APPENDIX K – Environmental Impact Statement

Aquatic ecology assessment

Prepared for Lake Lyell Project Pty Ltd

a u s t r a l

research and consulting

Lake Lyell Pumped Hydro Energy Storage Project

Aquatic ecology assessment

November 2025

a u s t r a l

research and consulting

Lake Lyell Pumped Hydro Energy Storage Project

Aquatic ecology assessment

Rev 5, 20 November 2025

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Executive Summary

EnergyAustralia Portfolio Holdings Pty Ltd (EnergyAustralia) in partnership with EDF power solutions Australia (EDFA), referred to as Lake Lyell Project Pty Ltd (LLP) as trustee, is developing the Lake Lyell Pumped Hydro Energy Storage (PHES) Project (the project), a project that will have the capacity to store up to 3,080 megawatt hours (MWh) of energy and generate at 385 megawatts (MW) for 8 hours or generate up to around 440 MW for a shorter period. At a basic level, it will consist of upper and lower water reservoirs, a pipeline connecting them, and a hydro-electric power station connected to the national energy grid that is capable of generating or consuming electricity.

The project is subject to Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which requires the preparation of an environmental impact statement (EIS) in accordance with Secretary's environmental assessment requirements (SEARs) and the approval of the Minister. Austral Research and Consulting was engaged to undertake an *Aquatic Ecology Assessment* that supports the EIS for the project.

The aim of the *Aquatic Ecology Assessment* was to determine whether construction and operation of the project is likely to have significant impacts on key fish habitat (KFH), listed habitats, threatened aquatic communities, populations or species, or subterranean ecology, and to provide advice on mitigation and management measures capable of reducing impacts to these environmental values during construction and operation of the project, including offset requirements.

Detailed descriptions of aquatic ecological values within Lake Lyell, the Coxs River, Farmers Creek and Collits Swamp Creek, based on a desktop study and field surveys, are provided in this report.

The desktop assessment revealed that no aquatic species listed under the *Fisheries Management Act 1994* (FM Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are recorded to occur within the broader project area.

The desktop assessment and field surveys revealed that platypus are prevalent throughout the broader project area. Given the cultural and community significance of platypus, an assessment of likely impacts to platypus resulting from the project was undertaken and detailed mitigation measures are provided to minimise impacts to the species.

Habitat assessments undertaken across the project area found that all sites across each waterbody warranted classification as Type 1 highly sensitive KFH and Class 1 major KFH, due to the sites containing in-stream snags and/or native aquatic plants and permanent flow. Aquatic habitat such as macrophytes and instream woody debris (IWD), and habitat complexity, was sufficient to support the requirements of many aquatic species. However, none of the sites were recognised as providing habitat critical to the survival of any given species.

Aquatic surveys (including Environmental DNA (eDNA) surveys) were undertaken in accordance with the *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act* (Department of Sustainability, Environment, Water, Population and Communities, 2011), targeting appropriate habitat and using best practice survey methods. eDNA detects trace DNA of living organisms within aquatic ecosystems. No listed fish species were detected within Lake Lyell, the Coxs River, Farmers Creek or Collits Swamp Creek. As such, it is considered unlikely that the project area supports fish species listed under either the FM Act or EPBC Act.

Analyses of physical parameters from water and sediment samples indicated substantial variability between sites. Water quality analyses indicated that all critical parameters assessed, including concentrations of dissolved metals and trace elements, were either below or within acceptable analytical limits. Similarly, most parameter estimates associated with sediments did not exceed acceptable analytical limits, except for dissolved metals and trace elements. The concentrations of 13 out of 18 metals exceeded recommended thresholds for sediments as stated in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) and *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (Water Quality Australia, 2018) across all sites and waterways, indicating aquatic sediments associated with the project area contain elevated levels of heavy metals.

Surveys of aquatic algae and macrophytes found that species diversity and relative abundances were variable across all sites and waterways within the project area. However, none of the taxa recorded are considered threatened or have restricted distributions.

Macroinvertebrate derived river health scores varied between sites. Evidence of impacts to sensitive taxa sampled were evident at riffle habitats at some sites downstream of Lake Lyell on the Coxs River but not at upstream sites, indicating reduced river health at downstream sites. In contrast, clear reductions in abundance and diversity of sensitive taxa were evident across all sites from Farmers Creek, leading to poor river health scores across that waterway within the project area, pointing to existing impacts that may be attributed to land use impacts from the broader catchment. No stygofauna were detected in any bore across any survey event.

Targeted platypus surveys detected a total of 17 animals from the Farmers Creek and Coxs River arms of Lake Lyell. Tagged platypus had preferred, localised ranges and there was no recorded movement of platypus between the Coxs River and Farmers Creek. Tagging and tracking of platypus to analyse movement behaviour (within the Farmers Creek arm of Lake Lyell) showed the animals to be primarily utilising burrows located within Farmers Creek proper, although some platypus were observed to be utilising burrows within the Farmers Creek arm of Lake Lyell.

The majority of burrows were located in Farmers Creek which provides more suitable and stable habitat. Tracking analyses also confirmed that platypus spend most of their time benthic foraging within Lake Lyell at depths of up to 3 metres (m), with occasional dive depths up to 5 m. eDNA analyses detected evidence of platypus DNA in both the Coxs River and Farmers Creek arms of Lake Lyell.

Based on the findings from the desktop review and the collection of field data, we identify and summarise the potential pathways for direct and indirect impacts of construction and operation activities associated with the project, including proposed water fluctuations on key aquatic values and environmental receptors within Lake Lyell and associated waterways. These include:

- direct loss of riparian habitat
- direct loss of KFH
- direct loss of platypus habitat
- potential barriers to fish and platypus passage
- impacts to water quality and waterway health
- direct impacts to non-listed, native fish species
- potential disturbance of platypus foraging and supporting food webs
- disruption of species life cycles and trophic interactions.

Risks are summarised for specific project elements relevant to aquatic values, including:

- lake diversion
- Lake Lyell drawdown
- temporary and permanent waterway crossings
- cofferdams
- ancillary infrastructure including sediment basins, portal pads, access roads, etc.
- temporary and permanent waterway crossings
- inlet outlet structures including stockpiles and laydown area
- the high voltage switching yard including laydown area
- the accommodation camp.

For each of the project elements we provide a description of the proposed construction and operation activities (where relevant), potential risks of specific activities relevant to aquatic values and environmental receptors, and proposed mitigation measures.

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Abbreviations

The following abbreviations have been used:

ALA	Atlas of Living Australia
ALS	Australian Laboratory Group
ANZECC	Australia and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian River Assessment System
Austral	Austral Research & Consulting
AWQC	Australian Water Quality Centre
BoM	Bureau of Meteorology
cm	centimetre
CPI	Consumer price index
Commonwealth DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
NSW DCCEEW	New South Wales Department of Climate Change, Energy, the Environment and Water
DGV	Default guideline values
DNA	Deoxyribonucleic acid
DO	Dissolved Oxygen
DPI	Department of Primary Industries
DPHI	Department of Planning, Housing and Infrastructure
eDNA	Environmental deoxyribonucleic acid
EIS	Environmental Impact Statement
EPBC	Environment Protection and Biodiversity Conservation
FM	Fisheries Management
GDE	Groundwater dependent ecosystem
GPS	Global positioning system
IUCN	International Union for Conservation of Nature
IWD	Instream woody debris
km	Kilometres
LoO	likelihood of occurrence
LWD	Large Woody Debris
m	Metre
mbgl	Metres below ground level
MDS	Multidimensional scaling
mg	Milligrams
mg/l	Milligrams per Litre
ml	Millilitres
ML	Megalitres

MNES	Matters of national environmental significance
mtDNA	Mitochondrial DNA
NPWS	National Parks and Wildlife Service
NSW	New South Wales
ntu	Nephelometric Turbidity Units
OTU	Operational Taxonomic Units
PCR	Polymerase Chain Reaction
PHES	Pumped Hydro Electric Scheme
PIT	Passive integrated transponder
PMST	Protected Matters Search Tool
qPCR	quantitative Polymerase Chain Reaction
Sp.	Species
SCA	Sydney Catchment Authority
SEARs	Secretary's Environmental Assessment Requirement
SGDE	Subsurface groundwater dependent ecosystem
SIGNAL	Stream Invertebrate Grade Average Level
STP	sewage treatment plant
TDS	Total dissolved solids
TN	Total nitrogen
TP	Total phosphorus
TVI	Total volume index
WM	Water Management
WQO	Water Quality Objectives
µm	micrometers
µS/cm	Microsiemens per centimetre
°C	Degrees Celsius

Glossary

The following glossary have been included for technical terms used within the report:

Amphidromous	Amphidromous fish is used to describe a type of diadromous fish that migrates between fresh and marine (including estuaries) environments for reasons other than breeding.
Anadromous	Anadromous fish hatch and spend part of the larval and juvenile lifecycle in freshwater prior to migrating to the estuarine and marine environments to grow and mature. Anadromous fish spend most of their life in the marine environment.
Catadromous	Catadromous fish hatches and spend part of the larval and juvenile lifecycle in saltwater prior to migrating to freshwater to grow and mature. Catadromous fish spend most of their life in the freshwater environment.
Diadromous	Diadromous fish migrate between freshwater and salt water and includes to both anadromous and catadromous fishes.
Potamodromous	Potamodromous fish spend their entire lifecycle in freshwater and undertake migrations which may include short or long term movement for spawning.

1. Introduction

EnergyAustralia Portfolio Holdings Pty Ltd (EnergyAustralia) in partnership with EDF power solutions Australia (EDFA), referred to as Lake Lyell Project Pty Ltd (LLP) as trustee, is developing the Lake Lyell Pumped Hydro Energy Storage (PHES) Project (the project), a project that will have the capacity to store up to 3,080 megawatt hours (MWh) of energy and generate at 385 megawatts (MW) for 8 hours or generate up to around 440 MW for a shorter period. At a basic level, it will consist of upper and lower water reservoirs, a pipeline connecting them, and a hydro-electric power station connected to the national energy grid that is capable of generating or consuming electricity.

The project is located approximately 5 kilometres (km) west of Lithgow and 110 km west of the Sydney central business district, shown in Figure 1 and Figure 2. The project takes advantage of existing infrastructure (i.e. Lake Lyell) associated with Mt Piper power station which will be decommissioned in the coming decades and allows Lake Lyell to continue to serve a specific purpose in electricity generation (consistent with its existing use).

In June 2024, the Minister for Planning and Public Spaces declared the project to be critical State significant infrastructure (CSSI). Accordingly, approval for the project is required under Part 5, Division 5.2 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). This requires the preparation of an environmental impact statement (EIS) for the project in accordance with Secretary's environmental assessment requirements (SEARs) and the approval of the Minister. EMM Consulting Pty Limited (EMM) has been engaged by EnergyAustralia to prepare the EIS.

This *Aquatic Ecology Assessment* is an appendix to the project's EIS and should be read in conjunction with it. The *Aquatic Ecology Assessment* addresses the SEARs issued for the project.

1.1. Project location

Lake Lyell lies within the South-Eastern Highlands bioregion and is bounded by the Sydney Basin, the South East Corner and Australian Alps bioregions to the south and the South Western Slopes bioregion to the west and north (refer to Figure 3) (Department of Climate Change, Energy, the Environment and Water, 2023a; NSW National Parks and Wildlife Service, 2003). The South-Eastern Highlands bioregion includes most of the Australian Capital Territory (ACT) and extends south into Victoria (NSW National Parks and Wildlife Service, 2003). The total area of the South-Eastern Highlands bioregion is 8,749,155 hectares (ha) making up approximately 6.11% of the state of New South Wales (NSW). The project area lies within two subregions, Hill End and Bathurst. Hill End, which encompasses the northern portion of the project area, is characterised by hilly to mountainous plateaus becoming deeply entrenched into channels of the Turon and Macquarie rivers. The geology of the subregion consists of slates, sandstones and volcanic rock with numerous quartz veins running throughout.

The Hill End subregion is considered of ecological significance due to its location as a break in the Great Dividing Range. This gap provides a link between coastal and inland NSW including an overlap between tropical and temperate climate zones (Macfarlane, et al., 2016). The Bathurst subregion is characterised by a granite basin with rounded hills bounded by steep slopes. The geology of the subregion is primarily carboniferous granite with pockets of Tertiary basalt caps and Quaternary sands along the Macquarie River (Macfarlane, et al., 2016).

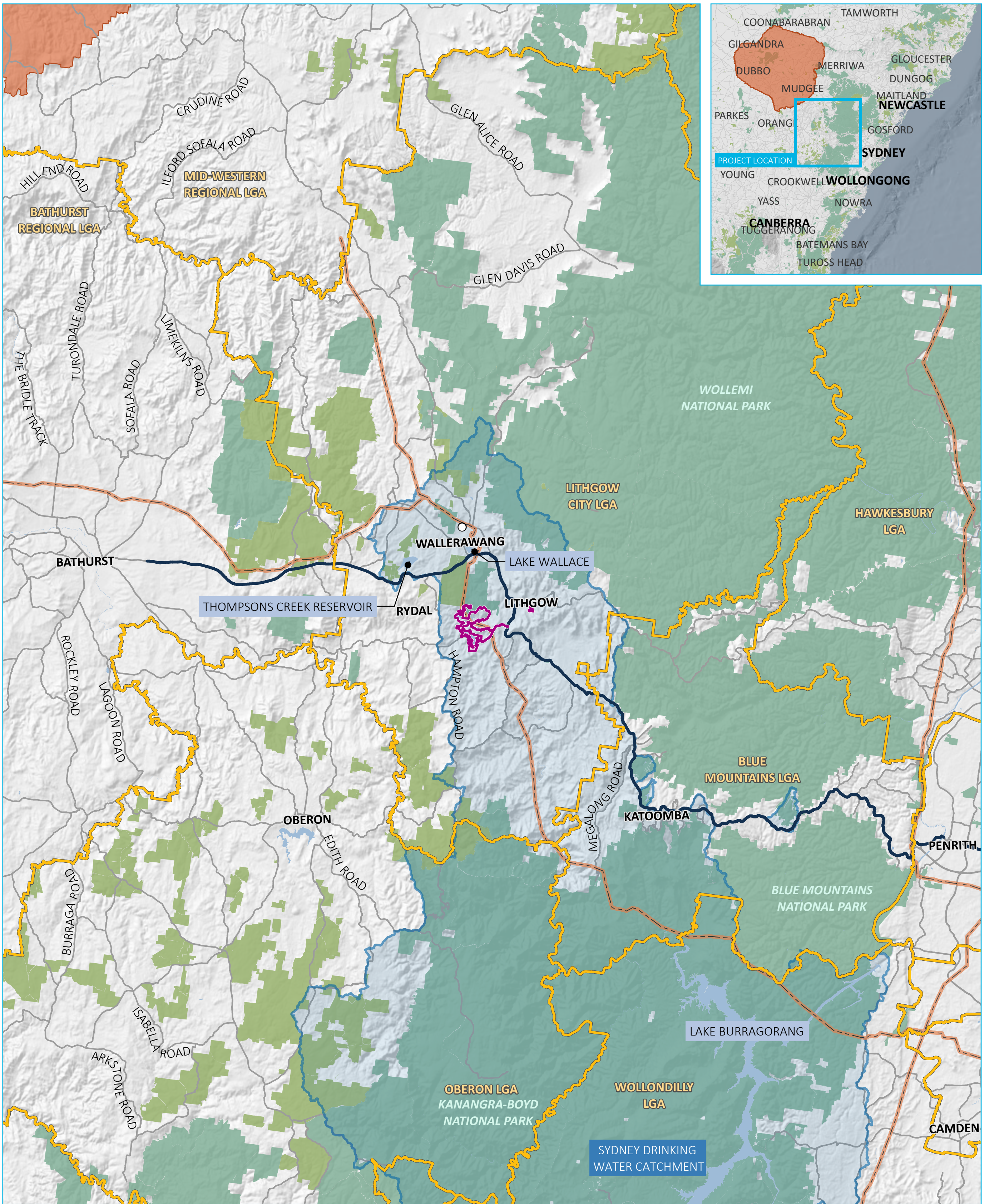
Lake Lyell specifically lies within the Hawkesbury-Nepean catchment which spans major rivers in the region including the Hawkesbury, Nepean, Wollondilly, Mulwaree, Tarlo, Wingecarribee, Nattai, Coxs, Kowmung, Grose, Colo and Macdonald (Department of Environment, Climate Change and Water, 2010a). The region provides the majority of the drinking water for over 4,000,000 people residing in Sydney, the Blue Mountains, the Southern Highlands, Lithgow Valley and the Central Coast (70 % of the NSW's population) (Department of Environment, Climate Change and Water, 2010a).

The Coxs River is a major tributary of the Hawkesbury-Nepean River system and is part of the Sydney Water Catchment Area (refer to Figure 2). The river is perennial and approximately 155 km long. It originates at Gardiners Gap, about 6 km east of Cullen Bullen, and flows generally south and then east, before entering Lake Burragorang, the largest of Sydney's water-supply reservoirs (Cardno, 2014a). The Coxs River has been impounded to form Lake Wallace and Lake Lyell, both of which serve to provide cooling water, among other uses, to Mt Piper (Bowmer, et al., 2007; Young, et al., 2000).

The former Sydney Catchment Authority (SCA) undertook an assessment of Sydney's drinking water catchment which includes the Coxs River catchment (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water, 2010b). The Upper Coxs catchment is considered to be under a high level of stress. Two local sewage treatment plants (STPs) located at Wallerawang and Lithgow are known to impact water quality locally (Department of Environment, Climate Change and Water, 2010b). A total of seven barriers to fish passage occur within the catchment and there is also geomorphological disturbance due to both current and historic mining operations. A number of areas are also known to be affected by dryland salinity (Department of Environment, Climate Change and Water, 2010b). Farmers Creek was identified as being impacted by the Lithgow STP, urban stormwater and road runoff. Unfortunately, as a result of both historic and continued extensive landuse along the Upper Coxs River catchment, the majority of the river reaches are highly degraded (Young, et al., 2000).

Judge (2013) describes the Upper Coxs catchment as "environmentally significant", with high biodiversity values indicating considerable flora and fauna values are present.

Lake Lyell is located on the Coxs River within the Upper Coxs River catchment. Lake Lyell is intersected by the Coxs River, Haystack Creek, Collits Swamp Creek, Sandals Creek and Farmers Creek (refer to Figure 2). Lake Lyell is recognised as a 6^{th} order waterway, as is the Coxs River, while Farmers Creek is a 4^{th} order stream (Strahler, 1952) (refer to Figure 4).



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Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); ABS (2021); DCSSS (2024); GA (2009); ESRI (2025)

0 10 20 km
GDA2020 MGA Zone 56
N

KEY

- Project area
- Existing environment
- Mt Piper Power Station
- Major road
- Great Western Highway
- 330 kV transmission line
- Named waterbody
- NPWS reserve
- State forest
- Local government area
- Sydney Drinking Water Catchment
- Central West Orana Renewable Energy Zone

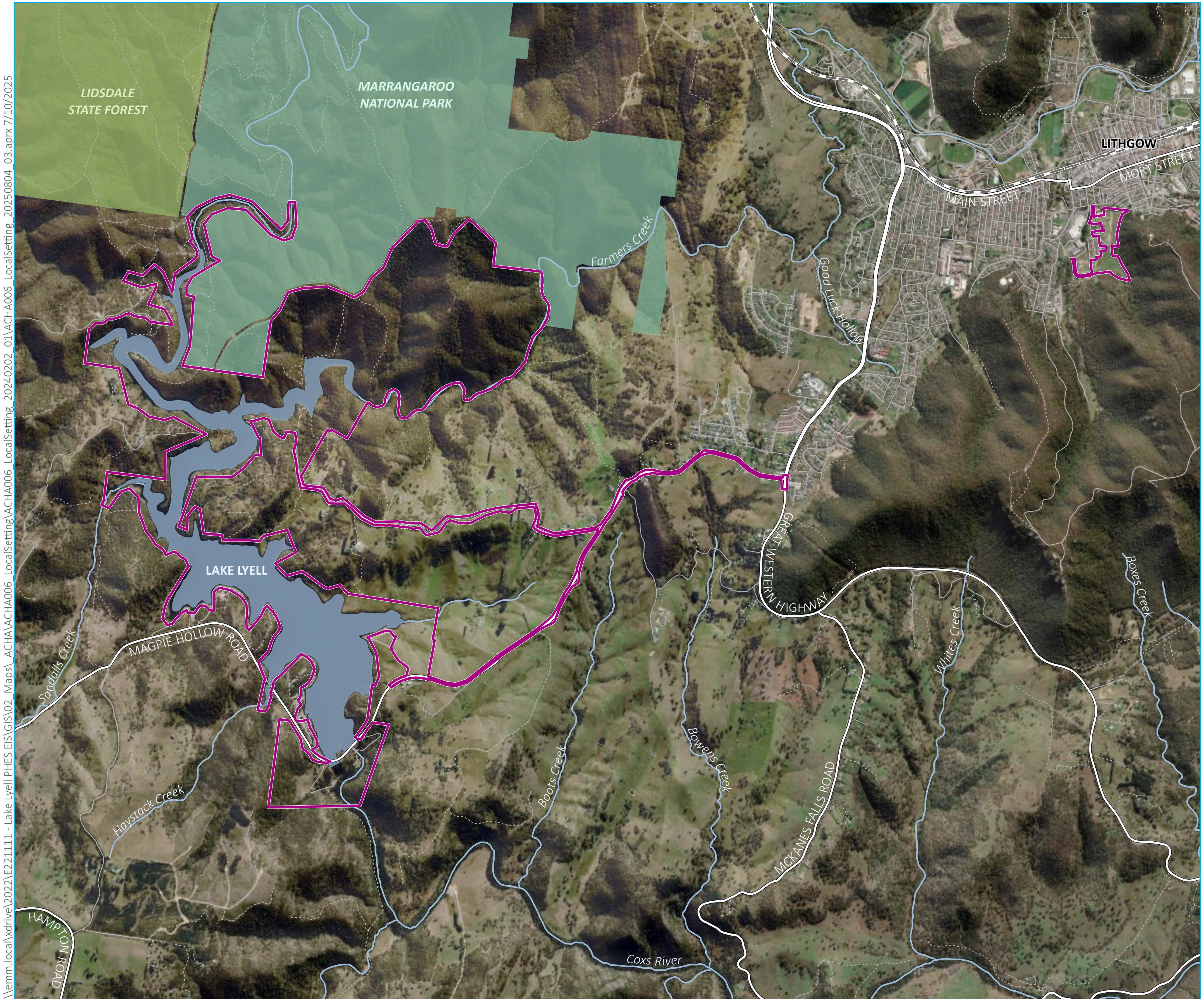
INSET KEY

- Major road
- NPWS reserve
- State forest
- Central West Orana Renewable Energy Zone

Regional context

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 1

EMM
creating opportunities



KEY

- Project area

Existing environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); ESRI (2025)

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Local context

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 2

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creating opportunities

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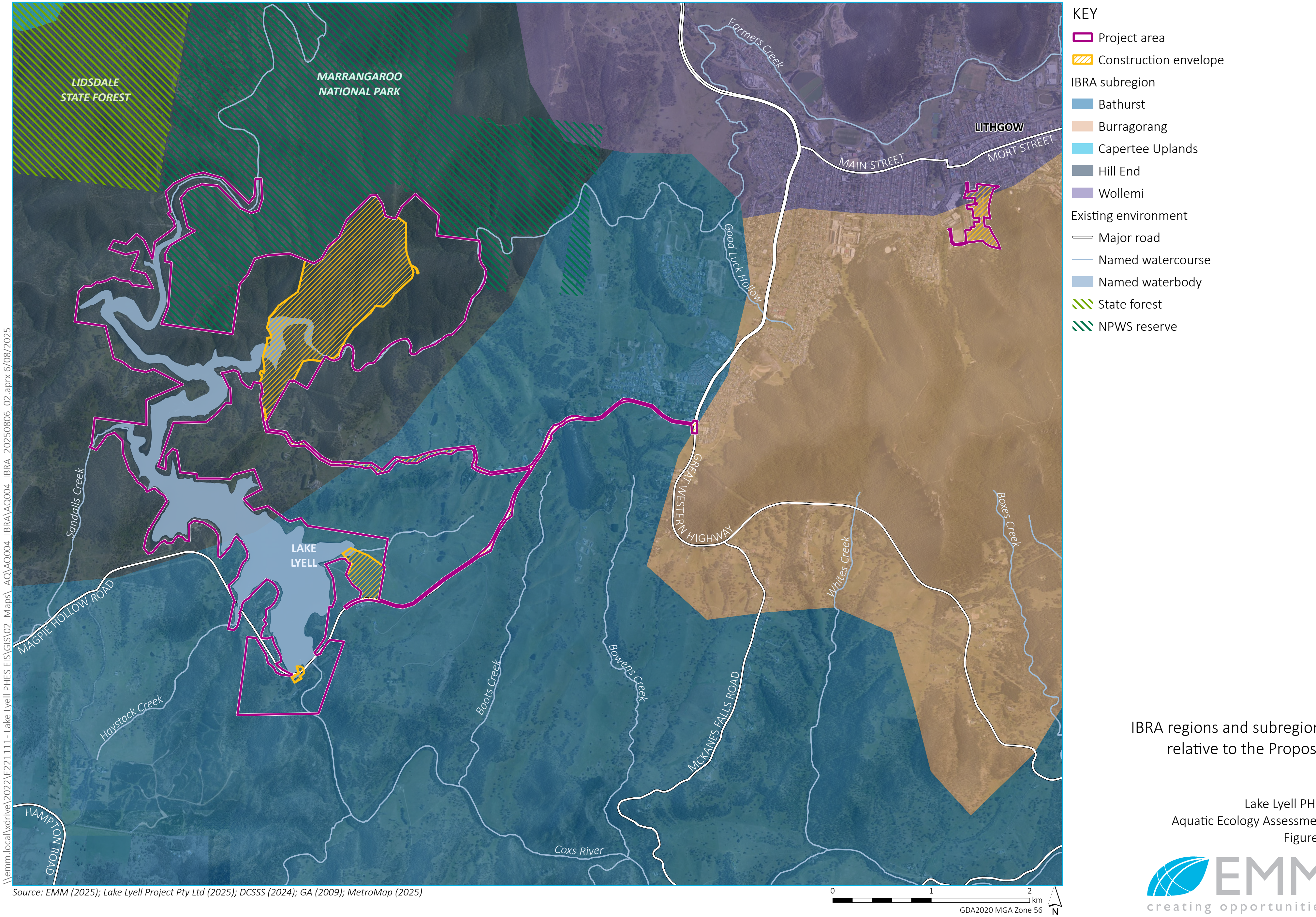

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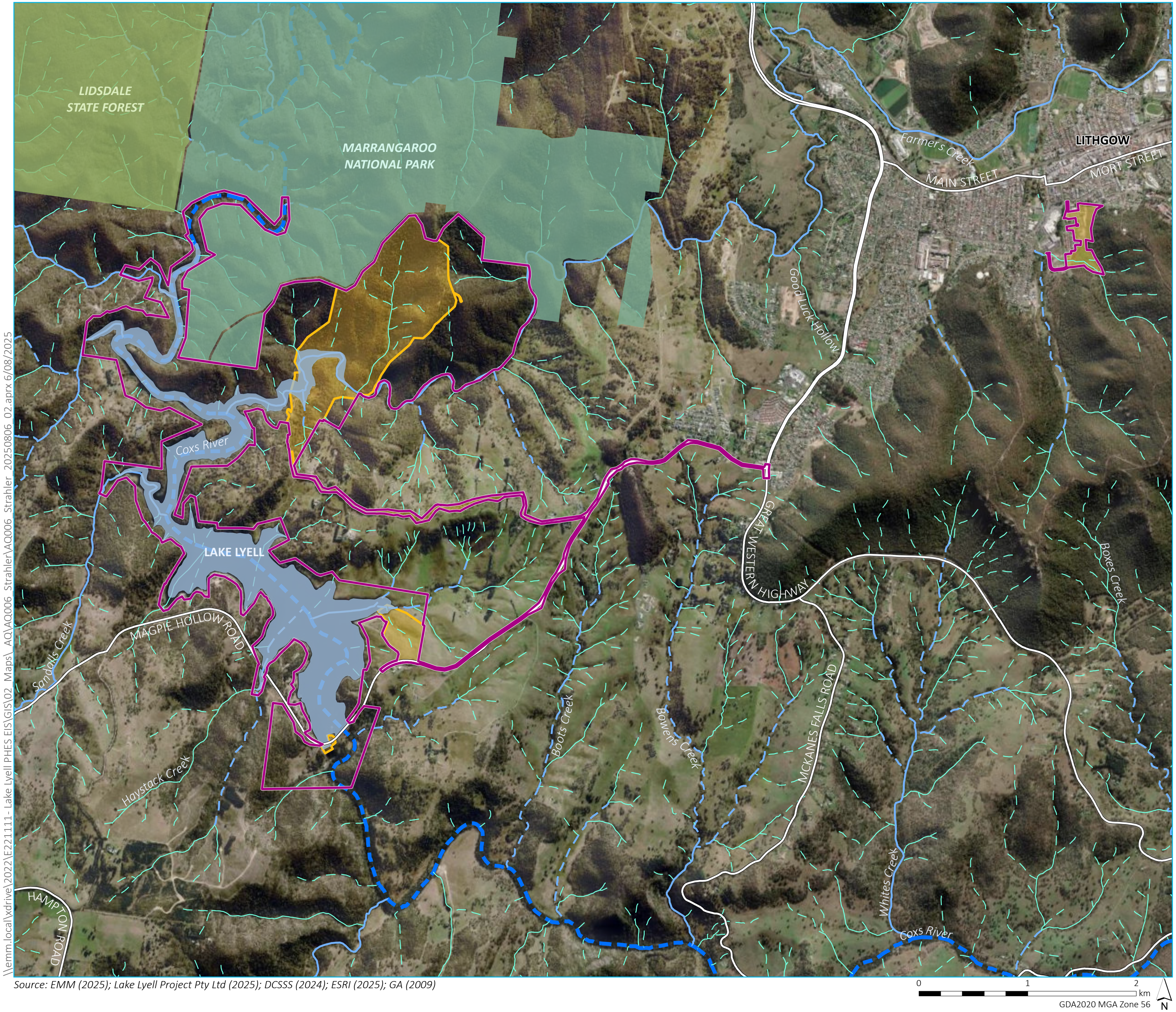
Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); MetroMap (2025)

IBRA regions and subregions relative to the Proposal

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 3

EMM creating opportunities



KEY

- Project area
- Construction envelope
- Strahler stream order
  - 1st order
  - 2nd order
  - 3rd order
  - 4th order
  - 6th order
- Existing environment
  - Major road
  - Named waterbody
  - NPWS reserve
  - State forest

Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); ESRI (2025); GA (2009)

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Strahler order for waterways relevant to the Project

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 4

creating opportunities

1.2. Aquatic ecology impact areas

To accommodate future optimisation and refinement to the design as it progresses, a ‘project area’, ‘construction envelope’, and ‘disturbance footprint’ approach have been defined for the project:

- The *project area* is a broader buffer around the project and represents the area that was investigated during the environmental assessments. The project area is largely confined to land owned by EnergyAustralia except for the primary access route on Council owned land. The project area includes both the land that will be physically disturbed for the project (directly and indirectly) as well as land where no disturbance or impact will occur.
- The *construction envelope* represents the maximum extent of where disturbance may occur during the construction of the project. To derive the construction envelope, buffers have been applied around project infrastructure and work areas to provide a level of flexibility where required. Some areas have reduced buffers due to environmental or design constraints.
- The *disturbance footprint* represents the physical disturbance that can be expected during the construction works. As the design is refined, the final siting of the disturbance footprint can move within the construction envelope, subject to the recommended environmental management measures, and provided it does not exceed any limits defined by the construction envelope or vegetation clearing thresholds.

1.3. Assessment guideline and requirements

This *Aquatic Ecology Assessment* supports the EIS for the project. It documents aquatic and subterranean ecology assessment methods and results (“*Aquatic Ecology Assessment*”). The initiatives built into the project design to avoid and minimise associated environmental impacts are presented. The mitigation and management measures, including offset requirements, proposed to address any unavoidable residual impacts are considered.

This *Aquatic Ecology Assessment* has been prepared with reference to relevant guidelines, policies and industry requirements, and following consultation with stakeholders, including relevant government agencies and the community. Guidelines and policies referenced are as follows:

- Policy and guidelines for fish habitat conservation and management (Department of Primary Industries, 2013).
- *Survey guidelines for Australia’s threatened fish: Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Department of Sustainability, Environment, Water, Population and Communities, 2011).
- NSW Biodiversity Offsets Policy for Major Projects. Factsheet: Aquatic biodiversity (Department of Primary Industries, 2014).
- NSW Aquifer Interference Policy (Department of Primary Industries, 2012a).

- The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002).
- Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework (Department of Primary Industries, 2012b), as well as associated guidelines in this series (where applicable).
- Guidelines for controlled activities on waterfront land: Riparian corridors (Department of Primary Industries, 2019).
- Matters of National Environmental Significance (MNES) Significant impact guidelines 1.1 (Department of the Environment, 2013).

The aim of the *Aquatic Ecology Assessment* was to determine whether construction and operation of the project is likely to have significant impacts on key fish habitat (KFH), listed habitats, threatened aquatic communities, populations, species, or subterranean ecology. The specific objectives of this assessment were to:

- describe existing aquatic and subterranean biodiversity values and habitats
- identify and assess the potential occurrence of aquatic biodiversity values relevant to the project, including threatened species, populations and communities listed under the NSW *Fisheries Management Act 1994* (FM Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and associated policies and guidance material
- identify and assess the potential for occurrence of subterranean biodiversity values within the project area, in accordance with the NSW *Water Management Act 2000* (WM Act) and associated polices and guidance material
- identify potential direct, indirect and cumulative impacts of the project on aquatic and subterranean biodiversity
- provide mitigation measures to reduce the impacts from the project on aquatic and subterranean biodiversity where possible/relevant
- consider appropriate compensatory measures (aquatic offsets), where impacts are unavoidable.

Austral has ensured that the aim and objectives of the *Aquatic Ecology Assessment* have been addressed to a standard suitable for assessment by relevant regulators, following best practice and in accordance with relevant legislation, policy and guidance material, summarised in Section 1.3.1.

1.3.1. SEARs and agency engagement

This *Aquatic Ecology Assessment* has been prepared in accordance with the SEARs for the project, as well as relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. To inform preparation of the SEARs, the NSW Department of Planning, Housing and Infrastructure (DPHI) invited relevant government agencies to advise on matters to be addressed in the EIS. These matters were considered by the Secretary for DPHI when preparing the SEARs. Table 1 lists the matters relevant to this assessment and where they are addressed in this report.

The project team met with the Department of Primary Industries Fisheries (DPI Fisheries) in November 2023 to introduce the project and present proposed survey methods and design. Further information was requested, once available, pertaining to the diversion of Farmers Creek arm of Lake Lyell, the design of the intake structure, and other relevant construction and operational management details.

A follow up meeting was held in October 2025 and included:

- presentation of survey effort and findings
- discussion on diversion and inlet designs, with DPI Fisheries feedback to recommend deeper pools in diversion to minimise risks of stranding, need to manage/offset entrainment risks, and discussion on KFH loss during operation
- discussion on KFH offset strategy, with DPI Fisheries agreeing in principle support for catchment level initiatives and re-stocking

Table 1: Matters for consideration relating to aquatic ecology and groundwater-dependent ecosystems raised in the SEARs

Requirement	Source	Chapter / Section addressed
Water and soils		
10. The EIS must assess the impact of the project on hydrology, including: B. effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas C. effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems D. impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	Biodiversity, Conservation and Science Directorate / NPWS – Appendix A 'Standard Environmental Assessment Requirements'	Section 8
Aquatic Biodiversity		
• an assessment of the likely impacts on listed aquatic threatened species, populations or ecological communities, scheduled under the *Fisheries Management Act 1994* (FM Act), and a description of the measures to minimise and rehabilitate impacts, including impacts to Lake Lyell, Coxs River and Farmers Creek • a cumulative impact assessment of biodiversity values in the region from nearby developments.	SEARs Key issues - biodiversity	Section 8
An aquatic ecological assessment is required that addresses all direct and indirect impacts of the Lake Lyell Pumped Hydro project on KFH and associated flora and fauna including threatened species, populations, and communities during construction and operation for the life of the asset. The Aquatic Ecological Assessment should cover the assessment	DPI Fisheries	Section 7 Section 8 Section 10

Requirement	Source	Chapter / Section addressed
requirements outlined in Chapter 3 of the Policy and Guidelines for Fish Habitat Conservation and Management (2013) including: • recent aerial photograph (preferably colour), map or GIS of the locality which details the KFH of the development site, all habitats impacted by the development, and waterway classification (CLASS) as defined in Tables 1 and 2 of the Policy and Guidelines for Fish Habitat Conservation and Management (2013) • mapping of the full aerial extent of KFH types that will be impacted either directly or indirectly by the development and subsequent operation of the Lake Lyell Pumped Hydro project, with impacted habitats clearly identified on recent aerial photographs, maps or GIS • description, quantification, and mapping of all aquatic and riparian vegetation communities potentially impacted by the development, including that of the lake foreshore. This should include an assessment of the extent and condition of aquatic and riparian vegetation and the presence of significant habitat features (e.g. gravel beds, snags, reed beds, rock bars, etc) • quantification of the extent of aquatic and riparian habitat removal, modification or inundation (whether temporary or permanent) that will result from the proposed development within and outside the footprint of the development (including lake foreshore) • development of mitigation measures during construction (e.g. Environmental Management Plans) and operation (e.g. Operational Management Plan) including monitoring of proposed mitigation measures and plans to confirm their effectiveness • an assessment is required of impacts during construction and operation of the Lake Lyell Pumped Hydro project on lake hydrology, hydraulics, geomorphology, and water quality, and associated impacts on lake ecological communities • lake hydrology - Alteration to the natural flow regimes of rivers is recognised as a major contributing factor to the loss of biological diversity and ecological function in		

Requirement	Source	Chapter / Section addressed
aquatic ecosystems and is considered a Key Threatening Process (The Installation and Operation of Instream Structures that alter Natural Flow Regimes of Rivers and Streams) under the FMA 1994. Specification of the Lake Lyell Pumped Hydro project operational protocol is required for the EIS to allow modelling and assessment of impacts of the altered lake hydrology (frequency, duration, timing) on aquatic and riparian ecosystems. The assessment should include an analysis of impacts on aquatic species life cycles processes including the potential disruption of environmental cues for fish migration and spawning, as well as the potential exposure of fish spawning nests, aquatic vegetation, snags, and other hard substrate (e.g. rocks) within the storage • lake hydraulics, Water Quality, and Geomorphology - The Lake Lyell Pumped Hydro project will need to quantify the impacts of altered lake hydraulics on associated aquatic and riparian flora and fauna. The assessment must also consider water quality impacts, including storage nutrification, stratification and the potential for blue green algal issues, with mitigation strategies provided to limit identified impacts. Finally, a geomorphic assessment is required of the impacts of the Lake Lyell Pumped Hydro operations and the potential for bank slumping or erosion to occur within the lake foreshore • description of Water Quality Objectives (NSW WQO) and how these objectives will be achieved for receiving waters downstream and within the lake, noting there should be no net increase in sediment/nutrient loads entering watercourses • details of water quality monitoring programs identifying monitoring locations, equipment, and protocols (e.g. frequency and duration). THREATENED SPECIES, POPULATIONS AND ECOLOGICAL COMMUNITIES An assessment under Part 7A of the FM Act 1994 is required to address whether there are likely to be any significant impacts on listed threatened species, populations or ecological communities.		

Requirement	Source	Chapter / Section addressed
Assessment of the impacts may require initial 'Seven-Part Test's. Updated Threatened species distributions can be found at www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps. NSW BIODIVERSITY OFFSETS POLICY: AQUATIC BIODIVERSITY An Aquatic Biodiversity Offsets Strategy may be required that is adequately funded to mitigate and manage impacts of the Lake Lyell Pumped Hydro project during construction and subsequent operation. The EIS aquatic ecological assessment will determine all direct and indirect impacts of the Lake Lyell Pumped Hydro Project on KFH. The Policy and Guidelines for Fish Habitat Conservation and Management (2013) requires a minimum 2:1 offset for Type 1–3 KFHs to help redress identified impacts. The NSW Biodiversity Offsets Policy for Major Projects outlines requirements for site-based offsets to compensate for the loss of each aquatic habitat type, and/or payment (currently $114.40 m-2 adjusted yearly with CPI) to the NSW DPI Fish Conservation Trust Fund to compensate for the value of the aquatic habitat being lost. The EIS should address whether an Aquatic Biodiversity Offsets Strategy that is adequately funded that ensures a minimum 2:1 offset for impacted Type 1-3 KFHs is required.		
Lake Lyell Pumped Hydro Energy Storage project, Lithgow, NSW (2022/09445) – controlled action. • listed threatened species and communities (sections 18 & 18A) • listed migratory species (sections 20 & 20A).	Commonwealth DCCEEW	Section 5

1.3.2. Other relevant reports

This *Aquatic Ecology Assessment* report has been prepared with reference to other technical reports prepared for the project, listed below:

- *Appendix B of the EIS: Project description* (EMM Consulting Pty Limited, 2025a).
- *Lake Lyell Pumped Hydro Energy Storage Project Biodiversity Development Assessment Report* (EMM Consulting Pty Limited, 2025d).
- *Lake Lyell Pumped Hydro Energy Storage Project Surface Water Assessment* (EMM Consulting Pty Limited, 2025b).
- *Lake Lyell Pumped Hydro Energy Storage Project Groundwater Impact Assessment* (EMM Consulting Pty Limited, 2025c).

2. The project

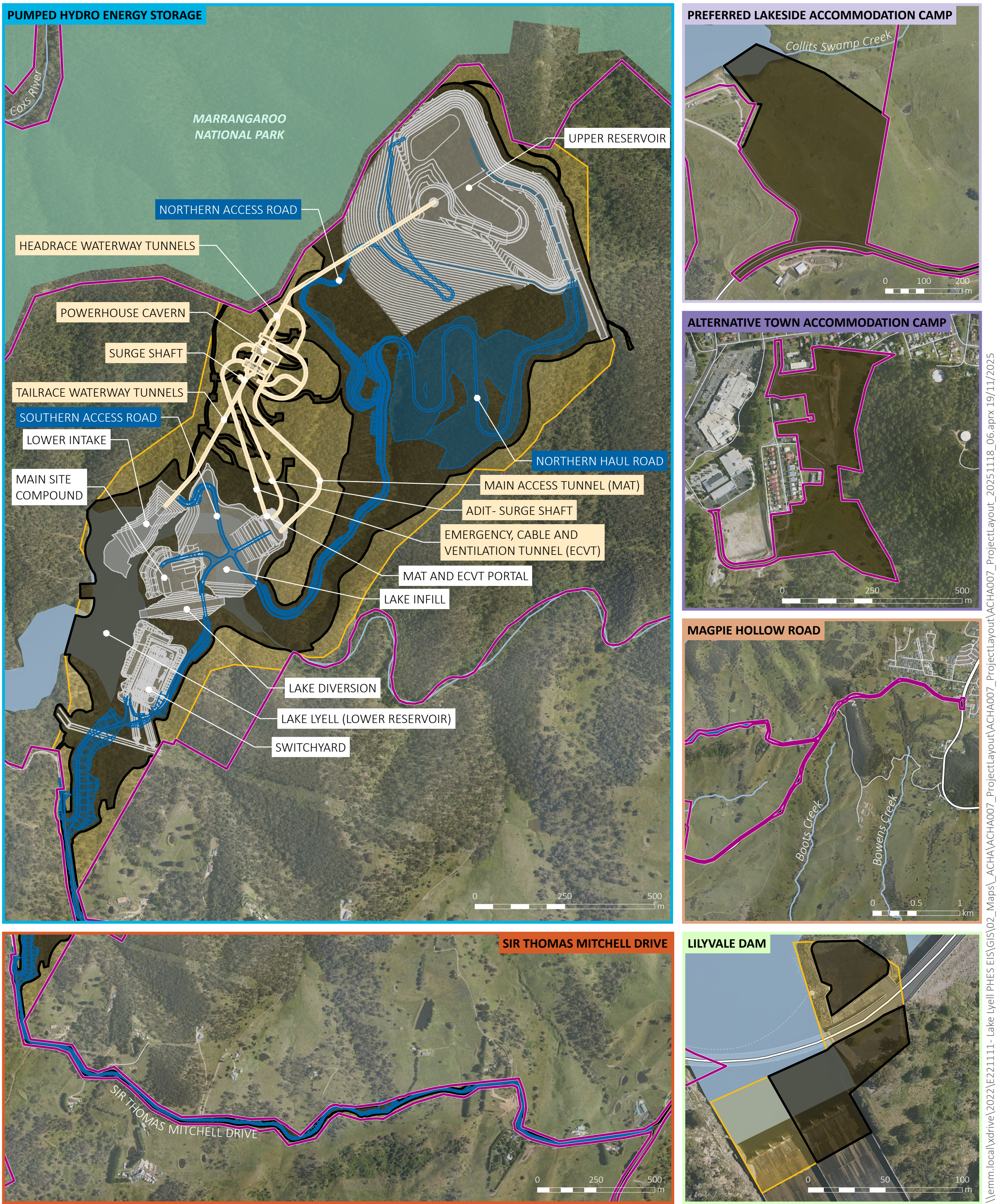
A detailed description of the project, including an overview of its design, construction and operation is provided in the project's environmental impact statement (EIS). The EIS (specifically Chapter 3 and Appendix B) should be read in conjunction with this report. A summary of the project's key elements is provided below.

The project design, as shown in Figure 5, can be broadly categorised into:

- pumped hydro generation components – including a 5.3 gigalitres (GL) upper reservoir to be constructed behind the southern ridge of Mount Walker, a 33.5 GL lower reservoir (existing Lake Lyell), inlet/outlet structures, and an underground powerhouse, surge shaft and waterway tunnels
- transmission connection components – including a new high voltage switchyard and connection to the existing 330 kilovolt (kV) transmission line that runs through the site
- site access and ancillary facilities – including upgrade of existing and construction of new access roads and bridges, a diversion and infill of a section of Lake Lyell, administration and utilities
- other construction components or works – including geotechnical investigations, temporary workforce accommodation, site work pads, laydown areas and facilities, and spoil management
- construction will be completed in stages, including:
    - pre-construction / enabling works – consisting of initial access works (internal and external roads), geotechnical investigations, site establishment and preparation of the worker's accommodation camp
    - main works – consisting of all other construction activities needed to enable operation of the project.

During operation, the project will act as an electrical energy storage system through the conversion of electrical to kinetic energy to gravitational energy and back via water as it is transferred from the elevated upper reservoir to a lower reservoir. The project will provide services to the wholesale 'spot' market on the national electricity market (NEM), and support ancillary services used to manage the power system reliably.

After the 80 to 100-year design life of the project, the asset may remain viable for a plant refurbishment and extension of life as has been seen for other older assets globally. Following the plants final refurbishment or once it has reached the end of its serviceable life then the project would look to return the site to a more natural state and encourage community beneficial use.



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); MetroMap (2025)

GDA2020 MGA Zone 56

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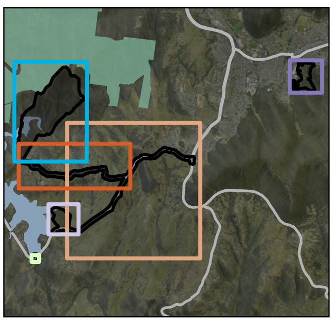


KEY

- Project area
- Permanent road
- Above ground design
- Underground design
- Construction envelope
- Disturbance footprint

Existing environment

- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve

Project overview

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 5

EMM
creating opportunities

2.1.1. Water level fluctuations

A full pump cycle will draw the existing lake water level down between 2.3 and 2.7 m between 9 to 10 hours with the high-water level mark determined by the water level at the beginning of the pump cycle. The 2.3 to 2.65 m range will occur within an overall 5.5 m potential operational water level height (refer to Figure 6).

Water levels in Lake Lyell can be replenished in approximately 7 to 8 hours at maximum generation rate or just over 11 hours at minimum generation for both units, and 22 hours for a single unit. A ~2.2 GL allowance for operation water level management is nominated at a range between full supply level (FSL) 785.5 to 784.5 m relative level (RL). This is for outflow requirements and provides buffer capacity for inflow events. Factoring in recreational use, dam safety needs, and existing asset inflow and outflow needs, the lake level is expected to fluctuate 2.1 to 2.6 m over a full cycle and the operational target bandwidth is expected to range between RL 784.5 and 781.0 m (refer to Figure 6).

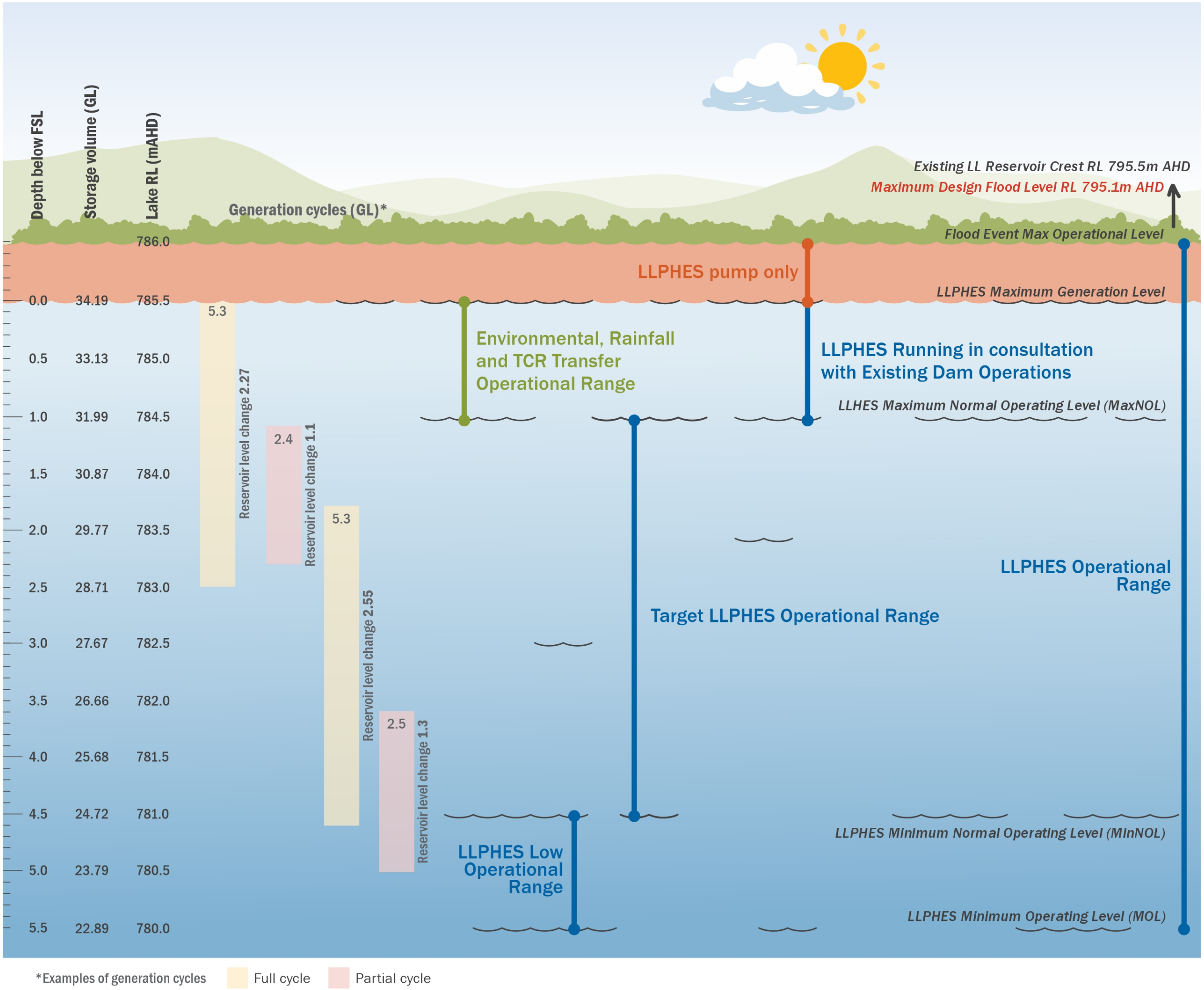


Figure 6: Lake Lyell PHES operational philosophy

3. Legislative context

This section provides a brief outline of the key legislation and government policy considered in this assessment.

