APPENDIX 10

Assessment of Commonwealth Matters Report

umwelt
Environmental & Social Consultants

GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

ASSESSMENT OF COMMONWEALTH MATTERS

FINAL

November 2019

GLENDELL CONTINUED OPERATIONS PROJECT

ASSESSMENT OF COMMONWEALTH MATTERS

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
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Report No.	4166/R16
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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
FINAL	Allison Riley	29 November 2019	David Holmes	29 November 2019

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1.0 Introduction

On 10 July 2019, the Department of the Environment and Energy (DoEE) confirmed the Glendell Continued Operations Project (the Project) is a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions under the EPBC Act for the proposed action are:

- listed threatened species and communities (sections 18 and 18A) and
- a water resource, in relation to coal seam gas development and large coal mining development (section 24D & section 24E).

Specifically, DoEE considered the Project is likely to have, or has the potential to have, a significant impact on:

- *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC)
- regent honeyeater (*Anthochaera phrygia*)
- swift parrot (*Lathamus discolor*)
- green and golden bell frog (*Litoria aurea*)
- spotted-tailed quoll (*Dasyurus maculatus maculatus*)
- koala (*Phascolarctos cinereus*)
- large-eared pied bat (*Chalinolobus dwyeri*)
- New Holland mouse (*Pseudomys novaehollandiae*)
- grey-headed flying fox (*Pteropus poliocephalus*)
- trailing woodruff (*Asperula asthenes*)
- water resources – the value of groundwater and surface water resources from changes to hydrological characteristics and water quality.

Under the bilateral agreement, the Secretary of the NSW Department of Planning, Industry and Environment's (DPIE) Environmental Assessment Requirements (SEARs) for the Project include the assessment requirements from DoEE. These are listed in **Table 1.1** including where the requirements have been addressed in this document.

This report provides a summary of the key MNES assessment findings in relation to the SEARs which outlines DoEE's assessment requirements and the requirements of the IESC. This report should be read in conjunction with the EIS and specifically the following specialist reports:

- The Biodiversity Development Assessment Report (BDAR) prepared by Umwelt (Umwelt 2019a) including the Aquatic Ecology Assessment (which forms Appendix F of the BDAR) refer to Appendix 20 and Section 7.6 of the EIS

- Groundwater Impact Assessment prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (AGE, 2019), refer to Appendix 16 and Section 7.5 of the EIS

- Surface Water Impact Assessment (including site water balance) prepared by GHD Pty Ltd (GHD, 2019), refer to Appendix 17 and Section 7.5 of the EIS

- Geochemical Assessment prepared by Environmental Geochemistry International Pty Ltd (EGI) (EGI, 2019), refer to Appendix 19 of the EIS

- Stygofauna Assessment prepared by Eco Logical Australia Pty Ltd (ELA) (ELA, 2019), refer to Appendix 21 of the EIS

It is noted that DoEE refers to the Project as the 'action'. For ease of response to the DoEE assessment requirements this section uses the terms 'action' and 'Project' interchangeably. Importantly, however the 'action' for the purposes of the EPBC Act specifically excludes components of the Project that form part of the existing and approved operations at the Mount Owen Complex (including any approved land disturbance activities within the Referral Area).

1.1 Project Overview

The existing 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**). In addition to the Glendell Mine, the Mount Owen Complex comprises mining operations at Mount Owen Mine (North Pit) and Ravensworth East Mine (Bayswater North Pit). The Mount Owen Complex also includes a coal handling and preparation plant (CHPP) and coal handling and transport infrastructure.

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

- an increase to the existing approved maximum rate of mining from 4.5 million tonnes per annum (Mtpa) up to approximately 10 Mtpa of coal. This increase coincides with a decrease in production rates at the other Mount Owen Complex pits to maintain the currently approved throughput at the CHPP

- disturbance of approximately 750 hectares (ha) of primarily cleared rural land outside of areas already approved for disturbance

- continued use of the existing Mount Owen Complex infrastructure for the life of the Project including hauling coal to the existing coal handling, processing and transportation facilities and the use of these facilities for up to a year following the completion of mining (i.e. to 2045) to finalise the processing of coal mined in the last year of operations

- 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, an ephemeral tributary of Bowmans Creek
- relocation of Ravensworth Homestead
- construction of a water management system that will be integrated with the existing Mount Owen Complex water management system and wider Greater Ravensworth Area Water and Tailings Scheme (GRAWTS)
- other ancillary infrastructure works such as the construction of a Heavy Vehicle Access Road
- a peak construction workforce of approximately 350 people and continued employment opportunities for the existing operational workforce at the Mount Owen Complex
- progressive rehabilitation of the site
- establishment of a final landform that utilises natural landform design principles and provides connectivity to established offsets and areas of existing vegetation. Mount Owen Complex has been recognised as having industry leading rehabilitation practice and this approach will continue to be used for the Project.

The Project is described in further detail in **Section 3.0** of the EIS and **Figures 1.1** and **Figure 1.2** illustrates the Project location and key features of the Project respectively.

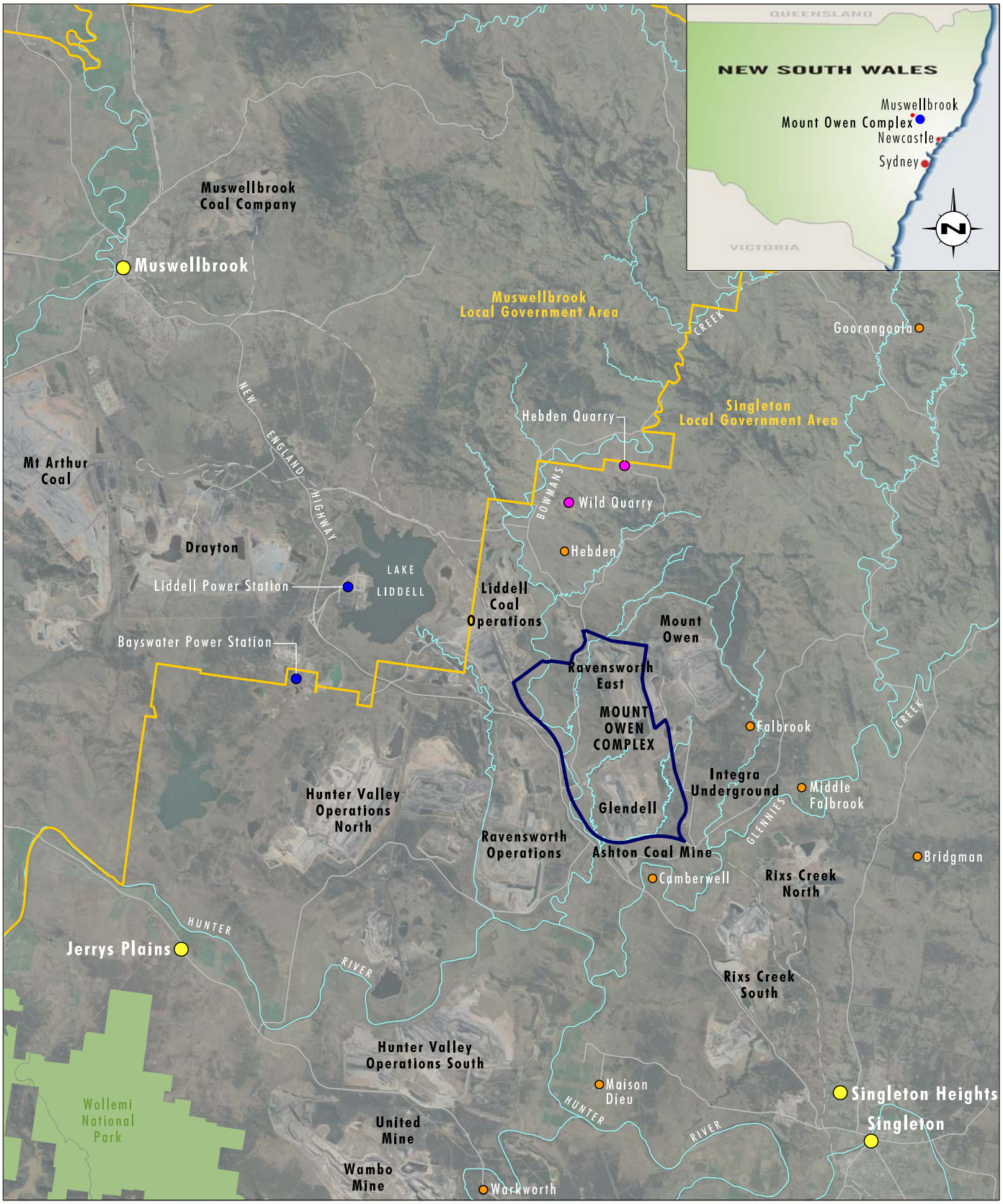

Image Source: Google Earth (2018)
Data Source: Glencore (2019), OEH (2018)

0 2.5 5.0 10km

Legend

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

FIGURE 1.1

Project Locality

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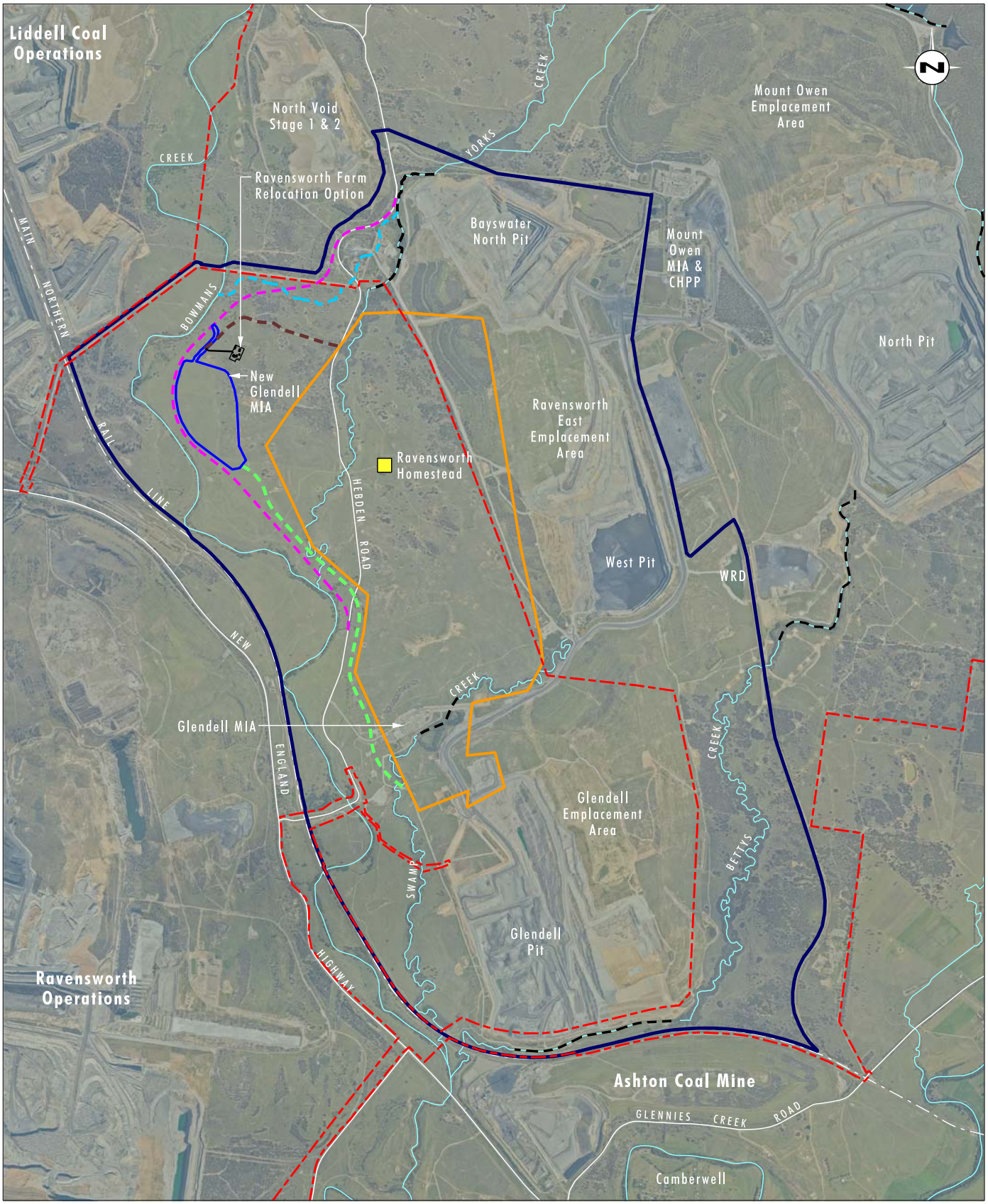

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)
Notes: Ravensworth Homestead to be relocated, Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

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

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

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20191128 16.27

1.2 Assessment Requirements

A checklist of DoEE and the IESC assessment requirements as outlined in the SEARs and where they have been addressed in the EIS documentation is outlined in **Table 1.1**. As previously discussed, the following summary should be read in conjunction with the EIS main text and specifically the following specialist reports:

- The BDAR including the Aquatic Ecology Assessment (which forms Appendix F of the BDAR) (refer to Appendix 20 and Section 7.6 of the EIS)
- Groundwater Impact Assessment (refer to Appendix 16 and Section 7.5 of the EIS)
- Surface Water Impact Assessment (including site water balance), (refer to Appendix 17 and Section 7.5 of the EIS)
- Geochemical Assessment (refer to Appendix 19 of the EIS)
- Stygofauna Assessment (refer to Appendix 21 of the EIS)

Under section 87 of the EPBC Act the action will be assessed under the State's accredited assessment process under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Attachment 4 of the SEARs provides information on environmental assessment requirements for the action.

Table 1.1 DoEE and IESC Requirements and where they have been addressed in this document

Requirement	Where Assessed
DoEE - Biodiversity (threatened species and communities and migratory species)	
Key significant impacts associated with proposed action on MNES are associated with the removal of native vegetation, particularly the Central Hunter Valley Eucalypt Forest and Woodland ecological community, and habitat for the Swift Parrot, Regent Honeyeater, Spotted-tailed Quoll, Koala, Grey-headed Flying-fox, New Holland Mouse, Large-eared Pied Bat and the Green and Golden Bell Frog. These impacts must be appropriately offset for EPBC Act purposes.	
For each of the EPBC Act controlling provisions impacted by the proposed action, the EIS must provide:	
1. Survey results, including details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Commonwealth guidelines and policy statements. For ecological communities, this includes any condition thresholds provided in the listing advice or approved conservation advice.	**Section 2.1, BDAR** and **Stygofauna Assessment**
2. A description and quantification of habitat in the study area (including suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advices, conservation advices and recovery plans, threat abatement plans.	**Section 2.2, BDAR** and **Stygofauna Assessment**
3. Maps displaying the above information (specific to EPBC matters) overlaid with the proposed action. It is acceptable, where possible, to use the mapping and assessment of Plant Community Types (PCTs) and the species surveys prescribed by the BAM as the basis for identifying EPBC Act-listed species and communities. The EIS must clearly identify which PCTs are considered to align with habitat for the relevant EPBC Act-listed species or community and provide individual maps for each species or community.	**Section 2.2** and **BDAR**

Requirement	Where Assessed
4. Description of the nature, geographic extent, magnitude, timing and duration of any likely direct, indirect and consequential impacts on any relevant EPBC Act-listed species and communities. It must clearly identify the location and quantify the extent of all impact areas to each relevant EPBC Act-listed species or community. 5. Information on proposed avoidance and mitigation measures to deal with the impacts of the action, and a description of the predicted effectiveness and outcomes that the avoidance and mitigation measures will achieve. 6. Quantification of the offset liability for each species and community significantly impacted, and information on the proposed offset strategy, including discussion of the conservation benefit for each species and community, how offsets will be secured, and the timing of protection. It is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action i.e. 'like-for-like'. Like-for-like includes protection of native vegetation that is the same ecological community or habitat being impacted (preferably in the same region where the impact occurs), or funding to provide a direct benefit to the matter being impacted e.g. threat abatement, breeding and propagation programs or other relevant conservation measures.	**Section 2.3** **Section 4.1** **Section 2.5**
Key significant impacts associated with groundwater (both alluvium associated with water courses and deeper hard rock aquifers) and surface water resources and quality, including: • Groundwater drawdown/depressurisation • Groundwater-surface water connectivity • Potential cumulative impacts and interaction with impacts from neighbouring projects • Potential long term impacts of mine void, including groundwater losses to evaporation	**Section 3.0**
IESC Requirements	
• Provide further information on the baseline conditions of both groundwater and surface water resources including water quality, flow regimes and hydrological connectivity.	**Section 3.0**
• After completion of the proposed field mapping of alluvial aquifers in the project area, provide estimation of groundwater drawdown and the likely effects on surface flows (especially low flows and ecologically important flow components) in associated creeks.	**Section 3.0**
• Update the groundwater model, including a sensitivity and uncertainty analysis and quantification of surface water-groundwater connectivity.	**Section 3.0**
• Flood modelling that incorporates infrastructure changes, the Yorks Creek diversion and the final landform to assess flood risks to mine pits and detention storages and changed floodplain behaviour.	**Section 3.3**
• A detailed site water balance that specifies uncertainties in inputs and performance under future climatic conditions.	**Appendix D1 and Appendix 17 of the EIS**
• A geochemistry study specific to the project area which assesses all waste rock material.	**Appendix D1 and Appendix 19 of the EIS**

Requirement	Where Assessed
• Further information on the salt balance of the site and salt sources and stores within the final landform, including salt derived from the alluvial aquifer.	**Appendix D1 and Appendix 17 of the EIS**
• Provide a general ecohydrological conceptual model showing potential impact-effect pathways on water-related ecological assets, including GDEs and aquatic biota. An additional ecohydrological model specifically addressing the proposed Yorks Creek diversion and its confluence with Bowmans Creek may be needed to further understand potential impacts from changes to flows, bank and bed stability and hyporheic conditions in Bowmans Creek.	**Section 3.4**
• Provide detail on the proposed diversion of Yorks Creek and how the diversion will be built and managed to preserve ecological functions (including those occurring in hyporheic and riparian corridors) currently supported by Yorks Creek.	**Appendix 7 and 18 of the EIS**
• Ecological studies to determine the baseline condition of the aquatic ecosystems including permanent and semi-permanent pools (e.g. surface water flora and fauna), riparian vegetation and alluvial sediments (e.g. stygofauna, hyporheos) in all creeks potentially affected by the project.	**Section 3.4 and Appendix 20 and 21 of the EIS**
• Explicit consideration and assessment of project-specific risks, and their materiality at different stages of the project, including during rehabilitation. This is required to inform the selection of appropriate mitigation options and development of management plans	**Appendix B1, Section 3.1 and Appendix 5 of the EIS**
• Assessment of potential cumulative impacts on groundwater and surface water quality, dynamics (e.g. flow regimes, groundwater flux) and biota (e.g. riparian vegetation, fish).	**Section 7.5 and Appendix 16 and 17 of the EIS**

2.0 MNES Biodiversity Assessment

2.1 Biodiversity Surveys for Listed Threatened Species and Communities

Extensive ecological surveys have been completed within the broader Mount Owen Complex land holding and specifically within the Project Area as part of previous assessments including the Greater Ravensworth Biodiversity Certification Assessment prepared as part of the Upper Hunter Strategic Assessment (UHSA) (Umwelt 2015) and, more recently, surveys as part of the proposed Project.

Surveys completed within the Project Area and immediate locality include bird and herpetological searches, terrestrial and arboreal Elliott trapping, cage trapping, pitfall trapping, hair tubes, harp traps, spotlighting, diurnal and nocturnal call playback, targeted threatened species searches, Anabat echolocation surveys, habitat assessment and opportunistic observation. Threatened species, vegetation communities and Threatened Ecological Communities (TECs) considered likely to occur within the local area were targeted as part of these surveys utilising meander transect surveys and semi-quantitative plot based survey in accordance with the NSW Biodiversity Assessment Method (BAM) and relevant NSW and Commonwealth survey guidelines.

Field surveys undertaken as part of this assessment are considered adequate to have identified the extent of MNES species or habitat occurring in the Project Area and were conducted in accordance or with consideration of the following survey guidelines, policy statements or recovery plans:

- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities –Working Draft (DEC 2004)
- NSW Guide to Surveying Threatened Plants (OEH 2016)
- Survey Guidelines for Australia's threatened bats (DEWHA 2010a)
- Survey Guidelines for Australia's threatened birds (DEWHA 2010b)
- Survey guidelines for Australia's threatened frogs (DEWHA 2010c)
- Survey guidelines for Australia's threatened mammals (DSEWPC 2011)
- Commonwealth Conservation Advice on Central Hunter Valley Eucalypt Forest and Woodland Critically Endangered Ecological Community (TSSC 2015)
- National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*) (Department of Environment (DoE) (2016))
- National Recovery Plan for the Swift Parrot *Lathamus discolor* (Saunders and Tzaros (2011)).

Consistent with the BAM, the assessment area has been limited to the Development Footprint which are those areas of the Project Area that are impacted by the Project but are outside existing approved disturbance areas or are identified as being Category 1 – exempt areas under the NSW *Local Land Services Act 2013* as per the BAM.

2.1.1 Central Hunter Valley Eucalypt Forest and Woodland CEEC

A total of 69 BAM plots and 3 rapid assessments were conducted within, and in proximity to, the Project Area during the surveys undertaken for this assessment. Of these, 27 plots and 2 rapid assessments were undertaken in areas that were determined to conform to the *Central Hunter Valley Eucalypt Forest and Woodland CEEC*.

These surveys were undertaken during four separate survey periods in order to accurately sample the vegetation communities and potentially occurring threatened flora species:

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

Table 2.1 outlines the plot survey effort within the CEEC located within the Development Footprint.

Table 2.1 Summary of Floristic Survey Effort in *Central Hunter Valley Eucalypt Forest and Woodland CEEC*

Plant Community Type (PCT) *Condition Class*	CEEC Area (ha)	Floristic Plots	Rapid Assessments
1603 Narrow-leaved Ironbark – Bull Oak - Grey Box shrub – grass open forest of the central and lower Hunter			
Moderate - Good	26.7	4	0
Regeneration	52.3	5	0
Plantation	1.8	1	1
Derived Native Grassland	14.4	7	0
1692 Bull Oak Grassy Woodland of the Central Hunter Valley			
Moderate - Good	17.7	3	0
Regeneration	9.7	3	0
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter			
Woodland Rehabilitation	0.3	4	1
TOTAL	**122.9**	**27**	**2**

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

- full-floristic quadrat assessment, rapid assessments and meandering survey to determine floristic composition and structure of each ecological community (refer to **Figure 2.1**)
- comparison with published species lists, including lists of indicative and contra-indicative species as identified on the conservation advice provided by the Commonwealth Threatened Species Scientific Committee

- comparison with habitat descriptions and distributions for listed TECs
- assessment using guidelines and recovery plans published by DoEE
- assessment against diagnostic and condition criteria, where relevant, and
- comparison with other assessments of TECs in the region.

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 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 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 (2017a), a 30-metre (m) 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 PCT 1692 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 per the key diagnostic characteristics and condition thresholds outlined in the Approved Conservation Advice (TSSC 2015) and the advice from OEH (2017a), areas of vegetation were excluded from the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* in the Development Footprint (refer to **Figure 2.1**) 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 m 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 (TSSC 2015) as further clarification on interpretation of the CEEC.

Derived native grasslands were included in the CEEC based on the 'gap and indent' rules that were provided by DoEE as further clarification on interpretation of the Conservation Advice for the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC (TSSC 2015). This interpretation has been applied rather than a rigid 30 m 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 m 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.

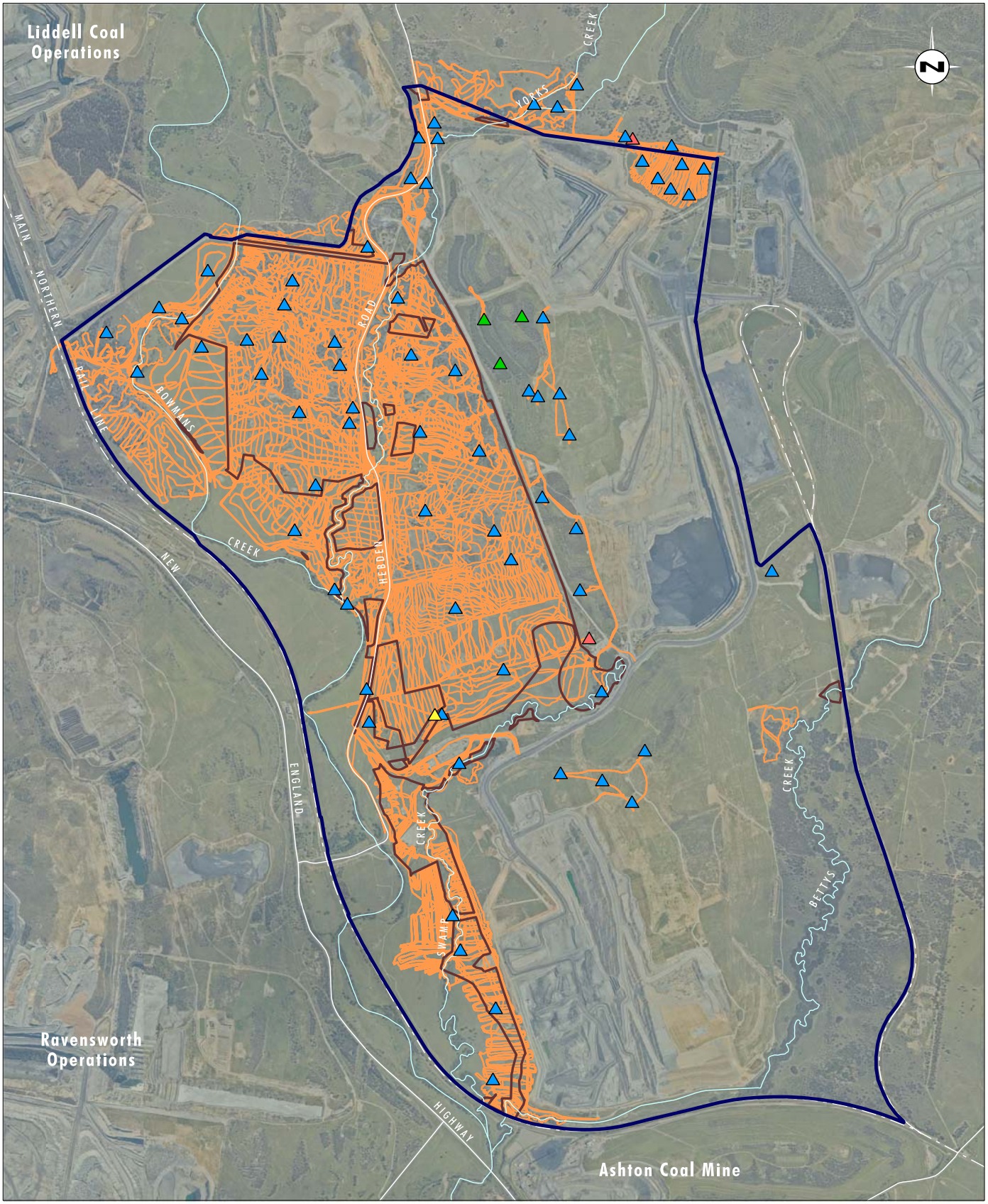

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

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 2.1

Project Specific Floristic and Vegetation Mapping Survey Effort

File Name (A4): R16/4166_544.dgn
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2.1.2 Regent Honeyeater (*Anthochaera phrygia*)

Diurnal call playback and bird searches targeting regent honeyeater were undertaken across the Project Area in 13 locations in June 2018 (refer to **Figure 2.2**) as is recommended in the Commonwealth *Survey Guidelines for Australia's threatened birds* (DEWHA 2010b). 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. 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 Project Area.

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 and 2017. Diurnal winter bird searches are undertaken as part of the monitoring in the Mount Owen Complex annually (refer to **Figure 2.3** and **Table 2.2**).

Table 2.2 Summary of Survey Effort for Regent Honeyeater

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	June 2018	Call playback and diurnal bird searches. Habitat assessments for potential foraging habitat.	13 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	July 2016 July 2017	Call playback and diurnal bird searches	14 person hours
Mount Owen Continued Operations Project	Mount Owen Complex	August 2011 June 2012 July 2014	Call playback and diurnal bird searches	42 person hours
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	July-August annually	Diurnal bird searches	Approx. 12 person hours annually

2.1.3 Swift Parrot (*Lathamus discolor*)

Diurnal call playback and bird searches targeting swift parrot were undertaken across the Project Area in 13 locations in June 2018 (refer to **Figure 2.2**) as is recommended in the Commonwealth *Survey Guidelines for Australia's threatened birds* (DEWHA 2010b). 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. Furthermore, habitat assessments to determine the extent of potential resource trees as per the approved *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros 2011) were also undertaken across the vegetation communities of the Project Area.

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 and 2017. Diurnal winter bird searches are undertaken as part of the monitoring in the Mount Owen Complex annually (refer to **Table 2.3**).

Table 2.3 Summary of Survey Effort for Swift Parrot

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	June 2018	Call playback and diurnal bird searches Habitat assessments for potential foraging habitat.	13 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	July 2016 July 2017	Call playback and diurnal bird searches	14 person hours
Mount Owen Continued Operations Project	Mount Owen Complex	August 2011 June 2012 July 2014	Call playback and diurnal bird searches	42 person hours
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	July-August annually	Diurnal bird searches	Approx. 12 person hours annually

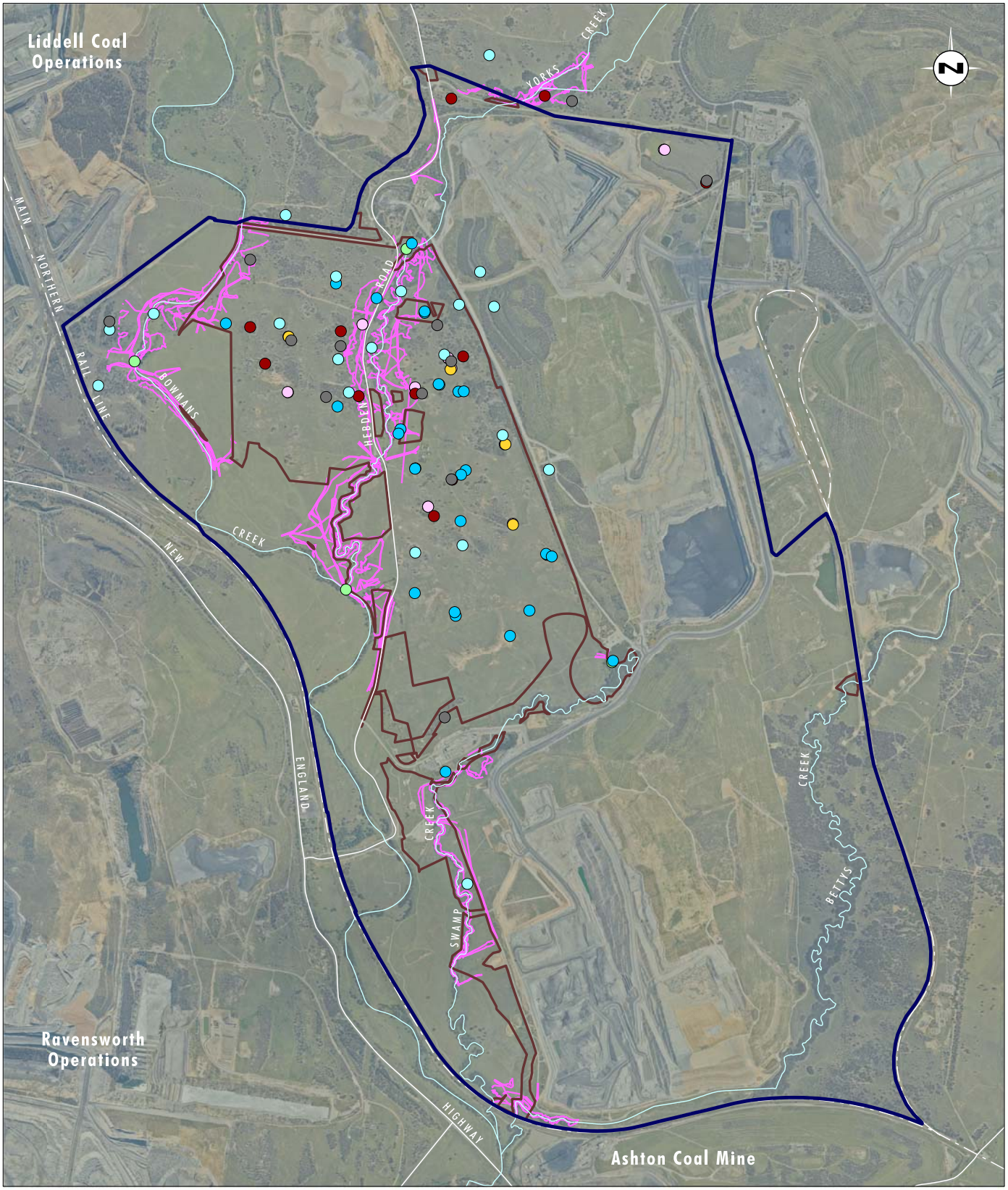

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Targeted Southern Myotis Breeding Habitat Inspections
- Anabat Survey for Large-eared Pied Bat
- Call Playback for Threatened Nocturnal Birds and Mammals
- Green and Golden Bell Frog Survey Locations
- Koala Call Playback
- Koala SAT Survey
- Remote Camera for Spotted-tailed Quoll and New Holland Mouse
- Swift Parrot and Regent Honeyeater Survey Locations

FIGURE 2.2

Project Specific Threatened Species Survey Effort

File Name (A4): R16/4166_545.dgn
20191113 12.57

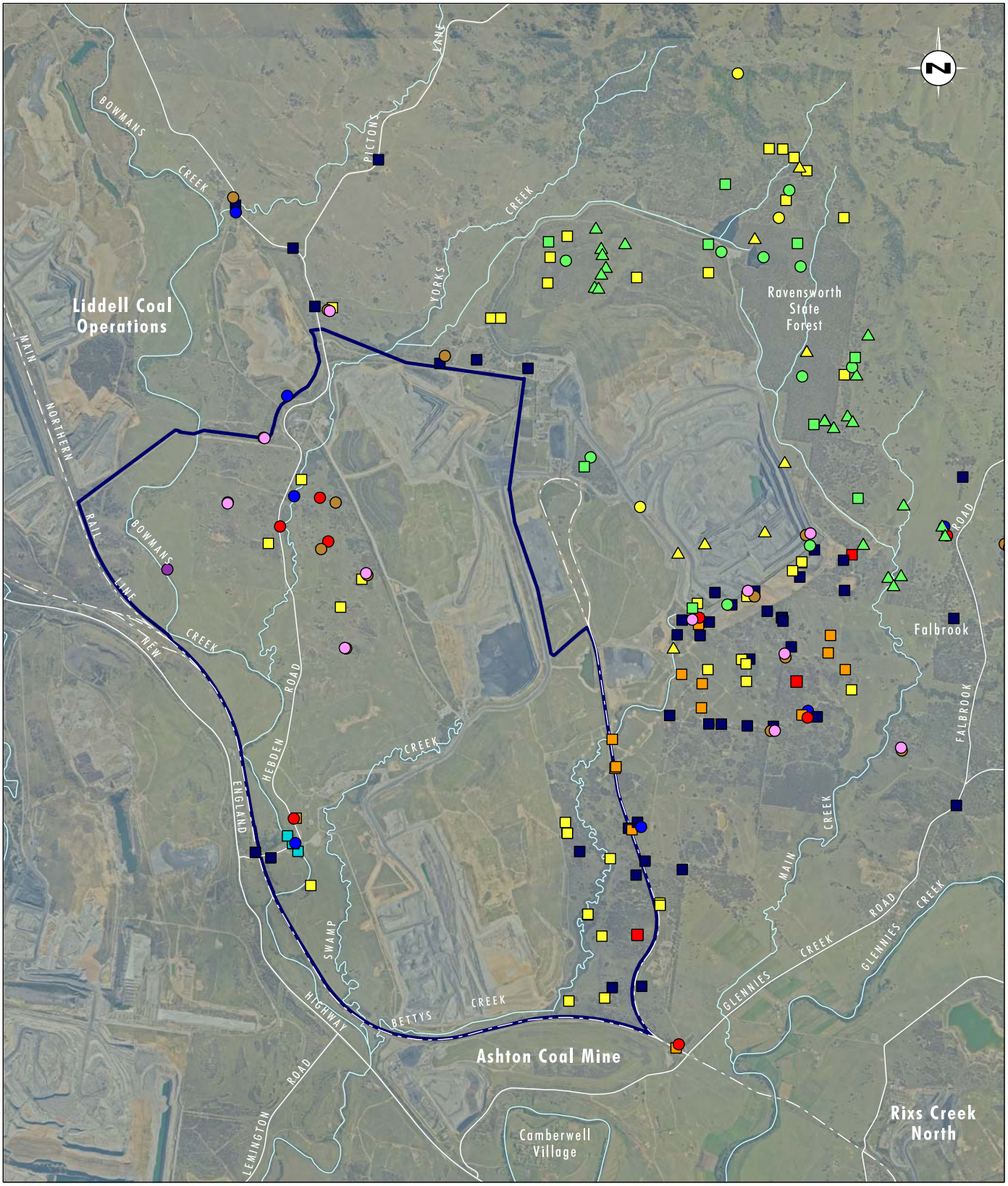

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2014-2019)

0 1 2 3 km

Legend

- Project Area

Targeted Fauna Survey:
- Green and Golden Bell Frog Survey
- Habitat and Condition Assessment
- Aquatic Survey Site
- Diurnal Bird Survey
- Swift Parrot and Regent Honeyeater Survey

Previous Monitoring Locations:
- Targeted Frog Survey Location
- Targeted Microbat Survey Location

Current Monitoring Locations:
- Targeted Frog Survey Location
- Targeted Microbat Survey Location
- General Fauna Survey Location

UHSA Targeted Fauna Survey:
- Green and Golden Bell Frog Survey
- Koala SAT Survey
- Micro-bat Echolocation Recording
- Red Goshawk Black-breasted Buzzard Survey
- Remote Camera Survey

General Fauna Survey Site:
- Terrestrial and Arboreal Elliot Trapping
- Terrestrial Cage Trapping
- Harp Trapping
- Terrestrial and Arboreal Hair Funnel
- Diurnal Bird Survey
- Diurnal Herpetological Survey
- Spotlight Survey
- Nocturnal Call Playback Survey
- Micro-bat Echolocation Recording

FIGURE 2.3

Previous Threatened Species Survey Effort in the Project Area and Locality

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2.1.4 Spotted-tailed Quoll (*Dasyurus maculatus maculatus*)

The spotted-tailed quoll was surveyed by installing 20 remote cameras from 26 October 2017 to 9 March 2018 (135 nights, equating to 2700 camera nights) which is noted as a suitable survey technique in the Commonwealth *Survey guidelines for Australia's threatened mammals* (DSEWPC 2011). Bushnell Trophy Cam HDs (remote cameras) were mounted approximately 1 m above the ground on a tree trunk and positioned facing a bait station containing tuna, honey and peanut butter. The bait station was used to increase the likelihood of detecting the spotted-tailed quoll. The cameras were programmed to take three photos in quick succession when movement was detected. The remote cameras were programmed to record movement on an ongoing basis until removed from the site. The locations of the remote cameras are shown in **Figure 2.2**.

Remote camera surveys were also undertaken in the wider locality as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and the Mount Owen Continued Operations Modification 2 in 2016 and 2017. Elliot trapping was undertaken for the Mount Owen Continued Operations Project in February 2012. Elliot trapping and spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex (refer to **Table 2.4**).

Table 2.4 Summary of Survey Effort for Spotted-tailed Quoll

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	October 2017 – March 2018	Remote cameras	2,700 camera nights
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	February - March 2017 July 2017 - October 2017	Remote cameras	971 camera nights
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March - April 2014	Remote cameras	430 camera nights
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012	Cage trapping	48 trap nights
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	July-December annually	Remote cameras	Approx. 140 camera nights annually.

2.1.5 Green and Golden Bell Frog (*Litoria aurea*)

Call playback and spotlighting surveys targeted green and golden bell frog were undertaken across the Project Area in 22 locations in March 2017, and 19 locations in March 2018 (refer to **Figure 2.2**) as is recommended by the Commonwealth *Survey guidelines for Australia's threatened frogs* (DEWHA 2010c). 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). 32.6 mm of rainfall was recorded during the first night of survey in 2018 (5 March) with 4.2 mm and 0.4 mm recorded the following two evenings. Relative humidity during the 2018 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 Project Area.

Aquatic habitat assessments were also undertaken in March 2018, October 2018 and November 2018 to identify potential habitat available for the species across the Project Area. AUSRIVAS Physical Assessment Protocol was used to score habitat parameters at streams and waterbodies within the Project Area.

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, in March 2014 as part of the Greater Ravensworth Upper Hunter Strategic Assessment and in 2017 as part of the Mount Owen Continued Operations Modification 2. Call playback surveys and targeted waterbody searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex (refer to **Figure 2.3** and **Table 2.5**).

Table 2.5 Summary of Survey Effort for Green and Golden Bell Frog

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	March 2017 March 2018 October 2018 November 2018	Call playback and spotlighting. Aquatic habitat assessments.	27 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	February 2017 March 2017 April 2017 October 2017	Call playback and spotlighting. Diurnal habitat searches.	15 person hours
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March 2014	Call playback and spotlighting.	8 person hours
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012 January 2013 February 2013	Call playback and spotlighting.	56 person hours

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	Variable	Call playback and spotlighting. Habitat monitoring.	Approx. 62 person hours annually.

2.1.6 Koala (*Phascolarctos cinereus*)

Searches for signs of the presence of koalas were undertaken at 11 locations across the Project Area in February and June 2018 using the Spot Assessment Technique (SAT) (refer to **Figure 2.2**). 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 Project Area.

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 2.2**). 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 Project Area.

Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.2**) within the Project Area 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, however, that remote camera surveys can only be an opportunistic method for detecting koala in the landscape.

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 Ravensworth Upper Hunter Strategic Assessment and in 2017 as part of the Mount Owen Continued Operations Modification 2. Spotlighting searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex (refer to **Figure 2.3** and **Table 2.6**).

Table 2.6 Summary of Survey Effort for Koala

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	March 2018 June 2018	SAT survey Spotlighting	330 trees inspected 22 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	July 2017 October 2017	SAT survey Spotlighting	270 trees inspected 7 person hours

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March 2014	SAT survey Spotlighting	600 trees inspected 8 person hours
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012	Spotlighting Call playback	8 person hours
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	Variable	Spotlighting	9 person hours

2.1.7 Large-eared Pied Bat (*Chalinolobus dwyeri*)

The presence of threatened micro-bat species was surveyed using Titley Scientific Anabat Express recorders at four locations within the Project Area from 5 March to 9 March 2018 (refer to **Figure 2.2**) as recommended by the Commonwealth *Survey Guidelines for Australia's threatened bats* (DEWHA 2010a). 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 Project Area.

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 for potential rocky areas containing caves, overhangs, escarpments, outcrops and crevices and old mines or tunnels that could provide roosting habitat for the species were undertaken throughout Umwelt's survey periods, however none were identified.

Anabat echolocation surveys were also undertaken in the wider locality for the Mount Owen Continued Operations Project in 2012, as part of the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014, and as part of the Mount Owen Continued Operations Modification 2 in 2017. Surveys are also undertaken annually as part of the monitoring surveys of the Mount Owen Complex (refer to **Figure 2.3** and **Table 2.7**).

Table 2.7 Summary of Survey Effort for Large-eared Pied Bat

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	March 2018	Echolocation surveys Targeted searches for breeding habitat.	20 recording nights
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	March 2017 October 2017	Echolocation surveys	22 recording nights
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March 2014 April 2014	Echolocation surveys	25 recording nights
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012 March 2014	Echolocation surveys Harp trapping	8 recording nights 16 trap nights
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	Variable	Echolocation surveys Harp trapping	Approx. 10 recording nights annually Approx. 18 trap nights annually

2.1.8 New Holland Mouse (*Pseudomys novaehollandiae*)

General habitat assessments were undertaken to refine potential habitat mapping for this species in February 2018. Habitat requirements for this species includes open heathland, open woodland with a heathland understorey and is usually found to peak in abundance during the early to mid-stages of vegetation succession, three to five years after fire or other disturbances.

Bushnell Trophy Cam HD cameras were installed at 20 locations (refer to **Figure 2.2**) within and surrounding the Project Area from 26 October 2017 to 9 March 2018 (2700 camera nights). At each site, a remote camera was mounted approximately 1 m 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.

Extensive survey efforts have been undertaken in previous years and seasons for this species in the wider Mount Owen Complex including remote cameras, Elliot trapping, hair funnels and pitfall trapping (refer to **Figure 2.3** and **Table 2.8**). Surveys are also undertaken annually as part of the monitoring surveys of the Mount Owen Complex.

Table 2.8 Summary of Survey Effort for New Holland Mouse

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	October 2017 – March 2018 February 2018	Remote camera traps Habitat assessments	2,700 camera nights 17 habitat assessment locations
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	February - March 2017 July 2017 - October 2017	Remote cameras	971 camera nights
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March – April 2014	Remote cameras	430 camera nights
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012	Elliot A traps Terrestrial hair funnels	200 Elliot A trap nights 1,000 funnel trap nights
Mount Owen Annual Fauna Monitoring	Mount Owen Complex, Ravensworth State Forest and surrounds	Variable	Elliot traps Pitfall traps	Approx. 1,470 Elliot trap nights annually Approx. 663 pitfall trap nights annually

2.1.9 Grey-headed Flying-fox (*Pteropus poliocephalus*)

Nocturnal spotlighting searches were undertaken in March 2018 over 2 nights and June 2018 over 4 nights in suitable habitat areas (refer to **Figure 2.2**). 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 Project Area.

Opportunistic observations for breeding camps and evidence of potential use of the Project Area 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 2018 (refer to **Figure 2.1**).

Spotlighting surveys were also undertaken in the wider locality as part of the Mount Owen Continued Operations Project in 2012, the Greater Ravensworth Upper Hunter Strategic Assessment in March 2014 and as part of the Mount Owen Continued Operations Modification 2 in 2017. Diurnal and nocturnal searches are undertaken annually as part of the monitoring surveys of the Mount Owen Complex (refer to **Figure 2.3** and **Table 2.9**).

Table 2.9 Summary of Survey Effort for Grey-headed Flying-fox

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	March 2018 June 2018	Spotlighting	22 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	July 2017 October 2017	Spotlighting	7 person hours
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March 2014	Spotlighting	8 person hours
Mount Owen Continued Operations Project	Mount Owen Complex	February 2012	Spotlighting	8 person hours
Mount Owen Annual Fauna Monitoring	Ravensworth State Forest and surrounds	Variable	Spotlighting	Approx. 9 person hours annually

2.1.10 Trailing Woodruff (*Asperula asthenes*)

Targeted threatened flora walking transects were undertaken in suitable habitat areas within the Project Area 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 Greater Ravensworth Upper Hunter Strategic Assessment in March and April 2014 and as part of the Mount Owen Continued Operations Modification 2 in 2016 2017 (refer to **Figure 2.3** and **Table 2.10**).

Table 2.10 Summary of Survey Effort for Trailing Woodruff

Project Name	Location in Relation to Project Area	Dates	Methods	Effort
Glendell Continued Operations Project	Project Area	October 2017 September 2018 October 2018	Walking transects in suitable habitat	190 person hours
Other Relevant Surveys in the Locality				
Mount Owen Continued Operations Modification 2	Mount Owen Complex	September 2016 October 2017	Walking transects in suitable habitat	72 person hours
Greater Ravensworth UHSA	Project Area and Greater Ravensworth Area	March 2014 April 2014	Walking transects in suitable habitat	Approx. 300 person hours

2.2 Description and Quantification of Habitat for Impacted MNES

Table 2.11 below provides a summary of the extent of direct impact for each potentially impacted MNES in the DoEE controlled action decision. Further detail and description of the impacted habitat is provided in the sections below.

Table 2.11 Summary of Impact Areas for MNES

MNES	Habitat Type	Impacted area (ha)
Known Habitat (MNES recorded on site)		
Central Hunter Valley Eucalypt Forest and Woodland CEEC	Woodland and forest	122.9
spotted-tailed quoll	Foraging and movement	154.5
Potential Habitat (MNES not recorded on site)		
regent honeyeater	Foraging	81.3
swift parrot	Foraging	81.3
green and golden bell frog	Dams with fringing vegetation	2.0
koala	Foraging	83.9
large-eared pied bat	Foraging	154.5
New Holland mouse	Young mine rehabilitation	4.1
grey-headed flying-fox	Foraging	154.5
Asperula asthenes	N/A	0

2.2.1 Central Hunter Valley Eucalypt Forest and Woodland CEEC

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.

The controlled action decision (DoEE 2019) (refer to Appendix 4 of the EIS) states that the Project is likely to have a significant impact on the CEEC due to the loss of 166 ha of the community, however following impact boundary reductions, the area of direct impact is estimated to be approximately 123 ha (refer to **Figure 2.4**). Components of the PCTs outlined in **Table 2.12** conform to the CEEC.

Table 2.12 ***Central Hunter Valley Eucalypt Forest and Woodland CEEC*** **in the Development Footprint**

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC.	26.7
Regeneration		52.3
Plantation		1.8
Derived Native Grassland	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC where the 'gap and indent' rule was applied	14.4
1692 Bull Oak Grassy Woodland of the Central Hunter Valley		
Moderate	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC where the patch size was greater than 0.5 ha and contained the required number of diagnostic eucalypt canopy species.	17.7
Regeneration		9.7
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC where dominant species were native and characteristic of the CEEC.	0.3
	TOTAL	**122.9**

Plate 2.1 ***Central Hunter Valley Eucalypt Forest and Woodland*** **CEEC in the Project Area**

The majority of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in the Development Footprint was represented by the PCT 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 PCT 1692 – Bull Oak Grassy Woodland 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 (2017a).

The Conservation Advice for the CEEC identifies habitat critical to its survival as areas that meet the minimum (moderate quality condition class) condition thresholds or are within the buffer zone. Therefore, all areas of the CEEC which meet the minimum condition criteria outlined in the Conservation Advice are critical to the survival of this ecological community.

The estimated total current national extent of the CEEC is estimated to be approximately 37,000 ha (TSSC 2015). The permanent loss of approximately 123 ha as a result of the Proposed Action represents a minor reduction in the estimated current extent of the community across its national range, estimated to be approximately 0.3% of the current predicted extent of the community in NSW.

Umwelt and the DoEE has assessed the Project as having a likely significant impact on the CEEC.

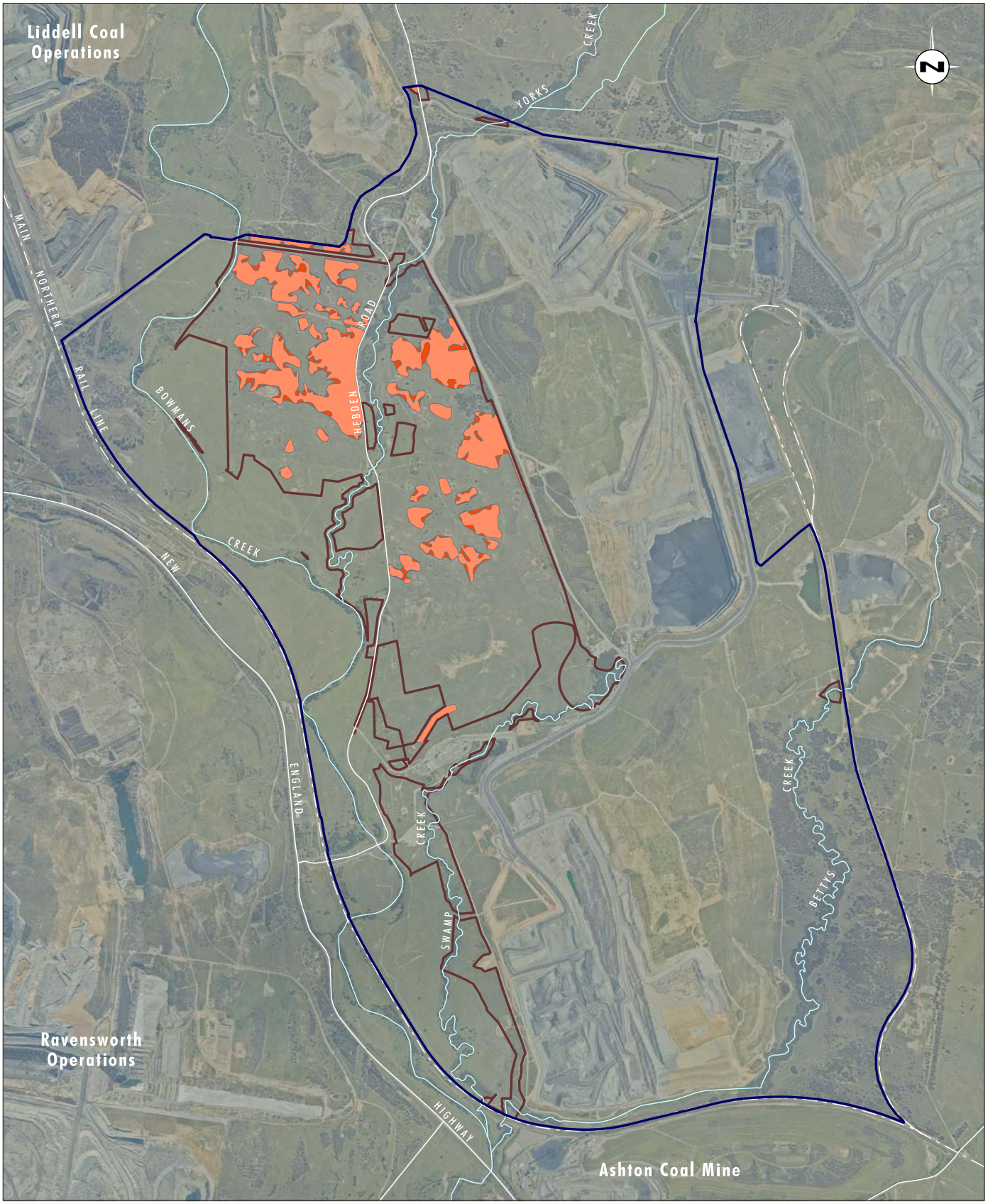

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

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

FIGURE 2.4

Central Hunter Valley Eucalypt Forest and Woodland CEEC in the Development Footprint

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2.2.2 Regent Honeyeater (*Anthochaera phrygia*)

The regent honeyeater is listed as critically endangered under the EPBC Act and has a patchy distribution extending from south-east Queensland, into NSW and the Australian Capital Territory, to central Victoria (CoA 2016). The species is highly mobile, capable of travelling large distances and occurs only irregularly at most sites in varying numbers. Adding further difficulty to the survey and study of this species is its ability to often go long periods without being observed anywhere (CoA 2016).

The regent honeyeater is endemic to mainland south-eastern Australia and mostly inhabits inland slopes of the Great Dividing Range (TSSC 2015). The regent honeyeater comprises a single population, with some exchange of individuals between regularly used areas (CoA 2016). As at 2010, the total population size is estimated at 350–400 mature individuals (CoA 2016).

As the species occurs as a single population in Australia, any record of the species would constitute part of a population as described above. The population of regent honeyeater has not been recorded within the Project Area. The closest record of this species is approximately 16 km south-west of the Project Area near Warkworth (OEH 2019). No regent honeyeater individuals were identified utilising the Project Area during the winter bird surveys conducted in June 2018 and the species has not been previously recorded in the Project Area or the locality, despite extensive survey.

The National Recovery Plan for the regent honeyeater identifies the following canopy species as key tree and mistletoe species across the species range:

- Mugga (or Red) Ironbark (*Eucalyptus sideroxylon*)
- Yellow Box (*E. melliodora*)
- White Box (*E. albens*)
- Yellow Gum (*E. leucoxylon*)
- Spotted Gum (*Corymbia maculata*)
- Swamp Mahogany (*E. robusta*)
- Needle-leaf Mistletoe (*Amyema cambagei*) on River Sheoak (*Casuarina cunninghamiana*)
- Box Mistletoe (*A. miquelii*)
- Long-flower Mistletoe (*Dendropthoe vitelline*).

