Springvale Water Treatment Project

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Environmental Impact Statement
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EnergyAustralia

Centennial Coal

Appendix H Aquatic ecology

Springvale Coal/EnergyAustralia

Water Treatment Project

Aquatic Ecology Impact Assessment

August 2016

Executive summary

Springvale Coal Pty Limited (Springvale Coal) is seeking consent for the Water Treatment Project (the Project). Springvale Coal and EnergyAustralia have agreed to work together to develop the Project. The Project involves the transfer of water from existing underground mine dewatering facilities for industrial reuse at Mt Piper Power Station (MPPS) to improve environmental outcomes and water quality within the upper Coxs River catchment.

This Aquatic Ecology Impact Assessment (AEIA) has been prepared to characterise the existing aquatic ecology within the vicinity of the Project, determine potential impacts of the Project on aquatic ecology and to develop mitigation measures to minimise impacts of the Project on aquatic ecology. An Impact Assessment Area (IAA) has been established to more easily focus the scale of the assessment. The IAA includes the waterways with the highest potential to be impacted by the Project which are:

- Wangcol Creek, downstream of the proposed discharge point.
- Coxs River, between the confluence of Wangcol Creek and Lake Wallace.
- Sawyers Swamp Creek, downstream of LDP009 discharge.

This assessment also considers potential impacts of the Project on groundwater dependent ecosystems (GDEs) through changes to waterways or groundwater within the vicinity of the Project.

Existing aquatic habitats and species present

Wangcol Creek, downstream of the proposed discharge point, is a fourth order stream which is highly degraded due to past land-use activities. Minimal instream habitat remains within the creek and the riparian zone is largely cleared. The water quality within this system is relatively poor, characterised by electrical conductivity (EC) in exceedance of ANZECC (2000) guideline values and dissolved oxygen (DO) below the ANZECC (2000) guideline values for ecosystem protection. These conditions are reflected on the macroinvertebrate community with low diversity and low macroinvertebrate sensitivity (to water pollution) observed at most Wangcol Creek sites. Two native fish species and one invasive fish species has been observed in Wangcol Creek.

Coxs River is a perennial waterway with evidence of moderate to good instream habitat but generally poor riparian vegetation condition. In general, monitoring sites on the Coxs River were found to have macroinvertebrate communities in relatively good condition, despite evidence of elevated EC, compared to ANZECC (2000) guideline values, downstream from the Wangcol Creek and Sawyers Swamp Creek confluences. Site CR6 (downstream from Lake Wallace) appears to support a less diverse macroinvertebrate community, with lower index scores which is generally inconsistent with observed water quality and diversity relationships. Two native fish species and two invasive fish species have been observed across the Coxs River sites.

Sawyers Swamp Creek displayed variable results depending on the monitoring location. The limited data available from upstream of LDP009 indicates higher quality instream and riparian habitat and macroinvertebrate community condition when compared to the site downstream from LDP009. The high EC (median EC of 1,170 µS/cm) discharge from LDP009 is likely to be influencing the macroinvertebrate community downstream of LDP009. No fish have been recorded in Sawyers Swamp Creek.

Presence or likelihood of aquatic threatened species

The Project is unlikely to impose a significant impact on any threatened aquatic fauna species listed under the EPBC Act, TSC Act or the FM Act.

A search of the Protected Matters Search Tool for MNES listed under the EPBC Act identified the potential for three threatened fish, the Macquarie perch (endangered under both the FM Act and EPBC Act), the Murray cod (vulnerable under the EPBC Act) and the Australian grayling (vulnerable under the EPBC Act and protected under the FM Act) to occur within 10 km of the Project Application Area. Given the habitat preferences of these species, the presence of large physical barriers to fish movement within the system and the lack of sightings within the IAA, these fish species unlikely to be present.

A BioNet Atlas search identified the potential for the presence of the endangered Giant Dragonfly, listed as Endangered under the TSC Act within 10 km of the PAA. There are two records of this species within 10 km of the Project, one within Ben Bullen State Forest and one within Newnes State Forest. There are no records of this species within the local waterways relevant to the Project. Based on the outcomes of historic field surveys undertaken by MPR and GHD, habitat availability and the lack of sightings recorded in the Atlas, it is considered highly unlikely that the Giant Dragonfly occur within the IAA.

The threatened Blue Mountains Water Skink was identified as likely to occur in the area. However, there are no records of sighting within the IAA. There are numerous records of this species within 10 km of the PAA. However, RPS (2016) have identified that there is no suitable habitat for this species in the PAA. Therefore, this species is considered to be unlikely to occur.

Presence or likelihood of groundwater dependent ecosystems

No terrestrial GDEs were determined to be associated with the waterways within the IAA. Discussions of any potential terrestrial GDEs associated with the proposed disturbance areas are discussed within the Biodiversity Assessment Report (RPS, 2016).

Stygofauna communities are known to exist within the groundwater environments associated with the Neubecks Coal Project, Springvale Mine and Angus Place Colliery. The monitoring program conducted in relation to the Neubeck Coal Project, which sampled bores located in close proximity to Neubecks Creek and Wangcol Creek within the alluvial groundwater environment, identified obligate stygofauna. However, the alluvial groundwater environment has been identified as discontinuous along Wangcol Creek with soil mapping indicating no alluvial material past the confluence of Wangcol and Neubecks Creek. Therefore, there is limited potential for stygofauna to be present within the PAA.

Impact assessment on aquatic ecology and GDEs

The Project is unlikely to directly or indirectly result in a change to water hydrology or quality that that is of sufficient scale or intensity as to reduce the current or future utility of the water for aquatic ecology. It is likely that there will be some localised changes to macroinvertebrate and/or fish communities as a result of the new discharge into Wangcol Creek and the cessation of discharges to Sawyers Swamp Creek. The water quality of the new discharge will be representative of the background catchment which will be protective of aquatic ecology within Wangcol Creek and waterways downstream. The expected scale and duration of proposed treated water discharges to Wangcol Creek is low, with a maximum increase in water level of 0.2 m based on “worst case” scenario (maximum discharge) on a dry day. Based on the predicted frequency, quality and volume of proposed discharges, there is not expected to be any impacts to aquatic ecology of Wangcol Creek or the Coxs River as a result of the discharge, beyond the natural variation currently exhibited between sampling events. In events where there is no discharge from the Proposed LDP (that is, complete uptake of WTP water by MPPS),

Wangcol Creek may be subject to a slight worsening of water quality (elevated EC) compared to existing conditions through increased discharges from LDP006 as a result of residual transfers (GHD, 2016). Therefore, the aquatic ecology of Wangcol Creek may potentially be impacted downstream of the discharge point during these periods. During periods of discharge from the proposed LDP, LDP006 discharges will be diluted leading to an overall improvement in water quality of Wangcol Creek which is likely to positively influence aquatic ecology.

Due to the larger volume of water in the Coxs River it is unlikely that the proposed new discharges into Wangcol Creek, or any temporary increase in discharge volume from LDP006, during periods of no discharge from the proposed LDP, would lead to measurable changes on the aquatic ecology of this system.

Cessation of 20 to 25 ML/day of mine water discharges, currently with a median EC of 1,170 µS/cm, from LDP009 is expected to have a beneficial effect, overall, on the aquatic ecology of Sawyers Swamp Creek and Coxs River downstream of the Sawyers Swamp confluence. The improved water quality in Sawyers Swamp Creek may allow for habitation by more sensitive taxa, although diversity of macroinvertebrates may be limited by water availability following cessation of discharges. Sawyers Swamp Creek is naturally ephemeral, therefore, the removal of continual mine water discharges will represent a return towards the natural flow regime and, thus, a positive outcome of the Project.

The improvement in water quality that will occur in Sawyers Swamp Creek as a result of cessation of LDP009 discharges will also lead to improvements in water quality within the Coxs River. This is likely to result in improvements to aquatic ecology within the Coxs River. The Project will also reduce the volume of water extraction needed for MPPS operations. If this water allocation is instead returned to the catchment this would benefit aquatic ecology through reestablishment of environmental flows.

No threatened species or habitat for such species are expected to be impacted as a result of the Project. The Project is not predicted to alter the current water quality, recharge of groundwater systems or the hydraulic connectivity between groundwater and surface waters (GHD, 2016). Therefore, no impacts to aquatic GDEs are expected as a result of the Project.

Mitigation measures and monitoring requirements

Direct impacts to aquatic ecosystems have been minimised by using the existing pipeline and infrastructure easements where possible. Direct disturbance to waterways has been limited to:

- The Lamberts Gully channel, which will need to be modified in order to construct the new discharge point adjacent to LDP006.
- The under drilling of Coxs River and localised, temporary impacts to low order waterways along the path of the pipeline.

Cessation of untreated mine water discharges from LDP009 will address existing water quality risks to Sawyers Swamp Creek and the upper Coxs River catchment.

Water quality of Wangcol Creek and Coxs River will be monitored through existing Springvale Coal and EnergyAustralia Surface Water Monitoring Programs as detailed in the Water Resources Impact Assessment (GHD, 2016).

Macroinvertebrate monitoring will be conducted in Wangcol Creek and Coxs River biannually (autumn and spring) for two years following commencement of initial discharge from the new discharge point into Wangcol Creek. The requirement for ongoing macroinvertebrate monitoring beyond this point will be determined depending on the frequency and volume of discharges from the new discharge point over that two-year period and the outcomes of aquatic ecology and water quality monitoring.

Fish monitoring and fish habitat assessment is to be conducted annually for two years following commencement of initial discharge from the new discharge point into Wangcol Creek.

Impacts to groundwater dependent fauna are not expected given that there is not predicted to be any changes to groundwater quality or hydrology as a result of the Project. However, the risk of potential impacts to groundwater dependent fauna will be managed via the existing Springvale Coal and EneryAustralia groundwater monitoring programs as detailed in the Water Resources Impact Assessment (GHD, 2016).

Given the above consideration of potential impacts and proposed mitigation measures, it is considered unlikely that the Project would result in any significant impacts to native aquatic flora and fauna or their habitats or overall aquatic biodiversity values in the locality. As such, no specific offset is considered necessary to compensate for proposed impacts to aquatic habitats, flora or fauna as a result of the Project.

Table of contents

Table index

Figure index

Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of mg/L of calcium carbonate ($CaCO_3$).
Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Baseflow	The component of flow in a watercourse that is driven from the discharge of underground water.
Biota	All of the living organisms found in a given area.
Canopy cover	The above-ground portion of a plant community.
Community	An assemblage of organisms occupying a specified location and time, usually interacting with one another.
Community composition	All of the taxa present in a community.
Contaminant	Any physical, chemical, biological or radiological substance capable of producing an adverse effect in a biological system or the natural environment.
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Dissolved oxygen	A measure of the amount of oxygen that is dissolved in water.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Electrical conductivity	A measure of the concentration of dissolved salts or ions in water.
Emergent vegetation	A plant or plants rooted underwater that grows above the water surface.
Endemism	Ecologically unique to a defined geographic area.
Ephemeroptera, Plecoptera, Trichoptera taxa index	An index based on the number of taxa of the environmentally sensitive orders Ephemeroptera, Plecoptera and Trichoptera identified in a sample.
Estuarine	A partly enclosed coastal body of brackish water with one or more rivers flowing into it and with a free connection to the open sea.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Groundwater	Water occurring naturally below ground level.

Guideline	A numerical concentration or narrative statement that provides appropriate guidance for a designated water use or impact.
Hyporheic	Any physical, chemical, biological or radiological substance capable of producing an adverse effect in a biological system or the natural environment.
Index	Composite value that can give a quick ranking to an ecosystem feature (e.g. a water body), derived via a formula that combines measurements of important ecosystem characteristics; typically used to rank 'health' or naturalness.
Karst	Any physical, chemical, biological or radiological substance capable of producing an adverse effect in a biological system or the natural environment.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site Environmental Protection License.
Macroinvertebrate	An animal species that does not develop a vertebral column that is large enough to be seen without the use of a microscope. These animals generally include insects, crustaceans, molluscs, arachnids and annelids.
Macrophyte	A member of the macroscopic plant life of an area, especially of a large body of water.
Organic carbon	Generally, carbon which is chemically bonded to other carbon atoms, although methane (one carbon atom only) and its derivatives are considered organic.
Organic matter	Matter composed of organic compounds that have come from the remains of once-living organisms such as plants and animals and their waste products.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Phreatic	Relating to or denoting underground water in the zone of saturation (beneath the water table)
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Rapid bioassessment	A form of biological assessment that uses standardised, cost-effective protocols to provide rapid sample processing, data analysis, reporting and management response. The results from such assessments are likely to be reliable to detect large impacts but not small or minor impacts.
Reach	A defined section of a stream with a uniform character and behaviour.
Richness	The number of species or taxa present (generally applied to a sample or community).

Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Salinity	The dissolved salt content of a body of water or soil.
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Slightly disturbed ecosystems	A classification used by ANZECC (2000) guidelines applied to ecosystems where there has been a relatively small adverse effect to biodiversity due to anthropogenic activity with largely intact habitats and biological communities.
Stygofauna	Stygofauna are entirely groundwater dependent (obligate) fauna restricted to locations of groundwater discharge or within aquifers.
Taxa	Any group of organisms considered to be sufficiently distinct from other groups to be treated as a separate unit (e.g. species, genera, families).
Taxonomic	An organism's location in the biological classification system used to identify and group organisms with similar physical, chemical and/or structural composition.
Toxicity	The inherent potential or capacity of a substance to cause adverse effects in a living organism.
Tributary	A stream or river that flows into a main river or lake.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Univariate analysis	Statistical analysis concerned with data collected on one dimension of the same subject.

Abbreviations

AEIA	Aquatic Ecology Impact Assessment
AHD	Australian Height Datum
AUSRIVAS	Australian Rivers Assessment System
BOM	Bureau of Meteorology
CMA	Catchment Management Authority
DO	Dissolved oxygen
DPI	Department of Primary Industries
EA	EnergyAustralia
EC	Electrical conductivity
EIS	Environmental impact statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPT	Ephemeroptera, Plecoptera, Trichoptera
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater dependent ecosystem
GHD	GHD Pty Ltd
ha	Hectare
km	Kilometre
KTP	Key threatening process
kV	Kilovolt
L	Litre
LDP	Licensed discharge point
LGA	Local Government Area
m	Metre
m bgl	Metre below ground level
m btoc	Metre below top of casing
mg/L	Milligram per litre
ML	Megalitre

ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
MMP	Macroinvertebrate Monitoring Program monitoring location
MNES	Matters of National Environmental Significance
MPPS	Mt Piper Power Station
MPR	Marine Pollution Research
Mt	Million tonnes
Mtpa	Million tonnes per annum
NOW	NSW Office of Water
NTU	Nephelometric turbidity unit
OEH	Office of Environment and Heritage
RBA	Rapid bioassessment
RCE	Riparian, channel and environment
ROM	Run of mine
SCSS	Springvale Coal Services Site
SEARs	Secretaries Environmental Assessment Requirements
SIGNAL 2	Stream Invertebrate Grade Number Average Level – Version 2
Springvale Coal	Springvale Coal Company Limited
SSD	State Significant Development
SWL	Standing water level
TSC Act	*Threatened Species Conservation Act 1995*
µm	Micrometre
µS/cm	Microsiemens per centimetre
WM Act	*Water Management Act 2000*
WRIA	Water Resources Impact Assessment
WTP	Water treatment plant
°C	Degree Celsius

1. Introduction

Springvale Coal Pty Limited (Springvale Coal) is seeking consent for the Water Treatment Project (the Project). The Project involves the transfer of water from existing underground mine dewatering facilities for industrial reuse at Mt Piper Power Station (MPPS) to improve environmental outcomes and water quality within the upper Coxs River catchment. GHD Pty Ltd (GHD) was commissioned to prepare an Aquatic Ecology Impact Assessment (AEIA) for the Project. This assessment forms part of an Environmental Impact Statement (EIS) to support a State Significant Development (SSD) application for the Project under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This AEIA has been prepared in accordance with relevant statutory conditions and the *Secretary's Environmental Assessment Requirements Application Number SSD 16_7592* (SEARs).