3.1. Fisheries Management Act

The *Fisheries Management Act 1994* (FM Act), administered by the Department of Primary Industries (DPI) Fisheries, provides for the sustainable management of fish and fish habitats, and outlines approval processes for activities that may impact on threatened fish species and habitats. It also contains provisions for the conservation of fish stocks, KFH, biodiversity, and threatened aquatic species, populations and ecological communities. It regulates the conservation of fish, aquatic vegetation and some aquatic macroinvertebrates, and the development and sharing of the fishery resources of NSW for present and future generations. The FM Act lists threatened aquatic species, populations and ecological communities, key threatening processes and declared critical habitat. Assessment guidelines to determine whether a significant impact is expected are detailed in section 220ZZ and section 220ZZA of the FM Act.

A key objective of the FM Act is to conserve KFH. 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. KFH is defined in Section 3.2.1 and Section 3.2.2 of the Policy and guidelines for fish conservation and management (Department of Primary Industries, 2013) and is ranked based on a combination of habitat sensitivity (waterway type) and water classification (waterway class). These habitats include rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank, but do not include small ephemeral headwater creeks and gullies (i.e. 1st and 2nd order streams (Strahler, 1952) or farm dams constructed on these (Department of Primary Industries, 2013). Generally, 3rd order tributaries and above (Strahler, 1952) are considered KFH that require conservation and management, although threatened species still have the potential to inhabit waterways of a 1st or 2nd order when inundated. In alignment with the FM Act's primary objective to 'conserve key fish habitats', permanent and semi-permanent freshwater habitats must be assessed if they intersect areas of impact related to a project.

To inform aquatic offsets, the assessment of impacts on aquatic biodiversity must be undertaken in accordance with NSW Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity (Department of Primary Industries, 2014). The policy notes that "offset sites can include the same or a similar habitat in the same catchment that is more threatened than the habitat being impacted on".

3.2. Water Management Act 2000

The *Water Management Act 2000* (WM Act), administered by the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) governs the sustainable and integrated management of NSW's water for the benefit of both present and future generations. In the context of aquatic ecology, the WM Act provides the physical definition of a waterway, and other waterbodies, pertinent to this assessment:

'Watercourse means a river, creek or other natural stream of water (whether modified or not) flowing in a defined channel, or between banks, notwithstanding that the flow may be intermittent or seasonal or the banks not clearly or sharply defined, and includes:

(a) a dam that collects water flowing in any such stream
(b) a lake through which water flows
(c) a channel into which the water of any such stream has been diverted
(d) part of any such stream
(e) the floodplain of any such stream.

The WM Act also provides guidance on controlled actions undertaken within the riparian zone of a waterway, with assessment of the potential impact of any controlled activity to be undertaken to ensure that minimal impacts will occur to "waterfront land".

Division 6 of the WM Act requires consideration of aquifer interference activities. The NSW Aquifer Interference Policy (Department of Primary Industries, 2012a) requires an assessment of potential impacts on water dependent assets, including groundwater-dependent ecosystems (GDEs). In addition, specific guidance relating to the assessment of GDEs is provided within the NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002) and risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework (Department of Primary Industries, 2012b).

3.3. Environmental Protection and Biodiversity Conservation Act 1999

The EPBC Act, administered by the Commonwealth Department of Climate Change, Energy, the Environment and Water (Commonwealth DCCEEW), is the primary piece of Commonwealth legislation that may be relevant to the assessment of aquatic ecology, providing a framework for the protection of the Australian environment, including its biodiversity and its natural and culturally significant places. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, heritage places and water resources which are defined as Matters of National Environmental Significance (MNES) under the EPBC Act. These include:

- world heritage properties
- places listed on the National Heritage Register

- Ramsar wetlands of international significance
- threatened flora and fauna species and ecological communities
- migratory species
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mining)
- water resources, in relation to coal seam gas or large coal mining development.

The EPBC Act also facilitates a more streamlined national environmental assessment and approvals process between the Commonwealth and the States and Territories.

Under the EPBC Act, an action that may have a significant impact on a MNES is deemed to be a 'controlled action' and can only proceed with the approval of the Commonwealth Minister for the Environment. An action that may potentially have a significant impact on a MNES is to be referred to the Commonwealth DCCEEW for determination as to whether or not it is a controlled action. The project has been deemed a controlled action and is to be assessed under the EPBC Act and a decision made as to whether or not to grant approval.

Of the nine MNES that are regulated by the EPBC Act, the following have the potential to be associated with the project, and this report aims to evaluate as to whether these MNES are applicable:

- listed threatened species and ecological communities (sections 18 & 18A)
- listed migratory species (sections 20 & 20A).

Assessment guidelines to determine whether a significant impact is expected are detailed in *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Department of the Environment, 2013).

In addition to the above, the NSW DCCEEW (Department of Climate Change, Energy, the Environment and Water, 2020) released a revised provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season in southern and eastern Australia (24 March 2020). Most of the species have potentially had at least 30% of their range burnt. The list includes a number of bird, mammal, reptile, frog, invertebrate, crayfish and fish species. The priority animals were identified based on the extent to which their range has potentially been burnt, their conservation status prior to the fires, and the physical, behavioural and ecological traits which influence their vulnerability to fire. While the list primarily comprises species already listed under the EPBC Act, it also includes species which are not currently listed as threatened under the FM Act or EPBC Act but have more than 30% of their range within burnt areas. From this list only platypus have been assessed for potential impacts as a result of the project. Platypus have since been removed from the provisional list.

4. Methods

The following tasks were completed to address the aim and objectives of the *Aquatic Ecology Assessment*:

- database searches and a literature review
- assessment of surface and groundwater data, and bore lithology logs, where available
- an aquatic ecology field survey, including:
  - assessment of KFH using a combination of habitat sensitivity (waterway type) and water classification (waterway class) to determine whether Lake Lyell and associated waterways and tributaries meets the definition of 'KFH'
  - targeted platypus and supporting macroinvertebrate surveys
  - cataloguing of photographs at each site assessed within Lake Lyell and associated waterways
  - assessment of the suitability of identified habitats to support threatened aquatic species, communities or populations
  - collection of abiotic and biotic samples to aid in determining existing environmental values and documenting the presence of threatened communities, populations and species
- preparation of this *Aquatic Ecology Assessment* report to:
  - summarise the above information and outline the environmental receptors
  - present assessments of significance for aquatic species listed under the FM Act and the EPBC Act
  - assess the potential for the occurrence of direct, indirect and cumulative impacts to the aquatic biodiversity and ecology of Lake Lyell, and associated tributaries and waterways, as a result of the construction and operation of the project
  - propose an aquatic offsets approach where needed
  - provide management and monitoring recommendations as appropriate.

4.1. Desktop assessment

4.1.1. Database searches

The database search results are provided in Annexure A.

The desktop assessment included a review of the following databases and datasets:

- Freshwater threatened species distribution maps (DPI Fisheries; August 2024)
- Threatened species lists (DPI Fisheries; August 2024)
- Key Fish Habitat maps (DPI Fisheries; August 2024)
- Fish stocking (DPI Fisheries; November 2023)

- Fisheries NSW Spatial Data Portal (DPI Fisheries; August 2024)
- BioNet Atlas (DPHI; August 2024)
- Australian Museum (November 2023)
- Protected Matters Search Tool (PMST) (Commonwealth DCCEEW; August 2024)
- Australian Ramsar Wetlands: Internationally Important Wetlands (Commonwealth DCCEEW; November 2022)
- Directory of Important Wetlands: Nationally Important Wetlands (Commonwealth DCCEEW; November 2022)
- Groundwater Dependent Ecosystems Atlas (Bureau of Meteorology; November 2023)
- NSW Fish Passage Database (DPI Fisheries; November 2023)
- WaterNSW Continuous water monitoring network data
- Climate data online (BoM; November 2023).

4.1.2. Literature review

4.1.2.1. General project literature review

A review of publicly available literature relating to aquatic and subterranean environments in the region of the project was undertaken to investigate the occurrence of communities and taxa of conservation significance. Information was compiled from reports, books, peer-reviewed journal articles, and relevant government, academic or regulatory publications.

Information was also taken, where applicable, from the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023*.

A summary of the results of the literature review is provided in Annexure B (excluding online databases, websites and reports listed in Section 4.1.1).

4.1.2.2. Impacts to platypus literature review

A literature review was undertaken to determine the likely impacts of fluctuating water levels on macroinvertebrates, which make up the diet for platypus. Peer reviewed journal articles focussing on impacts to invertebrates resulting from water abstraction, hydropower induced water fluctuations, natural water fluctuations, and platypus' diet were assessed. The literature review included both globally and nationally available articles and research databases including sources such as Google Scholar and Web of Science.

4.1.3. GDE identification and assessment

Consideration was given to aquatic GDEs in the context of potential project impacts with reference to Risk assessment guidelines for groundwater dependent ecosystems: Volume 1 – The conceptual framework (Department of Primary Industries, 2012b), following the process detailed below where possible:

- identify potential GDEs
- assess the degree of groundwater dependency of identified GDEs
- determine ecological values of GDEs, where possible.

The identification of potential aquatic GDEs (i.e. surface waterways, subterranean fauna) was undertaken via a desktop assessment. Impacts to GDEs have been determined in the *Groundwater Impact Assessment* (EMM Consulting Pty Limited, 2025b).

4.1.4. Likelihood of occurrence assessment

The criteria for assessing the likelihood of occurrence of threatened species is summarised in Table 2 with the assessment outcomes being presented in Table 18. While Commonwealth and State data sources may indicate possible presence of a species or habitat, local conditions should be considered when determining their actual likelihood of occurrence.

Table 2: Likelihood of occurrence criteria

Likelihood	Description	Further assessment conducted?
Negligible	The potential for the species to occur is considered so unlikely as to not be worth considering.	No
Low	Based on data collected during the field survey, it was considered that the species was unlikely to occur in, or use habitats within, the project footprint. A species may utilise identified habitat on rare occasions.	No
Moderate	The species is known to occur in the catchment/sub-catchment/waterway and the field survey identified some habitat value for the species. Habitat values are somewhat degraded and considered suboptimal.	Yes
Likely	The species is known to occur in the catchment/sub-catchment/waterway and the field survey identified optimal habitat features for the species.	Yes
Recorded	The species was recorded during the field survey. The species has been recorded in the catchment/sub-catchment/waterway previously and there has not been any change in habitat values since this time.	Yes

4.1.5. Risk assessment

Table 3 outlines the risk matrix prepared and adopted for aquatic values when assessing the project impacts. Potential consequences resulting from an impact along with the likelihood of an impact occurring assist in determining the 'risk' associated with the impact. Table 4 outlines the consequence criteria developed for the aquatic ecology assessment for the construction and operation impacts. Based on the risk as determined in Table 3, Table 4 allows for a more detailed assessment of specific impacts.

Table 3: Risk matrix adopted for the risk assessments

		Likelihood				
		Almost Certain	Likely	Possible	Unlikely	Rare
Consequence	Insignificant	M	L	L	L	L
	Minor (Mi)	M	M	L	L	L
	Moderate (Mo)	H	H	M	M	L
	Major (Ma)	E	H	H	M	M
	Catastrophic	E	E	H	H	M

Table 4: Consequence criteria adopted for the risk assessments

	Insignificant	Minor	Moderate	Major	Catastrophic
	Minimal, if any, impact which have an overall negligible net effect	Localised, reversible short term reversible event with minor effects which are contained to an onsite level	Localised long term but reversible event with moderate impacts on a local level	Extensive, long term, but reversible event with high impacts on a regional level	Long term, extensive, irreversible with high level impacts at potential state wide levels
Aquatic vertebrates - fish	No measurable permanent impacts on aquatic vertebrates	Minor short-term impacts, life cycle may be disrupted but for less than a year. May include loss of individuals.	Medium term (1 to 2 year) impacts, life cycle disrupted and resulting in no recruitment for a year. May include loss of >10	Long term (2 to 5 year) impacts, life cycle significantly disrupted no recruitment for successive years. Long. Potential mass fish kill	Loss of species and population. Minimal possibility of recovery

	Insignificant	Minor	Moderate	Major	Catastrophic
	Minimal, if any, impact which have an overall negligible net effect	Localised, reversible short term reversible event with minor effects which are contained to an onsite level	Localised long term but reversible event with moderate impacts on a local level	Extensive, long term, but reversible event with high impacts on a regional level	Long term, extensive, irreversible with high level impacts at potential state wide levels
Surface water biodiversity- Aquatic Ecology (algae, macrophytes, macroinvertebrates)	No measurable impacts on surface water biodiversity	Minor short-term impacts to surface biodiversity – 1 to 2 weeks of impacts	Medium term impacts 1 to 2 months of impacts	Long term impacts up to 1 year of impact	Complete loss of surface water biodiversity
Surface Water - Water Quality and sediment quality	No measurable change to surface water quality or quality changes are not measurable	Changes to Surface Water quality during the activity, no further changes noted once activity is finished	Changes to Surface Water quality due to activity, recovery up to 1 year	Changes to Surface Water Quality due to activity, recovery 1 to 2 years	Changes to Surface water quality, where water becomes toxic, or permanent changes to quality, recovery is greater than 2 years
Platypus	No measurable or observable impact on behaviour of condition detected	Short term changes in behaviours observed, i.e. platypus not observed in certain locations feeding no measurable change in health condition of the population	Short term changes in platypus behaviour observed i.e. platypus not observed in certain locations feeding and measurable change in health condition of the population observed	Significant measurable changes in health condition of the population may be associated with behavioural/feeding changes. Including loss of individuals from the population	Loss of population of platypus (10 to 20 individuals)
KFH	No impact to KFH	Loss of any KFH	-	-	Complete loss of KFH

4.2. Field survey design

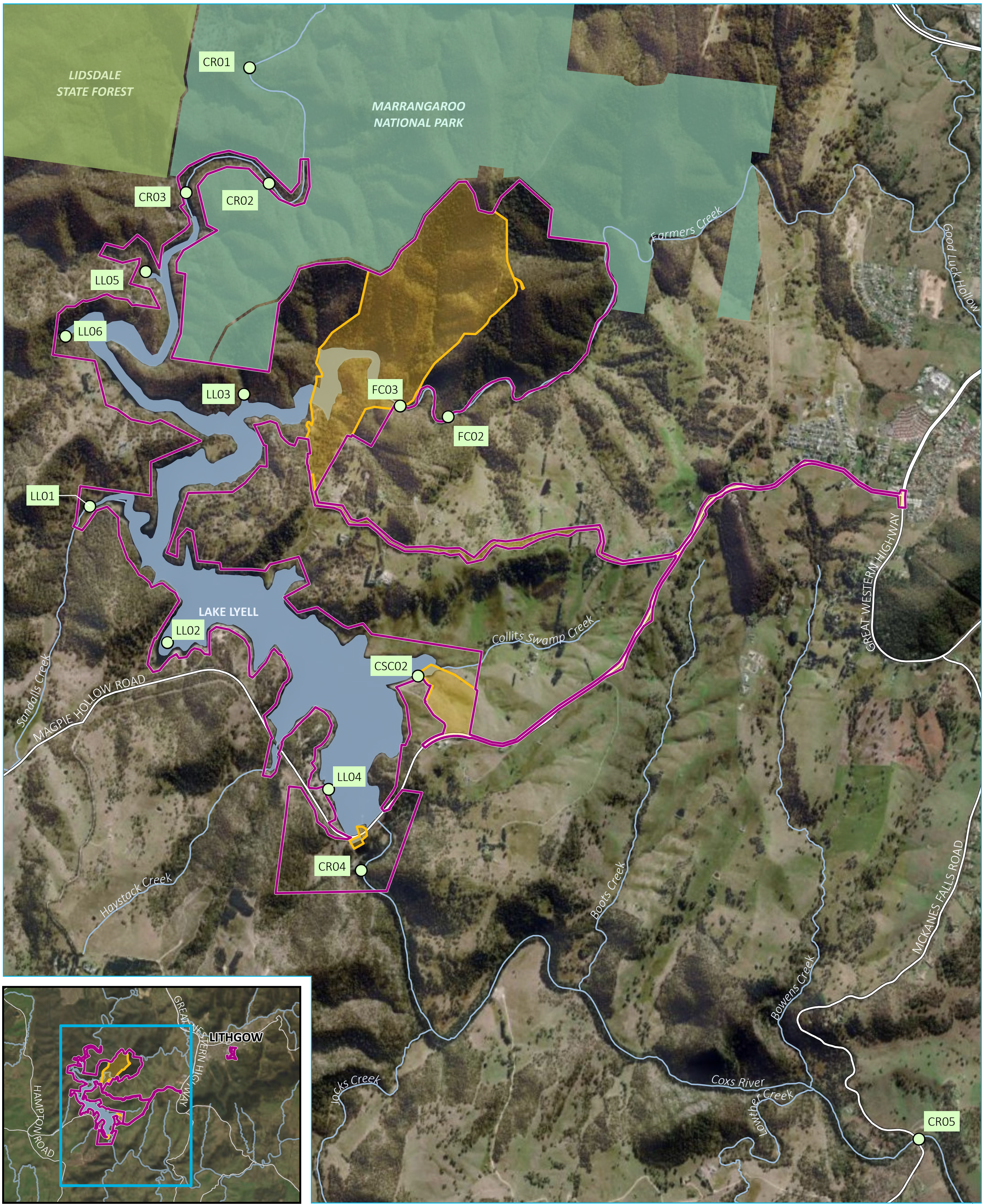
To aid in determining the ecological values of waterways with the potential to be impacted by the project, field surveys were undertaken from 21 to 30 November 2023. A total of 14 sites were assessed within Lake Lyell, Coxs River and Farmers Creek (refer to Table 5). The survey comprised a range of abiotic and biotic components (refer to Table 5). Field sampling was undertaken in accordance with DPI Fisheries s 37 FM Act Scientific Collection Permit No P19/0050-1.0.

At each site, waterway type and waterway class assessments were completed, and broad habitat characterisation was undertaken to document attributes of the local ecosystem including:

- habitat and substrate types
- riparian vegetation condition and presence of weeds
- vegetation cover and presence of native species
- waterway morphology and presence/absence/flow of surface water
- refuge availability (snags , aquatic vegetation, rocks, etc.)
- amount of erosion and bank incision
- livestock impact.

Photographs were taken of upstream and downstream reaches, including the bed, banks and riparian zone at all sites (where the features were present) to provide a record of habitat conditions at the time of assessment Appendix D. Each waterway assessed had previously been ranked by the DPI according to the Strahler (1952) method for waterway ordering, and only waterways ranked as 3rd order and above have been included in the *Aquatic Ecology Assessment*.

The content of this *Aquatic Ecology Assessment* was limited to aquatic and riparian habitat and did not address terrestrial ecology or document plant species. Further information on riparian plant species that may be impacted by the project are detailed in the *Lake Lyell Pumped Hydro Energy Storage Project Biodiversity Development Assessment Report* (BDAR) (EMM Consulting Pty Limited, 2025d)). Riparian vegetation is defined by the DPI Fisheries as "*The plants growing on the water's edge, the banks of rivers and creeks and along the edges of wetlands…*", and consist of trees, shrubs, grasses and/or vines across a number of structural components (i.e. groundcovers, understorey and canopy) (Department of Primary Industries, 2019).



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Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2023); ESRI (2024); GA (2009); DPI (2009)

KEY

- Project area
- Construction envelope
- Survey site

Existing environment

- Major road
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

Locations of survey sites for the aquatic ecology surveys undertaken in November 2023

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 7

EMM
creating opportunities

Table 5: Location of, and components sampled at, each aquatic ecology site during the November 2023 field survey.

Waterway	Site	Stream order	Coordinates	Sample date	Key fish habitat	Water quality	Sediment quality	In-situ water quality	Macrophytes	Phytoplankton	Periphyton	Aquatic invertebrates	Aquatic vertebrates	eDNA
Lake Lyell	LL01	6th	226869 6288802	23-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	LL02	6th	227444 6287792	23-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	LL03	6th	228011 6289631	22-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	LL04	6th	228637 6286706	28-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	LL06	6th	226690 6290060	24-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	CR03	6th	227582 6291125	22-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	CSC02	6th	229299 6287545	30-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Lake Lyell	LL05	6th	227283 6290540	28-November-2023	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Coxs River	CR01	6th	228052 6292049	27-November-2023	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coxs River	CR02	6th	228196 6291193	23-November-2023	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coxs River	CR04	6th	228878 6286106	25-November-2023	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coxs River	CR05	6th	233007 6284115	27-November-2023	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Farmers Creek	FC02	4th	229522 6289464	22-November-2023	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Farmers Creek	FC03	4th	229167 6289544	21-November-2023	✓	✓	✓	✓	✓	-	✓	✓	✓	✓

4.2.1. Key fish habitat

Fish habitat sensitivity was assessed at 14 sites in accordance with Policy and guidelines for fish habitat conservation and management (Department of Primary Industries, 2013) (refer to Table 5) by assigning a 'waterway type', while the functionality of the waterway for fish passage was assessed by assigning a 'waterway class'. 'Sensitivity' is defined by '…*the importance of the habitat to the survival of fish and its robustness (ability to withstand disturbance)*' (Department of Primary Industries, 2013). Definitions, relevant to the *Aquatic Ecology Assessment* report, of the waterway types and waterway classes are summarised in Table 6 and Table 7, respectively. The Department of Primary Industries (Fisheries) only recognises native aquatic plants with regard to waterway type classification (Department of Primary Industries, 2013).

Table 6: Waterway type definitions for habitat sensitivity

Classification	Characteristics of waterway class
Type 1 – Highly sensitive KFH	Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants.
Type 2 – Moderately sensitive KFH	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in Type 1.
Type 3 – Minimally sensitive KFH	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

Table 7: Waterway class definitions for fish passage

Classification	Characteristics of waterway class
Class 1 – Major KFH	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
Class 2 – Moderate KFH	Generally named intermittently flowing stream, creek or waterway with clearly defined bed and banks, semi-permanent to permanent water in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and Type 2 habitats present.
Class 3 – Minimal KFH	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for 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 other Class 1 to 3 fish habitats.

Classification	Characteristics of waterway class
Class 4 – Unlikely KFH	Generally 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 post-rain events (e.g. dry gullies, shallow floodplain depressions with no aquatic flora).

4.2.2. Water quality

Surface water samples were collected at 14 sites (refer to Table 5) using sterilised bottles provided by the NATA accredited Australian Laboratory Group (ALS), containing preservative where required. Bottles were filled with water and sealed, excluding air from the samples where possible. Samples were then couriered to ALS and analysed for dissolved metals, metalloids and other trace elements ("metals") (refer to Table 8).

In-situ water quality parameters were measured at the time of the assessment. Dissolved oxygen (mg/L), temperature (°C), specific conductivity (µS/cm) and pH were recorded using a YSI ProPlus water quality meter, while turbidity was measured using a HACH 2100Q turbidity meter.

Water quality data was compared to the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs or lowland rivers where applicable). Surface water pH was compared to the classification system developed by Foged (1978), comprising acidic water (4.5 to 6.5), circumneutral water (6.5 to 7.5), and alkaline water (>7.5) (Foged, 1978). Salinity was compared to Hammer (1986), classifying surface water into freshwater (<3,000 mg/L), hyposaline (3,000 mg/L to 20,000 mg/L), mesosaline (20,000 mg/L to 50,000 mg/L) and hypersaline (>50,000 mg/L) categories (Hammer, 1986). Metals and metalloids were compared to the Australian and New Zealand Guidelines for Fresh & Marine Water Quality (ANZG) (Water Quality Australia, 2018) based on default guideline values (DGV) for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

It should be noted that the results provided as part of this assessment are a 'snapshot' in time and should be considered as indicative only. Long term water quality monitoring within Lake Lyell has been undertaken by EnergyAustralia and is discussed in the *Surface Water Assessment* (EMM Consulting Pty Limited, 2025c).

Table 8: Water quality parameters analysed from surface water during the November 2023 field survey

Basic	Major ions	Nutrients	Dissolved metals
Biological Oxygen Demand	Alkalinity (total)	Ammonia	Antimony
Dissolved oxygen	Bicarbonate Alkalinity	Kjeldahl Nitrogen (total)	Aluminium
Electrical conductivity	Calcium	Nitrate	Arsenic
pH	Carbonate Alkalinity	Nitrite	Cadmium
Total dissolved solids	Chloride	Nitrite + Nitrate	Chromium
Turbidity	Hydroxide Alkalinity	Nitrogen (total)	Copper
	Ionic Balance	Phosphorus (total)	Hexavalent Chromium
	Magnesium		Iron
	Potassium		Lead
	Sodium		Mercury
	Sulphate		Nickel
	Total Anions		Selenium
	Total Cations		Silver
			Trivalent Chromium
			Zinc

4.2.3. Sediment quality

Surface sediment samples were collected at 14 sites (refer to Table 5) using sterilised glass jars provided by ALS. The top two to three centimetres of sediment was scraped into a sterilised glass container and couriered to ALS for analysis (refer to Table 9). Samples were collected for the analysis of total metals, metalloids and other trace elements ("metals") as described above.

Sediment pH was compared to Hazelton and Murphy (2007) which ranges from very strongly acidic (<5.0) to very strongly alkaline (>9.0) (Hazelton & Murphy, 2007). Metal concentrations were compared to the DGV (Water Quality Australia, 2018) (where available).

Table 9: Sediment quality parameters analysed during the November 2023 field survey

Basic	Major ions	Nutrients	Total metals
Electrical conductivity	Calcium	Ammonium (N)	Antimony
Moisture content	Chloride	Ammonium (NH_4)	Aluminium
pH	Magnesium	Kjeldahl Nitrogen (total)	Arsenic
	Potassium	Nitrate	Cadmium
	Sodium	Nitrite	Chromium
	Sulphate	Nitrite + Nitrate	Cobalt

Basic	Major ions	Nutrients	Total metals
		Nitrogen (total)	Copper
		Phosphorus (total)	Hexavalent Chromium
		Phosphorus (total)	Iron
			Lead
			Manganese
			Mercury
			Nickel
			Selenium
			Silver
			Trivalent Chromium
			Vanadium

4.2.4. Algae and macrophytes

Samples of phytoplankton, periphyton and macrophytes were collected during the November 2023 field survey (refer to Table 5). Details are provided below:

I. Phytoplankton

A sample of phytoplankton (free-floating algae) was collected from surface water to document algal communities (in particular, toxic and/or bloom-forming taxa) at 13 sites across Lake Lyell, the Coxs River and Farmers Creek (refer to Table 5). Sample bottles were provided by the Australian Water Quality Centre (AWQC) and filled completely at each site. Samples were refrigerated and couriered to the laboratory for analysis. In the laboratory, three representative slides were prepared and observed under a compound microscope at 40x magnification, where algae were identified to at least genus level. The relative abundance for each taxon was recorded, calculated based on cells, colonies or filaments, depending on the morphological form. Holding times were breached for all samples due to the distance from the site to the laboratory. However, the results are considered sufficient to provide accurate information on algal diversity and abundance.

II. Periphyton

Periphyton growing on submerged vegetation, sediment, rocks or woody debris in shallow waters of the littoral zone were collected for the analysis of diatoms (microalgae). Sample bottles were provided by the AWQC and filled completely at six sites only due to lack of appropriate substratum at the remaining sites. Samples were refrigerated and couriered to the laboratory for analysis. In the laboratory, samples were treated in 70% nitric acid to remove organic material, and permanent slides were prepared according to John (1983). Three replicate slides were made from each sample, and enumeration was carried out at 100x magnification using a compound microscope. A maximum of 100 diatoms were counted at each site to provide a representation of community structure. The abundance and diversity of taxa were recorded, with identification to species level undertaken where possible. Holding times were breached for all samples, although the results are considered sufficient to provide accurate information on algal diversity and abundance.

III. Macrophytes

During the November 2023 field survey, macrophytes (aquatic plants) were assessed and documented in the field by an experienced aquatic ecologist. All species were identified in the field and taxonomic verification was undertaken to at least genus level (where possible).

4.2.5. Aquatic invertebrates (AUSRIVAS)

Macroinvertebrates are recognised as important biological indicators of environmental conditions, where the presence, absence and relative abundance of certain species (varying in stress / tolerance thresholds) are commonly used to score local ecosystem health (Simpson & Norris, 2000; Turak, et al., 2004). During the November 2023 field survey, samples were collected from six sites (assessments being limited to lotic ecosystems) (refer to Table 5). Macroinvertebrates were collected at each site and both photographs and site assessment sheets were completed as per NSW's Australian River Assessment System (AUSRIVAS) sampling and processing manual (Turak, et al., 2004). Samples representing ten metres of representative edge habitat were collected at each site using a 250µm mesh dip net and a longer net was used in the riffle habitat where present. Net contents were tipped into a white sorting tray to be picked through for at least 40 minutes into 70% ethanol for later identification to family level following the AUSRIVAS manual (Turak, et al., 2004). Macroinvertebrates were identified in the laboratory in accordance with the guidelines; to class for oligochaetes, mites and ostracods, sub-family for chironomids, and all other taxa to family level. Species indicator measures (SIGNAL2 scores were calculated using the *New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual* (Turak, et al., 2004).

In addition to AUSRIVAS (Turak, et al., 2004) field sampling and habitat assessments, in-situ water quality parameters were also measured at each site. Dissolved oxygen (mg/L), temperature (°C), specific conductivity (µS/cm) and pH was estimated using a YSI ProPlus water quality meter, while turbidity (NTU) and alkalinity (mg/L) were measured using HACH test kits.

4.2.6. Aquatic vertebrates

Aquatic vertebrates were assessed at 14 sites during the November 2023 field survey (refer to Table 5), using a number of survey methods (electrofishing, bait traps and fyke nets). Sampling efforts followed the *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Department of Sustainability, Environment, Water, Population and Communities, 2011). For the purposes of reporting, aquatic vertebrate data has been combined, irrespective of collection method. Specific methods are described below and total survey effort is presented in Table 10.

I. Electrofisher

Electrofishing (including boat or backpack surveys) was undertaken at 14 sites (refer to Table 5; Table 10) to assess the presence of small bodied and large bodied fish. Electrofishing involves passing an electrical current through water, immobilising aquatic fauna so that they can be netted and identified. Water temperature was monitored closely to ensure that an appropriate electrical current was maintained. The electrofisher maintained an upstream path to avoid recapture of previously stunned individuals. The voltage output was also monitored continuously, to ensure only the minimum current necessary was used to attract and capture fish effectively. The boat electrofisher was active for 1080 seconds per site and the backpack electrofisher was active for 1,200 seconds per site. Electrofisher settings per site are provided in Appendix F. Once aquatic fauna entered the electric field, the operator ceased administering current into the water and the second field team member netted the individuals and placed them into a holding vessel fitted with an aeration system. Taxonomic verification was undertaken in-situ at all sites and specimens were measured using a ruler and returned to the same waterway in an area of low flow near the bank once recovered.

II. Fyke nets

Two, three or four small meshed (2 to 4 mm) mesh) fyke nets were set in appropriate habitat at each of the 14 sites depending on habitat suitability (refer to Table 5; Table 10). A six-inch foam float was placed in the cod end of the net which was staked above water surface, with a 30 cm air space maintained to protect air breathing animals such as turtles. Fyke nets were set overnight and retrieved the next morning.

III. Bait traps

A total of 10 bait traps (250 mm x 250 mm x 450 mm) consisting of a 2 mm mesh were set at each of the 14 sites (refer to Table 5). This trap size rating complies with restrictions set by DPI Fisheries (i.e. that a single bait trap must not be larger than 500 mm x 350 mm x 250 mm with an entrance not larger than 65 mm and mesh between 10 mm and 40 mm). Bait traps have a small aperture and are a passive trap. The traps were set overnight and retrieved the next morning. Captured fish were processed on a flat area immediately adjacent to the site. Taxonomic verification was undertaken in-situ at all sites, and specimens placed back into the same waterway in an area of low flow near the bank.

Table 10: Total survey effort for the November 2023 field survey

Site	Boat electrofishing (secs)	Backpack electrofishing (secs)	Fyke nets	Bait nets
LL01	1080	-	4	10
LL02	1080	-	4	10
LL03	1080	-	4	10
LL04	1080	-	4	10
LL05	1080	-	4	10
LL06	1080	-	4	10
CR03	1080	-	4	10
CSC02	1080	-	4	10
CR01	-	1200	2	10
CR02	-	1200	2	10
CR04	-	1200	2	10
CR05	-	1200	2	10
FC02	-	1200	-	10
FC03	-	1200	3	10

IV. Environmental DNA (eDNA) sampling (fish, platypus and macroinvertebrates)

Analysis of environmental DNA (eDNA) is a non-invasive method for detecting single species or, more recently, entire taxonomic groups (Rees, et al., 2014; McColl-Gausden, et al., 2019; Thomsen & Willerslev, 2015). Genetic material that an organism sheds into its environment is known as eDNA. Qualitative comparisons with traditional sampling methods indicate that eDNA methods are often more effective at detecting scarce, elusive or cryptic species (Biggs, et al., 2015; Lugg, et al., 2018; Smart, et al., 2015; Thomsen, et al., 2012; Valentini, et al., 2016). Environmental DNA (eDNA) sampling was undertaken at 14 sites from 21 to 25 November 2023 (refer to Figure 7) to further assess the presence and distribution of platypus and aquatic fauna. eDNA samples were collected using prepared kits from Wilderlab (https://www.wilderlab.co.nz/). eDNA reporting was completed by grouping sites as outlined in Table 11.

Table 11: eDNA grouping for reporting

Aquatic Site Code	eDNA reporting code
LL01	LL
LL02	LL
LL03	LL
LL04	LL
LL05	LL
LL06	LL
CSC02	CS
CR01	CR
CR02	CR
CR03	CR
CR04	CRDS
CR05	CRDS
FC02	FC
FC03	FC

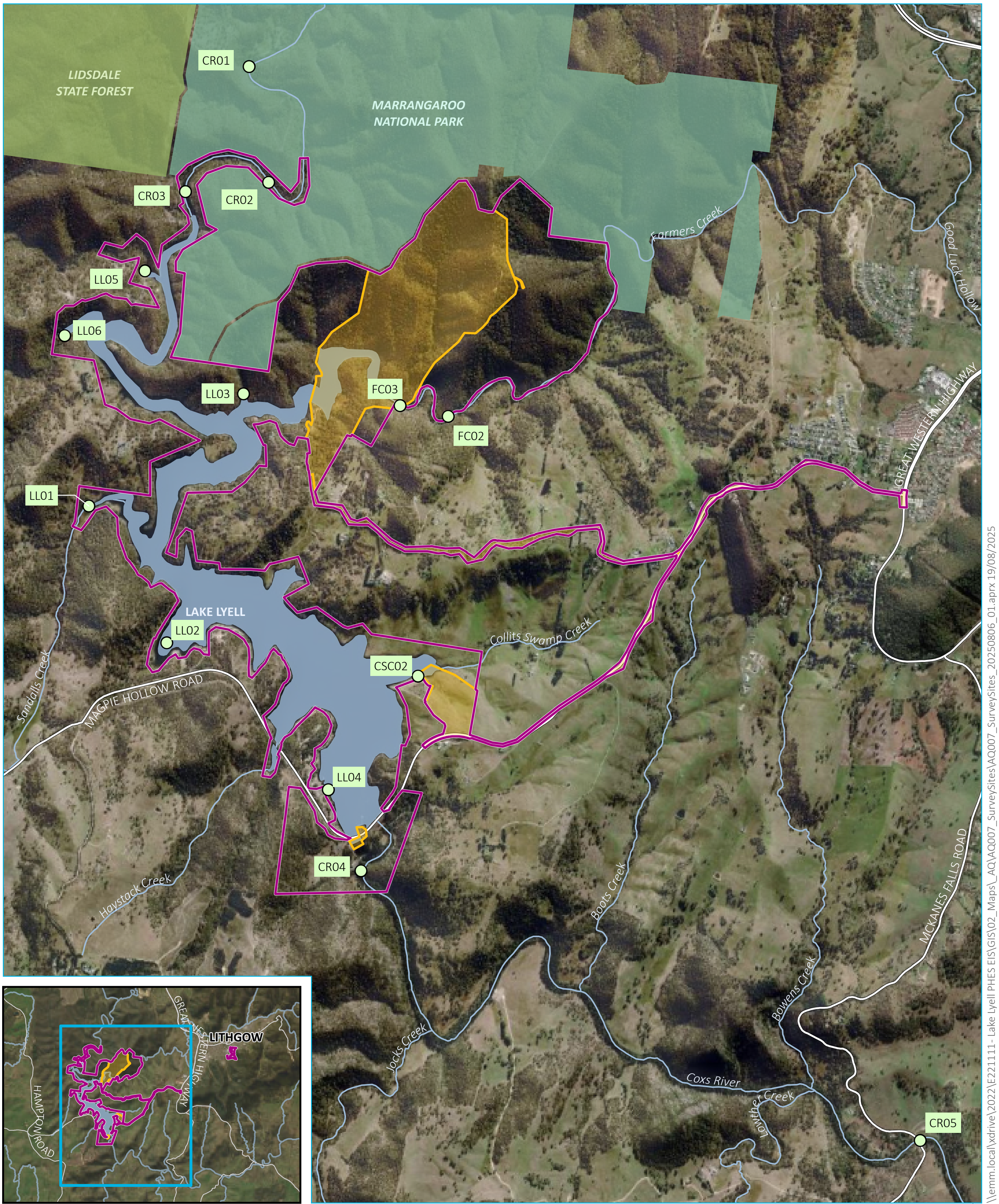
At each site, 50 millilitres (mL) of water was drawn up through a syringe, collected from just below the surface of the water. The water was then passed through a filter until 1L of water was filtered, or the filter became clogged, and then a preservative was added to the filter per section 3.2.6IV. This procedure was repeated three times at each site to increase detection reliability. Multispecies sample analysis and sequencing was performed by Wilderlab using the basic freshwater eDNA package, targeting fish, mammals, birds, and invertebrates. Multi-species eDNA analysis produces a list of all DNA sequences detected in the samples, which are then compared against a reference database to assign sequences to taxonomic groups/species. Twenty-three extensively tested PCR primers were used to compare DNA sequences to a well curated reference database. Wilderlab runs several different assays on each of the samples to target a broad range of species, with each assay designed to target a certain taxonomic group. DNA sequence counts were then provided for each detected sequence and the associated Taxon. Additional information on the distribution of fish species was also obtained at no extra cost from these surveys, given the universal nature of the genetic assay adopted for analytical purposes.

eDNA samples were classified into four distinct regions, CR – Coxs River, CRDS - Coxs River Downstream, FC – Farmers Creek, LL – Lake Lyell.

4.2.7. Targeted platypus surveys

Live trapping of platypus was undertaken by Austral with Dr Gilad Bino and Tahneal Hawk from the University of New South Wales (UNSW) on two occasions over six nights, on 21 November 2023 to 27 November 2023 and 14 February 2024 to 19 November 2024, for a total of 12 nights. Trapping was undertaken at three sites on the Coxs River arm of Lake Lyell and three sites on the Farmers Creek arm (refer to Figure 8). Platypus were captured using unweighted multi-strand mesh nets (two-inch gill net) in FC2-3, and CR1-3 (Bino, et al., 2019). At each location, 50 to 100 m of mesh net was deployed, parallel to the riverbank, using a small unpowered six-foot punt. Nets were set around dusk (17:00) and monitored continuously until the removal of the nets at around midnight. Once captured, the animals were carefully removed from the nets and placed in pillowcases and placed in a cool, dark box until processing. At site FC1 (refer to Figure 8), fyke nets were used which are suitable for shallow (< 0.5 m water depth) sections. Four pairs of fyke nets were set up, with one net facing upstream and the other facing downstream, ensuring that the net wings were extended along the bottom of the river and up to the edge of each riverbank. Fyke net pairs were set before dusk (17:00) and checked every three hours throughout the night until after dawn the following day (06:00).

Platypus were processed following established protocols (Hawke, et al., 2021a). Each animal was anaesthetised using isoflurane gas inside an induction chamber for 5 to 7 minutes (Pharmachem 5% in oxygen 3 litres per minute (L/min)). Anaesthesia was then maintained through a T-piece facemask (isoflurane 1.5% in oxygen 1L/min). Vital signs (pulse, SPO_2, temperature) were continuously monitored throughout the procedures. Platypus were implanted with a Passive Integrated Transponder (PIT) Tag (Trovan ID-100B/125), facilitating the identification of recaptures. Each platypus was sexed and weighed and had body measurements taken. A tail volume index (TVI) score was also recorded from all individuals to assess fat stores within the tail (ranging from 1 to 5 with 5 being the poorest condition).



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2023); ESRI (2024); GA (2009); DPI (2009)

KEY

- Project area
- Construction envelope
- Survey site

Existing environment

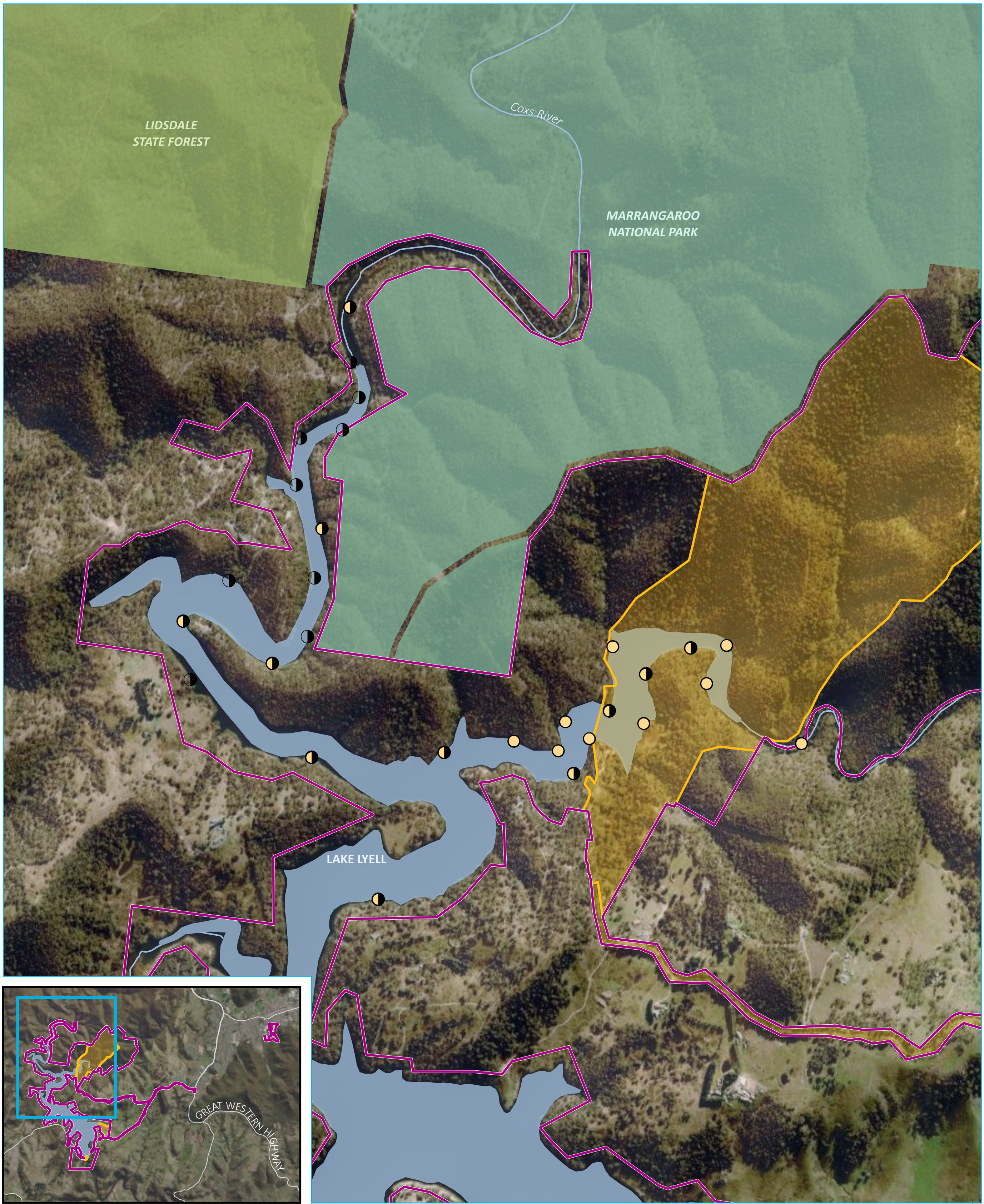
- Major road
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

Locations of Platypus surveys

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 8

EMM creating opportunities

Platypus caught on Farmers Creek arm during the first survey also had a radio and an acoustic tag externally attached using glue to allow tracking of movements. Radio tracking was only undertaken for the first survey period on Farmers Creek and undertaken during the daytime, outside the typical foraging window for platypus, to pinpoint burrows. Burrow locations were accurately stored with a GPS at the point of strongest signal. Acoustic tags (Vemco, model V9-2X) were used for tracking movements of animals in the water using an array of 20 receivers deployed in the lake. The location of the receivers for the first survey event is provided in Figure 9. For the second tracking study platypus from the Coxs River were targeted and some locations within the array were moved (refer to Figure 9).



\\emm.local\xdrive\2022\E221111 - Lake Lyell PHES EIS\GIS\02_Maps_AQ\AQ009_AcousticRecievers\AQ009_AcousticRecievers_20250819_01.aprx 21/08/2025

Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2023); ESRI (2025); GA (2009); DPI (2009)

KEY

Project area

Construction envelope

Acoustic receiver

Tracking period 1

Tracking period 2

Existing environment

Named watercourse

Named waterbody

NPWS reserve

State forest

Locations of acoustic receivers during both platypus tracking periods

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 9

EMM
creating opportunities

4.2.8. Targeted platypus related macroinvertebrate surveys and statistical analysis

The operation of the PHES will result in fluctuating water levels in Lake Lyell between 2.1 to 2.5 m over a 24-hour period with a total operational range of 5.5 m. Lake Lyell is home to a population of platypus with higher occupancy around the Coxs River and Farmers Creek arms of Lake Lyell based on anecdotal evidence. Farmers Creek was found to support a higher population of platypus around the location of the proposed inlet/outlet pipe of the PHES. Platypus feed predominantly on aquatic invertebrates and have a preferred dive depth of 1 to 2 m (based on data collected in the current platypus monitoring program). The potential impact of fluctuating water levels on the macroinvertebrate community structure and abundance is unclear and potential impacts on the platypus population are also unknown. To investigate the potential impacts of water level fluctuations, a macroinvertebrate monitoring survey was undertaken to assess the differences in macroinvertebrate community structure and abundance across a depth gradient (1 m, 2 m and 3 m) in the Coxs River, Farmers Creek, and Lake Lyell.

4.2.8.1. Methodology

The platypus macroinvertebrate monitoring program used two techniques for sampling macroinvertebrates:

1. An air lift sampler was used to sample deeper water locations across all sites.

   The air lift sampler (refer to Figure 10, Figure 11) is a sampling device that is held down onto the substrate and compressed air is used to dislodge the macroinvertebrates and associated material from the substrate. The sampler was driven by a compressor mounted on the boat. Each sample had the compressed air operated for a fixed 30 second period for consistency. The material is lifted to the surface by the air and is collected in a net (35 µm) and sample jar. The sample was then preserved in 70% ethanol. The airlift sampler used had a 30 cm diameter (surface area of 706.86 cm).

2. A surber sampler was used to sample the shallow riffle habitats in Farmers Creek. No surber samples were collected in the Coxs River due to restricted boat access.

   The surber sample (refer to Figure 12) is held down to the substrate in shallow (<30 cm) flowing waters and the substrate is manually agitated to dislodge the macroinvertebrates and material which collects in the downstream net (~1 mm mesh). The sample is then transferred to a jar and preserved in 70% ethanol for later identification. Each sample consisted of five separate samples collected from an area that was approximately 5 m x 5 m area of riverbed. The Surber sampler had a quadrat size of 30 cm x 30 cm (total surface area 900 cm^2) which resulted in a total sampled area 4,500 cm^2.

Figure 10: Airlift sampler used to sample macroinvertebrates (tape for scale)

Figure 11: Airlift sampler used to sample macroinvertebrates

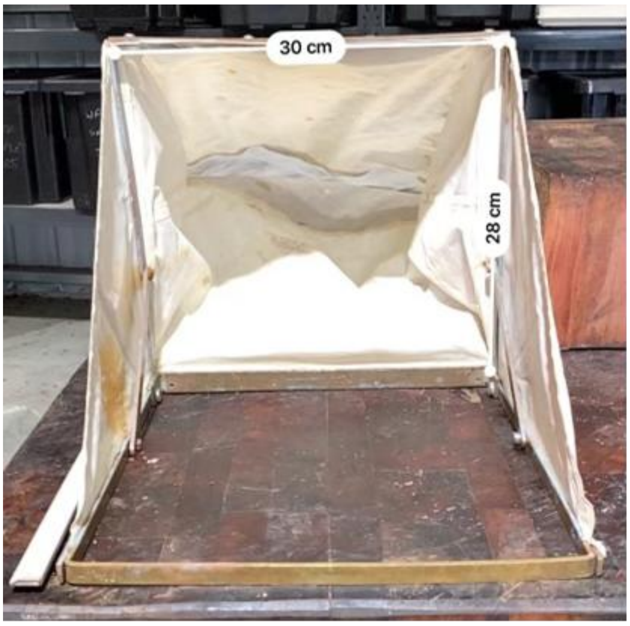


Figure 12: Surber sampler used to sample macroinvertebrates

The number and type of samples collected at each site is detailed in Table 12. The sampling methodology at each location varied due to variations in water depth and habitat type between sites. No surber samples were collected from the Coxs River as access to the riffle habitat of the Coxs River was not possible. A combination of surber and airlift samples (described below) was used for Farmers Creek, while airlift sampling only was used to collect macroinvertebrates from the Coxs River and Lake Lyell as access to the riffle habitat was not possible. Sample locations are provided in Figure 14.

Table 12: Number, sample type and depth of macroinvertebrate samples collected in each site

Site	**Number of samples**			
	Surber	Air lift 1 m deep	Air lift 2 m deep	Air lift 3 m deep
Lake Lyell	-	20	10	10
Coxs River	-	10	-	-
Farmers Creek	7	3	-	-

Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2023); ESRI (2025); GA (2009); DPI (2009)

KEY

Project area

Construction envelope

Macroinvertebrate survey site

1 m depth

Existing environment

Named watercourse

Named waterbody

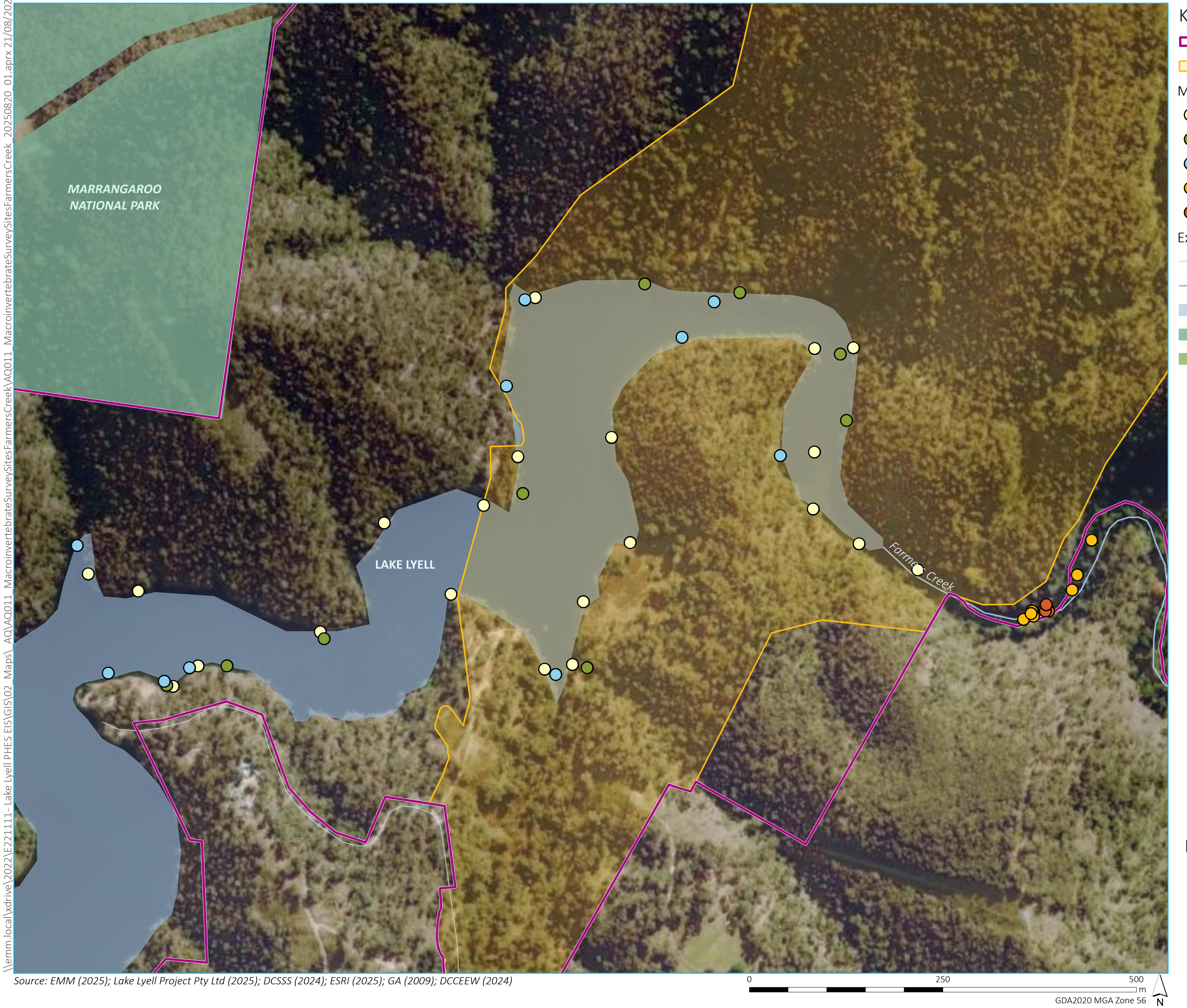
NPWS reserve

State forest

Macroinvertebrate survey sites within the Coxs River

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 13

EMM creating opportunities



\\emm.local\xdrive\2022\E221111 - Lake Lyell PHES EIS\GIS\02_Maps_AQ\AQ011_MacroinvertebrateSurveySitesFarmersCreek\AQ011_MacroinvertebrateSurveySitesFarmersCreek_20250820_01.aprx 21/08/2025

Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); ESRI (2025); GA (2009); DCCEEW (2024)

Macroinvertebrate survey sites within the Farmers Creek arm of Lake Lyell and Farmers Creek proper

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 14

EMM creating opportunities

4.2.8.2. Macroinvertebrate identification

Samples were sorted under the microscope and all macroinvertebrates identified as per AUSRIVAs guidelines and counted. Whole samples were processed in most cases. In some cases where the samples were large the samples were split into subsamples and the species abundances adjusted accordingly.

