)
- planned works will, where possible, consider the forecasted weather conditions and install appropriate controls for periods of rainfall leading to flow events within the watercourse

- appropriate erosion and sediment controls will be implemented for all construction works, including the works within the riparian corridor
- management of sediment that has accumulated upstream to avoid sediment mobilisation
- spoil material removed would be disposed appropriately.

Watercourse crossings can act as a barrier to fish passage. To avoid the creation of barriers to fish passage, all in-stream watercourse structures will be designed to the minimum required for the watercourse classification as provided in **Table 5.1**. Guidelines for the design and construction of watercourse structures to minimise impact on fish passage and aquatic habitats are provided in *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003).

Table 5.1 Preferred Watercourse Crossing Type in Relation to Watercourse Classification (DPI 2013)

Watercourse Classification	Minimum Recommended Crossing Type	Additional Design Information
Class 1 Major Key Fish Habitat	Bridge, arch structure or tunnel.	Bridges are preferred to arch structures
Class 2 Moderate Key Fish Habitat	Bridge, arch structure, high flow design culvert or tunnel.	Bridges are preferred to arch structures, box culverts and fords
Class 3 Minimal Key Fish Habitat	Culvert or ford	Box culverts are preferred to fords and pipe culverts.
Class 4 Unlikely Key Fish Habitat	Culvert, causeway or ford	Culverts and fords are preferred to causeways

To establish operational access to the MCCO Additional Project Area it is proposed to construct a dual haul road and light vehicle road overpass over Wybong Road and Big Flat Creek to provide access from the existing Mangoola Coal Mine. The overpass will enable the efficient haulage of material and equipment between the two operational areas and once constructed will ensure that there are no disruptions to traffic flows on Wybong Road.

The overpass construction will have an overall width of approximately 150 m including the haul road and light vehicle road, underpass, culvert structures as well as temporary erosion and sediment control works.

Where the MCCO Project may require removal of large woody debris from watercourses in the MCCO Additional Project Area, this would be relocated upstream or downstream where practicable.

To minimise loss of fish within any semi-permanent pools in the impact zone, a dewatering procedure will be developed and included in the biodiversity management plan. The dewatering procedure will outline methods for collection and relocation of any native fish and euthanasia of pest species.

5.3 Operational Phase Impact Mitigation

A range of strategies are proposed to mitigate adverse impacts during the operational phase of the MCCO Project. This includes specific measures to minimise the potential impacts on the aquatic ecological values of the MCCO Additional Project Area and the locality, including:

- implementation of permit for work controls so that unintended impacts on aquatic habitats are avoided during operations
- ongoing weed management
- regular inspection and maintenance of built watercourse structures to check functionality and minimise blockage of fish passage
- management of spills
- mine water will be contained and re-used within the MCCO Project water management system, with any mine water discharges managed in accordance with HRSTS
- all sediment and erosion control dams will be designed to meet relevant standards to maintain water quality of all water overflows from the water management system
- re-instatement the section of Big Flat Creek impacted by the MCCO Project following decommissioning and removal of the Big Flat Creek haul road overpass. This includes re-instating the creek landform and re-establishing riparian vegetation.

6.0 Summary and Conclusion

The aquatic ecological assessment for the MCCO Project has been prepared based on a combination of field investigations and a review of available aerial photographs, topographic maps, databases, literature, policies and guidelines, and using impact information from the water resources assessments completed for the MCCO Project. The MCCO Project crosses one named watercourse, being Big Flat Creek (fourth order), which a number of minor in-named first and second order tributaries occur within the MCCO Additional Project Area. Wybong Creek (sixth order) is located downstream of the MCCO Additional Project Area. While the watercourses are fourth and sixth order streams, they are characterised by variable and unpredictable patterns of flow and water levels exacerbated by heavily cleared catchments and prevalence of agricultural and mining land use.

Waterways were classified in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013) and un-named tributaries occurring within the MCCO Additional Project Area have been classified as not sensitive and are not considered as a watercourse for fish passage. Big Flat Creek was classified as Class 3 minimal key fish habitat that is considered to be Type 3 minimally sensitive fish habitat and Wybong Creek was assessed as Class 1 – Major key fish habitat, with Type 1 - high habitat sensitivity.

One threatened species and one endangered fish population listed under the FM Act are predicted to occur in ecosystems downstream of the MCCO Additional Project Area. Neither the Darling River hardyhead EP or the southern purple spotted gudgeon are expected to occur in the MCCO Additional Project Area or in Big Flat Creek, and adverse surface water and groundwater impacts are not predicted to adversely affect potential habitat for these species.

The assessment has considered the impact of the proposal on aquatic MNES as listed under the EPBC Act. No nationally listed threatened aquatic species, endangered populations, TECs or aquatic migratory species are expected to occur in the watercourses within or adjacent to the MCCO Additional Project Area.

The results of the groundwater assessment have shown that there are no incremental impacts due to the MCCO Project predicted on GDEs. The Groundwater Assessment (AEG 2019) predicts no drawdown impacts on the Wybong Creek or the Wybong Creek alluvium and no impact on the Goulburn River.

Therefore, the MCCO Project is not expected to have an adverse effect on downstream groundwater resources such that aquatic biodiversity, stygofauna or terrestrial biodiversity associated with GDEs are adversely impacted.

Surface water impacts associated with flooding, surface water flow and water quality have been modelled and the MCCO Project is not expected to result in adverse surface water impacts on Big Flat Creek or in the downstream environments of Wybong Creek and the Goulburn River (HEC 2019). Therefore, the MCCO Project is not expected to have an adverse effect on downstream surface water resources such that aquatic biodiversity are adversely impacted.

Overall, no aquatic biodiversity is anticipated to be adversely impacted due to the MCCO Project.

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APPENDIX A

Mangoola Coal Stream health monitoring Program: Autumn and Spring 2018

Mangoola Coal

Stream Health Monitoring Program: Autumn and Spring 2018

DRAFT REPORT

Prepared for Glencore Pty Ltd

13 February 2019

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- Lauren Harley (mapping)

Contents

Tables

Figures

Summary

Biosis was engaged by Glencore to undertake twice-annual stream health monitoring to fulfil the requirements of the Mangoola Open Cut Surface Water Monitoring Plan (SWMP). As part of the SWMP, a stream health monitoring program was developed to facilitate compliance with the development consents and Environmental Protection Licences associated with the mine's operation, and enable monitoring of stream health and identification of changes that may be the result of mining activities. The initial stream health assessment was undertaken in November 2004 (Tuft 2007), and Biosis was engaged in 2009 to establish and conduct biannual stream health monitoring surveys to date. The autumn and spring 2018 surveys form the subject of this report.

The stream health monitoring program encompasses ten potential impact sites (monitoring sites) across Four major waterways that traverse the Mangoola Open Cut site - Big Flat Creek, Wybong Creek, Anvil Creek and Sandy Creek. The program also established eight control sites in 2013 with catchments similar to the monitoring sites to differentiate potential mining impacts from environmentally driven variations due to natural processes. The control sites are located across four waterways - Cuan Creek, Wybong Creek (upstream of the mine site), Unnamed Creek 1 and Unnamed Creek 2.

The monitoring program assesses macroinvertebrate community structures, water quality and overall catchment-riparian health using NSW AUSRIVAS and SIGNAL2 sampling and analyses, HABSCORE assessments, and physicochemical surface water quality testing.

Stream health criteria have been established for major waterways identified as being potentially subject to impacts associated with mining activities. One site was identified as not conforming with the stream health criteria, however these results were not considered indicative of impacts associated with mining. These results were identified as being caused by broader catchment conditions following an extended low rainfall period, with a sustained drought period experienced throughout the region during the survey period.

Monitoring sites and control sites overall have remained in a relatively stable but poor condition since the stream health monitoring project commenced in 2009, and no significant difference has been observed between monitoring sites and the control sites. A number of sites were dry at the time of survey, a result of the prolonged dry conditions within the region. Water was found only at the larger waterways, such a Wybong Creek and Cuan Creek where water levels and flows were still highly reduced.

HABSCORE assessments during 2018 surveys indicated a decrease in habitat quality in comparison to the 2017 monitoring period across the monitoring and control sites, a result of dry condition continuing through the 2018 survey period. The HABSCORE results were comparable between autumn and spring 2019. The AUSRIVAS and SIGNAL2 analyses showed that while sites have been in poor condition since the commencement of baseline monitoring, the macroinvertebrate assemblages are relatively stable. Year to year fluctuations in these metrics are observed across both monitoring and control sites and therefore likely associated with changes in water availability and environmental conditions.

1 Introduction

Biosis was engaged by Glencore to undertake biannual stream health monitoring to fulfil the requirements of the Mangoola Open Cut Surface Water Monitoring Plan (SWMP). Project approval to construct and operate the Mangoola Coal Open Cut coal mine (previously known as Anvil Hill) was granted by the Minister for Planning on 7 June 2007 under Part 3a of the Environmental Planning & Assessment Act 1979.

As part of the SWMP, a stream health monitoring program was developed to facilitate compliance with the development consents and Environmental Protection Licences associated with the mine's operation, and enable monitoring of stream health and identification of changes that may be the result of mining activities. The initial stream health assessment was undertaken in November 2004 (Tuft 2007). Habitat assessment and macroinvertebrate sampling was conducted in Anvil Creek within the proposed mine site, while Big Flat Creek, Wybong Creek and Sandy Creek were sampled, with a total of eight sites identified as potentially subject to impacts associated with the operation of Mangoola Open Cut coal mine. Following commencement of mining activities in 2009 Biosis was engaged to establish and conduct biannual stream health monitoring surveys (Table 1). The autumn and spring 2018 surveys form the subject of this report.

1.1 Scope of assessment

The stream health monitoring program encompasses eight potential impact sites (monitoring sites) across three major waterways that traverse the Mangoola Open Cut site - Big Flat Creek, Wybong Creek and Sandy Creek. The program has also established eight control sites with catchments similar to the monitoring sites to differentiate potential mining impacts from variations due to natural processes. The control sites are located across four waterways - Cuan Creek, Wybong Creek (upstream of the mine site), Unnamed Creek 1 and Unnamed Creek 2 (Figure 2).

The Stream Health Monitoring Program assesses macroinvertebrate community structures, water quality, channel stability and overall catchment-riparian health through:

- NSW AUSRIVAS and SIGNAL2 sampling and analyses.
- HABSCORE assessments.
- Physical and chemical multiparameter water testing.

The SIGNAL2 method (Stream Invertebrate Grade Number Average Level version 2) assigns each macroinvertebrate group a number representative of that group's pollution tolerance, which is then used to calculate the overall water quality of the site. Combined with a HABSCORE assessment that evaluates physical habitat structure and availability, these methods provide a thorough assessment of the relative ecological health at a monitoring site. HABSCORE has the additional benefit of providing a measure of relative stream health even when a sample site is dry and AUSRIVAS sampling is not possible. These data are further useful in evaluating the effectiveness of water quality protection measures and impact mitigation implemented throughout the Mangoola Open Cut site, and detecting impacts to ecological values and water quality as a result of mining operations.

Table 1 Survey dates for completed sampling seasons

Year	Season	Survey Dates
2018	Spring	2 – 5 October
2018	Autumn	22 – 25 May
2017	Spring	25-29 September
2017	Autumn	5 – 9 June
2016	Spring	14 – 16 November
2016	Autumn	1 – 3 June
2015	Spring	21-23 October
2015	Autumn	19-20 May
2014	Spring	9 - 11 December
2014	Autumn	14 - 16 April
2013	Spring	23 - 25 September
2013	Autumn	7 - 9 May
2012	Spring	12 - 15 November
2012	Autumn	1 - 3 May
2011	Spring	8 - 10 November
2011	Autumn	7 - 9 June
2010	Spring	25 - 28 October
2010	Autumn	19 - 21 April
2009	Spring	12-13 October
2009	Autumn	28 - 29 July

1.2 Location of the study area

Mangoola Open Cut is an open-cut coal mine located approximately 20 km west of Muswellbrook and approximately 50 km north west of Singleton (Figure 1), and is within the:

- Upper Hunter Valley.
- Hunter-Central Rivers Catchment Management Authority (H-C CMA).
- Muswellbrook Shire Local Government Area (LGA).

For the purposes of the SWMP the study area is considered to include the full extent of the catchments of the waterways flowing through the Mangoola Open Cut Lease area. This includes areas downstream of the mine site that may be indirectly impacted by the mining operations. Table 2 details the location of the monitoring sites.

1.2.1 Monitoring sites

Six monitoring sites were established during the initial baseline assessment with three additional sites established in the spring 2009 survey (Figure 3). These monitoring sites are located across the four main creeks that drain the Mangoola Open Cut site: Big Flat Creek, Wybong Creek, Anvil Creek and Sandy Creek (Table 2). During 2012 WBC-DS2 was moved approximately 200 m upstream to a property where access is likely to be maintained throughout the life of the monitoring program. Also during 2012 both SAC-US1 and SAC-DS2 were relocated downstream to locations where the sites are more likely to sustain pooling water and access be maintained. Monitoring at SAC-US1 was discontinued in 2016 following a continued lack of water, with SAC-DS1 providing an adequate level of assessment for Sandy Creek. Monitoring of ANC-AQ1 ceased in 2018 and has been replaced by BFC-AQ1.

