APPENDIX 20

Biodiversity
Development
Assessment Report

umwelt
Environmental & Social Consultants

GLENDELL CONTINUED OPERATIONS PROJECT

Biodiversity Development Assessment Report

FINAL

November 2019

GLENDELL CONTINUED OPERATIONS PROJECT

Biodiversity Development Assessment Report

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Ltd

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Report No.	4166/R03
Date:	November 2019

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

Executive Summary

The Glendell Mine forms part of the Mount Owen Complex located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales. Glendell Tenements Pty Ltd, an entity owned by Glencore Coal Pty Ltd, is proposing to extend the life of operations at the Glendell Mine and optimise the use of infrastructure at the Mount Owen Complex by extending mining in the existing Glendell Pit to the north.

Glendell Mine has an approved production rate of up to 4.5 million tonnes per annum (Mtpa) of run of mine (ROM) coal and proposed extension of the current Glendell Mine would extract an additional 135 Mt, approximately, of ROM coal. The Project seeks to extend the life of Glendell Mine to 2044, with an increase in extraction rate over the life of the Project up to 10 Mtpa from the current approved 4.5 Mtpa.

The Additional Disturbance Area has been extensively impacted by past agricultural activities including cultivation on alluvial flats and lower slopes and clearing in most other areas. Large areas were contoured in the 1960s and 1970s to mitigate erosion risks associated with past clearing and agricultural activities.

This Biodiversity Development Assessment Report (BDAR) has been prepared by Umwelt Environmental and Social Consultants (Umwelt) for the Project using the Biodiversity Assessment Method (BAM) in accordance with the *Biodiversity Conservation Act 2016* (BC Act).

Following the application of appropriate avoidance and mitigation measures, the BAM assessment identified the following biodiversity credits required to offset the impacts of the Project:

- 5,972 ecosystem credits for six native plant community types (10 vegetation zones)
- 2 tiger orchid (Cymbidium canaliculatum) endangered population credit
- 732 southern myotis (Myotis macropus) credits
- 2,559 brush-tailed phascogale (Phascogale tapoatafa) credits
- 17 eastern cave bat (Vespadelus troughtoni) credits

The biodiversity offset strategy will be developed during the assessment process in consultation with the BCD and DPIE and based on the following offset options available under the BC Act and Biodiversity Conservation Regulation including:

- land based offsets (Glencore will retire the credits calculated for this Project through either new Stewardship sites or alternatively use credits from other existing Stewardship Sites)
- ecological rehabilitation (allowable for mining projects)
- purchasing credits from the market, and/or
- paying into the Biodiversity Conservation Fund.

Glossary

Abbreviation	Description
Additional Disturbance Area	The Additional Disturbance Area is the area that will be disturbed outside of areas that are already approved for disturbance.
BDAR	Biodiversity Development Assessment Report
BAM	Biodiversity Assessment Method (OEH 2017a)
BC Act	NSW *Biodiversity Conservation Act 2016*
BCD	Biodiversity Conservation Division (formerly OEH)
CEEC	Critically Endangered Ecological Community
CHPP	Coal Handling Preparation Plant
Development Footprint	The total impact zone assessed by this BDAR. The Additional Disturbance Area is referred to throughout this report as the Development Footprint according to the BAM.
DoEE	Commonwealth Department of the Environment and Energy
DNG	Derived Native Grassland
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 site 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*
GDEs	Groundwater-dependent Ecosystems
Glencore	Glencore Coal Pty Ltd
GRAWTS	Greater Ravensworth Area Water and Tailings Scheme
GIS	Geographical Information System
IBRA	Interim Biogeographic Regionalisation for Australia (Version 7)
LGA	Local Government Area
LLS Act	*Local Land Services Act 2013*
MNES	Matters of National Environmental Significance
MGA	Map Grid of Australia
MOC	Mount Owen Complex
Mtpa	million tonnes per annum
NVRM	Native Vegetation Regulatory Map
NSW	New South Wales
OEH	NSW Office of Environment and Heritage, now BCD
PCT	Plant Community Type

Abbreviation	Description
PMST	Protected Matters Search Tool
Project	Glendell Continued Operations Project
Proponent	Glendell Tenements Pty Ltd
ROM	Run of Mine
SEARs	Planning Secretary's Environmental 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 Biodiversity Data Collection.
SSD	State Significant Development
Strahler Stream Order	Classification system that gives a waterway an 'order' according to the number of tributaries associated with it.
TEC	Threatened Ecological Community
TBDC	Threatened Biodiversity Data Collection
UHSA	Upper Hunter Strategic Assessment
VIS	Vegetation Information System

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1.0 Introduction

The Glendell Mine forms part of the Mount Owen Complex in the Hunter Region of New South Wales (NSW) and is owned and operated by subsidiaries of Glencore Coal Pty Ltd (Glencore). The site is part of the Hunter Valley Coalfields and is located approximately 20 kilometres (km) northwest of Singleton in the Singleton local government area (LGA) (refer to **Figure 1.1**). The Mount Owen Complex includes Mount Owen Mine, Ravensworth East Mine, Glendell Mine and a coal handling and preparation plant (CHPP) and coal transport infrastructure.

The Glendell Continued Operations Project (the Project) is an extension of open cut mining operations immediately to the north of the existing Glendell Mine (refer to **Figure 1.2**). The Project would extend the life of the Glendell Mine to approximately 2044 and allow for the recovery of approximately 135 million tonnes of run-of-mine (ROM) coal and provide ongoing employment opportunities for existing Mount Owen Complex workforce.

The key features of the Project include:

- extension of open cut mining to the north of the existing Glendell Mine until 2044
- extraction of approximately 135 million tonnes of ROM coal
- continued integration of the mine with the wider Mount Owen Complex, including the use of the Mount Owen CHPP, rail loop and associated infrastructure for ROM coal processing and product coal transport
- demolition of the existing Glendell Mine Infrastructure Area (MIA) and the construction of a new MIA
- realignment of a section of Hebden Road
- realignment of the lower section of Yorks Creek
- relocation of Ravensworth Homestead
- other ancillary infrastructure works such as the construction of a Heavy Vehicle Access Road
- progressive rehabilitation of the site.

This Biodiversity Development Assessment Report (BDAR) has been prepared by Umwelt Environmental and Social Consultants (Umwelt) for the Project using the Biodiversity Assessment Method (OEH 2017a) (BAM) in accordance with the *Biodiversity Conservation Act 2016* (BC Act).

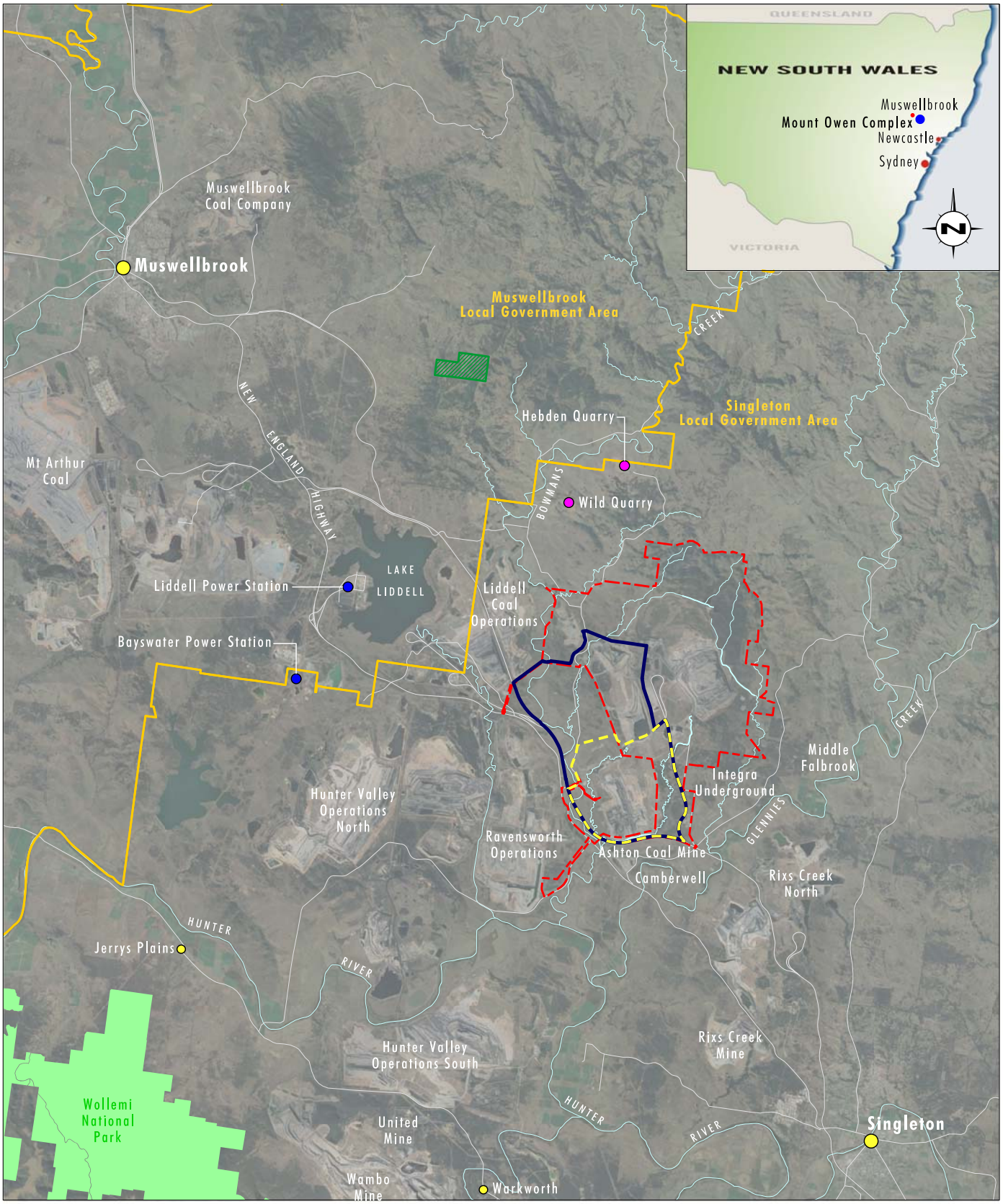

Image Source: Google Earth (2018)
Data Source: Glencore (2019), OEH (2018), Forest Corporation of NSW (2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

- Project Area
- Glendell Consent Boundary
- Mount Owen Consent Boundary
- Local Government Area Boundary
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Power Stations
- Quarry

FIGURE 1.1

Locality Plan

File Name (A4): R03/4166_302.dgn
20191126 14.32

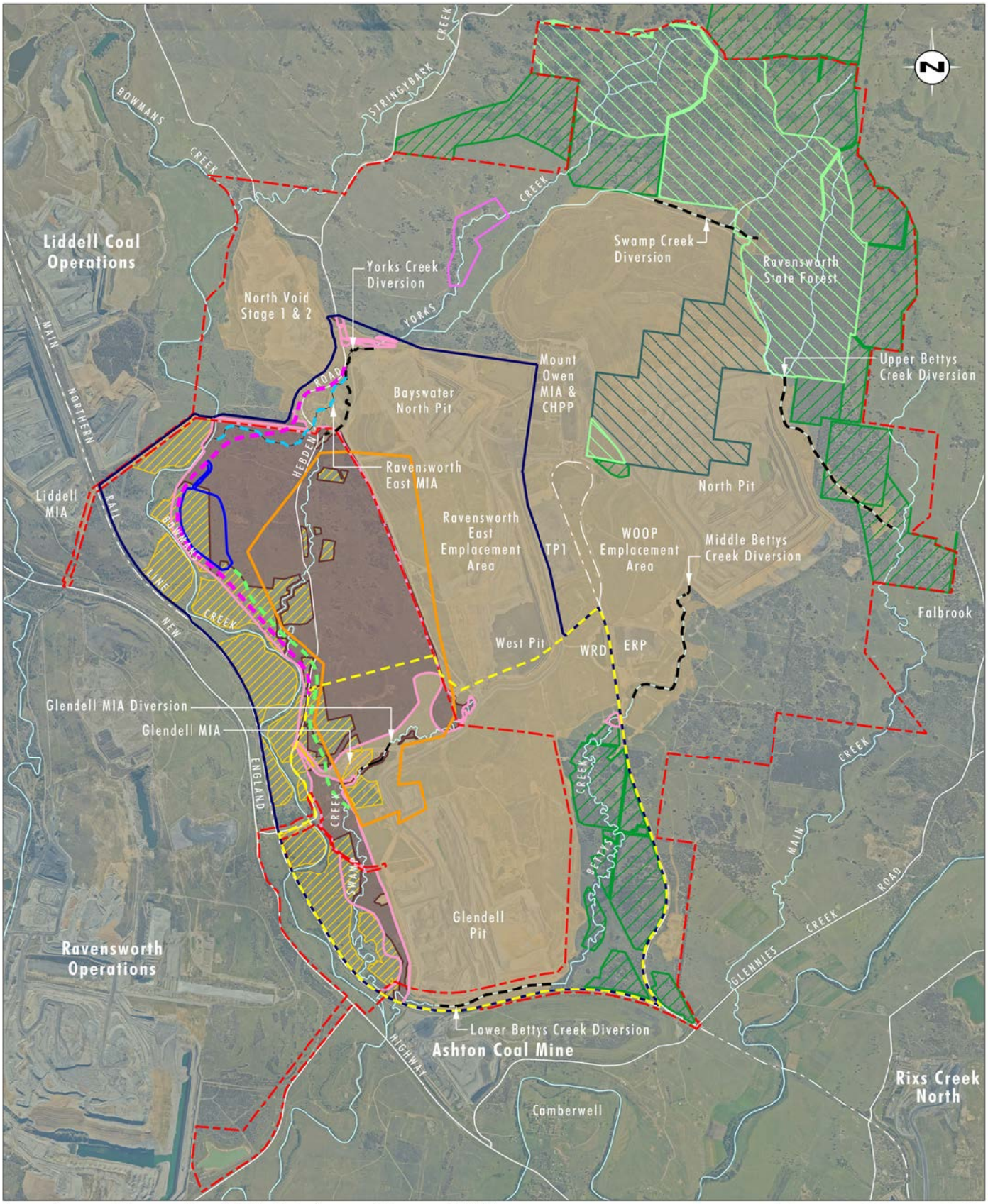

Image Source: Glencore (Dec 2018), Data Source: Glencore (2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Mount Owen Consent Boundary
- Biodiversity Assessment Area (Development Footprint)
- Glendell Pit Extension
- Additional Disturbance Area
- Category 1 - Exempt Land (Agriculture) - Excluded from Assessment
- Category 1 - Exempt Land (Mining) - Excluded from Assessment
- Existing Creek Diversion
- Mount Owen Complex Biodiversity Offset Area
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Approved Operational Area
- Yorks Creek Voluntary Conservation Area
- New Glendell MIA
- Heavy Vehicle Access Road
- Yorks Creek Realignment
- Hebden Road Realignment

FIGURE 1.2

Project Overview

File Name (A4): R03/4166_139.dgn
20191128 15.26

1.1 Development footprint

The Biodiversity Assessment Area is hereafter referred to as 'Development Footprint' and represents permanent impacts outside the existing Approved Glendell Disturbance Area (assuming Glendell Modification 4 application is approved) and the Mount Owen Operational Area, as shown in **Figure 1.2**. The Development Footprint also excludes areas that conform to Category 1-exempt land as identified by the *Local Land Services Act 2013* (LLS Act). The methodology for excising the Category 1-exempt land is documented in **Section 1.1.4**. The Development Footprint will be subjected to a range of disturbances as outlined in **Section 5.0**.

1.1.1 Location

The Development Footprint is situated approximately 20 km north-west of Singleton in the Hunter Valley of NSW (refer to **Figure 1.1**) within the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) bioregion and the Hunter 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 the BAM 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

Development Footprint Location in the Landscape		
IBRA Bioregion	Sydney Basin	
IBRA Subregion	Hunter	
Mitchell Landscape	Central Hunter Foothills	
LGA	Singleton Council	
Lot and DP	1/DP940619 2/DP6842 2A/DP6842 5/DP1077004 6/DP1077004 7/DP1077004 11/DP592404 71/DP625171 310/ DP848411 311/DP848411 1/DP865784 2/DP865784	2/DP1180252 2/DP859544 3/DP859544 1/DP375485 1/ DP375486 A/DP380246 2/DP534889 4/DP232149 3/DP232149 228/DP752470 2/DP1089438 1/DP1089438
Assessment Type	Site-based	

1.1.2 Size

The Development Footprint covers approximately 614 hectares (ha).

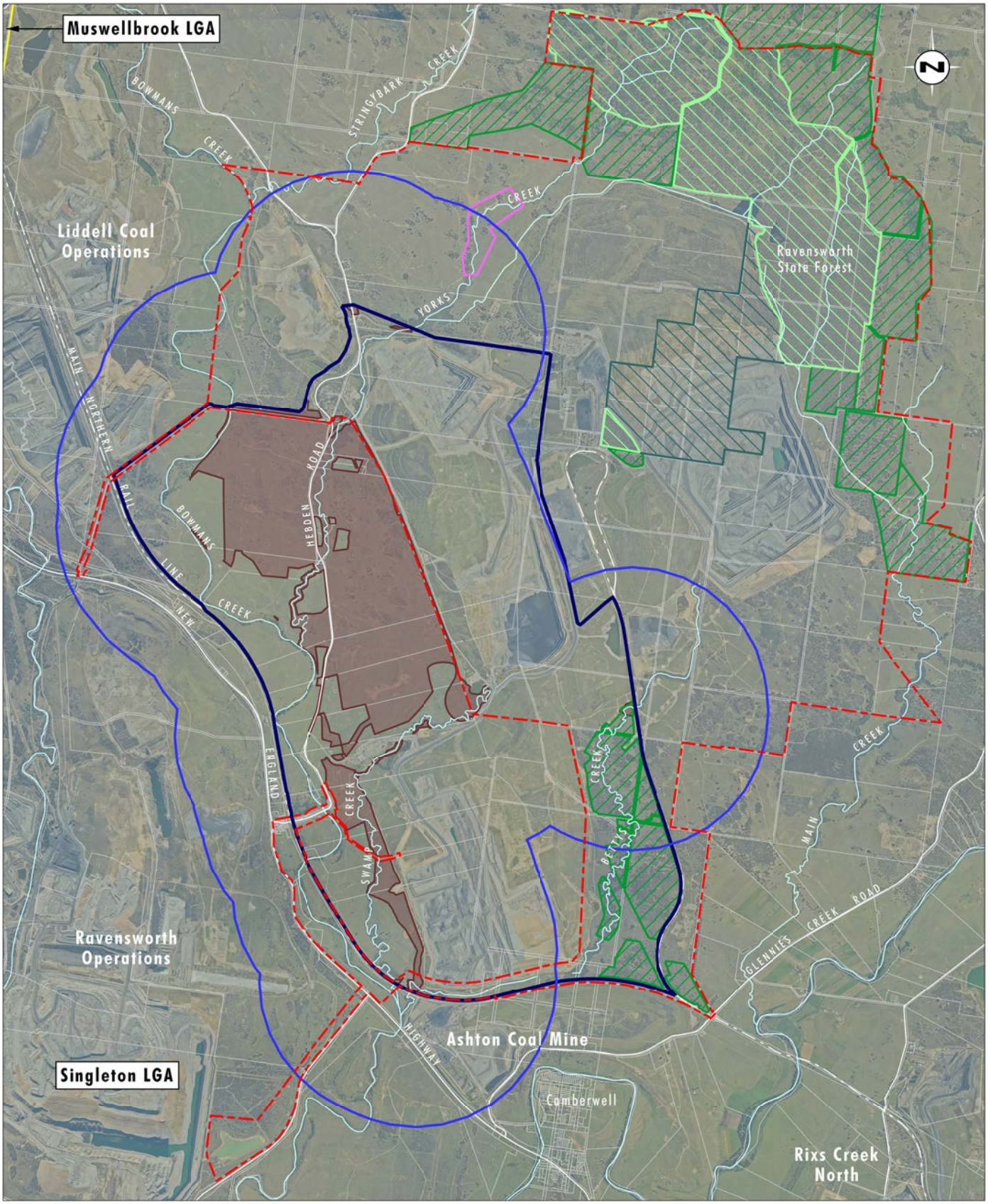

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Department of Finance, Services & Innovation (2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

0 1.0 2.0 3.0km

Legend

- Project Area
- Mount Owen Consent Boundary
- Biodiversity Assessment Area (Development Footprint)
- 1500m Buffer
- Local Government Area (LGA)
- Existing Mount Owen Complex Biodiversity Offset Area
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Approved Operational Area
- Yorks Creek Voluntary Conservation Area

FIGURE 1.3

Location Map - Local Government Area

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20191126 13.59

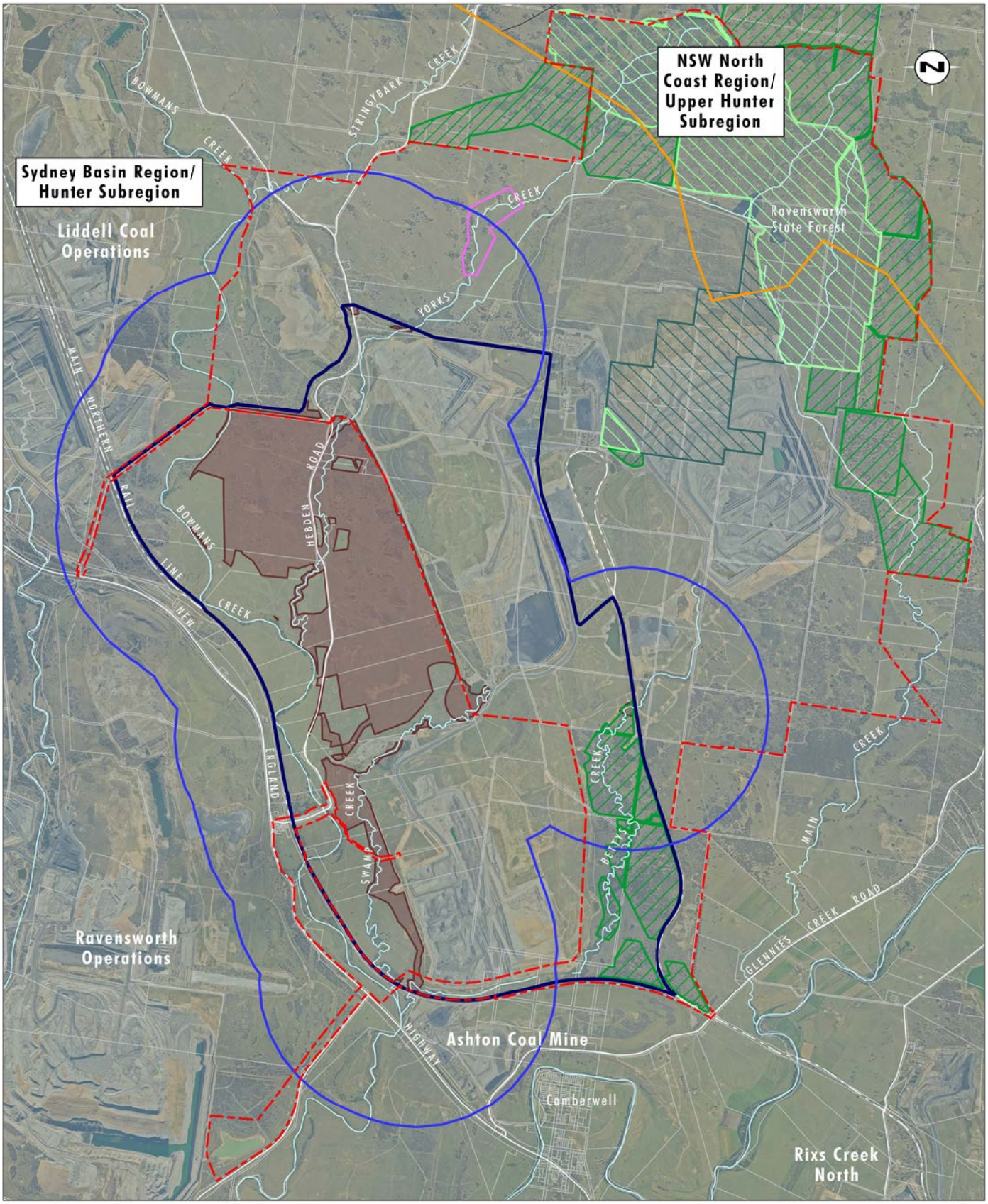

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Department of Finance, Services & Innovation (2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

- Project Area
- Mount Owen Consent Boundary
- Biodiversity Assessment Area (Development Footprint)
- 1500m Buffer
- IBRA Region/Subregion
- Existing Mount Owen Complex Biodiversity Offset Area
- Ravensworth State Forest
- Ravensworth State Forest within Mount Owen Continued Operations Approved Operational Area
- Yorks Creek Voluntary Conservation Area

FIGURE 1.4

Location Map - IBRA Regions/Subregions

File Name (A4): R03/4166_141.dgn
20191126 14.28

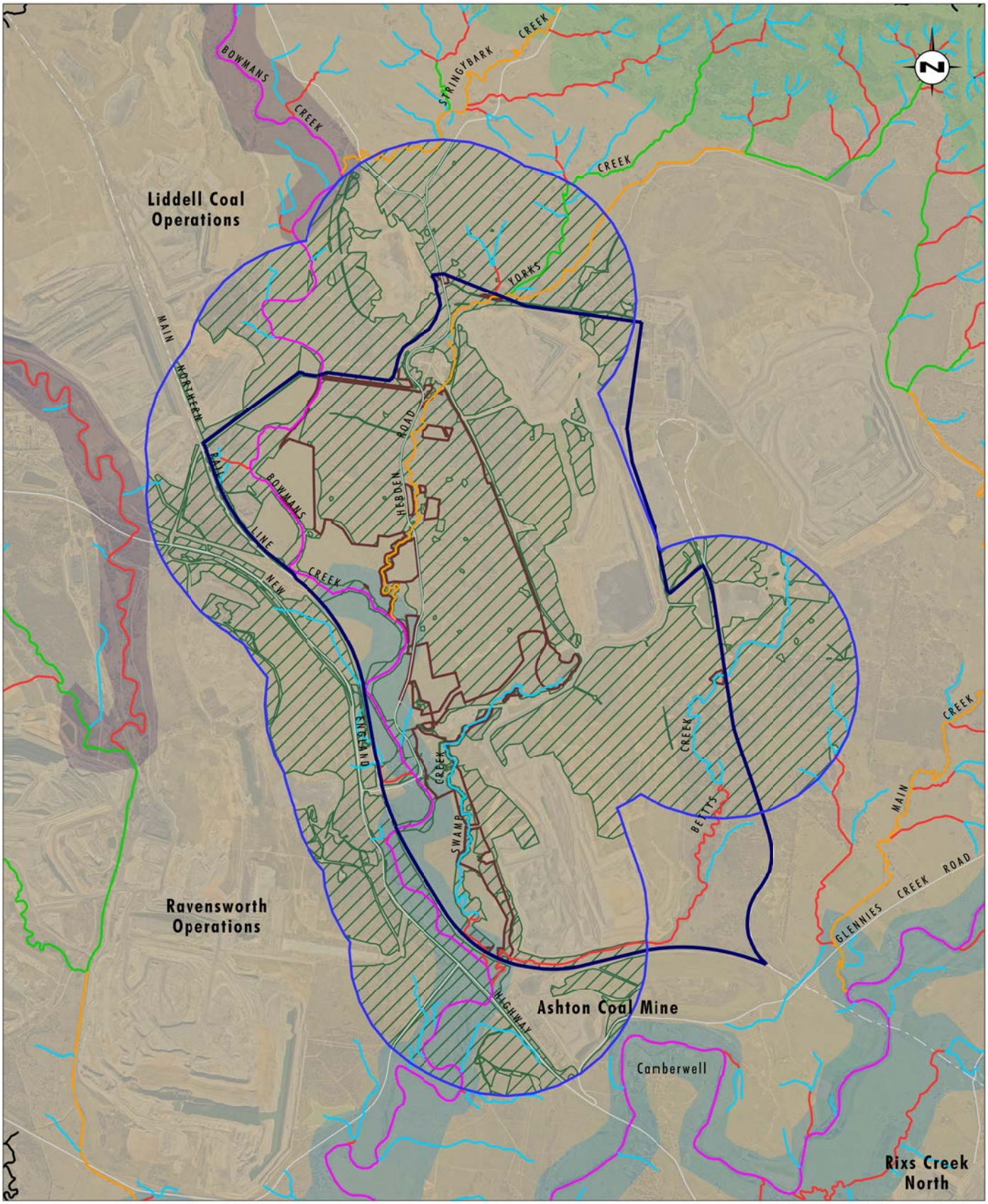

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Department of Finance, Services & Innovation (2019), Umwelt (2019)

0 1.0 2.0 3.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- 1500m Buffer
- Native Vegetation

Mitchell Landscapes:

- Central Hunter Alluvial Plains
- Central Hunter Foothills
- Scone - Gloucester Foothills
- Upper Hunter Channels and Floodplain

Stream Order:

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order and Above

FIGURE 1.5

Location Map - Landscape Features

File Name (A4): R03/4166_142.dgn
20191128 11.07

1.1.3 Local ecological context

The central Hunter Valley has been largely 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 Mount Owen Complex and the Development Footprint, which is surrounded by agricultural land and coal mining operations, with scattered patches of native vegetation, the most significant of which is Ravensworth State Forest. Ravensworth State Forest and adjoining areas represents a significant link and refuge area between remnant patches of vegetation in the central Hunter Valley. Ravensworth State Forest is located approximately 3 km to the east of the Development Footprint (refer to **Figure 1.1**).

The central location of the vegetation in Ravensworth State Forest and the surrounds is important for its functionality as a fauna refuge and 'stepping stone' in a highly fragmented landscape. The remnant includes Ravensworth State Forest, including the New Forest Area, the existing Mount Owen Biodiversity Offset Areas, and other native woodland and forest vegetation that are connected to these conservation areas. The remnant provides an important link in the generally north/south movement of highly mobile species, from other sizeable remnants in the north-west, to large remnants to the south-east and south-west of the Development Footprint.

The majority of the existing vegetation within and surrounding the Mount Owen Complex exists as a result of extensive re-growth over the past 30 years (Umwelt 2014). The extant woodland in the Development Footprint is majority 'regrowth' vegetation, that is, it has been previously cleared and its present extent is based entirely on natural regeneration or on targeted planting of canopy species.

The Development Footprint occurs in the Sydney Basin IBRA Bioregion and the Hunter subregion. The Hunter Valley is considered to be of great ecological significance given that it represents the only major break in the Great Dividing Range (linking coastal and inland areas of NSW), and includes an overlap between tropical and temperate climate zones (McVicar T.R *et al.* 2015). The Hunter subregion contains 27 endangered ecological communities, eight endangered populations and 116 threatened animal species, listed under NSW legislation, of which 33 are also listed under Commonwealth legislation (McVicar T.R *et al.* 2015). Twelve groundwater-dependent ecosystems have been identified in the Hunter subregion (McVicar T.R *et al.* 2015).

1.1.4 Category 1 – exempt land

The Secretary's Environmental Assessment Requirements (SEARs) were provided for the Project and, relevant to the assessment of biodiversity impacts, require:

> *an assessment of the likely biodiversity impacts of the development, paying particular attention to threatened species, populations and ecological communities and groundwater dependent ecosystems, undertaken in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report or, subject to agreement with OEH and the Department, undertaken in accordance with the Upper Hunter Strategic Assessment (UHSA);*

Section 6.12 of the BC Act requires the BDAR to be prepared in accordance with the BAM which is established under Section 6.8 of the BC Act.

Relevantly, section 6.8(3) of the BC Act provides:

> *(3) The biodiversity assessment method is to exclude the assessment of the impacts of any clearing of native vegetation and loss of habitat on category 1-exempt land (within the meaning of Part 5A of the Local Land Services Act 2013), other than any impacts prescribed by the regulations under section 6.3.*

The Native Vegetation Regulatory Map (NVRM) has not been finalised and the mapping of Category 1-exempt land has not been released to the public. As such, landholders are responsible for determining the categorisation of their land in accordance with the LLS Act. Category 1-exempt land is defined in Part 5A, Division 2 of the LLS Act. Subject to certain exceptions, Category 1-exempt land is broadly defined as being:

- Land cleared of native vegetation as at 1 January 1990 or lawfully cleared after 1 January 1990 (but before 25 August 2017)
- Low conservation grasslands
- Land containing only low conservation groundcover (not being grasslands)
- Native vegetation identified as regrowth in a Property Vegetation Plan under the repealed *Native Vegetation Act 2003*
- Land bio-certified under the BC Act.

Land meeting the above criteria is not considered to be Category 1-exempt land if certain exceptions apply.

Based on information provided by BCD, including the Land Categorisation Fact Sheet, clearing has been interpreted as any areas where there has been a lawful removal of all native vegetation (all strata) prior to the commencement of Part 5A of the LLS Act, being 25 August 2017. Complete removal of native vegetation has been interpreted for the purposes of the mapping as being areas where complete removal of ground cover has occurred, namely:

- areas that were cropped/ploughed or significantly disturbed (see clause 114 of the *LLS Regulation*) for agricultural purposes
- areas disturbed by approved mining (or other) approved activities.

These areas were identified through the following process:

- aerial photography/imagery from 1967 to 2017 was reviewed.
- areas which were identified as having been lawfully cleared/disturbed as set out above were then mapped using geo-rectified imagery.

Areas disturbed as a result of mining related disturbance have been checked against historical approvals to confirm the disturbance of these areas was lawful. It is noted that some areas of historical disturbance from mining related activities had commenced regeneration prior to 1990 and where these areas have not been again disturbed post 1990, these areas have been excluded from the areas mapped as being Category 1-exempt land. Areas falling within the exceptions to Category 1-exempt land as set out in s.60H (including land identified as Category 2-regulated land) has also been excluded. The extent of land within the Project Area that meets the criteria as being Category 1-exempt land is identified on **Figure 1.2** and has been subsequently excluded from the Development Footprint and BAM assessment. **Appendix A** contains a summary of the process used to identify the Category 1-exempt land excluded from the assessment.

1.2 Purpose and scope of this report

This report provides the findings of the Biodiversity Assessment of the Project. It addresses the specific requirements of the BAM as requested through the SEARs and the submission from OEH in relation to biodiversity impacts that informed the preparation of the SEARs (refer to **Table 1.2**).

Table 1.2 SEARs related to biodiversity and OEH submission on SEARs

Secretary's Environmental Assessment Requirements	Relevant Section
Accurate predictions of any vegetation to be cleared on site.	**Section 5.1**
An assessment of the likely biodiversity impacts of the development, paying particular attention to threatened species, populations and ecological communities and groundwater dependent ecosystems, undertaken in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report or, subject to agreement with OEH and the Department, undertaken in accordance with the Upper Hunter Strategic Assessment (UHSA)	**Section 5.0**
Assessment of the likely impacts of the development on listed threatened species and communities under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (see Attachment 4);	**Refer to Appendix 10**
A strategy to offset any residual impacts of the development in accordance with the offset rules under the Biodiversity Offsets Scheme.	**Section 7.0**
Where the Yorks Creek diversion is proposed: • demonstrate how a 'natural' system can be successfully created; and • include an assessment of potential impacts to aquatic habitat and fish populations.	**Appendix F**

The BDAR has been prepared in accordance with the BAM which applies to all State Significant Developments (SSD). Specifically, this assessment:

- describes the existing terrestrial environment of the Development Footprint
- identifies flora and fauna species and ecological communities within the Development Footprint that have the potential to be impacted by the Project
- determines the presence or likelihood of occurrence of threatened flora and fauna species and populations and Threatened Ecological Communities (TECs) listed under the 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 Project in accordance with the BAM and
- describes the offset strategy to satisfy the impacts of the Project.

Although this BDAR has been prepared to conform to the requirements of the BAM, there is still substantial packages of information that are yet to been finalised or released by the Biodiversity & Conservation Division (BCD) within the Department of Planning, Industry and Environment (DPIE) (formerly OEH) that affect the outcomes of the assessment. Specifically, this BDAR has been prepared in the absence of the following mapping products, policies and guidelines:

- the Native Vegetation Regulatory map (NVRM). For SSD projects, a BDAR is required to be prepared in accordance with the BAM and the BAM states that Category 1-exempt land (as defined by the LLS Act) is excluded from assessment
- the ancillary rules for mine rehabilitation

- important habitat mapping for species-credit species including (but not limited to) the regent honeyeater and swift parrot
- survey guidelines for all species-credit species
- the revised East Coast Plant Community Type (PCT) mapping, PCT descriptions or benchmark data
- drought benchmarks
- inadequate and inappropriate options for the allocation of vegetation communities recorded in the Development Footprint to PCTs in the BAM calculator
- a final bilateral agreement between the NSW government and the Commonwealth Department of Environment and Energy (DoEE). DoEE have determined that the Commonwealth will accredit the NSW assessment process for this Project however the details of the Bilateral Agreement have not been finalised at the time of writing.

1.3 Key resources, policies and documents

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

- Biodiversity Assessment Method (OEH 2017a)
- Biodiversity Assessment Calculator Version 1.2.4.00
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities –Working Draft (DEC 2004)
- BioNet Atlas of NSW Wildlife database and mapping tool (BCD 2019a), accessed July 2019
- Threatened Biodiversity Data Collection (TBDC) (BCD 2019b), accessed July 2019
- Vegetation Information System (VIS) Classification Database (BCD 2019c), accessed July 2019
- NSW Guide to Surveying Threatened Plants (OEH 2016)
- Department of the Environment and Energy (DoEE) Protected Matters Search Tool (DoEE 2019), accessed July 2019.

1.4 Report preparation

This BDAR was prepared by Shaun Corry (Principal Ecologist), with review and technical direction from Allison Riley (Principal Ecologist) and Kate Connolly (Principal Ecologist). Field surveys were undertaken by a range of Umwelt ecologists including Trish Robinson (Senior Ecologist) and James Garnham (Senior Ecologist). Vegetation and threatened ecological community mapping was reviewed by Travis Peake (National Ecology Practice Lead) and Ryan Parsons (Principal Ecologist – Botanist).

Table 1.3 below outlines the details of the Accredited BAM Assessors involved in the survey, calculations and reporting for the Project.

Table 1.3 Accredited BAM Assessors and their role on this project

Name	Assessor ID	Role
Allison Riley ***Principal Ecologist***	BAAS17042	Review and technical direction
Kate Connolly ***Principal Ecologist***	BAAS17005	Review and technical direction
Shaun Corry ***Principal Ecologist***	BAAS17041	BAM calculator application BDAR preparation
Travis Peake ***National Ecology Practice Lead***	BAAS17081	Vegetation mapping and PCT allocation review
Ryan Parsons ***Principal Ecologist - Botanist***	BAAS17048	Vegetation mapping and PCT allocation review
Trish Robinson ***Senior Ecologist - Botanist***	BAAS18123	Field Surveys Vegetation mapping and PCT allocation BDAR preparation
James Garnham ***Senior Ecologist***	BAAS19021	Field Surveys

1.4.1 Structure of the report

The structure of the report is outlined below as per the requirements of Table 25 and 26 of the BAM:

- **Stage 1 Biodiversity Assessment:**
  - 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 BAM credit calculator application
- **Stage 2 Impact Assessment:**
  - Section 4 – describes the avoidance measures implemented and minimisation of impacts as part of the Project
  - Section 5 – provides an assessment of the impacts in accordance with the BAM
  - Section 6 – summarises the credit requirements for the Project
  - Section 7 – describes the proposed biodiversity offsetting strategy for the Project
  - Section 8 – outlines the results of the Biodiversity Credit Report
- **Other sections:**
  - Section 9 - provides a list of references used throughout the report and assessment.
  - Appendix A Category 1 – Exempt Land Vegetation Classification

- Appendix B Candidate Ecosystem and Species-credit Species and Targeted Surveys
- Appendix C Vegetation Integrity Data
- Appendix D Flora Species List
- Appendix E Biodiversity Credit Report

1.5 Use of data from Upper Hunter strategic aAssessment

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 (UHSA) process which is a Strategic Assessment being undertaken as a joint initiative by the NSW and Commonwealth government. The resultant *UHSA – Greater Ravensworth Biodiversity Certification Assessment Report* (Umwelt 2015) assessed areas that Glencore had identified as potential areas for future mining activities. The Biodiversity Certification Assessment Report prepared for Greater Ravensworth was approved by OEH in March 2015.

The Development Footprint lies within the targeted UHSA survey area and, as a result of the extensive surveys completed for the Greater Ravensworth UHSA report, this BDAR utilises the information from this approved assessment in relation to survey effort and identification of significant ecological features. Notwithstanding, this BDAR has been prepared in accordance with the BAM with further extensive survey and addresses the SEARs.

2.0 Methods

The methods described herein reflect an assessment process that has spanned 5 years. As noted above, the initial survey work in the Development Footprint was undertaken as part of the UHSA process and the SEARs issued for this Project still identify the UHSA as an assessment pathway option. **Figure 2.1** documents the timeline and survey approach and highlights any change in the approvals pathway or timing of prominent 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 – Greater Ravensworth Biodiversity Certification Assessment Report* (Umwelt 2015). OEH reviewed the Greater Ravensworth Biodiversity Certification Assessment Report and on 17 March 2015 provided written approval of the surveys and report confirming adequacy in accordance with the BioCertification methodology.

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

2.1 Landscape features

2.1.1 Identifying landscape features

Landscape features within the Development Footprint and the 1,500 m buffer area were determined through reviewing relevant mapping products, aerial photography and GIS layers. Landscape features that were reviewed included:

- IBRA bioregions, IBRA subregions and NSW Mitchell Landscape regions
- Native vegetation extent in the buffer area
- Cleared areas
- Rivers, streams and estuaries (using the Strahler (1952) ordering system)
- Wetlands
- Connectivity features and fauna movement
- Areas of geological significance and soil hazard features

2.1.2 Determining site context

Determining the 'Site Context' of the Development Footprint is calculated by assessing the native vegetation cover and patch size as outlined below.

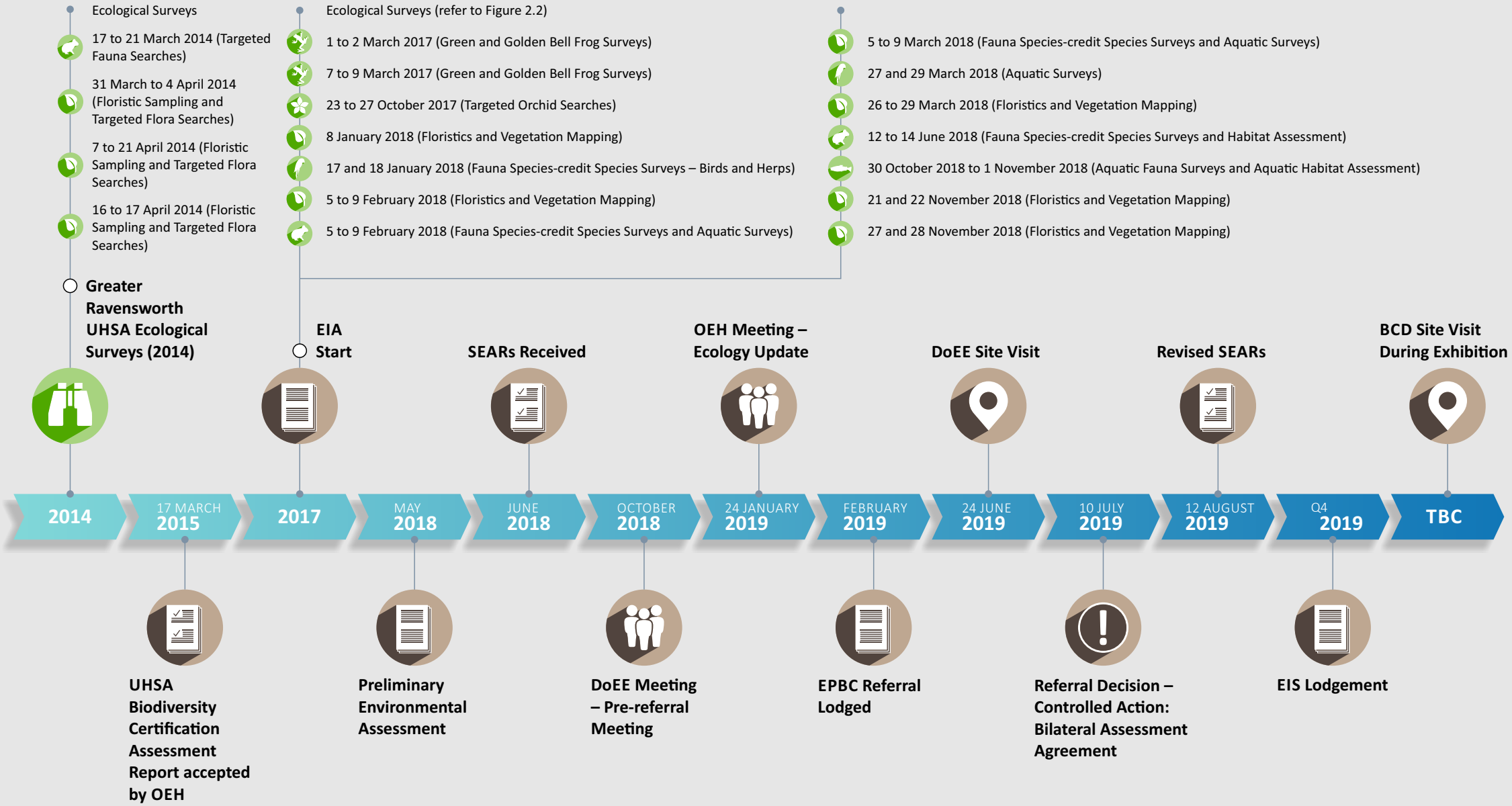

FIGURE 2.1

Project Timeline and Ecological Surveys and Assessment

Native Vegetation Cover

'Native Vegetation Cover' is determined by the percent native vegetation cover in the 1,500 m buffer area for woody and non-woody vegetation relative to the approximate benchmarks for the PCT. The presence of native over-storey vegetation is used to determine the percent cover in woody vegetation types (e.g. grassy woodland formation), and native ground cover is used to assess cover in non-woody vegetation types (e.g. grassland formation). Native vegetation cover is assigned to a class, being 0–10%, >10–30%, >30–70% and >70% for the development and is used to assess the habitat suitability of the subject land for threatened species.

All areas of native vegetation cover in the Development Footprint and within the 1,500 m buffer area surrounding the Development Footprint was mapped onto digital aerial photography using the best available imagery of the area.

Patch Size

A 'Patch' is an area of native vegetation that:

- occurs on the development site, and
- includes native vegetation that has a gap of less than 100 m from the next area of moderate to good condition native vegetation (or ≤ 30 m for non-woody vegetation).

The patch size is determined for each vegetation zone and is assigned to a range class being <5 ha, 5–24 ha, 25–100 ha or ≥100 ha. The patch size is used to assess the habitat suitability of the subject land for threatened species.

2.2 Native vegetation assessment

2.2.1 Literature and database review

A review of previous documents and reports relevant to the Project was undertaken. This included regional and vegetation mapping reports, previous site-specific surveys, previous 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 threatened and migratory species, endangered populations (EPs) and TECs.

Relevant documents included:

- Upper Hunter Strategic Assessment – Greater Ravensworth 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 for the Mount Owen Continued Operations Project (Umwelt 2014)
- Biodiversity Assessment Report for the Mount Owen Continued Operations Modification 2 (Umwelt 2018a)
- Biodiversity Development Assessment Report for the Glendell Mine Modification 4 (Umwelt 2018b)

- Draft Biodiversity Development Assessment Report for the Narama Pipeline Modification (Umwelt in prep)
- VIS Classification Database (BCD 2019), accessed January 2018
- Threatened Biodiversity Data Collection (BCD 2019) reporting for known/predicted threatened communities in the Hunter IBRA subregion
- DoEE Protected Matters Search Tool for known/predicted EPBC Act-listed TECs, accessed July 2019.

2.2.2 Previous floristic survey effort in proximity to the development footprint

Extensive previous floristic survey effort has been undertaken in proximity to the Development Footprint over more than 20 years, resulting in a detailed understanding of the biodiversity occurring in the surrounding area. **Figure 2.2** shows the floristic survey effort in the areas surrounding the Development Footprint undertaken for other assessments. This includes:

Greater Ravensworth Upper Hunter Strategic Assessment

Floristic surveys in the Greater Ravensworth UHSA Project Area (including adjacent to the Development Footprint), were undertaken in March and April 2014 and focused on assigning vegetation mapping to biometric vegetation types (BVTs) as per the VIS database. This included:

- 30 plot and transects as per BioBanking Assessment Methodology (BBAM) (OEH 2014c)
- 90 qualitative and semi-quantitative rapid sampling plots
- meandering transects and
- digital photograph interpretation

Mount Owen Continued Operations Project (Umwelt 2014)

Flora field surveys were carried out for the Mount Owen Continued Operations Project in late spring 2011, spring 2012 and in multiple seasons in 2014. Survey methods included 43 vegetation survey plots, BioBanking plots, 21 transects, rapid assessment points and field reconnaissance to identify spatial arrangement of vegetation.

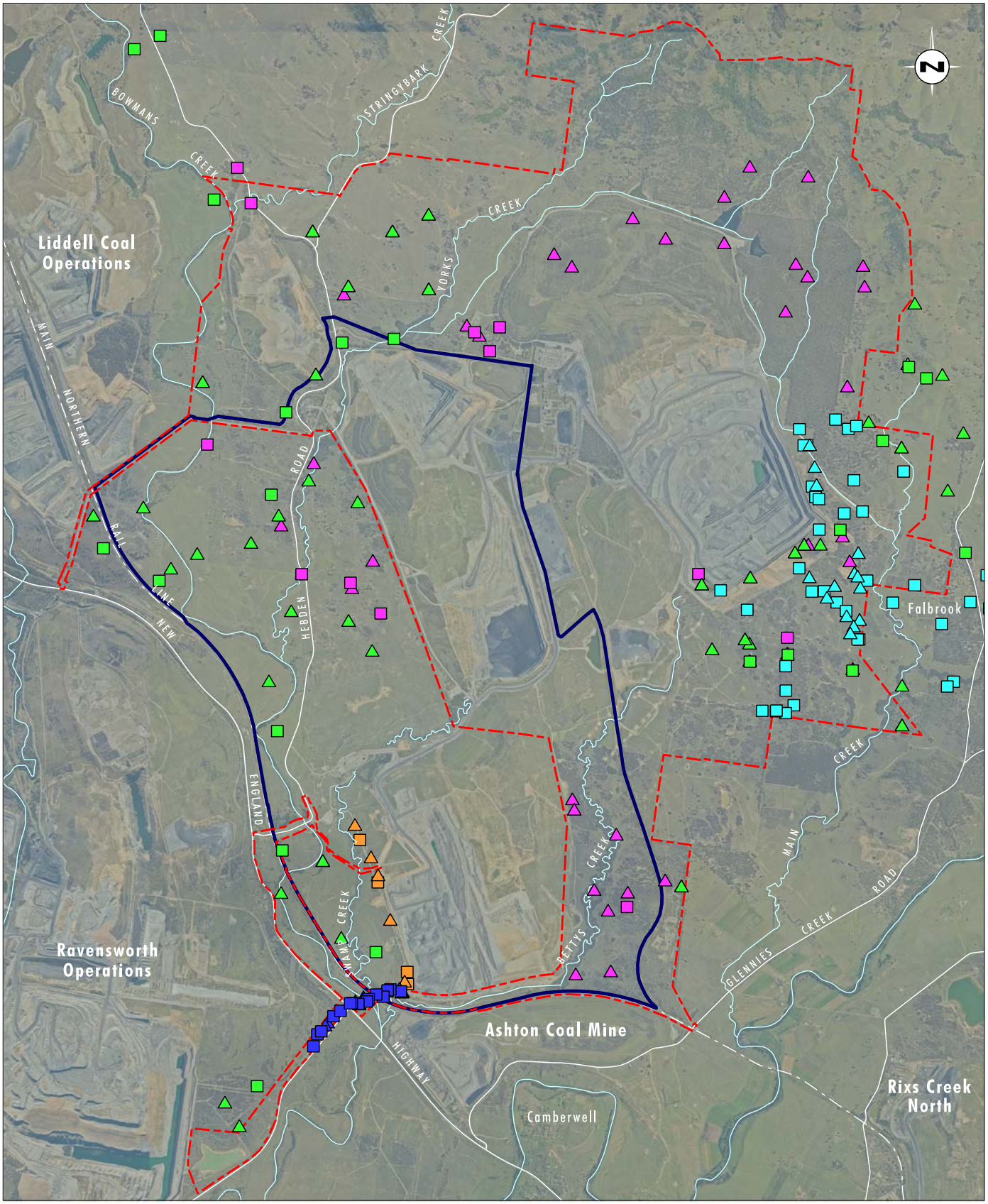

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2014, 2017, 2018, 2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

- Project Area
- Mount Owen Consent Boundary
- Floristic Plot (Umwelt 2014)
- Semi-quantitative Rapid Assessment (Umwelt 2014)
- Floristic Plot (Umwelt 2015)
- Semi-quantitative Rapid Assessment (Umwelt 2015)
- Floristic Plot (Umwelt 2017)
- Semi-quantitative Rapid Assessment (Umwelt 2017)
- Floristic Plot (Umwelt 2018)
- Semi-quantitative Rapid Assessment (Umwelt 2018)
- Floristic Plot (Umwelt 2019)
- Semi-quantitative Rapid Assessment (Umwelt 2019)

FIGURE 2.2

Other Flora Surveys

Mount Owen Continued Operations Project Modification 2 (Umwelt 2018)

Umwelt (2018b) prepared a Biodiversity Assessment Report (BAR) for the Mount Owen Continued Operations Project Modification 2 in accordance with the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014a) and the Framework for Biodiversity Assessment (FBA) (OEH 2014b). Flora Surveys included:

- 14 floristic plots according to Section 5 of the FBA
- 12 rapid assessments
- Meandering transects to target potentially occurring threatened flora species and assist in the delineation of vegetation communities*.*

Biodiversity Development Assessment Report for the Glendell Mine Modification 4 (Umwelt 2018b)

Umwelt prepared a BDAR for the Glendell Mine Modification 4 comprising the extension of mining activities in the Glendell Pit (Barrett Pit) in order to access an additional approximately 2.5 Mt ROM coal. The Development Footprint covered approximately 12 ha and is located between the current Glendell Mine and the Glendell Pit Extension.

Floristic and vegetation integrity surveys with habitat assessment and threatened species searches were undertaken on 13 August 2018. Rapid floristic assessments and threatened species searches were undertaken on 11 July 2017. A total of five BAM plots were conducted during the surveys undertaken for this assessment. Floristic and vegetation integrity data was collected in accordance with minimum requirements under the BAM.

Biodiversity Development Assessment Report for the Narama Pipeline Modification (Umwelt in prep)

Glencore is seeking approval for the relocation of an existing water pipeline (the Narama Pipeline) from Glendell Mine to Ravensworth Operations. The Development Footprint covers an area of approximately 7.5 ha.

A total of five BAM plots were conducted during the surveys undertaken for this assessment. Floristic and vegetation integrity data was collected in accordance with minimum requirements under the BAM.

2.2.3 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. These 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 high resolution aerial photographs provided by Glencore and Nearmap imagery from 2019.

2.2.4 Vegetation mapping and floristic sampling

Floristic and vegetation integrity surveys were undertaken over the following survey periods:

- 8 January 2018
- 5 - 9 February 2018
- 26 - 29 March 2018
- 21, 22, 27 and 28 November 2018

A total of 69 BAM plots and 3 rapid assessments were conducted within, and in proximity to, the Development Footprint during the surveys undertaken for this assessment (refer to **Figures 2.3** and **2.4**). Floristic and vegetation integrity data was collected in accordance with Section 5 of the BAM, as shown in **Table 2.2**. Rapid vegetation assessments were also conducted to assist in the delineation of vegetation zone boundaries and TEC identification.

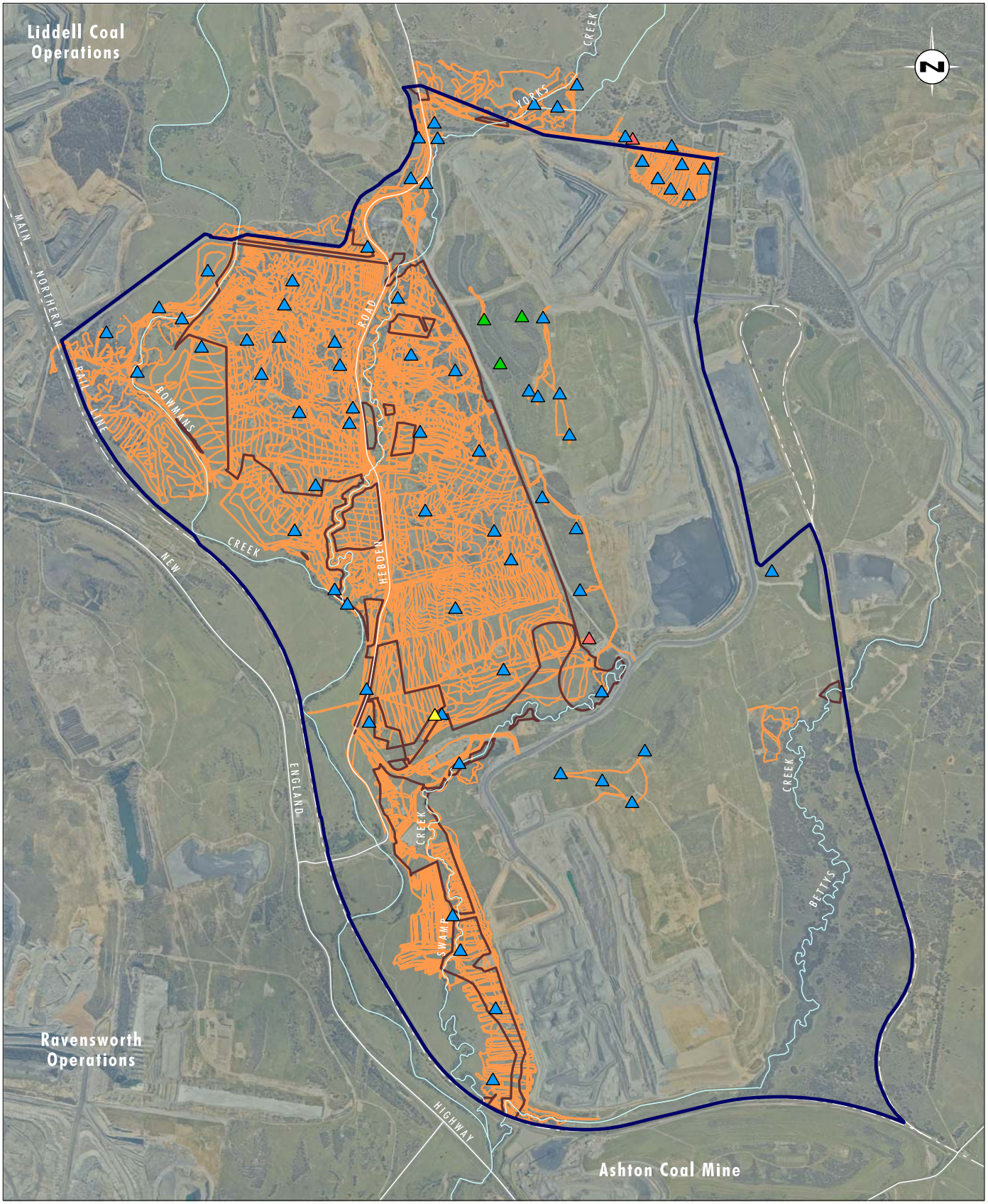

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Walking Transects
- Floristic Plot
- Semi-quantitative Rapid Assessment
- Qualitative Rapid Assessment
- Koru Environmental Floristic Plot

FIGURE 2.3

Flora Survey Effort

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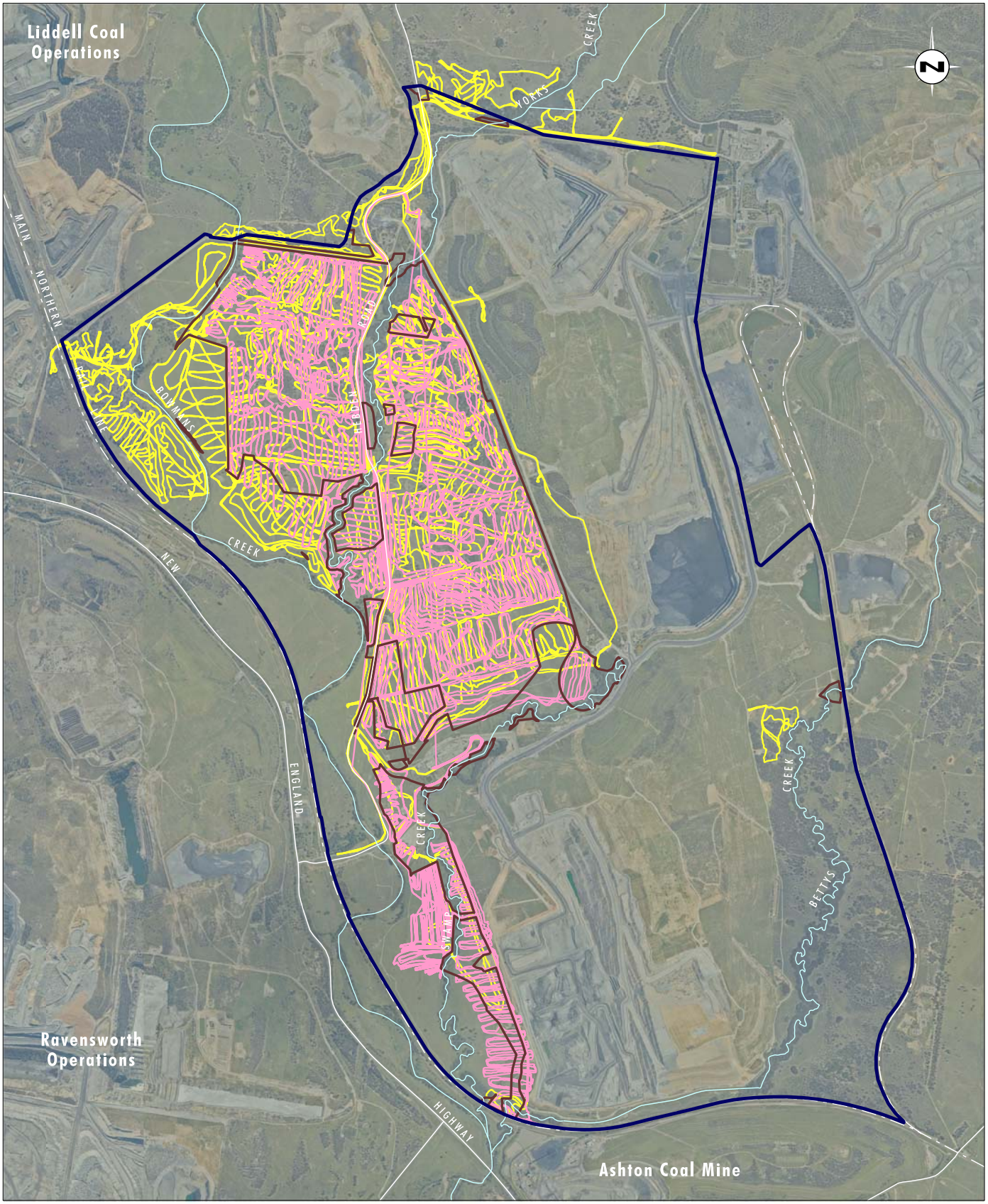

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Targeted Species-credit Flora Transects (October 2017)
- Targeted Species-credit Flora Transects (September/October 2018)

FIGURE 2.4

Targeted Species-credit Flora Transect Locations

Table 2.1 Adequacy of floristic and vegetation integrity survey in the development footprint

Veg. Zone	Plant Community Type (PCT) *Condition Class*	Area in the Development Footprint (ha)	Number of Floristic and Vegetation Integrity Plots		Rapid Assessment
			Required	Completed	
1	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Moderate - Good*	26.7	4	4	0
2	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Regeneration*	53.1	5	5	0
3	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Plantation*	1.8	1	1	1
4	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Derived Native Grassland*	386.0	7	7	0
5	PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley *Moderate - Good*	18.0	3	3	0
6	PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley *Regeneration*	10.2	3	3	0
7	PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley *Moderate - Good*	2.4	2	3	0
8	PCT 1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter *Woodland Rehabilitation*	0.5	1	4	1
9	PCT 1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley *Moderate – Good*	40.0	4	5	0

Veg. Zone	Plant Community Type (PCT) *Condition Class*	Area in the Development Footprint (ha)	Number of Floristic and Vegetation Integrity Plots		Rapid Assessment
			Required	Completed	
10	PCT 1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley *Plantation*	1.8	1	3	0
-	Exotic Vegetation	54.8	0	10	0
-	Cleared land	19.3	0	0	0
TOTAL		614.2	39	44*	2^

* 69 plots were completed in total however with project refinements only 44 plots were used for the calculator assessment.