4.2.8.3. Statistical analysis

Data manipulation and analyses for macroinvertebrate statistical analyses were conducted using (v4.4.0; R Core Team 2024), RStudio (Posit team 2024), and the tidyverse package (Wickham, et al., 2023).

Multidimensional Scaling (MDS) analysis followed the classical method of using the cmdscale: Classical (Metric) Multidimensional Scaling of the R Statistical Software (v4.4.0; R Core Team 2024). Analysis incorporated all seven indicator variables (Total abundance, Number of taxa, Macroinvertebrate abundance, Number of macroinvertebrate taxa, % EPT, EPT richness and SIGNAL2).

The Levene test (car R package: (Fox & Weisbege, 2019)) was used to check for homogeneity of variance and data were arcsine transformed as required prior to analysis. Treatments were analysed with either the Welch Two Sample t-test (comparison between Coxs Creek and Farmers Creek) or the Kruskal-Wallis non-parametric test (comparison of airlift sample depths in Farmers Creek sites), followed by Dunn’s test (Benjamini-Hochberg FDR method) (FSA car package: (Ogle, et al., 2023)) to identify which treatments were significantly different.

4.3. Stygofauna surveys

Stygofauna are the fauna that inhabit subsurface groundwater dependent ecosystems (SGDE). Stygofauna live their entire lives below the surface in groundwater and are broadly characterised by their lack of eyes or being blind, whitish or translucent in appearance and have an elongate shaped-body (adapted to burrowing movement) (Tomlinson, et al., 2007). They also have low reproductive rates, generally long lifespans and slow metabolic rates that make them well adapted to low-oxygen, subterranean groundwater environments (Marmonier, et al., 1993).

Stygofauna are mostly invertebrates, with very few vertebrate representatives currently known. The “stygofauna” includes a range of different organisms found in groundwater including, obligate animals, groundwater-adapted species (stygobionts) and those that are not specifically adapted but are able to survive in the groundwater (stygoxenes) (Hose & Lategan, 2011).

Stygofauna are potential providers of important ecosystem processors. Their feeding, movement and excretion are likely to facilitate the transfer of organic matter through aquifers, thereby helping to transform nutrients and maintain water quality (Boulton, et al., 2008). They may also play an important role in preventing small channels and pores within an aquifer from becoming clogged by their feeding and burrowing behaviour, which in turn may contribute to purifying and maintaining flow of groundwater through an aquifer (Thulin & Hahn, 2008).

Stygofauna are also potentially useful as biological indicators of ecosystem health in SGDE (Tomlinson, et al., 2007). Their application is similar to the use of macroinvertebrates as biological indicators in surface water environments, where the presence, absence and relative abundance of certain species is used to reveal a temporally longer record of environmental conditions compared with water quality testing that only reveals the water quality conditions at the time of sampling.

4.3.1. Groundwater bore selection

Groundwater bores were selected based on access and availability of monitoring bore associated with the hydrogeological investigation program as part of the Groundwater Impact Assessment (EMM Consulting Pty Limited, 2025c).

4.3.2. In-situ water quality

Samples were collected using the installed pumps as described in the ground water sampling report (EMM Consulting Pty Limited, 2025b). In-situ water quality parameters including dissolved oxygen (mg/l), temperature (°C), specific conductivity (µS/cm) and pH were measured in each borehole using a YSI ProPlus water quality meter. In-situ observations about water quality in each bore were also recorded, including water odours as being either normal, sewage, petroleum, chemical, stormwater or musty and turbidity as being either clear, slight, turbid or opaque/liquid silt.

4.3.3. Stygofauna sampling and identification

Stygofauna surveys were undertaken at six bores, with bore coordinates, elevation, depth and target outlined in Table 13.

Samples were then retrieved from the borehole using the installed pumps (EMM Consulting Pty Limited, 2025c) and filtered through a 53 µm mesh sieve and preserved in 100% ethanol and stained with Rose Bengal (a staining agent which facilitates easier sorting in the laboratory). Samples were sorted in the laboratory using a dissection microscope and any animals present were transferred into a separate sample jar for subsequent identification. Stygofauna specimens were identified to the lowest possible taxonomic level using a Zeiss Stemi DV4 microscope.

Table 13: Bore coordinates, elevation, depth and target

Site number	Bore ID	Easting	Northing	Elevation (mAHD)	Indicative depth (mbgl)
1	MB2201B	230079	6290412	1,051	40
2	MB2202A	229280	6290069	906	150
	MB2202B				40
3	MB2203A	229865	6290819	1,086	200
	MB2203B				40
4	MB2204A	229207	6290724	1,008	200
	MB2204B				40
5	MB2205A	229193	6290436	961	200
	MB2205B				40

4.4. Limitations

Austral has relied on information provided by third parties and publicly available information to undertake this assessment. Errors or omissions in the data provided could affect the reliability of the assessment. The eDNA results are presented as ‘positive’, ‘negative’ or ‘equivocal’ where equivocal indicates that only one or two of the three assays returned a positive result, indicating very low levels of target DNA were present. This may happen as a result of sample contamination through the sampling or laboratory screening process, facilitated movement of DNA between waterbodies, or dispersal from further upstream. In addition, fauna DNA usually degrades after approximately one to seven days, independent of the animal, in the environment (J. Griffiths, pers. comm, March 2020), meaning that while a ‘positive’ result is likely to confirm presence, a ‘negative’ result does not necessarily exclude presence of a species from a site at that point in time.

Aquatic ecology field surveys undertaken here provide a sample of the conditions and species presence across the survey area at a single point in time. Consequently, there are a number of reasons as to why not all of the predicted species were recorded at the time of survey, including low abundance, spatial variability in distribution within a catchment/waterway site, seasonal and daily conditions, water temperature, and species activity, phenology and habitat usage at the time of sampling.

While some species have been assessed as having a low likelihood of occurrence, it is acknowledged that this does not indicate the species does not occur in the area. Rather, it means that based on the desktop assessment and/or the field survey it was considered that the species was unlikely to occur within the catchment or waterway. A species may utilise the catchment/waterway on rare occasions and is therefore unlikely to be impacted by the proposed project. This report investigates aquatic species listed under the FM Act only. Semi-aquatic species such as turtles are listed under the *Biodiversity Conservation Act 2016* (BC Act) and are addressed in the Lake *Lyell Pumped Hydro Energy Storage Project Biodiversity Development Assessment Report* (BDAR) prepared by EMM Consulting Pty Limited (EMM Consulting Pty Limited, 2025d).

5. Desktop assessment results

5.1. Aquatic habitats

The State of the Catchments (2010a) reports that wetlands in the Hawkesbury-Nepean region are in "very poor" condition and that pressure to wetlands is "high". Although no significant wetland habitats have been formally recognised in the NSW part of the South-Eastern Highlands Bioregion (NSW National Parks and Wildlife Service, 2003), 13 wetlands regarded as nationally important occur in other parts of the South-Eastern Highlands Bioregion, covering an area of 17,916 hectares (ha) (Environment Australia, 2001).

Wetlands within the Hawkesbury - Nepean catchment consist of upland, floodplain and estuarine wetlands. These wetlands are exposed to a variety of threats including exotic weed invasion, feral animals, grazing pressure, sedimentation and altered water regimes. Four-wheel driving and camping can also threaten the biodiversity of wetlands in the bioregion (NSW National Parks and Wildlife Service, 2003).

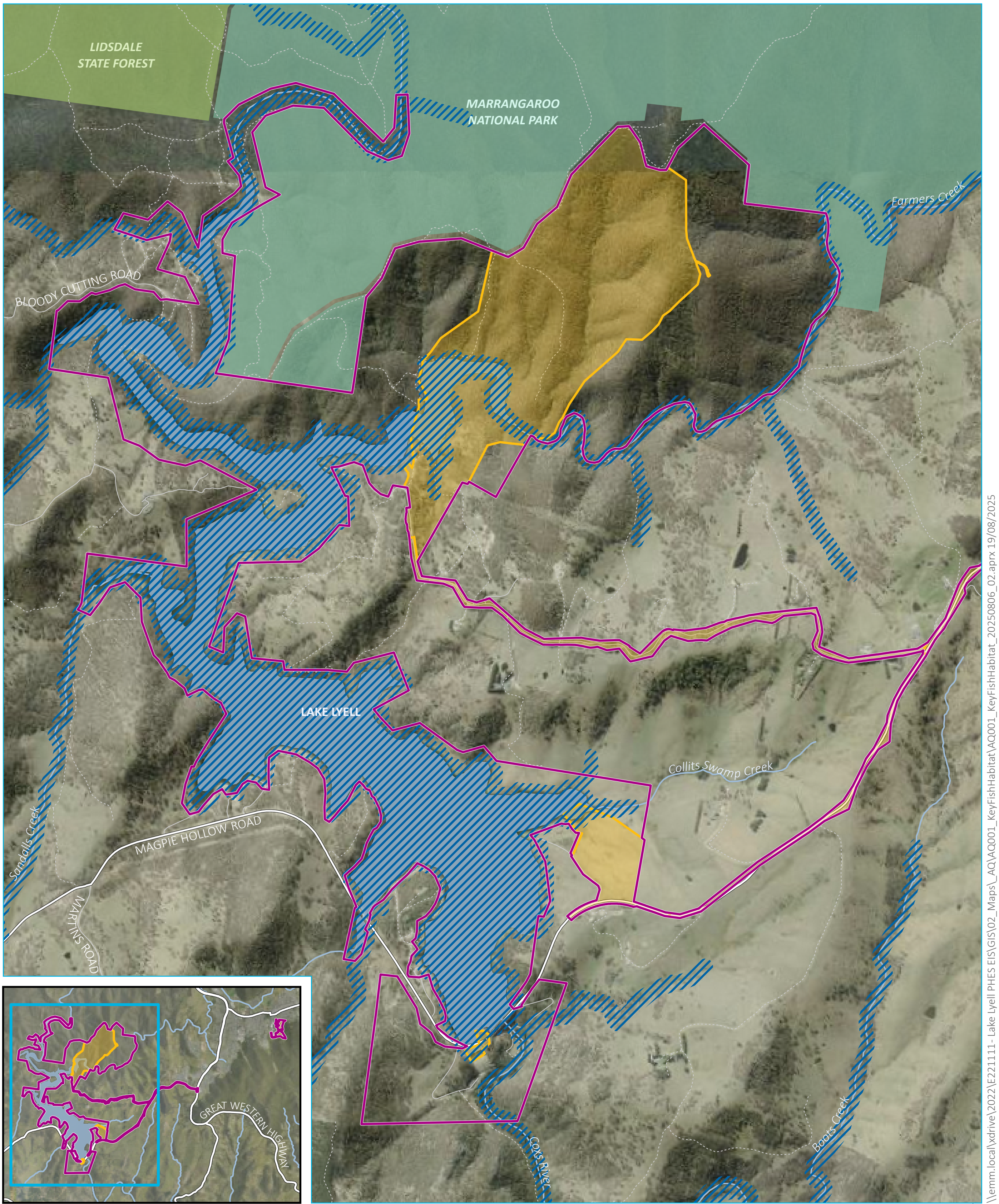
The Upper Coxs River catchment sits within the broader Hawkesbury-Nepean catchment and within the Warragamba drinking water catchment. The Hawkesbury-Nepean catchment covers an area of approximately 21,400 km^2 (Department of Planning and the Environment, 2022). The broader region contains a number of wetland types such as upland lakes and wetlands, coastal floodplains and coastal swamps of which at least 495 are of regional significance (P and J Smith Ecological Consultants, 1996). A total of 187 of these regionally significant wetlands occur within the Coxs River catchment (P and J Smith Ecological Consultants, 1996). The State of the Catchment report (Department of Planning and the Environment, 2010b) states that the condition of fauna and threatened species within the Hawkesbury-Nepean catchment is 'very poor' and that pressure on fauna and threatened species is 'very high'. Wetland condition is 'very poor' and pressure on wetlands within the catchment is 'very high' with the risk from invasive species considered 'very high' (Department of Planning and the Environment, 2010b). The report also states that seven freshwater pest fish are emerging within the catchment (Department of Planning and the Environment, 2010b). The greatest pressure on wetlands in the region is from habitat disturbance caused by drainage, grazing, feral animals, and roads crossing (Department of Planning and the Environment, 2010b).

Macroinvertebrate condition in the region of the Coxs River and Lake Lyell is reported as ‘moderate to good’ and fish condition is considered to be ‘extremely poor’ (Department of Planning and the Environment, 2010b). Reports state that much of the riparian zone of the Coxs River has been modified or cleared, however, areas of intact riparian vegetation remain. River Oak (*Casuarina cunninghamiana*) is reported as dominating the overstory of remnant riparian vegetation (Young, et al., 2000). Willows, mainly *Salix fragilis*, are reported as having invaded the channel and riparian zone, forming dense stands in some areas. The mid and understory are reportedly dominated by *Acacia* sp., *Callistemon* sp., *Leptospermum* sp., *Lomatia* sp. and *Bursaria* sp., but invasion by alien species such as Blackberry (*Rubus fruticosus*) and Broom (*Genista* sp.) is common. Emergent and fringing vegetation reportedly consists of *Carex* sp., *Cyperus* sp., *Juncus* sp., *Lomandra* sp., *Phragmites* sp., *Schoenoplectus* sp. and *Typha* sp. (Young, et al., 2000).

Lake Lyell is located on the border of the South-East Highlands and Sydney Basin bioregions and was constructed in 1982 for the purpose of supplying water to the Mt Piper power station and former Wallerawang power station and has a capacity of approximately 32,000 megalitres (ML). The lake is also a well-known recreational destination and is used for swimming, sailing, wind surfing, fishing, water skiing, picnicking and camping (Birch & Siaka, 2001). Lake Lyell is reported as having a higher salinity level than surrounding streams although the lake is still considered fresh (Judge, 2013). Nutrient loading within Lake Lyell is considered comparable with surrounding streams although Lake Lyell supported a higher nitrogen loading than other sites, which likely influenced the low SIGNAL2 score attributed to the lake (Judge, 2013).

5.2. Key fish habitat

The KFH map for the project area (Department of Primary Industries, 2023a) indicates that, of the waterways within project area, all are considered to contain KFH, including Lake Lyell, Coxs River, Farmers Creek and Sandalls Creek (Figure 15).



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2023); ESRI (2024); GA (2009); DPI (2009)

KEY

Project area

Construction envelope

Key fish habitat

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

Named waterbody

NPWS reserve

State forest

Key fish habitat distribution within the Proposal area

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 15

EMM
creating opportunities

5.3. Water quality

Young, et al (2000) report that water quality data was collected between 1962 to 1990, and 1998 to 1999 allowed for an assessment of general water quality in the Coxs River and storages. In general, nutrient concentrations and faecal coliform counts in the Coxs River were higher than those found in streams in the Blue Mountains. Faecal coliforms exceeded the 150 organisms/100ml limit recommended for primary contact recreation (Young, et al., 2000). High nutrient concentrations were recorded in periods of high flow with the main source of nutrients assumed to be from agriculture sources and sewage effluent. Particularly high phosphorous concentrations were recorded below Farmers Creek and were assumed to be due to inputs from the Lithgow sewage treatment plant (Young, et al., 2000). Turbidity, concentrations of suspended particulate matter, and conductivity were highly variable and indicative of a disturbed catchment. In contrast, pH was within the range considered safe for aquatic organisms (5 to 9) and where higher pH values were observed (>8.5) it was considered likely to be caused by increased algal growth (Young, et al., 2000). Lower pH values were thought to be likely to be a result of acid mine drainage. Two sites on the Coxs River showed extremely low dissolved oxygen concentrations and was thought likely to be due to a high organic material load. Low oxygen values were 0.2 mg/L and the report states that the recommended minimum oxygen concentration to protect aquatic life is 4 mg/L (Young, et al., 2000). Table 14 shows recorded concentrations of some water quality variables recorded prior to the construction of Lake Lyell and post construction.

Table 14: Water quality variable recorded prior to construction, and post construction of Lake Lyell. Samples were taken approximately 400 m downstream of Lake Lyell (Young, et al., 2000)

Variable	Pre-dam 1980-83	Post-dam 1989-93
Ammonia (mg/L)	0.14	0.04
Total phosphorous (mg/L)	0.196	0.025
Nitrate/nitrite (mg/L)	1.46	0.2
Non-filterable residue (mg/L)	18.5	4.5
Turbidity (NTU)	5.0	1.9

Another assessment was undertaken by the SCA indicating that water quality within the Upper Coxs catchment is impacted by local industry and land use (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water, 2010b). Specifically, the median total nitrogen (TN) was highest in Farmers Creek near Lake Lyell (median = 1.9 mg/L) which exceeds the ANZECC guideline trigger values for upland rivers (ANZECC and ARMCANZ, 2000). Elevated TN concentrations exceeding ANZECC guideline trigger values were observed for upland rivers at all sites on the Coxs River at the time of survey (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water, 2010b).

High median concentrations of total phosphorous (TP) were also recorded at a number of sites on the Coxs River (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water, 2010b). Median concentrations of TP in Farmers Creek were reported as 0.4 mg/L, again exceeding the ANZECC guideline trigger values for upland rivers (ANZECC and ARMCANZ, 2000).

In terms of lake water quality, TN concentrations were highest in Lake Lyell (1.89 mg/L) in the assessment period, exceeding the ANZECC guideline trigger values for upland rivers (ANZECC and ARMCANZ, 2000). Median TP levels were also higher in Lake Lyell than other reservoirs within the catchment (0.1 mg/L) with concentrations in both Lake Lyell and Lake Wallace TP exceeding the ANZECC guideline trigger values for upland rivers (ANZECC and ARMCANZ, 2000). Median chlorophyll-a levels were moderate in Lake Lyell at 3.6 µg/L; however, previous readings within Lake Lyell were much higher. Median conductivity levels were reported as relatively high for freshwater lakes and reservoirs (ANZECC and ARMCANZ, 2000) with conductivity recorded as 0.52 mS/cm (Department of Environment, Climate Change and Water, 2010a; Department of Environment, Climate Change and Water, 2010b).

Water quality monitoring undertaken by EnergyAustralia in Lake Lyell, Coxs River and Farmers Creek is summarised in the Surface Water Assessment (SWA) (Sections 4.4 to 4.6; EMM Consulting Pty Limited, 2025c). This data has been used to describe recent, baseline conditions for Lake Lyell and key receiving waters.

5.4. Sediment quality

Birch and Siaka (2001) undertook an investigation into the source of anthropogenic heavy metals in the Coxs River after a serious health scare involving Sydney's drinking water occurred in 1998. Sediment samples were collected from sites spanning the entirety of the Coxs River and tributaries. High concentrations of copper (>150 µg/g), lead (>150 µg/g) and zinc (>1,250 µg/g) were reported from Farmers Creek (Birch & Siaka, 2001). Analyses of metal concentrations from sediment cores collected from relatively untouched areas of the broader catchment were also undertaken. Table 15 shows the background heavy metal concentrations in the Coxs River sediments compared to the Water Quality Australia (2018) default guideline values (DGVs) for 80% level of species protection. All ambient or background metal concentrations except cadmium (Cd) exceed the Water Quality Australia (2018) default guideline values (DGVs) for 80% level of species protection.

Table 15: Background heavy metal concentrations in the Coxs River sediments (Birch & Siaka, 2001)

Metals	Coxs River concentrations	Highest heavy metal enrichment in the Coxs River catchment	Water Quality Australia (2018) DGVs for 80% level of species protection
Cadmium (Cd)	<1	6.0	0.0008
Cobalt (Co)	13	6.3	0.0014*
Chromium (Cr)	16	3.6	0.0033
Copper (Cu)	18	31.2	0.0025
Iron (Fe)	2.3	4.1	-
Manganese (Mn)	156	19.5	3.6
Nickel (Ni)	12	13.2	0.017
Lead (Pb)	17	18.4	0.0094
Zinc (Zn)	48	52.0	0.031

Note: All concentrations are in µg/g except Fe which is in %. * denotes species protection level is unknown.

No DGVs were available for iron. For reference, background metal concentrations in the Coxs River were similar to those found in the Hawkesbury River and its tributaries (Birch & Siaka, 2001). Birch and Siaka (2001) go on to report that over time, three of the highest enrichment of metals (Chromium (Cr), lead (Pb) and zinc (Zn)) concentrations samples occurred in samples from the Coxs River catchment occurred in Farmers Creek in the vicinity of Lithgow.

One active coal fired power station, Mt Piper and one decommissioned coal fired power station Wallerawang, are located on the Coxs River upstream of Lake Lyell. Treated wastewater from Wallerawang Power Station, including water used in the cooling towers and runoff from coal stockpiles at both stations, were reported to be discharged directly into the Upper Coxs Catchment (Birch & Siaka, 2001). Sediment sampled downstream of the two power stations appeared to have different chemistries. Samples taken downstream of the Wallerawang power station were enriched approximately two-fold in Cd, Cr, nickel (Ni), Pb and Zn compared to sediment upstream of the plant, but were one magnitude higher in copper (Cu) (maximum concentration was 562 µg/g) (Birch & Siaka, 2001).

5.5. Algae

Young et al. (2000) reported that much of the Coxs Riverbed was coated with an algal-detrital matrix including extensive diatom growth and some cyanobacterial mats at the time of survey. Filamentous diatoms (e.g. *Melosira* spp.), and strand forming filamentous green algae (*Cladophera* or *Rhizoclonium*) were also recorded. EnergyAustralia monitors algae in Lake Lyell and the Coxs River. Additional algal monitoring methods and results are summarised in the SWA (Sections 4.4 to 4.6; EMM Consulting Pty Limited, 2025c). Algal alerts have occurred historically, typically during summer and autumn, in dry periods in the upstream reaches of Lake Lyell (particaulrly Farmers Creek) (EMM Consulting Pty Limited, 2025c).

EnergyAustralia undertake algae monitoring at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell (EMM Consulting Pty Limited, 2025b). EMM Consulting Pty Limited (2025b) discusses impacts to algae concentrations wthin Lake Lyell resulting from operation of the PHES and state the following:

The operation of the PHES facility will beneficially reduce the extent and magnitude of algae blooms in Lake Lyell as:

- "the PHES induced mixing and circulation will create less favourable conditions for algae growth which thrive in still and calm conditions
- less lake stratification will reduce the release of nutrients to the epilimnion during the seasonal destratification that typically occurs (for the existing condition) in March and April and is associated with the highest annual algae levels."
- the residual impact would be a beneficial change (EMM Consulting Pty Limited, 2025b).

5.6. Aquatic flora

Limited information was available on floristic vales within the Upper Coxs River catchment, however, Young, et al. (2000) report that the riparian zone of the lower Coxs River had a tree layer dominated by River oak (*Casuarina cunninghamiana*) near the water's edge and that Willows, dominated by Crack Willow (*Salix fragilis*) had invaded the channel and riparian zone, forming dense stands in some places. In places a riparian understorey of native taxa such as *Acacia*, *Callistemon*, *Leptospermum*, *Lomatia* and *Bursaria* remained, although invasion by alien species such as Blackberry (*Rubus fruticosus* agg.) and Broom (*Genista* sp.) was apparent and widespread. At the time of survey, the margins of the Coxs River comprised a wide range of emergent macrophytes including reeds, rushes and sedges such as *Phragmites, Typha*, *Juncus, Carex*, *Cyperus*, *Lomandra* and *Schoenoplectus*. Floating and submerged macrophytes were found to be in low abundance in the lower Coxs River, but included Curly pondweed (*Potamogeton crispus*), the exotic Canadian pondweed (*Elodea canadensis*) and *Myriophyllum* spp.

A follow up survey of the Coxs River in the upper Coxs catchment by Cardno (2014a) reported the presence of River buttercup (*Ranunculus inundates*), Softstem bulrush (*Schoenoplectus tabernaemontani*), Spikerush (*Eleocharis* spp.), Tall spikerush, (*Eleocharis sphacelate*), Jointed rush (*Juncus articulatus*), Starwort (*Callitriche* spp.) and *Carex gaudichaundiana*, Tall spikerush (*Eleocharis sphacelate*), Curly pondweed, and Cumbungi (*Typha* spp.), Common reed (*Phragmites australis*), Water primrose (*Ludwigia peploides*) and Blue water speedwell (*Veronica anagallis-aquatica*), Blunt pondweed (*Potamogeton ochreatus*), Watercress (*Nasturtium officinale*) Willow, and Blackberry.

5.7. Aquatic fauna

A search of the NSW Department of Planning and Environment (DPE) *Bionet Atlas* revealed that a total of 771,864 records of 872 animal species have been recorded from the Hawkesbury-Nepean catchment (Department of Environment and Heritage, 2023). Non-aquatic species are beyond the scope of this report and were subsequently excluded. Aquatic fish and mammal species occurring within the Hawkesbury-Nepean catchment and reported on the *Bionet Atlas* are shown in Table 16. A total of 10 common fish species have been reported as occurring in the catchment. One listed species, (Macquarie Perch (*Macquaria australasica*) has been reported within the catchment however all records are located east of the Blue Mountains, and a total of 661 records for platypus have been reported as occurring within the catchment, including throughout the project area and associated waterways. The platypus was previously included on the NSW DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season however the species no longer holds any elevated ecological status under the EPBC Act and is not listed in NSW.

Table 16: Fish species recorded from the Hawkesbury-Nepean catchment and reported on the Bionet Atlas (Department of Environment and Heritage, 2023)

Common name	Taxonomic name	Status	Number of records
Fish			
Longfin eel	*Anguilla reinhardtii*	Common	45
Shortfin eel	*Anguillia australis*	Common	26
Common carp	*Cyprinus carpio*	Exotic; noxious listing	53
Common galaxias	*Galaxias maculatus*	Common	2
Mountain galaxias	*Galaxias olidus*	Common	6
Macquarie perch	*Macquaria australasica*	Threatened species (Endangered – EPBC Act; Endangered – FM Act)	6
Australian bass	*Macquaria novemaculeata*	Common	28
Striped gudgeon	*Gobiomorphus australis*	Common	2
Coxs gudgeon	*Gobiomorphus coxii*	Common	21
Firetail gudgeon	*Hypseleotris galii*	Common	2
Flathead gudgeon	*Philypnodon grandiceps*	Common	14
Eastern gambusia,	*Gambusia holbrooki*	Exotic; noxious listing	86
Australian smelt	*Retropinna semoni*	Common	36

Common name	Taxonomic name	Status	Number of records
Mammals			
Platypus	*Ornithorhynchus anatinus*	Common	661

The NSW Department of Primary industries (DPI) *the impact of road crossings on aquatic habitat in coastal waterways – Hawkesbury-Nepean, NSW* (Department of Primary Industries , 2006) reports the following fish species as occurring in the Hawkesbury-Nepean catchment (refer to Table 17) (Department of Primary Industries , 2006):

Table 17: Fish species recorded within the Hawkesbury-Nepean catchment (Department of Primary Industries , 2006)

Common name	Taxonomic name	Status	Migration and habitat
Silver bream	*Acanthopagrus australis*	Common	Amphidromous; coastal marine; estuaries and inshore reefs
Yellowfin goby	*Acanthogobius flavimanus*	Exotic	Freshwater reaches of streams just above tidal influence.
Banded grunter	*Amniataba percoides*	Exotic; noxious listing, NSW	Freshwater habitats – in Clarence River and has the Potential to spread to the Hawkesbury- Nepean region
Shortfin eel	*Anguillia australis*	common	Catadromous; coastal rivers & wetlands
Longfin eel	*Anguilla reinhardtii*	Common	Catadromous; coastal rivers
Smallmouthed hardyhead	*Atherinosoma microstoma*	Common	Unknown migration pattern; coastal estuarine and fresh waters
Silver Perch	*Bidyanus bidyanus*	Threatened Species (Critically Endangered EPBC Act; Vulnerable – FM Act)	Large scale migration: Habitat is predominantly in lowland and slope waterways. Present as a result of stocking.
Bigeye trevally	*Caranx sexfasciatus*	Common	Marine: juveniles common in mangrove estuaries, tidal creeks and can enter freshwater
Goldfish	*Carassius auratus*	Exotic	Widespread in lowland rivers.
Bull shark	*Carcharhinus leucas*	Common (not abundant)	Estuaries, lower reaches of rivers; coastal waters.
Milkfish	*Chanos chanos*	Common	Marine and warm water, shallow estuaries and rivers, will travel up rivers
Common carp	*Cyprinus carpio*	Exotic; noxious listing	Still gentle flowing rivers in inland NSW and some catchments along the coast.
Giant herring	*Elops hawaiensis*	Common	Sheltered embayment's and estuaries.
Climbing galaxias	*Galaxias brevipinnis*	Uncertain; distribution contracted	Amphidromous; headwaters and forested streams

Common name	Taxonomic name	Status	Migration and habitat
Common galaxias	*Galaxias maculatus*	common	Catadromous; coastal streams, lakes and lagoons – salt and fresh water environs
Mountain galaxias	*Galaxias olidus*	Common	Local migration; moderate and high elevations in coastal and inland rivers.
Eastern gambusia,	*Gambusia holbrooki*	Exotic; noxious listing	Widespread in coastal and inland NSW.
Striped gudgeon	*Gobiomorphus australis*	Common	Amphidromous; coastal streams generally at lower elevations.
Coxs gudgeon	*Gobiomorphus coxii*	Common	Potamodromous; freshwater reaches of coastal rivers
Empire gudgeon	Hypseleotris compressa	Common throughout its range	Unknown migration; lower reaches of coastal rivers.
Firetail gudgeon	*Hypseleotris galii*	common	Potamodromous; freshwater reaches of coastal streams
Macquarie perch	*Macquaria australasica*	Threatened species (Endangered – EPBC Act; Endangered – FM Act)	Potamodromous; Hawkesbury River, Shoalhaven River and inland NSW.
Trout cod	*Maccullochella macquariensis*	Threatened species (Endangered – EPBC Act; Endangered – FM Act)	Potamodromous; prefer deep flowing freshwaters with woody debris. Present as a result of stocking.
Australian bass	*Percalates novemaculatea*	Common	Catadromous; Coastal rivers up to 600m altitude.
Murray cod	*Maccullochella peelii peelii*	Threatened species (Vulnerable – EPBC Act)	Potamodromous; Habitat predominantly in lowland and slope waterways. Present as a result of stocking
Oxeye herring	*Megalops cyprinoides*	Abundant throughout its range	Amphidromous; tropical waters, estuaries and northern coastal fresh waters
Duboulays rainbowfish	*Melanotaenia duboulayi*	Relatively common throughout its range	Local migration; coastal waterways from Macleay River north into QLD

Common name	Taxonomic name	Status	Migration and habitat
Oriental weatherloach	*Misgurnis anguillicaudatus*	Exotic	Still and slow-flowing freshwaters with muddy substrate.
Shortheaded lamprey	*Mordacia mordax*	Moderately abundant in some rivers	Anadromous; coastal rivers from Hawkesbury River to southern catchments
Non-parasitic lamprey	*Mordacia praecox*	Uncertain	Anadromous; has been found in Moruya and Tuross Rivers in NSW.
Sea mullet	*Mugil cephalus*	Common	Amphidromous; lower reaches and estuaries of coastal catchments
Flat backed goby	*Mugilogobius platynotus*	Common	Estuaries, can tolerate freshwater but mainly a marine species
Freshwater mullet	*Myxus petardi*	Common	Catadromous; freshwater reaches of coastal rivers north of Georges River into QLD
Bullrout	*Notesthes robusta*	Limited abundance but not threatened	Catadromous; tidal estuaries and fresh waters
Rainbow trout	*Oncorhynchus mykiss*	Exotic	Local migration; montane regions along the Great Dividing Range
Flathead gudgeon	*Philypnodon grandiceps*	Common	Unknown migration; inland and coastal waters especially lakes and dams
Dwarf flathead gudgeon	*Philypnodon* sp.1	Common	Unknown migration; coastal and inland streams
Freshwater herring	*Potamalosa richmondia*	Not common but not considered under threat	Catadromous; estuaries and coastal fresh water rivers
Australian grayling	*Prototroctes maraena*	threatened species (Vulnerable – EPBC Act; Endangered – FM Act)	Catadromous; coastal freshwater systems.
Green sawfish	*Pristis zijsron*	threatened species (Vulnerable – EPBC Act; Presumed extinct – FM Act)	Amphidromous; lower reaches and estuaries of coastal catchments. Last confirmed sighting in 1972

Common name	Taxonomic name	Status	Migration and habitat
Southern blue-eye	*Pseudomugil signifer*	Common	Amphidromous; eastern draining catchments
Australian smelt	*Retropinna semoni*	Common	Potamodromous; Inland and coastal freshwater
Tarwhine	*Rhabdosargus sarba*	Common	Coastal waters, often entering estuaries
Softspined rainbowfish	*Rhadinocentrus ornatus*	Common	Potamodromous; Inland and coastal freshwater
Brown trout	*Salmo trutta*	Exotic	Restricted to cooler waters; montane waterways above 600m elevation.
Spotted scat	*Scatophagus argus*	Common	Estuarine and coastal, mangrove creeks, lower reaches of freshwater streams.
Banded scat	*Selenotoca multifasciata*	Common	Estuarine and coastal, mangrove creeks, lower reaches of freshwater streams
Mountain minnow	*Tanichthys albonubes*	Exotic	Temperate freshwaters
Freshwater catfish	*Tandanus tandanus*	not common	Potamodromous, still and slow moving freshwater in mid to lowland slopes

Recher, Hutchings, & Rosen (1993) report in *The biota of the Hawkesbury-Nepean catchment: reconstruction and restoration* that Australian bass (*Percalates novemaculatea*), Freshwater herring (*Potamalosa richmondia*), Longfin eel (*Anguilla reinhardtii*), Shortfin eel (*Anguilla australis*), Bullrout (*Notesthes robusta*), Murray cod (*Maccullochella peelii peelii*), Common carp (*Cyprinus carpio)*, Goldfish (*Carassius auratus*), Eastern gambusia (*Gambusia holbrooki*) and Trout either occur, or are stocked in the Hawkesbury-Nepean catchment.

Young, et al. (2000) reported that fish diversity within the lower Coxs River was limited. Flathead gudgeon (*Philypnodon grandiceps*) was reported to be common. It was suggested that predatory species such as Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*) had severely reduced Mountain galaxias (*Galaxias olidus*) numbers, however the species was still present (Young, et al., 2000). Young et al. (2000) reported exotic Eastern gambusia to be the most abundant species across the survey area and the report states that Australian bass, Mullet, and Macquarie perch once inhabited the river but had declined in the lower reaches of the river. Native water rat/rakali (*Hydromys chrysogaster*) and platypus were reported as occurring within the river.

A review of the Department of the Primary Industries' Fish stocking database (Department of Primary Industries, 2024b) found evidence for a total of four species being stocked within Lake Lyell. Australian bass is reported as being stocked every year since 2009/10 except 2011 and 2016/17 (Department of Primary Industries, 2024b). Brown trout has been stocked in Lake Lyell across the same time period excluding 2011/12. Rainbow trout have been stocked within Lake Lyell every year since 2009 and Tiger trout (*Salmo trutta* x *Salvelinus fontinalis*) were stocked in Lake Lyell from 2020 to 2022 (Department of Primary Industries, 2024b). Brown trout and Rainbow trout have been stocked in the Coxs River upstream of Lake Lyell with Brown trout stocked from 2014 to 2020 and Rainbow trout were stocked from 2019 to 2022. Anecdotally, Trout have continued to be stocked into 2023. Rainbow trout have been stocked in a number of locations on the Coxs River downstream of Lake Lyell over a number of years however the presence of the dam wall prevents access to Lake Lyell (Department of Primary Industries, 2024b). Both Brown trout and Rainbow trout have been stocked across a number of years between 2009 and 2022 in Farmers Creek, upstream of Lake Lyell in the vicinity of the township of Lithgow (Department of Primary Industries, 2024b).

The State of the Catchments reported that fish condition was poor and fish nativeness was moderate within the Hawkesbury-Nepean catchment while macroinvertebrate condition for the Lithgow area ranged from moderate to good (NSW Government, 2010c). Macroinvertebrate condition for the Lithgow area ranged from moderate to good. Pressures identified include exotic fish species, water regulation and alteration of seasonal temperature patterns, artificial barriers to fish passage, agricultural and urban development, loss of native riparian vegetation and climate change (NSW Government, 2010c).

The *Fisheries Spatial Data Portal* revealed that the freshwater fish community status in waterways intersecting Lake Lyell (Coxs River, Farmers Creek) are considered to be in 'poor' condition and that the freshwater fish community status in Lakel Lyell proper is 'very poor' (Department of Primary Industries, 2023b).

5.7.1. Threatened and culturally significant aquatic fauna

The results of the desktop assessment and literature review indicate that five threatened aquatic species listed under the FM Act and/or the EPBC Act, and the platypus have the potential to occur in waterways within 50 km of Lake Lyell (refer to Table 18) (Department of Climate Change, Energy, the Environment and Water, 2023a; Department of Environment and Heritage, 2023; Department of Primary Industries, 2023b) (refer to Annexure A; Annexure B). These species include:

- Trout cod (*Maccullochella macquariensis*)
- Murray cod (*Maccullochella peelii*)
- Macquarie perch (*Macquaria australasica*)
- Australian grayling (*Prototroctes maraena*)
- Silver perch (*Bidyanus bidyanus*)
- Platypus (*Ornithorhynchus anatinus*).

Trout cod and Macquarie perch are listed as Endangered under both the EPBC Act and FM Act, while Murray cod is listed as Vulnerable under the EPBC Act. The Australian grayling is listed as Vulnerable under the EPBC Act and Endangered under the FM Act. The Silver perch is listed as Critically Endangered under the EPBC Act and Vulnerable under the FM Act.

The platypus was previously included on the Commonwealth DCCEEW (2020) provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season but currently lacks any elevated conservation status under the EPBC Act and is not listed in NSW. While the platypus is not currently listed under the FM Act or the EPBC Act, there is a lack of knowledge regarding species abundance at the local catchment level and the species is subject to similar impacts as threatened fish, including waterway bank erosion, channel sedimentation, regulated waterways, barriers to water flow (e.g. dams and weirs), riparian zone degradation and loss of riparian vegetation (Grant & Temple-Smith, 2003; Hawke, et al., 2021). The species is also of high cultural significance for Australia's First Nation people and community significance for local residents to the Lake Lyell area.

An assessment was undertaken to evaluate the likelihood of each of these threatened aquatic species, and platypus, occurring within waterways intersecting the project area, or downstream of the project area, based on the aquatic habitats likely to be present as well as existing literature and DPI Fisheries datasets (Department of Environment and Heritage, 2023; Department of Primary Industries, 2023b); (refer to Annexure A; Annexure B). Of the six species, only the platypus has been recorded in Lake Lyell, the Coxs River and tributaries intersecting Lake Lyell, with the most recent records for platypus reported in 2021 (Department of Environment and Heritage, 2023); DPI Fisheries data indicates that Southern purple-spotted gudgeon (*Mogurnda adspersa*) has the potential to occur within Solitary Creek, located approximately five kilometres west of Lake Lyell. DPI Fisheries has not indicated that Southern purple-spotted gudgeon occurs in Lake Lyell, the Coxs River, or waterways intersecting Lake Lyell and it appears that there is no habitat connectivity between Solitary Creek and the project area (Department of Primary Industries, 2023b). The likelihood of occurrence assessment is provided in Table 18 and summaries of the ecology of the one species (platypus) with the potential to occur are provided in subsequent sections.

Given that only the platypus is recorded within the project area and the likelihood of occurrence of all other species is considered negligible to low, only the platypus is discussed further in this report. Despite the lack of elevated conservation listing for the species, the platypus is of high cultural significance and warrants further investigation.

Table 18: Results of the desktop analysis and literature review including species, conservation listing and likelihood of occurrence

Family	Common name	Scientific name	Data source				Conservation status		LoO
			DPI	BioNet	PMST	Lit.	FM Act	EPBC Act	
Fish									
Percichthyidae	Trout cod	*Maccullochella macquariensis*	-	-	x	x	E	E	Negligible
Percichthyidae	Murray cod	*Maccullochella peelii*	-	-	x	x	-	V	Negligible
Percichthyidae	Macquarie perch	*Macquaria australasica*	-	x	x	x	E	E	Low
Retropinnidae	Australian Grayling	*Prototroctes maraena*	-	-	x	x	E	V	Negligible
Terapontidae	Silver perch	*Bidyanus bidyanus*	-	-	x	x	V	CE	Low
Mammals									
	Platypus	*Ornithorhynchus anatinus*	-	x	-	x	-	PL	Recorded

Note: LoO = Likelihood of occurrence; E = Endangered; V = Vulnerable; CE = Critically Endangered; PL = Species is listed on the NSW DCCEEW revised provisional list of animals requiring urgent management intervention.

I. Platypus

The platypus is a semiaquatic, egg-laying mammal endemic to stream and river ecosystems throughout eastern Australia, including Tasmania (Grant, 2004). The platypus is adapted to feed exclusively in water where they forage for benthic macroinvertebrates, with adults consuming approximately 15 to 30% of their bodyweight daily (Krueger, et al., 1992; Holland & Jackson, 2002). Habitat requirements include large riparian trees, overhanging vegetation, pools 1 to 3m deep, and near vertical or undercut banks at least 0.5 m above the water (Serena, et al., 1998; Ellam, et al., 1998; Bethge, et al., 2003; Serena, et al., 2001; Worley & Serena, 2000). Reproduction in Platypus has been linked with rainfall events and typically occurs between June and October, with some local variation (Serena, et al., 2014; Grant & Temple-Smith, 2003). Platypus are highly mobile with individual home ranges and daily movements encompassing several kilometres (Gust & Handasyde, 1995; Griffiths, et al., 2014; Kelly, et al., 2012). Platypus are vulnerable to a number of threatening anthropogenic processes including reductions in the available surface water due to water extraction or diversion, changes to flow regimes, clearing of riparian and broader catchment vegetation, poor water quality, barriers to dispersal, entanglement in litter or fishing equipment, and predation by cats and foxes (Grant & Temple-Smith, 2003). Platypus were recently listed as Near Threatened by the International Union for the Conservation of Nature (IUCN) (Woinarski, et al., 2014; Woinarski & Burbidge, 2016). Whilst various individual councils across Australia have prepared Recovery Plans for platypus, no formal, overarching recovery plan has been prepared at the state or federal level for platypus. Platypus have been 'recorded' within the study area.

A literature review revealed that limited research has been undertaken into the direct impacts of water fluctuations on platypus. This section discusses known/possible direct impacts of water fluctuations on platypus. Although water fluctuations are expected to have significant impacts on habitat stability and suitability, including access to foraging habitats and burrows, water fluctuations that negatively impact water quality (i.e. sedimentation, turbidity, dissolved oxygen) could also directly impact platypus through direct displacement, disruption of reproductive cues, and visibility for movement, including foraging. It is also important to acknowledge the potential for indirect impacts of water fluctuations on platypus, most notably through the reduction in diet sources and decoupling of trophic interactions underpinning local platypus populations.

The platypus is a carnivorous predator, feeding primarily on macroinvertebrates that it digs out of the riverbed with its snout or catches while swimming (Hawke, et al., 2021; McLachlan-Troup, et al., 2010). Studies have shown that the platypus has a broad diet exceeding 60 families and 18 orders of macroinvertebrates, including a large variety of insects, crustaceans (shrimps, yabbies, ostracods), worms (annelids and nematodes), and bivalve molluscs (Gagher, et al., 1979; Grant, 1982; Hawke, et al., 2022; McLachlan-Troup, et al., 2010). Diet compositions have been shown to vary significantly between seasons, suggesting some diet selectivity (Hawke, et al., 2022; McLachlan-Troup, et al., 2010).

Some studies have demonstrated a dominance of mayfly larvae (Ephemeroptera), caddisfly larvae (Trichoptera), dragon- and damselfly larvae (Odonata) and fly larvae (Diptera) in platypus diets in some parts of its distribution (Grant, 1982; Hawke, et al., 2022). However, spatial variation in diet composition is recognised, likely reflecting local variation in macroinvertebrate assemblages and the flexibility of the platypus diet and feeding behaviour to accommodate shifts in resources (McLachlan-Troup, et al., 2010). The ability for platypus to accommodate changes in prey availability is further emphasised by the persistence of platypus populations in agricultural and urban waterways where macroinvertebrate assemblages are dominated by pollution tolerant taxa (e.g. Chironomidae) (Griffiths, et al., 2018). Anecdotally, the persistence of platypus populations seems to depend more on local abundances of macroinvertebrates, rather than species diversity or presence of any particular taxon (Griffiths Pers. Comm).

Extensive research has been performed on the effects of water fluctuations and quality on macroinvertebrates, including those supporting the diet of platypus. In particular, some of the primary prey species are recognised as being particularly sensitive to environmental disturbance (i.e. Ephemeroptera and Trichoptera) and are commonly used as bioindicators of ecosystem health (Turak, et al., 2000). Consequently, inappropriate management of flow regimes and habitat disturbances which compromise these key prey species could have cascading ecological effects, including impacts to platypus.

Extensive research has been performed on the effects of water fluctuations and quality on macroinvertebrates. Our review of the literature (refer to Annexure H) suggests the following potential consequences of a 2.1 to 2.5 m fluctuation in water level:

- Exposure of macroinvertebrates occupying a 0.2 to 0.5 m depth may lead to mortality and declines in local macroinvertebrate abundances (McEwen & Butler, 2010).
- Temperature changes associated with the reintroduction of water may compromise macroinvertebrates through direct physiological stress (causing mortality) and the disruption of life cycles (Miller, et al., 2007; Bonacina, et al., 2023; Yan, et al., 2021).
- Ephemeroptera and Trichoptera, pre-dominant dietary species in some parts of the species range, are effectively intolerable of declines in water quality (Turak, et al., 2004).
- A single function in water levels caused temporary negative impacts to large stoneflies, mayfly nymphs and amphipods (Hofmann, et al., 2008).
- If the water fluctuations continue long term, there may be a decrease in the diversity of macroinvertebrate taxa.
- There is potential for less sensitive taxa to fill the niche that may be left if sensitive species decrease in abundance.

Despite the potential impacts of water fluctuations on local macroinvertebrates, negative impacts to the local platypus populations through trophic cascades is unlikely. Platypus are likely to be resilient to the disturbance of macroinvertebrate assemblages and will modify their diets and feeding behaviour to accommodate shifts in resource availability (providing overall local abundances of macroinvertebrates remains high).

5.8. Groundwater dependent ecosystems

The condition of GDEs within the Coxs River catchment is not currently known as they are not monitored directly and are yet to be fully identified and mapped (Department of Planning and the Environment, 2010b) however the Bureau of Meteorology Groundwater Dependent Ecosystems Atlas reports that both high potential and low potential aquatic GDEs occur in the vicinity of the study area (Bureau of Meteorology, 2023).

A detailed *Groundwater Impact Assessment* (GIA) has been prepared by EMM Consulting Pty Limited as part of the EIS (Sections 6.7, 9.3.4 and 9.5) (EMM Consulting Pty Limited, 2025c)) and further considers impacts to GDEs including terrestrial, aquatic and subterranean GDEs. Groundwater drawdown is predicted to have negligible impacts on terrestrial GDEs whereas there will be a minor reduction in baseflow available to rivers and creeks. However, impacts are predicted to discrete stream-lengths only and residual impact are predicted to be negligible (EMM Consulting Pty Limited, 2025c).

6. Field survey results

6.1. Key fish habitat and habitat characterisation

The results of the KFH assessments undertaken at 14 sites during the November 2023 field survey are discussed below. General habitat characteristics of each site are summarised in Table 19.

All 14 sites were classified as Type 1 highly sensitive KFH and Class 1 major KFH. Type 1 classifications were assigned to all sites due to the presence of key habitat features including: in-stream snags or native aquatic plants, and the potential for the waterway to provide habitat for threatened aquatic species (LoO of any threatened species is considered low or negligible, see Section 5.7.1) (refer to Table 19).

The riparian zone was largely intact and comprised remanent forest at eight sites, although extensive disturbance and clearance for recreational activities was observed at six sites (refer to Table 19).