Table 2 Monitoring site locations

Site Code	SWMP Site Code	Description	MGAE	MGAN
ANC-AQ1	N/A	Anvil Creek downstream of Mangoola Open Cut Lease area. ANC-AQ1 is located at the crossing of a powerline access track and Anvil Creek. Located south of Wybong Road. Anvil Creek is a tributary of Big Flat Creek.	280288	6426081
BFC-US1	W3	Big Flat Creek upstream of Mangoola Open Cut Lease area. BFC-US1 is located adjacent to Wybong Road on the southern side of the road immediately downstream of the crossing culvert, approximately 2 km west of the intersection between Wybong Road and Ridgelands Road.	283053	6428147
BFC-DS1	W14	Big Flat Creek, first downstream sampling location below Mangoola Open Cut Lease area. BFC-DS1 is located adjacent to Wybong Road on the left of the road (driving West) in the far South-West corner of the paddock immediately before the "Angle Vale" property; approximately 800 m south-west of the intersection of Wybong Road and Wybong Post Office Road. The sample site is located immediately adjacent to the paddock fence corner.	281175	6426922
BFC-AQ1	N/A	Big Flat Creek, second downstream sampling location below Mangoola Open Cut Lease area. BFC-AQ1 is located adjacent to Wybong Road on the left of the road (driving West); approximately 450 m downstream of the confluence of Big Flat Creek and it's tributary Anvil Creek.	279724	6426249
BFC-DS2	W7	Big Flat Creek, third downstream sampling location below Mangoola Open Cut Lease area. BFC-DS2 is located approximately 50 m downstream of the private road (property 2567) entering off Wybong Road approximately 1 km north-east of the Wybong Bridge crossing Wybong Creek.	279338	6426046
WBC-US1	W5	Wybong Creek upstream of Mangoola Open Cut Lease area. WBC-US1 is located immediately below the Yarraman Road crossing, approximately 1 km south of the Wybong Post Office Road and Yarraman Road intersection. This site is located upstream of any potential mining impacts.	277610	6427220

Site Code	SWMP Site Code	Description	MGAE	MGAN
WBC-DS1	W9	Wybong Creek, first downstream sampling location below Mangoola Open Cut Lease area. WBC-DS1 is located in the property of Minnie Vale off Wybong Road, directly south-east of the rock formation Wallaby Rocks to the west of the Mangoola Open Cut Lease area. Access to the site is to the east of the property through the two lower paddocks.	278421	6423863
WBC-DS2	W11	Wybong Creek, second downstream sampling location below Mangoola Open Cut Lease area. WBC-DS2 was relocated during 2012 to a property owned by Glencore Mangoola. The site is accessed via the property at 3079 Wybong Road. The dirt drive way passes to the north of a rocky outcrop and bends south-east past a residential house and yards before leading to Wybong Creek.	277261	6421867
SAC-DS1	W2	Sandy Creek, first downstream sampling location below Mangoola Open Cut Lease area. The Sandy Creek downstream monitoring site (W2) SAC-DS1 is located immediately upstream of a culvert road crossing on Mangoola Road, along a stretch of Mangoola Road that runs directly east-west.	288624	6427138

1.2.2 Control sites

Eight control sites were established during the spring 2012 AusRivAs season to allow for differentiation between catchment-wide changes and site-specific impacts that may occur (Figure 3). The control sites are located on four different creek lines: Cuan Creek and Wybong Creek to the north of the Mangoola Open Cut Lease area, which are similar in catchment size and surrounding land use to Sandy Creek and Wybong Creek monitoring sites; and two unnamed creeks located to the south of the Mangoola Open Cut Lease area, which have similar catchment sizes and surrounding land use to the Big Flat Creek monitoring sites (Table 3).

Table 3 Control site locations

Site	Description	MGAE	MGAN
UN1-AQ1	Unnamed creek approximately 20 km south of Mangoola Open Cut Lease area; located within the Ravensworth Complex Stewart offset area approximately 3 km north of Lake Liddell. Access is from the New England Highway along an unnamed dirt road. This dirt road is followed for approximately 2 km to the northern extent of the offset area.	308527	6423900
UN1-AQ2	Unnamed creek approximately 20 km south of Mangoola Open Cut Lease area; located within the Ravensworth Complex Stewart offset area approximately 3 km north of Lake Liddell. Access is from the New England Highway along an unnamed dirt road. This dirt road is followed for approximately 2 km to the northern extent of the offset area. Site AQ2 is approximately 300 m downstream of site AQ1.	308528	6424439

Site	Description	MGAE	MGAN
UN2-AQ1	Unnamed creek approximately 20 km south of Mangoola Open Cut Lease area; located within the Ravensworth Complex Clifton offset area approximately 3 km north of Lake Liddell. Access is from the New England Highway along an unnamed dirt road. This dirt road is followed for approximately 1 km, to the intersection with the second creek equipped with a culvert. The site is approximately 300 m upstream of site UN2 AQ2 and approximately 100 m upstream of the waterfall.	308537	6421671
UN2-AQ2	Unnamed creek approximately 20 km south of Mangoola Open Cut Lease area; located within the Ravensworth Complex Clifton offset area approximately 3 km north of Lake Liddell. Access is from the New England Highway along an unnamed dirt road. This dirt road is followed for approximately 1 km, to the intersection with the second creek. The site is approximately 30 m upstream of the road culvert.	308888	6421677
CUC-AQ1	Cuan Creek upstream of Mangoola Open Cut Lease area; located on the property of Reedy Valley off Ridgelands Road. The site occurs to the north of the property and is accessed by crossing Wybong Creek then following Cuan Creek north along the western bank. The site occurs downstream of the confluence with Coxs Gully.	278932	6446560
CUC-AQ2	Cuan Creek upstream of Mangoola Open Cut Lease area; located on the property of Reedy Valley off Ridgelands Road. The site is located to the south of the property and is accessed by crossing Wybong Creek and Cuan Creek, then following Cuan Creek south along the eastern bank for approximately 1.5 km.	278820	6443491
WBC-AQ1	Wybong Creek upstream of Mangoola Open Cut Lease area; located on the property of Wybong Heights off Ridgelands Road, to the north of the Mangoola Mine Project area. Access to the site is to the west of Ridgelands Road approximately 20 m from the road.	279027	6440491
WBC-AQ2	Wybong Creek upstream of Mangoola Open Cut Lease area; located on the property of Wybong Heights off Ridgelands Road, to the north of the Mangoola Mine Project area. Access to the site is to the west of Ridgelands Road approximately 250 m from the road.	279224	6438779

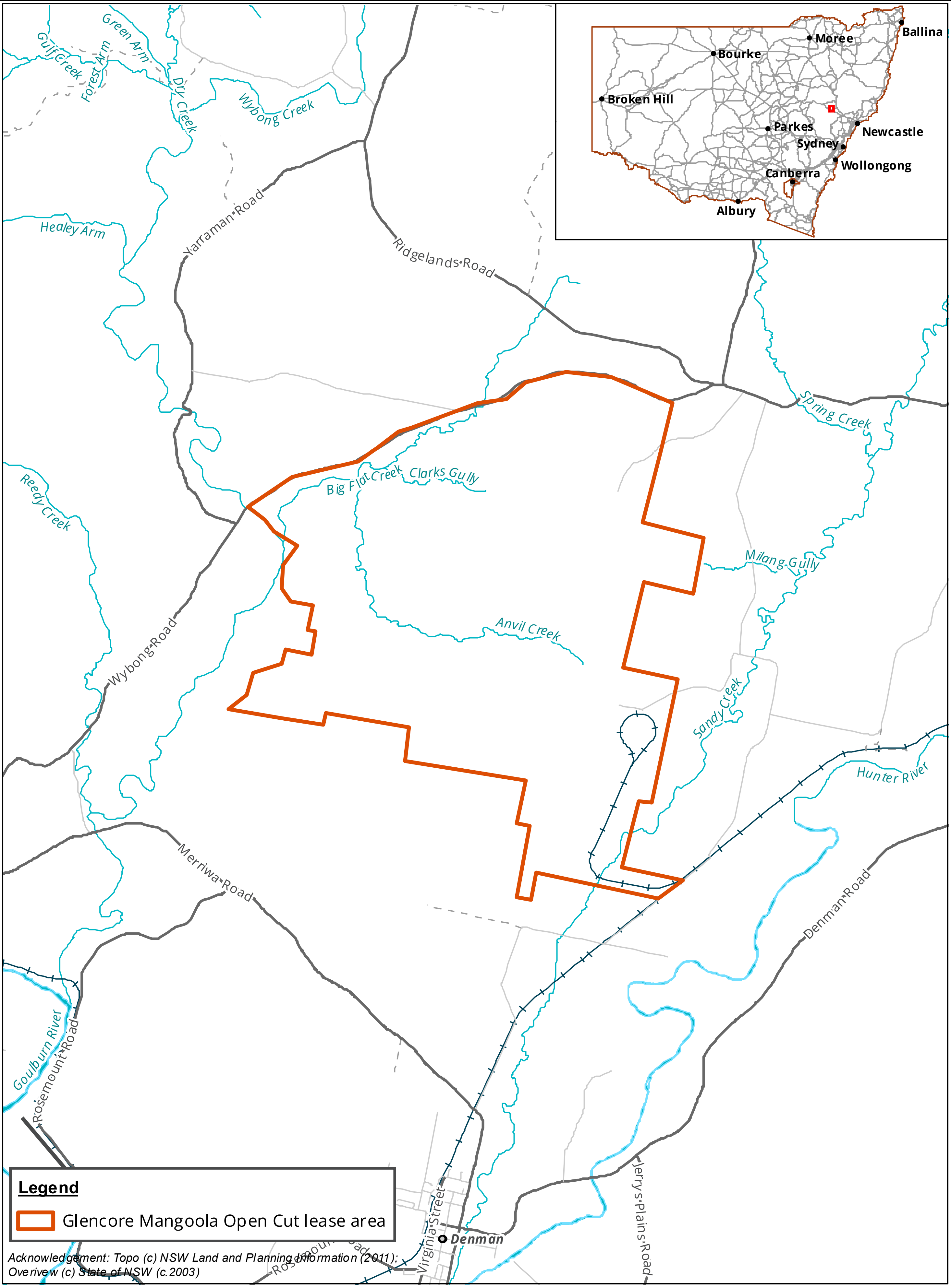

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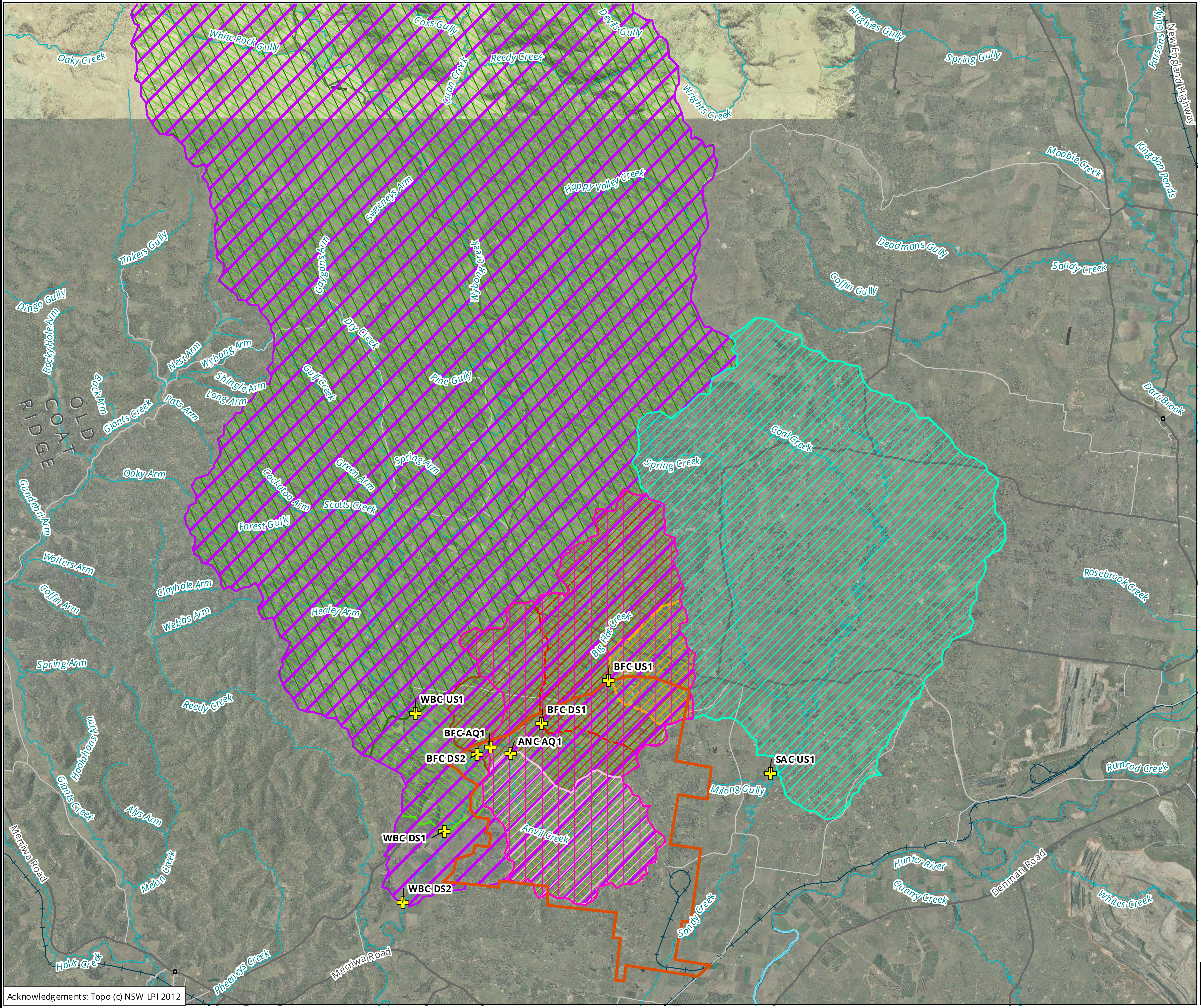
Figure 1: Location of the Project Area - Glencore Mangoola Open Cut lease area, New South Wales