^ 3 rapid assessments were completed in total however with project refinements only 2 remained in the Development Footprint.

2.2.4.1 Floristic sampling

At each floristic and vegetation integrity plot, data was recorded according to Section 5 of the BAM. This involved setting out 20 x 50 m, 20 x 20 m and 1 x 1 m plots. At each plot, data was collected in accordance with Table 2 of the BAM and approximately 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 m plot. Searches of each 20 x 20 m plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of any shrub, mid-storey, canopy and emergent layers were also thoroughly examined.

2.2.4.2 Weather conditions and limitations

Table 2.2 below outlines the weather conditions for the floristic and vegetation integrity surveys. Data is derived from the Singleton STP (061397) from the Bureau of Meteorology (2018).

Table 2.2 Weather conditions for floristic and vegetation integrity surveys

Date	Daily Data			Monthly Data		
	Min-Max Temp.	Rainfall	Relative Humidity	Min-Max Temp. (Average)	Rainfall (total)	Relative Humidity (Average)
8 January 2018	22.5-43.5˚C	0 mm	44%	17.7-34.6˚C	3.3 mm	38%
5 February 2018	11.3-31.6˚C	0 mm	27%	17.0-33.9	61.9 mm	37%
6 February 2018	13.7-30.6˚C	0 mm	37%			
7 February 2018	14.2-31.5˚C	0 mm	34%			
8 February 2018	12.6-35.6˚C	0 mm	23%			
9 February 2018	14.9-41.1˚C	0 mm	17%			
26 March 2018	NR-32.6˚C	0 mm	NR	16.9-29.5˚C	95 mm	60%
27 March 2018	10.0-25.1˚C	15.6 mm	53%			
28 March 2018	14.0-29.7˚C	0 mm	NR			
29 March 2018	15.9-28.3˚C	0 mm	59%			

Date	Daily Data			Monthly Data		
	Min-Max Temp.	Rainfall	Relative Humidity	Min-Max Temp. (Average)	Rainfall (total)	Relative Humidity (Average)
21 November 2018	19.0-30.2˚C	0 mm	52%	14.7-29.4˚C	39.4 mm	38%
22 November 2018	17.4-27.7˚C	0 mm	12%			
27 November 2018	11.5-31.0˚C	0 mm	27%			
28 November 2018	18.5-25.4˚C	10.4 mm	84%			

NR = not recorded. Source: http://www.bom.gov.au/climate/dwo/IDCJDW2122.latest.shtml

It should be noted that the floristic surveys were undertaken at a time where the Hunter region had experienced a prolonged period of extremely dry and hot conditions. This is likely to have resulted in a decrease in detectable or identifiable plant species.

2.2.4.3 Meandering transects

Meandering transects were walked across much of the Development Footprint. 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, especially where the number of plots is limited. 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.

2.2.4.4 Vegetation mapping

Vegetation mapping was undertaken using best-practice techniques to delineate vegetation communities across the Development Footprint. Vegetation mapping involved the following key steps:

- preliminary review of digital airborne imagery 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 PCTs (BCD 2019c) and plant communities as described by Peake (2006) and Umwelt (2015).
- ground-truthing of the vegetation map based on survey effort
- 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.

2.2.4.5 Plant community type (PCT) allocation

Each of the vegetation communities described within the Development Footprint were aligned with an equivalent PCT as detailed in the VIS Classification Database (BCD 2019c). 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 PCTs was generated. The profiles for each of the possible PCT were then interrogated and the most appropriate match assigned based on floristic, structure, soil, landform and distribution details.

Further detail regarding this allocation for individual PCT/BVTs is outlined in **Section3.2.1.**

2.2.4.6 Threatened ecological community delineation techniques

Where applicable, 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 Scientific Committee Final Determinations and the Commonwealth Threatened Species Scientific Committee Listing and Conservation Advice. The following approach was used:

- full-floristic plot assessments and meandering surveys to determine floristic composition and structure of each ecological community
- comparison with published species lists, including lists of 'important species' as identified on the listing advice provided by the NSW 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 the NSW BCD
- comparison with other assessments of TECs in the region.

Section 3.2.3 provides the analysis of PCTs with TECs listed under the Commonwealth EPBC Act and NSW BC Act

2.3 Threatened species

2.3.1 Literature and database review

A review of previous documents and reports relevant to the Project was undertaken. This included ecological reports, previous 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 where required, and was also used to assist in the assessment of potentially occurring ecosystem-credit and species-credit species. Relevant documents and resources included:

- Upper Hunter Strategic Assessment – Greater Ravensworth Biodiversity Certification Assessment Report (Umwelt 2015)
- Ecological Assessment for the Mount Owen Continued Operations Project (Umwelt 2014)
- Biodiversity Assessment Report for the Mount Owen Continued Operations Modification 2 (Umwelt 2018b)

- Biodiversity Development Assessment Report for the Glendell Mine Modification 4 (Umwelt 2018a)
- Draft Biodiversity Development Assessment Report for the Narama Pipeline Modification (Umwelt in prep)
- BCD BioNet Atlas of NSW Wildlife database and mapping tool (BCD 2019a), accessed August 2019
- BCD Threatened Biodiversity Data Collection (BCD 2019b) (TBDC) for known/predicted threatened species in the Hunter IBRA subregion, accessed August 2019
- PlantNET (Botanic Gardens Trust) database search for threatened plants within a 10 kilometre radius search from Ravensworth, accessed August 2019
- DoEE Protected Matters Search Tool (DoEE 2019) for known/predicted EPBC Act-listed species, accessed August 2019.

A preliminary assessment using the TBDC was undertaken which provided a list of species-credit species that might require survey and the suitable survey periods for each species. The results of these database searches, literature review and TBDC review were used to design the appropriate survey requirements for species-credit species.

2.3.2 Ecosystem-credit species

Ecosystem-credit species are those threatened species that can be predicted by vegetation surrogates and landscape features. Ecosystem-credit species are not required to be specifically targeted during field surveys, however an assessment of the suitability of habitat in the Development Footprint is undertaken to determine the species presence or otherwise in each vegetation zone identified. The list of ecosystem-credit species predicted to occur by the BAM calculator and/or the literature review and whether they were recorded within the Development Footprint is provided in **Appendix B**.

2.3.3 Species-credit species

An assessment of candidate species-credit species was completed in accordance with Section 6.4.1 of the BAM. For those candidate species considered to have the potential to occur within the Development Footprint are listed in Figure 2.3 below and, where required, targeted surveys transects and opportunistic searches were undertaken as described in **Appendix B**. Species-credit species surveys were undertaken over two years and multiple seasons, being:

- 1, 2, 7, 8 and 9 March 2017
- 23-27 October 2017
- 8, 16-18 January 2018
- 5-9 February 2018
- 26 October 2017 – 9 March 2018 (remote camera surveys)
- 5-9 March 2018
- 26-29 March 2018

- 12-14 June 2018
- 24 and 28 September 2018
- 8-10 October 2018
- 30 October - 1 November 2018
- 21, 22, 27 and 28 November 2018

Table 2.3 below documents the candidate species-credit species potentially occurring in the Development Footprint and the timing of targeted surveys for each species within the Development Footprint that satisfies the requirements of the TBDC and BAM calculator. The table only documents the targeted searches completed since the approval of the UHSA survey effort in March 2015. The table does not document all the surveys in which the species may have been able to be detected. Further detail on the specific surveys for each species is provided in **Appendix B**.

Justification for candidate species-credit species that do not require further assessment is provided in Table A1.5 of **Appendix A**.

Table 2.3 Candidate Species-credit Species Survey Timing in the Development Footprint

Species	Survey Period	Targeted Surveys within Development Footprint
Bynoe's wattle ***Acacia bynoeana***	All year	October 2017 September 2018 October 2018
Acacia pendula **population in the Hunter catchment**	All year	
trailing woodruff ***Asperula asthenes***	Oct-Nov	
netted bottlebrush ***Callistemon linearifolius***	Oct-Jan	
Cymbidium canaliculatum **population in the Hunter Catchment**	All year	
white-flowered wax plant ***Cynanchum elegans***	All year	
pine donkey orchid ***Diuris tricolor***	Sep-Oct	
Eucalyptus camaldulensis **population in the Hunter catchment**	All year	
slaty red gum ***Eucalyptus glaucina***	All year	
Eucalyptus parramattensis **subsp.** ***decadens***	All year	
small-flower grevillea ***Grevillea parviflora*** **subsp.** ***parviflora***	Aug-Nov	
large-leafed Monotaxis ***Monotaxis macrophylla***	Aug - Feb	
Ozothamnus tesselatus	Sept-Oct	

Species	Survey Period	Targeted Surveys within Development Footprint
scant pomaderris *Pomaderris queenslandica*	All year	
Singleton mint bush *Prostanthera cineolifera*	Sept-Oct	
Illawarra greenhood *Pterostylis gibbosa*	Sept-Oct	
tall knotweed *Persicaria elatior*	Dec-May	March 2017 January 2018 February 2018 March 2018
regent honeyeater *Anthochaera phrygia*	N/A	June 2018
bush stone-curlew *Burhinus grallarius*	All year	March 2018
gang-gang cockatoo *Callocephalon fimbriatum*	Oct-Jan	January 2018 June 2018
glossy black-cockatoo *Calyptorhynchus lathami*	Mar-Aug	January 2018 June 2018
eastern pygmy-possum *Cercartetus nanus*	Oct-Mar	October 2017 March 2018 June 2018
large-eared pied bat *Chalinolobus dwyeri*	Nov-Jan	January 2018 March 2018 November 2018
white-bellied sea-eagle *Haliaeetus leucogaster*	Jul-Dec	October 2017 January 2018 June 2018
little eagle *Hieraaetus morphnoides*	Aug-Oct	October 2017 January 2018 June 2018
pale-headed snake *Hoplocephalus bitorquatus*	Nov-Mar	January 2018 March 2018
swift parrot *Lathamus discolor*	N/A	June 2018
green and golden bell frog *Litoria aurea*	Nov-Mar	March 2017 March 2018
green-thighed frog *Litoria brevipalmata*	Oct-Mar	March 2018
square-tailed kite *Lophoictinia isura*	Sept-Jan	October 2017 January 2018 June 2018

Species	Survey Period	Targeted Surveys within Development Footprint
little bentwing-bat ***Miniopterus australis***	Dec-Feb	January 2018 March 2018
eastern bentwing-bat ***Miniopterus schreibersii oceanensis***	Dec-Feb	January 2018 March 2018
southern myotis ***Myotis macropus***	Oct-Mar	March 2018
barking owl ***Ninox connivens***	May-Dec	June 2018
powerful owl ***Ninox strenua***	May-Aug	June 2018
squirrel glider ***Petaurus norfolcensis***	All year	October 2017 March 2018 June 2018
brush-tailed phascogale ***Phascogale tapoatafa***	All year	October 2017 March 2018 June 2018
koala ***Phascolarctos cinereus***	All year	February 2018 March 2018 June 2018
common planigale ***Planigale maculata***	All year	October 2017 March 2018 June 2018
grey-headed flying-fox ***Pteropus poliocephalus***	Oct-Dec	October 2017 March 2018 June 2018 October 2018
masked owl ***Tyto novaehollandiae***	May-Aug	June 2018
eastern cave bat ***Vespadelus troughtoni***	Nov-Jan	January 2018 March 2018

The flora survey effort is shown on **Figure 2.3** with targeted flora transects on **Figure 2.4**, and the fauna survey effort is detailed on **Figure 2.5.**

Appendix B documents the details of the targeted surveys undertaken for each species which considered the following survey guidelines:

- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* – Working Draft (DEC 2004)
- *NSW Guide to Surveying Threatened Plants* (OEH 2016)
- *Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians* (DECC 2009)

- *Survey Guidelines for Australia's Threatened Frogs* (DEWHA 2010b)
- *Hygiene protocol for the control of disease in frogs* (DECC 2008)
- *Draft Survey Guidelines for Australia's Threatened Orchids* (DoE 2013)
- *Survey Guidelines for Australia's Threatened Birds* (DEWHA 2010a)
- *Survey Guidelines for Australia's Threatened Mammals* (DSEWPC 2011a)
- *Survey Guidelines for Australia's Threatened Frogs* (DEWHA 2010b)
- *Survey Guidelines for Australia's Threatened Bats* (DEWHA 2010c).

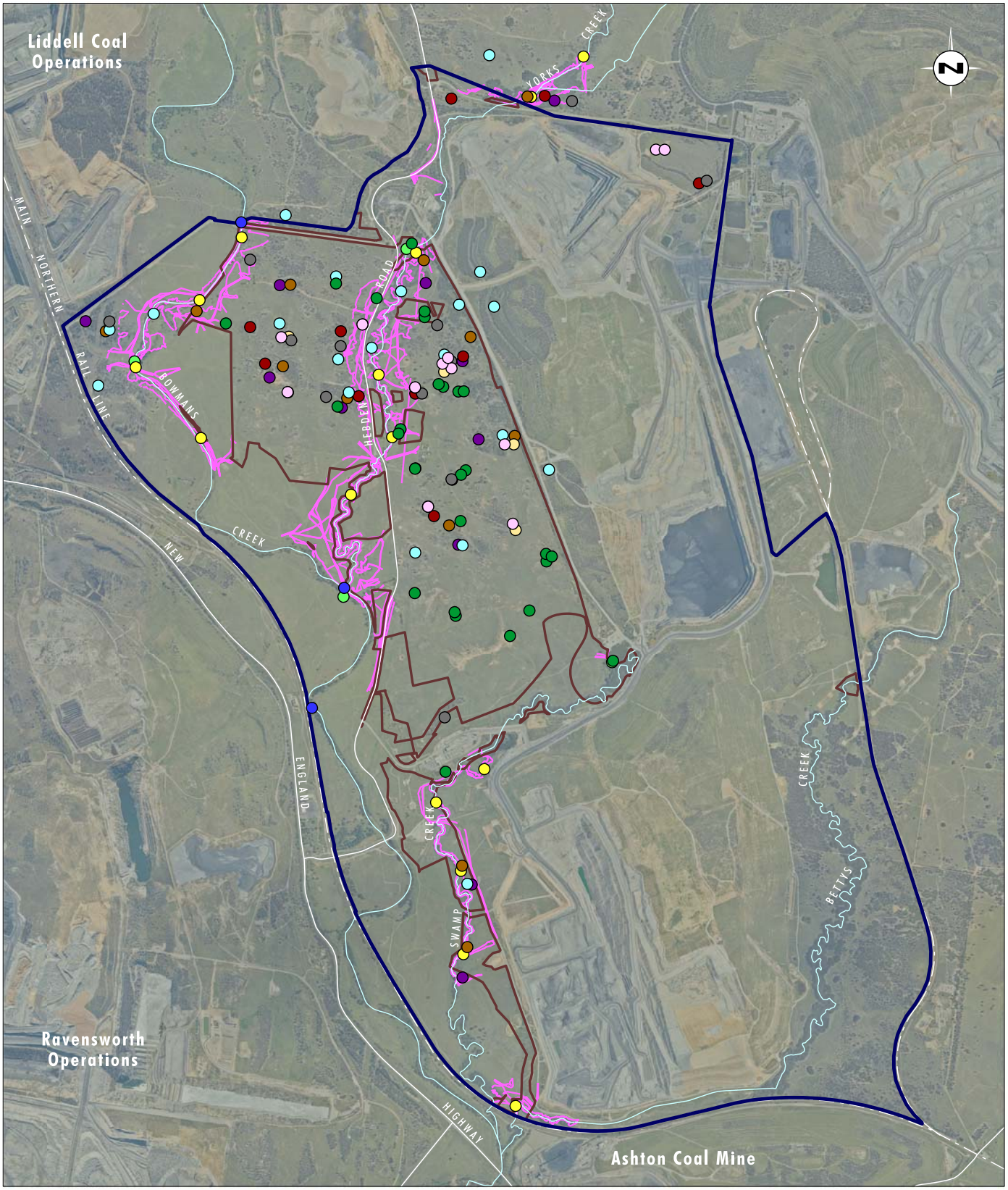

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Targeted Southern Myotis Breeding Habitat Inspections
- Anabat Survey
- Aquatic Habitat Survey
- Aquatic Habitat, Fish and Macroinvertebrate Survey
- Raptor Stick Nest, Gang Gang Cockatoo and Glossy Black-cockatoo Breeding Habitat Searches
- Call Playback for Threatened Nocturnal Birds and Mammals
- Pale-headed Snake Survey Locations
- Koala and Bush Stone Curlew Call Playback
- Koala SAT Survey
- Remote Camera for Squirrel Glider, Brush-tailed Phascogale, Common Planigale and Eastern Pygmy Possum
- Green and Golden Bell Frog and Green-thighed Frog Survey Locations
- Swift Parrot and Regent Honeyeater Survey Locations

FIGURE 2.5

Targeted Species-credit Fauna Survey Effort

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2.3.3.1 Weather conditions and limitations

Table 2.4 below outlines the weather conditions for all species-credit surveys conducted. Data is derived from the Singleton STP (061397) from the Bureau of Meteorology (2018).

Table 2.4 Weather Conditions for Species-credit Surveys

Date	Daily Data			Monthly Data		
	Min-Max Temp.	Rainfall	Relative Humidity	Min-Max Temp. (Average)	Rainfall (total)	Relative Humidity (Average)
1 March 2017	19.1-29.2˚C	6.2 mm	84%	17.7-28.5˚C	137.7 mm	82%
2 March 2017	19.0-30.5˚C	0 mm	82%			
7 March 2017	14.6-27.0˚C	0 mm	61%			
8 March 2017	NR-24.5˚C	1.0 mm	79%			
9 March 2017	18.6-26.2˚C	1.0 mm	81%			
23 October 2017	11.3-22.5˚C	17.8 mm	78%	11.9-27.3˚C	59.8 mm	66%
24 October 2017	8.0-30.0˚C	0.0 mm	85%			
25 October 2017	13.5-32.2˚C	0.0 mm	47%			
26 October 2017	14.0-30.4˚C	0.0 mm	81%			
27 October 2017	10.2-25.4˚C	20.6 mm	86%			
30 October 2017	13.0-35.7˚C	0.0 mm	46%			
8 January 2018	22.5-43.5˚C	0 mm	44%	17.7-34.6˚C	3.3 mm	60%
16 January 2018	17.9-27.1˚C	0 mm	53%			
17 January 2018	11.2-29.7˚C	0 mm	56%			
18 January 2018	10.6-34.8˚C	0 mm	65%			
5 February 2018	11.3-31.6˚C	0 mm	65%	17.0-33.9˚C	61.9 mm	65%
6 February 2018	13.7-30.6˚C	0 mm	65%			
7 February 2018	14.2-31.5˚C	0 mm	60%			
8 February 2018	12.6-35.6˚C	0 mm	62%			
9 February 2018	14.9-41.1˚C	0 mm	47%			
5 March 2018	19.5-27.4˚C	32.6 mm	93%	16.9-29.5˚C	95 mm	77%
6 March 2018	18.7-NR˚C	4.2 mm	81%			
7 March 2018	NR-25.6˚C	0.6 mm	NR			
8 March 2018	13.9-25.7˚C	0 mm	73%			
9 March 2018	17.2-26.6˚C	0 mm	80%			
26 March 2018	NR-32.6˚C	0 mm	NR			
27 March 2018	10.0-25.1˚C	15.6 mm	60%			
28 March 2018	14.0-29.7˚C	0 mm	95%			
29 March 2018	15.9-28.3˚C	0 mm	99%			

Date	Daily Data			Monthly Data		
	Min-Max Temp.	Rainfall	Relative Humidity	Min-Max Temp. (Average)	Rainfall (total)	Relative Humidity (Average)
12 June 2018	5.4-17.3˚C	0.4 mm	94%	7.2-17.7˚C	45 mm	87%
13 June 2018	6.0-19.1˚C	0 mm	92%			
14 June 2018	4.4-19.5˚C	0 mm	NR			
24 September 2018	9.6-18.5˚C	0 mm	60%	9.4-23.2˚C	20.8 mm	40 %
28 September 2018	7.0-31.5˚C	0 mm	14%			
8 October 2018	11.1-26.7˚C	3.4 mm	34%	13.4-25.1˚C	66.9 mm	50%
9 October 2018	11.4-28.6˚C	0 mm	29%			
10 October 2018	13.3-17.9˚C	0.8 mm	78%			
30 October 2018	10.5-32.2˚C	0 mm	27%			
31 October 2018	14.4-35.7˚C	0 mm	21%			
1 November 2018	20.4-36.7˚C	0 mm	27%	14.7-29.4˚C	39.4mm	38%

NR = not recorded. Source: http://www.bom.gov.au/climate/dwo/IDCJDW2122.latest.shtml

3.0 Results

3.1 Landscape value

3.1.1 Landscape features

The buffer area contains a range of landscape features typical of the landscapes around the central Hunter Valley. These landscape features are shown in **Figures 1.4** and **1.5** and outlined in relation to the Development Footprint in **Table 3.1** below.

Table 3.1 Landscape features in the development footprint

Landscape Features	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Hunter
Mitchell Landscape	Central Hunter Foothills
Rivers, Streams, Estuaries	Bowmans Creek (5th order) Yorks Creek (3rd order) Swamp Creek (2nd order) Bettys Creek (2nd order)
Wetlands (within, adjacent to and downstream)	None identified
Native Vegetation Extent	3,626 ha in the 1,500 m buffer area (73%)
Connectivity Features	Not identified within a Priority Investment Area (OEH 2017a) Not identified as an important flyway for migratory species
Areas of Geological Significance	None identified
Soil Hazard Features	None identified

3.2 Native vegetation within the development footprint

3.2.1 Plant community types and vegetation zones

Surveys of the Development Footprint identified six Plant Community Types (PCTs) which have been split into 10 condition classes (refer to **Table 3.2** and **Figure 3.1**).

Table 3.2 Plant community types and vegetation zones within the development footprint

Plant Community Type	Condition Classes Mapped within the Development Footprint
1603 – Narrow- leaved Ironbark – Bull Oak – Grey Box shrub- grass open forest of the Central and Lower Hunter	*Moderate to Good*
	Regeneration
	Plantation
	Derived Native Grassland

Plant Community Type	Condition Classes Mapped within the Development Footprint
1604 – Narrow- leaved Ironbark – Bull Oak – Grey Box shrub- grass woodland of the Central and Lower Hunter	*Woodland Rehabilitation*
1692 – Bull Oak Grassy Woodland of the Central Hunter Valley	*Moderate to Good*
	Regeneration
1731 – Swamp Oak – Weeping Grass grassy riparian forest of the Hunter Valley	*Moderate to Good*
	Plantation
485 – River Oak riparian grassy tall woodland of the Western Hunter Valley	*Moderate to Good*

In addition to the native vegetation communities identified above, some areas within the Development Footprint contained exotic vegetation, disturbed land and dams. Under the BAM, areas of exotic vegetation are not subject to a calculator assessment and do not generate ecosystem credits. Sufficient sampling of the exotic vegetation, including floristic plots and vegetation integrity plots in accordance with the BAM, was completed to be confident that these areas do not comprise a native plant community and do not generate ecosystem credits.

A description of the vegetation zones is outlined below and a flora species list for all vegetation integrity plots and rapid assessments surveyed is included in **Appendix C.**

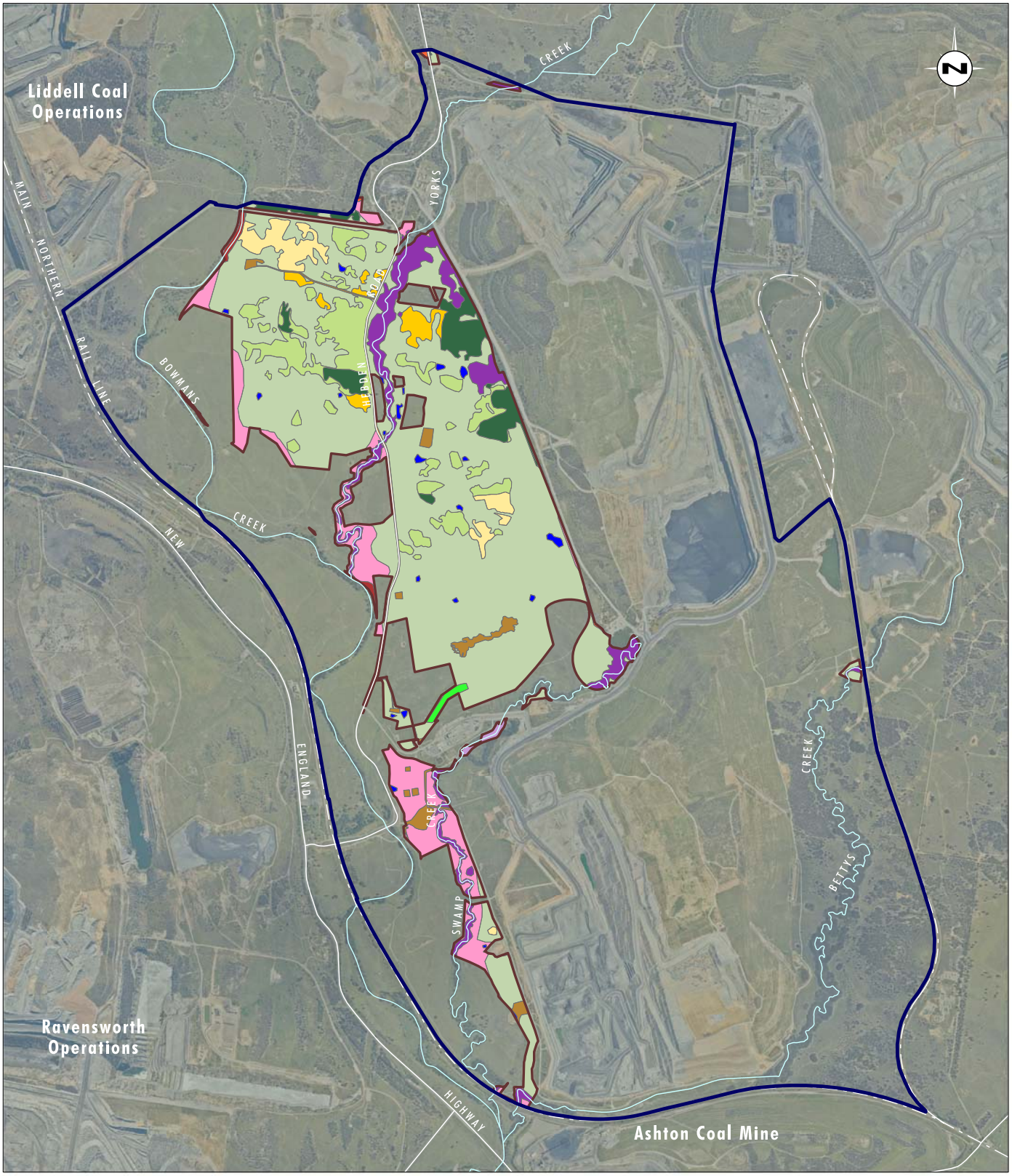


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- 485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Moderate to Good Condition
- 1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good Condition
- 1603 - Plantation
- 1603 - Regeneration
- 1603 - Derived Native Grassland
- 1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central And Lower Hunter - Woody Rehab
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition
- 1692 - Regeneration
- 1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good Condition
- 1731 - Plantation
- Dam
- Disturbed Land
- Exotic Vegetation

FIGURE 3.1

Vegetation Zones in the Development Footprint

File Name (A4): R03/4166_146.dgn
20191126 13.57

3.2.1.1 Zone 1 – PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter (Moderate to Good)

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter	
Condition	**Moderate to Good**	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	74.00	
Area (ha)	26.7	
Patch Size Class	>100 ha	
General Description	Occurs on lower slopes in the central part of the Development Footprint (refer to **Figure 3.1**).	
Canopy Description	The sparse to mid-dense canopy was dominated by narrow-leaved ironbark (*Eucalyptus crebra*), with occurrences of grey box (*Eucalyptus moluccana*). Where this community occurred in proximity to a depression or minor drainage line, forest red gum (*Eucalyptus tereticornis*) was occasionally observed in the canopy layer and typically as a co-dominant with narrow-leaved ironbark and/or grey box. The height of the canopy generally ranged from 12 to 16 m.	
Mid-storey and Shrub Layer Description	A very sparse to sparse mid-storey was often present, dominated by bulloak (*Allocasuarina luehmannii*). The mid-storey ranged from 1 to 4 m in height. The shrub layer was very sparse to sparse. Common shrubs included small-leaf bluebush (*Maireana microphylla*), native blackthorn (*Bursaria spinosa*), forest nightshade (*Solanum prinophyllum*) and gorse bitter pea (*Daviesia ulicifolia*). The shrub layer generally ranged from 0.5 to 2 m in height.	
Ground Cover Description	This vegetation zone was characterised by a diverse and sparse to mid-dense ground layer generally less than 0.5 m in height. Common forbs, ferns, sedges, rushes and sub-shrubs included poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), blue trumpet (*Brunoniella australis*), wattle mat-rush (*Lomandra filiformis*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), amulla (*Eremophila debilis*), *Vernonia cinerea*, ruby saltbush (*Enchylaena tomentosa*), *Glycine tabacina*, corrugated sida (*Sida corrugata*) and kidney weed (*Dichondra repens*). Native grasses included barbed wire grass (*Cymbopogon refractus*), purple wiregrass (*Aristida ramosa*), threeawn speargrass (*Aristida vagans*), speargrass (*Austrostipa scabra*), slender bamboo grass (*Austrostipa verticillata*) and *Rytidosperma monticola.*	

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter
Condition	**Moderate to Good**
Introduced Species	Introduced species generally occurred at low abundance in Vegetation Zone 1. African olive (*Olea europaea* subsp. *cuspidata*) was commonly recorded in the shrub layer and kei apple (*Dovyalis caffra*) was occasionally present. Commonly recorded groundcover species include tiger pear (*Opuntia aurantiaca*), common prickly pear (*Opuntia stricta* var. *stricta*), fireweed (*Senecio madagascariensis*) and Paddys lucerne (*Sida rhombifolia*).
PCT Allocation	Characteristic native species of Vegetation Zone 1 were entered into the VIS Classification Database (BCD 2019c). Distribution details were then used to further refine the candidate PCTs. Vegetation Zone 1 is aligned with PCT1603 as it supports a high proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (BCD 2018c). Of the 14 flora species listed on the database as characteristic for PCT1603, Vegetation Zone 1 supports 10 of them (71%). Other similar PCTs considered include: • PCT1691 Narrow-leaved Ironbark - Grey Box grassy woodland of the Central and Lower Hunter Very similar to PCT1603, both of which share strong floristic similarity with Vegetation Zone 1. However, as Vegetation Zone 1 contains bulloak (*Allocasuarina luehmannii*), which is a diagnostic species of PCT1603, this was deemed a more suitable fit for Vegetation Zone 1. Other similar PCTs that were considered, however were ruled out based on lower floristic similarity (between 50 to 60 %) include: • PCT623 Narrow-leaved Ironbark +/- Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Basin Bioregion • PCT1604 Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter • PCT1601 Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter • PCT1605 Narrow-leaved Ironbark - Native Olive shrubby open forest of the central and upper Hunter
BC Act Status	Vegetation Zone 1 is consistent with the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act.
EPBC Act Status	Vegetation Zone 1 is consistent with the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act.

3.2.1.2 Zone 2 – PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter (Regeneration)

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter	
Condition	**Regeneration**	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	74.00	
Area (ha)	53.1	
Patch Size Class	>100 ha	
General Description	Occurs on lower slopes in the central part of the Development Footprint (refer to **Figure 3.1**). Separated from other areas of this PCT based on the dominance of regenerating trees in the mid and canopy strata.	
Canopy Description	The canopy of Vegetation Zone 2 generally comprised a sparse to mid-dense canopy of regenerating narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*), with occurrences of grey box (*Eucalyptus moluccana*) and forest red gum (*Eucalyptus tereticornis*). The height of the canopy generally ranged from 4 to 10 metres. In some instances mature narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*Eucalyptus moluccana*) occurred as a sparse canopy emergent layer over regenerating eucalypts and bulloak (*Allocasuarina luehmannii*). The height of mature eucalypts was generally up to 20 m.	
Mid-storey and Shrub Layer Description	When a sparse canopy of mature eucalypts was present, the mid-dense mid-storey was dominated by young narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*). The mid-storey ranged from 2 to 8 m in height. Mid-storey and shrub layers were generally absent from Vegetation Zone 2. When present, it occurred as a sparse shrub layer less than 1 m in height, and included the common shrubs small-leaf bluebush (*Maireana microphylla*) and gorse bitter pea (*Daviesia ulicifolia*).	
Ground Cover Description	Vegetation Zone 2 was characterised by a sparse ground layer generally less than 0.5 metre in height. Common forbs, ferns, rushes and sub-shrubs included poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), yellow burr-daisy (*Calotis lappulacea*), common everlasting (*Chrysocephalum apiculatum*), lemon beauty-heads (*Calocephalus citreus*), blue trumpet (*Brunoniella australis*), wattle mat-rush (*Lomandra filiformis*), many-flowered mat-rush (*Lomandra multiflora* subsp. *multiflora*), slender wire lily (*Laxmannia gracilis*), ruby saltbush (*Enchylaena tomentosa*), *Glycine tabacina* and zornia (*Zornia dyctiocarpa* var. *dyctiocarpa*). Native grasses included barbed wire grass (*Cymbopogon refractus*), purple wiregrass (*Aristida ramosa*), threeawn speargrass (*Aristida vagans*), slender rats tail grass (*Sporobolus creber*), common couch (*Cynodon dactylon*) and speargrass (*Austrostipa scabra*).	

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter
Condition	Regeneration
Introduced Species	Introduced species generally occurred at low abundance in Vegetation Zone 2, however mother of millions (*Bryophyllum delagoense*) was occasionally recorded in high abundance. Other commonly recorded species include tiger pear (*Opuntia aurantiaca*), common prickly pear (*Opuntia stricta* var. *stricta*), lambs tongues (*Plantago lanceolata*), galenia (*Galenia pubescens*) and Paddys lucerne (*Sida rhombifolia*).
PCT Allocation	Vegetation Zone 2 has been attributed to PCT1603 based on its position in the landscape, often adjoining remnant woodland patches of Vegetation Zone 1 - PCT1603. Additionally, Vegetation Zone 2 contains a large proportion (70 %) of the characteristic species for PCT1603, including regenerating narrow-leaved ironbark (*Eucalyptus crebra*), bulloak (*Allocasuarina luehmannii*) and grey box (*Eucalyptus moluccana*).
BC Act Status	Vegetation Zone 2 is consistent with the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. Further information is provided in **Section 3.2.3**.
EPBC Act Status	Vegetation Zone 2 is consistent with the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act.

3.2.1.3 Zone 3 – PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter (Plantation)

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter	
Condition	Plantation	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	74.00	
Area (ha)	1.8	
Patch Size Class	<5 ha	
General Description	Vegetation Zone 3 occurs immediately north of the existing Glendell mine infrastructure area (refer to **Figure 3.1**). The identification of Vegetation Zone 3 was based on the presence of a variety of planted native tree species and a derived native grassland understorey.	
Canopy Description	The canopy comprised a number of planted native and locally occurring tree species including grey box (*Eucalyptus moluccana*), spotted gum (*Corymbia maculata*), narrow-leaved ironbark (*Eucalyptus crebra*), forest red gum (*Eucalyptus tereticornis*), slaty gum (*Eucalyptus dawsonii*), weeping myall (*Acacia pendula*) and swamp oak (*Casuarina glauca*).	

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter
Condition	**Plantation**
Mid-storey and Shrub Layer Description	The mid-storey was sparse and dominated by non-local Cootamundra wattle (*Acacia baileyana*). A very sparse low shrub layer dominated by small-leaf bluebush (*Maireana microphylla*) was also present.
Ground Cover Description	The groundcover vegetation was low and sparse and dominated by native forbs, sedges and sub-shrubs. Common species included ruby saltbush (*Enchylana tomentosa*), corrugated sida (*Sida corrugata*), slender flat-sedge (*Cyperus gracilis*), *Einadia polygonoides*, kidney weed (*Dichondra repens*) and yellow burr-daisy (*Calotis lappulacea*). Native grasses included slender bamboo grass (*Austrostipa verticillata*), purple wiregrass (*Aristida ramosa*), speargrass (*Austrostipa scabra*), *Paspalidium distans* and couch (*Cynodon dactylon*).
Introduced Species	Introduced species occurred in low to moderate abundance in Vegetation Zone 3. Commonly recorded species included galenia (*Galenia pubescens*), Paddys lucerne (*Sida rhombifolia*), creeping pear (*Opuntia humifusa*) and kei-apple (*Dovyalis caffra*).
PCT Allocation	This is a planted community that does not conform to any native PCT. For the purposes of the BDAR and to generate ecosystem credits, this vegetation zone has been attributed to PCT1603 based on its position in the landscape, in proximity to Vegetation Zone 4 - PCT1603 (derived native grassland), as well as the presence of several of the characteristic canopy species and ground cover species for PCT1603.
BC Act Status	Vegetation Zone 3 is consistent with the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. Despite the presence of planted species such as slaty gum (*Eucalyptus dawsonii*), the vegetation in this zone is still dominated by the typical canopy species of this EEC, being grey box (*Eucalyptus moluccana*) and narrow-leaved ironbark (*Eucalyptus crebra*). Further information is provided in **Section 3.2.3**.
EPBC Act Status	Vegetation Zone 3 meets the diagnostic characteristics and condition thresholds to be considered part of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act. Further information is provided in **Section 3.2.3**.

3.2.1.4 Zone 4 – PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter (Derived Native Grassland)

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter	
Condition	**Derived Native Grassland**	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	74.00	
Area (ha)	386.0	
Patch Size Class	0 ha (patch size is calculated for intact native vegetation only)	
General Description	This vegetation zone occurred widely across the Development Footprint on the lower and mid slopes (refer to **Figure 3.1**). The identification of Vegetation Zone 4 was based on the location of scattered remnant eucalypt trees, as well as taking into consideration topography and landscape position.	
Canopy Description	In some areas scattered narrow-leaved ironbark (*Eucalyptus crebra*), bulloak (*Allocasuarina luehmannii*) and grey box (*Eucalyptus moluccana*) occurred, however generally the ground layer was the dominant stratum.	
Mid-storey and Shrub Layer Description	Mid-storey and shrub layers were generally absent from Vegetation Zone 4, however some scattered shrubs were present, the most commonly recorded being small-leaf bluebush (*Maireana microphylla*).	
Ground Cover Description	Vegetation Zone 4 was characterised by a diverse and dense ground layer generally less than 1 metre in height. Common herbs, sedges, ferns and rushes included common everlasting (*Chrysocephalum apiculatum*), common fringe-sedge (*Fimbristylis dichotoma*), poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), wattle mat-rush (*Lomandra filiformis*), slender stackhousia (*Stackhousia viminea*), wiry spurge (*Phyllanthus virgatus*) and *Glycine tabacina*. Native grasses included barbed wire grass (*Cymbopogon refractus*), purple wiregrass (*Aristida ramosa*), slender rats tail grass (*Sporobolus creber*), *Paspalidium distans*, red grass (*Bothriochloa macra*), common couch (*Cynodon dactylon*), shorthair plumegrass (*Dichelachne micrantha*), kangaroo grass (*Themeda triandra*) and common wheatgrass (*Elymus scaber*).	

PCT Name	Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter
Condition	Derived Native Grassland
Introduced Species	Introduced species generally occur at low abundance in Vegetation Zone 4. African olive (*Olea europaea* subsp. *cuspidata*) and kei apple (*Dovyalis caffra*) occurred occasionally throughout Vegetation Zone 4. Commonly recorded groundcover species include lambs tongues (*Plantago lanceolata*), fireweed (*Senecio madagascariensis*), Paddys lucerne (*Sida rhombifolia*), catsear (*Hypochaeris radicata*) and *Verbena quadrangularis*.
PCT Allocation	Vegetation Zone 4 has been attributed to PCT1603 based on its position in the landscape between remnant woodland patches of Zone 1 - PCT1603 and the presence of several of the characteristic ground cover species for PCT1603.
BC Act Status	Not consistent with any listed TEC under the BC Act.
EPBC Act Status	Derived native grasslands are not holistically included in the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act, however some areas of this vegetation zone situated in gaps or between remnants of the CEEC are considered to form part of the CEEC 'patch' (DoEE 2016). In these instances, the area of Vegetation Zone 4 is mapped as the CEEC. Further information is provided in **Section 3.2.3**.

3.2.1.5 Zone 5 – PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley (Moderate to Good)

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley	
Condition	Moderate to Good	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	53.00	
Area (ha)	18.0	
Patch Size Class	>100 ha	
General Description	Patches of Vegetation Zone 5 occur on slopes in the north-west and centre of the Development Footprint (refer to **Figure 3.1**).	
Canopy Description	Vegetation Zone 5 supported a mid-dense canopy dominated by bulloak (*Allocasuarina luehmannii*), with scattered occurrences of narrow-leaved ironbark (*Eucalyptus crebra*). The height of the canopy was generally less than 12 metres.	
Mid-storey and Shrub Layer Description	A midstorey was usually absent from Vegetation Zone 5. A sparse shrub layer less than 1 metre in height and dominated by small-lead bluebush (*Maireana microphylla*) was occasionally present.	

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley
Condition	Moderate to Good
Ground Cover Description	Vegetation Zone 5 typically contained a very sparse ground layer, generally with less than 10 % cover. The ground layer was dominated by native grasses, rushes, forbs and ferns. Commonly recorded species included poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), wattle mat-rush (*Lomandra filiformis*) and mat-rush (*Lomandra confertifolia*). Common native grass species included barbed wire grass (*Cymbopogon refractus*), purple speargrass (*Aristida ramosa*), threeawn wiregrass (*Aristida vagans*) and slender bamboo grass (*Austrostipa verticillata*).
Introduced Species	Introduced species generally occurred in low abundance in Vegetation Zone 5. Commonly recorded introduced species included tiger pear (*Opuntia aurantiaca*), common prickly pear (*Opuntia stricta* var. *stricta*) and fireweed (*Senecio madagascariensis*).
PCT Allocation	Vegetation Zone 5 has been attributed to PCT1692 based on its position in the landscape and its floristic composition, containing a large proportion (56 %) of the characteristic species for PCT1692. Vegetation Zone 5 was distinguished from other similar vegetation zones based on the dominance of bulloak (*Allocasuarina luehmannii*) in the canopy and the low occurrence of eucalypt species.
BC Act Status	Not consistent with any listed TEC under the BC Act.
EPBC Act Status	The majority of this vegetation zone contains sufficient numbers of characteristic eucalypts to be considered as part of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act, based on advice received from OEH on identifying the CEEC in bulloak-dominated vegetation (OEH 2017c). The delineation of the CEEC within this vegetation zone is discussed in detail in **Section 3.2.3**.

3.2.1.6 Zone 6 – PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley (Regeneration)

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley	
Condition	Regeneration	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	53.00	
Area (ha)	10.2	
Patch Size Class	>100 ha	
General Description	Scattered patches of Vegetation Zone 6 occurred in the north-west of the Development Footprint (refer to **Figure 3.1**).	

PCT Name	Bull Oak Grassy Woodland of the Central Hunter Valley
Condition	**Regeneration**
Canopy Description	Vegetation Zone 6 supported a sparse to mid-dense canopy dominated by regenerating bulloak (*Allocasuarina luehmannii*), with scattered occurrences of narrow-leaved ironbark (*Eucalyptus crebra*). The height of the canopy ranged from 2 to 10 m.
Mid-storey and Shrub Layer Description	A mid-storey layer was largely absent from Vegetation Zone 6. The shrub layer was generally very sparse, comprising gorse bitter pea (*Daviesia ulicifolia*) and small-leaf bluebush (*Maireana microphylla*), generally less than 0.5 m in height.
Ground Cover Description	Vegetation Zone 6 was characterised by a sparse to mid-dense ground layer generally less than 1 metre in height. Common non-grass species included poison rock fern (*Cheilanthes sieberi* subsp. *sieberi*), common fringe-sedge (*Fimbristylis dichotoma*), *Glycine tabacina*, blue trumpet (*Brunoniella australis*), wattle mat-rush (*Lomandra filiformis*), lemon beauty-heads (*Calocephalus citreus*), yellow burr-daisy (*Calotis lappulacea*), common everlasting (*Chrysocephalum apiculatum*) and wiry spurge (*Phyllanthus virgatus*). Native grass species present included barbed wire grass (*Cymbopogon refractus*), purple wiregrass (*Aristida ramosa*), threeawn wiregrass (*Aristida vagans*), Browns lovegrass (*Eragrostis brownii*), paddock lovegrass (*Eragrostis leptostachya*), speargrass (*Austrostipa scabra*) and common couch (*Cynodon dactylon*).
Introduced Species	Introduced species generally occurred at low abundance in Vegetation Zone 6. Commonly recorded species include Paddys lucerne (*Sida rhombifolia*), galenia (*Galenia pubescens*) and *Verbena quadrangularis*.
PCT Allocation	Vegetation Zone 6 has been attributed to PCT1692 based on its position in the landscape and its similarity to Vegetation Zone 5, containing a large proportion (78 %) of the characteristic species for PCT1692. This vegetation zone was distinguished from other similar vegetation zones based on the dominance of regenerating bulloak (*Allocasuarina luehmannii*) in the canopy and the low occurrence of eucalypt species.
BC Act Status	Not consistent with any listed TEC under the BC Act.
EPBC Act Status	The majority of Vegetation Zone 6 contains sufficient numbers of characteristic eucalypts to be considered as part of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act, based on advice received from OEH on identifying the CEEC in bulloak-dominated vegetation (OEH 2017c). The delineation of the CEEC within this vegetation zone is discussed in detail in **Section 3.2.3**.

3.2.1.7 Zone 7 – PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley (Moderate to Good)

PCT Name	River Oak riparian grassy tall woodland of the western Hunter Valley	
Condition	**Moderate to Good**	
PCT Formation	KF_CH9 Forested Wetlands	
PCT Class	Eastern Riverine Forests	
PCT Percent cleared	50.00	
Area (ha)	2.4	
Patch Size Class	>100 ha	
General Description	Occurs on the banks of Bowmans Creek within the Development Footprint (refer to **Figure 3.1**). This community is restricted to the creek line and does not extend onto the floodplain.	
Canopy Description	Vegetation Zone 7 supported a mid-dense canopy dominated by river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*).	
Mid-storey and Shrub Layer Description	Mid-storey and shrub layers were generally absent from Vegetation Zone 7 however sandpaper fig (*Ficus coronata*) was recorded in low abundance, along with introduced pepper tree (*Schinus areira*) in some parts of this community.	
Ground Cover Description	Vegetation Zone 7 was characterised by a sparse to mid-dense ground layer generally less than 1 metre in height. Common native non-grass species included native wandering Jew (*Commelina cyanea*), stinging nettle (*Urtica incisa*), berry saltbush (*Einadia hastata*), *Juncus usitatus* and *Oxalis exilis*. Slender knotweed (*Persicaria decipiens*) and sea celery (*Apium prostratum* var. *prostratum*) were recorded in waterlogged areas. Native grass species present included slender bamboo grass (*Austrostipa verticillata*), weeping grass (*Microlaena stipoides* var. *stipoides*), common couch (*Cynodon dactylon*) and slender rats tail grass (*Sporobolus creber*). Salt-water couch (*Paspalum vaginatum*) also occurred in waterlogged areas.	
Introduced Species	Introduced species were regularly recorded in Vegetation Zone 7, some in moderate densities. Sharp rush (*Juncus acutus* subsp. *acutus*) was regularly recorded in-stream. Commonly recorded species include Paddys lucerne (*Sida rhombifolia*), Madeira winter cherry (*Solanum pseudocapsicum*), galenia (*Galenia pubescens*), blue heliotrope (*Heliotropium amplexicaule*) and red-flowered mallow (*Modiola caroliniana*).	

PCT Name	River Oak riparian grassy tall woodland of the western Hunter Valley
Condition	Moderate to Good
PCT Allocation	This community occurs along the banks of Bowmans Creek. Characteristic native species of Vegetation Zone 7 were entered into the VIS Classification Database (BCD 2019c). Distribution details were then used to further refine the candidate PCTs. Most likely PCTs considered include: • PCT42 River Red Gum/River Oak riparian woodland wetland in the Hunter Valley • PCT485 River Oak riparian grassy tall woodland of the western Hunter Valley • PCT486 River Oak moist riparian tall open forest of the upper Hunter Valley, including Liverpool Range • PCT1713 River Oak - Sandpaper Fig riparian forest of the Upper Hunter and Liverpool Ranges The floristic similarity to the above PCTs was relatively low which is attributed to the history of disturbance across the Development Footprint. This community showed some similarities to two PCTs above being PCT 485 and PCT42 with 6 species occurring in PCT 485 and 5 species in PCT 42. For the Greater Ravensworth UHSA (Umwelt 2015) Vegetation Zone 7 was aligned with HU712/PCT485 due to similarities in floristic composition and landscape position as it is a riparian community dominated by river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) with the absence of river red gum (*Eucalyptus camaldulensis*).
BC Act Status	Not consistent with any listed TEC under the BC Act.
EPBC Act Status	Not consistent with any listed TEC under the EPBC Act.

3.2.1.8 Zone 8 – PCT 1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter (Woodland Rehabilitation)

PCT Name	Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	
Condition	Woodland Rehabilitation	
PCT Formation	KF_CH3 Grassy Woodlands	
PCT Class	Coastal Valley Grassy Woodlands	
PCT Percent cleared	71.00	
Area (ha)	0.5	
Patch Size Class	>100 ha	

PCT Name	Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter
Condition	**Woodland Rehabilitation**
General Description	Situated on previous mining areas in the north and central eastern portions of the Development Footprint (refer to **Figure 3.1**). Whilst only 0.5 ha of this community occurs within the Development Footprint, Vegetation Zone 8 extends beyond the Development Footprint and the description below documents the floristic assemblage across the whole patch, not just what occurs in the Development Footprint.
Canopy Description	Common native and locally occurring canopy species recorded in this vegetation zone included spotted gum (*Corymbia maculata*), grey box (*Eucalyptus moluccana*), white box (*Eucalyptus albens*), forest red gum (*Eucalyptus tereticornis*), narrow-leaved ironbark (*Eucalyptus crebra*) and hickory wattle (*Acacia implexa*). Canopy species not native to NSW which were common, and often dominant, in Vegetation Zone 8 included sugar gum (*Eucalyptus cladocalyx*) and lemon-scented gum (*Corymbia citriodora*). The canopy varied in age and density, depending on the age of the rehabilitation.
Mid-storey and Shrub Layer Description	A mid-storey was generally absent from Vegetation Zone 8, primarily due to the young age of the rehabilitation and low height of the canopy. A sparse shrub layer less than 2 m in height was often present and dominated by western silver wattle (*Acacia decora*).
Ground Cover Description	The ground layer in Vegetation Zone 8 ranged from sparse to dense and was usually less than 0.5 m in height. Native and introduced grasses comprised the majority of the ground cover. Native forbs were also present and included ruby saltbush (*Enchylaena tomentosa*), climbing saltbush (*Einadia nutans*), kidney weed (*Dichondra repens*) and fuzzweed (*Vittadinia cuneata*). Common native grasses included barbed wire grass (*Cymbopogon refractus*), slender rats tail grass (*Sporobolus creber*), slender bamboo grass (*Austrostipa verticillata*) and couch (*Cynodon dactylon*).
Introduced Species	Introduced species were common and often dominant in the ground layer of Vegetation Zone 8. Introduced grasses included Rhodes grass (*Chloris gayana*), Coolatai grass (*Hyparrhenia hirta*), guinea grass (*Megathyrsus maximus* var. *maximus*), *Setaria parviflora* and red Natal grass (*Melinis repens*). Common introduced forbs and sub-shrubs included galenia (*Galenia pubescens*), lambs tongues (*Plantago lanceolata*), Paddys lucerne (*Sida rhombifolia*) and fireweed (*Senecio madagascariensis*). African olive (*Olea europaea* subsp. *cuspidata*), a weed of national significance, was recorded in older rehabilitation in the north of the Development Footprint.
PCT Allocation	Being a planted vegetation zone, PCT1604 was selected as the most suitable due to the presence of a number of characteristic species for this PCT as well as the Development Footprint being located in a region where PCT1604 is known to naturally occur.
BC Act Status	Being a planted vegetation zone, the composition of flora species varies across the community. For most parts, the groundcover and canopy contained enough native species to be generally consistent with the TEC descriptions and therefore, it is consistent with *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC listed under the BC Act. Further information is provided in **Section 3.2.3**.
EPBC Act Status	Vegetation Zone 8 meets the diagnostic characteristics and condition thresholds to be considered part of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC listed under the EPBC Act. The delineation of the CEEC within this vegetation zone is discussed in detail in **Section 3.2.3**.

3.2.1.9 Zone 9 – PCT 1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley (Moderate to Good)

PCT Name	Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	
Condition	**Moderate to Good**	
PCT Formation	KF_CH9 Forested Wetlands	
PCT Class	Coastal Swamp Forests	
PCT Percent cleared	62.00	
Area (ha)	40.0	
Patch Size Class	>100 ha	
General Description	Vegetation Zone 9 typically occurred in the riparian zone along Yorks Creek, Swamp Creek and Bettys Creek (refer to **Figure 3.1**).	
Canopy Description	Vegetation Zone 9 supported a mid-dense canopy dominated by swamp oak (*Casuarina glauca*), with scattered occurrences of forest red gum (*Eucalyptus tereticornis*) and narrow-leaved ironbark (*Eucalyptus crebra*). Needle-leaf mistletoe (*Amyema cambagei*) was often present in the canopy of the swamp oak (*Casuarina glauca*). The height of the canopy ranged from 8 to 18 m.	
Mid-storey and Shrub Layer Description	A sparse mid-storey was present in some areas, and was dominated by young swamp oak (*Casuarina glauca*) 5 to 8 m high. A sparse shrub layer was occasionally present and included devils needles (*Solanum stelligerum*) and cooba (*Acacia salicina*).	
Ground Cover Description	Vegetation Zone 9 was characterised by a sparse to mid-dense ground layer generally less than 1 m in height. Common herbs and sub-shrubs included blue trumpet (*Brunoniella australis*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), bristly cloak fern (*Cheilanthes distans*), corrugated sida (*Sida corrugata*), native wandering Jew (*Commelina cyanea*), berry saltbush (*Einadia hastata*), amulla (*Eremophila debilis*), ruby saltbush (*Enchylaena tomentosa*), *Glycine tabacina* and kidney weed (*Dichondra repens*). Weeping grass (*Microlaena stipoides* var. *stipoides*), slender bamboo grass (*Austrostipa verticillata*), common couch (*Cynodon dactylon*) were the dominant grasses in Vegetation Zone 9.	
Introduced Species	Introduced species were relatively common in Vegetation Zone 9, however they were usually present in low abundance. Kei apple (*Dovyalis caffra*), Madeira winter cherry (*Solanum pseudocapsicum*) and African olive (*Olea europaea* subsp. *cuspidata*) occurred occasionally in the shrub layer. Sharp rush (*Juncus acutus* subsp. *acutus*) often occurred as a dominant species within the creek. Other commonly recorded introduced species included galenia (*Galenia pubescens*), Paddys lucerne (*Sida rhombifolia*) and *Verbena quadrangularis*.	

PCT Name	Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley
Condition	Moderate to Good
PCT Allocation	Characteristic native species of Vegetation Zone 9 were entered into the VIS Classification Database (BCD 2019c). Distribution details were then used to further refine the candidate PCTs. Vegetation Zone 9 is aligned with PCT1731 as it supports a relatively high proportion of the characteristic species listed in the PCT description according to the VIS Classification Database (BCD 2019c). Of the 9 flora species listed on the database as characteristic for PCT1731, Vegetation Zone 9 supports 7 of them (78 %). Other similar PCTs that were considered, however were ruled out based on lower floristic similarity (between 15 to 30 %) include: • PCT1800 Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley • PCT485 River Oak riparian grassy tall woodland of the western Hunter Valley • PCT42 River Red Gum/River Oak riparian woodland wetland in the Hunter Valley
BC Act Status	This community was compared to the *Swamp Oak Floodplain Forest of the NSW North Coast Sydney Basin and South East Corner Bioregions* EEC listed under the BC Act, however it was found not to conform to the Final Determination, which is discussed further in **Section 3.2.3.**
EPBC Act Status	This community was compared to the *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* EEC. The Development Footprint is at an elevation greater than 50 m above sea level and as such it does not conform to this TEC.

3.2.1.10 Zone 10 – PCT 1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley (Plantation)

PCT Name	Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	
Condition	Plantation	
PCT Formation	KF_CH9 Forested Wetlands	
PCT Class	Coastal Swamp Forests	
PCT Percent cleared	62.00	
Area (ha)	1.8	
Patch Size Class	>100 ha	
General Description	This is a planted community. Vegetation Zone 10 was situated along diversions of Swamp Creek, near the existing Glendell mining infrastructure area, and Yorks Creek, in the north of the Development Footprint (refer to **Figure 3.1**).	

PCT Name	Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley
Condition	**Plantation**
Canopy Description	The canopy of Vegetation Zone 10 was dominated by planted swamp oak (*Casuarina glauca*) with other species recorded including forest red gum (*Eucalyptus tereticornis*), spotted gum (*Corymbia maculata*), grey box (*Eucalyptus moluccana*) and narrow-leaved ironbark (*Eucalyptus crebra*). The height of the canopy ranged from 5 to 14 m.
Mid-storey and Shrub Layer Description	A mid-storey dominated by young canopy species was often present. A variety of planted shrubs and low trees were sometimes present and included sticky hop-bush (*Dodonaea viscosa*), flaxleaf paperbark (*Melaleuca linariifolia*), prickly-leaved tea tree (*Melaleuca styphelioides*) and bottlebrushes (*Callistemon* spp.).
Ground Cover Description	The ground layer of Vegetation Zone 10 was sparse to mid-dense and generally less than 1 metre in height. Common forbs included kidney weed (*Dichondra repens*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), amulla (*Eremophila debilis*), ruby saltbush (*Enchylaena tomentosa*), whiteroot (*Pratia purpurascens*), spiny-headed mat-rush (*Lomandra longifolia*) and *Glycine tabacina*. Common native grasses included couch (*Cynodon dactylon*), scented-top grass (*Capillipedium spicigerum*), barbed wire grass (*Cymbopogon refractus*), slender rats tail grass (*Sporobolus creber*) and purple wiregrass (*Aristida ramosa*).
Introduced Species	Introduced species were relatively common in Vegetation Zone 10 and they were present in moderate abundance. Common introduced groundcover species included Rhodes grass (*Chloris gayana*), red Natal grass (*Melinis repens*), galenia (*Galenia pubescens*), lambs tongues (*Plantago lanceolata*), fireweed (*Senecio madagascariensis*) and Paddys lucerne (*Sida rhombifolia*). Golden wreath wattle (*Acacia saligna*) and African olive (*Olea europaea* subsp. *cuspidata*) occurred in the shrub layer of this vegetation zone.
PCT Allocation	This is a planted community that does not conform to any native PCT. For the purposes of the BDAR and to generate ecosystem credits, Vegetation Zone 10 has been attributed to PCT1731. Vegetation Zone 10 occurs along diversions to Swamp Creek and Yorks Creek. It is floristically consistent with the remnant vegetation along Swamp Creek and Yorks Creek, both of which have been mapped as Vegetation Zone 9-PCT1731. When compared with the list of characteristic species for PCT1731, Vegetation Zone 10 was found to support 5 of the 9 flora species listed on the VIS Classification Database (BCD 2019c) (56 %). For these reasons, Vegetation Zone 10 is aligned with PCT1731.
BC Act Status	Not consistent with any listed TEC under the BC Act.
EPBC Act Status	Not consistent with any listed TEC under the EPBC Act.

3.2.2 Exotic vegetation

The Development Footprint contains areas that are dominated by exotic species (refer to **Figure 3.1**), covering approximately 55 hectares. These areas, as a patch, typically contain greater than 50% perennial weed species cover and are located around existing infrastructure or on the lower alluvial flats where there has been a long history of agricultural activities. These areas do not represent native vegetation communities and cannot be assigned to a PCT. Commonly recorded exotic grasses in these zones include Rhodes grass (*Chloris gayana*), kikuyu (*Cenchrus clandestinus*), prairie grass (*Bromus catharticus*), Coolatai grass (*Hyparrhenia hirta*), soft brome (*Bromus molliformis*) and perennial ryegrass (*Lolium perenne*), as well as groundcovers such as galenia (*Galenia pubescens*) and spear thistle (*Cirsium vulgare*).

A large number of species recorded in this area are identified as high threat weeds under the BAM and Weeds of National Significance under the *Biosecurity Act 2015*. These are species that if not controlled will invade and outcompete native plant species, which is evident in the Development Footprint in places. These are identified in the flora species list in **Appendix C**.

Plate 3.1 Exotic Vegetation within the Development Footprint

3.2.3 Threatened Ecological Communities (TEC)

Seven of the vegetation zones described above and mapped within the Development Footprint conform to State and/or Commonwealth listed TECs. TECs listed under the BC Act were compared to the PCTs within the Development Footprint and, where necessary, analysis of the species listed in the scientific determinations for each TEC with consideration of the Final Determinations provided by the NSW Threatened Species Scientific Committee. These analyses are presented in **Table 3.3** to **3.4**. Two BC Act listed TECs occurred in the Development Footprint (*Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC and *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions* EEC). In addition, one EPBC Act listed TEC occurred in the Development Footprint (*Central Hunter Valley Eucalypt Forest and Woodland* CEEC) and an assessment of the PCTs within the Development Footprint and the Approved Conservation Advice published by the Commonwealth Threatened Species Scientific Committee for that TEC is provided in **Section 3.2.1.**

Table 3.3 Assessment of vegetation zones conforming to the *Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC listed under the BC Act*

***Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC* listed under the BC Act**			
Vegetation Zones	**Area (ha)**	**Assessment of Similarity – Proportion of Species in the list of Characteristic species for the EEC**	**Diagnostic Characteristics – Conservation Advice**
Zone 1 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter *Moderate to Good Condition*	26.7	• 24 out of 58 (41 %) native species recorded in this unit are characteristic species in the EEC listing • 24 out of 38 (63 %) species in the characteristic species list for the EEC were recorded in this unit.	The vegetation zones comply with the Final Determination of the EEC (NSW Scientific Committee 2011a) with regard to the following attributes: • occur on Permian sediments within the NSW Sydney Basin Bioregion • occur in the Singleton Local Government Area where the EEC has previously been recorded • dominated by the characteristic canopy species narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*Eucalyptus moluccana*) • support a reasonable proportion of species that are in the list of characteristic species for the EEC It should be noted that the derived native grassland form of this community does not form part of the EEC *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions*.
Zone 2 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter *Regeneration*	53.1	• 18 out of 48 (38 %) native species recorded in this unit are characteristic species in the EEC listing • 18 out of 38 (47 %) species in the characteristic species list for the EEC were recorded in this unit.	
Zone 3 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter *Plantation*	1.8	• 18 out of 48 (38 %) native species recorded in this unit are characteristic species in the EEC listing • 18 out of 38 (47 %) species in the characteristic species list for the EEC were recorded in this unit.	

Table 3.4 Assessment of vegetation zones conforming to the *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregion EEC under the BC Act*

Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregion EEC under the BC Act			
Vegetation Zones	**Area (ha)**	**Assessment of Similarity – Proportion of Species in the list of Characteristic species for the EEC**	**Diagnostic Characteristics – Conservation Advice**
Zone 8 PCT 1604 – Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter *Woodland Rehabilitation* Approximately 0.3 ha of Vegetation Zone 8 is consistent with the EEC. The remaining 0.2 ha is dominated by sugar gum (*Eucalyptus cladocalyx*), which is a South Australian species, and is not considered to conform to the EEC as the community needs to be dominated by one of the characteristic canopy species.	0.3	• 9 out of 40 (23 %) native species recorded in this unit are characteristic species in the EEC listing • 9 out of 44 (20 %) species in the characteristic species list for the EEC were recorded in this unit.	The vegetation zone complies with the Final Determination of the EEC (NSW Scientific Committee 2011b) with regard to the following attributes: • occur on Permian sediments within the NSW Sydney Basin Bioregion • occur in the Singleton Local Government Area where the EEC has previously been recorded • dominated by the characteristic canopy species spotted gum (Corymbia maculata), grey box (Eucalyptus moluccana) and narrow-leaved ironbark (Eucalyptus crebra) • support a reasonable proportion of species that are in the list of characteristic species for the EEC

3.2.3.1 EPBC Act listed Threatened Ecological Communities

Central Hunter Valley Eucalypt Forest and Woodland CEEC listed under the EPBC Act

Central Hunter Valley Eucalypt Forest and Woodland CEEC occurs in the Hunter Valley region on soils derived from Permian sedimentary bedrock (TSSC 2015). Typically, it is characterised as a eucalypt woodland and open forest, with a shrub layer of variable density and/or a grassy ground layer. Across its range, one or more of a complex of four eucalypt tree species, namely spotted gum (*Corymbia maculata*), narrow-leaved ironbark (*Eucalyptus crebra*), slaty gum (*Eucalyptus dawsonii*) or grey box (*Eucalyptus moluccana*) dominate the canopy (TSSC 2015). Bulloak (*Allocasuarina luehmannii*) may be dominant in combination with one of more of these eucalypt species.