Other tree species may be regionally important. For example, the Lower Hunter Spotted Gum forests have recently been demonstrated to support regular breeding events of regent honeyeaters. Flowering of associated species such as thin-leaved stringybark (*Eucalyptus eugenioides*) and other stringybark species, and broad-leaved ironbark (*Eucalyptus fibrosa*) can also contribute important nectar flows at times. The recovery plan also identifies that 'mature, large individual trees tend to be more important as they are more productive, particularly on highly fertile sites and in riparian areas'.

The regent honeyeater mainly breeds in three key sites in NSW being the Bundarra-Barraba area, the Capertee Valley, and the Lower Hunter Valley (DoE 2016 and OEH 2019). Other breeding areas are known in the Pilliga woodlands and the Mudgee-Wollar areas of NSW. The regent honeyeater has not been recorded in the Project Area and it is unlikely to contain breeding or nesting habitat for the species.

The controlled action decision (DoEE 2019) states that the Project is likely to have a significant impact on the regent honeyeater due to the loss of approximately 166 ha of potential foraging habitat for the species, however following detailed habitat assessments and impact boundary reductions, the area of potential habitat is estimated to be approximately 81 ha. This includes approximately 2 ha of vegetation containing key foraging species being spotted gum (*Corymbia maculata*) as per the National Recovery Plan for the species (DoE 2016) (refer to **Figure 2.5** and **Table 2.13**). The majority of the spotted gum in the Development Footprint has been planted and represents regrowth vegetation of between 10 and 30 years.

Furthermore, the Policy Statement for the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC (DoEE 2016) notes that this community may be a valuable source of winter-flowering eucalypts for transient species such as the regent honeyeater. This community covers approximately 123 ha of the Development Footprint; however, a large portion of this vegetation consists of derived native grasslands or a very low cover of eucalypt species within bulloak woodlands. Based on an analysis of the occurrence of winter-flowering eucalypts in the CEEC in the Development Footprint, approximately 81 ha of the CEEC is considered to provide potential foraging habitat for the species (Note: some of these areas also contain key feed trees - refer to **Table 2.13**).

Table 2.13 Potential Habitat for the Regent Honeyeater in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover[1] ranges from 10-25% (avg. 18%).	26.7
Regeneration	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover[1] ranges from 6-20% (avg. 15%).	52.3
Plantation	Contains key feed tree spotted gum (*Corymbia maculata*). Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover[1] is approximately 16%.	1.8
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Contains key feed tree spotted gum (*Corymbia maculata*) (refer to **Plate 3.2**).	0.2
	Contains key feed tree spotted gum (*Corymbia maculata*). Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover[1] ranges from 20-35% (avg. 29%).	0.3
	TOTAL	**81.3**

1. Eucalypt cover ranges and averages are derived from floristic plots undertaken in accordance with the BAM (OEH 2017b).

Plate 2.2 Woodland rehabilitation containing suitable feed trees for regent honeyeater in the Project Area

Areas of PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley that conform to the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in the Development Footprint were found to have extremely low cover scores for eucalypt species (narrow-leaved ironbark (*Eucalyptus crebra*) being the only eucalypt species occurring in this zone). Cover for narrow-leaved ironbark ranged from 0-1%, with an average of 0.3% across the floristic plots undertaken in this PCT. As such, this PCT has been excluded from the estimated areas of potential foraging habitat impacts for the regent honeyeater.

Based on fieldwork that considered the extent of habitat within the Development Footprint in accordance with the National Recovery Plan and the regional ecology of the species within the Hunter Valley, approximately 81 ha of habitat containing key foraging resources for the species and/or *Central Hunter Valley Eucalypt Forest and Woodland* CEEC containing suitable eucalypt resources was identified in the Development Footprint as potential habitat for the species. The habitat within the Development Footprint is substantially degraded as a result of previous clearing, with key foraging eucalypt species (as per the National Recovery Plan) only recorded in approximately 2 ha of plantation and rehabilitation.

The regent honeyeater has not been recorded within the Project Area and potential habitat for the species is considered to be low quality, however the DoEE determined a significant impact is likely for this species in its controlled action decision. Umwelt's assessment considers a significant impact unlikely based on the fragmentated and limited mature foraging resources in the Project Area.

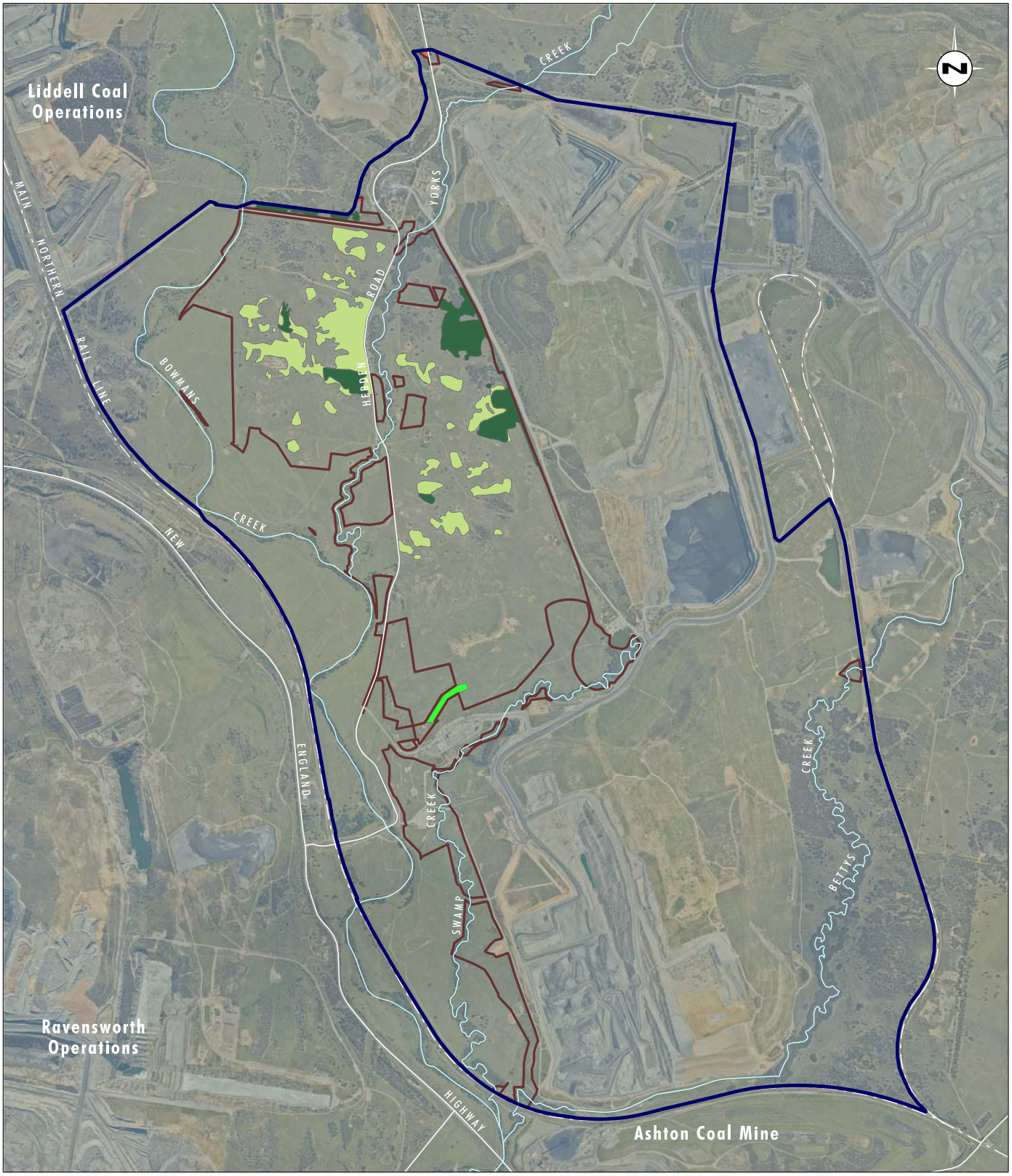


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)

Potential Regent Honeyeater Foraging Habitat:

- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation

FIGURE 2.5

Potential Regent Honeyeater Foraging Habitat in the Development Footprint

2.2.3 Swift Parrot (*Lathamus discolor*)

The swift parrot is listed as critically endangered under the EPBC Act. The species breeds in Tasmania and moves to mainland Australia for the non-breeding season (usually arriving between February and March) (Saunders and Tzaros 2011). Most of the population winters in Victoria and NSW where it disperses across broad landscapes foraging on nectar and lerps in eucalypts. Until recently it was believed that in NSW, swift parrots forage mostly in the coastal and western slopes region along the inland slopes of the Great Dividing Range but are patchily distributed along the north and south coasts including the Sydney region (Saunders and Tzaros 2011). However, evidence is gathering that the forests on the coastal plains from southern to northern NSW are also important. They return to Tasmania in spring (September-October). The movements of this species on the mainland are poorly understood, but it is considered to be nomadic and irruptive, moving in response to food supply.

The swift parrot occurs as a single population that migrates annually from breeding grounds in Tasmania to the winter foraging grounds on the coastal plains and slope woodlands of mainland eastern Australia (Saunders and Tzaros 2011). Approximately 200 mature birds (10% of the total estimated population) are known to over-winter in the Lower Hunter Region of NSW (Roderick *et al.* 2013).

As the species occurs as a single population in Australia, any record of the species would constitute a part of a *population* as described above. The swift parrot has been recorded on three occasions within the Ravensworth State Forest and the Mount Owen Complex Southeast Offset Area during annual monitoring surveys located approximately 2.4 km north-east and 3 km east respectively of the Project Area. The species was recorded in July 2005 and September 2007 within the northern section of Ravensworth State Forest and in Southeast Offset Area in June 2014 (Forest Fauna Surveys 2019). No swift parrots were identified utilising the Project Area during the winter bird surveys conducted in June 2018.

This species has the potential to make use of the woodland habitats of the Project Area, particularly where there are prolific flowering eucalypts and this migratory species is likely to move throughout the area in response to mass flowering events. This species does not breed on mainland Australia, and as such the Project Area only represents potential foraging habitat for this species.

The controlled action decision (DoEE 2019) states that the Project is likely to have a significant impact on the swift parrot due to the loss of 166 ha of potential foraging habitat for the species, however following detailed habitat assessments and impact boundary reductions, the area of potential habitat is estimated to be approximately 81 ha. This includes approximately 55 ha of vegetation containing key foraging species being spotted gum (*Corymbia maculata*) and forest red gum (*Eucalyptus tereticornis*) as per the National Recovery Plan for the species (Saunders and Tzaros 2011) (refer to **Figure 2.6** and **Table 2.14**). The majority of the spotted gum and forest red gum in the Development Footprint has been planted and represents regrowth vegetation of between 10 and 30 years.

Furthermore, the Policy Statement for the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC (DoEE 2016) notes that this community may be a valuable source of winter-flowering eucalypts for transient species such as the swift parrot. This community covers approximately 123 ha of the Development Footprint; however, a large portion of this vegetation consists of derived native grasslands or a low cover of eucalypt species. Based on an analysis of the occurrence of winter-flowering eucalypts in the CEEC in the Development Footprint, approximately 81 ha of the CEEC is considered to provide potential foraging habitat for the species (refer to **Figure 2.6** and **Table 2.14**).

Table 2.14 Potential Habitat for the Swift Parrot in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub – grass open forest of the Central and Lower Hunter		
Moderate to Good	Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover ranges from 10-25% (avg. 18%).	26.7
Regeneration	Contains key feed tree forest red gum (*Eucalyptus tereticornis*). Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover ranges from 6-20% (avg. 15%).	52.3
Plantation	Contains key feed tree spotted gum (*Corymbia maculata*) and forest red gum (*Eucalyptus tereticornis*) (refer to **Plate 3.3**). Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover is approximately 16%.	1.8
1604 – Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the Central and Lower Hunter		
Woodland Rehabilitation	Contains key feed tree spotted gum (*Corymbia maculata*).	0.2
	Contains key feed tree spotted gum (*Corymbia maculata*). Conforms to *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. Eucalypt cover ranges from 20-35% (avg. 29%).	0.3
	TOTAL	**81.3**

1. Eucalypt cover ranges and averages are derived from floristic plots undertaken in accordance with the BAM (OEH 2017b).

Plate 2.3 Plantation forest containing suitable feed trees for swift parrot

Areas of PCT 1692 Bull Oak Grassy Woodland of the Central Hunter Valley that conform to the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC in the Development Footprint were found to have extremely low cover scores for eucalypt species (narrow-leaved ironbark (*Eucalyptus crebra*) being the only eucalypt species occurring in this zone). Cover for narrow-leaved ironbark ranged from 0-1%, with an average of 0.3% across the floristic plots undertaken in this PCT. As such, this PCT has been excluded from the estimated areas of potential foraging habitat impacts for the swift parrot.

Based on fieldwork that considered the extent of habitat within the Development Footprint in accordance with the National Recovery Plan and the regional ecology of the species within the Hunter Valley, approximately 81 ha of habitat containing key foraging resources for the species and/or *Central Hunter Valley Eucalypt Forest and Woodland* CEEC containing suitable eucalypt resources was identified in the Development Footprint as potential habitat for the species. The habitat within the Development Footprint is substantially degraded as a result of previous clearing, with key foraging eucalypt species recorded in approximately 55 ha of regeneration, plantation and rehabilitation.

The swift parrot has not been recorded within the Project Area and known habitat does not occur, however the DoEE determined a significant impact is likely for this species in its controlled action decision. Umwelt's assessment considers a significant impact unlikely based on the fragmentated and limited mature foraging resources in the Project Area.

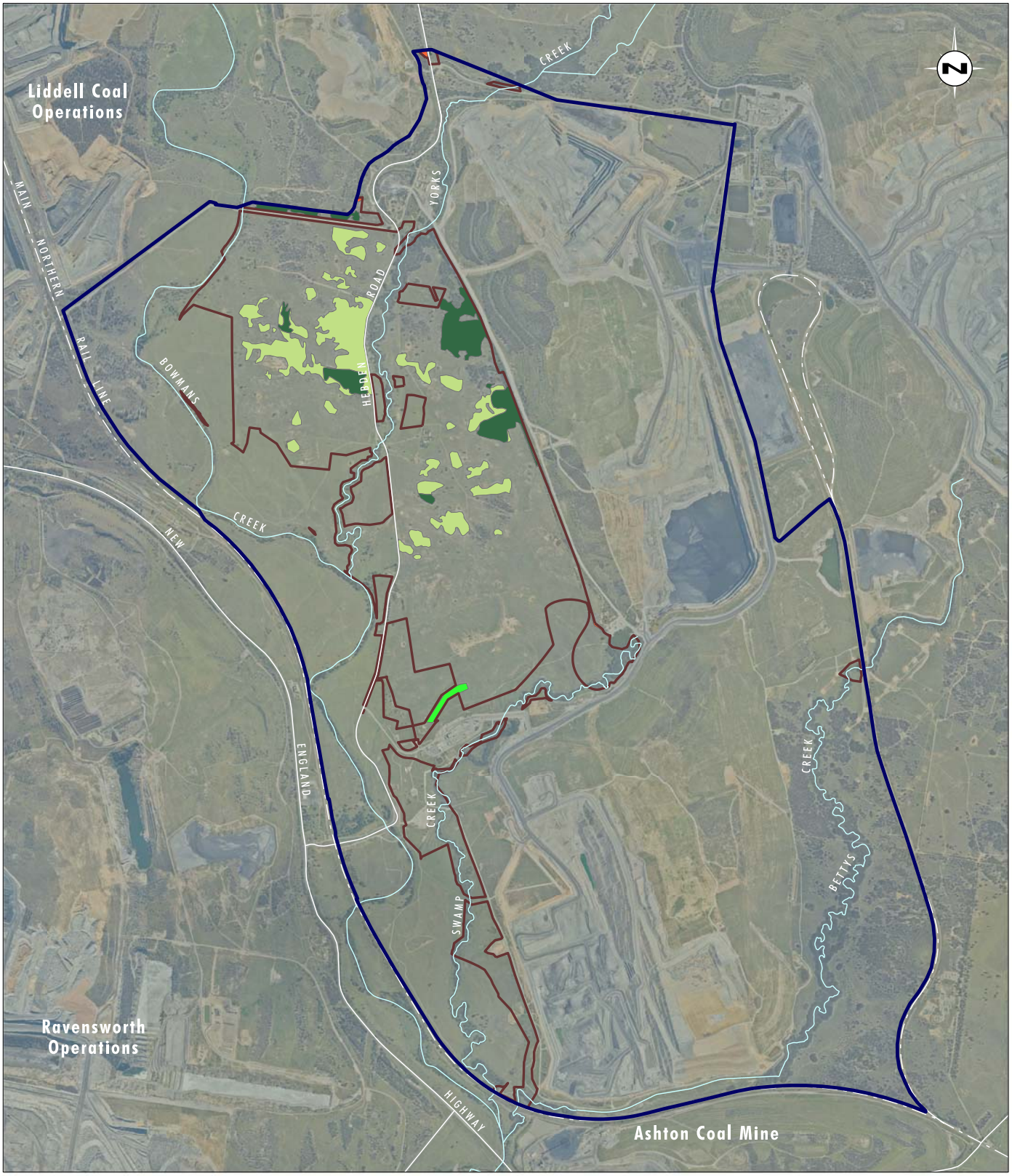


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)

Potential Swift Parrot Foraging Habitat:

- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation

FIGURE 2.6

Potential Swift Parrot Foraging Habitat in the Development Footprint

2.2.4 Spotted-tailed Quoll (*Dasyurus maculatus maculatus*)

The spotted-tailed quoll is listed as endangered under the EPBC Act. According to the National Recovery Plan for the species (DELWP 2016), it is considered that this species has declined by 50-90%. Home range estimates vary considerably according to location and habitat quality, however females have been known to occupy home ranges up to 1,515 ha and males up to 5,512 ha and both sexes usually traverse their ranges along densely vegetated creek lines. Extant populations are highly fragmented and declining. The geographic distribution of the species is contracting and its subpopulations are becoming increasingly fragmented.

The species was recorded during targeted surveys on four remote cameras within the Project Area in 2017 and 2018. The camera records include one in November 2017 in the eastern section of the Development Footprint, one from January 2018 located in the north-western portion of the Project Area, west of Bowmans Creek, a camera located at Yorks Creek had three recordings, one from late October 2018 and two consecutive days in early November 2018, and an additional remote camera record identified the species in 5 January 2018 within the Ravensworth East mine rehabilitation. Previous records also exist from a radio-tracking program that monitored individual movements around the Mount Owen Complex, indicating that the woodland remnants and rehabilitation provide movement habitat for the local population of the species (Peter York, pers comm). Other local records include from 2013 in the north and eastern parts of the Project Area, three records from 2009 (observation) and 2010 (observation and cage trap) also within the eastern section of Hebden Road (refer to **Figure 2.7**).

The spotted-tailed quoll has been recorded regularly at the Mount Owen Complex during fauna monitoring, with the species recorded annually between 1994 and 2014 (except 1998, 1999 and 2005) in Ravensworth State Forest and surrounding woodland and forest communities, including mine rehabilitation (Forest Fauna Surveys 2019). However, records are generally concentrated on Bowmans Creek and Ravensworth State Forest, with extension into the more disturbed operational areas surrounding these core areas.

The habitat critical to the survival of the spotted-tail quoll includes large patches of forest with adequate denning resources and relatively high densities of medium-sizes mammalian prey (DELWP 2016). The threshold densities of these critical habitat components to support quoll populations are currently unknown meaning that the critical habitat to the survival of the species is not possible to define (DELWP 2016). Therefore, all habitats within the species current distribution that are known to be occupied are considered important.

The spotted-tailed quoll generally dens in rock shelters, small caves, hollow logs or tree hollows and utilises numerous dens within its home range. It is a highly mobile species and there are numerous records of overnight movements of several kilometres. Known den sites occur in the Ravensworth State Forest and in the Mount Owen Complex in mine rehabilitation to the east of the Project Area and to the north along Bowmans Creek (outside of the Project Area). The species has not been recorded breeding within the Project Area, and potential den sites have not been recorded during surveys. There is no evidence to suggest that breeding has occurred within the Project Area. Known breeding habitat for the species will not be impacted by the Project.

The controlled action decision (DoEE 2019) states that the Project is likely to have a significant impact on the spotted-tailed quoll due to the loss of 247 ha of foraging and dispersal habitat for the species, however following impact boundary reductions, the area of potential habitat is now estimated to be approximately 155 ha (refer to **Figure 2.7** and **Table 2.15**). All of the native woodland vegetation communities within the Project Area are likely to provide foraging or dispersal habitat for the spotted-tail quoll and habitats in the Project Area are considered to form part of a local home range for the species. As noted above, the Project Area is not known to contain den or breeding sites for the species.

Table 2.15 Known Foraging and Dispersal Habitat for the Spotted-tailed Quoll in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Native forest habitat suitable for foraging and dispersal.	26.7
Regeneration		53.1
Plantation		1.8
1692 Bull Oak Grassy Woodland of the Central Hunter Valley		
Moderate to Good	Native woodland habitat suitable for foraging and dispersal.	18.0
Regeneration		10.2
485 River Oak riparian grassy tall woodland of the western Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging and dispersal.	2.4
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Woodland habitat suitable for foraging and dispersal.	0.5
1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging and dispersal (refer to **Plate 3.4**).	40.0
Plantation		1.8
	TOTAL	**154.5**

Plate 2.4 Typical riparian dispersal habitat for the spotted-tailed quoll in the Project Area

The proposed action will result in the reduction of movement habitat for the species connecting the remnant vegetation with Bowmans Creek, Yorks Creek and Swamp Creek. Alternative movement corridors between the main habitat areas in Ravensworth State Forest and Mount Owen Complex offset areas with Bowmans Creek will remain to the north of the Project Area and will not be impacted.

Based on fieldwork that considered the extent of habitat in accordance with the National Recovery Plan and the regional ecology of the species within the Hunter Valley, approximately 155 ha of native woodland and forest habitat was identified in the Development Footprint as likely and known habitat for the species. Any impacts to known habitat for the spotted-tailed quoll will likely contravene the objectives of the recovery plan.

DoEE determined a significant impact is likely for the spotted-tailed quoll in its controlled action decision, however Umwelt's assessment determined a significant impact was unlikely on the Barrington Tops regional population of the species.

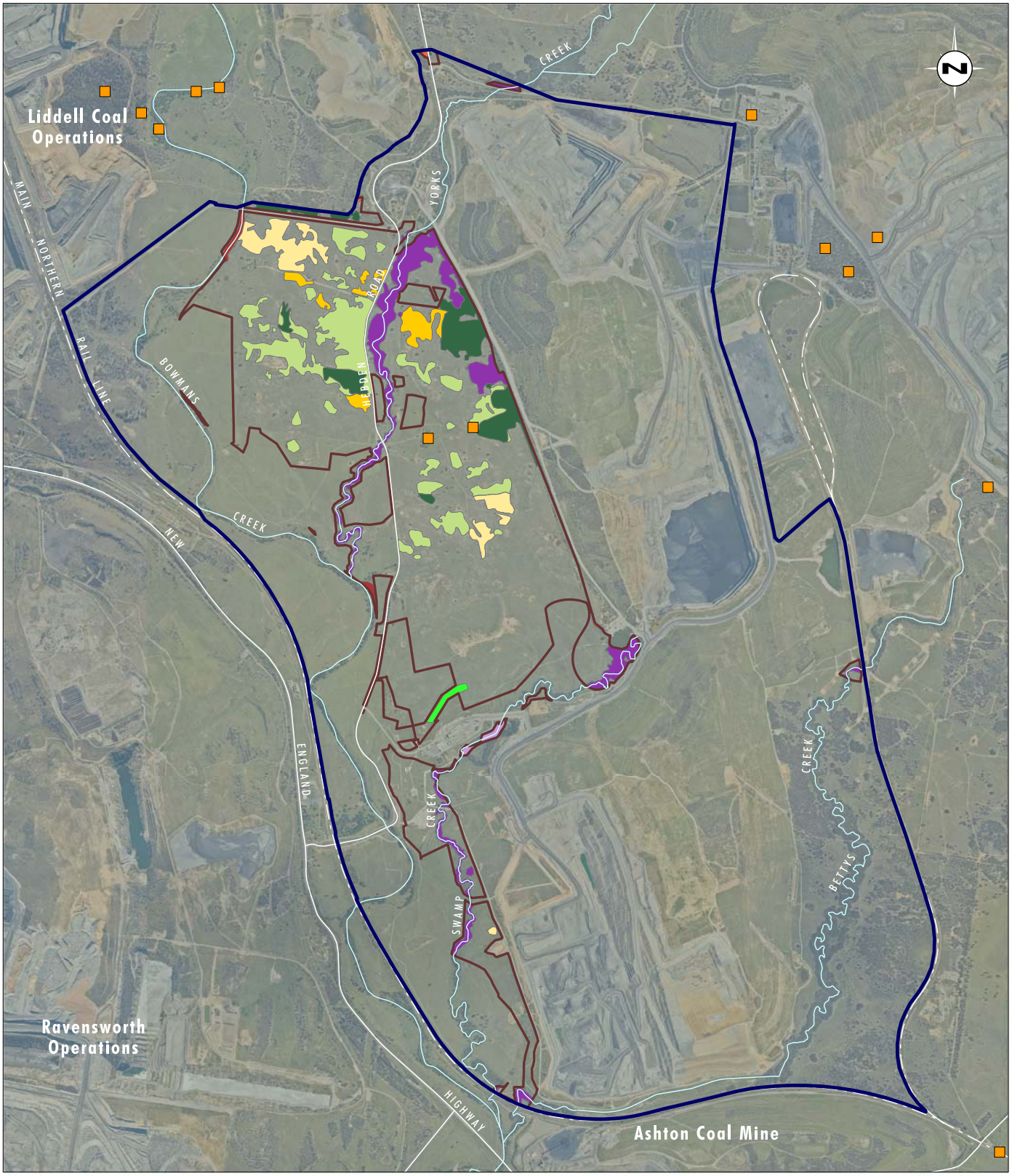


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), ATLAS (2019)

0 0.5 1.0 2.0 km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Spotted-tailed Quoll Record (Bionet 2019)

Potential Spotted-tailed Quoll Foraging Habitat:

- 485 Moderate - Good
- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation
- 1692 Regeneration
- 1692 Moderate - Good
- 1731 Plantation
- 1731 Moderate - Good

FIGURE 2.7

Potential Spotted-tailed Quoll Foraging Habitat in the Development Footprint

File Name (A4): R16/4166_550.dgn
20191113 13.06

2.2.5 Green and Golden Bell Frog (*Litoria aurea*)

The green and golden bell frog is listed as vulnerable under the EPBC Act. The species was formerly distributed from the NSW North Coast near Brunswick Heads southwards along the NSW coast to Victoria, where it extends into East Gippsland, and west to Bathurst, Tumut and the ACT. In the 1960s, the species was considered widespread, abundant and commonly encountered (DECC 2007). In the Hunter, the species is now only known from three key populations. The Upper Hunter Green and Golden Bell Frog Key Population is located between the settlements of Singleton and Muswellbrook (DECCW 2007).

The green and golden bell frog has not been recorded in the locality for over 20 years. The species was 'rediscovered' in the upper Hunter in 1994 at the nearby Mount Owen mine where it was subsequently recorded in 1996, 1997 and 1999 (Forest Fauna Surveys and Newcastle Innovation 2013) (refer to **Figure 3.5**). It is considered highly likely that the precipitous state of the Upper Hunter Key Population is directly due to the impact of disease (chytrid fungus) rather than habitat loss or other ecological factors (Forest Fauna Surveys and Newcastle Innovation 2013).

The green and golden bell frog population within the adjacent Mount Owen Complex has been monitored annually since its discovery in Bettys Creek in 1994 by well-recognised frog researchers from the University of Newcastle. Despite extensive surveys and monitoring, the species has not been recorded in the locality for over 20 years (since 1999). Furthermore, this species has not been recorded from within the Project Area historically or recently despite extensive targeted surveys conducted in 2017 and 2018.

The controlled action decision (DoEE 2019) states that the Project is likely to have a significant impact on the green and golden bell frog due to the removal or degradation of suitable aquatic or ephemeral habitat where the species has been recorded; however, the species has not been recorded in the Project Area. As the species is not known to occur within the Project Area, the aquatic habitats represent potential habitat only (refer to **Table 2.16** and **Figure 2.8**).

Table 2.16 Potential Habitat for the Green and Golden Bell Frog in the Development Footprint

Area	Justification	Area (ha)
9 farm dams	Containing suitable aquatic and fringing vegetation habitat (refer to **Plate 3.5**)	2.0
	TOTAL	**2.0**

Plate 2.5 Typical Farm Dam Habitat with Fringing Vegetation in the Project Area

The Project will remove dams, creek habitat and associated terrestrial habitat that provides potential habitat for the green and golden bell frog. Following impact boundary reductions, the Project will disturb up to nine farm dams with suitable fringing riparian vegetation or shelter habitat for the species, totalling 2 ha of potential habitat (refer to **Plate 2.5**).

DoEE determined a significant impact is likely for the green and golden bell frog in its controlled action decision, however based on the lack of records of the species in the Project Area and that the species has not been confirmed in the locality for over 20 years, and the small area of potential habitat removal, a significant impact is considered unlikely.

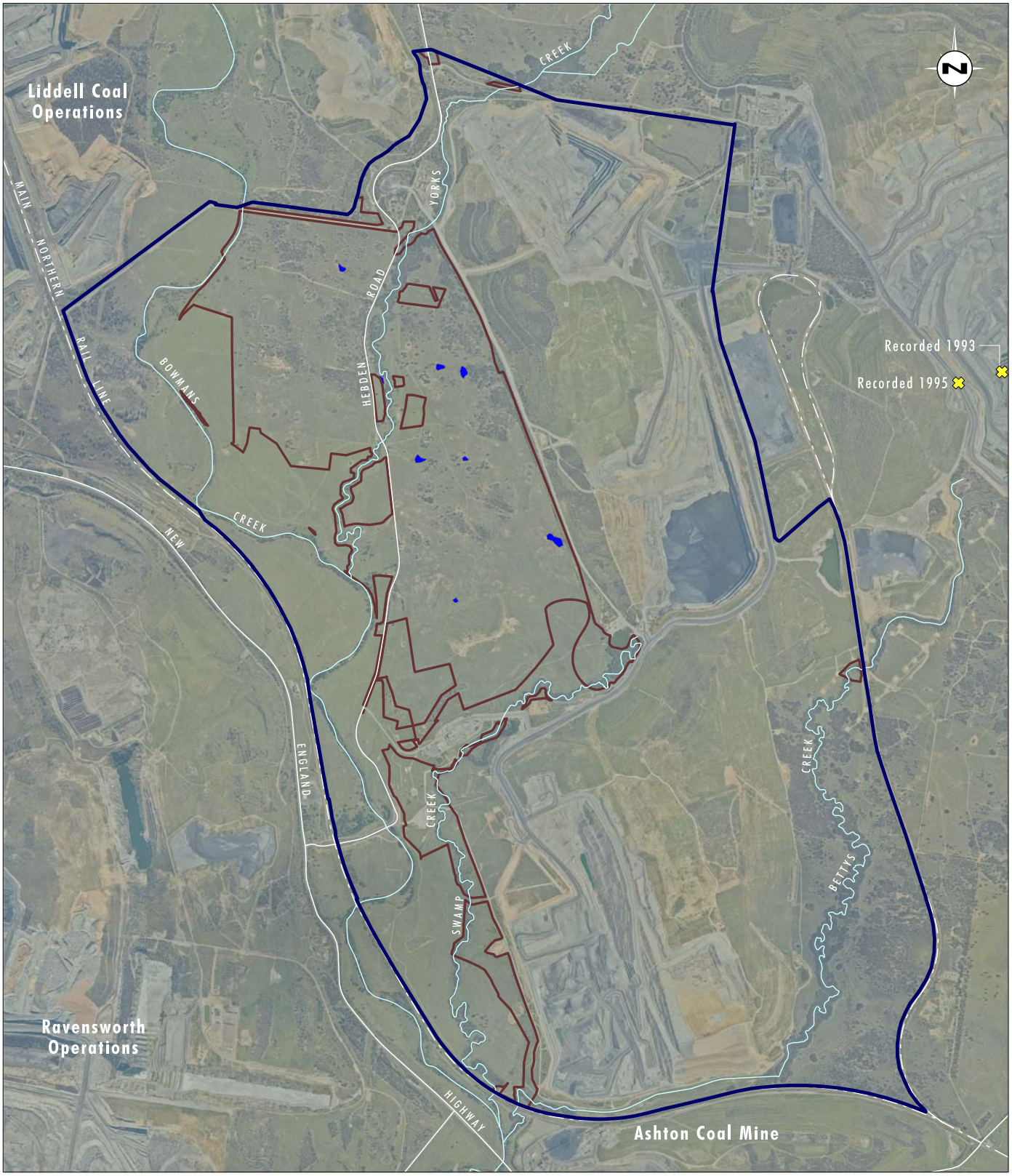


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), ATLAS (2019)

0 0.5 1.0 2.0 km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Green and Golden Bell Frog (Bionet 2019)

Potential Green and Golden Bell Frog Habitat:

- Dam

FIGURE 2.8

Potential Green and Golden Bell Frog Habitat in the Development Footprint

2.2.6 Koala (*Phascolarctos cinereus*)

The koala is listed as vulnerable under the EPBC Act. The species is known to occur in eucalypt woodlands and forests from the north-eastern Queensland, along the eastern coast of NSW, to the south-east corner of South Australia. The species has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range.

The koala was tentatively recorded during monitoring in 1995 in Ravensworth State Forest through the collection of scats resembling those of the koala (Forest Fauna Surveys and Newcastle Innovation 2013). There are several sporadic records proximate to the Project Area, however the majority of these records are historic, ranging from 1980 - 2006. The most recent record includes a June 2012 record at the corner of Hebden Road and the New England Highway within 1 km west of the Development Footprint. In addition to this the koala has also been recorded approximately 6 km to the north-west of the Project Area in the Glencore managed Hillcrest Offset Area (Umwelt 2010) (refer to **Figure 2.9**).

Koalas feed on the foliage of eucalypt tree species and in some areas exhibit extremely strong preferences for particular eucalypt species. The Approved Recovery Plan for the Koala (DECC 2008) outlines preferred feed tree species in the Central Coast Koala Management Area. State Environmental Planning Policy (SEPP) 44 Koala Habitat Protection also details in schedule 2 koala feed trees important to the koala. One primary feed tree according to the Approved Recovery Plan for the Koala (DECC 2008), forest red gum (*Eucalyptus tereticornis*), was recorded within the Project Area. In addition to the primary food trees, the Project Area also contains one secondary food tree, grey box (*Eucalyptus moluccana*).

The controlled action decision (DoEE 2019) states that the Project is likely to have a significant impact on the koala due to the action involves the clearing of approximately 156 ha of vegetation that potentially provides foraging habitat for this species, however following impact boundary reductions, the area of potential habitat is now estimated to be approximately 84 ha (refer to **Table 2.17** and **Figure 2.9**). In accordance with the EPBC Act Referral Guidelines for the Vulnerable Koala (DoE 2014), the habitat assessment tool was applied, which determined that the Development Footprint is considered to contain habitat critical to the survival of the species (DoE 2014). The habitat scored a 5 out of 10 (≥ 5 indicates habitat critical for the survival of the koala).

Table 2.17 Potential Habitat for the Koala in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Contains secondary key feed tree grey box (*Eucalyptus moluccana*). Grey box cover approximately 5%.	26.7
Regeneration	Contains primary feed tree forest red gum (*Eucalyptus tereticornis*) and secondary key feed tree grey box (*Eucalyptus moluccana*). Feed tree cover ranges from 5-10% (avg. 7%).	53.1
Plantation	Contains primary feed tree forest red gum (*Eucalyptus tereticornis*) and secondary key feed tree grey box (*Eucalyptus moluccana*). Feed tree cover ranges from 2-4% (avg. 3%).	1.8
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Contains secondary key feed trees grey box (*Eucalyptus moluccana*) and grey gum (*Eucalyptus punctata*). Feed tree cover ranges from 5-15% (avg. 5%).	0.5

Vegetation Zone	Justification	Area (ha)
1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley		
Plantation	Contains primary feed tree forest red gum (*Eucalyptus tereticornis*) and secondary key feed tree grey box (*Eucalyptus moluccana*). Feed tree cover approximately 5%.	1.8
	TOTAL	**83.9**

1. Feed tree cover ranges and averages are derived from floristic plots undertaken in accordance with the BAM (OEH 2017b).

Plate 2.6 Typical habitat containing potential feed trees for koala in the Project Area

The proposed action will result in the loss of approximately 84 ha of vegetation containing primary and secondary koala feed trees (refer to **Table 2.17** and **Figure 2.9**), however these tree species were recorded in low abundance in the vegetation communities in the Development Footprint. The majority of the trees are relatively young and the Development Footprint contained few mature trees (refer to **Plate 2.6**). While sporadic, and mainly historic, records of the species occur in the locality, the Project Area does not provide known habitat for this species.

Based on fieldwork that considered the extent of habitat within the Project Area in accordance with the regional ecology of the species within the Hunter Valley, approximately 84 ha of native woodland and forest habitat was identified in the Development Footprint as potential and occasional foraging habitat for the species.

DoEE determined a significant impact is likely for the koala in its controlled action decision. However, the Project is considered unlikely to result in a significant impact on the koala given the very low abundance of primary koala feed trees (approximately 5% forest red gum – *Eucalyptus tereticornis*) present within the Development Footprint and the low number of recent records of the koala in the locality.

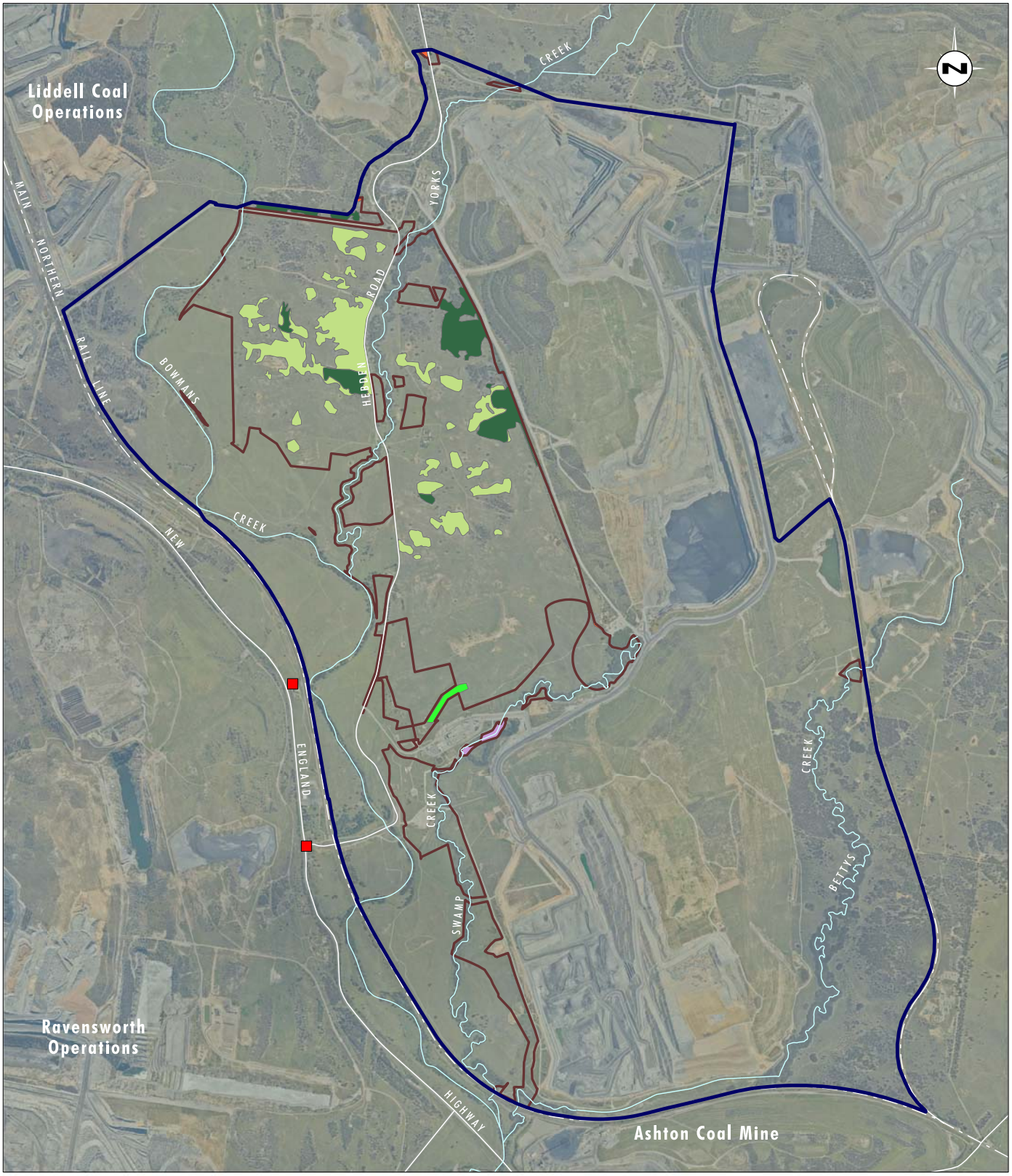


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), ATLAS (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Koala (Bionet 2019)

Potential Koala Habitat:

- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation
- 1731 Plantation

FIGURE 2.9

Potential Koala Habitat in the Development Footprint

File Name (A4): R16/4166_552.dgn
20191113 13.09

2.2.7 Large-eared Pied Bat (*Chalinolobus dwyeri*)

The large-eared pied bat is listed as vulnerable under the EPBC Act. The species is known from Shoalwater Bay, north of Rockhampton, Qld, south to the vicinity of Ulladulla in NSW. Much of the known distribution of the large-eared pied bat occurs in NSW. In Coolah Tops, Mt Kaputar and Warrumbungle National Park it is present in areas of volcanic strata. It is more widely distributed, but still uncommon and patchy within its distribution, in the sandstone areas of the Sydney Basin and the western slopes. The large-eared pied bat is dependent on the presence of diurnal roosts for shelter. Roosts are utilised during the day and also at night when not feeding, as well as for the raising of young. The species has been known to roost in disused mine shafts, caves, overhangs and abandoned fairy martin nests. No evidence exists of the large-eared pied bat roosting in tree hollows (DERM 2011).

The majority of records within the Hunter Valley generally occur near the escarpment habitat associated with Yengo and Wollemi National Parks approximately 17 km south from the Project Area. The species has been tentatively recorded in the adjacent Mount Owen Complex during annual fauna monitoring surveys in 1999, 2001, 2006, 2008, 2014 and 2015 using call echolocation recording, however, no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019). The closest and most recent record of this species was recorded in the Project Area at the intersection of Hebden Road and Bowmans Creek as part of the 2014 UHSA echolocation surveys undertaken by Umwelt.

Sandstone cliffs and fertile wooded valley habitat in proximity should be considered habitat critical to the survival of the large-eared pied bat (DECC 2007). Due to the absence of suitable cliffline or cave roosting (or other suitable artificial structure) habitat near the Project Area and the infrequency of unconfirmed records of the species within the wider Mount Owen Complex, the Project Area is not considered to contain habitat critical to the survival of the species. Modelling based on presence-only data indicates that bats forage in fertile valleys and plains, as well as areas with moderately-tall to taller trees along water courses. The majority of records are from canopied habitat, suggesting a sensitivity to clearing (DERM 2011). All woodland and forest vegetation within the Project Area is therefore expected to provide potential foraging habitat for this species, however no roosting habitat for this cave-roosting species has been identified within or proximate to the Project Area.

The controlled action decision (DoEE 2019) states that the Project has a real chance or possibility to have a significant impact on the large-eared pied bat without further assessment of the potential impacts. The original Referral documentation estimated an impact of up to 247 ha of foraging habitat, however following impact boundary reductions, the area of potential habitat is now estimated to be approximately 155 ha (refer to **Table 2.18** and **Figure 2.10**).

Table 2.18 Potential Habitat for the Large-eared Pied Bat in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Native forest habitat suitable for foraging.	26.7
Regeneration		53.1
Plantation		1.8
1692 Bull Oak Grassy Woodland of the Central Hunter Valley		
Moderate to Good	Native woodland habitat suitable for foraging.	18.0
Regeneration		10.2

Vegetation Zone	Justification	Area (ha)
485 River Oak riparian grassy tall woodland of the western Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging.	2.4
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Woodland habitat suitable for foraging.	0.5
1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging.	40.0
Plantation		1.8
	TOTAL	**154.5**

Plate 2.7 Typical forest and woodland habitat in the Project Area

The Proposed Action will result in the loss of approximately 155 ha of forest and woodland vegetation that may contain suitable foraging habitat for the species (refer to **Table 2.18** and **Figure 2.10**), however these areas are not within proximity to suitable cliffline or cave roosting habitats where foraging habitat is critical for the species.

Based on fieldwork that considered the extent of habitat within the Development Footprint in accordance with the regional ecology of the species within the Hunter Valley, approximately 155 ha of native woodland and forest habitat was identified in the Development Footprint as potential foraging habitat for the species.

DoEE determined that a significant impact is possible for the large-eared pied bat, however noting the lack of suitable roosting habitat within and proximate to the Project Area and the relatively low number of records in the locality despite extensive survey effort, a significant impact on this species is not likely to occur.

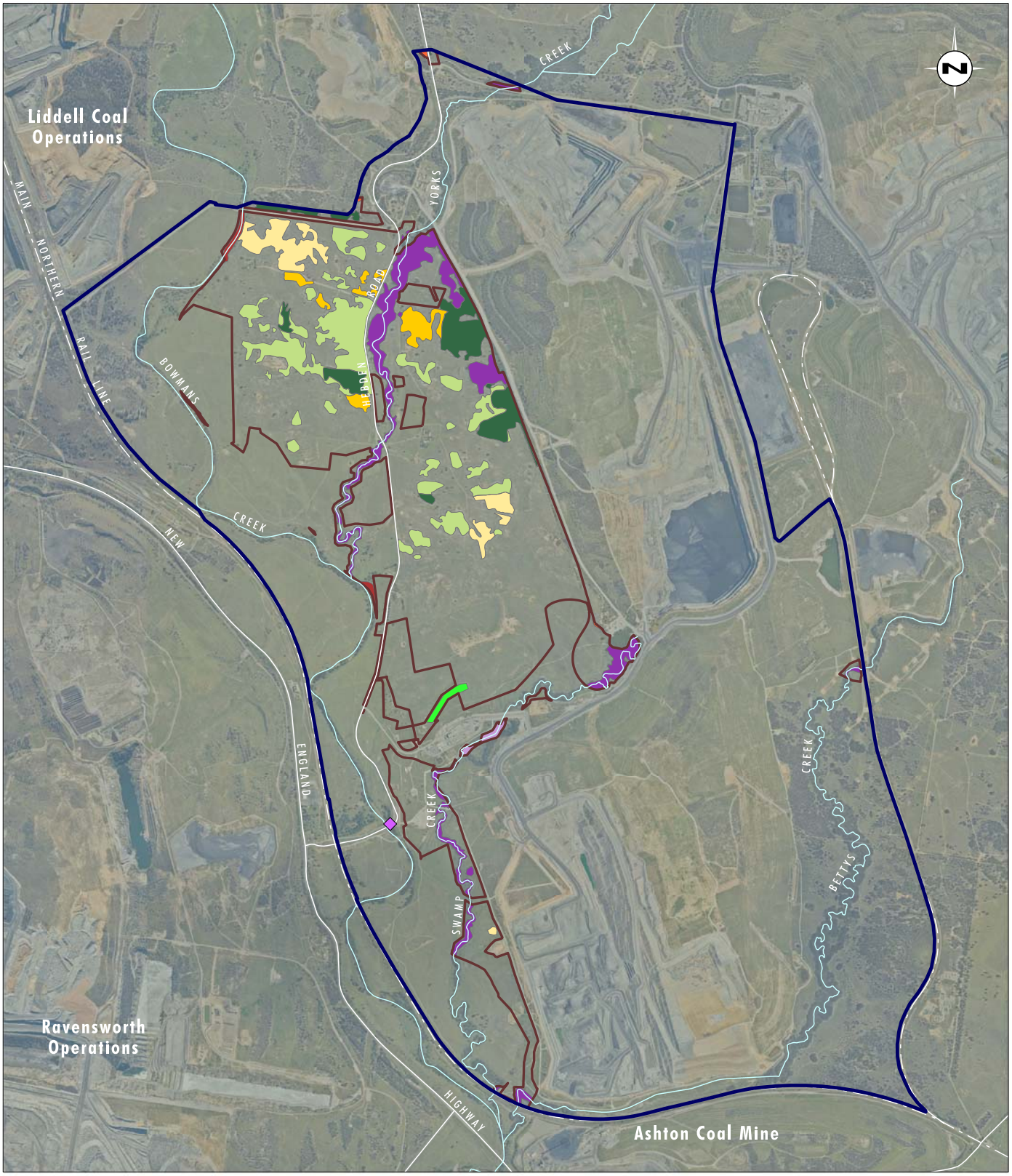


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), ATLAS (2019)

0 0.5 1.0 2.0 km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)
- Large-eared Pied Bat (Bionet 2019)

Potential Large-eared Pied Bat Habitat:

- 485 Moderate - Good
- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation
- 1692 Regeneration
- 1692 Moderate - Good
- 1731 Plantation
- 1731 Moderate - Good

FIGURE 2.10

Potential Large-eared Pied Bat Habitat in the Development Footprint

File Name (A4): R16/4166_553.dgn
20191113 13.25

2.2.8 New Holland Mouse (*Pseudomys novaehollandiae*)

The New Holland mouse is listed as vulnerable under the EPBC Act. Habitat preferences across the species range include open heathland; open woodland with a heathland understorey; and vegetated sand dunes. The species is usually found to peak in abundance during the early to mid-stages of vegetation succession three to five years after fire or other disturbances. Due to the largely granivorous nature of the species, sites where the New Holland mouse is found are often high in floristic diversity, especially leguminous perennials.

The species has been recorded during five of the last 18 years of fauna monitoring in the adjoining Mount Owen Complex, with most captures of the species occurring between 2003 and 2007 (Forest Fauna Surveys 2019). The most recent record of the species was 2016 where it was captured during fauna monitoring in the northern portion of Ravensworth State Forest (Forest Fauna Surveys 2019). The species has also been recorded in areas of rehabilitation in the North Pit of the adjacent Mount Owen Complex and to the east of Ravensworth State Forest. The species selectively prefers habitats which have been disturbed by events in which it rapidly colonises following the event (Forest Fauna Surveys and TUNRA 2007). Populations of the species remain high for a period following disturbance and decline in abundance in areas not subjected to disturbance.

Habitat critical to the survival of the New Holland mouse has not been defined. Habitats occurring in the Project Area do not comprise preferred habitat for the species, which generally occurs in heath and coastal dune habitats. The potential habitats in the Project Area have not been subject to recent (within 5 years) disturbances such as fire. Given the results of the nearby Mount Owen Complex fauna monitoring, early mine rehabilitation within the Hunter Valley is likely providing suitable early successional habitat for this species (refer to **Table 2.19**). Established woodland and grassland habitats in the Project Area do not conform to the preferred habitat types in which the species is typically located. Areas of naturally regenerating habitats occurs within the Project Area, however the understorey of this habitat is reasonably sparse, open and species poor.

The controlled action decision (DoEE 2019) states that the Project has a real chance or possibility to have a significant impact on the New Holland mouse without further assessment of the potential impacts. The original Referral documentation estimated an impact of up to 64 ha of foraging habitat, however following impact boundary reductions, the area of potential habitat is now estimated to be approximately 4 ha (refer to **Table 2.19** and **Figure 2.11**).

Table 2.19 Potential Habitat for the New Holland Mouse in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Plantation	Young plantation vegetation.	1.8
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Young mine rehabilitation vegetation.	0.5
1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley		
Plantation	Young plantation vegetation.	1.8
	TOTAL	**4.1**

Plate 2.8 Young rehabilitation vegetation in the Project Area

The Proposed Action will result in the loss of approximately 4 ha of young plantation and rehabilitation vegetation that may contain suitable habitat for the species (refer to **Table 2.19** and **Figure 2.11**). However, given the paucity of nearby recent records and the relatively small area of potential habitat to be removed compared to much larger areas of similar or better habitat to the north-east in the Ravensworth State Forest and Mount Owen Mine rehabilitation, the Project Area is unlikely to support key source habitat for New Holland mouse populations for breeding or dispersal.

DoEE determined that a significant impact is possible for the New Holland mouse, however noting the lack of records within the Project Area and the small area of potential habitat impacts, a significant impact on this species is not likely to occur.

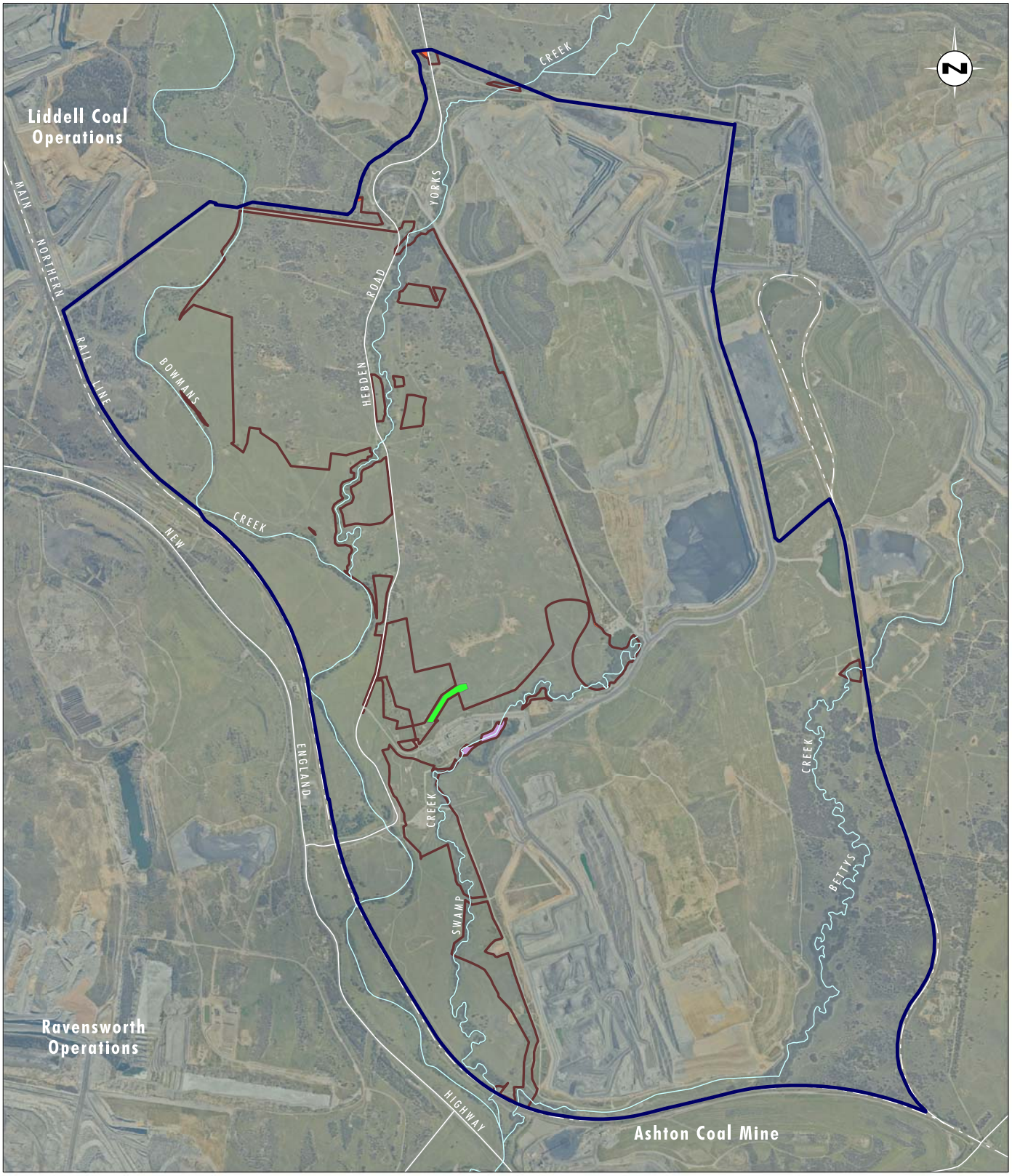


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

Legend

Project Area
Biodiversity Assessment Area (Development Footprint)

Potential New Holland Mouse Habitat:
1603 Plantation
1604 Woodland Rehabilitation
1731 Plantation

FIGURE 2.11

Potential New Holland Mouse Habitat in the Development Footprint

File Name (A4): R16/4166_554.dgn
20191113 13.27

2.2.9 Grey-headed Flying-fox (*Pteropus poliocephalus*)

The grey-headed flying-fox is listed under the EPBC Act. The species occurs in the coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. The Grey-headed Flying-fox requires foraging resources and roosting sites. It is a canopy-feeding frugivore and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, *Melaleuca* swamps and *Banksia* woodlands. The primary food source is blossom from *Eucalyptus* and related genera but also feeds on commercial fruit crops and on introduced tree species in urban areas. The grey-headed flying-fox roosts in aggregations of various sizes on exposed branches which are typically located near water.