Matter: 26948
Date: 13 February 2019, Checked By: LS, Drawn By: lharley
Location: P:\26900s\26948\Mapping\26948_F1_Locality.mxd

0 1,000 2,000 3,000
Metres
N
Scale 1:80,000 @ A4, GDA 1994 MGA Zone 55



Legend

- Glencore Mangoola open cut lease area
- Monitoring site

Watersheds by Monitoring Site Name

- ANC AQ1
- BFC AQ1
- (W14) BFC DS1
- (W7) BFC DS2
- (W3) BFC US1
- (SCU1) SAC US1
- (W9) WBC DS1
- (W11) WBC DS2
- (W5) WBC US1

Figure 2: Overview of stream health monitoring sites

0 1,000 2,000 3,000 4,000 5,000

Metres

Scale: 1:100,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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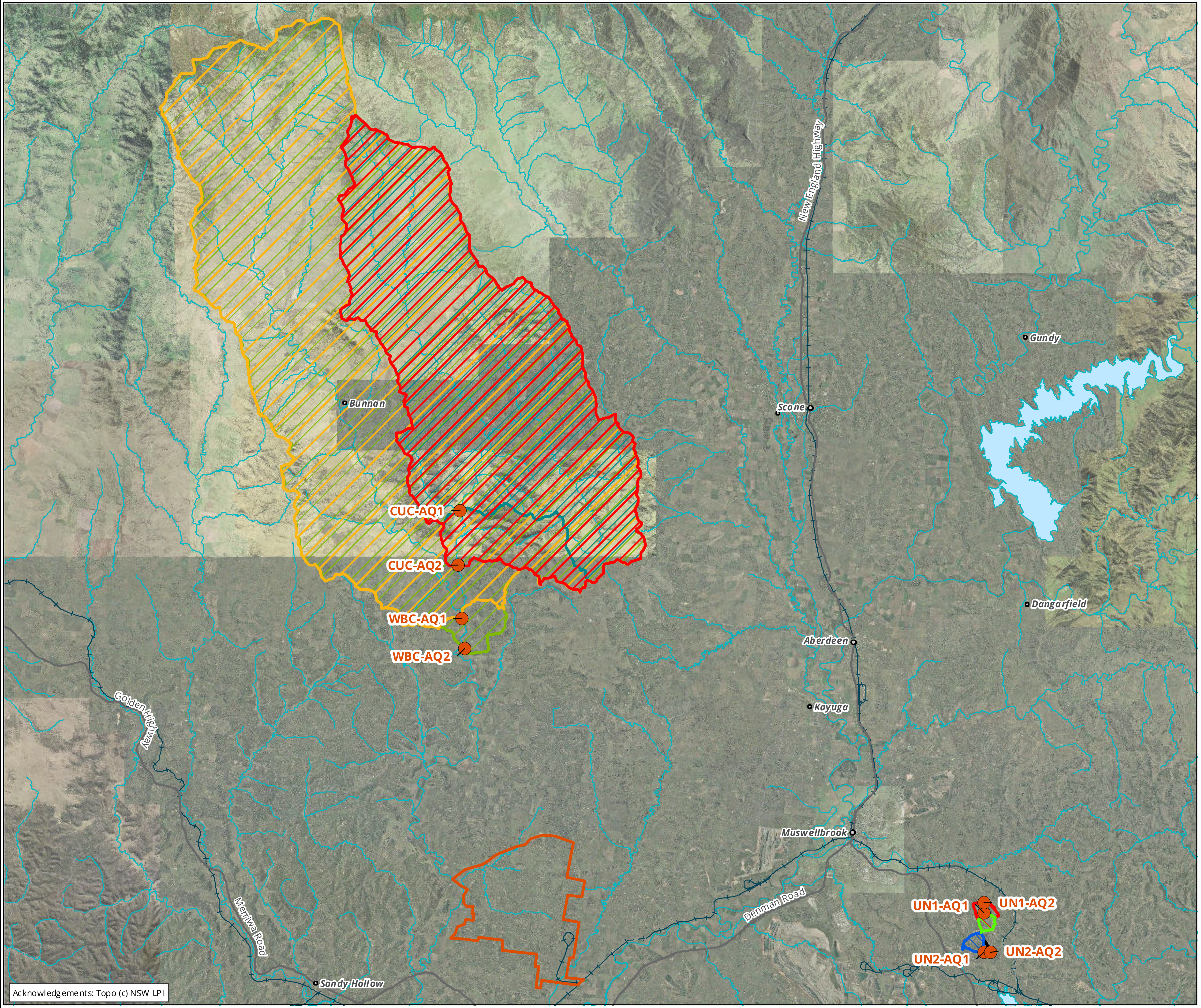
Matter: 26948
Date: 13 February 2019,
Checked by: LS, Drawn by: lharley
Location:P:\26900s\26948\Mapping\26948_F2_HydroSites_Overview



Legend

Glencore Mangoola open cut lease area

Control sites

Watersheds of control sites

CUC AQ1
CUC AQ2
UN1 AQ1
UN1 AQ2
UN2 AQ1
UN2 AQ2
WBC AQ1
WBC AQ2

Figure 3: Overview of stream health control sites

0 2,000 4,000 6,000 8,000 10,000

Metres

Scale: 1:200,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 26948
Date: 13 February 2019,
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Location:P:\26900s\26948\Mapping\26948_F3_ControlSites

2 Methods

The NSW AusRivAs survey methodology stipulates that autumn sampling be completed between 15 March and 15 June and spring sampling between 15 September and 15 December. The timing of biannual sampling completed by Biosis over the previous twelve seasons is shown in Table 1.

The surveys consisted of habitat assessments, macroinvertebrate sampling and water quality data collection. AusRivAs macroinvertebrate sampling was conducted at each site following the methods detailed in Section 2.2. During site visits weather conditions were recorded, and local rainfall data for the 12 weeks prior to the field survey was obtained. HABSCORE assessments were also undertaken at all sites, including those recorded as dry, to enable a comparison of relative health when macroinvertebrate sampling could not be undertaken due to insufficient water present.

2.1 Aquatic Habitat Assessments

HABSCORE assessments were completed at each site, and provide a measure of the relative health of aquatic habitat which is especially useful when the site is dry and no AusRivAs assessment can be completed. Barbour et al. (1999) describe HABSCORE as a 'visually based habitat assessment that evaluates the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community'.

HABSCORE assessments are based on the presence and condition of the following habitat characteristics:

- Pool substrate characterisation.
- Pool variability.
- Channel flow status.
- Bank vegetation (score for each bank).
- Bank stability (score for each bank).
- Width of riparian zone (score for each bank).
- Epifaunal substrate / available cover.

These characteristics provide an indicator of the quality of the waterway even when there is insufficient water for AusRivAs and SIGNAL2 assessments. HABSCORE categories are derived from the sum of scores divided by the maximum possible score for the characters assessed and range from 'Poor' to 'Optimal' condition, and are described by Barbour et al. (1999) as follows:

- **Optimal**: watercourses that contain numerous large, permanent pools and generally have flow connectivity except during prolonged drought. They provide extensive and diverse aquatic habitat for aquatic flora and fauna.
- **Suboptimal**: watercourses that contain some larger permanent and semi-permanent refuge pools, which would persist through prolonged drought although, become greatly reduced in extent. These watercourses should support a relatively diverse array of aquatic biota including some fish, freshwater crayfish and aquatic macroinvertebrates. There may also be some aquatic plant species present.

- **Marginal**: watercourses that contain some small semi-permanent refuge pools which are unlikely to persist through prolonged drought. Flow connectivity would only occur during and following significant rainfall. These pools may provide habitat for some aquatic species including aquatic macroinvertebrates and freshwater crayfish.
- **Poor**: water courses or drainages that only flow during and immediately after significant rainfall. Permanent or semi-permanent pools that could provide refuge for aquatic biota during prolonged dry weather are absent.

The descriptors and categories for the HABSCORE assessment used in this survey are provided in Appendix 1.

2.2 Surface water quality assessments

Water quality sampling was undertaken at each site using a Horiba Multi-parameter Water Probe, calibrated prior to sampling. Measurements were taken ~30 cm below the water surface. Variables measured on site included pH, dissolved oxygen (DO), turbidity and electrical conductivity (EC). Alkalinity was also assessed using a Hach Alkalinity Kit. Parameters were then assessed against Australian and New Zealand Conservation Council (ANZECC) water quality guidelines and, where available, site-specific impact assessment criteria. Site-specific impact assessment criteria for highly disturbed ecosystems are derived from the 80th percentile of the site-specific baseline monitoring data in flow and no-flow conditions (Umwelt 2013). Both ANZECC and site-specific impact assessment criteria provide an appropriate benchmark for monitoring water quality and provide insight into the current condition of the aquatic habitat and environmental values (ANZECC 2000).

2.3 Aquatic macroinvertebrate surveys

2.3.1 Taxonomy

Macroinvertebrates were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily) as outlined in the NSW AusRivAs Sampling and Processing Manual (Turak et al. 2004). All macroinvertebrates were identified using the taxonomic keys and names listed in Hawking (2000). Common names for key macroinvertebrates are used in the body of the report with names of all macroinvertebrates collected being provided in Appendix 1.

2.3.2 AUSRIVAS index

Aquatic macroinvertebrates were surveyed according to the techniques described in the NSW AusRivAs Rapid Assessment Method developed by the NSW Environment Protection Authority (now part of OEH) (Turak et al. 2004). This method involves the collection of samples from two habitat types (where possible) within a site using two different sampling techniques: slow-flowing river edges (dip-net technique) and fast-flowing riffles (kick-net technique). In the studied waterways, only edge habitat was suitable for sampling and monitoring and was therefore restricted to this technique.

Macroinvertebrates were live picked from the samples while in the field, and identified in the lab. Results were then analysed using the AusRivAs software package, which contains predictive models that assess the ecological health of a site by comparing its macroinvertebrate community with those of similar 'control' sites within the model. The macroinvertebrates recorded at these control sites are considered to be a strong representation of what macroinvertebrate communities would be expected to occur at a study site if it is in a 'control' or undisturbed condition. If a site does not contain the taxa expected by the model, then its condition is described as being 'lower than control'.

The AusRivAs model provides several outputs, including a ratio of the macroinvertebrates recorded at a study site to those predicted by the model. This is a ratio of observed taxa versus expected taxa and is called an 'O/E score' (Observed/Expected). Many macroinvertebrates are very rare, so the full list of expected taxa will often contain animals that have only been recorded once and typically at only one control site. If these were expected by the model to be present at a study site the result would often be very low O/E scores, so the most commonly used ratio is the 'O/E 50' score which only gives the ratio of observed/expected taxa that have a greater than 50% chance of occurring at a site (that is, the taxa which were recorded at more than 50% of matching control sites within the model).

The second output from the model is a 'band' rating of each study site. Band ratings are a simple description of stream condition and are described as follows:

- X – The site is richer than control condition
- A – The site is equivalent to control condition
- B – The site is in moderately impaired condition
- C – The site is in significantly impaired condition
- D – The site is in extremely impaired condition.

Separate AusRivAs models are used for stream edge and riffle habitats.

Macroinvertebrate populations can vary according to season, hence the AusRivAs assessment is based around predicted taxa within either the autumn or spring sampling periods. Sampling should ideally be conducted from March 15 to June 15 (autumn survey), and September 15 to December 15 (spring survey) in order to properly utilise the model. The samples collected in the present study were analysed with the NSW autumn and spring models separately. This allows comparisons of the status of the sites between seasons.

2.3.3 Signal2 Index

Another model for macroinvertebrate community assessment is the SIGNAL2 (Stream Invertebrate Grade Number Average Level) biotic index scores (Chessman 1995; Chessman et al. 1997). The SIGNAL2 index describes the tolerance of macroinvertebrate taxonomic families to pollution. Each taxa identified during the AusRivAs assessment is given a SIGNAL2 grade which is dependent upon their sensitivity to pollution. SIGNAL2 grades range between 1 and 10, with pollution-tolerant taxa (such as freshwater worms) having scores close to 1 and pollution-sensitive taxa (such as certain mayflies) score closer to 10 (Table 4). The index is derived from the sum of scores divided by the sum of abundances. This provides a comprehensive ecological indicator that produces an average SIGNAL2 score for each site as an indication of the macroinvertebrate community's overall tolerance to pollution or disturbance.