OEH provided advice to Umwelt on the application of the Approved Conservation Advice (TSSC 2015) and the identification of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in bulloak-dominated woodland for another ecological assessment in the Hunter Valley (OEH 2017c). OEH (2017c) described a patch of the CEEC as an area containing at least three individuals of diagnostic eucalypts at least one metre in height per hectare, where at least one forms part of the canopy. A patch must be at least 0.5 hectares in size to conform to the CEEC.

Targeted surveys to map the CEEC were undertaken in the Development Footprint in accordance with the sampling protocols and with consideration of the key diagnostic characteristics and condition thresholds provided within the Approved Conservation Advice (TSSC 2015). These 'key diagnostic characteristics' and 'condition thresholds' provided by the Approved Conservation Advice (TSSC 2015) and Identification Guide (Policy Statement) (DoEE 2016) formed the basis for delineating and identifying patches of native vegetation as being the CEEC and distinguishing between patches of different quality.

The identification of potential areas of the CEEC within bulloak-dominated vegetation was initially undertaken as a desktop assessment using high resolution aerial photography (Nearmap 2019) to identify eucalypts in the canopy and to measure the distance between tree canopies. Areas that did not contain a large number of eucalypts in the canopy were selected for further field survey undertaken in February and March 2018. These surveys involved mapping the location of diagnostic eucalypts within bulloak-dominated areas with a handheld GPS and recording the height and diameter of the canopy of the tree and whether the tree formed part of the canopy. Following the advice of OEH (2017c), a 30-metre buffer was then applied to the recorded eucalypt using GIS and those areas where buffers overlapped were mapped as a patch of the CEEC, if the patch also met the criteria discussed above. These surveys identified that the majority of bulloak-dominated vegetation contained the required density of eucalypts to comprise the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Some areas of vegetation zones allocated to PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley were excluded from the CEEC when the required number of diagnostic eucalypts was not met.

As a result of the above steps, several vegetation zones that occur in the Development Footprint conform to the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. A total of approximately 123 ha of *Central Hunter Valley Eucalypt Forest and Woodland* CEEC was identified within the Development Footprint. Components of the following PCTs present in the Development Footprint conform to the CEEC:

- Zone 1 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter *Moderate to Good Condition* (26.7 ha)

- Zone 2 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter – *Regeneration* (52.3 ha)

- Zone 3 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter – *Plantation* (1.8 ha)

- Zone 4 PCT 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter – *Derived Native Grassland* (14.4 ha) – where the 'gap and indent' rule was applied (see below).

- Zone 5 PCT 1692 – Bull Oak Grassy Woodland of the Central Hunter Valley – *Moderate Condition* (17.7 ha) – note that the area of this vegetation zone excluded from the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC was based on the patch size being less than the minimum 0.5 ha and because the patch did not contain the required number of diagnostic eucalypt canopy species (see below). As a result, the necessary CEEC condition thresholds were not met in these areas.

- Zone 6 PCT 1692 – Bull Oak Grassy Woodland of the Central Hunter Valley – *Regeneration* (9.7 ha) – note that the area of this vegetation zone excluded from the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC was based on the patch size being less than the minimum 0.5 ha and because the patch did not contain the required number of diagnostic eucalypt canopy species (see below). As a result, the necessary CEEC condition thresholds were not met in these areas.

- Zone 8 PCT 1604 – Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter – *Woodland Rehabilitation* (0.3 ha) – note that the area of this vegetation zone excluded from the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC was based on the dominant canopy species being non-native or not naturally occurring in NSW and not characteristic of the CEEC (see below). As a result, the necessary CEEC condition thresholds were not met in these areas.

As per the key diagnostic characteristics and condition thresholds outlined in the Approved Conservation Advice (TSSC 2015) and the advice from OEH (2017c), areas of vegetation were excluded from the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in the Development Footprint when:

- patches were less than the minimum 0.5 ha (woodland component) condition threshold

- the key diagnostic characteristic for the canopy was not met, in which the canopy was not dominated by one or more of the four characteristic species

- bulloak (*Allocasuarina luehmannii*) dominated the canopy, where less than 3 characteristic eucalypt species occurred within a 'patch' (where eucalypt canopies are separated by 60 metres or less) and with at least one individual forming part of the canopy

- the perennial understorey vegetative cover was less than 50%

- it did not meet the 'gap and indent' rules that were provided by DoEE as further clarification on interpretation of the CEEC.

The majority of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in the Development Footprint was represented by the 1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter. The woodland form of this community has a canopy dominated by grey box (*Eucalyptus moluccana*), narrow-leaved ironbark (*Eucalyptus crebra*) and bulloak (*Allocasuarina luehmannii*). In addition, a regenerating form of this community was identified within the central portion of the Development Footprint, dominated by young narrow-leaved ironbark, grey box and bulloak.

The vast majority of the PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley was considered to conform to the CEEC listing, despite the dominance of bulloak (*Allocasuarina luehmannii*) in the canopy. Several small patches were excluded from the CEEC when the eucalypt composition and density did not satisfy the conditions specified by OEH (2017c).

Derived native grasslands were included in the CEEC based on the 'gap and indent' rules that were provided by DoEE (TSSC 2015) as further clarification on interpretation of the Conservation Advice for the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. This interpretation has been applied rather than a rigid 30 metre buffer within woodland/forest edges. The gap component of this interpretation means that where there is an area of grassland within a patch of woodland/forest, then the 30 metre strip of grassland within the woodland/forest conforms to the CEEC. The indent component requires that there are no sharp "indent" angles within the boundary of the CEEC, thus the boundary is to be "smoothed" so that no angles are greater than 150 degrees.

3.2.4 Summary of TECs within the development footprint

Table 3.5 provides a summary of the TECs and the area they occupy within the Development Footprint

Table 3.5 Summary of TECs within the development footprint

Threatened Ecological Community	Listing Status	Area (ha)
BC Act		
Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions	EEC	81.6
Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregion	EEC	0.3
EPBC Act		
Central Hunter Valley Eucalypt Forest and Woodland	CEEC	122.9

3.2.5 Vegetation integrity score

Table 3.6 details the vegetation integrity scores for each of the vegetation zones in the Development Footprint. The vegetation integrity data for each of the vegetation zones is provided in **Appendix C**.

Table 3.6 Vegetation Integrity Scores

Vegetation Zone	PCT Name *Condition*	Composition	Structure	Function	Current Vegetation Integrity Score
1	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Moderate to Good Condition*	72.2	13.3	55.6	**37.6**

Vegetation Zone	PCT Name *Condition*	Composition	Structure	Function	Current Vegetation Integrity Score
2	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Regeneration*	37	14.8	57	**31.5**
3	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Plantation*	77	14.5	45.5	**37**
4	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Derived Native Grassland*	22.5	17.4	15.6	**18.3**
5	1692 - Bull Oak Grassy Woodland of the Central Hunter Valley *Moderate to Good Condition*	18.4	20.3	48.8	**26.3**
6	1692 - Bull Oak Grassy Woodland of the Central Hunter Valley *Regeneration*	57.7	6.9	42.6	**25.7**
7	485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley *Moderate to Good Condition*	21.5	40.4	37.7	**32**
8	1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter *Woodland Rehabilitation*	57.7	31.7	50	**45**
9	1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley *Moderate to Good Condition*	35.1	27.6	60.2	**38.8**
10	1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley *Plantation*	47.6	22.6	43.8	**36.1**

3.3 Threatened species within the development footprint

3.3.1 Ecosystem-credit species

A list of the ecosystem-credit species predicted to occur by the BAM calculator and/or the literature review and whether they are considered likely to occur in the vegetation zones within the Development Footprint is provided in **Appendix B**.

3.3.2 Species-credit species

Targeted species-credit surveys were undertaken across the Development Footprint as described in **Appendix B. Table 3.7** outlines the species-credit species predicted to occur by the BAM calculator and/or the literature review and whether they were recorded or are considered likely to occur in the Development Footprint.

Table 3.7 Predicted species-credit species

Species	BC Act	EPBC Act	Presence/Absence	Justification
Flora Species				
Bynoe's wattle *Acacia bynoeana*	E	V	Absent	This species was not recorded within the Development Footprint despite extensive flora transects in the known detection period for the species (refer to **Appendix B**). The species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record of this species occurs over 35 km to the southeast of the Development Footprint near Branxton (BCD 2019a). Furthermore, this species is not known from the central Hunter Valley area. This species is known to occur from Branxton in the lower Hunter Valley, south to the Southern Highlands and west to the Blue Mountains and is associated with heath or dry sclerophyll forest on sandy soils.
***Acacia pendula* population in the Hunter catchment**	EP	-	**Present**	Thirteen individuals of this species were recorded during flora surveys north of Glendell MIA within a community of planted natives. A total of 13 planted individuals were recorded. The plants were not planted as a Threatened Species Recovery Project and as such, in accordance with Appendix D of the revised BAM, the planted *Acacia pendula* do not generate species credits
trailing woodruff *Asperula asthenes*	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record of this species occurs approximately 40 km to the northeast of the Development Footprint.
netted bottle brush *Callistemon linearifolius*	V	-	Absent	This species was not recorded within the Development Footprint despite extensive flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record of this species occurs over 35 km to the south of the Development Footprint near Broke (BCD 2019a).
***Cymbidium canaliculatum* population in the Hunter Catchment**	EP	-	**Present**	One individual of this species was recorded in the middle of the Development Footprint during surveys undertaken in 2018 (refer to **Appendix B**).

Species	BC Act	EPBC Act	Presence/Absence	Justification
white-flowered wax plant ***Cynanchum elegans***	E	E	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs approximately 30 km southwest of the Development Footprint in Wollemi National Park (BCD 2019a).
pine donkey orchid ***Diuris tricolor***	V	-	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Surveys were timed according to local reference populations at Wybong and Jerrys Plains and whilst 2017 and 2018 were dry years, this species did flower at the reference sites. This species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years across the Mount Owen Complex. The closest record occurs approximately 15 km northwest of the Development Footprint near Muscle Creek (BCD 2019a).
Eucalyptus camaldulensis **population in the Hunter catchment**	EP	-	Absent	This population was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). *Eucalyptus camaldulensis* is known to occur along Swamp Creek. Despite this, no individuals have been recorded in the Development Footprint.
slaty red gum ***Eucalyptus glaucina***	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). The nearest documented record was recorded in 1998 in from the Ravensworth State Forest which has subsequently been removed (BCD 2019a). Other proximate and documented records occur approximately 15 km to the southeast of the Development Footprint.

Species	BC Act	EPBC Act	Presence/Absence	Justification
Eucalyptus parramattensis* subsp. *decadens	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs approximately 30 km southeast of the Development Footprint near Branxton (BCD 2019a).
small-flower grevillea ***Grevillea parviflora* subsp. *parviflora***	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record for the species occurs around 40 km southeast of the Development Footprint near Lochinvar (BCD 2019a).
large-leafed Monotaxis ***Monotaxis macrophylla***	E	-	Absent	This species is not known from the central Hunter Valley area. It only appears to be detectable following fire events and is known to grow on rocky ridges and hillsides. This species was not recorded within the Development Footprint despite extensive and repeated flora transects (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs approximately 45 km west of the Development Footprint in Wollemi National Park (BCD 2019a). The Development Footprint does not contain suitable rocky habitat for this species.
Ozothamnus tesselatus	V	V	Absent	This species was not recorded within the Development Footprint despite extensive flora transects in the known detection period for the species (refer to **Appendix B**). The species has been previously recorded during surveys undertaken within Ravensworth State Forest to the east of the Development Footprint (Cole 2004), however this relatively detectable species has not been found in the Development Footprint.

Species	BC Act	EPBC Act	Presence/Absence	Justification
tall knotweed *Persicaria elatior*	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs approximately 60 km southeast of the Development Footprint near Seaham (BCD 2019a).
scant pomaderris *Pomaderris queenslandica*	E	-	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). This species is found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs approximately 30 km to the southwest of the Development Footprint.
Singleton mint bush *Prostanthera cineolifera*	V	V	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The species is restricted to a few localities around Walcha, Scone, Cessnock and St Albans. The closest record of this species occurs approximately 30 km to the south near Pokolbin State Forest and the Singleton Military Area (BCD 2019a).
Illawarra greenhood *Pterostylis gibbosa*	E	E	Absent	This species was not recorded within the Development Footprint despite extensive and repeated flora transects in the known detection period for the species (refer to **Appendix B**). This species is known primarily from the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). Furthermore, the species has not been recorded in the wider locality despite extensive survey effort across multiple seasons and years. The closest record occurs in Milbrodale, approximately 30 km southeast of the Development Footprint.

Species	BC Act	EPBC Act	Presence/Absence	Justification
regent honeyeater **Anthochaera phrygia**	CE	CE	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex. The Development Footprint is not within the important habitat areas for the species mapped by the BCD.
bush stone-curlew ***Burhinus grallarius***	E	-	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken in 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex. This species has not been recorded in the wider locality, with the closest record occurring 45 km to the west of the Development Footprint near Gungal (BCD 2019a). While the Development Footprint contains suitable areas of open forest, the species has not been recorded utilising these habitats.
gang-gang cockatoo (breeding) ***Callocephalon fimbriatum***	V	-	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken in 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex. This species has not been recorded in the wider locality, with the closest record occurring 15 km to the southeast of the Development Footprint near Singleton (BCD 2019a). While the Development Footprint contains areas of open eucalypt forest for foraging and suitable hollow-bearing trees for potential breeding habitat, the species has not been recorded utilising these habitats and therefore no confirmed breeding habitat has been recorded.
glossy black-cockatoo (breeding) ***Calyptorhynchus lathami***	V	-	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken in 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex. The closest record for the species occurs 15 km to the south of the Development Footprint near Warkworth (BCD 2019a). While the Development Footprint contains areas of river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*), swamp oak (*Casuarina glauca*) and bulloak (*Allocasuarina luehmannii*) which provide potential foraging habitat, and suitable hollow-bearing trees for potential breeding habitat, the species has not been recorded utilising the habitats of the Development Footprint and therefore no confirmed breeding habitat has been recorded.

Species	BC Act	EPBC Act	Presence/Absence	Justification
eastern pygmy-possum *Cercartetus nanus*	V	-	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken in 2017 and 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex. This species has not been recorded in the wider locality, with the closest record occurring 20 km to the north-east of the Development Footprint near Mount Royal National Park (BCD 2019a). While the Development Footprint contains suitable areas of forest, the species has not been recorded utilising these habitats.
large-eared pied bat *Chalinolobus dwyeri*	V	V	Absent	This species has been tentatively recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 1999, 2001, 2005, 2008, 2014 and 2015 using call echolocation recording, however no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019. This species was not recorded within the Development Footprint during targeted surveys in 2018 (refer to **Appendix B**). Roosting and breeding habitat for this species includes land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels. While it is acknowledged that suitable foraging habitat may occur within the Development Footprint, the Development Footprint does not contain this roosting and breeding habitat suitable for this species and is not within 2 km of these features.
white-bellied sea-eagle (breeding) *Haliaeetus leucogaster*	V	-	Absent	This species was recorded foraging in the northern part of the Development Footprint during surveys undertaken in 2018 (refer to **Appendix B**). A white-bellied sea-eagle nest has previously been recorded to the north east of the Development Footprint, above a dam in Mount Owen mine rehabilitation (Forest Fauna Surveys 2019). While potential breeding habitat for this species occurs within the Development Footprint in the form of large trees suitable for nesting, no nesting behaviours and no stick nests were observed during any surveys undertaken in 2017 and 2018 (refer to **Appendix B**).
little eagle (breeding) *Hieraaetus morphnoides*	V	-	Absent	This species has been previously recorded at multiple locations in the locality, and within 1 km of the Development Footprint (BCD 2019a). While potential breeding habitat for this species occurs within the Development Footprint in the form of large trees suitable for nesting, no individuals and no stick nests were observed during surveys undertaken in 2017 and 2018 (refer to **Appendix B**).

Species	BC Act	EPBC Act	Presence/Absence	Justification
pale-headed snake *Hoplocephalus bitorquatus*	V	-	Absent	This species is not generally known to occur in the Hunter Valley. A historical record (from 1992) occurs approximately 55 km to the south-east of the Development Footprint near Paterson (BCD 2019a). While suitable habitat for the species occurs within the Development Footprint in the form of tree hollows, this species was not recorded within this area despite extensive and repeated surveys in suitable habitat and in the known detection period for the species (refer to **Appendix B**).
green and golden bell frog *Litoria aurea*	E	V	Absent	This species was previously recorded within the Mount Owen Complex in 1996, 1997, 1999 and tentatively in 2005 (Forest Fauna Surveys 2019).This species was not recorded within the Development Footprint despite targeted surveys undertaken in the known detection period for the species (refer to **Appendix B**). The Upper Hunter green and golden bell frog key population consists of one main diffuse population at, or in the vicinity of, the Ravensworth and Liddell area and bordering areas of the Singleton and Muswellbrook LGA. No records of the population in the Upper Hunter have been found since 2009. Although the water bodies (predominantly farm dams) within the Development Footprint provide potential habitat for the species the absence of individuals in the locality following annual monitoring surveys indicates that the Development Footprint is unlikely to provide habitat for the species.
green-thighed frog *Litoria brevipalmata*	V	-	Absent	This species has been recorded on the central coast of NSW and prefers wetter rainforest habitats. The closest record occurs approximately 55 km southeast of the Development Footprint near Kurri Kurri (BCD 2019a). This species was not recorded within the Development Footprint despite targeted surveys undertaken in the known detection period for the species (refer to **Appendix B**).
square-tailed kite (breeding) *Lophoictinia isura*	V	-	Absent	This species has not been recorded within the Development Footprint or the locality despite targeted surveys undertaken in 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex since 2004. The closest record for this species occurs approximately 11 km to the north-west of the Development Footprint (BCD 2019a). While the Development Footprint contains suitable breeding habitat in the form of large trees suitable for nesting, no individuals or nests were observed during targeted fauna surveys conducted in 2018 (refer to **Appendix B**).

Species	BC Act	EPBC Act	Presence/Absence	Justification
little bentwing-bat (breeding) ***Miniopterus australis***	V	-	Absent	This species has been tentatively recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 2001, 2007 and 2009 using call echolocation recording however no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019. While potential roosting habitat in the form of tree hollows occurs in the Development Footprint, this species was not recorded utilising any habitat within the Development Footprint during targeted surveys in 2018 (refer to **Appendix B**) and no caves, tunnels, mines, culverts or other structures known or suspected to be used for breeding was recorded on the site.
eastern bentwing-bat (breeding) ***Miniopterus schreibersii oceanensis***	V	-	Absent	This species has been previously captured in the Mount Owen Complex in 2014 (Forest Fauna Surveys 2019) and was confidently recorded within the Development Footprint during 2018 fauna surveys (refer to **Appendix B**). Roosting and breeding habitat for this species includes land containing caves, old mine shafts, buildings or tunnels. While it is acknowledged that suitable foraging habitat may occur within the Development Footprint, the Development Footprint does not contain this roosting and breeding habitat suitable for this species.
southern myotis ***Myotis macropus***	V	-	Present	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 1999, 2001, 2005, 2007, 2008, 2009, and 2015 using call echolocation recording however no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019). While potential roosting habitat in the form of tree hollows occurs in the Development Footprint, this species was not recorded utilising any habitat within the Development Footprint during targeted surveys in 2018 (refer to **Appendix B**). This species is a dual-credit species and breeding habitat relates to appropriate vegetation (as defined by the TBDC) within 200 m of riparian zones. Despite this species not being detected, breeding habitat (as defined by the BAM) occurs within the Development Footprint.

Species	BC Act	EPBC Act	Presence/Absence	Justification
barking owl (breeding) ***Ninox connivens***	V	-	Absent	This species has not been recorded within the Development Footprint despite targeted surveys undertaken in 2018 (refer to **Appendix B**). The closest record for this species occurs approximately 8 km east of the Development Footprint near Greenlands (BCD 2019a). While the Development Footprint contains potential breeding habitat in the form of large hollow-bearing trees, the species has not been recorded utilising these habitats. Nest sites are generally used repeatedly over years by a pair.
powerful owl (breeding) ***Ninox strenua***	V	-	Absent	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 2004, 2005, 2006 and 2007 (Forest Fauna Surveys 2019). While the Development Footprint contains suitable hollow-bearing trees which form potential breeding habitat, no individuals or signs of nesting were recorded during call-playback and spotlighting surveys in 2018 (refer to **Appendix B**).
squirrel glider ***Petaurus norfolcensis***	V	-	Absent	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys every year from 1996- 2017 (Forest Fauna Surveys 2019). Records of this species in the locality are confined to Ravensworth State Forest. While the Development Footprint contains suitable hollow-bearing trees which form potential nesting habitat, no individuals were recorded in the Development Footprint despite extensive fauna surveys conducted in 2017 and 2018 (refer to **Appendix B**). Surveys included 11 nights of spotlighting and 2,700 remote camera nights (20 cameras over 135 nights). In addition, much of the woodland on site is dominated or co-dominated by bulloak and the shrub layer is typically absent or reduced and therefore the availability of the foraging resources for this species is limited when compared to surrounding areas where they have been recorded, such as Ravensworth State Forest.
brush-tailed phascogale ***Phascogale tapoatafa***	V	-	**Present**	This species was recorded on remote cameras utilising the woodland habitats of the Development Footprint. Furthermore, this species was also recorded during the surveys undertaken for the UHSA through the use of remote cameras west of the Mount Owen mine near Hebden Road and Lake Liddell. The species has also been previously recorded in Ravensworth State Forest in 2017 (Forest Fauna Surveys 2019) and in surveys undertaken for the Mount Owen Modification 2 (Umwelt 2018c) It is likely that all of the eucalypt woodland and forest communities in the Development Footprint provide suitable habitat for the species.

Species	BC Act	EPBC Act	Presence/Absence	Justification
koala ***Phascolarctos cinereus***	V	V	Absent	This species was tentatively recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 1996 based on the presence of a possible scat (Forest Fauna Surveys 2019). Other records exist along the New England Highway outside the Development Footprint from 2012 and 2016 with the latter being a roadkill record. While the Development Footprint contains a number of feed tree species for koalas including forest red gum (*Eucalyptus tereticornis*), grey box (*E. moluccana*) and narrow-leaved ironbark (*E. crebra*), no individuals or signs of koala presence were recorded during repeated Spot Assessment Technique (SAT) searches conducted in 2018 (refer to **Appendix B**)**.** Additionally, the Development Footprint does not constitute 'potential' or 'core' koala habitat, as described by SEPP 44, as the canopy does not comprise 15% or more of the koala feed trees listed in the policy.
common planigale ***Planigale maculata***	V	-	Absent	This species has rarely been recorded in the Hunter Valley and all records occur east of the Barrington Tops over 60 km from the Development Footprint (BCD 2019a). This species has not been recorded within the Development Footprint or the locality despite appropriate surveys undertaken in 2017 and 2018 (refer to **Appendix B**) as well as monitoring surveys undertaken annually in the Mount Owen Complex.
grey-headed flying-fox (breeding) ***Pteropus poliocephalus***	V	V	Absent	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 1997, 2000, 2004, 2006, 2007, 2010 and 2016 (Forest Fauna Surveys 2019). While the Development Footprint contains habitat with flowering eucalypt species suitable for foraging, no individuals or breeding camps were observed during fauna surveys in 2017 and 2018 (refer to **Appendix B**).
masked owl (breeding) ***Tyto novaehollandiae***	V	-	Absent	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys in 1997, 1999, 2001, 2002, 2003, 2004, 2005, 2006, 2008, 2009, 2011, 2013 and 2014 (Forest Fauna Surveys 2019). While the Development Footprint contains suitable hollow-bearing trees which form potential breeding habitat, no individuals or signs of nesting were recorded during call-playback and spotlighting surveys in 2018 (refer to **Appendix B**).

Species	BC Act	EPBC Act	Presence/Absence	Justification
eastern cave bat *Vespadelus troughtoni*	V	-	**Potentially present**	This species has been recorded in the Mount Owen Complex during previous annual fauna monitoring surveys using call echolocation recording however no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019). The species was identified as potentially occurring within the site during surveys in 2018 (refer to **Appendix B**) but could not be confidently identified Roosting and breeding habitat for this species includes land containing rocky escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels. While it is acknowledged that suitable foraging habitat may occur within the Development Footprint, the Development Footprint does not contain this roosting and breeding habitat suitable for this species.

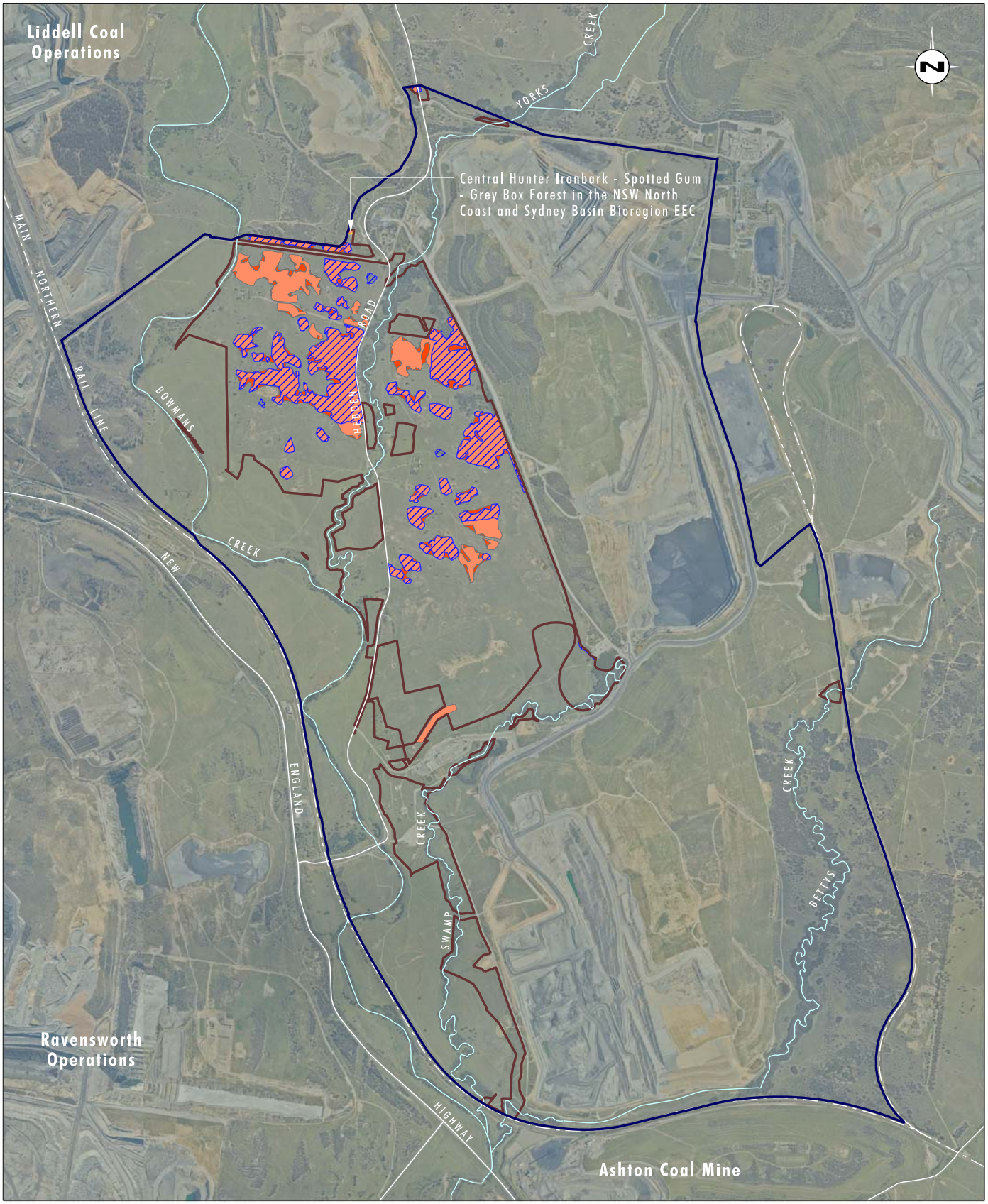


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)

EPBC Act:

- Central Hunter Valley Eucalypt Forest and Woodland CEEC
- Central Hunter Valley Eucalypt Forest and Woodland CEEC - Derived Native Grassland

BC Act:

- Central Hunter Grey Box Ironbark 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 Bioregion EEC

FIGURE 3.2

EPBC and BC Act Listed Threatened Ecological Communities in the Development Footprint

File Name (A4): R03/4166_147.dgn
20191030 14.08

3.3.3 Species habitat polygons and biodiversity risk weighting

Species habitat polygons have been prepared for the species outlined in **Table 3.8** below. Polygons are shown on **Figure 3.3**.

Table 3.8 Predicted Species-credit Species

Species	Biodiversity Risk Weighting	Species Habitat Polygon Area (ha)	Species Habitat Polygon Description
brush-tailed phascogale ***Phascogale tapoatafa***	2	152.1	Species polygon boundaries aligns with PCTs within the Development Footprint to which the species is associated in the TBDC (PCT 1603, 1604, 1692 and 1731)
southern myotis ***Myotis macropus***	2	46.6	Species polygon boundaries aligns with PCTs within the Development Footprint to which the species is associated (PCT 1603, 1604, 1692 and 42) in the TBDC that are within 200 m of waterbodies with pools greater than 3 m across
***Cymbidium canaliculatum* – endangered population in the Hunter catchment**	1	1 individual	Counted as individuals. Species habitat polygon represents a 30 m buffer of the individual
eastern cave bat ***Vespadelus troughtoni***	3	0.5	Species polygon boundaries aligns with PCT within the Development Footprint to which the species is associated (PCT 1604) in the TBDC

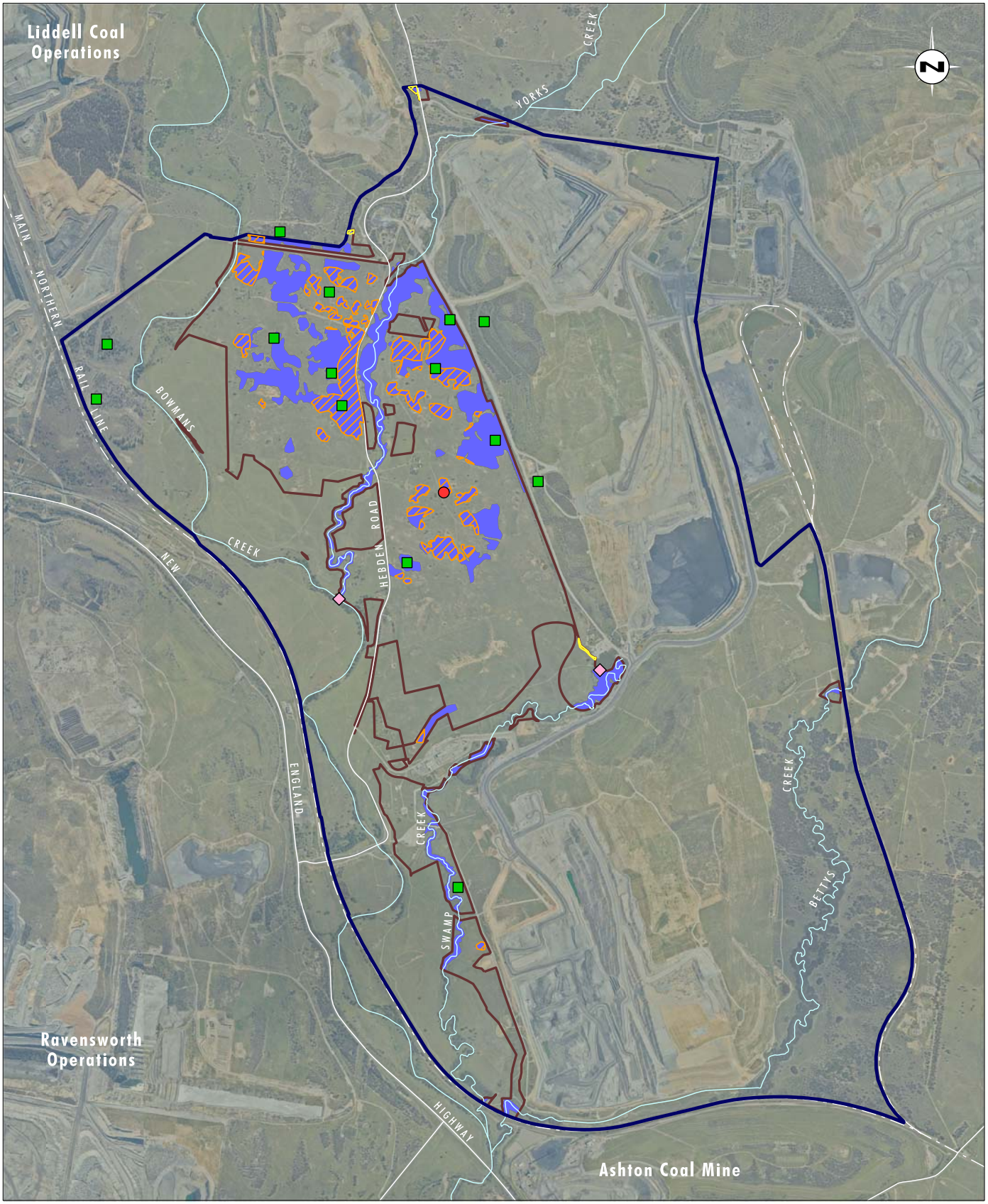


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Tiger Orchid Species Polygon
- Brush-tailed Phascogale
- Brush-tailed Phascogale Suitable Habitat
- Southern Myotis
- Southern Myotis Suitable Habitat
- Eastern Cave Bat Suitable Habitat

FIGURE 3.3

Species-credit Flora/Fauna Species Locations

File Name (A4): R03/4166_149.dgn
20191126 13.32

4.0 Avoidance and minimisation of impacts

4.1 Avoidance and minimisation

4.1.1 Site selection and planning

Glencore has sought to avoid and minimise potential impacts on ecological values throughout the Project planning process. This included targeted avoidance and minimisation of disturbance of key vegetation communities through designing the Project to maximise use of existing mining facilities.

The majority of the Project Area comprises disturbed and low quality vegetation in the form of derived native grasslands. Native forest, woodland and plantation areas comprise approximately 25 % of the Biodiversity Assessment Area and the larger and higher quality remnant patches of native forest and woodland have been avoided.

Section 1.2.2 and Appendix 1 of the EIS detail the mining alternatives considered during the Project planning phase.

4.2 Construction and operational phase minimisation/mitigation measures

Glencore has committed to the design and implementation of a comprehensive biodiversity mitigation strategy to mitigate the unavoidable impacts of the Project. The following specific control measures, as detailed in the existing approved Mount Owen Complex Biodiversity and Offset Management Plan, are considered to be integral to the mitigation of impacts on the biodiversity features. The following specific control measures are considered to be integral to the mitigation of impacts on the biodiversity features of the Mount Owen Complex.

- landform and rehabilitation establishment
- salvage of biodiversity features, including habitat resources (e.g. hollow logs, tree hollows, fallen timber and rocks/boulders) and material for rehabilitation (e.g. seed collection, and topsoil) for mine rehabilitation
- a pre-clearing procedure will be implemented to minimise the potential for impacts on native fauna species (focusing on threatened species) as a result of the clearing of hollow-bearing trees. The pre-clearing procedure is designed to minimise impacts to hollow-dependent and ground-dwelling fauna. In addition to this, a Ground Disturbance Permit will identify any specific ecology requirements, such as wildlife spotter/catcher requirements prior to clearing being permitted to commence on-site
- weed management
- pest animal control
- fencing and access control
- bushfire management
- riparian zone management
- erosion and sedimentation control

- providing appropriate environmental management measures as part of the mining operations to minimise the potential for indirect impacts, and
- workforce education and training.

The integration of the Mount Owen Complex with other operations through the Greater Ravensworth Area Water and Tailing Scheme (GRAWTS) enables water to be used more efficiently and reduces water extraction from creek systems and reduces discharge requirements.

Each of these control measures will contribute to the maintenance of habitat quality in proximity to the Development Footprint outside existing approved disturbance. The proposed revegetation strategy for disturbed areas has aimed to enhance regional connectivity between remnant vegetation areas and vegetated creeklines.

Should the Project be approved, Glencore will review and revise the existing approved Mount Owen Complex Biodiversity and Offset Management Plan in accordance with any additional development consent requirements. The revised plan will guide the implementation of the mitigation steps and will be reviewed and adapted in response to new information.

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.

4.2.1 Landform establishment and rehabilitation

Changes to landform, geology and drainage regimes associated with mining have the potential to impact adjacent and nearby habitat areas. For example, the creation of overburden emplacement areas typically results in changes in surface water and groundwater movement, availability and quality. The following mitigation controls will be undertaken to mitigate such potential impacts:

- appropriate drainage will be integrated in the design of rehabilitation areas to effectively manage drainage of the final landform without resulting in adverse impacts
- utilisation of natural landform design principles in the establishment of the final landform (as discussed in the EIS) and improved habitat outcomes
- identified areas of moderate to severe erosion will be remediated as soon as practicable

4.2.2 Salvage of biodiversity features

Salvaged habitat resources including tree hollows, fallen timber and rocks/boulders provide foraging and refuge habitat for a number of key threatened species, particularly insectivorous woodland birds and terrestrial mammal species. The microclimates provided around fallen timber and rocks/boulders can assist in the establishment of flora species and the decomposing woody material from fallen timber can assist in soil conditioning.

The relocation of salvaged habitat resources are proposed for rehabilitation areas according to the Mount Owen Complex Biodiversity and Offset Management Plan. This will increase habitat complexity for fauna species sooner than when they would naturally develop.

Where salvaged resources are to be installed:

- they are to be of structurally good condition for habitat use
- sizes should be variable to capture for the range of threatened species known to occur in the Mount Owen Complex such as woodland birds, arboreal mammals and micro-bats
- hollow resource density should be consistent with densities in unaffected vegetation on the site (i.e. reference sites), and
- fallen timber resource density should be consistent with densities in unaffected vegetation on the site (i.e. reference sites).

When re-instating habitat features, care must be taken not to damage existing native vegetation and where possible should take place prior to revegetation work commencing. Habitat features can be stockpiled in unused areas, if necessary, in a manner that minimises damage and deterioration, until able to be reinstated.

4.2.3 Pre-clearance and tree-felling

Pre-clearance surveys and tree-felling supervision recommendations will be implemented according to the Mount Owen Complex Biodiversity and Offset Management Plan. Tree felling processes are implemented at Mount Owen Complex to minimise the potential for impacts on native fauna species (including threatened species) as a result of the clearing of hollow-bearing trees.

4.2.3.1 Pre-clearance surveys

Pre-clearance surveys are to be undertaken prior to tree felling works, be undertaken by suitably qualified and experienced person and include:

- the demarcation of areas approved for clearing to reduce risk of accidental clearing
- habitat resources and habitat trees should be identified and marked (Note: habitat trees are those containing hollows, cracks or fissures and spouts, active nests, dreys or other signs of recent fauna usage. Other habitat features to be identified include fallen timber/hollow logs, burrows and boulder piles)
- the potential presence of threatened flora and fauna species, endangered populations and TECs should be identified
- the identification of threatened species or habitat features that are suitable for translocation or salvage. This includes native plant species containing seed for collection and propagation purposes and habitat features to be used in habitat augmentation, and
- disturbance activities should be targeted to specific times of the year to minimise impacts to threatened species usage of habitat features for breeding and roosting, where practicable.

4.2.3.2 Tree-felling supervision

Tree felling will be completed as close to the completion of pre-clearance surveys as practicable to limit the potential for new issues to arise (such as new active nests being built). Tree felling supervision will be undertaken by an appropriately qualified and experienced person after pre-clearance surveys have identified potential habitat features.

The tree-felling process will include the following:

Prior to Felling Habitat Trees

- Completion of actions recommended from the pre-clearing surveys, including (but not limited to) salvage of identified habitat features, additional surveys to determine threatened fauna usage of the area (if required), identification of active dens or burrows, any actions required to discourage fauna occupation and weed or feral fauna management requirements
- Removal of non-habitat trees/vegetation as close to the habitat tree felling date as possible in order to create disturbance to discourage fauna usage of the habitat trees, and
- Shaking of habitat trees (with heavy machinery) as appropriate to encourage fauna to abandon trees.

On the Day of Felling Habitat Trees

- All habitat trees will be subject to a visual inspection to survey for threatened species
- Trees previously identified as containing fauna will be shaken and then felled, providing no threatened species are identified
- The lowering of hollow-bearing trees will be done as gently as possible with heavy machinery
- If a threatened species is identified in a habitat tree on the day of felling, the supervising person is to advise the most appropriate method to minimise potential harm. This may include leaving the tree overnight, further shaking to encourage the animal to vacate the tree, gradual removal of branches to discourage ongoing use, soft-felling of the tree with the animal in the tree, or measures to capture and relocate the animal to secure habitats
- Uninjured animals should be released on the day of capture into nearby suitable secure habitat and should not be held for extended periods of time
- Injured animals will be taken to the nearest veterinary clinic or wildlife carer as soon as possible for assessment and treatment
- Felled trees are to be rolled where appropriate so that the number of hollows blocked against the ground is minimised
- All felled habitat trees should remain in place for a least one night to allow any remaining fauna to escape, and
- Habitat features identified for translocation or salvage operations should be extracted and stored appropriately.

4.2.4 Weed management

Weed species could be inadvertently brought into the Development Footprint or surrounding habitats with imported materials, or could invade naturally through removal of native vegetation. The presence of weed species has the potential to be an impediment to revegetation and regeneration activities. In addition, the presence of weed species has the potential to decrease the value of vegetation for native species, particularly threatened species.

Existing weed management controls as specified in the Mount Owen Complex Biodiversity and Offset Management Plan will be applied to the Project. Weed control will be undertaken in accordance with current mine practices and, for high- threat weed species, in accordance with NSW control guidelines.

Regular weed inspections will be undertaken across the Development Footprint and appropriate weed control methods will be implemented.

4.2.5 Pest animal control

Introduced fauna species such as deer, foxes, rabbits, pigs, wild dogs and feral cats could change in distribution and abundance in the Development Footprint and adjoining areas as future areas are cleared, mined and then rehabilitated. Clearing, thinning of vegetation and the creation of tracks through existing dense vegetation could assist the penetration of introduced fauna species such as pigs, cats and foxes, and allow them to establish in new areas. An increase in feral species within the Development Footprint and adjoining areas has the potential to increase impacts on existing native species, particularly via predation and habitat destruction.

Pest and feral animal control will be undertaken in accordance with current mine practices and as outlined in the Mount Owen Complex Biodiversity and Offset Management Plan.

Feral animal control works will be undertaken periodically to provide for the suppression of feral animals, and this will be undertaken in a manner that is sympathetic to ecological outcomes.

4.2.6 Fencing and access control

Fencing may be used to demarcate vegetation where required.

Access control is an important feature in protecting and demarcating areas outside disturbance footprints from vehicle access, human access and accidental disturbance. Measures include:

- appropriate fencing and signposting of areas to prevent the uncontrolled entry of people, accidental disturbance and to minimise vehicular and human traffic
- clear and visible signage is to be appropriately located to inform the workforce and others of the restricted access or otherwise of areas outside the disturbance footprint and
- locking of gates to prevent unwanted vehicle, person access and disturbance.

4.2.7 Bushfire management

The vegetation that will be retained within areas adjoining of the Development Footprint in the Mount Owen Complex will require appropriate bushfire management to protect life and property, while supporting appropriate conditions for the significant ecological features identified.

The objectives of the Mount Owen Complex Biodiversity and Offset Management Plan will be achieved through the implementation of a range of measures, including;

- maintaining a suitably equipped response to any fires on site and assisting the Rural Fire Service and emergency services on site in the event of a fire at the Mount Owen Complex
- control burning and/or where permitted, appropriate grazing management regimes to reduce ground fuel loads whilst minimising impacts on biodiversity and
- maintaining strategically positioned fire breaks and access roads.

4.2.8 Erosion and sediment control

Erosion and sediment control is critical to the long term stability of the land surface and downstream water quality. Mount Owen Complex has developed an Erosion and Sediment Control Plan with the main objective being to protect soil resources and maintain local water course quality. The Mount Owen Complex Erosion and Sediment Control Plan outlines the requirements for erosion and sediment control across the Mount Owen Complex and will be implemented for the Project.

Measures outlined in the Erosion and Sediment Control Plan includes:

- minimising the area of disturbance
- diverting run-off water around disturbed areas
- maintaining flow velocity at less than the erosive velocity
- avoiding disturbance in areas of concentrated flows and
- maximising ground cover.

4.2.9 Environmental management measures

Appropriate environmental management measures will be used as part of the mining operations to minimise the potential for indirect impacts through currently approved management plans, including:

- water management systems that seek to minimise the potential for damage to flora and fauna and their habitats from erosion and unnatural flooding events
- noise control systems to minimise noise impacts
- air quality control measures to minimise air quality impacts
- lighting controls to minimise night light impacts and
- blasting controls to minimise blast overpressure and vibration impacts.

4.2.10 Workforce education and training

The development of education packages and the facilitation of mine site awareness training can help to mitigate anthropogenic impacts on biodiversity. The ability of non-ecological personnel to identify key threatened species or key ecological threats can help to mitigate impacts on threatened species. Improved awareness and stewardship of the mine site workforce can potentially benefit all flora and fauna species and vegetation communities. The following existing mitigation actions will be implemented for the Project to develop a greater understanding and awareness of biodiversity issues in non-ecological trained personnel:

- Inductions for the workforce and visitors will be undertaken to make them aware of the key ecological issues present in the Development Footprint and so that they know their role and responsibilities in the protection and/or minimisation of impacts to all native biodiversity.
- Inductions will identify the location of sensitive flora and fauna and the policies being implemented to protect the biodiversity values of such areas.

5.0 Assessment of impacts

5.1 Direct impacts

The development of the 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 5.1 below outlines these impacts as they were entered into the BAM calculator, which totals approximately 540 ha of direct impacts to native vegetation communities.

Avoidance and mitigation measures associated with minimising the impacts of these direct impacts are discussed in **Sections 4.1** and **4.2** above.

Table 5.1 Direct Impacts of the Project on Native Biodiversity Features

Ecological Feature	Area within the Development Footprint (ha)	Area that conforms to BC Act TEC	Area that Conforms to EPBC Act TEC
Plant Community Type *Condition*			
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Moderate to Good Condition*[#+]	26.7	26.7	26.7
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Regeneration*[#+]	53.1	53.1	52.3
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Plantation*[#+]	1.8	1.8	1.8
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter *Derived Native Grassland*[+]	386.0		14.4
1692 - Bull Oak Grassy Woodland of the Central Hunter Valley *Moderate to Good Condition*[+]	18.0		17.7
1692 - Bull Oak Grassy Woodland of the Central Hunter Valley *Regeneration*	10.2		9.7

Ecological Feature	Area within the Development Footprint (ha)	Area that conforms to BC Act TEC	Area that Conforms to EPBC Act TEC
485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley *Moderate to Good Condition*	2.4		
1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter *Woodland Rehabilitation*+	0.5	0.3	0.3
1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley *Moderate to Good Condition*	40.0		
1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley *Plantation*	1.8		
Total	**540.5**	**81.9**	**122.9**
Species-credit Species Habitats			
Cymbidium canaliculatum – endangered population in the Hunter catchment	1 individual	-	-
brush-tailed phascogale *Phascogale tapoatafa*	152.1	-	-
southern myotis *Myotis macropus*	46.6	-	-
eastern cave bat *Vespadelus troughtoni*	0.5	-	-

Conforms to *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC (BC Act)
* Conforms to *Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregion* EEC (BC Act)
+ Conforms to *Central Hunter Eucalypt Forest and Woodland* CEEC (EPBC Act)

5.2 Indirect Impacts

The 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, air quality, noise, groundwater changes, weeds and feral animals may occur during the Project. This is further discussed in the sections below in accordance with Section 9.1.4 of the BAM. Whilst Section 9.1.4 of the BAM identifies a range of potential indirect impacts to be considered, only those relevant to the Project are discussed below. Impacts to groundwater are discussed in **Section 5.3.**

5.2.1 Connectivity and Corridors

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 an already 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 fauna movement corridor (comprising highly fragmented remnant woodland and rehabilitation patches), as well as the riparian corridor of Yorks Creek, exists within the Development Footprint linking woodland and forest habitats, particularly along Bowmans Creek which acts as an important corridor. The Development Footprint will fragment the riparian vegetation within the existing creekline of Yorks Creek, with realignment of these creek proposed. This will potentially disrupt movement of fauna that utilises Yorks Creek as a movement corridor, as well as limiting the exchange of genetic material in local flora species by altering this corridor.

While the proposal will remove approximately 540 ha of native vegetation, the majority of forest and woodland is already highly fragmented and disturbed. Additionally, forested vegetation represents approximately 25 % of the Development Footprint, most of which is in a rehabilitated or regenerative state. This represents lower value habitat when compared with native vegetation in a remnant state, of which none is present within the Disturbance Footprint due to historical and ongoing clearing for mining and agriculture in the area. Therefore, the relative loss of connectivity and movement corridors for native flora and fauna as a result of the proposed Project is fairly minor, though it will result in some loss of biodiversity.

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 and rehabilitation of the proposed Yorks Creek Realignment will re-instate connectivity at a local and regional scale in the medium to long-term.

5.2.2 Fugitive light emissions

Fugitive light emissions resulting from the 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). Appropriate lighting controls to minimise impacts will be implemented as part of the 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 part of, and adjacent to, existing mining operations with existing lighting impacts.

5.2.3 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).

Details of the noise controls that will be implemented as part of the Project are outlined in the Mount Owen Complex Noise Management Plan.

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 blast vibration with the vibration impacts broadly consistent with the blasting impacts from the existing mining operations (refer to Appendix 12 of the EIS for the Noise Impact Assessment and Appendix 15 for the Blast Impact Assessment).

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

5.2.4 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 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 as discussed in the main text of the Biodiversity and Offset Management Plan and the Air Quality and Greenhouse Gas Management Plan.

In regard to potential impacts on biodiversity, there will be no substantial change to air quality impacts (refer to Appendix 11 of the EIS for the Air Quality Impact Assessment) given that the proposed mine is part of, and adjacent to, an already existing operation with existing impacts.

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

5.2.5 Weed and feral animal encroachment

Weed species could be inadvertently brought into the Mount Owen Complex with imported materials or could invade naturally through removal of native vegetation. The presence of weed species has the potential to decrease the value of extant vegetation to native species, particularly threatened species. Mitigation measures outlined in the Mount Owen Complex Biodiversity and Offset Management Plan (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, as well as invasive weed species. Mitigation measures outlined in the Biodiversity and Offset Management Plan (refer to **Section 4.2**) will minimise the potential for feral animal spread and impacts into surrounding areas around the Development Footprint. 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.

5.2.6 Cumulative habitat loss and vegetation clearance impacts

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 Project will result in a loss of approximately 540 ha of native grassland, woodland and forest vegetation.

It is recognised that the Project will remove vegetation and further increase fragmentation and isolation of habitats in an already degraded landscape, 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:

- delineation of clearance areas to prevent unwanted incursion into, 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, and
- the implementation of a biodiversity offset strategy in accordance with the BC Act.

5.2.7 Mitigation and onsite management of indirect impacts

Section 8.0 of the BAM relates to onsite avoidance and minimisation measures required for consideration for impacts related to the operational phase of the Project. **Section 4.2** outlines the mitigation measures proposed for the Project for direct and indirect impacts including:

- landform establishment and rehabilitation
- 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 high-threat weed control
- fencing and access control
- bushfire management
- water management systems that seek to minimise the potential for damage to flora and fauna and their habitats from erosion, build of sediment, and unnatural flooding events
- control systems to minimise noise, air quality, lighting and blasting impacts

- workforce education and training.

Should the Project be approved, Glencore will update the existing Biodiversity and Offset Management Plan in accordance with any relevant development consent requirements.

5.3 Prescribed impacts

Prescribed impacts have been considered for the entire Additional Disturbance Area (refer to **Figure 1.2**), which includes those areas mapped as Category 1-exempt land. The following impacts are considered 'prescribed impacts' under the BC Regulation:

- impacts on the habitat of threatened species or ecological communities associated with karst, caves, crevices, cliffs and other geological features of significance, rocks, human-made structures or non-native vegetation.
- impacts on the connectivity of different areas of habitat of threatened species that facilitates the movement of those species across their range
- impacts on movement of threatened species that maintains their life cycle
- impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities
- impacts of wind turbine strikes on protected animals
- impacts of vehicle strikes on threatened species or on animals that are part of a TEC.

The Project will not involve impacts related to wind farms, substantial changes to vehicle strike risk, or on karst ecosystems. The Project will not lead to subsidence associated impacts as it is an open cut mine. Cliff falls can be a risk associated with highwalls within mining voids, however, no natural cliff areas will be impacted by the Project.

Important connectivity and movement habitat is unlikely to be impacted by the Project (refer to **Section 5.2.1**). The Development Footprint's current disturbed and fragmented state does not provide any substantial movement habitat for terrestrial, arboreal or aquatic threatened species.

The potential impacts on groundwater dependent ecosystems (GDEs) and downstream impacts on hydrology and environmental flows on vegetation are outlined in the Appendix 10 of the EIS (Umwelt 2019). It was concluded that the Project would not result in significant downstream impacts on terrestrial vegetation. The Project is predicted to have a negligible impact on the ecological value of groundwater dependent ecosystems relative to existing approved operations.

5.4 Serious and irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made in accordance with the principles prescribed in the BC Regulation. The principles have been designed to capture those impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in NSW. These are impacts that:

- will cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or

- will further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or

- impact on the habitat of a species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or

- impact on a species or ecological community that is unlikely to respond to measures to improve habitat and vegetation integrity and is therefore irreplaceable.

Six species-credit species predicted by the BAM calculator or according to the literature for this Project are listed as potential serious and irreversible impact (SAII) entities in the *Guidance to Assist a Decision-Maker to Determine a Serious and Irreversible Impact* (OEH 2017c). These are shown in **Table 5.2** below:

Table 5.2 Likelihood of impacts to SAII entities

Species	Reason for Listing	Likelihood of Impact
regent honeyeater (*Anthochaera phrygia*)	Current rapid rate of decline (OEH 2017c).	The Development Footprint does not occur in the area mapped as "important habitat" and the species has not been recorded in the Development Footprint or across the wider Mount Owen Complex despite targeted surveys over many years. The Project is not expected to result in a serious and irreversible impact on this species.
large-eared pied bat (*Chalinolobus dwyeri*)	Dependence on rocky areas containing caves, overhangs or crevices, or old tunnels or culverts, for breeding habitat. This species is considered unlikely to respond to management (OEH 2017c).	While the Development Footprint may contain foraging habitat for this species, no rocky areas supporting the aforementioned habitat features are present, and therefore no impact on breeding habitat for species will occur as a result of the Project. The Project is not expected to result in a serious and irreversible impact on this species.
swift parrot (*Lathamus discolor*)	Current rapid rate of decline (OEH 2017c).	The Development Footprint does not occur in the area mapped as "important habitat" and the species has not been recorded in the Development Footprint. The Project is not expected to result in a serious and irreversible impact on this species.
little bentwing-bat (*Miniopterus australis*)	Dependence on rocky areas containing caves, overhangs or crevices, or old tunnels or culverts, for breeding habitat. This species is considered unlikely to respond to management. (OEH 2017c).	While the Development Footprint may contain foraging habitat for this species, no rocky areas supporting the aforementioned habitat features are present, and therefore no impact on breeding habitat for species will occur as a result of the Project. The Project is not expected to result in a serious and irreversible impact on this species.
eastern bentwing bat (*Miniopterus schreibersii oceanensis*)	Dependence on rocky areas containing caves, overhangs or crevices, or old tunnels or culverts, for breeding habitat. This species is considered unlikely to respond to management. (OEH 2017c).	While the Development Footprint may contain foraging habitat for this species, no rocky areas supporting the aforementioned habitat features are present, and therefore no impact on breeding habitat for species will occur as a result of the Project. The Project is not expected to result in a serious and irreversible impact on this species.

Species	Reason for Listing	Likelihood of Impact
eastern cave bat (*Vespadelus troughtoni*)	Dependence on rocky areas containing caves, overhangs or crevices, or old tunnels or culverts, for breeding habitat. This species is considered unlikely to respond to management. (OEH 2017c).	While the Development Footprint may contain foraging habitat for this species, no rocky areas supporting the aforementioned habitat features are present, and therefore no impact on breeding habitat for species will occur as a result of the Project. The Project is not expected to result in a serious and irreversible impact on this species.

For the reasons discussed above, the Project is unlikely to have an impact that is serious and irreversible.

6.0 Biodiversity credit impact summary

6.1 Impacts not requiring assessment

Impacts not requiring further assessment under the BAM include areas of land without native vegetation. The Development Footprint contains approximately 74 ha of cleared land (containing disturbed land and dams) and non-native vegetation that will be removed as a result of the Project that does not meet the definition of 'native vegetation' under the BC Act. This impact does not require further assessment under the BAM.

In addition, impacts to areas of Category 1-exempt land as described by the LLS Act (refer to **Section 1.1.4**), other than for prescribed impacts (refer to **Section 5.3**), do not require assessment under the BAM. Areas of Category 1-exempt land do occur within the Additional Disturbance Area however they have been excised from the Development Footprint, in accordance with the LLS Act (refer to **Figure 1.2**).

Figure 6.1 shows the areas within the Development Footprint not requiring assessment in accordance with Section 10.4 of the BAM.

6.2 Impacts not requiring offset

Impacts on native vegetation not requiring offsets under the BAM include native vegetation that has a vegetation integrity score of less than 20 (where it is not associated with ecosystem-credit species habitat or a TEC), less than 17 (where it is not associated with ecosystem-credit habitat or a VEC) or less than 15 (where it is representative of a EEC or CEEC).

No vegetation zone identified within the Development Footprint has a vegetation integrity score lower than 17 and as such, all areas of native vegetation impacted will require offsetting.

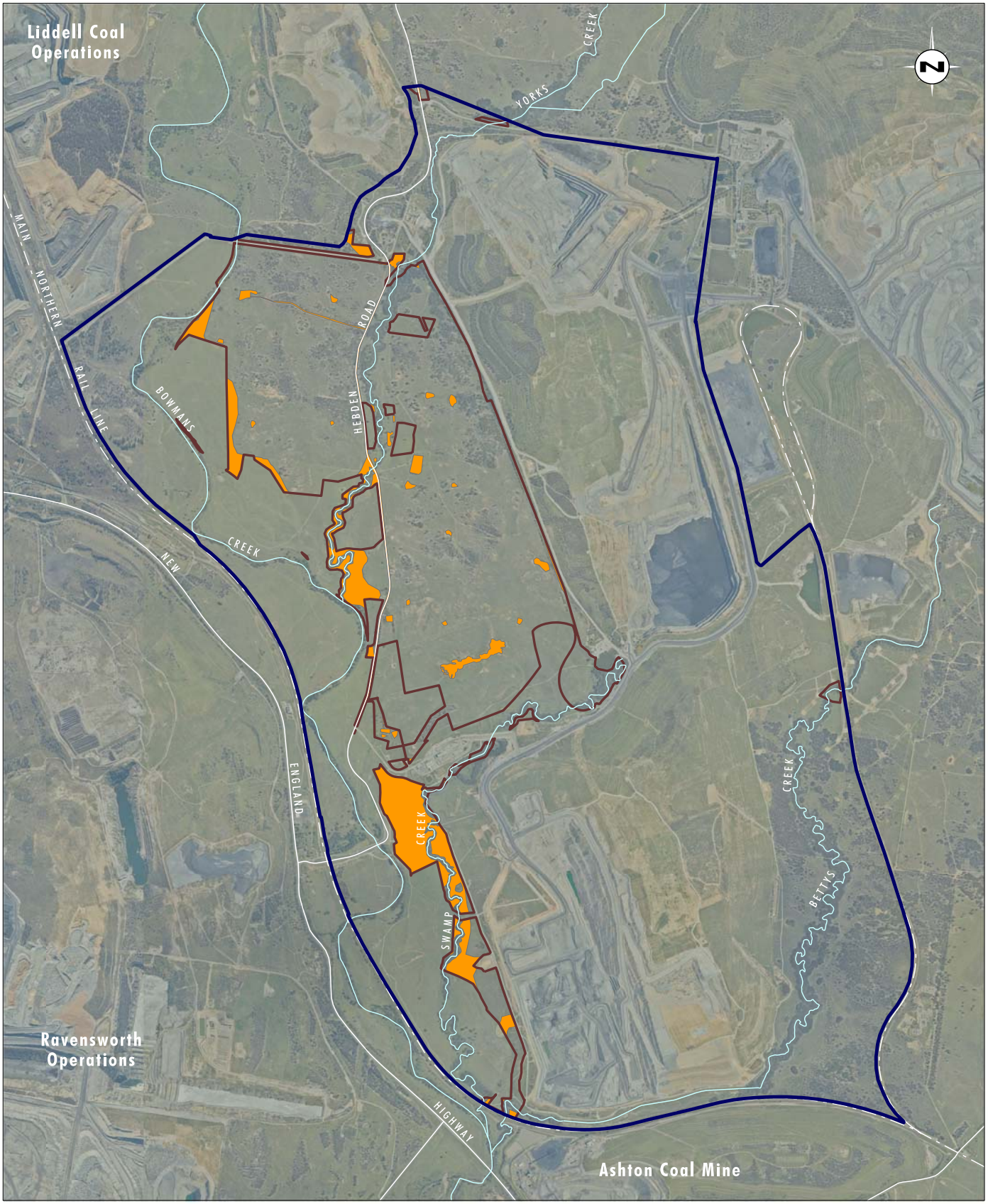


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Areas not Requiring Assessment

FIGURE 6.1

Areas within Development Footprint not requiring Assessment

File Name (A4): R03/4166_304.dgn
20191126 13.25

6.3 Impacts requiring offset

Table 6.1 summarises the offsetting requirements for PCTs and species-credit species habitat impacted by the Project as calculated in accordance with the BAM.

Table 6.1 Impacts requiring offset

Vegetation Zone	PCT/Species-credit	Area (ha)	Vegetation Integrity Score		
			Current	Future	Change
1	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - *Moderate to Good Condition*	26.7	37.6	0	-37.6
2	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - *Regeneration*	53.1	31.5	0	-31.5
3	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - *Plantation*	1.8	37.0	0	-37.0
4	1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - *Derived Native Grassland*	386.0	18.3	0	18.3
5	1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - *Moderate to Good Condition*	18.0	26.3	0	-26.3
6	1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - *Regeneration*	10.2	25.7	0	-25.7
7	485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - *Moderate to Good Condition*	2.4	32.0	0	-32.0
8	1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter – *Woodland Rehabilitation*	0.5	45.0	0	-45.0
9	1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - *Moderate to Good Condition*	40.0	38.8	0	-38.8
10	1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - *Plantation*	1.8	36.1	0	-36.1
-	brush-tailed phascogale *Phascogale tapoatafa*	152.1	-	-	-
-	southern myotis *Myotis macropus*	46.6	-	-	-
-	*Cymbidium canaliculatum* – endangered population in the Hunter catchment	1 (individual)	-	-	-
-	eastern cave bat *Vespadelus troughtoni*	0.5	-	-	-

7.0 Biodiversity Offsets

Glencore is committed to delivering a biodiversity offset strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Project.

As discussed in **Section 4.0**, Glencore has, where possible, altered the Project to avoid and minimise ecological impacts in the 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 offset requirements for the Project, as calculated in accordance with the BAM are 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. Glencore is committed to delivering a biodiversity offset strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Project. The offset strategy will be implemented in consideration of the process outlined in the BC Act and the final composition of the offset strategy may evolve as the Project progresses.