1.1 Background

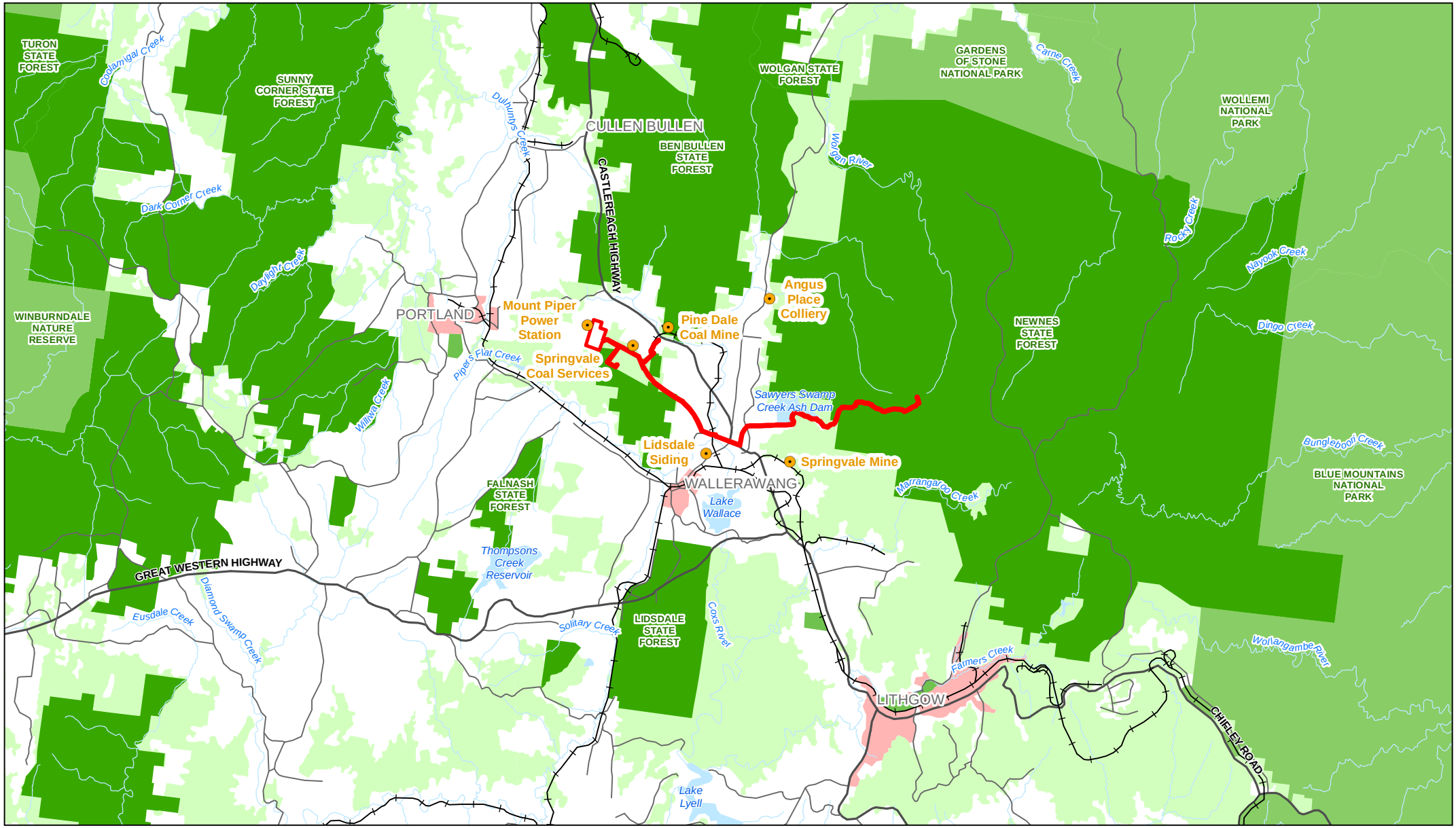
Angus Place Colliery and Springvale Mine are underground coal mining operations in the Western Coalfield of NSW near Lithgow, as shown in Figure 1-1. Angus Place Colliery is located approximately 15 km west of Lithgow and is managed by Centennial Angus Place Pty Ltd (Centennial Angus Place) under a joint venture arrangement between Centennial Springvale Pty Ltd (Centennial Springvale) and Springvale SK Kores Pty Ltd (Springvale SK Kores). Springvale Mine is located approximately 6 km south of Angus Place Colliery and is managed by Springvale Coal under a joint venture arrangement between Centennial Springvale and Springvale SK Kores.

Groundwater inflows into the underground workings at both Angus Place Colliery and Springvale Mine are transferred to the Springvale-Delta Water Transfer Scheme (SDWTS). The SDWTS consists of a pipeline network from existing dewatering facilities on the Newnes Plateau that discharges through Springvale Mine's licensed discharge point (LDP) LDP009 to Sawyers Swamp Creek within the upper Coxs River catchment. Springvale Mine is currently approved to discharge up to 30 ML/day through LDP009. Mine water from Springvale Mine is taken as a priority, with the remaining capacity supplied by mine water from Angus Place Colliery.

MPPS is a coal fired power station owned and operated by EnergyAustralia NSW Pty Ltd (EnergyAustralia), located approximately 17 km north-west of Lithgow and 8 km west of the pit top at Springvale Mine. The power station is one of the greatest users of surface water in the region, due to the significant demand for water required in the cooling water system that is subsequently lost to evaporation. Water for the operation of MPPS is currently supplied from the Coxs River via Lake Lyell and Thompsons Creek Reservoir and is supplemented by the Fish River Water Supply Scheme.

Springvale Mine currently operates under development consent SSD-5594, granted on 21 September 2015 for the Springvale Mine Extension Project. A number of water management performance measures are specified by Schedule 4, Condition 12 of SSD-5594, including the requirement to reduce the electrical conductivity (EC) of mine water discharges to meet the following limits:

- 700 µS/cm (50th percentile), 900 µS/cm (90th percentile) and 1,000 µS/cm (100th percentile) by 30 June 2017.
- 500 µS/cm (90th percentile) by 30 June 2019.



Paper Size A4

0 0.75 1.5 3 4.5 6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Principal Road
- Secondary Road
- Minor Road
- Existing Rail
- Waterway
- Waterbody
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub

Springvale Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Locality plan

Figure 1-1

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\AquaticEcology\2125109_AE001_Locality_0.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: Commonwealth of Australia (Geoscience Australia); 250K Topographic Data Series, 2006. Created by: tmorton

1.2 Project objectives

The key objective of the Project is to improve environmental outcomes for the receiving waters in the upper Coxs River catchment. This will be achieved through:

- Treatment of all Angus Place and Springvale mine water to a standard suitable for either industrial reuse or environmental release.
- Maximising reuse of mine water within the MPPS cooling water system.
- Reducing the reliance on extraction of water from the upper Coxs River catchment to meet the demand for make-up water within the MPPS operations.
- Avoiding the volume of untreated mine water to the environment.
- Compliance with water management performance measures required under development consent SSD-5594 for Springvale Mine.

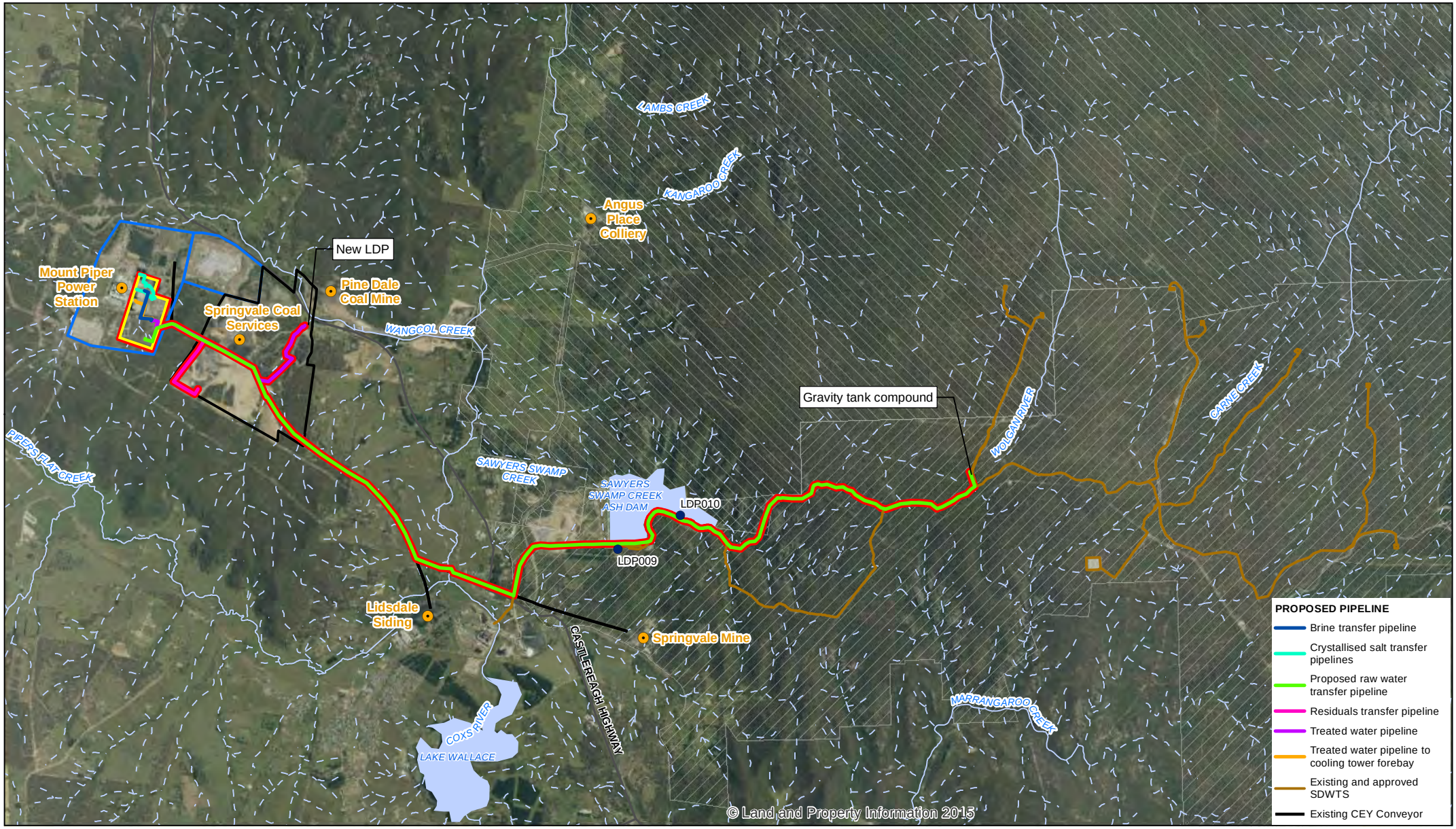
1.3 Project description

An overview of the Project Application Area (PAA) is provided in Figure 1-2. The Project includes the following major elements:

- A system to transfer up to 36 ML/day of dewatered mine water from the existing gravity tank forming part of the approved dewatering facilities on the Newnes Plateau to a new water treatment plant (WTP) to be located at the MPPS site.
- A water treatment plant incorporating desalinisation processes to reduce the salinity in mine water to a standard suitable for either industrial reuse or environmental release.
- Transfer of treated water from the water treatment plant to the MPPS cooling water to contribute to the demand for make-up water.
- Discharge of any excess treated water not able to be reused within the MPPS cooling water system to Wangcol Creek via a new licensed discharge point to be located within the Springvale Coal Services Site (Western Coal Services Project).
- Transfer of residual material from the pre-treatment process to the existing reject emplacement area (REA) at the Springvale Coal Services site (SCSS).
- Transfer of the saline brine stream from the water treatment plant to the MPPS cooling water blowdown system for integration with existing treatment and brine disposal practices.
- Installation of a crystalliser to provide further treatment of the additional salt load generated within the MPPS cooling water blowdown system.

The key aspects of the Project that have the potential to influence the aquatic ecology of waterways in the vicinity of the Project are:

- Treated water discharge (maximum of 32 ML/day) to Wangcol Creek
- Cessation of untreated mine water discharges via LDP009 into Sawyers Swamp Creek



Paper Size A4

0 0.25 0.5 1 1.5 2

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Principal Road
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Project overview

Figure 1-2

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

1.3.1 Project water-cycle

A brief explanation of the proposed Project water-cycle is provided in this section to give context regarding possible changes to the aquatic environment that may influence aquatic ecology. A more detailed explanation of the proposed water-cycle is provided in the Water Resources Impact Assessment (GHD, 2016).

The Project will supply water to the MPPS to supplement cooling water demands. The cooling water demand varies depending on power generation, which typically varies diurnally. Future power generation rates cannot be predicted however based on historical conditions power generation typically is above rates that require at least 30 ML/day for cooling water (GHD, 2016). It is likely that as power generation rates increase and decrease any water that is not consumed through re-use at MPPS will be discharged via a new discharge point located at SCSS.

Water supply volumes through the proposed pipeline will vary also over time depending on the predicted groundwater make of both Springvale Mine and Angus Place Colliery. Groundwater volumes are predicted to vary between approximately 17 ML/day to 36 ML/day.

In the event that treatment of water cannot occur, emergency storage locations are available both at MPPS and underground at Angus Place Colliery. Together these emergency storage locations have capacity to manage approximately 12 days of storage. In the event that power generation rates fall to a level where discharges occur via the new discharge location, the rate at which discharges increase and decrease will be controlled in a manner that mitigates rapid changes in water level. It is likely that the operation of plant will operate discharge events at a rate of change less than that observed from rainfall runoff events.

Two waste outputs from the WTP will occur as a result of the Project, one of which is new compared with the other which is already existing. The two waste streams will be the new transfer of residual material to the SCSS Reject Emplacement Area (REA) and the continuation of brine related outputs to the ash emplacement area at MPPS. Waste forms between 11 to 15 % of the water treated by the plant. Typically, this means that at a predicted upper limit of transfer volume at 36 ML/day is only likely to yield 32 ML/day of available water.

The management of these two waste streams are discussed further within the Water Resources Impact Assessment (GHD, 2016) and will be managed as part of the respective Centennial and EnergyAustralia operations.

1.4 Report objectives

This AEIA has been developed to assess the potential aquatic ecological impacts associated with the Project. The purpose of the AEIA is to address the aquatic ecology components of the SEARs as well as the requirements of the *Fisheries Management Act 1994* (FM Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This report has been prepared to characterise the existing aquatic ecology within the Project, determine potential impacts of the Project on aquatic ecology and to develop mitigation measures to minimise impacts of the Project on the biodiversity values of the Project. This assessment also considers potential impacts of the Project on groundwater dependent ecosystems (GDEs) through changes to waterways or groundwater within the vicinity of the Project.

1.5 Scope of work

The scope of work for the AEIA included:

- Identify and describe the aquatic habitats and aquatic fauna species present (and likely to be present) in the vicinity of the Project.