Table 4 Signal2 classification system

Signal2 Value	Impairment	Water Quality Status
Greater than 7	Unimpaired & rich in sensitive taxa	Excellent water quality
6 - 7	Unimpaired	Good water quality
5 - 6	Mildly impaired	Fair quality, possible mild pollution
4 - 5	Moderately impaired	Poor quality
Less than 4	Severely impaired	Very poor water quality

2.3.4 Stream health criteria

Biosis (2017) established stream health criteria for the impact monitoring sites based on examination of the long term monitoring data recorded for both monitoring and control sites within the program. The stream health criteria were developed following the biplot method described by Chessman (1997). The biplots can be divided into four quadrants which indicate the relative condition of waterways and are described below:

Signal Score -→	Quadrant 3 Sites plotted within this quadrant are representative of typical water quality, however harsh site conditions may be prevalent e.g. low water	Quadrant 1 Sites plotted within this quadrant are representative of stream health being within the ranges typically observed within the locality.
	Quadrant 4 Sites plotted within this quadrant are representative of poor stream health and macroinvertebrate community composition.	Quadrant 2 Sites plotted within this are representative of typical species diversity however high levels of salinity or nutrients may be present in the water.
	Number of taxa -→	

The borders of quadrant 4 along the top and right hand side form the stream health criteria with any sites plotted within this quadrant being subject to further scrutiny and investigation.

The bounds of quadrant 4 are defined as a Signal2 score below 4 and a number of taxa score below 10. Signal scores below 4 are indicative of severely impaired stream health and very poor water quality. These low scores are consistent with both control sites and monitoring (Impact) sites. As all sites have typically low Signal scores, the number of taxa present has been used in conjunction with the signal scores to produce a biplot for Big Flat Creek and Wybong Creek, with Anvil Creek to be established when longer term data becomes available.

2.4 Incidental observations

In addition to macroinvertebrate sampling, any observations or signs of vertebrates within the stream environment (e.g. fish, amphibian, aquatic birds or reptiles) were also recorded. The relative abundance of stream algae and macrophytes were included as observations, to assess the degree of eutrophication and weed infestation of the riparian zone.

2.5 Limitations

The survey effort, combined with information available from other sources, is considered suitable to assess the overall stream health at each site. The study is, therefore, not considered subject to any significant limitations; however, the following qualifications apply:

- The objective of this study is to provide data to build an assessment of current stream relative health within the study area. The study area, as a whole, has been impacted by historical and current open cut mining operations making these bi-annual samples a snapshot of current conditions and inadequate for assessing the overall health of aquatic habitats. Continuation of this monitoring program coupled with the control site data improve accuracy and provide context to these results while building a more detailed understanding of the of prevalent stream health within the Mangoola Open Cut Project area.
- The water quality parameters measured/analysed provide a snapshot of conditions at a given point in time. Some of these parameters typically exhibit a high degree of temporal variation and can change substantially over small periods of time (weeks, days and even hours), particularly in response to significant weather events.
- Mapping is conducted using hand-held (non-differential) GPS units and aerial photo interpretation. The accuracy of this mapping is therefore subject to the accuracy of the GPS units (generally +/- 7 metres) and dependent on the limitations of aerial photo rectification and registration.

3 Results

Rainfall records from the Muswellbrook (Lindisfarne) weather station (061168), 5.06 kilometres from the Mangoola Open Cut Lease area, indicate that 20.5 millimetres fell in the four weeks preceding the autumn survey. No rainfall was recorded in the four weeks preceding the spring survey. A total of 452 millimetres of rainfall was recorded at the Lindisfarne weather station for the whole of 2018, and a total of 407.4 millimetres in 2017, both of which are below the average recorded rainfall at this station of 593 millimetres.

3.1 Site observations

The overarching observation across all sites during the 2018 monitoring period was that the dry conditions observed during 2017 had continued through 2018. A number of sites were dry or exhibited substantially reduced water levels during both autumn and spring monitoring seasons following an extended period of extremely low rainfall.

3.1.1 Monitoring sites

Anvil Creek ANC-AQ1

Monitoring site ANC-AQ1 had been subject to clearing and mulching as result of mine works and as such this site would be subject to substantial modification. The site was not accessible during autumn and spring 2018. A replacement site, BFC-AQ1 was established in spring 2018, downstream of the confluence of Big Flat Creek and Anvil Creek. Sites BFC-AQ1 and BFC-US1 will be used to infer any impacts occurring along Anvil Creek.

Big Flat Creek (W3) BFC-US1

Monitoring site BFC-US1, located on Big Flat Creek comprised of shallow, poorly-connected pools, likely filled with rainfall from the day of sampling during autumn 2017. BFC-US1 was dry during both the autumn and spring 2018 surveys, with all instream surfaces exposed. Riparian vegetation was dominated by non-native herbs and grasses with dense growth of Spiny Rush *Juncus acutus* occurring within the channel. The stream substrate was composed primarily of gravel and sand with scattered pebbles.

Big Flat Creek (W14) BFC-DS1

Monitoring site BFC-DS1 was dry during both autumn and spring monitoring seasons. Emergent macrophytes within the channel zone were reduced in 2018 in comparison to previous monitoring years, a result of continued dry conditions at this site. The riparian zone was well vegetated, dominated by *Casuarina* spp. and small patches of introduced woody and herbaceous weeds (African Boxthorn *Lycium feroccissimum* and Spiny Rush).

Big Flat Creek BFC – AQ1

Monitoring site BFC-AQ1 was monitored for the first time in spring 2018. The site was found to be dry, with the dry conditions extending for distances both upstream and downstream of this site on Big Flat Creek. The channel is relatively wide in comparison to the other sites along Big Flat Creek. The active channel zone is dominated by Spiny Rush with trees, dominated by *Casuarina* spp., lining portions of the bank. A substantial amount of bank erosion and gullying was identified along the monitoring site.

Big Flat Creek (W15) BFC-DS2

Big Flat Creek at site BFC-DS2 was dry during both autumn and spring monitoring seasons. Low habitat diversity and little in stream structure was recorded at this site, consistent with previous years. The channel edges were dominated by Spiny Rush and introduced grasses that were marginally reduced in comparison to previous years. The site has a very steep and unstable northern bank, with grassy woodland on both sides.

Wybong Creek (W5) WBC-US1

Water levels at monitoring site WBC-US1 were highly reduced during the autumn and spring 2018 monitoring seasons, with the majority of channel substrates exposed along the monitoring site. The extended dry conditions had led to some colonisation of the channel by herbaceous weed species. Two large refuge pools were present. These were highly turbid and contained a small number of floating aquatic macrophytes and some algae. In previous monitoring years this site has had one of the larger wetted widths of the monitoring sites, ranging between 3 m and 11 m. The riparian zone mostly consists of native and exotic grasses and shrubs interspersed with tree species (*Casuarina* spp.). The stream substrate was mostly pebble, gravel and sand, with some large snags present but concentrated on the banks rather than within the channel. The diverse emergent macrophyte community that has been previously recorded fringing the banks at this site were highly reduced in 2018, reflecting the prolonged dry conditions.

Wybong Creek (W9) WBC-DS1

Wybong Creek at site WBC-DS1 is comprised mostly of a single wide slow-moving pool up to 1 m in depth. The western bank is bare rock and scattered exotic grasses, while the eastern bank is dominated by eroded and undercut banks with exotic grasses and a few isolated *Casuarina* spp.. The waterway ranged between 6 m and 8 m in wetted width in autumn and spring 2018. The substrate was mostly gravel and sand, with beds of emergent macrophytes present along the length of the reach. A large amount of coarse woody debris was recorded in 2018, having accumulated in log jams on the margins of bank-attached lateral bars. This debris has remain largely in place since spring 2016. Indicating no high flows had passed through the site since spring 2016.

Wybong Creek (W11) WBC-DS2

At monitoring site WBC-DS2 Wybong Creek presents a variety of instream habitats, including shallow slow pools, a short narrow riffle and a small backwater section. The site is surrounded by steep hills dominated by exotic grasses and isolated paddock trees, and the wetted width ranged between 1 m and 3 m in autumn and spring 2018 with a maximum depth of approximately 0.5 metres. Substantially reduced from previous monitoring years. The substrate was dominated by gravel and sand, with undercut banks, trailing vegetation and exposed roots on the western bank. However, the low water levels reduced the availability of this habitat for aquatic fauna.

Sandy Creek (SCU1) SAC-DS1

The monitoring reach at site SAC-DS1 is surrounded by cleared grazing land and subsequently the riparian zone is mostly cleared and dominated by exotic grasses, with a scattered clumps of *Casuarina* spp.. Both banks are steep and heavily eroded in places. Aquatic vegetation, dominated by Typha, chokes the stream in several places upstream and downstream.

3.1.2 Control sites

Wybong Creek WBC-AQ1

The control site WBC-AQ1 on Wybong Creek held similar amounts of water during spring 2018 and autumn 2018 sampling. This site exhibited reduced flow during spring 2017 with a reduced maximum wetted with of 5 metres and more riffle substrates exposed. A marginally further reduction in water levels was observed in 2018. The sampling reach consisted of a large pool with no noticeable flow with an upstream short shallow riffle area with slow flow. Dense clusters of the aquatic floating fern *Azolla* spp. along the banks were observed in autumn 2018, which had expanded in spring 2018 to cover the majority of the water's surface. The average depth was 0.5 m. Availability of seasoned snags, exposed roots and trailing vegetation was fair, with the substrate primarily composed of cobble and pebble.

Wybong Creek WBC-AQ2

The control site WBC-AQ2 is surrounded by cleared gazing land dominated by exotic grasses with a couple of isolated trees scattered through the riparian zone. This site appears to be subject to a limited amount of change, with conditions remaining consistent throughout the monitoring program. The reach consists of two slow-flowing pools connected by a small riffle. Maximum depth in the pools was approximately 2 m, and the substrate was comprised of a mix of cobble, pebble, gravel and sand with some silty areas. Beds of emergent macrophytes provided the only available instream structure.

Cuan Creek CUC-AQ1

Cuan Creek upstream control site CUC-AQ1 held less water during the 108 monitoring seasons in comparison to 2017, with a wetted width of between 1 to 4 metres mostly occurring within non-flowing large refuge pools. The site comprises a mix of shallow riffle and pool sections. Algae was abundant in autumn 2018 and somewhat reduced in spring 2018 where Azolla spp. was more prevalent. The incised channel banks are moderately stable, being covered by native and exotic grasses and several large trees (Casuarina spp.). The substrate is mostly comprised of cobble, pebble and gravel.

Cuan Creek CUC-AQ2

The Cuan Creek site CUC-AQ2 had a good mix of shallow riffle, fast shallow and slow deep areas with large seasoned snags and some trailing vegetation through the reach. The western bank was moderately unstable with undercut areas in some places. The substrate was dominated by cobble and gravel, and the average depth during both autumn and spring sampling was 1 metre. The riparian vegetation has largely been cleared, leaving the waterway exposed with minimal shading throughout the reach. Carp *Cyprinus carpio* were observed during both autumn and spring 2018.

Unnamed Creek UN1-AQ1

The site UN1-AQ1 on Unnamed Creek 1 was dry during autumn and spring 2018. The substrate of the pools was mostly sand with some gravel and clay/silt. The riparian zone and dry creek bed were dominated by exotic grasses with a canopy of Spotted Gum *Corymbia maculata*, and Rough Bark Apple *Angophora floribunda*.

Unnamed Creek UN1-AQ2

The Unnamed Creek 1 control site UN1-AQ2 is located in a large paddock, downstream of a dam that regulates the flow regime within the site. Grazing is the dominant land use and canopy species within this area have been eradicated. Despite the dam upstream holding some water the sampling site was dry during both autumn and spring 2018.

Unnamed Creek UN2-AQ1

The site UN2-AQ1 on Unnamed Creek 2 lies at the northern boundary of the offset area and is surrounded by grazed paddocks with some native canopy species present within the riparian area. The sampled reach has a mixed substrate with areas of bedrock, sand and gravel with leaf packs and snags throughout. No macrophytes were present and are unlikely to occur given the rocky nature of the surrounding area. The site was entirely dry in autumn and spring 2018.

Unnamed Creek UN2-AQ2

The Unnamed Creek 2 control site UN2-AQ2 is surrounded by relatively undisturbed native bushland and shows minimal evidence of bank erosion. The site was dry during both autumn and spring monitoring seasons in 2018. The substrate at this monitoring location was dominated by gravel with sand and fine sediment also present. The bank vegetation present was largely unchanged from previous monitoring years with the minor amount of seasoned snags still present.

3.2 Habitat assessment

The overall score for each site is summarised in Table 5. HABSCORE assessments are largely based on structural attributes of sites to provide a relative measure of the condition or quality of aquatic habitat available, and incorporate aspects of the wetted channel, such as riffle quality. This results in dry sites scoring lower than previous seasons when they may have held water, while still allowing relative comparison with other 'wet' sites.

There was a general trend of reduced HABSCORES across monitoring sites in 2018 when compared to previous years, although the 2018 scores are relatively consistent with the results of the 2017 monitoring. This reduction is considered to be due to widespread dry conditions resulting in a lack of water during the survey periods, resulting in reduced scores. A number of sites recorded similar scores between autumn and spring, reflecting relatively stable conditions at these sites, which have commonly been dry during previous sampling years.