The two nearest substantial camp sites of the grey-headed flying-fox proximate to the Project Area are at Burdekin Park, Singleton (approximately 16 km) and at Muswellbrook (approximately 25 km) (DoEE 2019). The population estimate for the grey-headed flying-fox population at Burdekin Park is estimated to be between 500 and 2,499 individuals during the most recent survey in November 2018 and the population at Muswellbrook estimated to be between 2,500 and 9,999 individuals during the most recent survey in August 2018 (DoEE 2019). The Muswellbrook camp is noted in the National Flying-Fox Monitoring Viewer as a nationally important grey-headed flying-fox camp.

This species has been previously recorded on seven occasions during monitoring of the adjacent Mount Owen Complex (Forest Fauna Surveys 2019). It was noted during May 2016 annual monitoring spotlighting surveys that several thousand individuals of the grey-headed flying-fox were present within Ravensworth State Forest, however no roost sites were recorded within the nearby Mount Owen Complex and large numbers of individuals were observed arriving shortly after dusk each evening (Forest Fauna Surveys 2019). Foraging individuals in the nearby Mount Owen Complex are likely to be from the above camp sites located within 50 km of the site.

According to the draft National Recovery Plan for the grey-headed flying-fox (DECCW 2009), foraging habitat that meets one of the following criteria is considered critical to the survival of the species:

- productive during winter and spring, when food bottlenecks have been identified
- known to support populations of >30,000 individuals within an area of 50 km radius (the maximum foraging distance of an adult)
- productive during the final weeks of gestation, and during the weeks of birth, lactation and conception
- productive during the final stages of fruit development and ripening in commercial crops affected by grey-headed flying-foxes, and/or
- known to support a continuously occupied camp.

The Project Area does not support a population greater than 30,000 individuals, does not support an occupied camp and is not consistently productive during breeding events or during winter and spring. Flowering events in the adjacent Mount Owen Complex are sporadic and apart from the May 2016 records, only a few individuals of the species have been recorded in previous annual monitoring events utilising these habitats over the last 18 years. All forest, woodland and riparian vegetation within the Project Area is expected to provide potential foraging habitat for this species. Camp sites (breeding habitat) have not been identified within the Project Area and are not expected to occur.

The controlled action decision (DoEE 2019) states that the Project has a real chance or possibility to have a significant impact on the grey-headed flying-fox without further assessment of the potential impacts. The original Referral documentation estimated an impact of up to 247 ha of foraging habitat, however following impact boundary reductions, the area of potential habitat is now estimated to be approximately 155 ha (refer to **Table 2.20** and **Figure 2.12**).

Table 2.20 Potential Foraging Habitat for the Grey-headed Flying-fox in the Development Footprint

Vegetation Zone	Justification	Area (ha)
1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter		
Moderate to Good	Native forest habitat suitable for foraging.	26.7
Regeneration		53.1
Plantation		1.8
1692 Bull Oak Grassy Woodland of the Central Hunter Valley		
Moderate to Good	Native woodland habitat suitable for foraging.	18.0
Regeneration		10.2
485 River Oak riparian grassy tall woodland of the western Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging.	2.4
1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter		
Woodland Rehabilitation	Woodland habitat suitable for foraging.	0.5
1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley		
Moderate to Good	Riparian habitat suitable for foraging.	40.0
Plantation		1.8
	TOTAL	**154.5**

Plate 2.9 Moderate quality forest and woodland habitat in the Project Area, providing potential Grey-headed Flying-fox habitat

The Proposed Action will result in the loss of approximately 155 ha of forest and woodland vegetation that may contain suitable foraging habitat for the species (refer to **Table 2.20** and **Figure 2.12**).

DoEE determined that a significant impact is possible for the grey-headed flying-fox, however noting the lack of records within the Project Area and the much larger areas of better habitat to the north-east in the Ravensworth State Forest, a significant impact on this species is not likely to occur.

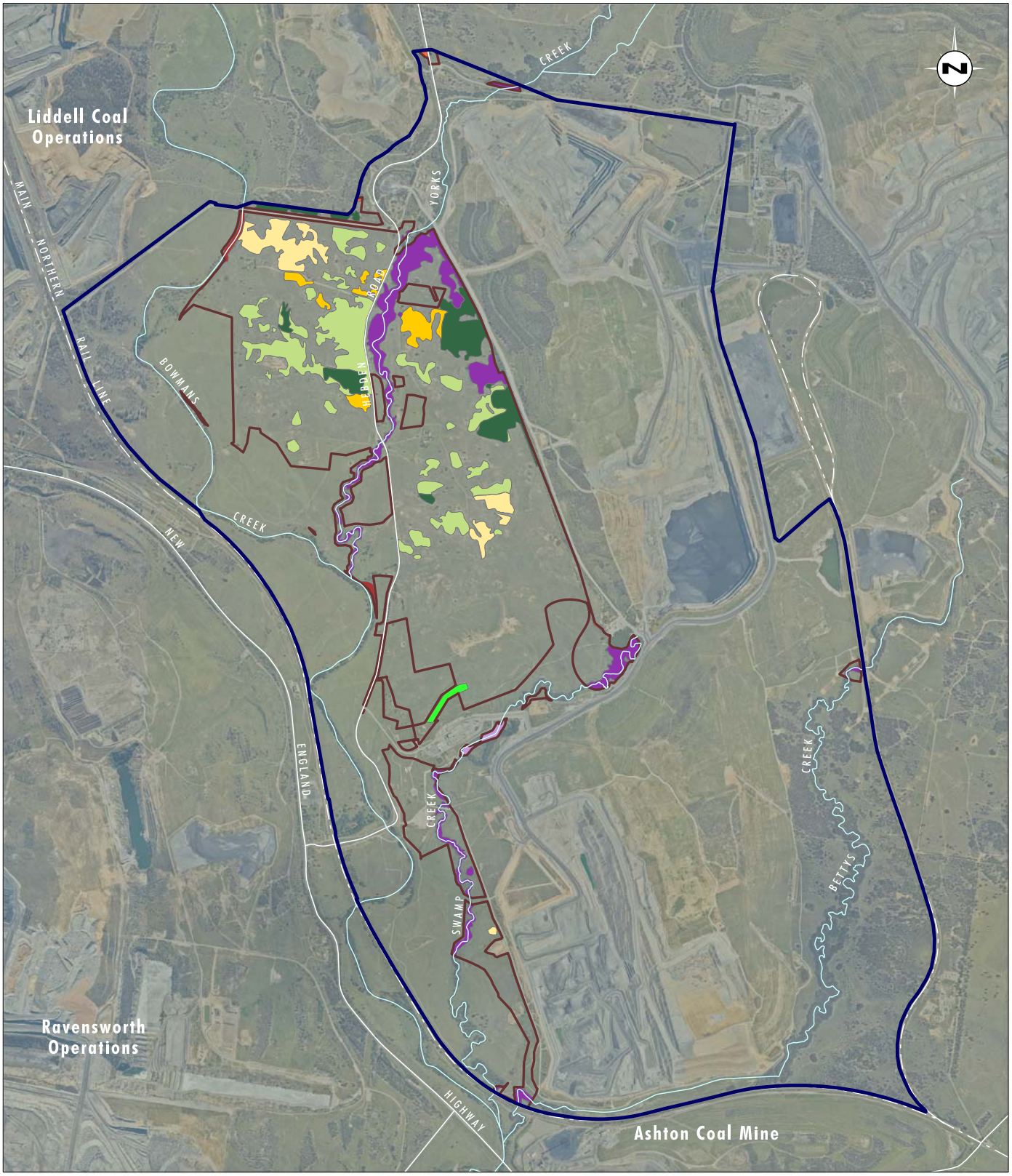


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), ATLAS (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Biodiversity Assessment Area (Development Footprint)

Potential Grey-headed Flying-fox Foraging Habitat:

- 485 Moderate - Good
- 1603 Plantation
- 1603 Regeneration
- 1603 Moderate - Good
- 1604 Woodland Rehabilitation
- 1692 Regeneration
- 1692 Moderate - Good
- 1731 Plantation
- 1731 Moderate - Good

FIGURE 2.12

Potential Grey-headed Flying-fox Foraging Habitat in the Development Footprint

File Name (A4): R16/4166_582.dgn
20191113 13.29

2.2.10 Trailing Woodruff (*Asperula asthenes*)

Trailing woodruff (*Asperula asthenes*) is listed as vulnerable under the EPBC Act. It is found in scattered locations within NSW from Bulahdelah to Kempsey, with several records from the Port Stephens/Wallis Lakes area. The species typically inhabits damp areas, often along riverbanks.

The controlled action decision (DoEE 2019) states that the Project has a real chance or possibility to have a significant impact on *Asperula asthenes* without further assessment of the potential impacts. It is acknowledged that a record of the species is on the NSW Atlas of Wildlife as occurring to the south east of the Project Area in woodland habitat, which likely prompted DoEE to request further information and assessment on this species. The record is derived from Umwelt surveys of the area in 2006 which identified common woodruff (*Asperula conferta*). This record is erroneously shown on the NSW Atlas of Wildlife as *Asperula asthenes*. The closest confirmed record of the trailing woodruff actually occurs over 50 km to the northeast of the Project Area in the Barrington Tops. The next closest record occurs over 70 km to the southeast near Raymond Terrace.

Notwithstanding the above, the species typically inhabits damp areas, often along riverbanks. The Project Area contains farm dams and creek lines associated with Bowmans Creek, Yorks Creek and Swamp Creek that contains potential damp habitat for this species. Extensive targeted threatened flora surveys involving walking transects in suitable habitat was undertaken in the species known detection period in 2017 and 2018 failed to record this species in the Project Area. Furthermore, floristic surveys undertaken to sample vegetation across the site did not record *Asperula asthenes* (however *Asperula conferta* was recorded in the Project Area).

The proposed action will not result in the loss of habitat for *Asperula asthenes* as it does not occur in the Project Area. Noting the lack of confirmed records within the Project Area and the wider region, a significant impact on this species is highly unlikely to occur.

2.3 Assessment of Impacts to Listed Threatened Species and Communities

The development of the Project will result in direct, indirect and consequential impacts on biodiversity values. Direct impacts include the loss of native vegetation and fauna habitats as a result of clearance works and subsequent mining activity. 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, dust, noise, groundwater changes, weeds and feral animals may occur during the Project.

Consequential impacts arise where a project creates a requirement for additional development or where additional development is facilitated to a significant extent by a project. The Project is not expected to result in substantial consequential biodiversity impacts.

It is recognised that the Project will remove vegetation and further increase fragmentation and isolation of habitats, and thus contribute to cumulative habitat loss and vegetation clearance in the locality.

These impacts are summarised in **Table 2.21**.

Table 2.21 Predicted Impacts from the Project on EPBC Act listed threatened species and communities

Impact Type	MNES	Description	Nature of Impact	Direct Impact Area
Direct	*Central Hunter Valley Eucalypt Forest and Woodland CEEC*	Loss of 108.5 ha of woodland/forest and 14.4 ha of derived native grassland through clearing.	Permanent	**122.9 ha**
Direct	spotted-tailed quoll	Loss of 154.5 ha of woodland, forest and riparian foraging and dispersal habitat through clearing	Permanent	**154.5 ha**
Direct	regent honeyeater	Removal of potential foraging habitat containing key feed trees and suitable *Central Hunter Valley Eucalypt Forest and Woodland CEEC* areas	Permanent	**81.3 ha**
Direct	swift parrot	Removal of potential foraging habitat containing key feed trees and suitable *Central Hunter Valley Eucalypt Forest and Woodland CEEC* areas	Permanent	**81.3 ha**
Direct	green and golden bell frog	Removal of dams containing fringing vegetation and shelter potential habitat	Permanent	**2.0 ha**
Direct	koala	Removal of potential habitat containing primary and secondary feed trees	Permanent	**83.9 ha**
Direct	large-eared pied bat	Removal of potential foraging habitat	Permanent	**154.5 ha**
Direct	New Holland mouse	Removal of potential habitat in young mine rehabilitation and plantation	Permanent	**4.1 ha**
Direct	grey-headed flying-fox	Removal of potential foraging habitat	Permanent	**154.5 ha**
Indirect	Non-specific Biodiversity related MNES	Removal of 'stepping stone' corridor pathways for fauna movement and gene flow. A potential corridor exists within the Project Area linking woodland and forest habitats to the north and south via Bowmans Creek, Yorks Creek and Swamp Creek.	Medium term	**540.5 ha**
Indirect	green and golden bell frog	One farm dam identified as having suitable potential fringing vegetation habitat will not be directly impacted, but wholly isolated by direct disturbances in surrounding lands.	Permanent	**0.14 ha**

Impact Type	MNES	Description	Nature of Impact	Direct Impact Area
Indirect	Non-specific Biodiversity related MNES	Fugitive light emissions resulting from the Project may result in adverse impacts on adjacent habitats and cause behavioural changes in nocturnal birds and bats. The grey-headed flying fox could potentially be affected if present within, or near to, the Project Area. Given that the proposed action is part of, and adjacent to an existing mine operation with existing impacts, any additional lighting impacts are not expected to be substantial for threatened species, populations and communities.	Medium term	-
Indirect	Non-specific Biodiversity related MNES	Noise and blasting impacts may have a minor indirect impact on fauna species. Potential impacts include noise disturbing the roosting and foraging behaviour of fauna species and/or reducing the occupancy of areas of otherwise suitable habitat. Given that the proposed action is part of, and adjacent to an existing mine operation with existing impacts, any additional impacts resulting from noise emissions are not expected to be substantial for threatened species, populations and communities.	Medium term	-
Indirect	Non-specific Biodiversity related MNES	Air quality impacts have the potential to adversely impact native species from dust generating activities during ground disturbing works. Potential impacts include dust covering vegetation thereby potentially reducing vegetation health and growth and increased air pollutants for native species (flora and fauna). Given that the proposed action is part of, and adjacent to an existing mine operation with existing impacts, any additional impacts resulting from air quality are not expected to be substantial for threatened species, populations and communities.	Medium term	-

Impact Type	MNES	Description	Nature of Impact	Direct Impact Area
Indirect	Non-specific Biodiversity related MNES	Weed species could be inadvertently brought into Project Area with imported materials or could invade naturally through removal of native vegetation. The presence of weed species within the Project Area has the potential to decrease the value of extant vegetation to native species, particularly threatened species. 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. 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 and various land management practices currently implemented. Any additional impacts resulting from weeds or feral animals are insignificant in relation to threatened species, populations and communities.	Medium term	-
Cumulative	Non-specific Biodiversity related MNES	The history of land clearing associated with agriculture and approved mining development has resulted in an incremental loss of vegetation and fauna habitat surrounding the Project Area, and within the Hunter Valley more generally. The Project will result in a loss of approximately 540 hectares of native vegetation. The Project will remove vegetation and further increase fragmentation and isolation of habitats, and thus contribute to cumulative habitat loss and vegetation clearance in the locality.	Medium – long term	-
Consequential	Non-specific Biodiversity related MNES	The Project is an extension of an existing mining operation which uses existing mining facilities. The extension includes the identified economic mining resources therefore consequential impacts are not predicted.	Medium – long term	-

The relevant impacts of the Project are considered to be well known and predictable based on the extensive knowledge of the ecological values of the Project Area and a sound understanding of the impacts of the Project (e.g. clearing of vegetation, earthworks and water management). The direct impacts of the Project, as they relate to the clearing of EPBC Act-listed CEEC and threatened species habitat is predicted to be permanent; however, a detailed biodiversity offset and rehabilitation program has been proposed as part of the Project in order to compensate for the residual impacts of habitat loss that cannot be adequately avoided or minimised. The proposed rehabilitation and reinstatement of habitat will mean that, over time, impacts will not be completely irreversible as most key ecological features will be recovered. Rehabilitation and regeneration of the mine site, in addition to an appropriate biodiversity offset strategy will ensure that there is no residual significant impact to the landscape in the medium-long term as a result of the Project. Further details regarding the proposed biodiversity offset strategy are discussed in Section 8 of the BDAR (refer to Appendix 20 of the EIS).

2.4 Assessment of Outcomes and Effectiveness

The avoidance and mitigation measures proposed are expected to be effective in minimising the impact on the ecological features of the Project Area during construction and operation of the proposed action. As discussed in **Section 4.1.1** above, the changes to the physical components of the Project have resulted in an overall reduction of approximately 158 ha of the native vegetation impacts in the Project Area, and in the preservation of approximately 43 ha of *Central Hunter Valley Eucalypt Forest and Woodland* CEEC.

The majority of the Project Area comprises heavily modified vegetation in the form of grazed derived native grasslands and the Project largely avoids the highest quality remnant forest and woodland occurring in the immediate locality.

Indirect impacts of the construction and operation of the Project (i.e. noise, light, blasting, air quality impacts) on surrounding biodiversity values are expected to be minor as the proposed mine operation is already part of, and adjacent to, existing mining operations with existing indirect impacts. Potential impacts on EPBC Act listed threatened species and communities as a result of mine operations will continue to be managed as per existing site practices.

In addition, the proposed conceptual final land use for the Project includes the development of native vegetation rehabilitation in locations that will enhance connectivity to established offsets and areas of existing vegetation. The conceptual location and extent of this native vegetation is set out in the Rehabilitation and Mine Closure Strategy as documented in Appendix 24 and Section 7.9 of the EIS. The current rehabilitation program at the Mount Owen Complex has proven success in restoring areas of former open cut pits to native vegetation recognisable as PCTs and TECs and trending towards being self-sustainable.

2.5 Biodiversity Offset Strategy

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 biodiversity offset strategy will be developed during the assessment process in consultation with the BCD, DPIE and DOEE and based on the credits required to be retired to offset the impacts of the Project as specified in the BDAR 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.

The biodiversity offset strategy will be developed to meet the stated aims of the EPBC Act Environmental Offsets Policy, being:

- to ensure the efficient, effective, timely, transparent, proportionate, scientifically robust and reasonable use of offsets under the EPBC Act
- to provide proponents, the community and other stakeholders with greater certainty and guidance on how offsets are determined and when they may be considered under the EPBC Act
- to deliver improved environmental outcomes by consistently applying the policy
- to outline the appropriate nature and scale of offsets and how they are determined, and
- to provide guidance on acceptable delivery mechanisms for offsets.

Glencore has a strong record in preparing and implementing biodiversity offset strategies that address significant biodiversity matters and adequately counterbalance impacts on them. Glendell 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 per the results of the BAM assessment, no targeted species-credits for EPBC Act listed threatened species are generated for the Project, however the assessment determined an ecosystem (landscape) credit requirement which includes credits generated for Commonwealth listed communities. The like-for-like offset rules under the NSW Biodiversity Offset Scheme will ensure that the values identified in the Project Area are suitability offset with similar habitat values in the locality and are commensurate with the EPBC Act Environmental Offsets Policy. The like-for-like offset rules under the NSW Biodiversity Offset Scheme include:

- For TECs, offsets must be the same TEC located within the same or adjoining IBRA subregion or in any subregion within 100 km of the impacted site. Where the impacted area contains hollows, the offset must also contain hollows.
- For habitat for threatened species (ecosystem credits), the same class of native vegetation located in the same or adjoining IBRA subregion or in any subregion within 100 km of the impacted site, and within the same or a higher offset trading group.

Table 2.22 outlines the credit requirement for the relevant habitat areas for impacted MNES outlined in **Section 2.2** of this report, as calculated by the BAM. Note: ecosystem credit requirements outlined in **Table 2.22** are not cumulative.

Table 2.22 Ecosystem Credits Relevant for Impacted MNES

MNES	PCTs and Habitats	Area of Impact (ha)	Ecosystem Credits Required
Central Hunter Valley Eucalypt Forest and Woodland CEEC	1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter	95.2	1,490
	1692 Bull Oak Grassy Woodland of the Central Hunter Valley	27.4	313
	1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	0.3	7
	TOTAL	**122.9**	**1,810**
regent honeyeater **swift parrot**	1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter	80.8	1,358
	1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	0.5	11
	TOTAL	**81.3**	**1,369**
spotted-tailed quoll **large-eared pied bat** **grey-headed flying-fox**	1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter	81.6	1,371
	1692 Bull Oak Grassy Woodland of the Central Hunter Valley	28.2	322
	485 River Oak riparian grassy tall woodland of the western Hunter Valley	2.4	34
	1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	0.5	11
	1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	41.8	707
	TOTAL	**154.5**	**2,445**
green and golden bell frog	9 farm dams	2.0	N/A
	TOTAL	**2.0**	**N/A**
koala	1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter	81.6	1,371
	1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	0.5	11
	1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	1.8	28
	TOTAL	**83.9**	**1,410**

MNES	PCTs and Habitats	Area of Impact (ha)	Ecosystem Credits Required
New Holland mouse	1603 – Narrow- leaved Ironbark – Bull Oak – Grey box shrub- grass open forest of the Central and Lower Hunter	1.8	33
	1604 Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter	0.5	11
	1731 Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley	1.8	28
	TOTAL	**4.1**	**72**

3.0 Water Resources

At the time of drafting the referral of the action (Umwelt, 2019b) (the Referral), the groundwater, surface water, aquatic ecology and stygofauna assessments for the Project had not yet been completed. Due to the extent of the Glendell Pit Extension, the proximity to the Bowmans Creek alluvial system and the requirement to realign a section of Yorks Creek, the Referral identified that the Project could potentially have a significant impact on water resources. A similar conclusion was identified in the Gateway Application prepared for the Project (Umwelt, 2019d).

The 10 July 2019 determination that the Project was a controlled action under section 75 of the EPBC Act due to potential impacts on a water resource in relation to coal seam gas development and large coal mining development, requires:

- a consideration of the Project's impacts on water resources and water dependent ecosystems potentially affected as a consequence of these impacts, and
- information on proposed avoidance and mitigation measures to deal with the impacts of the action, and a description of the predicted effectiveness and outcomes that the avoidance and mitigation measures will achieve.

In determining that the Project was a controlled action, DoEE have identified the key significant impacts of the Project associated with groundwater (both the alluvium associated with watercourses and deeper hard rock aquifers) and surface water resources and quality as being:

- groundwater drawdown/depressurisation
- groundwater-surface water connectivity
- potential cumulative impacts and interaction with impacts from neighbouring projects
- potential long-term impacts of mine void, including groundwater losses to evaporation

The Conditional Gateway Certificate for the Project obtained on 24 July 2019 (refer to Appendix 4 of the EIS), included advice provided by the IESC in relation to the Project which identified key areas in which additional assessment would be required as part of the preparation of the EIS.

The IESC considers the key potential impacts from the Project to be:

- diversion of Yorks Creek into Bowmans Creek which will disconnect Yorks Creek from its alluvium and riparian corridor, and potentially alter sediment and flow regimes, bed structure and in-stream habitat availability in both Yorks and Bowmans Creeks
- changes to catchment areas and runoff patterns that could impact sediment and flow regimes and aquatic ecosystems within Yorks, Bettys, Bowmans, Swamp and Main Creeks
- groundwater drawdown within the alluvial aquifers, with potential impacts on groundwater-dependent ecosystems (GDEs) such as saturated alluvial sediments (including stygofauna) and groundwater-dependent vegetation
- the presence of a final void in the rehabilitated landscape which could impact long-term surface water and groundwater quality (particularly salinity) and

- the further contribution to cumulative impacts on groundwater (possibly until 2200), surface water and native flora and fauna in the wider Hunter Region.

The IESC strongly encouraged the assessment to include information on Glencore's experience with rehabilitation in the area and their control of the mines in the area linked through the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS) and how this existing data and information is used to assess potential cumulative impacts of the Project.

The IESC also encouraged consideration of appropriate rehabilitation strategies that will protect riparian corridors and link to current offset areas and other refuge habitats as source areas for plant and animal colonists in a changing climate.

Additionally, the IESC made the following recommendations in relation to the assessment of water resources to be undertaken during the preparation of the EIS:

- provide further information on the baseline conditions of both groundwater and surface water resources including water quality, flow regimes and hydrological connectivity

- after completion of the proposed field mapping of alluvial aquifers in the project area, provide estimation of groundwater drawdown and the likely effects on surface flows (especially low flows and ecologically important flow components) in associated creeks

- update the groundwater model, including a sensitivity and uncertainty analysis and quantification of surface water-groundwater

- include flood modelling that incorporates infrastructure changes, the Yorks Creek diversion and the final landform to assess flood risks to mine pits and detention storages and changed floodplain behaviour

- include a detailed site water balance that specifies uncertainties in inputs and performance under future climatic conditions

- include a geochemistry study specific to the project area which assesses all waste rock material

- provide further information on the salt balance of the site and salt sources and stores within the final landform, including salt derived from the alluvial aquifer

- provide a general ecohydrological conceptual model showing potential impact-effect pathways on water-related ecological assets, including GDEs and aquatic biota. An additional ecohydrological model specifically addressing the proposed Yorks Creek diversion and its confluence with Bowmans Creek may be needed to further understand potential impacts from changes to flows, bank and bed stability and hyporheic conditions in Bowmans Creek.

- provide detail on the proposed diversion of Yorks Creek and how the diversion will be built and managed to preserve ecological functions (including those occurring in hyporheic and riparian corridors) currently supported by Yorks Creek.

- undertake ecological studies to determine the baseline condition of the aquatic ecosystems including permanent and semi-permanent pools (e.g. surface water flora and fauna), riparian vegetation and alluvial sediments (e.g. stygofauna, hyporheos) in all creeks potentially affected by the project.

- include explicit consideration and assessment of project-specific risks, and their materiality at different stages of the project, including during rehabilitation. This is required to inform the selection of appropriate mitigation options and development of management plans.

- include assessment of potential cumulative impacts on groundwater and surface water quality, dynamics (e.g. flow regimes, groundwater flux) and biota (e.g. riparian vegetation, fish).

Section 3 has been structured as follows to address the assessment requirements set out by the IESC and other relevant Commonwealth assessment requirements for impacts on water resources:

Section 3.1 describes the general approach to the assessment, including the use of a specific water resources risk assessment to refine the assessment approach

Section 3.2 identifies the key impact pathways considered in the assessment and summarises the results of the various studies undertaken in relation to impacts on groundwater and surface water systems

Section 3.3 contains a summary of results of the specialist studies undertaken to assess the impacts on surface and groundwater systems

Section 3.4 contains a detailed summary of the Project's potential impacts on water dependant ecosystems.

The assessment of water resources and associated biodiversity impacts for the Project have been influenced and refined through the development of multiple studies. **Section 3** should be read in conjunction with the relevant studies including:

- The Biodiversity Development Assessment Report (BDAR) including the Aquatic Ecology Assessment (which forms Appendix F of the BDAR), refer to Appendix 20 of the EIS

- Groundwater Impact Assessment, refer to Appendix 16 of the EIS

- Surface Water Impact Assessment, refer to Appendix 17 of the EIS

- Geochemical Assessment, refer to Appendix 19 of the EIS

- Stygofauna Assessment, refer to Appendix 21 of the EIS

Appendix D1 includes a table identifying the areas identified by the IESC requiring further assessment in relation to the impact on water resources and associated biodiversity, a summary of the assessment findings and details regarding where the specific assessment details regarding these key assessment areas could be found in the EIS.

Appendix D2 includes an assessment against the Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (Commonwealth of Australia, 2013).

3.1 Context and approach to the assessment

3.1.1 Approach to Assessment

The Project Area and surrounding areas have been subject to open cut and underground mining for over 50 years which has impacted the local and regional groundwater system. Previous mining operations and existing and approved mining operations have already significantly altered the groundwater environment in the vicinity of the Project Area and surrounds, with some of the coal seams proposed for mining currently being significantly depressurised. Over the life of the Project, these existing and approved mining operations will further affect these systems. The impacts are complex and vary both spatially and temporally depending on the timing and scale of the operations.

To ensure a comprehensive assessment of potential impacts on water resources, a risk assessment (guided by the impact pathway approach used by the IESC for regional assessments) was developed with technical and expert input from Glencore, Umwelt, AGE and GHD. This risk assessment was undertaken in an iterative manner and was refined over the duration of the assessment as additional information became available on both the receiving environment and the Project itself.

Due to the existing modified state of the groundwater systems in the region, a conceptual groundwater model was used to inform the risk assessment with detailed numerical groundwater model predictions used to verify impacts considered in the risk assessment. The assessment of groundwater related impacts was informed by the conceptual groundwater model developed for the area. The conceptual hydrogeological model is included as **Appendix B1**. The water resources risk assessment which covers the various Project components and potential impact pathways on water resources and water dependent ecosystems is included as **Appendix C1**. The risk assessment provides an analysis of the Project's potential risks to water resources and water dependent assets having regard to the outcomes of the assessments and the proposed mitigation measures. The risk assessment also identifies where more detailed assessment studies may be required to inform the detailed design of water management structures (e.g. detailed design features to manage erosion risks and sedimentation).

The early iterations of the water resources risk assessment guided a comprehensive assessment of potential groundwater and surface water impacts that have been undertaken for the Project in accordance with the SEARs. The SEARs require 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. The assessments address the requirements of all relevant NSW and Commonwealth Government legislation and policies including the NSW Aquifer Interference Policy (AIP), national groundwater modelling requirements and the requirements of the Independent Expert Scientific Committee (IESC). The Groundwater Impact Assessment (AGE, 2019) also considers the significance of the impact of the Glendell Pit Extension on groundwater resources according to the Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (Commonwealth of Australia, 2013).

The Groundwater Impact Assessment (AGE, 2019) and the Surface Water Impact Assessment (GHD, 2019) provide a detailed description of the relevant methodology applied to the assessments.

3.1.2 Context

3.1.2.1 Topography

Existing Landscape and Topography

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 characterised by an undulating and hilly landscape extending to lower areas associated with the creek lines that traverse the Project Area. Elevations range between 70 mAHD in the south and 400 mAHD in the northern extent of the Mount Owen Complex, north of Mount Owen Mine. 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.

Emplacement areas at the Mount Owen Complex are approved to up to approximately 230 mAHD. The Glendell Pit Extension will affect land with elevations of between approximately 70 mAHD and 130 mAHD (excluding areas of the Glendell and Ravensworth East emplacement areas impacted by the Glendell Pit Extension).

The Ashton Coal Mine emplacement area is located between the current Glendell mining area and Camberwell to the south. This emplacement area rises to approximately 135 mAHD and precludes direct views of the current Glendell operations from Camberwell.

There is an extensive alluvial floodplain associated with Bowmans Creek. The Yorks, Swamp and Bettys Creek systems all have alluvial areas directly connected to the Bowmans Creek alluvium. Areas associated with the alluvial plains of Bowmans Creek, Yorks Creek, Swamp Creek and Bettys Creek are generally flat to gently sloping. The Bettys Creek alluvium located to the east of the Glendell Mine would have historically been connected to the Bowmans Creek alluvium however the diversion of Bettys Creek around the south of the Glendell Mine has effectively removed the alluvial connection in this area.

Extensive field investigations and a desktop study have been undertaken as part of the Groundwater Impact Assessment to confirm the extent and thickness of the Bowmans Creek (and its tributaries Swamp and Yorks Creek) alluvium in proximity to the Project (refer to Appendix 16 of the EIS). This work supplements earlier studies to define the extent of the Bettys Creek and Main Creek alluvium in proximity to the Mount Owen North Pit (AGE, 2017). The extent and depth of mapped alluvium is discussed further in Section 7.5 of the EIS.

The current topography, creek lines and alluvial extent surrounding the Project Area is shown in **Figure 3.1.**

Future approved topography

At the Mount Owen Complex, mining operations in the Bayswater North Pit are approved to extend to the east with in-pit emplacement behind the active mining area and on the Ravensworth East emplacement area. Mining in North Pit will progress to the south with in-pit emplacement behind the active mining area and on the Mount Owen emplacement area and out-of-pit emplacement at the western out of pit (WOOP)

emplacement area and over areas of the Eastern Rail Pit (ERP) former tailings storage facility. West Pit will be used as a tailings storage facility as part of the GRAWTS (refer to **Section 3.1.2.6**) until filled when it will be capped and the Ravensworth East emplacement area shaped to ensure this area is free draining. The approved conceptual final landform for the Mount Owen Complex has the area between the Ravensworth East and the WOOP emplacement areas and part of the Mount Owen emplacement area draining towards Swamp Creek. The voids (North Void Stage 1 & 2) in the northern parts of the former Ravensworth East mining area (west of Hebden Road) have been used for tailings emplacement and are in the process of being capped and rehabilitated as free draining landforms.

Three final voids are currently approved at the Mount Owen Complex in the North Pit, Bayswater North Pit and the currently approved Glendell Pit. Pit lakes are modelled to develop in each of these mining voids following the cessation of mining, each operating as a long-term groundwater 'sink'.

The approved conceptual final landform for the Mount Owen Complex and likely topography surrounding the Project Area is shown in **Figure 3.2.**

3.1.2.2 Hydrology

The Project Area 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. Mining associated with existing approved operations at Glendell and Mount Owen is also located within the Bettys Creek and Main Creek catchments.

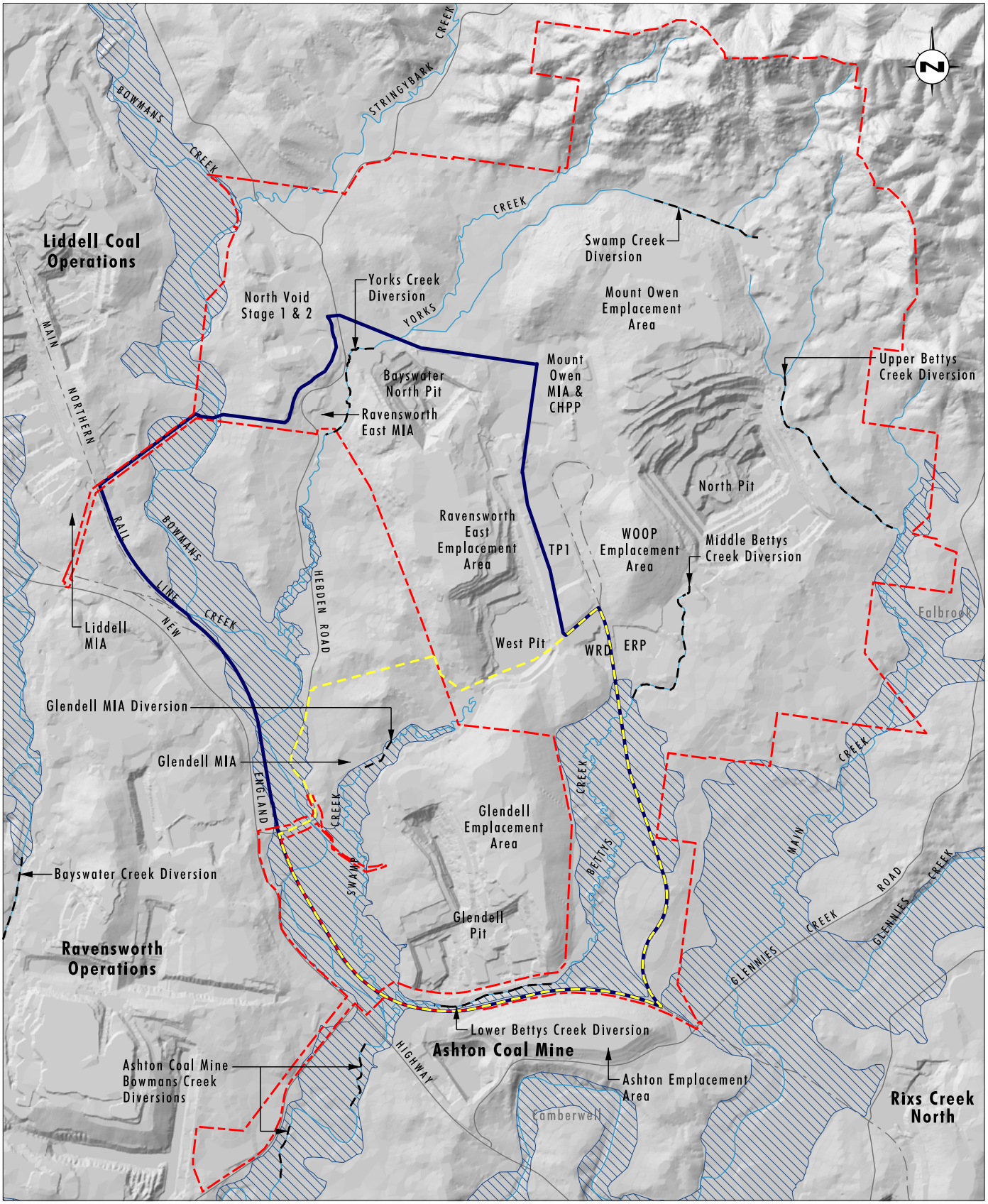
Bowmans Creek and Glennies Creek are the two most significant creeks surrounding the Project Area. Bowmans Creek is a semi-permanent creek with flow rates heavily influenced by rainfall. Bowmans Creek includes pools (refer to **Plate 3.1**) including some which have maintained water throughout the most recent drought. Bowmans Creek also contains long sections of creek bed lined with cobbles (refer to **Plate 3.2**). Glennies Creek is located downstream of Lake St Clair and is a regulated creek system meaning it has almost permanent flow. The Glennies Creek catchment is not directly affected by the Project.

Yorks Creek, Swamp Creek and Bettys Creek (refer to **Plates 3.3** and **3.4**) are all ephemeral systems which only flow after heavy rainfall events. These creeks have few persistent pools and no permanent pools.

Previous mining operations have significantly modified local catchments through the capture of runoff from disturbed areas and diversion of upslope runoff around the mining operations (refer to **Figure 3.1**). The upper sections of the former Swamp Creek catchment are upstream of the Mount Owen Complex. These remnant tributaries to Swamp Creek have been diverted around the Mount Owen Complex to the west via a series of dams. Following large rainfall events, these dams overflow towards Yorks Creek. These dams are the only permanent water in the Yorks Creek catchment. The existing diversions of Yorks, Swamp and Bettys Creeks are discussed in further detailed in the EIS. Bowmans Creek has also been diverted downstream of the Project Area as part of the approved Ashton Coal Mine.

Surface water runoff from the disturbed areas of the Bowmans Creek catchment in and around the Project Area are currently managed by the water management systems for the relevant mining operations. As a result, the catchment area of Bowmans Creek in the vicinity and downstream of the Project Area is smaller than the pre-mining environment. The progressive release of rehabilitated areas to the Bowmans Creek catchment will increase flows in local tributaries and Bowmans Creek itself throughout the life of the Project.

The key drainage lines in the vicinity of the Project are shown in **Figure 3.1**)



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

0 1.0 2.0 3.0 km

Legend

- Project Area
- Glendell Consent Boundary
- Mount Owen Consent Boundary
- Existing Creek Diversion
- Mapped Alluvium (AGE 2019)
- Drainage Line

FIGURE 3.1

Topography and Drainage (Existing Conditions)

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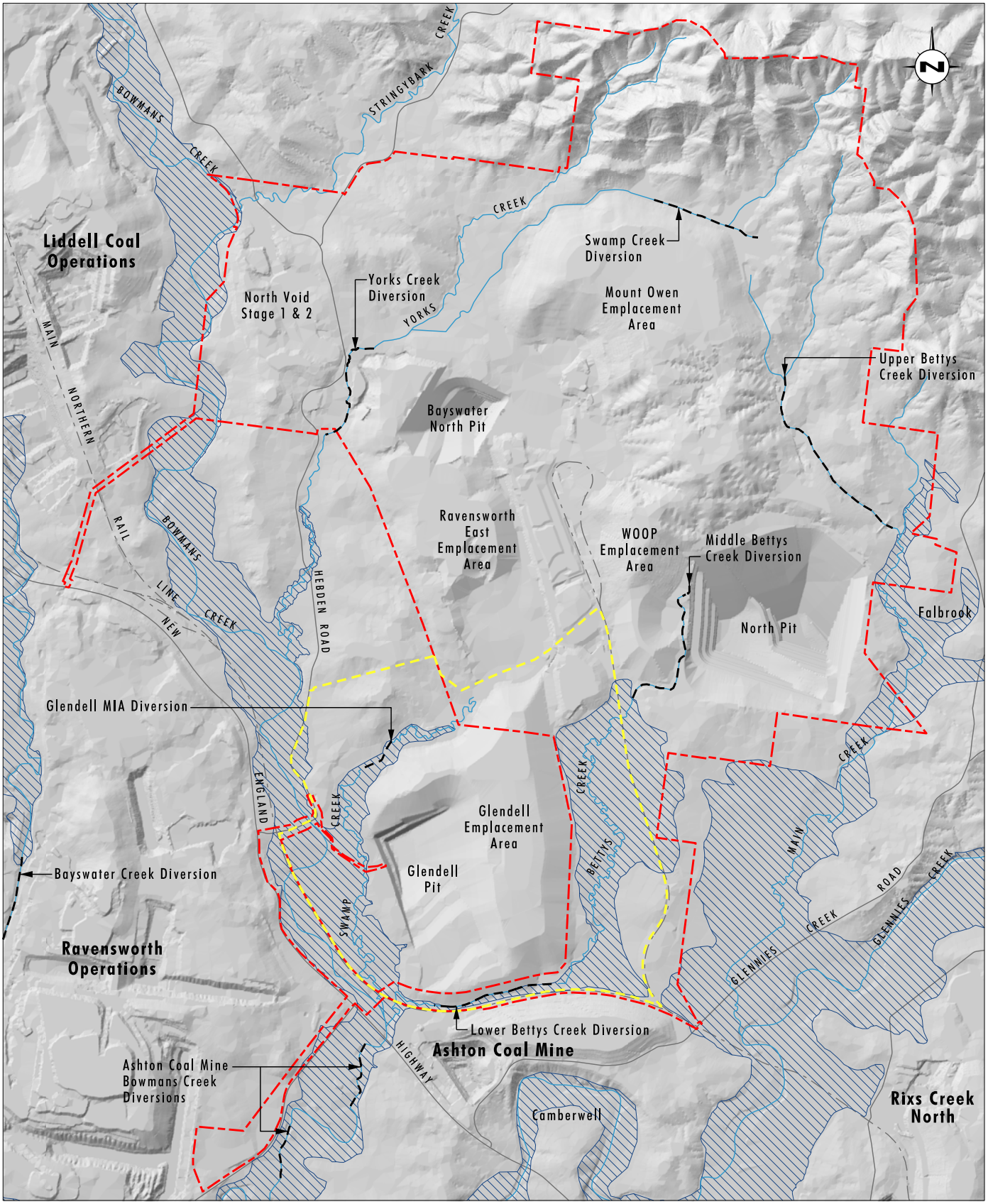


Data Source: Glencore (2019)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

0 1.0 2.0 3.0km

Legend

- Glendell Consent Boundary
- Mount Owen Consent Boundary
- Existing Creek Diversion
- Mapped Alluvium (AGE 2019)
- Drainage Line

FIGURE 3.2

Future Approved Topography (Conceptual Final Landform)

Plate 3.1 **Pool in Bowmans Creek upstream from confluence with Yorks Creek (January 2018)**

Plate 3.2 **Bowmans Creek upstream from proposed Yorks Creek Realignment confluence (October 2017)**

Plate 3.3 **Yorks Creek downstream from Hebden Road crossing (September 2019)**

Plate 3.4 **Yorks Creek upstream from Hebden Road crossing (September 2019)**

3.1.2.3 Hydrogeology

The two main hydrogeological features occurring within and surrounding the Project Area are:

- Quaternary alluvium
- Permian sediments – which can be divided into:
    - thin and variably permeable weathered rock (regolith)
    - non-coal interburden that forms aquitards (a body of rock that retards but does not completely stop the flow of water)
    - low to moderately permeable coal seams that act as the most transmissive strata within the coal measures.

The alluvium along Bowmans Creek (refer to **Figure 3.1**) forms a thin aquifer system in the Project Area and adjacent to the Glendell Pit Extension. The Bowmans Creek alluvium is commonly less than 10 m in thickness with the most permeable part of the sequence being the 'bed load' sand and gravels that readily transmit groundwater.

Geological maps show alluvial sediments occur along Bettys Creek, Swamp Creek and Yorks Creek. Field investigations indicate the alluvium occurring along these tributaries is thin, clayey and contains saline groundwater. The Bowmans Creek alluvium is the only geological strata in the Project Area that has the potential at certain times to meet the NSW government criteria to be classified as a 'highly productive' groundwater source, which requires TDS concentrations less than 1,500 mg/L and contain water supply works that can yield water at a rate greater than 5 L/s. The Glennies Creek alluvium is also classified as a 'highly productive' groundwater source. All other formations are classified as 'less productive' including the areas of alluvial sediments occurring along Yorks Creek and Swamp Creek within the Glendell Pit Extension.

The Permian coal measures form less productive groundwater systems, with the coal seams being the most permeable lithology within the Permian sequences. The Project is situated along the hinge of an anticline structure with the sequence of coal seams dipping from the hinge axis towards the east and west where adjacent mining operations extract coal via open cut and underground methods. The Permian strata is also not considered to form a highly productive aquifer because of generally poor water quality and low yields that preclude any beneficial use. TDS concentrations in the Permian strata are generally in the range of 500 mg/L to 15,000 mg/L.

Permian sediments outcrop in the Glendell Pit Extension and are recharged via rainfall infiltrating through the soil cover and weathered Permian profile. Groundwater flows from areas of high head (pressure plus elevation) to low head via the most permeable and transmissive pathways. In the absence of mining activities the main discharge mechanism for groundwater within the Permian strata is typically through slow upward flow to low lying alluvium along creeks, particularly Bowmans Creek. However, groundwater monitoring from the Project Area and surrounds shows that approved mining activities have depressurised the Permian groundwater systems and reduced water levels below the base of the alluvium. This means the main discharge zone for groundwater within the Permian interburden and coal seams is to surrounding mining operations, either closed or operating.

The monitoring data indicates a high degree of variability within the groundwater system in relation to salinity, which is the key constraint to groundwater use. Groundwater with the lowest levels of salinity occurs within the Glennies Creek alluvium, which is likely attributed to the releases from the upstream dam regulating flow. Records of Bowmans Creek alluvium indicate typically fresh to brackish groundwater, dependent on the location and duration following rainfall and flows within the ephemeral system,

indicating that some areas of Bowmans Creek alluvium can be considered 'highly productive' based on salinity and in other areas it is categorised as 'less productive' according to the NSW government criteria.

Samples of groundwater from Bettys Creek, Swamp Creek, and Yorks Creek, all of which are tributaries of Bowmans Creek, record widely varying salinity from fresh to highly saline waters. However, available data indicates high salinity, low transmissivity and low saturated thickness within Bettys Creek, Swamp Creek and Yorks Creek alluvium, indicating these systems are classified as a 'less productive' groundwater source.

The generally variable nature of salinity within the smaller tributaries of Bowmans Creek indicates relatively slow movement of groundwater, with low permeability areas hindering the recharge and flushing of salts from the sediments. The occurrence of the salinity is due to evapo-concentration of rainfall recharge and flow of saline groundwater from the underlying Permian strata into the base of the alluvium where the regional water table is above the base of alluvium or has been in the past.

With the exception of parts of the Bowmans Creek alluvium and the Glennies Creek alluvium, water quality monitoring indicates the alluvium and Permian groundwater systems are generally not suitable for potable or irrigation uses due to salinity. The concentration of some metals also exceeds the ANZECC (2000) guidelines for freshwater aquatic ecosystems, however this is typical in groundwater systems where trace elements can be naturally concentrated above guideline values for aquatic ecosystems that would rely on fresh water. The results also indicate that groundwater from some areas within the alluvium and Permian systems could yield groundwater with salinity levels that could be used for stock water supply according to the ANZECC (2000) guidelines, however these areas are not consistent throughout the groundwater systems.

3.1.2.4 Regulatory Context

The Mount Owen Complex exists within a well-regulated water resource management system that has been designed to provide for the sustainable management of the NSW's water resources. This includes licensing of allowable water take with consideration of environmental flow requirements of watercourses and the needs of other water users; control of water pollution, management of sustainable salt loads associated with all water sources, mine water discharges; and guidelines that govern the appropriate design of water management systems for mines to provide for appropriate water quality in accordance with NSW *Protection of the Environment Operations Act 1997* (POEO Act) requirements.

Regulation of water quality

The POEO Act is the key piece of environment protection legislation that regulates the pollution of water in NSW. Section 120 of the POEO Act contains a general prohibition on the pollution of water except where authorised by an Environment Protection Licence (EPL) issued under the POEO Act. Pollution of waters is broadly defined in the POEO Act as:

> *placing in or on, or otherwise introducing into or onto, waters (whether through an act or omission) any matter, whether solid, liquid or gaseous, so that the physical, chemical or biological condition of the waters is changed*

The definition of water pollution also includes the emplacement of material in locations where it has the potential to cause a change in water quality. It is a defence to a prosecution under Section 120 of the POEO Act if the discharge is authorised under an EPL.

The Hunter River Salinity Trading Scheme (HRSTS) is implemented under the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*. The HRSTS is a market-based instrument that uses a cap-and-trade mechanism to control the discharge of salt into the Hunter River. The scheme ensures that salinity in the Hunter River is maintained at an appropriate level that is suitable for local primary producers to use for irrigation and to manage the impact of saline discharges on the health of

the river. The scheme is operated by WaterNSW under a service agreement with the EPA. All licenced discharges from mining operations in the Hunter Valley are subject to the HRSTS.

As discussed in **Section 3.1.2.4**, neither of the EPLs applicable to the Mount Owen Complex authorise water discharges.

Regulation of water 'take'

Water sources in NSW are managed via Water Sharing Plans (WSP)s under the *Water Management Act 2000* (WM Act). Provisions within WSPs provide water to support the ecological processes and environmental needs of groundwater dependent ecosystems and waterways. WSPs also regulate how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

Water Access Licenses (WALs) issued under the WM Act entitle licence holders to specified share components in the available water that may be sustainably extracted from a particular water source. The actual volume of water available to be extracted may vary, dependent on available water determinations made under the WM Act. Available water determinations are made for each WAL category in each water source and are generally made at the start of a water year, although may be altered at any time.

Landholder Rights

Under the WM Act, extraction of water for basic landholder rights is protected by allocating and prioritising water for basic landholder rights. There are three types of basic landholder rights in NSW under the WM Act:

- domestic and stock rights
- native title rights
- harvestable rights.

Native title rights are not relevant to the assessment of licensing requirements for the Project. Domestic and stock rights are relevant to the retention or creation of water storages in the final landform. These rights and their implications for licensing need to be considered in the mine closure planning process.

Landholders are entitled to collect a portion of runoff from their property and store it in one or more dams up to a certain size, known as a 'harvestable right', which is determined from the total contiguous area of land ownership. In the Central and Eastern Divisions of NSW (where the Project is located), landholders may capture and use up to 10% of the average regional runoff for their property without requiring a licence under the WM Act. If the maximum harvestable right is exceeded, licensing for the volume of water extracted from the surface water source exceeding the harvestable right is required under the WM Act.

The total contiguous landholdings at the Mount Owen Complex are currently approximately 8,560 ha. Based on the maximum harvestable rights calculator (DNR 2019), this entitles Glencore to capture up to 599 ML/annum. Existing water storages on the contiguous landholdings outside of the WMS at the Mount Owen Complex have a total catchment area of about 21 ha, with an estimated volume of 165 ML, based on a typical average depth of 2 m. This total volume is well within the maximum harvestable rights, based on the current contiguous landholdings, affording an estimated net harvestable rights entitlement of 434 ML.

The following classes of dam are exempt from the calculation of the maximum harvestable right:

- dams solely for the control or prevention of soil erosion, provided no water is reticulated or pumped from the dams and the size of the dam is the minimum necessary to fulfil the erosion control function.

- dams solely for flood detention and mitigation, provided no water is reticulated or pumped from the dams.
- dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by regulation to prevent the contamination of a water source.
- dams endorsed for specific environmental management purposes.
- dams without a catchment (i.e. turkey nest dams).

Water captured within the Mount Owen Complex WMS (other than clean catchment areas which report to the WMS) are exempt from the harvestable rights requirements and do not require licensing while meeting the above criteria.

Water Sharing Plans

In terms of surface water and alluvial water licensing, the Project is located within the area regulated by the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (Hunter Unregulated WSP). The Project is located within the Jerrys Water Source. The eastern parts of the North Pit at Mount Owen are located within the Glennies Water Source. The Hunter Regulated River Alluvium Water Source applies to alluvial aquifers associated with regulated sections of the Hunter River; this includes alluvium adjacent to Glennies Creek.

The Water Sharing Plan for the Hunter Regulated River Water Source 2016 (Hunter Regulated WSP) applies to surface flows in the Hunter River and Glennies Creek which are downstream of the Project Area. The Hunter Regulated WSP covers the Hunter River surface water flows and highly connected alluvials described in the plan. The Hunter Regulated WSP is divided into three management zones (Zone 1, Zone 2, Zone 3). The zones are defined from a single common point, which is the junction of Glennies Creek with the Hunter River. The Project is located adjacent to and to the north of Zone 3A along Glennies Creek. This zone extends from the upper reaches of Glennies Creek Dam to the Hunter River junction.

The coverage of the various WSPs and water sources and management zones applying to surface flows and alluvial systems in the vicinity of the Project are shown in **Figure 3.3**.

Groundwater in the Permian systems are regulated by the North Coast Fractured and Porous Rock Groundwater Sources 2016 (North Coast Fractured and Porous Rock WSP). The North Coast Fractured and Porous Rock WSP commenced on 1 July 2016 and establishes the management regime relevant for groundwater taken from the Permian bedrock. The Project falls within the Sydney Basin – North Coast Groundwater Source of the North Coast Fractured and Porous Rock WSP.

The Proponent is required to hold adequate water entitlements to account for licensable take from water sources as a result of the Project at the time the take occurs.

Regulation of activities in the vicinity of water courses

In addition to the POEO Act and water take licensing requirements under the WM Act, the WM Act and *Fisheries Management Act 1994* both require approvals for certain works in the vicinity and in the bed of water sources. The two key approvals in this regard are:

- Controlled activity approvals under section 90 of the WM Act – apply to works within 40 m of a watercourse)
- Dredging permit under section 201 of the *Fisheries Management Act 1994* – applies to works in the beds of watercourses.

Neither of these approval requirements apply to the Project due to the operation of section 4.41 of the EP&A Act (whereby certain approvals are not required for State significant development); instead, the issues regulated through these approvals are managed through the conditions imposed on the development consent for the Project.