- Determine the presence or likelihood of occurrence of groundwater dependent ecosystems (GDEs) in the vicinity of the Project.
- Determine the presence or likelihood of occurrence of aquatic threatened species, populations and ecological communities (and their habitats) listed under the NSW FM Act.
- Determine the presence or likelihood of occurrence of 'Matters of National Environmental Significance' (MNES) pursuant to the EPBC Act, particularly threatened species, threatened ecological communities and migratory species listed under the EPBC Act.
- Assess the likely impacts of the proposed works on the aquatic ecology and GDEs including stygofauna.
- Assess the likely significance of impacts on threatened aquatic biota in accordance with the EP&A Act and the EPBC Act threatened species assessment requirements.
- Develop measures to avoid, minimise and mitigate impacts on aquatic biodiversity values of the PAA.

1.6 Definitions

For the purposes of the AEIA, the following definitions are employed:

- Project Application Area (PAA) – The area encompassing the pipeline routes and the water treatment plant infrastructure required for the Project.
- Site – An aquatic ecology monitoring location.
- Impact Assessment Area (IAA) – section of waterway which is expected to be most strongly impacted by the Project. The Impact Assessment Area is defined as:
  - Wangcol Creek, downstream of the proposed discharge point.
  - Coxs River, between the confluence of Wangcol Creek and Lake Wallace.
  - Sawyers Swamp Creek, downstream of LDP009 discharge.
- Regional Assessment Area – Sites that are not expected to be impacted by the Project. They provide an understanding of waterway health in the region outside the Impact Assessment Area. These include:
  - Coxs River downstream from Lake Wallace to Lake Lyell.
  - Coxs River downstream from Lake Lyell.

1.7 Structure of the report

Table 1-1 provides a description of the structure of the AEIA.

Table 1-1 Report structure

Section	Contents
Section 1 – Introduction	Project overview and scope of works.
Section 2 – Legislation, Policies and Guidelines	Legislative requirements, polices and guidelines relevant to the assessment of the water management and potential surface water impacts.
Section 3 – Site Description	Site location, geology, soils, topography, climate, hydrology and regional context. Sensitive receptors are also identified within this section.
Section 4 – Assessment Methodology	Description of assessment methodology used to assess aquatic biota or GDEs potentially impacted by the Project.
Section 5 – Conservation Significance	Identification of threatened aquatic species, populations and ecological communities of national and state significance that may occur within the PAA.
Section 6 – Existing Environment – Aquatic ecology	Descriptions of aquatic habitats, water quality, aquatic macroinvertebrates and fish identified at selected sites in the Wangcol Creek, Sawyers Swamp Creek and Coxs River catchments.
Section 7 – Existing Environment – GDEs	Description of GDEs known to or likely to occur in the PAA.
Section 8 - Impact assessment – Aquatic Ecology	Potential impacts to identified aquatic ecology as a result of the Project.
Section 9 - Impact assessment – GDEs	Potential impacts to identified GDEs as a result of the Project.
Section 10 – Cumulative Impacts	Description of how the Project will form part of a potential cumulative impact on the Wangcol Creek and Coxs River catchments. This section also includes a description of current projects within the region that potentially contribute a cumulative impact to aquatic ecology.
Section 11 – Avoidance, Mitigation and Management Measures	Description of recommended measures to avoid, minimise or mitigate impacts to aquatic ecology and GDEs as a result of the Project.
Section 12 – Conclusion	Summary of key findings.
Section 13 – References	A list of the reports, scientific publications and other documents referenced within this report.

2. Legislation, policies and guidelines

2.1 Legislation

2.1.1 Environmental Planning and Assessment Act 1979

The EP&A Act, which is administered by the NSW Department of Planning and Environment, is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

The AEIA forms part of an EIS to support a new development application under Part 4, Division 4.1 of the EP&A Act for the Project. The Minister for Planning and Environment (or delegate, such as the NSW Planning Assessment Commission) is the determining authority for the Project.

The AEIA report supports the Water Resources Impact Assessment in addressing the following component of the SEARs specific to water:

*"**Water** – including an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, particularly having regard to* State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 *and the requirements and recommendations from EPA, DPI, OEH and WaterNSW."*

Specific State government agency requirements from the NSW Environment Protection Authority (EPA), Department of Primary Industries – Office of Water (DPI-Water), Office of Environment and Heritage (OEH) and WaterNSW addressed in the AEIA report are presented in Table 2-1.

Table 2-1 Summary of state government agency requirements relating to aquatic ecology and GDEs

Agency	Elements	Where addressed
DPI-Water	Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Water Resources Impact Assessment, This document
DPI-Water	A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework	Section 7 Section 9
DPI-Water	Identify any potential impacts on GDEs as a result of the proposal including: • The effect of the proposal on the recharge to groundwater systems; • The potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and	Water Resources Impact Assessment, Section 7 Section 9

Agency	Elements	Where addressed
	• The effect on the function of GDEs (habitat, groundwater levels, connectivity). Provide safeguard measures for any GDEs.	
OEH	Water and soils The EIS must map the following features relevant to water and soils including: • Groundwater dependent ecosystems.	Section 7
WaterNSW	The potential impacts of any discharges on the water quality of receiving waters and whether there would be any consequences on geomorphology or ecology (flora and fauna) of the receiving watercourses.	Water Resources Impact Assessment, Section 8

Consideration of environmental impact

Section 111(4) of the EP&A Act states that the determining authority must consider the effect of an activity on:

- 'Critical habitat' as defined under the *Threatened Species Conservation Act* 1995 (TSC Act) and FM Act.
- Species, populations or ecological communities, or their habitats (as listed under the TSC Act and FM Act) and whether there is likely to be a 'significant effect' on those species, populations or ecological communities.
- Other protected fauna or protected native plants listed under the *National Parks and Wildlife Act 1974*.

The AEIA addresses the aquatic ecological components of the 'environment' as required under section 111 of the EP&A Act.

Assessment of significance

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of a proposed activity on threatened species, populations or ecological communities (or their habitats) listed under the TSC Act and FM Act. The '7-part test' is used to assist in the determination of whether a proposal is 'likely' to impose 'a significant effect' on threatened biota and thus whether a species impact statement is required.

The AEIA assesses the likelihood of threatened biota listed under the FM Act occurring in the PAA and their potential to be impacted by the Project.

2.1.2 Fisheries Management Act 1994

The objects of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In particular, this includes:

- To conserve fish stocks and key fish habitats.

- To conserve threatened species, populations and ecological communities of fish and marine vegetation.
- To promote ecologically sustainable development, including the conservation of biological diversity.

and, consistently with those objects:

- To promote viable commercial fishing and aquaculture industries.
- To promote quality recreational fishing opportunities.
- To appropriately share fisheries resources between the users of those resources.
- To provide social and economic benefits for the wider community of New South Wales.
- To recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

Key fish habitats

One of the aims of the FM Act is to conserve key fish habitats. These are defined as aquatic habitats that are important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species.

In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies (known as first and second order streams) that flow for a short period after rain and farm dams on such systems are generally excluded, as are artificial waterbodies except for those that support populations of threatened fish or invertebrates.

Assessment of significance

The FM Act lists the factors to be addressed in the assessment of significance of impact on threatened species, populations and ecological communities of fish and marine vegetation. Threatened aquatic species are addressed in Section 5 of the AEIA. The classification of fish habitat within waterways in the vicinity of the Project is discussed in Section 6.

2.1.3 Water Management Act 2000

Approval is required under the *Water Management Act 2000* (WM Act) for certain types of developments and controlled activities that are carried out in or near a river, lake or estuary. Four types of controlled activities are recognised:

- Erection of a building or the carrying out of a work.
- Removal of material or vegetation from land, by way of excavation or other means.
- Deposition of material on land as a result of landfill operations or other means.
- Carrying out any other activity that affects the quantity or flow of water in a water source.

Any works proposed within the defined riparian zone of a creek are to be carried out in accordance with the WM Act. Works undertaken on waterfront land (i.e. near a river, lake or estuary) require a controlled activity approval under section 91 of the WM Act, unless defined as exempt. Under section 89J(1) of the EP&A Act, controlled activity approvals are not required for projects that are defined as state significant developments and as such no controlled activity approvals will be required for any aspect of the Project. However, the potential impacts of such

works on instream ecology has been addressed in the AEIA. Impacts of the Project on riparian vegetation are discussed in the Biodiversity Assessment Report (RPS, 2016).

2.1.4 Environment Protection and Biodiversity Conservation Act 1999

The purpose of the EPBC Act, administered by the Commonwealth Department of the Environment, is to ensure that actions likely to cause a significant impact on MNES undergo an assessment and approval process. Under the EPBC Act, an action includes a proposal, undertaking, or activity. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Environment Minister (the 'Minister').

The EPBC Act identifies MNES as:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- Great Barrier Reef Marine Park.
- A water resource, in relation to coal seam gas development and large coal mining development.

The EPBC Act is also relevant to the determination of the ecological value of a GDE. If a GDE contains a threatened species as listed under the EPBC Act, the GDE is then taken to have a higher ecological value.

Potential impacts on any MNES must be subject to assessments of significance pursuant to the EPBC Act *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (Department of the Environment, 2013a). If a significant impact is considered likely, a referral under the EPBC Act must be submitted to the Commonwealth Environment Minister.

The *Significant Impact Guidelines 1.3* (Department of the Environment, 2013b) includes general criteria for whether an action is likely to have a significant impact on water resources, which are for the possibility for direct or indirect changes to:

- The hydrology of a water resource.
- The water quality of a water resource.

According to the *Significant Impact Guidelines 1.3* (Department of the Environment, 2013b), the value of the water resource needs to be confirmed such that impacts from actions can be evaluated on their significance. The guidelines indicate that key factors for evaluating a water resource's value include its utility for all third party users. Third party user categories specific to the Project include:

- Provisioning services (e.g. use by other industries and use as drinking water).
- Cultural services (e.g. recreation and tourism, science and education).
- Supporting services (e.g. maintenance of ecosystem function).

If evidence can be provided that proposed actions would not materially affect the availability and quality for third party users, then the likelihood of an action having a significant impact would be reduced (Department of the Environment, 2013b).

An assessment of whether the Project may have a significant impact on any MNES or on the environment of Commonwealth land was undertaken during the EIS investigations and preparation. The *Significant Impact Guidelines 1.3* (Department of the Environment, 2013b) states that the development of associated infrastructure, such as pipelines and environment protection, monitoring and associated land management activities, that is not part of the extraction process does not need to be referred for its impacts on a water resource. As the Project involves a water transfer and treatment system that is not part of the extraction process of a large coal mining development, it was determined that the Project did not need to be referred under the EPBC Act. An assessment of the Project against the significant impact guidelines has been undertaken as part of the Water Resources Impact Assessment (WRIA) (GHD, 2016).

2.2 Policies

2.2.1 Policy and guidelines for Aquatic Habitat Management and Fish Conservation

The *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (DPI, 2013a) are applicable to all planning and development proposals and various activities that affect freshwater, estuarine and marine ecosystems. This document contains:

- General policies for the conservation of fish, marine vegetation and aquatic habitats.
- Descriptions of aquatic habitats, fish and fisheries resources in NSW waters.
- An outline of NSW fisheries legislation.
- Background information, legislation, policy and guidelines that are applicable to activities that may impact on aquatic habitats, including dredging and reclamation (including that involved in laying of pipelines), water front development, water extraction, bridges, roads, causeways, culverts, pipelines, cables or similar structures, water pollution and snag management, harm of selected aquatic habitats and species.
- A description of biodiversity conservation and habitat rehabilitation activities.
- An outline of the requirements for the preparation of environmental planning and assessment documents.

Although the policy does not specifically refer to mining proposals, several guidelines are relevant to this Project, including:

- Instream structures and barriers to fish passage.
- General waterway management.

2.2.2 NSW State Groundwater Policy

The *NSW State Groundwater Policy Framework* document (DLWC, 1997) encouraged the ecological sustainable management of the state's groundwater resources so as to:

- Slow and halt, or reverse any degradation of groundwater resources.
- Ensure long-term sustainability of the systems' ecological support characteristics.
- Maintain the full range of beneficial users of these resources.
- Maximise economic benefit to the region, state and nation.

Three component policies fall under this framework, including:

- NSW Groundwater Quantity Management Policy.
- NSW Groundwater Quality Protection Policy.
- NSW Groundwater Dependent Ecosystems Policy.

The policy for GDEs was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy provides guidance on the protection and management of GDEs. It sets out management objectives and principles to:

- Ensure that the most vulnerable and valuable ecosystems are protected.
- Manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity.
- Ensure that sufficient groundwater of suitable quality is available to ecosystems when needed.
- Ensure that the precautionary principle is applied to protect GDEs, particularly the dynamics of flow and availability and the species reliant on these attributes.
- Ensure that land use activities aim to minimise adverse impacts on GDEs.

This AEIA discusses the Projects influence on existing GDEs whereas groundwater generally is discussed within the Water Resources Impact Assessment (GHD, 2016).

2.2.3 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining.

The Policy outlines the water licensing requirements under the *Water Act 1912* and WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void), even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The WAL must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

The Level 1 minimal impact considerations for less productive groundwater sources are relevant to the groundwater sources at Centennial sites and are as follows:

- **Water table:** less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A

maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply.

- **Water pressure:** a cumulative pressure head decline of not more than 40% of the 'post-water sharing plan' pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work.
- **Water quality:** any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. For alluvial water sources, there should be no increase of more than 1% per activity in the long-term average salinity in a highly connected surface water source at the nearest point to the activity.

It is not proposed to modify the existing groundwater extraction activities of Angus Place Colliery or Springvale Mine as part of the Project. During construction works, however, if groundwater is encountered as result of excavation or drilling, the policy would be applicable.

2.3 Guidelines

2.3.1 Risk Assessment Guidelines for Groundwater Dependent Ecosystems

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW, 2012a) comprises four volumes and provides a conceptual framework for identifying and assessing ecosystems and worked examples of assessments as well as a discussion on the identification of high probability GDEs and the ecological value of GDEs. Volume 1 of the guidelines provides general material while Volumes 2 through 4 are related specifically to coastal aquifers and are not applicable to this assessment.

3. Site description

3.1 Land use

Land use in the vicinity of the Project consists of residential, coal handling infrastructure, commercial forestry, power generation and national parks. Wallerawang is the closest retail and commercial centre, located approximately three kilometres west of the Springvale Mine pit top and approximately six kilometres from the MPPS.

Extensive mining operations have been undertaken in and around the vicinity of the Project over the past (over 100 years). Commercial forestry occurs within the Newnes State Forest, where the majority of the Springvale Mine dewatering infrastructure is located. Newnes State Forest is approximately 25,000 hectares in size and also supports a number of recreational uses. Public access is permitted in the Newnes State Forest with common recreational activities consisting of motorcycle riding, four-wheel driving, bushwalking, camping, mountain bike riding, canyoning, photography, bird watching and other recreational and adventure activities.

There are a number of national parks and state forests in the region. These include:

- Ben Bullen State Forest, located adjacent to the Project north, north-east and north-west.
- Newnes State Forest, located outside the Project to the east.
- Lidsdale State Forest, located outside the Project to the west.
- Blue Mountains National Park, located outside the Project to the south east.
- Turon State Forest, located outside the Project to the west.

Key operations in the vicinity of the Project include:

- Angus Place Colliery.
- Lidsdale Siding Rail Loading Facility (Lidsdale Siding).
- MPPS.
- Pine Dale Coal Mine.
- Western Coal Services Project.
- Springvale Mine.
- Wallerawang Power Station (decommissioned).