Table 19: Habitat characteristics at each aquatic ecology site assessed during the November 2023 field survey

Waterway	Site	Stream order	KFH: Waterway type	KFH: Waterway class	Description
Lake Lyell	LL01	6th	Type 1	Class 1	LL01 is located on Lake Lyell within the Sandalls Creek arm (refer to Figure 1). The Sandalls Creek arm is up to 50 m wide with a mix of clay, cobble and pebble substrate. The riparian zone is predominantly remnant forest with an infestation of Willow (*Salix* spp.) along the creek and Blackberry (*Rubus fruticosus L*. agg.) present in the understory. *Juncus* sp. and *Carex* sp. were present in the margins with beds of *Vallisneria* sp. and Curly-leafed pondweed (*Potamogeton crispus*) also present. Small amounts of dead standing timber were observed.
Lake Lyell	LL02	6th	Type 1	Class 1	LL02 is located on Lake Lyell within an embayment (refer to Figure 1). The substrate is a mixture of predominately sand, silt and gravel with smaller amounts of cobble and pebble. The riparian zone has been cleared in sections for recreation/camping and was dominated by an overstory of *Eucalyptus* sp. with Blackberry and weedy pasture grasses present. Macrophytes present were *Juncus* sp., *Carex* sp. and *Vallisneria* sp.
Lake Lyell	LL03	6th	Type 1	Class 1	LL03 is located on Lake Lyell within the Farmers Creek arm (refer to Figure 1). The banks have a 1:1 or greater steepness and the substrate was dominated by clay with a light covering of shale/rock rubble. The riparian zone was largely intact remnant native forest with a small amount of clearing for vehicle tracks. Submerged macrophytes including *Vallisneria* sp. and Curly-leafed pondweed were limited due to water depth. Fringing macrophytes included *Juncus* sp. and *Carex* sp.
Lake Lyell	LL04	6th	Type 1	Class 1	LL04 is located near the Lake Lyell Recreation Park and the dam wall (refer to Figure 1). The substrate was a mixture of sand and clay, with a boulder rock wall along the recreation park bank. The riparian zone was cleared along the recreation park bank with only an overstory of *Eucalyptus* sp. and a ground cover of weedy pasture grasses. The opposite bank supported a small section of remnant native forest. There is a small amount of large woody debris (LWD) along both banks, predominately flooded trees. Macrophytes present were *Vallisneria* sp. and the algae *Nitella* sp.
Lake Lyell	LL05	6th	Type 1	Class 1	LL05 is located on Lake Lyell in a small ephemeral tributary arm at the northern extent of the lake (refer to Figure 1). The arm is 2 to 20 m wide, averaging around 10 m. The substrate was dominated by clay and silt with a small covering of gravel, pebble, cobble and bedrock. The riparian zone was mostly remnant native forest with a small amount of clearing for vehicle tracks and camping sites, additionally there were large sections of Blackberry infestation. A large amount of LWD was present in the shallower sections of the arm including flooded trees and snags. Macrophytes present included *Vallisneria* sp., Curly-leafed pondweed and *Juncus* sp..
Lake Lyell	LL06	6th	Type 1	Class 1	LL06 is located on Lake Lyell in a small ephemeral tributary arm of the lake (refer to Figure 1). The arm was 5 to 50 m wide, averaging around 40 m. The substrate was dominated by clay and silt with some cobble. The riparian zone was mostly remnant native forest with a small amount of clearing for vehicle tracks and camping sites. Large clusters of Blackberry infestation were present along and near the bank. LWD was comprised of mainly flooded trees in shallower sections of the arm. Macrophytes present included *Vallisneria* sp., *Carex* sp. and *Juncus* sp.
Lake Lyell	CR03	6th	Type 1	Class 1	CR03 is located on Lake Lyell at the upper extent of the dam on the Coxs River arm (refer to Figure 1). The arm was 10 to 40 m wide, averaging around 30 m. The substrate was dominated by cobble, pebble and silt with smaller volumes of bedrock, boulder, gravel, sand and clay. The riparian zone was dominated by remnant native forest with clearing along vehicle tracks and infestations of Blackberry. Large amounts of flooded trees are present along the arm. Macrophytes present included *Vallisneria* sp., Curly-leafed pondweed, *Myriophyllum* sp. and *Typha* sp., and the algae *Chara* sp.
Lake Lyell	CSC02	6th	Type 1	Class 1	CSC02 is located on Lake Lyell in the Collits Swamp Creek arm of the dam (refer to Figure 1). The substrate was dominated by sand and silt with the bank edges shallower than at the other sites around the dam. The riparian zone was absent on both banks with no overstory present. Blackberry infestations dominated the banks with *Juncus* sp. and weedy pasture grass also present. No LWD was present at the site. Macrophytes present included *Vallisneria* sp. and Curly-leafed pondweed.
Coxs River	CR01	6th	Type 1	Class 1	CR01 is located on the Coxs River upstream of Lake Lyell at the Spinulosa Road river crossing (refer to Figure 1). The river was an average of 6 m wide and up to 1.5 m deep with a predominately cobble and pebble substrate. The riparian zone was remanent native forest with cleared areas for camping and vehicle tracks along both banks. A small amount of LWD was present at the site. Submerged macrophytes present include *Nitella* sp., Curly-leafed pondweed, *Myriophyllum* sp. and *Vallisneria* sp. Fringing and emergent species were present along the margins of the river including *Juncus* sp., *Eleocharis* sp., *Typha* sp. and Common reed.
Coxs River	CR02	6th	Type 1	Class 1	CR02 is on the Coxs River upstream of Lake Lyell at the Gauging Station Road river crossing (refer to Figure 1). The river was an average of 7 m wide and up to 1.5 m deep with a predominately cobble and pebble substrate. The riparian zone was dominated by remnant native forest with areas cleared for camping and vehicle tracks along both banks. Submerged macrophytes present at the time of the surveys include Curly-leafed pondweed and *Myriophyllum* sp. Emergent macrophytes present were *Typha* sp. and *Juncus* sp. The algae *Nitella* sp., was present and a small amount of LWD was present at the site at the time of the surveys.

Waterway	Site	Stream order	KFH: Waterway type	KFH: Waterway class	Description
Coxs River	CR04	6th	Type 1	Class 1	CR04 is located on the Coxs River immediately downstream of the Lake Lyell dam wall (refer to Figure 1). The river was an average of 10 m wide and 1.5 m deep downstream from the large spillway pool at the base of the dam wall. The substrate was dominated by cobble, pebble and boulder with a small coverage of bedrock. The banks were 20 m high and have been modified significantly with large amounts of boulders added to stabilise them. The riparian zone was dominated by remnant native forest along the left bank with the right bank dominated by *Allocasuarina* sp. and weedy pasture grasses and small clusters of Blackberry. Macrophytes were lacking at the site with only *Typha* sp. observed in the spillway pool. A small amount of LWD was present at the site.
Coxs River	CR05	6th	Type 1	Class 1	CR05 is located on the Coxs River downstream of Lake Lyell at the McKanes Falls Bridge (refer to Figure 1). The river was an average of 8 m wide and up to 1.5m deep, with a sand and cobble substrate. Land use along this section of the Coxs River was agriculture and residential with small sections of the riparian zone cleared and other sections fenced. The riparian overstory was dominated by *Allocasuarina* sp. with some scattered *Eucalyptus* sp. The understory was dominated by Blackberry and the ground cover consisted of weedy pasture grass and *Juncus* sp. Submerged macrophytes present included Curly-leafed pondweed and *Myriophyllum* sp. A moderate amount of LWD was present at the site at the time of the survey as was the algae *Nitella* sp.
Farmers Creek	FC02	4th	Type 1	Class 1	FC02 is located on Farmers Creek approximately 1000 m upstream from the Lake Lyell FSL (refer to Figure 1). The creek was an average of 5 m wide and up to 1.2 m deep, with a sand and cobble substrate. The riparian zone consisted of intact remnant native forest with Blackberry infestations along the right bank including a private residence with a cleared riparian understory. The overstorey was dominated by *Allocasuarina* sp. and the ground cover consisted of weedy pasture grass along the left bank. Curly-leafed pondweed was the only species of submerged macrophyte present. Fringing macrophytes included the invasive species, Water speedwell (*Veronica anagallis-aquatica*) and *Juncus* sp. Small amounts of LWD were present instream at the time of the survey.
Farmers Creek	FC03	4th	Type 1	Class 1	FC03 is located on Farmers Creek immediately upstream from Lake Lyell FSL (refer to Figure 1). The creek was an average of 6 m wide and up to 1.2 m deep, with a sand and cobble substrate. The site supported an intact remnant native forest along both banks with an infestation of Willow along the site reach. Fringing macrophytes present at the time of the surveys included *Persicaria* sp., *Juncus* sp. and Water speedwell. No submerged macrophytes were present at the site. The floating attached species *Callitriche* sp. was in some sections. Small amounts of LWD were present instream at the time of the survey.

6.2. In-situ water quality

In-situ water quality parameters were measured at each survey site (refer to Figure 7; Table 5) and are shown in Table 20. These measurements provide a 'snapshot' of water quality at a specific moment in time. In-situ water quality parameters have not been compared to the ANZECC and ARMCANZ (2000) trigger values or to the default guideline values (DGVs) (Water Quality Australia, 2018).

Water temperature ranged from 18ºC (CR04) to 21.6ºC (CR01) at the time of the survey, with variability between sites likely attributed to differences in water velocity, depth profiles and elevation (Table 20). Dissolved oxygen (mg/L; %) ranged from 6.96 mg/L; 86.6 % (LL05) to 9.85 mg/L and 117.4 % (FC03) indicating high levels of oxygen availability across all sites, with subtle differences likely due to local water velocities, temperatures and abundance of instream vegetation and algae (Table 20). Conductivity ranged from 239.6 µS/cm (CR04) to 511 µS/cm (CR03) and all sites should be considered fresh (Hammer, 1986). pH ranged from 7.99 (FC03) to 8.74 (LL03) suggesting all sites moderately alkaline (Foged, 1978). Finally, turbidity ranged from 1.16 NTU (LL03) to 12 NTU (CR01) which are all considered 'low turbidity' values.

Table 20: In-situ water quality parameters measured during the November 2023 surveys

Site	Temp (ºC)	Dissolved Oxygen (mg/L)	DO %	Specific Conductivity @ 25ºC (µS/cm)	Conductivity (µS/cm)	pH	Turbidity (NTU)
LL01	20.8	8.5	100.5	324.5	298.0	8.6	3.26
LL02	19.8	8.37	91.8	312.6	281.6	8.33	1.94
LL03	20.3	9.04	109.2	330.5	301.1	8.74	1.16
LL04	19.6	8.33	90.9	307.5	275.5	8.23	1.18
LL05	21.5	6.96	86.6	443.3	414.9	8.29	2.12
LL06	20.9	8.14	91.4	403.1	371.4	8.47	3.35
CR03	20.3	9.53	107.4	562.0	511.0	8.6	2.11
CSC02	19.9	8.53	93.8	313.4	282.9	8.32	3.18
CR01	21.6	8.97	104.2	427.2	399.1	8.67	12.0
CR02	20.5	9.33	112	532.1	486.1	8.81	11.6
CR04	18	8.33	94.7	276.7	239.6	8.06	1.22
CR05	18.3	9.5	108.8	277.4	241.8	8.0	13.7
FC02	20.4	9.06	110.2	316.2	288.5	8.64	2.27
FC03	19.2	9.85	117.4	297.3	264.5	7.99	3.48

6.3. Water quality (laboratory analyses)

Surface water samples were collected at 14 sites (refer to Figure 7; Table 5) and analysed in the laboratory for water quality with all results presented in Table 21. Water quality parameters were compared to the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed ecosystems in south-eastern Australian (freshwater lakes and reservoirs or lowland rivers where applicable). In contrast, all metals and metalloids were compared to the DGVs for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018). It should be noted that water quality parameters were evaluated based on single time point surveys, and results from more temporally replicated surveys are typically required for reliable comparisons with guidelines values. Consequently, comparisons to the ANZECC and ARMCANZ (2000) trigger values should be interpreted as indicative only. Results are summarised below:

- Laboratory analysis for pH of surface water were consistent with in-situ values ranging from circumneutral (pH 7.6 at LL03 – Lake Lyell) to alkaline (pH 8.55 at CR03 – Coxs River) with only CR03 on the Coxs River falling outside the ANZECC and ARMCANZ (2000) guideline trigger values (refer to Table 21). No sites were outside the trigger values for the ANZECC and ARMCANZ (2000) guideline trigger values. pH is often driven by surrounding land uses and soil type.
- Total dissolved solids (TDS) ranged from 160 mg/L (LL04) to 355 mg/L (CR03) (refer to Table 21). Typically, water can be considered potentially corrosive with a TDS concentration of less than 50 mg/L, or 'hard' with a TDS concentration of over 250 mg/L (Water Research Center, 2023).
- Conductivity (salinity) were again consistent with in-situ values ranging from 301 µS/cm (CR04) to 573 µS/cm (CR03). Conductivity fell outside the ANZECC and ARMCANZ (2000) guideline trigger values at all sites (refer to Table 21). Overall, salinity measured higher in the Coxs River than all other waterbodies (refer to Table 21).
- Contributing to salinity, the major ions recorded in surface water included sodium, calcium, potassium, magnesium, chloride and sulphate with sodium and sulphate the dominant ions. Concentrations of major ions were variable both within and between waterways, with differences in ionic dominance likely occurring in response to various factors such as evapo-concentration, salinity, and local geology and hydrogeology (Boulton, et al., 2014).

- Dissolved oxygen concentrations were provided in mg/l rather than as a percent saturation. While it is possible to calculate percent saturation from mg/l, the temperature of the sample must be known but was not recorded in the laboratory. As such it was not possible to compare dissolved oxygen to the ANZECC and ARMCANZ (2000) guideline trigger values however the data provided is still comparable to the in-situ estimates and suggests that all sites supported highly oxygenated waters (refer to Table 21).
- Surface water turbidity was consistently low across sites and waterways (refer to Table 21). Turbidity concentrations fell below the acceptable limits for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) in Lake Lyell at two sites (LL01 and LL03). Turbidity was also below the acceptable limits for slightly disturbed ecosystems in south-east Australia (lowland rivers) at all river or stream sites except in Collits Swamp Creek (CSC02) (refer to Table 21). Turbidity is often a sign of surrounding land use, suspended solids and flows at the time of, or prior to the surveys.
- Concentrations of total nitrogen were extremely low at all sites ranging from 0.3 to 0.7 mg/L (refer to Table 21). Values for all sites were below the ANZECC and ARMCANZ (2000) guideline trigger values for the relevant site (refer to Table 21). Nitrogen concentrations are often influenced by surrounding land uses (nutrient run-off) and microbial action within waterways.
- Concentrations of total phosphorus across all sites were well below the ANZECC and ARMCANZ (2000) guideline trigger values ranging from below the detectable limit at LL01, LL05 and CR03, to 0.05 mg/L at FC03 (Farmers Creek) (refer to Table 21). Like nitrogen, phosphorous concentration is driven by surrounding land uses and levels of run-off. High phosphorus concentrations are strongly associated with eutrophic conditions and algal blooms.
- Concentrations of dissolved metals and trace elements were generally either below, or within acceptable analytical limit of reporting or within ANZECC and ARMCANZ (2000) DGVs. These findings suggest that waterways associated with the project area are free of excessive metals which can arise from surrounding land use and industry (Water Quality Australia, 2018) (refer to Table 21).

Table 21: Water quality parameters recorded during the November 2023 field survey

	Water quality parameters	LL01	LL02	LL03	LL04	LL05	LL06	FC02	FC03	CR01	CR02	CR03	CR04	CR05	CSC02	ANZECC & ARMCANZ (2000) triggers Lower	Upper	DGVs for 80% species protection
		Lake Lyell						Farmers Creek		Coxs River					Collits Swamp Creek			
Basic	pH	7.93	7.94	7.6	7.85	8.32	8.02	7.95	7.77	7.97	8.22	8.55	7.69	7.91	7.88	6.5 6.5	8.5 8.0	-
	Total Dissolved Solids	182	164	184	160	292	224	178	174	334	319	355	161	167	172	-	-	-
	Specific Conductivity (µS/cm)	326	314	351	304	519	408	337	327	530	534	573	301	304	313	200.0 20.0	300.0 30.0	-
	Turbidity (NTU)	0.7	2.1	0.5	1.2	3.5	1.4	0.7	1.0	2.2	1.0	0.7	0.9	1.5	7.9	6.0 1.0	50.0 20.0	-
	Dissolved Oxygen	9.4	9.7	9.5	9.4	9.5	9.1	9.3	8.4	8.9	9.1	9.4	7.8	8.8	9.2	-	-	-
	Biological Oxygen Demand	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	-	
Major Ions	Sodium	37	35	41	33	69	51	50	47	80	80	84	32	32	33	-	-	-
	Calcium	12	12	13	12	18	21	14	14	23	21	17	12	21	14	-	-	-
	Potassium	4	4	5	4	6	5	6	6	6	6	6	4	4	4	-	-	-
	Magnesium	8	7	8	8	12	12	4	4	14	13	12	7	10	8	-	-	-
	Chloride	16	16	18	15	23	19	23	22	22	22	23	15	16	15	-	-	-
	Sulphate	67	63	71	60	144	91	60	68	120	118	141	70	53	66	-	-	-
	Total Alkalinity	65	62	69	60	100	80	66	66	123	120	141	62	80	72	-	-	-
Nutrients	Nitrogen (total)	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.7	0.3	0.5	0.3	0.4	0.4	0.5	-	500.0 350.0	-
	Kjeldahl Nitrogen (total)	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.6	0.3	0.3	0.3	0.3	0.4	0.4	-	-	-
	Ammonia	0.03	0.04	0.03	0.09	0.04	0.05	0.04	0.06	0.02	0.02	0.02	0.05	0.05	0.14	-	-	2.3
	Nitrite	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
	Nitrate	0.04	0.04	0.03	0.04	<0.01	0.01	0.04	0.07	0.01	0.18	<0.01	0.10	0.04	0.11	-	-	-
	Nitrite + Nitrate	0.04	0.04	0.03	0.04	<0.01	0.01	0.04	0.07	0.01	0.18	<0.01	0.10	0.04	0.11	-	-	-
	Phosphorus (total)	<0.01	0.01	0.01	0.01	<0.01	0.01	0.04	0.05	0.01	0.01	<0.01	0.02	0.02	0.03	-	50.0 10.0	-
Metals	Aluminium	<0.01	<0.01	0.01	<0.01	0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	0.15 (based on pH >6.5)
	Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.14
	Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	0.0008
	Chromium (III)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	-	-	0.0033
	Chromium (VI)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
	Copper	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	<0.001	<0.001	0.001	<0.001	<0.001	-	-	0.0025

	Lake Lyell						Farmers Creek		Coxs River					Collits Swamp Creek	ANZECC & ARMCANZ (2000) triggers		DGVs for 80% species protection
Water quality parameters	**LL01**	**LL02**	**LL03**	**LL04**	**LL05**	**LL06**	**FC02**	**FC03**	**CR01**	**CR02**	**CR03**	**CR04**	**CR05**	**CSC02**	**Lower**	**Upper**	
Iron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.06	<0.05	<0.05	<0.05	<0.05	0.06	0.06	-	-	-
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	**0.0094**
Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	**0.0054**
Nickel	0.006	0.004	0.006	0.005	0.009	0.007	0.001	0.002	0.008	0.009	0.010	0.005	0.004	0.004	-	-	**0.017**
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	**0.034**
Zinc	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	0.010	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	**0.031**

Notes: All parameters are dissolved unless otherwise specified; all units are mg/L unless otherwise specified; DGV for arsenic is AsV; DGV for chromium is CrIII; DGV for mercury is inorganic; DGV for selenium is total; Pink denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lakes and reservoirs) and blue denotes default trigger values for slightly disturbed ecosystems in south-east Australia (lowland rivers) (ANZECC and ARMCANZ, 2000) ; Green values exceed the DGVs, DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

6.4. Sediment quality (laboratory analysis)

In-situ sediment samples were collected from each survey site (refer to Figure 7; Table 5), and analysed for an array of parameters with results shown in Table 22. These measurements provide a 'snapshot' of sediment conditions at a specific moment in time and therefore should be interpreted as indicative only. Parameter values have not been compared to the ANZECC and ARMCANZ (2000) trigger values however metals have been compared to the DGVs (Water Quality Australia, 2018). Results are summarised below:

- Sediment pH values ranged from 6.5 (LL01 and CR03) to 7.3 (CR01) (refer to Table 22) and can be classified as ranging from mildly acidic to neutral (Hazelton & Murphy, 2007). Groundwater associated with the area, as well as a range of natural hydrogeochemical processes including concentrations of carbonates and organic matter, and redox reactions, can influence sediment pH (Ponnamperuma, 1972).
- Salinity (measured as conductivity standardised at 25°C) ranged from 28 µS/cm (CR04) to 86 µS/cm (LL05) (refer to Table 22). These low salinity concentrations are likely attributed to water volume and flow, and runoff from surrounding agricultural areas. Low salinity concentrations as shown on both the water quality results (refer to Table 21) and sediment quality results (refer to Table 22) can be considered 'fresh' (Hammer, 1986). Calcium, potassium and magnesium were the dominant ions recorded in sediment (Table 22).
- The moisture content of sediment ranged from 16.1 % (FC03) to 53.3 % (CR03) across sites (refer to Table 22).
- Sediment concentrations of total nitrogen ranged from 60 mg/kg (CR01 and CR04) to 12,080 mg/kg (CR03) (refer to Table 22).
- Total phosphorus concentrations ranged from 20 mg/kg (LL02) to 235 mg/kg (LL05) (refer to Table 22). These findings are consistent with the low nutrient concentrations seen in the water quality results (refer to Table 21). These values are likely attributed to the minimal amount of intensive farming activities surrounding Lake Lyell and the presence of an intact or semi-intact riparian zone at eight survey sites.
- The concentration of metals in sediments was variable across sites with 13 out of 18 parameters being detected in concentrations higher than the DGVs. Metals exceeding these thresholds included aluminium, arsenic, chromium (total), trivalent chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium and zinc (refer to Table 22) indicating the sediments from waterways associated with the project area are contaminated by heavy metals. The origin of the elevated metals concentrations is not currently known.

Table 22: Sediment quality parameters recorded during the November 2023 field survey

		Lake Lyell						Farmers Creek		Coxs River					Collits Swamp Creek	DGVs for 80% species protection
	Water quality parameters	**LL01**	**LL02**	**LL03**	**LL04**	**LL05**	**LL06**	**FC02**	**FC03**	**CR01**	**CR02**	**CR03**	**CR04**	**CR05**	**CSC02**	
Basic	pH (unit)	6.5	6.7	6.8	6.6	6.8	6.6	7.0	6.9	7.3	7.1	6.5	7.0	6.8	6.6	-
	Moisture content (%)	34.2	20.3	27.2	23.7	50.9	21.4	20.5	16.1	19.5	25.8	53.3	18.2	29.9	19.8	-
	Specific Conductivity (µS/cm)	63	33	64	22	86	55	35.0	41	47	68	68	28	41	45	-
Major Ions	Sodium	110	<50	120	50	190	60	<50	<50	<50	60	200	<50	70	<50	-
	Calcium	2200	100	740	390	2020	540	1610	1380	150	640	1330	180	1140	770	-
	Potassium	720	100	2550	100	580	280	100	290	270	230	510	100	330	610	-
	Magnesium	1520	<50	3480	250	2640	4970	120	390	280	540	2720	130	720	1230	-
	Chloride	10	<10	20	<10	30	40	<10	<10	<10	<10	30	30	<10	10	-
	Sulphate	30	30	30	10	80	10	20	<10	30	40	90	10	20	<10	-
Nutrients	Nitrogen (total)	850	90	830	140	1740	270	110	150	60	290	12080	60	240	170	-
	Kjeldahl Nitrogen (total)	850	90	830	140	1740	270	110	150	60	290	1280	60	240	170	-
	Ammonium (N)	13.6	5.9	3.4	2.1	27.9	7.5	1.4	5.6	0.4	6.0	10.6	0.2	10.2	1.5	-
	Ammonium (NH_4)	17.5	7.6	4.4	2.7	35.9	9.7	1.9	7.2	0.6	7.7	13.6	0.3	13.1	2.0	-
	Nitrite	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
	Nitrate	0.1	<0.1	0.2	0.1	0.1	0.1	0.7	1.8	0.1	0.3	0.2	0.2	0.1	<0.1	-
	Nitrite + Nitrate	0.1	<0.1	0.2	0.1	0.3	0.1	0.7	1.8	0.1	0.3	0.2	0.2	0.1	<0.1	-
	Phosphorus (total)	112	20	114	76	235	154	62	132	43	78	199	38	127	142	-
Metals	Aluminium	4780	480	12200	490	6610	9350	940	1300	790	1650	6270	530	1750	2540	0.15 (based on pH >6.5)
	Antimony	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-
	Arsenic	2.62	<1.0	1.8	<1.0	1.48	2.8	<1.0	<1.0	2.83	1.55	2.46	<1.0	<1.0	<1.0	0.14
	Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0008
	Chromium (Total)	19.0	1.3	41.9	1.4	10.5	27.6	1.6	2.0	4.6	4.0	11.4	<1.0	1.7	2.2	3.3
	Hexavalent Chromium	<0.5	<0.5	<0.5	<0.5	<0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.8	<0.5	<0.5	<0.5	0.04
	Trivalent Chromium	19	1	42	1	10	28	2.0	2.0	5.0	4.0	11	<1	2	2	0.0033
	Cobalt	4.3	<0.5	14.8	0.6	5.9	12.7	0.7	1.1	2.1	2.3	8.8	<0.5	1.2	2.0	0.0014
	Copper	11.6	<1.0	28.3	1.5	11.4	13.8	1.3	3.0	2.1	3.7	14.3	<1.0	1.5	1.4	0.0025
	Iron	18400	780	17000	1400	9830	29400	3320	5120	2010	3860	11200	1660	4000	6150	-
	Lead	27.3	1.3	17.8	1.0	8.2	8.3	2.6	4.9	2.7	2.5	8.5	1.4	1.9	1.6	0.0094
	Manganese	134	14	108	24	134	177	64	87	98	134	283	1.4	74	71	3.6
	Mercury	0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.0054
	Nickel	9.1	<1.0	36.5	1.1	11.4	24.0	1.4	1.8	3.4	5.4	15.8	<1.0	<1.0	<1.0	0.017
	Selenium	0.3	<0.1	0.4	<0.1	0.3	0.1	<0.1	<0.1	<0.1	0.1	0.4	<0.1	<0.1	<0.1	0.034
	Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0002
	Vanadium	55.2	3.8	53.9	5.0	14.8	39.5	3.5	7.6	9.4	6.1	17.5	4.0	12.9	21.8	0.006
	Zinc	20.3	1.6	66.8	19.1	35.5	60.8	14.9	22.5	11.9	16.4	49.8	5.4	6.6	7.8	0.031

Notes: All units are mg/kg unless otherwise specified; DGV for arsenic is AsV; DGV for mercury is inorganic; DGV for selenium is total; DGV species protection level for vanadium is unknown; Green values exceed the DGVs, DGVs are for the protection of 80% of species representative of highly disturbed systems (Water Quality Australia, 2018).

6.5. Algae and macrophytes

6.5.1. Phytoplankton and periphyton

Algal analysis performed on surface water samples from all 14 sites revealed a total of 80 taxa representing both phytoplankton and periphyton (refer to Table 23). Phytoplankton were recorded at all sites, while periphyton was recorded at only six sites due to a lack of appropriate substrate.

Taxa recorded included representatives from seven phyla; Bacillariophyta, Chlorophyta, Gyrista, Cyanophyta, Cryptophyta, Myzozoa and Ochrophyta. The diversity and abundance of algal taxa was variable between sites, ranging from 20 taxa (FC03 and CR01) to 31 taxa (LL04 and CR03) and from 11,974 cells/ml (CR01) to 2,681,240 cells/ml (CR03) (Table 23). The Coxs River supported the second highest diversity of taxa with 30 taxa recorded at CR02 (Table 23). The Coxs River sites supported the highest abundance of algae with the number of cells recorded in the millions and typically increasing from upstream to downstream (refer to Table 23). Collits Swamp Creek and LL01 and LL02 in Lake Lyell also supported cell abundances in the millions/ml whereas Farmers Creek supported cell counts in the hundreds of thousands/ml and abundances at LL01 to LL06 (Lake Lyell) ranged from tens of thousands to hundreds of thousands/ml. Overall, a general increase in abundance was observed moving downstream (refer to Table 23).

The majority of taxa recorded during the surveys belonged to the Chlorophyta (31 taxa), while the Bacillariophyta accounted for 17 taxa, Cyanophyta for 19 taxa, Myzozoa for three taxa, Gyrista for four taxa and Ochrophyta and Cryptophyta for one taxon each (refer to Table 23).

Of the Cyanophyta, *Aphanothece* spp. was the most abundant and was recorded at eight sites however the most widespread genera of the Cyanophyta were the *Phormidium* which was recorded at 11 out of 14 sites (refer to Table 23). The *Phormidium* and *Aphanothece* genera are both known to contain species that have the potential to produce anatoxin and can be bloom forming (Humbert, 2009).

Of the Bacillariophyta, Pennate diatoms were the most abundant and were recorded at 10 sites although this group is diverse and taxa belonging to multiple genera were recorded. The most widespread of the Bacillariophyta was the *Nitzschia* genera which was recorded at 13 out of 14 sites (refer to Table 23). *Nitzschia* species occur in fresh, estuarine, marine and hypersaline conditions and is considered to be widespread genera across Australia (McCarthy, 2013).

Of the Gyrista, the *Diatoma* was the most abundant genus and includes multiple species, with a total of 1,126,015 cells/ml recorded across five sites (refer to Table 23). The *Denticula* were the second most abundant genera and were recorded across two sites and the most widespread genera for the Gyrista was *Asterionella* which was recorded across eight sites (refer to Table 23).

Of the Chlorophyta, *Asterococcus* spp. was the most abundant and was recorded at seven sites. The *Nephrocytium* and *Oocystis* genera were more widespread being recorded at 12 sites each. The *Asterococcus* genera consists of five species and is found throughout Australia (Atlas of Living Australia, 2024a). *Nephrocytium* and *Oocystis* are both commonly found throughout Australia as well (Atlas of Living Australia, 2024b; Atlas of Living Australia, 2024c). *Peridinium* was the most abundant and widespread genera of the Myzozoa being recorded across five sites whereas all other Myzozoa were recorded at only two sites (refer to Table 23). The Ochrophyta were widespread being recorded across 10 sites and the Cryptophyta were less widespread being recorded at only two sites (refer to Table 23).

A total of 23 genera with the potential to be toxic and/or bloom forming were widespread but recorded in low abundances (refer to Table 23). Specifically, these included taxa belonging to Cyanophyta such as *Aphanocapsa* sp., *Aphanothece* sp., *Pediastrum* sp. and *Anabaena* sp.. Both *Pediastrum* and *Anabaena* are considered widespread across Australia and are typically planktonic in standing water, having the potential to be toxic and to form blooms (Entwistle, et al., 1997) (Mitrovic, et al., 2003). Some species can produce an anatoxin which can result in livestock death after drinking and may cause skin irritation (Entwistle & Skinner, 2002). Anabaena blooms can produce a distinctive musty odour linked to the chemical geosmin, and its toxin producing representatives in Australia, to date, include *Anabaena circinalis*, *Anabaena bergii*, *Anabaena crassa* and *Anabaena flos-aquae* (Mitrovic, et al., 2003).

Overall, none of the taxa recorded are considered to be threatened or to have restricted distribution.

Table 23: Phytoplankton and periphyton taxa recorded during the November 2023 field survey. Note: Values = cells/ml. Shading indicates potentially toxic and/or bloom forming species

		LakeLyell						Farmers Creek		Coxs River					Collits Swamp Creek
Phylum	**Taxonomic name**	**LL01**	**LL02**	**LL03**	**LL04**	**LL05**	**LL06**	**FC02**	**FC03**	**CR01**	**CR02**	**CR03**	**CR04**	**CR05**	**CSC02**
Bacillariophyta	*Achnanthidium*	10													
Bacillariophyta	*Aulacoseira*	142	160	100	80	640				180	82	714			638
Bacillariophyta	*Bacillaria*		820					34000	120					60	
Bacillariophyta	*Cocconeis*							450	450						
Bacillariophyta	*Cyclotella*	40	30	580			3550	10	220	20		10	110	40	
Bacillariophyta	*Cymbella*		2490		200			2			300				
Bacillariophyta	*Euglena*		190			12									
Bacillariophyta	*Gomphonema*				260						20520		2000		
Bacillariophyta	*Gyrosigma*									6	6				
Bacillariophyta	*Melosira*		330					8558	1638				19110	2400	
Bacillariophyta	*Navicula*					420		2	1070	180	2			7804	90
Bacillariophyta	*Naviculoids*					120		72000	3900	14	350		3500		6
Bacillariophyta	*Nitzschia*	20	10	250	270	480	70	32	2790	90	202		600	80	40
Bacillariophyta	*Pennate diatoms*				560	560	883	2560	1900	390	50		95600	80648	950
Bacillariophyta	*Rhoicosphenia*							25510	7750					4308	
Bacillariophyta	*Rhopalodia*														2
Bacillariophyta	*Staurosira*	144	850		1850		20				865				15460
Bacillariophyta	*Synedra*	124			170	250	283	1288		20			10500		
Chlorophyta	*Ankistrodesmus*													16	
Chlorophyta	*Asterococcus*	370	380	1270	600	180	184267					875			
Chlorophyta	*Botryococcus*	200		3500								200			
Chlorophyta	*Chlorella*					240									
Chlorophyta	*Cladophora*							120	120				4650	1300	
Chlorophyta	*Closterium*	180	220	880	320	226	48	2	32		6	284	30		342
Chlorophyta	*Closterium* large_spp					30		30					104	412	
Chlorophyta	*Coenochloris*	6820	800		7830		220				350	28290	1060		5350
Chlorophyta	*Coelastrum*	160											310		
Chlorophyta	*Cosmarium*							50	10		22				
Chlorophyta	*Desmidium*										1700				
Chlorophyta	*Elakatothrix*	1650	30	920			60					2050			
Chlorophyta	*Eudorina*	44				920						128			120
Chlorophyta	*Geminella*											66			
Chlorophyta	*Gloeocystis*		1300	3450	300	190					104	40			
Chlorophyta	*Gonatozygon*	8			190	276	350	75		242	780	16		84	50
Chlorophyta	*Monoraphidium*							20	580						
Chlorophyta	*Nephrocytium*	150	720	24600	1030	470	3320			230	832	2055	70	56	925
Chlorophyta	*Oedogonium*	80			150		32	72	72	30		64	1274	500	
Chlorophyta	*Oocystis*	4250	750	4750	2210	110	700			160	450	5370	450	44	4000
Chlorophyta	*Pandorina*		1320	2920									240		156
Chlorophyta	*Pediastrum*				2380	866	99			984	3656	100	15044	27308	1000

		LakeLyell						Farmers Creek		Coxs River					Collits Swamp Creek
Phylum	**Taxonomic name**	**LL01**	**LL02**	**LL03**	**LL04**	**LL05**	**LL06**	**FC02**	**FC03**	**CR01**	**CR02**	**CR03**	**CR04**	**CR05**	**CSC02**
Chlorophyta	*Phytoflagellates*					260		90							
Chlorophyta	*Phytoflagellates* small_spp									7700					
Chlorophyta	*Pseudodidymocystis*							30	30						
Chlorophyta	*Rhizoclonium*													1700	
Chlorophyta	*Scenedesmus*			80	340			101060	7470	530	1200			7000	
Chlorophyta	*Sphaerocystis*		2400	40000	1030	500	183								
Chlorophyta	*Spirogyra*						12						528		
Chlorophyta	*Staurastrum*	100	165	460	60	170	116			30	2	254		16	156
Chlorophyta	*Volvox*		700			150									
Chlorophyta	*Zygnema*				950		16					8	52		
Cryptophyta	*Chroomonas*	40									20				
Cyanophyta	*Anabaena*							56	60						
Cyanophyta	*Aphanothece*	1003000	1038000		475500	1810	754				125000	2630000			1917000
Cyanophyta	*Coelosphaerium*					2108				630	330	660			
Cyanophyta	*Dinobryon*											10			
Cyanophyta	*Dolichospermum circinale*	16													
Cyanophyta	*Geitlerinema*				534						32				
Cyanophyta	*Komvophoron*				770			7900					36046		
Cyanophyta	*Lyngbya*							1380				302			
Cyanophyta	*Merismopedia*						100								
Cyanophyta	*Microcystis aeruginosa*	2000	378	1030		390				139	84	394			554
Cyanophyta	*Microcystis flos-aquae*		640	1614	834		516								
Cyanophyta	*Microcystis wesenbergii*									92					
Cyanophyta	*Oscillatoria*	240		4174	974	268						164			986
Cyanophyta	*Phormidium*	180	3892	9580	4189		293236	4070	164	307		1070	5490		240
Cyanophyta	*Phormidium* narrow spp.			3850	543		1180						2500	12300	
Cyanophyta	*Planktothrix*			848											
Cyanophyta	*Pseudanabaena*	620					720				100				380
Cyanophyta	*Snowella*	2100	3100				282				6160	3330	1630		5350
Cyanophyta	*Synura*											10			
Cyanophyta	*Tychonema*			12600	1750							118	1800		164
Gyrista	*Actinocyclus*				30										
Gyrista	*Asterionella*	58	16	240	110		868					464	20		90
Gyrista	*Denticula*												23000	11000	
Gyrista	*Diatoma*							75	2020		1800		1081200	40920	
Gyrista	*Encyonema*							1100	100		450		1950		
Myzozoa	*Ceratium*	6										160			
Myzozoa	*Glenodinium*			30										8	
Myzozoa	*Peridinium*	2		225		10						64			180
Ochrophyta	*Fragilaria*	1448	1580	9750	1580	1154	230				122	3970	39835		1291
	Diversity	**30**	**26**	**25**	**31**	**27**	**27**	**27**	**20**	**20**	**30**	**31**	**29**	**22**	**26**
	Total	**1024202**	**1061271**	**127701**	**507594**	**12810**	**492115**	**260542**	**30496**	**11974**	**165577**	**2681240**	**1348703**	**198004**	**1955520**

6.5.2. Macrophytes

A total of 11 macrophytes from 11 families were recorded across 14 sites during the November 2023 survey (refer to Table 24). A total of nine native species of macrophyte and two exotic species of macrophyte were recorded across all sites. All sites supported macrophytes although diversity and relative abundances were variable between sites with LL04, CR04 and CR01 supporting the highest diversity with six species recorded (refer to Table 24). Exotic species were recorded in Farmers Creek only with one exotic species, Water speedwell, considered to be highly invasive across Australia.

Vallisneria sp. and *Juncus* sp. were the most widespread species, recorded at nine sites and eight sites respectively (refer to Table 24). Seven species of *Vallisneria* are known to occur across all states in Australia with all species considered native (PlantNET, 2011). A total of 68 species of *Juncus* occur within Australia 31 of which are recognised as endemic, and 21 species have been introduced and naturalised (PlantNET, 2022).

Carex sp. was recorded from four sites within Lake Lyell (refer to Table 24). Australia supports approximately 85 species of *Carex* and has been recorded in all states except the Northern Territory (Sainty & Jacobs, 2003).

Cumbungi (*Typha* sp.) was recorded from the Coxs River only. Cumbungi is a common species in Australia and can form dense stands of vegetation (Sainty & Jacobs, 2003).

Eleocharis sp. was recorded in the Coxs River only. *Eleocharis* sp. is a common wetland species in Australia and is often found in or alongside perennial wetlands (Sainty & Jacobs, 2003). Common reed was recorded from the same site (refer to Table 24).

Myriophyllum sp. was recorded in the Coxs River only (refer to Table 24). *Myriophyllum* sp. are common freshwater macrophytes found around the world. There are approximately 69 species in Australia, of which 37 are endemic and five are naturalised (Australian Plants Society NSW, 2020).

Common reed was recorded at one site on the Coxs River only (refer to Table 24). Common reed is an iconic reed species found throughout Australia. Common reed is found in many damp or wet habitats and may form a monoculture, often outcompeting other native macrophytes (PlantNET, 1993a).

Knotweed is an introduced macrophyte but was recorded at one site only (FC03) on Farmers Creek (refer to Table 24). Knotweed is a common aquatic herb that can rapidly invade riverbanks, forming dense, leafy thickets that smother the native understory (Sainty & Jacobs, 2003).

The exotic Curly-leafed pondweed (*Potamogeton crispus*) was recorded from six sites and was present in all waterways surveyed (refer to Table 24). The species is common to many waterways in eastern Australia and is known to form dense mats that inhibit growth of native species and impede recreational activities (Catling & Dobson, 1985).

Overall, none of the native taxa recorded are considered to be threatened or have a restricted distribution.

Table 24: Macrophyte taxa recorded during the November 2023 field survey

Macrophyte taxa	Lake Lyell						Farmers Creek		Coxs River					Collits Swamp Creek
	LL01	LL02	LL03	LL04	LL05	LL06	FC02	FC03	CR01	CR02	CR03	CR04	CR05	CSC02
Alismatales														
Potamogetonaceae														
Potamogeton crispus	✓				✓		✓			✓			✓	✓
Alismatales														
Hydrocharitaceae														
Vallisneria sp.	✓	✓	✓	✓	✓	✓			✓		✓			✓
Caryophyllales														
Polygonaceae														
Persicaria sp.								✓						
Cyperales														
Cyperaceae														
Carex sp.	✓	✓	✓			✓								
Lamiales														
Plantaginaceae								✓						
Callitriche sp.*														
Lamiales														
Plantaginaceae														
*Veronica anagallis-aquatica**							✓							
Poales														
Typhaceae														
Typha sp.									✓	✓	✓	✓		
Poales														
Cyperaceae														
Eleocharis sp.									✓					
Poales														
Juncaceae														
Juncus sp.	✓	✓	✓		✓		✓	✓	✓	✓				
Poales														
Gramineae														
Phragmites australis									✓					
Saxifragales														
Haloragaceae														
Myriophyllum sp.									✓	✓	✓		✓	
Diversity	**4**	**3**	**3**	**1**	**3**	**2**	**3**	**3**	**6**	**4**	**2**	**1**	**2**	**2**

Note: * indicates introduced species.

6.6. Aquatic invertebrates

SIGNAL2 is a biotic index based on the tolerance or intolerance of biota (macroinvertebrates) to water pollution. Sites with high scores are likely to have low nutrient, salinity and turbidity levels and high oxygen levels but its accuracy in identifying toxicants is less certain (EPA, 2021). As some biological objectives use the SIGNAL scores, these have been provided but SIGNAL2 uses updated, refined scores (Chessman, 2003).

The Ephemoptera, Plecoptera, Trichoptera (EPT) score indicates the number of families that are sensitive to pollution that are present at the site with a low score usually indicating that there has been some type of disturbance. Together, these scores give a good picture of the health of the waterway at a site.

Taxa richness, measured by the number of macroinvertebrate families collected, can give a good overview of the health of a waterway. High numbers (invertebrate families or diversity) are associated with diverse habitats present at the site but can also be influenced by mild nutrient enrichment which can increase the food supply. Taxa with a >0.5 probability of occurrence provide the best compromise between predicting taxa that are unlikely to occur at a site regardless of aquatic health and predicting taxa that will occur even at moderately impacted sites. Therefore, the results based on observed and expected scores represent the best way to assess the data to detect impacts on aquatic health. A score of anything below one is representative of a less than expected score and may indicate disturbance or pollution impacts.

6.6.1. Edge samples

The sites for Farmers Creek (FC02 and FC03) and Coxs River site CR04 had lower OE50 (number of families), OE50 (Signal) and EPT values suggesting that there is evidence of disturbance and pollution at these sites (refer to Table 25). CR01 had a marginally lower OE50 (Signal) score of 0.99. Site CR04 is immediately downstream of the Lilyvale Dam wall and is likely impacted by temperature stress because of controlled discharges from Lake Lyell. Farmers Creek (FC02 and FC03) are likely impacted by upstream discharges as cloudy and grey water smells were noted after a rain event typical of discharges from wastewater treatment systems (samples taken prior to this rain event). Sites CR01 and CR02 had scores close to one indicating that more sensitive taxa are present and may have minimal impacts. The impacts seen at site CR04 have dissipated at CR05 based on all metrics (refer to Table 25) which is further downstream.

These observations and scores are broadly reflected in the AUSRIVAS banding scores with impacted sites scoring lower. However, FC02 was still scored in band A suggesting impacts may not be as significant as those at FC03.

Table 25: AUSRIVAS modelling results for edge samples collected from Coxs River and Farmers Creek sites. Data is presented from most upstream to downstream sites

Site	Number of families	OE50 (number of families)	OE50 Signal	Signal 2	EPT	Band
Coxs River						
CR01	15	1.09	0.99	4.11	6	A
CR02	22	1.15	1.08	4.54	7	A
CR04	14	0.5	0.62	2.91	2	C
CR05	21	1.11	1	3.74	7	A
Farmers Creek						
FC02	18	0.93	0.94	3.91	2	A
FC03	18	0.75	0.87	3.63	4	B

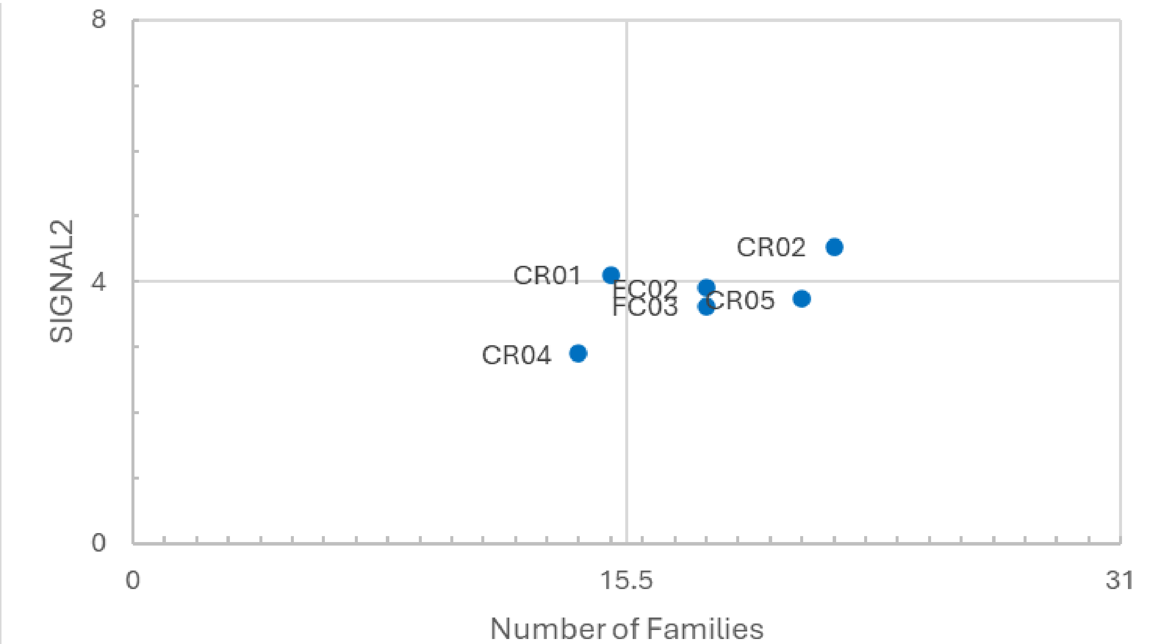


Figure 16: Edge samples collected from Coxs River and Farmers Creek, number of families and SIGNAL2

Whilst SIGNAL2 scores give an indication of water quality in the waterway from which the sample was collected, combining the SIGLAN2 score with the richness score (how many different macroinvertebrate families are present), can provide an indication of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community. This is shown in Figure 16 where quadrant boundaries are defined according to Chessman (2003) with the top right quadrant containing the healthiest sites and the bottom left quadrant containing sites that may be subject to urban, industrial or agricultural pollution or the downstream effect of dams. All sites are generally around the middle and to the right quadrants with the impacted CR04 the only site in the lower left quadrant. CR01 is around the centre, just above the middle in the upper left quadrant suggesting some impacts.

6.6.2. Riffle samples

Riffle sample results followed a similar pattern to the edge samples. Farmers Creek site FC03 had lower OE50 (number of families), OE50 (Signal) and EPT values suggesting that there is evidence of disturbance and pollution at this site (refer to Table 26). Sites CR01, CR02 and CR04 had OE50 (number of families) scores lower than one, however the pattern was not reflected in the OE50 (Signal) scores were not as severely impacted based on the numbers of sensitive taxa observed (EPT scores). CR05 and FC02 demonstrated a reverse pattern with scores above one for OE50 (number of families) and scores lower than one OE50 (signal) suggesting impacts are affecting more sensitive taxa which is seen in the EPT score for FC02 however not seen in CR05.

These observations and scores are broadly reflected in the AUSRIVAS banding scores. CR04 is the only site that scored lower than expected which is aligned with a low OE50 (number of families) score. The marginally low OE50 scores for all other sites didn't impact the AUSRIVAS banding scores.

Table 26: AUSRIVAS modelling results for riffle samples collected from Coxs River and Farmers Creek sites. Data is presented from most upstream to downstream sites

Site	Number of families	OE50 (number of families)	OE50 Signal	Signal 2	EPT	Band
Coxs River						
CR01	17	0.96	1.04	4.83	6	A
CR02	16	0.91	1.02	4.35	6	A
CR04	11	0.64	1.04	5.65	7	B
CR05	18	1.01	0.93	4.77	7	A
Farmers Creek						
FC02	16	1.01	0.94	5.38	5	A
FC03	14	0.88	0.89	5.48	4	A

Figure 17 shows the number of families and SIGNAL2 scores with quadrant boundaries defined by Chessman (2003). No sites are within the lower left quadrant. CR01, CR02 and CR05 are all within the lower right quadrant suggesting some impacts to sensitive taxa. CR04 and FC03 are in the upper left quadrant suggesting impacts to number of families. FC02 is in the upper right quadrant and can be considered the 'healthiest', however it is quite close to the centre.

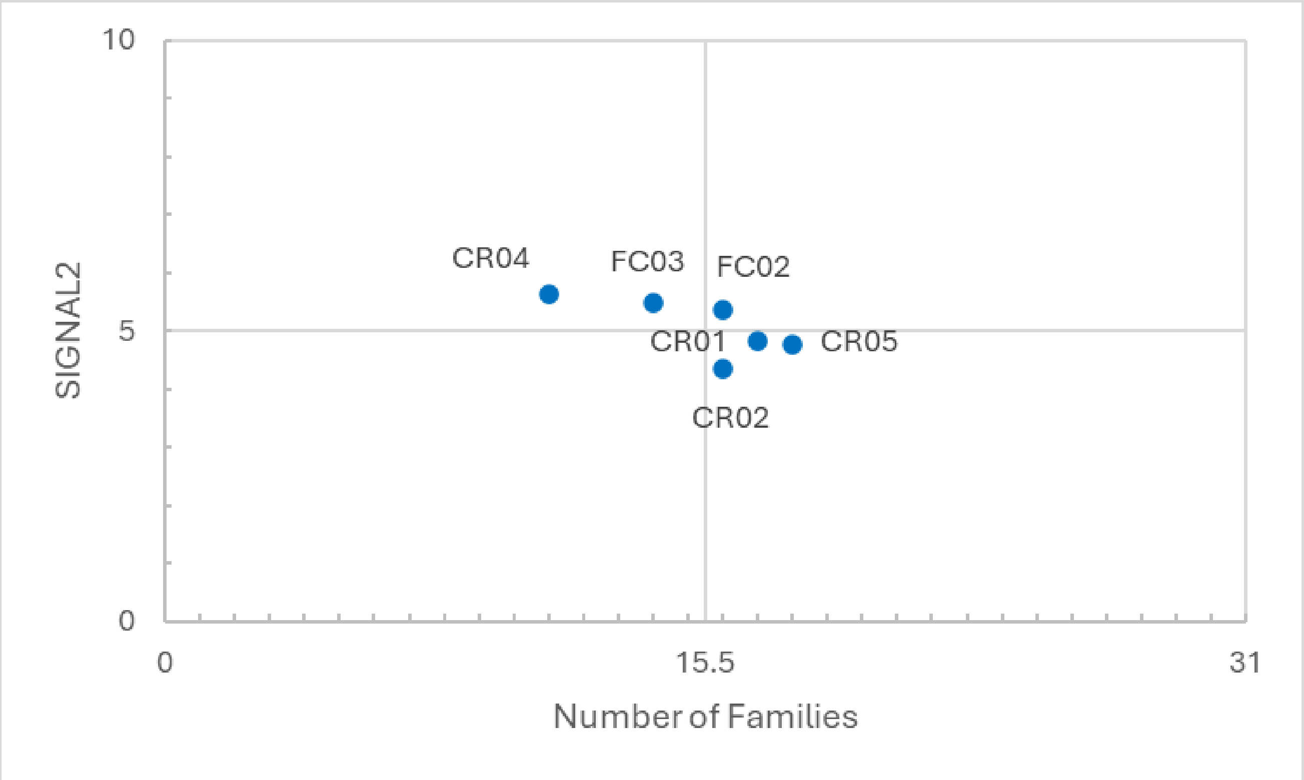


Figure 17: Riffle samples collected from Coxs River and Farmers Creek, number of families and SIGNAL2

6.7. Aquatic vertebrates/fish surveys

Aquatic surveys were undertaken by Austral at 14 sites in November 2023 (refer to Figure 7; Table 5). A total of nine fish species and one mammal species were recorded during the surveys (refer to Table 27). Fish species consisted of seven exotic species including Brown trout (*Salmo trutta*), Common carp (*Cyprinus carpio*), Eastern gambusia (*Gambusia holbrooki*), Goldfish (*Carassius auratus*), Rainbow trout (*Oncorhynchus mykiss*), Redfin perch (*Perca fluviatilis*) and Tiger trout (*Salmo trutta* x *Salvelinus fontinalis*) (refer to Table 27). In contrast, only two native species were recorded and included Australian bass (*Percalates novemaculeata*) and Flathead gudgeon (*Philypnodon grandiceps*) (refer to Table 27). Australian bass are not endemic to the system and are regularly stocked (Department of Primary Industries, 2024b).