The biodiversity offset strategy will be developed during the assessment process in consultation with the BCD and DPIE and based on the credits required to be retired to offset the impacts of the Project as specified in **Table 6.1** and the offset options available under the BC Act and BC Regulation including:

- land based offsets (Glencore would retire the required number and class of credits determined in accordance with the BDAR and the offset rules in the BC Regulation) through the establishment of new Stewardship Sites (and the subsequent retirement of credits) or by retiring credits from existing Stewardship Sites)
- ecological rehabilitation (allowable for mining projects)
- purchasing credits from the market, and/or
- paying into the Biodiversity Conservation Fund.

8.0 Biodiversity Credit Report

A full Biodiversity Credit Report is included in **Appendix D**.

A summary of the key outcomes in provided in **Table 8.1**.

Table 8.1 Credits Required to Offset the Project

PCT/Species-credit	Credits Required
Ecosystem Credits for PCTs, ecological communities and threatened species habitat	
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good Condition	**502**
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Regeneration	**836**
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Plantation	**33**
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Derived Native Grassland	**3,527**
1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition	**207**
1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Regeneration	**115**
485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Moderate to Good Condition	**34**
1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter – Woodland Rehabilitation	**11**
1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good Condition	**679**
1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Plantation	**28**
Total	**5,972**
Species Credits for threatened species	
brush-tailed phascogale *Phascogale tapoatafa*	**2,559**
southern myotis *Myotis macropus*	**732**
Cymbidium canaliculatum – endangered population in the Hunter catchment	**2**
eastern cave bat *Vespadelus troughtoni*	**17**
Total	**3,310**

9.0 References

Anstis, M, (2002) Tadpoles of South-eastern Australia. Reed New Holland, Sydney.

Barker, J, Grigg, G, C, & Tyler, M, J, (1995) A Field Guide to Australian Frogs. Surrey Beatty & Sons, Sydney.

Biodiversity Conservation Division (BCD) (2019a) BioNet Atlas of NSW Wildlife, accessed July 2019.

Biodiversity Conservation Division (BCD) (2019b) Threatened Biodiversity Data Collection (TBDC), accessed July 2019

Biodiversity Conservation Division (BCD) (2019c) Vegetation Information System (VIS) accessed July 2019.

Birdlife International (2017) Birdlife Taxonomic Checklist, Version 2.0, December 2017.

Botanic Gardens Trust, (2017) *PlantNET* – The Plant Information Network System of Botanic Gardens Trust, Sydney, Australia (version 2.0). <http://plantnet.rbgsyd.nsw.gov.au> accessed January 2018.

Cole, M., Nussbaumer, Y., and Castor, C. (2004) Integrating Vegetation Community Construction at the Rehabilitation Sites of Mt Owen Open-Cut Coal Mine with Vegetation Community Restoration in the Large Remnant of Ravensworth State Forest and the New Forest - Towards the Development of a Model Research Site in the Upper Hunter.

Cronquist, A, (1981) An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.

Department of the Environment (2013) Significant Impact Guidelines 1.1 – Matters of National Environmental Significance.

Department of Environment and Climate Change (DECC) (2008) *Hygiene protocol for the control of disease in frogs*, Information Circular Number 6. DECC (NSW), Sydney South.

Department of Environment and Climate Change (DECC) (2009) *Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians*

Department of Environment and Conservation (DEC) (2004) *Threatened Species Survey and Assessment: Guidelines for development and activities (working draft)*, November 2004.

Department of the Environment and Energy (DoEE) (2016) Central Hunter Valley Eucalypt Forest and Woodland: A Nationally-protected Ecological Community – Identification Guide http://www.environment.gov.au/system/files/resources/5d6386ad-ce46-4b33-993f-8518ab9c972a/files/central-hunter-valley-eucalypt-forest-guide.pdf accessed July 2019

Department of the Environment and Energy (DoEE) (2019) Protected Matters Search Tool http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf

Department of the Environment and Energy (DoEE) (2018b) Species Profiles (SPRAT), accessed January 2018.

Department of the Environment (DoE) (2013) *Draft Survey Guidelines for Australia's Threatened Orchids*

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008) Approved Conservation Advice for *Diuris praecox* (Newcastle Doubletail). Canberra: Department of the Environment, Water, Heritage and the Arts.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008) Approved Conservation Advice for *Eucalyptus pumila* (Pokolbin Mallee). Canberra: Department of the Environment, Water, Heritage and the Arts.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2010a) Survey Guidelines for Australia's Threatened Birds. Department of the Environment, Water, Heritage and the Arts: Canberra, Australia.

Department of the Environment, Water, Heritage and the Arts (DEWHA (2010b) Survey Guidelines for Australia's Threatened Frogs. Department of the Environment, Water, Heritage and the Arts: Canberra, Australia.

Department of the Environment, Water, Heritage and the Arts (DEWHA (2010c) Survey Guidelines for Australia's Threatened Bats. Department of the Environment, Water, Heritage and the Arts: Canberra, Australia.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) (Australian Government) (2010). Advice on the Presence of Hybrids in Listed Ecological Communities. Letter to the Minister of DSEWPC, Tony Burke MP. Canberra, ACT.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) (2011a) Survey Guidelines for Australia's Threatened Mammals. Department of Sustainability, Environment, Water, Population and Communities: Canberra, Australia.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) (2011b) Survey Guidelines for Australia's Threatened Reptiles. Department of Sustainability, Environment, Water, Population and Communities: Canberra, Australia.

Forest Fauna Surveys Pty Ltd (2019) Mount Owen Complex Fauna Monitoring 2016 Annual Report. Report prepared for Mount Owen Complex.

Gleeson, J and Gleeson, D (Eds)(2012) Reducing the impacts of development on wildlife, CSIRO Publishing, Melbourne.

Harden, G, J, editor, (1992) *Flora of New South Wales. Volume 3*. Royal Botanic Gardens Sydney & New South Wales University Press, Sydney.

Harden, G, J, editor, (1993) *Flora of New South Wales. Volume 4*. Royal Botanic Gardens Sydney & New South Wales University Press, Sydney.

Harden, G, J, editor, (2000) *Flora of New South Wales. Volume 1*. 2nd edition. New South Wales University Press and Royal Botanic Gardens, Sydney.

Harden, G, J, editor, (2002) *Flora of New South Wales. Volume 2*. Revised edition. Royal Botanic Gardens Sydney & New South Wales University Press, Sydney.

Mt Owen / Glendell Operations (MGO) (2019) *Noise Management Plan*.

McVicar TR, Langhi L, Barron OV, Rachakonda PK, Zhang YQ, Dawes WR, Macfarlane C, Holland KL, Wilkes PG, Raisbeck-Brown N, Marvanek SP, Li LT and Van Niel TG (2015) Context statement for the Hunter subregion. Product 1.1 from the Northern Sydney Basin Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.

Nearmap (2019) High Resolution Aerial Maps & Imagery in Australia. Electronic resource accessed January 2018: https://www.nearmap.com.au/

NSW Scientific Committee (2011a) Central Hunter Grey Box – Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions – Endangered Ecological Community Listing. Electronic resource accessed July 2018: http://www.environment.nsw.gov.au/determinations/centralhuntergreyboxFD.htm

NSW Scientific Committee (2011b) Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions – Endangered Ecological Community Listing. Electronic resource accessed July 2018: http://www.environment.nsw.gov.au/determinations/centralhunterironbarkFD.htm

NSW Scientific Committee (2011c) Swamp Oak Floodplain Forest of NSW North Coast, Sydney Basin and South East Corner Bioregions – Endangered Ecological Community Listing. Electronic resource accessed July 2018: http://www.environment.nsw.gov.au/determinations/swampoak36a.htm

NSW Scientific Committee (NSWSC) (2019) Final Determination to list the mallee *Eucalyptus castrensis* K. D. Hill as an ENDANGERED SPECIES in Part 1 of Schedule 1 of the Act.

Office of Environment and Heritage (OEH) (2012) Greater Hunter Native Vegetation Map

Office of Environment and Heritage (OEH) (2014a) NSW Biodiversity Offsets Policy for Major Projects, September 2014.

Office of Environment and Heritage (OEH) (2014b) Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects, September 2014.

Office of Environment and Heritage (OEH) (2014c) BioBanking Assessment Methodology, September 2014.

Office of Environment and Heritage (OEH) (2016) NSW Guide to Surveying Threatened Plants, February 2016

Office of Environment and Heritage (OEH) (2017a) Biodiversity Assessment Method, August 2017.

Office of Environment and Heritage (OEH) (2017b) *Guidance to Assist a Decision-Maker to Determine a Serious and Irreversible Impact*, August 2017.

Office of Environment and Heritage (OEH) (2017c) Determining Central Hunter Valley eucalypt forest and woodland CEEC in Bulloak-dominated woodland. Letter from Steven Cox, OEH Senior Team Leader Planning.

Office of Environment and Heritage (OEH) (2017d) Native Vegetation Integrity Benchmarks: An Information Sheet

Office of Environment and Heritage (OEH) (2018) Upper Hunter State Vegetation Map

Peake T.C. (2006) *The Vegetation of the Central Hunter Valley, New South Wales. A report on the findings of the Hunter Remnant Vegetation Proposed Modification*. Hunter- Central Rivers Catchment Authority, Paterson.

Sivertsen, D., Roff, A., Somerville, M., Thonell, J., and Denholm, B. (2011). *Hunter Native Vegetation Mapping. Geodatabase Guide (Version 4.0)* Published by Office of Environment and Heritage, Department of Premier and Cabinet, Sydney, Australia.

Strahler, A. N., (1952) Hypsometric (area-altitude) analysis of erosional topography, *Geological Society of America Bulletin* 63 (11): 1117-1142.

Threatened Species Scientific Committee (TSSC) (2015) *Approved Conservation Advice (including listing advice) for the Central Hunter Valley eucalypt forest and woodland ecological community*. http://www.environment.gov.au/biodiversity/threatened/communities/pubs/130-conservation-advice.pdf

Umwelt (Australia) Pty Limited (2014) Ecological Assessment - Mount Owen Continued Operations Project, October 2014.

Umwelt (Australia) Pty Limited (2015b) Mount Owen Continued Operations Project Environmental Impact Statement. Prepared for Mt Owen Pty Limited. January 2015.

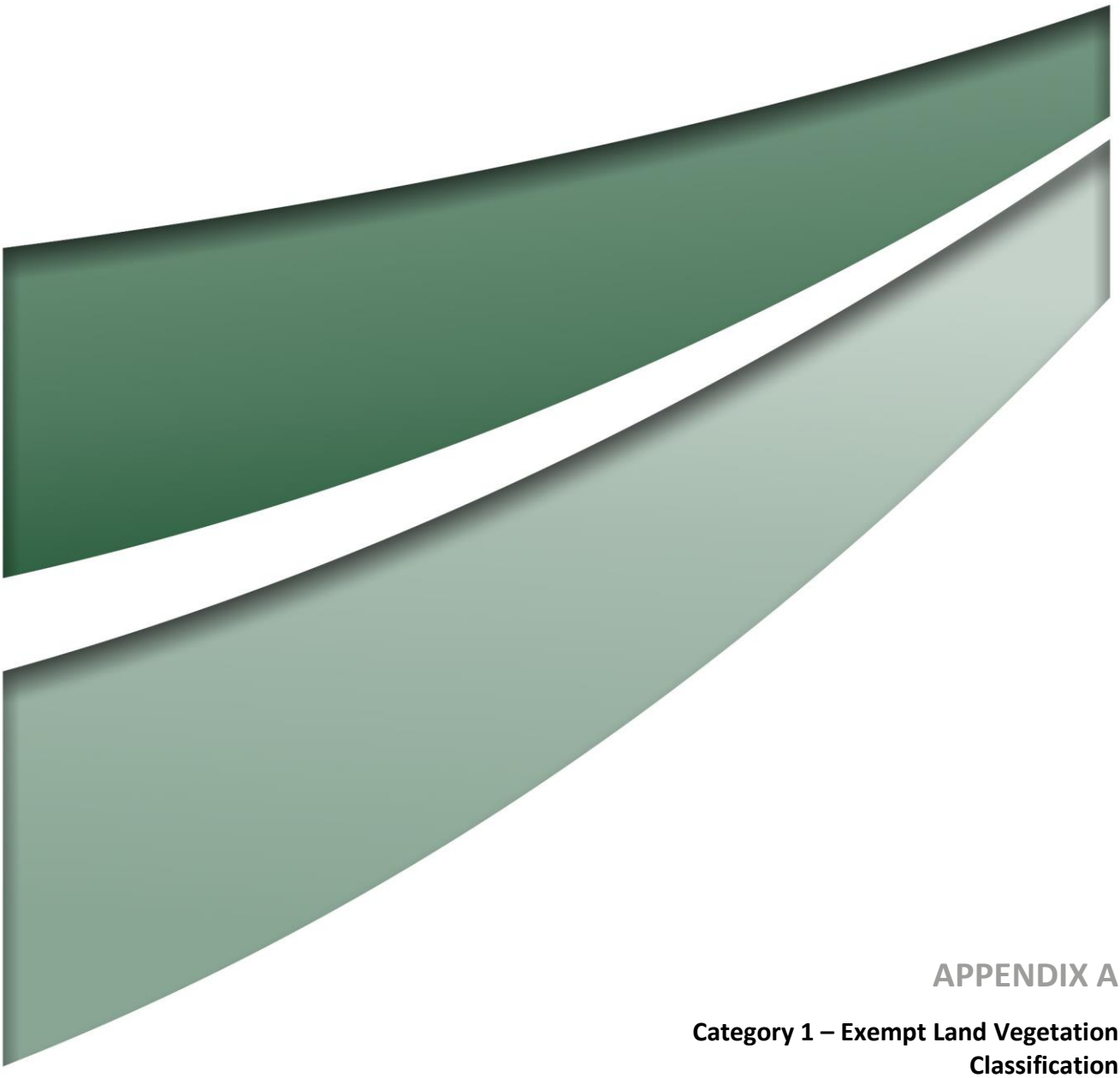
Umwelt (2015) Greater Ravensworth Upper Hunter Strategic Assessment. Unpublished report prepared for on behalf of GCAA.

Umwelt (2018a) Biodiversity Assessment Report (BAR) for the Mount Owen Continued Operations Project Modification 2. Report prepared for Mt Owen Pty Limited.

Umwelt (2018b) Biodiversity Development Assessment Report (BDAR) for the Glendell Mine Modification 4. Report prepared for Mt Owen Pty Limited.

Umwelt (2018c) Biodiversity Assessment Report (BAR) for the Mount Owen Modification 2. Report prepared for Mt Owen Pty Limited.Umwelt (in prep) *Biodiversity Development Assessment Report for the Narama Pipeline Modification.* Unpublished report prepared for Mt Owen Pty Limited.

Wheeler D, J, B, Jacobs S, W, L, and Whalley R, D, B, (2002) *Grasses of New South Wales*, 3rd Edition. The University of New England, Armidale.



APPENDIX A

Category 1 – Exempt Land Vegetation Classification

umwelt

Environmental & Social Consultants

GLENCORE

CATEGORY 1 – EXEMPT LAND

Classification Report

FINAL

November 2019

GLENCORE

CATEGORY 1 – EXEMPT LAND

Classification Report

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Ltd

Project Director:	Bret Jenkins
Project Manager:	David Holmes
Technical Director:	Alison Riley
Report No.	4166B/R17
Date:	November 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	David Holmes	29 November 2019	David Holmes	29 November 2019

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1.0 Introduction

The Secretary's Environmental Assessment Requirements (SEARs) were issued by the Department of Planning Industry and Environment (DPIE), relevant to the assessment of biodiversity impacts, require:

> *an assessment of the likely biodiversity impacts of the development, paying particular attention to threatened species, populations and ecological communities and groundwater dependent ecosystems, undertaken in accordance with the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report or, subject to agreement with OEH and the Department, undertaken in accordance with the Upper Hunter Strategic Assessment (UHSA);*

Section 6.12 of the *Biodiversity Conservation Act 2017* (BC Act) requires the Biodiversity Development Assessment Report (BDAR) to be prepared in accordance with the Biodiversity Assessment Method (BAM) which is established under Section 6.8 of the BC Act.

Relevantly, section 6.8(3) of the BC Act provides:

> *(3) The biodiversity assessment method is to exclude the assessment of the impacts of any clearing of native vegetation and loss of habitat on category 1-exempt land (within the meaning of Part 5A of the Local Land Services Act 2013), other than any impacts prescribed by the regulations under section 6.3.*
>
> ***category 1-exempt land** means areas of the State to which this Part applies designated as category 1-exempt land on the native vegetation regulatory map.*
>
> ***category 2-regulated land** means areas of the State to which this Part applies designated as category 2-regulated land on the native vegetation regulatory map (including category 2-vulnerable regulated land that is so designated).*
>
> ***60E Purpose of native vegetation regulatory map***
>
> *The purpose of the native vegetation regulatory map is to designate areas of the State to which this Part applies—*
>
> *(a) where the clearing of native vegetation is not regulated under this Part (**category 1-exempt land**), and*
>
> *(b) where the clearing of native vegetation is regulated under this Part (**category 2-regulated land**), and*
>
> *(c) where the clearing of native vegetation is regulated under this Part but (because of its vulnerability) is subject to additional restrictions and extended to the clearing of dead and non-native plants (**category 2-vulnerable regulated land**).*

The Native Vegetation Regulatory Map has not been finalised and the mapping of Category 1 land has not been released to the public. As such, landholders are responsible for determining the categorisation of their land in accordance with the *Local Land Services Act 2013* (LLS Act).

1.1 Definition of Category 1-Exempt Land

Category 1-exempt land is defined in Part 5A, Division 2 of the LLS Act. Subject to certain exceptions, Category 1-exempt land is broadly defined as being:

- land cleared of native vegetation as at 1 January 1990 or lawfully cleared after 1 January 1990 (but before 25 August 2017)
- low conservation grasslands
- land containing only low conservation groundcover (not being grasslands)
- native vegetation identified as regrowth in a Property Vegetation Plan under the repealed Native Vegetation Act 2003
- land bio-certified under the BC Act.

Land meeting the above criteria is not considered to be Category 1-exempt land if certain exceptions apply. These exemptions are discussed further in the following sections below.

1.1.1 Meaning of 'cleared'

Based on information provided by the Biodiversity Conservation Division (BCD, formerly OEH), including the Land Categorisation Fact Sheet, clearing has been interpreted as any areas where there has been a lawful removal of all native vegetation (all strata) prior to the commencement of Part 5A of the LLS Act, being 25 August 2017.

114 Determining whether native vegetation has been significantly disturbed or modified (s 60J (2))

(1) Native vegetation that comprises grasslands or other non-woody vegetation is taken to have been significantly disturbed or modified (and therefore cleared) only if:

(a) there has been a detectable variation (from information obtained from aerial or satellite imagery) in the structure or composition, or both, of non-woody vegetation, and

(b) that variation is consistent with management of pasture or crops for agricultural purposes, and

(c) that variation has been sustained for at least 12 months on more than one occasion before the commencement of Part 5A of the Act, and

(d) that variation has not been caused only by grazing on the land, and

(e) that variation occurred (from information obtained from aerial or satellite imagery) between 1 January 1990 and the date of commencement of Part 5A of the Act.

(2) During the transitional period referred to in section 60F of the Act, the information that may be used for the purposes of this clause includes information obtained from a source other than from aerial or satellite imagery, but only if the landholder has prepared a record of the information and a map showing the areas to which it applies. The landholder is required to retain the record and map for at least 5 years after any clearing that is carried out in reliance on that information.

60B Meaning of "native vegetation"

(1) For the purposes of this Part, ***native vegetation*** *means any of the following types of plants native to New South Wales—*

(a) trees (including any sapling or shrub or any scrub),

(b) understorey plants,

(c) groundcover (being any type of herbaceous vegetation),

(d) plants occurring in a wetland.

(2) A plant is native to New South Wales if it was established in New South Wales before European settlement. The regulations may authorise conclusive presumptions to be made of the species of plants native to New South Wales by adopting any relevant classification in an official database of plants that is publicly accessible.

(3) For the purposes of this Part, native vegetation extends to a plant that is dead or that is not native to New South Wales if—

(a) the plant is situated on land that is shown on the native vegetation regulatory map as category 2-vulnerable regulated land, and

(b) it would be native vegetation for the purposes of this Part if it were native to New South Wales.

(4) For the purposes of this Part, native vegetation does not extend to marine vegetation (being mangroves, seagrasses or any other species of plant that at any time in its life cycle must inhabit water other than fresh water). A declaration under section 14.7 of the Biodiversity Conservation Act 2016 that specified vegetation is or is not marine vegetation also has effect for the purposes of this Part.

60C Meaning of "clearing" native vegetation

For the purposes of this Part, ***clearing*** *native vegetation means any one or more of the following—*

(a) cutting down, felling, uprooting, thinning or otherwise removing native vegetation,

(b) killing, destroying, poisoning, ringbarking or burning native vegetation.

Complete removal of native vegetation has been interpreted for the purposes of the mapping as being areas where complete removal of ground cover has occurred, namely:

- areas that were cropped/ploughed or significantly disturbed (see clause 114 of the LLS Regulation) for agricultural purposes
- areas disturbed by approved mining (or other) approved activities.

While it is reasonably straight forward to classify land that has had all vegetation removed since 1990 by identifying land were surface disturbance activities have taken place, the legislation provides little clarity on what is meant by 'cleared as at 1 January 1990'. This is particularly important in the present case where there is a long history of disturbance within the Project Area associated with mining (more than 50 years) and agriculture (more than 190 years). This process is complicated in the present conditions by the absence of any high resolution aerial photography of the Project Area in 1990. The methodology for assessing areas 'cleared' of native vegetation is set out in **Section 2.1**.

1.1.2 Native Vegetation Identified as Regrowth in a Property Vegetation Plan Under the Repealed Native Vegetation Act 2003

Although the *Native Vegetation Act 2003* was repealed in 2017, Property Vegetation Plans approved before the repeal of the Act remain valid and the obligations to manage and maintain the associated offset areas continue. There are no valid Property Vegetation Plans relevant to the Project Area.

1.1.3 Low Conservation Groundcover

Low Conservation Groundcover is likely to be applicable to the Project Area however the "*Interim Grasslands and other Groundcover Assessment Method*" published by the Minister for the Environment in the Gazette on 25 August 2017 set out a requirement that the process of determining whether low conservation grasslands exist in any given area specifically provides:

> *The Grassland and other Groundcover Assessment Method, including any surveys cannot be used to classify vegetation as of low or moderate conservation value:*
>
> - *If the Vegetation has been disrupted within six months prior to the assessment (e.g. by fire, heavy grazing, drought, etc) such that the typical assemblage of species is absent*
> - *When total groundcover vegetation is less than 10 per cent cover across a vegetation zone. This is insufficient representation to determine dominance by native or exotic vegetation, or*
> - *If the vegetation is a wetland community.*

The Project Area is located in an area that has been drought declared since mid 2017 (refer to **Figure 1.1**). Accordingly, the ability to assess whether grasslands within the Project Area are 'Low Conservation Grasslands' cannot be applied under current climactic circumstances.

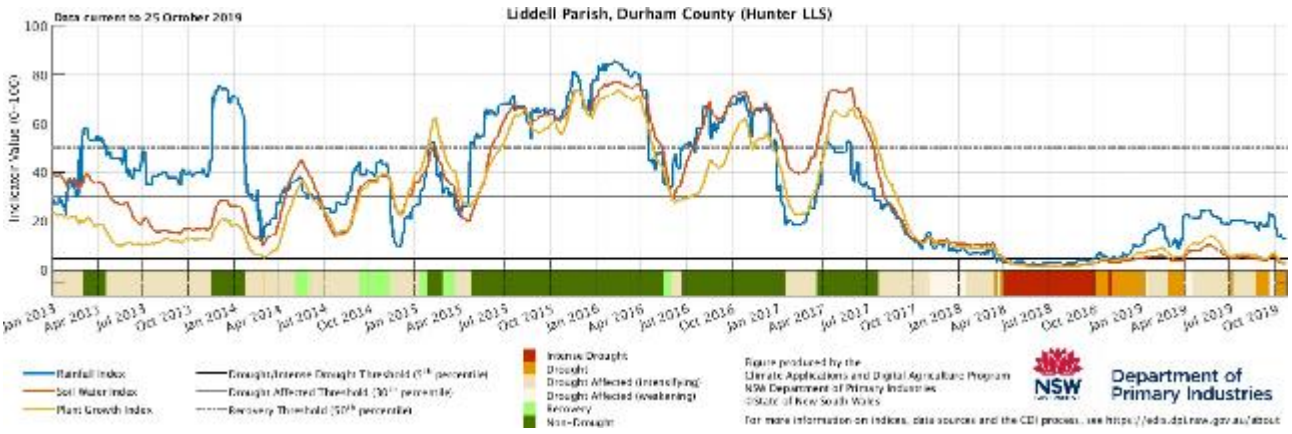

Figure 1.1 Combined Drought Indicator – Liddell Parish, Durham County (January 2013 – October 2019)

1.1.4 Land bio-certified under the BC Act.

The land within the Project Area is not subject to bio-certification under the BC Act.

1.2 Category 2-Regulated Land

Category 2-regulated land is divided into:

Regulated land, which is any Category 2 land that is not vulnerable or sensitive regulated land, includes:

- land not cleared as at 1 January 1990 or unlawfully cleared after 1 January 1990
- native vegetation grown with the assistance of public funds (but clearing under the Land Management Code is not permitted on such land while the agreement providing the funds is in force)
- land that was subject to a Private Native Forestry Property Vegetation Plan that is no longer in force
- grasslands that are neither low nor high conservation grasslands
- travelling stock reserves, apart from travelling stock reserves in the Western Division
- land that is (or was previously) subject to a Private Native Forestry Plan or Private Native Forestry Property Vegetation Plan
- land that is of a kind prescribed by the LLS Regulation as being Category 2- regulated land (clauses 108 and 113 of the LLS Regulation).

Vulnerable regulated land, which is land where clearing of native vegetation may not be permitted under the Land Management (Native Vegetation) Code 2018 and includes:

- steep or highly erodible land
- protected riparian areas
- land susceptible to erosion, or land that is otherwise environmentally sensitive.

Sensitive regulated land, which is where clearing is not permitted and includes:

- land subject to a private land conservation agreement
- land set aside under the Land Management Code
- land subject to a bio-certification conservation measure
- land comprising an offset under a Property Vegetation Plan or set aside under a code under the *Native Vegetation Act 2003*
- coastal wetlands and littoral rainforests (*Coastal Management Act 2016*)
- high conservation grasslands

- core koala habitat identified in a plan of management (State Environmental Planning Policy No 44 (Koala Protection))
- critically endangered plants and critically endangered ecological communities
- Ramsar wetlands (EPBC Act)
- land subject to remedial action or conservation measures under the BC Act
- land subject to a property, trust or conservation agreement
- land recommended for listing as an Area of Outstanding Biodiversity Value
- Conservation Areas under the Southern Mallee Land Use Agreement
- native vegetation that must be retained under the *Plantation and Reafforestation Act 1999*
- land subject to a condition of development consent requiring the land to be set aside for conservation purposes under the *Environmental Planning and Assessment Act 1979* (EP&A Act)
- rainforest and old-growth forest.

Clauses 108 and 113 of the LLS Regulation prescribe additional land as being eligible as being Category 2-regulated land. Of these, only the LLS Regulation Clause 113 (1)(i) appears to be potentially relevant to the Project Area:

> *(1) Land is also to be designated as category 2-regulated land if the Environment Agency Head reasonably believes that:*
>
> *(i) the land is, by a condition of a development consent or approval under the Environmental Planning and Assessment Act 1979 that has been notified to the Environment Agency Head, required to be set aside for nature conservation, for re-vegetation of native vegetation or as a native vegetation offset*

Aspects of the Project will impact on areas of partly rehabilitated land established on areas disturbed by approved past mining activities since 1990. The majority of this rehabilitation was undertaken pursuant to development consents that have now been surrendered and are now the subject the obligations under development consent SSD-5850 (Mount Owen Consent). Some rehabilitation has also been undertaken in the southern areas of the Project Area covered by development consent DA 80/952 (Glendell Consent).

The Mount Owen Consent includes a specific commitment to establish 518 hectares (ha) of 'Rehabilitation Woodland' as a biodiversity offset. The disturbance associated by the Project does not impact on any areas which fall within this area. The Mount Owen Consent also requires the establishment of 'at least 2,037 ha of self-sustaining native woodland ecosystems characteristic of vegetation communities found in the local area, as shown conceptually in Figure 7A in Appendix 7' of the Mount Owen Consent. While the areas of rehabilitation impacted by the Project includes areas of woodland shown conceptually in Figure 7A of the Mount Owen Consent, it is noted that these areas are not to be 'set aside' and are only shown conceptually in Figure 7A. This obligation under the Mount Owen Consent remains irrespective of any changes associated with the Project. Accordingly, the rehabilitation potentially impacted by the Project does not fall within the definition of Category 2-regulated land as extended by clause 113 of the LLS Regulation.

All Category 2-regulated land mapping available on the Native Vegetation Regulatory Map has been applied to the definition of Category 1-exempt land and is discussed further in **Section 3.2**.

2.0 Methodology

The process for identifying Category 1-exempt land has adopted the following basic process:

- identify land had had been disturbed and could meet the requirements of Category 1-exempt land on this basis
- exclude land that meets the requirements of Category 2-regulated land, vulnerable regulated land or sensitive regulated land

2.1 Mapping of Category 1-Exempt Land

Category 1-exempt land areas were identified through the following process:

- aerial photography/imagery from 1967 to July 2017 was reviewed.
- areas which were identified as having been lawfully cleared /disturbed as set out above were then mapped using geo-rectified imagery.

Figure 2.1 shows illustrative snapshot years of the aerial photography viewed. A full list of the imagery and detailed metadata is set out in **Section 4.0**.

'Cleared as at 1990' has been interpreted as areas where there is clear evidence of the complete removal of all vegetation or evidence of compositional change in the grassland prior to 1990 and in which shrubs or trees had not regrown prior to 1990. It should be noted that for the purposes of this assessment an aerial photo from 1993 has been included as the 1990 aerial was not available.

Complete removal of native vegetation has been interpreted for the purposes of the mapping as being areas where complete removal of ground cover has occurred, namely:

- areas that were cropped/ploughed or significantly disturbed (see clause 114 of the LLS Regulation) for agricultural purposes
- areas disturbed by approved mining (or other) approved activities.

Change in composition has been identified through evidence of comparison of sequential aerial photographs which indicate a clear change in the form of the grassland and that change is sustained for at least an additional subsequent image.

It is noted that some areas of historical disturbance from mining related activities had commenced regeneration prior to 1990 and where these areas have not been again disturbed post 1990, these have been excluded from the areas mapped as being Category 1-exempt land.

Areas disturbed as a result of mining related disturbance have been checked against historical approvals to confirm the disturbance of these areas was lawful. The identification of these areas is set out in **Section 3.0**.

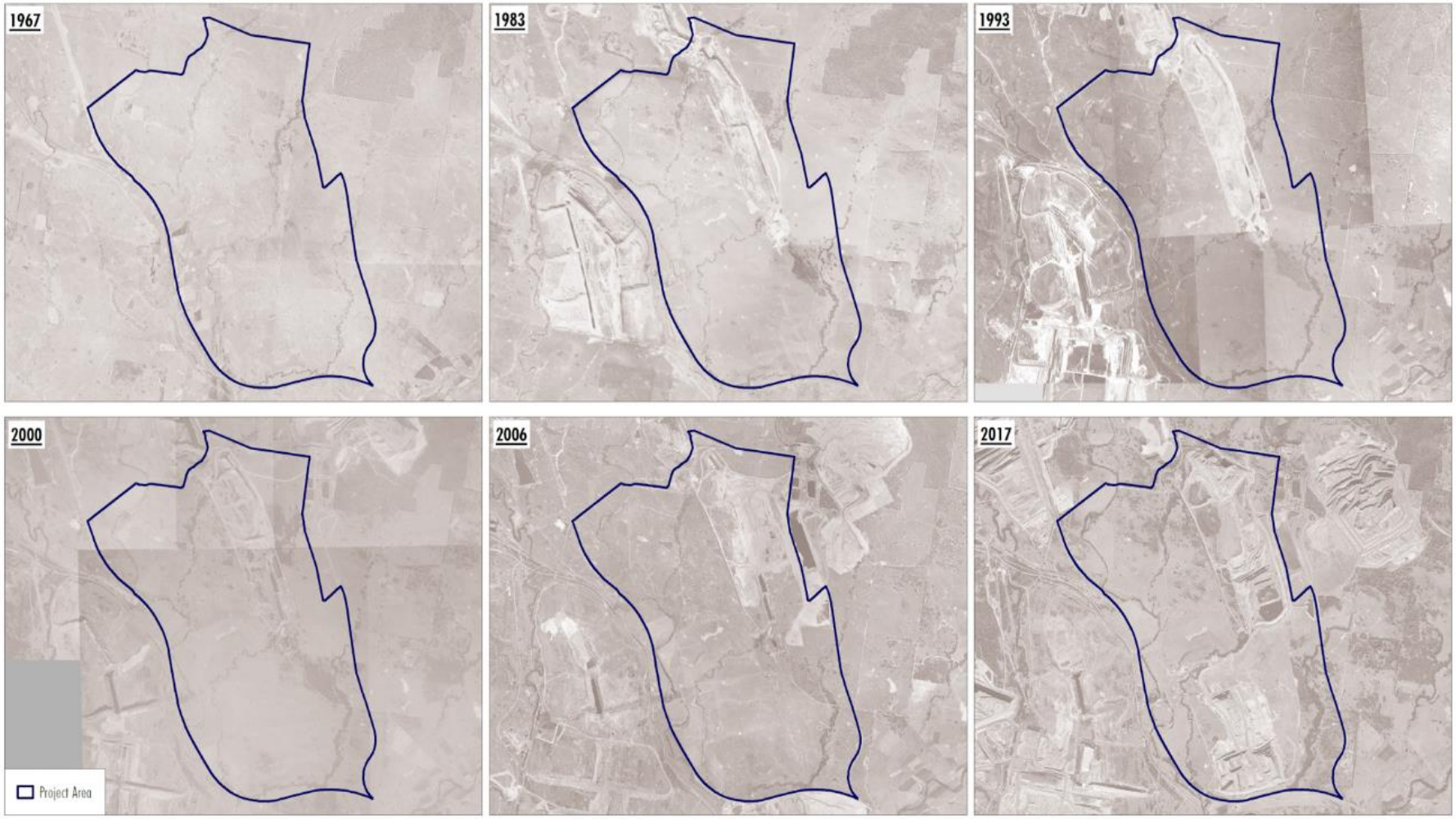

Figure 2.1 Historic Aerial Photography Overview

© Image Source: NSW LPI Historic Aerial Photography (1967, 1983, 1993, 2000); Glencore (2006, 2017)

2.2 Category 2-Regulated Land Exclusion Process

The Category 2-sensitive regulated land and vulnerable regulated land layers from the DPIE SEED data portal have been applied to the Project Area in order to exclude Category 2-regulated land from the areas mapped as being Category 1-exempt land. The data layers are applied to aerial photography to illustrate where the landscape has changed by mining, to identify where the Category 2-regulated land mapping layer no longer applies, (refer to **Section 3.2**).

Biodiversity offset areas established under development consents in the area are also considered in **Section 3.2.**

3.0 Mapping of Category 1-Exempt Land

3.1 Category 1-Exempt Land Mapping

Figures 3.1 to **3.6** provide a detailed review of the historic aerial photographs from 1967 to July 2017, with relevant disturbance annotated.

Figure 3.7 shows the areas within the Project Area where the review of historic aerial photography determined that they were cleared as of 1990 or were lawfully cleared between 1990 and 25 August 2017.

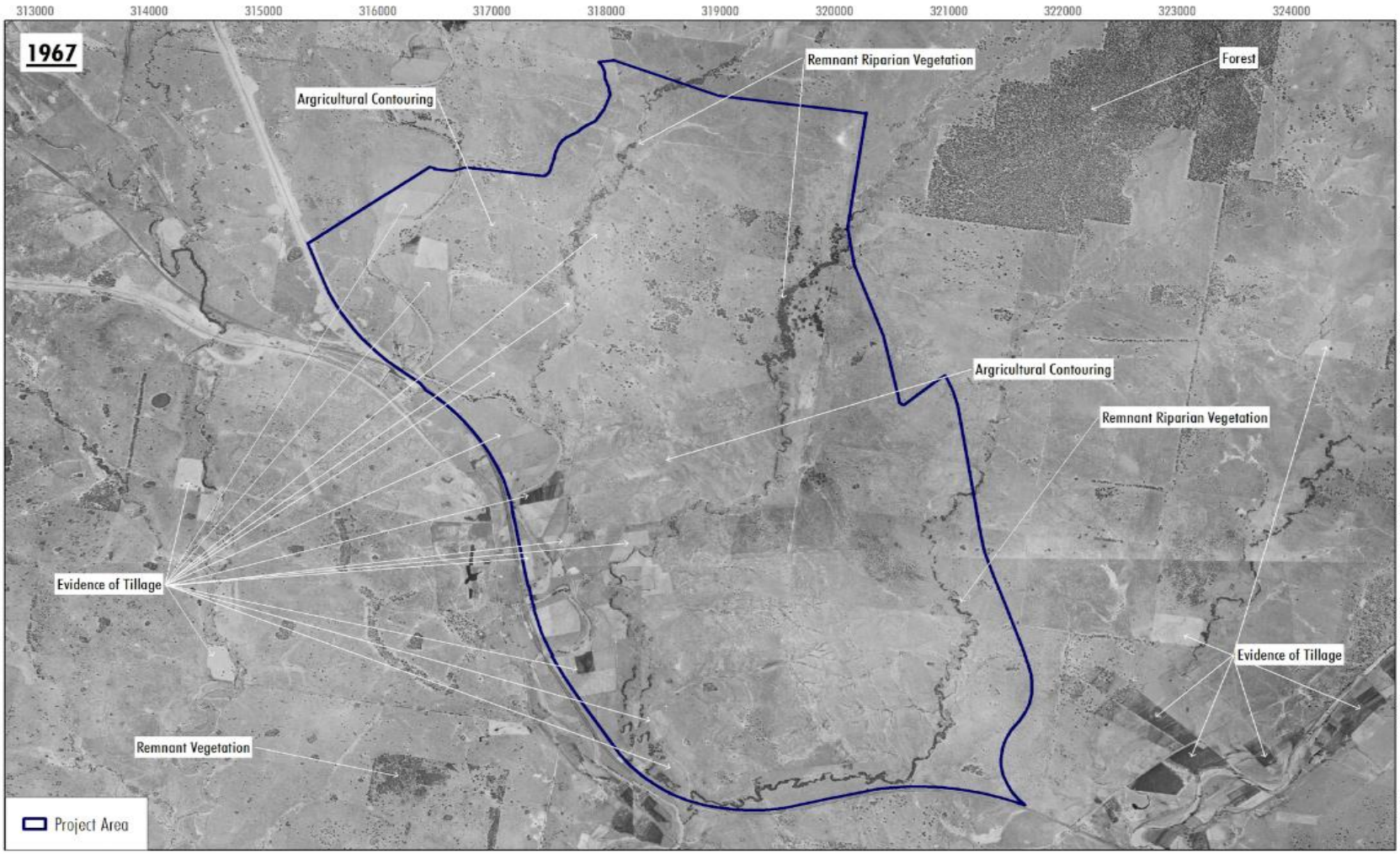

Figure 3.1 Historic Aerial Photo Review - 1967

© Image Source: NSW LPI Historic Aerial Photography (1967); Glencore (2019)

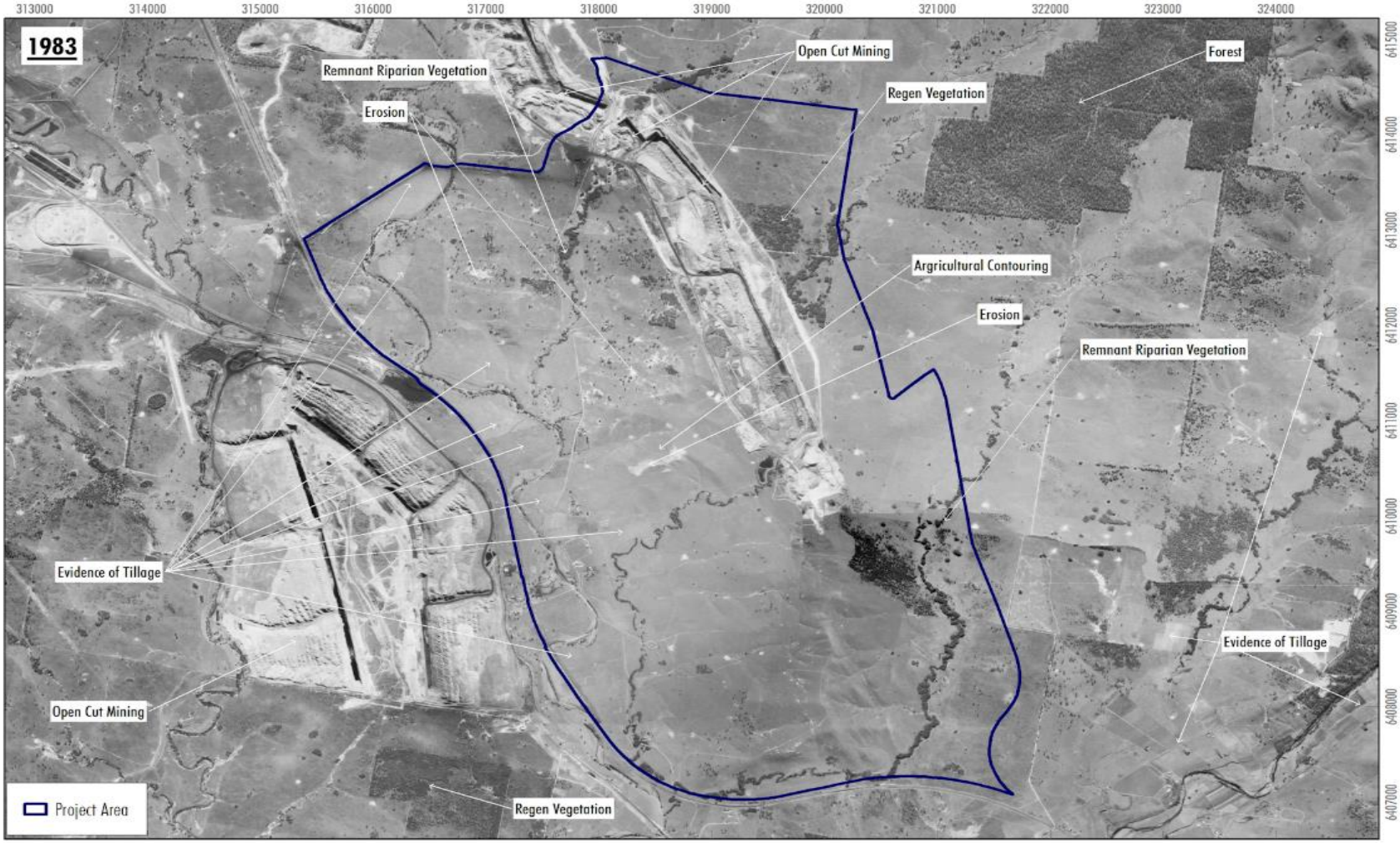

Figure 3.2 Historic Aerial Photo Review - 1983

© Image Source: NSW LPI Historic Aerial Photography (1983); Glencore (2019)

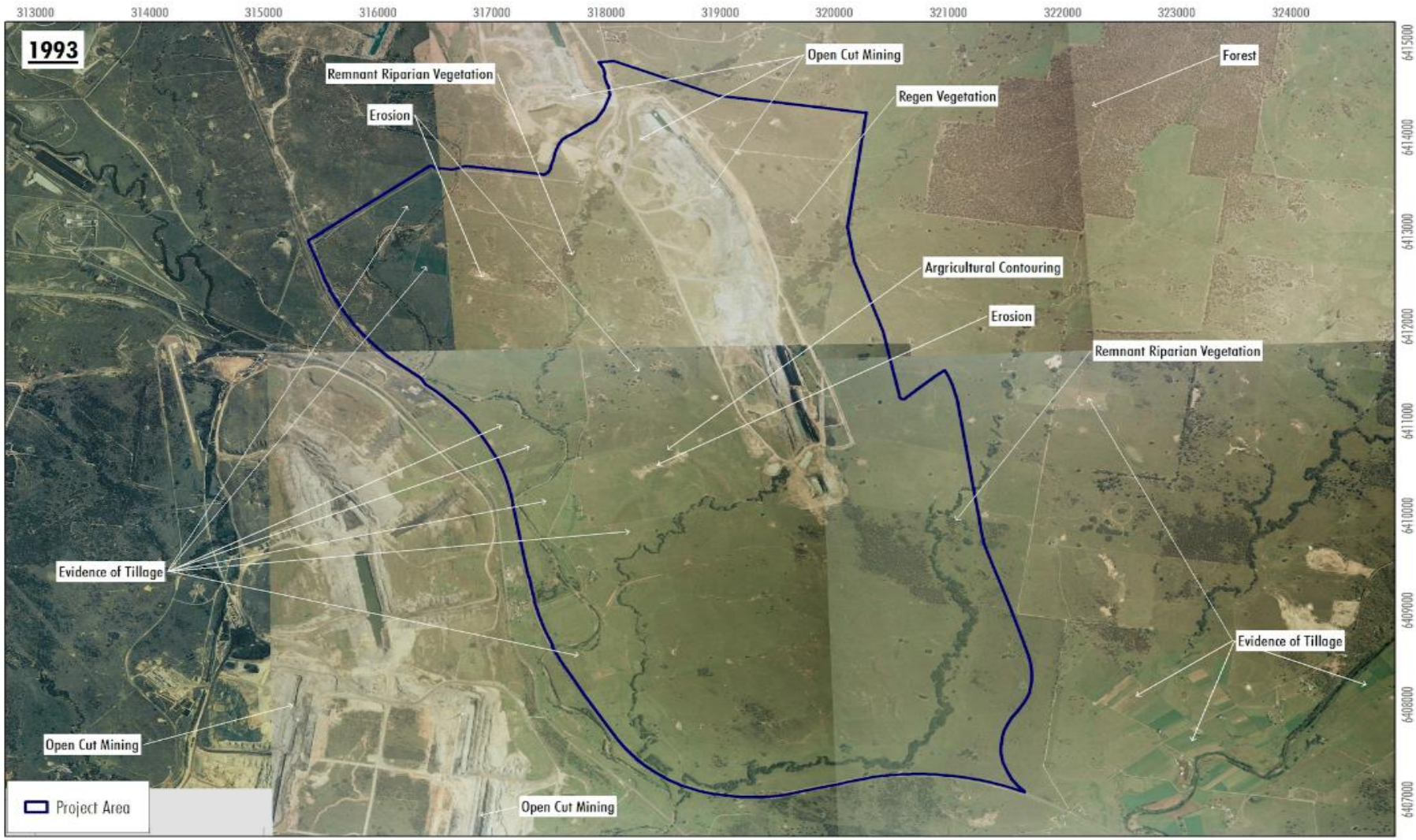

Figure 3.3 Historic Aerial Photo Review - 1993

© Image Source: NSW LPI Historic Aerial Photography (1993); Glencore (2019)

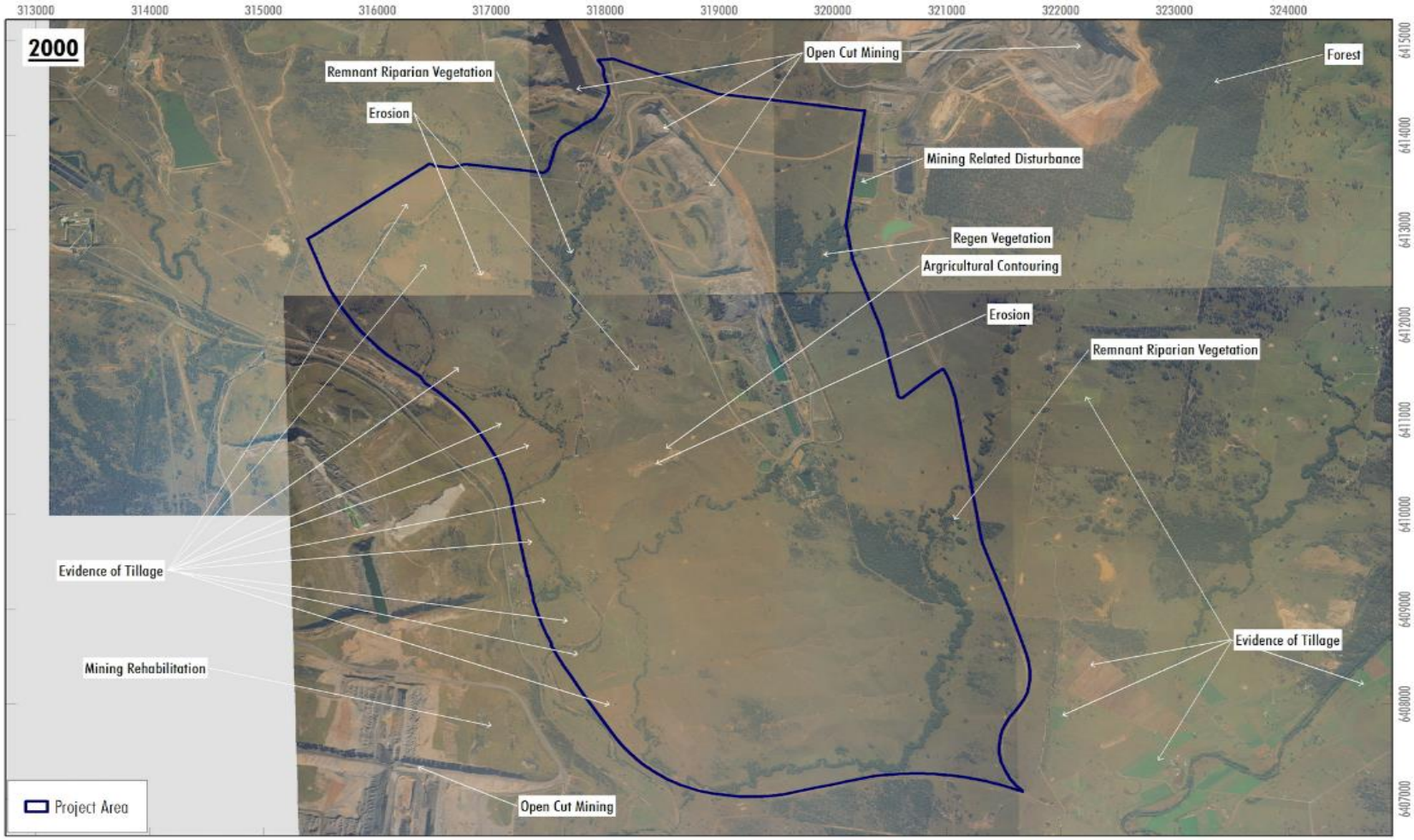

Figure 3.4 Historic Aerial Photo Review - 2000

© image source: NSW LPI Historic Aerial Photography (2000); Glencore (2019)

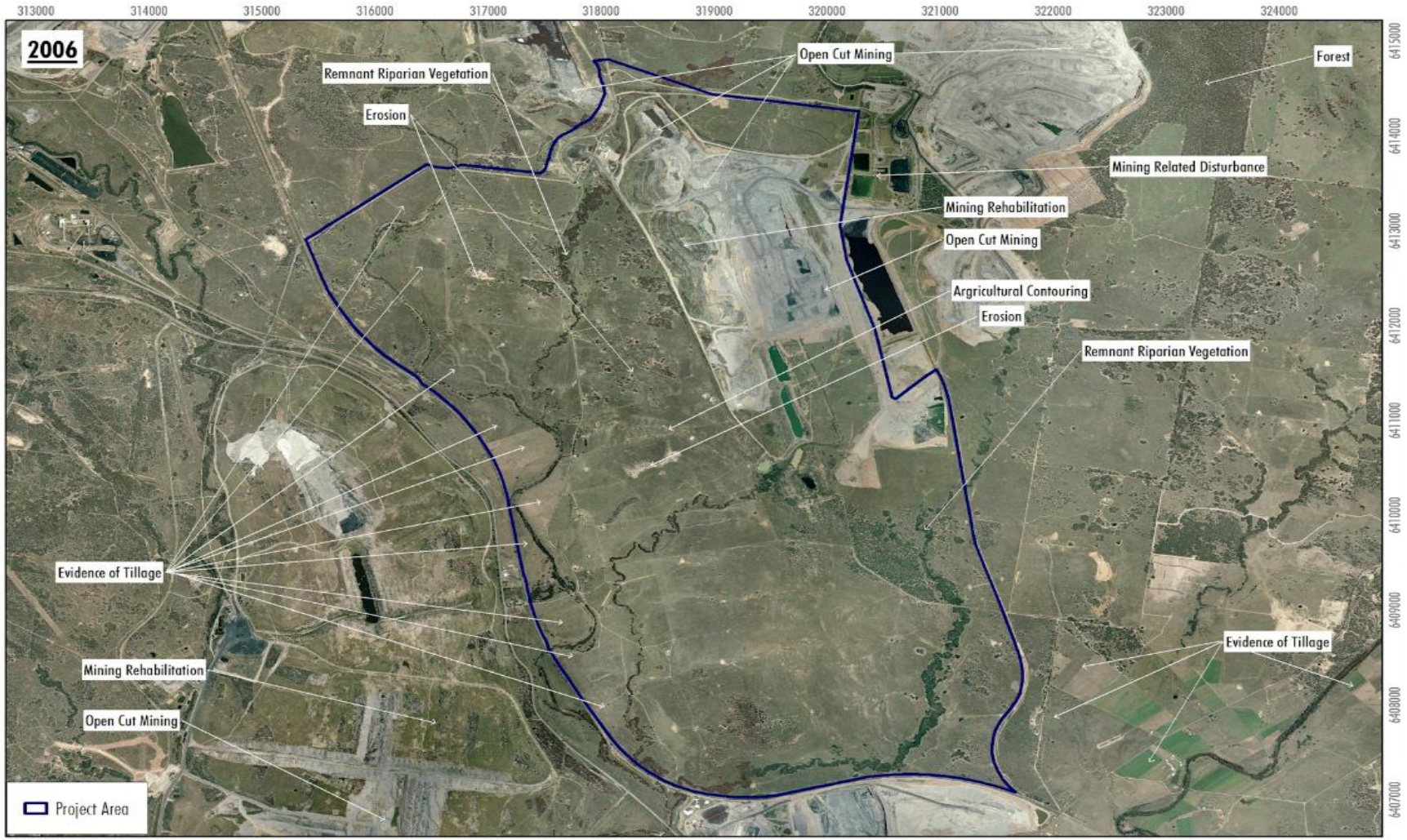

Figure 3.5 Historic Aerial Photo Review - 2006

© Image Source: Glencore (2006); Glencore (2019)

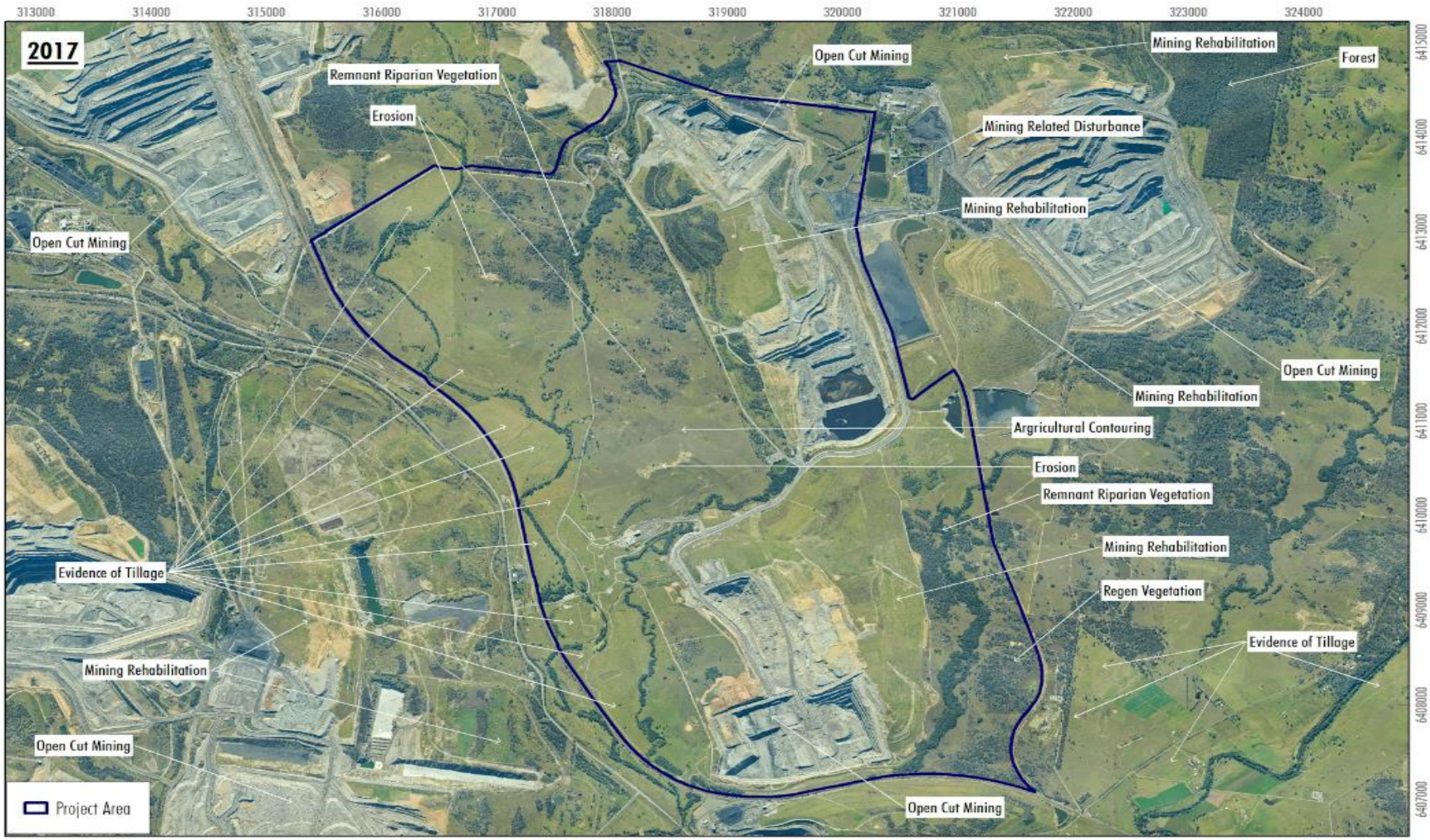

Figure 3.6 Aerial Photo Review – July 2017

© Image Source: Glencore (2017); ; Glencore (2019)

Figure 3.7 Disturbed Areas

© Image Source: Glencore (2017); Umwelt (2019); Glencore (2019)

3.2 Areas Excluded as Category 2-Regulated Land

Figure 3.8 shows the areas mapped as being Category 2-regulated land or areas otherwise meeting the requirements of Category 2-regulated land under the LLS Act or LLS Regulation. The DPIE SEED mapping identifies the Ravensworth Sate Forest and some of the existing Mount Owen Biodiversity Offset Areas as land excluded from the LLS Act.

As can be seen from **Figure 3.8**, there is no mapped sensitive regulated land within the Project Area. There are areas mapped as vulnerable regulated land associated with Bowmans Creek, Yorks Creek, Swamp Creek and Bettys Creek. The vulnerable regulated land mapping obtained from DPIE SEED appears to be based on historical terrain data as mining voids have been mapped as being vulnerable land, likely due to a slope filter being applied to define vulnerable regulated land. As mining voids would not typically be considered vulnerable regulated land, these have been excluded from further consideration. Similarly, areas impacted by mining related disturbance have altered the terrain in these areas. Accordingly, apart from creek lines which remain extant as of 25 August 2017, these areas are similarly not considered as being vulnerable regulated land.

The historical agricultural disturbance (evidence of tillage) mapping (refer to **Figure 3.7**) within the Project Area excluding the areas mapped as Category 2-vulnerable regulated land or areas otherwise meeting the requirements of Category 2-regulated land is shown in **Figure 3.9**.

Other areas of consideration, including existing approved mine disturbance, Biodiversity Offset Areas and Ravensworth State Forest, are shown on **Figure 3.10**.