Surrounding sites will be discussed in detail with respect to their operation and their relevance to the Project within Section 3.6. The potential cumulative impact of existing operations is discussed within the Water Resources Impact Assessment (GHD, 2016).

3.2 Topography

The topography around Springvale Mine comprises narrow gorges with high ridgelines and steep-sided slopes of sandstone cliffs. The cliffs rise above incised valleys and hilly areas with relatively flat crests and some spurs with moderately sloped ephemeral drainage lines. Rivers and streams, such as Coxs Creek and Kangaroo Creek, are found in the vicinity.

The proposed pipeline alignment is located partially within the Newnes Plateau, which forms part of the divide between the Coxs River and Wolgan River catchments with elevations ranging from 900 m Australian Height Datum (AHD) to greater than 1,175 m AHD.

The local topography at MPPS and the SCSS is on a northern aspect with elevations ranging from 900 m AHD to 985 m AHD in the south. The catchments of Lamberts Gully and Huon Gully

drain through the SCSS to Wangcol Creek. MPPS similarly also has catchment from the south contributing to Wangcol Creek. The headwaters of Wangcol Creek are up to 1,060 m AHD in the south-west.

3.3 Climate

The climate in the region is typical of a cool temperate mountain climate, characterised by cold winters and warm summers. The highest temperatures occur throughout December, January and February, with the coolest temperatures occurring in July. Snow and/or sleet are common in winter months. Mean daily maximum temperatures range from 25.1 °C in summer to 11.2 °C in winter with mean minimum temperatures ranging from 10.1 °C in summer down to 1.3 °C in winter.

3.3.1 Rainfall

Daily rainfall data was obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation. SILO patched point data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' with interpolations from nearby stations.

The period of rainfall data extended from January 1889 to December 2015 and is summarised as annual totals in Figure 3-1.

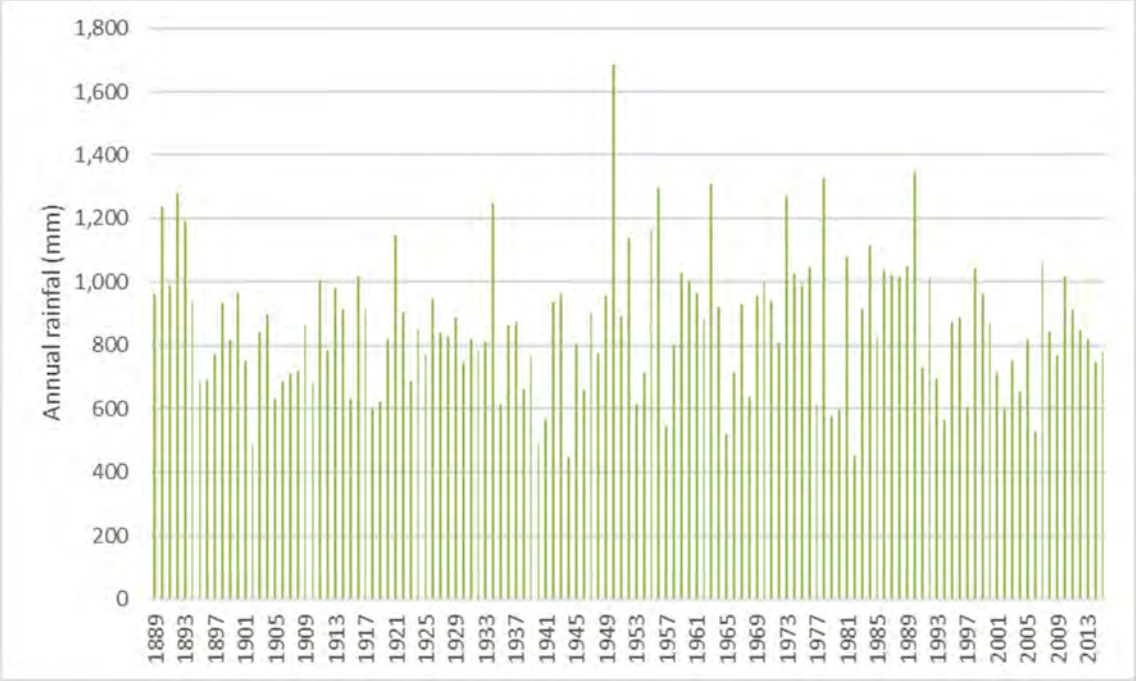


Figure 3-1 Annual rainfall recorded at Lithgow (Birdwood St) Station

The statistics for this rainfall set shown in Figure 3-1 are:

- Minimum annual rainfall – 447 mm in 1944.
- Average annual rainfall – 862 mm.
- Median annual rainfall – 853 mm.
- Maximum annual rainfall – 1,683 mm in 1950.

3.4 Geology

The Project is located in the southern part of the Western Coalfield and on the western edge of the Sydney Basin. The stratigraphy of the region consists of material from the Tertiary, Triassic and Permian periods.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. These form the gently dipping beds of the Illawarra Coal Measures, capped by shale and sandstone from the Wiannamatta and Narrabeen Group (Triassic Period) and Basalt from the Tertiary period.

Directly below the Illawarra Coal Measures lies the silty, coaly sedimentary rocks of the Nile Subgroup and sandy siltstone of the Berry Siltstone.

Basement rocks of Western Sydney are folded Palaeozoic metamorphosed rocks of the Lachlan Fold Belt, Late Carboniferous granites and Early Permian Rylstone Volcanics.

There are seven identified coal seams within this region, listed in descending stratigraphical order as follows:

- Katoomba Seam.
- Middle River Seam.
- Moolarben Seam.
- Upper Irondale Seam.
- Irondale Seam.
- Lidsdale Seam.
- Lithgow Seam.

Seismic activity has been noted along the Coxs River Lineament Fault Zone, a 250 m wide, north-south trending graben structure which follows the valley of Coxs River.

The regional stratigraphy of the Project is further discussed within the Water Resources Impact Assessment (GHD, 2016).

3.5 Water resources

3.5.1 Surface water

Regionally, the Project is located within the upper Hawkesbury River catchment, which includes the greater Warragamba Dam catchment and the upper Coxs River sub-catchment. The Coxs River is a perennial river that drains a catchment area of approximately 1,700 km^2. The river rises within the Ben Bullen State Forest east of Cullen Bullen and flows generally in a south-east direction. The river is bounded to the west by the Great Dividing Range, to the north by the upper Colo River catchment, and to the south by the Wollondilly River catchment. The flow in Coxs River is regulated by two reservoirs, Lake Wallace and Lake Lyell, which are used to supply power generation activities at MPPS. The Coxs River flows into Lake Burragorang (impounded by Warragamba Dam), which is the primary reservoir for drinking water supply to Sydney.

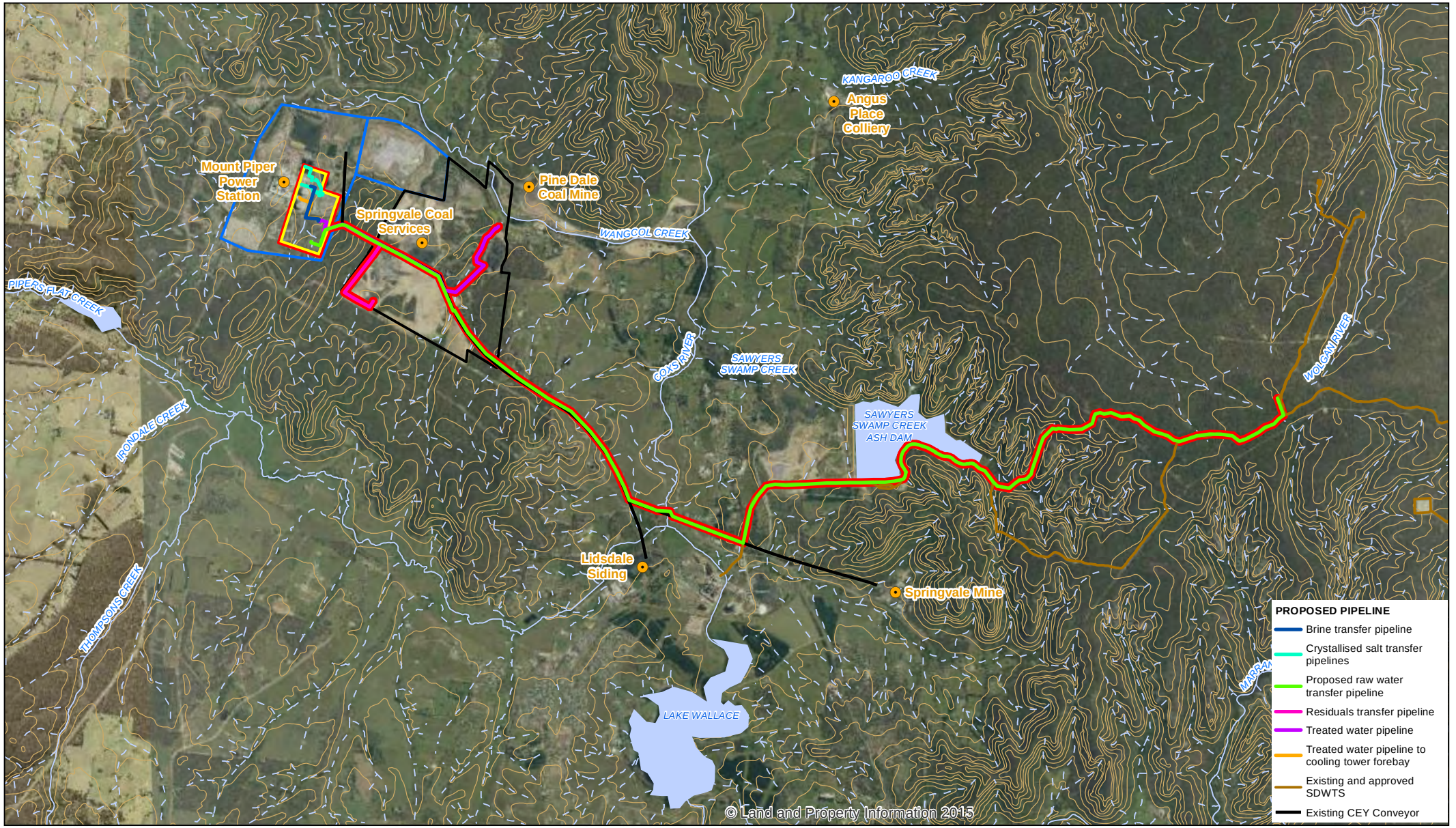
Neubecks Creek flows in a south-west direction into Wangcol Creek. It is an ephemeral creek that rises north of the Project in Ben Bullen State Forest and is characterised by low or zero flow for most of the year. There are currently no mine discharges to this system.

Wangcol Creek is a heavily modified perennial stream located to the north of the MPPS and SCSS. Wangcol Creek drains into the Coxs River approximately three kilometres to the east of

the MPPS. The historic mining operations in the Wangcol Creek catchment have altered the natural flow paths and water chemistry of the system. Diversion within the creek have been undertaken historically for operations such as the Commonwealth Open Cut (around the confluence with Coxs River) and more recently by Pine Dale Coal Mine (mid reach, downstream of SCSS).

Sawyers Swamp Creek is an ephemeral stream located to the east of the Coxs River, below the Sawyers Creek Ash Dam. Sawyers Swamp Creek drains to the Coxs River approximately two kilometres west of the existing Springvale Mine LDP009.

Figure 3-2 presents the watercourses in the vicinity of the Project.



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0 0.25 0.5 1 1.5 2

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Site location
- Project application area
- Proposed water treatment site
- 20m Contour
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Waterways

Figure 3-2

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015; Centennial: Site location, boundaries, alignment, imagery, 2016. Created by: tmorton

3.5.2 Groundwater

The primary hydrogeological units identified within the Western Coal Services Project (RPS, 2013) and MPPS (SKM, 2010) are defined in Figure 3-1. The mudstone and siltstone units that are present between coals seams (Lidsdale and Lithgow seams) and sandstones throughout the profile will significantly retard vertical flow between aquifer units.

Table 3-1 Hydrogeological units in the west of the Project Application Area

Unit	Features
Quaternary Alluvium	Isolated to Wangcol Creek, discontinuous, very little presence adjacent to MPPS and SCSS. Typically around the confluence of Neubecks and Wangcol Creek.
Triassic Sandstone	Areas of fracturing due to historical underground mining allowing for some vertical connection.
Permian Illawarra Coal Measures	Areas of Lidsdale and Lithgow seam have been mined historically
Marrangaroo Conglomerate	Outcrops to the south
Basal unit comprising the Shoalhaven Group	Outcrops to the south with a high porosity but low permeability

In accordance with the NSW Aquifer Interference Policy and the Greater Metropolitan Region (GMR) WSP, the existing aquifer systems within the PAA are expected to form less productive porous rock aquifer systems associated with the Sydney Basin Coxs River groundwater source.

The groundwater environment present along the pipeline route is less impacted by historical mining and is typically elevated into the Narrabeen group typically comprised of sandstone.

The Groundwater Dependent Ecosystem Atlas (BOM, 2016) indicates limited potential for groundwater dependence along the waterways between Wangcol Creek, downstream of the proposed discharge point, and Coxs River at Lake Wallace and moderate potential at Sawyers Swamp Creek. Groundwater dependence is discussed further in Section 7.

Historically, Wangcol Creek was considered to be ephemeral, however recent level gauging indicates perennial flow due to groundwater influence from shallow aquifers. The results of various site specific hydrogeological investigations (GHD, 2016) suggest periodic connectivity between shallow groundwater aquifers and surface water but limited or no connectivity to deeper aquifers regionally flowing to the north-east. Comparison of groundwater levels to rainfall records identified that groundwater levels are largely reflecting rainfall patterns within alluvial bores and bores monitoring groundwater levels above the Lithgow seam (GHD, 2016).

3.6 Regional setting

The Project sits within a significantly developed catchment with pre-existing industrial and mining land uses. The location of operations in the regional area that may influence water quality and, thus, aquatic ecology is shown in Figure 3-3. A brief overview of these operations is provided below. A detailed description of operations in the region is provided in the WRIA (GHD, 2016).

3.6.1 Wangcol Creek catchment

The operations that contribute to Wangcol Creek are MPPS and SCSS. Prior to 2014, there was water discharge from Pine Dale Coal Mine to Wangcol Creek, downstream of SCSS LDP006, however, the mine is now under care and maintenance and no longer has any active discharges to the creek.

Water required for the operation of MPPS is supplied from the Coxs River via Thompsons Creek Reservoir and is supplemented by the Fish River Water Supply Scheme. Surface water runoff from contributing catchments is directed through a LDP into Wangcol Creek.

The SCSS is a coal processing facility that currently receives coal from Springvale Mine by overland conveyor and provides coal storage, handling and processing functions. Treated excess water is discharged through LDP006 into Wangcol Creek via Lamberts Gully.