Fish abundances were highest in Lake Lyell across all sites (range 57 to 201 fish), with the exception for site FC03 within Farmers Creek where 108 fish were recorded (refer to Table 27). Abundances were greatest at site LL02 in Lake Lyell (201 fish) and lowest at site CR01 in Coxs River (seven fish). Fish species diversity was also variable across sites and waterways, ranging between two and seven species among sites within Lake Lyell, two and four species within Coxs River, and two and four species within Farmers Creek, with the greatest diversity recorded at site LL06 from Lake Lyell (refer to Table 27).

Neither abundance or diversity appeared to be influenced by location (upstream or downstream) on the Coxs River whereas the downstream site on Farmers Creek supported both higher abundance and diversity when compared to the upstream site. Diversity of fishes recorded within Lake Lyell may have been influenced by the deeper waters. The majority of fishes recorded in Lake Lyell were captured using gill nets as bycatch during the platypus surveys rather than in fyke nets, bait nets or via electrofishing suggesting that fishes occupying deeper water habitats were less detectable using survey methods limited to shallow waters particularly during daytime surveys.

Flathead gudgeon was the most abundant native species (refer to Table 27). Flathead gudgeon is a relatively common freshwater species and is frequently recorded in large numbers when encountered (Native Fish Australia, 2022). In contrast, only 13 Australian bass were recorded from Lake Lyell and the Coxs River, however, this species is regularly stocked for recreational fishing purposes. Lake Lyell does not support a self-sustaining population of Australian bass which are catadromous, meaning they migrate to saline waters to spawn, which they are unable to do in Lake Lyell due to the presence of the spillway which is a significant barrier to fish passage. Regular stocking is therefore required for the species to persist within Lake Lyell.

Redfin perch, Rainbow trout and Brown trout were relatively common, with Redfin perch and Brown trout recorded in all waterways surveyed. Based on these surveys, fish assemblages within all waterways surveyed are considered of poor health and are an indicator of poor waterway health (NSW Government, 2010c; Department of Primary Industries, 2023b).

Based on the results of the November 2023 fish surveys it is considered unlikely that Lake Lyell, the Coxs River in the vicinity of Lake Lyell, Farmers Creek or Collits Swamp Creek support any fish species listed under the EPBC Act or FM Act.

One platypus was recorded during the November general aquatic surveys (refer to Table 27), however targeted platypus surveys were undertaken as part of this EIS process and are discussed in Section 6.8.

Table 27: Aquatic vertebrate species presence/absence and abundance recorded during the November 2023 field survey

		Lake Lyell						Coxs River					Farmers Creek		Collits Swamp Creek	
Common Name	**Taxonomic name**	**LL01**	**LL02**	**LL03**	**LL04**	**LL05**	**LL06**	**CR01**	**CR02**	**CR03**	**CR04**	**CR05**	**FC02**	**FC03**	**CSC02**	**Total**
Fish																
Australian bass^	*Percalates novemaculeata*	1		4	1	4	1			2						**13**
Brown trout*	*Salmo trutta*	1						2	1		4	1	15	5	2	**31**
Common carp*	*Cyprinus carpio*						2									**2**
Eastern gambusia*	*Gambusia holbrooki*		5				2		6	2						**15**
Flathead gudgeon	*Philypnodon grandiceps*	138	194	94	114	53	141	2	8	29	18			94	10	**895**
Goldfish*	*Carassius auratus*	2														**2**
Rainbow trout*	*Oncorhynchus mykiss*						4	2	11		2	7	5	5		**36**
Redfin perch*	*Perca fluviatilis*		2	17	1		13	1		4			1	4	2	**45**
Tiger trout^	*Salmo trutta × Salvelinus fontinalis*	1														**1**
Mammals																
Platypus	*Ornithorhynchus anatinus*						1									**1**
	Total	**143**	**201**	**115**	**116**	**57**	**164**	**7**	**26**	**37**	**24**	**8**	**21**	**108**	**14**	**1,041**

Note: Does not include targeted platypus monitoring results, see Section 6.8. * indicates exotic species. ^Indicates a stocked species.

6.8. Platypus surveys

Across the two survey periods in 2023 and 2024, a total of 17 platypus were caught across all six survey sites (refer to Table 28). Specifically, 12 platypus were caught within Farmers Creek arm of Lake Lyell (nine from FC1) and, five caught from the Coxs River arm of Lake Lyell (three from CR1). No individual platypus were caught at more than one survey site.

Platypus tagged during 2023 within the Farmers Creek arm of Lake Lyell were also fitted with radio telemetry allowing more detailed analysis of movements. This radio tracking identified that platypus tagged on the Farmers Creek arm of Lake Lyell typically burrowed in the creek system upstream of the lake FSL which is above the influence of the projects operational impacts.

Four platypus were recorded during daytime tracking within Lake Lyell, in the four suspected burrows identified in Lake Lyell (refer to Table 29). It is likely that the habitat provided in Farmers Creek provides more stable water levels compared to Lake Lyell and is more suitable habitat for burrows and nesting given that Lake Lyell water levels fluctuate significantly.

Table 28: Platypus numbers during the 2023/2024 surveys

Survey	Site	Female	Male
2023	FC1	2	0
	FC2	5	2
	FC3	0	0
	CR1	0	0
	CR2	0	1
	CR3	0	0
2024	FC1	1	0
	FC2	0	2
	FC3	0	0
	CR1	2	1
	CR2	0	1
	CR3	0	0
Total		**10**	**7**

Table 29: Number of days platypus were detected in the lake and creek sections of Farmers Creek arm of Lake Lyell using radio telemetry

Platypus	Number in creek	Number in lake
P1	7	0
P2	4	0
P3	8	0
P4	9	0
P5	7	2
P6	7	1
P7	8	0
P8	4	3
P9	3	6

Acoustic tracking results, showing platypus movements (refer to Figure 18) and utilisation (refer to Figure 19) are shown for the Farmers Creek arm of Lake Lyell.

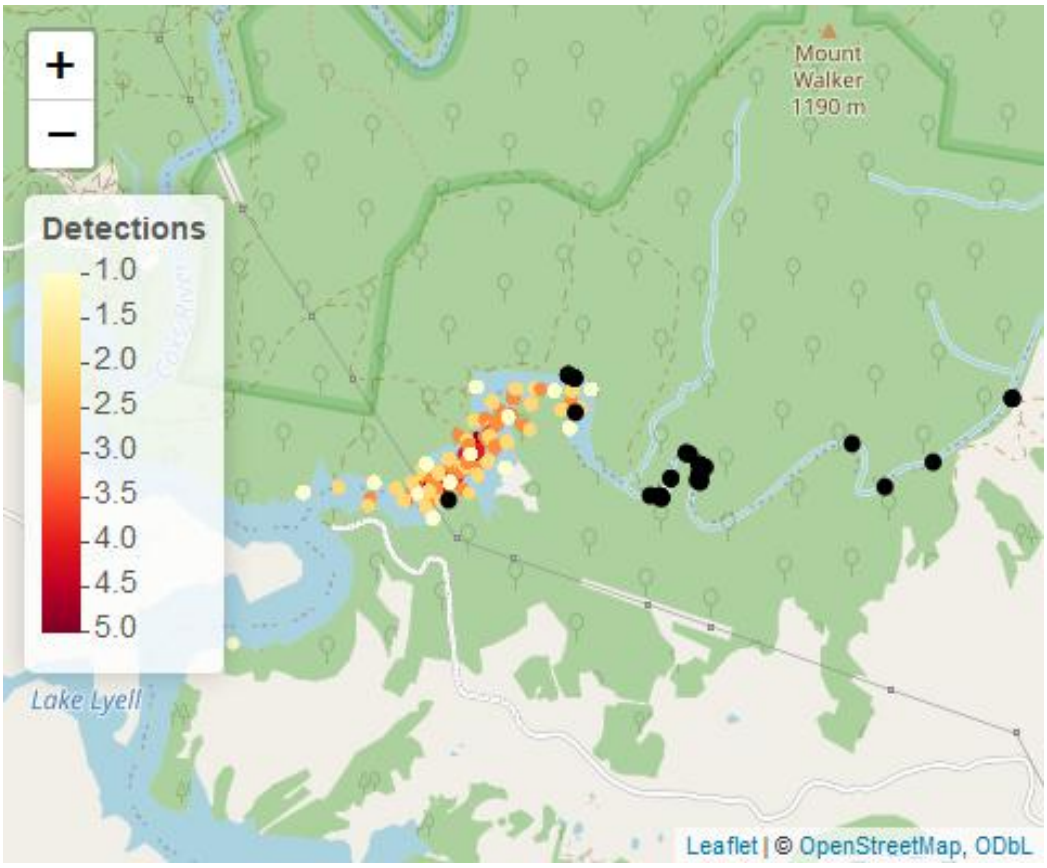


Figure 18: Triangulated detections of platypus in the water (white-red circles) and burrows (black circles)

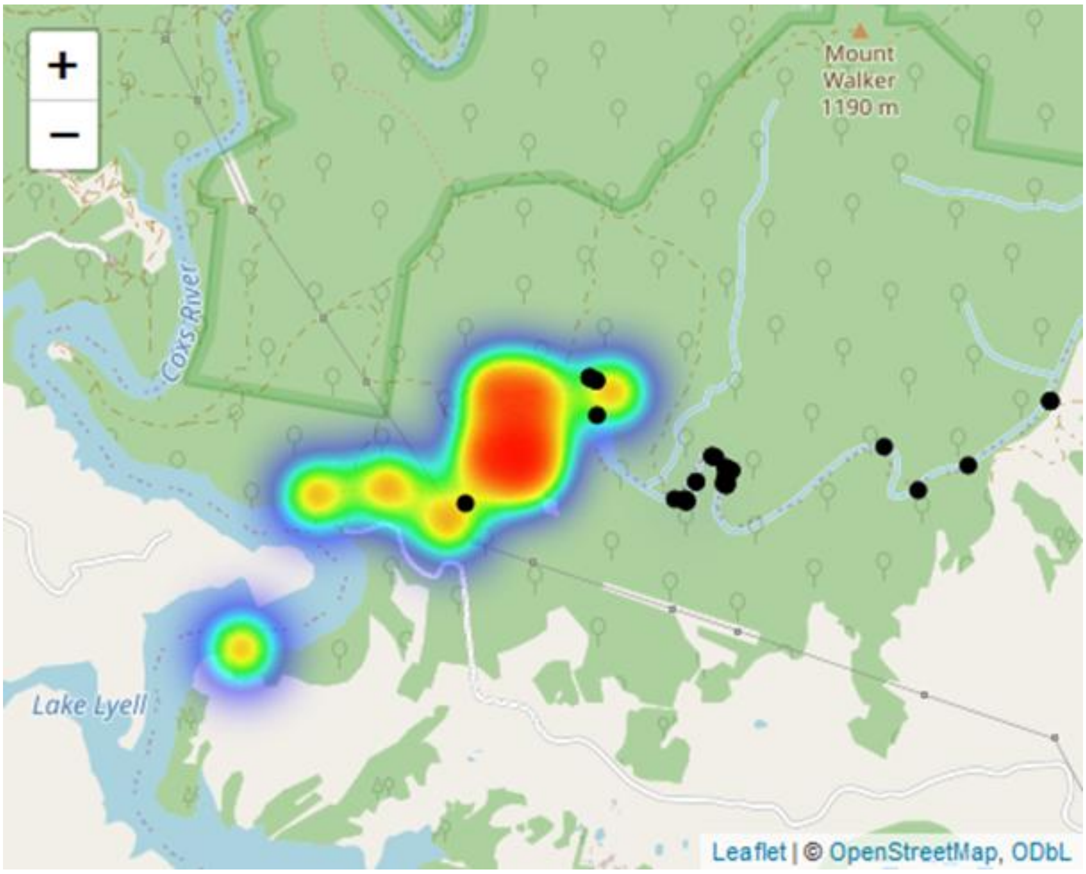


Figure 19: Heat map of triangulated detections of platypus in the water and burrows (black circles)

Based on acoustic telemetry (i.e. confined to range of acoustic receivers), four platypus were detected in the lake over 90% of the days tracked (45 days), another over 75% of the time, three between 31% and 58% and one less than 4% of the time (refer to Table 30). When foraging in the lake, platypus foraged predominantly in depths around 2 m but also extended to a maximum depth of 5 m (refer to Figure 20). Platypus were also noted to co-use burrows. Of the 26 burrows \ shelters, 10 were used by two to three platypus over the tracking period (refer to Table 31), and platypus were shown to use three to seven distinct shelter \ burrows over the tracking period (refer to Table 31). Contrary to the observed spatial patterns of burrow use, tracking data showed platypus spent most of their time foraging in the lake itself (refer to Table 30; Table 31). Platypus were shown to predominantly use burrows/shelters in Farmers Creek (refer to Table 32). Only four platypus were detected in burrows within the lake and only a single platypus had a preference for occupying burrows / shelters within the lake (P9) (refer to Table 32).

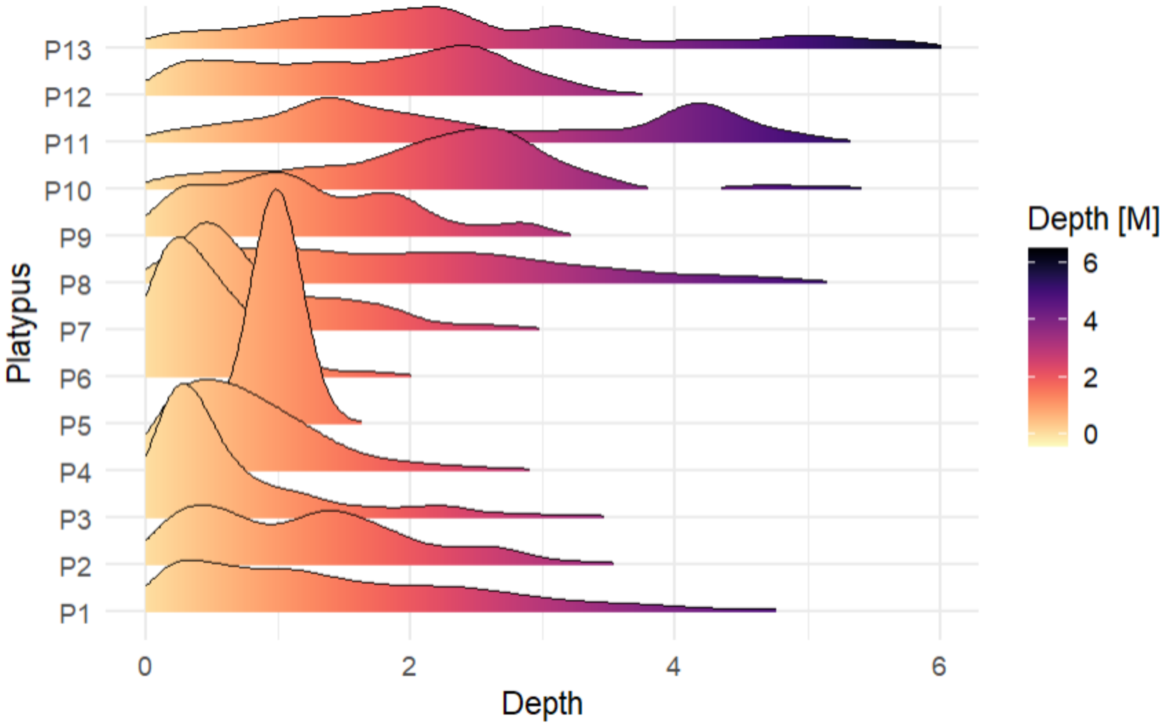


Figure 20: Depths of platypus recorded by the acoustic telemetry

Table 30: Number of days platypus were detected using acoustic telemetry (Farmers Creek survey 1 data only)

Platypus	Days detected	Days not detected	Proportion
P1	34	11	0.76
P2	26	19	0.58
P3	22	23	0.49
P4	45	0	1.00
P5	45	0	1.00
P6	42	3	0.93
P7	14	31	0.31
P8	45	0	1.00
P9	2	43	0.04

Table 31: The number of detections of platypus during survey 1 in distinct burrow\shelters, indicating possible co-use of burrows from the radio tracking data

Platypus	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26
P1	3																					1		1		
P2								1		1		2														
P3			1		1		1					2											1	1	1	
P4							7																		1	1
P5					1				5		1									1	1					
P6		2				5									1											
P7			1	1			1			1			1			2								1		
P8																		3		3			1			
P9											4			3					1	1						

Table 32: Detections of platypus over the tracking period during survey 1 in burrow\shelters in the lake and creek sections of Farmers Creek arm of Lake Lyell

Date	P1 (Creek)	P1 (Lake)	P2 (Creek)	P2 (Lake)	P3 (Creek)	P3 (Lake)	P4 (Creek)	P4 (Lake)	P5 (Creek)	P5 (Lake)	P6 (Creek)	P6 (Lake)	P7 (Creek)	P7 (Lake)	P8 (Creek)	P8 (Lake)	P9 (Creek)	P9 (Lake)
25/11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
26/11	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
27/11	1	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	0	1
28/11	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	0	1
29/11	0	0	0	0	1	0	1	0	0	1	1	0	1	0	0	0	1	0
30/11	1	0	1	0	1	0	1	0	1	0	0	1	1	0	1	0	0	1
1/12	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1	0
4/12	1	0	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1
6/12	0	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1
8/12	1	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1

A total of four platypus were tagged with acoustic tags during the second survey. Data from the second survey indicates that platypus preferred to access and use Lake Lyell within close proximity to the Coxs River (refer to Figure 21), suggesting that platypus from the Coxs River demonstrate a similar behaviour to the platypus from Farmers Creek (refer to Figure 22). Platypus from the second survey are likely to have burrows in the Coxs River and forage in Lake Lyell on a nightly bases however this was not monitored during the second survey. Platypus tagged on the Coxs River during the second survey demonstrated similar diving behaviours to those captured tracked and tagged on Farmers Creek with most dives occurring between 0 to 3 m, and less frequent diving up to 6 m deep (P10 to P13 in Figure 20).

Figure 21: Triangulated detections of platypus during the second survey from the Coxs River (white-red circles) and receiver locations (black circles)

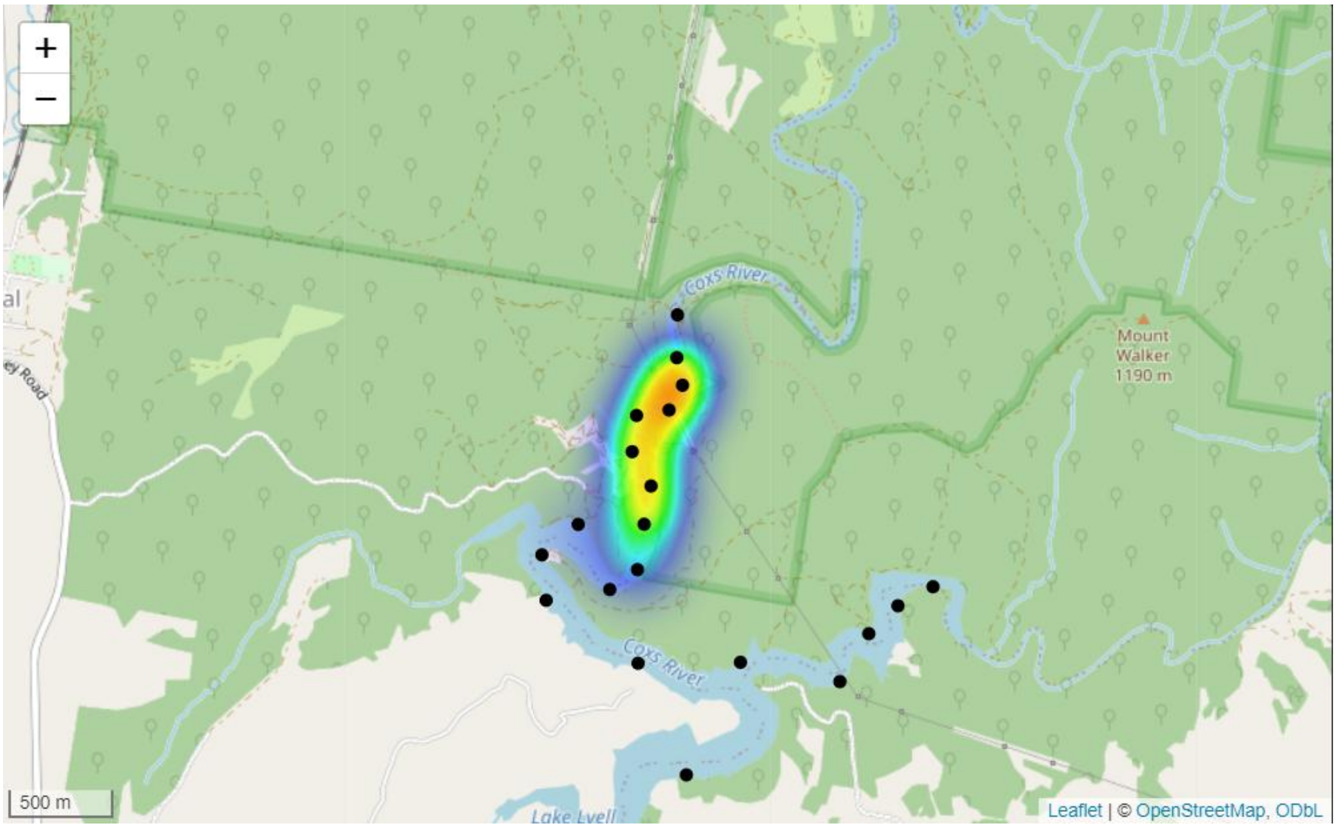


Figure 22: Heat map of triangulated detections of platypus in the water and receiver locations (black circles) from the second survey illustrating habitat use of Lake Lyell by the Coxs River platypus

Individual platypus acoustic tracking results for both the Farmers Creek arm and Coxs River arm of Lake Lyell as presented in Annexure G.

6.9. Environmental DNA (eDNA) assessment of Lake Lyell

6.9.1. Platypus

Environmental DNA surveys detected platypus in both the Coxs River and Farmers Creek arms of Lake Lyell (refer to Figure 23). However, the surveys did not detect the presence of platypus in the main Lake Lyell areas. Given the known presence of platypus within the broader Lake Lyell and Coxs River system we suggest these results are interpreted with caution. It is likely that platypus eDNA was not detected in Lake Lyell due to low local abundances of platypus and concentrations of genetical material. Given the eDNA analyses undertaken for Lake Lyell were based on the use of a universal vertebrate PCR assay and a DNA metabarcoding approach (as opposed to a specific qPCR assay), it is likely that platypus DNA was too dilute and swamped by genetic material from more abundant vertebrate taxa (e.g. fishes).

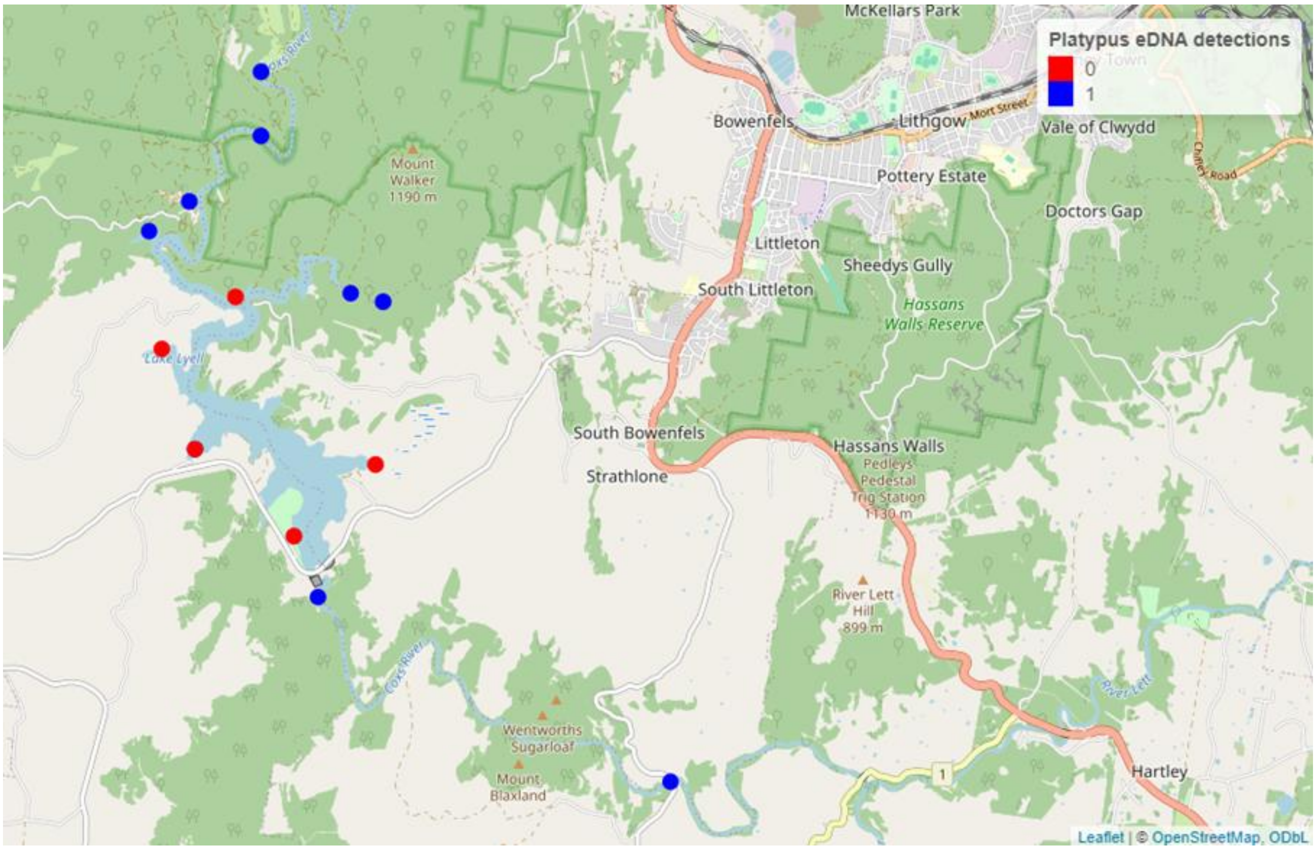


Figure 23: eDNA detections of platypus

6.9.2. Fish

Environmental DNA surveys detected all nine species reported from the surveys using traditional survey methods (refer to Table 33). While eDNA surveys detected Striped gudgeon (*Gobiomorphus australis*), this is likely due to be mistaken for Flathead gudgeon given the insensitivity of the eDNA assay to discriminate between closely related species. The eDNA surveys also detected an additional six species across the study areas not previously detected using the traditional survey methods. These included Mountain galaxias (*Galaxias olidus*), Dwarf galaxias (*Galaxiella pusilla*) and Golden perch. The detection of Dwarf galaxias is considered a false positive as the project area is outside the current known distribution for the species and does not support habitat characteristics preferred by Dwarf galaxias. Detections of Mountain galaxias and Golden perch may be true positive results. Additionally, eDNA detections of several species, including Yelloweye mullet (*Aldrichetta forsteri*), Grey mullet (*Mugil cephalus*) and Estuary perch (*Percalates colonorum*) are unlikely to be true positives as these are estuarine species (refer to Table 33).

The presence of Golden perch (*Macquaria ambigua*) DNA suggests that the species may have been introduced to the area for recreational purposes or the species was introduced to a private waterbody and escaped into the broader water system during a time of flood or other source. Given the widespread DNA detection (refer to Table 33) it is considered possible that Golden perch is present in the catchment.

Overall, the eDNA results support the November 2023 survey results showing that the waterways are dominated by exotic species, and it is considered unlikely that fish listed under either the EPBC Act or FM Act are present within the study area.

Table 33: number of eDNA detections of fish species by the area (CR – Coxs River, CRDS - Coxs River Downstream, FC – Farmers Creek, LL – Lake Lyell). Numbers indicate number of sites and proportions

Common name	Taxonomic name	CR	CRDS	FC	LL
Yelloweye mullet	*Aldrichetta forsteri*		1(0.17)		
Goldfish	*Carassius auratus*	3(0.33)	3(0.5)		21(1)
Common carp	*Cyprinus carpio*	6(0.67)	4(0.67)	2(0.33)	10(0.48)
Mountain galaxias	*Galaxias olidus*		3(0.5)	1(0.17)	
Dwarf galaxias	*Galaxiella pusilla*			1(0.17)	
Gambusia	*Gambusia affinis or holbrooki*	1(0.11)			3(0.14)
Eastern gambusia	*Gambusia holbrooki*	2(0.22)	1(0.17)	2(0.33)	8(0.38)
Striped gudgeon	*Gobiomorphus australis*		1(0.17)		
Golden perch	*Macquaria ambigua*	1(0.11)	1(0.17)		5(0.24)
Grey mullet	*Mugil cephalus*	2(0.22)	1(0.17)	2(0.33)	7(0.33)
Rainbow trout	*Oncorhynchus mykiss*	9(1)	6(1)	6(1)	8(0.38)
Redfin perch	*Perca fluviatilis*	9(1)	2(0.33)	6(1)	21(1)
Estuary perch	*Percalates colonorum*		2(0.33)	2(0.33)	5(0.24)
Australian bass	*Percalates novemaculeata*	1(0.11)	3(0.5)		10(0.48)
Flathead gudgeon	*Philypnodon grandiceps*	7(0.78)	6(1)	3(0.5)	21(1)
Brown trout	*Salmo trutta*	9(1)	6(1)	6(1)	11(0.52)
Tench	*Tinca tinca*				1(0.05)

6.10. Targeted macroinvertebrate surveys

6.10.1. Site descriptions

I. Farmers Creek

Farmers Creek is a shallow waterway that is a series of riffles and runs with pool habitat also present. The creek is generally 3 to 6 m wide and has a good riparian cover that provides shading and bank stability. The substrate is dominated by boulder, cobble, gravel and sand. Farmers creek receives discharge effluent from the Lithgow STP and passes through Lithgow's urban areas, semi-rural and rural areas of land use. Samples collected from Farmers Creek were dominated by gravel and sand Figure 24.

Figure 24: Macroinvertebrate sample from Farmers Creek

II. Coxs River

The Coxs River varied in width from 8 to 40 m in width at the time of sampling. The Coxs River sites typically supported macrophytes. The banks were modified however the riparian zone typically supported remnant forest. The substrate comprised of sand, cobble, pebble and boulder with a small coverage of bedrock. Samples collected from Farmers Creek were dominated by sand and silt (refer to Figure 25).

Figure 25: Macroinvertebrate sample from the Coxs River

III. Lake Lyell

Macroinvertebrate samples were collected from three depth ranges in Lake Lyell, 1, 2 and 3 m deep. All of the Lake Lyell samples were collected from the Farmers Creek arm of the lake. All of the samples collected were dominated by sand and silt (refer to Figure 26). Farmers Creek terminates into Lake Lyell at this point and sand, silt and other material forms a delta within the Farmers Creek arm of Lake Lyell. Macroinvertebrate samples collected from Lake Lyell.

Figure 26: Macroinvertebrate sample from Farmers Creek

6.10.2. Macroinvertebrate Statistical Analyses

I. Comparison between Coxs River and Farmers Creek

Statistical analyses were performed to test for differences in species indicator measures between sampling locations (i.e. Coxs River vs Farmers Creek). Analyses were undertaken using data from 10 airlift samples from Coxs River (sites CR01 to CR10) and data from 10 samples from Farmers Creek (sites FC01 to FC10) (refer to Figure 27) collected using a combination of airlift and riffle samples. MDS identified three distinct clusters / groups distributed across the x-axis. However, each cluster included samples from both sampling locations, suggesting location is having little effect on species indicator measures (refer to Figure 27). Likewise, analyses performed on individual indicator measures analysed found no significant effect of location (refer to Figure 28, Table 34). Finally, statistical analyses were performed to test the effect of location on the abundances of selected taxonomic groups (restricted to taxa recorded from >40% of samples). Results suggest a significant difference ($p < 0.05$) between Coxs River and Farmers Creek for the abundances Cladocera, Ostracoda, Atyidae, Tanypodinae and Leptoceridae, all of which were more abundant in the Coxs River than Farmers Creek (refer to Figure 29, Table 35).

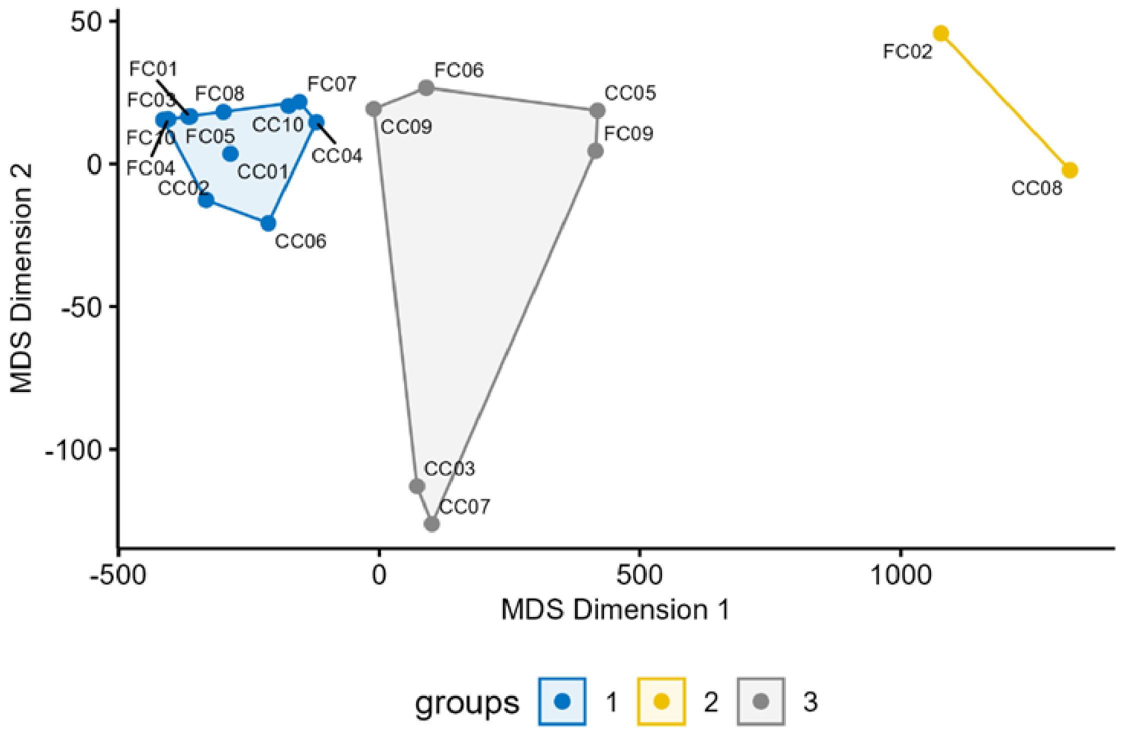


Figure 27: K-means clustering of MDS data for seven species indicators in Coxs River and Farmers Creek

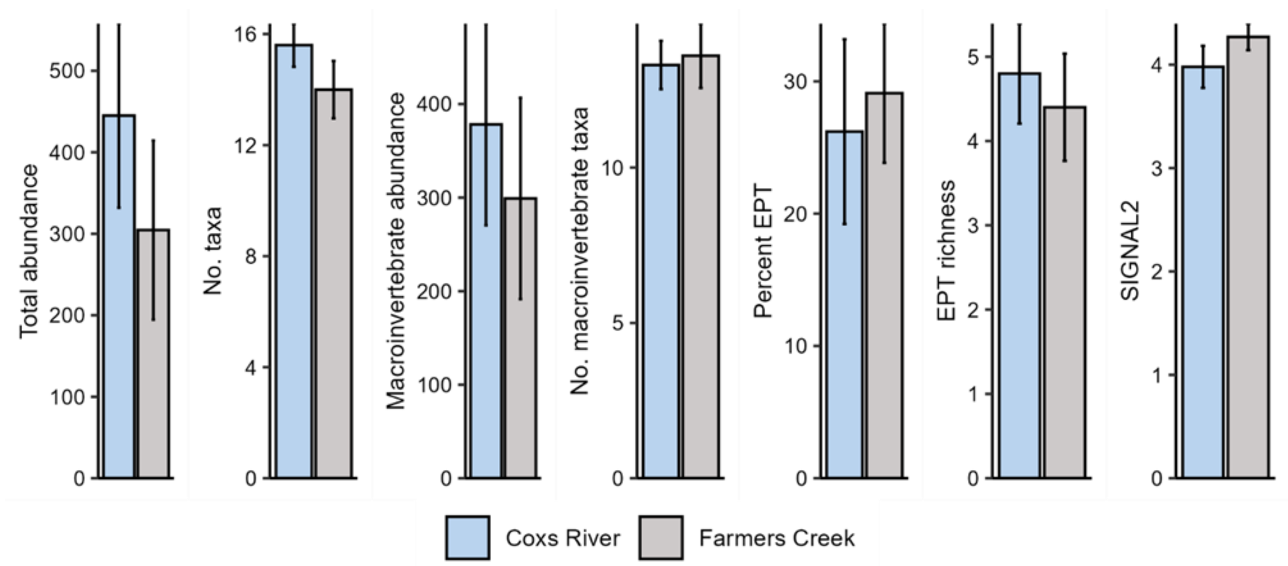


Figure 28: Species indicator measures in Coxs River and Farmers Creek (Values = mean ± s.e.)

Table 34: Species indicator measures in Coxs River and Farmers Creek. Mean values (± s.e.) and Welch Two Sample t-test analyses

Indicator	Coxs River	Farmers Creek	Statistics
Total abundance	445 ± 113	304 ± 110	t = 0.89164, df = 17.987, p-value = 0.3844
Number of taxa	16 ± 0.8	14 ± 1.0	t = 1.2377, df = 16.721, p-value = 0.2329
Macroinvertebrate abundance	378 ± 108	299 ± 108	t = 0.51911, df = 18, p-value = 0.61
Number of macroinvertebrate taxa	13 ± 0.8	14 ± 1.0	t = -0.23199, df = 16.682, p-value = 0.8194
% EPT	26 ± 7	29 ± 5	t = -0.33225, df = 16.736, p-value = 0.7438
EPT richness	4.8 ± 0.6	4.4 ± 0.6	t = 0.46018, df = 17.911, p-value = 0.6509
SIGNAL2	4.0 ± 0.2	4.3 ± 0.1	t = -1.208, df = 15.232, p-value = 0.2455

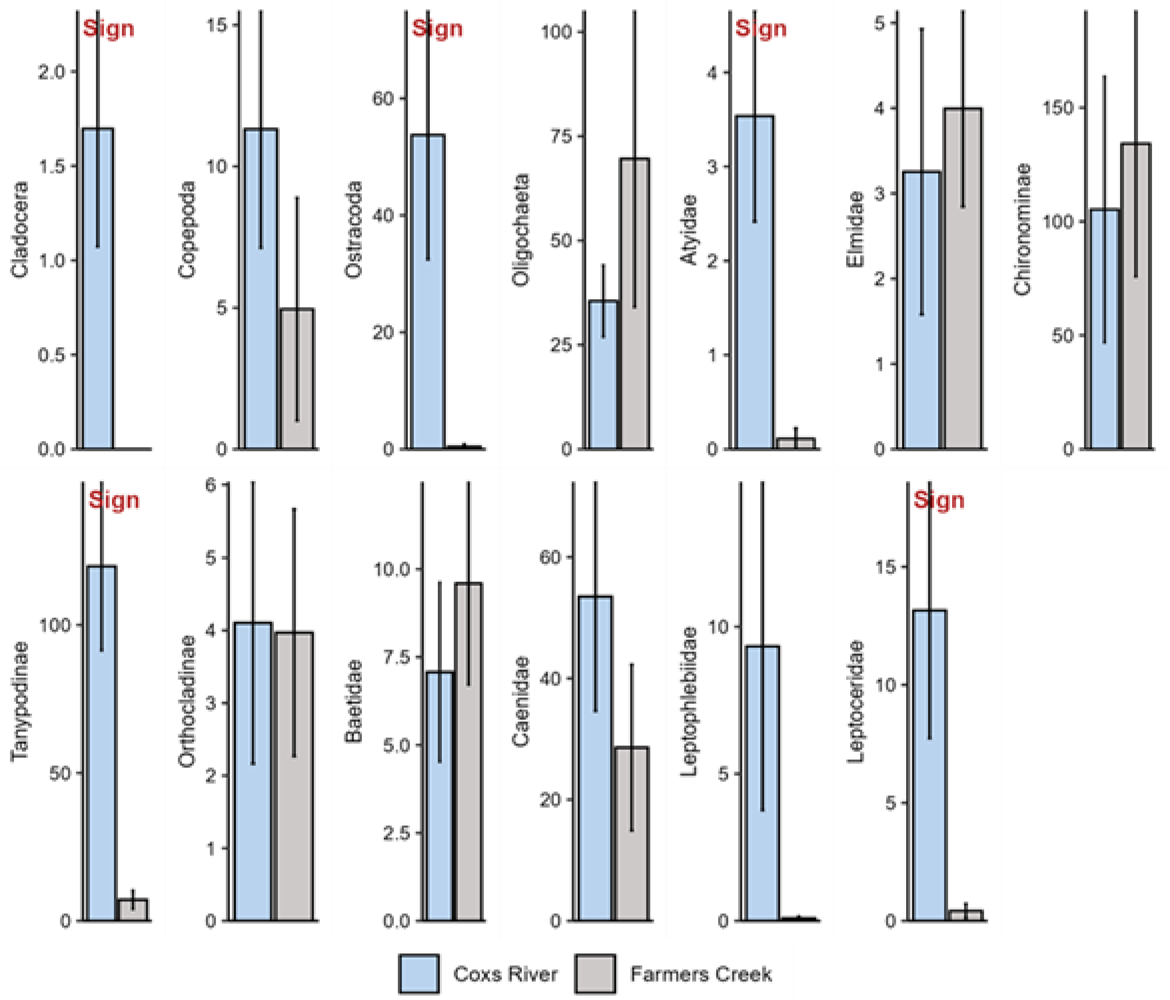


Figure 29: Selected taxa abundance measures in Coxs River and Farmers Creek (Values = mean ± s.e.). Sign = significant difference detected between locations

Table 35: Selected taxa abundance measures in Coxs River and Farmers Creek. Mean values (± s.e.) and Welch Two Sample t-test analyses

Taxa	Coxs Ck	Farmers Ck	statistics	SIGN
Cladocera	1.7 ± 0.626	0	t = 3.3369, df = 9, p-value = 0.008703	SIGN
Copepoda	11.3 ± 4.2	4.95 ± 3.94	t = 1.1058, df = 17.929, p-value = 0.2834	
Ostracoda	53.8 ± 21.3	0.424 ± 0.424	t = 3.717, df = 9.3428, p-value = 0.004491	SIGN
Oligochaeta	35.5 ± 8.58	69.6 ± 35.5	t = -0.93251, df = 10.045, p-value = 0.3729	
Atyidae	3.54 ± 1.12	0.11 ± 0.11	t = 4.1191, df = 10.7, p-value = 0.001804	SIGN

Taxa	Coxs Ck	Farmers Ck	statistics	SIGN
Elmidae	3.25 ± 1.67	3.99 ± 1.15	t = -0.36463, df = 15.949, p-value = 0.7202	
Chironominae	105 ± 58	134 ± 58	t = -0.35063, df = 18, p-value = 0.7299	
Tanypodinae	120 ± 28	7 ± 3	t = 6.0022, df = 13.739, p-value = 3.51e-05	SIGN
Orthocladinae	4.1 ± 1.9	3.97 ± 1.70	t = 0.05195, df = 17.702, p-value = 0.9592	
Baetidae	7.07 ± 2.55	9.59 ± 2.88	t = -0.65575, df = 17.74, p-value = 0.5204	
Caenidae	53.5 ± 18.9	28.6 ± 13.7	t = 1.0675, df = 16.422, p-value = 0.301	
Leptophlebiidae	9.34 ± 5.58	0.09 ± 0.06	t = 1.6583, df = 9.002, p-value = 0.1316	
Leptoceridae	13.2 ± 5.43	0.424 ± 0.302	t = 2.3428, df = 9.0557, p-value = 0.04365	SIGN

II. Comparison between Airlift samples and riffle samples at Farmers Creek.

Statistical comparisons of the effects sampling methods on species indicator measures were performed on samples from 10 Farmers Creek sites (FC01 to FC10). Results showed that sample method had a significant effect of some indicator measures, namely total abundance, macroinvertebrate abundance, % EPT and SIGNAL2 (refer to Figure 30). Results also showed that sample method had a significant effect on abundance measures for some taxa, including Chironominae, Tanypodinae, Baetidae and Caenidae (Figure 31). Consequently, the results from Experiment 1 (Comparison between Coxs River and Farmers Creek), need to be interpreted with caution given the associated analyses included data from a mix of airlift and riffle sampling. Reducing analyses to a single survey method for Experiment 1 led to highly skewed sample sizes between locations (i.e. removing riffle samples, Coxs River – 10, Farmers Creek – 4) and makes statistical analyses less reliable.

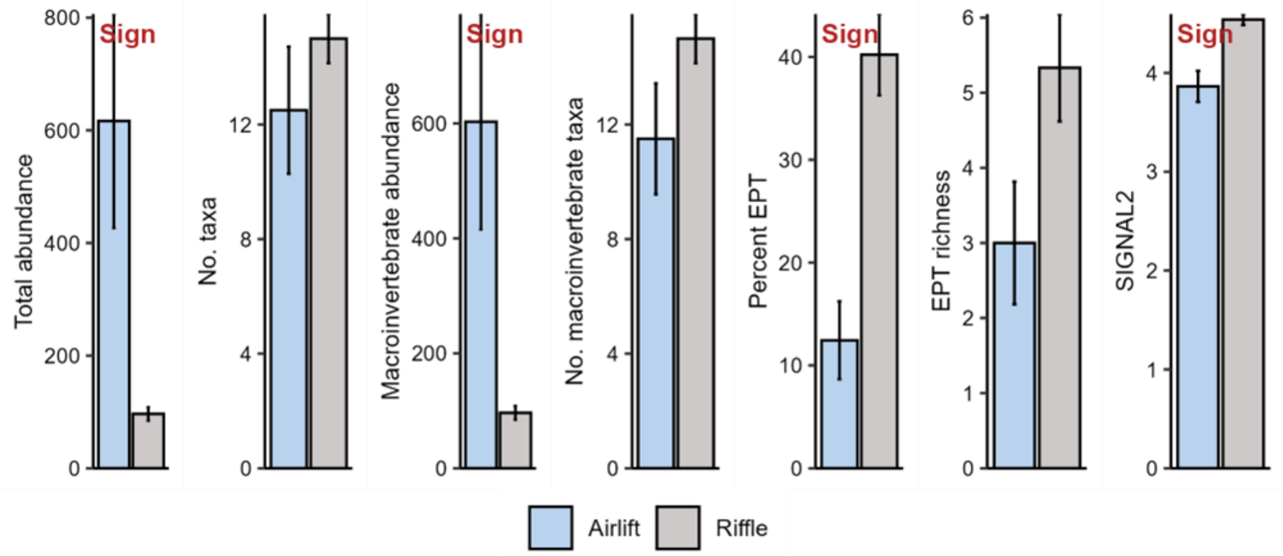


Figure 30: Species indicator measures in Farmers Creek for airlift and riffle sample collection methods (Values = mean ± s.e.)

III. Comparison between sample depths at Farmers Creek

Statistical analyses were performed to assess the effect of depth (1, 2 or 3 m) on species indicator measures and were performed using depth stratified airlift samples from 40 Farmers Creek sites (FC01 to FC40. MDS identified three distinct clusters distributed across the x-axis, however, each cluster included samples from all three sampling depths, suggesting depth is having little effect on species indicator measures (refer to Figure 32). Similarly, analyses performed on individual indicator measures analysed found that depth had a significant effect ($p < 0.05$) on total abundance only, with abundance increasing significantly with depth (refer to Figure 33; Table 36). Although depth had no statistically significant effect on any other indicator measures, trends with depth were apparent for some measures and should be noted. For example, the abundance of more disturbance tolerant macroinvertebrate species increased with depth, whereas % EPT and EPT richness, were highest at 1 m depth (EPTs are less tolerant to disturbance). Finally, statistical analyses were performed to test the effect of depth on selected taxonomic groups (restricted to taxa recorded from > 40% of samples). Results suggest that depth had a significant effect ($p < 0.05$) on the abundances of taxa belonging to Oligochaeta and Tanypodinae, with abundances increasing with depth (refer to Figure 34; Table 37). In contrast, depth had no significant effect ($p < 0.05$) on the abundances of any other common taxonomic groups.