3.1.2.5 Mount Owen Complex Water Management System

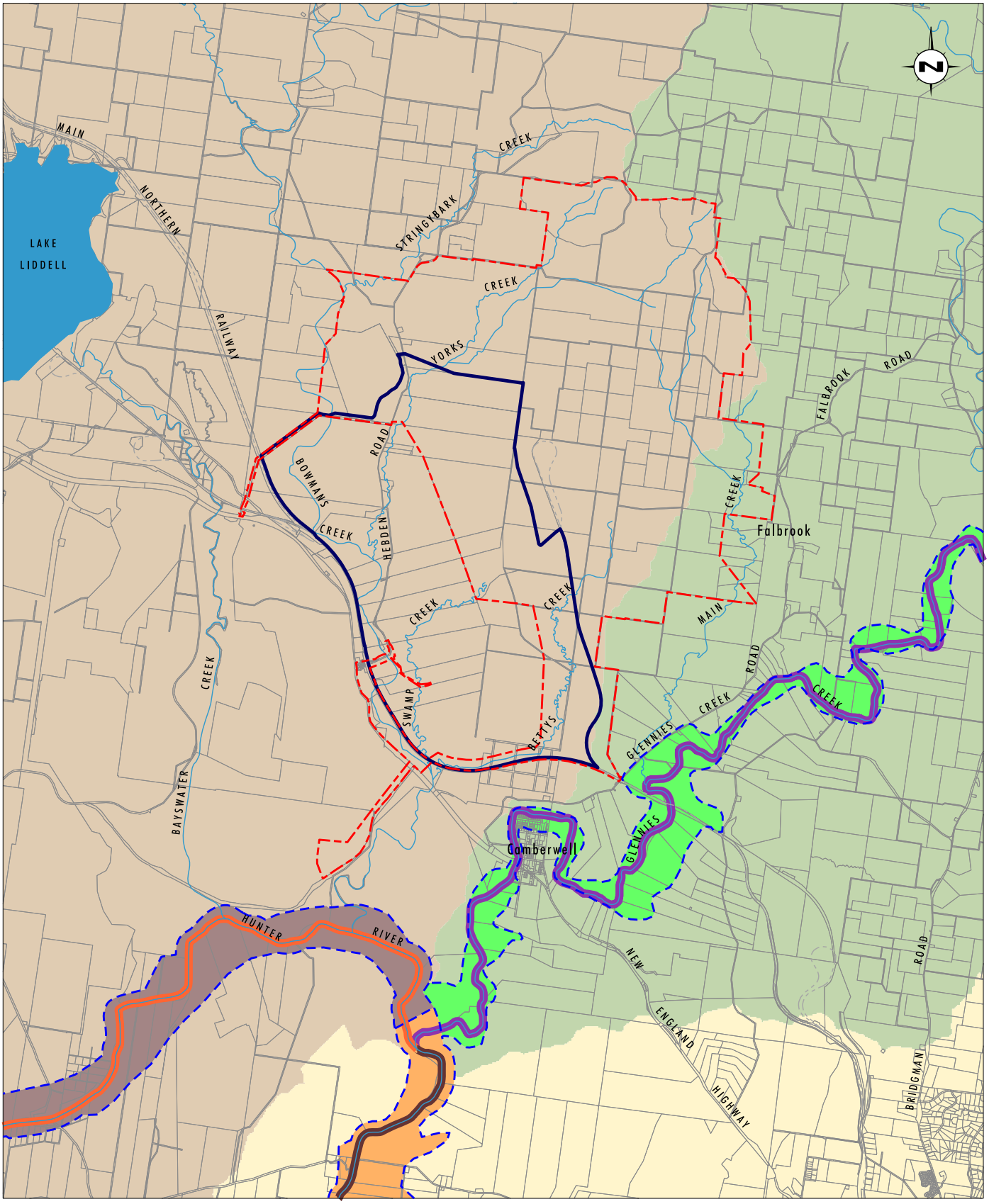
Water management at the Mount Owen Complex considers three categories of water, each with different potential to cause environmental harm. The target design criteria for water storages holding the three categories of water are based on the management of pollution risk and are summarised in **Table 3.1**.

Table 3.1 Design Criteria for Components of Mount Owen Complex Water Management System

Water Category	Water Description	Target Storage Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas and selected hard surface areas where coal and fuel/oil contamination risks are low. Raw water sourced under licence from Glennies Creek is also managed as clean water until use.	N/A – no pollution risk from discharge. Runoff from clean catchments is released, where feasible and practicable, to downstream environment.
Dirty	Runoff from disturbed areas and overburden emplacement areas (does not include water captured in mining pit areas, runoff from coal processing areas and workshops).	Managed in line with the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*). Designed with capacity to manage runoff from the 5 day, 95th percentile rainfall event. Water captured in sediment dams is pumped to storage dams where it is used for operational purposes.
Mine	Runoff from active mining areas and areas exposed to coal, runoff from coal processing areas and workshops, groundwater recovered from mining areas, or water used in coal processing or from coal stockpile areas and water recovered from tailings.	Contained for events up to and including the 1% annual exceedance probability (AEP) 24-hour storm event.

Raw water obtained under licences from Glennies Creek is used at the Mount Owen and Glendell MIAs. Mine water (including water pumped from the dirty water system sediment dams) is used for operational purposes at the Mount Owen Complex, including the CHPP and for dust suppression.

The Project does not contemplate any water discharge points which require licensing under the *Protection of the Environment Operations Act 1997* (POEO Act) (see **Section 3.1.2.5** below).



Data Source: Glencore (2018), Geoscience Australia (2006), LPI (2017)
Note: Mount Owen Consent Boundary assumes Narama Pipeline Modification is approved

Legend

- Project Area
- Mount Owen Consent Boundary
- Drainage Line

Hunter Unregulated and Alluvial Water Sharing Plan Water Sources:

- Glennies Water Source
- Jerrys Water Source
- Singleton Water Source
- Downstream Glennies Creek Management Zone
- Glennies Creek Management Zone
- Upstream Glennies Creek Management Zone

Hunter Regulated River Water Sharing Plan Management Zones:

- Management Zone 1B
- Management Zone 2B
- Management Zone 3A

FIGURE 3.3

Surface and Alluvial Water Sharing Plans

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The design of dirty water storages is consistent with relevant NSW guidelines including the 'Managing Urban Water – Soils and Construction' series, commonly referred to as the 'Blue Book'. The Blue Book is a set of guidelines developed for particular industries to manage the risk of water pollution from activities associated with those industries; Volume 2E applies specifically to mines and quarries. The Blue Book identifies specific erosion and sediment control measures for implementation at mine sites. The guidelines are based on a principle of preventing pollution through erosion control as well as implementing best practice sediment control practices. The Blue Book operates on a principle of managing run-off such that it is of an appropriate quality to meeting the broad objective of not causing pollution of receiving waters. This is done through a range of factors including design criteria for sediment control dams which have regard to sediment risks (including soil dispersibility) and run-off rates. The applicability of these controls for any given mining operation should also have regard to the geochemical characteristics of material potentially entrained in run-off as sediment.

3.1.2.6 Greater Ravensworth Area Water and Tailings Scheme

Through the linkage with the Mount Owen Complex WMS, the Project will be connected with Glencore's Greater Ravensworth Area Water and Tailings Scheme (GRAWTS) which enables the transfer of water between the mining operations linked to the GRAWTS. At present, the Mount Owen Complex, Integra Underground, Liddell Coal Operations and Ravensworth Coal Operations are all linked via this scheme. The GRAWTS also includes pipeline infrastructure which enables the transfer of tailings material between operations to enable tailings facilities to be managed more efficiently.

The GRAWTS allows greater flexibility in water management for the Mount Owen Complex by allowing mine water to be transferred from sites with excess water to sites with storage capacity and/or higher usage demands or discharge opportunities. This flexibility assists in reducing the need to draw raw water from licenced external sources, including the Hunter River and Glennies Creek, and reduces the need to discharge water under the Hunter River Salinity Trading Scheme (HRSTS). The Mount Owen Complex does not have a licenced discharge point.

The key GRAWTS linkages between the Mount Owen Complex and other mines include:

- linkage between Ravensworth Operations and the Mount Owen Complex for the transfer of tailings
- linkage between Liddell Coal Operations and the Mount Owen Complex for the transfer of tailings
- linkage between Liddell Coal Operations and the Mount Owen Complex for the transfer of mine water
- linkage between Integra Underground and the Mount Owen Complex for the transfer of mine water
- a linkage between Ravensworth Operations and the Mount Owen Complex for the transfer mine water (referred to as the Narama Pipeline).

Excess mine water at the Mount Owen Complex is managed under the GRAWTS with any necessary discharges occurring at the Ravensworth Operations and/or Liddell Coal Operations pursuant to licenses held for those operations. The Project does not propose any change to these arrangements, in terms of either allowable levels of discharge (frequency or volume) or the location of the existing approved discharge points. Water quality from these discharges must meet the quality requirements set out in the applicable environmental protection licence (EPL) and the Hunter River Salinity Trading Scheme (HRSTS). The Project does not propose any change to water quality limits currently imposed on the Ravensworth Operations or Liddell Coal Operations EPLs.

3.2 Impact Pathways

The Project's potential impacts on groundwater, surface water and water dependent ecosystems are identified in the water resources risk assessment in **Appendix C1** including specific impact pathways and interactions between groundwater and surface water systems. The following summarises the key impact pathways relevant to the assessment of impacts on water resources associated with the Project.

3.2.1 Potential Groundwater Impacts

As previously discussed, the previous mining operations and existing and approved mining operations have already significantly modified the groundwater environment in the Project Area and surrounds. Over the life of the Project, these existing and approved mining operations will further affect these systems. The impacts are complex and vary both spatially and temporally depending on the timing and scale of the operations.

The following aspects of the Project have the *potential* to impact on groundwater resources and have been assessed:

- direct interception of Permian (hard rock and regolith) aquifer systems by the mining operations
- depressurisation of Permian aquifer systems as a result of intersection by the mining operations
- direct interception of alluvial aquifers in Swamp Creek and Yorks Creek by the mining operations
- induced drawdown in alluvial aquifer systems as a result of depressurisation of Permian aquifer systems
- changes in water quality (positive and negative) in alluvial aquifer systems as a result of changes in flow between alluvial and Permian aquifer systems
- changes in Permian aquifer systems water quality associated with water table and pit lake recovery in mined areas and voids.

3.2.2 Potential Surface Water Impacts

The following aspects of the Project have the *potential* to impact on surface water resources and have been assessed:

- 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 disturbed by the Project
- changes to the site water balance and subsequent impacts to the GRAWTS
- permanent realignment of the lower reach 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 catchments and potential impacts on downstream catchments from changes to flow regimes and flooding, and
- reduced baseflow in creeks associated with impacts on groundwater systems.

The above impact pathways are common to most mining operations in the Hunter Valley, including historical and approved operations in an around the Project Area, and have been considered for the Project in both a Project specific and a cumulative context. A key component of the assessment of the Project's potential impacts on groundwater systems has therefore been understanding the existing impacts associated with previous and approved mining operations in the region.

The Groundwater Impact Assessment (Appendix 16 of the EIS) and the Surface Water Impact Assessment (Appendix 17 of the EIS) provide a full assessment of the potential impacts of the Project and a consolidated list of proposed management and mitigation measures are contained in Appendix 5 of the EIS. Assessment of the potential impacts against the Significant Impact Guidelines 1.3 (Commonwealth of Australia, 2013) (refer to **Appendix D2** of this report and Appendix E2 of the Groundwater Impact Assessment) and against the IESC information guidelines has also been undertaken (refer to Appendix E2 of the Groundwater Impact Assessment).

3.3 Groundwater and Surface Water Impact Summary

The following provides a summary of the groundwater and surface water impact assessment results. Further detail is provided in the Groundwater Impact Assessment (Appendix 16 of the EIS) and the Surface Water Impact Assessment (Appendix 17 of the EIS). Details regarding the assessment methodology are contained in the relevant assessment documentation and Section 4.5 of the EIS.

3.3.1 Groundwater Impact Summary

There is little to no historical monitoring of pre-mining water table levels in the vicinity of the Project due to the long and extensive history of mining (>50 years). There is however an extensive monitoring network of standpipes and vibrating wire piezometers in the region which monitor groundwater levels and pressures in both the Permian aquifers potentially impacted by the Project and the alluvial systems in the region. The groundwater assessment has therefore focussed on understanding the extent of impacts from existing approved operations to enable the scale and extent of impacts from the Project to be understood relative to both existing conditions and modelled impacts of existing approved operations.

Monitoring and modelling indicates the regional groundwater system is in an ongoing state of flux with some areas continuing to experience ongoing depressurisation associated with active mining operations while others will begin a process of recovery as mining is completed and final voids and in-pit-emplacement areas refill through a combination of groundwater inflows and rainfall contributions and underground mines recover through groundwater inflows. This ongoing state of flux has both spatial and temporal components.

Despite the Project's proximity to Bowmans Creek, the conceptual model developed indicates that the Project's impacts on Bowmans Creek are expected to be relatively minor relative to other mining operations, due to the location of the Glendell Pit Extension along the Camberwell anticline. The approved operations modelling scenarios indicate that the cumulative impacts from historical and approved mining in the area will peak near the end of the life of the Project.

The modelling of the approved operations at Glendell and the Project indicates that the Projects impacts on the Permian system is largely confined to the area immediately surrounding the Glendell Pit Extension. The Project is predicted to have only minor impacts on the alluvial system during the life of the Project with all predicted depressurisation impacts limited to the immediate vicinity of the intersection of the Glendell Pit Extension with Yorks Creek and Swamp Creek.

The only potential highly productive aquifer in the Project Area is Bowmans Creek alluvium. The Project is not expected to increase the extent of desaturation, however post-mining recovery of the water table is slower due to the effects of the Project. The impact of existing approved operations is predicted to result in

lowering of groundwater levels in the alluvium with the Project predicted to have no impact on the magnitude of this lowering of water tables other than in a limited area immediately adjacent to the Glendell Pit Extension. The predicted cumulative drawdown in Bowmans Creek alluvium (relative to existing conditions) is up to 2 metres in isolated areas. This predicted drawdown will have no significant impact on any registered groundwater bores held by private landholders.

The Project is predicted to result in increased take from the alluvial systems following the cessation of mining however this occurs in an environment where the impacts from other operations on these systems are declining and, despite an increasing take associated with the Project, the water table in the alluvial systems is expected to rise in the post mining environment (albeit slower in some areas than would otherwise be the case). Again, these predictions are consistent with what was expected by the conceptual hydrogeological model and is primarily attributable to the location of the Glendell Pit Extension along the hinge of the anticline resulting in strata dipping away from the Project and the minimal direct interaction with the alluvial system. An area of localised impact on the Bowmans Creek alluvium close to the existing confluence with Yorks Creek is predicted and is discussed in more detail in **Section 3.4**.

Glencore will hold adequate water entitlements to account for licensable take from water sources as a result of the Project at the time the take occurs.

3.3.2 Surface Water Impact Summary

The Yorks Creek Realignment has been designed to be geomorphically stable, with appropriate aquatic and riparian habitat, and to mitigate the potential impact of erosion on downstream water quality. The realigned Yorks Creek will join Bowmans Creek approximately 4 km upstream of the current confluence.

The existing and approved WMS at the Mount Owen Complex is extensive and includes mine dewatering systems, water storages, sedimentation and retention basins, settling ponds, tailings storages and diversion drains. The extension to the WMS, as part of the Project, will be integrated into the existing Mount Owen Complex WMS to limit the potential impacts on downstream water quality by managing water that has the potential to cause environmental harm. The conceptual WMS 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.

Consistent with approved operations at the Mount Owen Complex, no discharges will occur from the Mount Owen Complex as part of the Project. Surplus water on site will be transferred via the GRAWTS to the other Glencore managed sites that form part of the GRAWTS.

No significant flooding impacts to Bowmans Creek and Yorks Creek are expected due to the Project. The Surface Water Impact Assessment includes detailed flood modelling incorporating the proposed infrastructure associated with the Project (refer to Appendix 17 of the EIS):

- The Yorks Creek Realignment has been designed to provide flood conveyance while including scour and erosion protection during construction and operation. The results of the flood modelling indicate that the Yorks Creek Realignment design elements are likely to mitigate the potential impact of erosion on downstream water quality.
- Preliminary studies as part of the conceptual detailed design of the Yorks Creek Realignment indicate that the design of the creek can effectively manage the expected sediment load in runoff entering the stream.
- The modelled increase in the peak velocity for the 1% AEP design flood was used to identify areas where watercourse stability in the constructed sections of the Yorks Creek Realignment may potentially be affected. This modelling indicates that some areas of the conceptual detailed Yorks Creek

Realignment design may be subject to increased erosion risks. These increased erosion risks can be managed through appropriate erosion control measures, such as rock armouring, which are proposed as part of the conceptual detailed design (refer to Appendix 7 of the EIS).

- The realigned section of Hebden Road is modelled to remain above flood water levels in Yorks Creek and Bowmans Creek in the 5% AEP (1 in 20 year) event. This exceeds the performance of the current Hebden Road alignment which is overtopped in a 5% AEP event in Yorks Creek. The conceptual design of the Hebden Road realignment was modelled and is predicted to be partly inundated in a 1% AEP (1 in 100 year) event but remain passable.

- The new Glendell MIA is also modelled to remain above flood level in the 1% AEP event.

- The design of the Yorks Creek Realignment includes the development of a levee to prevent inundation of the Glendell Pit Extension in flood events up to the 0.1% AEP (1 in 1000 year) event. A similar levee adjacent to the points of intersection of the Glendell Pit Extension with Yorks Creek and Swamp Creek will also be implemented where necessary to prevent flood ingress into the Glendell Pit Extension during mining operations. These levees, if required, will also be developed to the 0.1% AEP event design standard. In the final landform, the flood modelling indicates that a Probable Maximum Flood (PMF) event would exceed the Yorks Creek Realignment levee resulting in inflows to the pit (during operations) or final void (post mining). The modelling indicates that the final void would retain a freeboard of at least 100 m even if the PMF event occurred with the pit lake at its modelled equilibrium level. Such an event would provide fresh water to the pit void and, given there is no discharge from the void, the overall impact of such an event occurring are considered to be positive. The PMF modelling also indicates that the conceptual final landform modelled may also result in flood ingress to the final void as a result of elevated water levels in Bowmans Creek. Similar to the modelled overtopping of the Yorks Creek Realignment levee, such an event would not result in any decant from the final void. Relatively minor changes to the final landform would be required to avoid any overtopping from a PMF event in Bowmans Creek and this will be considered as part of the detailed mine closure planning process.

- The modelling of pit lake recovery in the proposed final void indicates that significant freeboard will be maintained at equilibrium (approximately 140 m) to avoid any risk of decant. Groundwater modelling indicates there is no risk of decant from the final void through spoil to the downstream environment.

- The Project will change the catchments of Bowmans, Yorks, Swamp and Bettys Creeks and also realign Yorks Creek to a new confluence with Bowmans Creek. 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. Further, the proposed Swamp Creek catchment will be slightly larger than the existing conditions (which have existed for more than 10 years) and the Bettys Creek catchment will be similar (albeit slightly larger) to its pre-mining catchment.

- 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 licensed water users or basic landholder rights are expected.

- Potential impacts to downstream water users on Glennies Creek associated with changes in baseflow (also considered to be less than measurable) will be managed by appropriate licencing requirements under the WM Act.

- No adverse effects on downstream water quality or stream flows are expected due to the Project.

The interception of clean water associated with the Project during operations, dams in the final landform and groundwater baseflow losses, will be appropriately accounted for with net harvestable rights entitlements or water access licences, prior to the take occurring, if required.

3.4 Ecohydrological Assessment

The Project has the potential to impact biodiversity systems both directly, through habitat removal, or indirectly, including through changes to hydrological systems on which 'downstream' ecosystems may rely. The IESC guidance provided on the Gateway Application includes the following recommendation:

- *Provide a general ecohydrological conceptual model showing potential impact-effect pathways on water-related ecological assets, including GDEs and aquatic biota. An additional ecohydrological model specifically addressing the proposed Yorks Creek diversion and its confluence with Bowmans Creek may be needed to further understand potential impacts from changes to flows, bank and bed stability and hyporheic conditions in Bowmans Creek*

This section discusses the impact-pathways on water related ecological assets insofar as they may be affected by the Project. This summary is broken down into direct impacts and indirect impacts and considers impacts associated with changes to surface water systems and groundwater systems.

3.4.1 Impact Pathway

3.4.1.1 Direct Impacts

The Project's direct impact on water related ecosystems is limited to areas of direct removal of habitat. These changes are restricted to the Glendell Project Disturbance Area and Mount Owen Additional Operational Area (refer to **Figure 3.6**). Water dependent ecosystems potentially impacted include:

- aquatic and riparian habitat in sections of Yorks Creek, Swamp Creek and Bettys Creek directly impacted by earthworks and mining operations
- riparian habitat in the area of Bowmans Creek at the proposed confluence with the Yorks Creek Realignment where 'tie-in' works are required
- movement of aquatic fauna upstream in Yorks Creek can be impacted by temporary or permanent barriers to movement or the absence of appropriate refugia
- aquatic habitat impacted by spills of pollutants into waterways
- stygofauna and hyporheic fauna in (or adjacent to) saturated areas of alluvium in Yorks Creek and Swamp Creek removed through mining operations.

3.4.1.2 Indirect Impacts

The Groundwater Impact Assessment (AGE, 2019) and the Surface Water Impact Assessment (GHD, 2019) include a detailed assessment of the Project's potential indirect impacts on surface and groundwater systems.

Surface Water Changes

Table 3.2 summarises the key changes to water resources associated with the Project which have the potential to indirectly impact on water dependent ecosystems.

Table 3.2 Surface water – Impact pathways

Potential change	Impact Pathway	Potential Impacted environments
Reduced downstream flows due to reduced catchment	Reduced flows may mean reduced recharge of alluvial aquifers, reduced flows of water into pools, reduced oxygenation of water in persistent pools, reduced wetting of soil material adjacent to creeks and associated availability to riparian vegetation.	Yorks Creek downstream of Yorks Creek Realignment Swamp Creek downstream of the Glendell Project Disturbance Area Bowmans Creek (generally)
Increased downstream flows due to altered catchment discharge points	Potential for scouring and increased sediment movement due to increased flows. Increased flood levels downstream during high flow events. Increased alluvial recharge during high flow events (positive). Increased flows may assist in downstream pool refill (positive).	Bowmans Creek downstream from Yorks Creek Realignment confluence Bettys Creek downstream from WRD retention basin in final landform Bowmans Creek following final rehabilitation of landform and release of clean catchments
Runoff from disturbed areas, increased turbidity, salinity, increased metals	Sediment laden water entering downstream catchments. Increased sediment can fill pools if insufficient water velocity. Sediment can impact aquatic vegetation. Some sediment flow essential and provides nutrients and growing medium for downstream environments (positive). Elevated salinity and dissolved metals can adversely impact aquatic fauna.	Bowmans Creek Swamp Creek Yorks Creek (existing alignment and Realignment) Bettys Creek
Changed flow environments during floods	Works within the flood plain and alterations to flow volumes (e.g. increase catchments, changed points of inflow) can increase flood levels and velocities which can impact on riparian vegetation and geofluvial environment.	Bowmans Creek Yorks Creek Realignment Bettys Creek in final landform
Spills of water containing elevated levels of pollutants	Elevated pollutants can adversely affect aquatic fauna and flora and riparian vegetation	Bowmans Creek Yorks Creek Swamp Creek Bettys Creek

As discussed in **Section 3.1.2.5**, water management at the Glendell Mine is managed as part of the Mount Owen Complex WMS which is linked to the GRAWTS (refer to **Section 3.1.2.6**). The GRAWTS facilitates the transfer of mine water between different mining operations in the area. The Project does not include any direct discharge of water into downstream environments, but some water captured in the Mount Owen Complex WMS may ultimately be transferred to either Ravensworth Operations and/or Liddell Coal Operations where it may be discharged pursuant to their EPLs. The Project does not propose any changes to existing approved operations in this regard and the potential impacts associated with these discharges are considered to already be approved and are therefore not considered further.

Groundwater Changes

The Project is predicted to result in a range of changes to the groundwater system. The key indirect impact pathways that can affect the different GDE types are summarised below:

- Terrestrial GDEs
  - lowering of the water table below the depth of tree roots that utilise groundwater resources for their water needs
  - changes in groundwater quality which is accessed by terrestrial vegetation
- Aquatic GDEs
  - lowered water levels or the drying of pools due to reduced baseflows or the lowering of water tables in alluvial aquifers directly connected to pools (e.g. pools which are 'windows' to the alluvial aquifer)
  - changes in groundwater quality which affects surface water quality where directly connected
- Subterranean GDEs
  - desaturation of habitat aquifers
  - changes in groundwater quality

As detailed in the Groundwater Impact Assessment (AGE, 2019) , the Project is not predicted to have any observable changes on groundwater quality, accordingly, the assessment of impacts on GDEs has not further considered this potential impact pathway.

The key groundwater changes considered are therefore those associated with changes affecting baseflows and changes in water tables.

3.4.2 Assessment Methodology – Aquatic and Stygofauna Survey

Detailed assessments of the impact of the Project on aquatic biodiversity due to groundwater and surface water impacts have been undertaken. These surveys are set out below but are also detailed in the Aquatic Ecology Assessment (refer to Appendix F of the BDAR (Umwelt, 2019a)) and the Stygofauna Assessment (ELA, 2019).

3.4.2.1 Riparian and Aquatic Habitat Description and Mapping

Detailed aquatic habitat assessments were undertaken at seven locations along Bowmans Creek, four locations along Swamp Creek, six locations along Yorks Creek and one on Bettys Creek (refer to **Figure 3.4**). An assessment of the aquatic habitat characteristics within each of the sampling sites was undertaken, and indicators of stream condition were also noted.

During the survey, no flow was recorded in Yorks and Bettys Creeks due to the prolonged dry conditions experienced in the Hunter Valley between 2017 and the time of the assessment. 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 undertaken through the 2017-18 survey period.

Key fish habitat mapping has been prepared by Fisheries Ecosystems Branch of NSW DPI for LGAs across NSW. The key fish habitat map output for the Singleton LGA was reviewed; Bowmans Creek, Swamp Creek and Bettys Creek have been mapped as key fish habitat. With the exception of a 200 m section at the confluence with Bowmans Creek, Yorks Creek has not been identified as key fish habitat.

3.4.2.2 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. Aquatic fauna survey locations are shown on **Figure 3.4.**

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 3.4**). 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).

A detailed description of the sampling procedures is provided in the Aquatic Ecology Assessment, refer to Appendix 20 of the EIS.

Aquatic Vertebrate Fauna Sampling

Aquatic vertebrate fish sampling was undertaken in Bowmans Creek at three locations where pooling water was present. The site locations include one upstream of the proposed Yorks Creek Realignment, one site at the existing confluence with Yorks Creek and one site located downstream of the existing confluence with Yorks Creek (refer to **Figure 3.4**).

A detailed description of the sampling procedures is provided in the Aquatic Ecology Assessment, refer to Appendix 20 of the EIS.

3.4.2.3 Key Fish Habitat Classification and Sensitivity Analysis

Key fish habitat mapping has been prepared by Fisheries Ecosystems Branch of NSW DPI for LGAs across NSW. The intent of the mapping was to recognise key fish habitat that are important to the sustainability of recreational and commercial fishing industries, maintenance of fish populations and the survival and recovery of threatened aquatic species. The definition includes most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank but excluding first and second order streams that only flow for a short period following rain and farm dams on these streams (NSW DPI, 2013).

For the purposes of the application of the *Fisheries Management Act 1994* (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. The classification of the watercourses within and in proximity to the Project Area for fish passage was assessed in accordance with NSW DPI (2013).

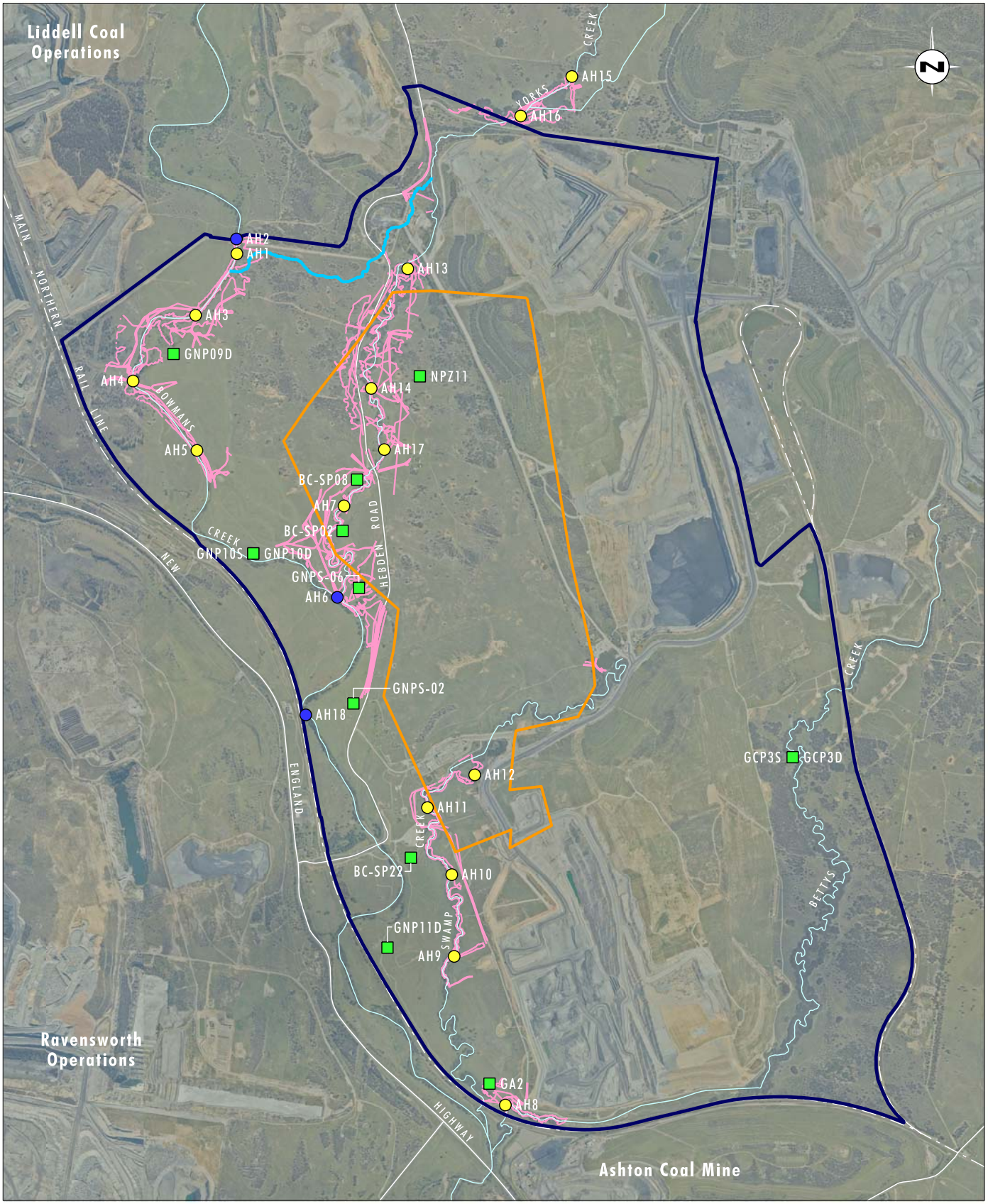

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

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

FIGURE 3.4

Aquatic Survey Locations

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3.4.2.4 Stygofauna

Thirteen bores were sampled during the survey, in addition to the existing sixteen bores previously sampled as part of the Mount Owen Continued Operations Modification 2 which were used for this assessment. A detailed description of the sampling procedures is provided in the Stygofauna Assessment, refer to Appendix 21 of the EIS.

3.4.3 Assessment Methodology – Indirect Groundwater Impacts

The IESC has developed the 'Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems' (Explanatory Note) (Doody, Hancock and Pritchard, 2019). The Explanatory Note describes GDEs as complex dynamic 'natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services' (Richardson et al, 2011 – in Doody, Hancock and Pritchard, 2019).

The Explanatory Note classifies groundwater as water occurring naturally below ground level (whether in an aquifer or otherwise) and includes perched aquifers, water in the saturated zone and water in the soil capillary zone (capillary fringe) but not the water held in the soil above this zone in the unsaturated or vadose zone (Doody, Hancock and Pritchard, 2019). Figure 1 from the Explanatory Note is replicated in **Figure 3.5** and summarises what is considered to be groundwater for the purposes of this assessment.

The Explanatory Note defines GDEs using a combination of typologies from Hatton and Evans (1998) and the GDE Toolbox (Richardson *et al*, 2011) as described in **Table 3.3**.

Table 3.3 GDE typologies

GDE Classification	Description
Subterranean	Aquifer and cave ecosystems.
Aquatic	River-base flow systems: aquatic and riparian ecosystems that exist in or adjacent to streams (including the hyporheic zone) fed by groundwater.
	Wetlands: aquatic communities and fringing vegetation dependent on groundwater-fed lakes and wetlands. These include palustrine, lacustrine and riverine wetlands that receive groundwater discharge and can include some spring ecosystems.
	Submarine discharge of groundwater: Ecosystems which rely on submarine discharge of groundwater for its nutrients and/or physico-chemical attributes.
Terrestrial	Subsurface expression of groundwater: Ecosystems dependent on the subsurface expression of groundwater.

GDEs can be 100% dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas (Doody, Hancock and Pritchard, 2019).

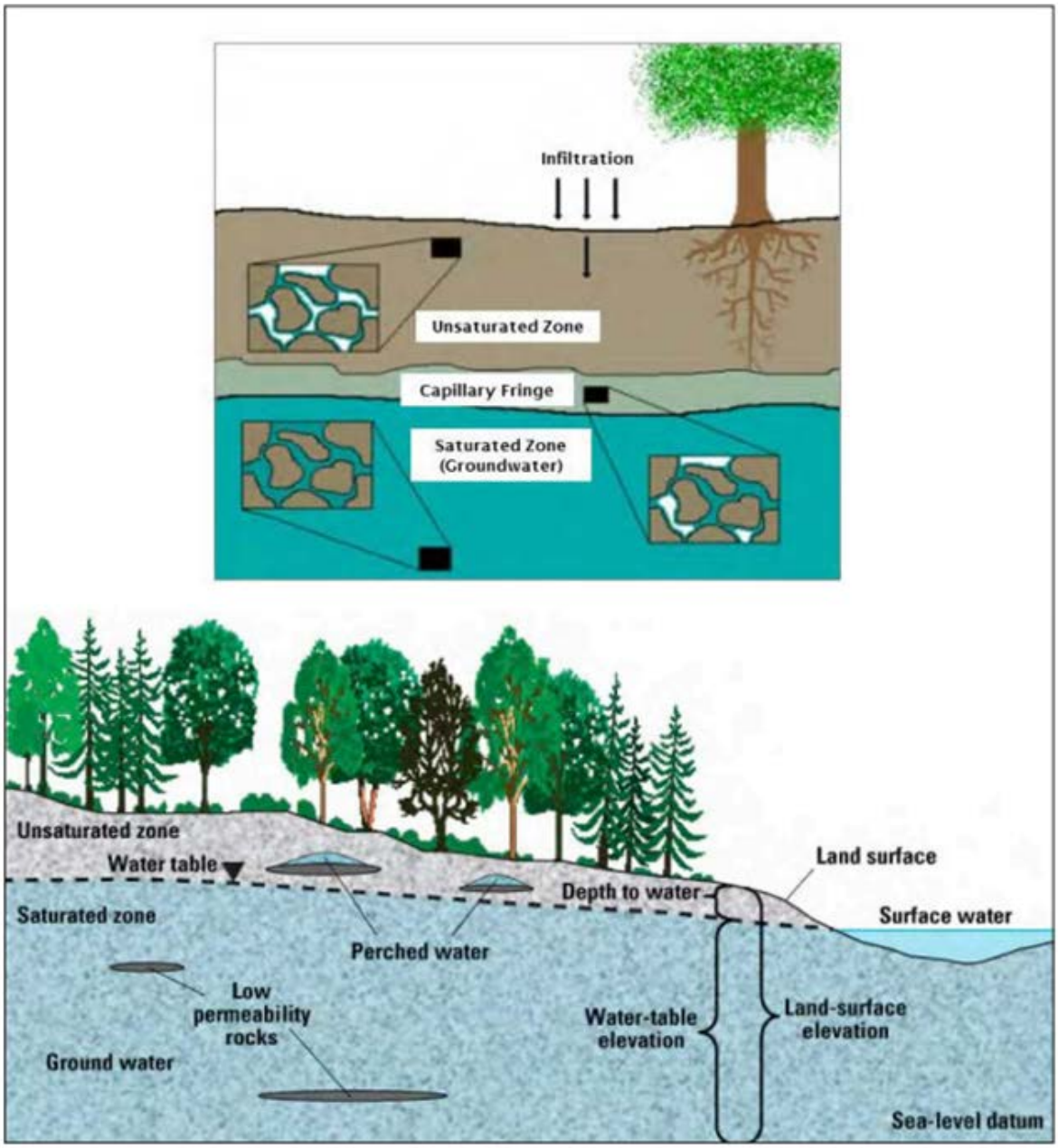

Figure 1. Top: difference in saturation among particles in the unsaturated zone, capillary fringe and saturated zone (Michigan State University 2018); bottom: perched aquifers in the unsaturated zone, which can be an important water source for some GDEs (Snyder 2008)

Figure 3.5 Summary of Groundwater for Ecohydrological Assessment Purposes

© Michigan State University (2018) and Snyder (2008) in Doody, Hancock and Pritchard, (2019)

A review of the Bureau of Meteorology Groundwater Dependent Ecosystems Atlas (GDE Atlas) shows potential for terrestrial GDEs to be present in the Project region. The GDE Atlas was developed as a national dataset of Australian GDEs to inform groundwater planning and management. The register indicates there are areas of low and high potential terrestrial GDE interaction along Yorks Creek, Bettys Creek, Swamp Creek and Bowmans Creek. There is moderate potential aquatic GDE along Bowmans Creek. The GDE Atlas does not identify any wetlands in the areas potentially impacted by the Project. Additionally, there are no wetlands in close proximity to the Project that are likely to be affected by the Project and this GDE type is therefore not considered further.

Stygofauna and hyporheic fauna have previously been recorded in the Bowmans Creek catchment and the Project's potential impacts on alluvial aquifer systems may impact on subterranean GDEs. A detailed Stygofauna Assessment (refer to Appendix 21 of the EIS) has been undertaken in accordance with relevant Commonwealth legislation. The outcomes of the Stygofauna Assessment are discussed in **Section 3.4.4**.

The assessment of the impacts associated with changes in groundwater levels is discussed further below and is based on data obtained from the Groundwater Impact Assessment ((AGE, 2019) refer to Appendix 16 of the EIS).

3.4.3.1 Identifying changes in groundwater levels that may impact on Terrestrial GDEs

As previously discussed, the Project is located in an area where the hydrogeological environment has been highly modified by mining which has occurred over the past 50 years or more. Accordingly, it is not possible to fully establish the pre-mining hydrogeological environment due the absence of any pre-mining groundwater information. Due to the dynamic nature of the regional groundwater system, ongoing impacts associated with approved and historic mining will continue to affect groundwater levels irrespective of whether the Project occurs. In order to assess the potential impact of these changes on aquatic and terrestrial GDEs, changes in the depth to water table were assessed relative to both the 2019 modelled water table levels and the water table levels that would occur under the currently approved mining operations.

It should be noted that the calibration of the regional groundwater model was based on groundwater monitoring data up to 2018 and does therefore not include the effects of the 2018 - 2019 drought on groundwater levels. Accordingly, and conservatively, references to 2019 levels in this section are a reference to groundwater levels as modelled assuming an average annual rainfall rate and not actual 2019 water table levels.

The assessment has focussed on changes to the depth to water table within Layers 1 and 2 of the regional groundwater model which represent alluvium and regolith. The assessment was limited to areas where the water table in these layers is modelled as being within 10 m of the surface. The base assumption in the assessment is that groundwater more than 10 m below the surface was not accessible to terrestrial vegetation and water in the hardrock systems in the area modelled was typically not accessible by terrestrial vegetation even where within 10 m of the surface and the water quality within these Permian hard rock systems was typically unsuitable for plant use due to elevated salinity levels (AGE, 2019).

The assessment approach for GDEs included:

- undertaking a desktop assessment to identify potential GDEs including review of:
    - regional studies
    - previous assessments
    - spatial data including aerial photographs
    - vegetation mapping for the area of interest

- identifying areas where there is the potential for near surface groundwater (i.e. areas where the water table is within 10 m of the surface) to occur to identify a potential zone where interactions between terrestrial vegetation and groundwater could occur based on the above information, identify potential GDEs and assess their likely level of groundwater dependence, model the impacts of the Project on groundwater including the areas containing potential GDEs and use this information to assess GDE impacts.

The study area for the GDE assessment is based on the groundwater model extent used for the Groundwater Impact Assessment (AGE, 2019).

This extent was developed for use in the groundwater model to go beyond the extent of any possible impact on groundwater as a result of the Project. Therefore, by using this boundary as the area for investigation, all potential impacts have been considered. The key focus of the investigation is to identify any areas where changes in groundwater levels have the potential to reduce any identified GDE's access to water. The assessment has focussed on the water table within the alluvium and regolith as these are likely to be the only groundwater systems which are readily accessible to terrestrial vegetation. As discussed in the Groundwater Impact Assessment (AGE, 2019), the water quality in the Permian coal seams is typically unsuitable for plant growth due to elevated salinity levels.

3.4.3.2 Focus of assessment on areas where vegetation present

Vegetation mapping for the area of investigation obtained from the surveys undertaken for this Project (refer to **Section 2.**0) and the Upper Hunter Strategic Assessment (Umwelt, 2015) has been overlaid with areas where the water table in the alluvium and regolith is modelled to occur within 10 m of the surface in 2019 to further refine the location of potential GDEs in the area of investigation (refer to **Figure 3.6**). The vegetation communities, located within areas where the water table is modelled as being within 10 m of the surface in 2019, and their assessed likelihood of dependence on groundwater, are listed in **Table 3.4**.

Table 3.4 PCTs mapped in areas of shallow groundwater and likely level of groundwater dependence

Plant Community Type ***Condition***	**Likely Level of Groundwater Dependence**
485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley (River Oak Woodland)	High
1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter	Low
1692 - Bull Oak Grassy Woodland of the Central Hunter Valley (Bull Oak Woodland)	Low
1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter	Low
1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley (Swamp Oak Forest)	Moderate

As shown on **Figure 3.6**, five plant community types (PCTs) have been mapped in the vicinity of the Project where groundwater may occur within 10 m of the surface. The review of the relevant PCTs indicates that while there is the potential for each of the vegetation communities listed to access groundwater from time to time based on pre-mining shallow groundwater in these areas, the majority of the communities are considered likely to have a low dependence on groundwater. This assessed likely low level of groundwater dependence is based on the location of these communities in the landscape and their floristic composition. Derived Native Grasslands and exotic grasslands are not considered to be groundwater dependent.

One community, being PCT 485 River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley (River Oak Woodland) was considered to have a higher potential level of groundwater dependence due to its occurrence in the Bowmans Creek alluvium which is known to have a more substantial groundwater resource. The predominant tree species in this PCT is river oak (*Casuarina cunninghamiana*) with forest red gum (*Eucalyptus tereticornis*) and rough-barked apple (*Angophora floribunda*) also occurring.

As discussed above, the assessment of likely groundwater dependence does not mean that these communities will source all their water requirements from groundwater, however, it is considered likely that groundwater makes a contribution to their water requirements (particularly for trees which have deeper root systems). The moderate and high rated PCTs are expected to be more dependent on groundwater than the low ranked PCTs.

The Groundwater Impact Assessment (AGE, 2019) indicates the impact from past and approved mining will continue to impact on water tables within the vicinity of the Project, and particularly along Bowmans Creek. The Project's predicted impacts on alluvial groundwater systems as far as the water table is concerned is to delay recovery of the water table level. Modelling indicates that the Project will have negligible impacts on the magnitude of drawdown in alluvial aquifers except in areas close to points where the Glendell Pit Extension intercepts the Yorks Creek alluvium and Swamp Creek alluvium.

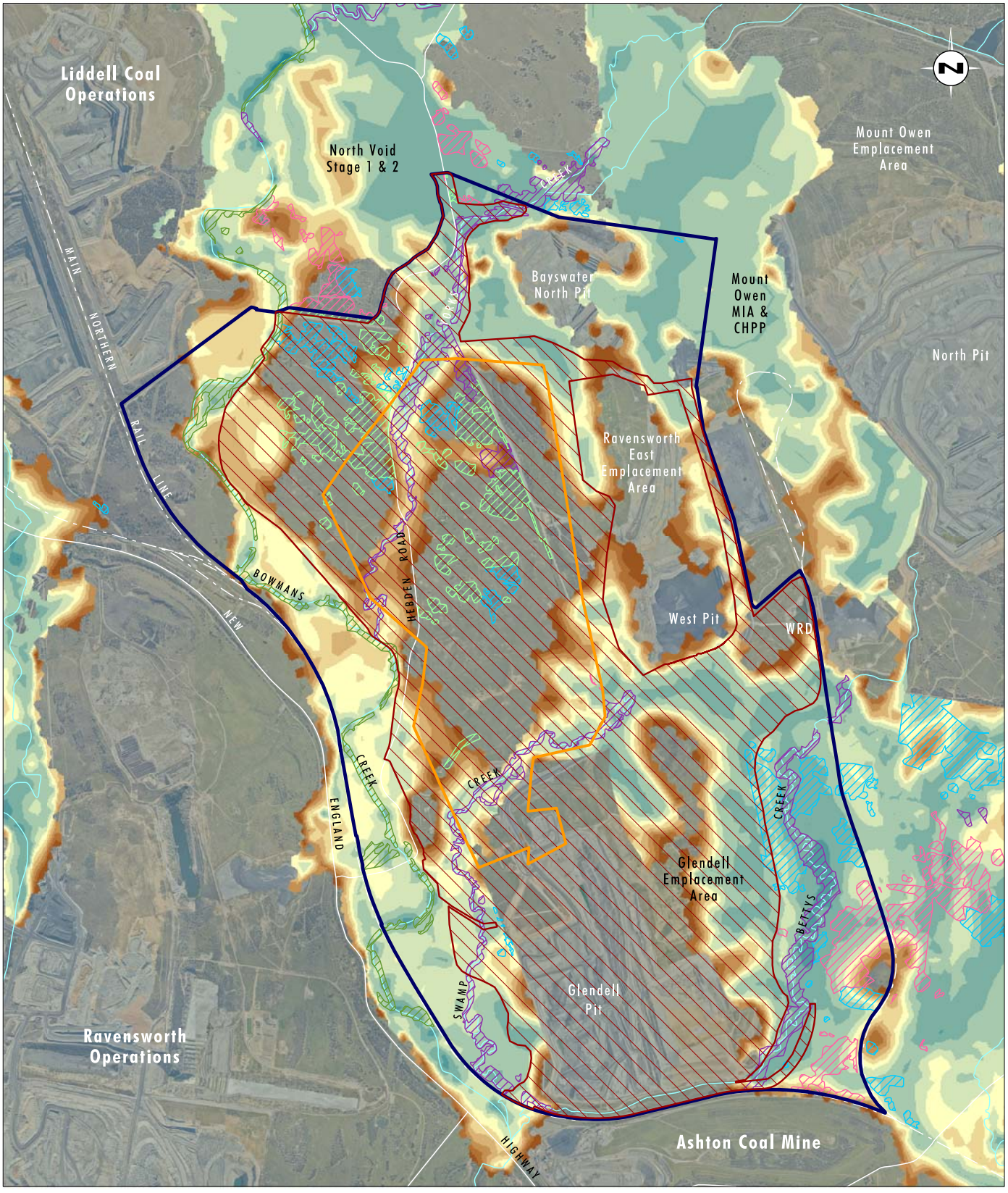

Image Source: Glencore (Dec 2018), Data Source: Glencore (2019), AGE (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area

Depth to Water Table (m)

- Less than 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- 5.0 to 6.0
- 6.0 to 7.0
- 7.0 to 8.0
- 8.0 to 9.0
- 9.0 to 10.0

- 485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Woodland
- 1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Woodland, Regeneration and Plantation
- 1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central and Lower Hunter Woodland, Rehabilitation and regeneration
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Woodland and Regeneration
- 1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Forest

FIGURE 3.6

Vegetation Communities and Modelled 2019 Water Table

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3.4.3.3 Identifying Changes in Water Tables that may impact Terrestrial GDEs

To assess the Project's potential impacts on terrestrial GDEs, the 'depth to water' was extracted for various scenarios from the groundwater modelling for areas where groundwater was modelled to be within 10 m of the surface. The modelled scenarios considered in assessing potential impacts on terrestrial ecosystems is discussed in **Table 3.5.**

As discussed in **Section 3.3.1** (and in detail in Appendix 16 of the EIS) the change to the hydrogeological environment associated with historical and existing approved mining projects have already affected groundwater levels in the region and will continue to do so over the life of the Project. These 'non-Project' related changes have potential to impact on GDE's irrespective of any impact the Project will have. Three modelling scenarios have been therefore been used to assess the predicted impacts of historical and approved operations and Project impacts on the water table:

- No Glendell Scenario – models historical and approved mining operations in the modelling domain other than mining at Glendell
- Approved Scenario – models historical and approved mining operations in the modelling domain including the currently approved mining at Glendell
- Approved + Project Scenario (i.e. Cumulative Scenario) – models historical and approved mining operations in the modelling domain including the currently approved mining at Glendell and the Project.

Two time periods were selected for the analysis, 2046 (close to end of mining (2044) and modelled maximum cumulative impact on take from alluvial groundwater systems) relative to 2019 (representing the relative difference between maximum cumulative impacts in terms of take from the alluvial groundwater system) and 2500 relative to 2019 (representing water table levels after water levels in the Glendell Pit Extension pit lake have reached equilibrium). These modelling scenarios are summaries in **Table 3.5.** The relative changes in depth to water table for each of the Approved and Cumulative Scenarios was then considered to identify the Project's relative contribution to the changes in water table over the two time periods considered.

Table 3.5 Modelling Scenarios to Assess Potential Impacts on Groundwater Dependant Terrestrial Vegetation

Time Period	Modelling Scenarios Considered*	Comment
Existing conditions (2019)	No Glendell Approved	The Approved Scenario identified the current predicted water table (in locations where it is within 10 m of the surface). The No Glendell Scenario identifies the theoretical water table if mining had not occurred at Glendell.
End of mining (2046)	Approved Cumulative	2046 represents the period when maximum cumulative take is predicted to occur from the alluvial groundwater system. This also coincides closely to the end of mining associated with the Project. At this time, there is no further approved or currently proposed mining in the local region. The comparison of the Approved and Cumulative Scenarios enables the effects of the Project on the water table potentially accessible by terrestrial vegetation to be identified.

Time Period	Modelling Scenarios Considered*	Comment
Equilibrium (circa 2500)	Approved Cumulative	The comparison of Approved and Cumulative Scenarios enables the effects of the Project on the water table potentially accessible by terrestrial vegetation to be identified.

The baseline against which to assess the Project's impact on GDEs has been taken from three different time points from the Approved Scenario:

- Existing conditions (2019) – to represent changes relative to existing conditions
- End of mining (2046) – to represent changes relative to the point at which cumulative impacts on the alluvial groundwater system are predicted to be at their highest (AGE, 2019)
- Equilibrium (circa 2500) – to represent changes relative to the groundwater system once water levels in the Glendell Pit Extension pit lake have reached equilibrium.

The theoretical No Glendell Scenario outputs was compared to the Approved Scenario outputs for 2019 to identify predicted impacts on the water table associated with the existing approved Glendell Mine (noting that this was approved prior to the EPBC 'water trigger' being legislated).

Figures 3.7 to **3.9** show the depth to water table modelled for the different scenarios considered. **Figures 3.10** to **3.12** provides a comparison between the different scenarios considered. **Figure 3.10** shows the change in water table level between 2019 and 2046 with the Project (i.e. cumulative conditions). **Figure 3.11** shows the incremental impact in 2046 due only to the Project. **Figure 3.12** shows the changes in water table level between 2019 and 2500 with the Project (i.e. cumulative conditions). As can be seen from **Figure 3.12**, the water table level in 2500 is at or above the modelled 2019 water table in all area except the areas immediately adjacent to the Glendell Pit Extension intersection points with the Swamp Creek and Yorks Creek alluvium.