3.6.2 Coxs River catchment

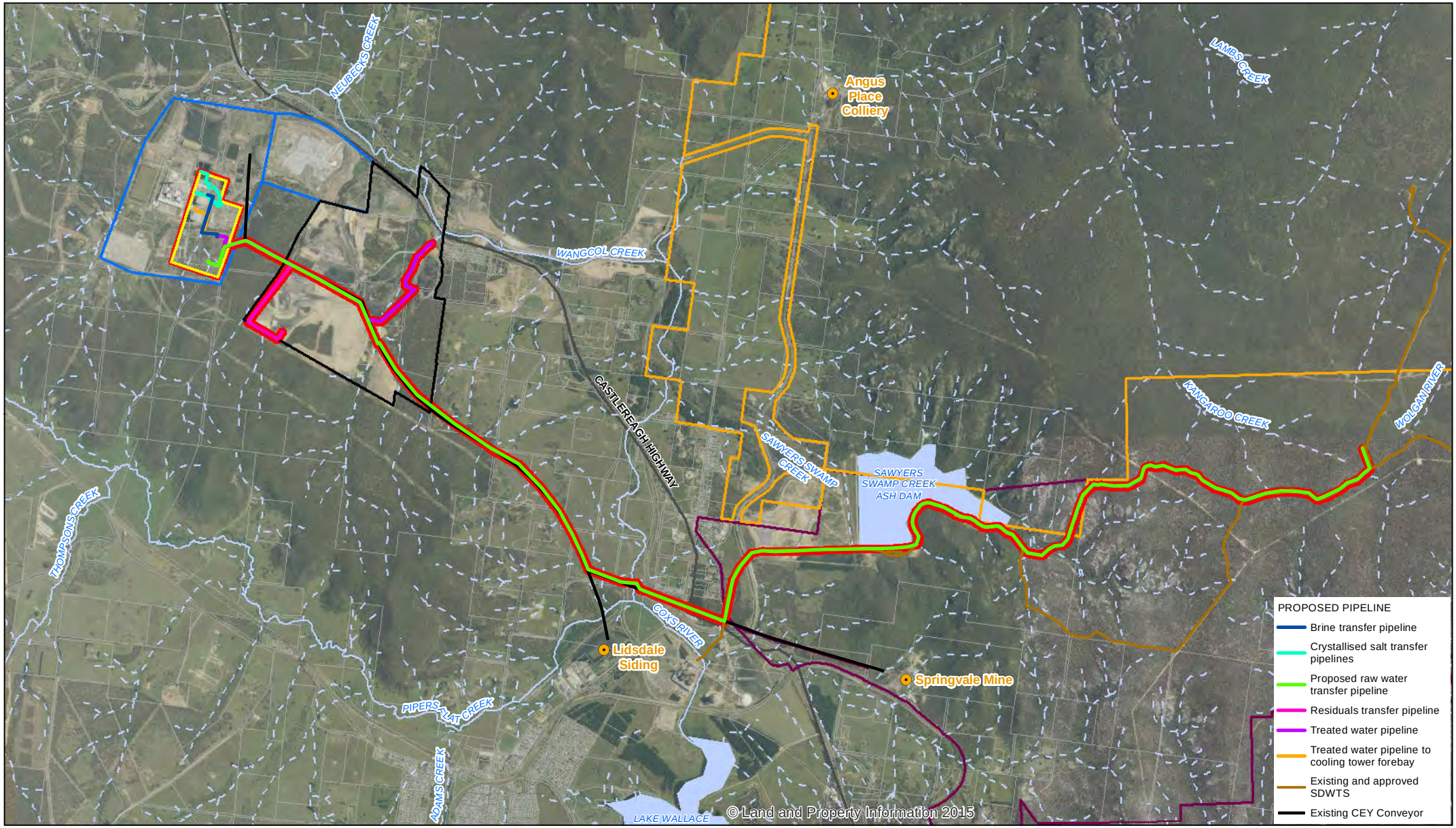
The operations that discharge water to the Coxs River are Angus Place Colliery, located upstream of the confluence with Wangcol Creek, and Lidsdale Siding and Springvale Mine, located downstream of Wangcol Creek. Wallerawang Power Station is also located downstream of the confluence of Wangcol Creek and Coxs River, however, it is currently being decommissioned and does not have an active discharge point.

Excess water from Angus Place Colliery is discharged through LDPs into Kangaroo Creek and Coxs River upstream of the confluence with Wangcol Creek. Mine water from Springvale Mine currently discharges to Sawyers Swamp Creek via LDP009.

3.7 Sensitive receptors

The following sensitive surface and groundwater receptors have been identified:

- GDEs located along Wangcol Creek and Sawyers Swamp Creek.
- Aquatic ecology maintained in local waterbodies, including macroinvertebrate fauna, frogs, macrophytes and algae, fish, semi-aquatic invertebrate species and semi-aquatic mammals.
- Watercourses described in Section 3.5.1, including Wangcol Creek and Coxs River.



Paper Size A4

0 0.2 0.4 0.8 1.2 1.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Principal Road
- Angus Place Colliery boundary
- Springvale Mining lease boundary
- Cadastre
- Waterbody
- Watercourse - Non Perennial
- Watercourse - Perennial

Springvale Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Regional setting of the Project

Figure 3-3

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Centennial: Site location, boundaries, 2016. Created by: tmorton

4. Assessment methodology

4.1 Instream ecology

4.1.1 Literature review

A review of relevant available literature, background information and searches of databases was undertaken for threatened aquatic species, populations and aquatic ecological communities recorded within the locality. Information and databases reviewed included:

- Centennial aquatic ecology monitoring reports:
  - *Aquatic Ecology Monitoring: Coxs and Wolgan River Catchments –Autumn 2013* (MPR, 2013), *Spring 2013* (MPR, 2014a), Autumn 2014 (MPR, 2014b), *Spring 2014* (MPR, 2015a), Autumn 2015 (MPR, 2015b) and Spring 2015 (MPR, 2016b).
  - *Centennial West Aquatic Ecology Monitoring: Wangcol and Piper Flat Creeks – Autumn 2015 (MPR, 2015c), Spring 2015 (MPR, 2016a).*
  - *The Neubeck Coal Project: Aquatic Ecology Impact Assessment* (GHD 2014b).
- Raw data records from WaterNSW for annual macroinvertebrate monitoring program (2012 to 2015) for the Mid Coxs River catchment sites.
- Office of Environment and Heritage (OEH) *Atlas of NSW Wildlife* (Bionet) for threatened species, populations and endangered ecological communities listed under the TSC Act and FM Act.
- Department of Primary Industries (DPI) *Threatened and Protected Species – Records Viewer* for records and distribution of threatened and protected species of fish within Lithgow LGA and Hawkesbury-Nepean Catchment Management Authority (CMA).
- Department of the Environment *Protected Matters Search Tool* for MNES listed under the EPBC Act.
- Atlas of Living Australia website at http://www.ala.org.au.

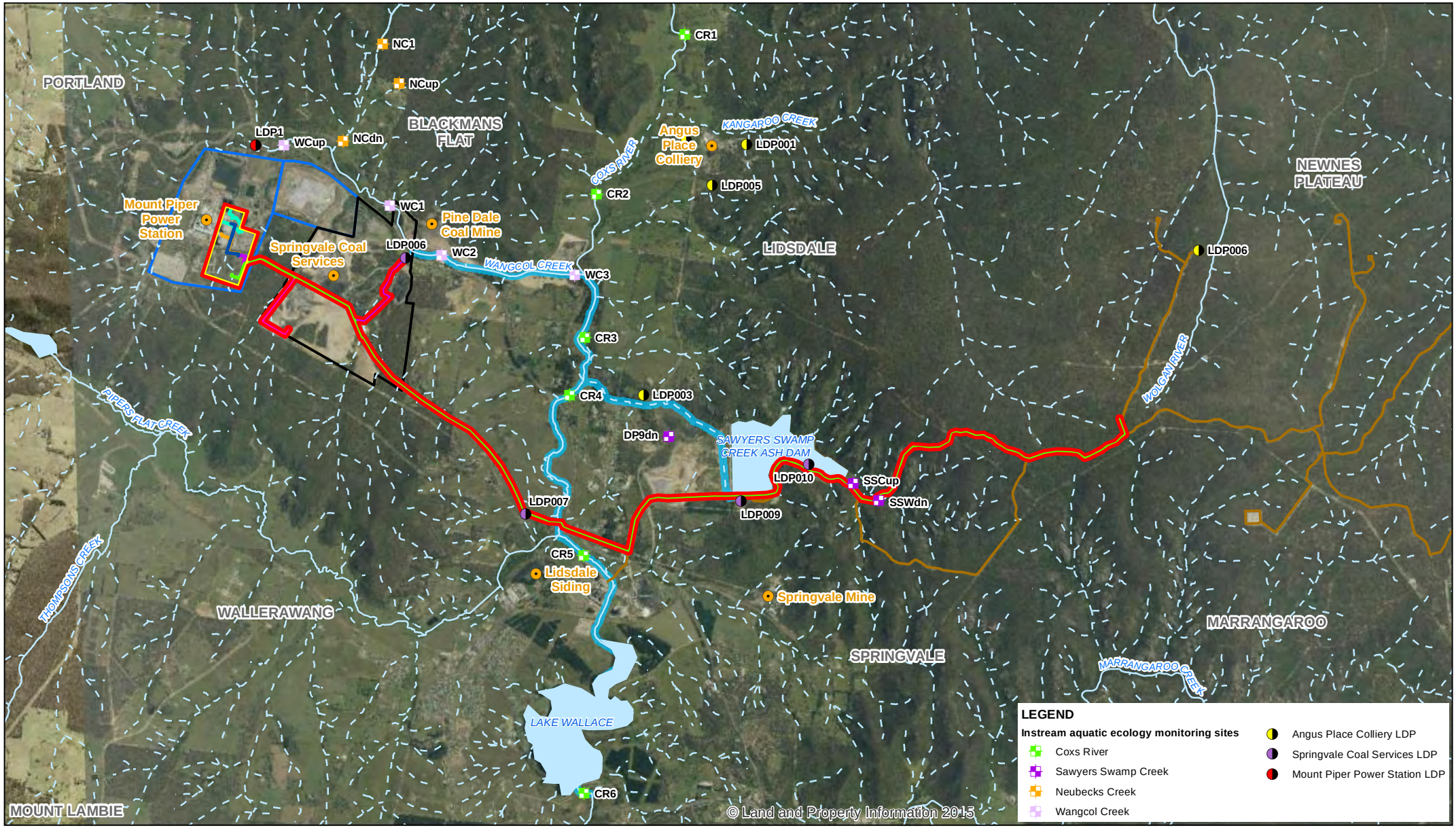
4.1.2 Historic aquatic ecology surveys relevant to the Project

Marine Pollution Research (MPR) has undertaken macroinvertebrate monitoring in the IAA as part of the Centennial West aquatic ecology monitoring program. GHD conducted further macroinvertebrate monitoring at some sites between 2013 and 2014 as part of the Neubeck Coal Project (GHD, 2014b).

Data collected by MPR and GHD between 2011 and 2014 has been used as baseline data for Neubecks Creek (sites NCup, NC1 and NCdn) (MPR 2012; GHD, 2014b). Data collected by MPR and GHD between 2013 and 2015 have been used as baseline data for Wangcol Creek (sites WCup, WC1, WC2 and WC3), Sawyers Swamp Creek (sites SSWdn & SCup and DP9dn) and Coxs River (sites CR1, CR2, CR3, CR4, CR5 and CR6) (MPR 2013; 2014a; 2014b; 2015a; 2015b; 2016a,b,c). The monitoring locations relevant to the IAA and used within the AEIA are shown in Figure 4-1.

GHD has conducted an annual macroinvertebrate survey of the Coxs River catchment on behalf of WaterNSW. Data collected from sites lower in the Coxs River catchment (WaterNSW monitoring locations MMP37 and E086) between 2012 and 2015 have been used as baseline data representative of the wider catchment. The location of WaterNSW macroinvertebrate sites in shown in Figure 4-2.

Based on location, sites were classified as being either ‘background’ sites – those that are not likely to be impacted by any Project activities or ‘baseline’ sites, which provide information on existing conditions at sites that have the potential to be impacted by the Project.



Paper Size A4

0 0.375 0.75 1.5 2.25

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Project application area
- Proposed water treatment site
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- Impact assessment area
- Brine transfer pipeline
- Crystallised salt transfer pipelines
- Proposed raw water transfer pipeline
- Residuals transfer pipeline
- Treated water pipeline
- Treated water pipeline to cooling tower forebay
- Existing and approved SDWTS

Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

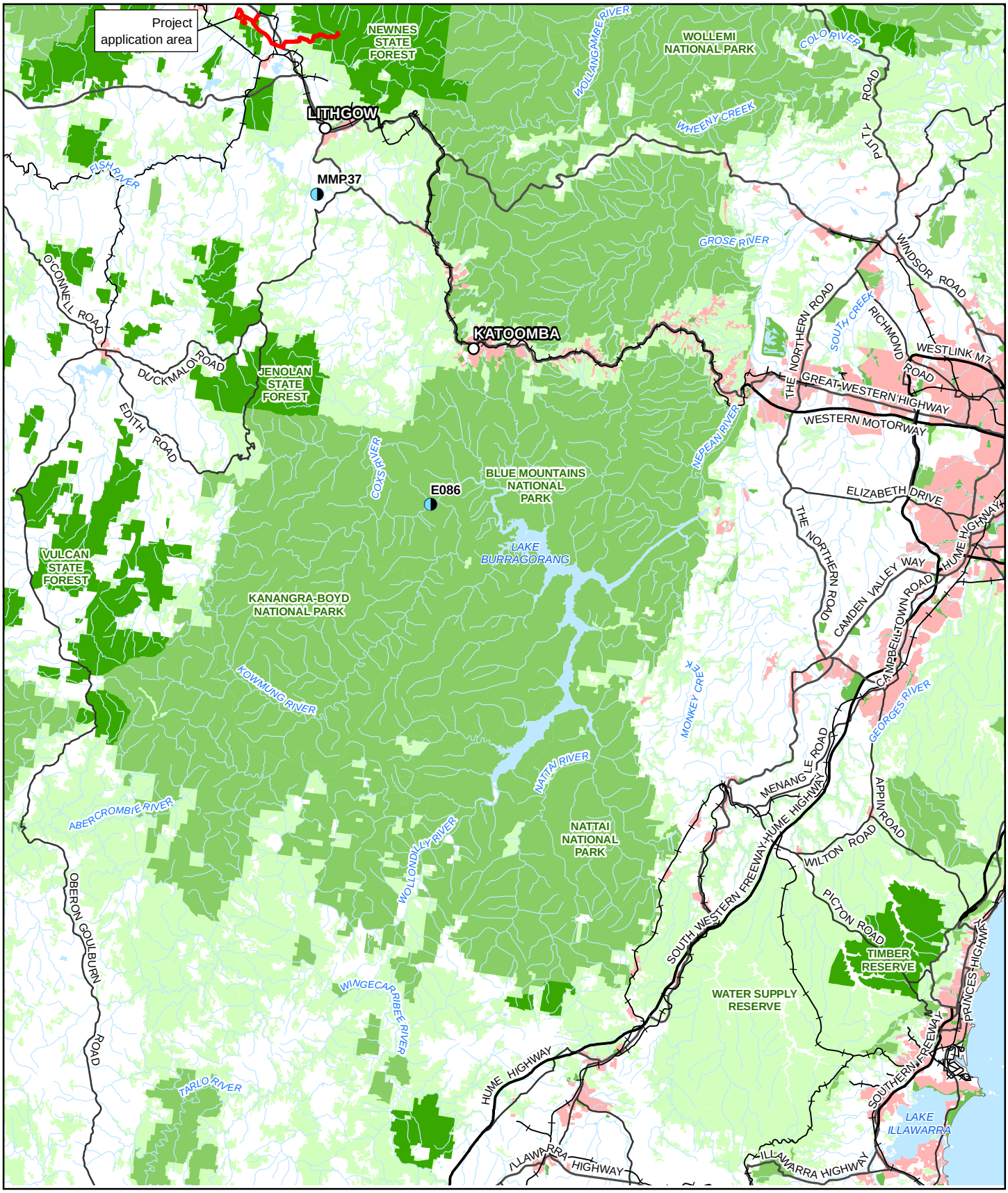
Location of local instream monitoring sites

Figure 4-1

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\AquaticEcology\2125109_AE002_InstreamMonitoringLocations_0.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton, kpsroba



LEGEND

- Instream monitoring site
- Project application area
- Dual Carriageway
- Principal Road
- Secondary Road
- Existing Rail
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub
- Waterbody
- Waterway

Paper Size A4

0 2,125 4,250 8,500 12,750 17,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Regional instream ecology monitoring sites

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Figure 4-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\AquaticEcology\2125109_AE004_Regional_AquaticMonitoring_Locations_B.mxd

Data source: LPI: DTDB/Imagery, 2012, 2015. Created by: tmorton, kpsroba

4.1.3 Aquatic survey methods

The survey methods used by MPR and GHD are both focused on macroinvertebrate community composition, habitat assessments, water quality and fish presence. Methods are summarised in the following paragraphs. Methods of habitat assessment varied between studies conducted by GHD and MPR.