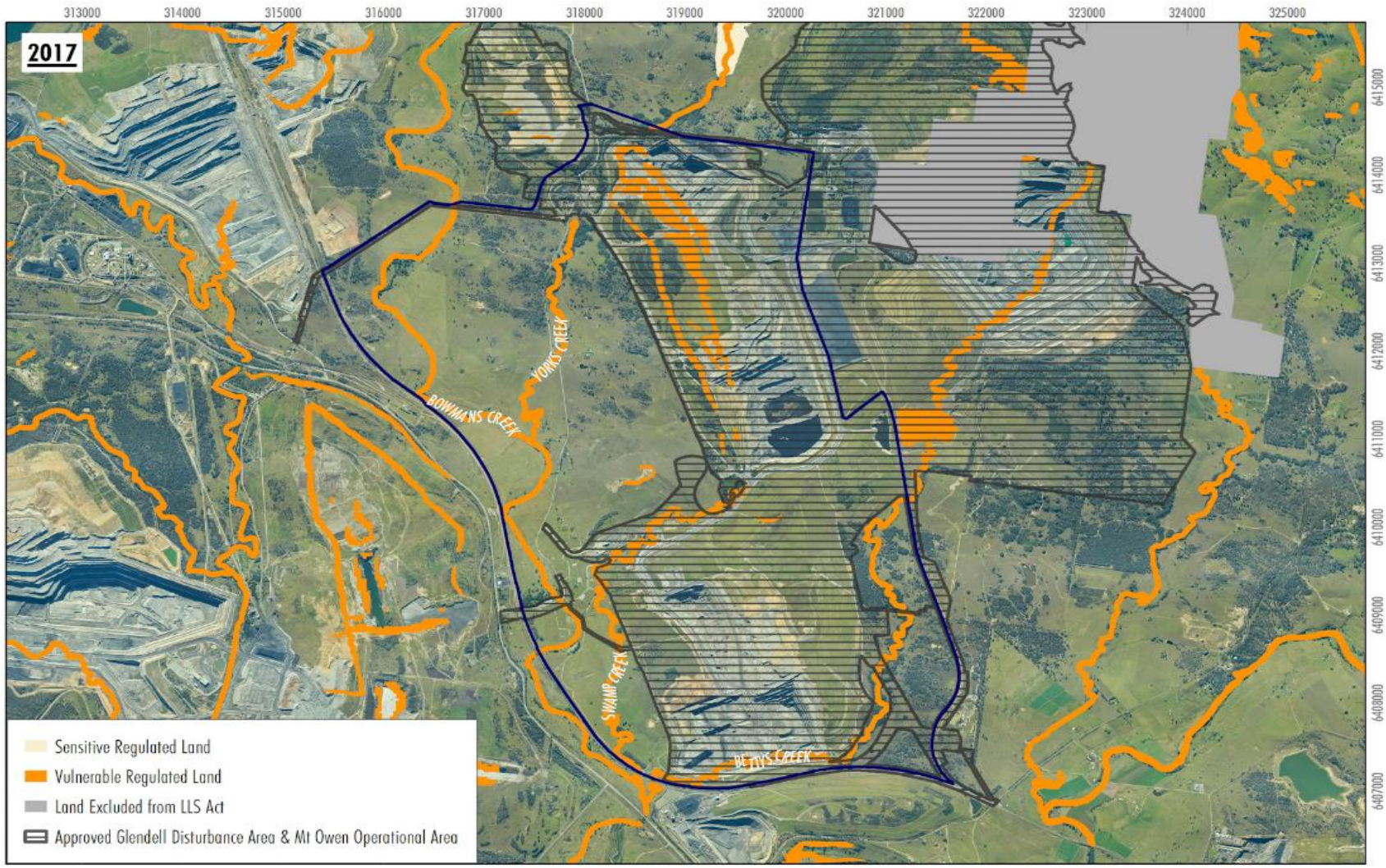

Figure 3.8 Category 2 - Regulated Land

© Image Source: Glencore (2017); DPIE SEED (2019); Glencore (2019)

Figure 3.9 Historic Agricultural Disturbance Excluding Category 2 - Regulated Land

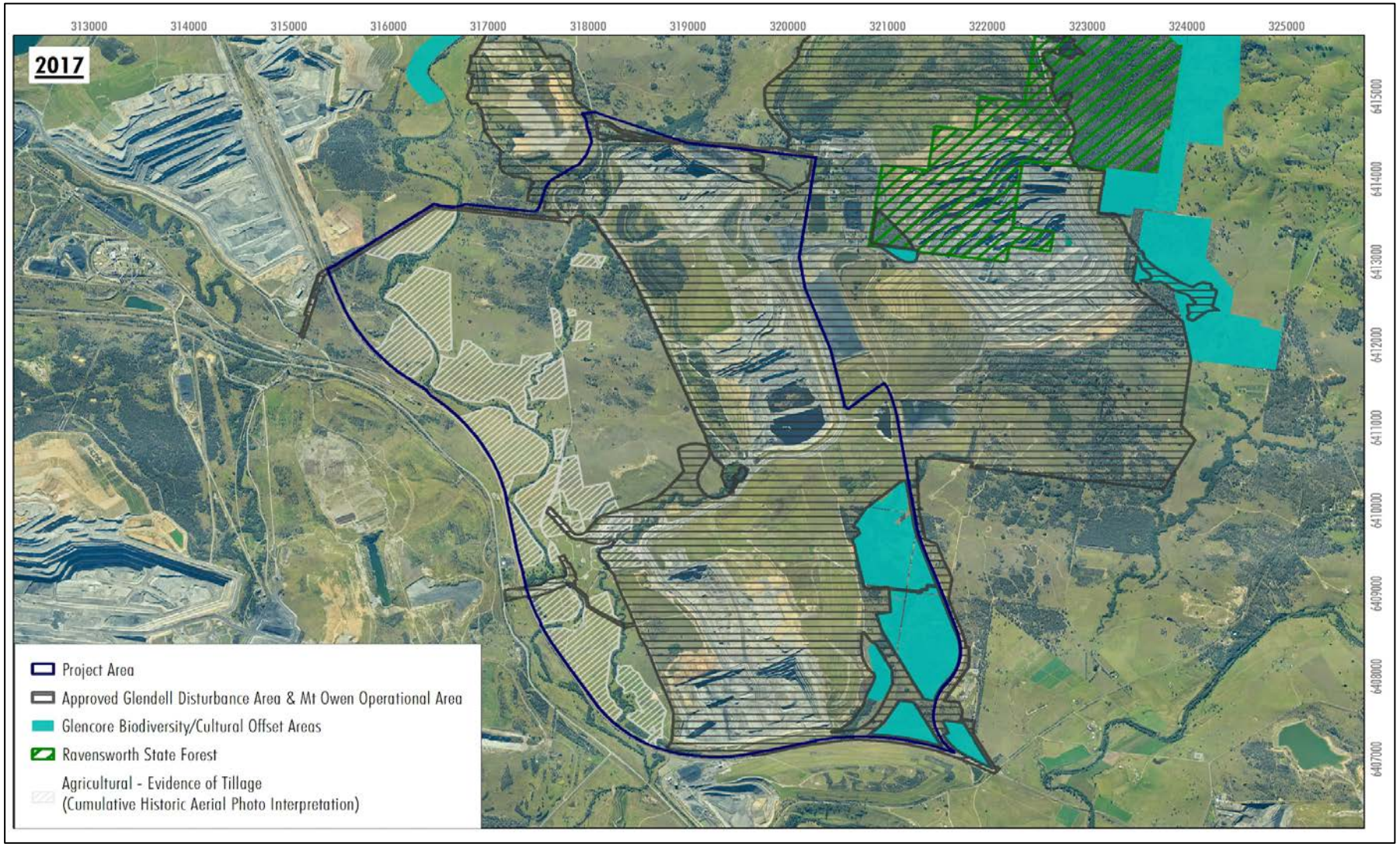

Figure 3.10 Historic Disturbed Areas and other areas of consideration

© Image Source: Glencore (2017); Umwelt (2019); Glencore (2019) ; Forestry Corp

3.3 Identified Category 1-Exempt Land within the Project Area

While the agricultural contouring earthworks (refer to **Figure 3.7**) involved extensive ground disturbance (earthworks approximately 4-5 m apart), a decision was made not to include these areas as works that would qualify as 'clearing' due to the remnant grassland remaining between contours. Accordingly, the land mapped as Category 1-exempt land was identified as the land where evidence of agricultural (tillage) clearing was observed and the approved mining disturbance areas but excluding areas which were either mapped as Category 2-regulated land or were identified as biodiversity offset areas. The area mapped as Category 1-exempt land within the Project Area is shown in **Figure 3.11.**

The Category 1-exempt land mapping was then applied to the Additional Disturbance Area for the Project in order to exclude the mapped Category 1-exempt land and determine the appropriate Development Footprint for the BDAR (refer to **Figure 3.12**).

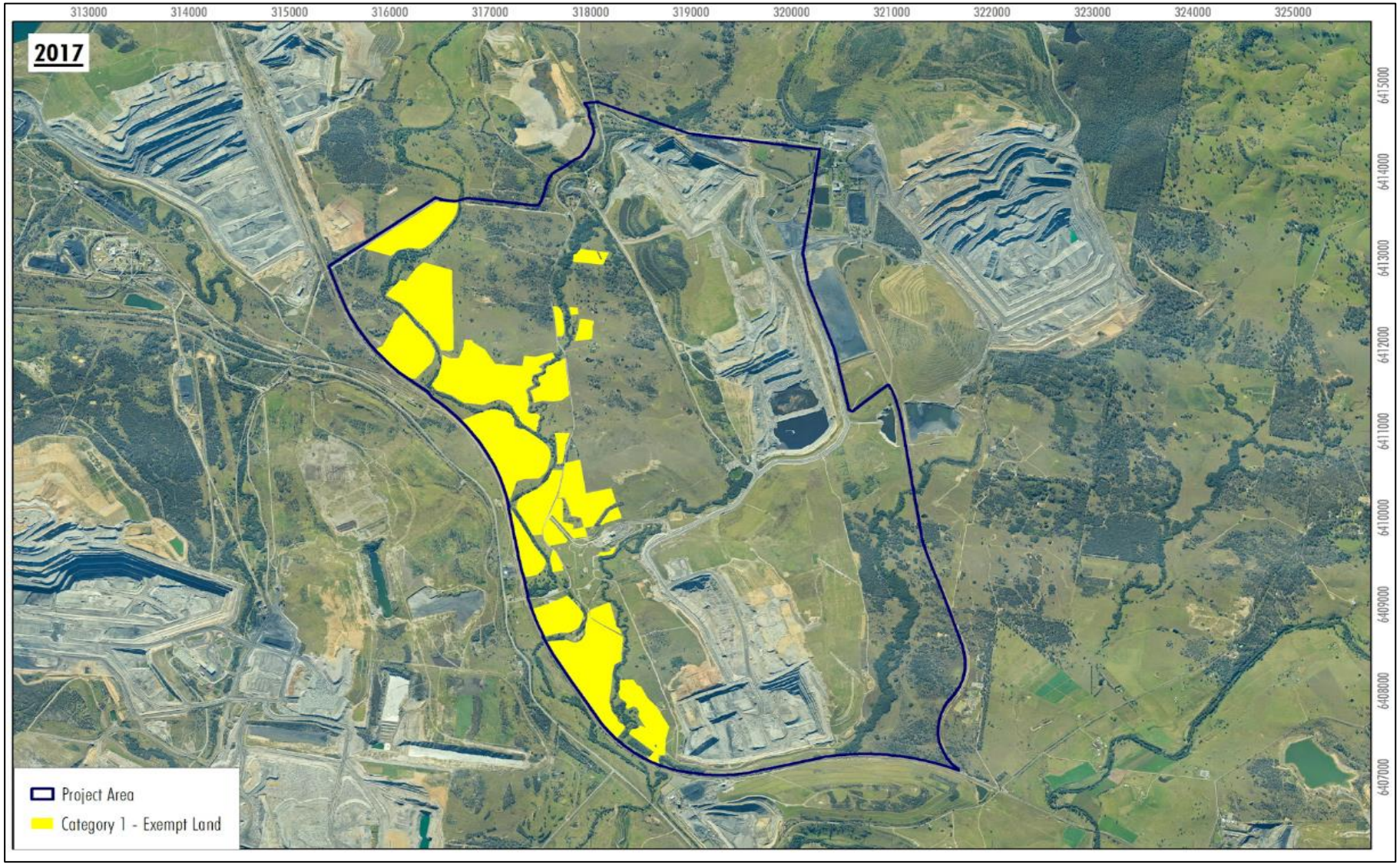

Figure 3.11 Category 1-Exempt Land

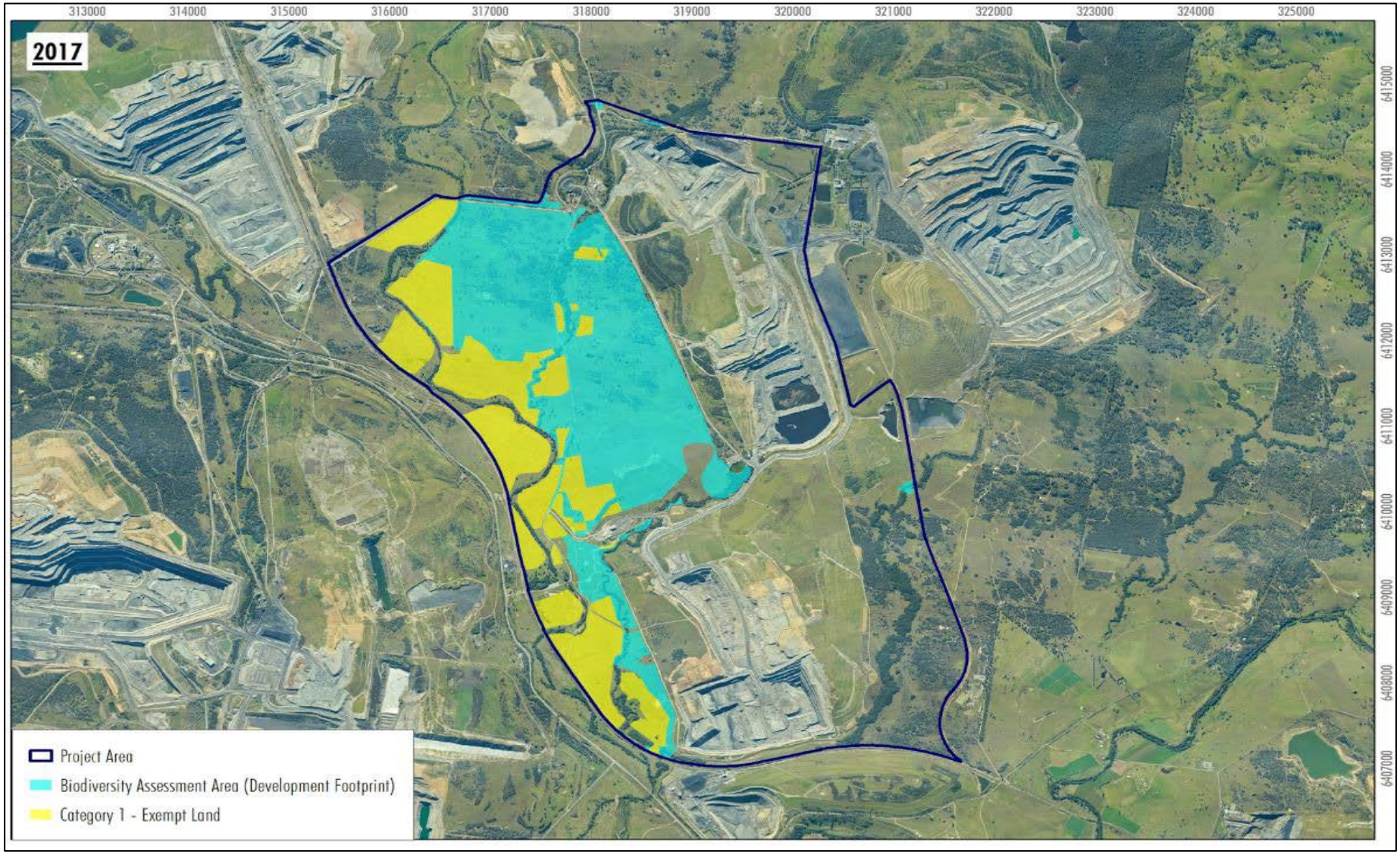

Figure 3.12 Biodiversity Assessment Area - Development Footprint

© Image Source: Glencore (2017); Umwelt (2019); Glencore (2019)

4.0 Metadata List

Images	Date	Source
Combined_Aerials_19670107_rev1_georef_MGA56.ecw	7/01/1967	NSW LPI Historical Aerial Photography
Combined_Aerials_19830722_rev1_georef_mga56 2.ecw	22/07/1983	NSW LPI Historical Aerial Photography
4106_12_223.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4109_10_093.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4109_10_095.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4109_11_168.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4109_11_170.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4109_11_172.jp2	30/06/1993	NSW LPI Historical Aerial Photography
4106_12_225.jp2	30/06/2000	NSW LPI Historical Aerial Photography
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4480_11_148.jp2	30/06/2000	NSW LPI Historical Aerial Photography
4480_12_135.jp2	30/06/2000	NSW LPI Historical Aerial Photography
4480_12_137.jp2	30/06/2000	NSW LPI Historical Aerial Photography
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AERIAL_May03.jpg	30/05/2003	NSW LPI
GLENDELLOCT2006.jpg	30/10/2006	Glencore
MTOWENOCT2006.jpg	30/10/2006	Glencore
GE_2007_5_3.jpg	3/05/2007	Google Earth
GE_2009_5_15.jpg	15/05/2009	Google Earth
19468A_Narama_120113.ecw	13/01/2012	Glencore
19468A_Ravensworth_2m_13012012.ecw	13/01/2012	Glencore
9950A_Glendell_1m_250612.ecw	25/06/2012	Glencore
Mt_Owen_G_Aerial_Oct13_MGA56_20131111.ecw	11/11/2013	Glencore
NSW_Landuse_2013_FeatureClass	1/12/2013	DPIE
22360A_Greater_Ravensworth_Ortho_20Dec2013_Mga 56_2M.jpg	20/12/2013	Glencore
ROC_2m_Overall_20141217.jpg	17/12/2014	Glencore
EPSG28356_Date20150306_Lat-32.416141_Lon151.077552_Mpp2.389.jpg	6/03/2015	Nearmap
Ravensworth_50cm_Overall_Quickview.ecw	Sep-15	Glencore
EPSG28356_Date20151230_Lat-32.416141_Lon151.077552_Mpp2.389.jpg	30/12/2015	Nearmap
EPSG28356_Date20161102_Lat-32.416141_Lon151.077552_Mpp2.389.jpg	2/11/2016	Nearmap
EPSG28356_Date20180207_Lat-32.416141_Lon151.077552_Mpp2.389.jpg	7/02/2018	Nearmap
Ravensworth_04Jul2018_RGB_1m.ecw	4/07/2018	Glencore

Images	Date	Source
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Glendell_03July2017_RGB_50cm.ecw	3/07/2017	Glencore
Ravensworth_03July2017_RGB_50cm.ecw	3/07/2017	Glencore

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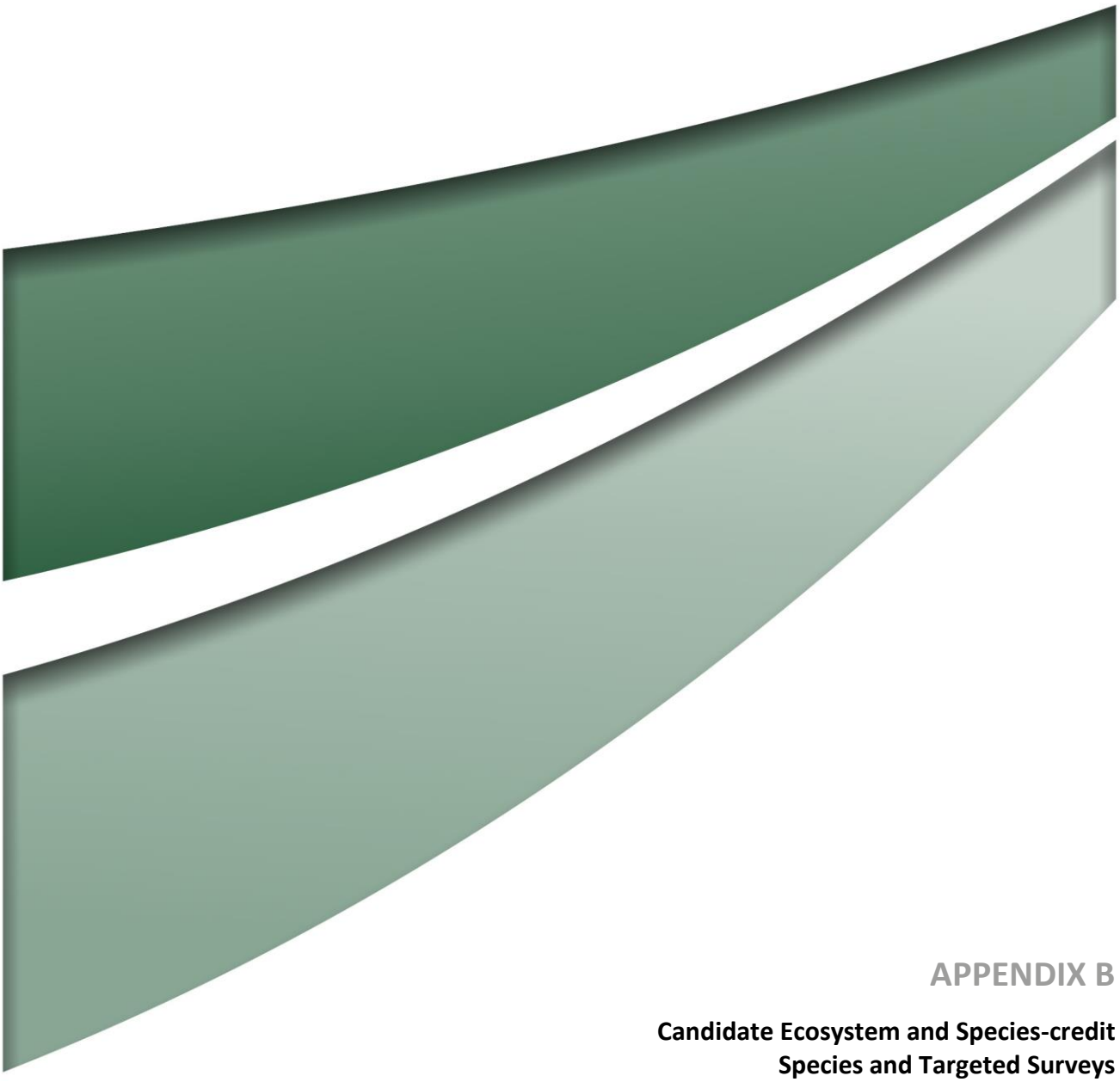


APPENDIX B

Candidate Ecosystem and Species-credit Species and Targeted Surveys

Table B1.1 Ecosystem-credit Species

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
regent honeyeater ***Anthochaera phrygia***	CE	CE	No	No	1603 – Moderate Good 1603 – Regeneration 1604 – Woodland Rehabilitation 1603 – Plantation 485 – Moderate Good
dusky woodswallow ***Artamus cyanopterus cyanopterus***	V	-	Yes	Yes	1603 – Moderate Good 1603 – Plantation 1603 – Plantation
gang-gang cockatoo ***Callocephalon fimbriatum***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1731 – Moderate Good 1731 – Plantation 1603 – Plantation
glossy black-cockatoo ***Calyptorhynchus lathami***	V	-	No	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
speckled warbler ***Chthonicola sagittata***	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
spotted harrier ***Circus assimilis***	V	-	Yes	Yes	1731 – Moderate Good 1731 – Plantation
brown treecreeper (eastern subspecies) ***Climacteris picumnus victoriae***	V	-	Yes	No	1603 – Moderate Good 1603 – Regeneration 1604 – Woodland Rehabilitation 1603 – Plantation
varied sittella ***Daphoenositta chrysoptera***	V	-	Yes	No	1603 – Moderate Good 1603 – Regeneration 1604 – Woodland Rehabilitation 1731 – Moderate Good 1731 – Plantation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
spotted-tailed quoll ***Dasyurus maculatus***	V	E	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1603 – DNG 1692 – Moderate Good 1604 – Woodland Rehabilitation 1731 – Moderate Good 1731 – Plantation 1603 – Plantation
eastern false pipistrelle **Falsistrellus tasmaniensis**	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
little lorikeet ***Glossopsitta pusilla***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation 485 – Moderate Good

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
painted honeyeater ***Grantiella picta***	V	V	No	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation 485 – Moderate Good
white-bellied sea-eagle ***Haliaeetus leucogaster***	V	-	Yes	Yes	1692 – Regeneration 1692 – Moderate Good 1731 – Moderate Good 1731 – Plantation
little eagle ***Hieraaetus morphnoides***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1603 – DNG 1692 – Moderate Good 1604 – Woodland Rehabilitation 1604 – Exotic Grassland Rehabilitation 1731 – Moderate Good 1731 – Plantation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
swift parrot ***Lathamus discolor***	E	CE	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
square-tailed kite **Lophoictinia isura**	V	-	No	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1603 – DNG 1692 – Moderate Good 1604 – Woodland Rehabilitation 1604 – Exotic Grassland Rehabilitation 1603 – Plantation
hooded robin (south-eastern form) ***Melanodryas cucullata***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
black-chinned honeyeater (eastern subspecies) ***Melithreptus gularis***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
little bentwing-bat *Miniopterus australis*	V	-	Yes	No	1604 – Woodland Rehabilitation
eastern bentwing-bat *Miniopterus schreibersii oceanensis*	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
eastern freetail-bat *Mormopterus norfolkensis*	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
turquoise parrot *Neophema pulchella*	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
barking owl ***Ninox connivens***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1731 – Moderate Good 1731 – Plantation 1603 – Plantation 485 – Moderate Good
powerful owl ***Ninox strenua***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1603 – DNG 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
yellow-bellied glider **Petaurus australis**	V	-	No	No	1604 – Woodland Rehabilitation
scarlet robin ***Petroica boodang***	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
flame robin ***Petroica phoenicea***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
koala ***Phascolarctos cinereus***	V	V	Yes^	No	1603 – Moderate Good 1603 – Regeneration 1604 – Woodland Rehabilitation 1603 – Plantation
grey-crowned babbler (eastern subspecies) ***Pomatostomus temporalis***	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
grey-headed flying-fox ***Pteropus poliocephalus***	V	V	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

Species	BC Act	EPBC Act	Previously Recorded		Predicted Vegetation Zones
			Mount Owen Complex	Development Footprint	
yellow-bellied sheathtail-bat ***Saccolaimus flaviventris***	V	-	Yes	Yes	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
greater broad-nosed bat ***Scoteanax rueppellii***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation
diamond firetail ***Stagonopleura guttata***	V	-	Yes	No	1604 – Woodland Rehabilitation
eastern grass owl ***Tyto longimembris***	V	-	Yes	No	1731 – Moderate Good 1731 – Plantation
masked owl ***Tyto novaehollandiae***	V	-	Yes	No	1692 – Regeneration 1603 – Moderate Good 1603 – Regeneration 1603 – DNG 1692 – Moderate Good 1604 – Woodland Rehabilitation 1603 – Plantation

^ As defined by mapping products by OEH.

Table B1.2 identifies the candidate species-credit species predicted by the BAM calculator or identified in the literature review and documents the surveys undertaken within the Development Footprint for each species.

Table B1.2 Candidate Species-credit Species

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
Flora Species						
Bynoe's wattle *Acacia bynoeana*	E	V	All year	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes slightly disturbed areas of heath and dry sclerophyll forest which was not recorded in the Development Footprint.
***Acacia pendula* population in the Hunter catchment**	EP	-	All year	-	N/A	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. The *Acacia pendula* Hunter population is currently known to occur at six locations within the Muswellbrook and Singleton LGAs (OEH 2018). Suitable habitat for this population includes open grasslands.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
trailing woodruff *Asperula asthenes*	V	V	Oct-Nov	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes damp sites, often along river banks.
netted bottle brush *Callistemon linearifolius*	V	-	Oct-Jan	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a), and in 2016 as part of the Mount Owen Continued Operations Modification 2. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes dry sclerophyll forest.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
***Cymbidium canaliculatum* population in the Hunter Catchment**	EP	-	All year	Must be within Hunter catchment as defined by Australia's River Basins (Geoscience Australia 1997). Epiphytic in a range of Eucalypts and Angophora. Cut stumps or logs on ground.	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted surveys for threatened orchid species were also undertaken in the wider locality in 2016 as part of the Mount Owen Continued Operations Modification 2. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat of this species includes hollows, fissures, trunks and forks of trees in dry sclerophyll forest or woodland, where its host trees typically occur on Permian Sediments of the Hunter Valley floor.
white-flowered wax plant *Cynanchum elegans*	E	E	All year	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes sclerophyll forest and woodlands.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
pine donkey orchid *Diuris tricolor*	V	-	Sep-Oct	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted surveys for threatened orchid species were also undertaken in the wider locality in 2016 as part of the Mount Owen Continued Operations Modification 2. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes sclerophyll forest among grass, often with native Cypress Pine (*Callitris* spp.).
***Eucalyptus camaldulensis* population in the Hunter catchment**	EP	-	All year	Floodplains of watercourses, including rivers, creeks, intermittent streams or billabongs.	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a), and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. The *Eucalyptus camaldulensis* Hunter population is currently known to occur in seven LGAs, including Muswellbrook and Singleton (OEH 2018). Suitable habitat for this population includes woodland and open woodland on floodplains.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
slaty red gum ***Eucalyptus glaucina***	V	V	All year	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes grassy woodland and dry eucalypt forest.
Eucalyptus parramattensis **subsp.** ***decadens***	V	V	All year	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes dry sclerophyll woodland.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
small-flower grevillea *Grevillea parviflora* subsp. *parviflora*	V	V	Aug-Nov	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes heath, shrubby woodland and open forest.
large-leafed Monotaxis *Monotaxis macrophylla*	E	-	Aug - Feb	-	No	Targeted threatened flora walking transects were undertaken across the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes rocky ridges and hillsides.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
Ozothamnus tesselatus	V	V	Sept-Oct	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes eucalypt woodland.
tall knotweed ***Persicaria elatior***	V	V	Dec-May	Within 50m of semi-permanent/ephemeral wet areas, swamps and waterbodies.	No	Targeted searches for this species was undertaken in suitable wetland habitat in conjunction with the March 2017 and March 2018 amphibian surveys (refer to **Figure 2.4**), floristic surveys in January, February and March 2018 (refer to **Figure 2.1**) and aquatic surveys in February and March 2018. Targeted threatened flora searches were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes damp areas, such as dams, creeks and swamp forests.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
scant pomaderris ***Pomaderris queenslandica***	E	-	All year	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a) and the Mount Owen Continued Operations Modification 2 in 2016. Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.
Singleton mint bush ***Prostanthera cineolifera***	V	V	Sept-Oct	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes open woodlands on exposed sandstone ridges.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
Pterostylis chaetophora	V		Sept-Nov	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes open forest or woodland, on flat or gently sloping land with poor drainage
Illawarra greenhood ***Pterostylis gibbosa***	E	E	Sept-Oct	-	No	Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). Targeted threatened flora searches were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in October 2011 and 2012 (Umwelt 2014) as well as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 (Umwelt 2015a). Opportunistic observations were completed throughout all Umwelt survey periods. Suitable habitat for this species includes open forest or woodland, on flat or gently sloping land with poor drainage.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
Fauna Species						
regent honeyeater ***Anthochaera phrygia***	CE	CE	N/A	*Important habitat only.* (as defined by mapping products supplied by the BCD)	Yes	While it is acknowledged that surveys are not required for this species under the BAM (due to habitat being confirmed through BCD mapping products), targeted regent honeyeater surveys were undertaken across the Development Footprint in 13 locations in June 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Regent honeyeater 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. The surveys targeted areas of quality habitat and flowering resources for the regent honeyeater and were timed to coincide with the known presence of the species in the Hunter Valley. A total of 13 person hours of survey were conducted across the Development Footprint. Furthermore, habitat assessments to determine the extent of potential resource trees as per the National Recovery Plan for the Regent Honeyeater (DoE 2016) were also undertaken across the vegetation communities of the Development Footprint in June 2018. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted winter bird surveys have been previously undertaken in the wider locality as part of the Mount Owen Continued Operations Project in August 2011, June 2012 and July 2014, and the Mount Owen Continued Operations Modification 2 in 2016. Diurnal winter bird searches are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
bush stone-curlew *Burhinus grallarius*	E	-	All year	Fallen/standing dead timber including logs.	No	Targeted nocturnal call playback and spotlighting surveys were undertaken across the Development Footprint in 19 locations in March 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Bush stone-curlew 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. A total of 19 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Spotlighting surveys have been undertaken in in the wider locality as part of the Mount Owen Continued Operations Project and the Greater Ravensworth Upper Hunter Strategic Assessment in 2011, 2012, 2013 and 2014. Spotlighting surveys are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
gang-gang cockatoo ***Callocephalon fimbriatum***	V	-	Oct-Jan	*Breeding habitat only.* Eucalypt tree species with hollows greater than 9 cm diameter.	No	Diurnal bird surveys were conducted in January and June 2018 at 23 locations across the Development Footprint which included targeted searches for potential nest trees (refer to **Figure 2.4**). Surveys were conducted at each site for a minimum of 30 minutes. 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. Potential breeding habitat for the species was inspected for breeding pairs. Suitable tree species containing hollows greater than 9 cm were recorded. A total of 23.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Diurnal and opportunistic bird surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and diurnal bird surveys are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
glossy black-cockatoo ***Calyptorhynchus lathami***	V	-	Mar-Aug	*Breeding habitat only.* Living or dead tree with hollows greater than 15cm diameter and greater than 5m above ground.	No	Diurnal bird surveys were conducted in January and June 2018 at 23 locations across the Development Footprint which included targeted searches for potential nest trees (refer to **Figure 2.4**). Surveys were conducted at each site for a minimum of 30 minutes. 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. Potential breeding habitat for the species was inspected for breeding pairs. Suitable tree species containing hollows greater than 15 cm were recorded. A total of 23.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Diurnal and opportunistic bird surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and diurnal bird surveys are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
eastern pygmy-possum *Cercartetus nanus*	V	-	Oct-Mar	-	No	Nocturnal spotlighting searches were undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Bushnell Trophy Cam HD cameras were installed at 20 locations within and surrounding the Development Footprint from 26 October 2017 to 9 March 2018 (135 nights). 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 peanut butter, honey and tuna. Cameras were set to take three photos in quick succession when movement was detected. Opportunistic observations were completed throughout all Umwelt survey periods. Remote camera surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and Elliot trapping and spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
large-eared pied bat ***Chalinolobus dwyeri***	V	V	Nov-Jan	*Breeding habitat only.* Within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels.	Yes	Opportunistic observations for potential rocky areas containing caves, overhangs, escarpments, outcrops and crevices and old mines or tunnels were undertaken throughout Umwelt's survey periods, including in January and November 2018. The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Development Footprint from 5 March to 9 March 2018 (refer to **Figure 2.4**). At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flyaways along areas of suitable habitat. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. A total of 16 survey nights were undertaken across the Development Footprint. All recorded calls were analysed by Anna McConville of Echo Ecology using AnalookW (Version 4.2n) software. The identification of calls was undertaken with reference to Pennay *et al*. (2004) and through the comparison of recorded reference calls from north-eastern NSW and the Sydney Basin. Each call sequence ('pass') was assigned to one of five categories, being definite, probable, possible, species group and unknown. For the purposes of this assessment, definite and probable levels of confidence were treated as positive identifications. Anabat echolocation surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
Striped legless lizard ***Delma impar***	V		Sep-Dec		No	Diurnal reptile surveys were undertaken over four days at 12 locations in January 2018 (refer to **Figure 2.4**). Loose bark, logs, hollow trunks and dead tree limbs were searched for sheltering individuals. A total of 13 person hours of survey were conducted across the Development Footprint. Extensive surveys of grassland habitat were undertaken in combination with the threatened orchid searches across the Development Footprint in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**) Opportunistic observations were completed throughout all Umwelt survey periods.
white-bellied sea-eagle ***Haliaeetus leucogaster***	V	-	Jul-Dec	*Breeding habitat only.* Living or dead mature trees within suitable vegetation within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines.	No	Targeted bird of prey nest searches were undertaken in October 2017 over five days, and further habitat assessments were undertaken in February and June 2018 over six days to identify potential habitat available for the species across the Development Footprint. Suitable nest trees and stags were recorded and inspected for large nests. Diurnal bird surveys were also conducted in January and June 2018 at 23 locations across the Development Footprint. Surveys were conducted at each site for a minimum of 30 minutes. 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. A total of 23.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Diurnal and opportunistic bird surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and diurnal bird surveys are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
little eagle ***Hieraaetus morphnoides***	V	-	Aug-Oct	*Breeding habitat only.* Nest trees - live (occasionally dead) large old trees within vegetation.	No	Targeted bird of prey nest searches were undertaken in October 2017 over five days, and further habitat assessments were undertaken in February and June 2018 over six days to identify potential habitat available for the species across the Development Footprint (refer to **Figure 2.4**). Suitable nest trees and stags were recorded and inspected for large nests. Diurnal bird surveys were conducted in January and June 2018 at 23 locations across the Development Footprint. Surveys were conducted at each site for a minimum of 30 minutes. 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. A total of 23.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Diurnal and opportunistic bird surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and diurnal bird surveys are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
pale-headed snake ***Hoplocephalus bitorquatus***	V	-	Nov-Mar	-	No	Diurnal reptile surveys were undertaken over four days at 12 locations in January 2018 (refer to **Figure 2.4**). Loose bark, logs, hollow trunks and dead tree limbs were searched for sheltering individuals. A total of 13 person hours of survey were conducted across the Development Footprint. Nocturnal spotlighting searches were also undertaken in March 2018 over four nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. 32.6mm of rainfall was recorded at the Singleton station during the first night of survey (5 March 2018) with 4.2mm and 0.4mm recorded the following two evenings. Relative humidity during the survey ranged between 93% and 73% providing suitable surveying conditions for the species. A total of 18 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Reptile searches have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and pitfall trapping is undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
swift parrot ***Lathamus discolor***	E	CE	N/A	*Important habitat only.* (as defined by mapping products supplied by the BCD)	Yes	While it is acknowledged that surveys are not required for this species under the BAM (due to habitat being confirmed through BCD mapping products), targeted swift parrot surveys were undertaken across the Development Footprint in 13 locations in June 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. 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. The surveys targeted areas of quality habitat and flowering resources for the swift parrot and were timed to coincide with the known presence of the species in the Hunter Valley. A total of 13 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted winter bird surveys have been previously undertaken in the wider locality as part of the Mount Owen Continued Operations Project in August 2011, June 2012 and July 2014, and the Mount Owen Continued Operations Modification 2 in 2016. Diurnal winter bird searches are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
green and golden bell frog *Litoria aurea*	E	V	Nov-Mar	Semi-permanent/ephemeral wet areas and within 1km of swamps and waterbodies.	No	Targeted call playback surveys were undertaken across the Development Footprint in 22 locations in March 2017, and 19 locations in March 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Green and golden bell frog 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. Minimal rainfall was recorded at the nearest weather station (Singleton) during the 2017 survey period, however humidity ranged between 84% and 61% (BoM 2018). 32.6mm of rainfall was recorded during the first night of survey in 2018 (5 March) with 4.2mm and 0.4mm recorded the following two evenings. Relative humidity during the survey ranged between 93% and 73% providing suitable surveying conditions for the species. A total of 27 person hours of survey were conducted across the Development Footprint. Aquatic habitat assessments were undertaken in March 2018, October 2018 and November 2018 to identify potential habitat available for the species across the Development Footprint. AUSRIVAS Physical Assessment Protocol was used to score habitat parameters at streams and waterbodies within the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted green and golden bell frog surveys have also been previously undertaken in the wider locality in February 2012, January and February 2013 as part of the Mount Owen Continued Operations Project and in March 2014 as part of the Greater Ravensworth Upper Hunter Strategic Assessment. Call playback surveys and targeted waterbody searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
green-thighed frog ***Litoria brevipalmata***	V	-	Oct-Mar	-	No	Targeted call playback surveys were undertaken across the Development Footprint in 19 locations within dam and wetland habitat in March 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Green-thighed frog 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. 32.6mm of rainfall was recorded during the first night of survey (5 March 2018) with 4.2mm and 0.4mm recorded the following two evenings. Relative humidity during the survey ranged between 93% and 73% providing moderately suitable surveying conditions for the species. A total of 18 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted amphibian surveys were also undertaken in the wider locality in February 2012, January and February 2013 as part of the Mount Owen Continued Operations Project and in March 2014 as part of the Greater Ravensworth Upper Hunter Strategic Assessment. Amphibian surveys and targeted waterbody searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
square-tailed kite ***Lophoictinia isura***	V	-	Sept-Jan	*Breeding habitat only.* Nest trees.	No	Targeted bird of prey nest searches were undertaken in October 2017 over five days, and further habitat assessments were undertaken in February and June 2018 over six days to identify potential habitat available for the species across the Development Footprint (refer to **Figure 2.4**). Diurnal bird surveys were conducted in January and June 2018 at 23 locations across the Development Footprint. Surveys were conducted at each site for a minimum of 30 minutes. 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. A total of 23.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Diurnal and opportunistic bird surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2011, 2012, 2013 and 2014, and diurnal bird surveys are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
little bentwing-bat ***Miniopterus australis***	V	-	Dec-Feb	*Breeding habitat only*. Caves, tunnels, mines, culverts or other structures known or suspected to be used for breeding.	Yes	Opportunistic observations for potential caves, tunnels, mines, culverts or other structures were undertaken throughout Umwelt's survey periods, including in January 2018. The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Development Footprint from 5 March to 9 March 2018 (refer to **Figure 2.4**). At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flyaways along areas of suitable habitat. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. A total of 16 survey nights were undertaken across the Development Footprint. All recorded calls were analysed by Anna McConville of Echo Ecology using AnalookW (Version 4.2n) software. The identification of calls was undertaken with reference to Pennay *et al.* (2004) and through the comparison of recorded reference calls from north-eastern NSW and the Sydney Basin. Each call sequence ('pass') was assigned to one of five categories, being definite, probable, possible, species group and unknown. For the purposes of this assessment, definite and probable levels of confidence were treated as positive identifications. Anabat echolocation surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
eastern bentwing-bat ***Miniopterus schreibersii oceanensis***	V	-	Dec-Feb	*Breeding habitat only*. Caves, tunnels, mines, culverts or other structures known or suspected to be used for breeding.	Yes	Opportunistic observations for potential caves, tunnels, mines, culverts or other structures were undertaken throughout Umwelt's survey periods, including in January 2018. The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Development Footprint from 5 March to 9 March 2018 (refer to **Figure 2.4**). At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flyaways along areas of suitable habitat. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. A total of 16 survey nights were undertaken across the Development Footprint. All recorded calls were analysed by Anna McConville of Echo Ecology using AnalookW (Version 4.2n) software. The identification of calls was undertaken with reference to Pennay et al. (2004) and through the comparison of recorded reference calls from north-eastern NSW and the Sydney Basin. Each call sequence ('pass') was assigned to one of five categories, being definite, probable, possible, species group and unknown. For the purposes of this assessment, definite and probable levels of confidence were treated as positive identifications. Anabat echolocation surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
southern myotis ***Myotis macropus***	V	-	Oct-Mar	*Breeding habitat only*. Hollow bearing trees within 200 m of riparian zone. Bridges, caves or artificial structures within 200 m of riparian zone.	No	Targeted hollow bearing tree searches were undertaken within 200m of Bowmans Creek over 5 days in March 2018 (refer to **Figure 2.4**). Hollow-bearing trees and structures containing suitable crevices for the species were recorded. The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Development Footprint from 5 March to 9 March 2018 (refer to **Figure 2.4**). At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flyaways along areas of suitable habitat. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. A total of 16 survey nights were undertaken across the Development Footprint. All recorded calls were analysed by Anna McConville of Echo Ecology using AnalookW (Version 4.2n) software. The identification of calls was undertaken with reference to Pennay et al. (2004) and through the comparison of recorded reference calls from north-eastern NSW and the Sydney Basin. Each call sequence ('pass') was assigned to one of five categories, being definite, probable, possible, species group and unknown. For the purposes of this assessment, definite and probable levels of confidence were treated as positive identifications. Opportunistic observations were completed throughout all Umwelt survey periods. Anabat echolocation surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
barking owl ***Ninox connivens***	V	-	May-Dec	*Breeding habitat only*. Living or dead trees with hollows greater than 20 cm diameter and greater than 4m above the ground.	No	Targeted searches for hollows greater than 20 cm diameter and greater than 4m above the ground were undertaken in June 2018 to identify potential breeding habitat available for the species across the Development Footprint. Suitable living trees and stags were recorded and then targeted for call playback and spotlighting surveys. Targeted call playback surveys were undertaken across the Development Footprint in six locations in June 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Barking owl 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. A total of 6.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted owl surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in August 2011, June 2012 and July 2014, and targeted call playback and spotlighting searches are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
powerful owl ***Ninox strenua***	V	-	May-Aug	*Breeding habitat only*. Living or dead trees with hollow greater than 20cm diameter.	No	Targeted searches for hollows greater than 20 cm diameter were undertaken in June 2018 days to identify potential breeding habitat available for the species across the Development Footprint. Suitable living trees and stags were recorded and then targeted for call playback and spotlighting surveys. Targeted call playback surveys were undertaken across the Development Footprint in 6 locations in June 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Powerful owl 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. A total of 6.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted owl surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in August 2011, June 2012 and July 2014, and targeted call playback and spotlighting searches are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
squirrel glider *Petaurus norfolcensis*	V	-	All year	-	No	Searches for hollow-bearing trees were undertaken in June 2018 to identify potential habitat available for the species across the Development Footprint. Suitable hollow-bearings trees and stags were recorded. Nocturnal spotlighting searches were also undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.4**) within and surrounding the Development Footprint from 26 October 2017 to 9 March 2018 (135 nights). 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 peanut butter, honey and tuna. Cameras were set to take three photos in quick succession when movement was detected. Opportunistic observations were completed throughout all Umwelt survey periods. Remote camera surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and Elliot trapping and spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
brush-tailed phascogale ***Phascogale tapoatafa***	V	-	All year	Hollow bearing trees	No	Searches for hollow bearing trees were undertaken in June 2018 to identify potential habitat available for the species across the Development Footprint. Hollow-bearing trees in woodland patches were recorded. Nocturnal spotlighting searches were also undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.4**) within and surrounding the Development Footprint from 26 October 2017 to 9 March 2018 (135 nights). 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 peanut butter, honey and tuna. Cameras were set to take three photos in quick succession when movement was detected. Opportunistic observations were completed throughout all Umwelt survey periods. Remote camera surveys were also undertaken in the wider locality as part of the Greater Upper Hunter Strategic Assessment in March 2014, and Elliot trapping and spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

koala ***Phascolarctos cinereus***	V	V	All year	*Important habitat only* (as defined by mapping products supplied by the BCD)	No	Searches for signs of the presence of koalas were undertaken at 11 locations across the Development Footprint in February and June 2018 using the Spot Assessment Technique (SAT) (refer to **Figure 2.4**). The koala SAT was undertaken in eucalypt dominated sites only as per the technique outlined in Phillips and Callaghan (2011). Searches were undertaken on and around the base of 30 trees at each survey site, with a total of 330 trees inspected. The searches focused on signs of presence including scats at the base of trees and characteristic scratches on tree trunks. Furthermore, habitat assessments to determine the extent of potential koala feed trees were also undertaken across the vegetation communities of the Development Footprint. Nocturnal spotlighting searches were also undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.4**) within and surrounding the Development Footprint from 26 October 2017 to 9 March 2018 (135 nights). 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 peanut butter, honey and tuna. Cameras were set to take three photos in quick succession when movement was detected. It is acknowledged that remote camera surveys can only be an opportunistic method for detecting koala in the landscape. Opportunistic observations were completed throughout all Umwelt survey periods. Nocturnal call playback for koala was undertaken previously in the wider locality for the Mount Owen Continued Operations Project in 2012, and targeted koala SAT and spotlighting surveys were undertaken in March 2014 as part of the Greater Upper Hunter Strategic Assessment. Spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
common planigale *Planigale maculata*	V	-	All year	-	No	Habitat assessments were undertaken in June 2018 over six days to identify potential habitat available for the species across the Development Footprint. Hollow logs, crevices and rocks were inspected and recorded. Nocturnal spotlighting searches were also undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.4**) within and surrounding the Development Footprint from 26 October 2017 to 9 March 2018 (135 nights). 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 peanut butter, honey and tuna. Cameras were set to take three photos in quick succession when movement was detected. Opportunistic observations were completed throughout all Umwelt survey periods. Remote camera surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and Elliot trapping and spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
grey-headed flying-fox ***Pteropus poliocephalus***	V	V	Oct-Dec	Breeding camps.	No	Opportunistic observations for breeding camps and evidence of potential use as roosting habitat were undertaken throughout Umwelt's survey periods for this highly detectable species, including during the extensive survey coverage undertaken for threatened flora species in October 2017 and October 2018 (refer to **Figure 2.2**). Nocturnal spotlighting searches were also undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.4**). Surveys were conducted between sunset and midnight using 30 watt Lightforce hand-held spotlights and head torches. A total of 22 person hours of survey were conducted across the Development Footprint. Spotlighting surveys were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2012 and the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014. Diurnal and nocturnal searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
masked owl ***Tyto novaehollandiae***	V	-	May-Aug	*Breeding habitat only*. Living or dead trees with hollows greater than 20cm diameter.	No	Targeted searches for hollows greater than 20 cm diameter were undertaken in June 2018 to identify potential breeding habitat available for the species across the Development Footprint. Suitable living trees and stags were recorded and then targeted for call playback and spotlighting surveys. Targeted call playback surveys were undertaken across the Development Footprint in 6 locations in June 2018 (refer to **Figure 2.4**). These sessions began with a period of quiet listening for approximately 5 minutes. Masked owl 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, nocturnal spotlighting searches were conducted at each site for between 15-30 minutes. This involved walking a meandering transect and recording any fauna species seen or heard calling. Species were visually identified using 10 x 40 magnification binoculars or by call recognition. A total of 6.5 person hours of survey were conducted across the Development Footprint. Opportunistic observations were completed throughout all Umwelt survey periods. Targeted owl surveys have been undertaken in the wider locality as part of the Mount Owen Continued Operations Project in August 2011, June 2012 and July 2014, and targeted call playback and spotlighting searches are undertaken as part of the monitoring in the Mount Owen Complex annually.

Species	BC Act	EPBC Act	Survey Period	Habitat Constraint	SAII Entity	Survey Method
eastern cave bat ***Vespadelus troughtoni***	V	-	Nov-Jan	*Breeding habitat only.* Within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, crevices or boulder piles, or within two kilometres of old mines, tunnels, old buildings or sheds.	Yes	Opportunistic observations for potential rocky areas containing caves, overhangs, escarpments, outcrops, crevices, boulder piles, old mines, tunnels, old buildings or sheds were undertaken throughout Umwelt's survey periods, including in January 2018. The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Development Footprint from 5 March to 9 March 2018 (refer to **Figure 2.4**). At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flyaways along areas of suitable habitat. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise. A total of 16 survey nights were undertaken across the Development Footprint. All recorded calls were analysed by Anna McConville of Echo Ecology using AnalookW (Version 4.2n) software. The identification of calls was undertaken with reference to Pennay *et al*. (2004) and through the comparison of recorded reference calls from north-eastern NSW and the Sydney Basin. Each call sequence ('pass') was assigned to one of five categories, being definite, probable, possible, species group and unknown. For the purposes of this assessment, definite and probable levels of confidence were treated as positive identifications. Anabat echolocation surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and are undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Table B1.3 identifies the species-credit species predicted by the BAM calculator that were determined to not require further assessment due to a lack of specific habitat constraints and/or geographic limitations in relation to the Development Footprint as per Step 3 in Section 6.4 of the BAM.

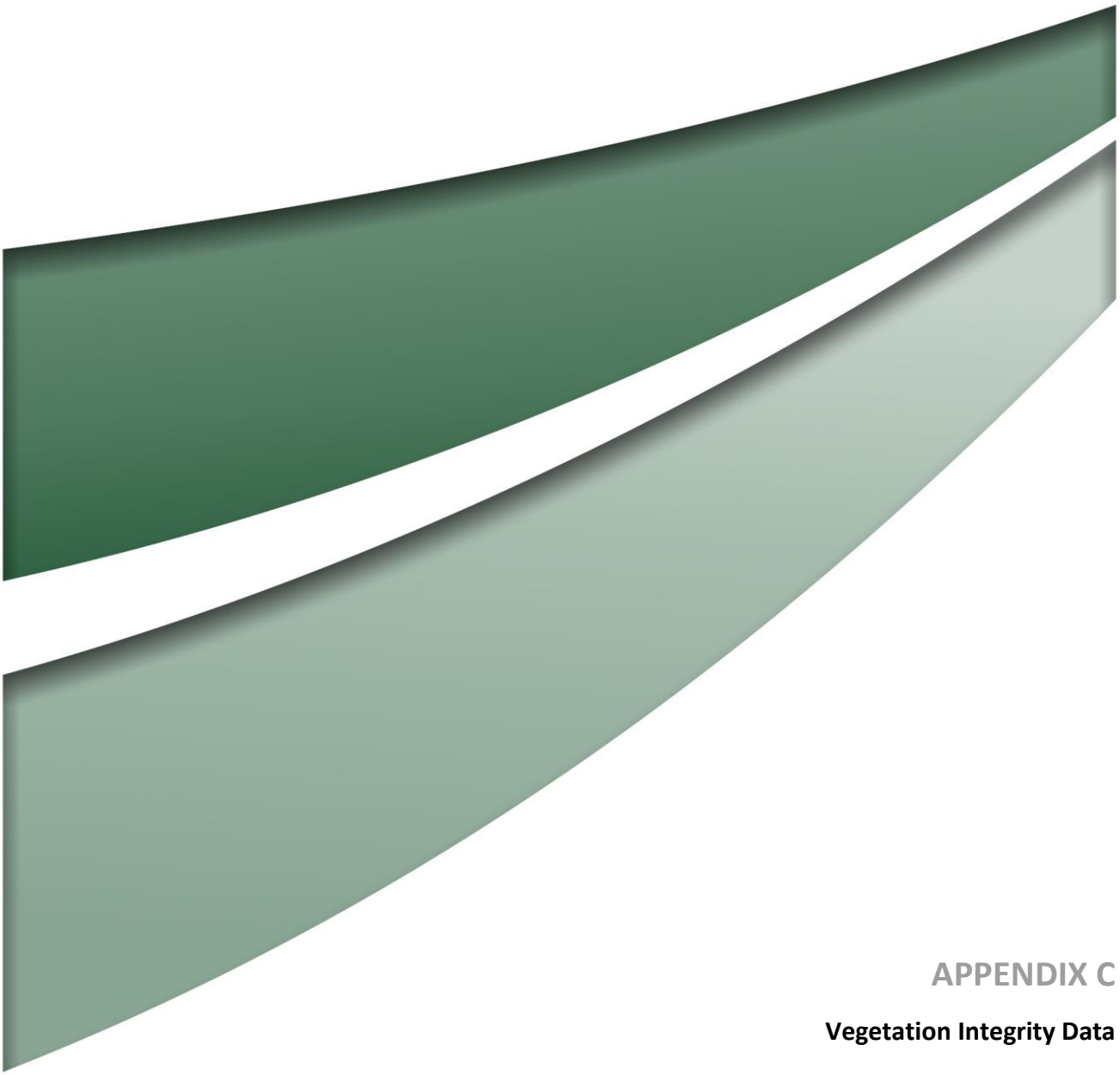
Table B1.3 Candidate Species-credit Species Not Requiring Further Assessment

Species	BC Act	EPBC Act	Survey Period	Habitat or Geographic Constraint	SAII Entity	Survey Method
Flora Species						
Charmhaven apple *Angophora inopina*	V	V	All year	East of Kurri Kurri	No	The Development Footprint is not located east of Kurri Kurri. Additionally, targeted threatened flora walking transects were undertaken throughout the Development Footprint habitat in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). This species is highly detectable and was not recorded during the surveys undertaken for this assessment, nor has it been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator, known vegetation associations and the surveys undertaken for this assessment, this species is unlikely to occur in the Development Footprint and does not require further assessment.
leafless tongue orchid *Cryptostylis hunteriana*	V	V	Nov-Jan	-	No	One PCT recorded in the Development Footprint is listed as associated vegetation types in the TBDC for this species (being PCT 1604). PCT 1604 occurs within the Development Footprint as mine rehabilitation woodland and exotic grasslands. As outlined in **Section 3.2.1.9**, this habitat is associated with an area previously cleared and disturbed following open cut coal mining. PCT 1604 was allocated for the purposes of the BAM assessment due to the presence of a number of characteristic species for this PCT as well as the Development Footprint being located in a region where PCT1604 is known to naturally occur. This area does not contain suitable habitat for leafless tongue orchid. In accordance with Section 6.4.1.17 of the BAM, the associated PCTs for this species in the Development Footprint are not naturally occurring and are too degraded for the species to occur, and as such, this candidate does not require further assessment.

Species	BC Act	EPBC Act	Survey Period	Habitat or Geographic Constraint	SAII Entity	Survey Method
rough doubletail *Diuris praecox*	V	V	August	East of Maitland	No	The Development Footprint is not located east of Maitland. The species occurs on hills and slopes of near-coastal districts in open heathy forests which have a grassy to moderately dense understory, on well-drained sandy soils (DEWHA 2008). This species has not been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator, known vegetation and soil associations, this species is unlikely to occur in the Development Footprint and does not require further assessment.
Singleton mallee *Eucalyptus castrensis*	E	-	All year	Singleton Training Area	Yes	The Development Footprint is not located within the Singleton Training Area. This species is known only from the Singleton Training Area near Broken Back repeater station, despite considerable survey effort over the past 10 years in the Broken Back - Singleton - Broke districts involving detailed sampling (NSWSC 2019). Additionally, targeted threatened flora walking transects were undertaken throughout the Development Footprint habitat in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). This species is highly detectable and was not recorded during the surveys undertaken for this assessment, nor has it been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator and the surveys undertaken for this assessment, this species is unlikely to occur in the Development Footprint and does not require further assessment.

Species	BC Act	EPBC Act	Survey Period	Habitat or Geographic Constraint	SAII Entity	Survey Method
Pokolbin mallee *Eucalyptus pumila*	V	V	All year	Sandstone slopes	Yes	The Development Footprint does not contain sandstone slopes. This species occurs only on north and north-west facing hills on sandy soils over sandstone with conglomerate outcrops (DEWHA 2008). Additionally, targeted threatened flora walking transects were undertaken throughout the Development Footprint habitat in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). This species is highly detectable and was not recorded during the surveys undertaken for this assessment, nor has it been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator and the surveys undertaken for this assessment, this species is unlikely to occur in the Development Footprint and does not require further assessment.
North Rothbury persoonia *Persoonia pauciflora*	CE	CE	All year	Within 10 km of North Rothbury	Yes	The Development Footprint is not located within 10 km of North Rothbury. Additionally, targeted threatened flora walking transects were undertaken throughout the Development Footprint habitat in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). This species is highly detectable and was not recorded during the surveys undertaken for this assessment, nor has it been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator and the surveys undertaken for this assessment, this species is unlikely to occur in the Development Footprint and does not require further assessment.

Species	BC Act	EPBC Act	Survey Period	Habitat or Geographic Constraint	SAII Entity	Survey Method
heath wrinklewort ***Rutidosis heterogama***	V	V	All year	South and east of Jerrys Plains	No	The Development Footprint is not located south or east of Jerrys Plains. Additionally, targeted threatened flora walking transects were undertaken throughout the Development Footprint habitat in October 2017, September 2018 and October 2018 over ten days, for a total of 190 person hours of survey (refer to **Figure 2.2**). This species is relatively detectable and was not recorded during the surveys undertaken for this assessment, nor has it been recorded in any of the previous extensive survey events in the locality. Based on the geographic constraints listed in the BAM calculator and the surveys undertaken for this assessment, this species is unlikely to occur in the Development Footprint and does not require further assessment.
FAUNA SPECIES						
brush-tailed rock-wallaby ***Petrogale penicillata***	E	V	All year	Land within 1 km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or clifflines	Yes	The Development Footprint does not contain rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or clifflines and is not within 1 km of these features. Additionally, a range of fauna and flora surveys were undertaken across the Development Site that did not record these habitat features (refer to **Figure 2.2** and **2.4**). Evidence of this species has not been recorded in any of the previous extensive survey events in the locality. Based on the habitat constraints listed in the TBDC, this species is unlikely to occur in the Development Footprint and does not require further assessment.



APPENDIX C

Vegetation Integrity Data

Vegetation Integrity Data

The following vegetation integrity data was collected from surveys of the Development Footprint. It includes the composition, structure and function attributes that are recorded in each BAM plot. This data is assessed against benchmark data for PCTs and entered into the BAM calculator to assess the condition of each PCT in the Development Footprint.

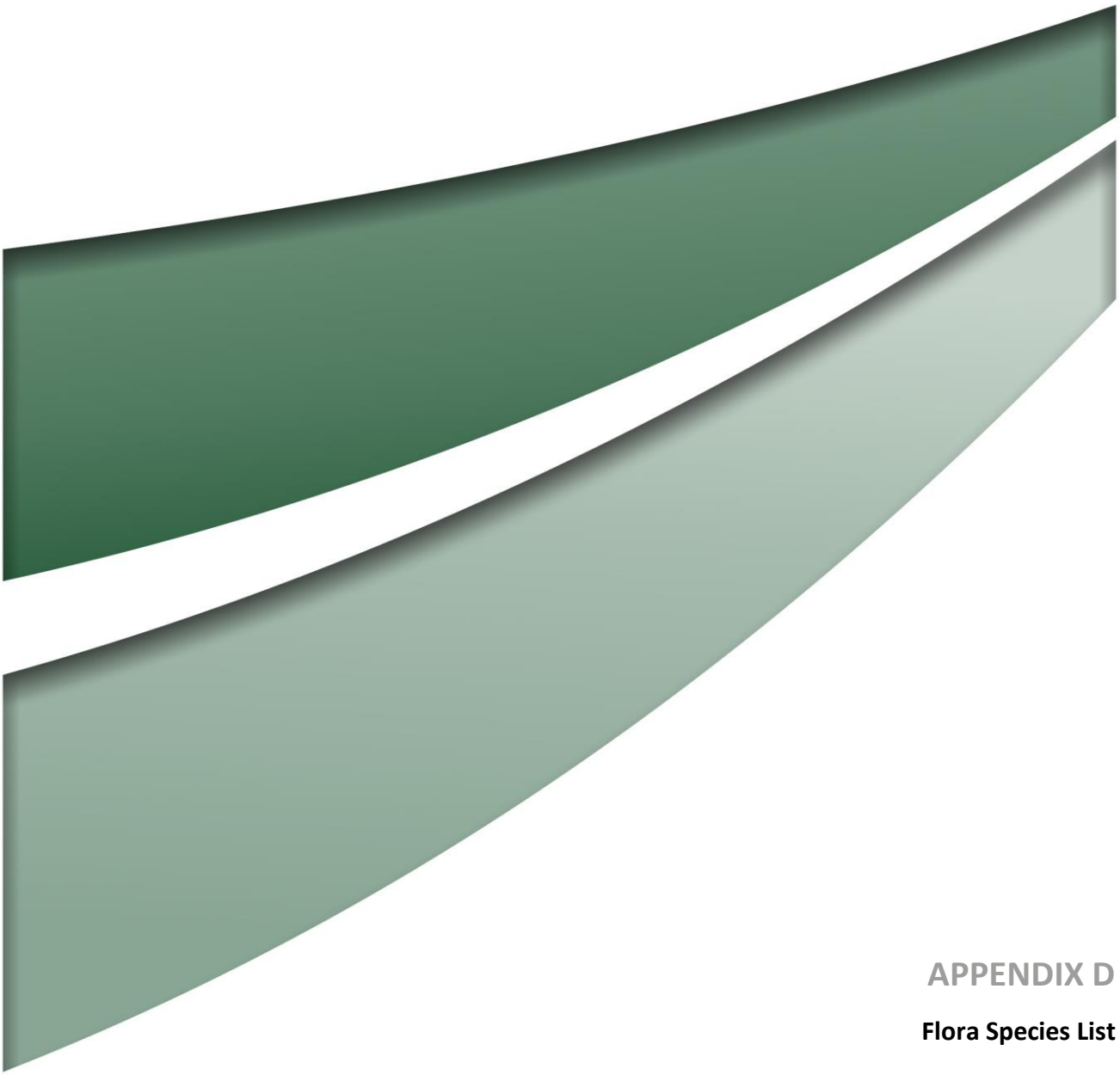
The following abbreviations are used in the table below:

Tr	Tree (growth form)
Sh	Shrub (growth form)
Gr	Grass (growth form)
Fb	Forb (growth form)
Fn	Fern (growth form)
Ot	Other (growth form)

	COMPOSITION						STRUCTURE						FUNCTION										
	Tr	Sh	Gr	Fb	Fn	Ot	Tr	Sh	Gr	Fb	Fn	Ot	Regen	Stem Classes (cm)					No. Large Trees	No. Hollow Trees	Litter (%)	Fallen Logs (m)	High Threat Weeds
													>5	5-10	10-20	20-30	30-50	50-80					
Vegetation Zone 1 – PCT1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Moderate - Good*																							
Q16	3	6	10	3	1	0	21.1	0.7	8.3	0.3	0.1	0.0	1	1	1	1	0	1	0	0	80.0	13.0	0.5
Q22	2	6	8	5	2	0	20.0	0.8	3.1	0.5	0.2	0.0	1	1	1	1	1	1	0	0	89.0	21.0	0.5
Q43	1	6	12	13	2	2	10.0	1.7	11.7	3.5	0.3	0.2	1	1	0	0	1	1	0	1	48.0	6.0	0.7
Q49	3	4	12	13	2	1	25.5	1.1	4.0	1.6	0.3	0.1	1	1	1	0	1	1	0	0	76.8	40.0	1.2
Vegetation Zone 2 – PCT1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Regenerating*																							
Q7	4	2	6	3	1	0	8.0	3.1	7.5	0.3	0.1	0.0	1	1	1	1	0	0	1	1	77.0	54.0	7.4
Q23	2	1	6	5	2	1	30.0	1.0	4.7	0.6	0.2	0.1	1	1	1	1	0	0	0	0	41.0	17.0	0.6
Q24	4	2	6	3	1	0	25.3	0.2	5.3	0.3	0.1	0.0	1	1	1	1	1	0	0	0	69.0	0.0	0.1
Q45	3	2	4	10	1	1	19.0	0.2	9.2	1.4	0.5	0.1	1	1	1	0	0	0	0	0	60.0	13.5	0.1
Q48	2	2	7	5	1	1	20.1	0.3	0.7	0.5	0.1	0.1	1	1	1	1	0	1	0	1	73.0	7.0	0.3
Vegetation Zone 3 – PCT1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Plantation*																							
Q47	7	5	9	10	1	0	18.1	6.2	1.5	1.1	0.1	0.0	1	0	1	1	1	0	0	0	90.0	8.0	1.1
Vegetation Zone 4 – PCT1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter *Derived Native Grassland*																							
Q8	0	1	6	2	1	0	0.0	2.0	31.6	0.2	0.1	0.0	0	0	0	0	0	0	0	0	75.0	0.0	0.6
Q9	0	0	5	2	1	1	0.0	0.0	27.2	0.4	0.5	0.1	0	0	0	0	0	0	0	0	64.0	2.5	0.9
Q12	0	0	6	1	1	0	0.0	0.0	19.4	0.2	0.2	0.0	0	0	0	0	0	0	0	0	76.0	0.0	0.1

	COMPOSITION						STRUCTURE						FUNCTION										
	Tr	Sh	Gr	Fb	Fn	Ot	Tr	Sh	Gr	Fb	Fn	Ot	Regen	Stem Classes (cm)					No. Large Trees	No. Hollow Trees	Litter (%)	Fallen Logs (m)	High Threat Weeds
													>5	5-10	10-20	20-30	30-50	50-80					
Q15	1	0	10	3	1	0	1.0	0.0	15.8	0.3	0.1	0.0	1	0	0	1	0	0	0	0	59.0	0.0	0.1
Q21	0	0	6	1	1	1	0.0	0.0	9.3	0.5	0.2	0.1	0	0	0	0	0	0	0	0	80.0	0.0	2.2
Q26	0	0	4	2	1	0	0.0	0.0	17.2	0.3	0.1	0.0	0	0	0	0	0	0	0	0	83.0	0.0	0.3
Q46	0	0	10	6	2	1	0.0	0.0	53.4	0.6	1.1	0.1	0	0	0	0	0	0	0	0	36.0	0.0	0.3
Vegetation Zone 5 – PCT1692 Bull Oak grassy woodland of the central Hunter Valley *Moderate - Good*																							
Q2	2	0	4	0	0	0	30.5	0.0	5.2	0.0	0.0	0.0	1	1	1	1	1	0	0	1	74.0	3.0	0.2
Q4	2	0	5	1	1	0	25.2	0.0	4.4	0.1	0.1	0.0	1	1	1	1	1	1	0	0	61.0	28.0	0.2
Q10	1	3	7	1	2	0	20.0	2.2	3.7	0.1	0.2	0.0	1	1	1	1	0	0	0	0	84.0	3.5	0.4
Vegetation Zone 6 – PCT1692 Bull Oak grassy woodland of the central Hunter Valley *Regenerating*																							
Q18	2	1	8	3	1	1	10.0	0.2	9.9	0.3	0.2	0.1	1	1	1	0	0	0	0	0	73.0	18.5	0.2
Q41	1	2	10	13	1	1	10.0	0.4	15.8	1.7	0.2	0.1	1	1	1	0	0	0	0	0	63.0	0.0	0.4
Q44	2	2	12	11	1	2	10.2	0.2	9.6	1.3	5.0	0.2	1	1	1	0	1	0	0	0	83.0	5.0	0.3
Vegetation Zone 7 – PCT485 River Oak riparian grassy tall woodland of the western Hunter Valley *Moderate - Good*																							
Q1	1	0	3	4	0	0	15.0	0.0	10.4	0.4	0.0	0.0	0	0	0	1	1	1	0	0	80.0	15.0	0.7
Q5	1	0	1	6	0	0	35.0	0.0	8.0	0.7	0.0	0.0	0	0	1	1	0	1	2	1	56.0	19.0	1.5
Q40	1	1	8	13	0	0	30.0	1.0	68.7	1.5	0.0	0.0	1	1	1	1	1	0	0	0	39.0	80.0	5.8

	COMPOSITION						STRUCTURE						FUNCTION										
	Tr	Sh	Gr	Fb	Fn	Ot	Tr	Sh	Gr	Fb	Fn	Ot	Regen	Stem Classes (cm)					No. Large Trees	No. Hollow Trees	Litter (%)	Fallen Logs (m)	High Threat Weeds
													>5	5-10	10-20	20-30	30-50	50-80					
Vegetation Zone 8 – PCT1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter *Woody Rehabilitation*																							
Q51	7	2	9	7	0	2	36.0	0.3	6.8	0.8	0.0	0.2	0	1	1	1	1	0	0	0	74.0	39.0	1.9
Q56	3	3	3	5	0	0	25.3	3.0	0.8	0.5	0.0	0.0	1	1	1	1	0	0	0	0	58.0	0.0	20.4
Q57	2	3	4	4	0	0	35.0	0.8	2.7	0.5	0.0	0.0	1	1	1	0	0	0	0	0	42.2	6.0	2.4
Q60	2	4	3	3	0	2	20.5	2.9	0.3	0.3	0.0	0.2	1	1	0	0	0	0	0	0	27.6	0.0	45.5
Vegetation Zone 9– PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley *Moderate - Good*																							
Q11	2	2	3	1	0	0	30.1	0.2	5.0	0.1	0.0	0.0	1	1	1	1	1	0	0	0	77.0	1.0	8.2
Q17	1	1	2	4	1	1	30.0	0.2	2.3	0.5	0.1	0.2	1	1	1	1	0	0	0	0	92.0	1.0	0.3
Q28	1	1	4	2	0	0	25.0	0.1	3.6	0.3	0.0	0.0	1	1	1	1	1	0	0	1	85.0	24.5	5.2
Q36	2	4	4	11	2	3	15.0	3.2	36.3	1.1	0.2	0.4	1	1	1	1	1	0	0	1	85.0	80.0	1.3
Q37	1	2	2	8	0	4	20.0	1.5	55.5	1.2	0.0	3.4	1	1	1	1	1	0	1	4	89.0	33.0	0.0
Vegetation Zone 10 – PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley *Plantation*																							
Q64	6	2	4	5	0	0	30.5	0.5	1.4	0.5	0.0	0.0	1	1	1	1	0	0	0	0	58.0	0.0	3.7
Q65	3	1	1	1	0	1	31.2	0.1	2.0	0.1	0.0	0.5	1	1	1	1	1	0	0	0	57.0	15.0	16.3
Q69	4	6	5	7	2	1	14.0	4.0	6.7	0.8	0.2	0.1	1	1	1	1	1	0	0	0	63.6	22.0	1.3



APPENDIX D

Flora Species List

The following list was developed from the floristic plot and rapid transect surveys of the Development Footprint and surrounding areas used in the BAM calculator assessment. 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.