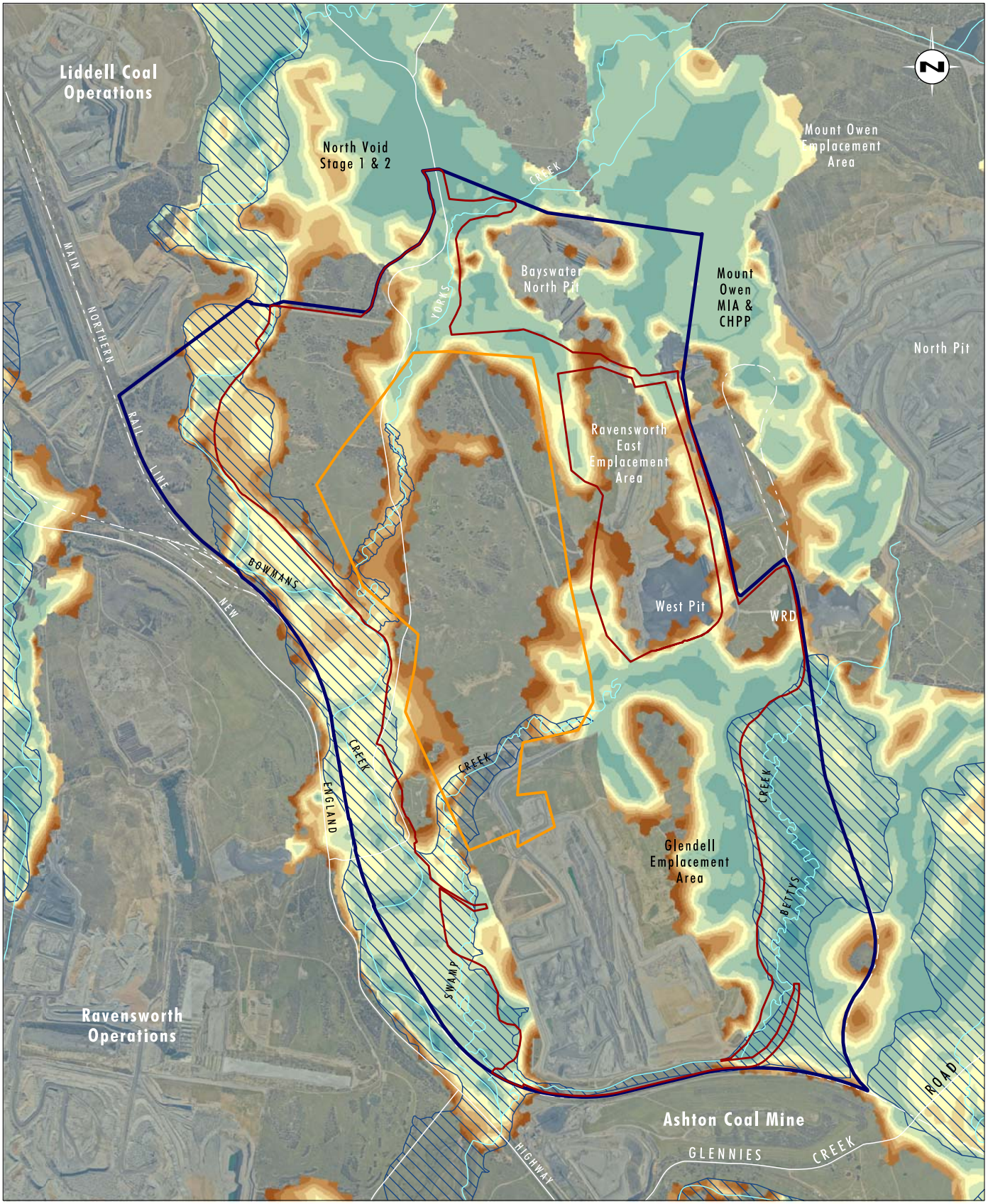


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

0 0.5 1.0 2.0km
1:45 000

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Depth to Water Table (m)

- Less than 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- 5.0 to 6.0
- 6.0 to 7.0
- 7.0 to 8.0
- 8.0 to 9.0
- 9.0 to 10.0

FIGURE 3.7

Modelled Depth to Water Table 2019 (Approved Scenario)

File Name (A4): R16/4166_575.dgn
20191121 9.01

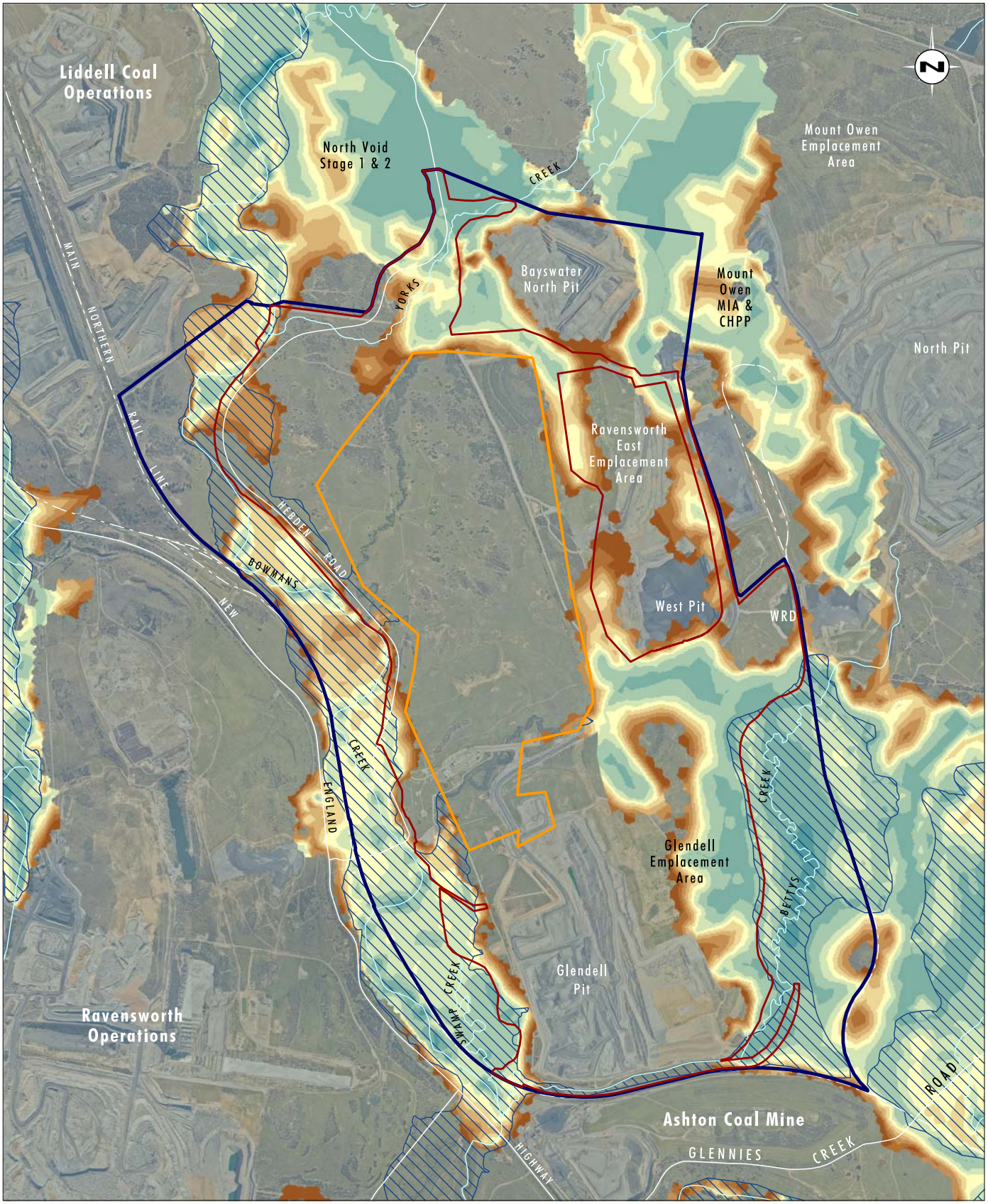


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Depth to Water Table (m)

- Less than 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- 5.0 to 6.0
- 6.0 to 7.0
- 7.0 to 8.0
- 8.0 to 9.0
- 9.0 to 10.0

FIGURE 3.8

Modelled Depth to Water Table 2046 (Cumulative Scenario)

File Name (A4): R16/4166_576.dgn
20191121 9.07

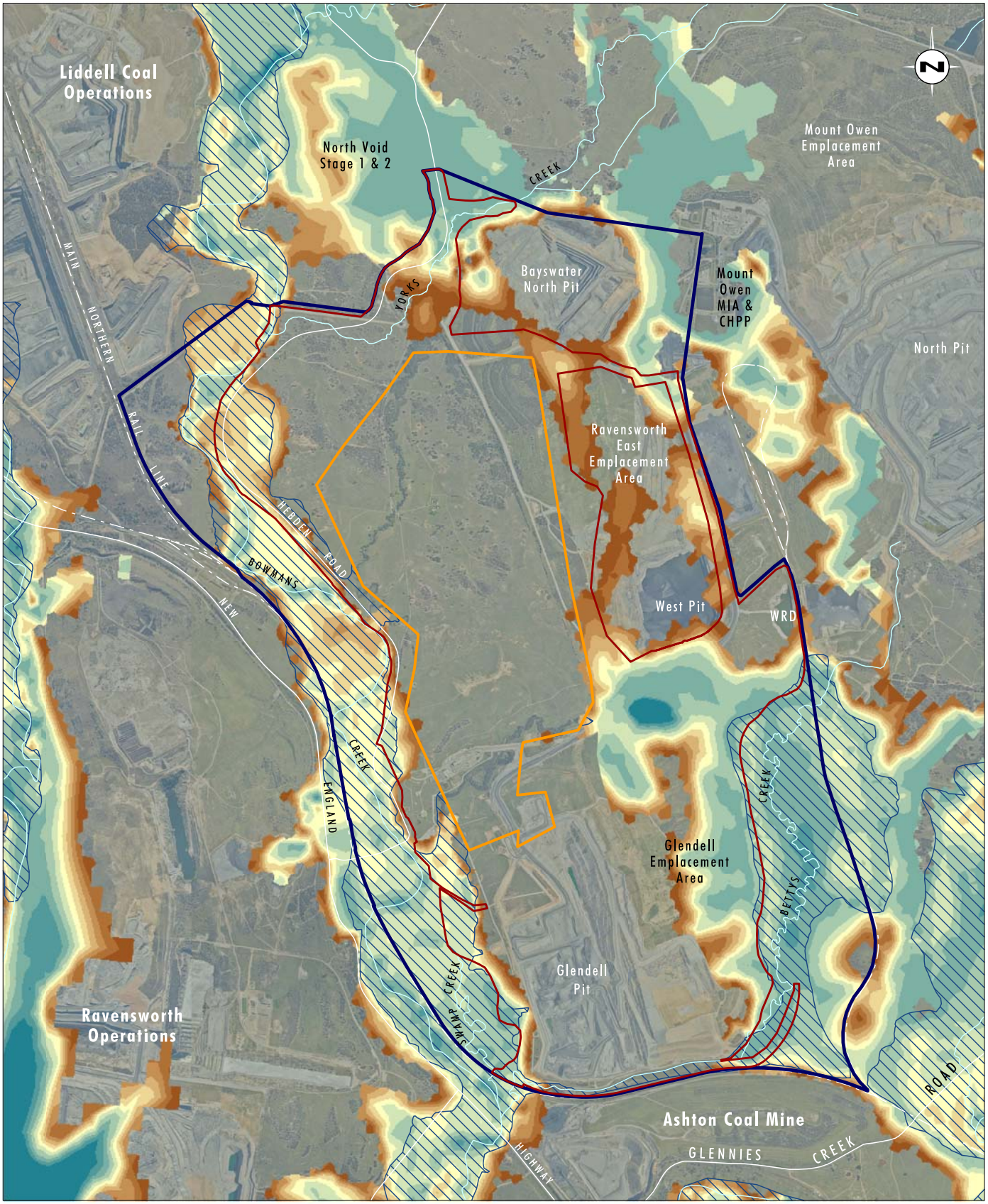


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Depth to Water Table (m)

- Less than 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- 5.0 to 6.0
- 6.0 to 7.0
- 7.0 to 8.0
- 8.0 to 9.0
- 9.0 to 10.0

FIGURE 3.9

Modelled Depth to Water Table 2500 (Cumulative Scenario)

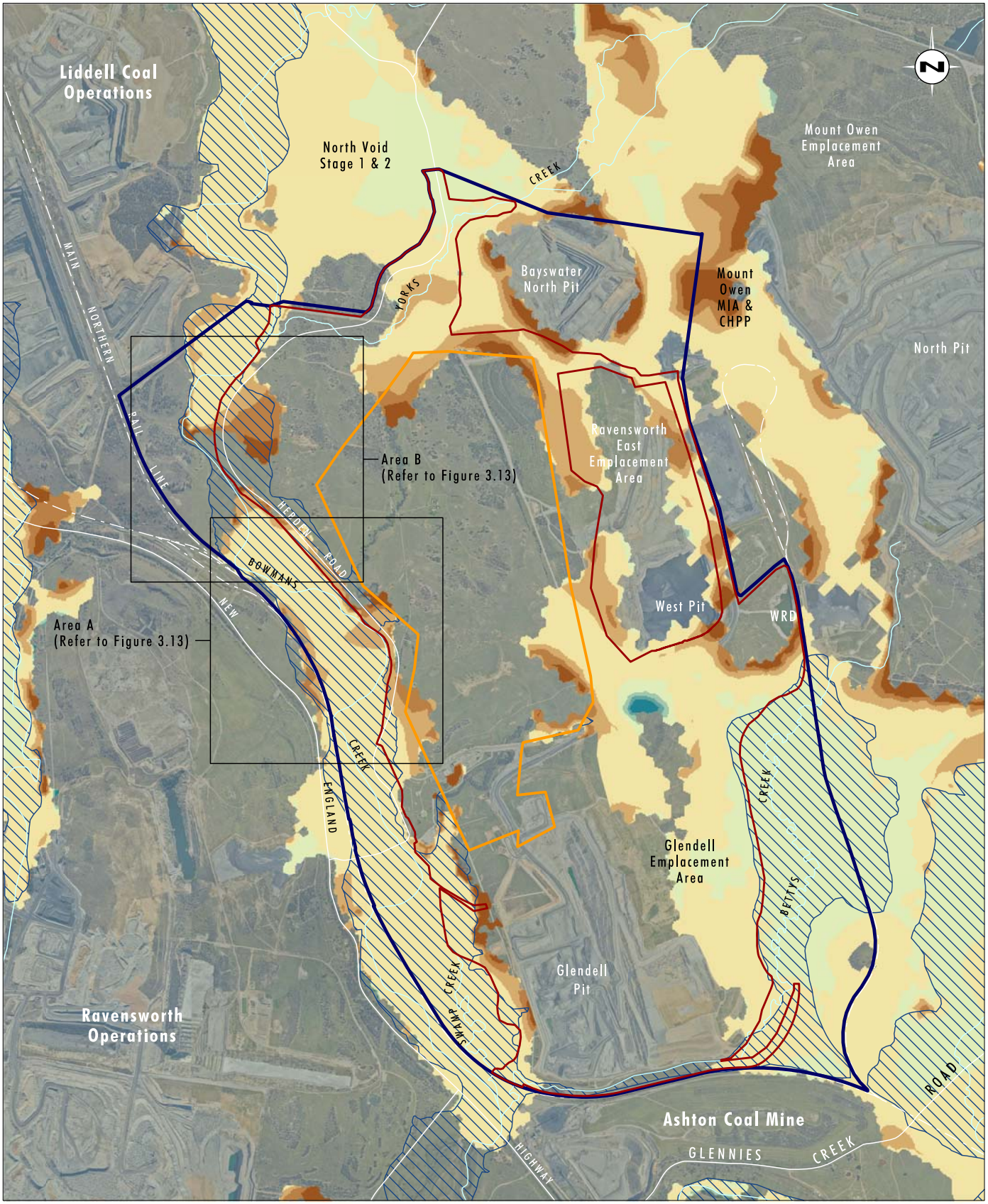


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Change in Depth to Water Table (m)

- Greater than -3
- -3.0 to -2.0
- -2.0 to -1.0
- -1.0 to 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- Greater than 3.0

FIGURE 3.10

Change in Depth to Water Table: 2019 (Approved Scenario) relative to 2046 (Cumulative Scenario)

File Name (A4): R16/4166_578.dgn
20191121 9.17

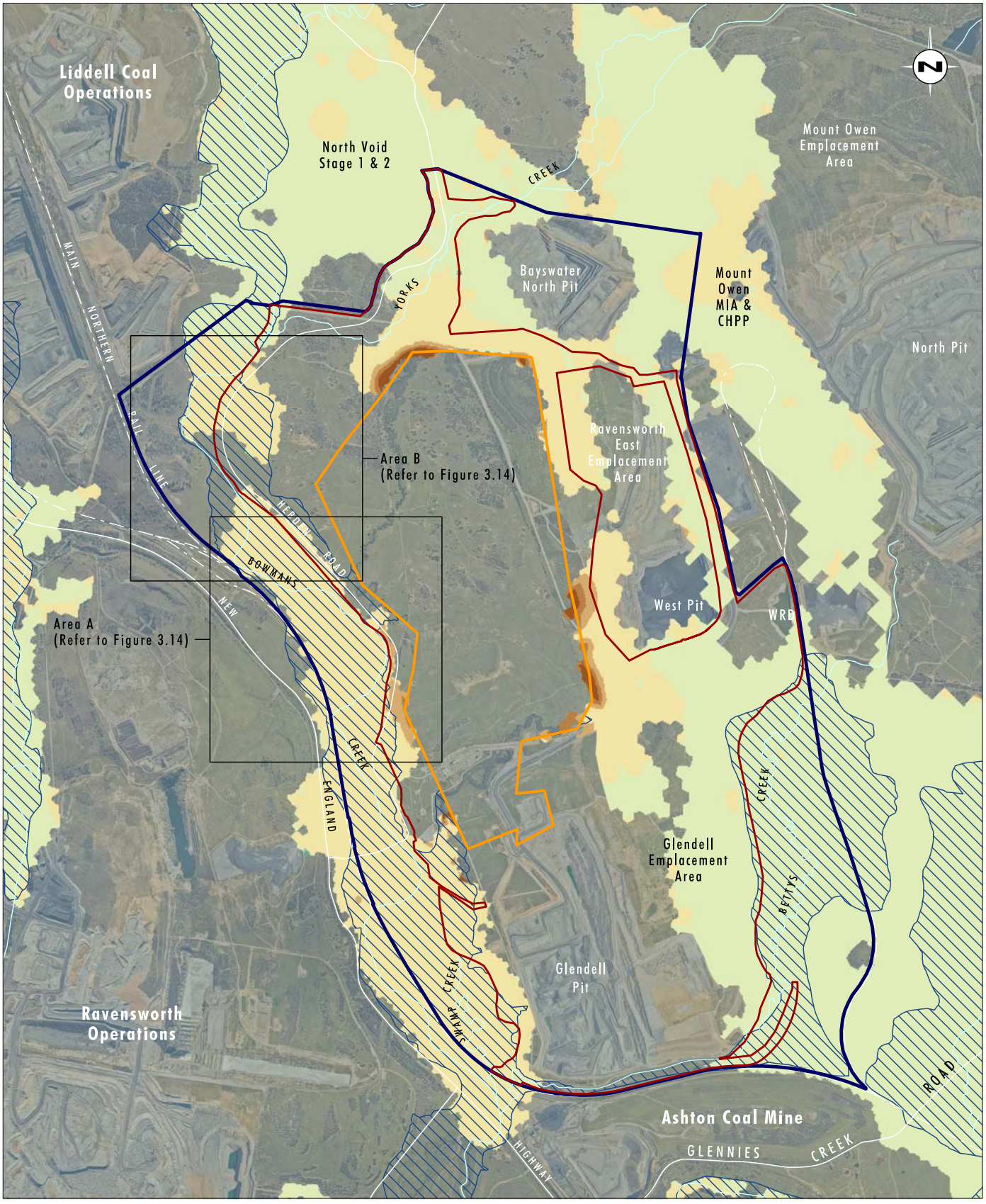


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Change in Depth to Water Table (m)

- Greater than -3
- -3.0 to -2.0
- -2.0 to -1.0
- -1.0 to 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- Greater than 3.0

FIGURE 3.11

Change in Depth to Water Table: 2046 (Cumulative Scenario) relative to 2046 (Approved Scenario)

File Name (A4): R16/4166_579.dgn
20191121 9.20

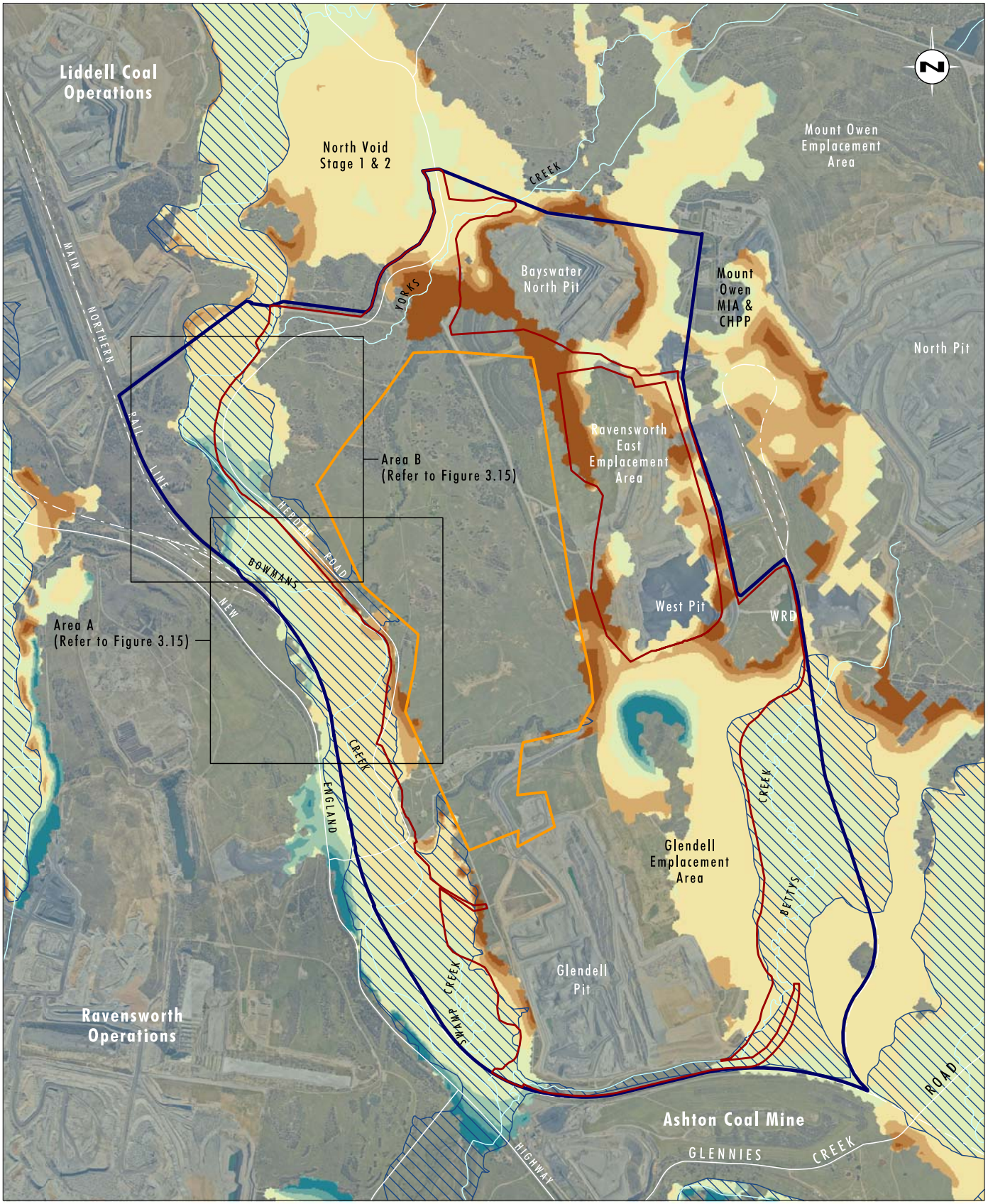


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), AGE (2019)

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Mapped Alluvium (AGE 2019)

Change in Depth to Water Table (m)

- Greater than -3
- -3.0 to -2.0
- -2.0 to -1.0
- -1.0 to 0
- 0 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- Greater than 3.0

FIGURE 3.12

Change in Depth to Water Table: 2019 (Approved Scenario) relative to 2500 (Cumulative Scenario)

File Name (A4): R16/4166_580.dgn
20191121 9.23

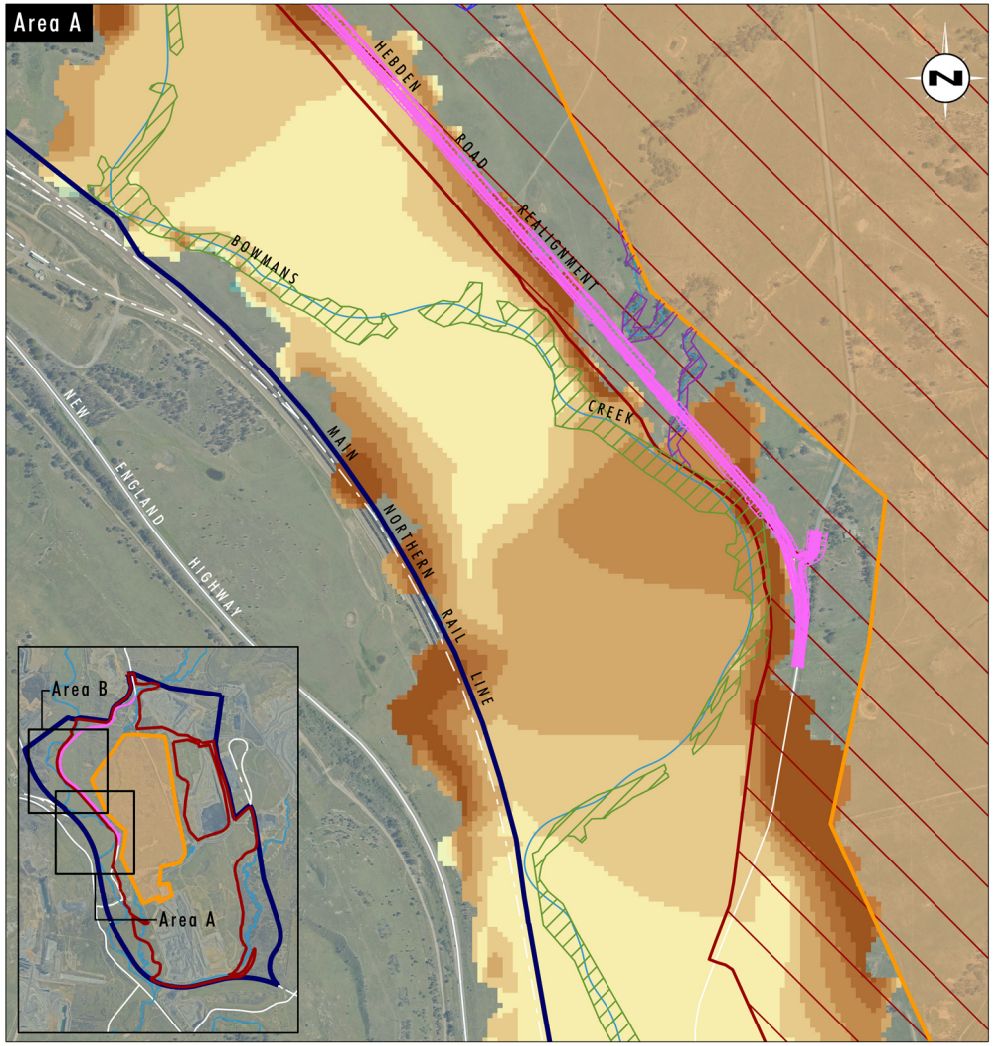
The Project is predicted to result in some additional lowering of the water table in the areas close to the point at which the Glendell Pit Extension intersects the Yorks Creek and Swamp Creek alluvium in 2046 and this impact is modelled to persist in the areas closest to the Glendell Pit Extension out to 2500. The area of additional impact around the Swamp Creek intersection is located almost entirely within the Glendell Project Disturbance Area and will be largely covered by overburden emplacement required for natural landform shaping purposes. Accordingly, the impacts associated with changes to groundwater levels on terrestrial GDEs in this area are not assessed any further. The key areas of focus of the assessment are Areas A and B shown in **Figures 3.10** to **3.12**. Area A is an area of predicted drawdown associated with the Project near the existing junction of Yorks Creek and Bowmans Creek. Area B is an area where there is a predicted loss of saturation on Bowmans Creek upstream of Area A. These areas have been selected as they represent the areas of maximum cumulative impact (Area B) and the area of maximum predicted impact associated with the Project (Area A).

Figure 3.13 shows the relative changes in water table level in Area A and Area B in 2046 (Cumulative Scenario) relative to 2019 modelled conditions. As can be seen from **Figure 3.13,** there is a predicted lowering of the water table in the alluvium in the vicinity of the Yorks Creek and Bowmans Creek confluence of up to 2 m with greater reductions modelled within the Glendell Project Disturbance Area. **Figure 3.14** shows the incremental impact in 2046 due only to the Project by comparing the 2046 Cumulative Scenario relative to the 2046 Approved Scenario. As can be seen from **Figure 3.14**, the Project is not predicted to have any observable impact on the water table level in Area B relative to existing approved operations in 2046. The assessment of impacts over the short term has therefore focussed on the potential impacts on terrestrial and aquatic ecosystems in Area A. As can be seen from **Figure 3.14,** the Project is predicted to result in an incremental impact on a section of Bowmans Creek in Area A of up to 1 m.

Figure 3.15 shows the relative changes in the water table level in Area A and Area B in 2500 (Cumulative Scenario) relative to 2019 modelled conditions (Approved Scenario). In Area A, the Project is predicted to lower the water table in areas adjacent to the Glendell Pit Extension in 2500 relative to 2019 modelled conditions. An approximately 1 m decline relative to the modelled 2019 levels is predicted in the area around the existing Yorks Creek/Bowmans Creek confluence with a small area of decline of up to 1.5 m. It is noted however that these water table levels are higher than the water tables modelled for the Cumulative Scenario in 2046 (refer to **Figure 3.8**).

The Project's impacts on aquatic GDEs or terrestrial GDEs are constrained to Area A. The predicted cumulative impacts on the water table in the area of River Oak Woodland in Area A appear to be almost entirely associated with the Project in both the short to medium term and the long term. These changes are likely to occur over a period of 5-10 years commencing around the time mining in the Glendell Pit Extension progresses close to this area (approximately Years 6-10). The lower water table in this area is predicted to be permanent in a short section of Bowmans Creek alluvium in Area A (approximately 250 m) close to the existing confluence with Yorks Creek where the water table is modelled to be up to approximately 1 m lower than modelled 2019 levels. This modelled reduction in groundwater levels will occur against a background of natural fluctuations in groundwater levels following rainfall events and high river flow events. Larger declines are modelled closer to the Glendell Pit Extension however, as shown on **Figure 3.15**, these areas are within the Glendell Project Disturbance Area where Hebden Road will be realigned and landform changes associated with overburden emplacement and final landform integration will occur.

As can be seen in **Figure 3.12**, groundwater levels in all other areas of the alluvium will have generally recovered by this time to levels similar to or above modelled 2019 levels in all areas along Bowmans Creek even with the effect of the Project. This recovery is predicted to commence shortly after mining associated with the Project ceases. The Project's primary impact being to slow the rate of recovery in some areas adjacent to the Glendell Pit Extension. The water table level in Area B is modelled to be similar to or higher in 2500 than modelled 2019 levels. Accordingly, the Project is not considered likely to have any observable impacts in Area B relative to existing approved operations.



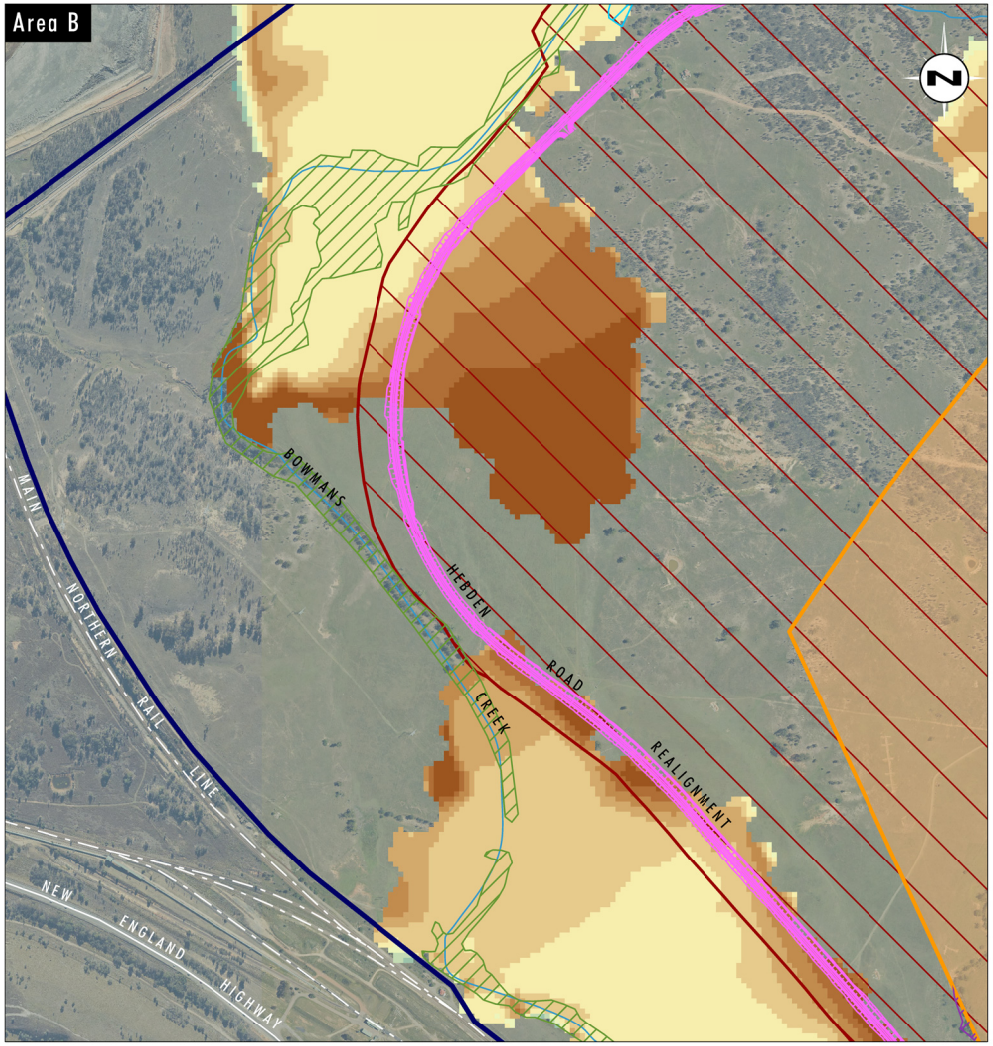


Image Source: Glencore (2018)
Data Source: Glencore (2019), AGE (2019), Umwelt (2019)

0 250 500 750m

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Hebden Road Realignment (Conceptual Alignment)

Change in Depth to Water Table (m)

- Greater than -2.5
- -2.5 to -2.0
- -2.0 to -1.5
- -1.5 to -1.0
- -1.0 to -0.5
- -0.5 to 0.0
- 0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- Greater than 2.5

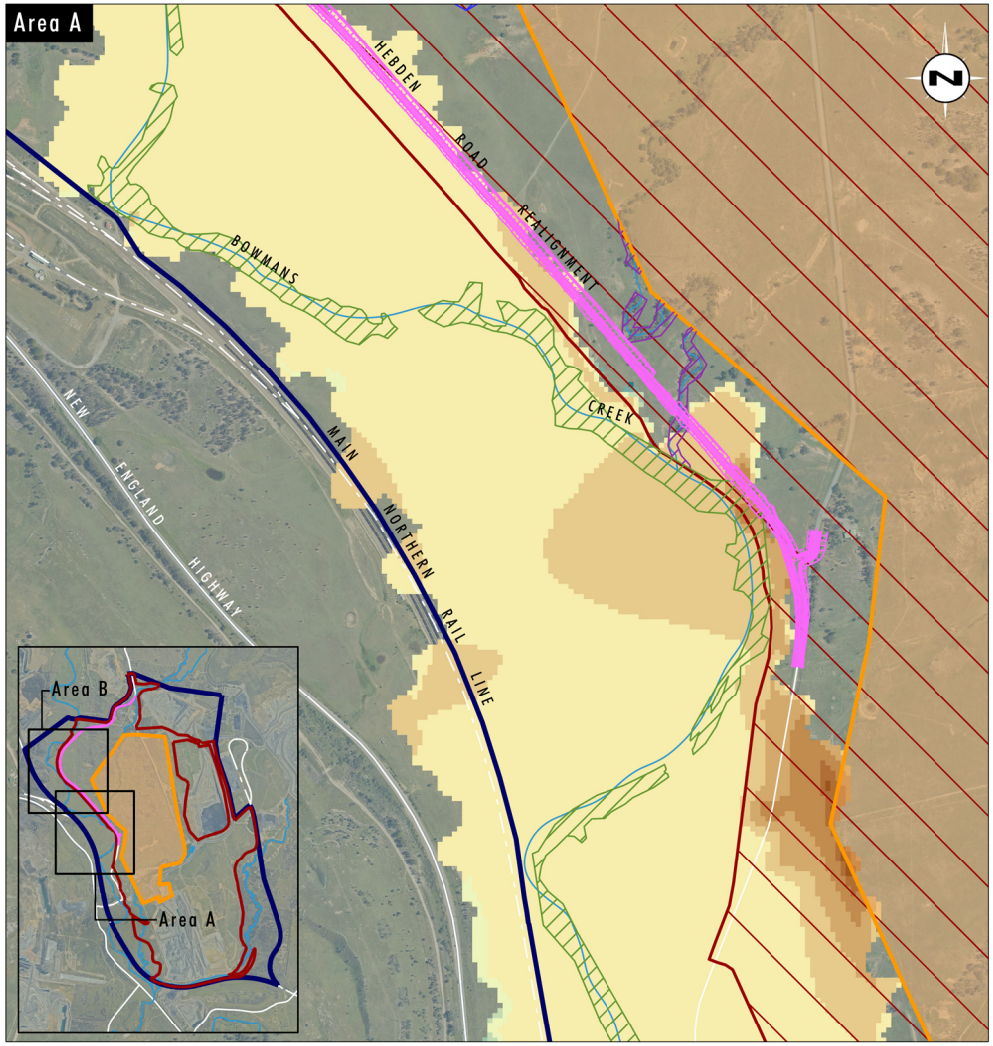
Vegetation Community

- 435 - River Oak Riparian Grassy Tall Woodland in the Western Hunter Valley
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- 1731 - Swamp Oak Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 3.13

Change in Water Table: Focus of Assessment 2019 (Approved Scenario) relative to 2046 (Cumulative Scenario)

File Name (A4): R16/4166_591.dgn
20191121 9.32



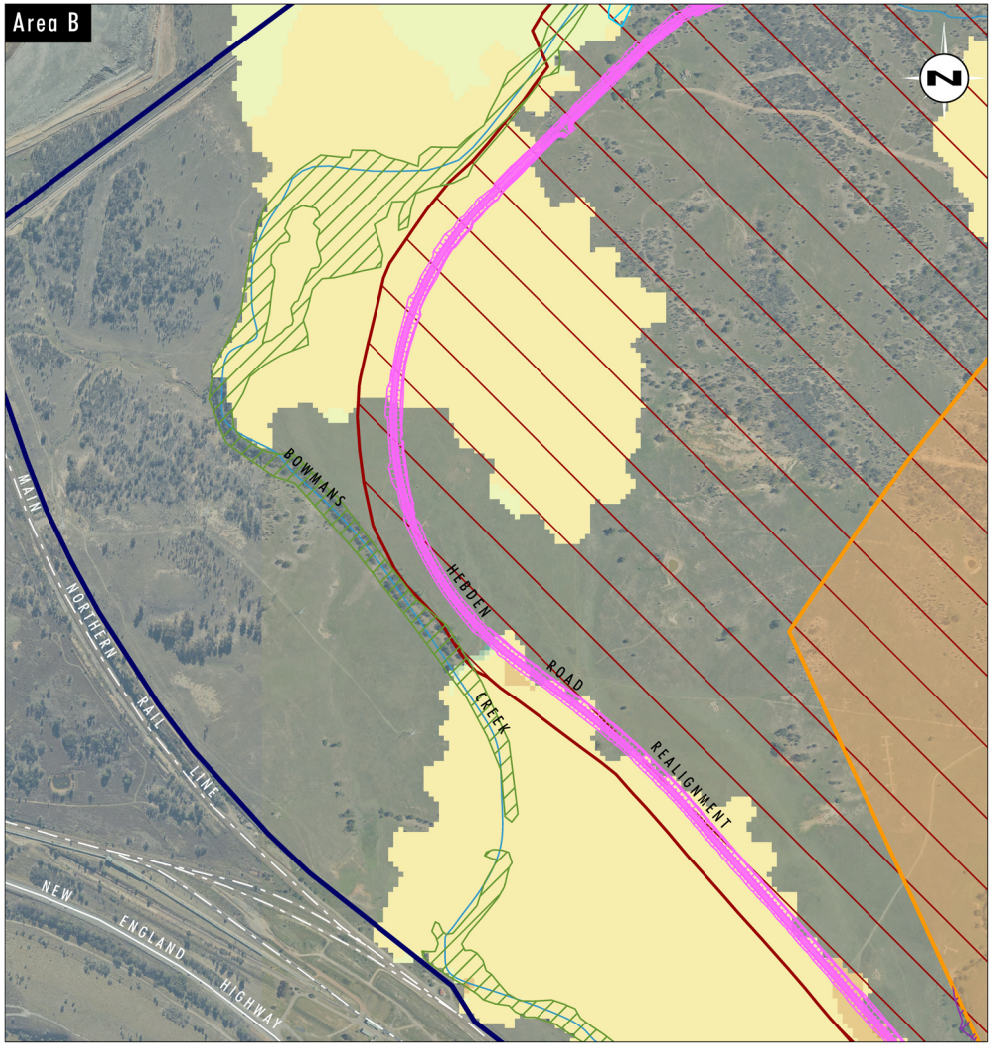


Image Source: Glencore (2018)
Data Source: Glencore (2019), AGE (2019), Umwelt (2019)

0 250 500 750m
1:15,000

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Hebden Road Realignment (Conceptual Alignment)

Change in Depth to Water Table (m)

- Greater than -2.5
- -2.5 to -2.0
- -2.0 to -1.5
- -1.5 to -1.0
- -1.0 to -0.5
- -0.5 to 0.0
- 0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- Greater than 2.5

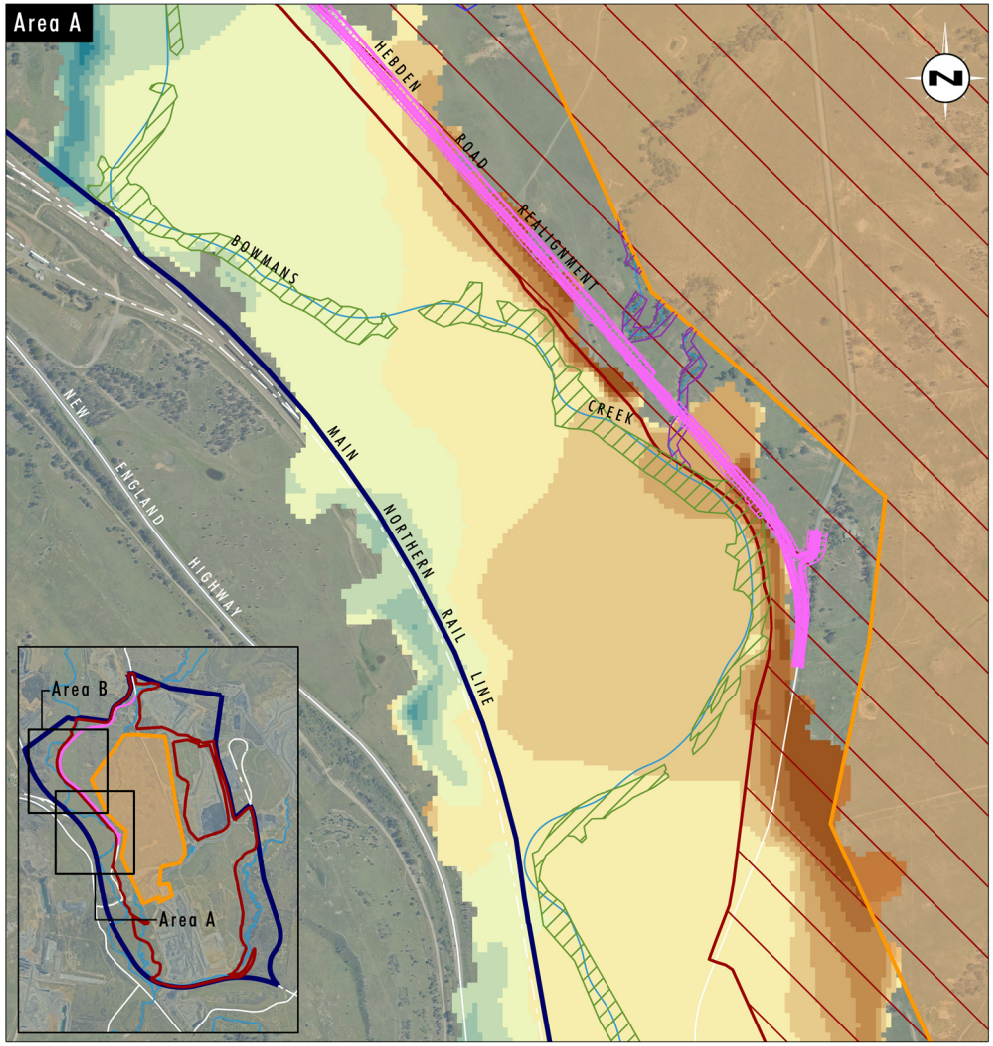
Vegetation Community

- 435 - River Oak Riparian Grassy Tall Woodland in the Western Hunter Valley
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- 1731 - Swamp Oak Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 3.14

Change in Water Table: Focus of Assessment 2046 (Cumulative Scenario) relative to 2046 (Approved Scenario)

File Name (A4): R16/4166_594.dgn
20191121 9.35



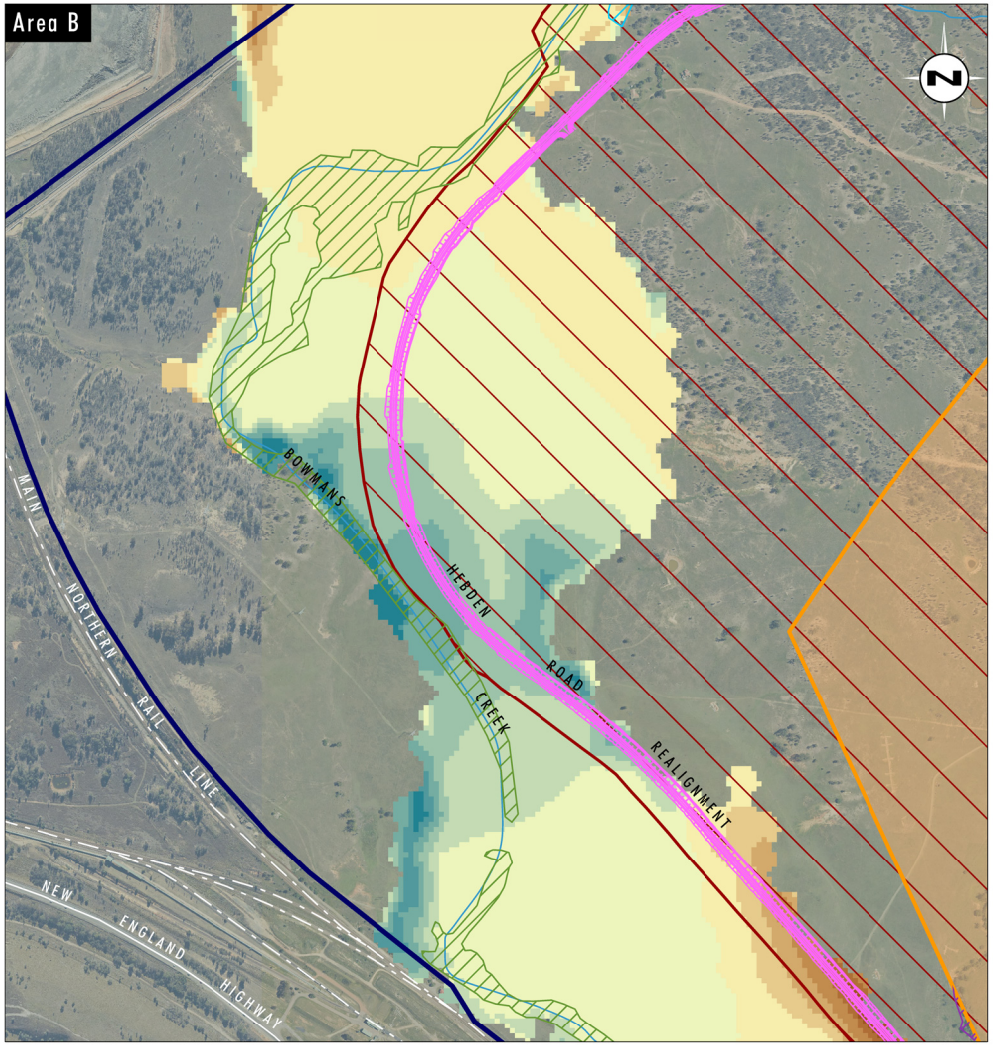


Image Source: Glencore (2018)
Data Source: Glencore (2019), AGE (2019), Umwelt (2019)

0 250 500 750m
1:15,000

Legend

- Project Area
- Glendell Pit Extension
- Glendell Project Disturbance Area
- Hebden Road Realignment (Conceptual Alignment)

Change in Depth to Water Table (m)

- Greater than -2.5
- -2.5 to -2.0
- -2.0 to -1.5
- -1.5 to -1.0
- -1.0 to -0.5
- -0.5 to 0.0
- 0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- Greater than 2.5

Vegetation Community

- 485 - River Oak Riparian Grassy Tall Woodland in the Western Hunter Valley
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley
- 1731 - Swamp Oak Weeping Grass Grassy Riparian Forest of the Hunter Valley

FIGURE 3.15

Change in Water Table: Focus of Assessment 2019 (Approved Scenario) relative to 2500 (Cumulative Scenario)

File Name (A4): R16/4166_595.dgn
20191121 9.25

3.4.3.4 Natural variability

The Groundwater Impact Assessment (AGE 2019) included a review of monitoring data in alluvial bores to identify the variability attributable to natural climatic variability. The monitoring period reviewed including the low recharge conditions associated with the drought which has occurred from 2017 to the time of writing this report. The overall conclusion drawn from the baseline monitoring conducted within the alluvium is that the water levels fluctuate some 1 to 4 m and are strongly correlated with climatic conditions. The influence of approved surrounding mining is less significant, and not readily evident in the water level datasets due to the masking influence of climate. The highest level of fluctuation was observed in the alluvial bore GNP02 which is located in the area close to the confluence of Bowmans Creek and Yorks Creek. Water levels in this bore have declined by over 4 metres since late 2015 with declines of over 2 m observed within 6 month periods over this period; recovery of close to 2 m was also observed in a 3 month period in 2014. The review of monitoring in the alluvium at GNP02 (and other locations) indicates that large variability in the alluvial water table at this location can occur over short periods.

3.4.4 Water Dependent Ecosystems Impact Assessment – Direct Impacts

3.4.4.1 Riparian and Aquatic Habitat Values

Bowmans Creek

Bowmans Creek is located adjacent to the Glendell Pit Extension and contains a variety of aquatic micro-habitats for a comparatively wide range of aquatic flora and fauna species, despite the low water levels recorded at the time of the survey.

Although predominantly dry during the survey period, pool and run habitats were present within Bowmans Creek, with evidence of pool/riffle sequences, overhanging riparian vegetation and fallen woody debris and snags that would provide niche habitat during periods of inundation recorded during surveys.

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 agricultural 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.

The presence of aquatic vegetation was located only in association with pools along Bowmans Creek where encroaching floodplain vegetation was commonly observed throughout the generally dry creek beds.

An assessment of fish habitat classification and sensitivity undertaken in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (NSW DPI, 2013) has identified Bowmans Creek as including:

- Type 1 - Highly sensitive key fish habitat
- Class 2 – Moderate key fish habitat.

Bowmans Creek demonstrated reasonable species diversity with a total of 15 fauna species recorded during aquatic vertebrate sampling. No FM Act or Commonwealth listed threatened aquatic flora or fauna species were recorded within the Project Area.

An assessment of significance was undertaken in accordance with Part 7A of the FM Act and 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, which are known to occupy the Hunter River catchment.

No additional threatened aquatic species, populations or EECs potentially impacted by changes in surface and groundwater conditions have potential to occur within the Project Area

Further details regarding the in-stream and riparian characteristics of Bowmans Creek are contained in the Aquatic Ecology Assessment (refer to Appendix 20 of the EIS).

Yorks Creek

Yorks Creek is ephemeral, is frequently dry and is considered typical of the 3rd order watercourses in the local area.

No water flow was observed in Yorks Creek at the time of survey. Water was scarcely observed along Yorks Creek with the exception to a few small, very shallow pools scattered along the watercourse. These pools contained no aquatic vegetation at the time of survey and were likely a result of limited run off from the adjacent floodplain. 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 agricultural land use.

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 in the dry watercourse.

Except for the lower section near the confluence with Bowmans Creek, Yorks Creek is *not* mapped as key fish habitat by Fisheries Ecosystems Branch of NSW DPI.

An assessment of fish habitat classification and sensitivity undertaken in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (DPI, 2013) has identified Yorks Creek as being:

- Type 3 - Minimally sensitive key fish habitat
- Class 3 – minimal key fish habitat.

Yorks Creek demonstrated poor fish habitat during the survey period. The presence of water was reduced to small, shallow pools persisting, providing limited refuge habitat for aquatic species.

Further details regarding the in-stream and riparian characteristics of Yorks Creek are contained in the Aquatic Ecology Assessment (refer to Appendix 20 of the EIS).

Swamp Creek

No water flow was observed in Swamp Creek 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 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 swamp oak (*Casuarina glauca*). 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 of time.

Swamp Creek is *not* mapped as key fish habitat by Fisheries Ecosystems Branch of NSW DPI.

An assessment of fish habitat classification and sensitivity undertaken in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013) has identified Swamp Creek as being:

- Type 3 - Minimally sensitive key fish habitat
- Class 3 – Minimal key fish habitat.

Swamp Creek demonstrated poor fish habitat during the survey period.

Further details regarding the in-stream and riparian characteristics of Swamp Creek are contained in the Aquatic Ecology Assessment (refer to Appendix 20 of the EIS).

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 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.

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 three to five metres. 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.

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.

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.

An assessment of fish habitat classification and sensitivity undertaken in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013) has identified Bettys Creek as being:

- Type 3 - Minimally sensitive key fish habitat
- Class 3 – Minimal key fish habitat.

Further details regarding the in-stream and riparian characteristics of Swamp Creek are contained in the Aquatic Ecology Assessment (refer to Appendix 20 of the EIS).

3.4.4.2 Direct Impacts on Riparian Habitat

The riparian habitat within the Glendell Project Disturbance Area and Mount Owen Additional Operational Area will be cleared. The Yorks Creek Realignment includes the re-establishment of riparian vegetation along the realigned section of Yorks Creek. The conceptual detailed design also includes the use of woody debris in the channel (where practicable) and the creation of riffle areas and ponds within the channel to enhance instream habitat values for when the creek is flowing. These features of the Yorks Creek Realignment design will ensure that it operates as healthy functioning ephemeral creek system. The establishment of riparian vegetation along the realigned section of Yorks Creek will also maintain terrestrial habitat connectivity between the upper reaches of Yorks Creek and Bowmans Creek. Further details regarding the design of the Yorks Creek Realignment are contained in the Surface Water Impact

Assessment (refer to Appendix 17 of the EIS) and the proposed Rehabilitation Strategy (refer to Appendix 24 of the EIS).

The removal of the riparian vegetation within the Additional Disturbance Area is assessed as part of the BDAR (refer to Appendix 20 of the EIS). Riparian vegetation removed as a result of the Project has been assessed under the BC Act with relevant credits generated to be offset as part of the biodiversity offset strategy for the Project.

3.4.4.3 Direct Impacts on Aquatic Habitat

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 reach of Yorks Creek. These aspects of the Project impacts have the potential to impact on 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 creek 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 (refer to Appendix 20 of the EIS).

Swamp Creek

The Project will mine through a section of Swamp Creek located immediately north of Glendell Pit reducing the catchment area. As Swamp Creek is an ephemeral creek system, it has few or no persistent pools. Direct impacts on aquatic communities located within the creek will be limited to circumstances where the creek contains 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 (refer to Appendix 20 of the EIS).

3.4.5 Water Dependent Ecosystems Impact Assessment – Indirect Impacts

3.4.5.1 Indirect Impacts on Aquatic Ecosystems

Water Quality

The Mount Owen Complex WMS is designed to avoid downstream pollution of waters through the design of water storages, infrastructure and water management practices (refer to **Section 3.1.2.4**). While spills from storages are expected when design criteria is exceeded, the quality of water 'spilt' from the storages is expected to be of a quality that is unlikely to result in any adverse impacts on aquatic ecosystems in the receiving environments, particularly given the dilution effects of the receiving environment following such rainfall events and the naturally elevated turbidity within receiving waters during high flow events. The Geochemical Assessment (EGI, 2019) undertaken for the Project indicates there is a low risk of elevated metal and metalloid concentrations in water exposed to overburden material.

Changes in groundwater flows are not predicted to have any observable impact on groundwater quality.

The Project is therefore not considered likely to have any observable impacts on aquatic ecosystems as a result of changes in water quality.

Changes in flow conditions

As part of the Surface Water Impact Assessment (GHD, 2019) flow regime modelling was used to estimate the potential impacts to low flows (surface and subsurface) and the water levels in persistent pools, assuming that the regional water table was sufficiently high that subsurface flow moved through the pool. Based on the results of the flow regime modelling, no measurable impact on total low flows or persistent pools in Bowmans Creek or Glennies Creek is expected as a result of the incremental impacts on baseflow associated with the Project. Any consequential impacts on aquatic fauna are predicted to be small and not observable in the context of natural fluctuations. Accordingly, the Project is unlikely to have any observable impact on aquatic GDEs in Bowmans Creek associated with changes in baseflows.

Baseflow in Yorks Creek, Swamp Creek and Bettys Creek is expected to occur as subsurface flows through alluvial material. Persistent pools in these systems are uncommon and are typically short-lived with little evidence of aquatic habitats observed during the surveys undertaken for the Project. The Project's predicted impact on baseflow in these systems is therefore considered to have only negligible impact on any aquatic ecosystems that may be present in pools in these creeks.

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 also predicts small changes to baseflow in Bowmans and Glennies Creek and the Hunter River associated with a delay in the recovery of the groundwater system. The incremental changes to baseflow for Glennies Creek, Yorks, Swamp and Bettys Creek are predicted to be negligible and overall baseflow is predicted to increase following the cessation of mining as regional groundwater systems recover.

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 minor 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 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 reach 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.

The reconfiguration of final landform drainage in the central areas of the Mount Owen Complex to direct runoff towards Bettys Creek rather than Swamp Creek will increase the catchment of Bettys Creek relative to its current conditions but return the catchment to a similar size to its pre-mining catchment. The WRD will be used as a retention basin in the final landform to manage flows into Bettys Creek to minimise erosion and scouring risks. This change is unlikely to have any significant adverse impacts on aquatic ecosystems in Bettys Creek and is likely to contribute to improved riparian and aquatic ecosystems in this system.

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.

Connectivity with alluvial groundwater

Bowmans Creek meanders through the flood plain adjacent to the Glendell Pit Extension and pools within the creek can form windows to the underlying aquifer. The aquatic ecosystems in these pools in Bowmans Creek and the adjacent riparian vegetation potentially depend on the underlying alluvial water table, particularly during extended dry periods such as that occurring throughout 2017 - 2019. As discussed in **Section 3.4.3.3**, the reduction in the water table in this area attributable to the Project is modelled as being between 1 m and 1.5 m below the 2019 modelled levels in a 250 m section of Bowmans Creek with cumulative impacts modelled as resulting in an approximately 2 metre reduction in the water table in this area. A pool is present in this area. This modelled cumulative reduction is less than the natural variability in the alluvial water table levels observed over a 12 month period in 2018 due to extended drought conditions (refer to **Section 3.4.3.4**) with an overall decline of over 4 m observed in this area between 2015 and 2019 due primarily to climatic factors. During 2018 and 2019, water remained in this pool and the water depth was greater than the predicted drawdown impacts associated with the Project indicating water is likely to remain in this pool even during extreme dry periods.

Should this pool dry, this would result in localised impacts on some aquatic species. While this is a significant impact on the ecosystem potentially impacted, there are no recorded threatened or endangered species within the area of potential impact and no significant impacts on broader aquatic species populations are expected as a consequence of this localised impact.