Table 5 HABSCOREs for autumn and spring 2018 sampling seasons and corresponding habitat condition categories where O=optimal; S=suboptimal; M=marginal; P=poor

Site	Autumn		Spring	
	Score	Category	Score	Category
Monitoring				
BFC-AQ1	-	-	42	M
BFC-DS1	23	P	23	P
BFC-DS2	23	P	23	P
BFC-US1	8	P	8	P
WBC-US1	24	P	24	P
WBC-DS1	45	M	44	M
WBC-DS2	43	M	49	M
Control				
CUC AQ1	26	M	44	M
CUC AQ2	57	S	44	M
WBC AQ1	57	S	61	S

Site	Autumn		Spring	
	Score	Category	Score	Category
WBC AQ2	44	M	48	M
UN1 AQ1	28	M	27	M
UN1 AQ2	19	P	21	P
UN2 AQ1	29	M	29	M
UN2 AQ2	39	M	39	M

3.3 Surface water quality assessment

Water quality parameters recorded during autumn and spring 2018 sampling were compared against the Mangoola Coal adopted impact assessment criteria (Umwelt 2013) and ANZECC default impact assessment criteria for lowland rivers in south-east Australia (ANZECC 2000), shown in Table 6. All control sites were compared against ANZECC guidelines only.

Table 6 Adopted impact assessment criteria and ANZECC default impact assessment criteria for south-east Australia

Site	Flow Conditions	pH		Oxygen % Saturation		Turbidity (NTU)		Conductivity (µs/cm)
		Min[1]	Max	Min[1]	Max[1]	Min[1]	Max[1]	Max
BFC-AQ1	All conditions	6.5	8.0[1]	85	110	6	50	2200[1]
BFC-US1	All conditions	6.5	8.5	85	110	6	50	25240
BFC-DS1	All conditions	6.5	8.4	85	110	6	50	17240
BFC-DS2	All conditions	6.5	8.4	85	110	6	50	17240
WBC-US1	Flow	6.5	8.5	85	110	6	50	1660
	No flow	6.5	8.1	85	110	6	50	4150
WBC-DS1	Flow	6.5	8.4	85	110	6	50	3180
	No flow	6.5	7.8	85	110	6	50	7050
WBC-DS2	Flow	6.5	8.4	85	110	6	50	3180
	No flow	6.5	7.8	85	110	6	50	7050
SAC-DS1	All conditions	6.5	8.1	85	110	6	50	5850
SAC-DS2	All conditions	6.5	8.3	85	110	6	50	2200
Control Sites	All conditions	6.5	8.0[1]	85	110	6	50	2200[1]

ANZECC (2000), Umwelt (2013).
Note 1: Use ANZECC (2000) criterion.

The results of the surface water quality monitoring at both the monitoring and control sites are presented in Table 7. A number of surface water quality parameters were found to be outside of the water quality guideline values (Table 6) at both control and monitoring sites. All sites recorded at least one exceedance of the guideline values in each monitoring season. With the exception of WBC-DS2 which recorded parameters within all guideline levels during autumn 2018. The recorded exceedances in 2018 were comparable to those previously recorded during the monitoring program. The electrical conductivity scores recorded at the monitoring sites in 2018, and at control site WBC-AQ2 in spring, are slightly higher than generally recorded. This is likely to be a result of reduced flow leading to pooling and evaporation concentrating salts within the water due to the reduced rainfall during this period. However future iterations of this program should examine the results from these sites in the future to establish whether this is part of a trend.

Table 7 Water quality parameters measured during autumn and spring 2018 sampling

Site	pH		Dissolved oxygen (%)		Conductivity (µS/cm)	
	Autumn	Spring	Autumn	Spring	Autumn	Spring
Monitoring						
ANC-AQ1	-	Dry	-	Dry	-	Dry
BFC-US1	Dry	Dry	Dry	Dry	Dry	Dry
BFC-DS1	Dry	Dry	Dry	Dry	Dry	Dry
BFC-DS2	Dry	Dry	Dry	Dry	Dry	Dry
WBC-US1	8.11	5.40	83.9	97.6	4150	5660
WBC-DS1	8.10	6.60	52.9	70.8	5180	3140
WBC-DS2	8.38	7.19	87.1	60.2	3100	5040
SAC-DS1	Dry	Dry	Dry	Dry	Dry	Dry
Control						
CUC-AQ1	8.55	7.90	59.3	54.8	1790	1530
CUC-AQ2	8.62	8.30	50.2	56.7	1330	1250
WBC-AQ1	8.44	8.00	54.1	46.3	1230	1110
WBC-AQ2	8.35	8.00	49.1	40.3	1540	5040
UN1-AQ1	Dry	Dry	Dry	Dry	Dry	Dry
UN1-AQ2	Dry	Dry	Dry	Dry	Dry	Dry
UN2-AQ1	Dry	Dry	Dry	Dry	Dry	Dry
UN2-AQ2	Dry	Dry	Dry	Dry	Dry	Dry

3.4 Aquatic macroinvertebrates

The results of the AUSRIVAS predictive models are provided in Table 8. Broadly speaking the stream health scores throughout 2018 indicate that the monitoring sites were, in general, moderately impaired and water quality was generally very poor, broadly consistent with previous monitoring years. The control sites were also mostly moderately impaired and subject to very poor water quality, a slight decline on previous years.

Table 8 AUSRIVAS results for monitoring sites during autumn and spring 2018

Site	OE50		Band		Signal2 grade (O0signal)		Number of families	
	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Monitoring								
BFC-AQ1	-	Dry	-	Dry	-	Dry	-	Dry
BFC-US1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
BFC-DS1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
BFC-DS2	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
WBC-US1	0.70	0.53	B	B	3.29	3.09	17	11
WBC-DS1	0.57	0.67	B	B	3.50	3.55	12	19
WBC-DS2	0.44	0.64	C	B	3.80	3.85	9	12
Control								
CUC AQ1	0.69	0.60	B	B	3.18	3.27	16	14
CUC AQ2	0.71	0.67	B	B	3.95	3.83	18	17
WBC AQ1	0.62	0.66	B	B	3.60	3.47	15	18
WBC AQ2	0.91	0.49	A	C	3.53	3.33	19	10
UN1 AQ1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
UN1 AQ2	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
UN2 AQ1	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
UN2 AQ2	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

3.4.1 Monitoring sites

Half of the monitoring sites were dry during the autumn survey with the majority of sites dry during the spring survey, a continuation of the observed conditions during the 2017 monitoring year. All monitoring sites, with water, recorded a Band B scores in autumn except WBC-DS2. The Band B scores indicate the sites were in moderately impaired conditions in comparison to reference conditions. WBC-DS2 recorded a Band C score indicating the site was in a significantly impaired condition in comparison to reference conditions. The site recorded a Band B score in spring 2018 and slightly higher OE50 score, indicating a slight improvement in stream health. This may be a result of a very minor increase in the availability of water at this site during this survey which may have contributed to a minor degree of aquatic habitat rejuvenation and increase in aquatic habitat availability.

SIGNAL2 scores were generated for each site through the AUSRIVAS modelling software, providing an average score of water quality based on the macroinvertebrates collected at the site. Figure 4 shows that available SIGNAL2 data for monitoring sites tends to cluster in the 'severely impaired' category, indicating very poor water quality and that all monitoring sites were subject to similar levels of water quality and aquatic habitat availability. The 2018 scores are all within the range of scores previously recorded at the monitoring sites. A trend of declining scores at site WBC-US1 since spring 2016 has been observed. Previous monitoring at this site has recorded values that vary among years and seasons, with spring 2016 being an above average season in terms of Signal2 score, with freshly deposited and abundant large woody debris along Wybong Creek during this season indicating large flows had occurred prior to monitoring. The same pattern is observed in the Wybong Creek control sites WBC-AQ1 and WBC-AQ2. It is likely that the declining Signal2 scores at this site may be attributed to reduced rainfall and associated reductions in water and aquatic habitat availability. However, it is recommended that stream health scores be reviewed for this site in subsequent monitoring seasons.

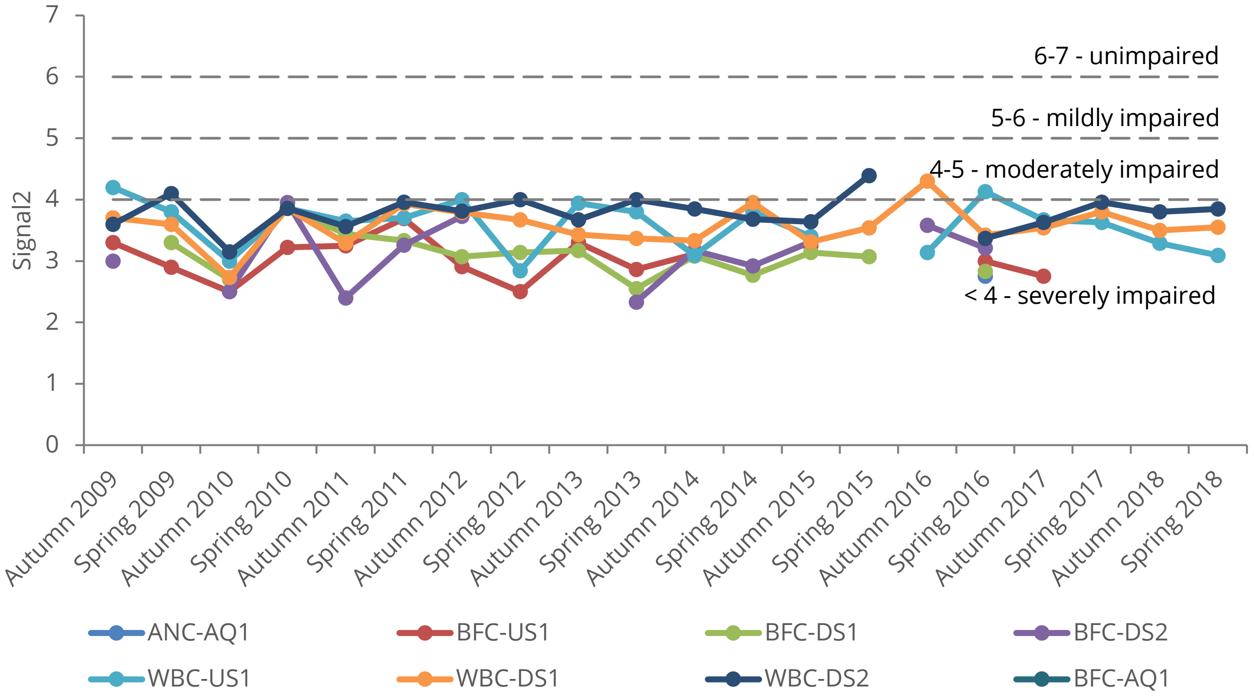

Figure 4 **SIGNAL2 scores for monitoring sites across all monitoring years**

3.4.2 Control sites

Only the Wybong Creek and Cuan Creek sites held water during the 2018 monitoring year. This is in contrast to 2017 where all control sites held water during the autumn monitoring survey, with the majority also holding water in the spring survey. Indicative of the decline in water availability during 2018. The majority of sites recorded Band B scores, indicating moderately impaired conditions in comparison to reference conditions. Site WBC-AQ2 recorded a Band A score in autumn and a Band C score in spring 2018. This may be attributed to a decline in the condition and extent of fringing emergent macrophytes present as well as a substantial increase in the presence of the floating fern *Azolla* sp. during spring 2018, contributing to an overall reduction in aquatic habitat variability and extent.

Figure 5 shows that the 2018 Signal2 scores for control sites cluster within the 'severely impaired' category and are within the range of previously recorded scores when considered as a whole. These scores are indicative of very poor water quality and suggest that all control sites were subject to similar levels of water quality and aquatic habitat availability. Sites WBC-AQ1, WBC-AQ2 and CUC-AQ1 all recorded reduced scores in comparison to previous monitoring years in 2018. It is likely that the declining Signal2 scores at these sites may be attributed to reduced rainfall and associated reductions in water and aquatic habitat availability. However it is recommended that stream health scores be reviewed for these sites in subsequent monitoring seasons.

biosis.

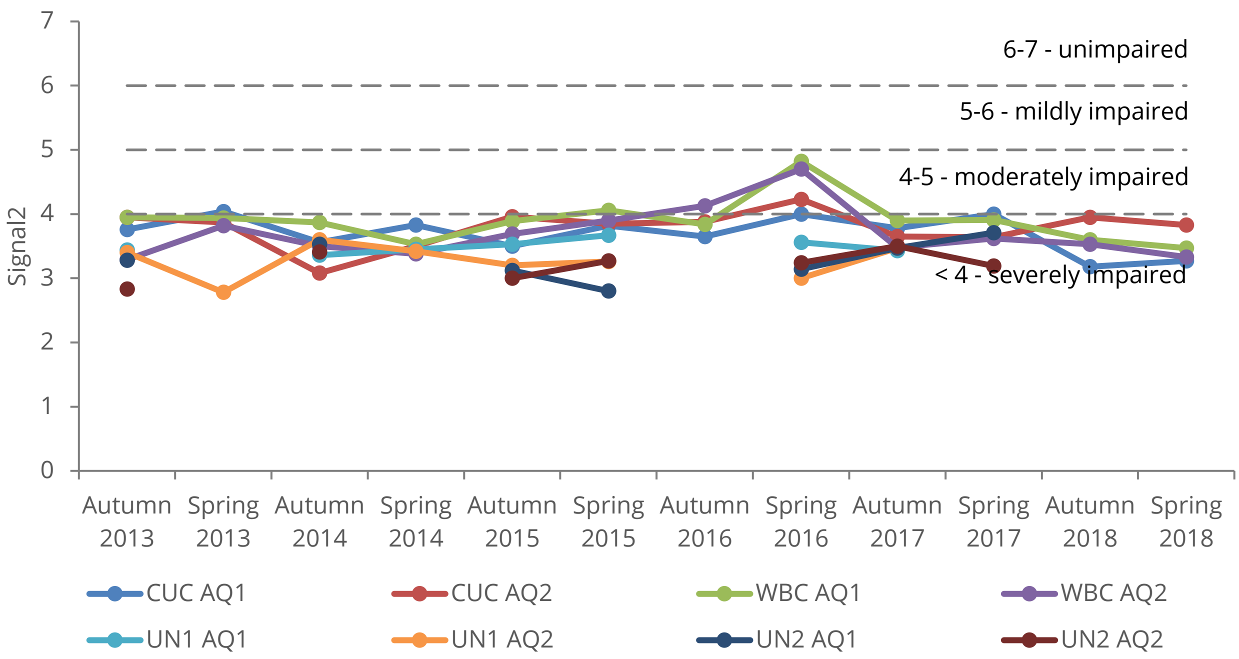

Figure 5 SIGNAL2 scores for control sites across all monitoring years

3.5 Stream health criteria

The stream health criteria for monitoring sites within the stream health monitoring program were developed by Biosis (2017) based upon the long term monitoring data collected as part of the program. The aim of the stream health criteria is to direct further investigation into the health of the monitoring sites where the scores fall outside of scores considered to be within a normal or acceptable range (Quadrant 4), based on analysis of historic data.