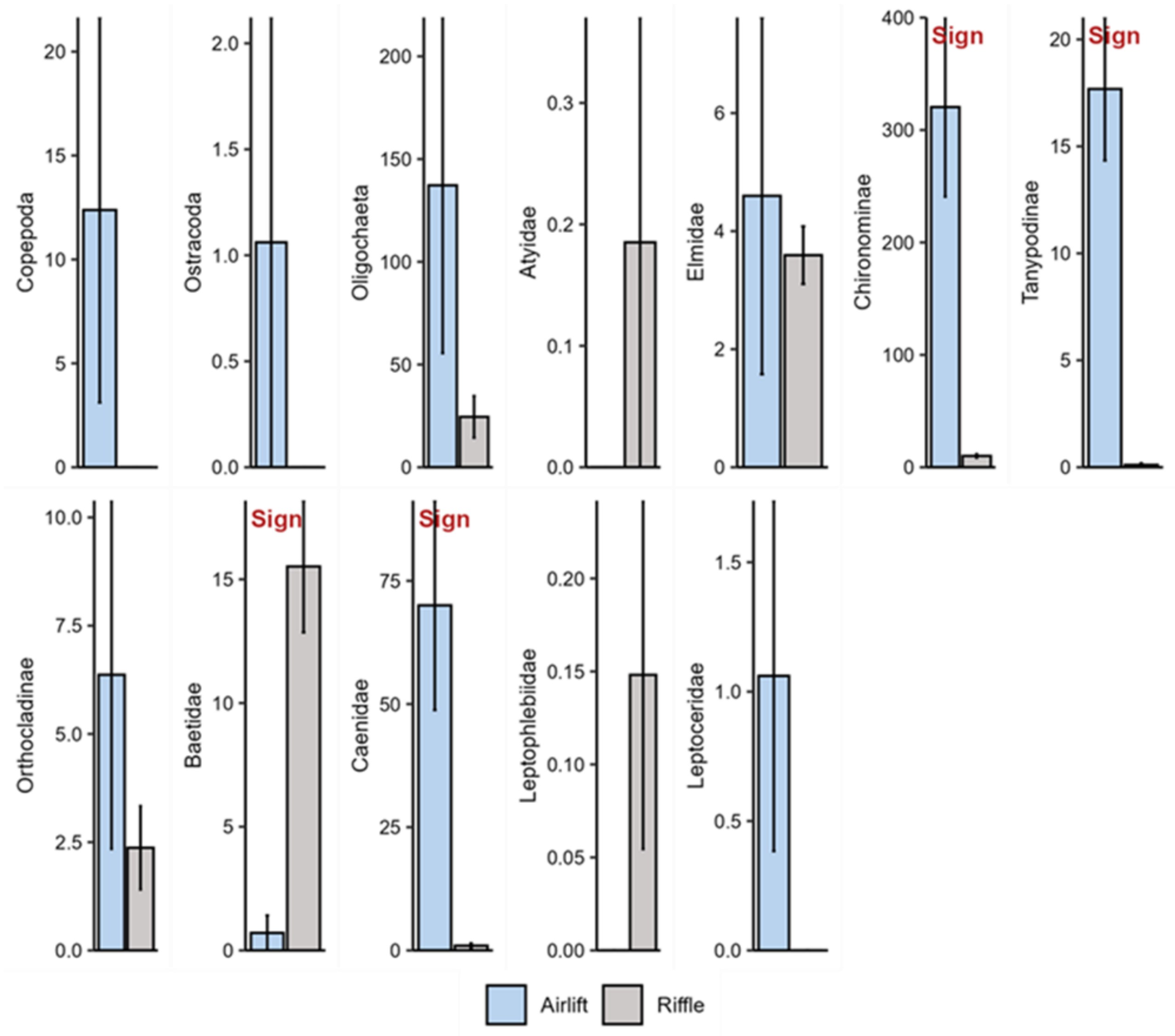


Figure 31: Selected taxa abundance measures in Farmers Creek using different sample methods (Values = mean ± s.e.). Sign = significant difference detected between locations

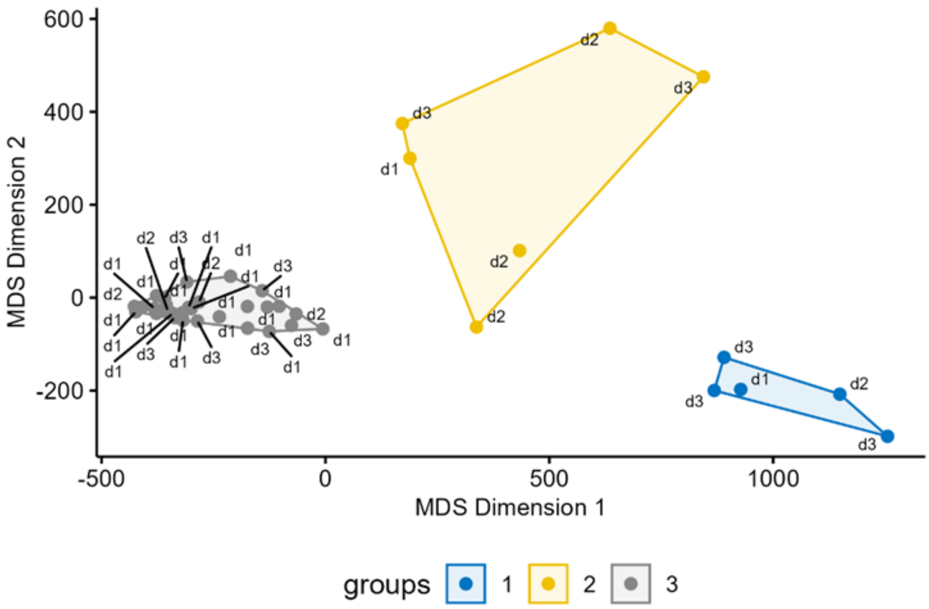


Figure 32: K-means clustering of MDS data for seven species indicators in Farmers Creek sampled at different depths (d1 = 1 m, d2 = 2 m, d3 = 3 m)

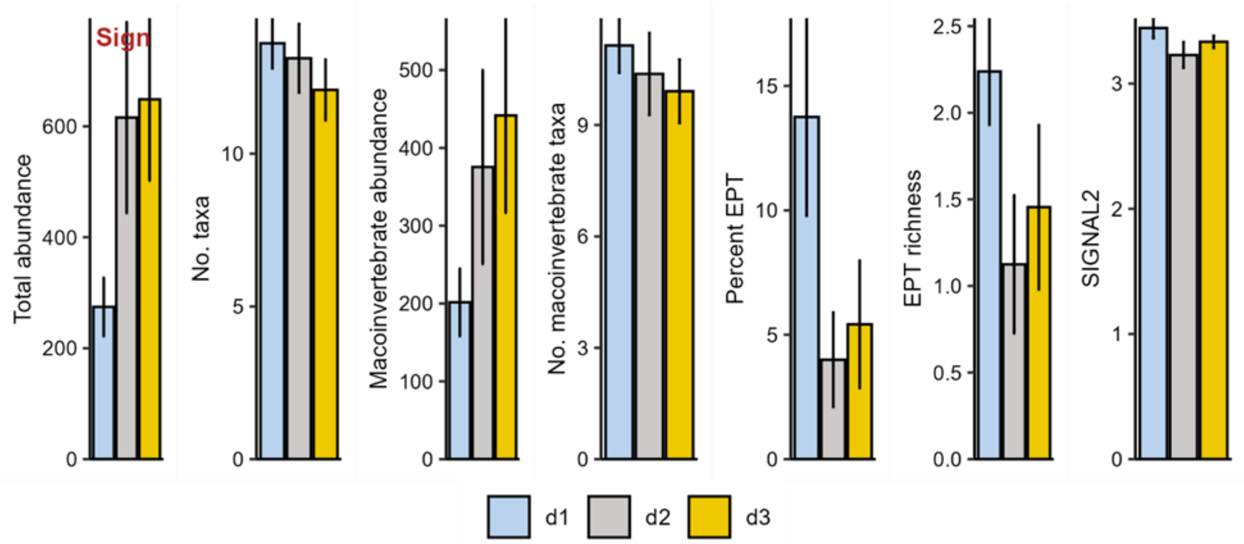


Figure 33: Selected taxa abundance measures in Farmers Creek sampled at different depths (Values = mean ± s.e.). Sign = significant difference detected between locations

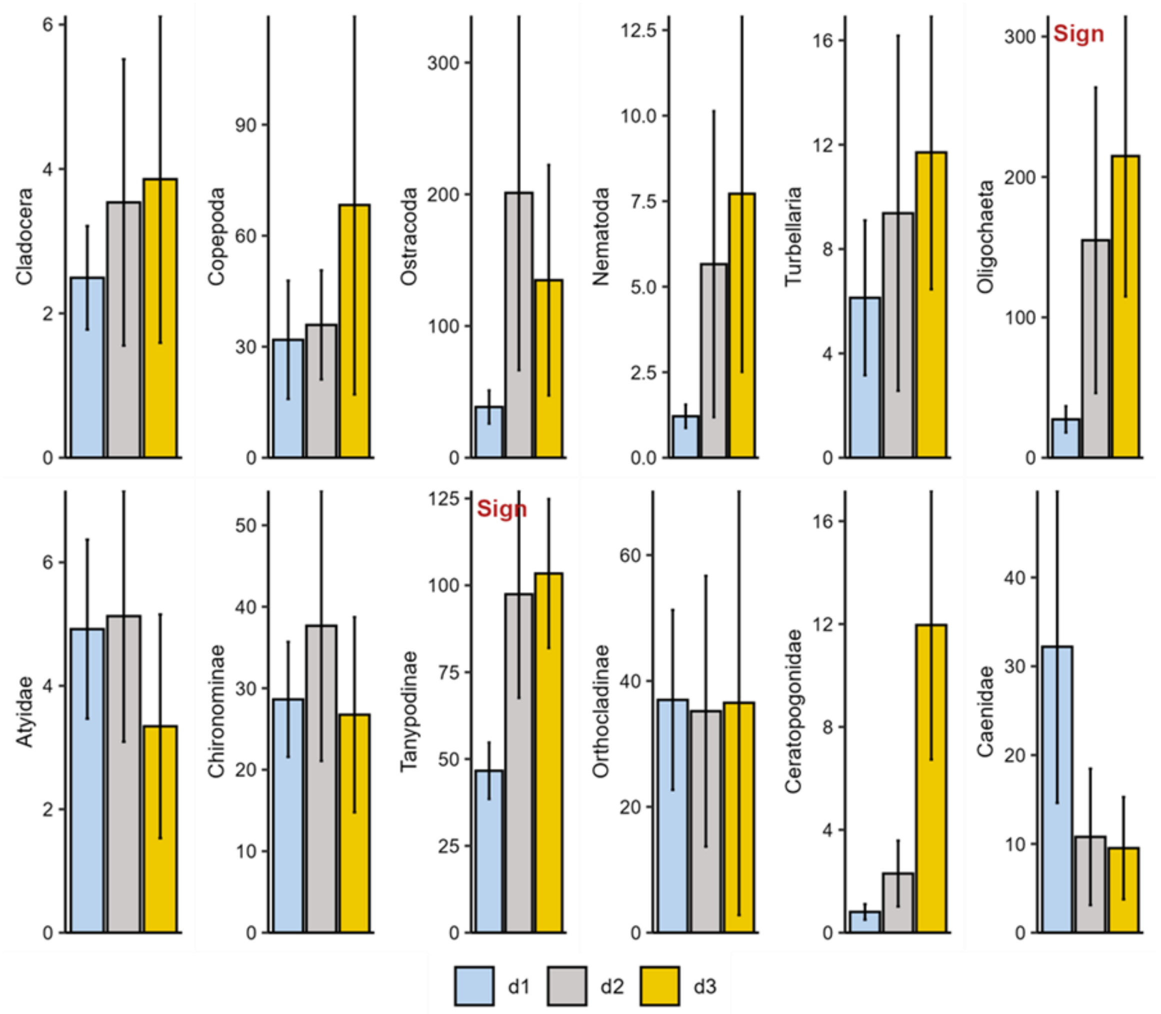


Figure 34: Species indicator measures in Farmers Creek sampled at three different depths (d1 = 1 m, d2 = 2 m and d3 = 3 m) (Values = mean ± s.e.)

Table 36: Species indicator measures in Farmers Creek sampled at different depths. Mean values (± s.e.) and Kruskal-Wallis analyses

Indicator	Depth D1*	Depth D2*	Depth D3*	statistics	SIGN
Total abundance	274 ± 52[a]	616 ± 172[ab]	649 ± 146[c]	chi-squared = 7.0101, df = 2, p-value = 0.03004	SIGN
Number of taxa	13.6 ± 0.8	13.1 ± 1.1	12.1 ± 1.0	chi-squared = 1.5737, df = 2, p-value = 0.4553	
Macroinvertebrate abundance	202 ± 43	375 ± 124	442 ± 125	chi-squared = 4.502, df = 2, p-value = 0.1053	
Number of macroinvertebrate taxa	11.1 ± 0.7	10.4 ± 1.1	9.9 ± 0.9	chi-squared = 1.128, df = 2, p-value = 0.5689	
% EPT	13.8 ± 4.0	4.0 ± 1.9	5.4 ± 2.6	chi-squared = 5.219, df = 2, p-value = 0.07357	
EPT richness	2.24 ± 0.31	1.12 ± 0.4	1.45 ± 0.47	chi-squared = 4.5797, df = 2, p-value = 0.1013	
SIGNAL2	3.44 ± 0.08	3.23 ± 0.1	3.33 ± 0.05	chi-squared = 3.7817, df = 2, p-value = 0.1509	

* Values with the same superscript letter are not significantly different from each other (Dunn test).

Table 37: Selected taxa abundance measures in Farmers Creek sampled at different depth. Mean values (± s.e.) and Kruskal-Wallis analyses

Indicator	Depth D1*	Depth D2*	Depth D3*	statistics	SIGN
Cladocera	2.5 ± 0.7	3.5 ± 2.0	3.9 ± 2.3	chi-squared = 0.32419, df = 2, p-value = 0.8504	
Copepoda	32 ± 16	36 ± 15	68 ± 51	chi-squared = 0.14706, df = 2, p-value = 0.9291	
Ostracoda	38 ± 13	201 ± 135	135 ± 87	chi-squared = 0.51924, df = 2, p-value = 0.7713	
Nematoda	1.2 ± 0.3	5.7 ± 4.5	7.7 ± 5.2	chi-squared = 4.0202, df = 2, p-value = 0.134	
Turbellaria	6.1 ± 3.0	9.4 ± 6.8	11.7 ± 5.2	chi-squared = 0.36978, df = 2, p-value = 0.8312	
Oligochaeta	27 ± 9[a]	155 ± 109[b]	215 ± 100[b]	chi-squared = 12.54, df = 2, p-value = 0.001892	SIGN
Atyidae	4.9 ± 1.4	5.1 ± 2.0	3.3 ± 1.8	chi-squared = 2.4677, df = 2, p-value = 0.2912	
Chironominae	28 ± 7	38 ± 17	27 ± 12	chi-squared = 1.288, df = 2, p-value = 0.5252	
Tanypodinae	47 ± 8[a]	97 ± 30[b]	103 ± 21[b]	chi-squared = 6.1168, df = 2, p-value = 0.04696	SIGN
Orthocladinae	37 ± 14	35 ± 21	36 ± 34	chi-squared = 2.193, df = 2, p-value = 0.334	
Ceratopogonidae	0.8 ± 0.3	2.3 ± 1.3	12.0 ± 5.2	chi-squared = 5.6753, df = 2, p-value = 0.05856	
Caenidae	32 ± 18	11 ± 8	9 ± 6	chi-squared = 2.7353, df = 2, p-value = 0.2547	

6.11. Stygofauna surveys

Stygofauna surveys were undertaken across three surveys events on 3 May, 31 May and 4 July 2024 at bores located on Mount Walker, north of Farmers Creek (EMM Consulting Pty Limited, 2025b). The number of bores sampled varied due to various pumps malfunctioning across survey events with all bores being sampled at least once. The yield from the bores was highly variable and ranged from 100 ml to 2 L. The results of the stygofauna surveys are shown in Table 38. In-situ water quality from water samples collected during each survey event are shown in Table 20.

Overall stygofauna were not recorded in any bore (refer to Table 38) and it is considered unlikely that the project will impact stygofauna associated with the regional deep groundwater system or regional shallow groundwater system.

Table 38: Results of the Lake Lyell PHES stygofauna surveys (three survey events)

Site number	Bore ID	Biota recorded in sample	Comments
1	MB2201B	-	-
2	MB2202A	-	-
	MB2202B		
3	MB2203A	-	-
	MB2203B		
4	MB2204A	-	Small amount of silt and sand. One blue plastic fibre
	MB2204B	-	-
5	MB2205A	-	Small amount of fine sediment
	MB2205B	-	Fine sand. Small clear plastic fragments

7. Ecological values

7.1. Aquatic ecology

Detailed descriptions of aquatic ecological values within Lake Lyell, the Coxs River, Farmers Creek and Collits Swamp Creek based on field surveys performed during November 2023 are provided in the sections above. Provided below is a summary of these values.

All survey sites across each waterway were classified as Type 1 highly sensitive KFH and Class 1 major KFH, due to the sites containing in-stream snags and/or native aquatic plants and permanent flows. Aquatic habitat such as macrophytes and IWD was present at all sites (refer to Table 19). Habitat complexity was suitable to support the requirements of many aquatic species, and no sites supported habitat critical to the survival of any given species.

Aquatic surveys (including eDNA surveys) were undertaken in accordance with the *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act* (Department of Sustainability, Environment, Water, Population and Communities, 2011) targeting appropriate habitat and using appropriate survey methods (Table 5). Despite these efforts no listed fish species were detected within Lake Lyell, the Coxs River, Farmers Creek or Collits Swamp Creek. As such, it is considered unlikely that the project area supports fish species listed under either the FM Act or EPBC Act.

Analyses of physical parameters from water and sediment samples indicated substantial variability between sites (refer to Table 21; Table 22). Overall, the results indicate that the waterway health at the majority of sites is considered to be in 'moderate' condition.

A total of 80 algal taxa, belonging to phytoplankton and periphyton assemblages, were identified from surface water samples at across the 14 sites, with phytoplankton being present at all sites and periphyton being present at six sites (refer to Table 23). A total of 11 macrophytes representing 11 families were recorded across all sites at the time of survey. A total of nine native species of macrophyte and two exotic species were recorded across the survey area, with macrophyte species diversity and relative abundances being variable between sites (refer to Table 25; Table 26).

Macroinvertebrate derived river health scores varied between sites. Evidence of impacts to macroinvertebrate communities was evident on the Cox's River at the site immediately downstream of the Lake Lyell outlet leading to reduced river health at downstream sites. In contrast, clear reductions in abundance and diversity of sensitive taxa was evident across all sites from Farmers Creek leading to poor river health's scores across the waterway in the project area, pointing to existing issues relating to pollution and/or land-use activities.

Fish surveys performed across the study area detected a total of nine species, including seven exotic species two native fish species (refer to Table 27), with species diversity and abundances again being variable across survey sites within and between waterways. Despite introduced species being detected at all waterways, Flathead gudgeon was commonly the most abundant taxa recorded. Australian bass were also recorded from Lake Lyell and the Coxs River and are stocked for recreational fishing purposes. Environmental DNA surveys detected the same nine fish species, plus an additional six native species however there is some question over the validity of certain results such as Dwarf galaxias (Table 33).

Surveys confirmed the presence of a single aquatic mammal species, the platypus. Targeted platypus surveys detected a total of 17 animals from the Farmers Creek and Coxs River arms of Lake Lyell (refer to Table 28). Tagging and tracking analysis of platypus (tagged with the Farmers Creek arm of Lake Lyell) movement behaviour showed the animals to be primarily utilising burrows located within Farmers Creek, however some platypus were also observed to be utilising burrows within Lake Lyell. Tracking analyses also confirmed platypus spend most of their time benthic foraging within Lake Lyell. eDNA analysis also detected evidence of platypus DNA in both the Coxs River and Farmers Creek arms of Lake Lyell. In contrast to direct observations and the tracking study there was no evidence of platypus DNA from the main Lake Lyell areas (refer to Figure 23).

Based on the surveys and investigations, it is considered that Lake Lyell, the Coxs River, Farmers Creek and Collits Swamp Creek are of moderate ecological value based on the following findings:

- KFH is classified as Type 1 highly sensitive KFH and Class 1 major KFH, based on the presence of moderate to high quality KFH features.
- The presence of diverse and abundant macroinvertebrate assemblages.
- Native macrophytes.
- Water quality parameters being below or within acceptable limits based on appropriate guidelines.
- Poor health of the fish community.
- High abundance of introduced species.
- Elevated metal concentrations in sediments.
- The absence of threatened or protected species.
- The existence of a population of platypus in the Cox's River arm and Farmer Creek arm of Lake Lyell that are recognised as culturally significant to first nations communities and of high importance to the local community.

7.2. Environmental impacts and receptors

The primary environmental receptors identified by this *Aquatic Ecology Assessment*, in relation to potential impacts associated with 3rd order and above waterways, comprise:

- surface water and sediment quality
- KFH
- surface water aquatic biodiversity (i.e. algae, macrophytes, aquatic invertebrates)
- riparian vegetation addressed in the BDAR (EMM Consulting Pty Limited, 2025d)
- aquatic vertebrates including fish
- platypus.

Based on the desktop review and the collection of field data the construction and operation of the project has the potential to impact aquatic ecology values. Table 39 summarises the potential pathways for a project activity to impact identified aquatic values during the construction (C) and operation (O) stages of the project. These pathways and potential impacts are discussed in detail along with potential mitigations strategies for the various stages of the project in Section 8 and Section 10.

Table 39: Pathway for impacts and aquatic receptors impacted

Pathway	Aquatic environment receptors possibly impacted				Comments
	Native fish and KFH	Surface water aquatic biodiversity	Platypus	Surface water and sediment quality	
Poor Water quality as a result of construction and operational activity	C, O	C, O	C, O	C, O	Poor water quality from construction activities including turbid water discharges, fuels and oils from machinery. Poor water quality has the potential to impact native fish and platypus during construction and the initial phases of operation. Native aquatic vegetation (submerged macrophytes) where present will be susceptible to risk associated with turbid water from construction and operational activities. Platypus may be impacted by poor water quality from construction however impacts to the food web as a result of operational impacts (fluctuating water levels and turbidity) have a greater potential to impact food resources. Increased turbidity has the potential to resuspend nutrients with potential flow on effects to algae which may result in algal blooms. Placement of infill material (from the diversion or tunnelling activities) into the lake has the potential to result in poor water quality.

Pathway	Aquatic environment receptors possibly impacted				Comments
	Native fish and KFH	Surface water aquatic biodiversity	Platypus	Surface water and sediment quality	
Lake Diversion/ Farmers Creek diversion	C, O	-	C, O	C	Native fish and platypus have the potential to be impacted during the construction and operation of the new diversion. Appropriate design and construction of the bypass will be critical to mitigating potential impacts. It is not intended that the lake diversion design will provide habitat values such as feeding habitat and platypus nesting habitat. The intent of the lake diversion design is to provide suitable conditions to support native fish and platypus passage. The diversion will be 230 m long and cover a vertical drop of 3 m. This equates to a 1.3% grade (EMM Consulting Pty Limited, 2025a)
Temporary waterway crossings	C, O		C, O	C	The construction of the temporary waterway crossings over Farmers Creek have the potential to be an impediment to fauna passage.
Altered hydrology – includes lowering of Lake Lyell during construction and fluctuation water levels during operation	C, O	C, O	C, O	O	Alterations to hydrology have the potential to impact the life history of native fish and platypus. Operation of the PHES has potential for impacts to macrophytes, macroinvertebrates and higher order fauna such as fish and platypus.
Noise			C		Noise may discourage and interfere with platypus feeding in the vicinity of the inlet/outlets structure and construction areas.

Pathway	Aquatic environment receptors possibly impacted				Comments
	Native fish and KFH	Surface water aquatic biodiversity	Platypus	Surface water and sediment quality	
Fauna entrapment	C		C		There is a risk of aquatic fauna, fish and platypus to be trapped within coffer dams once constructed.
Fauna entrainment	O		O	C	There is a risk of fish and platypus entrainment into the inlet. Any entrainment will likely be fatal for platypus however previous projects report high survival rates for entrained fish dependent on size (Baumgartner, et al., 2017; Doyle, et al., 2022; Ning, 2019). The planned controls to mitigate these risks is outlined in Table 56. The response of resident Australian bass to flows from the inlet/outlet into Lake Lyell is unknown, Australian bass are known to be triggered to undertake migrations in response to high/increased flows. Any attraction impacts are likely to result in increased entrainment. Australian bass are stocked within Lake Lyell and no offsets to impacts to the species are proposed.

7.3. Threatened species and communities

A detailed desktop assessment and thorough aquatic surveys undertaken in accordance with the *Survey guidelines for Australia's threatened fish: Guidelines for detecting fish listed as threatened under the EPBC Act* (Department of Sustainability, Environment, Water, Population and Communities, 2011) revealed that no threatened species or communities listed under either the FM Act or EPBC Act were identified or are considered likely to occur within the vicinity of the project, and as such, no threatened species or communities listed under either the FM Act or EPBC Act will be negatively impacted by the project.

8. Assessment of potential impacts

Due to the complexity of the construction and operation of the PHES and potential impacts on aquatic values, a risk based environmental impact assessment has been undertaken for each of the specific projects elements. Below we provide a:

1) description of the relevant project element / area, including a summary of the proposed construction and operations methods; and identified risks on aquatic values during construction and operation (Section 8.1)
2) A summary of potential impacts on aquatic values (Section 8.2)
3) Risk assessment for each of the identified potential impact pathways on aquatic values (Section 8.3)
4) Assessment of potential impacts on platypus and risk assessment for each of the identified potential impact pathways (Section 8.3).

Mitigation measures for each of the key risks are discussed in Section 10.

8.1. Project water management

Surface water management has discussed in detail in the *Surface Water Assessment* (EMM Consulting Pty Limited, 2025b) and termed the "Construction Water System" which includes the sources and descriptive qualities of water that will be generated/present in various volumes throughout the construction program. Given the potential impacts to aquatic values derived from the surface water sources a summary of the system is provided below (refer to Table 40).

Table 40: Elements of the construction water system (EMM Consulting Pty Limited, 2025b)

System	Description	Relevant management plan
Contaminated water system	In this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria. The contaminated water system will manage potentially contaminated water generated from construction activities to minimise pollution of the stormwater system and receiving surface and groundwater systems.	Nitrogen Management Plan
Stormwater system	The stormwater system will manage surface water runoff that is not contaminated water from areas disturbed by construction. The stormwater system will be separated from the contaminated water system.	Construction Water Management Plan
Construction water supply system	The construction water supply system will supply water to construction activities. The system will beneficially use water from the contaminated water and stormwater systems.	Construction Water Management Plan
Potable water supply system	The potable water system will supply water that is suitable for human consumption to the accommodation camp and amenities within the main construction complex.	-
Wastewater system	The wastewater system will manage wastewater (i.e. sewage) produced at the accommodation camp and amenities within the main construction complex.	Construction Water Management Plan

8.1.1. Contaminated water system

Sources of contaminated water will include:

1) seepage from permanent spoil emplacements (PSEs)
2) water pumped from subsurface excavations during construction
3) surface water from high intensity construction areas.

The preferred treatment system will be determined after project approval. Treated water may be used for construction purposes and excess treated water is expected to be discharged to Farmers Creek arm of Lake Lyell after meeting the discharge water quality requirements (EMM Consulting Pty Limited, 2025b).

8.1.2. Stormwater system

The stormwater system will be separated from the contaminated water system and will manage runoff from areas disturbed by construction that have a low risk of producing contaminated water. These areas include:

1) roads and earthworks areas (excluding drill and blast areas)
2) accommodation camp (during construction and operation of the camp)
3) construction pads.

The stormwater system has been separated into three categories based on the expected water quality and scale/type of works, they are:

1) Clean water diversions – The stormwater system will include several temporary and permanent clean water systems to divert clean water runoff either around or through construction areas.
2) Stormwater management for minor works – applies to construction of roads, service trenches and minor works where construction will disturb a small portion of a catchment for a short period (i.e. typically less than three months).
3) Stormwater management for major works – applies to construction works that will disturb a moderate to large portion of a catchment for a longer period of time (i.e. more than three months). Major works stormwater management areas include construction pads and the accommodation camp.

Stormwater may be used for construction purposes throughout the process, and excess treated stormwater is expected to be discharged to Farmers Creek arm of Lake Lyell after meeting the discharge water quality requirements (EMM Consulting Pty Limited, 2025b).

8.2. Project elements

Figure 5 provides a graphical depiction of the proposed project layout and details of the features associated with project elements. A brief description of the construction methodologies associated with various project elements, relative to the *Aquatic Ecology assessment*, is provided below. Details have been taken from the Project Description (EMM Consulting Pty Limited, 2025a) and the *Surface Water Assessment* (EMM Consulting Pty Limited, 2025b).

In summary the Lake Lyell PHES will require the construction and operation of a number of project elements with potential to impact on aquatic ecology values, comprising:

1) Lake Lyell drawdown during construction
2) Lake diversion – including two small sheet piled cofferdams (section 8)
3) Inlet outlet structures including stockpiles and laydown area (multiple) (section 8.2.3)
4) Waterway crossings - Temporary (x4) and Permanent (x1) (section 8.2.4)
5) Cofferdam x 4 (section 8.2.5)
6) Ancillary infrastructure including sediment basins, stormwater management basin, portal pads, access roads etc. (section 0)
7) High voltage switching yard including laydown area (section 8.2.7)
8) Accommodation camp (section 8.2.8).

8.2.1. Lowering of Lake Lyell water levels for construction

Prior to construction commencing, the water levels in Lake Lyell will be lowered by temporary relocation of one or more of the fusegates at Lilyvale Dam.

Specifically, the task of lowering Lake Lyell water levels has been proposed to:

1) be achieved by repositioning fusegates on Lilyvale Dam and lowering the spill level to RL 782.6 m and will result in Lake Lyell FSL water levels being lowered by 2.9 m
2) improve constructability of the project (reduces cofferdam water levels and mitigates flood risk at the inlet/outlet works area)
3) reduce environmental impacts throughout the construction phase as are result of reduced works required under wet conditions.

8.2.1.1. Description of works

Lowering of the Lake Lyell for construction will be achieved by changes to the fusegates at Lilyvale Dam.

8.2.1.2. Risks and impacts

Table 41 provides a breakdown of the risks and impacts associated with lowering water levels in Lake Lyell for construction purposes.

Table 41: Construction risks and impacts associated with the lowering of Lake Lyell

Risk receptor or activity	Impact
Impacts to platypus burrows in banks	Platypus burrows may be present at the site of the diversion. Construction at the site could disrupt access to burrows or burrows may be destroyed as result of the construction process
Reduced platypus feeding habitat	Lowering of the water levels in Lake Lyell for construction may reduce feeding habitat for platypus.
Increased predation potential	Lowering of water levels for construction may expose platypus to increased predation potential when moving from Farmer Creek to foraging/feeding areas within the Farmers Creek arm of Lake Lyell.

There will be no impacts from the lowering of Lake Lyell water levels for the construction phase. Operation impacts, including the lowering of Lake Lyell, have been identified and discussed in Sections 8.3 to 9.2.

8.2.2. Lake diversion

The Farmers Creek arm of Lake Lyell will be diverted near the lower inlet/outlet structure (refer to Figure 5). This will be undertaken to mitigate risks to project operation from flooding, risks associated with sedimentation, and to improve the overall constructability of the project. The lake diversion will be an open channel and designed to allow continued upstream and downstream passage of fish and aquatic fauna.

Specifically, the lake diversion has been proposed to:

1) minimise the impacts of sedimentation and debris on the operation of the lower inlet/outlet structure
2) improve the constructability of the lower inlet/outlet structure and tailrace tunnel
3) comprise a waterway with a width of around 40m with sides with berms and overall slope of 70 degrees
4) allow for continued upstream and downstream passage of fish and aquatic fauna and provision of habitat
5) provide a pathway for flood debris to enter the lake downstream of the inlet / outlet structures

6) the diversion also allows for separation between the project inlet / outlet area and Farmers Creek.

A permanent bridge will be established to cross the diverted path of Farmers Creek arm of Lake Lyell. This bridge will provide operational access to the upper reservoir and powerhouse.

8.2.2.1. Description of works

The lake diversion will be excavated in stages to allow the permanent bridge construction to commence at the earliest time. Excavation will be completed while maintaining two plugs of rock left at each end of the channel to prevent water inundation; these will be removed last to engage the lake diversion.

A summary of the key construction features and operations are summarised below:

1) The lake diversion will involve excavation to a depth of approximately RL 783 to 780m AHD.
2) The diversion base will be designed to have a riffle/run and pool sequence to encourage aquatic passage similar to existing conditions.
3) The channel will be excavated, using traditional excavation methods including drill and blast with scrapers, excavators and trucks.
4) Two small cofferdams will be constructed to facilitate the removal of the rock plugs to complete the lake diversion.
5) The bridge will be constructed while the site is dry.
6) It is proposed that the excavated material from the diversion channel will be placed in the adjacent creek infill area or within the current lake footprint to create a laydown area for the switchyard.
7) Engagement of the lake diversion will allow for the existing Farmers Creek arm to be naturally dewatered (depending on lake levels).

8.2.2.2. Risks and impacts

Table 42 provides a breakdown of the risks and impacts associated with construction of the Lake Diversion.

Table 42: Construction risks and impacts for the lake diversion

Risk receptor or activity	Impact
Impacts to platypus burrows in banks	Platypus burrows may be present at the site of the diversion. Construction at the site could disrupt access to burrows or burrows may be destroyed as a result of the construction process.
Water quality - Stockpiling	Potential for runoff from stockpiles during high rainfall events.
Water quality - Infill activities	Where the infilling is to occur there will be impacts to water quality if the receiving site is inundated. Potential for longer and greater turbidity to be generated if infilling is to occur in the proposed infill area upstream of the inlet outlet structure due to the presumed higher volume of silt and organics in the depositional zone of Farmers Creek.

Table 43 provides a breakdown of the risks and impacts associated with operation of the Lake Diversion.

Table 43: Operational Risks and impacts of lake diversion

Risk receptor or activity	Impact
Poor fish and platypus passage across the Lake Diversion – understanding of Farmers Creek hydrology critical to design. Overdesigning the Lake Diversion for capacity only without the correct low flow / base flow considerations could result in shallow flow through the diversion and poor fish and platypus passage outcomes.	Operation of the Lake Diversion may impede fish and platypus passage if poorly designed.

8.2.3. Inlet / outlet structure

The proposed location for the lower reservoir inlet / outlet structure is shown in Figure 5. The design ensures that the inlet / outlet screens are deep enough to prevent air entrainment into the waterway and deeper than the recorded platypus diving depths from research undertaken in Lake Lyell (refer to Figure 20). The inlet area will be lower than the surrounding finished surface level of the lake and will create a sump. Screens are set out at 150 mm spacings to prevent debris and large woody material from entering the waterways, and maximum water velocity at the screens is expected to range from 1.0 to 2.0 m/s.

A floating boom is proposed as a barrier to the public, to be used to keep floating material (including logs) and surface-active aquatic species (including platypus) out of the inlet/outlet area. The boom will consist of hanging grate that allows water flows but reduces risks of blockage. With two units running, depending on the power generation, with Lake Lyell at Minimum Operating Level (LLPHES MOL), the velocity in Farmers Creek at the floating boom is between 1 to 1.5m/s in generation mode and 1 to 1.3 m/s in pump mode. As the level in Lake Lyell increases these velocities at the boom decrease and when in “normal operating” range the velocity in pump mode is <0.5 m/s and <0.7 m/s in max generation mode. These reduce further as the lower reservoir rises during generation or when the lake level is above the minimum operation low level.

8.2.3.1. Description of works

Two cofferdams (refer to Section 8.2.5) will be built to allow for Farmers Creek to isolate the construction works area (refer to Figure 5). The construction site will be dewatered prior to construction starting, as outlined in Section 8.2.1. A deepened pocket for the inlet / outlet screen will be created using bulldozer, excavator and drill and blast excavation. All works will be performed in dry conditions, with no dredging required. Spoil will be relocated to the creek infill area to create a stable area and ultimately accommodate a permanent crossing to the generation facility. The finalised inlet / outlet structure will include a floating boom to manage the entrainment of logs and material and to discourage aquatic fauna.

The inlet outlet/structure will be constructed from reinforced concrete.

8.2.3.2. Risks and impacts

Table 44 provides a breakdown of the risks and impacts associated with construction of the inlet/outlet structure.

Table 44: Inlet/outlet construction risks and impacts

Risk receptor or activity	Impact
Water quality runoff from the construction earth/site works	Potential impacts of poor water quality as a result of construction activities
Water quality impacts from construction of intake/offtake	Potential impacts of poor water quality as a result of construction activities. Primarily impacts of concrete and impacts on pH in runoff water and waste after concrete pours. Additional contaminants are likely to be present in this wastewater.
Poor water quality from Infill material runoff	Leaching of sediment and residual blasting nitrates have potential to contaminate waterways
Platypus and aquatic fauna impacts	Impacts to platypus burrows in banks in the vicinity of the inlet /outlet structure Platypus may become trapped within the inlet/outlet construction footprint after the western cofferdam is completed.
Loss of KFH	KFH lost due to construction of inlet/outlet structure
Dewatering	Impacts and risks addressed in section 8.2.5 (Cofferdams)

Table 45 provides a breakdown of the risks and impacts associated with operation of the inlet/outlet structure.

Table 45: Operational risks and impacts of the inlet/outlet structure

Risk receptor or activity	Impacts
Water quality	Fluctuating water levels may result in increases in bank slumping, increased turbidity and poor water quality
Platypus	Potential entrainment of platypus
Native fish	Operation of the PHES may result in cues for fish to migrate toward the inlet/outlet structure and increase risk of entrainment
Native fish/aquatic fauna	Entrainment of aquatic fauna in the inlet outlet structure during operation
Native fish/aquatic fauna	Entrapment of fauna within the inlet/outlet sump when lake levels are below the operating level of the PHES, once isolated by receding lake levels water quality will deteriorate.

Risk receptor or activity	Impacts
Water quality	Potential for generation of turbidity as a result of the operation of the PHES. Flow rates at the boom are expected to have a maximum flow rate of 1.5 m/s for short periods of time depending on the lake water level. Short term increase in turbidity likely as a result of project operation with some scouring anticipated. These short-term events are likely to occur after the Lake Lyell PHES is turned off as a result of low water levels and then refills to an acceptable operating level. The amount of potential turbidity from this event is expected to be a short-term impact

8.2.4. Waterway crossing – temporary and permanent (bridges)

The project requires the installation of four temporary bridges across Farmers Creek and one permanent crossing (across the lake diversion) (refer to Figure 5).

Temporary bridges across Farmers Creek are critical to allow plant to access the project area north of Farmers Creek for the commencement of clearing, pioneering, tunnelling works and upper reservoir construction. As such, temporary bridges are proposed as shown in Figure 5.

The four temporary bridges are listed as:

1) Tunnel Portal access bridge
2) Eastern cofferdam causeway
3) Upper reservoir access causeway
4) Western Cofferdam bridge
5) a single permanent bridge will be constructed across the lake diversion.

8.2.4.1. Description of works

1) Tunnel Portal Access Bridge and Western Cofferdam Bridge

These two bridges will be constructed by using piling techniques to support the roadway surfaces. The bridge will be constructed using a proprietary system which can be installed in a short amount of time. Bank and vegetation clearing and the placement of Kyowa or Bidim rock bags and sand/cement bags into the water way. The Tunnel Portal Access bridge is required to gain access to the portal works site. The Western cofferdam bridge is expected to take 8 to 9 weeks to construct. The bridge will be constructed at the same time as the creek diversion is excavated. Upon opening of the creek diversion, the bridge will be in place to commence cofferdam installation (refer to Section 8.2.5).

The tunnel portal bridge will become incorporated into the infill area around the tunnel portal. The Western cofferdam bridge will be removed.

2) Upper Reservoir Access Causeway and Eastern Cofferdam Causeway

The upper reservoir access causeway will be constructed at a location outside of the permanent works footprint and will therefore require removal and remediation at completion of the project. The Eastern cofferdam causeway crossing will be incorporated into the infill area and will not be removed.

Construction of the causeways will include the following construction activities:

1) Stream side vegetation clearing
2) Placement of rock bags and material to support the culverts
3) Placement of culverts
4) Topping of the roadway over the culvers
5) Some bank stabilisation/protection.

3) Permanent waterway crossing

A permanent bridge will be constructed across the Farmer Creek diversion. This bridge will provide access across the diversion to the site compounds and the northern section of the project site where the tunnel portals, inlet / outlet structure and upper reservoir are located.

Construction of the bridge will occur concurrently with the lake diversion works (refer to Section 8.2.5) and involve:

1) establishment and stabilisation of abutments
2) installing pre-cast structures
3) construction of deck, parapets installation, etc.

No impacts are expected from the installation of the permanent waterway crossing as it will be constructed prior to the Lake Diversion being engaged.

8.2.4.2. Risks and impacts

Table 46 provides a breakdown of the risks and impacts associated with construction of the temporary waterway crossings.

Table 46: Construction risks and impacts from the construction of waterway crossings

Risk	Construction Impacts
Fauna passage	Disruption of fauna passage at waterway crossing.
Fauna entrapment via placement of rock into Farmers Creek	Fauna may be trapped during the placement and construction of the rock to form the base of the bridge to support concrete culverts.
Poor Water quality from materials used	Dirty (silt and other contaminants) rock fill in bags may results in the generation of turbidity during rewetting and placement.
Impacts to platypus burrows	Burrows will be destroyed if present in the banks at any temporary bridge crossing
Noise and vibration	Noise and vibration have an impact on aquatic values Night works/sheet piling may disrupt platypus feeding behaviour and passage past the site
Piling – water quality/turbidity	Sheet piling may cause short term increase in turbidity
Water quality	Impacts to water quality as a result of runoff from roadway and bridge crossings
Water quality	Impacts to water quality during the removal of the Upper Reservoir causeway and the Western Cofferdam bridge

No operational risks are anticipated for the permanent waterway crossing.

8.2.5. Cofferdams

The project will require the construction of four cofferdams (refer to Figure 5):

1) Upstream end of the Lake Diversion
2) Downstream of the Lake Diversion
3) Western cofferdam – installed from the western cofferdam bridge
4) Eastern cofferdam – installed from the eastern cofferdam causeway.

8.2.5.1. Description of works

The lake diversion cofferdams will be installed from the banks to facilitate completion of the lake diversion and will be removed prior to the construction of the western and eastern cofferdam causeways. Upon completion of the lake diversion, works will commence on the inlet/outlet structure and lake infill to provide additional overland access to the tunnel portals. Extensive earthworks are required at the intake/outlet structure and within the channel, therefore two cofferdams will be constructed - the Western Cofferdam and Eastern Cofferdam. Part of the works area between the cofferdams will be filled in with spoil removed from the underground works and lower intake structure and part will be drained for construction of the intake/outlet structure.

Construction methods for the coffer dams will include:

1) Piling (Sheet or continuous tubular steel wall with sockets)
2) Infill activities of either side of the piling for structural support (Western cofferdam and Eastern cofferdam only) using rock
3) Dewatering activities
4) Removal of coffer dams.

8.2.5.2. Risks and impacts

Table 47 provides an overview of the risks and impacts associated with construction of the cofferdams.

Table 47: Risks and impacts associated with construction of the cofferdams

Risk	Construction Impacts
Water Quality – Fuel and fluid leaks from machinery	Potential for fuel and fluid leaks from machinery
Water quality from construction	Possible discharge of turbid water to waterways
Water quality impacts from infill to support cofferdams	Placement of infill material into Lake Lyell will result in increased turbidity from the action of placement.
	Potential of increased nitrate levels (Residual blasting contaminants) from rock spoil used for infill
Noise and Vibration	Noise and vibration have an impact on aquatic values
	Night works/sheet piling may disrupt platypus feeding behaviour and passage past works sites
Impacts to aquatic fauna	Aquatic fauna may be trapped or present at the time of installing the cofferdam.
Platypus	Platypus burrows may be impacted during construction of coffer dams

Risk	Construction Impacts
Sheet Piling – water quality/turbidity	Sheet piling may cause short term increase in turbidity
Dewatering – small cofferdam	Dewatering may result in the isolation of aquatic fauna
Dewatering – large cofferdam (behind the western cofferdam)	Greater potential for more aquatic fauna to be present and trapped
Water quality – western cofferdam	Once the cofferdam is isolated there is the risk that anaerobic conditions could occur resulting in low DO levels and fish deaths. This is due to the silt and organic material that has accumulated in Farmers Creek.
Water quality - removal of cofferdams	Removal of piling may cause short term increase in turbidity
Water quality – flooding of inlet/outlet works area	Flooding of the inlet / outlet works areas at completion of construction may result in increases in turbidity.

8.2.6. Ancillary infrastructure (including sediment basins)

Construction of the upper reservoir and associated access roads will require extensive earth works. All of these construction activities will be located away from waterways and a sedimentation basin will be constructed prior to earth works commencing on the major aspects of this project element. Access to the site for road construction and establishment of the sediment basin construction will rely on sediment and erosion control measures for construction prior to the establishment of the stormwater basin.

After construction of the stormwater basin is completed. Potential impacts from the construction activities for the upstream project elements (Upper Reservoir) are expected to be minimal provide appropriate management of the stormwater basin.

The primary stormwater basin is required downstream of the building pad in the upper reservoir works area. Preliminary planning based on the topography and the volume of water and shape of the valley it is installed in; the basin will require up to 14 m high walls. Works on the stormwater dam are expected to progress with the construction program and capacity will be increased by raising the wall height up to 14 m. The stormwater basin will need to be completed prior to major excavation works on the upper reservoir and tunnels commence.

8.2.6.1. Description of works

Construction methods for the stormwater basin are in preparation and methods for roadways, upper access tunnels and upper reservoir are unlikely to impact downstream receiving waters and impact aquatic values and have not been discussed.

8.2.6.2. Risks and impacts

Risks and impacts will be as per the inlet /outlet structure with the greatest potential impacts associated with runoff from the construction footprint, fuel and fluid leaks and spills the greatest risks (refer to Section 8.2.3.2)

8.2.7. High voltage switching yard (including laydown area)

A 330 kV switchyard pad will be built over a 130 m x 200 m area located in the west of the project site to house electrical equipment necessary for connecting the project to the transmission network (refer to Figure 5). Key infrastructure within the site will include:

1) overhead 330kV towers and conductors from existing transmission lines to switchyard
2) construction of an earthen bund around the infill area
3) switchyard including cable bays, busbars, overhead gantries and HV overhead lines, voltage and current transformers, circuit breakers & grid metering point
4) auxiliary transformer
5) drainage, access road and earth grid
6) site buildings, fire systems & and balance of plant systems
7) SCADA and communication systems
8) control building, auxiliary services building and storage shed
9) firefighting equipment
10) security equipment.

From the switchyard, an approximate 220 m long dual circuit transmission line will be constructed to connect with the existing 330 kV lines that pass through the project area. Due to the relatively short length of the transmission connection, up to six monopole towers are anticipated for each circuit. A cleared easement of about 60 m will be maintained along the transmission connection.

8.2.7.1. Description of works

Construction of the switchyard will involve clearing and earthworks to create a level pad. The switchyard pad will be constructed quickly relative to main project works, and therefore it will be utilised for a variety of additional purposes prior to the switchyard itself being constructed. These purposes include laydown area, concrete batch plant, fuel storage, heavy vehicle parking, and overflow parking for light vehicles if required.

Once these temporary uses are no longer required, construction of the switchyard will involve:

1) establishment of a bund during construction to manage environmental impacts of infill activities including runoff from the infill that may impact water quality
2) construction of the laydown area using infill material from the lake diversion and intake which will require some in-water works to stabilise the area
3) grading and pavement works, creating the permanent, platform for the switchyard and infrastructure
4) general construction of the infrastructure for this element such as temporary buildings, comms and LV local power
5) construction of the switching yard and electrical infrastructure of foundation and civil works including earth works, switchyard pad drainage, foundations, operational buildings, etc.
6) fencing and local drainage
7) HV connections from existing transmission lines to new switchyard.

8.2.7.2. Risks and impacts

Table 48 provides an overview of the risks and impacts associated with construction of the High voltage switching yard including the laydown area.

Table 48: Risks and impacts associated with the high-voltage switching yard including laydown area (construction)

Risk	Construction impacts
Water quality - Batching plant waste leak of waste material to waterways	Potential for waste materials from batching plant to enter water ways Runoff from Stockpiles and material results in discharge of turbid water to water ways
Water Quality - Fuel spill or leak from storage facility	Possible seepage of fuel into waterways
Water quality from construction	Possible discharge of turbid water to waterways
Water quality impacts from infill activities for the formation of the laydown area	Placement of infill material into Lake Lyell will result in increased turbidity from the action of placement and as a result of the wetting

Risk	Construction impacts
	and drying cycle associated with altering lake levels once completed
	Duration of impact will depend on the frequency of the altered hydrology and the time it takes for the exposed rock surfaces to stabilise
	Increase in Nitrates in Lake Lyell as a result of runoff from infill material sourced from blasting activities.
Impacts to platypus burrows in banks	Burrows will be destroyed if present in the banks at any location where infilling occurs
Loss of KFH	Construction of laydown area will result in the loss of KFH

Table 49 provides an overview of the risks and impacts associated with operation of the high voltage switching yard including laydown area.

Table 49: Risks and impacts associated with the high-voltage switching yard including laydown area (operation)

Risk	Operational Impacts
Water quality risks from fire risks associated with electrical infrastructure (transformers) and fire management	Switching yard fire may result in the leakage and discharge of transformer fluids to waterways.
	Switching yard fire may result in the leakage and discharge of subsequent firefighting chemicals to waterways.

8.2.8. Accommodation camp

The preferred accommodation camp site is proposed to be constructed at the south end of Lake Lyell (Lot 2 DP792415). The proposed location for the camp and the expected travel route between camp and the project site is shown in Figure 5. The accommodation camp will include a jetty that will extend into Lake Lyell. It is assumed the jetty will be constructed using pylons and a floating platform.

8.2.8.1. Description of works

A flat pad for the camp will be established. Although there is no geotechnical information available for the proposed camp location, approx.110,000 m^3 of cut and fill will be needed for the pad, which will require heavy ripping on site (no blasting). Wastewater from the accommodation camp and site ablution facilities will be transported from the site by tanker truck and disposed of at the wastewater treatment plant.

8.2.8.2. Risks and impacts

Table 50 provides an overview of the risks, impacts and mitigation measures associated with construction of the accommodation camp.

Table 50: Risks and impacts associated with accommodation (construction)

Risk receptor or activity	Construction impact
Water quality runoff from the construction site	Possible discharge of turbid water to waterways.
Spills	Potential for chemicals such as hydrocarbons to enter waterways.
Stockpiling	Potential for runoff from stockpiles during high rainfall events
Jetty	Potential for a decrease in water quality resulting from construction of the jetty (primarily from pilling).
Water quality – stormwater runoff	Operation of the accommodation camp will include storage of light vehicles (LV) and there will be risks relating to the associated sediment, small amounts of fuel, oils and greases typically associated with vehicles. Potential for runoff from carparks and hard stand to enter Lake Lyell resulting in on poor water quality.
Water quality – wastewater	Potential for overflow from wastewater treatment storage and discharge directly to Lake Lyell.

8.3. Summary of potential impacts

8.3.1. Direct and indirect impacts

The potential exists for direct and indirect impacts on aquatic and riparian ecology receptors to occur during construction and the operation phase as a result of the proposed project and are summarised below in Table 51.

Table 51: Summary of potential direct and indirect impacts of the project on aquatic ecology values

Impact type – direct or indirect	Impact	Comments
Direct	Direct loss of riparian habitat for Lake Lyell	The project will result in a direct loss of riparian habitat. Riparian habitat is beyond the scope of the aquatic component of the Lake Lyell EIS and is discussed in the Lake Lyell Pumped Hydro Energy Storage project Biodiversity Development Assessment Report (EMM Consulting Pty Limited, 2025d))
Direct	Direct loss of KFH within Lake Lyell	Construction of infrastructure relating to the project will result in a loss of 11.88 ha of KFH. Offsets associated with the loss of KFH are discussed in Section 10.4.
Direct	Potential barrier to fish passage between Lake Lyell and Farmers Creek resulting from construction of the Lake Diversion	The construction and operation of the Lake Diversion has the potential to act as a barrier to fish passage between Farmers Creek and Lake Lyell. The Lake Diversion and appropriate design recommendations are presented in Section 10.3 and Annexure J.
Direct	Direct loss of macroinvertebrate habitat within Lake Lyell	Repeat water fluctuations of 2.1 to 2.5 m resulting from the operation of the Lake Lyell PHES may result in a loss of macroinvertebrate habitat, biodiversity and abundance. Impacts to macroinvertebrates resulting from the operation of the Lake Lyell PHES are discussed in section 9.
Indirect	A decrease in water quality within Lake Lyell as a result of construction activities	Construction activities have the potential to negatively impact water quality with Lake Lyell. Impacts to water quality are discussed further in Section 8.2.
Direct	Potential for aquatic values to be impacted by noise and vibration	Construction activities associated with multiple project elements may impact aquatic fauna due to noise and vibration.
Direct	Potential for fauna entrapments	Construction of waterway crossings and cofferdams processes may lead to isolation and entrapment of fauna. These impacts are discussed further in Sections 8.2.4 and 8.2.5.

Impact type – direct or indirect	Impact	Comments
Direct/Indirect	Potential smothering of aquatic biota, their propagules, and habitats due to erosion and sedimentation issues associated with construction earthworks and frequent changes in water levels	Increased turbidity and sedimentation has the potential to smother aquatic biota, reducing photosynthesis and decreasing primary production which may have cascading effects on various trophic levels. Impacts are expected to be transient and are discussed further in Section 8.2.
Direct	Direct impacts to non-listed, native fish species	It is likely that any impact to native unlisted aquatic biota resulting from the construction of the PHES will be minimised by the implementation of detailed EMPs that will provide appropriate minimisation and mitigation measures. However, fish assemblages within the lake and associated waterways are dominated by introduced species, and therefore impacts to native species resulting from construction activities are likely to be minimal. There is potential for a direct loss of fish through the PHES intake. Both native (Australian bass) and introduced species may be attracted to flows generated by the intake / outlet pipes and there is potential for both fish and Platypus to be drawn up into the intake pipe. Risks associated with the inlet/outlet structure are discussed in Section 8.2.3.2.

8.3.2. Cumulative impacts

Lake Lyell is currently operated to supply water to the Mt Piper power station and the existing operational guidelines include impacts to aquatic ecology values within Lake Lyell as a result of fluctuating water levels. The construction of the PHES will alter the frequency of changes in water level within the existing operation guidelines of Lake Lyell. No other projects or uses are known to be considered to contribute to cumulative impacts. As such no cumulative impacts are predicted.

8.3.3. Impacts to KFH from fluctuating waters

Indirect impacts to KFH as a result of the operation of the PHES and diurnal fluctuations in water level in Lake Lyell have not been considered as these impacts already occur within the existing operational guidelines for Lake Lyell. As such, no offsets are proposed for impacts to KFH as a result of fluctuating water levels.

9. Risk assessment – Aquatic ecology values

The risk assessment has been completed based on the risks to aquatic habitats and species from the construction and operation of the PHES as described in Section 7.1 and summarised in Section 7.2. Reference to increased turbidity for the purposes of the aquatic ecology risk assessment is an assessment of the potential of increased turbidity if it were to occur to impact aquatic ecology values from construction or operational pathways. The aquatic ecology assessment does not assess the likelihood of increased turbidity from operational or construction activities and pathways.

Provided below is a summary of the risk assessment for potential impacts to aquatic values as a result of construction of the PHES (refer to Table 52).

Table 52 details the results of the risk assessment for the construction phase of the Lake Lyell PHES and Table 53 details the results of the risk assessment for the operation phase of the Lake Lyell PHES.

Platypus impacts and risks have been assessed separately in Section 9.2.

Provided below is a summary of the risk assessment for potential impacts to aquatic values as a result of construction of the PHES (refer to Table 52).