3.4.5.2 Indirect Impacts on Groundwater Dependent Vegetation Communities

The Project's modelled impacts on shallow water tables that may affect terrestrial vegetation is generally limited to a small area of River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley (River Oak Woodland) (refer to Area A in **Figures 3.13** to **3.15**). The majority of the River Oak Woodland potentially impacted by changes in the water table level is located within the Glendell Project Disturbance Area and may be impacted by the construction of the Hebden Road realignment. A small area of Swamp Oak Weeping Grass Riparian Forest of the Hunter Valley (Swamp Oak Forest) located along the lower reach of Yorks Creek is also in the area of potential water table level impact however this community is within the Glendell Project Disturbance Area and will be removed as part of the Hebden Road realignment and Heavy Vehicle Access Road works and is not considered further. The remaining areas potentially impacted are limited to fringing vegetation along an approximately 250 m length of Bowmans Creek in Area A.

The modelling indicates a potential cumulative decline in water table level in this area in the order of 2 m relative to modelled 2019 levels (refer to **Section 3.4.3.3**) of which the Project is modelled as contributing up to 1 m. The overall cumulative decline is modelled to occur progressively from 2019 to 2046 with the additional decline associated with the Project likely to occur over a period of 5 – 10 years commencing around the time mining in the Glendell Pit Extension progresses close to this area (approximately mine Years 6 – 10). This modelled reduction in groundwater levels will occur against a background of natural fluctuations in groundwater levels following rainfall events and high river flow events. This natural fluctuation (refer to **Section 3.4.3.4**) is larger than the predicted decline in water table associated with the Project with monitoring indicating a climatic induced decline over the period 2016 to 2019 of over 4 m with a 2 m reduction in the water table during 2018 alone associated with the prevailing drought conditions.

Following the cessation of mining, there will be an increase in water table levels in this area however the water table level is modelled as remaining approximately 1 m lower than the modelled 2019 levels in Area A in 2500 (approximately 1 m higher than is modelled in 2046).

The reduction in the water table in Area A (both cumulatively and attributable to the Project) does not result in any desaturation of the alluvium where the River Oak Woodland is located. The reduction in the water table of up to 2 m over a 25 year period is within the natural variability in water tables (in excess of 4 m) observed in this area. The trees in this area are expected to able to adapt in the timeframes concerned

and 'chase' the water through deeper roots. Accordingly, no significant impact upon the River Oak Woodland community in this location is expected as a result of either the Project or cumulative impacts.

Cumulative groundwater impacts are modelled to result in a desaturation of the Bowmans Creek alluvium in Area B. The Project is not predicted to increase the extent of desaturation in this area but is modelled to delay the recovery of the water table level. This delay in recovery is not predicted to have a significant additional impact on terrestrial vegetation in this area relative to existing approved operations given the likely period for recovery in the Approved Scenario.

3.4.5.3 Indirect Impacts on Subterranean Water Dependent Ecosystems

Four stygofauna taxa, and one troglofauna taxon were collected in the shallow alluvial aquifers as part of the survey undertaken for the Stygofauna Assessment (ELA, 2019), which brings the total known stygofauna taxa within the vicinity of the Mount Owen Complex to seven. In considering all previous sampling in the area, stygofauna were collected from Bowmans, Glennies, Swamp, and Yorks Creeks alluvium, but not from the underlying Permian rock or coal seam aquifers or the alluvium of Bettys Creek. All taxa collected have a broad distribution in the Hunter Valley and are widespread along the Hunter River, Dart Brook, Kingdon Ponds and Pages River alluvial aquifers.

Groundwater modelling indicates that there will be complete desaturation in two sections of the Bowmans Creek alluvium, associated with the approved operations in the region, which will potentially isolate an approximately 5.5 km length of aquifer from both upstream and downstream reaches and separate the upstream reaches of Bowmans Creek alluvium from the Hunter River alluvium. The 5.5 km length of Bowmans Creek alluvium to be isolated includes the junctions with Yorks and Swamp Creeks and was where the stygofauna collected during survey sampling were identified (ELA, 2019). Isolation will last at least until beyond the end of mining, although there may be intermittent periods of reconnection. However, it should be noted that the modelling indicates the desaturation will be caused by already-approved and operating mining projects, and not a result of the Project.

The isolated section of alluvium will effectively become an island, with stygofauna unable to move between it and the aquifer upstream or downstream. This means that the stygofauna community would be less robust to change (because if an impact occurs that reduces the population size or biological diversity, there are no means of recolonising the aquifer through migration, except for brief periods of reconnection following recharge events). As the stygofauna collected during this current round of sampling all came from this 'island', it is possible that, over time these will be lost from this reach. However, the loss of these species will be localised, as all are widespread in the Hunter Valley.

Equally, there may be potential for repopulation of this 'island', if surrounding populations are able to migrate during reconnecting flow events. However, as the island would likely be isolated again, it is likely that such recolonizations would be considered temporary.

3.4.6 Summary of Ecohydrological Assessment Outcomes

A summary of the findings of potential ecohydrological impacts as they relate to MNES is provided below:

- The predicted impacts on groundwater levels are within the levels of natural variability of groundwater levels and the Project's impacts are considered unlikely to be observable in the context of natural fluctuations.

- The Project's potential impacts on groundwater in areas where medium or highly groundwater dependent ecosystems are located is limited to a small area of PCT 485 River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley. This PCT is expected to be able to adapt to the predicted

changes in groundwater levels given the small magnitude (0.5 – 1 m) of the change and the time period over which the change is predicted to occur.

- Based on the results of the flow regime modelling, no measurable impact on total low flows or pools in Bowmans Creek or Glennies Creek is expected as a result of the incremental impacts on baseflow associated with the Project. Any consequential impacts on aquatic fauna are predicted to be small and not observable in the context of natural fluctuations.

- Baseflow in Yorks Creek, Swamp Creek and Bettys Creek is expected to occur as subsurface flows through alluvial material. Pools in these systems are uncommon and are typically short-lived with little evidence of aquatic habitats observed during the surveys undertaken for the Project. The Project's predicted impact on baseflow in these systems is therefore considered to have only negligible impact on any aquatic ecosystems that may be present in pools in these creeks.

- The drying of some pools will result in localised impacts on some aquatic environments. While this is a significant impact on the local ecosystems potentially impacted, there are no recorded threatened or endangered species within the area of potential impact and no significant impacts on broader aquatic species populations are expected as a consequence of this localised impact.

- Groundwater modelling indicates that there will be complete desaturation in two sections of the Bowmans Creek alluvium, which will potentially isolate a 5.5 km length of aquifer from both upstream and downstream reaches and separate the upstream reaches of Bowmans Creek alluvium from the Hunter River alluvium. Isolation will last at least until beyond the end of mining, although there may be intermittent periods of reconnection. However, it should be noted that the modelling indicates the desaturation will be caused by existing approved mining projects, and not a result of the Project. As the stygofauna collected during this current round of sampling all came from the section modelled to be isolated, it is possible that, over time these will be lost from this reach. However, the loss of these species will be localised, as all are widespread in the Hunter Valley and recolonization would occur following resaturation and reconnection.

- Riparian vegetation removed as a result of the Project has been assessed under the BC Act with impacts to be offset as part of the biodiversity offset strategy for the Project (refer to **Section 2.5**). The Yorks Creek Realignment includes the re-establishment of riparian vegetation along the realigned section of Yorks Creek. The conceptual detailed design also includes the use of woody debris in the channel (where practicable) and the creation of riffle areas and ponds within the channel to enhance instream habitat values for when the creek is flowing. These features of the Yorks Creek Realignment design will ensure that it operates as healthy functioning ephemeral creek system.

A range of biodiversity mitigation and management measures are proposed as part of the Project, a consolidated list of the proposed management measures is provided as Appendix 5 of the EIS.

4.0 Avoidance and Mitigation of Impacts

4.1 Terrestrial Ecosystems

4.1.1 Avoidance Strategies

Glencore has sought and will continue to seek opportunities during the detailed design process to avoid and minimise impacts to biodiversity values, following the established hierarchy of avoid, minimise, mitigate and offset. This has included avoidance and minimisation of disturbance of key vegetation communities and fauna habitats. Where impacts are unavoidable the residual impact of the Project will be offset following the NSW Biodiversity Offset Scheme under the *Biodiversity Conservation Act 2016* and where MNES are impacted, the Commonwealth EPBC Act Environmental Offset Policy.

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

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 less than 20% of the Project Area and the higher quality remnant patches of native forest and woodland have been avoided (i.e. Bowmans Creek riparian corridor).

Through the iterative design process and the modifications made to the Project design, the potential biodiversity impacts of the Project have been significantly reduced. In total, the changes to the physical components of the Project and further assessments have resulted in an overall reduction of approximately 158 ha to the native vegetation impacts since the submission of the EPBC Referral. In terms of biodiversity values, the avoidance of certain infrastructure locations has resulted specifically in the preservation of approximately 43 ha of *Central Hunter Valley Eucalypt Forest and Woodland* CEEC and approximately 85 ha of swift parrot and regent honeyeater habitat.

Due to selecting the preferred option and not proceeding with the alternative mining options and infrastructure locations, the Project was able to avoid key physical impacts through the reduced surface disturbance footprint and extent of proposed operations. In addition to these avoided physical impacts there have also been significant reductions in predicted impacts of noise and dust emissions on the wider locality through mine scheduling and by deciding not to proceed with some of the alternative mine plan options.

4.1.2 Mitigation Measures

Glencore has committed to the design and implementation of a comprehensive strategy to mitigate the residual impacts of the Proposed Action. The impact mitigation measures proposed are based on best available practices and are widely used to mitigate the impact of coal mining developments in the Hunter Valley and elsewhere. Mitigation measures for the proposed action on EPBC listed threatened species and communities include:

- landform and rehabilitation establishment including the establishment of appropriate wooded vegetation habitat linkage corridors
- 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 soil)

- pre-clearing procedure 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 Project Area outside existing approved and proposed disturbance areas. The proposed revegetation strategy for disturbed areas has aimed to enhance regional connectivity between remnant vegetation areas and vegetated creeklines.

Table 4.1 provides an outline of the avoidance and minimisation measures to be implemented by Glencore for the impacts described above to those MNES that are predicted to be significantly impacted by the Project.

Table 4.1 Avoidance and mitigation methods for residual impacts on EPBC listed threatened species and communities

EPBC Act listed species or community	Impact	Avoidance and mitigation measures
Central Hunter Valley Eucalypt Forest and Woodland CEEC	Direct impact – removal of approximately 123 ha of vegetation	Project planning and design stage resulted in substantial avoidance of areas of *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. An extensive mitigation and offsetting strategy is proposed including the provision of: • the delineation of clearance areas to avoid unnecessary impacts and clearance of surrounding vegetation • habitat enhancement measures such as the installation of nest boxes, salvaged hollows, fallen timber, hollow logs and rocks to supplement mine rehabilitation areas • rehabilitation of the Project Area post mining as described in the EIS, and • the implementation of a biodiversity offset strategy in accordance with the NSW Biodiversity Offset Scheme and the EPBC Act Environmental Offsets Policy.
	Air quality impacts; dust covering vegetation impacting health and growth	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
	Weed encroachment	Glencore has an adaptive weed management strategy described within its Biodiversity and Offset Management Plan. Weed infestations are monitored as part of annual walkover inspections and ecological monitoring programs, and a response is required for significant infestations.
	Cumulative impacts of land clearing	Land-based offsetting of the CEEC will be a consideration in the development of the biodiversity offset strategy that will be prepared for the Project to ensure that there is no residual significant impact to the community in the medium-long term as a result of the Proposed Action. In addition, Glencore may seek to restore areas of CEEC into the post-mining landscape through rehabilitation. Glencore's rehabilitation objectives for the Project Area include the following: • Establish similar native vegetation communities to those that will be impacted by the Project. • Establishment of native vegetation rehabilitation as part of the conceptual final land use for the Project. • Develop native vegetation corridors linking surrounding remnant vegetation areas of the Project Area to existing remnants.

EPBC Act listed species or community	Impact	Avoidance and mitigation measures
regent honeyeater **swift parrot** **green and golden bell frog** **spotted-tailed quoll** **koala** **large-eared pied bat** **New Holland mouse** **grey-headed flying-fox**	Direct impact – loss of known or potential habitat	Project planning at design stage resulted in substantial avoidance of known and potential MNES habitats. An extensive mitigation and offsetting strategy is proposed including the provision of: • the delineation of clearance areas to avoid unnecessary impacts and clearance of surrounding vegetation • pre-clearance surveys and tree-felling supervision • 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 Project Area post-mining as described in the EIS, and • the implementation of a biodiversity offset strategy in accordance with the NSW Biodiversity Offset Scheme and the EPBC Act Environmental Offsets Policy.
	Removal of connectivity and corridor pathways for fauna movement and gene flow. Cumulative habitat loss and vegetation clearance in the locality.	Future mine rehabilitation will aim to re-instate connectivity at a local and regional scale in the medium to long-term. Glencore's rehabilitation objectives for the Project Area include the following: • establish similar native vegetation communities to those that will be impacted by the Project. • develop native vegetation corridors linking surrounding remnant vegetation areas to the southwest of the Project Area to existing remnants in the north
	Fugitive light emissions may result in behavioural changes in fauna; disruption of seasonal day length, trigger changes in foraging behaviour	As per existing site practice, appropriate lighting controls to minimise impacts will continue to 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.
	Noise and blasting impacts may disturb the roosting and foraging behaviour of fauna species and/or reduce the occupancy of areas of otherwise suitable habitat.	Mitigation of noise and blasting impacts are outlined in Noise Management Plan and Blast Management Plan respectively. Noise and blast control measures include both design and operational controls and adaptive management strategies are in place as part of each plan.

EPBC Act listed species or community	Impact	Avoidance and mitigation measures
	Air quality impacts; increased air pollutants for native species	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
	Introduction of feral animals	Glencore has an adaptive feral pest management strategy described within its Biodiversity and Offset Management Plan. Feral animal impacts are monitored as part of annual walkover inspections and ecological monitoring programs, and a response is required for moderate to severe impacts caused by feral animals.

4.2 Aquatic Ecology

4.2.1 Avoidance Strategies

The Project has avoided significant impacts on Bowmans Creek by designing the Project to avoid all direct impacts other than those associated with the construction of the Yorks Creek Realignment confluence with Bowmans Creek.

The location of the Glendell Pit Extension along the Camberwell anticline and the modified groundwater environment means that cumulative groundwater impacts are also significantly lower than would be the case for a 'greenfield' project. The timing of the Project also means that rehabilitated catchment areas are returned to Bowmans Creek during the life of the Project which mitigates the Project's impacts on stream flows.

The following section considers the range of additional mitigation and management measures that will be implemented for the Project to further mitigate potential impacts on aquatic ecosystems.

4.2.2 Construction Phase Mitigation and Management Measures

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:

- workforce 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 Glendell Project Disturbance Area are not impacted.

A Yorks Creek Realignment Plan will be developed to inform the construction and commissioning works for the Yorks Creek Realignment. To minimise the impacts on water quality, erosion and sedimentation associated with spills and/or construction activities within the watercourse, works within or adjacent to the watercourse will be undertaken in accordance with a Construction Erosion and Sediment Control Management Plan (developed as part of the Yorks Creek Realignment Plan) which will include specific requirements to address works within the riparian zones. In addition, 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).

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

During construction of the Yorks Creek Realignment, 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.

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

4.2.3 Operational Phase Mitigation

The Project will extend many of the existing groundwater and surface management processes currently employed at the Mount Owen Complex. The Mount Owen Complex WMS is an established system with a long history of effective management of potential impacts on water quality (refer to **Section 3.1.2.5**). The integration of the Mount Owen Complex WMS with the GRAWTS 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 and indicates that the continuation of the pit along the anticline is unlikely to have significant additional impacts on this system.

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 WMS or GRAWTS, with any mine water discharges managed in accordance with the 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.

Other than the monitoring associated with the Yorks Creek Realignment, no additional aquatic monitoring is considered to be warranted given the low levels of impacts predicted by the Project.

4.3 Groundwater Dependent Terrestrial Ecology

4.3.1 Avoidance Strategies

The use of a low permeability barrier between the Glendell Pit Extension and the alluvial aquifer system at the points of intersection (i.e. Swamp Creek and Yorks Creek) was considered. Modelling of the barriers in the alluvium indicated only a low level of impact mitigation, likely due to the regolith being the main flow path for the Project's impacts on the alluvial aquifer system.

Given the overall low magnitude of predicted impacts, and the ability to licence the modelled take and the limited effectiveness of the modelled barrier, the use of a low permeability barrier was not considered to be reasonable or feasible.

4.3.2 Mitigation and Management Strategies

The Project's potential impacts on groundwater in areas where medium or highly groundwater dependent terrestrial ecosystems are located is limited to a small area of River Oak Woodland (refer to **Figure 3.10**). The species potentially impacted are expected to be able to adapt to the proposed changes in groundwater levels given the small magnitude of the change and the time period over which the change is predicted to occur.

The predicted impacts on groundwater levels are within the levels of natural variability of groundwater levels and the Project's impacts are considered unlikely to be observable in the context of natural fluctuations.

Due to the limited impact the Project's predicted changes are likely to have of terrestrial ecosystems no additional monitoring is proposed.

4.4 Subterranean Water Dependent Ecosystems

The Project's is not predicted to have any significant impact on stygofauna with the main impacts associated with the modelled desaturation of parts of the Bowmans Creek alluvium which is predicted to occur irrespective of the Project.

Due to the limited impact the Project is predicted to have on stygofauna no additional monitoring of stygofauna is proposed.

5.0 References

AGE (2017) Report on Main Creek Alluvium Verification and Mapping, Mount Owen Continued Operations – Modification.

AGE (2019) Glendell Continued Operations - Groundwater Impact Assessment.

Birdline NSW (2019) Birdline New South Wales Available from: http://www.eremaea.com/BirdlineRecentSightings.aspx?Birdline=2,.

Bureau of Meteorology (2019) Monthly Climate Statistics from Singleton STP, 061397 http://www.bom.gov.au/climate/averages/tables/cw_061397.shtml

Department of Environment and Climate Change (DECC) NSW (2007) Management Plan for the Green and Golden Bell Frog Key Population in the Upper Hunter.

Department of Environment and Climate Change NSW (DECC) (2008) Recovery Plan for the Koala (*Phascolarctos cinereus*) – Approved Recovery Plan, November 2008.

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

Department of Environment and Conservation NSW (DEC) (2005) Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*). DEC NSW, Hurstville, NSW.

Department of Environment and Resource Management (DERM) (2011) National recovery plan for the Large-eared Pied Bat *Chalinolobus dwyeri.* Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Department of Environment, Land, Water and Planning (DELWP) (2016) National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus*. Australian government, Canberra.

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

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

Department of the Environment (DoE) (2014) EPBC Act Referral Guidelines for the Vulnerable Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory). Commonwealth of Australia.

Department of the Environment (DoE) (2015a) Referral Guideline for Management Actions in Grey-headed and Spectacled Flying-Fox Camps, September 2015.

Department of the Environment (DoE) (2016) National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*), April 2016.

Department of the Environment and Energy (DoEE) (2016) *Central Hunter Valley Eucalypt Forest and Woodland CEEC* Policy Statement

Department of the Environment and Energy (DoEE) (2019) SPRAT Species Profiles.

Department of the Environment and Energy (DoEE) (2019) National Flying-fox Monitoring Viewer. Available from: <http://www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf>.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009) Significant Impacts Guidelines for the Vulnerable Green and Golden Bell Frog, EPBC Act Policy Statement 3.19

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2010a) Survey Guidelines for Australia's Threatened Birds: Guidelines for Detecting Birds Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999.* Commonwealth of Australia.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2010b) Survey Guidelines for Australia's Threatened Frogs: Guidelines for Detecting Frogs Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2010c) Survey Guidelines for Australia's Threatened Bats: Guidelines for Detecting Bats Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia.

Department of the Sustainability, Environment, Water, Population and Communities (DSEWPC) (2011) Survey Guidelines for Australia's Threatened Mammals: Guidelines for Detecting Mammals Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia.

Department of Environment, Climate Change and Water NSW (DECCW) (2009) Draft National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus*. Prepared by Dr Peggy Eby. Department of Environment, Climate Change and Water NSW, Sydney.

Department of Environment, Climate Change and Water NSW (DECCW) (2007) Management Plan for the Green and Golden Bell Frog Key Population in the Upper Hunter. Department of Environment and Climate Change (NSW), Sydney.

Doody, Hancock and Pritchard (2019), Information Guidelines Explanatory Note, Assessing groundwater-dependent ecosystems (Explanatory Note)

Eco Logical Australia (2019) Glendell Continued Operations Project- Stygofauna Assessment. Prepared for Umwelt.

Fly by Night Bat Surveys Pty Ltd, Forest Fauna Surveys Pty Ltd and TUNDRA (2007) Mount Owen Coal Mine Fauna Monitoring 2005/2006, report to Mount Owen Coal Mine

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

Forest Fauna Surveys Pty Ltd and Newcastle Innovation (formerly TUNDRA Ltd) (2013) Mt Owen Complex Fauna Monitoring 2013 Annual Report to Mt Owen Complex.

GHD (2019) Glendell Continued Operations Project Surface Water Impact Assessment

Goldingay, R. L. (2008) Can the community contribute to conservation of the endangered green and golden bell frog at Port Kembla? Australian Zoologist 34: 387-392.

Mahony, M. J., A. J. Hamer, E. J. Pickett, D. J. McKenzie, M. P. Stockwell, J. I. Garnham, C. C. Keely, M. L. DeBoo, J. O'Meara, C. J. Pollard, S. Clulow, F. L. Lemckert, D. S. Bower and J. Clulow (2013). "Identifying

conservation and research priorities in the face of uncertainty: a review of the threatened bell frog complex in eastern Australia." *Herpetological Conservation and Biology* **8**(3): 519-538.

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

Office of Environment and Heritage (OEH) (2017a) Advice for Determining Central Hunter Valley eucalypt forest and woodland CEEC in Bulloak-dominated woodland.

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

Office of Environment and Heritage (OEH) (2019) VIS Classification Database.

Department of Planning, Industry and Environment (DPIE) (2019) Threatened Species Profiles.

Department of Planning, Industry and Environment (DPIE) (2019) BioNet Atlas of NSW Wildlife, accessed February 2019

Phillips, S. & J. Callaghan (2011) The Spot Assessment technique: a tool for determining localised levels of habitat use by Koalas; Phascolarctos cinereus. Australian Zoologist 35(3), p. 774-780.

Roderick, M., Ingwersen, D.A. and Tzaros, C.L. (2013) Swift Parrots and Regent Honeyeaters in the Lower Hunter Region of New South Wales: an assessment of status, identification of high priority habitats and recommendations for conservation. Report for Sustainable Regional Development Program. Department of Sustainability, Environment, Water, Population and Communities. BirdLife Australia, Melbourne.

Saunders, D. (2002) Swifts Across the Strait. February 2002.

Saunders, D.L. and Tzaros, C.L. (2011) National Recovery Plan for the Swift Parrot *Lathamus discolor*, Birds Australia, Melbourne.

Threatened Species Scientific Committee (TSSC) (2010). Commonwealth Conservation Advice on *Pseudomys novaehollandiae* (New Holland Mouse). Department of the Environment, Water, Heritage and the Arts. Canberra, ACT: Department of the Environment, Water, Heritage and the Arts.

Threatened Species Scientific Committee (TSSC) (2012a). Commonwealth Conservation Advice on *Phascolarctos cinereus* (combined population in Queensland, New South Wales and the Australian Capital Territory). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-conservation-advice.pdf, Accessed July 2017.

Threatened Species Scientific Committee (TSSC) (2012b). Listing advice for *Phascolarctos cinereus* (Koala). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-listing-advice.pdf, Accessed July 2017.

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

Threatened Species Scientific Committee (TSSC) 2015. Conservation Advice – *Anthochaera phrygia* – regent honeyeater.

Umwelt (2019) Glendell Continued Operations Project: Biodiversity Development Assessment Report.

Umwelt (2019) Glendell Continued Operations Project EPBC Act Referral Reference Number 2019/8409 dated 11 April 2019

Umwelt (2019), Glendell Continued Operations Project Environmental Impact Statement

Umwelt (2019) Glendell Continued Operations Project, Gateway Application, April 2019

Umwelt (Australia) Pty Limited (2010). Ravensworth Operation Ecological Assessment. Report prepared for Ravensworth Operations Pty Limited.

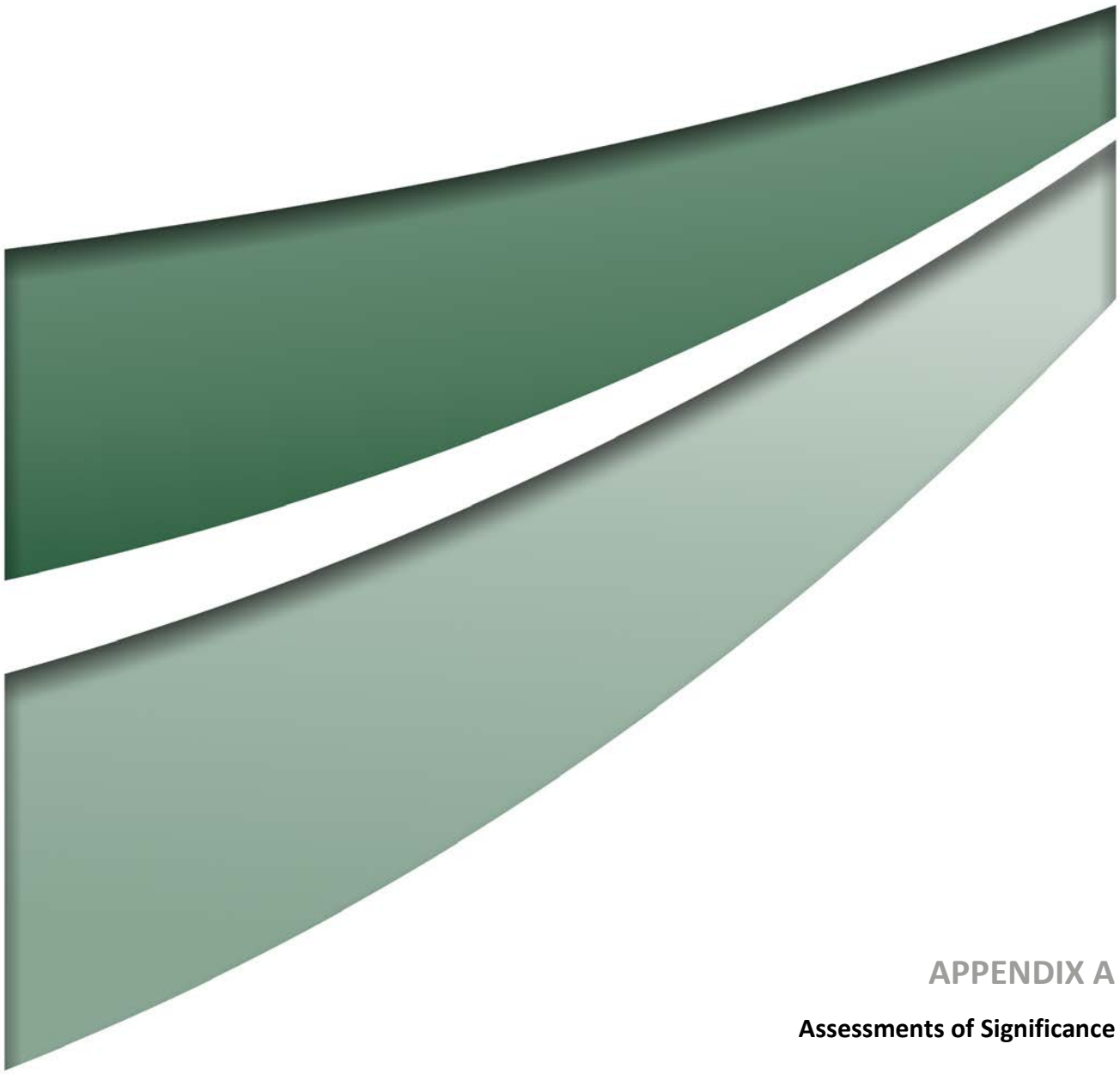
Umwelt (Australia) Pty Limited (2014) Ecological Assessment - Mount Owen Continued Operations Project, October 2014.

Umwelt (Australia) Pty Limited (2015) Upper Hunter Strategic Assessment (UHSA) Greater Ravensworth Biodiversity Assessment Report, March 2015.

Umwelt (Australia) Pty Limited (2016a) Ecological Constraints Analysis - Mount Owen Optimisation South-East (MOOSE) Project, December 2016.

Umwelt (Australia) Pty Limited (2016b). Biodiversity Offset Monitoring Report: Liddell Coal Operations. Report prepared for Liddell Coal Operations.

Umwelt (Australia) Pty Limited (2017). Mount Owen Continued Operations Modification 2 – Ecological Matters of National Environmental Significance Report, December 2017.



APPENDIX A

Assessments of Significance

The EPBC Act requires an Assessment of Significance relating to the potential impacts of a proposed action on listed MNES. These assessments have been conducted in accordance with the Significant Impact Guidelines 1.1 (DoE 2013), based on the current mine plan. Assessments of significance were provided in the original Referral documentation, however these have been updated as per the further assessment and project boundary revisions outlined in this report.

As outlined in **Section 1.0**, the following EPBC Act listed species and communities are considered by DoEE to be likely to be or have the potential to be significantly impacted by the Proposed Actions (the Project):

Critically Endangered or Endangered Ecological Communities

- *Central Hunter Valley Eucalypt Forest and Woodland CEEC*

Critically Endangered and Endangered Species

- regent honeyeater (*Anthochaera phrygia*)
- swift parrot (*Lathamus discolor*)
- spotted-tailed quoll (*Dasyurus maculatus maculatus*) (SE mainland population).

Vulnerable Species

- green and golden bell frog (*Litoria aurea*)
- koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT)
- large-eared pied bat (*Chalinolobus dwyeri*)
- New Holland mouse (*Pseudomys novaehollandiae*)
- grey-headed flying fox (*Pteropus poliocephalus*)
- trailing woodruff (*Asperula asthenes*)

A1 Critically Endangered or Endangered Ecological Communities

A1.1 Central Hunter Valley Eucalypt Forest and Woodland CEEC

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).

Targeted surveys to map *Central Hunter Valley Eucalypt Forest and Woodland CEEC* were undertaken in January, February, March and November 2018 (refer to **Section 2.1**) 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).

The original Referral documentation provided an estimated extent of the community in the Project Area based on preliminary vegetation assessments. This assessment outlines the final refinement of mapping the CEEC including Project Area boundary revisions and avoidance.

Section 3.1 provides a description of the CEEC and associated plant community types (PCTs) within the Project Area. The total area of vegetation that conforms to the CEEC Approved Conservation Advice (TSSC 2015) is approximately 122.9 ha.

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- **reduce the extent of an ecological community***;*

Available data indicates the ecological community has undergone a decline of at least 65%; and, if the condition of the ecological community is taken into account, the decline in extent is higher (i.e. greater than 70%) (TSSC 2015).

The *Central Hunter Valley Eucalypt Forest and Woodland CEEC* is present within Project Area of which approximately 122.9 ha will be directly impacted as a result of the Project. The CEEC present within the Project Area is represented by reasonably young, regenerating and highly fragmented vegetation with only a few areas containing larger mature trees. The removal of up to 122.9 ha represents a reduction in the extent of the community of approximately 0.3 %, based on an estimated extant area of 37,000 ha (TSSC 2015).

- **fragment or increase fragmentation of an ecological community;**

The *Central Hunter Valley Eucalypt Forest and Woodland CEEC* is highly fragmented and with a very restricted distribution, as indicated by an estimated median patch size of 1.7 ha. Almost all (86%) of the remnants are less than 10 ha in size and only 2% of patches are larger than 100 ha in size (TSSC 2015).

The Project will lead to further fragmentation of the CEEC. However, the CEEC present within the Project Area is represented by reasonably young, regenerating and already highly fragmented vegetation and the overall fragmentation to the community as a whole is expected to be minimal (122.9 ha or 0.3% of the community's extent).

- **adversely affect habitat critical to the survival of an ecological community;**

The Approved Conservation Advice for the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* (TSSC 2015) recommends that areas which meet the minimum condition thresholds, or are within the buffer zone (recommended buffer is 30 m), are considered critical to the survival of the CEEC. As the Project Area contains approximately 122.9 ha of the CEEC, the Project is therefore likely to adversely affect habitat critical to the survival of the ecological community.

- **modify or destroy abiotic factors necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns;**

The *Central Hunter Valley Eucalypt Forest and Woodland CEEC* occurs within the Project Area and the key impact will be the direct clearance of the community.

The Project is unlikely to modify or destroy abiotic factors necessary for the CEEC's survival in the locality of the Project Area.

- **cause substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species; or**

The *Central Hunter Valley Eucalypt Forest and Woodland CEEC* is an open forest or woodland, typically dominated by eucalypt species with mid-layer of shrubs and a ground layer of grasses, forbs and small shrubs. The CEEC is characterised by one or more of spotted gum (*Corymbia maculata*), narrow-leaved ironbark (*Eucalyptus crebra*), slaty gum (*Eucalyptus dawsonii*) or grey box (*Eucalyptus moluccana*) (TSSC 2015). Vegetative components of the ecological community are important as they provide food and habitat for faunal components of the ecological community. Specific data related to the role of functionally important species such as burrowing mammals and nomadic nectarivores in this CEEC are not available (TSSC 2015).

The CEEC is present within the Project Area and the Project will result in the removal of up to 122.9 ha of this community.

- **cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:**
    - **assisting invasive species that are harmful to the listed ecological community to become established, or**
    - **causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or**

It is well documented that the invasion and establishment of exotic species contributes to a reduction in ecological function of the *Central Hunter Valley Eucalypt Forest and Woodland CEEC*. Weeds compete with locally indigenous flora for available resources and often limit the diversity and regenerative capacity of a native ecosystem. Although a number of weeds pose a serious threat to the ecological community, amongst the most serious threats are African olive (*Olea europaea* subsp. *cuspidata*), fireweed (*Senecio madagascariensis*) and bridal creeper (*Asparagus asparagoides*) (TSSC 2015).

Although the Project will directly impact this CEEC, and will result in the loss of 122.9 ha of this community, it unlikely to result in indirect impacts such as increase in invasive weeds or mobilisation of fertilisers, herbicides or other chemicals or pollutants on adjoining and surrounding areas of CEEC habitat. Weeds will continue to be managed as per the Mount Owen Environmental Management Plan.

- **interfere with the recovery of an ecological community;**

A National Recovery Plan has not been prepared for *Central Hunter Valley Eucalypt and Woodland CEEC*. Due the direct impact of 122.9 ha of the CEEC, the Project will likely interfere with the recovery of the CEEC within the Project Area and in the wider regional context.

Conclusion

The DoEE has assessed the Project as having a likely significant impact on the CEEC. It is considered that the Project is likely to result in a significant impact on *Central Hunter Valley Eucalypt Forest and Woodland CEEC* due to the removal of 122.9 ha of this community and potential indirect impacts, including fragmentation, edge effects and potentially alteration of surface water drainage patterns.

A2 Critically Endangered and Endangered Species

A2.1 Regent Honeyeater (*Anthochaera phrygia*)

In this case, a *population* means:

- **a geographically distinct regional population, or collection of local populations; or**
- **a regional population, or collection of local populations, that occurs within a particular bioregion.**

The regent honeyeater comprises a single population, with some exchange of individuals between regularly used areas (DoE 2016). As at 2010, the total population size is estimated at 350–400 mature individuals (DoE 2016). As the species occurs as a single population in Australia, any record of the species would constitute a *population* as described above. The *population* of regent honeyeater has not been recorded within the Project Area or within the immediate vicinity.

The closest record of this species is approximately 16 km south-west of the Project Area near Warkworth (DPIE 2019). The Project Area contains approximately 2.3 ha of vegetation containing key foraging species as per the National Recovery Plan for the species (DoE 2016). The majority of the spotted gum (*Corymbia maculata*) has been planted and represents regrowth vegetation of between 10 and 30 years. The needle-leaf mistletoe (*Amyema cambagei*) which grows on river sheoak (*Casuarina cunninghamiana*) occurs sporadically along Bowmans Creek. No regent honeyeater individuals were identified utilising the Project Area during the winter bird surveys conducted in June 2018 or in winter 2019 during annual monitoring surveys.

The Policy Statement for the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* (DoEE 2016) also notes that this community may be a valuable source of winter-flowering eucalypts for transient species such as the regent honeyeater.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of a population; or**

The *population* of the regent honeyeater has not been recorded within the Project Area or the immediate locality. The Project may result in the loss of approximately 2.3 ha of vegetation containing key foraging species as per the National Recovery Plan for the species (DoE 2016) being spotted gum (*Corymbia maculata*) with some occurrences of broad-leaved ironbark (*Eucalyptus fibrosa*). An additional 79 ha of the Central Hunter Valley Eucalypt Forest and Woodland CEEC that contains suitable eucalypt resources also occurs in the Project Area. The majority of this vegetation has been planted and is reasonably young with limited mature trees present. The Project Area is not known as a historical or important foraging or nesting site for this species with the closest record being approximately 16 km to the south-west near Warkworth (OEH 2018b).

It is considered unlikely that the Project will lead to a decrease in the size of the *population* of regent honeyeater.

- **reduce the area of occupancy of the species; or**

Figure 1 in the National Recovery Plan (DoE 2016) notes that the Project Area is within an area where the species is "likely to occur". However, despite extensive surveys during key potential foraging periods, the regent honeyeater has not been recorded within the Project Area or the immediate locality. The closest record of the species is approximately 16 km to the south-west near Warkworth (DPIE 2019).

The Project may result in the loss of approximately 2.3 ha of vegetation containing spotted gum potential foraging resources. The majority of this vegetation has been planted and existing vegetation within and surrounding the adjacent Mount Owen Complex comprises extensive re-growth over the past 30 years (Umwelt 2014). While the Project will remove potential habitat for this species, it is not likely to lead to a significant reduction in potential habitat in the region or reduce the species occupancy in the Hunter Valley. Substantial areas of similar habitats for this species occur in proximity to the Project Area.

The Project may result in a reduction of the potential area of occupancy for the regent honeyeater in the Project Area, however this is unlikely to substantially reduce the area of known occupancy in the wider locality or region.

- **fragment an existing *population* into two or more populations; or**

The *population* of regent honeyeater has not been recorded within the Project Area or the immediate locality. The regent honeyeater is highly dispersive and it is unlikely that the Project would create a significant change to the species' dispersal capacity or create a significant barrier the movement of the species.

It is unlikely that the Project would result in the fragmentation of the existing *population* into two or more populations.

- **adversely affect habitat critical to the survival of a species; or**

Habitat critical to the survival of the regent honeyeater includes any breeding or foraging areas where the species is likely to occur and any newly discovered breeding or foraging locations (DoE 2016). The National Recovery Plan for the species (DoE 2016) indicates that the lower Hunter region is a key breeding area for the species. The regent honeyeater is also known to occur in the lower Hunter region (around Cessnock and Kurri Kurri) to utilise foraging resources in the winter months. These sites are located approximately 45 km from the Project Area.

The species has not been recorded breeding or foraging in the Project Area or in the wider Mount Owen Complex area despite extensive surveys in key observation periods over an extended period (greater than 20 years). The Project Area does include vegetation containing spotted gum and broad-leaved ironbark which are key feed tree species for the regent honeyeater (DoE 2016). The Project will result in the loss of approximately 3 ha of this habitat. The National Recovery Plan also notes that mature and large trees tend to be more important as they are more productive (DoE 2016) and the habitats of the Project Area are primarily younger (less than 30 years old).

The Project is unlikely to substantially adversely affect habitat that is critical to the survival of the species.

- **disrupt the breeding cycle of a population; or**

The regent honeyeater mainly breeds in three key sites in NSW being the Bundarra-Barraba area, the Capertee Valley, and the Lower Hunter Valley (DoE 2016). Other breeding areas are known in the Pilliga woodlands and the Mudgee-Wollar areas of NSW. The regent honeyeater has not been recorded in the Project Area and it is unlikely to contain breeding or nesting habitat for the species.

The Project is not expected to disrupt the breeding cycle of the *population* of regent honeyeater.

- **modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

The Project will involve the removal of approximately 2.3 ha of vegetation that contains areas of key feed tree species for the regent honeyeater and a further 79 ha of the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* containing potentially suitable eucalypt resources. The majority of the woodland and forest vegetation is highly fragmented, planted and reasonably young, with some areas containing larger, more mature trees. The wider Project Area supports other areas of habitat that contain suitable woodland and forest vegetation that would also provide potential habitat for this species. It is considered unlikely that the Project would modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the regent honeyeater would decline.

- **result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;**

According to the National Recovery Plan (DoE 2016) the regent honeyeater faces increased competition from larger, more aggressive nectarivores, such as the noisy friarbird (*Philemon corniculatus*), red wattlebird (*Anthochaera carunculata*) and the noisy miner (*Manorina melanocephala*). Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners was listed as a key threatening process under the EPBC Act in May 2014.

Surveys of the Project Area indicate that noisy minors and red wattlebirds are already established in this area, likely due to the existing fragmented and young woodland habitat. The Project is not expected to result in an increase in additional invasive species that are harmful to the regent honeyeater becoming further established in the species habitat.

- **introduce disease that may cause the species to decline; or**

No diseases are directly attributed to the decline in the regent honeyeater population. The Project is not expected to introduce any disease that may cause the regent honeyeater to decline.

- **interfere with the recovery of the species.**

The National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*) (DoE 2016) has been prepared for this species. Any impacts to known habitat for the regent honeyeater will likely contravene the objectives of the recovery plan. The regent honeyeater has not been recorded within the Project Area, however potential foraging habitat has been identified.

It is considered unlikely that the Project will substantially interfere with the recovery of the regent honeyeater.

Conclusion

The regent honeyeater has not been recorded within the Project Area, however the DoEE determined a significant impact is likely for this species in its Controlled Action decision. Umwelt's assessment considers a significant impact unlikely based on the fragmentated and limited mature foraging resources in the Project Area.

A2.2 Swift Parrot (*Lathamus discolor*)

In this case, a *population* means:

- **a geographically distinct regional population, or collection of local populations; or**
- **a regional population, or collection of local populations, that occurs within a particular bioregion.**

The swift parrot occurs as a single population that migrates annually from breeding grounds in Tasmania to the winter foraging grounds on the coastal plains and slope woodlands of mainland eastern Australia (Saunders and Tzaros 2011). The number of swift parrots that occur in the Lower Hunter Region over winter is difficult to determine, however historical estimates indicate up to 10% of the total estimated population are known to occur (Saunders 2002).

As the species occurs as a single population in Australia, any record of the species would constitute a *population* as described above. The swift parrot has been recorded on three occasions within the Ravensworth State Forest and the Southeast Offset Area during annual monitoring surveys located approximately 2.4 km north-east and 3 km east respectively of the Project Area. The species was recorded in July 2005 and September 2007 within the northern section of Ravensworth State Forest and in Southeast Offset Area in June 2014 (Forest Fauna Surveys 2019). There have been few records of the species within the central Hunter Valley in the past few years. Since 2015, most of the swift parrot records in the Hunter have been observed in areas of the lower Hunter (Paxton, Quorrobolong, Singleton) where eucalypt flowering has been prominent (Birdline 2019).

This species may make use of the open forest and woodland habitats of the Project Area, particularly where there are prolific flowering eucalypts as this species is likely to move throughout the area in response to mass flowering events. No swift parrots were identified utilising the Project Area during the winter bird surveys conducted in June 2018 or in 2019 during annual monitoring surveys.

The majority of the key foraging resource species, spotted gum (*Corymbia maculata*), occurring in the Project Area has been planted and is reasonably young and less likely to produce mass flowering foraging resources than the mature habitats in Ravensworth State Forest.

The Policy Statement for the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* (DoEE 2016) also notes that this community may be a valuable source of winter-flowering eucalypts for transient species such as the swift parrot. The swift parrot has been recorded utilising resources in the nearby Ravensworth State Forest. However, the majority of the vegetation within the Project Area is dominated by highly fragmented and young narrow-leaved ironbark (*Eucalyptus crebra*), bull oak (*Allocasuarina luehmannii*) and with scattered red-gum and grey box with limited larger trees that are considered to provide the important foraging resource for the swift parrot (Saunders and Tzaros 2011).

This species does not breed on mainland Australia, and as such the Project Area only represents potential foraging habitat for this species. Glendell and the wider Mount Owen Complex is considered to form part of a regional dispersal route close to important winter foraging areas in the lower Hunter Valley.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of a population; or**

The *population* of the swift parrot has not been recorded within the Project Area, however it has been recorded using adjacent habitats in Ravensworth State Forest as a winter foraging resource. The Project will result in the loss of approximately 81.3 hectares of habitat containing key foraging resources for the species and/or *Central Hunter Valley Eucalypt Forest and Woodland CEEC* containing suitable eucalypt resources. However, the Project Area is not known as a historical or important foraging site for this species.

It is considered unlikely that the Project will lead to a long-term decrease in the size of the *population* of swift parrot.

- **reduce the area of occupancy of the species; or**

The swift parrot has not been recorded within the Project Area and has been occasionally recorded in the greater Mount Owen Complex with the species being recorded on three occasions since 2005. Records of the species in the locality are limited to the higher quality and mature habitats associated with Ravensworth State Forest and the Mount Owen Southeast Offset Area, adjacent to Ravensworth State Forest.

The Project will result in the loss of approximately 81.3 ha of vegetation containing spotted gum and forest red gum or the *Central Hunter Valley Eucalypt Forest and Woodland CEEC* containing suitable eucalypt resources. While the Project will remove potential foraging habitat for the swift parrot, it is not likely to lead to a significant reduction in foraging habitat in the locality or the wider region. The wider Mount Owen Complex, including Ravensworth State Forest and adjacent existing offset areas, provides substantial areas of eucalypt forests and woodlands that provide known foraging habitat for this species.

The Project will result in a reduction of the potential area of occupancy for the swift parrot in the Project Area, however this is unlikely to substantially reduce the area of known occupancy in the wider locality or region.

- **fragment an existing *population* into two or more populations; or**

The *population* of the swift parrot has not been recorded within the Project Area and has only been occasionally recorded in the wider locality. As some habitat containing key feed trees will be removed as part of the Project, the level of fragmentation will increase for this species in the locality. However, given the highly dispersive nature of the swift parrot and the extensive areas of suitable and known foraging habitat in the surrounding area, it is unlikely that the Project would create a significant change to the species' dispersal capacity or create a significant barrier the movement of the species that would result in the existing population being fragmented.

The Project will not result in the fragmentation of the existing national *population* of swift parrot into two or more populations.

- **adversely affect habitat critical to the survival of a species; or**

Habitat critical to the survival of the swift parrot includes those areas of priority habitat for which the species has a level of site fidelity or areas that possess phenological characteristics likely to be of importance to the swift parrot (Saunders and Tzaros 2011). Foraging habitat occurring in the nearby Ravensworth State Forest could be considered habitat critical to the survival as the species has shown occasional site fidelity to these mature forest habitats. The swift parrot has not been recorded within the Project Area and has not shown site fidelity to the specific habitats of the Project Area. The Project Area does include vegetation containing young spotted gum and forest red gum, which are key feed tree species for the swift parrot in the Hunter-Central Rivers (Saunders and Tzaros 2011) and *Central Hunter Valley Eucalypt Forest and Woodland CEEC* containing suitable eucalypt resources. The Project will result in the loss of approximately 81.3 ha of this potential foraging habitat.

The Project will not adversely affect habitat critical to the survival of the swift parrot.

- **disrupt the breeding cycle of a population; or**

The swift parrot breeds and nests exclusively in Tasmania and migrates to mainland Australia during the non-breeding season. There is no potential for breeding habitat to occur in the Project Area.

The Project is not expected to disrupt the breeding cycle of the *population* of swift parrot.

- **modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

The Project will involve the removal of up approximately 81.3 ha of vegetation that contains key feed tree species for the swift parrot or *Central Hunter Valley Eucalypt Forest and Woodland CEEC* containing suitable eucalypt resources. The majority of the woodland and forest vegetation is reasonably young, with limited areas containing larger trees, and is highly fragmented. Larger trees provide a better foraging resource for swift parrots (Saunders and Tzaros 2011). Areas of the Hunter support habitat that contains suitable woodland and forest vegetation that would also provide potential habitat for this species (such as the Singleton Training Area, Ravensworth State Forest and existing Glencore offsets in the Greater Ravensworth locality).

It is considered unlikely that the Project would modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the swift parrot would decline.

- **result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;**

According to the National Recovery Plan for the species (Saunders and Tzaros 2011), swift parrots are less likely to occur at known foraging sites where there is an abundance of large, aggressive nectar feeders such as noisy miner (*Manorina melanocephala*). Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners was listed as a key threatening process under the EPBC Act in May 2014.

Surveys of the Project Area indicate that noisy minors are already established in this area, likely due to the existing fragmented and young woodland habitat. The Project is not expected to result in an increase in additional invasive species that are harmful to the swift parrot becoming further established in this habitat.

- **introduce disease that may cause the species to decline; or**

Psittacine beak and feather disease is a common and potentially deadly disease of parrots caused by a circovirus named beak and feather disease virus. The disease appears to have originated in Australia and is widespread and continuously present in wild populations of Australian parrots. Beak and feather disease affecting endangered psittacine species (parrots and related species) was listed in April 2001 as a key threatening process under the EPBC Act.

It is considered unlikely that the Project will introduce beak and feather disease or any other disease that may cause the swift parrot to decline.

- **interfere with the recovery of the species.**

The following recovery plan has been prepared:

- National Recovery Plan for the Swift Parrot (*Lathamus discolor*) (Saunders and Tzaros 2011)

Any impacts to known habitat of the swift parrot will likely contravene the objectives of the recovery plan, however the species has not been recorded within the Project Area. Potential foraging habitat has been identified and the species has been recorded utilising foraging habitats approximately 2.4 km to the north-east. It is unlikely that the Project will substantially interfere with the recovery of the swift parrot, given that it will only result in the removal of a small amount of vegetation containing key feed trees, of young age.

Conclusion

The swift parrot has not been recorded within the Project Area and known habitat does not occur, however the DoEE determined a significant impact is likely for this species in its Controlled Action decision. Umwelt's assessment considers a significant impact unlikely based on the fragmentated and limited mature foraging resources in the Project Area.

A2.3 Spotted-tailed Quoll (*Dasyurus maculatus maculatus*)

In this case, a *population* means:

- **a geographically distinct regional population, or collection of local populations; or**
- **a regional population, or collection of local populations, that occurs within a particular bioregion.**

The spotted-tailed quoll was recorded during targeted surveys on three remote cameras within the Project Area. The three camera records include one in November 2017 in the eastern section of Project Area, one from January 2018 located in the north-western portion, west of Bowmans Creek and the third camera located at Yorks Creek had three recordings, one from late October and two consecutive days in early November 2017. An additional remote camera record identified the species in 5 January 2018 within the mine rehabilitation in Ravensworth East Mine. Previous records also exist from a radio-tracking that monitored individual movements around the Mount Owen Complex, indicating that the woodland remnants and rehabilitation provide movement habitat for the local population of the species. Other local records include from 2013 in the north and eastern parts of the Project Area, three records from 2009 (observation) and 2010 (observation and cage trap) also within the eastern section of Hebden Road.

The spotted-tailed quoll has been recorded regularly at the Mount Owen Complex during fauna monitoring, with the species recorded annually between 1994 and 2014 (except 1998, 1999 and 2005) in Ravensworth State Forest and surrounding woodland and forest communities, including mine rehabilitation (Forest Fauna Surveys 2019). The species has been recorded through a variety of methods, including hair tube sampling, spotlighting, remote cameras, predator scat searches and cage trapping. There have also been a number of sightings within the nearby Mount Owen active mine area and the species has also been recorded at Bowmans Creek during fauna monitoring undertaken at the nearby Liddell Mine (Umwelt 2008, 2016b). At least three latrine sites were also recorded in 2010 within the Ravensworth Operations Hillcrest Offset Area approximately 6 km to the north-west of the Mount Owen Complex (Umwelt 2010). However, records are generally concentrated on Bowmans Creek and Ravensworth State Forest, with extension into the more disturbed operational areas surrounding these core areas. Additionally, radio-tracking undertaken in the adjacent Mount Owen Complex has shown a resident male spotted-tailed quoll occurring predominantly in Ravensworth State Forest and also in mine rehabilitation to the north and east of North Pit, and in remnant vegetation associated with Main Creek to the east of the Mount Owen Complex. Remote camera monitoring has also identified an additional individual (i.e. not the individual that is being tracked) occurring at a den site in the north of the Mount Owen Complex. Further recent remote camera monitoring at Glencore-owned land at Hebden in December 2017 to January 2018, recorded this species on three cameras over four nights approximately 5 km north of the Project Area.

According to the National Recovery Plan for the species (DELWP 2016), it is considered that this species has declined by 50-90%. Home range estimates vary considerably according to location and habitat quality, however females have been known to occupy home ranges up to 1,515 ha and males up to 5,512 ha and both sexes usually traverse their ranges along densely vegetated creek lines. Extant populations are highly fragmented and declining. The geographic distribution of the species is contracting and its subpopulations are becoming increasingly fragmented.

It is likely that the fragmented habitats of the Hunter Valley floor (as well as major road, rail and other infrastructure networks crossing it) would limit genetic exchange from the Barrington area in a southerly direction, thus providing a likely genetic barrier to records of this species from the Wollemi/Yengo National Parks areas. The Barrington Tops and Mount Royal Range areas provide reasonable geographic features with which to confine the population to the north, although there is likely to be no firm discontinuity in species records between the subject area and habitats to the north of Barrington Tops. It is likely that the records within the Mount Owen Complex indicate a small population of the species in the locality and records from the northern portion of the Hunter Valley are likely to comprise part of a regional population centred on the Barrington Tops southern and western footslopes.

For the purpose of this assessment, it is considered that a regional population of this species is focused on the Barrington Tops southern and western footslopes and that this is genetically distinct and fragmented from those on the southern side of the Hunter Valley. This area comprises some 1,800 km^2 of land, of which approximately 48% is wooded, with about 52% comprising agricultural lands. This includes an area centred on middle Foy Brook to the north of the adjacent Mount Owen Complex (approximately 9 km north) and west of Muswellbrook, which is regarded for the purposes of this assessment as supporting a local population of the species.

All of the native woodland vegetation communities within the Project Area are likely to provide foraging or dispersal habitat for the spotted-tail quoll and habitats in the Project Area are considered to form part of a local home range for the species. The Project Area is not known to contain den or breeding sites for the species. The presence of the spotted-tail quoll in the greater Mount Owen Complex is of importance as there are few areas within the Central Hunter Valley lowlands that are of sufficient size to support the home range of this species.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- **lead to a long-term decrease in the size of a population; or**

The spotted-tailed quoll has recently been recorded utilising the Project Area and rehabilitation areas at Ravensworth East Mine and is also frequently recorded across the wider Mount Owen Complex with the majority of sightings occurring in and around Ravensworth State Forest. It is likely that these records indicate a small local population of the species that forms part of a wider regional population centred on the Barrington Tops (southern and western) footslopes. Records of the species in combination with the known location of den sites, latrines and breeding records indicate that intact vegetation associated within Ravensworth State Forest and riparian vegetation on Bowmans Creek and Main Creek provide the most important habitat for the species in the locality. Habitats associated with the Project Area provide foraging habitat for the species as part of a wider home range.

All of the native and derived vegetation communities in the Project Area will provide foraging or dispersal habitat for the spotted-tailed quoll and the species is considered to be resident in the wider Mount Owen Complex. The Project will result in the loss of up to approximately 154.5 ha of woodland and forest habitat that provides for the movement and foraging of the species. The Project is likely to result in a reduction in the area of habitat available to the species in the local area and in the home range of the individuals occurring in the wider Mount Owen Complex.

No known denning sites have been recorded in the Project Area, however the removal of approximately 154.5 ha of known movement and foraging habitat will result in a very minor reduction to the approximately 86,000 ha of woodland habitat available to Barrington Tops (southern and western footslopes) regional population of the spotted-tailed quoll. This reduction in movement and foraging habitat represents less than 0.2% of available habitat for the regional population. The proposed reduction in habitat associated with the Project is not considered likely to result in a long term decrease in the size of the Barrington Tops (southern and western footslopes) regional population.