Habitat assessment

Field data collected included the range of physical habitat measurements in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak *et al.,* 2004). Field data were recorded by professionally qualified and experienced aquatic ecologists and included:

- Site information, water quality and habitat assessment.
- Macroinvertebrate habitat and sample collection.
- Reference condition selection criteria.
- A modified Riparian, Channel and Environment (RCE) Inventory (Chessman *et al.*, 1997).

Field data descriptions were based on visual estimates of characteristics such as streambed composition (percentage of total composition for each substrate category), aquatic and riparian vegetation cover, amount of instream organic material, area of aquatic habitats and canopy cover. The mean width (wetted width in metres), mean depth and sample depth were determined using visual estimation.

The assessment also included sketches of the longitudinal and cross-sectional profiles of the river reach assessed displaying the biological sampling site, location of in situ water quality sampling, riparian zone width, type and height and location where photos were taken. The cross-section includes the approximate bank height, stream width and depth and the approximate height of riparian vegetation.

Stream order was calculated using the Geoscience Australia (2007) 250,000 topographic waterway GIS layer.

The Fairfull and Witheridge (2003) **fish classification system** has been used for classification of fish habitat of the waterways in the Impact Assessment Area (Table 4-1). This system allows for classification of waterways into one of four classes relating to habitat values.

Table 4-1 Fish habitat classification criteria (Fairfull and Witheridge, 2003)

Classification	Characteristics of Waterway Type
CLASS1 Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek); habitat of a threatened fish species or 'critical habitat'.
CLASS 2 Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
CLASS 3 Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
CLASS 4 Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events (e.g.

	dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

The **Riparian, Channel, and Environmental (RCE) Inventory** (Petersen, 1992) allows a standardised approach to assess the adjacent land, condition of the banks, channel and bed using 13 descriptors/indicators. The RCE Inventory has been modified by Chessman *et al.*, (1997) to suit Australian conditions. The scoring system has been simplified to a range of 0 to 4 for each descriptor. The total score is derived by summing the scores for each descriptor. The maximum possible score for a site is 52. To allow for a more succinct summary of existing conditions the scores calculated for each season have been averaged for each site.

Macroinvertebrates

Field sampling

Field sampling by GHD and MPR following rapid bioassessment (RBA) protocols was undertaken in accordance with the NSW AUSRIVAS sampling and processing manual (Turak *et al.*, 2004). The AUSRIVAS program is a nationally recognised, standardised sampling method used to assess the health of Australian rivers and developed for Australia's National River Health Program.

At each site, the littoral or edge habitat was sampled by sweeping the collecting net along the edge of the stream in areas of little or no current. The net was swept around overhanging terrestrial vegetation, against snags if present, in backwaters and through beds of macrophytes. This process was continued, working upstream against the flow, over approximately 10 m of edge.

The objective of the RBA sorting protocol is to obtain a sample containing as diverse a fauna as possible (and hence provide a useful measure of taxa richness).

Data management

If taxa were too small to identify to family level and order level identification was the lowest resolution obtained, these taxa were retained in the data set only if no other representatives from that group were found in that sample, otherwise they were removed. Microcrustacea (Copepoda, Ostracoda and Cladocera) and Collembola were retained in the data set.

Macroinvertebrate indices

The following macroinvertebrate biotic indices were calculated:

- Taxonomic richness.
- EPT richness.
- SIGNAL 2 biotic index.
- Relative richness.
- NSW AUSRIVAS model.

Taxonomic richness: Taxonomic richness refers to the number of different taxa contained in a sample. A high number of taxa present at a given site can indicate that the site is in good condition and/or has a diverse range of habitats and an abundant food supply. However, in some cases, higher taxa richness can occur at impacted sites due to the provision or enhancement of habitats or food resources that may not occur naturally (e.g. enhanced riffle habitat availability due to altered flow conditions, enhanced periphyton food resource for macroinvertebrate grazing taxa due to increased nutrient levels). Consequently, results for taxa richness value must be assessed on a case-by-case basis and in relation to habitat conditions.

EPT richness (Ephemeroptera, Plecoptera and Trichoptera richness): Some groups of aquatic macroinvertebrates are more sensitive to changes in the aquatic environment than others and it is possible to refine the assessment of river health based on the presence or absence of sensitive taxa. It is generally accepted that three orders of aquatic insects, the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), are among the most sensitive to altered water quality and habitat conditions. The total number of families of EPT taxa can be used to assess degradation of habitat and water quality (Plafkin *et al.*, 1989). The use of this index is based on the premise that undisturbed sites will have relatively greater numbers of EPT than sites in a degraded condition. The use of EPT should be limited to regional or preferably within-catchment comparisons (as in this case), as the composition of the fauna varies between regions and river systems, with some systems naturally having more EPT taxa than others.

SIGNAL-2 biotic index (Stream Invertebrate Grade Number Average Level – Version 2) (Chessman, 2003): SIGNAL-2 is a simple scoring system for macroinvertebrates of Australian rivers. SIGNAL-2 is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrate families that have been derived from published and unpublished information on their tolerance to pollutants, such as sewage and nitrification (Chessman, 1995). Each taxon is assigned a grade from 1 (tolerant) to 10 (sensitive) based on ecotoxicity assessment data.

The average of the grades for each site is used as the SIGNAL-2 score. Those families in a sample for which no grade can be assigned are excluded from the analysis. The calculation of the SIGNAL-2 score has not been weighted in regards to the abundance of organisms.

Relative richness: Relative richness is the percentage of the major taxonomic orders found and has been derived from the presence/absence data for each sample. This measure provides an estimate of the percentage contribution of the major macroinvertebrate orders and allows for a visual representation of the macroinvertebrate community at each site and a pooled total representing the macroinvertebrate community.

NSW AUSRIVAS model: The NSW AUSRIVAS model provides a river health assessment based on predictive models of macroinvertebrate distribution (Turak *et al*., 2004). Physical and chemical data collected at each site is used to determine the predicted (expected) composition of the macroinvertebrate fauna if the site is in an undisturbed or reference condition. The AUSRIVAS assessment compares the macroinvertebrates collected at a site (Observed) to the predicted to occur (Expected) and the ratio derived indicates which band the site will be in. The AUSRIVAS bandings allow an assessment of the level of impact at a site. A summary of the AUSRIVAS bandings is provided in Table 4-2.

On occasion results will be outside of the experience of the model. This occurs when there is no appropriate reference group for comparison to the test sites.

Table 4-2 AUSRIVAS band explanations (Turak *et al.*, 2004)

Band label	Band name	Band description
Band X	More biologically diverse than reference sites.	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	Reference condition.	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	Significantly impaired.	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band C	Severely impaired.	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	Extremely impaired.	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Fish

Fish surveys were carried out by MPR in conjunction with the macroinvertebrate assessments between 2010 and 2015. MPR used a combination of overnight and spot bait-trapping, dip netting and observation to provide an understanding of fish likely to be present within each waterway. GHD undertook electrofishing at key site in spring 2013, autumn 2014 and spring 2014 as part of the Neubeck Coal Project survey (GHD, 2014b).

WaterNSW macroinvertebrate survey

An annual macroinvertebrate survey has been undertaken at selected sites throughout the Sydney Water Catchment between 2001 and 2013. Two sites surveyed under this monitoring program are relevant to the Coxs River catchment, MMP37 located on the Coxs River downstream of Lake Lyell and E086 located just upstream of Lake Burragorang. More information on these sites and the findings of this survey are provided in Section 6. Data collected from MMP37 and E086 between 2012 and 2015 has been used within this assessment. Field work during this period was undertaken by aquatic ecologists from GHD. Macroinvertebrates were sampled from edge habitat as well as riffle habitat, where available, following AUSRIVAS protocols (Turak *et al*., 2004).

4.2 Groundwater dependent ecosystems (GDEs)

Currently the approach for assessment of GDEs is not well documented or understood however the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems, Volume 1 – The Conceptual Framework* (Serov *et al*., 2012) has recently been developed by NOW and OEH. This presents an approach to GDE identification, classification, ecological valuation and ecological risk assessment for a given activity or potential impact on a groundwater source. This also details a series of steps to identify and infer the level of groundwater dependency and provides a summary of risk assessment guidelines for GDEs.

The guidelines were developed by NOW and OEH to:

- Define GDE types.
- Provide a method for determining the ecological value or an aquifer and associated GDEs.
- Provide a method for developing the risk of an activity to the ecological value of an aquifer and associated GDEs.
- Provide a method for developing management strategies for aquifers and identified GDEs using the risk matrix approach.
- Provide a method to identify the type and location of GDEs within an aquifer or defined area.
- Provide a method for inferring the groundwater dependency of identified ecosystems.
- Describe surface and subsurface activities that threaten aquifers and associated GDEs.

As part of the desktop assessment GHD followed this approach to identify the likelihood and level of dependency of GDEs within the vicinity of the Project. The desktop assessment considered:

- Existing groundwater depths.
- Vegetation mapping.
- Database searches.
- Previous studies in the area (RPS, 2014; GHD, 2014b); and
- The Groundwater Dependent Ecosystems Atlas (BOM, 2016).

The above components were used to identify the likely occurrence and distribution of GDEs that could be affected by the Project.

4.2.1 Subterranean aquatic ecosystems

Ecological requirements of stygofauna

Stygofauna are intricately linked both ecologically and physiologically to the aquifer environment and are adapted to the relative stability of their surroundings. Compared to surface environments, groundwater fluctuates less both in level and physicochemical variables such as EC, temperature and pH (Hancock *et al.*, 2005). Groundwater is also generally lower in DO and has less readily available organic matter than surface water environments (Humphreys, 2002).

In Australia, stygofauna are known from alluvial, limestone, fractured rock and calcrete aquifers (Hancock *et al.*, 2005; Humphreys, 2008). As stygofauna require a space to live, the porosity of the sediments, degree of fracturing or extent of cavity development must be sufficient, as must the connectivity between the living spaces. As yet, few species are known from coal seam

aquifers (although this is changing as further targeted sampling is undertaken in Queensland and NSW).

Preliminary observations in Queensland (Hancock and Boulton, 2008) suggest that the highest stygofauna diversity and abundance occurs in groundwater with EC less than 5,000 µS/cm, although records of some syncarid species and genera of Koonungidae in Victoria and Tasmania are adapted to exist in naturally high EC waters of 33,000 µS/cm (Serov, P. pers. comm.) and stygofauna have been recorded in salinity up to 60,000 mg/L TDS in Western Australia (Moulds, T. pers. comm.). In Queensland, stygofauna have been collected in bores with EC up to 26,000 µS/cm (GHD unpublished). Other variables thought to be favourable for stygofauna are a shallow water table (less than 20 m), moderate concentrations of DO (1 mg/L to 5 mg/L), and pH between 6.5 and 7.5 (Hancock and Boulton, 2008), although this range is considered quite narrow by other specialists (Serov, P. pers. comm.).

Terminology

Subterranean fauna can be classified by the degree to which they are dependent on groundwater. Those that are completely dependent on groundwater are termed stygobites/phreatobites (these animals are the focus in the AEIA) and consist predominantly of crustaceans. Those that rely on groundwater to a lesser extent and can live in mixed surface and groundwater are termed stygoxenes or stygophiles (Marmonier *et al.*, 1993). The distinction is often ambiguous because it is difficult to know the degree of surface/groundwater mixing in an aquifer (Boulton *et al.*, 2003), and the classifications are regularly disputed (Sket, 2010). However, classifications based on affiliation to groundwater can be useful when assessing the conservation status of species and their vulnerability to potential impacts and this report follows the system originally proposed in the mid-1900's for cave-dwelling animals (Hancock *et al.*, 2005):

Stygoxenes are organisms that have no affinities with groundwater systems but occur accidentally in caves and alluvial sediments. Some planktonic groups (calanoida copepoda) and a variety of benthic crustacean and insect species (simulid fly larvae, caenid mayflies) may passively infiltrate alluvial sediments (Gilbert *et al.*, 1994).

Edaphobites are deep soil dwelling (or endogean) species that frequently display troglomorphisms and may sometimes occur in caves. These animals are not classified as stygofauna.

Stygophiles are facultative subterranean species able to complete their whole life cycles both underground and on the surface. Stygophilic species often have populations above and below ground, with individuals commuting between them and maintaining genetic flow between these populations (Trajano, 2001). Examples of stygophiles include some ostracod or copepod species.

Stygobites (stygobionts) are obligate subterranean species restricted to subterranean environments and typically possessing character traits related to a subterranean existence (stygomorphisms) such as reduced or absent eyes and pigmentation and enhanced non-optic sensory structures.

Phreatobites are stygobites (obligate subterranean species) restricted to 'deep' groundwater substrata of alluvial aquifers (Gilbert *et al.*, 1994). All species within this classification have specialised morphological and physiological adaptations.

Stygofauna is an all-encompassing term for all animals that occur in subsurface waters, including hyporheic fauna (Ward *et al.*, 2000).

From a conservation biology perspective, stygobites/phreatobites usually face a higher risk of extinction because they are frequently short range endemic species (Harvey, 2002). As short

range endemic species live only in a small geographical area, any impact on their range can severely reduce their population. In assessing the environmental impact of projects on subterranean species it may become important to distinguish stygobites/phreatobites from other ecological categories of subterranean fauna, but it is still critical that the range of non-stygobites also be assessed, especially in areas where few groundwater biological surveys have been conducted and the likelihood of finding new species is high.

Sampling guidelines

There are currently no specific guidelines for sampling stygofauna in NSW. The criteria outlined in the Western Australian Environmental Protection Authority (WA EPA) guidelines are accepted as current industry best practice in Australia at this time.

Therefore, for this study the Western Australian methodologies were adopted, as detailed in the following two documents:

- *Guidance for the Assessment of Environmental Factors: Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (WA EPA, 2007).
- *Environmental Assessment Guideline for Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (WA EPA, 2013).

The Western Australian (WA) EPA guidelines provide information which the Western Australian EPA considers important when assessing proposals where subterranean fauna is considered a relevant environmental factor.

Stygofauna survey methods

A stygofauna survey has been undertaken by GHD in areas relevant to the Project between 2013 and 2014 (three sampling occasions). This survey was conducted as part of the Neubeck Coal Project (GHD, 2014b). Stygofauna surveys were conducted by GHD in:

- Spring 2013 between 30 September and 3 October 2013.
- Autumn 2014 between 6 and 9 May 2014.
- Spring 2014 between 27 and 30 October 2014.