Values in the following tables represent the cover measure according to BAM. The tables represent the flora species recorded in each PCT allocated in the Development Footprint.

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:

asterisk (*)	denotes species non-native species
double asterisk (**)	denotes High Threat Weed species under the BAM
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 2019), 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 Name	Scientific Name	Common Name	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter																
			Zone 1 *Moderate - Good*				Zone 2 *Regenerating*					Zone 3 *Plantation*	Zone 4 *Derived Native Grassland*						
			Q16	Q22	Q43	Q49	Q07	Q23	Q24	Q45	Q48	Q47	Q08	Q09	Q12	Q15	Q21	Q26	Q46
Magnoliopsida – Liliidae (monocots)																			
Anthericaceae	*Laxmannia gracilis*	slender wire lily								0.5									
Commelinaceae	*Commelina cyanea*	native wandering jew			0.1	0.1				0.1									
Cyperaceae	*Cyperus gracilis*	slender flat-sedge			0.1	0.1						0.5							
Cyperaceae	*Fimbristylis dichotoma*	common fringe-sedge				0.1						0.1							1
Iridaceae	*Romulea rosea* var. *australis**	onion grass												0.1					
Juncaceae	*Juncus* sp.	a rush	0.1																
Lomandraceae	*Lomandra multiflora* subsp. *multiflora*	many-flowered mat-rush			0.1					0.1									
Lomandraceae	*Lomandra filiformis*	wattle matt-rush	3	0.2		1	2	1	2	8	0.1				5	2	1		0.1
Lomandraceae	*Lomandra filiformis* subsp. *coriacea*	wattle matt-rush			0.1														
Lomandraceae	*Lomandra multiflora* subsp. *multiflora*	many-flowered mat-rush	0.2	0.2					0.1							0.2			
Phormiaceae	*Dianella longifolia*	blueberry lily		0.1						0.1									
Poaceae	*Austrostipa verticillata*	slender bamboo grass	0.2	0.2	0.1	1	0.2				0.1	0.2							
Poaceae	*Austrostipa scabra*	speargrass	1	0.2	0.5	0.2			0.1		0.1	0.2				0.2			
Poaceae	*Aristida ramosa*	purple wiregrass	0.5	0.1	5	1	5	2				0.1	15	15	9	5	5	15	15
Poaceae	*Aristida* sp.	a wiregrass									0.1								
Poaceae	*Aristida vagans*	threeawn speargrass	1	2	0.3				2	1									
Poaceae	*Bothriochloa macra*	red grass																	1
Poaceae	*Bothriochloa* sp.*	redgrass; bluegrass					0.1												
Poaceae	*Chloris divaricata* var. *divaricata*				0.1	0.1													0.1
Poaceae	*Chloris ventricosa*	tall chloris	0.1		0.1	0.1	0.1												
Poaceae	*Cymbopogon refractus*	barbed wire grass	2	0.1	5	0.1	0.1	1	1	0.1	0.1	0.1	0.5	1	0.1	5	2	1	
Poaceae	*Cynodon dactylon**	common couch			0.2			0.5			0.1	0.1	15	10	5	2	0.2	1	20
Poaceae	*Dichelachne micrantha*	shorthair plumegrass											0.5	1		0.1	0.1		
Poaceae	*Elymus scaber*	common wheatgrass											0.1	0.2	0.1				
Poaceae	*Eragrostis brownii*	Brown's lovegrass									0.1								
Poaceae	*Eragrostis leptostachya*	paddock lovegrass				0.1													0.1
Poaceae	*Hyparrhenia hirta***	coolatai grass												0.5					
Poaceae	*Panicum effusum*	hairy panic				0.1						0.1							0.1
Poaceae	*Paspalidium distans*											0.1							15

Family Name	Scientific Name	Common Name	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter																
			Zone 1 *Moderate - Good*				Zone 2 *Regenerating*					Zone 3 *Plantation*	Zone 4 *Derived Native Grassland*						
			Q16	Q22	Q43	Q49	Q07	Q23	Q24	Q45	Q48	Q47	Q08	Q09	Q12	Q15	Q21	Q26	Q46
Poaceae	*Paspalum dilatatum***	paspalum																	0.1
Poaceae	*Poa* sp.*																	0.2	
Poaceae	*Rytidosperma monticola*	mountain wallaby grass	0.2	0.1															
Poaceae	*Rytidosperma* sp.					0.1		0.1								0.1			
Poaceae	*Sporobolus creber*	slender rat's tail grass			0.1			0.1	0.1				0.5		0.2	0.2	1		1
Poaceae	*Themeda australis*	kangaroo grass														1			
Magnoliopsida – Magnoliidae (dicots)																			
Acanthaceae	*Brunoniella australis*	blue trumpet	0.1	0.1	1	0.1			0.1	0.1						0.1			
Aizoaceae	*Galenia pubescens***	galenia			0.1	0.1	0.1	0.2			0.1	0.5	0.3						
Amaranthaceae	*Alternanthera denticulata*	lesser joyweed				0.1													
Amaranthaceae	*Gomphrena celosioides**	gomphrena weed				0.1						0.1							
Apiaceae	*Cyclospermum leptophyllum**	slender celery											0.1						
Apocynaceae	*Gomphocarpus fruticosus**	narrow-leaved cotton bush	0.1		0.1														0.1
Apocynaceae	*Oxypetalum coeruleum* (syn. *Tweedia coerulea*)*															0.1			
Asteraceae	*Calocephalus citreus*	lemon beauty-heads						0.1	0.1										
Asteraceae	*Calotis cuneifolia*	purple burr-daisy										0.1							
Asteraceae	*Calotis lappulacea*	yellow burr-daisy			0.2	0.1		0.1			0.1	0.1							
Asteraceae	*Carthamus lanatus***	saffron thistle					0.1						0.1	0.1				0.2	
Asteraceae	*Cassinia cunninghamii*			0.2															
Asteraceae	*Cirsium vulgare**	spear thistle																0.1	
Asteraceae	*Chrysocephalum apiculatum*	common everlasting	0.1		0.1			0.2		0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.5	0.2	0.1
Asteraceae	*Conyza bonariensis**	flaxleaf fleabane											0.1		0.1				
Asteraceae	*Conyza* sp.*	a fleabane																0.1	
Asteraceae	*Glossocardia bidens*	cobbler's tack			0.1														
Asteraceae	*Hypochaeris radicata**	catsear										0.1						0.1	2
Asteraceae	*Ozothamnus diosmifolius*	white dogwood								0.1									
Asteraceae	*Senecio madagascariensis***	fireweed	0.1		0.1	0.1		0.1				0.1	0.1		0.1	0.1	0.1	0.1	0.1
Asteraceae	*Sonchus oleraceus**	common sowthistle																	0.1
Asteraceae	*Taraxacum officinale**	dandelion												0.1			0.1		
Asteraceae	*Vernonia cinerea*			0.1		0.1													
Asteraceae	*Vittadinia cervicularis*				0.1														
Asteraceae	*Vittadinia* sp.	fuzzweed	0.1				0.1												

Family Name	Scientific Name	Common Name	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter																
			Zone 1 *Moderate - Good*				Zone 2 *Regenerating*					Zone 3 *Plantation*	Zone 4 *Derived Native Grassland*						
			Q16	Q22	Q43	Q49	Q07	Q23	Q24	Q45	Q48	Q47	Q08	Q09	Q12	Q15	Q21	Q26	Q46
Brassicaceae	*Lepidium africanum**	common peppercress			0.1														
Cactaceae	*Opuntia aurantiaca***	tiger pear	0.1	0.2	0.1	0.2	0.1	0.1			0.1			0.1			0.1		0.1
Cactaceae	*Opuntia humifusa***	creeping pear				0.3	0.1					0.5	0.1						
Cactaceae	*Opuntia stricta var. stricta***	common prickly pear	0.2	0.1	0.2				0.1	0.1	0.1			0.1					
Campanulaceae	*Wahlenbergia communis*	tufted bluebell				0.1	0.1												0.1
Caryophyllaceae	*Paronychia brasiliana**	Brazilian whitlow			0.1														
Casuarinaceae	*Allocasuarina luehmannii*	bulloak	1	2		0.5	1	15	10	2	0.1					1			
Casuarinaceae	*Casuarina glauca*	swamp oak										0.1							
Chenopodiaceae	*Einadia hastata*	berry saltbush					0.1												
Chenopodiaceae	*Einadia nutans*	climbing saltbush		0.1															
Chenopodiaceae	*Einadia polygonoides*	knotweed goosefoot			0.2							0.2							
Chenopodiaceae	*Einadia trigonos*	fishweed				0.1				0.1									
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush	0.1	0.1	0.1	0.2					0.1	3							
Chenopodiaceae	*Maireana microphylla*	small-leaf bluebush	0.1	0.1	0.1	0.5	3	1			0.2	1	2						
Chenopodiaceae	*Einadia* sp.										0.1								
Convolvulaceae	*Dichondra repens*	kidney weed			0.1	0.1						0.1							
Crassulaceae	*Bryophyllum delagoense***	mother of millions					7	0.2											
Euphorbiaceae	*Euphorbia drummondii*				0.1							0.1							
Fabaceae (Faboideae)	*Daviesia ulicifolia*	gorse bitter pea	0.1	0.1					0.1	0.1									
Fabaceae (Faboideae)	*Glycine clandestina*	twining glycine			0.1														
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine			0.1	0.1		0.1		0.1	0.1			0.1			0.1		0.1
Fabaceae (Faboideae)	*Templetonia stenophylla*	leafy templetonia								0.1									
Fabaceae (Faboideae)	*Zornia dyctiocarpa var. dyctiocarpa*	zornia								0.1	0.1								
Fabaceae (Mimosoideae)	*Acacia baileyana*	Cootamundra wattle										2							
Fabaceae (Mimosoideae)	*Acacia decora*	western silver wattle		0.2															
Fabaceae (Mimosoideae)	*Acacia pendula*	boree										2							
Fabaceae (Mimosoideae)	*Acacia deanei* subsp. *deanei*	Deane's wattle			0.2														
Fabaceae (Mimosoideae)	*Acacia* sp.	wattle							0.1										
Flacourtiaceae	*Dovyalis caffra**	kei apple			0.3	0.1						0.1							
Gentianaceae	*Centaurium erythraea**	common centaury											0.1	0.1					
Malvaceae	*Sida corrugata*	corrugated sida			0.3	0.3					0.1	0.1							
Malvaceae	*Sida rhombifolia**	Paddy's lucerne			0.1	0.2	0.2	0.1				0.3	0.1				0.1		0.1

Family Name	Scientific Name	Common Name	PCT 1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter																
			Zone 1 *Moderate - Good*				Zone 2 *Regenerating*					Zone 3 *Plantation*	Zone 4 *Derived Native Grassland*						
			Q16	Q22	Q43	Q49	Q07	Q23	Q24	Q45	Q48	Q47	Q08	Q09	Q12	Q15	Q21	Q26	Q46
Malvaceae	*Sida hackettiana* (syn. *Sida subspicata*)	golden rod			1	0.1		0.1				0.1							
Myoporaceae	*Eremophila debilis*	amulla	0.1	0.1	1	0.3	0.1					0.1							
Myrsinaceae	*Anagallis arvensis**	scarlet pimpernel											0.1	0.1	0.1		0.1		0.1
Myrtaceae	*Eucalyptus crebra*	narrow-leaved ironbark	20	18	10	20	1	15	0.3	15	20	2							
Myrtaceae	*Eucalyptus dawsonii*	slaty gum										4							
Myrtaceae	*Eucalyptus moluccana*	grey box				5	5		10	2		2							
Myrtaceae	*Eucalyptus tereticornis*	forest red gum							5			4							
Myrtaceae	*Corymbia maculata*	spotted gum										4							
Oleaceae	*Olea europaea* subsp. *cuspidata***	African olive	0.1	0.2	0.2	0.5											2		
Oxalidaceae	*Oxalis exilis*																		0.1
Phyllanthaceae	*Phyllanthus virgatus*	wiry spurge			0.1	0.1				0.1		0.1						0.1	0.1
Pittosporaceae	*Bursaria spinosa*	native blackthorn	0.2																
Plantaginaceae	*Plantago lanceolata**	lamb's tongues			0.1		0.2	0.1				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Plantaginaceae	*Plantago* sp.	plantain											0.1						
Polygonaceae	*Rumex* sp.*	dock			0.1	0.1													
Portulacaceae	*Portulaca oleracea*	pigweed										0.1							0.1
Rhamnaceae	*Cryptandra amara*	bitter cryptandra			0.1														
Solanaceae	*Solanum brownii*	violet nightshade	0.1																
Solanaceae	*Solanum cinereum*	narrawa burr			0.2	0.1						0.1							
Solanaceae	*Solanum prinophyllum*	forest nightshade		0.1		0.2			0.1										
Solanaceae	*Solanum* sp.*																		0.1
Stackhousiaceae	*Stackhousia muricata*	stackhousia								0.1									
Stackhousiaceae	*Stackhousia viminea*	slender stackhousia						0.1						0.1		0.1			
Sterculiaceae	*Brachychiton populneus*	kurrajong	0.1				1												
Verbenaceae	*Verbena quadrangularis**				0.1			0.1					0.1					0.1	0.1
Filicopsida (ferns)																			
Adiantaceae	*Cheilanthes distans*	bristly cloak fern	0.1	0.1	0.1	0.2		0.1											0.1
Adiantaceae	*Cheilanthes sieberi* subsp. *sieberi*	rock fern		0.1	0.2	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.5	0.2	0.1	0.2	0.1	1

Family Name	Scientific Name	Common Name	PCT1692 Bull Oak grassy woodland of the central Hunter Valley					
			Zone 5 *Moderate - Good*			Zone 6 *Regenerating*		
			Q02	Q04	Q10	Q18	Q41	Q44
Magnoliopsida – Liliidae (monocots)								
Anthericaceae	*Laxmannia gracilis*	slender wire lily					0.1	
Anthericaceae	*Tricoryne elatior*	yellow autumn-lily					0.1	0.1
Commelinaceae	*Murdannia graminea*							0.1
Cyperaceae	*Carex inversa*	knob sedge						0.1
Cyperaceae	*Cyperus gracilis*	slender flat-sedge						0.1
Cyperaceae	*Fimbristylis dichotoma*	common fringe-sedge					0.1	0.5
Lomandraceae	*Lomandra confertifolia*	matrush	4					
Lomandraceae	*Lomandra filiformis*			0.1	0.2	2		1
Poaceae	*Aristida ramosa*	purple wiregrass	1	4	1	2	10	5
Poaceae	*Aristida vagans*	threeawn speargrass	0.1	0.1		0.2	0.1	0.5
Poaceae	*Austrostipa scabra*	speargrass			0.2	0.2	0.1	0.5
Poaceae	*Austrostipa verticillata*	slender bamboo grass			2			0.1
Poaceae	*Bothriochloa macra*	red grass					0.1	
Poaceae	*Bothriochloa* sp.*	redgrass; bluegrass				0.1		
Poaceae	*Chloris ventricosa*	tall chloris				0.1		
Poaceae	*Cymbopogon refractus*	barbed wire grass	0.1	0.1	0.1	5	5	1
Poaceae	*Cynodon dactylon*	common couch			0.1	0.3	0.1	0.5
Poaceae	*Eragrostis brownii*	Brown's lovegrass					0.1	0.1
Poaceae	*Eragrostis leptostachya*	paddock lovegrass					0.1	0.2
Poaceae	*Panicum* sp.	panicum		0.1				
Poaceae	*Rytidosperma monticola*	mountain wallaby grass			0.1			
Poaceae	*Sporobolus creber*	slender rat's tail grass					0.1	
Magnoliopsida – Magnoliidae (dicots)								
Acanthaceae	*Brunoniella australis*	blue trumpet			0.1		0.2	
Aizoaceae	*Galenia pubescens***	galenia						0.1
Apocynaceae	*Gomphocarpus fruticosus**	narrow-leaved cotton bush					0.1	
Asteraceae	*Calocephalus citreus*	lemon beauty-heads				0.1	0.2	
Asteraceae	*Calotis lappulacea*	yellow burr-daisy				0.1		0.1
Asteraceae	*Cassinia arcuata*	sifton bush			0.1			
Asteraceae	*Chrysocephalum apiculatum*	common everlasting		0.1			0.1	0.1
Asteraceae	*Glossocardia bidens*	cobbler's tack					0.1	
Asteraceae	*Senecio madagascariensis***	fireweed		0.1	0.1	0.1	0.1	0.1

Family Name	Scientific Name	Common Name	PCT1692 Bull Oak grassy woodland of the central Hunter Valley					
			Zone 5 *Moderate - Good*			Zone 6 *Regenerating*		
			Q02	Q04	Q10	Q18	Q41	Q44
Asteraceae	*Vittadinia pustulata*	fuzzweed					0.1	
Boraginaceae	*Heliotropium amplexicaule***	blue heliotrope						0.1
Brassicaceae	*Lepidium africanum**	common peppercress						0.1
Cactaceae	*Opuntia aurantiaca***	tiger pear	0.1	0.1	0.2			
Cactaceae	*Opuntia stricta var. stricta***	common prickly pear	0.1		0.1	0.1		
Campanulaceae	*Wahlenbergia communis*	tufted bluebell					0.1	
Casuarinaceae	*Allocasuarina luehmannii*	bulloak	30	25	20	9	10	10
Chenopodiaceae	*Chenopodium carinatum*	keeled goosefoot						0.3
Chenopodiaceae	*Einadia trigonos*	fishweed						0.1
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush			0.1			
Chenopodiaceae	*Maireana microphylla*	small-leaf bluebush			2		0.2	0.1
Convolvulaceae	*Convolvulus erubescens*	pink bindweed						0.1
Convolvulaceae	*Dichondra repens*	kidney weed					0.1	
Fabaceae (Faboideae)	*Daviesia ulicifolia*	gorse bitter pea				0.2		
Fabaceae (Faboideae)	*Desmodium varians*	slender tick-trefoil						0.1
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine				0.1	0.1	
Fabaceae (Faboideae)	*Pultenaea* sp.						0.2	
Fabaceae (Faboideae)	*Zornia dyctiocarpa* var. *dyctiocarpa*	zornia					0.1	
Lamiaceae	*Mentha satureioides*	native pennyroyal					0.3	
Malvaceae	*Sida corrugata*	corrugated sida						0.1
Malvaceae	*Sida rhombifolia**	Paddy's lucerne				0.1	0.1	0.1
Myrtaceae	*Eucalyptus crebra*	narrow-leaved ironbark	0.5	0.2		1		0.2
Oleaceae	*Olea europaea* subsp. *cuspidata***	African olive					0.3	
Phyllanthaceae	*Phyllanthus virgatus*	wiry spurge					0.1	0.1
Plantaginaceae	*Plantago lanceolata**	lamb's tongues				0.1		
Plantaginaceae	*Veronica plebeia*	trailing speedwell						0.1
Portulacaceae	*Portulaca oleracea*	pigweed						0.1
Rubiaceae	*Richardia stellaris**						0.1	
Solanaceae	*Solanum cinereum*	narrawa burr						0.1
Stackhousiaceae	*Stackhousia muricata*	stackhousia					0.1	0.1
Stackhousiaceae	*Stackhousia viminea*	slender stackhousia				0.1		
Verbenaceae	*Verbena quadrangularis**					0.1	0.1	

Family Name	Scientific Name	Common Name	PCT1692 Bull Oak grassy woodland of the central Hunter Valley					
			Zone 5 *Moderate - Good*			Zone 6 *Regenerating*		
			Q02	Q04	Q10	Q18	Q41	Q44
Filicopsida (ferns)								
Adiantaceae	*Cheilanthes sieberi subsp. sieberi*	rock fern		0.1	0.1	0.2	0.2	5
Adiantaceae	*Pellaea falcata*	sickle fern			0.1			

Family Name	Scientific Name	Common Name	PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley Zone 7 *Moderate - Good*		
			Q01	Q05	Q40
Magnoliopsida – Liliidae (monocots)					
Commelinaceae	*Commelina cyanea*	native wandering jew	0.1	0.1	0.1
Cyperaceae	*Cyperus fulvus*	sticky sedge			0.2
Juncaceae	*Juncus acutus* subsp. *acutus***	sharp rush		1	5
Juncaceae	*Juncus usitatus*				0.1
Poaceae	*Austrostipa verticillata*	slender bamboo grass	10		0.1
Poaceae	*Bromus catharticus**	prairie grass	0.1	0.1	
Poaceae	*Cynodon dactylon*	common couch	0.1	8	65
Poaceae	*Ehrharta erecta***	panic veldtgrass	0.1		
Poaceae	*Eriochloa pseudoacrotricha*	early spring grass			0.1
Poaceae	*Microlaena stipoides*	weeping grass	0.3		
Poaceae	*Paspalum dilatatum***	paspalum			0.1
Poaceae	*Paspalum vaginatum*	salt-water couch			3
Poaceae	*Pennisetum clandestinum***	kikuyu grass			0.1
Poaceae	*Setaria parviflora**				0.1
Poaceae	*Panicum* sp.	panicum			0.1
Poaceae	*Sporobolus creber*	slender rat's tail grass			0.1
Magnoliopsida – Magnoliidae (dicots)					
Aizoaceae	*Galenia pubescens***	galenia	0.2	0.1	0.1
Amaranthaceae	*Alternanthera denticulata*	lesser joyweed			0.1
Amaranthaceae	*Amaranthus hybridus**	slim amaranth			0.1
Anacardiaceae	*Schinus areira**	pepper tree			1
Apiaceae	*Apium prostratum* var. *prostratum*				0.1
Apiaceae	*Centella asiatica*	Indian pennywort			0.1
Apiaceae	*Cyclospermum leptophyllum**	slender celery			0.1

Family Name	Scientific Name	Common Name	PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley Zone 7 *Moderate - Good*		
			Q01	Q05	Q40
Apiaceae	*Hydrocotyle* sp.*				0.1
Apocynaceae	*Araujia sericifera***	moth vine		0.1	
Apocynaceae	*Gomphocarpus fruticosus**	narrow-leaved cotton bush		0.1	0.1
Asteraceae	*Aster subulatus**	wild aster			0.1
Asteraceae	*Bidens pilosa***	cobbler's pegs	0.1	0.1	0.2
Asteraceae	*Cirsium vulgare**	spear thistle			0.2
Asteraceae	*Conyza* sp.*	a fleabane			0.1
Asteraceae	*Senecio madagascariensis***	fireweed		0.1	0.1
Asteraceae	*Sigesbeckia orientalis* subsp. *orientalis*			0.1	
Asteraceae	*Sonchus oleraceus**	common sowthistle			0.1
Asteraceae	*Tagetes minuta**	stinking Roger			0.1
Asteraceae	*Taraxacum officinale**	dandelion		0.1	
Boraginaceae	*Heliotropium amplexicaule***	blue heliotrope	0.1	0.1	0.1
Brassicaceae	*Hirschfeldia incana**	buchan weed	0.1	0.1	
Brassicaceae	*Rorippa nasturtium-aquaticum**	watercress			0.2
Cactaceae	*Opuntia aurantiaca***	tiger pear	0.1		
Caryophyllaceae	*Cerastium glomeratum**	mouse-ear chickweed	0.1	0.2	
Casuarinaceae	*Casuarina cunninghamiana subsp. cunninghamiana*	river oak	15	35	30
Chenopodiaceae	*Einadia hastata*	berry saltbush	0.1	0.1	
Crassulaceae	*Bryophyllum delagoense***	mother of millions	0.1		0.1
Euphorbiaceae	*Euphorbia dallachyana*				0.1
Euphorbiaceae	*Euphorbia peplus**	petty spurge			0.1
Fabaceae (Faboideae)	*Trifolium repens**	white clover			0.1
Flacourtiaceae	*Dovyalis caffra**	kei apple		0.2	
Geraniaceae	*Geranium* sp.*				0.1
Malvaceae	*Modiola caroliniana**	red-flowered mallow	0.1	0.2	0.1
Malvaceae	*Sida rhombifolia**	Paddy's lucerne	0.1	0.2	0.1
Moraceae	*Ficus coronata*	creek sandpaper fig			1
Myrsinaceae	*Anagallis arvensis**	scarlet pimpernel			0.1
Oxalidaceae	*Oxalis exilis*		0.1		0.1
Oxalidaceae	*Oxalis perennans*			0.1	
Plantaginaceae	*Plantago lanceolata**	lamb's tongues			0.2
Plantaginaceae	*Plantago major**	large plantain			0.1

Family Name	Scientific Name	Common Name	PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley Zone 7 *Moderate - Good*		
			Q01	Q05	Q40
Polygonaceae	*Persicaria hydropiper*	water pepper			0.2
Polygonaceae	*Polygonum aviculare**	wireweed		0.1	
Polygonaceae	*Rumex brownii*	swamp dock		0.1	
Polygonaceae	*Rumex* sp.*	dock			0.1
Primulaceae	*Samolus valerandi*	common brookweed			0.1
Solanaceae	*Solanum pseudocapsicum**	madeira winter cherry	0.1	0.2	0.2
Urticaceae	*Urtica incisa*	stinging nettle		0.2	0.1
Verbenaceae	*Verbena* sp.*		0.1		

Family Name	Scientific Name	Common Name	PCT1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter			
			Zone 8 *Woody Rehabilitation*			
			Q51	Q56	Q57	Q60
Magnoliopsida – Liliidae (monocots)						
Cyperaceae	*Carex appressa*	tall sedge	0.1			
Cyperaceae	*Cyperus gracilis*	slender flat-sedge	0.1		0.1	
Phormiaceae	*Dianella longifolia*	blueberry lily		0.1		
Poaceae	*Aristida ramosa*	purple wiregrass	5			
Poaceae	*Austrostipa verticillata*	slender bamboo grass	0.2		0.5	
Poaceae	*Rytidosperma bipartitum*	wallaby grass	0.1			
Poaceae	*Bothriochloa* sp.*	redgrass; bluegrass	0.1			
Poaceae	*Bromus molliformis**	soft brome		0.1		
Poaceae	*Chloris gayana***	Rhodes grass	0.1	20		
Poaceae	*Cymbopogon refractus*	barbed wire grass	1	0.2	2	0.1
Poaceae	*Cynodon dactylon*	common couch	0.1	0.5	0.1	0.1
Poaceae	*Hyparrhenia hirta***	coolatai grass	0.1		2	45
Poaceae	*Megathyrsus maximus**					0.2
Poaceae	*Melinis repens**	red natal grass		0.1		2
Poaceae	*Microlaena stipoides* var. *stipoides*	weeping grass	0.1			
Poaceae	*Pennisetum clandestinum***	kikuyu grass				0.1
Poaceae	*Setaria parviflora**			15		
Poaceae	*Sporobolus creber*	slender rat's tail grass		0.1		0.1
Magnoliopsida – Magnoliidae (dicots)						
Aizoaceae	*Galenia pubescens***	galenia	0.3	0.2	0.3	0.1
Apocynaceae	*Gomphocarpus fruticosus**	narrow-leaved cotton bush	0.1		0.1	0.1
Asteraceae	*Bidens pilosa***	cobbler's pegs	0.1	0.1		

Family Name	Scientific Name	Common Name	PCT1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter			
			Zone 8 *Woody Rehabilitation*			
			Q51	Q56	Q57	Q60
Asteraceae	*Hypochaeris radicata**	catsear	0.1			
Asteraceae	*Senecio madagascariensis***	fireweed		0.1	0.1	0.1
Asteraceae	*Vittadinia* sp.	fuzzweed	0.1			0.1
Brassicaceae	*Lepidium africanum**	common peppercress			0.1	
Cactaceae	*Opuntia aurantiaca***	tiger pear	0.1			
Cactaceae	*Opuntia humifusa***	creeping pear	0.1			
Cactaceae	*Opuntia stricta* var. *stricta***	common prickly pear	0.1			
Caryophyllaceae	*Petrorhagia dubia**		0.1			0.1
Chenopodiaceae	*Einadia hastata*	berry saltbush	0.1		0.1	
Chenopodiaceae	*Einadia nutans* subsp. *linifolia*	climbing saltbush	0.1		0.1	
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush	0.2		0.2	
Chenopodiaceae	*Maireana microphylla*	small-leaf bluebush				0.1
Convolvulaceae	*Convolvulus erubescens*	pink bindweed	0.1			0.1
Convolvulaceae	*Dichondra repens*	kidney weed	0.1	0.1	0.2	0.1
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine				0.1
Fabaceae (Faboideae)	*Medicago* sp.*	a medic				0.1
Fabaceae (Mimosoideae)	*Acacia decora*	western silver wattle		1		0.5
Fabaceae (Mimosoideae)	*Acacia decurrens*	black wattle				0.5
Fabaceae (Mimosoideae)	*Acacia implexa*	hickory wattle		1		0.3
Fabaceae (Mimosoideae)	*Acacia salicina*	cooba	1			
Fabaceae (Mimosoideae)	*Acacia* sp.	wattle		1	0.5	2
Geraniaceae	*Geranium solanderi*	native geranium		0.1		
Linaceae	*Linum marginale*	native flax				0.1
Linaceae	*Linum trigynum**	French flax		0.1		0.1
Lobeliaceae	*Pratia purpurascens*	whiteroot	0.1			
Malvaceae	*Modiola caroliniana**	red-flowered mallow			0.1	
Malvaceae	*Sida corrugata*	corrugated sida		0.1		
Malvaceae	*Sida rhombifolia**	Paddy's lucerne	0.1	0.1	0.1	0.1
Malvaceae	*Sida spinosa**		0.1			
Myoporaceae	*Eremophila debilis*	amulla	0.1		0.1	
Myrtaceae	*Corymbia maculata*	spotted gum		20	30	20
Myrtaceae	*Corymbia* sp.		5			
Myrtaceae	*Eucalyptus albens*	white box		5		
Myrtaceae	*Eucalyptus cladocalyx**	sugar gum	5			
Myrtaceae	*Eucalyptus crebra*	narrow-leaved ironbark		0.3		
Myrtaceae	*Eucalyptus dawsonii*	slaty gum	5			
Myrtaceae	*Eucalyptus moluccana*	grey box	5		5	
Myrtaceae	*Eucalyptus punctata*	grey gum	10			

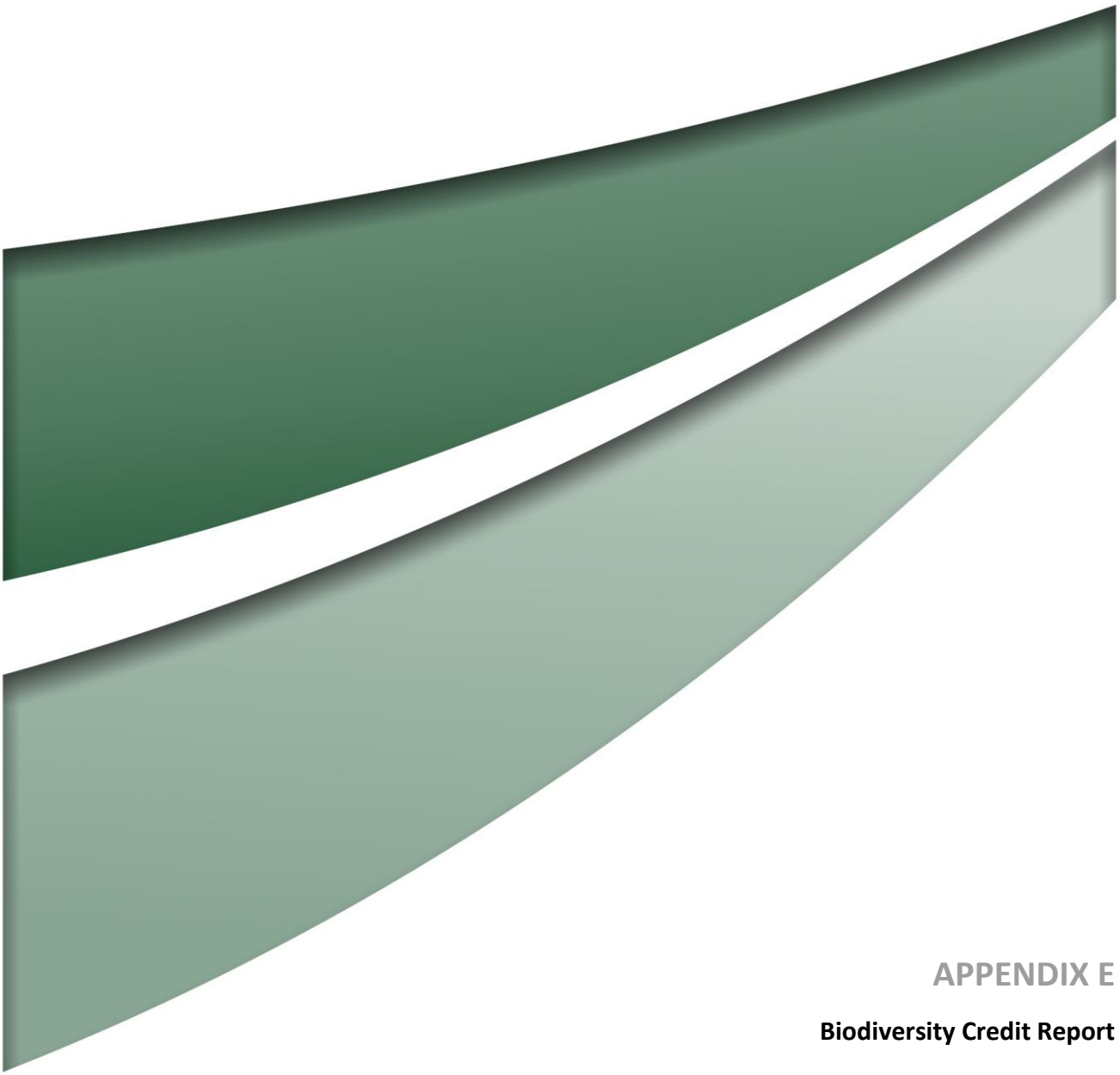
Family Name	Scientific Name	Common Name	PCT1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter			
			Zone 8 *Woody Rehabilitation*			
			Q51	Q56	Q57	Q60
Myrtaceae	*Eucalyptus* sp.		5			
Oleaceae	*Olea europaea* subsp. *cuspidata***	African olive	1			
Oxalidaceae	*Oxalis exilis*		0.1			
Oxalidaceae	*Oxalis* sp.				0.1	
Phyllanthaceae	*Phyllanthus virgatus*	wiry spurge		0.1		
Plantaginaceae	*Plantago lanceolata**	lamb's tongues	0.1	0.1	0.1	0.1
Ranunculaceae	*Clematis glycinoides*	headache vine	0.1			
Solanaceae	*Solanum* sp.*		0.2			

Family Name	Scientific Name	Common Name	PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley							
			Zone 9 *Moderate – Good*					Zone 10 *Plantation*		
			Q11	Q17	Q28	Q36	Q37	Q64	Q65	Q69
Magnoliopsida – Liliidae (monocots)										
Alliaceae	*Nothoscordum borbonicum*							0.1		
Anthericaceae	*Tricoryne elatior*	yellow autumn-lily								0.1
Commelinaceae	*Commelina cyanea*	native wandering jew			0.1		0.1			
Cyperaceae	*Cyperus gracilis*	slender flat-sedge				0.2				
Juncaceae	*Juncus acutus* subsp. *acutus***	sharp rush	7							
Lomandraceae	*Lomandra filiformis*				0.1	0.1				
Lomandraceae	*Lomandra longifolia*	spiny-headed mat-rush						0.2		
Poaceae	*Bromus catharticus**	prairie grass							0.1	
Poaceae	*Eragrostis curvula***	African lovegrass								1
Poaceae	*Briza subaristata***									0.1
Poaceae	*Capillipedium spicigerum*	scented-top grass								0.2
Poaceae	*Chloris gayana***	Rhodes grass		0.1		0.2		3	15	0.1
Poaceae	*Aristida ramosa*	purple wiregrass			0.3			0.1		0.2
Poaceae	*Austrostipa verticillata*	slender bamboo grass	1	2	3	35	0.5			
Poaceae	*Bothriochloa* sp.*	redgrass; bluegrass						0.1		
Poaceae	*Cymbopogon refractus*	barbed wire grass		0.3						6
Poaceae	*Cynodon dactylon*	common couch	2		0.2			1	2	0.1
Poaceae	*Lolium rigidum**	wimmera ryegrass						0.1		
Poaceae	*Melinis repens**	red natal grass								0.2
Poaceae	*Microlaena stipoides*	weeping grass				1	55			
Poaceae	*Phragmites australis*	common reed	2							

Family Name	Scientific Name	Common Name	PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley							
			Zone 9 *Moderate – Good*					Zone 10 *Plantation*		
			Q11	Q17	Q28	Q36	Q37	Q64	Q65	Q69
Poaceae	*Setaria parviflora**								20	
Poaceae	*Sporobolus creber*	slender rat's tail grass								0.2
Magnoliopsida – Magnoliidae (dicots)										
Acanthaceae	*Brunoniella australis*	blue trumpet		0.2		0.1				
Aizoaceae	*Galenia pubescens***	galenia	1		5	1		0.5	1	
Amaranthaceae	*Nyssanthes diffusa*	barbwire weed					0.1			
Apocynaceae	*Gomphocarpus fruticosus**	narrow-leaved cotton bush			0.1					
Apocynaceae	*Parsonsia straminea*	common silkpod							0.5	
Asteraceae	*Bidens pilosa***	cobbler's pegs	0.1						0.1	
Asteraceae	*Calotis lappulacea*	yellow burr-daisy				0.1				
Asteraceae	*Carthamus lanatus***	saffron thistle						0.1		
Asteraceae	*Chrysocephalum apiculatum*	common everlasting								0.1
Asteraceae	*Cirsium vulgare**	spear thistle							0.1	
Asteraceae	*Hypochaeris microcephala* var. *albiflora**									0.1
Asteraceae	*Hypochaeris radicata**	catsear				0.1				
Asteraceae	*Senecio madagascariensis***	fireweed						0.1	0.1	
Asteraceae	*Sonchus asper* subsp. *glaucescens**	prickly sowthistle							0.1	
Asteraceae	*Sonchus oleraceus**	common sowthistle							0.1	
Asteraceae	*Vittadinia muelleri*	a fuzzweed								0.1
Asteraceae	*Vittadinia* sp.	fuzzweed								0.1
Brassicaceae	*Lepidium africanum**	common peppercress				0.1				
Cactaceae	*Opuntia aurantiaca***	tiger pear			0.1					
Cactaceae	*Opuntia stricta var. stricta***	common prickly pear		0.1	0.1	0.1				
Campanulaceae	*Wahlenbergia gracilis*	sprawling bluebell								0.1
Casuarinaceae	*Casuarina glauca*	swamp oak	30	30	25	10	20	15	30	7
Chenopodiaceae	*Einadia hastata*	berry saltbush	0.1		0.2	0.1		0.1		
Chenopodiaceae	*Einadia nutans* subsp. *nutans*	climbing saltbush						0.1		
Chenopodiaceae	*Einadia polygonoides*	knotweed goosefoot				0.1				
Chenopodiaceae	*Einadia trigonos*	fishweed					0.1			
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush	0.1			0.1			0.1	0.1
Convolvulaceae	*Dichondra repens*	kidney weed				0.1		0.1		0.2
Fabaceae (Faboideae)	*Glycine clandestina*	twining glycine					0.1			
Fabaceae (Faboideae)	*Glycine tabacina*	variable glycine				0.1	0.3			0.1
Fabaceae (Faboideae)	*Desmodium gunnii*	slender tick-trefoil				0.1				

Family Name	Scientific Name	Common Name	PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley							
			Zone 9 *Moderate – Good*					Zone 10 *Plantation*		
			Q11	Q17	Q28	Q36	Q37	Q64	Q65	Q69
Fabaceae (Mimosoideae)	*Acacia implexa*	hickory wattle						0.3		
Fabaceae (Mimosoideae)	*Acacia salicina*	cooba	0.1						0.2	
Fabaceae (Mimosoideae)	*Acacia saligna**	golden wreath wattle							0.2	1
Fabaceae (Mimosoideae)	*Acacia* sp.	wattle				0.1				
Flacourtiaceae	*Dovyalis caffra**	kei apple		0.1	2					
Lobeliaceae	*Pratia purpurascens*	whiteroot				0.1			0.1	
Lobeliaceae	*Pratia concolor*	poison pratia					0.5			
Loranthaceae	*Amyema cambagei*	needle-leaf mistletoe		0.2			2			
Malvaceae	*Modiola caroliniana**	red-flowered mallow						0.1	0.1	
Malvaceae	*Sida corrugata*	corrugated sida		0.1		0.1				
Malvaceae	*Sida hackettiana* (syn. *Sida subspicata*)					0.1				
Malvaceae	*Sida rhombifolia**	paddy's lucerne		0.2	0.1	0.1	0.1	0.1	0.2	0.1
Malvaceae	*Sida spinosa**							0.1		
Malvaceae	*Sida* sp.*			0.1						
Meliaceae	*Melia azedarach*	white cedar							1	
Myoporaceae	*Eremophila debilis*	amulla	0.1	0.2		1				0.2
Myrsinaceae	*Anagallis arvensis**	scarlet pimpernel							0.1	
Myrtaceae	*Angophora floribunda*	rough-barked apple						2		
Myrtaceae	*Backhousia myrtifolia*	grey myrtle					1			
Myrtaceae	*Callistemon salignus*	willow bottlebrush								1
Myrtaceae	*Callistemon* sp.									0.2
Myrtaceae	*Corymbia maculata*	spotted gum						3		2
Myrtaceae	*Eucalyptus crebra*	narrow-leaved ironbark				5				2
Myrtaceae	*Eucalyptus fibrosa*	red ironbark						0.5		
Myrtaceae	*Eucalyptus moluccana*	grey box						5		
Myrtaceae	*Eucalyptus tereticornis*	forest red gum						5		3
Myrtaceae	*Melaleuca linariifolia*	flax-leaved paperbark								2
Myrtaceae	*Melaleuca styphelioides*	prickly-leaved tea tree								0.5
Oleaceae	*Olea europaea* subsp. *cuspidata***	African olive	0.1	0.1					0.1	0.1
Oxalidaceae	*Oxalis exilis*					0.1	0.1			
Phyllanthaceae	*Phyllanthus virgatus*	wiry spurge						0.1		

Family Name	Scientific Name	Common Name	PCT1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley							
			Zone 9 *Moderate – Good*					Zone 10 *Plantation*		
			Q11	Q17	Q28	Q36	Q37	Q64	Q65	Q69
Plantaginaceae	*Plantago lanceolata**	lamb's tongues		0.1				0.1	0.1	0.1
Plantaginaceae	*Veronica plebeia*	trailing speedwell					0.1			
Polygonaceae	*Rumex brownii*	swamp dock					0.1			
Polygonaceae	*Rumex* sp.*	dock				0.1				
Ranunculaceae	*Clematis glycinoides*	headache vine				0.1				
Rubiaceae	*Galium* sp.*						0.1			
Rubiaceae	*Asperula conferta*	common woodruff								0.1
Sapindaceae	*Dodonaea viscosa*	sticky hop-bush						0.2		
Solanaceae	*Solanum brownii*	violet nightshade			0.1					
Solanaceae	*Solanum nigrum**	black-berry nightshade							0.1	
Solanaceae	*Solanum prinophyllum*	forest nightshade		0.1						
Solanaceae	*Solanum pseudocapsicum**	madeira winter cherry		0.1			0.1			
Solanaceae	*Solanum pungetium*	eastern nightshade						0.1		
Solanaceae	*Solanum stelligerum*	devil's needles				2	0.5			
Solanaceae	*Withania somnifera**	winter cherry	0.1							
Verbenaceae	*Verbena quadrangularis**				0.1				0.1	
Vitaceae	*Cayratia clematidea*	native grape				0.2	1			
Filicopsida (ferns)										
Adiantaceae	*Cheilanthes distans*	bristly cloak fern				0.1				0.1
Adiantaceae	*Cheilanthes sieberi subsp. Sieberi*	rock fern		0.1		0.1				0.1



APPENDIX E

Biodiversity Credit Report

BAM Credit Summary Report

Proposal Details

Assessment Id
00011500/BAAS17005/19/00011501

Proposal Name
Glendell Continued Operations Project

BAM data last updated *
27/09/2019

Assessor Name
Kate Connolly

Report Created
10/10/2019

BAM Data version *
15

Assessor Number
BAAS17005

BAM Case Status
Open

Date Finalised
To be finalised

Assessment Revision
3

Assessment Type
Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	Vegetation integrity loss / gain	Area (ha)	Constant	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Bull Oak grassy woodland of the central Hunter Valley								
4	1692_ModGood	26.3	18.0	0.25	High Sensitivity to Potential Gain	1.75		207

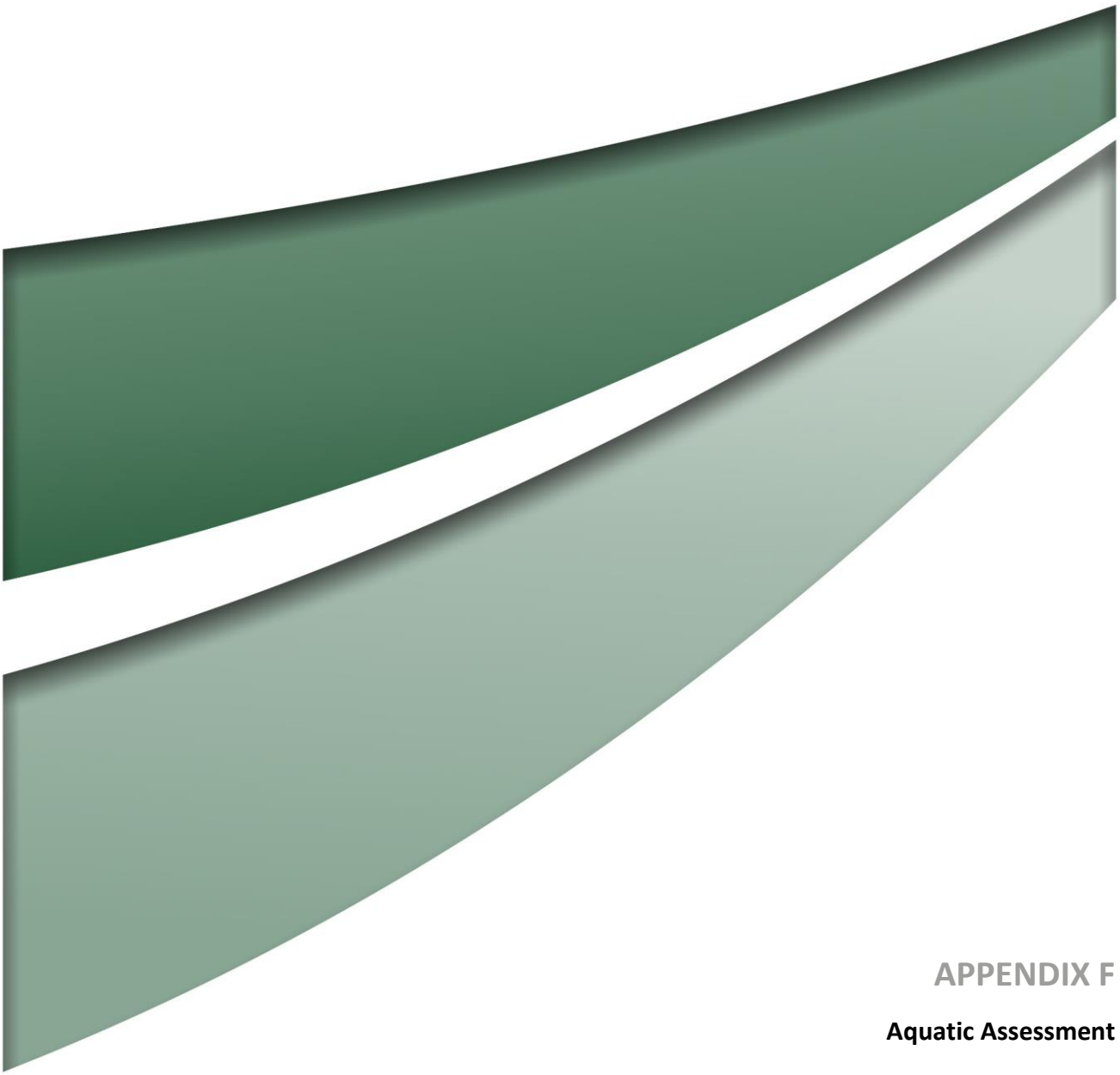
5	1692_Regeneration	25.7	10.2	0.25	High Sensitivity to Potential Gain	1.75		115
							Subtotal	**322**
Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter								
1	1603_ModGood	37.6	26.7	0.25	High Sensitivity to Potential Gain	2.00		502
2	1603_Regeneration	31.5	53.1	0.25	High Sensitivity to Potential Gain	2.00		836
3	1603_DNG	18.3	386.0	0.25	High Sensitivity to Potential Gain	2.00		3527
10	1603_Plantation	37.0	1.8	0.25	High Sensitivity to Potential Gain	2.00		33
							Subtotal	**4898**
Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter								
6	1604_WoodyRehab	45.0	0.5	0.25	High Sensitivity to Potential Gain	2.00		11
7	1604_ExoticGrasslandRehab	3.8	3.1	0.25	Moderate Sensitivity to Potential Gain	1.75		0
							Subtotal	**11**
River Oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion)								
11	485_ModGood	32.0	2.4	0.25	High Sensitivity to Potential Gain	1.75		34
							Subtotal	**34**

Swamp Oak - Weeping Grass grassy riparian forest of the Hunter Valley								
8	1731_ModGood	38.8	40.0	0.25	High Sensitivity to Potential Gain	1.75		679
9	1731_Plantation	36.1	1.8	0.25	High Sensitivity to Potential Gain	1.75		28
							Subtotal	**707**
							Total	**5972**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk weighting	Potential SAII	Species credits
Cymbidium canaliculatum - endangered population / Cymbidium canaliculatum population in the Hunter Catchment (Flora)						
1603_Regeneration	N/A	1	0.25	2	False	2
					Subtotal	**2**
Myotis macropus / Southern Myotis (Fauna)						
1692_Regeneration	25.7	7	0.25	2	False	90
1603_ModGood	37.6	8.9	0.25	2	False	167
1603_Regeneration	31.5	25	0.25	2	False	394
1692_ModGood	26.3	5.3	0.25	2	False	70
1604_WoodyRehab	45.0	0.2	0.25	2	False	5
1603_Plantation	37.0	0.3	0.25	2	False	6
					Subtotal	**732**
Phascogale tapoatafa / Brush-tailed Phascogale (Fauna)						
1692_Regeneration	25.7	10.2	0.25	2	False	131

1603_ModGood	37.6	26.7	0.25	2	False	502
1603_Regeneration	31.5	53.1	0.25	2	False	836
1692_ModGood	26.3	18	0.25	2	False	237
1604_WoodyRehab	45.0	0.5	0.25	2	False	11
1731_ModGood	38.8	40	0.25	2	False	776
1731_Plantation	36.1	1.8	0.25	2	False	33
1603_Plantation	37.0	1.8	0.25	2	False	33
					Subtotal	**2559**
Vespadelus troughtoni / Eastern Cave Bat (Fauna)						
1604_WoodyRehab	45.0	0.5	0.25	3	True	17
					Subtotal	**17**



APPENDIX F

Aquatic Assessment

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GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

Aquatic Ecology Assessment

FINAL

November 2019

GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

Aquatic Ecology Assessment

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements

Project Director:	Bret Jenkins
Project Manager:	David Holmes
Technical Director:	Allison Riley
Technical Manager:	Shaun Corry
Report No.	4166/R06
Date:	November 2019

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Certified System
Quality
ISO 9001

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

Document Status

Rev No.	Reviewer		Approved for Issue	
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Executive Summary

This aquatic ecology assessment for the Glendell Continued Operations Project (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 Project includes the realignment of an approximately 4 kilometre (km) section of Yorks Creek, with sections of Swamp Creek proposed to be impacted by mining activities. Bowmans Creek (sixth order) is located to the west of the Project Area. Yorks Creek, Swamp Creek and Bettys Creek are ephemeral and are characterised by variable and unpredictable patterns of flow including periods of no flow, have poor water quality and have 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). Yorks Creek and Swamp Creek occurring within the Project Area have been classified as Class 3 minimal key fish habitats and Type 3 minimal habitat sensitive. Bowmans Creek was assessed as Class 2 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 upstream and downstream of the 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 Project Area, and the surface water and groundwater impacts of the Project are not predicted to adversely affect potential habitat for these species. No nationally listed threatened aquatic species or Threatened Ecological Communities (TEC) or aquatic migratory species are expected to occur in the watercourses within or adjacent to the Project Area.

The results of the groundwater assessment (AGE 2019) concluded that the Project is not expected to have an adverse effect on groundwater resources such that local and regional aquatic biodiversity would be significantly impacted.

Surface water impacts associated with the Project are not predicted to result in adverse surface water impacts on Yorks Creek, Swamp Creek and Bettys Creek or in the downstream environments of Bowmans Creek and the Hunter River (GHD 2019) such that would result in significance impacts on local and regional aquatic ecology values in these streams.

Glossary

Abbreviation	Description
AIP	NSW Aquifer Interference Policy 2012
BCD	Biodiversity Conservation Division (formerly OEH)
BAR	Biodiversity Assessment Report
CEEC	Critically endangered ecological community
DECC	NSW Department of Environment and Climate Change (now BCD)
DoEE	Department of Environment and Energy
DPI	NSW Department of Primary Industries
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EP	Endangered population
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
Glencore	Glencore Coal Pty Limited
GDE	Groundwater Dependent Ecosystem
GRAWTS	Greater Ravensworth Area Water and Treatment Scheme
hah	Hectare
HRSTS	Hunter River Salinity Trading Scheme
IESC	Independent Expert Scientific Committee
km	Kilometres
LGA	Local Government Area
LPI	Land and Property Information
MNES	Matters of national environmental significance
Mtpa	Million tonnes per annum
OEH	Office of Environment and Heritage (now BCD)
PMST	Protected Matters Search Tool
Project	Glendell Continued Operations Project
Proponent	Glendell Tenements Pty Limited
ROM	Run of mine
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSD	State Significant Development
TEC	Threatened ecological community
the Regulation	*Environmental Planning and Assessment Regulation 2000*
Umwelt	Umwelt (Australia) Pty Limited

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1.0 Introduction

The Glendell Mine forms part of the Mount Owen Complex in the Hunter Region of New South Wales (NSW) and is owned and operated by subsidiaries of Glencore Coal Pty Limited (Glencore). The site is part of the Hunter Valley Coalfields and is located approximately 20 kilometres (km) northwest of Singleton in the Singleton Local Government Area (LGA) (refer to **Figure 1.1**). The Mount Owen Complex includes Mount Owen Mine, Ravensworth East Mine, Glendell Mine and a coal handling and preparation plant (CHPP) and coal transport infrastructure.

The Glendell Continued Operations Project (the Project) is an extension of open cut mining operations immediately to the north of the existing Glendell Mine (refer to **Figure 1.2**). The Project would extend the life of the Glendell Mine to approximately 2044 and allow for the recovery of approximately 135 million tonnes (Mt) of run-of-mine (ROM) coal and provide ongoing employment opportunities for existing Mount Owen Complex workforce.

The key features of the Project include:

- extension of open cut mining to the north of the existing Glendell Mine until 2044
- extraction of approximately 135 Mt of ROM coal
- continued integration of the mine with the wider Mount Owen Complex, including the use of the Mount Owen CHPP, rail loop and associated infrastructure for ROM coal processing and product coal transport to 2045
- demolition of the existing Glendell Mine Infrastructure Area (MIA) and the construction of a new MIA
- realignment of a section of Hebden Road
- realignment of the lower section of Yorks Creek (detailed further in **Section 4.3**)
- relocation of Ravensworth Homestead
- other ancillary infrastructure works such as the construction of a Heavy Vehicle Access Road
- progressive rehabilitation of the site.

This report has been prepared by Umwelt Pty Limited (Umwelt) and will form part of the environmental impact statement (EIS) for the proposal. The EIS has been prepared to accompany the application for approval of the Project, and addresses the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (DPIE) Environmental Assessment Requirements (the SEARs), as revised 12 August 2019.