3.5.1 Autumn 2018

A number of sites were dry during the autumn 2018 monitoring period, with the scores for sites holding water shown in Figure 6. The majority of sites fall into Quadrant 2 indicating typical species diversity for these sites, however high levels of salinity or nutrients may be present in the water. These sites do not require further data exploration. Site WBC-DS2 falls into Quadrant 4 indicating poor stream health and macroinvertebrate community composition. As this site falls within Quadrant 4, more detailed exploration of the data to determine the causes of the low stream health scores has been undertaken. It has been determined that the results are not likely to be attributed to any impacts associated with mining within the Mangoola Open Cut mine lease area. The Signal2 score is marginally above that recorded during autumn 2017, where WBC-DS2 was located in Quadrant 2. However the decline in the number of taxa recorded places the site into Quadrant 4. The water quality data for WBC-DS2 in autumn 2018 shows no exceedances of the water quality guideline values. An examination of the HABSCORE data shows that the site recorded a Poor grade and score, which is slightly below that previously recorded at this site. The reduced HASCORE grade is largely driven by the reduced water availability, with almost all stream substrate exposed and available water limited to refuge pools. The reduced water availability results in reduced aquatic habitat availability and condition. In particular the shallow riffle that is generally present at this site was not running due to the lack of water, which would also contribute to a reduction in habitat variability. As such, it is considered likely that the reduced number of taxa recorded is likely to be a result of the reduced water availability.

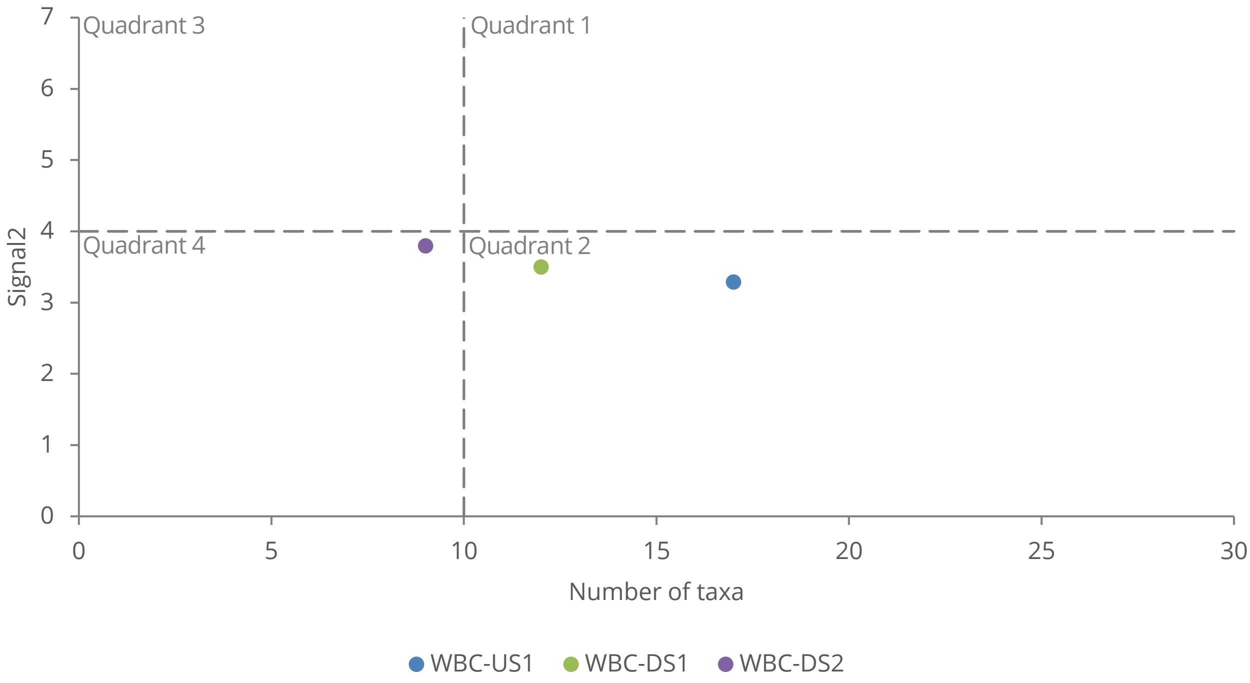

Figure 6 Stream health criteria: autumn 2018

3.5.2 Spring 2018

The majority of sites were dry during the spring 2018 monitoring period, with the scores for sites holding water shown in Figure 7. Sites WBC-DS1, WBC-DS2 and WBC-US1 fell into Quadrant 2 indicating typical species diversity for these sites, however high levels of salinity or nutrients may be present in the water. No sites fell into Quadrant 4 and therefore do not require further exploration of the data. WBC-DS2 was found to return within Quadrant 2 in spring 2018, after falling into Quadrant 4 in autumn 2018. Water availability at this site marginally increased in spring 2018 and is reflected in marginal HABSCORE increase during this season. This supports the conclusion that the reduced number of taxa recorded at WBC-DS2 in autumn 2018 is likely to be a result of the reduced water available, not as a result of mining activities.

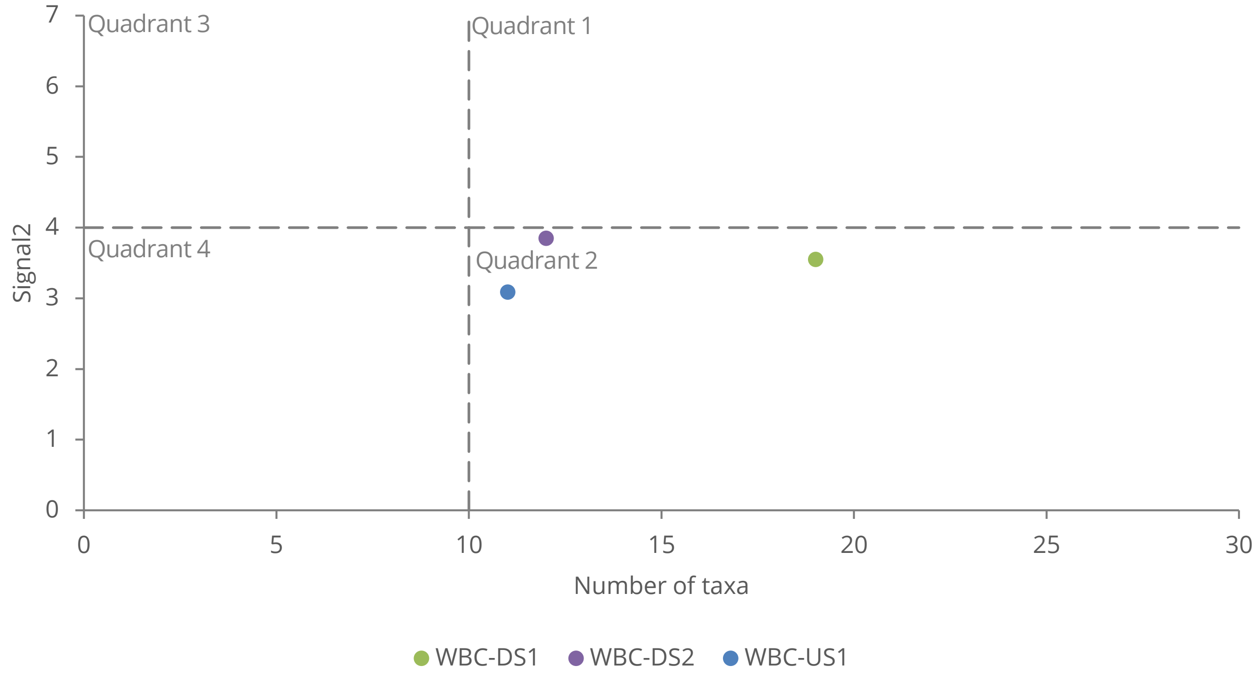

Figure 7 Stream health criteria: spring 2018

4 Discussion & conclusions

This report presents the results of the Mangoola Open Cut Stream Health Monitoring program for autumn and spring 2018 and evaluates these in the context of previous biannual monitoring undertaken as part of this program since 2009. Eight control sites have been included in the monitoring program since autumn 2013 and provide relevant comparisons with the seven monitoring sites to determine whether observed changes, if any, may be due to environmental conditions, management or mining activities. As baseline data (pre mining) is not available, future iterations of this program will continue to build a more comprehensive insight into the overall condition of waterways within the study area.

Despite environmental fluctuations in water availability, monitoring sites and control sites overall have remained in a relatively stable but poor condition since the stream health monitoring program incorporated control sites in autumn 2013, and no significant difference has been observed between monitoring sites and the control sites.

Most sites (monitoring and control) recorded decreased HABSCOREs in 2018 when compared to previous monitoring years. This reduction can largely be attributed to reduced flows leading to dry channels or the formation of isolated pools, decreased instream habitat availability and variability. This trend was observed across monitoring and control sites and follows the same trend identified during 2017 monitoring. Overall, HABSCOREs were generally low across sites and seasons. This is consistent with previous stream health monitoring assessments and is to be expected considering the highly modified and heavily managed nature of the region, which is not attributable to mining activities but reflects the agricultural history of the region.

Physicochemical water quality parameters fluctuate throughout the day and therefore do not generally provide a comprehensive indication of the overall quality of an aquatic habitat, however measurements of these parameters are useful to identify significant changes in water quality. Physicochemical surface water quality parameters measured during autumn and spring 2018 indicate scores outside of the water quality guidelines (Table 6, Table 7) are common amongst both monitoring and control sites. The exceedances recorded during the 2018 monitoring are considered to be within the ranges of scores previously recorded as part of the stream health monitoring and do not represent unusual scores considering the environmental conditions and land use history. Sites with low oxygen saturation and pH values, and high electrical conductivity values were generally associated with reduced flow. Therefore, it is reasonable to interpret the HABSCORE and AUSRIVAS data as an accurate representation of the condition of the monitoring and control sites sampled.

AUSRIVAS modelling results continue to indicate that most monitoring and control sites are far from the undisturbed condition of reference sites used within the model. Assessment of aquatic macroinvertebrate assemblages using the AUSRIVAS method provides a robust indication of the condition of a waterway, as many incremental changes which may be overlooked by conventional chemical water quality monitoring influence the assemblage of macroinvertebrates that inhabit the waterway. With these results interpreted in combination with surface water quality and HABSCORE results, it is possible to assess the overall physical and biological condition of the site which provides increased opportunity to identify changes in condition.

Throughout the stream health monitoring program most monitoring sites with sufficient water to obtain a sample have consistently recorded macroinvertebrate assemblages indicating waterways are in a ‘moderately impaired condition' (Band B), which was reflected in the autumn and spring 2018 monitoring periods. Despite the dry conditions, one site (WBC-AQ2) recorded a Band A grade, although this decreased to a Band C grade in spring. WBC-DS2 was the only other site to record a Band C grade in 2018, and this returned to a B grade in the following spring.

SIGNAL2 scores, an indication of the pollution sensitivity of macroinvertebrate assemblages at a site, remained relatively consistent for monitoring and control sites from previous years, and show a tendency to clump together from season to season suggesting that when changes occur they are at the regional rather than site scale. The SIGNAL2 scores for all monitoring and control sites for the 2017 monitoring period all recorded scores indicating very poor water quality, a reflection of the degraded nature of environmental conditions within the locality.

Only one monitoring site recorded stream health scores outside of the stream health criteria developed by Biosis (2017), requiring further examination of the stream health data collected. The poor results identified at this site are deemed to be the result of prolonged dry conditions, rather than the result of effects that may be attributed to mining activities.

The dry conditions across the Upper Hunter region during the 2018 monitoring period results in a considerable number of both control and monitoring sites being dry or exhibiting highly reduced water availability. As such the relatively poor scores recorded during 2018 must be considered within the context of this natural phenomena when used for comparisons in future iterations of the monitoring program.