Table 52: Risk assessment for the construction impacts for the Lake Lyell PHES

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
Surface Water - Water Quality and sediment quality	Construction activities – water way crossings, laydown areas, roadways	Sediment discharged to downstream Farmers Creek or Lake Lyell during construction activity	Appropriate sediment and erosion control measures (i.e. silt fencing, revegetation, timing of construction, stormwater diversions). Assumes CEMP measures in place for all construction activities and will be detailed in the Construction Water Management Plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	P	L	Poor water quality due to discharges possible due to natural rainfall events. Risk lowered if all mitigation and management measures followed including monitoring of the measures (i.e. silt fences).
Surface Water - Water Quality and sediment quality	Construction activities - water way crossings, laydown areas, roadways	Chemical or fuel spill from storage areas or when refuelling plant and equipment	Assumes CEMP developed and measures in place for all construction activities and will be detailed in the Construction Water Management Plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval. Appropriate bunding for stored materials and appropriate spill kits in place.	MO	R	L	Chemical and fuel spills will be rare if all mitigation measures are followed.
Surface Water - Water Quality and sediment quality	Stockpile management	Sediment discharged to downstream Farmers Creek or Lake Lyell during construction activity	Appropriate sediment and erosion control measures (i.e. silt fencing, revegetation, timing of construction, stormwater diversions). Assumes CEMP measures in place for all construction activities and will be detailed in the Construction Water Management Plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	P	L	-
Surface Water - Water Quality and sediment quality	Construction of infill areas	Placement of infill activity likely to be undertaken while the receiving area is inundated. Sediment turbidity impacts may occur from installation of the rock to infill area.	Additional sediment and erosion control measures will be required in the form of silt curtains.	MI	L	M	Severity of the impact will be dependent on the substrate which is present which is light organic silt throughout the Farmers Creek arm of the lake
Surface Water - Water Quality and sediment quality	Construction of infill areas	Impacts from nitrates and turbid runoff likely to be generated from the infill material dependent on rainfall and runoff, and fluctuating water levels of the lake	Additional sediment and erosion control measures will be required in the form of silt curtains and an earthen bund around the HV infill area to mitigate and manage nitrates. A specific Nitrate Management Plan will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	P	L	Impact of nitrates has been discussed in more detail in the Surface Water Assessment (EMM Consulting Pty Limited, 2025b)

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
Surface Water - Water Quality and sediment quality	Construction activities – Inlet/outlet structure construction	Sediment discharged to downstream Farmers Creek or Lake Lyell during construction activity	Runoff and construction wastewater will be contained within the construction footprint contained by the cofferdams. Construction water from the site is to be treated and disposed of in accordance with the Erosion and Sediment Control Plan (ESCP) and Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	R	L	Low likelihood of any impacts if measures in the Construction Water Management Plan adhered to (including construction wastewater) - to be prepared
Surface Water - Water Quality and sediment quality	Construction activities – Inlet/outlet structure construction	Chemical or fuel spill from storage areas or when refuelling plant and equipment	Runoff and construction wastewater will be contained within the construction footprint contained by the cofferdams. Construction water from the site is to be treated and disposed of in accordance with the Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MO	R	L	Low likelihood of any impacts if measures in the Construction Water Management plan that will be prepared are adhered to (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.
Surface Water - Water Quality and sediment quality	Construction activities	Batching plant waste leak of waste material discharged to waterways	Assumes all sediment and erosion control measures (i.e. silt fencing, revegetation, timing of construction, stormwater diversions) which will be detailed in the Erosion and Sediment Control Plan (ESCP) and Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	P	L	Possible likelihood of any impacts if measures in the Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) are adhered to - to be prepared post approval. Any impact would be expected to be short term in nature.
Surface Water - Water Quality and sediment quality	Construction activities – bridge crossing	Sediment discharged to downstream Farmers Creek or Lake Lyell during construction from bridge platforms	Assumes all sediment and erosion control measures (i.e. silt fencing, revegetation, timing of construction, stormwater diversions) which will be detailed in the Erosion and Sediment Control Plan (ESCP) and Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	IN	L	L	Any sediment and turbidity from the bridge platforms should be limited in its impact due to the small surface areas of the bridges and highest impacts will occur during rain events. Cleaning of the pavement surfaces of the bridge crossing would further reduce potential impacts from this sediment source.
Surface Water - Water Quality and sediment quality	Installation of piling activities under wet conditions	Pilling will generate turbidity	Install silt curtains during installation to limit turbidity generated during installation and to provide fauna exclusion.	IN	L	L	-
Surface Water - Water Quality and sediment quality	Placement of causeway materials for construction	Poor Water quality from materials used - Dirty (silt and other contaminants) rock fill in bags may results in the generation of turbidity during rewetting and placement	Clean materials to be used for rockfill in bags. Sediment Control Plan (ESCP) and Construction Water Management plan that will be prepared (EMM Consulting Pty Limited, 2025b) - to be prepared post approval.	MI	AC	M	Construction activity will be short term and sediment and erosion controls should mitigate potential impacts.
Aquatic Vertebrates - fish	Installation of waterway crossing - Upper Reservoir	Fauna may be trapped during the placement and construction of the rock to form the	Site to be inspected and aquatic vertebrate fauna removed and translocated form the construction area.	IN	P	L	-

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
	Access Causeway and western cofferdam	base of the bridge to support concrete culverts.	Barrier to prevent fauna access during construction to be installed during construction. Measures to be documented in the FFMP - to be prepared post approval.				
Surface water biodiversity- Aquatic Ecology (algae, macrophytes, macroinvertebrates)	Installation of waterway crossing - Upper Reservoir Access Causeway and western cofferdam	Macroinvertebrates will be impacted within the footprint of the causeway and water crossing	No control measures specified	IN	AC	M	Impacts will occur to a small area. Moderate Impacts a factor of the risk matrix used.
Surface Water - Water Quality and sediment quality	Stockpiling	Runoff from the stockpile areas results in contaminated water entering waterways.	All stockpile BMP sediment and erosion control measures in place. Construction water from the site is to be treated and disposed of in accordance with the Stormwater Management Plan (including construction wastewater) - to be prepared	MI	P	L	-
Surface Water - Water Quality and sediment quality	Infill installation	If lake infill activities are to be undertaken while the site receiving area is inundated sediment and turbidity impacts may occur. Severity of the impact will be dependent on the substrate which is light silt and organics in areas throughout the Farmers Creek arm of Lake Lyell.	Additional sediment and erosion control measures may be required in the form of silt curtains to manage turbidity.	MI	L	M	Construction of proposed earth bund around the HV switching yard laydown area considered as part of infill activities
Surface Water - Water Quality and sediment quality	Infill stabilisation	Leaching of sediment and residual blasting from nitrates potential to contaminate waterways during settlement of infill area. Blasting compounds/nitrates expected to increase in receiving waters during this stage.	Maintain silt curtains to control generation of turbidity during stabilisation of infill area.	MI	L	M	Time for infill to stabilise will depend on the lake levels and status of the infill material. Impacts not expected to be long term.
Surface water biodiversity- Aquatic Ecology (algae, macrophytes, macroinvertebrates)	Infilling installation	Direct infilling of Lake Lyell and Farmers Creek for construction of the inlet/outlet and the high voltage switching yard will result direct loss of macroinvertebrate habitat	No mitigation possible. Habitat will be lost.	MO	AC	H	No requirement for offsets for loss of macroinvertebrate habitat. Habitat loss will be covered by KFH offsetting.

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
Aquatic Vertebrates - fish	Construction of Cofferdam – Lake Diversion	Aquatic vertebrates – fish may be trapped within the cofferdam	Inspect and undertake salvage of native fauna after the cofferdam is completed	IN	AC	M	Almost certain that some aquatic vertebrates will be trapped as a result of the construction of the Cofferdam. Numbers of individuals impacted likely to be low.
Aquatic Vertebrates - fish	Construction of Cofferdam – Dewatering for construction	Aquatic vertebrates trapped prior to dewatering	Site to be inspected and animals removed and translocated form the construction the cofferdam prior to dewatering	IN	L	L	-
Surface Water - Water Quality and sediment quality	Engagement of Lake Diversion and removal of Coffer dams	Generation of turbidity during the engagement of the lake diversion	Downstream cofferdam to be removed first Downstream silt curtain to remain in place during initial engagement of the lake diversion Undertake engagement of the Lake Diversion slowly by removing one or two piles at a time. Monitor water quality visually at the outlet end. As turbidity tappers remove more piles and increase flows through the lake diversion Engaging the lake diversion slowly (two – three days) also allows for animals in the Farmers Creek Arm to move out of the area Engaging the Lake Diversion may take several days to allow for fauna movement and turbidity management at the outlet. Once the Lake Diversion is fully engaged the downstream silt curtain must be removed	MI	L	M	Impacts will be short term
Aquatic Vertebrates - fish	Engagement of Lake Diversion	Animals become stranded within the works footprint due to the rapid drawdown of the Farmers Creek arm within the inlet / outlet structure footprint	Engaging the lake diversion slowly (two – three days) also allows for animals in the Farmers Creek Arm to move out of the area Inlet / outlet cofferdams not to be completed prior to complete engagement of the lake diversion	MI	L	M	-
Aquatic Vertebrates - fish	Construction of Cofferdam – Inlet /outlet structure	Entrapment of aquatic vertebrates within the construction footprint of the inlet / outlet within the cofferdams	In deeper and larger areas there is a possibility of a greater abundance of aquatic fauna to be trapped. A dewater plan should be prepared and adaptive management will be required for any salvage operation is to be undertaken and will consider the following. Substrate conditions are likely to be unsuitable for personnel to wade in due to the expected unconsolidated substrate.	MI	AC	M	High likelihood that some aquatic fauna (fish) will be lost at this stage under the expected water quality conditions

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
			Boat based salvage operations are the most likely options. Lower water level to a total depth of ~1.5m. Use boats and boat based haul nets to seine the area and relocate salvaged aquatic fauna.				
KFH	Construction including PHES infrastructure, accommodation camp amenities and spill way upgrades	11.88 ha of KFH will be lost as a result of the activity.	Loss of KFH to be addressed by the agreed offset	MI	AC	M	Offsets to be agreed. Further details provided in section 10.4.
Aquatic Vertebrates - fish	Poor fish passage through culverts/bridges	Poor waterway crossing design may impede fish passage	Follow BMP guidelines for culvert design (Kapitzke, 2010)	IN	L	L	
Surface Water - Water Quality and sediment quality	Construction and operation of stormwater management dam	Failure or poor management of Stormwater management dam to provide adequate treatment or unplanned overflow or discharge	Construction water from the site is to be treated and disposed of in accordance with the Stormwater Management Plan (including construction wastewater) - to be prepared	MO	P	M	

9.1. Operational phase risks

Provided below is a summary of the risk assessment for potential impacts to aquatic values as a result of the operation of the PHES (Table 53).

Table 53: Risk assessment for the Operational Impacts for the Lake Lyell PHES

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
Aquatic Vertebrates – fish	Poor fish and platypus passage across the lake diversion	Operation of the Lake Diversion may impede fish and platypus passage with poor design	Follow BMP guidelines for fish way design. Design principles for the construction of the Lake Diversion to support best outcomes for Aquatic Fauna passage have been provided. These are design principals only and further consultation with ecologists, engineers and experienced constructors are recommended to obtain the best outcome (refer to Annexure J).	IN	L	L	
Aquatic Vertebrates – fish	Poor fish and platypus passage through culverts/bridges	Poor waterway crossing design may impede fish and platypus passage	Follow BMP guidelines for culvert design (Kapitzke, 2010)	IN	L	L	
Surface Water - Water Quality and sediment quality	Increased turbidity as a result of operation of the LLPHES	Operation of LLPHES results in increased turbidity in Lake Lyell as result of hydrology changes during operations.	No mitigation measures proposed.	MI	L	M	Generation of turbidity is likely to occur in the short term. Increased turbidity is predicted to be temporary (refer SWA). The degree of turbidity is currently unknown. If turbidity is significant and occurring over several months there is potential for a loss of macrophytes, an increase in the occurrence of algal blooms and associated trophic cascade including a decrease in macroinvertebrates which may result in impacts to platypus.
Surface Water - Water Quality and sediment quality	Operation of the LLPHES	Operation of LLPHES results in bank slumping as a result regular changed water levels	Assessments from the Surface Water Assessment (EMM Consulting Pty Limited, 2025b) suggest this is possible based on geology and modelling of flows during operation particularly in the Farmers Creek Arm of Lake Lyell	MO	P	M	Bank slumping and turbidity has potential for impacts. Impacts would be expected to reduce over time as landform stabilises under new hydrological regime, timeframe unknown. Bank stabilisation works may be undertaken if required.
Surface Water - Water Quality and sediment quality	Operation of the LLPHES	Water quality risks from fire associated with electrical infrastructure (transformers) and fire management	Assumes bunding and allowance for fire fighting capability and diversion of runoff into bunded area and/or stormwater basin for treatment. Plan and design to be prepared post approval.	MO	R	L	Chance of fire or leaks of chemical from equipment should be easily managed with appropriate BMPs and likelihood of and impact would be rare.

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments (including uncertainty)
Aquatic Vertebrates – fish	Operation of the LLPHES	Entrainment of fish in the inlet / outlet structure as a result of the operation of the LLPHES	Current mitigation measures are: - 200 mm grills on the inlet / outlet structure - a floating boom with a submerged grill intended to discourage platypus access to the inlet /outlet area. Maximum flows at the boom expected to range between 1 to 1.5m[s]	MI	L	M	Grill spacings of 200mm will not restrict aquatic fauna access to the intake/outlet structure. Entrained fauna will be at risk of death as a result. Previous projects report significant numbers of fish survive entrainment (Baumgartner, et al., 2017; Ning, 2019; Doyle, et al., 2022).
Aquatic Vertebrates – fish	Operation of the LLPHES	Possible attraction of Australian bass in response to the operation of the LLPHES	No mitigation currently available	MI	L	M	Potential of this impact are unknown. Species known to respond to increased flows. Species are a stocked species into the reservoir and there are no know self-sustaining population.
Aquatic Vertebrates – fish	Operation of the LLPHES	The inlet/outlet structure includes a sump area that will be constructed lower than the surrounding ground. As lake levels recede during non-operational times the sump will become isolated and Aquatic vertebrates may become entrapped. Water quality will deteriorate the longer the sump is isolated from the main body of the lake. The loss of all trapped fish is almost certain.	Fauna salvage may be possible. Access and safety concerns would need to be addressed	MO	R	L	
Surface Water - Water Quality and sediment quality	Fire risk in HV switching yard	Risk of fire in the HV switching yard results in potential leakage of transformer chemicals to water ways. Fire fighting activity may result in the discharge of fire suppressant chemicals to Lake Lyell	Bunding and containment designed to BMP	MI	UI	L	

9.2. Risks to platypus

Provided below is a summary of the potential direct and indirect impacts to platypus as a result of the construction and operation of the PHES (Table 54).

Table 54: Summary of potential direct and indirect impacts of the project on platypus

Impact type – direct or indirect	Impact	Comments
Direct	Noise and vibration disturbance	Blasting, piling and construction activities are likely to cause direct disturbance to platypus in the form of noise and physical tremors/movement.
Direct	Direct loss/shift of platypus habitat within Lake Lyell (foraging and burrowing)	Construction and operation of the project will result in the loss of both foraging and burrowing habitat for platypus. Includes the lowering of Lake Lyell for construction.
Direct	Potential barrier to platypus passage between Lake Lyell and Farmers Creek resulting from construction of the Lake Diversion	The construction and operation of the Lake Diversion has the potential to act as a barrier to platypus passage between Farmers Creek and Lake Lyell. The Lake Diversion and appropriate design recommendations are presented in section 10.3 and Annexure J.
Direct	Potential for direct platypus mortality	There is potential for a direct loss of platypus through the PHES intake. Mitigation measures in the form of screens or exclusion devices have been considered and are discussed further in Section 10.
Direct	A decrease in water quality within Lake Lyell as a result of construction activities	Construction activities have the potential to negatively impact water quality with Lake Lyell.
Indirect	Potential disturbance of platypus foraging and supporting food webs	Operation of the Lake Lyell PHES has the potential do indirectly impact platypus via changes to supporting food webs.
Indirect	Potential smothering of aquatic biota, macrophytes and habitats due to erosion	Increased turbidity and sedimentation has the potential to smother aquatic biota, reducing photosynthesis and decreasing primary production which may have

Impact type – direct or indirect	Impact	Comments
	and sedimentation issues associated with construction earthworks and frequent changes in water levels	cascading effects on various trophic levels. Impacts are expected to be transient and are discussed further in section 8.2.
Direct/Indirect	Increased turbidity in Lake Lyell as a result of erosional forces	Construction activities and operation of the PHES may increase turbidity within Lake Lyell. Increased turbidity will impact primary productivity, benthic habitat structure, water quality, and macroinvertebrate communities. Such changes could impact platypus habitat use, foraging behaviour and potential decouple important trophic interactions.

The specific risk assessment for platypus as a result of the construction (refer to Table 55) and operation (refer to Table 56) of the project are presented below.

Table 55: Risk assessment for platypus during construction of the Lake Lyell PHES

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including uncertainty
Platypus	Lowering of Lake Lyell by 2.9 m for construction	Lowering of lake levels may strand young in burrows	Do not drawdown Lake Lyell during breeding season (October to March in NSW) when young may be present in burrows to eliminate impacts. Drawdown to occur between April – August. Platypus monitoring during construction to occur and will be detailed in the Platypus Management Plan (PMP) – to be prepared post approval.	MI	P	L	Eggs lay - October Juveniles remain in the Burrows for approx. 19 weeks. Full breeding season may range from October – March Proposed water levels are within the existing operational guidelines and have occurred in the past
Platypus	Lowering of Lake Lyell by 2.9 m for construction	Change in water level may impact food resource availability.	Gradual draw down of Lake Lyell to proposed construction level will mitigate impacts to food resource availability. Platypus monitoring during construction to occur and will be detailed in the PMP – to be prepared post approval.	IN	P	L	Draw down of Lake Lyell will result in platypus foraging and feeding area being changed. A staged draw down will occur over a 4 to 6 month period will reduce impacts on recruitment /breeding success and allow for food resource availability to stabilise. Proposed water levels are within the existing operational guidelines and have occurred in the past. Impacts of this static water level for the total construction period unknown. Platypus monitoring essential.
Platypus	Installation of piling activities	Installation of sheet piling will result in vibrations and may be impede some aquatic fauna	The noise and vibration from sheet piling cannot be eliminated. Aquatic fauna are unlikely to be attracted to the area and are expected to be discouraged from the area during the construction activity due to the noise and vibration	MI	L	L	No nighttime piling to be undertaken to limit impacts on platypus feeding behaviours
Platypus	Construction of Cofferdam – Lake Diversion	Platypus burrows may be destroyed during the construction of the cofferdams	Inspect banks for platypus burrows prior to beginning construction.	MI	L	L	Undertaking works during breeding season if burrows are present in works sites is a risk should a burrow be identified.
Platypus	Construction of Cofferdam – Inlet /outlet structure	Entrapment of platypus within the construction footprint of the inlet / outlet within the cofferdams	Impacts to platypus burrows in banks in the vicinity of the inlet /outlet structure Platypus may become trapped within the inlet/outlet construction footprint after the western cofferdam is completed	MI	P	L	The drawdown of Lake Lyell for construction is intended to improve and mitigate environmental impacts during construction.

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including uncertainty
			If platypus are identified they will need to be captured and relocated. If these activities occur during breeding season the relocating and trapped animals will be critical as nesting females may have young				

Table 56: Risk assessment for platypus during operation of the Lake Lyell PHES

Consequence Criteria	Risk Activity	Risk Issue- What can happen & How can it happen	Existing Control Measures (Planned Controls)	C	L	R	Comments including uncertainty
Platypus	Poor fish and platypus passage across the lake diversion	Operation of the Lake Diversion may impede fish and platypus passage with poor design	Follow BMP guidelines for fish way design. Design principles for the construction of the Lake Diversion to support best outcomes for Aquatic Fauna passage have been provided. These are design principals only and further consultation with ecologists, engineers and experienced constructors are recommended to obtain the best outcome (Annexure J – Lake Diversion Design).	IN	L	L	-
Platypus	Poor fish and platypus passage through culverts/bridges	Poor waterway crossing design may impede fish and platypus passage	Follow BMP guidelines for culvert design (Kapitzke, 2010)	IN	L	L	-
Platypus	Operation of the LLPHES	Platypus food resource availability may be altered due to fluctuation water levels	Prepare PMP and undertake monitoring of the resident platypus population in Farmers Creek, Lake Lyell and the associated waterway. Key aspects of the monitoring program should include: 1) Monitoring of the macroinvertebrate community abundance and composition under an operation regime will inform on impacts to platypus 2) Monitoring of the platypus community abundance over the course of the project construction and operation 3) Consider tracking and tagging program over a longer period which will require implantation of tags to monitor the behavioural changes of platypus in response to the activities. 4) A mark and recapture study should be implemented to monitor platypus health and condition	MO	P	M	The literature suggests that Platypus feed on a wide variety of macroinvertebrates and invertebrate prey. Studies undertaken as part of the EIS indicate that, macroinvertebrate species composition varies between a range of water depths (1 to 3 m) and there is no correlation between macroinvertebrate abundance and depth. It is still unknown what the new hydrological regime will have on macroinvertebrate abundance, species diversity over the range of fluctuation water levels and the operation of the LLPHES. The current data available suggests that if platypus have a broad diet in Lake Lyell they may change their feeding patters and behaviour to meet physiological requirements. Moderate impact as a conservative assessment of potential risk.
Platypus	Operation of the LLPHES	Entrainment of platypus into the inlet/outlet structure	Current mitigation measures are: - 200 mm grills on the inlet / outlet structure - Maximum Flows at the grill expected to range between 1.5 m[s] - A floating boom with a submerged grill intended to discourage platypus access to the inlet /outlet area. - Maximum flows at the boom expected to range between 1 to 1.5m[s]	MA	P	H	A high risk of platypus entrainment exists. Boom and grill do not eliminate the risk.

10. Mitigation measures

10.1. General mitigation measures

A Platypus Management Plan (PMP), Flora and Fauna Management Plan (FFMP) and a Construction Environmental Management Plan (CEMP) will be developed and implemented, should the project proceed. A specific Aquatic Fauna Management Plan (AFMP) may be prepared rather than included in it within the proposed FFMP, this will be determined post approval. The mitigation measures provided within this section are additional measures that would need to be documented and incorporated into the construction and operational environmental documentation.

The proposed mitigation measures to be included in the development of the project environmental management documentation are summarised in Table 57.

Table 57: Safeguards and mitigation measures

No	Aspect/impact	Mitigation measure	Responsibility	Timing
	Aquatic ecology			
1	Management plan	The Biodiversity Management Plan (BMP) for the project will include measures and management actions should aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction.	Contractor	Pre-construction Construction Post-Construction
2	Construction near waterways	Construction periods in and around waterways would be kept to a minimum to limit disruption to aquatic fauna where practical relevant to specific construction elements.	Contractor	Pre-Construction Construction
3	Trapped aquatic fauna	Daily inspections of the works site (particularly around the waters edge) would be completed to check for aquatic fauna that may become entrapped in the works site after overnight foraging.	Contractor	Construction
4	Dewatering of cofferdams	During dewatering of cofferdams during construction, the following measures will be implemented: • A qualified ecologist must be on site during any dewatering activities to assist with fauna salvage. Appropriate permits and animal ethics approvals will be required. • The removal of instream habitat structures (e.g. cobbles, boulders, vegetation, snags) must be minimised. • Snags are not to be removed from waterways but should be realigned or relocated (ideally replaced into the same location) in accordance with the Policy and Guidelines for Fish Habitat Conservation and Management (2013). • No removal of native riparian vegetation beyond those areas defined in the BDAR.	Contractor	Construction

No	Aspect/impact	Mitigation measure	Responsibility	Timing
5	Riparian habitat	Where required, ensure bed, banks and riparian zone is progressively rehabilitated as soon as practicable following disturbance, in accordance with the Rehabilitation Plan	Contractor	Pre-construction Construction Post-Construction
6	Sedimentation	Sedimentation management protocols must be installed and utilised across the site in accordance with the project's Soil and Water Management Plan. The Soil and Water Management Plan is to include a trigger action response plan to minimise downstream water quality and aquatic ecology impacts (e.g. turbidity, dissolved oxygen, salinity, metals).	Contractor	Pre-construction Construction
7	Sedimentation	Installation of instream silt curtains may be required to reduce downstream transport of sediment. Where silt curtains are used, a qualified aquatic ecologist must undertake fauna salvage to relocate any aquatic species trapped within the enclosed area.	Contractor	Construction
8	Fish passage	Undertake a detailed design of the lake diversion to obtain the best outcomes for platypus and fish passage in accordance with the design principles outlined in Annexure J – Lake Diversion Design.	LLP	Design/ Pre-construction
9	Aquatic offset approach	Any offset strategy shall be developed in consultation with the DPI Fisheries, and relevant technical staff, to determine on-site improvement or contribution to priorities identified by DPI Fisheries to be funded by the project. The offset strategy and timing for its implementation will be agreed with DPI Fisheries prior to construction.	LLP	Construction

10.2. Platypus management plan (PMP)

The primary recipient of impacts resulting from the project will be the platypus. Platypus are of significant cultural importance for both Australia's First Nation people and local residents to the Lake Lyell area. A detailed PMP must be prepared prior to the project commencing. It is recommended that experts on platypus behaviour and First Nations representatives be consulted when preparing the PMP.

An appropriate PMP may include a range of different monitoring methodologies to address different priorities and could include the following:

1) Installation (surgical implanting) of long-lasting acoustic tags to monitor Platypus movement and behaviour during construction and hopefully operation. Tag life (i.e. battery life) is dependent on the size of the tag and therefore may not be achievable for the entire duration of both construction and operational phases of the project. This would require tags to be surgically implanted. An acoustic array would also need to be deployed for this aspect of the monitoring program. Only a select portion of the population would need to be tagged to address these questions.

2) Pit tagging and trapping could be undertaken to monitor platypus health and condition throughout the construction and initial operation of the project. Intervals of monitoring may be less frequent during part of the construction phase. An intense period of monitoring should be undertaken in the first 1 to 2 years of operation to monitor the health and condition of the platypus population. Metrics to assess health may include, evidence of recruitment, monitoring of biomass, physical inspections of individuals and measures such as tail volume indexes.

The PMP will also document all of the management actions specifically related to platypus for the construction and operation phases of the project. The PMP must include adaptive management strategies including options for translocation of platypus should long term monitoring reveal that platypus condition is decreasing in response to operation of the project.

Table 58 details a number of mitigation measures that will assist with minimising impacts to platypus resulting from the project. Mitigation measures listed in this section should be included in the PMP.

Table 58: Safeguards and mitigation measures for platypus

No	Aspect/impact	Mitigation measure	Responsibility	Timing
1	Platypus management	A platypus management plan (PMP) must be prepared prior to commencing any on ground site works that may impact platypus including the construction of the diversion or the proposed lowering of Lake Lyell for the construction works. The PMP must detail measures and management actions should aquatic fauna or fauna habitat be disturbed pre-, during, and post-construction. The PMP will include, but are not limited to, the following mitigation measures: • monitoring of platypus throughout the pre-construction and construction period (see monitoring requirements in AE11) • avoiding the platypus nesting period (October to March) where possible, or conducting suitable inspection and management actions to be identified in the PMP • installation of platypus exclusion controls, such as floating boom • aquatic areas to be impacted must be inspected for burrows prior to works commencing and outside of the breeding season. If burrows are detected, platypus must be relocated out of the immediate area by a qualified ecologist. Platypus must then be excluded from the area • all platypus must be excluded from works areas. Potential methods include silt curtains that rise above the water level and fencing on land • if any areas are to be dewatered a qualified animal handler with the appropriate permits will be on site to assist with relocating any platypus as required • no night works to be undertaken for temporary bridge construction and pilling activities. The PMP must be prepared in consultation with a suitably qualified aquatic ecologist.	Contractor / Advisory panel	Pre-construction Construction Post – Construction/ operation

No	Aspect/impact	Mitigation measure	Responsibility	Timing
2	Adaptive management strategies	The PMP must incorporate adaptive management strategies, including a translocation option if the Lake Lyell/Farmers Creek platypus population's fitness or condition declines (as determined by results of monitoring measures, see AE11). Translocation is considered a risk and is only to be used in response to observable, measurable and demonstrated deterioration due to the Lake Lyell PHES construction and operation. It will only proceed if recommended by an expert and in consultation with stakeholders.	Contractor LLP	Construction Operation
3	Long term monitoring	Monitoring will be carried out for the project as follows. • during the construction phase and first two years of operation: Tracking of platypus to monitor their behaviour and population. This will include assessment of platypus condition to assist with determine impacts to platypus resulting from the project • during the first two years of operation: The macroinvertebrate assemblage within Lake Lyell will be monitored for the first two years of operation to assess the long-term impacts of water level flux. This data will assist with determining short term and long-term impacts to macroinvertebrates resulting from this type of project.	LLP	Construction Operation

10.3. Lake diversion design

The Lake Diversion to be constructed at the mouth of Farmers Creek has the potential to form a significant barrier to both fish and platypus attempting to move between Farmers Creek and Lake Lyell. The Lake Diversion is described in section 8). The Lake Diversion must be designed in accordance with *Guidelines for the design, approval and construction of fishways* (O'Connor, et al., 2017) and the *NSW Government: Fishways* website to minimise impacts to both fish and platypus movement between Farmers Creek and Lake Lyell (Department of Primary Industries, 2024c). Further recommendations to inform this design are provided in Annexure J.

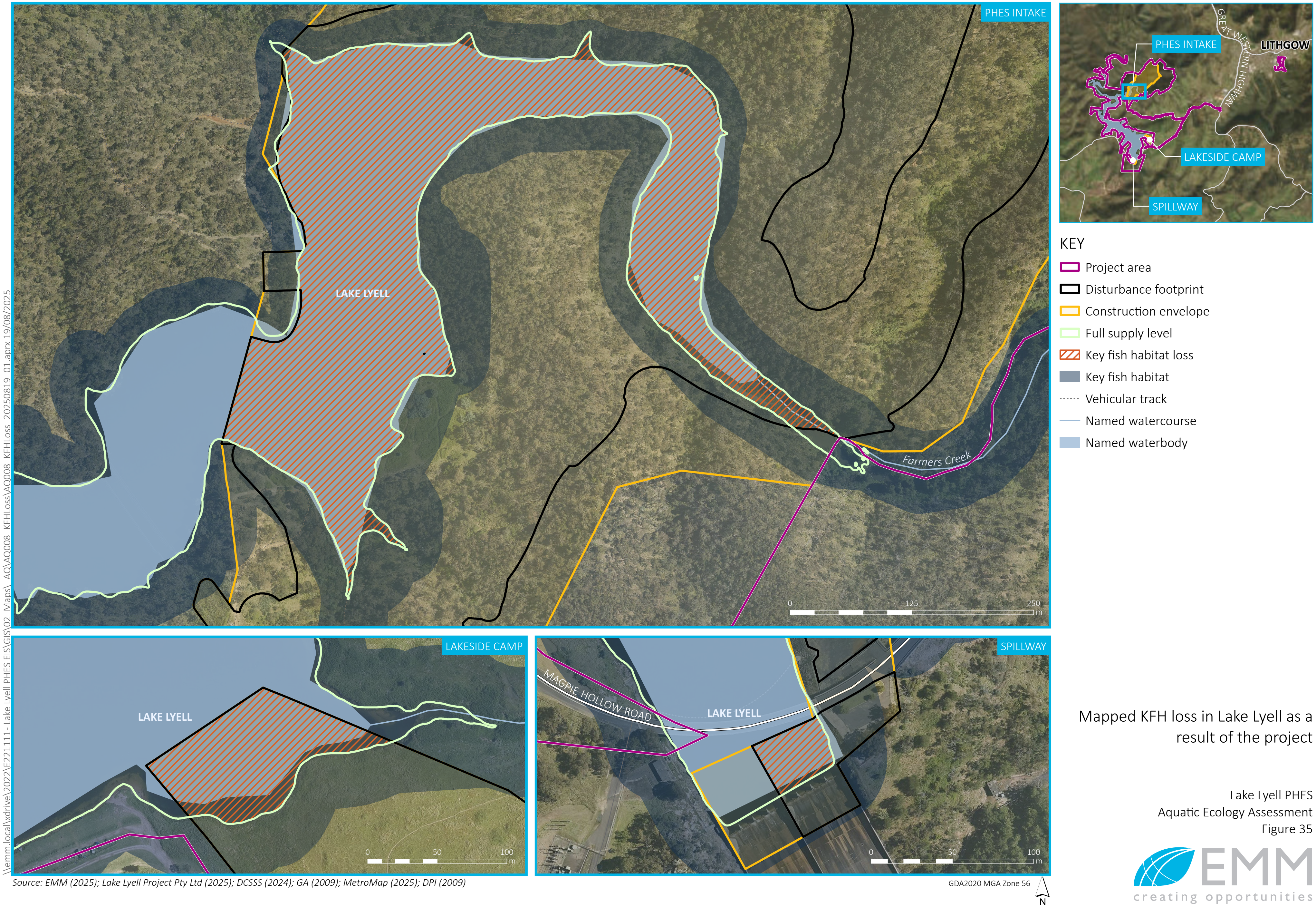
10.4. Aquatic offset approach

A total of 11.88 ha (refer to Figure 35) of Type 1 Class 1 KFH will be directly impacted as a result of the construction of the project, comprising:

1) PHES (10.92 ha) – this includes the construction of the inlet/outlet structure that will result in infilling of Farmers Creek and Lake Lyell, the construction of the Farmers Creek diversion and the infilling for the high voltage switching yard
2) Lake Accommodation (0.82 ha) – this includes lakefront land adjacent to the proposed accommodation camp that may include the development of amenities such as jetties and pontoon areas
3) Dam Spillway (0.14 ha) – this will include areas that will be utilised to lower the water levels in the lake during construction.

DPI (2014) requires a 2:1 offset for Type 1 to Type 3 KFHs to redress both the direct and indirect impacts of development, based on a calculation of impacted area. Following consultation with DPI Fisheries is has been agreed that the offset approach will focus on local / catchment level initiatives and re-stocking. The offset strategy shall be developed in consultation with the DPI Fisheries, and relevant technical staff.

There will be a change to the fringing habitat associated with the operation of the Lake Lyell PHES due to the daily fluctuations as a result of the operation of the project. However the loss of habitat will be located below the FSL and as such is not considered a new impact as this is within the existing operational guidelines for Lake Lyell.



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); MetroMap (2025); DPI (2009)

\\emm.local\xdrive\2022\E221111 - Lake Lyell PHES EIS\GIS\02_Maps_AQ\AQ008_KFHLoss\AQ008_KFHLoss_20250819_01.aprx 19/08/2025

Mapped KFH loss in Lake Lyell as a result of the project

Lake Lyell PHES
Aquatic Ecology Assessment
Figure 35

EMM creating opportunities

11. Summary and recommendations

No listed threatened species were recorded within waterways associated with the Lake Lyell PHES and as such the project does not pose a significant impact to any fauna listed under either the FM Act or EPBC Act.

The platypus has been identified as being of high cultural significance to Australia's First Nation people and local residents. As such the platypus has been discussed in detail within this aquatic assessment and appropriate management strategies and mitigation measures have been proposed.

A total of 10.29 ha of KFH will be lost resulting from construction of the project and must be offset accordingly and in discussion with DPI Fisheries.

To obtain the best environmental outcome for the Lake Diversion an ecologically sensitive concept design should be developed. Design recommendations are provided in Annexure J and draw on recommendations provided in Stuart, et al. (2024).

A Platypus Management Plan (PMP), Flora and Fauna Management Plan (FFMP) and a detailed Construction Environmental Management Plan (CEMP) must be prepared at a minimum prior to commencing the project. All management plans must incorporate the recommendations outlined in section 8. Preparation of the management plans and implementation of mitigation measures will ensure that impacts to the aquatic ecosystems within and associated with Lake Lyell will be protected during the construction phase of the project.

The PMP will include long term monitoring of the local platypus population and will provide adaptive management strategies, such as translocation, that may be implemented should a decrease in platypus condition be observed as a response to the construction or operation of the Lake Lyell PHES.

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Annexure A - Database search summary

Table 59: BioNet database search results (Hawkesbury-Nepean catchment).

	Vernacular	Species	# Records
Fish			
Native			
Anguillidae	Shortfin eel	*Anguilla australis*	26
Anguillidae	Longfin eel	*Anguilla reinhardtii*	45
Galaxiidae	Common galaxias	*Galaxias maculatus*	2
Galaxiidae	Mountain galaxias	*Galaxias olidus*	6
Percichthyidae	Macquarie perch	*Macquaria australasica*	6
Percichthyidae	Australian bass	*Macquaria novemaculeata*	28
Eleotridae	Striped Gudgeon	*Gobiomorphus australis*	2
Eleotridae	Cox's gudgeon	*Gobiomorphus coxii*	21
Eleotridae	Firetail Gudgeon	*Hypseleotris galii*	2
Eleotridae	Flathead gudgeon	*Philypnodon grandiceps*	14
Exotic			
Cyprinidae	Common Carp	*Cyprinus carpio*	53
Poeciliidae	*Eastern Gambusia	*Gambusia holbrooki*	89
Crustacean			
Parastacidae	Common Yabby	*Cherax destructor*	15
Mammal			
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	648

Table 60: PMST database search results (50 km buffer)

Family	Common name	Scientific name	Conservation status: EBPC Act	Potential distribution
Habitats				
-	The Coorong, Lakes Alexandrina and Albert Wetland	Ramsar site number 25	Wetlands of International Importance	900 to 1,000 km upstream from Ramsar site
-	Banrock Station Wetland Complex	Ramsar site number 63	Wetlands of International Importance	800 to 900 km upstream from Ramsar site

Family	Common name	Scientific name	Conservation status: EBPC Act	Potential distribution
-	The Macquarie Marshes	Ramsar site number 28	Wetlands of International Importance	300 to 400 km upstream from Ramsar site
-	Riverland	Ramsar site number 29	Wetlands of International Importance	700 to 800 km upstream from Ramsar site
-	Hattah-Kulkyne Lakes	Ramsar site number 16	Wetlands of International Importance	600 to 700km upstream from Ramsar site
Fish				
Percichthyidae	Trout cod	*Maccullochella macquariensis*	E	Species or species habitat may occur within area
Percichthyidae	Murray cod	*Maccullochella peelii*	V	Species or species habitat may occur within area
Percichthyidae	Macquarie perch	*Macquaria australasica*	E	Species or species habitat known to occur within area
Retropinnidae	Australian Grayling	*Prototroctes maraena*	V	Species or species habitat likely to occur within area
Terapontidae	Silver perch	*Bidyanus bidyanus*	CE	Species or species habitat may occur within area

Annexure B - Literature review summary

Table 61: Literature review results (aquatic ecology – Hawkesbury-Nepean catchment).

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(NSW Government, 2010b)	State of the Catchments 2010: Hawkesbury-Nepean Region – Overview report	Gives an overview of the conditions of various ecological components with the Hawkesbury-Nepean Catchment.	Impact of invasive species is fair. Impacts listed are: rapid development in coastal urban and peri-urban areas, mining impacts, ongoing land-use and land management, invasive species, water extraction, climate change, social and economic pressures.	In good condition.	-	Insufficient data.	-	-

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(NSW Government, 2010c)	State of the Catchments 2010: Hawkesbury-Nepean Region – Riverine ecosystems	Riverine ecosystem condition has been assessed using water quality, macro-invertebrate, fish and hydrology indicators.	Pest fish species, alteration of natural temperature patterns, artificial barriers to fish passage, agricultural and urban development, Loss of native vegetation, introduction of pest species, water management, climate change.	-	Macroinvertebrate condition for the Lithgow area catchment ranged from moderate –good.	Fish condition was poor. Nativeness was moderate.	-	-
(NSW Government, 2010a)	State of the catchments 2010: Hawkesbury-Nepean region - Wetlands	Overall, wetlands in the Hawkesbury-Nepean region are in very poor condition.	Catchment, hydrogeological and habitat disturbance caused by land-use and vegetation clearing, feral animals and recreational facilities in both wetlands and fringing zones. Pressure is typically high.	-	-	-	-	-

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(P and J Smith Ecological Consultants, 1996)	Regionally Significant Wetlands of the Hawkesbury-Nepean Catchment for Sydney Regional Environmental Plan 20	Seven types of upland wetlands occur in the SREP 20 area: Blue Mountains Sedge Swamps (929 ha), Upper Nepean Swamps (240 ha), Mellong Swamps (81 ha), Coxs River Swamps (40 ha), Hornsby Plateau Swamps (39 ha), Upland Lagoons (22 ha) and Kurrajong Fault Swamps (9 ha).	-	A total of 476 native plant species and subspecies have been recorded from wetlands in the SREP 20 area, of which 381 have been recorded in upland wetlands, 112 in floodplain wetlands and 41 in estuarine wetlands.	-	-	-	Coxs River Swamps are filled with clayey, organic sediments derived from the Illawarra Coal Measures, they occur where creeks draining the Triassic sandstone plateau dump their sediment load at the base of the escarpment.

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Recher, et al., 1993)	The biota of the Hawkesbury-Nepean catchment: reconstruction and restoration	Historical overview of land use in the catchment.	Clearing for agriculture, fragmentation for agriculture, changed fire regimes, naturalisation of exotic plants and animals as well as disease.	Ribbon weed, Water hyacinth (*Eichornia crassipes*).	*Potamopyrgus artipalum* and *Physa acuta*, Spiny crayfish.	Australian bass, Freshwater herring (*Potamalosa richmondia*) Long- and Short-finned eels., Bullrout (*Notesthes robusta*), Carp, Goldfish and Mosquito fish and Trout.	Murray cod	Geologically the catchment is dominated by Permian sandstones, shales and coal measures overlain by Triassic sediments. There are minor igneous intrusions through the sediments. The oldest of the Triassic sediments is the Narra- been Group comprised of conglomerates, lithic and quartz sandstone, and shales that outcrop below the more extensive and dominating Hawkesbury Sandstones.

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Judge, 2013)	Fauna of the Upper Coxs River catchment: An assessment of common freshwater species in a high-demand landscape.	Semi-aquatic animals were more prevalent at Marrangaroo Creek than along the more degraded main freshwater system of the Upper Coxs River catchment.	macro-invertebrate community assemblage, riparian habitat quality, and negative shifts in water chemistry parameters	Lake Lyell supports sparse riparian habitat, some native, mostly introduced.	SIGNAL2 scores low.	the Platypus (*Ornithorhynchus anatinus*), the native Eastern water rat (*Hydromys chrysogaster*)	-	Lake Lyell high in salinity and nitrogen. Salinity was outside the ANZECC trigger values. Nitrogen was higher in Lake Lyell than any other site.

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Department of Primary Industries , 2006)	Reducing the impact of road crossings on aquatic habitat in coastal waterways – Hawkesbury-Nepean, NSW	Describes aquatic habitat and fauna in the Hawkesbury – Nepean region.	Habitat degradation competition, and predation from introduced fish species.	Swamp oak (*Casuarina glauca*), Common reed (*Phragmites australis*), Paperbark (*Melaleuca quinquenervia*), River oak (*Casuarina cunninghamiana*), Water gum (*Tristania laurina*).	insects, prawns, crayfish and freshwater mussels. The macroinvertebrate communities of the Hawkesbury-Nepean catchment are moderately to significantly impaired. Both the threatened Adams emerald dragonfly1 (*Archaeophya adamsi*) and Sydney Hawk dragonfly2 (*Austrocordulia leonardi*) have an expected distribution within the Hawkesbury-Nepean catchment, with records indicating their presence in the lower subregion of the catchment.	Over 50 species of finfish.	Macquarie perch, Australian grayling, Silver perch, Murray cod, Trout cod.	-

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Birch & Siaka, 2001)	The Source of Anthropogenic Heavy Metals in Fluvial Sediments of a Rural Catchment: Coxs River, Australia	Provides a description of the accumulation of metals in sediments in the Upper Coxs catchment.	Mining, power production, sewage treatment.	-	-	-	-	Heavy metal concentrations in sediments in the Upper Coxs catchment are high. Sources of heavy metals are coal related, urban and power station related. Farmers Creek has particularly high concentrations.

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Hawkesbury-Nepean Catchment Management Authority, 2009)	Hawkesbury-Nepean Catchment Management Authority Annual Report 2008/09	Over 50% of the Blue Mountains Western Landscape is protected in reserves. The Coxs River flows into Sydney's water supply at Lake Burragorang.	Clearing of vegetation, exotic weed species, pest animal species, public access to rivers, loss of instream habitat.	Broom controlled along Farmers Creek and Lithgow. 56.1 km of riverbank rehabilitated (a total area of 489 ha) 50 km of fencing was undertaken to protect river and creek banks and a total of 35 off-river stock watering points were installed. 11.4 km of river and creek banks were revegetated with 22,990 native plants.	-	-	-	-

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Young, et al., 2000)	Assessments of river condition under the current flow regime and proposed flow regimes in the lower Coxs River, New South Wales	During 1999 and 2000 the New South Wales Department of Land and Water Conservation (DLWC), Delta Electricity, and a community representative worked cooperatively to devise a regulated flow regime that would lead to improved environmental conditions in the Coxs River	In addition to widespread grazing, forestry and coal mining now occur in the upper catchment. Alterations to hydrology. Fire. Erosion	The riparian zone of the lower Coxs River has a tree layer dominated by river oak (*Casuarina cunninghamiana*) near the water's edge. Willows – mainly *Salix fragilis* – have invaded the channel and riparian zone, forming dense stands in some places.	Macro-invertebrate fauna was diverse but lacked some of the pollution sensitive, and flow-obligate species that would be expected to occur under natural conditions.	Flathead gudgeon, Longfin eel, Brown trout and Rainbow trout. Eastern gambusia, Mountain galaxias. Previous anecdotal reports include Australian bass, Macquarie perch and Mullet.	Macquarie perch	Faecal coliforms exceeded the 150 organisms/100 m l limit recommended for primary contact recreation. Particularly high phosphorous concentrations were recorded below Farmers Creek and were assumed to be due to inputs from the Lithgow sewage treatment plant.
(GHD, 2016)	Springvale Water treatment Project: State Significant Development 7592. Environmental Impact Statement. Volume 2 - Appendix H1 - Aquatic Ecology	Aquatic Ecology EIS for the Springvale Coal/Energy Australia Water Treatment Project.	Introduced fish species.	Generally poor riparian vegetation condition.	Macroinvertebrate communities in relatively good condition.	Moderate to good instream habitat	-	EC elevated.

(Cardno, 2014a)	Aquatic Ecology and Stygofauna Assessment: Springvale Mine Extension Project	It is clear that although the upper Coxs River is degraded it supports a relatively diverse aquatic biota	-	A number of aquatic flora were recorded within the Coxs River.	On the Coxs River, above Lake Wallace, macroinvertebrate fauna was diverse. 62 taxa recorded with total numbers per site ranging from 34 to 47 taxa. The fauna consisted of insects, crustaceans, worms, molluscs, springtails, freshwater mites and leeches. The fauna was either equivalent to or significantly impaired relative to the AUSRIVAS reference condition.	Two native fish species, Flathead Gudgeon and Mountain Galaxias, and three introduced species, Eastern Gambusia, Goldfish and Brown Trout	Discussion of barriers inhibiting the movement of threatened fish species up the Coxs River.	Samples from the swamp boreholes contained four likely stygofauna taxa (cyclopoid copepods, harpacticoid copepods, copepod nauplii and bathynellid syncarids) and three possible stygofauna taxa (Rotifera, Tardigrada and phreatoicid isopods). The boreholes at Sunnyside East Swamp yielded the greatest number of likely and possible stygofauna taxa, but also yielded more water than the other swamp boreholes. One likely (Cyclopoid copepod) and two possible stygofauna taxa (Acarina and Rotifera) were found in the boreholes that targeted the

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
								shallow unconfined aquifer.
(Department of Environment, Climate Change and Water, 2010a)	2010 Audit of the Sydney Drinking Water Catchment: Volume 1 - Main report	Audit of Sydney's drinking catchment. Assessment of aquatic ecological health.	Erosion, pollutants. Removal of riparian vegetation.	-	Macroinvertebrate fauna assemblages dominated by pollution tolerant taxa such as worms or chironomids. Particularly evident in the Coxs River, Lake Lyell and Farmers Creek.	15 native species and 7 exotic species.	Macquarie perch.	Heavy metals and salinity an issue in the Upper Coxs River Catchment. Elevated nutrients in Farmers Creek.

Reference	Report title	General	Impacts	Aquatic flora and riparian vegetation	Aquatic invertebrates	Aquatic vertebrates (non-threatened)	Threatened species^	Aquifer geology and water quality
(Cardno, 2014b)	Airly Mine Extension Project: Aquatic Ecology and Stygofauna Assessment	Detailed environmental assessments were conducted for the Airly mine extension. Included Airly, Torbane, Dog Trap, Gap, Grotto and Genowlan creeks.	Vegetation clearing, soil stripping and stockpiling; erosion runoff and sediment works; discharge of sediment laden water; construction of additional dams; erosion caused be vehicular movement.	Blackberry and Willow present within the Lithgow LGA. Riparian vegetation consisted of *Allocasuarina* spp., *Lomandra* spp. Instream – *Typha* sp., *Phragmites* sp, *Ranunculus inundates*.	Adam's emerald dragonfly (*Archaeophya adamsi*) and Sydney hawk dragonfly (*Austrocordulia leonardil*) both listed as endangered under the FM Act recorded in the Hawkesbury-Nepean catchment. Signal scores varied between creeks for macro-invertebrates.	Eastern gambusia, Mountain galaxias, Cox's gudgeon, Longfin and shortfin eel, Australian smelt.	Platypus and Water Rat present within the Lithgow LGA. Protected under the NP&W Act. Australian grayling, Murray cod, Trout cod, Silver perch, Macquarie perch all assessed as part of the Project but considered unlikely to occur.	Stygofauna not detected however sampling was severely restricted. Precautionary principle applied and stygofauna assumed to be present.

Annexure C – Likelihood of occurrence

Table 62: Likelihood of occurrence assessment for the project

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence
			DPI	BioNet	PMST	Lit.	EPBC Act/FM Act		
-	The Coorong, Lakes Alexandrina and Albert Wetland - 25	-	-	-	✓	-	Wetland of International Importance	Negligible	PMST: 900 to 1,000 km upstream of the Ramsar site. In buffer area only.
-	Banrock Station Wetland Complex - 63	-	-	-	✓	-	Wetland of International Importance	Negligible	PMST: 800 to 900km upstream from Ramsar site. In buffer area only.
	The Macquarie Marshes - 28	-	-	-	✓	-	Wetland of International Importance	Negligible	300 to 400 km upstream from Ramsar site. In buffer area only.
	Riverland - 29	-	-	-	✓	-	Wetland of International Importance	Negligible	700 to 800 km upstream from Ramsar site. In buffer area only.
-	Hattah-Kulkyne Lakes - 16	-	-	-	✓	-	Wetland of International Importance	Negligible	600 to 700 km upstream from Ramsar site. In buffer area only.

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence
			DPI	BioNet	PMST	Lit.	EPBC Act/FM Act		
Percichthyidae	Trout cod	*Maccullochella macquariensis*	-	-	✓	✓	E/E	Negligible	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur in the Macquarie River, approximately 130 km NW of Lake Lyell; the species is also predicted to occur in the Murrumbidgee River in the south of the state. BioNet: No records in the Hawkesbury-Nepean catchment. PMST: May occur.
Percichthyidae	Murray cod	*Maccullochella peelii*	-	-	✓	✓	V/-	Negligible	DPI Fisheries: N/A BioNet: N/A PMST: May occur. Literature: Murray cod may occur in the broader catchment.

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence
			DPI	BioNet	PMST	Lit.	EPBC Act/FM Act		
Eleotridae	Macquarie perch	*Macquaria australasica*	-	✓	✓	✓	E/E	Low	DPI Fisheries: Predicted distribution indicates that the species has the potential to occur within the Lower Coxs River. More closely associated with waterways in the Blue Mountains National Park. BioNet: Two records occur east of the Blue Mountains National Park circa 2007-2012 in the vicinity of Kurrajong and Blaxland. PMST: Known to occur. Literature: The species is reported as having been recorded in the broader catchment.
Retropinnidae	Australian Grayling	*Prototroctes maraena*	-	-	✓	✓	V/E	Negligible	DPI Fisheries: Predicted distribution indicates that the nearest location that Australian grayling is likely to occur is Shoalhaven River northwest of Nowra. Approximately 150 km SSE of Lake Lyell. BioNet: No records occur within the Hawkesbury-Nepean catchment. PMST: Likely to occur.