- **reduce the area of occupancy of the species; or**

The spotted-tail quoll is known to occur in the Mount Owen locality and has been primarily recorded in Ravensworth State Forest. The species has been recorded within the Project Area during the surveys undertaken for this assessment. The Project will result in the loss of up to approximately 154.5 ha of woodland and forest that provides for the movement and foraging of the species, however no denning or breeding sites have been recorded in the Project Area. The majority of the impacts associated with the Project are related to the extensive areas of previously cleared grassland habitats currently utilised for agricultural purposes which are not likely to be permanently occupied by the species.

The reduction of up to 154.5 ha of known movement and foraging habitat for the species constitutes a small reduction in the area of occupancy for the regional population of the species (0.2%).

- **fragment an existing *population* into two or more populations; or**

A local population of spotted-tail quoll occurs in the Mount Owen locality however the regional population of the species identified as the Barrington Tops (southern and western) footslopes regional population encompasses an area of some 1,800 km^2. Although important habitat for the individuals occurring in the locality, including den sites, known breeding habitat and high quality foraging habitat associated with the Ravensworth State Forest and Bowmans Creek will not be directly impacted by the Project, the removal of connecting habitats in the Project Area may temporarily sever the habitats between Mount Owen to the east and Bowmans Creek in the west. The Project will contribute to the further fragmentation of habitat for the species in the local area, however the regional population of the species is not expected to be fragmented into two or more populations as a result of the Project. The Project will not remove the primary east west linkages between Ravensworth State Forest and Bowmans Creek but it will reduce the width of the existing corridor. It is considered that the Project may result in a reduction in the current habitat corridor used by the local population of spotted-tailed quoll in the Mount Owen Complex and Liddell localities, however the regional population of the species is not expected to be fragmented into two or more populations as a result of the Project.

- **adversely affect habitat critical to the survival of a species; or**

The habitat critical to the survival of the spotted-tail quoll includes large patches of forest with adequate denning resources and relatively high densities of medium-sizes mammalian prey (DELWP 2016). The threshold densities of these critical habitat components to support quoll populations are currently unknown meaning that the critical habitat to the survival of the species is not possible to define (DELWP 2016). Therefore, all habitats within the species current distribution that are known to be occupied are considered important.

The spotted-tail quoll has been recorded within the Project Area in 2018 and 2017 and the species is known to use this habitat for dispersal and foraging. Important habitat is present in the wider Mount Owen Complex, including den sites, known breeding habitat and high quality foraging habitat associated with the Ravensworth State Forest (to the east) and Bowmans Creek (to the north of Project Area). The Project will result in the loss of up to approximately 154.5 ha of moderate quality habitat.

While the Project will impact known dispersal and foraging habitat for the species, the Project Area does not contain areas of large patches of forest with adequate denning resources and relatively high densities of medium-sizes mammalian prey. Therefore the Project is unlikely to adversely affect habitat that is critical to the survival of the species.

- **disrupt the breeding cycle of a population; or**

The spotted-tailed quoll generally dens in rock shelters, small caves, hollow logs or tree hollows and utilises numerous dens within its home range. It is a highly mobile species and there are numerous records of overnight movements of several kilometres. Known den sites occur in the Ravensworth State Forest and in the Mount Owen Complex in mine rehabilitation to the east of the Project Area and to the north along Bowmans Creek (outside of the Project Area).

The species has not been recorded breeding within the Project Area, and potential den sites have not been recorded during surveys. There is no evidence to suggest that breeding has occurred within the Project Area. Known breeding habitat for the species will not be impacted by the Project.

While the Proposed Action is likely to result in local impacts to foraging and dispersal habitat for the species in proximity to the Project Area, the breeding cycle of the Barrington (southern and western footslopes) population of the spotted-tailed quoll is unlikely to be adversely affected.

- **modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or**

According to the National Recovery Plan for the species (DELWP 2016) it is considered that this species has declined by 50-90% and extant populations are highly fragmented and declining. The Project will involve the removal of up to approximately 154.5 ha of habitat for the species. The Central Hunter supports other areas of habitat that contain suitable habitat for the species, however the species has not been recorded in many of these areas. The area of habitat to be removed is not important, notable, or of consequence, in accordance with the significant impact guidelines (DoE 2013b).

The Project will not modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species as a whole is likely to decline. The removal of habitat as a consequence of the Project will also occur over a time frame where existing commitments to rehabilitate mine sites and improvements to existing offset sites in the vicinity will provide an increased area of similar or better habitat.

- **result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;**

The Project is not expected to result in invasive species that are harmful to the spotted-tailed quoll becoming established in the species habitat.

- **introduce disease that may cause the species to decline; or**

The spotted-tailed quoll is not known to be affected by diseases that are causing the species to decline. Therefore, the Proposed Action is not likely to result in the introduction of disease.

- **interfere with the recovery of the species.**

The following recovery plan has been prepared:

- National Recovery Plan for the Spotted-tailed Quoll (*Dasyurus maculatus*) (DELWP 2016).

Any impacts to known habitat for the spotted-tailed quoll will likely contravene the objectives of the recovery plan. This species has recently been recorded within the Project Area, in October, November 2017 and January 2018. Foraging habitat has been identified as part of a wider home range which includes areas of the wider Mount Owen Complex. The Proposed Action will result in the reduction of movement habitat for the species connecting the remnant vegetation with Bowmans Creek, Yorks Creek and Swamp Creek. Alternative movement corridors between the main habitat areas in Ravensworth State Forest and Mount Owen offset areas Bowmans Creek will remain to the north of the Project Area.

The loss of habitat connectivity and foraging habitat associated with the Proposed Action is unlikely to significantly interfere with the recovery of the species.

Conclusion

DoEE determined a significant impact is likely for the spotted-tailed quoll in its Controlled Action decision.

A3 Vulnerable Species

A3.1 Green and Golden Bell Frog (*Litoria aurea*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

The green and golden bell frog was formerly distributed from the NSW North Coast near Brunswick Heads southwards along the NSW coast to Victoria, where it extends into East Gippsland, and west to Bathurst, Tumut and the ACT. In the 1960s, the species was considered widespread, abundant and commonly encountered (DECC 2007). In the Hunter, the species is now only known from three key populations. The Upper Hunter Green and Golden Bell Frog Key Population is located between the settlements of Singleton and Muswellbrook (DECCW 2007).

The green and golden bell frog was 'rediscovered' in the upper Hunter in 1994 at the nearby Mount Owen Complex where it was subsequently recorded in 1996, 1997 and 1999 (Forest Fauna Surveys and Newcastle Innovation 2013). An unconfirmed report of a single calling male during August 2005 was reported (J Rennie, Earthtech, personal communication) at a small pond on a drainage line that enters Main Creek. However, intensive monitoring of this pond over the summer of 2005/2006 did not produce further evidence of the species; that is, no tadpoles, juveniles or adults were located, or calls heard in response to call playback surveys. The record has remained unconfirmed by physical identification. Nevertheless, it is possible that a transient male was present at this pond, but there is no evidence of the pond being utilised for breeding (Fly by Night Surveys *et al.* 2007). No more than three individuals were recorded at any one time at Mount Owen. An additional unconfirmed record of the species exists from the north-west shore of Lake Liddell in 2006 (DECC 2007) and the species was recently recorded during surveys for the Ravensworth Operations in 2009 in the Ravensworth North Offset Area. All confirmed records for the Upper Hunter population detail only low numbers of adult individuals (DECC 2007). This species has not been recorded from within the Proposed Disturbance Area historically or recently despite surveys conducted in 2017 and 2018.

In the case of the green and golden bell frog, all current populations of the species, where individuals have been detected on at least one occasion since 1995, are considered to be an '*important population*' due to the species tendency towards local extinction and recolonisation cycles (DEWHA 2009).

As such, this population (if still present) is one of high importance for the species being at the western limit of its distribution along the east coast of NSW and being one of only two inland populations potentially persisting. Therefore, the potential habitat for the species in the Project Area occurs within the limits of an *important population* of the species, as described above.

The green and golden bell frog has been recorded in the wider Mount Owen Complex on four occasions over a 15 year period, with the last confirmed record from 1999 (Forest Fauna Surveys and Newcastle Innovation 2013). The Mount Owen Complex forms part of the Upper Hunter Green and Golden Bell Frog Key Population consisting of one main diffuse population at, or in the vicinity of, the Ravensworth and Liddell area and bordering areas of the Singleton and Muswellbrook local government areas (DECC 2007). The Upper Hunter Key Population is one of two inland populations of the species and is known from eight verified locations. The population is assumed to have a diffuse distribution across lands encompassed by these locations and has been recorded sporadically, probably caused by climatic circumstances and/or seasonal life cycle changes of the species (DECC 2007). It is considered highly likely that the precipitous state of the Upper Hunter Key Population is directly due to the impact of disease (chytrid fungus) rather than habitat or other ecological factors (Forest Fauna Surveys and Newcastle Innovation 2013).

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an *important population* of a species;**

The green and golden bell frog population within the adjacent Mount Owen Complex has been monitored annually since its discovery in Bettys Creek in 1994 by well recognised frog researchers from the University of Newcastle. Despite extensive surveys, the species has not been recorded in the Project Area or surrounding areas since 1999.

The absence of individuals at historical sites, or the intermittent observation of single individuals, or very small numbers of green and golden bell frogs, fits with the pattern of observation of this species in the Upper Hunter over a period of more than two decades. The Upper Hunter, which is at the inland edge of the current, contracted distribution of the green and golden bell frog, appears to support only a precarious regional population that cannot be regarded as secure (DECC 2007).

The Project will disturb up to nine suitable farm dams, divert Yorks and Swamp Creek (already part of the current Glendell consent), and may have indirect impacts on Bowmans Creek and Bettys Creek., The occurrence of the species in the Project Area is not confirmed as the species has not been positively identified at the wider Mount Owen Complex in over 20 years, or the wider locality in 11 years despite extensive monitoring. The Project will impact potential habitat for this species but will not impact known habitat of the species.

As the species is not known to occur within the Project Area and the persistence of the species in the Project Area is expected to be limited due to infection by chytrid fungus, the loss of habitat from the Project Area is not considered likely to lead to a long term decrease in the size of this *important population*.

- **reduce the area of occupancy of an *important population*, or;**

The Project will disturb potential habitat for the green and golden bell frog, comprising up to nine farm dams containing suitable fringing vegetation and shelter habitat (approximately 2 ha). The species is not considered to be limited in its extent in the adjacent Mount Owen Complex by factors relating to habitat suitability; rather infection by the chytrid fungus limits the potential persistence of the species (Forest Fauna Surveys and Newcastle Innovation 2013).

The Project is therefore unlikely to result in a reduction in the potential area of occupancy of an *important population* of the species.

- **fragment an existing *important population* into two or more populations, or;**

The green and golden bell frog uses terrestrial habitat for dispersal, foraging and shelter. Potential routes of dispersal are not known within the Proposed Disturbance Area, and it is assumed that any potentially occurring frogs would move on wet nights to avoid desiccation, and that they would move along moisture gradients in the environment. These would include along the edge of large waterbodies such as dams and creek lines.

The Upper Hunter *important population* occurs within a highly fragmented landscape that is dominated by agricultural and mining land uses. The Project is therefore considered unlikely to further fragment the potentially occurring *important population*.

- **adversely affect habitat critical to the survival of a species, or;**

The Upper Hunter *important population* is considered to contain only a few adult individuals and is therefore more susceptible to stochastic impacts. The Upper Hunter population is considered disjunct from the larger more secure populations on the coast of NSW at locations such as Kooragang Island, Sydney and Nowra.

Dams and associated terrestrial habitat in this declining and small population may be critical for the survival of the *important population*, however it is unlikely to adversely affect habitat critical to the survival of the species throughout its wider range in NSW.

- **disrupt the breeding cycle of an *important population*, or;**

The species is not known to occur in the Project Area and there have been no confirmed recordings in the Upper Hunter area since 2009 despite extensive annual monitoring and targeted green and golden bell frog surveys over many years.

The loss of dams, creek habitat and associated terrestrial habitat within the bounds of the Upper Hunter *important population* is not likely to substantially disrupt the breeding cycle of the *important population* as known breeding habitat will not be impacted.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

The loss of dams and associated terrestrial habitat within the bounds of the Upper Hunter *important population* is not likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline. Substantial potential habitat in the way of farm dams, mine water dams and constructed habitats specifically designed for the species occurs in proximity to the Project Area in the agricultural landscapes in surrounding lands.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

The plague minnow (*Gambusia holbrooki*) is an invasive species that has been associated with the decline of the green and golden bell frog. The presence of the plague minnow has been identified as a major threatening process for the green and golden bell frog and the presence of the plague minnow has been demonstrated to reduce the breeding success of the species (Goldingay 2008). The plague minnow is present within Bowmans Creek and it can be assumed that as both Yorks and Swamp creeks are tributaries of this creek (when flowing), this species would also be present. All of the farm dams are expected to contain the plague minnow. It is unlikely that the Project will result in the establishment of further invasive species.

- **introduce disease that may cause the species to decline; or**

Green and golden bell frog populations are commonly affected by the amphibian chytrid fungus *Batrachochytrium dendrobatidis*. The 'infection of amphibians with chytrid fungus resulting in chytridiomycosis' is listed under the EPBC Act as a key threatening process for amphibian species. The green and golden bell frog is highly susceptible to infection by the chytrid fungus, which is likely to occur within the Upper Hunter *important population*. The effect of the Project on the rate of infection by *B. dendrobatidis* is not known. However, the chytrid fungus is considered likely to be contributing to the decline of the green and golden bell frog across NSW (Mahony *et al* 2013). A decline in population numbers as a result of habitat reduction may increase the susceptibility of the population to the disease.

The Project will not result in the introduction of a disease that may cause the species to decline.

- **interfere substantially with the recovery of the species.**

The following draft recovery plan has been prepared:

- Draft Green and Golden Bell Frog (*Litoria aurea*) Recovery Plan (DEC 2005).

The Project will remove dams, creek habitat and associated terrestrial habitat that provides potential habitat for the green and golden bell frog. The Upper Hunter *important population* is likely in decline or no longer present as it has not been positively recorded within the greater Mount Owen Complex since 1999 and not recorded in the broader Upper Hunter region since 2009. If persisting, the population likely consists of only a few adult individuals across a broad area in the Ravensworth and Liddell locality, which includes Glendell. It is possible that the Upper Hunter *important population* is not recoverable due to the impacts of amphibian chytrid fungus and critically low population numbers.

The habitat loss and impacts associated with the Project are not likely to interfere substantially with the recovery of this species.

Conclusion

DoEE determined a significant impact is likely for the green and golden bell frog in its Controlled Action decision, however based on the lack of records of the species in the Project Area and that the species has not been confirmed in the locality for over 20 years, and the small area of potential habitat removal, a significant impact is considered unlikely.

A3.2 Koala (*Phascolarctos cinereus*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

The koala is known to occur in eucalypt woodlands and forests from the north-eastern Queensland, along the eastern coast of NSW, to the south-east corner of South Australia. The species has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range.

The koala was tentatively recorded during monitoring in 1995 in Ravensworth State Forest through the collection of scats resembling those of the koala (Forest Fauna Surveys and Newcastle Innovation 2013). The koala has also been recorded approximately 6 km to the north-west of the Project Area in the Hillcrest Offset Area that was established as part of the Ravensworth Continued Operations Project (Umwelt 2010). There are also several OEH BioNet Atlas of NSW Wildlife (DPIE 2019) records of the koala that are proximate to the Project Area, including:

- June 2012 record at the corner of Hebden Road and the New England Highway within 1 km to the west the Project Area
- historic record from 1999 located approximately 1.6 km south of the Project Area
- one historic record between 1980-2006 with a low accuracy level (10 km) approximately 4.4 km east of the Project Area and
- historic 1997 record approximately 4.6 km east of the Project Area.

Given the paucity of nearby recent (in last 5 years) records and the low abundance of key food trees, the Project Area is unlikely to support a key source koala population for breeding or dispersal. The Project Area is unlikely to comprise populations necessary for maintaining genetic diversity given the minimal koala feed trees to be cleared and that, despite targeted surveys, the koala has not been recorded. The Project Area is also not near the limit of the known range of this species. Therefore the Project Area is unlikely to contain an *important population* of the koala.

The Assessment of Significance for the koala has been prepared in consideration of the EPBC Act Referral Guidelines for the Vulnerable Koala (DoE 2014).

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an *important population* of a species;**

No *important populations* of the koala have been recorded within the Project Area or the immediate locality; however potential habitat occurs within (refer to **Table 3.7**):

- Narrow-leaved Ironbark - Bull Oak - Grey Box - Open Forest – Moderate to Good,Regeneration and Plantation
- Narrow-leaved Ironbark – Grey Box – Spotted Gum shrub – grass woodland of the central and lower Hunter - Woodland Rehabilitation, and
- Swamp Oak Riparian Forest - Plantation.

The Project will result in the loss of approximately 83.9 ha of vegetation containing a low proportion of grey box (*Eucalyptus moluccana*), grey gum (*Eucalyptus punctata*) and/or forest red gum (*Eucalyptus tereticornis*) koala feed trees , however these tree species were recorded in low abundance in the vegetation communities in the Project Area. The majority of the trees are relatively young and the Project Area contained limited mature trees. While koalas have been recorded in the surrounding area, the Project Area is not known as a historical site for this species.

It is considered unlikely that the Project will lead to a decrease in the size of *important populations* of koala.

- **reduce the area of occupancy of an *important population*, or;**

The Project will result in the loss of approximately 83.9 ha of vegetation that includes minor occurrences of key feed trees for the koala. While the Project will remove potential habitat for this species, it is not likely to lead to a significant reduction in known habitat in the region. Substantial areas of higher quality habitats for this species occur in relative proximity to the Project Area, including in Ravensworth State Forest.

The Project may result in a reduction of the potential area of occupancy for the koala in the Project Area, however this is unlikely to substantially reduce the area of an important population in the wider locality or region.

- **fragment an existing *important population* into two or more populations, or;**

The habitats within the Project Area currently contain fragmented woodlands and are dominated by derived native grasslands, characteristic of the surrounding agricultural landscape. As the Project Area does not support an important population of the koala, the Project will not result in the fragmentation of an important population of koala into two or more populations.

- **adversely affect habitat critical to the survival of a species, or;**

The assessment of koala habitat within the context of the koala referral guidelines indicates that the Project Area comprises habitat critical to the survival of the species. The removal of approximately 83.9 ha of potential koala habitat containing a low abundance of feed trees (refer to **Table 3.7**), is considered a small area in the context of substantial areas of similar surrounding remnant vegetation, including the Ravensworth State Forest and the ranges north of the Mount Owen Complex. This habitat contains a very low abundance of primary koala feed trees with limited forest red gum – *Eucalyptus tereticornis* present, which comprises approximately 5% of the total number of trees within the potential koala habitat.. Furthermore, there are a low number of recent records of the koala in the local region and this species was not recorded as part of recent targeted surveys conducted in 2018.

The Project is unlikely to adversely affect habitat critical to the survival of the koala.

- **disrupt the breeding cycle of an *important population*, or;**

No important populations of the koala have been identified within the Project Area, nor have any breeding populations of this species been recorded in the locality.

The Project is therefore unlikely to disrupt the breeding cycle of an important population of this species.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

The Project contains a very low abundance of primary koala feed trees (approximately 5% of tree species occurring in the Project Area comprise forest red gum – *Eucalyptus tereticornis*) and is therefore unlikely to modify, destroy, remove, isolate, or decrease the availability or quality of habitat for this species to the extent that the koala would be likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

The Project is not expected to result in invasive species that are harmful to the koala becoming established in the species habitat.

- **introduce disease that may cause the species to decline; or**

The koala is known to contract strains of *Chlamydia* and the koala retrovirus. Chlamydia infections are known to cause reduced female fertility and are expected to reduce the reproductive potential of koala populations. It has been predicted that up to half of the koalas in south-east Queensland have reproductive disease likely to result in infertility (TSSC 2012a, 2012b). The koala retrovirus can cause a range of conditions including leukaemia and immunodeficiency syndrome. It is estimated that up to 100% of koala populations in Queensland and New South Wales have the koala retrovirus (TSSC 2012a, 2012b).

The Project does not involve any processes that are likely to introduce a disease for the koala that may cause this species to decline.

- **interfere substantially with the recovery of the species.**

Following determination of the importance of the habitat for the koala in the Project Area, an assessment was undertaken to determine the impacts which are likely to substantially interfere with the recovery of the koala. The Referral Guidelines (DoE 2014) identifies impacts likely to substantially interfere with the recovery of the koala .

The Project may:

- result in an increase to vehicle movements, however this is considered to be a negligible increase to the local area and it is unlikely to subject the koala to increased mortality levels.

The Project is not expected to:

- introduce or increase dogs to the local area and therefore is unlikely to increase the threat of dog attacks to any local koala population
- result in the creation of substantial additional barriers to koala movement in the local area
- facilitate the introduction or spread of pathogens as *Phytophthora cinnamomi* or Chlamydia or
- result in hydrological changes to the surrounding environment such that the function and integrity of the existing habitat for the koala is jeopardized.

Based on the above, it is considered unlikely that the Project will interfere with the recovery of the koala throughout its range in Qld, NSW and the ACT.

Conclusion

DoEE determined a significant impact is likely for the koala in its Controlled Action decision. However, the Project is considered unlikely to result in a significant impact on the koala given the very low abundance of one primary koala feed tree (approximately 5% forest red gum – *Eucalyptus tereticornis*) present within the Project Area and the low number of recent records of the koala in the local region.

A3.3 Large-eared Pied Bat (*Chalinolobus dwyeri*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

The large-eared pied bat has been tentatively recorded in the adjacent Mount Owen Complex during annual fauna monitoring surveys in 1999, 2001, 2006, 2008, 2014 and 2015 using call echolocation recording, however, no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019). The closest and most recent record of this species was recorded immediately adjacent (less than 100 m west) to the Project Area at the intersection of Hebden Road and Bowmans Creek as part of the 2014 UHSA surveys undertaken by Umwelt. This record was also using call echolocation recording. It has also been recorded 2 km to the north of the Project Area. All woodland and forest vegetation within the Project Area is expected to provide potential foraging habitat for this species, however no roosting habitat for this cave-roosting species has been identified.

The majority of records of the species occur within several kilometres of clifflines or caves. Records within the Hunter Valley generally occur near the escarpment habitat associated with Yengo and Wollemi National Parks approximately 17 km south from the Project Area. No evidence exists of the large-eared pied bat roosting in tree hollows (DERM 2011). Due to the absence of suitable cliffline or cave roosting habitat near the Project Area and the infrequency of unconfirmed records of the species within the wider Mount Owen Complex, the Project Area is not considered to contain an *important population* of this species.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an *important population* of a species;**

The Project will result in the loss of up to approximately 154.5 ha of potential forest and woodland foraging habitat for the species, however will not impact any cliffline or escarpment habitat that could be used as roosting or breeding habitat. The Project Area is not considered to contain an *important population* of this species.

It is unlikely that the Project will lead to a long-term decrease in the size of an *important population* of this species.

- **reduce the area of occupancy of an *important population*, or;**

The Project will result in the loss of up to approximately 154.5 ha of forest and woodland foraging habitat for the species, however will not impact any cliffline or escarpment habitat that could be used as roosting habitat. The large-eared pied bat has been tentatively recorded in the adjacent Mount Owen Complex during annual fauna monitoring surveys in 1999, 2001, 2006, 2008, 2014 and 2015 using call echolocation recording however no individuals have been captured to confirm its presence (Forest Fauna Surveys 2019). The closest and most recent record (2014) from the Atlas of NSW Wildlife (DPIE 2019) was recorded immediately adjacent (less than 100 m west) to the Project Area at the intersection of Hebden Road and Bowmans Creek.

It is unlikely that the Project will reduce the area of occupancy of an *important population* of this species.

- **fragment an existing *important population* into two or more populations, or;**

It is unlikely that the Project will fragment an existing *important population* into two or more populations of this highly mobile species given that the potential habitat within Project Area is already highly fragmented and the majority of the habitat present is derived native grasslands which is unlikely to be important to the large-eared pied bat.

- **adversely affect habitat critical to the survival of a species, or;**

The National Recovery Plan for the large-eared pied bat (DERM 2011) states that habitat critical for the survival of the species requires the presence of diurnal roosts and shelter habitat, usually in the form of sandstone cliffs and adjacent fertile woodland valley foraging habitat. Sandstone cliffs and fertile woodland valley habitat within proximity of each other is habitat of importance to the species. The habitat in the Project Area does not contain overhanging clifflines or adjacent fertile woodland valley habitat.

The Project Area is not considered to contain critical habitat for the large-eared pied bat and consequently the Project is not expected to adversely affect habitat critical to the survival of this species.

- **disrupt the breeding cycle of an *important population*, or;**

No *important populations* of the large-eared pied bat are likely to occur in the Project Area, nor have any breeding populations or roosting habitat for this species been recorded.

The Project is not expected to disrupt the breeding cycle of an *important population* of this species.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

Given the lack of preferred habitat in the Project Area and lack of confirmed records of the large-eared pied bat, the Project will not modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that this species area is likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

The Project is unlikely to result in an invasive species that is harmful to the large-eared pied bat becoming established in this species habitat.

- **introduce disease that may cause the species to decline; or**

The Project is unlikely to introduce disease that may cause the large-eared pied bat to decline.

- **interfere substantially with the recovery of the species.**

The Recovery Plan for the Large-eared Pied Bat (DERM 2011) has an overall objective to ensure the persistence of viable populations of the species throughout its geographic range.

The Project will result in the loss of up to approximately 154.5 ha of potential forest and woodland foraging habitat. It is not considered that an *important population* of the species occurs within the Project Area. No significant effect on the recovery of the large-eared pied bat is expected to occur as a result of the Project.

Conclusion

DoEE determined that a significant impact is possible for the large-eared pied bat, however noting the lack of suitable roosting habitat within and proximate to the Project Area and the relatively low number of records in the locality despite extensive survey effort, a significant impact on this species is not likely to occur.

A3.4 New Holland Mouse (*Pseudomys novaehollandiae*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

The New Holland mouse has been recorded during five of the last 18 years of fauna monitoring in the adjoining Mount Owen Complex, with most captures of the species occurring between 2003 and 2007 (Forest Fauna Surveys 2019). The most recent record of the species was 2016 where it was captured during fauna monitoring in the northern portion of Ravensworth State Forest (Forest Fauna Surveys 2019). The species has also been recorded in areas of rehabilitation in the North Pit of the adjacent Mount Owen Complex and to the east of Ravensworth State Forest. The species selectively prefers habitats which have been disturbed by events in which it rapidly colonises following the event (Forest Fauna Surveys and TUNDRA 2007). Populations of the species remain high for a period following disturbance and decline in abundance in areas not subjected to disturbance.

Habitat preferences across the species range include open heathland; open woodland with a heathland understorey; and vegetated sand dunes. The species is usually found to peak in abundance during the early to mid-stages of vegetation succession three to five years after fire or other disturbances. Due to the largely granivorous nature of the species, sites where the New Holland mouse is found are often high in floristic diversity, especially leguminous perennials. Established woodland and grassland habitats in the Project Area do not conform to the preferred habitat types in which the species is typically located. However, there is potential that this successional species will utilise limited habitats within the Project Area when conditions are optimal, followed by the decline of the species. The presence of the New Holland mouse within the adjacent Mount Owen Complex has been determined through the systematic, annual

monitoring of rehabilitated habitats within former mining areas using survey techniques conducive to the identification of the species, namely pit fall trapping and Elliot A trapping. It is considered likely that post-mining rehabilitation occurring on mine sites throughout the Hunter Valley provides areas of habitat conducive to the occupation of the New Holland mouse.

The New Holland mouse is not known to occur within the Project Area. The closest record from the Atlas of NSW Wildlife (OEH 2018b) is from 2005 located approximately 2.2 km north-east of the Project Area in rehabilitation near North Pit of the adjacent Mount Owen Complex. As noted above, the most recent record of the species was in 2016 where it was captured during fauna monitoring in the northern portion of Ravensworth State Forest (Forest Fauna Surveys 2019), approximately 3.4 km north-east of the Project Area. The Project Area is considered to provide only limited potential habitat for the species in areas which are regenerating.

Given the paucity of nearby recent (in last 5 years) records, the Project Area is unlikely to support key source habitat for New Holland mouse populations for breeding or dispersal. The Project Area is also unlikely to comprise populations necessary for maintaining genetic diversity given the small area to be cleared and the fact that this species has not been recorded in or immediately adjacent to the Project Area. The Project Area is also not near the limit of the known range of this species. Therefore the Project Area is unlikely to contain an *important population* of the New Holland mouse.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an *important population* of a species;**

The New Holland mouse has not been recorded in the Project Area however some regenerating habitats within the Project Area may provide potential habitat for the species (approximately 4.1 ha). The Project is not expected to lead to a long-term decrease in an *important population* of the species since it has not been recorded in or immediately adjacent to the Project Area.

- **reduce the area of occupancy of an *important population*, or;**

The Project is not expected to reduce the area of occupancy of an *important population* of New Holland mouse which is expected to have a diffuse distribution across the upper Hunter in rehabilitated and disturbed habitats suitable for the species.

- **fragment an existing *important population* into two or more populations, or;**

The Project Area is considered to provide some limited areas of potential habitat for the species in regenerating and rehabilitation habitats. It is expected that the species has a diffuse distribution across the upper Hunter where habitats and conditions are favourable. The closest confirmed records of this species, occurs in the north-east in the Ravensworth State Forest and Mount Owen Mine rehabilitation. The Project is not expected to result in the fragmentation of an *important population*.

- **adversely affect habitat critical to the survival of a species, or;**

Habitat critical to the survival of the New Holland mouse has not been defined. Habitats occurring in the Project Area do not comprise preferred habitat for the species, which generally occurs in heath and coastal dune habitats. Given the results of the nearby Mount Owen Mine fauna monitoring, early mine rehabilitation within the Hunter Valley is likely providing suitable early successional habitat for this species. Established woodland and grassland habitats in the Project Area do not conform to the preferred habitat types in which the species is typically located.

A small area of regenerating and planted habitats occurs within the Project Area, however the understorey of this habitat is reasonably open and species poor. Therefore the Project will not impact preferred habitat locations and is unlikely to adversely affect habitat critical to the survival of the species.

- **disrupt the breeding cycle of an *important population*, or;**

The New Holland mouse has not been recorded in the Project Area. The Project is not expected to disrupt the breeding cycle of an *important population* of the species. Breeding success is considered to be related to the availability and quality of food, which in turn is related to rainfall and fire succession.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

The loss of potential habitat is not likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline. Substantial potential habitat in the way of rehabilitated and disturbed lands occurs in proximity to the Project Area.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

Predation by introduced predators, including the red fox (*Vulpes vulpes*), cat (*Felis catus*) and dog (*Canis familiaris*) is a threat to the New Holland mouse and competition from introduced rodents, such as the house mouse is a potential threat (TSSC 2010).

No invasive species are likely to become established as a result of the Project that may have an impact upon habitat relevant to the New Holland mouse.

- **introduce disease that may cause the species to decline; or**

There are no diseases implicated in the decline of the New Holland mouse. The Project is not expected to introduce any diseases that may cause this species to decline.

- **interfere substantially with the recovery of the species.**

There is currently no published recovery plan for the New Holland mouse. No significant effect on the recovery of the New Holland mouse is expected to occur as a result of the Project.

Conclusion

DoEE determined that a significant impact is possible for the New Holland mouse, however noting the lack of records within the Project Area and the small area of potential habitat impacts, a significant impact on this species is not likely to occur.

A3.5 Grey-headed Flying Fox (*Pteropus poliocephalus*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

The grey-headed flying-fox has been previously recorded on seven occasions during monitoring of the adjacent Mount Owen Complex (Forest Fauna Surveys 2019). It was noted during May 2016 annual monitoring spotlighting surveys that several thousand individuals of the grey-headed flying-fox were present within the Mount Owen Complex, centred around the more mature and productive habitats of Ravensworth State Forest, however no roost sites were recorded within the nearby Mount Owen Complex and large numbers of individuals were observed arriving shortly after dusk each evening (Forest Fauna Surveys 2019). All forest and woodland vegetation within the Project Area is expected to provide potential foraging habitat for this species. Camp sites (breeding habitat) have not been identified within the Project Area and are not expected to occur. The closest and most recent record (2010) from the Atlas of NSW Wildlife (DPIE 2019) was located 1.4 km to the east of Project Area.

The two nearest substantial camp sites of the grey-headed flying-fox to the Project Area are at Burdekin Park, Singleton (approximately 16 km) and at Muswellbrook (approximately 25 km) (DoEE 2019). The population estimate for the grey-headed flying-fox population at Burdekin Park is estimated to be between 500 and 2,499 individuals during the most recent survey in November 2018 and the population at Muswellbrook estimated to be between 2,500 and 9,999 individuals during the most recent survey in August 2018 (DoEE 2019). Foraging individuals in the nearby Mount Owen Complex are likely to be from these camp sites located within 50 km of the site. The Muswellbrook camp is noted in the National Flying-Fox Monitoring Viewer as a nationally important grey-headed flying-fox camp.

According to the Referral Guideline for Management Actions in Grey-headed and Spectacled Flying-Fox Camps (DoE 2015a) nationally important grey-headed flying-fox camps are recognised as any camps that have contained 10,000 individuals or greater in the last 10 years or have been occupied by 2,500 individuals or greater permanently or seasonally every year for the last 10 years. The Project Area does not contain a grey-headed flying-fox camp considering the Referral Guideline for Management Actions in Grey-headed and Spectacled Flying-Fox Camps (DoE 2015a).

The Project Area does not support a population greater than 30,000 individuals, does not support an occupied camp and is not consistently productive during breeding events or during winter and spring. Flowering events in the adjacent Mount Owen Complex are sporadic and apart from the May 2016 record of several thousand individuals of the grey-headed flying-fox, only a few individuals of the species have been recorded in previous annual monitoring events utilising these habitats over the last 18 years.

The Project Area is considered to comprise a small area of suitable foraging habitat for this species but is unlikely to contain significant breeding and roosting habitat necessary for maintaining genetic diversity. The Project Area is also not near the limit of the known range of this species. Therefore the Project Area is unlikely to contain an *important population* of the grey-headed flying-fox.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an important population of a species;**

Given that there is not considered to be an *important population* of the grey-headed flying-fox present within the Project Area, the Project will not lead to a long-term decrease in the size of an *important population* of this species.

- **reduce the area of occupancy of an *important population*, or;**

The Project will result in the loss of approximately 154.5 ha of potential foraging habitat for grey-headed flying-fox. The majority of this area contains a relatively low abundance of eucalypt species with bulloak dominating (*Allocasuarina luehmannii*). However, since the Project Area does not contain an *important population* of the grey-headed flying-fox, The Project will not reduce the area of occupancy of an *important population* of this species.

- **fragment an existing *important population* into two or more populations, or;**

The habitat within the Project Area is already highly fragmented and does not contain an *important population* of the grey-headed flying-fox. Therefore the Project will not result in the fragmentation of an *important population* of this species.

- **adversely affect habitat critical to the survival of a species, or;**

According to the draft National Recovery Plan for the grey-headed flying-fox (DECCW 2009), foraging habitat that meets one of the following criteria is considered critical to the survival of the species:

- productive during winter and spring, when food bottlenecks have been identified
- known to support populations of >30,000 individuals within an area of 50 km radius (the maximum foraging distance of an adult)
- productive during the final weeks of gestation, and during the weeks of birth, lactation and conception
- productive during the final stages of fruit development and ripening in commercial crops affected by grey-headed flying-foxes, and/or
- known to support a continuously occupied camp.

The Project Area is considered to comprise approximately 154.5 ha of suitable foraging habitat for this species and may be productive during winter according to the above criteria. However given that this species has not been recorded in the Project Area, the relatively small area of suitable habitat when compared to the local area and that the vegetation in reasonably young, it is considered that the Project is unlikely to affect foraging habitat critical to the survival of the species.

The National Recovery Plan for the grey-headed flying-fox (DECCW 2009) also includes criteria for roosting habitat critical to the survival of the species. Since the Project Area does not contain a grey-headed flying-fox camp it will not impact roosting habitat critical to the survival of the species.

Therefore the Project is unlikely to substantially adversely affect habitat that is critical to the survival of the species.

- **disrupt the breeding cycle of an *important population*, or;**

No grey-headed flying-fox breeding populations or camps have been identified in the Project Area. The Project is not expected to disrupt the breeding cycle of an *important population* of this species.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

The Project will result in the loss of up to approximately 154.5 ha of potential foraging habitat for grey-headed flying-fox. The abundance of eucalypt species within the majority of this vegetation is relatively low with bulloak (*Allocasuarina luehmannii*) dominating. Given the small area of potential foraging habitat to be removed and the substantial area of high quality remnant vegetation in the nearby Ravensworth State Forest, the Project Area is unlikely to be depended upon by local grey-headed flying-fox colonies.

It is considered unlikely that the Project will modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the grey-headed flying-fox would decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

The Project is not expected to result in invasive species that are harmful to the grey-headed flying-fox becoming established in the species habitat.

- **introduce disease that may cause the species to decline; or**

No diseases that may cause the grey-headed flying-fox to decline are likely to be introduced as a result of the Project.

- **interfere substantially with the recovery of the species.**

There is currently no approved recovery plan for the grey-headed flying-fox. The overall objectives of the draft National Recovery Plan for the Grey-headed Flying Fox (DECCW 2009) are to:

- reduce the impact of threatening processes on grey-headed flying-foxes and arrest decline throughout the species' range
- conserve the functional roles of grey-headed flying-foxes in seed dispersal and pollination, and
- improve the standard of information available to guide recovery of the grey-headed flying-fox, in order to increase community knowledge of the species and reduce the impact of negative public attitudes on the species.

No significant effect on the recovery of the grey-headed flying-fox is expected to occur as a result of the Project as the potential areas of foraging habitat that will be impacted as a result of the Project are not expected to impact an *important population* of this species.

Conclusion

DoEE determined that a significant impact is possible for the grey-headed flying-fox, however noting the lack of records within the Project Area and the much larger areas of better habitat to the north-east in the Ravensworth State Forest, a significant impact on this species is not likely to occur.

A3.6 Trailing Woodruff (*Asperula asthenes*)

In the case of a vulnerable species, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- **key source populations either for breeding or dispersal; or**
- **populations that are necessary for maintaining genetic diversity, and/or**
- **populations that are near the limit of the species range.**

Trailing woodruff (*Asperula asthenes*) is listed as vulnerable under the EPBC Act. It is found in scattered locations within NSW from Bulahdelah to Kempsey, with several records from the Port Stephens/Wallis Lakes area. The species typically inhabits damp areas, often along riverbanks.

The controlled action decision (DoEE 2019) states that the Project has a real chance or possibility to have a significant impact on *Asperula asthenes* without further assessment of the potential impacts. It is acknowledged that a record of the species is on the NSW Atlas of Wildlife as occurring to the south east of the Project Area in woodland habitat, which likely prompted DoEE to request further information and assessment on this species. The record is derived from Umwelt surveys of the area in 2006 which identified common woodruff (*Asperula conferta*), however this record has erroneous been entered on the NSW Atlas of Wildlife as *Asperula asthenes*. The closest confirmed record of the trailing woodruff actually occurs over 50km to the northeast of the Project Area in the Barrington Tops. The next closest record occurs over 70km to the southeast near Raymond Terrace.

Notwithstanding the above, the species typically inhabits damp areas, often along riverbanks. The Project Area contains farm dams and creek lines associated with Bowmans Creek, Yorks Creek and Swamp Creek that contains potential damp habitat for this species. Extensive targeted threatened flora surveys involving walking transects in suitable habitat was undertaken in the species known detection period in 2017 and 2018 failed to record this species in the Project Area (refer to Section 2.10). Furthermore, floristic surveys undertaken to sample vegetation across the site did not record *Asperula asthenes* (*however Asperula conferta* was recorded in the Project Area).

The proposed action will not result in the loss of habitat for *Asperula asthenes* as it does not occur in the Project Area. Therefore, the Project Area is unlikely to contain an *important population* of the *Asperula asthenes*.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an important population of a species;**

Given that there is not considered to be an *important population* of the *Asperula asthenes* present within the Project Area, the Project will not lead to a long-term decrease in the size of an *important population* of this species.

- **reduce the area of occupancy of an *important population*, or;**

The Proposed Action will not result in the loss of habitat for *Asperula asthenes* as it does not occur in the Project Area. Therefore the Proposed Action is highly unlikely to reduce the area of occupancy of an *important population* of this species.

- **fragment an existing *important population* into two or more populations, or;**

Asperula asthenes does not occur in the Project Area. Therefore, the Proposed Action is highly unlikely to result in the fragmentation of an *important population* of this species.

- **adversely affect habitat critical to the survival of a species, or;**

No habitat critical to the survival of *Asperula asthenes* has been defined. As the species is not known or likely to occur in the Project Area, the Proposed Actions is unlikely to affect habitat critical to the survival of the species.

- **disrupt the breeding cycle of an *important population*, or;**

Asperula asthenes does not occur in the Project Area. Therefore, the Proposed Action is highly unlikely to disrupt the breeding cycle of an *important population* of this species.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or;**

It is considered unlikely that the Project will modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that *Asperula asthenes* would decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;**

The Project is not expected to result in invasive species that are harmful to *Asperula asthenes* becoming established in the species habitat.

- **introduce disease that may cause the species to decline; or**

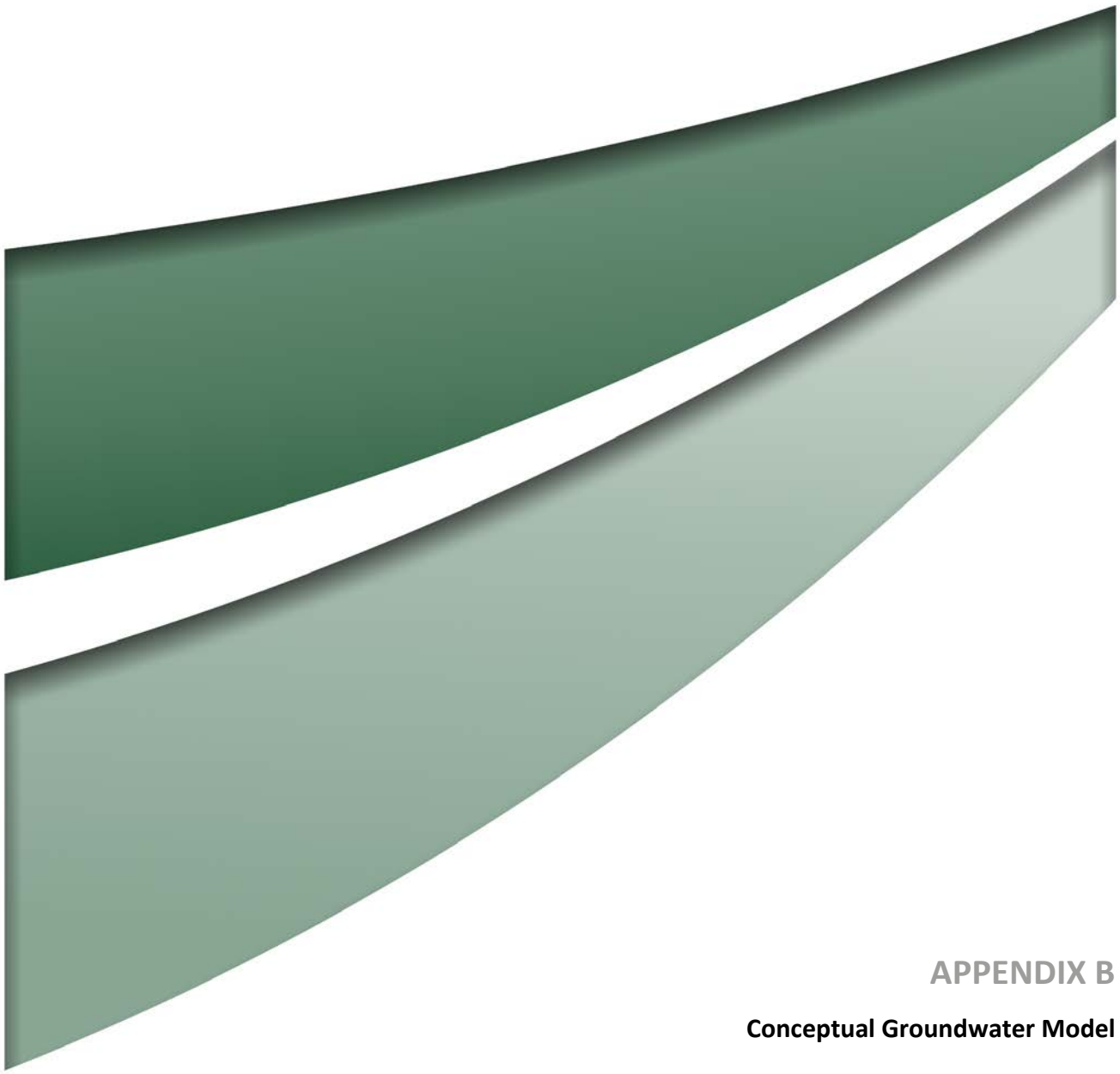
No diseases that may cause the *Asperula asthenes* to decline are likely to be introduced as a result of the Project.

- **interfere substantially with the recovery of the species.**

There is currently no recovery plan for the *Asperula asthenes*. *Asperula asthenes* does not occur in the Project Area or the surrounds. Therefore, the Proposed Action is highly unlikely to interfere with the recovery of the species.

Conclusion

The Proposed Action will not result in the loss of habitat for *Asperula asthenes* as it does not occur in the Project Area. Noting the lack of confirmed records within the Project Area and the wider region, a significant impact on this species is highly unlikely to occur.



APPENDIX B

Conceptual Groundwater Model

B1 Conceptual Hydrogeological Model

The following section provides a conceptual hydrogeological model of the regional hydrogeological environment and the potential impacts that mining, (historical, approved and proposed) may have on this system.

The two main aquifer systems occurring within and surrounding the Project Area are:

- Permian sediments – which can be divided into:
    - thin and variably permeable weathered rock (regolith)
    - non-coal interburden that forms aquitards (a body of rock that retards but does not completely stop the flow of water)
    - low to moderately permeable coal seams that act as the most transmissive strata within the coal measures.
- Quaternary alluvium – relatively thin aquifer systems which occur along Bowmans Creek, Glennies Creek and the Hunter River and tributaries, including Bettys Creek, Swamp Creek and Yorks Creek. The alluvium typically comprises clay, silt and sand overlying basal sands and gravels which unconformably overly the Permian strata.

Permian sediments outcrop in the Project Area and are recharged via rainfall infiltrating through the soil cover and weathered Permian profile. Groundwater flows from areas of high head (pressure plus elevation) to low head via the most permeable and transmissive pathways. The weathered regolith and coal seams are the most transmissive strata within these measures. The groundwater flow path and discharge zone for the Permian groundwater system is influenced by the land use activities in the Glendell Pit Extension. In the absence of mining activities, the main discharge mechanism for groundwater within the Permian strata is expected to be through slow upward flow to low lying alluvium along creeks, particularly Bowmans Creek. The Permian strata is not considered to form a highly productive aquifer because of generally poor water quality and low yields that preclude any beneficial use.

The alluvium is typically in the order of up to 10 m thick within the Bowmans Creek floodplain and slightly thinner in Yorks Creek and Swamp Creek where it is up to 6 m to 8 m in thickness. Extensive field investigations and a desktop study have been undertaken as part of the Groundwater Impact Assessment (AGE, 2019) to confirm the extent of the Bowmans Creek, Swamp Creek and Yorks Creek alluvium and monitoring data has been examined in detail to determine the thickness, permeability and water quality of the alluvium in proximity to the Glendell Pit Extension. The field investigations undertaken as part of the alluvial confirmation process (refer to Appendix 16 of the EIS) indicate the alluvium occurring along Yorks Creek and Swamp Creek tributaries is thin, clayey and contains saline groundwater. The saturated thickness within Bowmans Creek alluvium appears to be patchy and variable depending on location. Available data indicates that the alluvium becomes saturated where it thickens towards the centre of the floodplain but can be unsaturated towards the edges, or where the base of the alluvium is potentially affected by bedrock features such as buried rock bars.

The alluvial sediments along Bowmans Creek are recharged by rainfall, as well as by seepage through the bed of creeks, when they are flowing, where the stream bed sediments and the underlying groundwater levels promote this connectivity. As noted above, where the regional water table is higher than the base of the alluvium, the alluvial aquifers will also receive inflows from sub-cropping coal seams. Movement between the regolith and alluvium would also be expected. The monitoring of water levels and water quality in nested bores within the alluvium indicate however that there is connectivity between the regolith and alluvial systems, but this is retarded to some degree by contrasting permeability and potentially clay aquitards at the base of the alluvium which would also limit transmissivity between the alluvium and sub-

cropping Permian coal seams. The salinity of the groundwater within the Bowmans Creek alluvium varies from fresh to slightly brackish indicating relatively high recharge rates from rainfall and stream flow rather than from the more saline sub-cropping coal seams or weathered regolith.

The flow path within the Bowmans Creek alluvium is a reflection of the topography, with groundwater flowing 'downstream' in a south-westerly direction towards the Hunter River. Bowmans Creek meanders through the flood plain and forms a window to the underlying alluvial aquifer. In dry periods the baseflow in Bowmans Creek is low and the creek reduces to a series of disconnected ponds which are a reflection of the underling interconnected water table. Bowmans Creek is therefore expected to form both a recharge and discharge zone for alluvial groundwater depending on prevailing climate conditions and location within the flood plain.

The Bowmans Creek alluvium is the only geological strata in the region that has the potential to sometimes meet the NSW government criteria to be classified as a "highly productive" groundwater source, which requires TDS concentrations less than 1,500 mg/L and water supply works that can yield water at a rate greater than 5 L/s. All other formations are classified as "less productive" including the areas of alluvial sediments occurring along Yorks Creek and Swamp Creek. All areas of alluvium within the Glendell Pit Extension are considered to be "less productive".

The Glendell Pit Extension is located on the Camberwell anticline which is aligned in a north-south direction. The strata dips to the east (>20 degrees) and the west (12 degrees). A range of other geological structures are also known to occur in the area, including the block fault zone which has been identified as crossing the Glendell Pit Extension. Whilst the potential to transmit groundwater through the fault has not been established it is expected to be relatively limited, given the limited cross-sectional area of the fault zone and the potential for the fault gouge sediment to retard groundwater flow. Visual observations of the block fault zone in adjacent mines also do not indicate the fault zone promotes substantial ingress of groundwater to the mining areas.

Figure 1 provides a conceptual hydrogeological model of the pre-mining groundwater system in the vicinity of the Project.

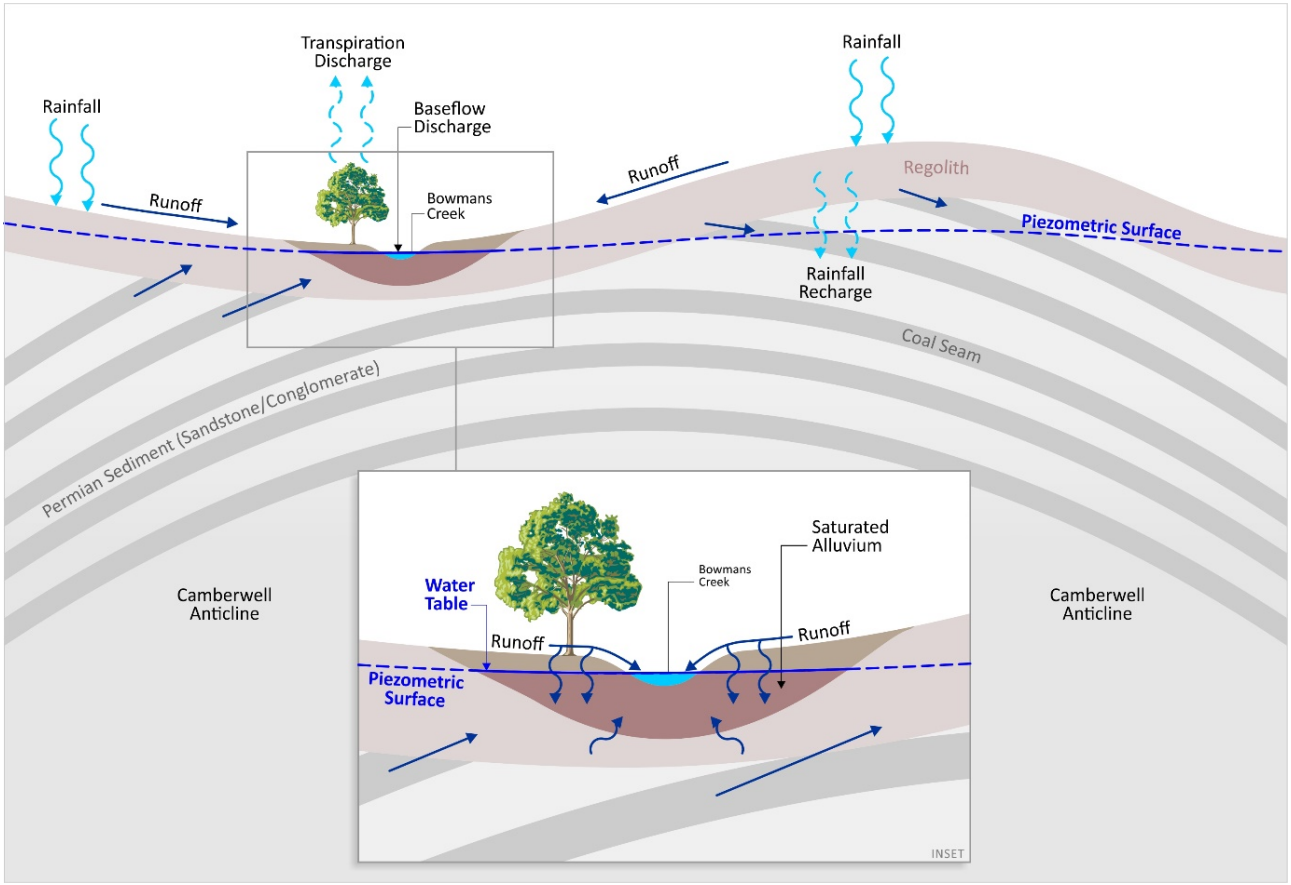


Figure 1 Conceptual Hydrogeological Model – Pre Mining

The proposed Glendell Pit Extension is surrounded by operating or completed open cut and underground mines targeting the same coal measures. Groundwater monitoring from the Project Area and surrounds shows that approved mining activities have depressurised the Permian groundwater systems and reduced water levels within the Permian strata to below the base of the alluvium/regolith. This means the main discharge zone for groundwater within the Permian interburden and coal seams, which was formerly to the alluvium/regolith, is now to surrounding mining operations, either operating or completed.

Unlike the Permian strata, drawdown within the Bowmans Creek alluvium is not readily evident within available monitoring datasets. The fact that the Bowmans Creek alluvial aquifer shows no notable drawdown in response to the observed Permian depressurisation from open cut and underground mining indicates the volume of groundwater moving downwards to the Permian is limited and less than recharge rates from rainfall and streamflow that serve to buffer any losses. The former Liddell underground mine is situated immediately to the north of the proposed Glendell Pit Extension and underlies the Bowmans Creek and Yorks Creek alluvium. Whilst the Permian Middle Liddell seam remains depressurised within this mine, the lack of detectable impact on groundwater levels within the overlying alluvium indicates the relatively low vertical permeability of the Permian strata and the lack of significant fracturing induced by the largely bord and pillar mining operation. The other significant influence on Permian groundwater levels is Ravensworth Operations which is located adjacent to the Project Area and west of Bowmans Creek and contains both open cut and underground operations. Ravensworth Operations is expected to have contributed to the observed Permian depressurisation, but similar to Liddell underground, no notable drawdown has been detected within the Bowmans Creek alluvial aquifer.

Figure 2 provides a conceptual hydrogeological model of the current environment in the vicinity of the Project and shows the influence of existing and historical mining activities in the area on the piezometric surface. The water table in the alluvial aquifer system associated with Bowmans Creek remains relatively unaffected by mining however the lowering of the piezometric water table in the area means the net movement of water between the sub-cropping Permian coal seam aquifers and the alluvium/regolith is reversed meaning there is a net loss of water from the alluvium to the Permian coal seams rather than the coal seams being a source of recharge for the alluvial aquifers.