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Appendices

Appendix 1: Macroinvertebrate catch data

Table 9 Number of macroinvertebrates collected at all sites during autumn 2018 sampling by family for each site

Taxon	Signal2	CUC-AQ1	CUC-AQ2	WBC-AQ1	WBC-AQ2	WBC-DS1	WBC-DS2	WBC-US1
Dugesiidae	2	1			1			
Planorbidae	2							1
Physidae	1	1	2	1	5	3		4
Sphaeriidae	5	2		1				
Oligochaeta	2		1					
Hydrachnidae	7		3					
Ostracoda		22	2					
Atyidae	3	3	4	2	2	10	5	10
Palaemonidae	4					1		
Parastacidae	4							
Dytiscidae	2	7					1	10
Dytiscidae (larva)	2	2			2			6
Hydrophilidae	2							
Hydrophilidae (larva)	2	2						
Tipulidae	5	1						
Culicidae	1							1
Ceratopogonidae	4	10			2			
Simuliidae	5		12	5				
Tanypodinae	4	14		15	8	2		1
Orthocladiinae	4		2	11	3			
Chironominae	3	47	4	8	34	21	26	34

Taxon	Signal2	CUC-AQ1	CUC-AQ2	WBC-AQ1	WBC-AQ2	WBC-DS1	WBC-DS2	WBC-US1
Chironomidae (Pupa)	3						1	
Baetidae	5	2	11	8	4	3	4	5
Leptophlebiidae	8		3		1		1	
Caenidae	4	23	6	11	26	3	32	1
Mesoveliidae	2		2					
Hebridae	3			1			2	
Veliidae	3			1	2			
Nepidae	3							2
Corixidae	2	4	6	14	7	3		7
Notonectidae	1	2	7					
Pleidae	2				1			
Coenagrionidae	2	5	6	6	9	7		3
Protoneuridae	4						1	
Lestidae	1							
Aeshnidae	4							
Gomphidae	5		1					1
Corduliidae	5						1	2
Libellulidae	4	1	1		5	1		2
Hydroptilidae	4				2	1		2
Hydropsychidae	6		22	3				
Ecnomidae	4			1	1			
Leptoceridae	6		3		7	3		1

Table 10 Number of macroinvertebrates collected at all sites during spring 2018 sampling by family for each site

Taxon	Signal2	CUC-AQ1	CUC-AQ2	WBC-AQ1	WBC-AQ2	WBC-DS1	WBC-DS2	WBC-US1
Atyidae	3		1		5	1	13	1
Baetidae	5	2	3	6	0	1		
Caenidae	4	3	28	15	10	10	12	9
Ceratopogonidae	4	2		3		1		1
Chironominae	3	26	1	8	3	38	29	36
Coenagrionidae	2		2		4		6	
Corduliidae	5		1					
Corixidae	2	5		4	8			1
Culicidae	1					1		
Dugesiidae	2	6	3	1	1	5		
Dytiscidae	2	4				3	1	10
Dytiscidae (larva)	2	16		5				8
Ecnomidae	4							1
Glossiphoniidae	1		1					
Hydrachnidae	7		1	1		6	2	
Hydraenidae	3					1		
Hydrobiidae	4							
Hydrochidae	4							1
Hydrophilidae	2	1		1			1	2
Hydrophilidae (larva)	2	1		1			2	1
Hydroptilidae	4	1		1				
Isostictidae	3					2		
Leptoceridae	6		1				2	
Leptophlebiidae	8	1	1		1	1		
Lestidae	1							
Libellulidae	4							

Taxon	Signal2	CUC-AQ1	CUC-AQ2	WBC-AQ1	WBC-AQ2	WBC-DS1	WBC-DS2	WBC-US1
Lymnaeidae	1							
Notonectidae	1	3		1				
Oligochaeta	2	3	1	3	1			7
Orthocladiinae	4	2	1	1	6	2	3	
Ostracoda		6	1	1		6	2	
Palaemonidae	4			2			1	
Physidae	1	5	3	4		3		
Pleidae	2							
Protoneuridae	4		3	20		1	1	
Scirtidae	6			1				
Simuliidae	5							
Stratiomyidae	2					2		
Tabanidae	3					1		
Tanypodinae	4		11	8		10	1	2
Veliidae	3		2			2		

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APPENDIX G

Mangoola Offset Site

Mangoola Offset Site

The information presented for the Mangoola Offset site is based on comprehensive biodiversity surveys in accordance with the BioBanking Assessment Methodology (OEH 2014) and the credits presented are based on a BioBanking Credit Calculator assessment using site data and undertaken by an accredited BioBanking Assessor. The credit number presented use the standard gain calculated by the credit calculator and no additional management actions have been proposed. Following approval, Mangoola will prepare a Stewardship Agreement for the Mangoola Offset site which will document the final credit numbers, with or without additional management actions.

Background

The Proposed Mangoola Offset site surrounds the Development footprint to the north and west and includes Glencore-owned properties to the west of the current mining operations. Mangoola Offset site is located within the Sydney Basin IBRA bioregion and the Kerrabee IBRA subregion. The Mangoola Offset site covers approximately 1005 ha.

Survey Methods

Surveys of the proposed Mangoola Offset site have included the following methodology:

- Detailed floristic and vegetation mapping surveys in 2013 as part of the UHSA project. This included 18 systematic plot-based surveys and collection of biometric data in accordance with BBAM 2014 (OEH 2014c).
- Detailed floristic and vegetation mapping surveys in 2017. This included 31 systematic plot-based surveys and collection of biometric data in accordance with BBAM 2014 (OEH 2014c).
- Targeted *Diuris tricolor* and *Prasophyllum petilum* surveys in September and October 2014, 2015, 2016, 2017 and 2018.

These surveys are discussed in further detail below.

Floristic Surveys 2013 and 2017

A total of 49 systematic plots/transect surveys were conducted across the Mangoola Offset site during the surveys undertaken for this assessment from 2013 and 2017. In addition 21 semi quantitative rapid vegetation assessments were completed to inform the vegetation mapping process.

Plot/Transect Data Collected

At each plot/transect data was recorded according to Section 5 of the FBA (OEH 2014b). At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to search the tree canopy and tree trunks for mistletoes, vines and epiphytes.

Additional details were also recorded in each quadrat, including soil texture, drainage and depth; site disturbances; physiography (position in the landscape); and vegetation structure (strata percentage covers, heights and dominant species). Photographic records were also taken at each site.

Qualitative Rapid Sampling

Qualitative rapid assessments were also completed during the surveys to assist with vegetation community mapping. Each comprised the recording of the dominant canopy and understorey species. The qualitative rapid assessments utilised a qualitative sampling approach, as this method was designed to allow rapid collection of non-quantitative species dominance data across the Mangoola Offset site. The data from the qualitative rapid assessments was primarily used to provide assistance in the delineation and refinement of vegetation mapping.

Meandering Transects

Meandering transects were walked through vegetation units across much of the Mangoola Offset site. Opportunistic sampling of vegetation was undertaken along these transects, particularly searches for threatened and otherwise significant species, EPs and TECs. Meandering transects enable floristic sampling across a much larger area than plot-based survey. Records along transects supplemented floristic sampling carried out in plots, however, the data collected are in the form of presence records, rather than semi-quantitative cover abundance scores.

Plot/Transect Selection and Stratification of the Development Footprint

Reference was made to the VIS Classification Database to identify Plant Community Types (PCTs), as well as reviews of other regional and local vegetation mapping and reporting when designing the field survey. The Mangoola Offset site PCTs were further stratified into Vegetation Zones (condition states) following the initial field survey of the site to determine the appropriate number of transect/plots required in accordance with the BBAM (OEH 2014b) as outlined in **Table G1**.

Table G1 Adequacy of Vegetation Survey in the Mangoola Offset Site

Veg Zone	Plant Community Type (BVT) *Condition Class*	Area in the Mangoola Offset Site (ha)	Number of Biometric Plots/Transects	
			Required (BBAM 2014)	Undertaken During Survey
1	HU812 - Forest Red Gum grassy open forest on floodplains of the lower Hunter *Moderate to Good - DNG*	7.0	3	6
2	HU812 - Forest Red Gum grassy open forest on floodplains of the lower Hunter *Moderate to Good*	31.4	4	5
3	HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter *Moderate to Good - Poor*	3.47	2	2
4	HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter *Moderate to Good*	48.0	4	5
5	HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter *Moderate to Good -DNG*	390.3	7	11

Veg Zone	Plant Community Type (BVT) *Condition Class*	Area in the Mangoola Offset Site (ha)	Number of Biometric Plots/Transects	
			Required (BBAM 2014)	Undertaken During Survey
6	HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter *Moderate to Good*	206.9	6	9
7	HU821 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter *Moderate to Good*	54.6	5	5
8	HU869 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin *Moderate to Good*	20.2	4	5
9	HU945 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley *Moderate to Good*	1.1	1	1
	Total	**763**	**36**	**49**

Targeted Threatened Flora Species Searches

Targeted searches of the Mangoola Offset site were first undertaken in 2013 as part of the UHSA project. Species-credit flora species recorded during those surveys were pine donkey orchid (*Diuris tricolor*) and Tarengo leek orchid (*Prasophyllum petilum*). The searches for the UHSA covered certain areas of the Mangoola Offset site.

Additional searches for pine donkey orchid (*Diuris tricolor*) and Tarengo leek orchid (*Prasophyllum petilum*) were undertaken in 2016 as part of a study into the distribution of these species across Glencore land in the wider Mangoola area (East Coast Flora and Umwelt 2016). Not all areas of the Mangoola Offset site were searched in 2016.

In 2017 and 2018 searches for pine donkey orchid (*Diuris tricolor*) and Tarengo leek orchid (*Prasophyllum petilum*) consisted of walking parallel transects approximately 10 metres apart, in accordance with the NSW Guide to Surveying Threatened Plants (OEH 2016) across areas of potential habitat within the Mangoola Offset site.

Prior to all of these surveys, a local reference population was checked to ensure the timing of surveys was appropriate.

Threatened Fauna Species Searches

Targeted fauna surveys, undertaken during the UHSA project (Umwelt 2015), were completed for large-eared pied bat (*Chalinolobus dwyeri*). This species was targeted using bat echolocation recording and potential roost searches.

Survey Results

A summary of the survey results are presented below.

Vegetation Communities

Surveys of the Mangoola Offset site identified six Biometric Vegetation Types (BVTs) being:

- HU812 - Forest Red Gum grassy open forest on floodplains of the lower Hunter
- HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter
- HU821 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
- HU869 - Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin
- HU945 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley

These BVTs were aligned with types described as part of the VIS Classification Database (OEH 2018c). The BVTs were then categorised into 9 vegetation zones. Detailed floristic information and BVT analyses will be provided in the BioBanking or Stewardship Agreement.

Threatened Ecological Communities

Four of the vegetation communities described above and mapped within the Mangoola Offset site conform wholly or partially to State and Commonwealth listed TECs, comprising:

- HU812 - Forest Red Gum grassy open forest on floodplains of the lower Hunter
    - *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
    - *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC* (EPBC Act)
- HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
    - *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
- HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower – Moderate to Good Condition
    - *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
- HU821 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
    - *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
    - *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC* (EPBC Act)

Analysis of consistency with the scientific determinations for each TEC was undertaken, with consideration of the advice provided by the NSW Scientific Committee and/or the Commonwealth Threatened Species Scientific Committee guidelines for interpreting listings for species, populations and ecological communities under the BC Act and EPBC Act respectively.

Species-credit Species

Two species-credit flora species and one species-credit fauna species have been recorded within the Mangoola Offset site, being:

- Tarengo leek orchid (*Prasophyllum petilum*)
- Pine donkey orchid (*Diuris tricolor*) and
- Large-eared pied bat (*Chalinolobus dwyeri*) (breeding habitat buffer)

Table G2 below identifies the number of individuals or area of habitat for species-credit species within the Mangoola Offset site.

Table G2 - Species-credit species at Mangoola Offset site

Species	Number/Area
pine donkey orchid (*Diuris tricolor*)(known)	7,567 ind
pine donkey orchid (*Diuris tricolor*)(Expert Report)	9,991 ind
Tarengo leek orchid (*Prasophyllum petilum*) (known)	877 ind
Tarengo leek orchid (*Prasophyllum petilum*) (Expert Report)	903 ind
Large-eared pied bat (*Chalinolobus dwyeri*)	118 ha

Credits Generated

Table G3 below outlines the BVTs at the proposed Mangoola Biobank Offset Site and the ecosystem credits generated at this site. In addition, the species credits-species recorded and identified through the Expert Report and the credits they generate are also shown.

Table G3 - Credits Generated at the Mangoola Offset Site

Plant Community Type *Condition Class*	Area (ha)	Credits Generated
HU812 Forest Red Gum grassy open forest on floodplains of the lower Hunter	38.4	510
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	51.5	742
HU817 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	583.4	8,991
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	54.6	860
HU945 - Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley	1.1	17
large-eared pied bat	94 ha	667
pine donkey orchid (*Diuris tricolor*)(known)	7,567 ind	53,725
pine donkey orchid (*Diuris tricolor*)(Expert Report)	9,991 ind	70,936
Tarengo leek orchid (*Prasophyllum petilum*) (known)	877 ind	6,226

Improvement in Site Values

The BBCC calculated the conservation management zones across the proposed Wybong Heights Offset site using the predicted gain in site value scores based on standard management practices. These include:

- management of grazing for conservation
- weed control
- ecological fire management
- management of human disturbance
- retention of regrowth and remnant native vegetation
- replanting or supplementary planning where natural regeneration is not sufficient
- retention of dead timber
- erosion control
- retention of rocks.