The stygofauna survey was conducted in accordance with the requirements for baseline surveys undertaken in Western Australia, as defined by guidelines by WA EPA (2007) and WA EPA (2013), with the following minor exceptions:

- Six hauls (where possible) were undertaken at each groundwater bore using a 50 µm mesh net of 40 mm or 150 mm diameter (depending on the diameter of the bore).
- Ideally the net diameter should be about two-thirds of bore diameter. A 150 mm net was used where the bore had a diameter of 300 m.

None of these modifications is expected to reduce the efficacy of the sampling program.

Established standard sampling techniques used in Australia and overseas (Hancock and Boulton, 2008; Dumas and Fontanini, 2001) were adopted and all field equipment was of high quality, well maintained, fully calibrated and operated to manufacturer's specifications. The stygofauna sampling program was conducted by professionally qualified and experienced GHD ecologists.

Three bores were sampled in close proximity to Neubecks Creek and Wangcol Creek, upstream of the proposed discharge point. These bores are considered to be important in establishing the presence of stygofauna in shallow alluvial aquifers associated with Wangcol Creek. The bore details are provided in Table 4-3.

Groundwater bores were selected by GHD for stygofauna sampling by using the following criteria:

- Diameter of 50 mm or greater.
- Intersect the water table.
- Preferably lined and slotted/screened through the water column.
- Vertical (not angled).
- Geographically spread across the proposed mine lease and ideally include reference bores outside the potential zone of impact (i.e. water drawdown zone).
- Cover all hydrogeological units present with a strong emphasis on shallower alluvial aquifers with high water quality (if present).
- Be of varying age, in excess of six months old, and preferably undisturbed (i.e. not regularly pumped or purged).
- Include a high number of bores with an EC less than 5,000 µS/cm (and preferably less than 1,500 µS/cm), a DO concentration greater than 1 mg/L and a pH within the range 6.5 to 7.5 units.

Table 4-3 Characteristics of the bores sampled for stygofauna

Bore ID (previous ID)	MGA Zone 56		Type	Period	Lithology	Mine workings	Drilled depth (m bgl)	Bore drilled	Bore diameter (mm)	Cased depth (m)	Static water level (m btoc)	Sample dates
	Easting	Northing										
Alluvium groundwater												
NGW10_a (NEU1)	225391	6305911	Standpipe piezometer	Quaternary	Alluvial deposit	No	2.2	25/09/12	50	1.2	1.2	01/10/13
											1.37	06/05/14
											2.95	29/10/14
NGW11_a (NEU2)	225317	6305864	Standpipe piezometer	Quaternary	Alluvial deposit	No	4.5	25/09/12	50	2.4	0.74	01/10/13
											0.75	06/05/14
											0.88	29/10/14
NGW12_a (NEU3)	22537	6305791	Standpipe piezometer	Quaternary	Alluvial deposit	No	2.2	25/09/12	50	1.2	1.27	01/10/13
											1.08	06/05/14
											1.38	29/10/14

bgl – below ground level

btoc – below top of casing

N/S – not sampled

N/D – no data

5. Conservation significance

The conservation status of species and communities within the vicinity of the PAA were determined with reference to the following:

- The EPBC Act for national significance.
- The FM Act and TSC Act for state significance.

Following collation of database records and species and community profiles, a 'likelihood of occurrence' assessment was prepared with reference to the broad habitats contained within the PAA and IAA. The likelihood of threatened biota occurring in the PAA was assessed based on presence of records from the locality (i.e. within 10 km of the PAA), species distribution and habitat preferences and the suitability of potential habitat present.

Table 5-1 provides a key to the likelihood of occurrence of threatened biota known or likely to occur in the PAA.

Table 5-1 Key to likelihood of occurrence for threatened species

Likelihood	Definition
Likely	Species previously recorded within a 10 km radius of the PAA and suitable habitat occurs.
Possible	Species previously recorded within a 10 km radius of the PAA but only marginal suitable habitat recorded.
	Species not previously recorded within a 10 km radius of the PAA, but the PAA is within the species known distribution and suitable habitat occurs within the PAA.
Unlikely	Species previously recorded within a 10 km radius of the PAA but no suitable habitat recorded.
Nil	Species not previously recorded within a 10 km radius of the PAA, suitable habitat not recorded within the PAA and/or PAA outside species' known distribution.

5.1 Threatened species

A summary of the listed threatened aquatic species that may potentially occur in the PAA is provided in Table 5-2.

The Department of the Environment *Protected Matters Search Tool* indicated three threatened aquatic species have the potential to occur within 10 km of the PAA:

- Murray cod (*Maccullochella peelii peelii).*
- Australian grayling (*Prototroctes maraena*).
- Macquarie perch (*Macquaria australasica*).

The *Atlas of NSW Wildlife* (Bionet) indicated one threatened aquatic species has the potential to occur within 10 km of the PAA which was the Giant dragonfly (*Petalura gigantea*).

Additional species have been identified within the SEARs for consideration including the following:

- Small Pale Grass-lily (*Caesia parviflora* var. minor).
- Black Gum (*Eucalyptus aggregate*).
- Silver-leafed Gum (*Eucalyptus pulverulenta*).
- *Leucopogon fletcheri* subsp. *Fletcheri.*
- Slaty Leek Orchid (*Prasophyllum fuscum*).
- Regent Honeyeater (*Anthochaera Phrygia*).

The likelihood of occurrence of these species in the PAA and potential impacts to these species are assessed as part of the Biodiversity Assessment Report (RPS, 2016). However, Black Gum has been considered as part of the AEIA given the preference of this species for waterlogged soils and the presence within the riparian zone of Wangcol Creek.

The Protected Matters Search identified threatened frog species within the PAA. Frogs and impacts on frogs have not been considered within this assessment. Refer to the Biodiversity Assessment Report (RPS, 2016) for a discussion on potential impacts of the Project on frog species.

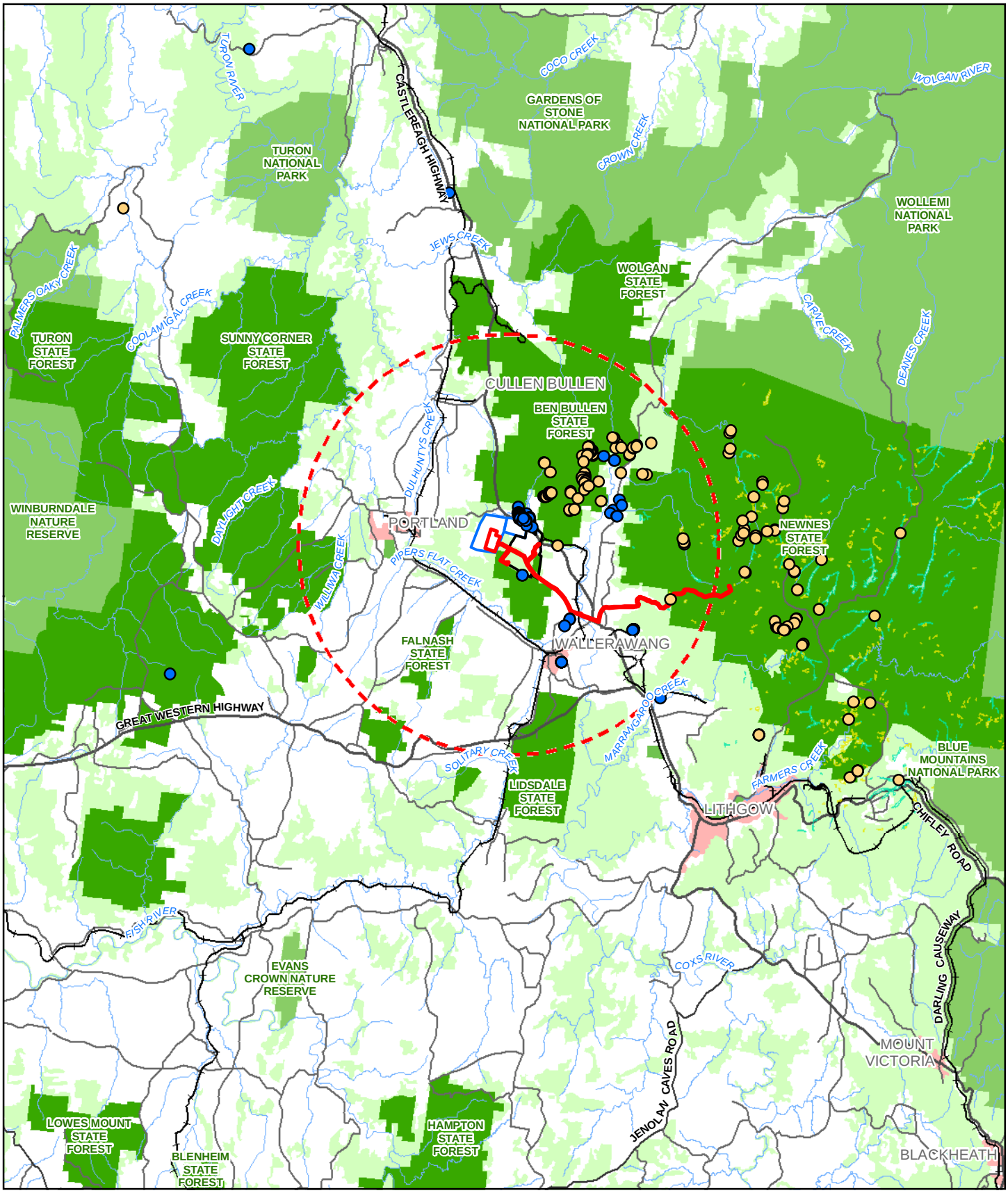
Table 5-2 Listed threatened species potentially occurring within 10 km of the Project Application Area

Common name	Scientific name	Listing*		Preferred habitat	Likelihood of occurrence in the Project Application Area
		FM / TSC Act	EPBC Act		
Plant Species					
Black Gum	*Eucalyptus aggregata*	V (TSC Act)	V	Grows in the lowest parts of the landscape. Grows on alluvial soils, on cold, poorly-drained flats and hollows adjacent to creeks and small rivers. Often grows with other cold-adapted eucalypts, such as Snow Gum or White Sallee (*Eucalyptus pauciflora*), Manna or Ribbon Gum (*E. viminalis*), Candlebark (*E. rubida*), Black Sallee (*E. stellulata*) and Swamp Gum (*E. ovata*). Black Gum usually occurs in an open woodland formation with a grassy ground-layer dominated either by River Tussock (*Poa labillardierei*) or Kangaroo Grass (*Themeda australis*), but with few shrubs. Also occurs as isolated paddock trees in modified native or exotic pastures. Many populations occur on travelling stock reserves, though stands and isolated individuals also occur on private land (Department of the Environment, 2016a).	Known to occur
Veronica blakelyi*	*Veronica blakelyi*	V (TSC Act)	-	Distribution limited to the western Blue Mountains in moist areas of eaucalypt forest (OEH, 2016). Associated with Red Box - Grey Gum - stringybark woodland on talus slopes of the western Blue Mountains	Known to occur
Fish Species					

Common name	Scientific name	Listing*		Preferred habitat	Likelihood of occurrence in the Project Application Area
		FM / TSC Act	EPBC Act		
Murray Cod	*Maccullochella peelii*	–	V	Prefer slowly flowing, turbid waters of rivers and streams at low elevations. Also occurs in fast moving, clear rocky upland streams (Allen *et al.*, 2002). This species favours deeper waters around boulders, logs, undercut banks and overhanging vegetation. Small numbers are still present in the Nepean River (NSW) (DPI, 2006a).	Unlikely
Australian Grayling	*Prototroctes maraena*	E (FM Act)	V	The Australian grayling is generally found in clear, moderate to fast flowing waters in both coastal and upper reaches of rivers. This species spends only part of its lifecycle in freshwater, where running ripe specimens have been captured. The species prefers gravel type substrates and often forms aggregations below barriers to upstream migration. The species is relatively uncommon in the coastal drainages of south-eastern Australia, from the Grose River (NSW) to the Hopkins River (Vic.) (Allen *et al.*, 2002).	Unlikely
Macquarie Perch	*Macquaria australasica*	E	E	Macquarie perch occur in cool, clear waters of rivers, lakes and reservoirs and prefer slow flowing, deep rocky pools. The species occurs between the middle and upper reaches of the Murray River and its tributaries in NSW and Victoria. Populations from the eastward-flowing Shoalhaven River and Hawkesbury River (NSW) are genetically distinct and may represent an undescribed species (Allen *et al.*, 2002).	Unlikely

Common name	Scientific name	Listing*		Preferred habitat	Likelihood of occurrence in the Project Application Area
		FM / TSC Act	EPBC Act		
Macroinvertebrate species					
Giant Dragonfly	*Petalura gigantea*	V (TSC Act)	–	The giant dragonfly is found along the east coast of NSW from the Victorian border to northern NSW. There are known occurrences in the Blue Mountains and Southern Highlands. They live in permanent swamps and bogs with some free water and open vegetation. Adults spend most of their time settled on low vegetation on or adjacent to the swamp hunting for flying insects. Females lay eggs into moss or other soft vegetation bordering swamps. Larvae dig long branching burrows under the swamp, leaving their burrows at night to feed on insects and other invertebrates on the surface and also use underwater entrances to hunt for food in the aquatic vegetation (OEH, 2015).	Unlikely
Reptile species					
Blue Mountains Water Skink	*Eulamprus leuraensis*	E	E	Species thought to be largely confined to Blue Mountains sedge swamps and Newnes Plateau shrub swamps. Coxs River swamps are other potential habitat (NSW NPWS, 2002)	Unlikely

CE – Critically Endangered
E – Endangered
V – Vulnerable
M – Migratory
P – Protected
*Labelled as Derwentia blakelyi in Figure 5-1



LEGEND

- Project application area
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- 10km buffer
- Existing Rail
- Principal Road
- Secondary Road
- Minor Road
- Waterway
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub
- Derwentia blakelyi
- Eucalyptus aggregata
- Newnes Plateau Shrub Swamp
- Newnes Plateau Hanging Swamp