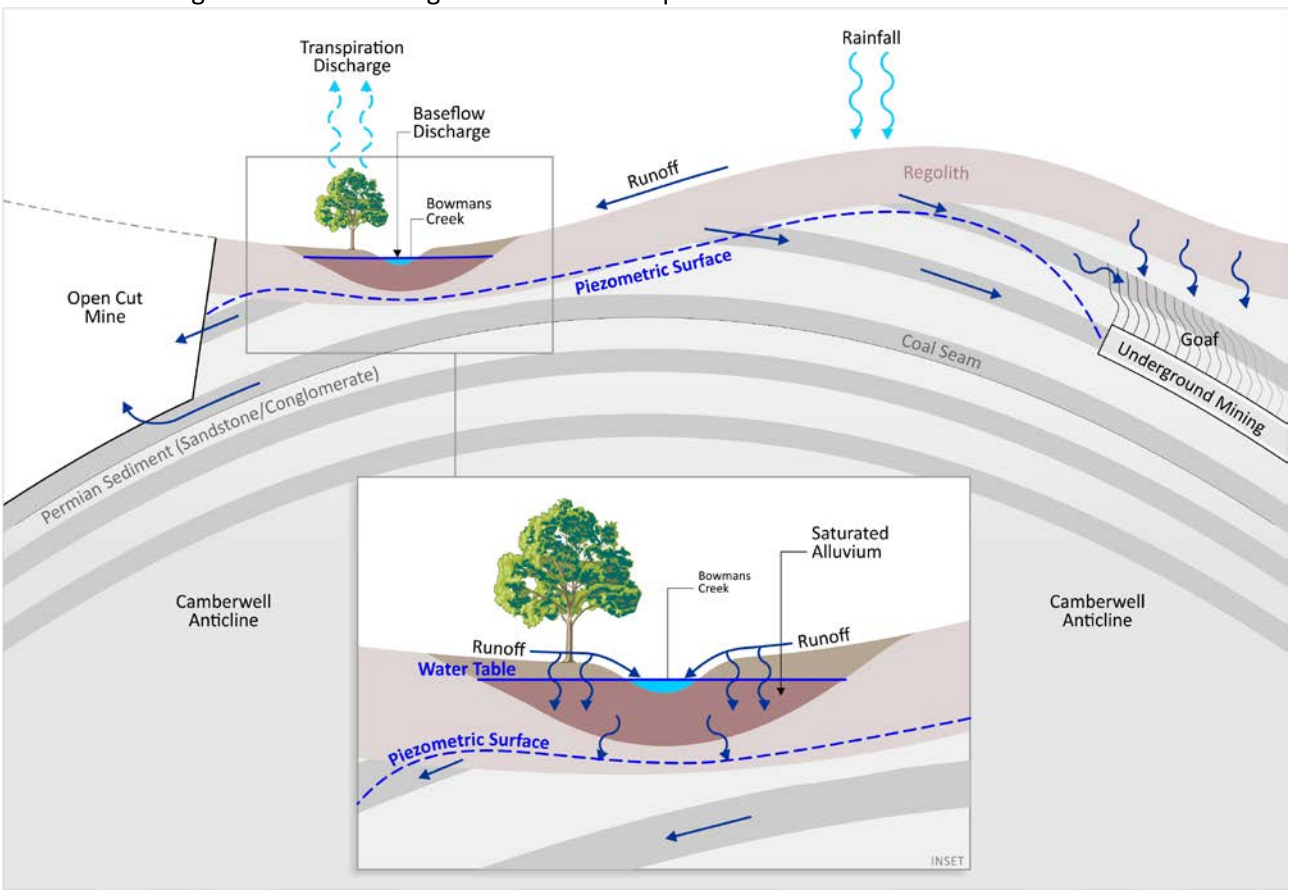


Figure 2 Conceptual Hydrogeological Model – Existing Conditions

The Project is expected to result in localised depressurisation of the coal seams in the vicinity of the Project Area however the location of the Glendell Pit Extension along sections of the Camberwell anticline in which surrounding areas have already been mined would suggest that the impacts on the regional water table during operations will be limited. Monitoring of the approved mining in the Glendell Pit shows little impact from these operations on the adjacent Swamp Creek and Bowmans Creek alluvial systems and this provides a strong indication that the continuation of the pit along the anticline is unlikely to have significant additional impacts on this alluvial system**.** Localised impacts on the alluvium in Swamp Creek and Yorks Creek where the Glendell Pit Extension will intersect the alluvium are expected but will be limited by the depth and saturation of the alluvium and connectivity with the regolith at the point of intersection.

Figure 3 provides a conceptual hydrogeological model of the during-mining operations groundwater system in the vicinity of the Project with the Project's expected interactions with the alluvium shown in greater detail in the inset figure.

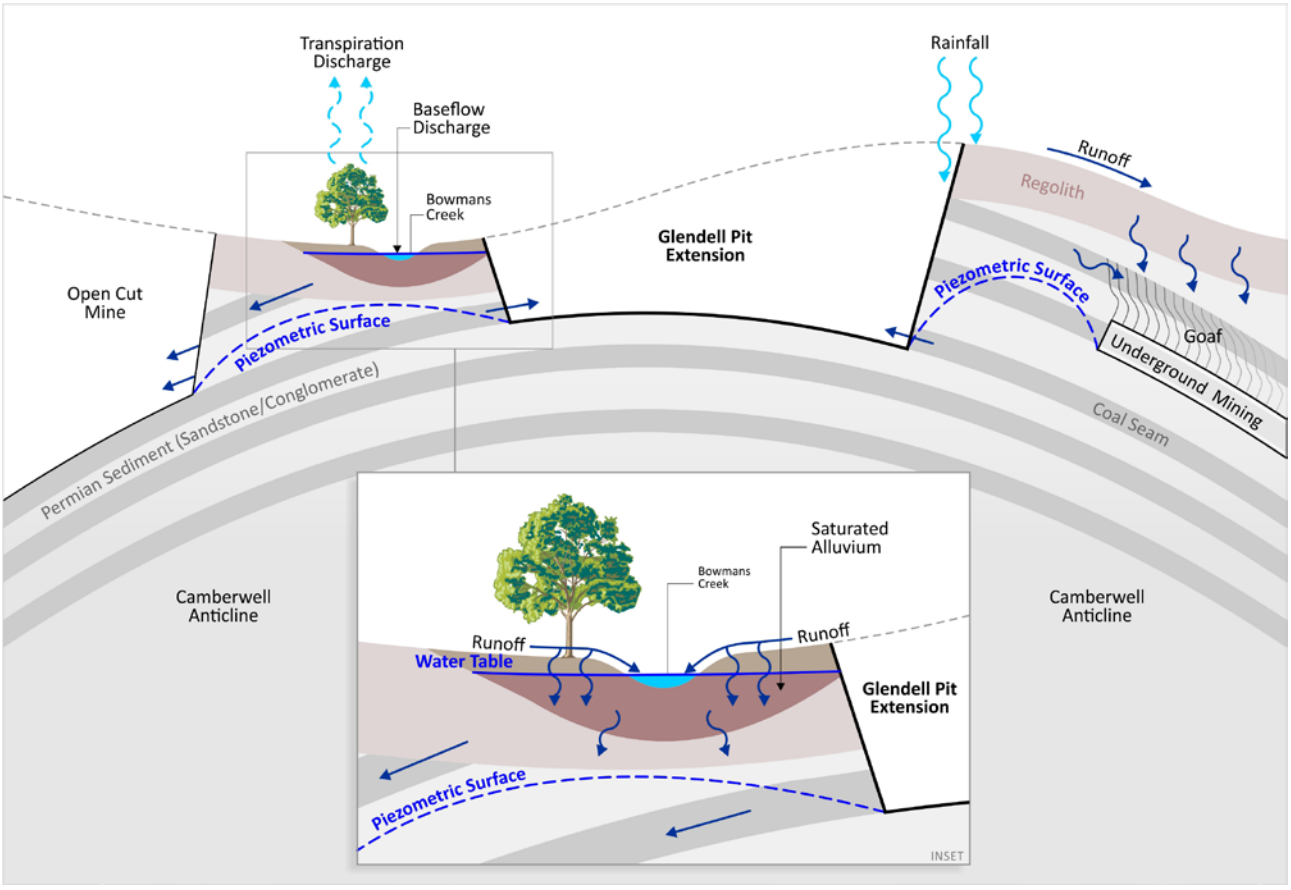


Figure 3 Conceptual Hydrogeological Model – During Mining Operations

Following the cessation of mining at all mining operations surrounding the Project Area, water levels will recover as underground voids and goaf areas fill with groundwater and pit lakes form in final voids. Complete recovery of the water tables in areas affected by underground mining is expected however the water tables around final voids are heavily influenced by evaporation from pit lakes which slowly reach a new equilibrium level after several hundred years.

Figure 4 provides a conceptual hydrogeological model of the regional system in the post-mining environment after equilibrium is reached. An important feature of this post-mining systems is that the flows from the Permian coal seams sub-cropping under the alluvium/regolith is expected to again reverse where the piezometric surface rises above the point of sub-crop.

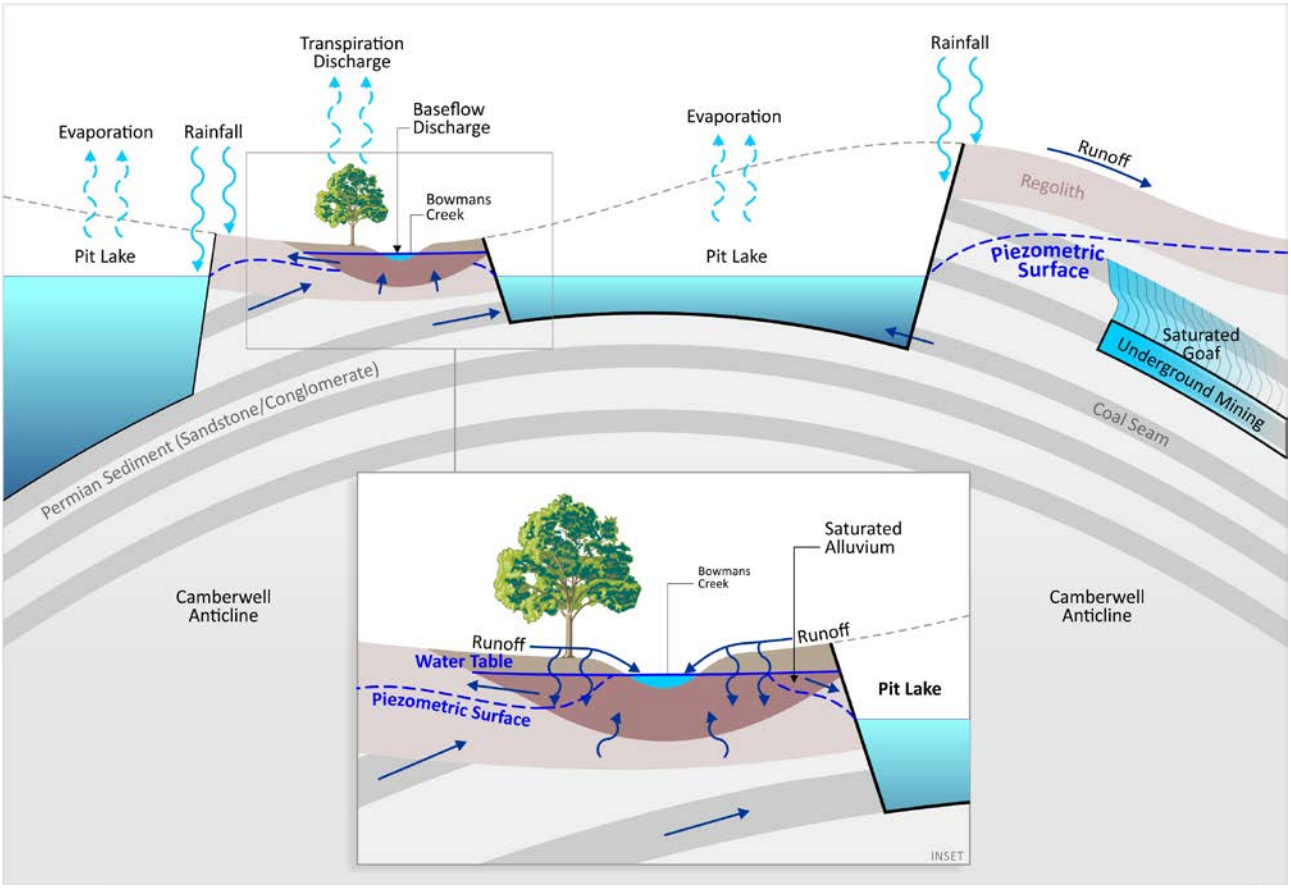
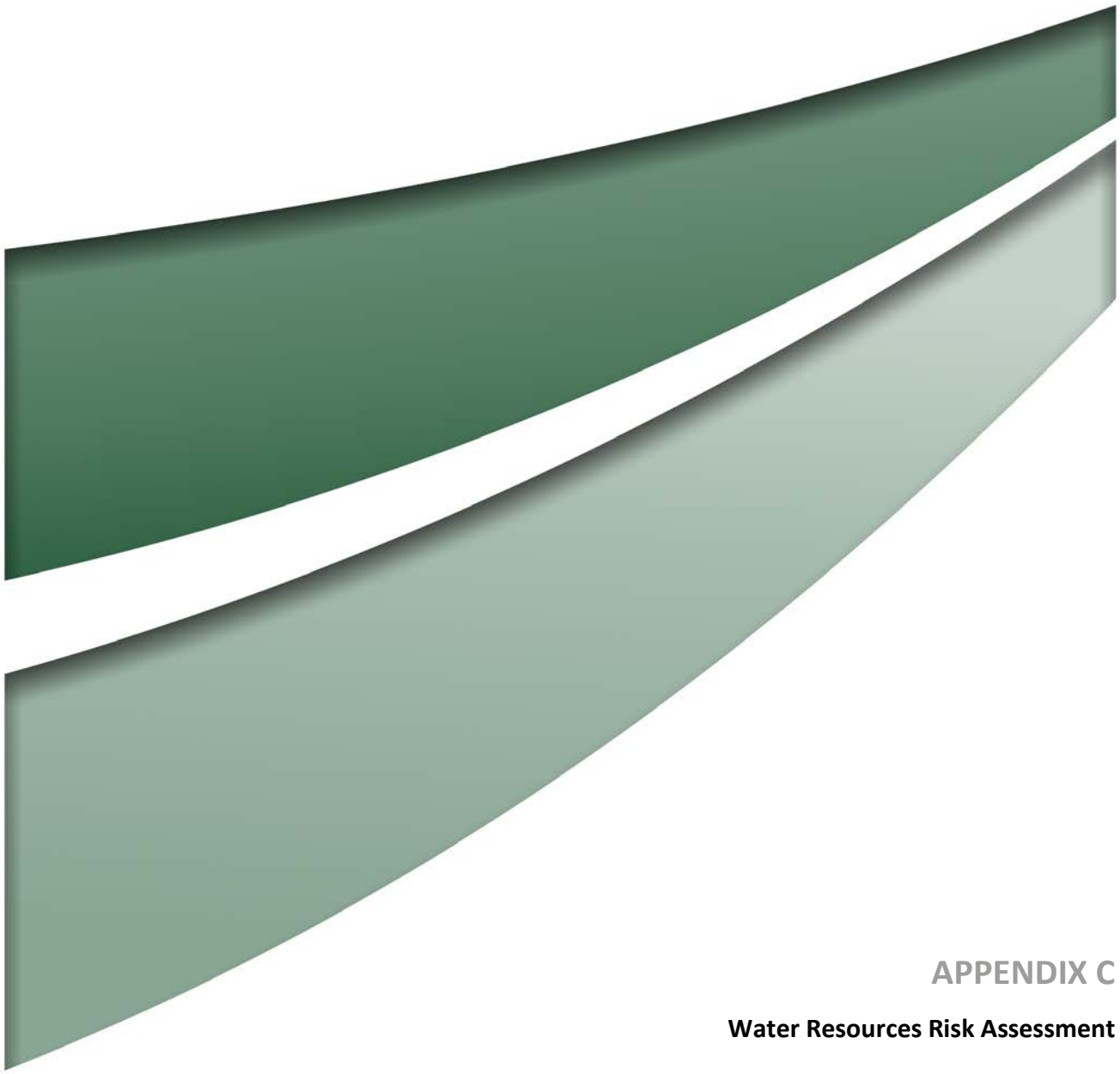


Figure 4 Conceptual Hydrogeological Model – Post-mining



APPENDIX C

Water Resources Risk Assessment

C1 Water Resources Risk Assessment

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
Construction Phase									
Hebden Road realignment	Sediment laden water entering downstream catchments	Runoff from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Yorks Creek	Blue Book controls	Off-site impacts are unlikely – Total suspended solids managed through adequacy of blue book controls. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solution.	Yes - Preparation of construction erosion and sediment control management plan.	Erosion and Sediment Control Plan	Section 120 of the POEO Act prohibits the pollution of waters. No EPL exception to this for Mount Owen Complex
	Changes to flow regimes – upstream and downstream	Impacts on flood flows in Bowmans Creek	Local	Yorks Creek	Bridge design	Off-site impacts are unlikely – managed through bridge design informed by flood modelling.	Yes – Additional flood modelling required for detailed design.		
	Construction of road to meet design criteria (>1:20 year event) may result in changes to flood flows in Bowmans Creek due to road being located in Bowmans Creek flood zone	Impacts on flood flows in Bowmans Creek	Local	Bowmans Creek – upstream/ downstream landowners or road users	Road design Flood assessment - Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study has indicated negligible off-site impacts.	No – flood modelling indicates no significant impacts.		
Heavy Vehicle Access Road	Sediment laden water entering downstream catchments	Runoff from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Yorks Creek	Blue Book controls	Off-site impacts are unlikely – Managed through adequacy of blue book controls. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solutions.	Yes - Preparation of construction erosion and sediment control management plan.	Erosion and Sediment Control Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.
	Changes to flow regimes – upstream and downstream	Impacts on flood flows in Bowmans Creek	Local	Yorks Creek	Culvert design	Off-site impacts are unlikely – managed through culvert design informed by flood modelling.	Yes – Additional flood modelling required in detailed design.		
	Construction of road may result in changes to flood flows in Bowmans Creek due to road being located in Bowmans Creek flood zone	Impacts on flood flows in Bowmans Creek	Local	Bowmans Creek – upstream/ downstream landowners	Road design Flood assessment - Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study has indicated negligible off-site impacts.	No – flood modelling indicates no significant impacts.		
Yorks Creek Realignment	Flows from new confluence entering Bowmans Creek at a point where inflows haven't historically entered Bowmans Creek Changed flow patterns in Bowmans Creek at point of new confluence and immediate downstream reach	Scouring at new confluence with Bowmans Creek. Increased turbidity associated with scouring and changed flow patterns.	Local	Bowmans Creek	Design of realignment at confluence. Inclusion of stilling ponds.	Off-site impacts are unlikely – managed through appropriate design of new confluence point and associated scour protection.	Yes – Additional flood modelling required in detailed design.	Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction which includes consideration of flow velocities at the confluence	

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
	Once commissioned, lower reaches of Yorks Creek will have reduced flows until point at which operations mine through creek.	Loss of flows to former Yorks Creek catchment	Local	Riparian vegetation along lower reach of Yorks Creek. Aquatic fauna in lower reach of Yorks Creek.	Timing of commissioning of realignment.	Negligible. Impacts limited to small remnant section of Yorks Creek.	No – Vegetation will be removed by progression of Glendell Pit Extension.	Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction which includes consideration of re-establishing riparian vegetation and providing habitat for aquatic fauna.	Yes – water take to be licensed under *Water Management Act 2000.*
	Movement of loose material in realignment channel during early flows	Turbid flows to Bowmans Creek during commissioning	Local	Bowmans Creek downstream of new confluence.	Design of Yorks Creek Realignment. Management of flows during commissioning process.	Off-site impacts are unlikely – managed through appropriate design of new confluence point and associated scour protection. Some sediment movement desirable.	Yes – Detailed design to be informed by flood modelling and sediment transport modelling.	Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction which includes consideration of these flow velocities and sediment movement during commissioning.	
	Cutting off Yorks Creek will reduce seepage through bed of Yorks Creek to underlying water table and flow of groundwater to Bowmans Creek alluvium	Drawdown within remaining downstream alluvium	Local because Yorks Creek alluvium has very limited saturation with groundwater	Bowmans and Yorks Creek alluvial aquifers	None required as drawdown predicted to be less than AIP acceptable thresholds	Negligible. Off-site impacts limited to downstream sections of Bowmans Creek – upstream inflows to Bowmans Creek at new confluence will provide supplementary recharge.	No	Groundwater Management and Monitoring Plan	Yes – water take to be licensed under *Water Management Act 2000.*
MIA construction	Construction of MIA (may result in changes to flood flows in Bowmans Creek due to MIA being located in Bowmans Creek flood zone	Impacts on flood flows in Bowmans Creek	Local	Bowmans Creek – Upstream/ downstream landowners	MIA design Flood assessment - Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – flood modelling indicates no significant impacts		
Transmission line/services relocation	Sediment laden water entering downstream catchments	Runoff from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Yorks Creek, Yorks Creek Realignment	Blue Book controls	Off-site impacts are unlikely – Managed through adequacy of blue book controls. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solutions.	Yes - Preparation of construction erosion and sediment control plan.	Erosion and Sediment Control Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.
GRAWTS pipeline relocations	Sediment laden water entering downstream catchments	Runoff from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Yorks Creek Realignment	Blue Book controls	Off-site impacts are unlikely – Managed through adequacy of blue book controls. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solutions.	Yes - Preparation of construction erosion and sediment control plan.	Erosion and Sediment Control Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.

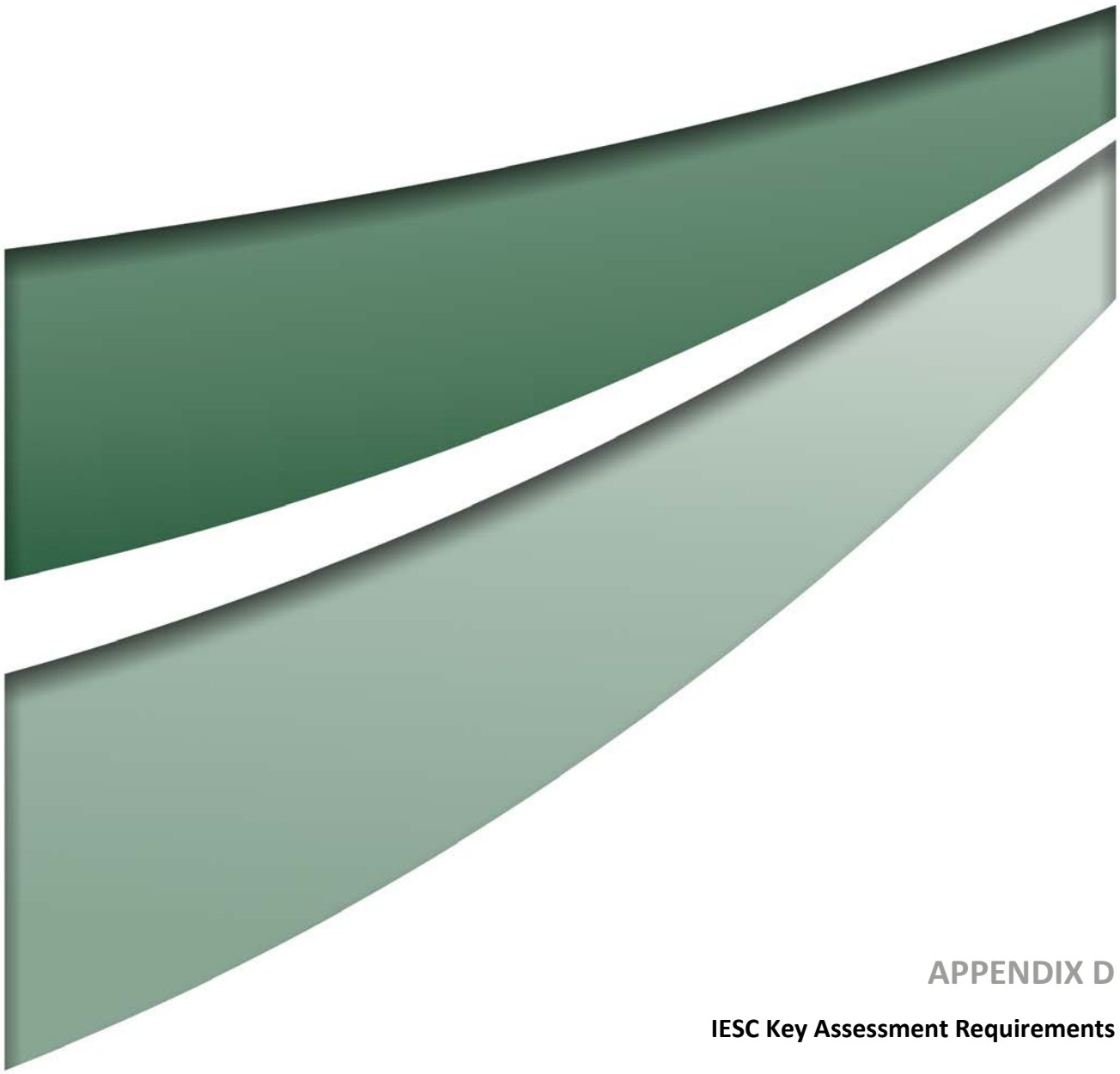
Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
Operation Phase									
Mining - pit development	Mining of coal seams results in changes to pressure gradients in coal seams and results in groundwater flows towards the mining void	Depressurisation of groundwater within coal seams	Local and Regional	Regional Groundwater – coal seams	Approved mining in region has already depressurised coal seams proposed to be mined. No mitigation has been required to manage adjacent water sources and additional management controls are not warranted given magnitude of predicted impacts.	Depressurisation of groundwater within coal seams is predicted to occur beyond the project boundary and merge with cumulative impacts already existing.	Regular measurement and validation of predicted drawdown through monitoring bores.	Groundwater Management and Monitoring Plan.	Yes – water take to be licensed under *Water Management Act 2000*.
	Depressurisation of coal seam aquifers sub-cropping under alluvial aquifers/weathered material can affect water movement between aquifers	Induced drawdown in alluvial aquifers due to reduced inflows from sub-cropping coal seams/increased recharge of coal seams. Reduced baseflow in creeks.	Local and Regional	Bowmans Creek, York Creek, Glennies Creek, Swamp Creek, Bettys Creek, Main Creek. Aquatic fauna and riparian vegetation in affected creeks.	Modelling indicates limited drawdown and no management measures required.	Potential for off-site impacts. Project has limited impact on cumulative base flow reductions during operations (<0.0067 ML/day of a modelled maximum 0.058 ML/day cumulative reduction). This impact is unlikely to be measurable.	Regular measurement and validation of drawdown through monitoring bores, and calculation of indirect water take from alluvial aquifer through modelling. Ongoing numerical modelling through life of Project to calculate take from alluvial system.	Groundwater Management and Monitoring Plan.	Yes – water take to be licensed under *Water Management Act 2000* Act.
	Draining of alluvial aquifers associated with interception of alluvium/ weathered material	Drawdown in alluvial aquifers. Reduced baseflow in creek.	Local	Bowmans Creek, Yorks Creek, Swamp Creek. Aquatic fauna and riparian vegetation in affected creeks.	Modelling indicates limited drawdown no management measures required.	Potential for off-site impacts. Project has limited impact on cumulative base flow reductions during operations (<0.0067 ML/day of a modelled maximum 0.058 ML/day cumulative reduction). This impact is unlikely to be measurable.	Regular measurement and validation of drawdown through monitoring bores and calculation of indirect water take from alluvial aquifer through modelling. Ongoing numerical modelling through life of Project to calculate take from alluvial system.	Groundwater Management and Monitoring Plan	Yes – water take to be licensed under *Water Management Act 2000*.
	Management of poor quality groundwater inflows and intercepted rainfall/surface flows in contact with coal material	Spills of water would affect downstream water quality	Local	Bowmans Creek, Yorks Creek, Swamp Creek, Bettys Creek.	All mine water managed as part of the Mount Owen Complex WMS. 1:100 yr design criteria for mine water storages. Water managed as part of GRAWTS with discharges from Ravensworth Operations and/or Liddell Coal Operations in accordance with the relevant EPLs.	Off-site impacts unlikely. Managed through design criteria for mine water storages.	No	Water Management Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
Mining - landform development	Sediment laden water entering downstream catchments	Run off from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Yorks Creek, Swamp Creek, Bettys Creek.	Blue Book controls	Off-site impacts are unlikely – Managed through adequacy of blue book controls. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solutions.	Yes – Ongoing monitoring of sediment dams and maintenance of associated infrastructure.	Erosion and Sediment Control Plan Water Management Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.
	Acid mine drainage – seepage through potentially acid forming (PAF) spoil material	Elevated metal concentrations in downstream environment	Local	Bowmans Creek, Swamp Creek, Bettys Creek Yorks Creek	Seepage from spoil managed through sediment dam controls and pumped to WMS. Emplacement of material managed to ensure PAF material emplaced in locations unlikely to cause impacts. Co-disposal with non-acid forming (NAF) material.	Off-site impacts are unlikely - geochemistry and management controls have been effective in past management of PAF at Mount Owen Complex. Geochemistry Assessment indicated buffering capacity in overburden material and very low risk of acid mine drainage. Geochemical Assessment indicates overburden/ interburden (and derived soil material) have low salinity potential and are unlikely to release significant metal/metaloid concentrations into solutions.	Yes – ongoing monitoring of pit water and water quality in sediment dams.	Water Management Plan Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	
	Saline seepage from spoil material	Elevated salinity in downstream environment	Local	Bowmans Creek, Swamp Creek, Bettys Creek Yorks Creek	Seepage from spoil managed through sediment dam controls and pumped to WMS.	Off-site impacts are unlikely - geochemistry assessment indicates low salinity risk from overburden leachate which will diminish with time. Effectively managed though sediment dam controls with catchments not released until monitoring indicates seepage is of acceptable water quality.	Ongoing monitoring required.	Water Management Plan Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	
Altered surface flows (quantity)	Increased WMS catchment area associated with Glendell Pit Extension and management of runoff from operational areas.	Reduced downstream flows	Local to Regional	Bowmans Creek downstream water users	Progressive rehabilitation of disturbed areas. Release of rehabilitated areas to downstream catchments as soon as possible.	Potential for off-site impacts. Assessment of stream flows indicates the Project will have a negligible effect on streamflow in Bowmans Creek due to the reduced catchment associated with the Project coinciding with the release of rehabilitated areas in other parts of the catchment.	No	Water Management Plan	Runoff from clean catchments captured in WMS will require licensing under *Water Management Act 2000*. Water take from sediment dams not required to be licensed.
	Increased WMS catchment area associated with Glendell Pit Extension and management of runoff from operational areas.	Reduced flooding impacts	Local to Regional	Bowman Creek, Hunter River, Yorks Creek, Swamp Creek	Flood assessment – Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – flood modelling indicates no significant impacts	Water Management Plan	

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
Spills from mine water system	Broken pipeline – GRAWTS or internal pipelines	Pollution of receiving waters	Local to regional	Bowmans Creek, Bettys Creek Yorks Creek (inc. realignment)	Managed through design of water and tailings transfer design system.	Potential for off-site impacts. No increased risk as a result of the Project.	No	Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	
	Spill from mine water storage	Pollution of receiving waters	Local to Regional	Bowmans Creek, Bettys Creek	All mine water managed as part of the Mount Owen Complex WMS. 1:100 yr design criteria for mine water storages. Water managed as part of GRAWTS with discharges from Ravensworth Operations and/or Liddell Coal Operations in accordance with the relevant EPLs.	Unlikely - Potential for off-site impacts managed through design criteria for storages and linkages to GRAWTS. Spills during design storm event will occur into high flow environment with onsite storage water diluted by rainfall and runoff intercepted by storage. Potential impacts on receiving environment are considered to be negligible given relatively low volumes of potential spill, diluted nature of spill water and large volume of water in receiving environment.	No	Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.
Mining through Swamp Creek	Intercepted flows in Swamp Creek	Loss of flows to Bowmans Creek. Loss of water from Swamp Creek alluvium. Loss of riparian vegetation and aquatic and hyporheic fauna	Local – very limited saturation of groundwater in Swamp Creek alluvium	Aquatic fauna, riparian vegetation, downstream water users	Licensing of intercepted water. Diversion of upper Swamp Creek catchment.	Potential for off-site impacts. Impacts predicted to be negligible and largely limited to area immediately adjacent to point of pit interception. Final landform catchment similar to existing catchment area.	Regular measurement and validation of drawdown through monitoring bores	Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	Yes – water take to be licensed under *Water Management Act 2000*.
	Intercepted flows in Swamp Creek	Reduced flooding impacts	Local to Regional	Bowman Creek, Hunter River, Swamp Creek	Flood assessment – Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – flood modelling indicates no significant impacts	Water Management Plan	
Mining through Yorks Creek	Intercepted flows in Yorks Creek	Loss of flows to Bowmans Creek. Loss of water from Yorks Creek alluvium. Loss of riparian vegetation and aquatic and hyporheic fauna	Local	Aquatic fauna, riparian vegetation, downstream water users	Realignment of Yorks Creek around pit. Licensing of intercepted water.	Potential for off-site impacts.	Regular measurement and validation of drawdown through monitoring bores. Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction	Surface Water Management and Monitoring Plan Surface and Groundwater Response Plan	Yes – water take to be licensed under *Water Management Act 2000*.
	Intercepted flows in Yorks Creek	Reduced flooding impacts	Local to Regional	Bowman Creek, Hunter River, Yorks Creek	Flood assessment – Flood modelling indicates no significant off-site impacts	Potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – flood modelling indicates no significant impacts	Water Management Plan	
Yorks Creek Realignment	Reduced length of Yorks Creek and changed bedding material in realignment may result in reduced sediment flows to Bowmans Creek	Changed sediment flows to Bowmans Creek	Local to Regional	Downstream catchments	Creek realignment design	Off-site impacts are unlikely – managed through realignment design	Yes – further detailed design to be undertaken. Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction		

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
	Sediment build-up may alter flows in realignment and result in changes to channels during high flow events. Sediment build-up may result in increased in-stream vegetation	Sediment build-up in low slope areas of the realignment	Local to Regional	Yorks Creek. Bowmans Creek downstream of confluence.	Creek realignment design	Off-site impacts are unlikely – managed through realignment design informed by flood modelling	Yes – Additional modelling required in detailed design. Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction		
	Steeper slopes in lower reaches may act as obstacles to fish and other fauna movement up stream	Impediments to fish and aquatic fauna movement due to slopes in lower reach		Aquatic fauna	Creek realignment design to avoid fish barriers.	Off-site impacts are unlikely – managed through realignment design	Yes – Additional modelling required in detailed design. Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction		
	Upper sections of proposed realignment have low slope, allowing sediment deposition during low flow events. May result in elevated turbidity during early flows in high flow events as sediment mobilised.	Elevated turbidity in high flow events due to sediment build-up	local	Yorks Creek. Bowmans Creek downstream of confluence	Creek realignment design	Off-site impacts are unlikely – managed through realignment design informed by flood and sediment transport modelling	Yes – Additional modelling required in detailed design. Yorks Creek Realignment Plan will be prepared as part of the detailed design prior to construction		
	Altered flow patterns in Bowmans Creek downstream of new confluence	Increased flooding downstream of new confluence during high flow events	Local	Section of Bowmans Creek between new confluence and former confluence	Flood assessment – Flood modelling indicates very minor impacts	No significant potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – Flood modelling indicates very minor impacts		
	Altered flow patterns in Bowmans Creek downstream of confluence	Increased flow velocity between new and old confluence during high flow events. Additional scour potential.	Local	Section of Bowmans Creek between new confluence and former confluence	Flood assessment – Flood modelling indicates no significant impacts	No significant potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – Flood modelling indicates no significant impacts		

Project Component	Impact/Causal Pathway	Potential Impact	Scale	Receptor	Management Controls	Offsite Impact Potential (with controls)	Further assessment required	Relevant Mount Owen Complex Management Plan	Licensing /regulator issues
Closure									
Removal of infrastructure	Sediment laden water entering downstream catchments	Run off from disturbed areas, increased salinity, increased metals	Local	Bowmans Creek, Swamp Creek, Bettys Creek Yorks Creek.	Blue Book controls	Off-site impacts are unlikely – Managed through adequacy of blue book controls.	Yes - Preparation of demolition erosion and sediment control plan	Surface Water Management and Monitoring Plan	Glendell and Mount Owen EPLs do not authorise discharges from the site.
Void Recovery	Water level within final void pit lake remains below the regional groundwater level and the evaporative pumping effects results in a continual draw of groundwater to the pit lake	Loss of water from alluvium. Loss of riparian vegetation and aquatic and hyporheic fauna.	Local around void	Bowmans Creek and remnant Yorks Creek alluvium. Riparian vegetation and aquatic and hyporheic fauna.	No controls feasible	Permanent flow of groundwater to void and slight drawdown in groundwater levels	Monitoring post mining until post mining impacts validated	Water Management Plan	Retirement of water licences to account for permanent water take of groundwater from adjacent water sources in accordance with *Water Management Act 2000*.
Release of catchment in rehabilitated areas	Altered flow patterns in downstream catchments	Increased flow velocity and flooding	Local	Yorks Creek, Swamp Creek, Bettys Creek, Bowmans Creek.	Flood assessment – Flood modelling indicates moderate velocity increases.	No significant potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	No – flood modelling indicates no significant impacts	Water Management Plan Rehabilitation Strategy Mining Operations Plan/Rehabilitation Management Plan Mine Closure Plan	
Diversion of part of Swamp Creek catchment to Bettys Creek	Altered flow patterns in Bettys Creek	Increased flooding in Bettys Creek	Local	Bettys Creek	Flood assessment – Flood modelling indicates moderate flood level increases. Flood levels in Bettys Creek returning to pre-mining levels.	No significant potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	Yes – Detailed design of final landform drainage as part of closure and rehabilitation	Rehabilitation Strategy Mining Operations Plan/Rehabilitation Management Plan Mine Closure Plan	
	Altered flow patterns in Bettys Creek	Increased velocities in Bettys Creek leading to additional scouring potential	Local	Bettys Creek	Flood assessment – Flood modelling indicates moderate velocity increases. Flood velocities in Bettys Creek returning to pre-mining levels.	No significant potential exists for off-site impacts. Flood study indicates negligible off-site impacts.	Yes – Detailed design of final landform drainage as part of closure and rehabilitation	Rehabilitation Strategy Mining Operations Plan/Rehabilitation Management Plan Mine Closure Plan	



APPENDIX D

IESC Key Assessment Requirements

D1 IESC Key Assessment Requirements

Advice to decision maker on coal mining project. IESC 2019-104: Glendell Continued Operations Project (GA-10005) – Expansion (24 June 2019)

IESC Requirements	Summary of assessment findings	Where assessed in EIS
Provide further information on the baseline conditions of both groundwater and surface water resources including water quality, flow regimes and hydrological connectivity.	Due to the long history of mining related development in the area in which the Project is located (more than 50 years), pre-mining baseline conditions for groundwater and surface water are not available. Nonetheless, a long period of baseline groundwater and surface water monitoring data is available to inform the assessment process and enable a detailed understanding. Further, the impacts from historical mining and existing approved mining continue to affect both surface water and groundwater systems and will continue to do so for many centuries. These changes include: **Groundwater:** • depressurisation of regional Permian aquifer systems and associated drawdown impacts on alluvial systems • recovery of groundwater systems following the cessation of mining • altered terrain associated with retained final voids, pit lakes, and overburden emplacement areas which alter regional recharge. **Surface Water** • altered terrain, including creek diversions, which affects catchment sizes • reduced catchment areas due to management as part of mine water management systems to prevent offsite pollution • changed landform and permanent reductions in creek catchments due to the presence of final voids • changed terrain affecting catchments, run-off flows and flood flows • construction of infrastructure in floodplains The assessment has therefore been undertaken by assessing the Project's incremental impacts against the changes expected as a result of the ongoing effects of historical and approved mining conditions as well as an assessment against current (2019 conditions). Both the Groundwater Impact Assessment and Surface Water Impact Assessment have considered regional changes over time associated with approved activities. These assessments have been based on a long period of monitoring with results calibrated where possible against historical monitoring.	**Sections 3.1.2.2** and **3.1.2.3** of this Report summarise the baseline conditions for groundwater and surface water systems potentially impacted by the Project. **Section 3.1.2.5** and **3.1.2.6** of this Report summarise the existing Mount Owen Complex WMS arrangements and interactions with GRAWTS. Section 7.5 of the **EIS** **Groundwater Impact Assessment** (Appendix 16 of the **EIS**) **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)

IESC Requirements	Summary of assessment findings	Where assessed in EIS
After completion of the proposed field mapping of alluvial aquifers in the project area, provide estimation of groundwater drawdown and the likely effects on surface flows (especially low flows and ecologically important flow components) in associated creeks.	A detailed process of refining the mapping of the extent of alluvium in Bowmans Creek, Yorks Creek and Swamp Creek was undertaken for the Project. This work supplements earlier alluvial definition work of Main Creek and Bettys Creek undertaken for the Mount Owen Continued Operations Modification 2 (AGE, 2017). Drawdown impacts associated with the Project have been assessed relative to a No Glendell Scenario as well as the Projects impacts on alluvial water tables relative to 2019 conditions. These modelled impacts have been compared with observed natural fluctuations. The Projects predicted impacts on baseflows have also been assessed and have had regard to the cumulative impact of mining operations in the region which are predicted to result in an overall decline in baseflows and then recovery post mining. The Project's contribution to reductions in baseflow during operations is modelled as being relatively small and unlikely to be observable. The drought conditions being experienced at the time of writing (November 2019) also enable the modelled impacts to be viewed in the context of extreme low flow conditions not previously experienced in the Hunter Valley for at least 20 years.	Impacts discussed in **Section 3.2** of this Report **Groundwater Impact Assessment** (Appendix 16 of the **EIS**) **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)
Update the groundwater model, including a sensitivity and uncertainty analysis and quantification of surface water-groundwater connectivity.	The regional groundwater model used for recent Mount Owen Complex and Integra Underground impact assessments has been refined and updated to assess the impacts of the Project. The Groundwater Impact Assessment includes a comprehensive sensitivity and uncertainty analysis of the model and impact predictions. The groundwater model has been used to inform the assessment of groundwater-surface water connections. The groundwater model and assessment has been peer reviewed.	**Groundwater Impact Assessment** (Appendix 16 of the **EIS**)
Flood modelling that incorporates infrastructure changes, the Yorks Creek diversion and the final landform to assess flood risks to mine pits and detention storages and changed floodplain behaviour.	The surface water assessment includes a detailed flooding assessment of the 10% (1:10 year), 5% (1:20 year), 1% (1:100 year), 0.5% (1:200 year) and 0.2% (1:500 year) annual exceedance probably (AEP) flood events as well as the Probable Maximum Flood (PMF). The flooding assessment was undertaken for the existing landform (as a baseline), Year 6 of the Project (to reflect the impacts of the construction of the Hebden Road realignment, Yorks Creek Realignment, the new Glendell MIA and Heavy Vehicle Access Road on flood flows), and the proposed conceptual final landform. Impacts for Year 6 and the conceptual final landform were compared against existing conditions and include the predicted cumulative impacts associated with changes to landform at both the Mount Owen Complex as well as other mining operations in the Bowmans Creek catchment. The flooding assessment includes consideration of flood extent and depths as well as flow velocities. Details of the flooding study and methods used are set out in the Surface Water Impact Assessment	Results are summarised in **Section 3.3.2** of this Report **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)

IESC Requirements	Summary of assessment findings	Where assessed in EIS
A detailed site water balance that specifies uncertainties in inputs and performance under future climatic conditions.	The impact of the Project on the site water and salt balance for the Mount Owen Complex and the GRAWTS was assessed using the existing Greater Ravensworth Area Water Balance Model (GRAWBM) which was modified to represent the conceptual WMS, predicted groundwater inflows and estimated production rates associated with the Project. The potential impact of rain variability and changing climatic conditions was also considered. Further details on the modelling methodology and the detailed input data is provided in Appendix B of the Surface Water Impact Assessment (refer to Appendix 17 of the EIS). The results of the water and salt balance are discussed in Section 7.5.7.1 of the EIS.	**Surface Water Impact Assessment** (Appendix 17 of the **EIS**) Section 7.5.7.1 of the **EIS**
A geochemistry study specific to the project area which assesses all waste rock material.	The Geochemical Assessment (EGI, 2019) (refer to Appendix 19 of the EIS), includes an assessment of the geochemical characteristics of material to be mined as part of the Project. The majority of overburden/interburden, coal and washery wastes for the Project are expected to be Non Acid Forming (NAF) with excess Acid Neutralising Capacity (ANC) and are not expected to require special handling. Dilution and mixing during mining are expected to be sufficient to mitigate Acid Rock Drainage (ARD) from any occasional thin zones of pyrite that may be present in pit walls and pit backfill, and prevent any significant impacts on downstream water quality. Although the Potentially Acid Forming (PAF) mine materials do not appear to represent a concern in terms of downstream water quality impacts, placement of PAF materials close to final surfaces could cause local effects on rehabilitation success through upward migration of acid and salinity into the growth horizon. The thorough intermingling of coarse rejects and overburden observed on site and the excess ANC in the overburden suggests, that these bulk fill zones are unlikely to result in any significant effects on rehabilitation. The low salinity potential of NAF overburden/interburden, and the expected relatively minor PAF overburden/interburden, washery waste and pit wall materials indicate that the Project is not likely to have a significant impact on pit water quality, or require modification of the current saline water management.	**Geochemical Assessment** (Appendix 19 of the **EIS**)
Further information on the salt balance of the site and salt sources and stores within the final landform, including salt derived from the alluvial aquifer.	The results of the water and salt balance are discussed in Section 7.5.7 and Appendix 17 of the EIS. In summary: • The forecast water inventory at the Mount Owen Complex is expected to be small compared to the available storage capacity at the Mount Owen Complex. The overall water volume in the GRAWTS is expected to remain well below the total water storage capacity. • The Project, as part of the Mount Owen Complex, does not propose to discharge water. Glencore proposes to continue to share water within the GRAWTS, including the use of	Results are summarised in **Section 3.3** of this Report **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)

IESC Requirements	Summary of assessment findings	Where assessed in EIS
	existing water storages and, where necessary, utilise existing approved discharge points under the HRSTS at Ravensworth Operations and/or Liddell Coal Operations. • The salt balance at the Mount Owen Complex is expected to remain proportional to the water balance. The overall mass of salt at the Mount Owen Complex is expected to increase, due to evapoconcentration of the water recycled within the WMS. The main source of salt at the Mount Owen Complex is from groundwater inflows to the open cut pits and transfers from Integra Underground mine that are reported as imports from the GRAWTS. Salt is entrained in water used for coal processing and dust suppression, which is, in part, returned to the WMS from tailings and catchment runoff from haul road and stockpile areas respectively. As the Project is essentially an extension of the existing operations under the Glendell Consent, any changes as a result of the Project to the site salt balance at the Mount Owen Complex are not expected to affect the discharges under the Hunter River Salinity Trading Scheme (HRSTS). A pit lake will form in the Glendell Pit Extension final void. The pit lake water level will progressively rise as a result of catchment inflows, rainfall infiltration through spoil and groundwater inflows until the evaporation from the pit lake exceeds or equals inflow rates. The Surface Water Impact Assessment included modelling the water level for the existing approved conceptual final landform to understand the relative differences between the approved and proposed operations. The same water quality assumptions were used for both run-off and groundwater in both scenarios modelled. Model results indicate that the final void pit lake would reach an equilibrium level of approximately -60 mAHD by 2500 (approximately 450 years following closure). This equilibrium level is approximately 140 m below the spill level. The equilibrium level of the proposed void would be reached in a similar timeframe to the approved operations, being approximately 450 years post mining. The modelling indicates that both the existing approved and proposed final voids would retain sufficient freeboard at equilibrium to avoid any risk of decant from the pit lake or seepage through regolith or alluvial material into the downstream environment. Salinity levels in the proposed final void pit lake would increase slowly as a result of evapoconcentration, however are expected to be approximately 6,500 mg/L after 450 years of recovery. These salinity levels are similar to those of the existing approved operations and are consistent with the modelled water quality in final void pit lakes at other open cut mining operations in the Hunter Valley. Modelled salinity levels in the final void remain below that of the Permian groundwater systems for the modelling period, meaning any recharge of Permian systems from the pit lake will not adversely affect the quality of water in the Permian systems.	

IESC Requirements	Summary of assessment findings	Where assessed in EIS
	Further discussion in relation to the water and salt balance is provided in Section 7.5 and Appendix 16 and 17 of the EIS.	
Provide a general ecohydrological conceptual model showing potential impact-effect pathways on water-related ecological assets, including GDEs and aquatic biota. An additional ecohydrological model specifically addressing the proposed Yorks Creek diversion and its confluence with Bowmans Creek may be needed to further understand potential impacts from changes to flows, bank and bed stability and hyporheic conditions in Bowmans Creek.	Section 3.4.1 discusses the impact-pathways on water related ecological assets insofar as they may be affected by the Project. The summary provided in Section 3.4.1 is broken down into direct impacts and indirect impacts and considers impacts associated with changes to surface water systems and groundwater systems.	**Section 3.4.1** of this Report Refer also to **Appendix C** of this Report
Provide detail on the proposed diversion of Yorks Creek and how the diversion will be built and managed to preserve ecological functions (including those occurring in hyporheic and riparian corridors) currently supported by Yorks Creek.	Section 7.5.5.3 of the **EIS** includes details regarding the design considerations and objectives the Yorks Creek Realignment. The **Yorks Creek Realignment Conceptual Detailed Design Drawings** have been provided with the **EIS** (refer to Appendix 7 of the **EIS**) and the Yorks Creek Diversion Constraints Analysis (refer to Appendix 18 of the **EIS**) provides further detail in relation to the design to preserve ecological function and also proposed management and monitoring measures.	Section 7.5.5.3 of the **EIS.** **Yorks Creek Conceptual Detailed Design Drawings** (Appendix 7 of the **EIS)** **Yorks Creek Diversion Constraints Analysis** (Appendix 18 of the **EIS)** **Aquatic Ecology Assessment (**Appendix F of the **Biodiversity Development Assessment Report** (Appendix 20 of the **EIS**) **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)

IESC Requirements	Summary of assessment findings	Where assessed in EIS
Ecological studies to determine the baseline condition of the aquatic ecosystems including permanent and semi-permanent pools (e.g. surface water flora and fauna), riparian vegetation and alluvial sediments (e.g. stygofauna, hyporheic fauna) in all creeks potentially affected by the project.	Survey methodology of baseline aquatic environment undertaken are summarised in **Section 3.4.2.** Outcomes of the impact assessment are discussed in **Sections 3.4.4**, **3.4.5** and **3.4.6**Refer to the **BDAR** (Appendix 20 of the **EIS**) and the Aquatic Ecology Assessment (Appendix F of the BDAR) for further detail.	**Sections 3.4.4**, **3.4.5**, and **3.4.6** of this Report **Stygofauna Assessment (**Appendix 20 of the **EIS**)
Explicit consideration and assessment of project-specific risks, and their materiality at different stages of the project, including during rehabilitation. This is required to inform the selection of appropriate mitigation options and development of management plans	The water resources risk assessment developed for the Project is provided as **Appendix C**, also refer to **Section 3.1** of this Report and Appendix 5 of the **EIS**.	**Section 3.1** and **Appendix C** of this Report Appendix 5 of the **EIS**
Assessment of potential cumulative impacts on groundwater and surface water quality, dynamics (e.g. flow regimes, groundwater flux) and biota (e.g. riparian vegetation, fish).	Results are summarised in **Section 3.3 and 3.4** of this Report. The Surface Water Impact Assessment and Groundwater Impact Assessment have considered the potential cumulative impacts of the Project. Section 7.5 of the EIS and the Groundwater Impact Assessment (Appendix 16 of the EIS) and the Surface Water Impact Assessment (Appendix 17 of the EIS) provides further discussion and detail in relation to the associated cumulative impacts.	Results are summarised in **Section 3.3 and 3.4** of this Report. Section 7.5 of the **EIS** **Groundwater Impact Assessment** (Appendix 16 of the **EIS**) **Surface Water Impact Assessment** (Appendix 17 of the **EIS**)

D2 Assessment Against Significant Impact Guidelines

The Groundwater Impact Assessment (AGE, 2019) (refer to Appendix 16 of the EIS) considers the impact of the Glendell Pit Extension on groundwater resources, and if the impacts are significant according to the *Significant Impact Guidelines 1.3* (Commonwealth of Australia, 2013). Appendix E2 of the Groundwater Impact Assessment provides an assessment of the Project against the Significant Impact Guidelines to determine if the Glendell Pit Extension will have a significant impact on water resources, including the potential for cumulative impacts with other developments. **Table 1** and **2** provides a summary of the conclusions of the assessment; further detail is provided in Appendix E2 of the Groundwater Impact Assessment (refer to Appendix 16 of the EIS).

Table 1 Summary of impacts to the hydrology of the water resource compared to the Significant Impact Guidelines

Is there a substantial change to the hydrology of the water resource for:	Comment
Flow volume	Modelling predicts changes in flows of groundwater from Permian bedrock to the alluvial aquifers, but this does not create flow on effects for private water bores or GDEs
Flow timing	Impacts are predicted to gradually increase during operations with some peaks post mining as system re-equilibrates to the changed conditions resulting from mining
Flow duration and frequency of water flows	Volumes of baseflow removed are negligible compared to surface water flows within the creek systems. Reductions in baseflows are not predicted to have a measurable effect on flows in Bowmans Creek
Recharge rates	Recharge rates may be altered due to mine spoil heaps – this has been assessed using numerical modelling
Aquifer pressure or pressure relationships between aquifers	Pressures will reduce in the coal measures during the mine life but slowly recover post mining.
Groundwater table levels	The water table within the alluvium will be largely unaffected with drawdown less than 1 m in all areas. The impact of existing approved operations is predicted result in lowering of groundwater levels in the alluvium with the Project predicted to have no impact on the magnitude of this lowering of water tables other than in a limited area immediately adjacent to the Glendell Pit Extension. The Projects impacts on the water table in alluvial systems is effectively limited to a slowing of the rate of recovery.
Groundwater/surface interactions	Water table drawdown within the alluvium will be unlikely to produce detectable changes in base flow to or from interconnected streams relative to the approved conditions.
River/floodplain connectivity	Alluvial tributaries of Swamp Creek and Yorks Creek that flow to the Bowmans Creek alluvium will be removed by mining. Monitoring indicates limited saturation within the alluvium where the mining is proposed and therefore inflow rates from the exposed alluvium will be low.
Inter-aquifer connectivity	No significant fracturing is considered likely outside of the pit shell
Coastal processes	Not applicable
Large scale subsidence	Only open cut mining is proposed
Other uses	No

Is there a substantial change to the hydrology of the water resource for:	Comment
State water resource plans	Numerical modelling has been used to assess volumes of groundwater that need to be accounted for with water licences. Proponent holds water licences for Permian water and will develop a strategy for potential minor alluvial water take in later phases of operations
Cumulative impact	Yes – extensive mining within the Permian strata has been assessed using the regional groundwater model

Table 2 Summary of Impacts to the Water Quality of the Resource Compared to the Significant Impact Guidelines

Is there a substantial change in water quality of the water resource:	Comment
Create a risk to human or animal health or the condition of the natural environment	No
Substantially reduce the amount of water available for human consumptive uses or for other uses dependent on water quality	No
Cause persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment	Evaporation will concentrate salts in the final void lake. The void will operate as a long term hydraulic sink and will maintain sufficient freeboard in the pit lake to avoid surface discharge into the downstream environment. Long term recovery modelling indicates that water table levels within the in-pit spoil areas directly connected to the pit lake will not reach levels above the low point in the pit crest.
Results in worsening of local water quality where local water quality is superior to local or regional water quality objectives (i.e. ANZECC guidelines for Fresh and Marine Water Quality)	No
Salt concentration/generation	Evaporation will concentrate salt in the final void lake
Cumulative impact	Cumulative impacts have been estimated using a numerical model – the Project will not significantly exacerbate already approved cumulative impacts
If significant impact on hydrology or water quality above, the likelihood of significant impacts to function and ecosystem function and integrity are to be assessed. The ecosystem function and integrity of a water resource includes the ecosystem components, processes and benefits/services that characterise the water resource	No

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