Additional management actions are proposed to improve habitats and increase site attribute scores using the following methods:

- targeted supplementary planting of native canopy and midstorey species to improve the native plant species richness, native overstorey cover, native midstorey cover and native ground cover (shrubs)
- targeted habitat augmentation including placement of logs and woody debris to improve the total length of fallen logs.

Table G4 below outlines the additional management actions and adjusted site value scores for the Mangoola Offset site.

Table G5 provides details of the additional management actions required to meet the requirements of Table 32 of BBAM (OEH 2014c).

Table G4 Site Value and Averted Loss Scores for Management Zones at the Mangoola Offset site

Plant Community Type *Condition Class*	Zone	Averted Loss	Site Value Score			Additional Management Actions to Increase Site Attribute Scores
			Current	Future	Gain	
HU817 - *Moderate to Good – DNG*	6	4.43	31.77	65.10	33.33	Supplementary planting and DNG restoration: • Native overstorey cover (2-2.5) • Native midstorey cover (1-1.5) • Native ground cover (shrubs) (2-2.5) Habitat augmentation: • Total length of fallen logs (1.5-2.0)

Table G5 Additional Management Actions to Increase Site Attribute Scores at the Mangoola Offset site

Site Attribute	Assessment Against Benchmark	Actions
HU817 - Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter *Moderate to Good – DNG*		
Native overstorey cover (2-2.5)	Must achieve >50-75% or >100 - <175% of benchmark. Benchmark for HU817 = 15.00-40.00	Supplementary planting of canopy species characteristic of surrounding areas of established HU817. Indicative species include: • grey box (*Eucalyptus moluccana*) • narrow-leaved ironbark (*Eucalyptus crebra*)
Native midstorey cover (1-1.5)	Must achieve >25-50% or >100 - <175% of benchmark. Benchmark for HU730 = 5.00-20.00	Supplementary planting of midstorey species characteristic of surrounding areas of established HU817. Indicative species include: • bulloak (*Allocasuarina luehmannii*) • blackthorn (*Bursaria spinosa*) • coffee bush (*Breynia oblongifolia).*
Native ground cover (shrubs) (2-2.5)	Must achieve >50-75% or >100 - <175% of benchmark. Benchmark for HU817 = 15.00-40.00	Supplementary planting of midstorey species characteristic of surrounding areas of established HU817. Indicative species include: • velvet mock olive (*Notelaea microcarpa* var. *microcarpa*) • shiny-leaved canthium (*Psydrax odoratum*)
Total length of fallen logs (1.5-2.0)	Placement of coarse woody debris is at least 10 cm diameter and 0.5 m long and will be in a range >25% and <50% of benchmark. Benchmark for HU817 = 5.00	Active placement of logs and placed in a configuration that reflects natural systems. This will include: • salvage of trees felled during construction works and emplacement within the vegetation zone as log piles (must be at least 10cm diameter and greater than 0.5m long). • salvage and placement of large rocks and boulders into piles as further potential habitat.

APPENDIX H

Wybong Heights Offset Site

Wybong Heights Offset Site

The information presented for the Proposed Wybong Heights BioBank is based on comprehensive biodiversity surveys in accordance with the BioBanking Assessment Methology (OEH 2014) and the credits presented are based on a BioBanking Credit Calculator assessment using site data and undertaken by an accredited BioBanking Assessor. The credit number presented use the standard gain calculated by the credit calculator and no additional management actions have been proposed. Following approval, Mangoola will prepare a Stewardship Agreement for the Wybong Heights Offset site which will document the final credit numbers.

Background

Wybong Height Offset site is located approximately 15 km north west of the MCCO Additional Project Area. It comprises land owned by Glencore, located in the Manobalai area, approximately 30 km northwest of Muswellbrook, NSW. The Wybong Heights Offset site is located within the Kerrabee IBRA subregion. The Wybong Heights Offset site covers approximately 760 ha.

Survey Methods

Surveys of the proposed Mangoola Offset site have included the following:

- Detailed floristic and vegetation mapping surveys in 2011 (Umwelt 2011). This included 16 systematic plot-based surveys and 11 rapid vegetation assessments.
- Detailed fauna surveys in 2011 (Umwelt 2011).
- Detailed floristic and vegetation mapping surveys in 2018. This included 50 systematic plot-based surveys and collection of biometric data in accordance with BBAM 2014 (OEH 2014c).
- Targeted *Myotis macropus* habitat surveys in 2018

These surveys are discussed in further detail below.

<u>Floristic Surveys 2011 and 2018</u>

A total of 60 systematic plots, of which 44 included biometric transect surveys were conducted across the Wybong Heights Offset site during the surveys undertaken for this assessment. In addition 11 semi quantitative rapid vegetation assessments were completed to inform the vegetation mapping process.

Plot/Transect Data Collected

At each of 44 biometric plots/transects, data was recorded according to Section 5 of the BBAM (OEH 2014b). At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to search the tree canopy and tree trunks for mistletoes, vines and epiphytes.

Additional details were also recorded in each quadrat, including soil texture, drainage and depth; site disturbances; physiography (position in the landscape); and vegetation structure (strata percentage covers, heights and dominant species). Photographic records were also taken at each site.

Qualitative Rapid Sampling

Qualitative rapid assessments were also completed during the surveys to assist with vegetation community mapping. Each comprised the recording of the dominant canopy and understorey species. The qualitative rapid assessments utilised a qualitative sampling approach, as this method was designed to allow rapid collection of non-quantitative species dominance data across the Wybong Heights Offset site. The data from the qualitative rapid assessments was primarily used to provide assistance in the delineation and refinement of vegetation mapping.

Meandering Transects

Meandering transects were walked through vegetation units across much of the Wybong Heights Offset site. Opportunistic sampling of vegetation was undertaken along these transects, particularly searches for threatened and otherwise significant species, endangered populations and TECs. Meandering transects enable floristic sampling across a much larger area than plot-based survey. Records along transects supplemented floristic sampling carried out in plots, however, the data collected are in the form of presence records, rather than semi-quantitative cover abundance scores.

Plot/Transect Selection and Stratification of the Development Footprint

Reference was made to the VIS Classification Database to identify Biometric Vegetation Types (BVTs), as well as reviews of other regional and local vegetation mapping and reporting when designing the field survey. The Wybong Heights Offset site BVTs were further stratified into Vegetation Zones (condition states) following the initial field survey of the site to determine the appropriate number of transect/plots required in accordance with the BBAM (OEH 2014b) as outlined in **Table H1**.

Table H1 Adequacy of Vegetation Survey in the Wybong Heights Offset site

PCT ID (BVT IDs) and PCT Name *Condition Class*	Area in the Wybong Heights Offset Site (ha)	Number of Biometric Plots/Transects	
		Required (BBAM 2014)	Plots Completed
HU701 - Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion *Moderate to Good Condition*	15.3	3	4
HU701 - Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion *Moderate to Good Condition – Derived Native Grassland*	56.3	5	5
HU730 – White Box x Grey Box – red gum – Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley *Moderate to Good Condition*	76.7	5	5
HU730 – White Box x Grey Box – red gum – Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley *Moderate to Good Condition – Shrubby Variant*	83.8	5	5

PCT ID (BVT IDs) and PCT Name *Condition Class*	Area in the Wybong Heights Offset Site (ha)	Number of Biometric Plots/Transects	
		Required (BBAM 2014)	Plots Completed
HU730 – White Box x Grey Box – red gum – Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley *Moderate to Good Condition – Derived Native Grassland*	136.9	6	6
HU816 – Spotted Gum – Narrow-leaved Ironbark shrub – grass open forest of the central and lower Hunter *Moderate to Good Condition*	133.2	6	6
HU821 – Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple shrubby woodland of the upper Hunter Moderate to Good Condition	140.4	6	6
HU868 - Narrow-leaved Ironbark - Grey Gum shrubby open forest on sandstone ranges of the upper Hunter Valley Moderate to Good Condition	105.8	6	6

Species-credit Surveys – Fauna

Targeted surveys were undertaken for one species-credit fauna species within the Wybong Heights Offset site, being the southern Myotis (*Myotis macropus*). This species was recorded during anabat echolocation surveys in 2011 and species specific habitat exists within the Wybong Heights Offset site. Searches for this species included traverses along the upper banks of Wybong Creek, within the Wybong Heights Offset site, and identifying hollow-bearing trees within 200m of the water source.

Survey Results

A summary of the survey results are presented below.

Vegetation Communities

Surveys of the Wybong Heights Offset site identified five Biometric Vegetation Types (BVTs) being:

- HU701 - Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion
- HU730- White Box x Grey Box – red gum – Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley
- HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
- HU821 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter

- HU868 - Narrow-leaved Ironbark - Grey Gum shrubby open forest on sandstone ranges of the upper Hunter Valley

These BVTs were aligned with types described as part of the VIS Classification Database (OEH 2018c). The BVTs were then categorised into 8 vegetation zones. Detailed floristic information and BVT analyses will be provided in the BioBanking or Stewardship Agreement.

Threatened Ecological Communities

Three of the vegetation communities described above and mapped within the Wybong Heights Offset site conform wholly or partially to State and Commonwealth listed TECs, comprising:

- HU730 - White Box x Grey Box – red gum – Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley
  - *White Box Yellow Box Blakely's Red Gum Woodland* EEC (BC Act)
  - *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC* (EPBC Act)
- HU816 - Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter
  - *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
- HU821 - Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter
  - *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
  - *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC* (EPBC Act)

Analysis of consistency with the scientific determinations for each TEC was undertaken, with consideration of the advice provided by the NSW Scientific Committee and/or the Commonwealth Threatened Species Scientific Committee guidelines for interpreting listings for species, populations and ecological communities under the BC Act and EPBC Act respectively.

Species-credit Species

One species-credit fauna species was recorded within the Wybong Heights Offset site, being:

- Southern Myotis(*Myotis macropus*) (breeding habitat)

This species has been detected within Wybong Heights (Umwelt 2011) and a total of 1.5 ha of potential breeding and foraging habitat (woodland containing hollow-bearing trees within 200m of a creek) was identified.

Credits Generated

Table H2 below outlines the PCTs at the proposed Wybong Heights Offset site and the credits generated at this site as required by Table 22 of the FBA (OEH 2014b). Only those BVTs relevant to the MCCO Project are shown in the table below.

Table H2 - PCTs and Credits Generated at the Wybong Heights Offset site

Plant Community Type	Area (ha)	Credits Generated
HU730 White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley	297.4	4,612
HU816 Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	133.2	2,042
HU821 Blakely's red Gum - Narrow-leaved Ironbark - Rough-barked apple shrubby woodland of the Hunter	140.4	2,549
southern myotis (*Myotis macropus*)	1.5	11

Improvement in Site Values

The BBCC calculated the conservation management zones across the proposed Wybong Heights Offset site using the predicted gain in site value scores based on standard management practices. These include:

- management of grazing for conservation
- weed control
- ecological fire management
- management of human disturbance
- retention of regrowth and remnant native vegetation
- replanting or supplementary planning where natural regeneration is not sufficient
- retention of dead timber
- erosion control
- retention of rocks.

Additional management actions are proposed to improve habitats and increase site attribute scores using the following methods:

- targeted supplementary planting of native canopy and midstorey species to improve the native plant species richness, native overstorey cover and native midstorey cover

Table H3 below outlines the additional management actions and adjusted site value scores for the Wybong Heights Offset site.

Table H4 provides details of the additional management actions required to meet the requirements of Table 32 of BBAM (OEH 2014c).

Table H3 Site Value and Averted Loss Scores for Management Zones at the Wybong Heights Offset site

Plant Community Type *Condition Class*	Management Zone	Averted Loss	Site Value Score			Additional Management Actions to Increase Site Attribute Scores
			Current	Future	Gain	
HU730 - *Moderate to Good – DNG*	1	4.43	22.40	51.56	29.16	Supplementary planting and DNG restoration: • Native overstorey cover (1-1.5) • Native midstorey cover (1-1.5)

Table H4 Additional Management Actions to Increase Site Attribute Scores at the Wybong Heights Offset site

Site Attribute	Assessment Against Benchmark	Actions
HU730 - White Box x Grey Box - red gum - Rough-barked Apple grassy woodland on rich soils on hills in the upper Hunter Valley ***Moderate to Good – DNG***		
Native overstorey cover (1-1.5)	Must achieve >25-50% or >100 - <175% of benchmark. Benchmark for HU730 = 15.00-40.00	Supplementary planting of canopy species characteristic of surrounding areas of established HU730. Indicative species include: • white box/grey box intergrades (*Eucalyptus albens – moluccana*) • grey box (*Eucalyptus moluccana*) • narrow-leaved ironbark (*Eucalyptus crebra*) • yellow box (*Eucalyptus melliodora*) • Blakely's red gum (*Eucalyptus blakelyi*).
Native midstorey cover (1-1.5)	Must achieve >25-50% or >100 - <175% of benchmark. Benchmark for HU730 = 5.00-20.00	Supplementary planting of midstorey species characteristic of surrounding areas of established HU730. Indicative species include: • velvet mock olive (*Notelaea microcarpa* var. *microcarpa*) • bulloak (*Allocasuarina luehmannii*) • shiny-leaved canthium (*Psydrax odoratum*) • cooba (*Acacia salicina*) • green wattle (*Acacia deanei* subsp. *deanei*).

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