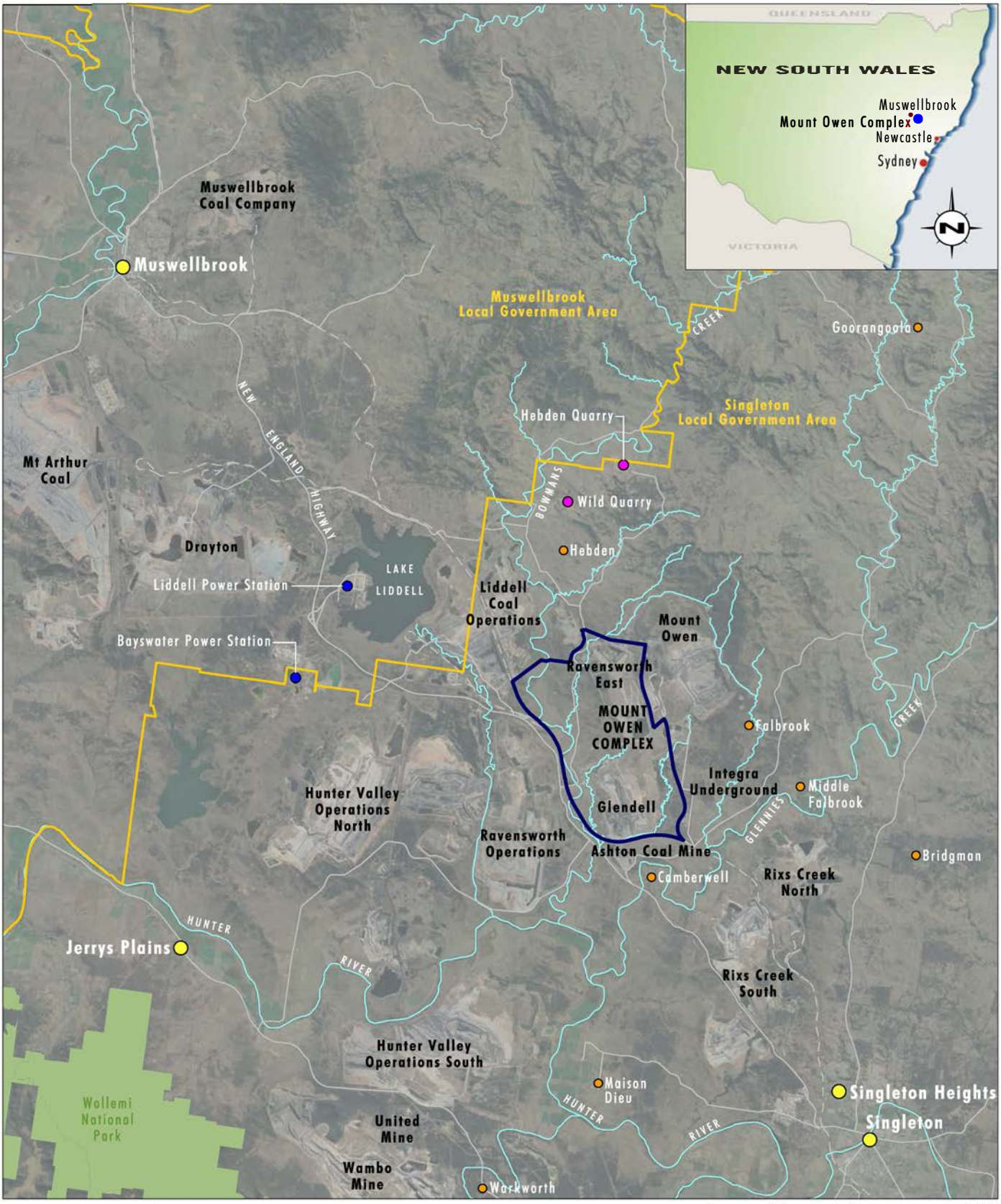


Image Source: Google Earth (2018)
Data Source: Glencore (2019), OEH (2018)

Legend

- Project Area
- Local Government Area Boundary
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Village/Localities
- Power Stations
- Quarry

FIGURE 1.1

Project Locality

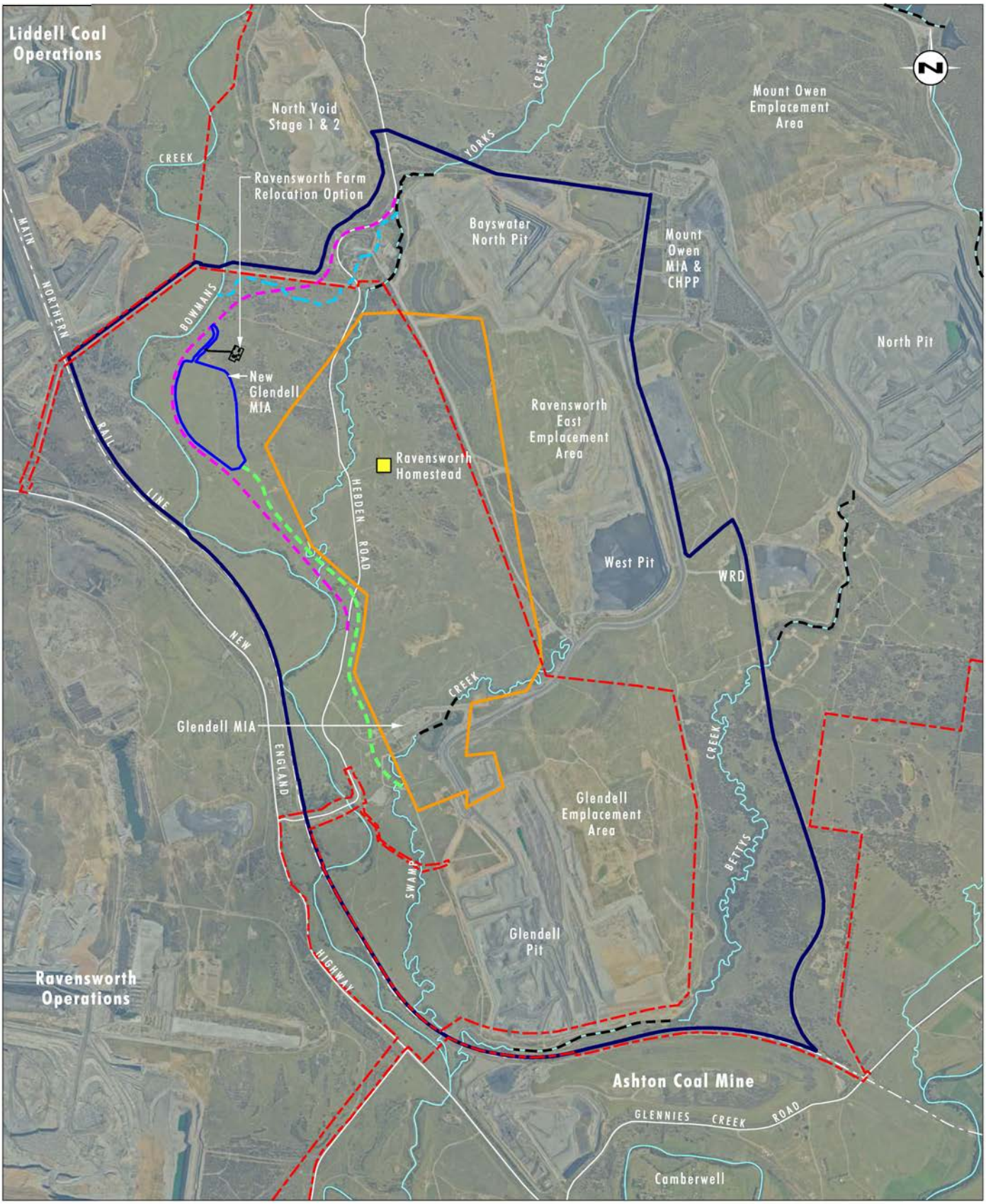


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)
Notes: Ravensworth Homestead to be relocated, Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

- Project Area
- Glendell Pit Extension
- Mount Owen Consent Boundary
- Ravensworth Homestead
- Existing Creek Diversion

Project Features:

- New Glendell MIA
- Heavy Vehicle Access Road
- Yorks Creek Realignment
- Hebden Road Realignment

FIGURE 1.2

Glendell Continued Operations Project
Key Project Features

1.1 Purpose and scope of this report

This report provides the results of the Aquatic Ecology Assessment of the 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
- 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 aquatic matters of national environmental significance (MNES) as listed under the *Environment Biodiversity and Conservation Act 1999* (EPBC Act)
- evaluates the impact of the Project on threatened fish species, populations and ecological communities
- assesses the impact of the Project on aquatic species and ecosystems, and
- determines the impact mitigation measures required to minimise and mitigate the impacts of the Project on aquatic species and ecosystems.

This report does not consider the impacts of the Project on stygofaunas or hyporheic fauna. The Project's potential impacts on stygofaunas have been assessed in the Stygofauna Assessment (Eco Logical2019).

The Project's potential impacts on groundwater dependent ecosystems is considered in the EIS (Umwelt 2019a, 2019b) and the Assessment of Commonwealth Biodiversity Matters Report (Umwelt 2019b).

Table 1.1 outlines the SEARs relevant to aquatic ecology and where they are addressed.

Table 1.1 Relevant SEARs

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in report
DPIE 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, undertaken in accordance with the *Biodiversity Assessment Method* and documented in a Biodiversity Development Assessment Report or, subject to agreement with OEH and the Department, undertaken in accordance with the *Upper Hunter Strategic Assessment (UHSA)*	**Section 4.0***
• where the Yorks Creek diversion is proposed: demonstrate how a 'natural' system can be successfully created	**Section 4.0**
• where the Yorks Creek diversion is proposed: include an assessment of potential impacts to aquatic habitat and fish populations	**Section 4.3** and Appendix 7 of the EIS. Refer also to the Surface Water Impact Assessment (GHD 2019)
• Guidelines: o Biodiversity Assessment Method(OEH 2017); o Policy and Guidelines for Fish Habitat Conservation and Management - Update (DPI 2013); o Why do fish need to cross the road? Fish passage requirements for waterway crossings (NSW Fisheries 2003); and o Aquatic Ecology in Environmental Impact Assessment EIA Guideline (Marcus Lincoln Smith 2003).	
DPIE SEARs – Water	
• an assessment of the likely impacts of the development on the quantity and quality of existing surface and groundwater resources including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives.	**Section 4.0***
• an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users, including downstream impacts from the Yorks Creek diversion	**Section 4.2***
• Guidelines: o Biodiversity Assessment Method (OEH 2017) o Risk assessment Guidelines for Groundwater Dependent Ecosystems (Office of Water 2012).	**Sections 3.0 and 4.0***

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in report
Department of Industry - Water	
• Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	**Section 4.0***
• Proposed surface and groundwater monitoring activities and methodologies.	Appendix 16 and 17 of the EIS
• Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the DPI Water Guidelines for Controlled Activities on Waterfront Land (2012) and the relevant Water Sharing Plans (available at http://www.water.nsw.gov.au/).	
Department of Primary Industries - Fisheries	
• The complete design of the creek diversion including changes in slope, length and habitat structures proposed in the diversion compared to the existing creek line.	**Section 4.3** and Appendix 7 of the EIS
• A detailed outline on how a "natural" system can be created in this landscape. Note - the preliminary report identifies the difficulty in establishing natural systems within large engineered cuttings, and is recommending a cutting of approximately 2km in length and 20 to 30m in depth in soil that is considered erodible. DPI Fisheries does not consider a trapezoidal rock lined drain as an appropriate natural system.	**Section 4.3**
• Identification of how the design will mitigate or offset the areas of aquatic habitat that is lost due to the shortening of the creek by the proposed diversion.	**Section 4.3**
• A complete assessment of the fish population in Yorks Creek to determine the presence or absence of any threated fish species. Reliance on past assessments may not give a complete picture as the species are small and similar species in inland waters have been shown to be quite mobile in ephemeral streams. This information is required to complete the required test of Significance under Part 7a of the *Fisheries Management Act 1994*.	**Section 4.4**
• An assessment of the diversion shall also include an assessment on the changes in flows entering Bowmans Creek at the proposed junction and ascertain how these flows can be introduced to the stream without creating erosion and turbidity issues in Bowmans Creek.	**Section 4.3**
• Relevant Guidelines/policies for assessment of impacts and requirements that should be addressed can be found in DPI Fisheries Policy & Guideline document: Policy and Guidelines for Fish Habitat Conservation and Management (2013 update) available on the Department's website at www.dpi.nsw.gov.au/fishing/habitat/publications/pubs/fish-habitat conservation.	

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in report
Office of Environment and Heritage	
• The EIS must assess the impacts of the development on hydrology: including effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	**Section 4.0**
• The EIS must assess the impacts of the development on hydrology: Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	**Section 4.3 and 4.4***
• The EIS must assess the impacts of the development on hydrology: Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	**Section 4.0**

*Impacts on groundwater dependent ecosystems are considered in the EIS (Umwelt 2019a2019), Stygofauna Assessment (Eco Logical2019) and the Assessment of Commonwealth Biodiversity Matters Report (Umwelt 2019b)

1.2 Legislative context

1.2.1 NSW Environmental Planning and Assessment Act 1979 (EP&A Act)

The *Environmental Planning and Assessment Act* 1979 (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (the EP&A Regulation) provide the framework for development assessment in NSW. The EP&A Act and the EP&A Act 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 Project on aquatic ecology.

1.2.2 NSW Fisheries Management Act 1994 (FM Act)

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.

Section 3.6 of this report identifies threatened species, populations and communities likely to occur within the Project Area and **Section 4.3** of this report assesses likely impacts of the Project in accordance with Part 7A of the FM Act.

1.2.3 Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) is the primary piece of Commonwealth legislation relating to the environment. Under the EPBC Act any 'action' that has, or is likely to have, a significant impact on a matter of national environmental significance (MNES) requires approval from the Commonwealth Minister for the Environment. 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
- a water resource, in relation to coal seam gas development and large coal mining development.

The Project is a coal mining development that will interact with water resources and some listed threatened species and communities are known to occur, with others having the potential to occur within the Project Area. On 10 July 2019, the Project was determined to be a Controlled Action requiring approval under the EPBC Act from the Commonwealth Minister for the Environment due to its likely significant impact on the value of groundwater and surface water resources from changes to hydrological characteristics and water quality. The Project is not a controlled action for impacts to any specific aquatic species or aquatic ecological communities.

2.0 Assessment method

2.1 Literature and database review

A desktop review of previous documents and reports relevant to the proposal was undertaken. The following public database searches were undertaken:

- a 5 km buffer search from the edge of the Project Area on the Commonwealth Department of the Environment Protected Matters Search Tool (DoEE 2018 – accessed August 2019).

Relevant documents reviewed included:

- Key Fish Habitat mapping for Singleton LGA (NSW DPI)
- Online publications and determinations for threatened fish, endangered populations and ecological communities as listed under the FM Act and the EPBC Act
- a search of the freshwater threatened species distribution maps (DPI 2018)
- Ashton Coal Project - Flora and Fauna Baseline Monitoring of Bowmans Creek (ERM 2006)
- Ashton Coal Pty Limited Aquatic Ecology Assessment, Upper Liddell Seam LW 1-8 (Marine Pollution Research 2009)
- Ashton Coal 2018 Annual Review (Ashton Coal 2018)
- Liddell Coal Mine Extension – Aquatic Ecology and Groundwater Dependent Ecosystem Assessment (Eco Logical Australia 2012)
- Mount Owen Complex Ecological Assessment (Umwelt 2014)
- Aquatic habitat and fish assessment for Bowmans Creek Temporary Crossing (Umwelt 2017).

The information obtained was used to inform survey design and to assist in the description of ecological context, assessment of potentially occurring threatened species, endangered populations (EPs) and Threatened Ecological Communities (TECs).

Prior to the design of field survey the following guidelines were considered to ensure that aquatic species and habitats were adequately surveyed and assessed:

- Biodiversity Assessment Method (OEH 2017)
- Policy and Guidelines for Fish Habitat Conservation and Management - Update (DPI 2013)
- Aquatic Ecology in Environmental Impact Assessment EIA Guideline (Marcus Lincoln Smith 2003).

2.2 Stream order mapping

In characterising the watercourses in the 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 first stream order has been manually assigned for irrigation channels and other artificial drainage lines. Stream orders have been mapped at 1:50000 scale and are shown on **Figure 2.1**.

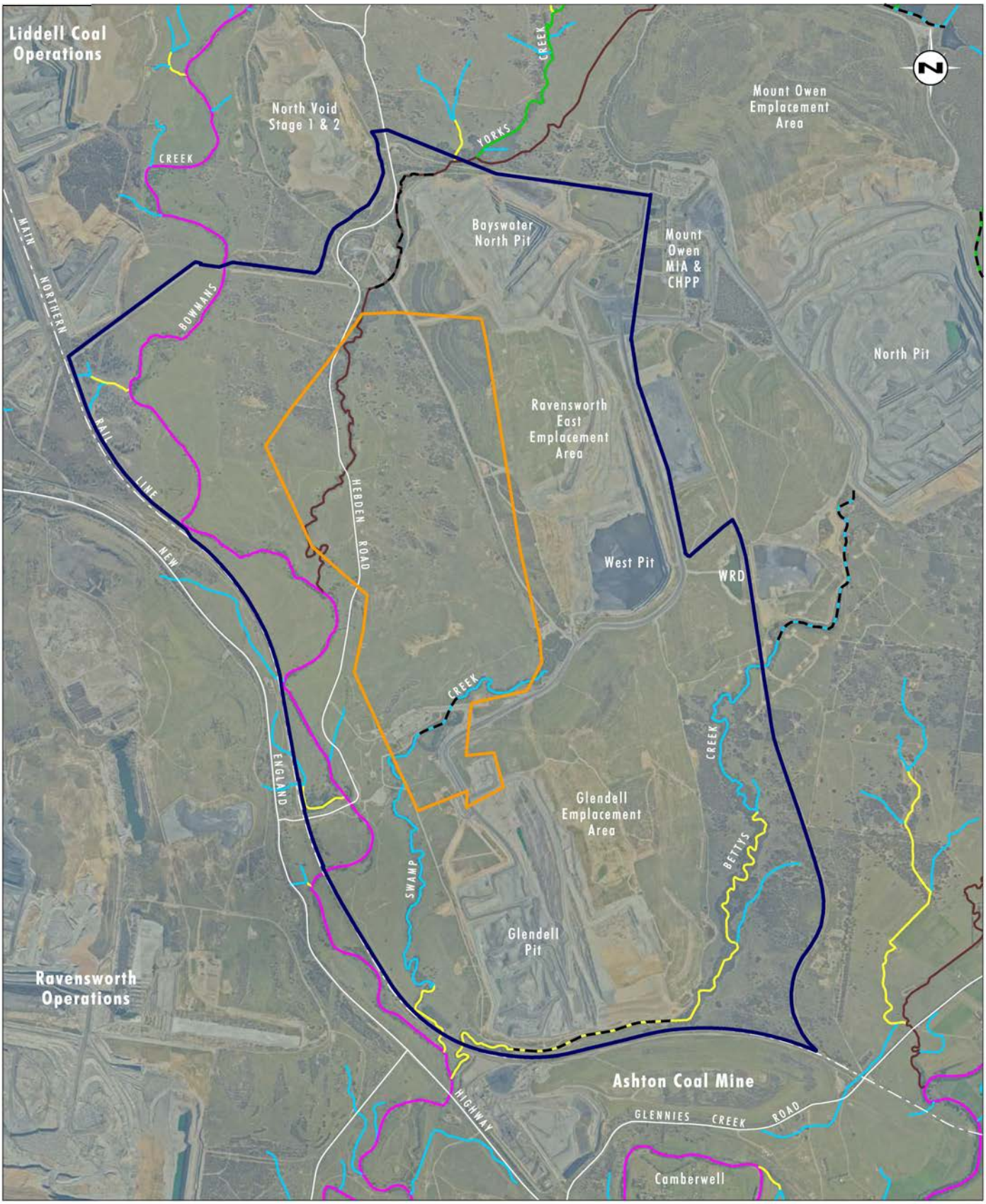


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

Legend

- Project Area
- Glendell Pit Extension
- Existing Creek Diversion

Stream Order:

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order and Above

FIGURE 2.1

Strahler Stream Order

2.3 Aquatic habitat description and mapping

Preliminary mapping of the broad scale aquatic habitats within the Project Area was undertaken using recent aerial photography 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.

Detailed aquatic habitat assessments were undertaken using recording sheets adapted from those developed for low gradient streams in the AUSRIVAS sampling protocol (available as a web resource (AUSRIVAS 2007) at seven locations along Bowmans Creek, four locations along Swamp Creek, one in Bettys Creek and six locations along Yorks Creek (refer to **Figure 2.2**). An assessment of the aquatic habitat characteristics within each of the sampling sites was undertaken, 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 for low gradient streams 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.

During the survey no flow was recorded in Yorks and Bettys Creeks due to the prolonged drought conditions experienced in the Hunter Valley between 2017 and the time of writing. Minimal flow was observed in Bowmans Creek. Bowmans Creek had residual pools of water with Swamp and Yorks Creeks mostly dry at the time of the surveys with only very isolated small shallow pools identified during surveys.

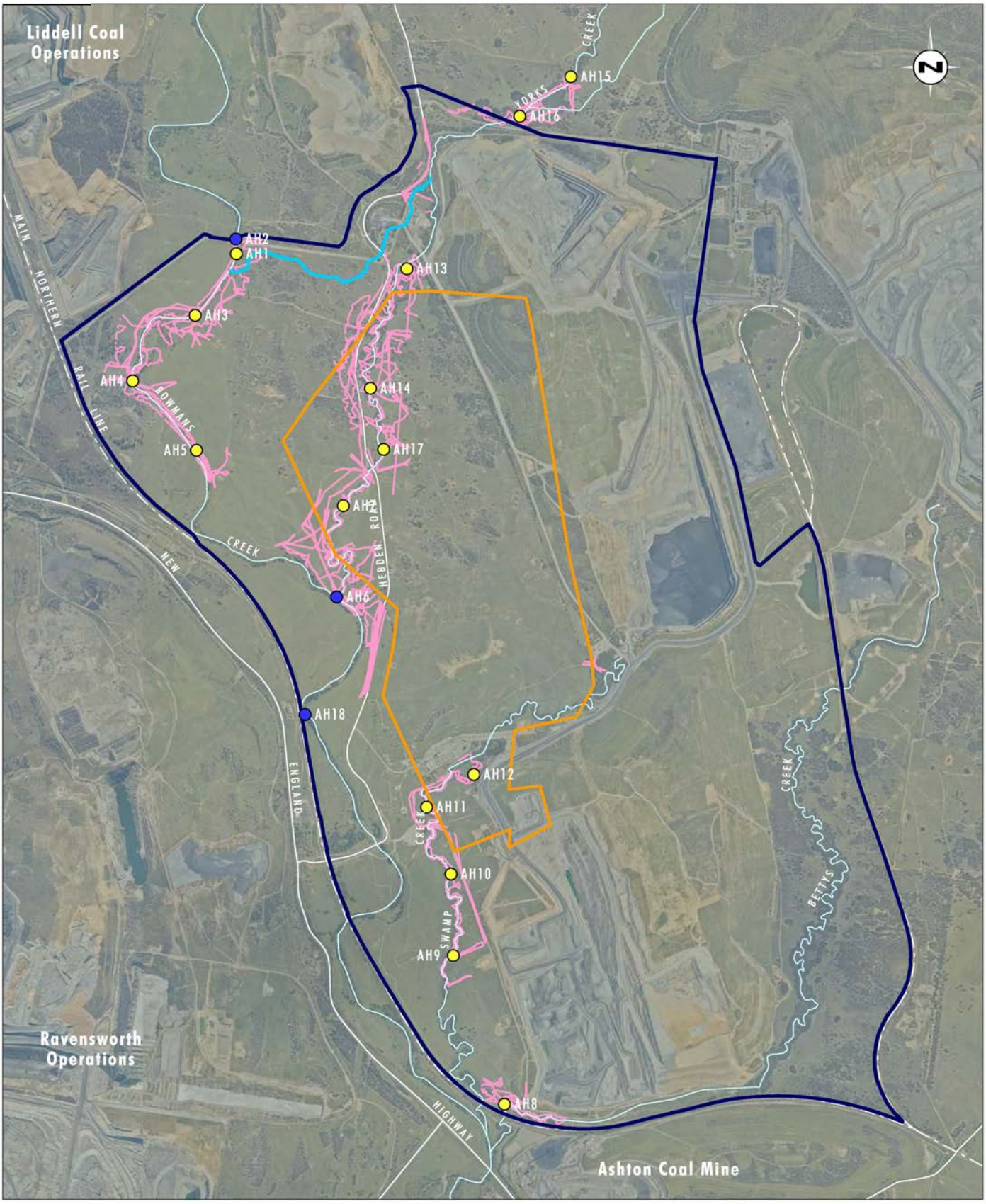


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

Legend

- Project Area
- Glendell Pit Extension
- Yorks Creek Realignment (Conceptual Alignment)
- Aquatic Habitat Survey Tracks
- Aquatic Habitat Survey
- Aquatic Habitat, Fish and Microinvertebrate Survey

FIGURE 2.2

Aquatic Survey Locations

2.4 Riparian and aquatic vegetation survey and mapping

Riparian and aquatic vegetation was surveyed to inform the Biodiversity Development Assessment Report (BDAR) (Umwelt 2019a). These surveys were undertaken over the following survey periods and the survey locations are shown on **Figure 2.2**:

- 8 January 2018
- 6-9 March 2018
- 27-29 March 2018
- 30-31 October 2018
- 1 November 2018.

Vegetation mapping was undertaken using best-practice techniques to delineate vegetation communities across the Project Area (refer to the BDAR (Umwelt 2019c) for further detail). Vegetation mapping involved the following key steps:

- preliminary review of digital airborne imagery to explore vegetation distribution patterns as dictated by change in canopy texture, tone and colour, as well as topography
- preliminary review of floristic survey data undertaken for the Greater Ravensworth Upper Hunter Strategic Assessment (UHSA) (Umwelt 2015)
- predicting the distribution of particular vegetation communities based on understanding the distribution of Plant Community Types (PCT) (OEH 2014b)
- preparation of draft vegetation community map based on interpretation of digital airborne imagery and preliminary delineation of vegetation community floristics
- ground-truthing of vegetation map based on survey effort documented in the BDAR (Umwelt 2019c, 2019a)
- revision of vegetation community floristic delineations based on plot data
- 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 NSW Biometric vegetation types database (OEH 2014b).

2.5 Aquatic fauna survey

Aquatic fauna surveys were conducted on the 30 and 31 October and 1 November 2018. The surveys involved both macroinvertebrate sampling and vertebrate trapping. The methods utilised are detailed in **Sections 2.5.1** and **2.5.2**.

2.5.1 Macroinvertebrate survey

Macroinvertebrates were sampled at three locations along Bowmans Creek including one at the existing confluence with Yorks Creek, one upstream of the proposed Yorks Creek Realignment confluence and one downstream of the existing confluence (refer to **Figure 2.2**). Sampling was limited in spatial and temporal extent due to the lack of water within the creek systems, due both to the ephemeral nature of Yorks and Swamp Creek and the prolonged dry conditions experienced in the Hunter Valley during the assessment phase of the Project.

The macroinvertebrate survey was conducted in accordance with the AUSRIVAS sampling protocol for edge habitats at all the sites due to the lack of riffle sites and flowing water (AUSRIVAS 2007).

2.5.2 Aquatic vertebrate fauna sampling

Aquatic vertebrate sampling targeted areas of persistent pools. A total of three sites were sampled on Bowmans Creek including one at the existing confluence with Yorks Creek, one upstream of the proposed Yorks Creek Realignment confluence and one downstream of the existing confluence (refer to **Figure 2.2**). Sampling was not possible on Yorks Creek or Swamp Creek due to the lack of pools.

Within the shallow pools of the upstream site, two box traps (25 centimetres (cm) x 25 cm x 40 cm with 7.5 cm opening) were deployed for two consecutive nights. Traps were baited with dry cat food, left overnight and checked in the early morning. As these pools were shallow, hand nets were also used to target vertebrate aquatic species, employing a catch and release method.

The two downstream sites had substantially more water which allowed each site to have one fyke net (with one, five metre wing and largest opening of 56 cm) and three box traps deployed for two consecutive nights. All traps were set late afternoon and checked early the next morning. The fyke net traps were removed during the day and reset in the afternoon. The fyke nets were set so that the top portion of the trap was out of the water to allow for any air-breathing fauna to survive the overnight period. The box traps were baited with dry cat food.

All fish captured were released alive except for pest species which were euthanized humanely as per the requirements of the fisheries licence (Permit number P11/0084-2.0).

3.0 Results

3.1 Catchment characteristics (topography and natural features)

The Project Area is situated centrally on the floor of the Hunter Valley (Central Lowlands) and occurs within the wider Hunter River catchment which covers approximately 22,000 km^2 of land bordered by the Liverpool Ranges, the Great Dividing Range, the Mount Royal Range and the Barrington Tops. The Project Area is situated approximately 87 km from the coast and 150 km from the western extremity of the Hunter catchment at the Great Dividing Range.

The Project Area is typical of the Central Lowlands of the Hunter Valley, which are characterised by undulating to low rolling hills formed on weak sedimentary rocks with low local relief (Kovac and Lawrie 1991). The topography of the Project Area is associated with the Hunter Thrust geological feature, characterised by an undulating and hilly landscape extending to lower areas associated with the creek lines that traverse the Project Area. The Glendell Pit Extension will affect land with elevations of between approximately 70 mAHD and 130 mAHD (excluding areas of the Ravensworth East emplacement areas impacted by the Glendell Pit Extension).

Approximately 18 km to the south of the Project Area are the dissected sandstone plateaus of Wollemi and Yengo National Parks, while approximately 30 km to the north, the foothills of the Barrington Tops and Mount Royal Range adjoin the Hunter Valley floor, which is bounded by the Hunter Thrust System (Peake 2006). To the east and west of the Project Area extend the highly eroded Permian lowlands of the floor of the Hunter Valley. The topography across the majority of the Project Area is generally flat to gently undulating with 0 to 5 degree slopes.

The Project is located within the Bowmans Creek catchment. Bowmans Creek is a tributary of the Hunter River. Mining in the proposed Glendell Pit Extension is primarily within two sub-catchments of Bowmans Creek, namely Yorks Creek and Swamp Creek. The Project will result in changes to the approved final landform which will also impact Bettys Creek. The Project will not have any direct impacts on the neighbouring Glennies Creek catchment. Areas associated with the alluvial plains of Bowmans Creek, Yorks Creek, Swamp Creek and Bettys Creek are generally flat to gently sloping.

The majority of the Project Area occurs in the Central Hunter Foothills Mitchell Landscape with a small portion in the Upper Hunter Channels and Floodplain.

3.2 Watercourse description and classification

3.2.1 Bowmans Creek

Bowmans Creek rises in the western foothills of the Mount Royal Range, and its upper catchment is deeply incised in steep bedrock controlled terrain. These reaches of Bowmans Creek are set in a broad alluvial flood plain and terrace sequence that is up to 1 km wide. In proximity to the Mount Owen Complex, Bowmans Creek catchment consists of four major tributaries being, Stringybark Creek, Yorks Creek, Swamp Creek, and Bettys Creek.

The channel carries an abundant cobble bed load, with grain sizes ranging 50 millimetres (mm) to 200 mm with well-developed point bar deposits. There are two levels of benches adjacent to the active channel, each with some evidence of former channels. The floodplain is approximately 1 metre (m) above the bed of the active channel and abandoned channel and is on average 20 m wide. There was moderate to heavy erosion in the catchment with agricultural and mining land uses identified. Cattle incursion of the creek was observed as the riverbanks are used for grazing.

Bowmans Creek exhibits the greatest diversity of habitats of all drainage systems in the locality. Bowmans Creek displayed varying water levels along the watercourse however was generally dry at the time of survey. Upstream of the Liddell Coal Operations pipeline a shallow small to medium pool demonstrated very low flow into a smaller pool over a cobble and pebbly substrate. A large pool was recorded isolated and stagnate at the confluence of Bowmans Creek and Yorks Creek. The remainder of Bowmans Creek presented a generally dry watercourse with an exposed cobble and pebbly substrate. Although dry, pool and run habitats were common, with evidence of pool/riffle sequences that would provide niche habitat during periods of inundation. Overhanging riparian vegetation was consistently recorded throughout the Project Area while macrophyte cover was present only in association with larger pools. Fallen woody debris and snags were also commonly recorded throughout the Project Area and were observed in persisting pools.

Bowmans Creek is considered to contain a variety of aquatic micro-habitats for a wide range of aquatic flora and fauna species, despite the low water levels recorded at the time of the survey.

3.2.1.1 Riparian Vegetation

Bowmans Creek supports a narrow strip of riparian vegetation that was observed to be depauperate and occurring in disjunct patches likely as a result of historical and ongoing land use. A moderately dense canopy is dominated by river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) with scattered forest red gum (*Eucalyptus tereticornis*) on the edge of floodplain grasslands. Mid-storey and shrub layers were generally absent from riparian vegetation however sandpaper fig (*Ficus coronata*) was present in low abundance, along with introduced pepper tree (*Schinus areira*) in some parts of this community.

The ground layer comprises a mix of exotic and native grasses, sedges, rushes and forbs. Native species recorded along upper banks included native wandering Jew (*Commelina cyanea*), stinging nettle (*Urtica incisa*), berry saltbush (*Einadia hastata*), *Juncus usitatus*, *Oxalis exilis*, slender bamboo grass (*Austrostipa verticillata*), weeping grass (*Microlaena stipoides* var. *stipoides*), common couch (*Cynodon dactylon*), and slender rats tail grass (*Sporobolus creber*). Native species such as slender knotweed (*Persicaria decipiens*) and sea celery (*Apium prostratum* var. *prostratum*), and salt-water couch (*Paspalum vaginatum*) were recorded in waterlogged areas.

Introduced species including Paddy's lucerne (*Sida rhombifolia*), madeira winter cherry (*Solanum pseudocapsicum*), galenia (*Galenia pubescens*), blue heliotrope (*Heliotropium amplexicaule*) and red-flowered mallow (*Modiola caroliniana*) were regularly recorded in moderate densities.

3.2.1.2 Instream vegetation

Bowmans Creek demonstrated persistent no-flow and drought conditions that reduced the presence of water to three stagnate pools in proximity to the Project Area. The presence of aquatic vegetation was located only in association with persistent water bodies along Bowmans Creek where encroaching floodplain vegetation was commonly observed throughout the generally dry creek beds.

No aquatic vegetation was observed in the reaches of the shallow, medium sized pool situated up stream of the proposed confluence between the Yorks Creek Realignment and Bowmans Creek. Remnants of aquatic vegetation were observed in proximity to the pool upstream with a small patch of broadleaf cumbungi (*Typha orientalis*) persisting. One exotic water tolerant species, being sharp rush (*Juncus acutus*) was commonly observed along the fringes of lower banks. The dry stream bed of Bowmans Creek generally demonstrated encroachment of riparian and floodplain vegetation.

Instream vegetation was observed occupying the large persisting pool situated at the existing confluence of Bowmans Creek and Yorks Creek. Although instream vegetation was moderately abundant, species diversity was considered low. Clumps of *Eleocharis sphacelata* were observed occupying areas of deep water, while broadleaf cumbungi (*Typha orientalis*) and common reed (*Phragmites australis*) were common along the fringes of the persisting pool. Low sloping areas of shallow banks were lined with salt-water couch (*Paspalum vaginatum*) growing into the large pool. One exotic water tolerant species, being sharp rush (*Juncus acutus*) was commonly observed along the fringes of lower banks.

Stagnate pools located downstream of the existing confluence of Yorks Creek and Bowmans Creek were found to support instream vegetation, however vegetation was limited to bull rush (*Typha sp*.) persisting in shallows of the large deep pool and sharp rush (*Juncus acutus*) commonly observed along lower and upper banks.

3.2.1.3 Fauna and Aquatic Fauna Habitat

Bowmans Creek demonstrated reasonable species diversity with a total of 15 fauna species recorded during aquatic vertebrate sampling. Of these, 13 native fauna species were identified including marbled eel (*Anguilla reinhardtii*), eastern long-necked turtle (*Chelodina longicollis*), Macquarie turtle (*Emydura macquarii*), water skink (*Eulamprus quoyii*), Cox's gudgeon (*Gobiomorphus coxii*), firetail gudgeon (*Hypseleostris galii*), western carp gudgeon (*Hypseleostris kluzingeri*), eastern water dragon (*Intellagama lesueurii*), sea mullet (*Mugil cephalus*), glass shrimp (*Paratya australiensis*), dwarf flathead gudgeon (*Philypnodon macrostomus*), Australian smelt (*Retropinna semoni*), and eel-tailed catfish (*Tandanus tandanus*).

Two exotic fauna species being common carp (*Cyprinus carpio*) and mosquito fish (*Gambusia holbrooki*) were recorded in pools located along the Bowmans Creek watercourse.

Numerous dead carp were observed along the length of Bowmans Creek situated adjoining the Project Area, likely due to the prevailing drought conditions and retraction of refuge habitats.

A full list of aquatic vertebrate fauna recorded during surveys is provided in **Table 1A** of **Appendix A**.

Table 3.1 provides a summary of the aquatic habitat observed at survey locations along Bowmans Creek.

Table 3.1 Riparian Vegetation and aquatic habitat features recorded at aquatic habitat assessment locations along Bowmans Creek

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photos
AH1	No water body present. Survey area demonstrated a rocky and gravel/sand substrate. Thin strip of riparian vegetation consistent with bull oak woodlandbull oak w found on slopes with a mix of native and exotic grasses influenced from adjacent floodplain habitats.	 photo direction: downstream
AH2	A shallow pool with limited water flow from upstream; no water flowing downstream. The creek bed featured rocky bars with sand/gravel substrate. Aquatic vegetation limited to bullrush (*Typha* sp.) and exotic sharp rush (*Juncus acutus*). Thin strip of riparian vegetation dominated by swamp oak (*Casuarina glauca*).	 photo direction: downstream
AH3	No water body present. Substrate rocky with sand/gravel. Few logs present. The assessment area demonstrated naturally regenerating swamp oak in-channel downstream. Thin strip of riparian vegetation dominated by swamp oak (*Casuarina glauca*).	 photo direction: upstream

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photos
AH4	No water body present. The survey area comprised the main channel and overflow stream. Main channel incised and rocky with gravel/sand substrate. Banks generally grassy and dominated by swamp oak (*Casuarina glauca*). Signs of erosion due to cattle access. The overflow stream was shallow with an island separating the overflow stream from the mainstream. The overflow stream is fed by floodplain run off and reconnects to the main channel approximately 100 m downstream.	 photo direction: upstream
AH5	No water body present. Shallow, steep eroded banks stabilized by swamp oak (*Casuarina glauca*). Riparian vegetation is influenced by floodplain grass species and rushes. Substrate rocky with gravel/sand. Few snags present with small vegetated islands downstream.	 photo direction: downstream
AH6 – existing confluence of Bowmans and Yorks Creeks	Large, moderately deep pool with instream vegetation consisting of *Juncus* sp., *Eleocarpus* sp. and bullrush (*Typha* sp). Left side bank steep; riparian vegetation dominated by pepper trees (*Schinus molle*), river oak (*Casuarina cunninghamiana*) and swamp oak (*casuarina glauca*). Right bank less steep; riparian vegetation a mix of native and exotic grasses. Few snags present. Common carp (*Cyprinus carpio*), freshwater mullet (*Trachystoma petard*) and eastern mosquito fish (*Gambusia holbrooki*) observed during sampling.	 photo direction: downstream

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photos
AH18	One large deep pool with shallow pools upstream. Stream morphology altered from adjacent railway on right bank. Right bank steep vertical surface cut into sandstone with no vegetation present. Left bank riparian vegetation dominated by pepper trees (*Schinus molle*) and river oak (*Casuarina cunninghamiana*). Ground layer dominated by common couch (*Cynodon dactylon*) and bullrush (*Typha sp.*) with exotic sharp rush (*Juncus acutus*). Signs of erosion with undercut banks. Small snags present but rare.	 photo direction: upstream

3.2.2 Yorks Creek

Yorks Creek is a tributary of Bowmans Creek and is located within the Project Area. Yorks Creek has a highly modified catchment with an area of approximately 1,656 hectares (ha) (GHD 2019). Prior to approved modifications by Mount Owen Complex, Yorks Creek had a catchment of approximately 1,230 ha. Yorks Creek typically has a defined channel several metres in width and approximately 1 to 1.2 m in depth, with a relatively wide floodplain. The creek varies from highly vegetated and sinuous, to areas with steep banks that support limited vegetation. Yorks Creek is ephemeral and is frequently dry and is considered typical of the 3rd order watercourses in the local area.

No water flow was observed in the Yorks Creek watercourse at the time of survey. The presence of water was limited to a number of isolated and stagnate small pools scattered along the watercourse. Stream substrate materials were found to vary in patches with influences of sedimentation. These patches consisted of mud/clay deposits and supported a mix of grasses and rushes along the creek bed and lower banks. The remainder of Yorks Creek was generally dry with an exposed cobble and pebbly substrate throughout the Project Area. Although dry, pool and run habitats were common, with evidence of pool/riffle sequences that may provide niche habitats during periods of inundation. Evidence of erosion was minor with deep steep banks generally stabilized by grasses, exotic shrubs and roots of river oak (*Casuarina cunninghamiana*). Overhanging riparian vegetation was consistently recorded throughout the Creek while macrophyte cover was rarely present and only in association with persisting pools or waterlogged areas. Fallen woody debris and snags were also commonly recorded. Leaf litter and detritus was commonly observed coving the creek bed indicating Yorks Creek has been without water for an extended period of time.

3.2.2.1 Riparian Vegetation

The width of riparian vegetation along Yorks Creek increases upstream with correlation to the meandering stream formation. Riparian vegetation of Yorks Creek narrows to disjunct patches downstream towards the confluence with Bowmans Creek as a result of historical and ongoing land use. The mid-dense canopy was dominated by swamp oak (*Casuarina glauca*) with scattered forest red gum (*Eucalyptus tereticornis*) and narrow-leaved ironbark (*Eucalyptus crebra*). Needle-leaf mistletoe (*Amyema cambagei*) was often present in the canopy of the swamp oak (*Casuarina glauca*). The mid-storey was present in patches generally occurring on fringes of ecotone. The mid-storey was dominated by young swamp oak (*Casuarina glauca*), devil's needles (*Solanum stelligerum*) and cooba (*Acacia salicina*).

The ground layer comprises a mix of native and exotic grasses, sedges, rushes and forbs. Native species commonly recorded along upper banks included blue trumpet (*Brunoniella australis*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), corrugated sida (*Sida corrugata*), native wandering Jew (*Commelina cyanea*), berry saltbush (*Einadia hastata*), amulla (*Eremophila debilis*), ruby saltbush (*Enchylaena tomentosa*), *Glycine tabacina*, weeping grass (*Microlaena stipoides* var. *stipoides*), slender bamboo grass (*Austrostipa verticillata*), common couch (*Cynodon dactylon*).

Commonly recorded introduced species included galenia (*Galenia pubescens*), Paddys Lucerne (*Sida rhombifolia*), *Verbena quadrangularis*, kei apple (*Dovyalis caffra*), madeira winter cherry (*Solanum pseudocapsicum*) and African olive (*Olea europaea* subsp. *cuspidata*).

3.2.2.2 Instream Vegetation

Water was scarcely observed along Yorks Creek with exception to a few small, shallow pools scattered along the watercourse. These persisting waterbodies contained no aquatic vegetation at the time of survey and were likely a result of limited localised run off from the adjacent floodplain rather than stream flow. Instream vegetation was limited to common reed (*Phragmites australis*) and spiny-headed mat rush (*Lomandra longifolia*) occurring in a wet depression upstream of the Bayswater North Pit, and sharp rush (*Juncus acutus* subsp. *acutus*) an exotic species which was commonly recorded with dry watercourses in the Hunter Valley. Yorks Creek generally demonstrated a moderate level encroachment from adjacent riparian and floodplain vegetation.

3.2.2.3 Fauna and Aquatic Fauna Habitat

No aquatic fauna species were recorded in Yorks Creek at the time of survey.

Yorks Creek demonstrated poor fish habitat during the persisting no-flow and drought conditions experienced during the survey period. The presence of water was reduced to small, shallow pools providing limited refuge habitat during the survey period.

The abundance and diversity of aquatic habitat resources along Yorks Creek are subject to both aquatic and terrestrial influences derived from cycles of flood and drought and influenced by human activity. The extent of fish habitat is considered to increase during moderate to high flow regimes and habitat features such as fallen woody debris, snags and over hanging banks provide niche habitats. Yorks Creek has potential to be colonised by aquatic fauna when conditions permit given the connectivity with downstream habitat areas of Bowmans Creek and the Hunter River. In many rivers, deep pools provide important fish habitat and refuge areas. As the flow in rivers decreases in drought, fish retreat to pools to wait for the return of higher flows (DPI 2013). Even after prolonged droughts, fish will rapidly recolonise a river provided these refuge areas are available (DPI 2013).

Native aquatic fauna species such as long-finned eel (*Anguilla reinhardtii*), short-finned eel (*Anguilla australis*), flathead gudgeon (*Philypnodon grandiceps*), common carp (*Cyprinus carpio*), striped gudgeon (*Gobiomorphus australis*), Cox's gudgeon (*Gobiomorphus coxii*), empire gudgeon (*hypseleotris compressa*), sea mullet (*Mugil cephalus*), and freshwater catfish (*Tandanus tandanus*) have been commonly recorded within the locality and could occur in Yorks Creek during periods of high flow.

Table 3.2 provides a summary of the aquatic habitat observed at survey locations along Yorks Creek.

Table 3.2 Riparian Vegetation and aquatic habitat features recorded at aquatic habitat assessment locations along Yorks Creek

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH7	No water body present. Few small, shallow pools present between AH7 and existing confluence of Bowmans Creek (AH6); offer limited capacity to support aquatic fauna in current conditions. Steep banks; riparian vegetation comprises mix of native and exotic grasses, exotic thistles, African box thorn (*Lycium ferocissimum*), and swamp oak (*Casuarina glauca*). Fallen timber and large rocks commonly observed albeit not within a water body.	 photo direction: upstream
AH13	No water body present. Substrate mud/clay influenced by sedimentation. Low banks formed on inside of bend. Creek bed generally grassy with patches of *Juncus* spp. and other rushes.	 photo direction: downstream

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH14	No water body present. Substrate sandy/gravel substrate with pool and riffle zones evident. Riparian vegetation dominated by swamp oak (*Casuarina glauca*). A mix of native and exotic grasses and sharp rush (*Juncus acutus*) occur on lower banks. Few logs present albeit not within a water body. Roots of swamp oak stabilize eroded banks and provide fauna habitat when inundated.	 photo direction: downstream
AH15	A wide section of stream featured small, shallow pools and a vegetated island. Riparian vegetation consisted narrow-leaved ironbark (*Eucalyptus crebra*) and swamp oak (*casuarina glauca*) with floodplain grasses spanning the creek bed. Aquatic vegetation was limited to bullrush (*Typha sp.*), sharp rush (*Juncus acutus*) and Juncus spp. in depressions. Few logs and rocks present albeit not within a water body.	 photo direction: downstream
AH16	Located downstream from a small first order tributary that joins Yorks Creek. Few small, shallow pools; offers limited capacity to support aquatic fauna Substrate rocky with sand/gravel. Riparian vegetation was dominated by swamp oak (*Casuarina glauca*) with African olive (*Olea europea* subsp. *cuspidata*), *Persicaria* sp. and native grass species. Fallen logs present; albeit not within the water body. Erosion formed overhanging banks.	 photo direction: upstream

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH17	No water body present. Stream channel was very narrow featuring steep banks. Substrate clay soils with small rocks. Riparian vegetation consists of swamp oak (*Casuarina glauca*), African box thorn (*Lycium ferocissimum*) with a mix of native and exotic grass species. Fallen logs present; albeit not within a water body.	 photo direction: downstream

3.2.3 Swamp Creek

Swamp Creek has a highly modified catchment with an area of approximately 267 ha (GHD 2019). Prior to approved modifications by Mount Owen Complex, Swamp Creek had a catchment of approximately 2,380380 ha. Swamp Creek is a second order stream and flows into Bowmans Creek approximately 6.2 km upstream of the confluence of Bowmans Creek and the Hunter River. The catchment area comprises large areas dedicated to farming and grazing and open cut mining.

The slopes of the catchment range from 3 to 4% in the southern section of the catchment to greater than 10% on the upper slopes. Riparian vegetation along the natural creek line is continuous and dominated by swamp oak woodland.

No water flow was observed in the Swamp Creek watercourse at the time of survey. Stream substrate materials were found to be variable with influences of sedimentation. Substrates generally consisted of mud/clay deposits over cobble or gravel substrate. Although dry, pool and run habitats were common, with evidence of pool/riffle sequences that would provide niche habitats during periods of inundation. Evidence of erosion was minor with deep steep banks generally stabilized by grasses, rushes, exotic shrubs, pepper tree (*Schinus areira)* and river oak (*Casuarina cunninghamiana*). Overhanging riparian vegetation was consistently recorded within Swamp Creek while macrophyte cover was not present. Fallen woody debris and snags were also commonly recorded. Deep leaf litter was commonly observed throughout the Project Area indicating that Swamp Creek has been without water for an extended period.

3.2.3.1 Riparian Vegetation

Riparian vegetation along Swamp Creek has been separated into two vegetation classes being remnant riparian forest and planted riparian forest situated along the diverted sections of Swamp Creek (refer to **Figure 1.2**). Remnant riparian forest exhibits a similar species composition to riparian vegetation occurring along Yorks Creek, while planted riparian forest differs slightly.

Planted riparian forest supports a mid-dense canopy and is dominated by planted swamp oak (*Casuarina glauca*) with other species recorded including forest red gum (*Eucalyptus tereticornis*), spotted gum (*Corymbia maculata*), grey box (*Eucalyptus moluccana*) and narrow-leaved ironbark (*Eucalyptus crebra*) (Umwelt 2019a).

The mid-storey comprises young canopy species and a variety of planted shrubs and low trees including sticky hop-bush (*Dodonaea viscosa*), flaxleaf paperbark (*Melaleuca linariifolia*), prickly-leaved tea tree (*Melaleuca styphelioides*) and bottlebrushes (*Callistemon spp*.) (Umwelt 2019a).

The ground layer comprises a mix of native and exotic grasses, sedges, rushes and forbs. Native species commonly recorded along upper banks included kidney weed (*Dichondra repens*), rock fern (*Cheilanthes sieberi* subsp. *sieberi*), amulla (*Eremophila debilis*), ruby saltbush (*Enchylaena tomentosa*), whiteroot (*Pratia purpurascens*), spiny-headed mat-rush (*Lomandra longifolia*), *Glycine tabacina*, couch (*Cynodon dactylon*), scented-top grass (*Capillipdeium spicigerum*), barbed wire grass (*Cymbopogon refractus*), slender rats tail grass (*Sporobolus creber*) and purple wiregrass (*Aristida ramosa*) (Umwelt 2019a).

Commonly recorded introduced species included Rhodes grass (*Chloris gayana*), red natal grass (*Melinis repens*), galenia (*Galenia pubescens*), lambs tongues (*Plantago lanceolata*), fireweed (*Senecio madagascariensis*), Paddys lucerne (*Sida rhombifolia*), golden wreath wattle (*Acacia saligna*), African box thorn (*Lycium ferocissimum*) and African olive (*Olea europaea* subsp. *cuspidata*) (Umwelt 2019a).

3.2.3.2 Instream Vegetation

No waterbodies or associated aquatic vegetation was observed in Swamp Creek at the time of survey. Water tolerant vegetation was limited to sharp rush (*Juncus acutus* subsp. *acutus*), an exotic species which was often recorded occurring along fringes of banks and within the creek. Swamp Creek generally demonstrated high levels of leaf litter and detritus as well as influences from encroaching riparian and floodplain vegetation culmination.

3.2.3.3 Fauna and Aquatic Fauna Habitat

Limited aquatic fauna habitat was observed in Swamp Creek at the time of survey. **Table 3.3** provides a summary of the aquatic habitat observed at survey locations along Swamp Creek.

Table 3.3 Riparian Vegetation and aquatic habitat features recorded at aquatic habitat assessment locations along Swamp Creek

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH9	No water body present. Substrate of large rocks with gravel, sand and clay sediments. Riparian vegetation was dominated by swamp oakswamp o (*Casuarina glauca*) with scatter pepper tree (*Schinus molle*) and native grass species. Few logs/snags present albeit not within a water body. High level of leaf litter and detritus along creek bed.	 photo direction: upstream

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH10	No water body present. Substrate gravel/sand over clay-loam sediment. Riparian vegetation was dominated by young swamp oakswamp o (*Casuarina glauca*) with a mix of native and exotic grasses and *Juncus* spp in low abundances. Few logs present albeit not within a water body. High level of leaf litter and detritus along creek bed.	 photo direction: upstream
AH11	No water body present. Substrate sand over clay-loam sediment. Riparian vegetation dominated by swamp oakswamp o (*Casuarina glauca*) with a mix of native and exotic grasses and forbs, and *Juncus* spp. Few logs present albeit not within a water body. High level of leaf litter and detritus along creek bed.	 photo direction: downstream
AH12	No water body present. Substrate gravel/sand over clay-loam sediment. Riparian vegetation dominated by swamp oakswamp o (*Casuarina glauca*) with African box thorn (*Lycium ferocissimum*). Exotic galenia (G*alenia pubescens*) dominated steep banks with a mix of native and exotic grass and forb species. Few logs present albeit not within a water body. High level of leaf litter and detritus along creek bed.	 photo direction: upstream

3.2.4 Bettys Creek

Bettys Creek occurs within a highly modified catchment with a current area of approximately 530 ha (GHD 2019). Previous mine operations have diverted approximately 490 ha of the upper catchment to the east of the Mount Owen Mine into Main Creek, while the middle reaches of Bettys Creek were diverted to the east around the WOOP emplacement area, and the lower reaches diverted to the south of the existing Glendell Pit (GHD 2019).

Bettys Creek is currently a second order stream (formerly fourth order) and minor tributary of Bowmans Creek. The creek is ephemeral with short periods of flow common after heavy rain events. Small shallow pools were evident along the creek during the survey, however additional aquatic microhabitats such as pool/riffle sequences and rocky substrates were not observed.

3.2.4.1 Riparian Vegetation

Bettys Creek supports similar riparian vegetation structure to Swamp Creek with well-defined riparian vegetation dominated by swamp oak (*Casuarina glauca*), with rough-barked apple (*Angophora floribunda*) occurring in low numbers. Bettys Creek generally comprises a narrow channel, with widths in the order of 3 to 5 m. The channel is typically well vegetated by a mix of sedges and rushes, dominated by the introduced sharp rush (*Juncus acutus* subsp*. acutus*), indicating an intermittent flow regime. Bank heights were generally one to three metres and evidence of active erosion was frequently observed.

3.2.4.2 Instream Vegetation

Limited waterbodies and associated aquatic vegetation was observed in the Bettys Creek tributary at the time of survey. Bettys Creek demonstrated high levels of leaf litter and detritus as well as minor influences from encroaching riparian and floodplain vegetation culmination.

3.2.4.3 Fauna and Aquatic Habitat

Limited aquatic fauna habitat was observed in Bettys Creek at the time of survey. The ephemeral habitats of Bettys Creek are likely to lack a wide range of aquatic vertebrate and invertebrate species due to an absence of suitable habitat structures and habitat variability. **Table 3.4** provides a summary of the aquatic habitat observed at the survey location along Bettys Creek.

Table 3.4 Riparian Vegetation and aquatic habitat features recorded at aquatic habitat assessment location along Bettys Creek

Assessment Location	Riparian Vegetation and Aquatic Habitat Features	Photo
AH8	One small, shallow standing pool at the assessment location; generally no water present in channel. Deeply channelized banks on both sides of the creek. Substrate of gravel, with sand and clay sediments. Riparian vegetation was dominated by swamp oak (*Casuarina glauca*) with scatter but common African box thorn (*Lycium ferocissimum*) and native grass species. Few logs/snags present albeit not within a water body High level of leaf litter and detritus along creek bed.	 photo direction: downstream

3.3 Previous modifications to aquatic ecosystems

The Mount Owen Complex and its water management system are located within the Bowmans Creek and Glennies Creek catchments. Land uses within the locality such as mining operations, State Forest, biodiversity offset areas, grazing, pasture cropping, and rural residential land holdings have modified local catchments through the capture of runoff. Yorks Creek, Swamp Creek and Bettys Creek (sub catchments of Bowmans Creek) and Main Creek (a sub catchment of Glennies Creek) are located within and in proximity to the Project Area and have been modified under existing approval conditions. **Sections 3.3.1** to **3.3.3** outline the modifications to the stream morphology of Yorks Creek, Swamp Creek and Bettys Creek. The locations of the existing creek diversions are shown on **Figure 3.1**.

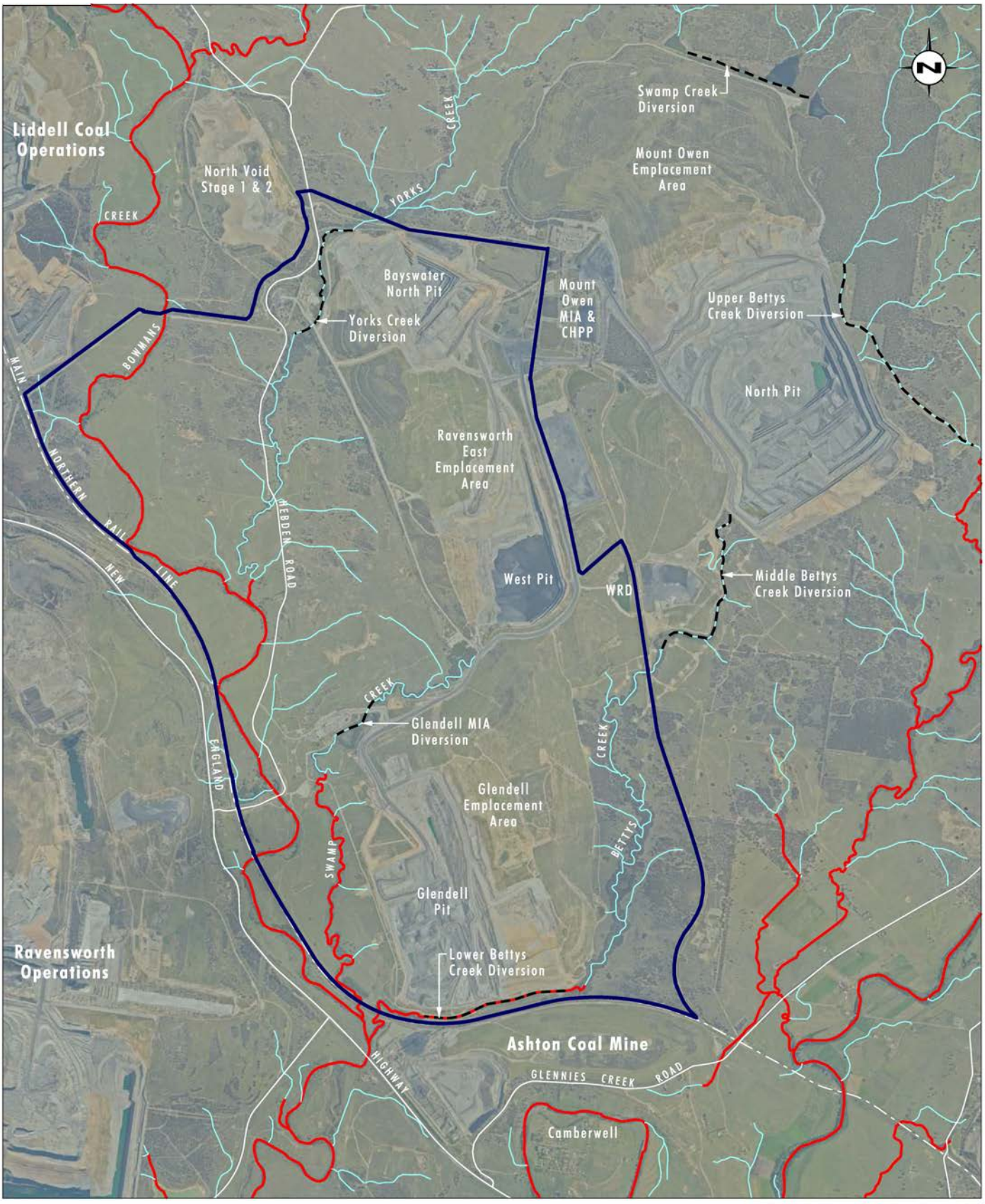


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Primary Industries (2019)

Legend

- Project Area
- Existing Creek Diversion
- Singleton Key Fish Habitat

FIGURE 3.1

Singleton Key Fish Habitat and Existing Creek Diversions

3.3.1 Yorks Creek

Yorks Creek is a tributary of Bowmans Creek. An approximately 1.5 km section of Yorks Creek has previously been diverted around the Ravensworth East MIA (Yorks Creek Diversion) as part of the former Swamp Creek Mine/Ravensworth East mining operations (occurring in approximately 1982) (refer to **Figure 3.1** for location of diversion). The Yorks Creek Diversion comprises a trapezoidal channel that does not reflect the geomorphology of the creek in both upstream and downstream undiverted sections (Fluvial Systems 2019). The upper catchment of Yorks Creek above the Glendell Pit Extension has been significantly modified due to approved mining at Ravensworth East and Mount Owen, however it includes a series of dams that provides an area of permanent water within the catchment. Yorks Creek also includes water diverted from the upper reaches of Swamp Creek as part of the approved Mount Owen Mine (refer to **Section 3.3.2**). As these areas are rehabilitated, runoff will be progressively returned into the Yorks Creek catchment. This progressive increase in the size of the upper catchment will occur during the life of the Project.

3.3.2 Swamp Creek

The upper reaches of Swamp Creek are intercepted by dams located to the immediate north of the North Pit emplacement area with overflow from the dams diverted to the west into Yorks Creek (known as the Swamp Creek Diversion). The central areas of the former Swamp Creek catchment are located within the approved disturbance area for Mount Owen and Ravensworth East Mines. This central section of the former catchment of Swamp Creek is managed as part of the Mount Owen Complex water management system. A section of the lower reach of Swamp Creek has been diverted around the Glendell MIA (known as the Glendell MIA Diversion). Refer to **Figure 3.1** for location of the existing diversions.

3.3.3 Bettys Creek

Bettys Creek is located to the south and east of the current Glendell operations and has previously been diverted around the southern end of the Glendell Pit mining area approved under the Glendell Consent (Lower Bettys Creek Diversion). The remnant upper reaches of Bettys Creek catchment to the north of the Mount Owen Complex have previously been diverted towards Main Creek as part of the approved Mount Owen operations (Upper Bettys Creek Diversion). A third diversion of Bettys Creek (known as the Middle Bettys Creek Diversion) occurs around the southern extent of the Eastern Rail Pit. Parts of the former Bettys Creek catchment are also located within the approved disturbance area for the Mount Owen Complex and are managed as part of the Mount Owen Complex water management system. The conceptual final landform under the Mount Owen Consent retains the diversion of the upper catchment of Bettys Creek towards Main Creek. Part of the former Bettys Creek catchment is also located within the approved final void catchment for North Pit. The existing diversions associated with Bettys Creek are shown on **Figure 3.1**.

3.4 AUSRIVAS habitat assessment

The AUSRIVAS Habitat Assessment (AUSRIVAS 2007) was undertaken to assess the physical condition of the streams with the potential to be impacted by the Project. To provide valid assessment outcomes an AUSRIVAS assessment is ideally undertaken in the presence of waterbodies and streamflow. Extended drought conditions were experienced during the survey period where the presence of water was reduced to three stagnate pools located in the Project Area along Bowmans Creek. The resulting habitat scores reflect the potential value of the watercourses if there was stream-flow based on the extent and type of habitats recorded.

3.4.1 Bowmans Creek

The AUSRIVAS habitat assessment scores the habitat of Bowmans Creek with an average of 100 (minimum score 81; maximum score 153) across six sample sites (refer to **Table 3.5**). A score between 51 and 100 indicates that the creek is in fair condition. 5 of the 6 sites (AH1-AH5) were assessed as being in 'fair' condition with score between 81 and 94). Site AH6, located near the existing confluence of Bowmans Creek and Yorks Creek was assessed as being in excellent condition with a score of 153. Bowmans Creek features limited variability in instream structures, low abundance of tall riparian vegetation, and moderate bank instability. These factors contribute to an overall low variability of available habitat features such as snags, undercut banks, aquatic vegetation and substrate formations.

Previous surveys undertaken in 2013 for the Mount Owen Continued Operations Project Ecological Assessment (Umwelt 2014) scored the habitat of Bowmans Creek at 55 and 58 at two sampling locations. These scores indicated that the creek was in fair condition and suggested that neither sampling location was considered to provide good habitat for aquatic fauna when flows were present.

The 2018 Ashton Coal Aquatic Ecology Monitoring was undertaken downstream of the Project Area in Bowmans Creek. Results from the Riparian Channel and Environmental (RCE) Assessment indicated that stream health was lower in 2018 than previous years due to the natural environmental responses to prevailing climatic conditions. Monitoring results identified that pooling areas contracted during periods of prolonged drought and low flow, the integrity of aquatic ecosystems declined due to both direct habitat loss and deteriorating water quality (Ashton 2018). Shallow isolated pools were subjected to increasing temperature and dissolved oxygen fluctuations, and turbidity plus nutrient levels were found to generally increase in part due to the limited water area that contains larger fish such as carp which disturb bottom sediment (Ashton 2018).

The Aquatic and Groundwater Dependent Ecosystem Assessment (Eco Logical 2012) undertaken for Liddell Coal Operations determined Bowmans Creek as having a RCE score of 34 at three sites, indicating a moderate ecological condition. Sampling undertaken by Eco Logical (2012) was undertaken between 2 and 6 km upstream of the sites that were the subject of the current assessment, with an additional (control) sampling location approximately 18 km upstream of the Project Area. The difference in the sampling results indicated that upstream environments of Bowmans Creek are in better condition and have greater habitat variability (Eco Logical 2012).

The retraction of habitats identified during surveys resulted in the concentration of remaining fish species and numbers into a small number of refuge pools. Direct sampling of aquatic vertebrate species resulted in an overall higher number of fish taxa recorded at monitoring sites in 2018, including six native species and two introduced species. Numerous dead carp were observed during the spring 2018 surveys in dry channel areas, it is likely that numerous other species would have perished during the drying out of refuge pools throughout Bowmans Creek over the previous two years. The results of the aquatic habitat assessment are provided in **Table 3.5.**

The results of the current and previous assessments indicate that the aquatic habitat provided by Bowmans Creek is generally considered to fluctuate between fair and good based on the prevailing environmental conditions.

Table 3.5 Aquatic Habitat Scores - Bowmans Creek

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score					
Site	**AH 1**	**AH 2**	**AH3**	**AH 4**	**AH 5**	**AH 6**
Epifaunal substrate / available cover	Fair 9	Fair 9	Fair8	Fair 9	Good 11	Excellent 17
Pool substrate characterisation	Fair 8	Good 11	Fair 9	Fair 9	Fair 8	Excellent 17
Pool variability	Poor 2	Poor 2	Poor 0	Poor 2	Poor 2	Excellent 16
Sediment deposition	Good 13	Good 13	Good 13	Good 13	Good 13	Excellent 16
Channel flow status	Poor 2	Poor 2	Poor 0	Poor 2	Poor 2	Excellent 17
Channel alteration	Excellent 16	Excellent 16	Excellent 16	Excellent 16	Excellent 16	Excellent 19
Channel sinuosity	Fair 9	Fair 9	Fair 7	Fair 9	Fair 9	Fair 9
Bank stability – left bank	Fair 5	Fair 5	Good 6	Fair 5	Fair 5	Good 7
Bank stability – right bank	Fair 5	Fair 5	Good 6	Fair 5	Fair 5	Excellent 9
Vegetative protection – left bank	Good 6	Good 6	Good 6	Good 6	Good 6	Good 6
Vegetative protection – right bank	Good 6	Good 6	Good 6	Good 6	Good 6	Good 8
Riparian zone – left bank	Poor 2	Good 6	Good 7	Excellent 10	Fair 5	Good 7
Riparian zone – right bank	Fair 3	Poor 2	Fair 5	Poor 2	Good 6	Good 5
Total score	**86 Fair**	**92 Fair**	**81Fair**	**94 Fair**	**94 Fair**	**153 Excellent**

3.4.2 Yorks Creek

Yorks Creek demonstrated persistent no-flow conditions that reduced the presence of water within the Project Area to a few small, shallow pools.