Paper Size A4

0 1 2 4 6 8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

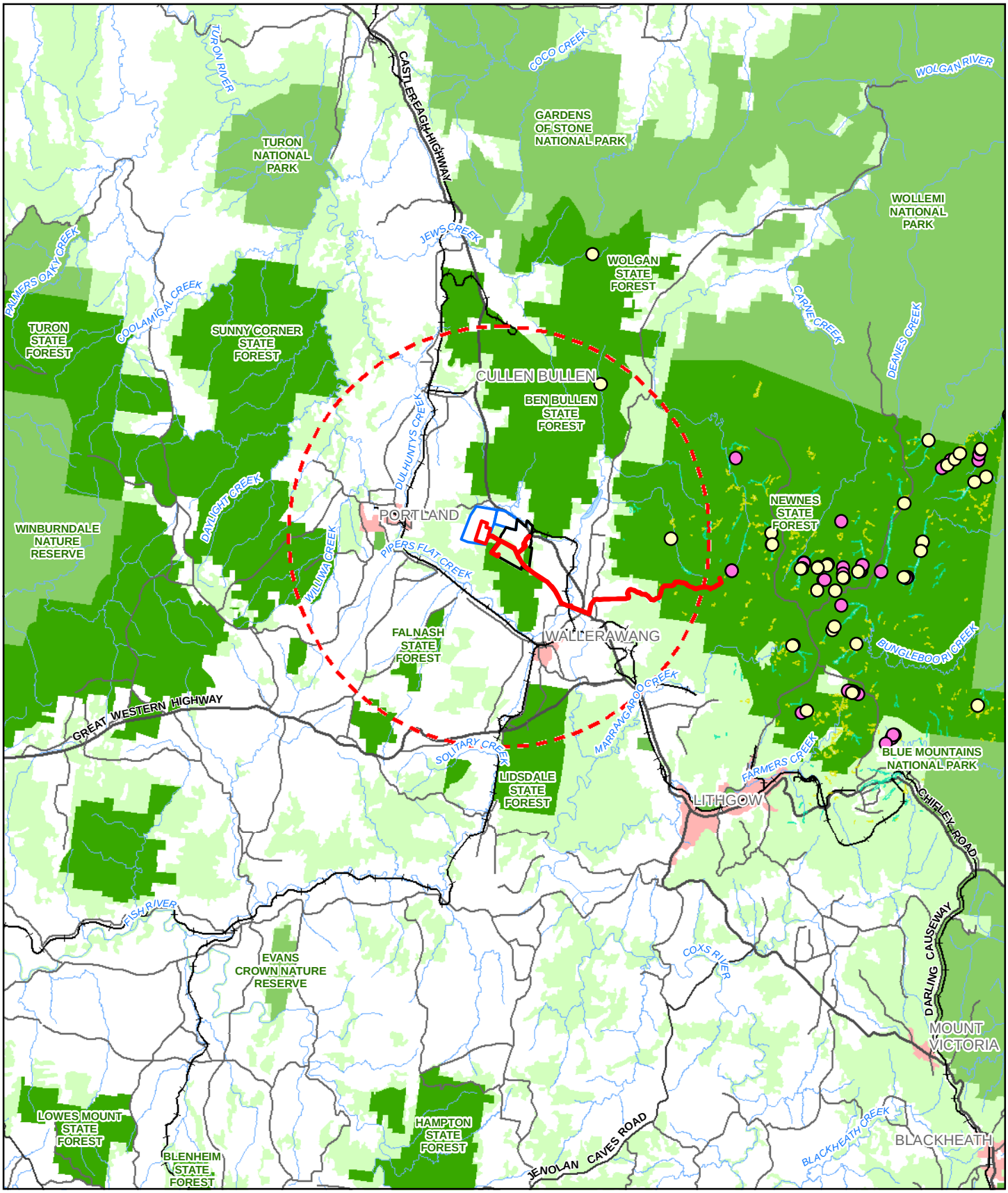
Threatened flora records within 10 km of the Project site

Figure 5-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\AquaticEcology\2125109_AE007_ThreatenedFlora_0.mxd

Data source: OEH: NPWS Wildlife Atlas data. Office of Environment and Heritage (NSW). (Data supplied by OEH Wildlife Threatened species, June, 2016). Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006.
Created by: tmorton, kpsroba



LEGEND

- Project application area
- Springvale Coal Services Development Consent
- Mount Piper Power Station
- 10km buffer
- Existing Rail
- Principal Road
- Secondary Road
- Minor Road
- Waterway
- Swamp
- Built up area
- Recreation area
- Nature Conservation
- State Forest
- Forest or shrub
- Newnes Plateau Shrub Swamp
- Newnes Plateau Hanging Swamp
- Eulamprus leuraensis
- Petalura gigantea

Paper Size A4

0 1 2 4 6 8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Centennial Coal
EA/CEY Water Treatment Project
Aquatic Ecology Impact Assessment

Job Number 21-25109
Revision 0
Date 12 Aug 2016

Threatened fauna records within 10 km of the Project site

Figure 5-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Springvale\2125109\AquaticEcology\2125109_AE006_ThreatenedFauna_0.mxd

Data source: OEH: NPWS Wildlife Atlas data. Office of Environment and Heritage (NSW). (Data supplied by OEH Wildlife Threatened species, June, 2016). Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006.
Created by: kpsroba

Murray Cod (*Maccullochella peelii peelii)* is the largest freshwater fish found in Australia and occurs naturally in the waterways of the Murray-Darling Basin in a wide range of warm water habitats that range from clear, rocky streams to slow flowing turbid rivers and billabongs. Populations of this species have also been supplemented through hatchery-bred programs and translocation of wild-caught individuals outside their natural distribution range, including the Hawkesbury-Nepean system. Records of this species within the Hawkesbury-Nepean system are, however, all from coastal rivers and represent stocked fish (DPI, 2006a). There are no recorded sightings of this species within 10 km of the PAA.

The Australian Grayling (*Prototroctes maraena*) is a diadromous species (requires access to freshwater and coastal environments to complete its life cycle) and prefers freshwater streams and rivers, especially clear gravelly streams with a moderate flow, as well as estuarine areas. Historically, this species occurred in coastal streams from the Grose River, west of Sydney, southwards through NSW and Victoria (Department of the Environment, 2013b). More recently, species have been recorded on the eastern and southern regions of the Great Dividing Range from Sydney southwards to the Otway Ranges in Victoria (DPI, 2006b); although the DPI *Threatened and Protected Species – Records Viewer* presented no records of this species north of Wollongong. Cardno (2013a) suggest the identification of this species in threatened species searches within the PAA may be a reflection of its historical distribution. There are no recorded sightings of this species within 10 km of the PAA.

Macquarie Perch (*Macquaria australasica*) prefers clear water and deep rocky holes with lots of cover in the form of aquatic vegetation, large boulders, debris and overhanging banks (Department of the Environment, 2013c). A search performed on the online DPI *Threatened and Protected Species – Records Viewer* identified Macquarie Perch as a threatened fish species listed under the FM Act relevant to the Lithgow LGA. This species was initially listed as 'vulnerable' under the FM Act but was revised to 'endangered' in 2008 due to a very large reduction in abundance and geographic distribution within a relevant time frame (FSC, 2008). A wider search of the Hawkesbury-Nepean CMA reported numerous records of Macquarie Perch associated with Wollemi National Park, including three records from 1994 and records from the mid Coxs River in 1994 and 2005. The sightings in the mid Coxs River were observed just upstream of Lake Burragorang (greater than 100 km downstream of the PAA). There are no recorded sightings of this species within 10 km of the PAA.

The current distribution range of the three identified threatened fish species, Murray Cod, Australian Grayling and Macquarie Perch, indicate they are unlikely to occur within the PAA or waterways of the IAA. There are two major fish barriers on the Coxs River downstream of the PAA, Lake Wallace and Lake Lyell, neither of which have fishways installed, hence limiting upstream fish migration potential from the mid Coxs River. There are no records of these species within the IAA. Consequently, an assessment of significance has not been undertaken for these species. No further consideration of these fish species has been given in this assessment.

The Giant dragonfly (*Petalura gigantea*) is listed under the TSC Act to potentially occur within 10 km of the PAA. This species, listed as 'endangered' under the TSC Act, is found along the east coast of NSW from the Victorian border to northern NSW, although not west of the Great Dividing Range. There are known occurrences in the Blue Mountains and Southern Highlands, in the Clarence River catchment and on a few coastal swamps from north of Coffs Harbour to Nadgee in the south (OEH, 2015). Records of the species are present in the Lithgow LGA using a search of the NSW *Atlas of NSW Wildlife* (Bionet) records database. They live in and around permanent swamps and bogs, with adults spending most of their time settling on vegetation along the swamp margins. Females lay eggs in the soft ground, moist litter and humic soils often associated with groundwater seepage areas within appropriate swamp and bog habitats (OEH, 2015). No records have been recorded in the BioNet Atlas of NSW Wildlife (OEH, 2016)

within the extent of the IAA nor has this species been observed by MPR or GHD at any of the monitoring locations in the IAA. RPS determined that no suitable swamp habitat was present within the PAA (RPS, 2016). Further, no swamp habitat is known to be present within Wangcol Creek or the Coxs River, downstream of the Wangcol Creek confluence. Therefore, this species is considered unlikely to occur in the IAA. No further consideration of this species is given in this assessment.

The Blue Mountains Water Skink has been identified in threatened species searches as potentially occurring within 10 km of the PAA. There are numerous records in the vicinity of the PAA or the waterways within the IAA (Figure 5-1). The distribution of this species is confined largely to the Blue Mountains swamps. Coxs River swamps were also listed as potential habitat for this species. There are numerous records of this species within 10 km of the PAA, however, there have been no records in the vicinity of the Coxs River within the extent of the IAA. RPS have identified that there is no suitable habitat for this species in the PAA (RPS, 2016). There are no swamps within the IAA, downstream of the proposed Wangcol Creek discharges that would provide suitable habitat for this species. Therefore, this species is considered to be unlikely to occur and is not considered further in this assessment.

Black Gum has been assessed within the aquatic ecology assessment due to the preference of this species for water logged conditions and the know presence of this species along Wangcol Creek. Black Gum typically grows on alluvial soils, on cold, poorly-drained flats and hollows adjacent to creeks and small rivers (Department of Sustainability and Environment, 2004). A number of records were identified along Wangcol Creek, however, all records are upstream of the proposed discharge point (Figure 5-2). The alluvial groundwater environment has been identified as discontinuous along Wangcol Creek with soil mapping indicating no alluvial material past the confluence of Wangcol and Neubecks Creek (Figure 7-2). Therefore, there is limited potential for this species to be present within the PAA. This species is, therefore, unlikely to be impacted by the Project and is not considered further in this assessment.

Veronica blakelyi have been identified in threatened species searches as potentially occurring within 10 km of the PAA and there is one record of this species in the vicinity of Wangcol Creek, downstream of the discharge point. There will be no impacts to water quality or velocity as a result of the Project that would impact on this species or reduce the potential for this species within the riparian zone of Wangcol Creek.

5.2 Migratory wetland species

The Department of the Environment *Protected Matters Search Tool* indicated four migratory wetland species have the potential to occur within 10 km of the PAA:

- Great Egret (*Ardea alba*).
- Cattle Egret (*Ardea ibis*).
- Latham's Snipe (*Gallinago hardwickii*).
- Osprey (*Pandion haliaetus*).

However, given that the Project is not predicted to reduce wetland or stream habitat (beyond cessation mine water discharges to Sawyers Swamp Creek), no further consideration of migratory species is given in this assessment.

5.3 Threatened populations

No threatened populations listed under the EPBC Act are relevant to aquatic ecosystems within the region.

5.4 Threatened ecological communities

Four threatened ecological communities listed under the EPBC Act were identified as having the potential to occur (may occur) in the PAA. These include:

- Natural Temperate Grassland of the South eastern Highlands (EPBC Act, critically endangered ecological community).
- Temperate Highland Peat Swamps on Sandstone (EPBC Act, endangered ecological community).
- Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion (EPBC Act, endangered ecological community).
- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland (TSC Act and EPBC Act, critically endangered ecological community).

Additionally, the SEARs specifically requested that impacts to the following vegetation communities are considered:

- Blue Mountains Swamps in the Sydney Basin Bioregion.
- Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregion.
- Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion.

These threatened ecological communities are not associated with aquatic ecosystems or not present within the waterways of the IAA and therefore have not been considered any further in this assessment. An impact assessment of terrestrial vegetation has been undertaken within the Biodiversity Assessment Report (RPS, 2016).

The vegetation community Mountain Hollow Grassy Fen, has been previously observed as a wetland associated with the confluence of Neubecks Creek and Wangcol Creek (RPS, 2014). This vegetation is commensurate with the TSC Act listed endangered ecological community Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions (RPS, 2014). The location of this EEC is upstream of the proposed discharge point, and, thus, will not be impacted by the Project.

5.5 Key threatening processes

A 'key threatening process' (KTP) is a threatening process specified in Schedule 6 of the FM Act. A 'threatening process' is "a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities". Potentially relevant KTPs to this Project under the FM Act, TSC Act and EPBC Act are listed below.

There are currently eight KTPs listed under the FM Act and of these, the following four are potentially relevant to this Project:

1. Degradation of native riparian vegetation along NSW water courses.
2. Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.
3. Removal of large woody debris from NSW rivers and streams.
4. The introduction of fish to fresh waters within a river catchment outside their natural range.

There are currently 37 KTPs listed under the TSC Act and of these, the following three are potentially relevant to aquatic ecosystems:

1. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.
2. Clearing of native vegetation.
3. Predation by *Gambusia holbrooki* (plague minnow or mosquito fish).

A summary of these KTPs and relevance to the Project is provided in Table 5-3. Relevant KTPs for this Project and specific mitigation measures to minimise potential adverse impacts on the riparian and aquatic environment are discussed in more detail in Section 11.

Table 5-3 Key threatening processes relevant to the Project

Act	Reference no.	Key threatening process	Relevance to the Project	Likelihood/further consideration required
FM Act	1	Degradation of native riparian vegetation along NSW water courses	There will be no degradation of native riparian vegetation along NSW water courses as a result of the proposed discharges. The Project contains a provision for rehabilitation of the riparian zone along Wangcol Creek and key sections of Coxs River. Any degradation of native riparian vegetation due to the construction of the pipeline or the wastewater treatment plant is assessed in the Biodiversity Assessment Report (RPS, 2016).	Low No further consideration required
FM Act	2	Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams	The Project will result in new discharges ranging between 0 and 32 ML/day into Wangcol Creek, with new discharge infrastructure adjacent to the current LDP006 discharge. The Project will result in the cessation of LDP009 discharges into Sawyers Swamp Creek. This represents a change back towards natural flow regime for this system. The likelihood of this KTP being applicable due to Project activities is considered high and will require further consideration in regards to the operational flow regime.	High Yes, refer to Section 8.2

Act	Reference no.	Key threatening process	Relevance to the Project	Likelihood/further consideration required
FM Act	3	Removal of large woody debris from NSW rivers and streams	There is no expectation of physical removal or manipulations of Wangcol Creek or Coxs River as part of the Project. Modifications are planned to the Lamberts Gully channel, however, this channel is already highly disturbed. The likelihood of this KTP being applicable due to Project activities is considered low in consideration of the above and no further consideration is required.	Low No further consideration required
FM Act	4	The introduction of fish to fresh waters within a river catchment outside their natural range	The introduced Mosquito fish (*Gambusia holbrooki*) has been recorded at sites on Coxs River and Wangcol Creek. The introduced Brown Trout (*Salmo trutta*) have been observed at Coxs River sites downstream of Sawyers Swamp Creek. The likelihood of this KTP being applicable due to Project activities is considered low as: • Gambusia already exists within Wangcol Creek and Coxs River • The additional flows are not likely to improve passage to existing fish barriers within the waterways affected. The additional flows may increase the fish habitat within Wangcol Creek and Coxs River between the Wangcol Creek and Sawyers Swamp Creek confluence, temporarily. However, Wangcol Creek does not provide suitable habitat for Brown Trout	Low Yes, refer to Sections 8.2.1, 8.2.2
TSC Act	1	Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	Refer to FM Act KTP No. 2 for further details. The likelihood of this KTP being applicable due to Project activities is considered high and will require further consideration in regards to the operational flow regime.	High Yes, refer to Section 8

Act	Reference no.	Key threatening process	Relevance to the Project	Likelihood/further consideration required
TSC Act	2	Clearing of native vegetation	Refer to FM Act KTP No. 1 for further details. The clearing of native riparian vegetation in connection with the Project is assessed in the Biodiversity Assessment Report (RPS, 2016).	Not relevant to this assessment, refer to RPS (2016)
TSC Act	3	Predation by *Gambusia holbrooki* (plague minnow or mosquito fish)	The introduced Mosquito fish (*Gambusia holbrooki*) has been recorded at sites on Coxs River and Wangcol Creek. This KTP is related to potential issues associated with predation of tadpoles by the mosquito fish. Frogs and impacts on frogs have not been considered within this assessment. Refer to the Biodiversity Assessment Report (RPS, 2016) for a discussion on potential impacts of the Project on frogs.	Not relevant to this assessment, refer to RPS (2016)