The AUSRIVAS habitat assessment scores the habitat of Yorks Creek with an average of 101 (minimum score 71; maximum score 116) across six sample sites despite the prevailing dry conditions (refer to **Table 3.6**). A total score between 101 and 150 indicates that Yorks Creek is in good condition.

Table 3.6 Aquatic Habitat Scores - Yorks Creek

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score					
Site	**AH 7**	**AH 13**	**AH 14**	**AH 15**	**AH 16**	**AH 17**
Epifaunal substrate/available cover	Good 13	Good 11	Good 11	Fair 8	Good 13	Good 11
Pool substrate characterisation	Fair 6	Good 11	Good 11	Good 11	Fair 9	Fair 6
Pool variability	Poor 0	Poor 0	Poor 0	Poor 2	Poor 2	Poor 0
Sediment deposition	Fair 6	Good 13	Good 13	Good 13	Good 13	Good 13
Channel flow status	Poor 0	Poor 0	Poor 0	Poor 1	Poor 2	Poor 0
Channel alteration	Excellent 16	Excellent 17	Excellent 17	Excellent 17	Excellent 18	Excellent 16
Channel sinuosity	Good 14	Excellent 17	Excellent 16	Fair 8	Good 13	Good 13
Bank stability – left bank	Fair 3	Good 7	Good 6	Fair 5	Good 7	Good 6
Bank stability – right bank	Fair 3	Good 7	Good 7	Good 7	Good 7	Good 8
Vegetative protection – left bank	Fair 3	Good 6	Good 6	Good 7	Good 7	Good 7
Vegetative protection – right bank	Fair 3	Good 6	Good 6	Good 7	Good 7	Good 7
Riparian zone – left bank	Poor 2	Good 7	Good 8	Fair 5	Excellent 9	Good 7
Riparian zone – right bank	Poor 2	Good 7	Excellent 9	Good 6	Excellent 9	Good 8
Total score	**71 Fair**	**108 Good**	**110 Good**	**97 Fair**	**116 Good**	**102 Good**

3.4.3 Swamp Creek

Swamp Creek demonstrated persistent no-flow conditions that reduced the presence of water to four shallow stagnate pools in the Project Area.

The AUSRIVAS habitat assessment scores the habitat of Swamp Creek with an average of 90 (minimum score 71; maximum score 102) across four sample sites despite the prevailing dry conditions (refer to **Table 3.7**). A total score between 51 and 100 indicates that the creek is in fair condition.

Table 3.7 Aquatic Habitat Scores - Swamp Creek

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score			
Site	**AH 9 – Swamp Creek**	**AH10 – Swamp Creek**	**AH 11 – Swamp Creek**	**AH 12 – Swamp Creek**
Epifaunal substrate / available cover	Good 13	Good 12	Good 11	Good 11
Pool substrate characterisation	Fair 7	Fair 8	Fair 8	Fair 8
Pool variability	Poor 0	Poor 0	Poor 0	Poor 0
Sediment deposition	Fair 6	Excellent 16	Good 16	Excellent 16
Channel flow status	Poor 0	Poor 0	Poor 0	Poor 0
Channel alteration	Excellent 16	Excellent 17	Excellent 16	Excellent 16
Channel sinuosity	Fair 9	Good 11	Good 15	Good 15
Bank stability – left bank	Fair 4	Good 6	Good 7	Fair 5
Bank stability – right bank	Fair 4	Good 6	Good 7	Fair 5
Vegetative protection – left bank	Fair 3	Good 6	Good 8	Good 6
Vegetative protection – right bank	Fair 3	Good 6	Good 8	Good 6
Riparian zone – left bank	Fair 3	Poor 2	Fair 3	Fair 4
Riparian zone – right bank	Fair 3	Poor 2	Fair 3	Fair 4
Total score	**71 Fair**	**92 Fair**	**102 Good**	**96 Fair**

3.4.4 Bettys Creek

Bettys Creek demonstrated persistent no-flow conditions that reduced the presence of water within the Project Area to a few small, shallow pools.

One AUSRIVAS habitat assessment was undertaken for the extent of Bettys Creek within the Project Area. The AUSRIVAS habitat assessment scores habitat of Bettys Creek with a total of 103 despite the prevailing dry conditions (refer to **Table 3.8**). A total score between 101 and 150 indicates that Yorks Creek is in good condition.

Table 3.8 Aquatic Habitat Scores – Bettys Creek

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score
Site	**AH 8 – Bettys Creek**
Epifaunal substrate / available cover	Excellent 16
Pool substrate characterisation	Fair 8
Pool variability	Poor 2
Sediment deposition	Fair 16
Channel flow status	Poor 1
Channel alteration	Excellent 18
Channel sinuosity	Good 14
Bank stability – left bank	Fair 5
Bank stability – right bank	Fair 5
Vegetative protection – left bank	Fair 3
Vegetative protection – right bank	Fair 3
Riparian zone – left bank	Fair 7
Riparian zone – right bank	Fair 5
Total score	**103 Good**

3.5 Macroinvertebrate sampling results

Macroinvertebrate sampling was undertaken at three locations along Bowmans, including the existing confluence of Yorks Creek and Bowmans Creek (AH6), one location upstream from the proposed confluence with the Yorks Creek Realignment (AH2) and one downstream of the existing confluence Creek (AH18) (refer to **Figure 2.2**). The identification of macroinvertebrate taxa was undertaken to determine species composition as an indication of stream and habitat health. A total of 26 macroinvertebrate taxa (identification to Class, Order and Family) were recorded persisting in the pools sampled along Bowmans Creek. All locations were dominated by generalist and opportunistic taxa, while rare or sensitive taxon were generally absent from the water bodies sampled. The low diversity of macroinvertebrates coincides with observations of habitat stress and deteriorating water quality as water levels decrease during the extended drought conditions.

Results of the macroinvertebrate analysis are summarised in **Table 3.8**.

Table 3.8 Macroinvertebrates taxa identified in Bowmans Creek

Class (Subclass)	Order	Family	Common Name	Sample Location		
				AH6	AH2	AH18
Phylum: Arthropoda						
Arachnida	Acarina		Watermite		✓	
Hexapoda (Insecta)	Coleoptera	Dytiscidae	Beetle	✓	✓	✓
	Coleoptera	Haliplidae	Crawling beetle	✓		
	Coleoptera	Hydraenidae	Beetle	✓		
	Decapoda	Pleidae	pygmy backswimmer	✓		

Class (Subclass)	Order	Family	Common Name	Sample Location		
				AH6	AH2	AH18
	Diptera	Ceratopogonidae	fly larvae	✓	✓	
	Diptera	Chironomidae	Non-biting midges		✓	
	Diptera	Culicidae	Larval mosquito	✓	✓	
	Diptera	Empididae				✓
	Diptera	Stratiomyidae	Soldier fly	✓		
	Diptera		fly larvae			✓
	Ephemeroptera	Baetidae	Mayflies		✓	
	Ephemeroptera	Caenidae	Mayflies		✓	
	Ephemeroptera		Mayflies	✓		✓
	Hemiptera	Corixidae	Bugs	✓	✓	
	Hemiptera	Notonectidae	Backswimmer	✓	✓	✓
	Odonata	Coenagrionidae	Damselflies	✓	✓	✓
	Odonata	Libellulidae	Dragonfly		✓	
	Odonata		Dragonfly	✓		
	Trichoptera		Caddisflies	✓		
Maxillopoda (Copepoda)			Copepods		✓	
Ostracoda			Seed shrimp		✓	
Phylum: Euarthropoda						
Malacostraca		Decapoda	Atyidae	✓		✓
Phylum: Mollusca						
Bivalvia			Clam	✓		
Gastopodia			Snail	✓		
Phylum: Nematoda						
			Nematodes		✓	

3.6 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 2013).

The key fish habitat map output for the Singleton LGA was reviewed and is provided in **Figure 3.1**. Bowmans Creek has been mapped as key fish habitat, along with the lower reaches of Swamp Creek and Bettys Creek. Apart from a short, approximately 200 m section of Yorks Creek at its confluence with Bowmans Creek, Yorks Creek has not been identified 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 m 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 watercourses relevant to the Project has been assessed and is identified in **Table 3.9**.

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 feeding 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 Project Area for fish passage has been assessed in accordance with NSW DPI (DPI 2013) and is identified in **Table 3.9**.

Table 3.9 Habitat Sensitivity Analysis

Watercourse	Strahler Order	Habitat Sensitivity Type	Classification of Watercourse for Fish Passage	Key Fish Habitat Mapping
Bowmans Creek	6	Type 1 highly sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
Yorks Creek	3	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Lower reach mapped as key fish habitat
Swamp Creek	2 (formerly 4)	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Lower reaches mapped as key fish habitat
Bettys Creek	2 (formerly 4)	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Lower reaches mapped as key fish habitat

Prior to the existing diversion of Swamp Creek and Bettys Creek, both would have been classified as 4th order streams; however, following the approved diversion works, both are now considered 2nd order streams. As outlined above, first and second order streams on gaining streams are not considered key fish habitat (DPI 2013).

3.7 Threatened aquatic species and endangered populations

No threatened aquatic fauna species were recorded, or are known to occur within the Project Area. Two threatened aquatic species were recorded as occurring within a 10 km radius of the Project Area, these being southern purple spotted gudgeon (*Mogurnda adspersa*) and Darling river hardhead (*Craterocephalus amniculus*). The following sections outline descriptions of their habitat, ecology and known distribution with regard to the location of the Project Area.

3.7.1 Southern purple spotted gudgeon (*Mogurnda adspersa*)

The southern purple spotted gudgeon is associated with rivers, creeks and billabongs with slow-flowing parts or still waters with low turbidity. This species requires aquatic vegetation, overhanging vegetation and variety of substrates including snags, rocks and leaf litter (Allen et al 2003; DPI 2017). The southern purple spotted gudgeon is a cryptic, benthic, sedentary species which has been known to migrate from deeper water to over winter in more sheltered positions, although it is unlikely this species moves large distances (Allen et al 2003; MPR 2009; DPI 2017). Breeding occurs in the warmer months between November and March with females producing several batches of eggs per season (30-1,300 eggs per batch) which are deposited on rocks, logs, broad-leaved aquatic plants and other debris (Allen et al 2003; DPI 2017). The male southern purple spotted-tailed gudgeon guards and fans the eggs until they hatch within 3-9 days, which is dependent on water temperature (Allen et al 2003; DPI 2017). The life cycle of this species is threatened by loss of habitat particularly aquatic plants, fluctuations in water levels and flows as a results of river regulations, increased turbidity, decreased water quality, thermal pollution, and threats from introduced species such as gambusia (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*) (DPI 2017).

This species is known from two populations in NSW, the western population, found within the Murray-Darling Basin and the eastern population in coastal catchments located north of the Clarence River (DPI 2017). Both populations have experience large declines, with the eastern population now limited to two extant populations, one in the Richmond catchment and the second located in the Hunter Valley. The southern purple spotted gudgeon was recorded in May 2009 in Goorangoola Creek which is located in the Glennies Creek catchment to the north-east of the Project Area. However, this record is considered outside of its natural range and may be the result of an aquarium introduction (MPR 2009; DPI 2017).

Bowmans Creek is mapped on DPI (2019) freshwater threatened species distribution map for the southern purple spotted gudgeon (refer to **Figure 3.2**). However, these maps do have limitations including that the data and records are not comprehensive and there may be errors and omissions within the species distributional ranges (DPI 2019).

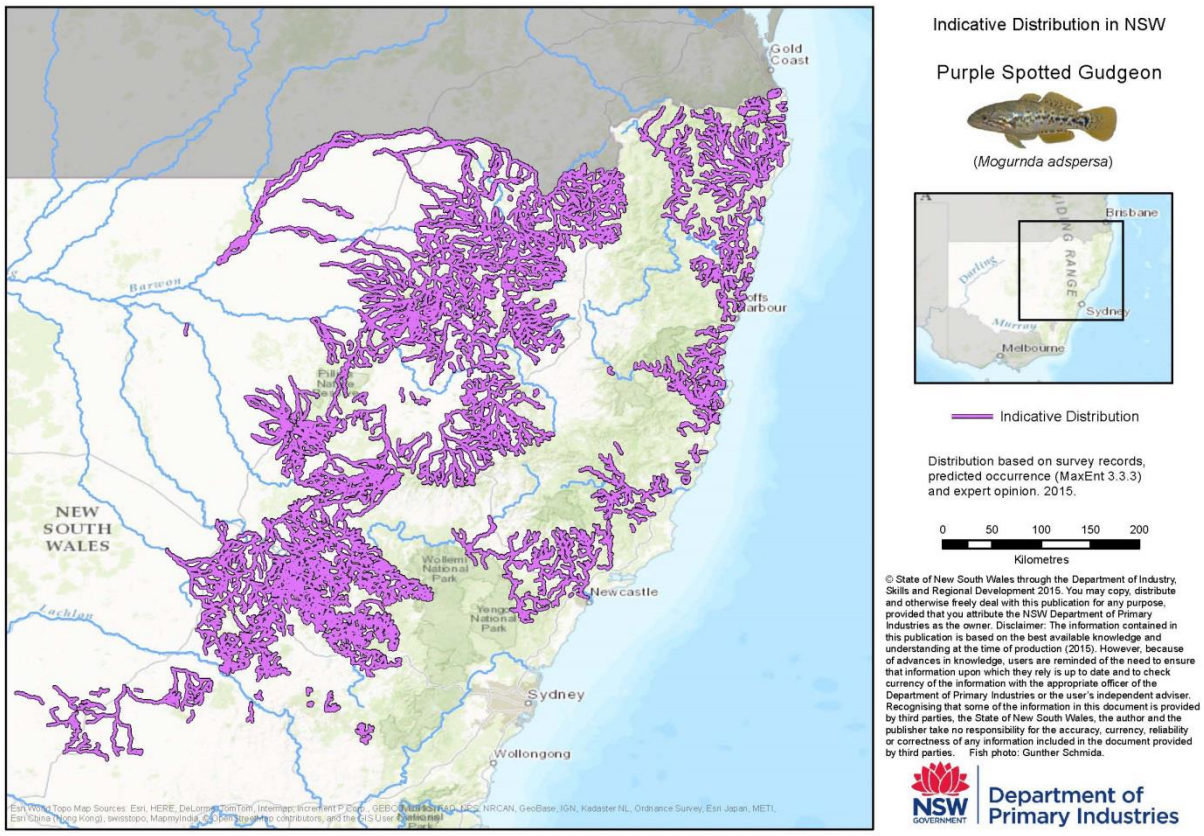


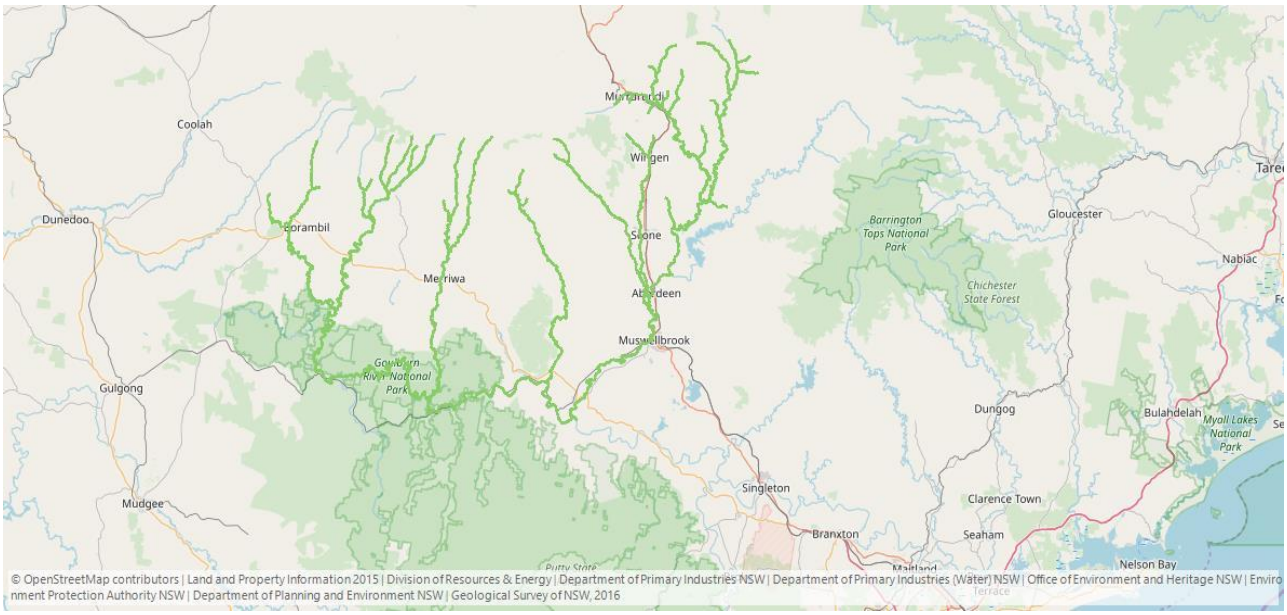
Figure 3.2 Indicative distribution of the purple spotted gudgeon in River NSW Department of Primary Industries 2015

No other historical records for this species currently exist, in or surrounding Bowmans Creek from searches of relevant databases and literature. The nearest record is located near Mudgee NSW, more than 138 km west-south-west of the Project (ALA 2019, OZCAM 2019, Bionet 2019). Despite numerous surveys being conducted over the last two decades, this species has not been recorded from Bowmans Creek. Previous surveys of the creek include those conducted for the Ashton Coal Project in the lower reaches (south of the Project Area) by ERM (2006) and by MPR (2009) who conducted numerous surveys between 2005 and 2009. In addition, Eco Logical (2012) conducted aquatic surveys for the Liddell Coal Operations in Bowmans Creek just north of the Project Area. The southern purple spotted gudgeon was also not recorded in Bowmans Creek during the aquatic surveys for the Project in October and November 2018 or in former Umwelt surveys of the creek in 2014 undertaken for the Mount Owen Continued Operations Project (Umwelt 2014).

The species is considered unlikely to occur in the ephemeral habitats Yorks, Swamp and Bettys Creeks.

3.7.2 Darling River hardhead (*Craterocephalus amniculus*) endangered population

The Hunter River catchment provides habitat for the Darling River hardyhead Endangered Population listed under the FM Act. Searches of the NSW DPI freshwater threatened species distribution maps listed this species as potentially occurring north and west of Muswellbrook (refer to **Figure 3.3**) within the Hunter River catchment area.



Source: SEED accessed February 2019

Figure 3.3 Indicative Distribution of the Darling River hardyhead in Hunter River (NSW DPI 2015)

Darling River hardyhead (*Craterocephalus amniculus*) is predicted to occur in the upper reaches of the Hunter River (refer to **Figure 3.3**). The population of this species has presumably always been uncommon in the Hunter River catchment as it has only ever been reported from nine widely dispersed sites. The most recent records of the species in the Hunter River catchment are from the Krui River approximately 90 km north 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 (*Craterocephalus amniculus*) prefers smaller rivers, creeks and streams with slow-flowing, clear and shallow waters frequently among aquatic vegetation (Allen et al 2003; DPI 2014). Little is known about this species breeding but it is considered closely related to the Murray hardyhead (*Craterocephalus fluviatilis*). The Murray hardyhead is an annual (short lived) species, with a long breeding season from spring to autumn. The eggs are generally laid amongst aquatic vegetation. The life cycle of this species is threatened by loss of habitat particularly aquatic plants, fluctuations in water levels and flows as a results of river regulations, increased turbidity, decreased water quality, thermal pollution, and threats from introduced species such as gambusia (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*) (DPI 2017).

The Darling River hardyhead is unlikely to utilise the marginal or intermittent aquatic habitats identified in the Project Area.

4.0 Impact assessment

The Project will directly impact and remove aquatic habitats associated with Yorks and Swamp Creeks and will interact with both surface waters and groundwater. The potential for adverse impacts on Bowmans Creek and its associated alluvial aquifers was identified as an issue of concern by several stakeholders during the community engagement process undertaken during the scoping phase of the Project. In recognition of the interactions of the Project with water resources, the effective management of this valuable natural resource was a key consideration in project planning.

Current and approved operations within the Mount Owen Complex include Mount Owen Mine's North Pit and Ravensworth East Mine (Bayswater North Pit) in addition to the Glendell Pit. The extensive history of past mining and the associated monitoring of the surrounding environment provides an extensive level of baseline information regarding the nature of impacts from mining in the area and the efficacy of different mitigation measures available. The data available from the monitoring associated with these historical and currently approved mining operations also enable models developed for the surface water and groundwater assessments to be calibrated. The combination of monitoring and anecdotal information also enables the results from the assessments to be tested and this provides increased confidence in both the assessment of impacts and the applicability and effectiveness of mitigation measures.

To assess the potential impact of the Project on water resources, comprehensive assessments of the potential groundwater impacts and surface water impacts (including site water balance) were undertaken and are included in Appendix 16 and Appendix 17 respectively of the EIS. These assessments were prepared in accordance with the SEARs for the Project (refer to **Table 1.1**) and were informed by a risk assessment prepared specifically for the Project's potential impacts on water resources. An overview of the key findings of the water resource assessments as they relate to aquatic ecology are provided in the following sections.

The direct impacts associated with removing riparian vegetation associated with Yorks Creek and Swamp Creek has been assessed and quantified in the BDAR (Umwelt 2019c). The following impact assessment does not consider the loss of riparian vegetation further.

4.1 Direct impacts on aquatic ecology

The Project will directly impact on Yorks Creek and Swamp Creek. The flow regimes of Bowmans Creek will be indirectly impacted by the realignment of Yorks Creek, to the north of its existing natural confluence (refer to **Figure 1.2**). **Section 4.1.1** and **Section 4.2.1** outline the impacts to Yorks Creek, Bowmans Creek, Swamp Creek and Bettys Creek.

The Project will not result in the creation of barriers to fish movement.

4.1.1 Yorks Creek Realignment Design

The Project includes the realignment of Yorks Creek, an ephemeral tributary of Bowmans Creek running north-south through the Project Area.

The need to realign Yorks Creek was identified early in the Project design phase with a number of potential routes considered; these alternatives were discussed in the PEA (Umwelt 2018). Fluvial Systems was engaged to prepare a geomorphic assessment constraints analysis for the Yorks Creek Realignment to identify geomorphic issues that needed to be considered in the detailed design of the proposed realignment. The Yorks Creek Realignment Constraints Analysis prepared by Fluvial Systems (Constraints Analysis) is included with the EIS as Appendix 18**.**

The Constraints Analysis considered the impact of moving the confluence point of Yorks Creek and Bowmans Creek upstream of the current confluence. The analysis also considered the geomorphic characteristics of the existing Yorks Creek alignment and identified design objectives for the realignment having regard to both the existing geomorphic characteristics of Yorks Creek and relevant guidelines for creek and river diversions.

Matters considered in Constraints Analysis

The Constraints Analysis includes a comprehensive review of the following in setting design objectives for the proposed realignment:

- the geomorphological characteristics of the existing Yorks Creek from upstream of Mount Owen Access Road to its junction with Bowmans Creek, and Bowmans Creek from upstream of the proposed confluence to downstream of the existing Yorks Creek confluence
- the load and grain-size of sediment transported from the Yorks Creek catchment upstream of the proposed realignment
- the performance of similar diversions was undertaken by review of selected literature.

Additionally, a regional terrain analysis was undertaken to locate potential alternative reference sites that had geomorphic form similar to that of the proposed realignment.

Yorks Creek Realignment Design Objectives

The Constraints Analysis includes a number of key design principles. Based on the design principles in the Constraints Analysis, the following design objectives have been developed for the Yorks Creek Realignment:

- minimise the risk of excessive erosion of the bed and bank in the realignment
- maintain hydrological integrity of the flood and low flows from the upper reaches of Yorks Creek to Bowmans Creek
- maintain sediment transport from the upper reaches of Yorks Creek to Bowmans Creek
- provide habitat in the riparian zone for vegetation, aquatic invertebrates, fish, reptiles and mammals typical of the existing ephemeral system.

Detailed Conceptual Design

The conceptual detailed design of the Yorks Creek Realignment (refer to Appendix 7 of the EIS) has been developed by Jacobs (Jacobs 2019) having regard to the objectives set out in the Constraints Analysis. This design was informed by early flood and sediment movement modelling undertaken for preliminary designs. The detailed conceptual design includes both long sections and cross sections of the creek as well as proposed vegetation treatments. An important feature of the detailed conceptual design is the stilling pond located at the downstream end of the lower (high gradient) reach to mitigate stream flow velocities associated with higher grade. A bridge crossing for realignment of Hebden Road has been assumed in the conceptual detailed design for the Yorks Creek Realignment.

The conceptual detailed design has had specific regard to a wide range of factors to ensure it operates as a functioning creek system.

Table 4.1 Yorks Creek Realignment Design Elements

Design element	Primary Design Objective
Appropriately sized rock will be placed to improve stability for major flood events, considering the relevant ACARP hydraulic guidelines, with particular attention to the risk of excessive valley wall erosion in the lower half of the diversion.	Minimise excessive erosion Maintain sediment transport
Where the bed shear stress exceeds the range of the existing creek, erosion resistant materials will be included. The bed material used in the upper low gradient zone will be free of contamination and have high cohesivity.	Minimise excessive erosion Maintain sediment transport
Measures of bank and bed variability in cross-section and long-profile similar to the existing Yorks Creek.	Provide habitat
Large wood will be sustainably supplied to the diversion channel by the riparian trees. Until such time that the trees are large enough to create significant wood loading, the realignment should be stocked with suitable anchored wood.	Provide habitat Minimise excessive erosion
Riparian vegetation will be similar to the existing Yorks Creek or other local drainage lines not currently disturbed by agriculture.	Provide habitat
An alluvial fan to capture sediment at the beginning of the alignment upstream of the low gradient zone between major flood events.	Maintain sediment transport
Bridge at the Hebden Road realignment crossing will minimise constraints on the movement of water and sediment.	Hydrological integrity Maintain sediment transport
Detailed design of backfill zone, including the levee, to minimise the risk of failure.	Hydrological integrity
Detailed design of confluence of Yorks Creek realignment with Bowmans Creek, considering a possible plunge pool for the management of high stream power in the lower reach of the realignment and replicate existing relatively high habitat value at the existing confluence with Bowmans Creek.	Hydrological integrity Provide habitat
Incorporate natural analogue features within rock cuttings.	Provide habitat
Investigate the potential loss of baseflow through the higher permeability bed and bank materials. Yorks Creek is intermittent, which means that its main contribution to the hydrology of Bowmans Creek is flood flow, rather than baseflow. The permeability of the bank and bed materials is expected to decrease over time.	Hydrological integrity
Appropriate erosion and sediment controls during construction (refer to Section 7.5.3.1 of the EIS).	Minimise excessive erosion Maintain sediment transport

The confluence with Bowmans Creek will be designed to minimise any scouring and erosive effects in Bowmans Creek.

Prior to construction, a detailed Yorks Creek Realignment Plan will be developed which will set out the detailed design of the proposed realignment, key design objectives and performance criteria, and ongoing monitoring requirements.

4.1.1.1 Design considerations of Yorks Creek realignment

The proposed Yorks Creek Realignment will commence north of the existing Ravensworth East MIA and progress in a south-westerly direction where it will enter Bowmans Creek. The realignment will require land forming works in the area east of the proposed Hebden Road realignment. Works for the Yorks Creek Realignment also include a cutting through the ridge west of the Hebden road realignment. The diverted creek will re-enter Bowmans Creek approximately 4 km upstream of the previous confluence. Works along Bowmans Creek in the vicinity of the new confluence may be required to manage stream stability in the areas immediately below the confluence.

Earthworks upstream of the Glendell Pit Extension will also be required to manage the risk of flood waters entering the pit. The proposed realignment consists of removing approximately 2 km of the riparian habitat in the lower portion of Yorks Creek and includes approximately 1.5 km of the existing diversion along the creek. This area has been previously disturbed by mining and infrastructure associated with the Ravensworth East Mine. Whilst direct impacts are unavoidable, the proposed realignment aims to re-establish stream connectivity to create a free passage for aquatic fauna, specifically fish species known to occur in the Bowmans Creek Catchment. Specific design considerations are documented below.

The detailed conceptual design for the realignment is shown in **Figure 4.1**. The realignment is proposed to be permanent and has been designed with consideration to a wide range of environmental factors. The design of Yorks Creek Realignment aims to re-establish stream connectivity to create a free passage aquatic fauna. Best practise techniques for design have been explored as a part of this Project for the construction of the realignment to reduce instream barriers and has considered *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (NSW Fisheries 2003).

The final landform of the Yorks Creek Realignment presents a minor increase in stream gradient, however this is considered to present a negligible impact to the overall stream health. The realignment will promote a natural, unimpeded stream flow allowing the free movement of fish between instream refuge structures should flow return to Yorks Creek as drought conditions ease. The realignment is required to be in place by approximately Year 7 and construction will primarily occur in Year 5 to 6 however aspects of the realignment will occur as part of the Hebden Road realignment works.

During construction, a combination of constructed channels and pipelines will be used to convey wet weather flows from the upper reaches of Yorks Creek to the sections of Yorks Creek downstream of the realignment works. Detention basins and dams will be constructed in the upstream sections of the realignment to manage high flow events during construction. A detailed Yorks Creek Realignment Plan will be developed to inform the construction and commissioning works for the Yorks Creek Realignment.

4.1.1.2 Yorks Creek Realignment rehabilitation design objectives

The upper section of the Yorks Creek Realignment overlaps with the existing Yorks Creek Diversion adjacent to the existing Ravensworth East MIA (refer to **Figure 4.1**). The proposed realignment will require the removal of the Ravensworth East MIA infrastructure and filling of sections of the existing Yorks Creek Diversion and extant creek to recreate a flood plain in this area.

A levee will be constructed at the southern end of the constructed flood plain to prevent inundation of the Glendell Pit Extension up to a 1000 year ARI flood event.

The realignment will require a cutting through the ridgeline to the west of the current alignment where the creek will re-enter Bowmans Creek, approximately 4 km upstream from the current confluence. The channel of the realigned creek through the upper floodplain section will be constructed through fill material while the lower sections will be constructed into sedimentary bedrock material.

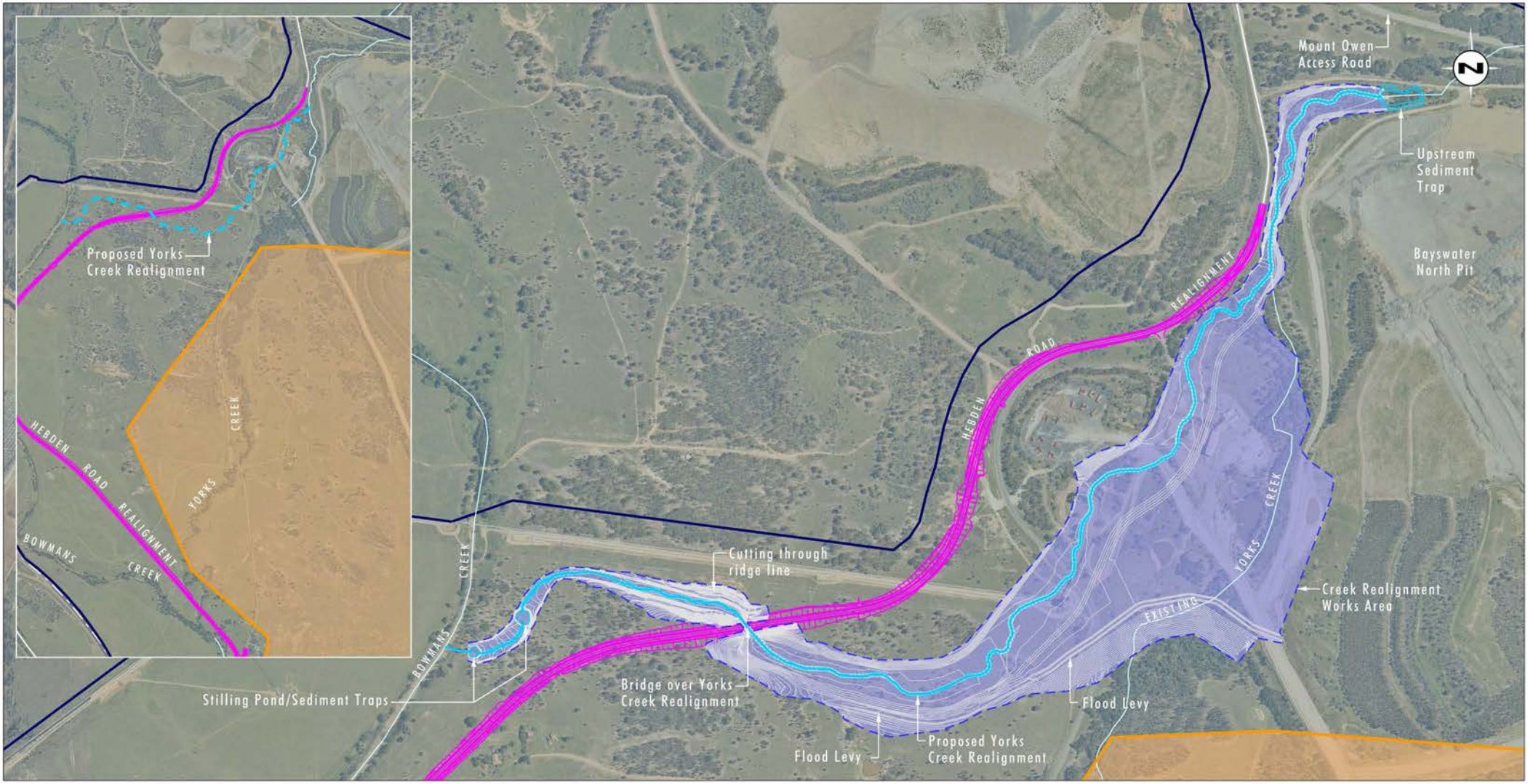


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

Legend

- Project Area
- Glendell Pit Extension
- Hebden Road Realignment
- Yorks Creek Realignment
- Creek Realignment Works Area

FIGURE 4.1

Yorks Creek Realignment - Conceptual Detailed Design

The detailed conceptual design drawings for the proposed Yorks Creek Realignment (Jacobs 2019) are provided in Appendix 7 of the EIS these designs will be further refined prior to construction and commissioning. The Mount Owen Complex Creek Diversion Plan will be updated to reflect the final design details for the Yorks Creek Realignment once complete.

4.1.2 Direct impacts on Yorks Creek

The Project will mine through the remnants of Yorks Creek and significantly reduce flow downstream of the Yorks Creek Realignment works. The construction of the realigned section of Hebden Road and the Heavy Vehicle Access Road will also directly impact on the lower reaches of Yorks Creek. These aspects of the Project impacts have the potential to impact on any aquatic fauna that may be present in the sections of creek impacted.

As Yorks Creek is an ephemeral creek system, it has few or no persistent pools. Direct impacts on aquatic communities located within the creeks will be limited to circumstances where the creeks contain water at the time of impact and the pools have been colonised by fauna movement from Bowmans Creek. These aquatic ecosystems are typically temporary and the loss of these habitats is not considered to be a significant impact. The impacts associated with the loss of this potential habitat on other vertebrate fauna such as amphibians is assessed in the BDAR (Umwelt 2019c refer to Appendix 20 of the EIS).

4.1.3 Direct impacts on Swamp Creek

The Project will mine through the remnants of Swamp Creek located immediately north of Glendell Pit reducing the catchment area. As Yorks Creek is an ephemeral creek system, it has few or no persistent pools. Direct impacts on aquatic communities located within the creeks will be limited to circumstances where the creeks contain water at the time of impact and the pools have been colonised by fauna movement from Bowmans Creek. These aquatic ecosystems are typically temporary and the loss of these habitats is not considered to be a significant impact. The impacts associated with the loss of this potential habitat on other vertebrate fauna such as amphibians is assessed in the BDAR (Umwelt 2019crefer to Appendix 20 of the EIS).

The terrain developed by the in-pit emplacement of overburden as part of the mining of the Project will result in a reduction to the Swamp Creek catchment during the life of the Project. This will result in reduced flows to the remnant sections of Swamp Creek downstream of the Project which is likely to result in reduced creation and recharge of persistent pools. Given the ephemeral nature of the creek, the potential impacts on the temporary aquatic ecosystems in the sections of the creek is not considered to be significant. Water from the rehabilitated slopes of the south-western part of the final landform of the Project will be directed towards the lower reaches of Swamp Creek and enable the return of some catchment flows to this lower reach of the creek. This will return downstream aquatic habitats (where present) to a standard similar to existing conditions.

4.2 Indirect Impacts

A detailed surface water impact assessment (SWIA) has been completed for the Project and is included as Appendix 17 of the EIS, with a summary of the key assessment findings included below as they relate to impacts on aquatic species, populations and habitats.

The following aspects of the Project have the potential to impact on surface water resources and subsequently aquatic species, populations and habitats:

- increased area of disturbance during the operation of the Project and associated impacts from reduced catchment run-off and management of water quality from areas impacted by the Project

- permanent realignment of Yorks Creek, resulting in changes to catchments, flood regimes, flooding behaviour and downstream water quality
- changes to the final void, resulting in changes in water level recovery and water quality
- changes to final landform catchment and potential impacts on downstream catchments from changes to flow regimes and flooding and
- reduced baseflow in creeks associated with impacts on groundwater systems.

4.2.1 Downstream water quality

No measurable change to the flow regime or water quality of Bowmans Creek is expected as a result of the Project, and therefore no impacts to aquatic ecosystems are expected (GHD 2019).

Potential impacts to the water quality downstream of the Yorks Creek Realignment are considered specific to scour and erosion control during construction. Design and construction elements have been considered to reduce potential impacts of erosion to water quality downstream of the new confluence (GHD 2019).

The extension to the water management system, as part of the Project, will be integrated into the existing water management system including mine dewatering systems, water storages, sedimentation and retention basins, settling and tailings ponds and diversion drains. The water management system aims to limit the potential impacts on downstream water quality by managing water that has the potential to cause environmental harm. The conceptual water management system has been designed to continue to divert clean water around mining operations (where practical) and segregate, store and reuse dirty and mine impacted water to minimise adverse effects on water quality from mining operations to downstream waterways (GHD 2019). The approved conceptual water management system is designed to manage water to meet licence conditions within the requirements of the POEO Act, taking account of both historical and current water qualities in the surrounding watercourses, and current and future downstream water users (GHD 2019).

The recovery and water quality of the pit lake final void in the Glendell Pit Extension has been modelled by GHD and indicates that the pit lake water level will reach equilibrium at approximately -60 mAHD with approximately 140 m freeboard to the void crest. Groundwater modelling indicates that the water table within areas of the Glendell Pit will remain below the pit crest. The Glendell Pit is therefore considered to be a hydraulic sink with no risk of decant of pit lake water to the downstream environment. Salinity levels in the pit lake are modelled to rise over time as a result of evapoconcentration with salinity levels predicted to be similar to those of the currently approved void at Glendell (GHD 2019).

4.2.2 Impacts on flow regimes

The Project has the potential to impact on flow regimes in watercourses due to changes to catchment areas and reductions in baseflow. The Project will change the catchments of Bowmans, Yorks, Swamp and Bettys Creek and also realign Yorks Creek to a new confluence with Bowmans Creek. Groundwater modelling reported in the Groundwater Impact Assessment (AGE 2019) also predicts changes to baseflow in Bowmans and Glennies Creek and the Hunter River associated with a delay in the recovery of the groundwater system, however the incremental changes to baseflow for Yorks, Swamp and Bettys Creek were predicted to be negligible and overall baseflow is predicted to increase following the cessation of mining as regional groundwater systems recover.

Overall, the total catchment of Bowmans Creek will increase in both the approved and proposed conceptual final landform compared to existing conditions, with a slight difference reflecting the catchment areas of the approved and proposed final voids. The lower catchment of Bowmans Creek is proposed to temporarily reduce by approximately 339 ha during the operation of the Project before increasing as rehabilitated catchment at the Mount Owen Complex and neighbouring operations is returned. This reduction is less than the Additional Disturbance Area associated with the Project as other areas of rehabilitated land at the Mount Owen Complex and Liddell Coal Operations are expected to have been returned to the catchment by the time the maximum extent of impacts associated with the Project occur. In this regard, the cumulative impact on the overall catchment size of Bowmans Creek relative to existing conditions is less than the incremental impact associated with the Project.

The realignment of Yorks Creek will substantially reduce the catchment of the reach of Yorks Creek discharging into Bowmans Creek at the existing confluence point once the Glendell Pit Extension mines through Yorks Creek. In the conceptual final landform, the drainage plan results in a return of flows to Bowmans Creek at this confluence point, but most of the Yorks Creek catchment will continue to be diverted to Bowmans Creek via the Yorks Creek Realignment at the upstream confluence point.

The proposed final landform catchment of Swamp Creek is substantially less than in the approved conceptual final landform, as most of the rehabilitated former Swamp Creek catchment proposed to be diverted to Bettys Creek. In the proposed conceptual final landform, the catchment of the lower reach of Swamp Creek will be slightly larger than the existing conditions.

The catchment area of Bettys Creek will increase as rehabilitated areas are returned during the operation of the Project. The Project will result in the Bettys Creek catchment being substantially increased in the proposed conceptual final landform due to the diversion of part of the former Swamp Creek catchment to Bettys Creek via WRDWRD. This change will result in Bettys Creek have a similar catchment size to its pre-mining catchment.

While the Project alters the catchment areas of various tributaries of Bowmans Creek during the life of operations, the overall impacts on the Bowmans Creek catchment during operations is considered to be small relative to existing conditions (less than 2% reduction). The conceptual final landform for the Project will have a negligible impact on the overall catchment size of Bowmans Creek relative to existing approved operations. The respective changes to the Swamp Creek and Bettys Creek catchments in the final landform, while significant in percentage terms, are unlikely to have significant environmental impacts as the confluence point of both creeks with Bowmans Creek occur within approximately 150 m of each other, immediately downstream of where they flow under the Main Northern Railway. Further, the proposed Swamp Creek catchment will be slightly larger than the existing conditions (which have existed for more than ten years) and the Bettys Creek catchment will be similar (albeit slightly larger) to its pre-mining catchment. These changes are considered unlikely to have any observable impact on aquatic ecosystems in the Bowmans Creek area.

Flood modelling indicates that the proposed realignment of Yorks Creek upstream of the existing confluence will have a negligible impact on flood levels and flow velocities in Bowmans Creek. The Project is not predicted to have any significant impacts on flood flows in Bowmans Creek. As a result, the Project is considered unlikely to have any observable impact on aquatic fauna in Bowmans Creek as a result of changes in flow regimes.

4.2.2.1 Cumulative impacts

Land use within the catchment of Bowmans Creek includes mining operations, quarrying, grazing and rural residential holdings. Outside of the Mount Owen Complex, established mining operations within the catchment of Bowmans Creek include Liddell Coal Operations to the north-west; Ravensworth Operations to the south-west, Integra Underground Mine to the south-east, and Ashton Coal Mine to the south.

The Project will result in changes to the catchment areas of Yorks Creek, Swamp Creek and Bettys Creek compared to the currently approved final landform at the Mount Owen Complex, but the overall impacts to Bowmans Creek are considered negligible relative to currently approved operations. As the impacts to Bowmans Creek as a result of the Project are considered negligible, it is considered that there will be no measurable changes to the cumulative impacts on Bowmans Creek. It is also noted that the Project will coincide with a reduction in impacts associated with other operations or other part of the Mount Owen Complex including:

- reduced cumulative groundwater impacts as regional groundwater systems recover following the cessation of mining in other pits at the Mount Owen Complex and at other operations
- increase catchment in Bowmans Creek as areas disturbed by mining activities are rehabilitated and run-off is returned to the downstream environment rather than being managed as part of the mine water management systems.

Despite the cumulative increase in the catchment of Bowmans Creek as runoff from rehabilitated areas is returned to the downstream catchment, flood modelling indicates that no significant changes to flood extent or watercourse stability are expected as result of the Project.

The detailed conceptual design of the Yorks Creek Realignment includes elements to mitigate the potential for erosion resulting in downstream water quality impacts. Overall, the cumulative potential impacts on water quality in downstream watercourses are considered negligible.

As the Project and adjacent mining operations operate in a highly regulated water system, any water take associated with the Project or existing approved operations will need to meet the requirements of the Water Management Act in regard to licensing of water take. As such, the Project is considered to have negligible cumulative impacts on downstream water users.

4.3 Threatened species, endangered populations and TECs assessed under the FM Act 1994

The 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 Project Area, however one threatened species and one endangered population are predicted to occur in the Hunter River catchment. As identified in **Section 3.7** the Project Area intersects with the following threatened species and populations listed under the FM Act:

- Darling River hardyhead (*Craterocephalus amniculus*) Endangered Population

- Southern purple spotted gudgeon (*Mogurnda adspersa*) endangered species

An assessment of significance is provided in **Table 4.2** which concludes that the 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 Project Area.

Table 4.2 Seven Part Test of Significance for matters listed under the FM Act

Darling River hardyhead (Craterocephalus amniculus), Endangered population	**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 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 in Bowmans Creek. The Project will not result in direct impacts to aquatic habitats in Bowmans Creek and groundwater and surface water impacts are expected to be negligible (refer to **Sections 4.2** and **4.3**). There are no known records of this species within the vicinity of the Project Area and the closest known record of this species is located in Goorangoola Creek; located northeast of the Project in the Glennies Creek catchment area. As this species requires permanent slow flowing or static waters, the realignmentrealignmentrealignment of Yorks Creek is unlikely to impact this species due to its highly ephemeral nature. It is likely that fish species only enter this system during high rainfall periods. The changes to the flow of Bowmans Creek from the realignmentrealignmentrealignment of Yorks Creeks to the north of its natural confluence is unlikely to impact this species due to the lack of records for this species within Bowmans Creek catchment and the limited disturbance to the creek. The proposal is unlikely to have an adverse effect on the life cycle of the southern purple spotted gudgeon such that a viable local population of the species is likely to be placed at risk of extinction.

Darling River hardyhead (Craterocephalus amniculus), Endangered population	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 by NSW DPI to occur upstream from the confluence of the Hunter River and the Goulburn River, approximately 35 km west of the Project Area. While Bowmans Creek and Yorks Creek are tributaries of the Hunter River, the 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 Project Area. The closest known record of this species in the Hunter River catchment are from the Krui River to the north west of the Project Area in 2002 and from the Hunter River at Dartbrook in 2003 (DPI 2014). The Project will not result in direct impacts to aquatic habitats in Hunter River or Bowmans Creek, while groundwater and surface water impacts are expected to be negligible (refer to **Sections 4.2** and **4.3**) and therefore the 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
(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), Bowmans Creek constitutes Type 1 highly sensitive fish habitat and Yorks and Swamp Creeks comprise Class 3 minimally sensitive fish habitat. The Darling River hardyhead has not been recorded within Project Area and it is not considered important habitat for this threatened species.	In accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013), Bowmans Creek constitutes Type 1 highly sensitive fish habitat and Yorks and Swamp Creeks comprise Class 3 minimally sensitive fish habitat. The southern purple spotted gudgeon has not been recorded within the Project Area and it is not considered important habitat for this threatened species.

Darling River hardyhead (Craterocephalus amniculus), Endangered population	purple spotted gudgeon (Mogurnda adspersa), Endangered 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 Project Area	No critical habitat has been identified in the Project Area
(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan; and	
The priority action statement for the Darling River hardyhead has the following recovery actions: • provide advice to consent and determining authorities on the distribution of the Darling River hardyhead • collate and review existing information • community and stakeholder liaison, awareness and education • compliance and enforcement of banning collection of this species • Enhance, modify or implement natural resource planning processes to minimize adverse impacts on threatened species • Habitat rehabilitation • pest eradication and control • research and monitoring • survey and mapping of current distribution including collection of data from incidental surveys • stocking/translocation The Project would realign and remove the existing Yorks Creek and remove part of Swamp Creek. This species has not been recorded within these two creeks and it is unlikely to be present in the local catchments. Therefore, the Project is not in-consistent with the recovery actions.	The priority action statement for the southern purple spotted gudgeon has the following recovery actions: • provide advice to consent and determining authorities on the distribution of the southern purple spotted gudgeon • collate and review existing information • community and stakeholder liaison, awareness and education • compliance and enforcement of banning collection of this species • Enhance, modify or implement NRM planning processes to minimize adverse impacts on threatened species • Habitat rehabilitation • pest eradication and control • research and monitoring • survey and mapping of current distribution including collection of data from incidental surveys • stocking/translocation The Project would realign and remove the existing Yorks Creek and remove part of Swamp Creek. This species has not been recorded within these two creeks and it is unlikely to be present in the local catchments. Therefore, the Project is not in-consistent with the recovery actions.

Darling River hardyhead (Craterocephalus amniculus), Endangered population	purple spotted gudgeon (Mogurnda adspersa), Endangered species
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.	
The Project may contribute to the following key threatening processes: • General habitat degradation caused by soil erosion, land clearing (including clearing of riparian vegetation) • Water extraction from drought refugia in smaller tributary streams The Project will alter the native riparian vegetation through the realignment of Yorks Creek (dry at the time of survey) and the direct removal of part of Swamp Creek. Through appropriate design of the Yorks Creek Realignment, avoiding/minimising disturbance of riparian vegetation, and the re-use of large woody debris, the Project minimises the above threatening processes.	The Project may contribute to the following key threatening processes: • degradation of native riparian vegetation • Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams • removal of large woody debris. The Project may remove large woody debris within dry creek beds and lead to degradation of native riparian vegetation. Through appropriate design of the Yorks Creek Realignment, avoiding/minimising disturbance of riparian vegetation, and the re-use of large woody debris, the Project minimises the above threatening processes.

Based on the above assessments of significance and the surface water and groundwater impacts described above, the Project is not expected to result in an adverse impact on threatened species, endangered populations or ecological communities listed under the FM Act.

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 matters of national environmental significance (MNES). Aquatic MNES predicted to occur within the Project Area and a 10 km buffer are discussed in **Section 3.4**.

No nationally listed threatened aquatic species or TECs or aquatic migratory species are expected to occur in the watercourses within the Project Area and therefore no adverse impacts to aquatic ecology are predicted. Accordingly, an assessment of the impact of the Project on matters of national environmental significance is not required.

5.0 Impact avoidance and mitigation measures

5.1 Impact avoidance measures

As part of the design of the Project, adapting the mine plan to minimise impacts and the extent of the disturbance footprint were key design considerations.

There were also a number of refinements made during the design process to the proposed water management system for the Project. The water management system design is a key driver for the avoidance of impacts of the Project on aquatic ecology.

5.2 Impact mitigation measures

The Project will extend many of the existing groundwater and surface management processes currently employed at the Mount Owen Complex. The Mount Owen Complex water management system is an established system with a long history of effective management of potential impacts on water quality. The integration of the Mount Owen Complex with the Greater Ravensworth Area Water and Treatment Scheme (GRAWTS) that enables water and tailings to be transferred between the Mount Owen Complex and adjacent mines within the GRAWTS which allows for greater flexibility and efficiency in water use and management across these interlinked sites. These existing water management related mitigation measures which will be extended to the Project have a high degree of effectiveness as they as based on engineered controls.

The extension of the Glendell Pit to the north along the Camberwell Anticline has significant benefits in terms of minimising potential impacts on the adjacent alluvial aquifer systems associated with Bowmans Creek. The monitoring of the approved mining at Glendell shows little impact from these operations on the adjacent Swamp Creek and Bowmans Creek alluvial systems which provides strong validation of the groundwater modelling which indicates that the continuation of the pit along the anticline is unlikely to have significant additional impacts on this system.

5.2.1 Construction phase impact mitigation

A range of general mitigation measures are proposed to be employed within the Project Area during the construction phase of the 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 Yorks 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 the Detailed Yorks Creek Realignment Plan which will include a Construction Erosion and Sediment Control Plan and 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.

The design of the Yorks Creek Realignment includes elements to mitigate the potential for erosion resulting in downstream water quality impacts. The conceptual detailed d also includes consideration of riparian habitat and instream structures and features for habitat.

Watercourse crossings can act as a barrier to fish passage. The realignment of both Yorks Creek and Hebden Road will necessitate a new crossing of Yorks Creek. A bridge will be used for this crossing which is considered to be the preferred crossing type in terms of mitigating potential barriers to fish movement. 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

Where the Project may require removal of large woody debris from watercourses in the Project Area, these will be used in the proposed Yorks Creek Realignment, where practicable.

5.2.2 Operational phase impact mitigation

A range of strategies are proposed to mitigate adverse impacts during the operational phase of the Project. This includes specific measures to minimise the potential impacts on the aquatic ecological values of the 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 Mount Owen Complex water management system and GRAWTS, with any mine water discharges managed in accordance with Hunter River Salinity Trading Scheme (HRSTS)
- all sediment and erosion control dams will be designed to meet relevant Blue Book design requirements
- re-instating the creek landform and re-establishing riparian vegetation for the realignment of Yorks Creek.

6.0 Summary and conclusion

The Project is located in the Bowmans Creek catchment throughout its lower ephemeral tributaries, being Yorks Creek and Swamp Creek. The Project includes the continuation of the Glendell Pit to the north, the realignment of part of Hebden Road, the realignment of the lower reach of Yorks Creek and relocation of Ravensworth Homestead.

The assessment of aquatic ecology was undertaken during periods of persistent no-flow and extended drought. This study considered the ecological values of the Bowmans Creek catchment, including Bowmans Creek, Yorks Creek, Swamp Creek and Bettys Creek. The aquatic habitat condition identified in Bowmans Creek and its ephemeral tributaries was considered poor in response to prevailing climatic conditions which has also been exacerbated by historic and ongoing surrounding land use. Extended periods of below average rainfall have resulted in a long term decline in surface flows and subsequently ecological condition, while mining operations in the locality have contributed to the depressurisation of groundwater.

The presence of aquatic vegetation along Bowmans Creek was generally found in association with persistent pools. Aquatic vegetation associated with the larger refuge pools located at the confluence of Yorks Creek and downstream of the Project Area were more abundant, however species diversity was low. Aquatic vegetation was scarce in the tributaries of Bowmans Creek. Vegetation in Yorks Creek was limited to a wet depression upstream of the Bayswater North Pit, while no permanent waterbodies or associated aquatic vegetation was observed in the Swamp Creek tributary at the time of survey.

Observations of aquatic habitat decline in relation to the prevailing climatic conditions were found to concentrate remaining fish species and numbers into refuge pools. Aquatic fauna surveys were undertaken for this study at the only three locations along Bowmans Creek that provided persistent aquatic refuge habitat. Bowmans Creek demonstrated reasonable species diversity in proximity to the Project Area with a total of 15 aquatic fauna species recorded comprising 13 native species. Yorks Creek and Swamp Creek demonstrated poor fish habitat exhibiting no-flow during the survey period, however the ephemeral nature of these streams is well documented. No aquatic fauna species were observed in Yorks Creek or Swamp Creek at the time of survey. Similarly, the results of the macroinvertebrate survey indicated that the condition of habitat within the Bowmans Creek catchment is moderate.

It is anticipated that the condition and quality of aquatic habitats within the Bowmans Creek catchment will improve following the return of average rainfall and climatic conditions, and aquatic flora and fauna species are expected to return following re-colonisation from the remaining persistent pools/refuge habitat and well-connected downstream environments.

The Project will directly impact the catchments of Yorks Creek and Swamp Creek. The realignment of Yorks Creek includes removing approximately 2 km of riparian habitat, while the Project will mine through the remnants of Swamp Creek reducing the overall catchment area in the short term. The final landform of the Project includes a final void, with a similar catchment area but located further north, as well as the transfer of the some of the rehabilitated site to Bettys Creek rather than Swamp Creek. The Project is not predicted to pose long term impacts to key fish habitat.

During stream flow events in Yorks Creek, the Bowmans Creek catchment fish will likely recolonise habitat areas in the Yorks Creek Realignment and upstream given the unimpeded stream connectivity of the Hunter River to Bowmans Creek and its ephemeral tributaries outlined in the final landform design.

Results of the flow regime modelling indicate that the Project is not predicted to have any observable impact on low flows in Bowmans Creek.

No FM Act listed threatened aquatic flora or fauna species were recorded within the Project Area, however the Project Area intersects with the predicted distribution of darling River hardyhead (*Craterocephalus amniculus*) Endangered Population and the southern purple spotted gudgeon (*Mogurnda adspersa*) endangered species. An assessment of significance was undertaken for both species and concluded that the Project is unlikely to result in a significant impact on an endangered population of the Darling River hardyhead or the purple spotted gudgeon.

The Project will seek to minimise and mitigate the unavoidable impacts associated with the Project on aquatic ecosystems through the range of actions documented in **Section 5.0**. As a result, the Project is not expected to have residual significant impacts on aquatic species, populations or habitats.

7.0 References

AUSRIVAS (2007) *AUSRIVAS, Australian River Assessment System* http://ausrivas.ewater.com.au/

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2019), *Groundwater Impact Assessment, Glendell Continued Operations Project*

Barbour MT, Gerritsen J, Snyder BD, and Stribling JB (1999) 'Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish.' U.S. Environmental Protection Agency, Office of Water, Washington., No. 841-B-99-002.

Bureau of Meteorology Atlas of Groundwater Dependant Ecosystems (2018) http://www.bom.gov.au/water/groundwater/gde/map.shtml accessed February 2018.

Department of Environment and Climate Change (DECC) (2008) Managing Urban Stormwater – Soils and Construction, Volume 2A, 2C, 2D and 2E (the Blue Book).

Department of Land and Water Conservation (DLWC) (2002) *The NSW State Groundwater Dependent Ecosystems Policy*. A report prepared for the NSW Government.

Department of the Environment (DoE) (2013) Significant Impact Guidelines 1.1 – Matters of National Environmental Significance.

Department of the Environment (2017) Protected Matters Search Tool http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf accessed October 2017.

Department of Primary Industries (DPI) (2004) Policy and Guidelines for Fish Friendly Waterway Crossings.

Department of Primary Industries (DPI) (2012) Risk Assessment Guidelines for Groundwater Dependent Ecosystems.

Department of Primary Industries (DPI) (2013) Policy and Guidelines for Fish Habitat Conservation and Management.

Department of Primary Industries (DPI) (2015) Indicative Distribution of the Darling River Hardyhead.

Department of Primary Industries (DPI) (2008) Threatened Species Assessment Guidelines.

Department of Primary Industries (DPI) (2018) Freshwater threatened species distribution maps https://www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps

Eco Logical Australia 2019. *Glendell Continued Operations Project- Stygofauna Assessment*. Prepared for Umwelt.'

Eco Logical Australia (2012) Liddell Coal Mine Extension – Aquatic Ecology and Groundwater Dependent Ecosystem Assessment, prepared for Liddell Coal Operations Pty Ltd, August 2012.

Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla.

GHD (2019) Glendell Continued Operations Project: Surface water impact assessment. A report prepared for Glendell Mine (Glencore).

Kovac, M. and Lawrie, J. W. (1991) Soil Landscapes of the Singleton 1:250 000 Sheet. Soil Conservation Service of NSW, Sydney.

Landcom (2004) Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.

Lincoln Smith, M. (2003) *Aquatic Ecology in Environmental Impact Assessment EIA Guideline.*

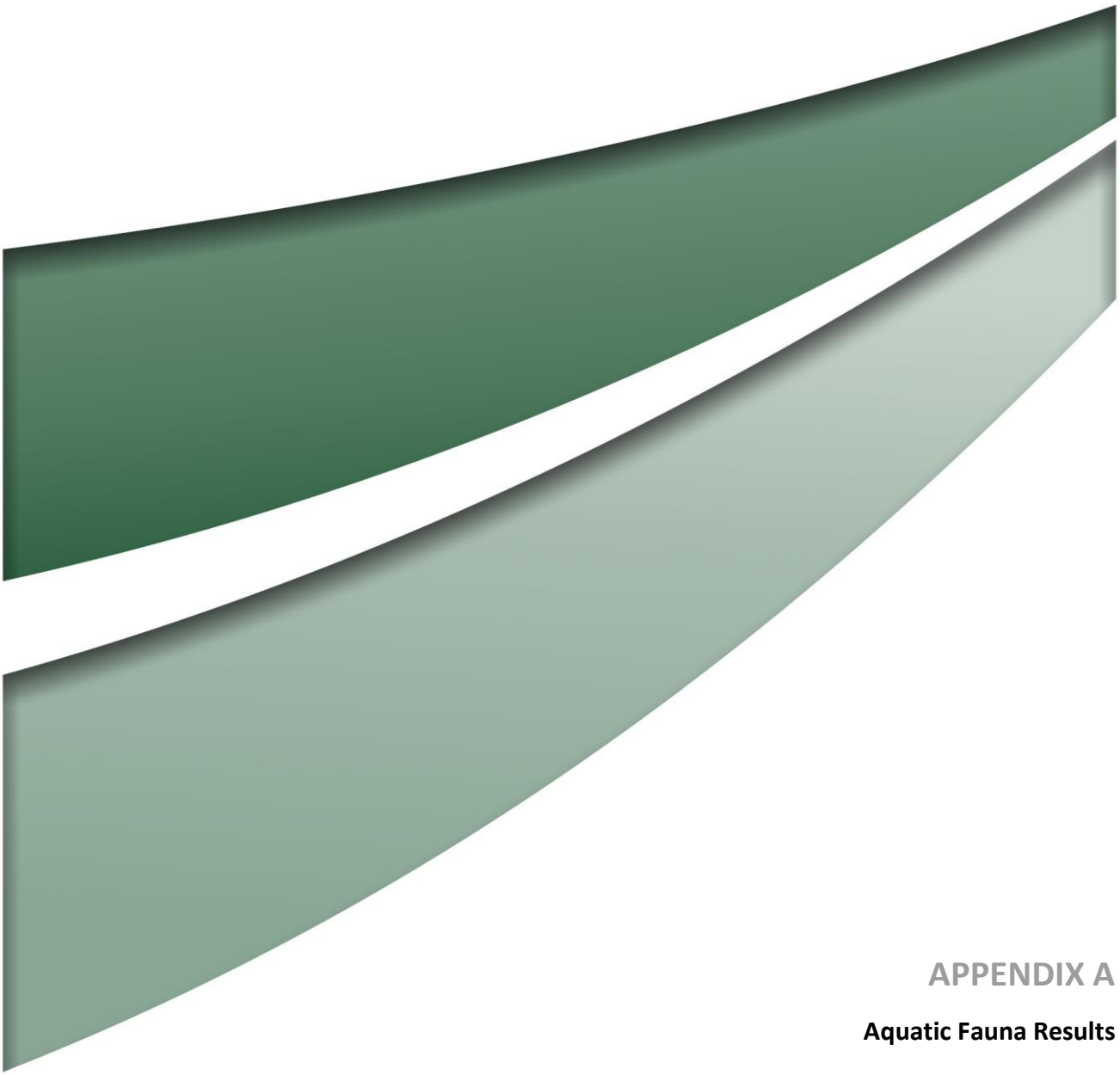
OEH BAM

Umwelt (2015) Greater Ravensworth Upper Hunter Strategic Assessment. Unpublished report prepared for Glencore Coal.

Umwelt (2019a) Glendell Continued Operations Project: Environmental Impact Statement. A report prepared for Glendell Tenements Pty Ltd (Glencore).

Umwelt (2019b) Glendell Continued Operations Project: Assessment of Commonwealth Matters Report. A report prepared for Glendell Tenements Pty Ltd (Glencore).

Umwelt (2019c) Glendell Continued Operations Project: Biodiversity Development Assessment Report. A report prepared for Glendell Tenements Pty Ltd (Glencore).



APPENDIX A

Aquatic Fauna Results

Table 1A outlines the aquatic fauna recorded in the Project Area.

Table 1A Aquatic Fauna Species Results

Common Name	Scientific Name	FM Act Status	Assessment Location		
			AH2	AH6	AH18
marbled eel	*Anguilla reinhardtii*	-		X	
eastern long-necked turtle	*Chelodina longicollis*	-		X	
common carp	*Cyprinus carpio*	-	X		
Macquarie turtle	*Emydura macquarii*	-	X	X	X
water skink	*Eulamprus quoyii*	-	X	X	X
mosquitofish	*Gambusia holbrooki*	-		X	X
cox's gudgeon	*Gobiomorphus coxii*	-		X	X
firetail gudgeon	*Hypseleostris galii*	-	X	X	X
western carp gudgeon	*Hypseleostris kluzingeri*	-			X
eastern water dragon	*Intellagama lesueurii*	-	X	X	X
sea mullet	*Mugil cephalus*	-	X	X	
glass shrimp	*Paratya australiensis*	-	X		
dwarf flathead gudgeon	*Philypnodon macrostomus*	-		X	X
Australian smelt	*Retropinna semoni*	-	X		X
eel tailed catfish	*Tandanus*	-		X	X

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