Family	Common name	Scientific name	Data source				Conservation status	LoO	Rationale for likelihood of occurrence
			DPI	BioNet	PMST	Lit.	EPBC Act/FM Act		
Terapontidae	Silver perch	*Bidyanus bidyanus*	-	-	✓	✓	CE/V		DPI Fisheries: Predicted distribution indicates that the nearest location that Silver perch is predicted to occur is Macquarie River approximately 85 km NW of Lake Lyell; or in the Abercrombie River approximately 83 km SW of Lake Lyell. BioNet: No records occur within the Hawkesbury-Nepean catchment. PMST: May occur.
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	-	✓	-	✓	PL/-	Recorded	DPI Fisheries: n/a BioNet: A number of records occur within Lake Lyell, the Coxs River, Farmers Creek and other waterways and tributaries in the area. Dates of records within Lake Lyell are as recent as 2021. PMST: n/a Literature: Platypus are known within the Hawkesbury-Nepean catchment.

Note: LoO = Likelihood of occurrence; E = Endangered, PL = Department of Climate Change, Energy, the Environment and Water (2000) provisional management list.

Annexure D – Site photographs

Site photographs, November 2023

Site	Upstream	Downstream
CR01		

Site	Upstream	Downstream
CR02		

<table>
<tr><th>Site</th><th>Upstream</th><th>Downstream</th></tr>
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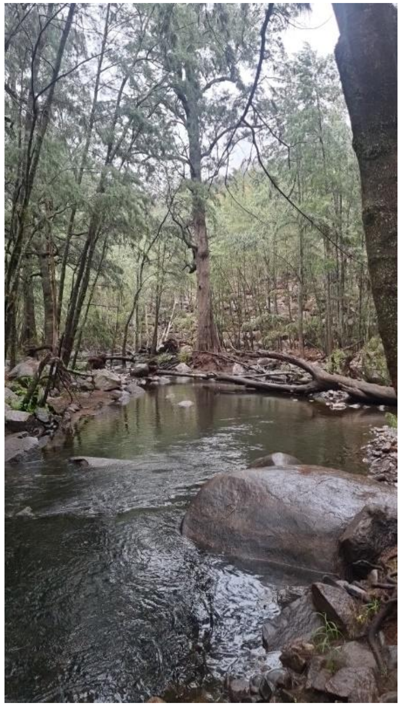
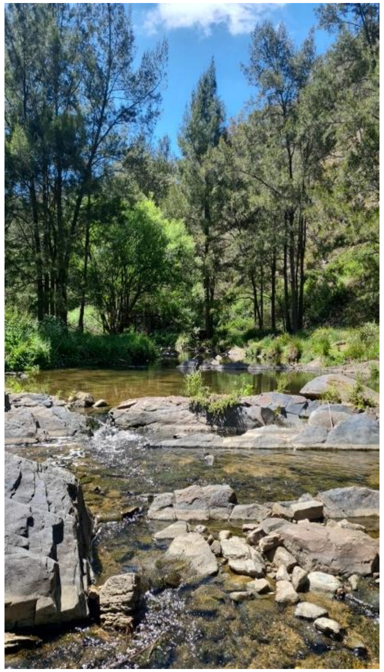
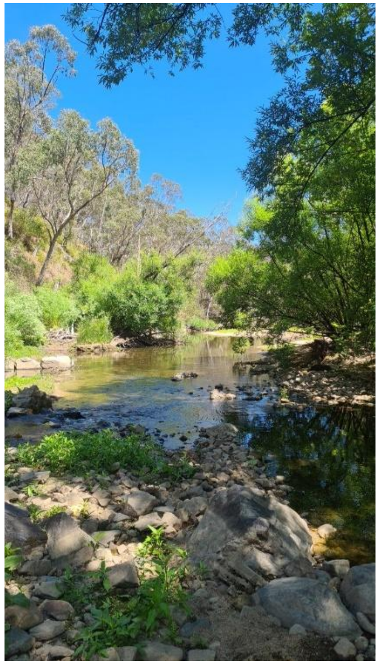
Site	Upstream	Downstream
CR04		

Site	Upstream	Downstream
CR05		

Site	Upstream	Downstream
CSC02		

Site	Upstream	Downstream
FC02		

Site	Upstream	Downstream
FC03		

Site	Upstream	Downstream
LL01	 	

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<tr><th>Site</th><th>Upstream</th><th>Downstream</th></tr>
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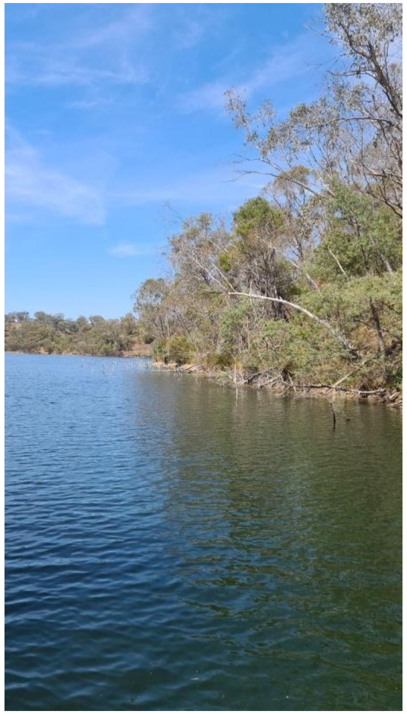
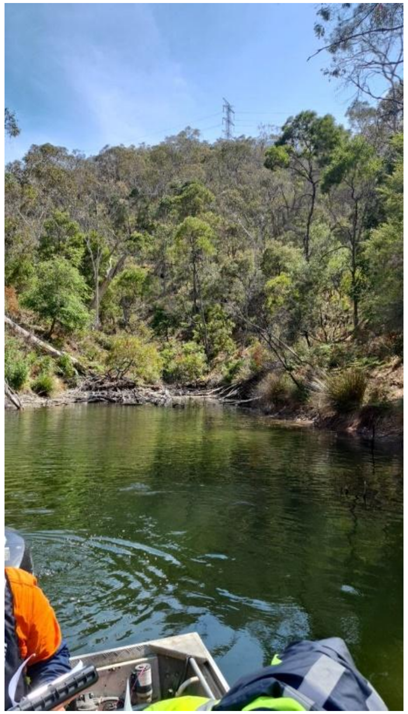
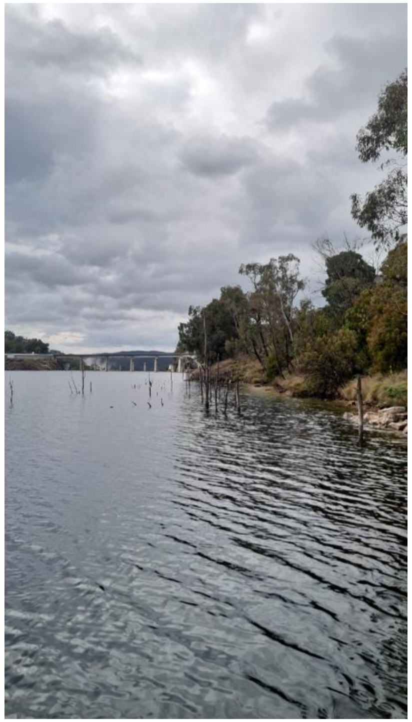
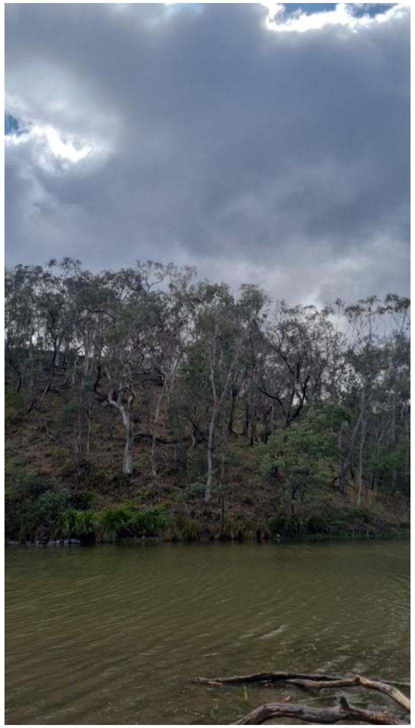
</table>

Site	Upstream	Downstream
LL03		

Site	Upstream	Downstream
LL04		

Site	Upstream	Downstream
LL05		

<table>
<tr><th>Site</th><th>Upstream</th><th>Downstream</th></tr>
<tr><td>LL06</td><td>
</td><td>
</td></tr>
</table>

Annexure E - DPI Fisheries fish habitat assessment proforma

Table 63: Key fish habitat – waterway type assessment

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive KFH		Type 2 – Moderately sensitive KFH		Type 3 – Minimally sensitive KFH	
Posidonia australis (a seagrass)		*Zostera*, *Heterozostera*, *Halophila* and *Ruppia* species of seagrass beds <5m^2 in area		Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	
*Zostera/*Heterozostera/*Halophila/Ruppia* species of seagrass beds >5m^2 in area		Mangroves		Coastal and freshwater habitats not included in TYPES 1 or 2	
Coastal saltmarsh >5m^2 in area		Coastal saltmarsh <5m^2 in area		Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	
Coral communities		Marine macroalgae such as *Ecklonia* and *Sargassum* species		Notes: For the purposes of these policy and guidelines the following are not considered KFH:	
Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially closed or are subject to one off unauthorised openings)		Estuarine and marine rocky reefs		First and second order streams on gaining streams (based on the Strahler method of stream ordering)	
Marine park, an aquatic reserve or intertidal protected area		Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan)		Farm dams on first and second order streams or unmapped gullies	

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive KFH		Type 2 – Moderately sensitive KFH		Type 3 – Minimally sensitive KFH	
SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia		Aquatic habitat within 100 m of marine park, aquatic reserve or intertidal protected area		Agricultural and urban drains	
Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants		Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna		Urban or other artificial ponds (e.g. evaporation basins, aquaculture ponds)	
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act		Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1		Sections of stream that have been concrete-lined or piped (not including a waterway crossing)	
Mound springs		Weir pools and dams up to full supply level where the weir or dam is across a natural waterway		Canal estates	

Table 64: Key fish habitat – waterway class assessment

Classification	Characteristics of waterway class	Present?
Class 1 – major KFH	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.	
Class 2 – moderate KFH	Generally named intermittently flowing stream, creek or waterway with clearly defined bed and banks, semi-permanent to permanent water in pools or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and Type 2 habitats present.	
Class 3 – minimal KFH	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for 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 other Class 1-3 fish habitats.
Class 4 – unlikely KFH	Generally 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 post-rain events (e.g. dry gullies, shallow floodplain depressions with no aquatic flora).

Annexure F - Electrofisher settings

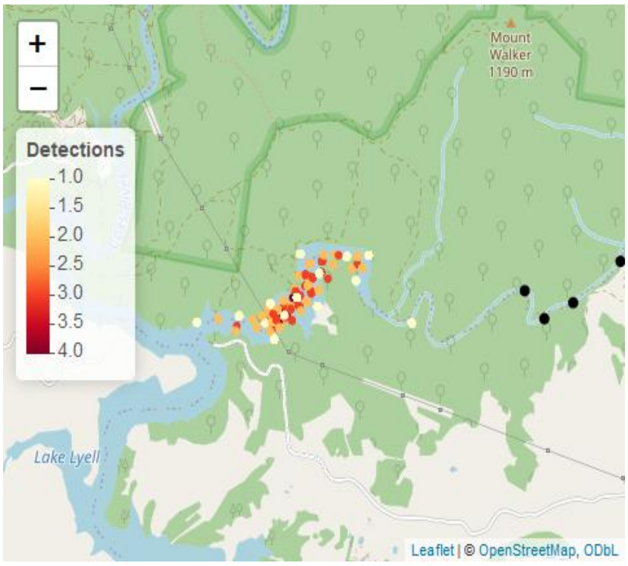
Table 65: Electrofisher settings, November 2023

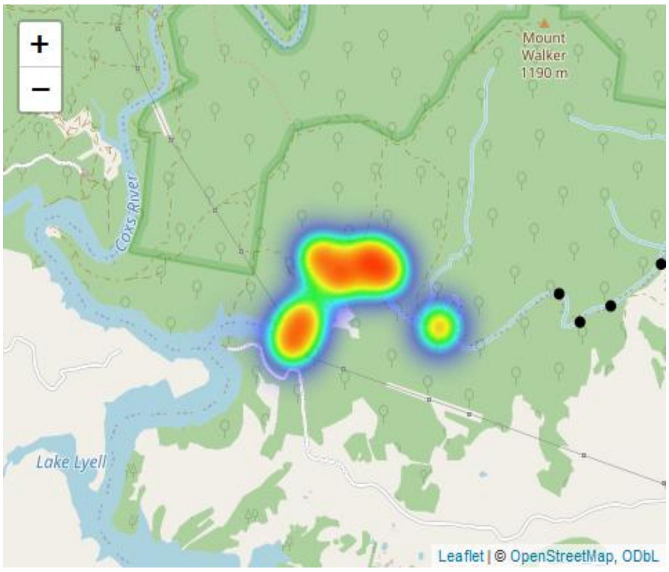
Waterway	Site	Volts	Amps	Frequency (Hz)	Duty cycle (%)	Power set	Impulse set	PPS	Seconds on time
Lake Lyell	LL01	400	5	high	-	1	3	100	1080
	LL02	400	5	low	-	1	3	40	1080
	LL03	400	5	low	-	1	3	40	1080
	LL04	400	5	low	-	1	3	40	1080
	LL05	400	5	low	-	1	3	40	1080
	LL06	400	5	low	-	1	3	40	1080
	CR03	220	-	80	30	-	-	-	1200
	CSC02	400	5	low	-	1	3	40	1080
Coxs River	CR01	180	-	80	30	-	-	-	1200
	CR02	180	-	80	30	-	-	-	1200
	CR04	220	-	80	30	-	-	-	1200
	CR05	220	-	80	30	-	-	-	1200
Farmers Creek	FC02	240	-	80	30	-	-	-	1200
	FC03	240	-	80	30	-	-	-	1200

Annexure G - Platypus tracking data

Triangulated detections of platypus in the water (white-red circles) and burrows (black circles) followed by Heat map of triangulated detections of platypus in the water and burrows (black circles) for each of the thirteen tagged platypus. Platypus P1 to P9 were tracked within the Farmers Creek Arm of Lake Lyell and P10 to P13 were tracked within the Coxs River arm.

P1





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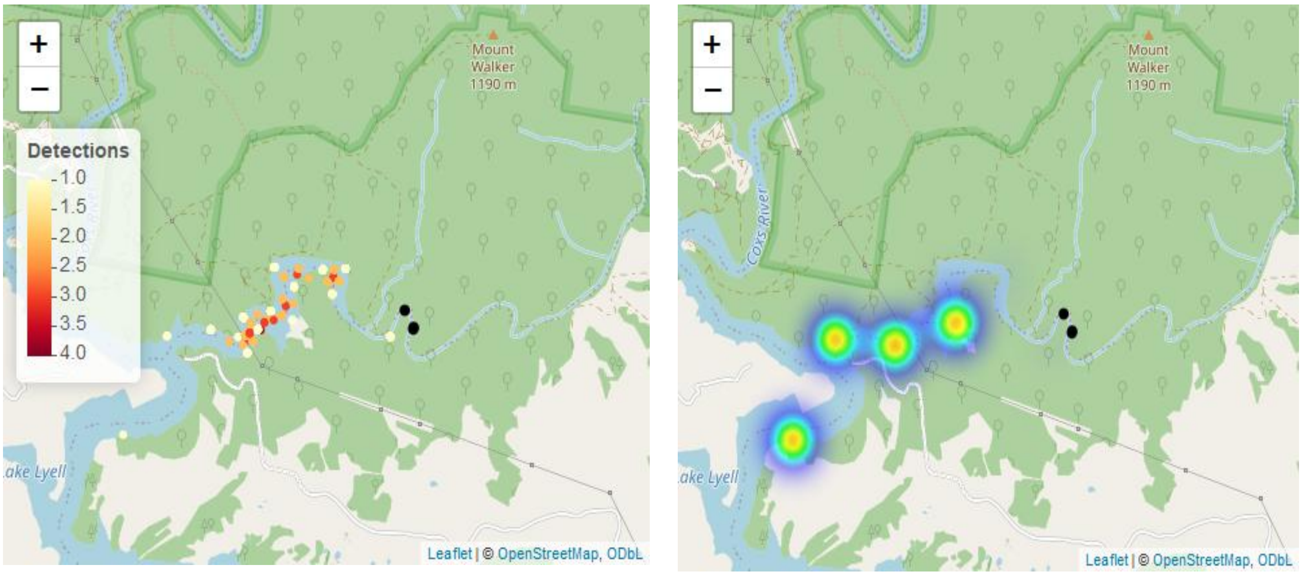
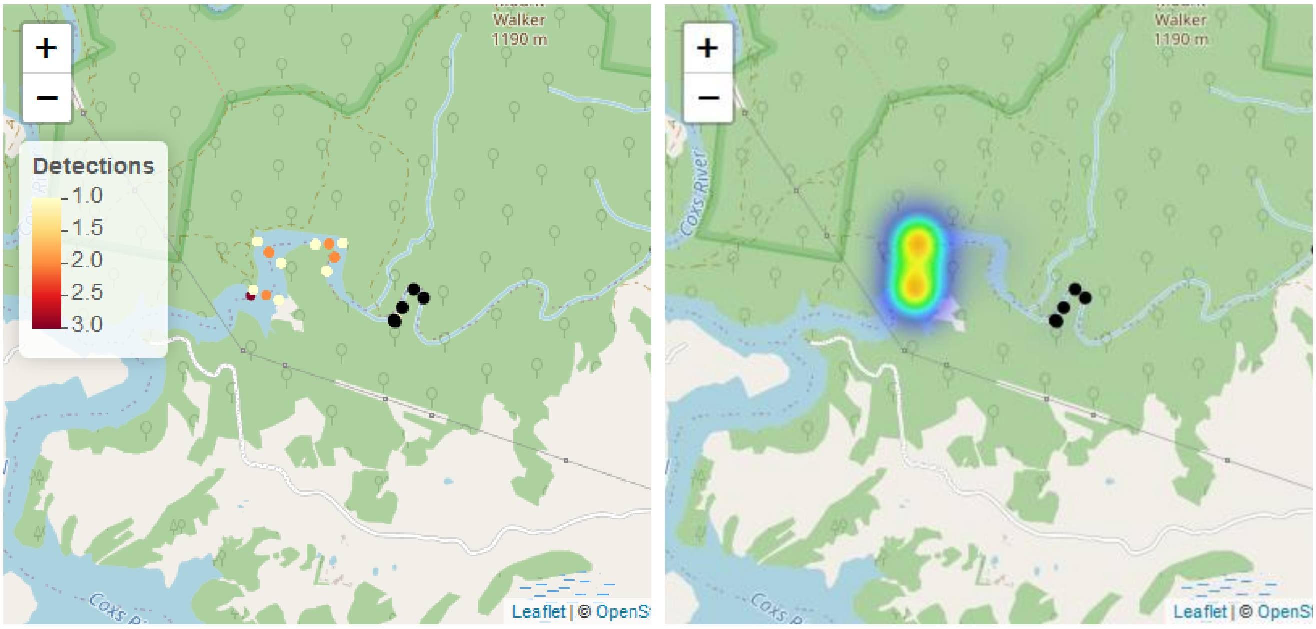
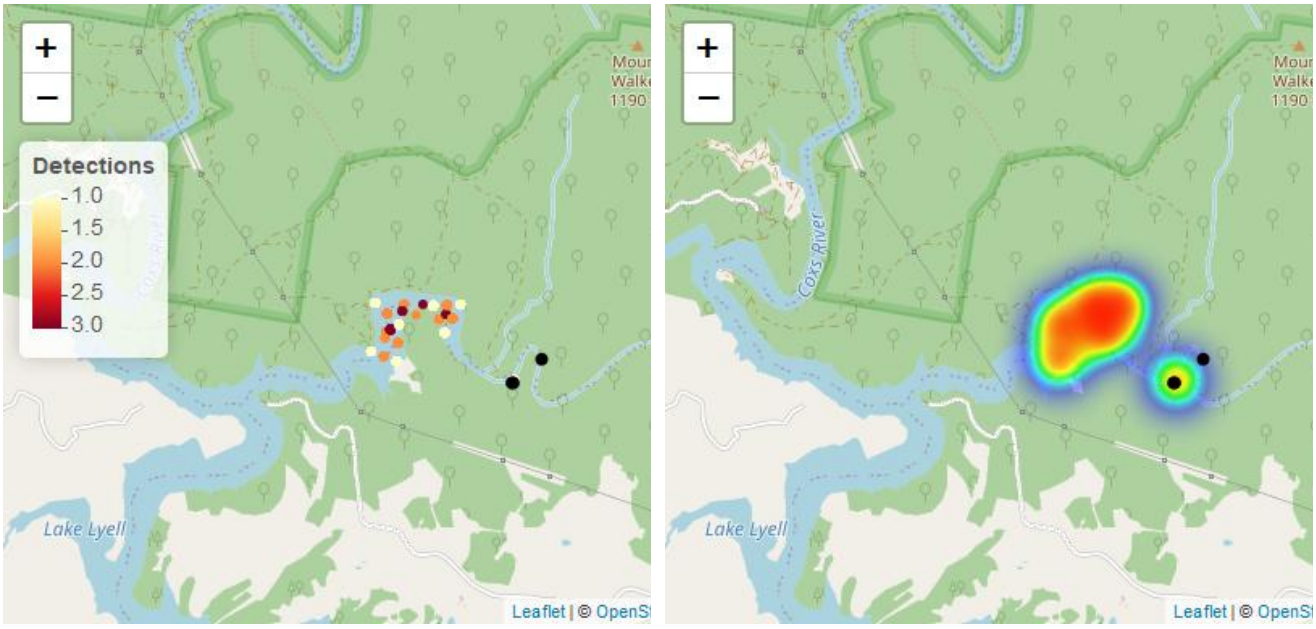

Detections
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Mount
Walker
1190 m
Lake Lyell
Coxs River
Leaflet | © OpenStreetMap, ODbL

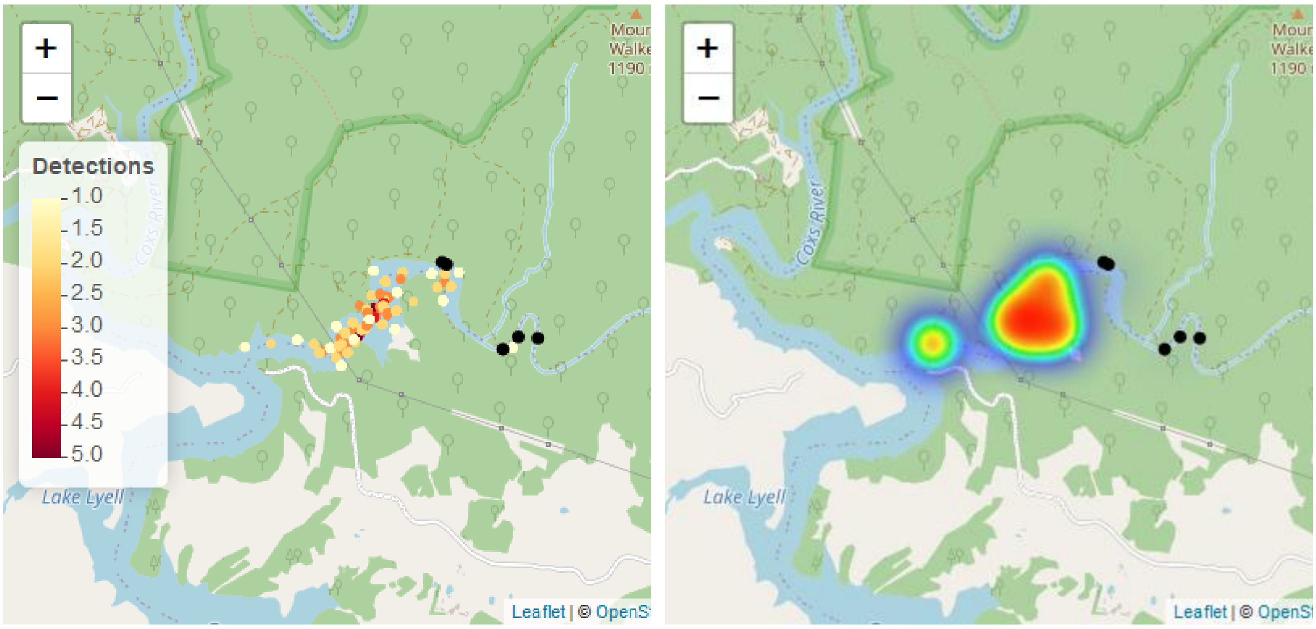
P3


Detections
1.0
1.5
2.0
2.5
3.0
Walker
1190 m
Coxs River
Leaflet | © OpenSt

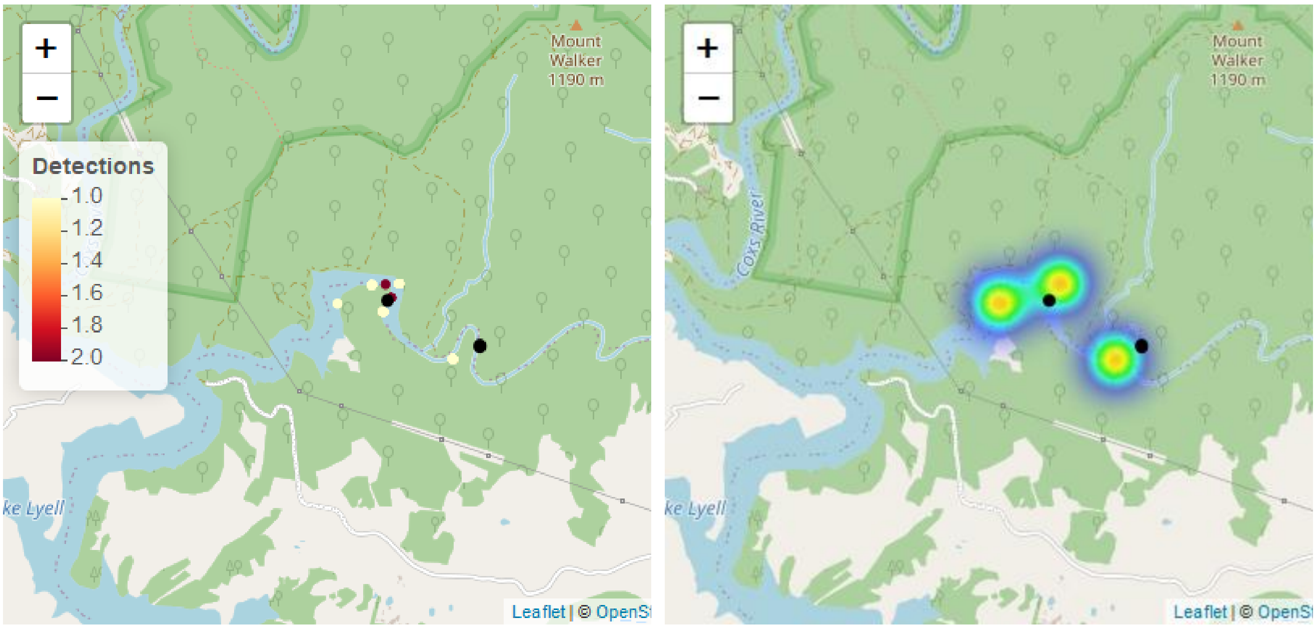
P4


Detections
1.0
1.5
2.0
2.5
3.0
Coxs River
Lake Lyell
Leaflet

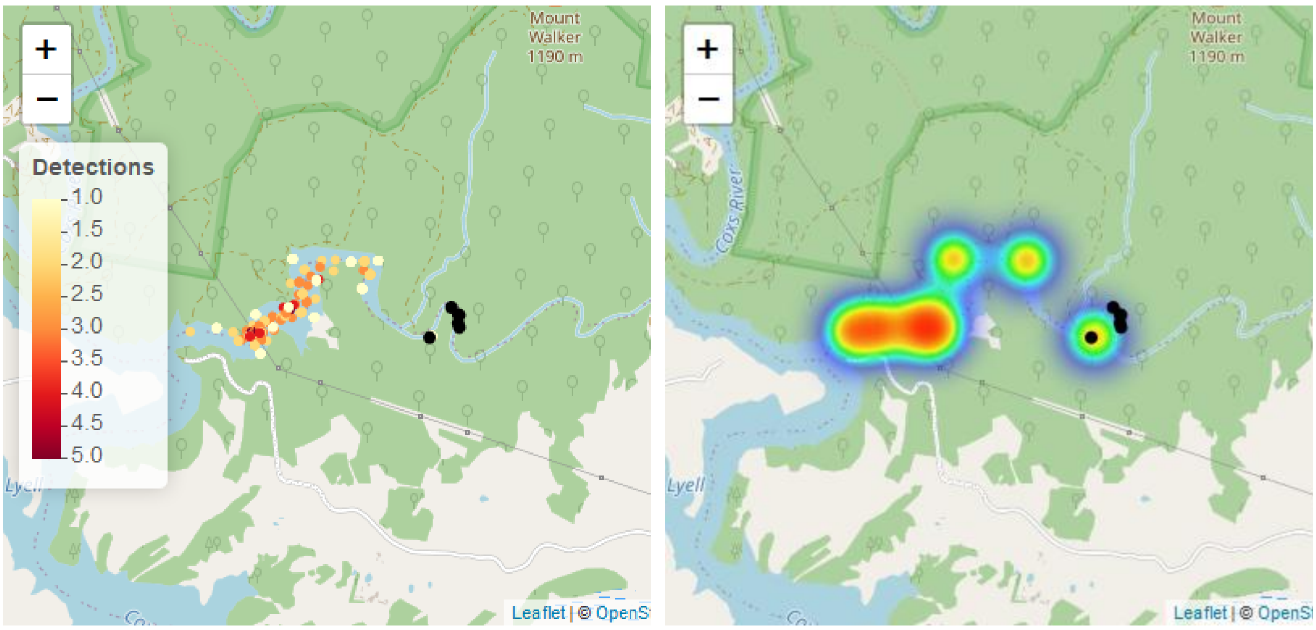
P5


Detections
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Coxs River
Lake Lyell
Leaflet

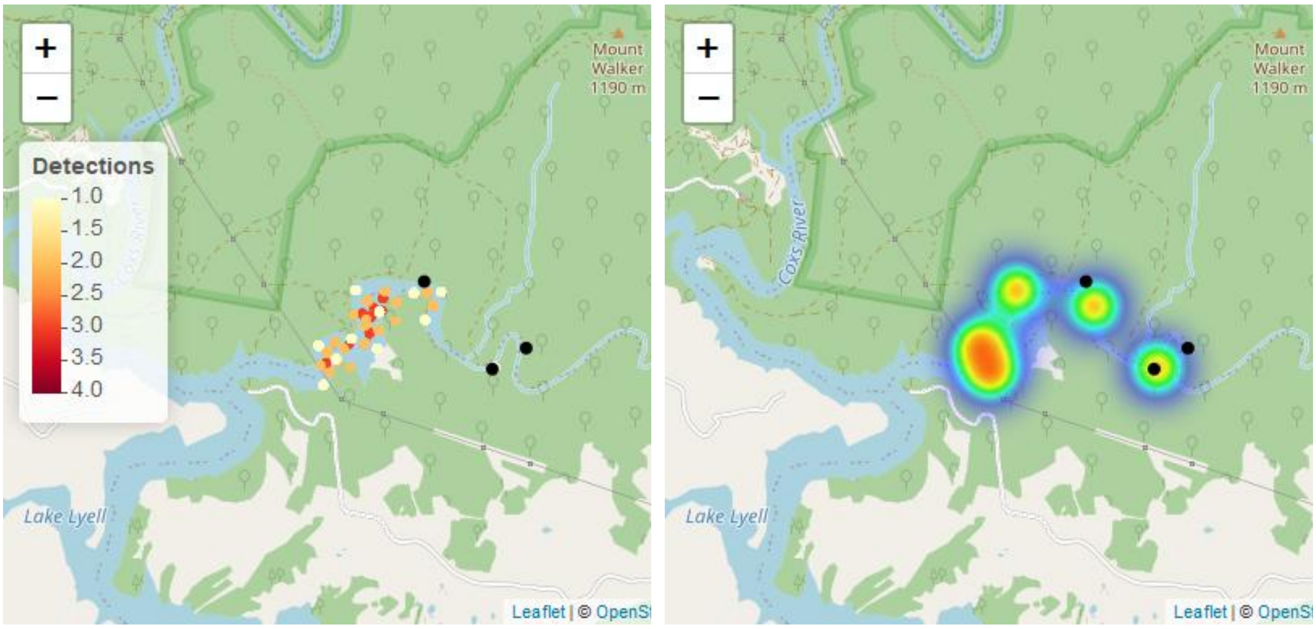
P6


+
−
Detections
1.0
1.2
1.4
1.6
1.8
2.0
Mount
Walker
1190 m
ke Lyell
Coxs River
Leaflet | © OpenS

P7

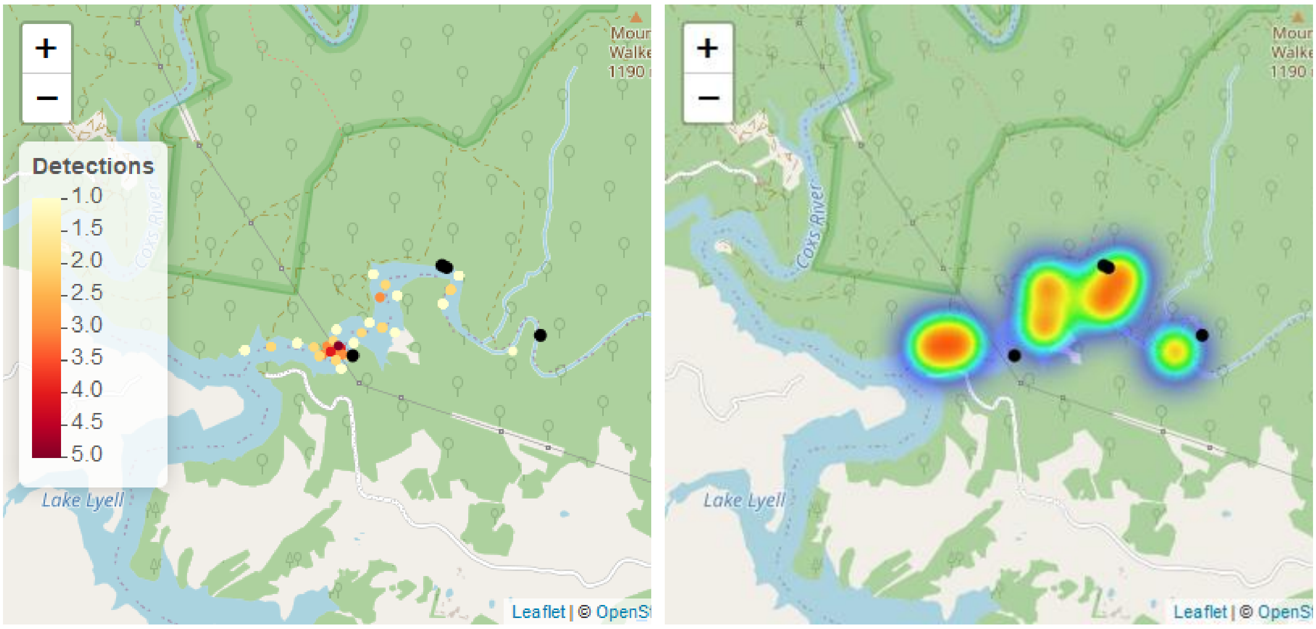

+
−
Detections
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Mount
Walker
1190 m
Lyell
Coxs River
Leaflet | © OpenS

P8



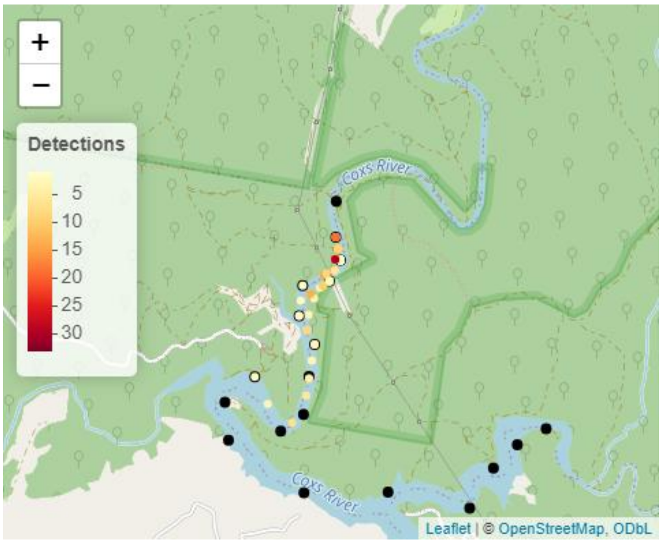
+
−
Mount
Walker
1190 m
Detections
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Coxs River
Lake Lyell
Leaflet | © OpenSt

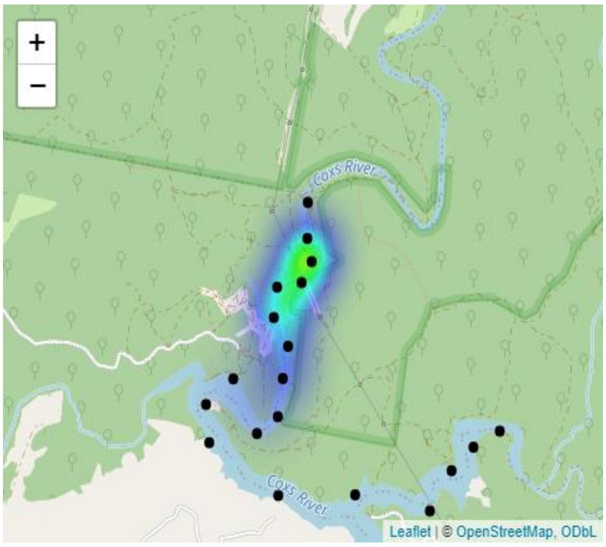
P9



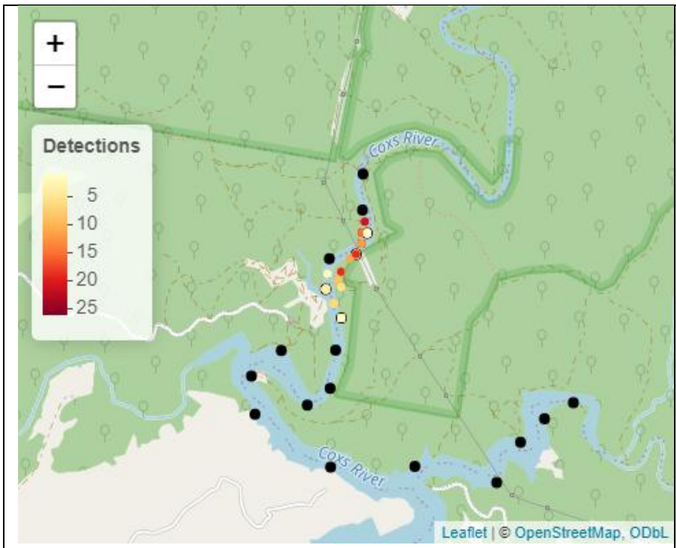
+
−
Detections
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Coxs River
Lake Lyell
Leaflet | © OpenSt

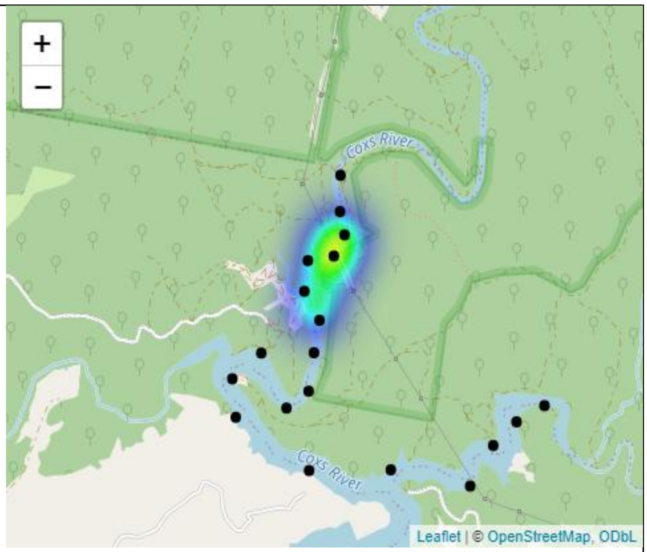
P10


Detections
5
10
15
20
25
30
Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

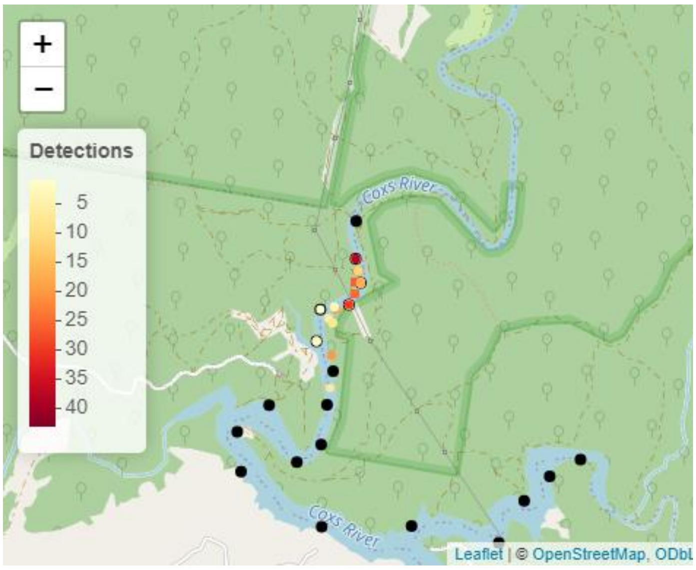

Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

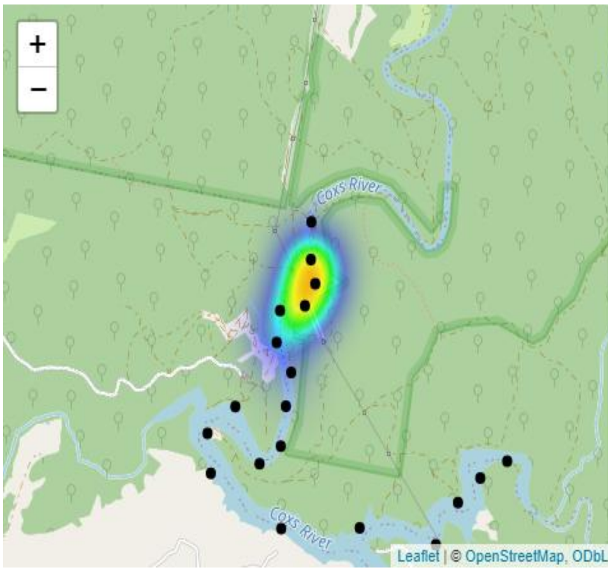
P11


Detections
5
10
15
20
25
Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

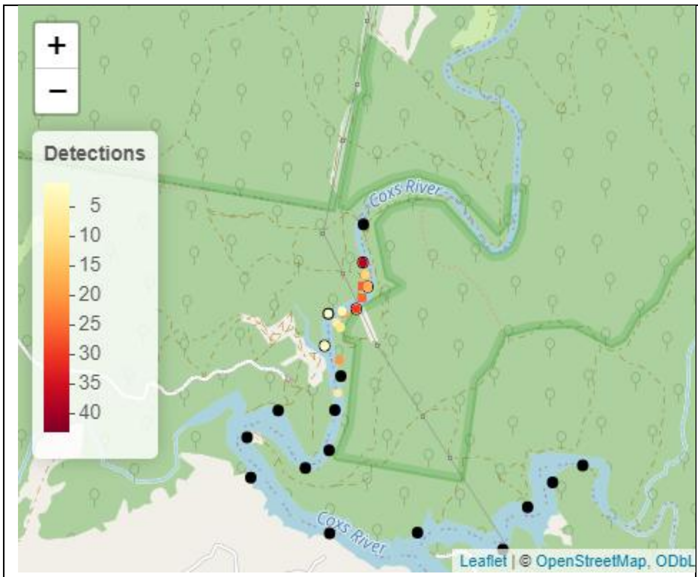

Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

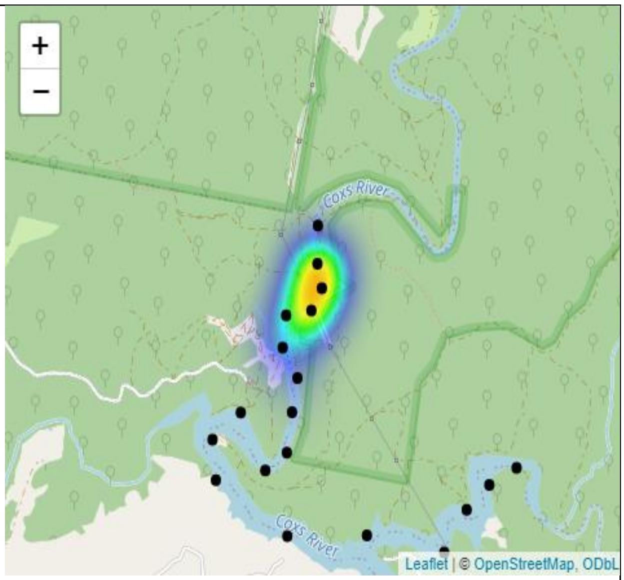
P12


+
−
Detections
5
10
15
20
25
30
35
40
Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL


+
−
Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

P13


+
−
Detections
5
10
15
20
25
30
35
40
Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL


+
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Coxs River
Coxs River
Leaflet | © OpenStreetMap, ODbL

Annexure H – Platypus literature review

The Platypus is highly dependent on riverine systems and other waterbodies feeding exclusively on freshwater macroinvertebrates (Hawke, et al., 2021). Platypus occupy freshwater benthic and lotic systems (Serena, et al., 2001) and opportunistically feed on macroinvertebrates (McLachlan-Troup, et al., 2010). Platypus are known to feed up to 8 to 14 hours, consuming 15 to 30% of their body mass per day (Serena, et al., 2001). Their prey consists of: Nematomorpha, Ostracoda, Decapoda, Ephemeroptera nymphs, Coleoptera, Megaloptera, Trichoptera, Diptera larvae, Hemiptera, Bivalve Mollusca and in one case, Anura (Gagher, et al., 1979). However, the main three macroinvertebrate species that are commonly seen to be dominant in the platypus' diet are Ephemeroptera, Diptera and Odonata (Gagher, et al., 1979).

There is a need for further research into these macroinvertebrate populations with particular emphasis on current environmental contexts such as water fluctuations and quality. The focus of research to date has investigated macroinvertebrates as bioindicators of determining water quality. Extensive research has also investigated the habitat conditions of macroinvertebrates and the species used as prey by Platypus. An emerging body of research has referred to the relationship between macroinvertebrate communities and fluctuating water level impacts. However, there is little known research into this notion.

Water level fluctuations impact water temperatures which in turn influence macroinvertebrate communities (Hofmann, et al., 2008). Dewson et al, (2007) supported this premise in their determination of a - 0.2 % drop in water temperature at one of their sites after flow reduction. Bonacina et al, (2023) confirmed that water temperatures influence macroinvertebrate life cycles. This is further substantiated by Miller et al (2007) who stated that water temperature induced species turnover after fluctuations occurred. Many authors such as Miller et al, (2007), Yan et al, (2021), Bonacina et al, (2023) all agree that there is a seasonal temperature factor to the macroinvertebrate life cycle separate from temperature changes generated by water level fluctuations. Contrary to general census, Martínez et al (2013) rejected the idea that minimal water temperature fluctuations in accordance with physiochemical properties influence macroinvertebrate assemblages. However, Martínez et al (2013) did not further elaborate and further investigation is required.

Researchers have found that thermal continuity can be disrupted through these changes (Kokavec, et al., 2017; Miller, et al., 2007). Sweeney et al, (1986) concluded the optimal temperature for quickest development of Plecoptera was at 10°C, however, had the capacity to maintain development at 5°C and 15°C. Storey (1986) concluded that Diptera had similar characteristics to Plecoptera, however, Diptera had a shorter larval stage when it reached 14°C. Early research by Ward and Stanford (1982) has noted a variation of thermal ranges amongst macroinvertebrates because of short mobility ranges, though further research into the direct impacts of water fluctuations in relation to water temperature is required.

Water fluctuations are known to impact sediment and nutrient quality (White, et al., 2008). A study by Hofmann, et al., (2008) highlights how surface waves of a lake have the capacity to resuspend organic particles to the point where they create shading and reduce light income by 2 to 3% at a depth of 1 m. The consequence of this was a reduction in food resources as more energy was devoted into removal of particles than food consumption (Jones, et al., 2012). Valdovinos et al., (2007) research findings concluded that increased particle release was a result of erosion caused by water level fluctuations. It is also important to note that macroinvertebrates in areas of low productivity are likely to be more sensitive to flow regimes and increased sedimentation (Hardie & Bobbi, 2018). However, this is controversial as Miller et al., (2007) found that high to moderate flows had little impact on organisms, organic or sediment transport downstream over the top of irrigation diversions. Burdon, et al., (2013) posed another theory which was that a relationship between the %age of Ephemeroptera, Plecoptera and Trichoptera (EPT) and sediment. The threshold for % EPT of sediment covering is around 20 % of < 2mm inorganic sediment (Burdon, et al., 2013).

Macroinvertebrate taxa have varying responses to water level fluctuations (Yan, et al., 2021). This theory dates back to 1991 where Brooks and Boulton (1991) revealed that two days post disturbance, large stoneflies, mayfly nymphs and amphipods returned to pre-disturbance levels. McEwen and Butler (2010) also saw this trend in amphipods. Further, Brooks and Boulton (1991) revealed that after five days of disturbance, five taxa (small oligochaete, chironomid hatchlings, afrochiltonia australis, nematodes, and *Bezzia* spp.) numbers increased ($p < 0.001$). This case was seen in a study completed by Kokavec et al., (2017) on the downstream effects of hydropower storage pumps. They noted that both mayfly and caddisfly species richness increased further downstream; but the density decreased alongside an inclining productivity trend. In one downstream location, the macrozoobenthos species *Rhithrogena semicolorata* contributed to 42.9 % of production compared to another site where its contribution was 10.7% (Kokavec, et al., 2017).

Yan et al., (2021) found that water fluctuations resulted in high species turnovers, favouring species that were more adaptable. This was documented when water fluctuation ranges exceeded 0.13 m and an increase in temporal dissimilarities amongst communities occurred ($P = 0.04$). Yan et al., (2021) highlighted how a decreased homogenization of community composition occurred at the same time as the temporal dissimilarity increased because of water fluctuations. Shrestha et al., (2021) relate to this theory as Ephemeroptera and Trichoptera richness decreased when water levels were low and Coleoptera and Diptera increased (5.0 to 96.9 cm over 12-month period in a wetland).

Another avenue of investigation included the relationship between water depth and macroinvertebrate assemblages. McEwen and Butler (2010) found that there was a relationship between water depth and macroinvertebrate assemblages (f = 1.678, P = 0.012), particularly at one and two metres deep. The authors proposed that this explained why impacts at 2 m depth were seen where small organisms increased to larger ones (McEwen & Butler, 2010). A further argument that arose from this was that macroinvertebrates within this niche are more at risk to gradient exposure from fluctuations. From here, there may be a decline in non-insect invertebrates as they are less mobile (McEwen & Butler, 2010).

After reviewing the literature, one conclusion can be drawn; That water fluctuations do impact the platypus diet. Some impacts of a 2 m water level fluctuation that may occur is:

- potential exposure of macroinvertebrates occupying a 0.2 to 0.5 m depth may lead to mortality
- temperature changes from reintroduction of water may disrupt the delicate life cycle of macroinvertebrates
- reintroducing water after abstraction could see an increase in mayflies, stoneflies and amphipods which will provide a steady food source for Platypus
- water extraction could disrupt sedimentation and may cause resuspension of particles for a few days that could inhibit food production for macroinvertebrates, potentially impacting abundance
- if the water fluctuations continue long term, there may become a decrease in various taxa
- taxa that struggle to adapt rapidly are more likely to decrease, such as non-insect taxa that are slow moving.

Overall, it is appropriate to assume that a one-off water fluctuation that is of low magnitude may cause some disruptions but won’t fully impact the platypus diet. However continuous, infrequent, or frequent fluctuations will have negative impacts on the benthic macroinvertebrate communities and could disrupt the Platypus’ diet however there is potential for more tolerant species to inhabit the niche left by less tolerant species. Further research is required into understanding how long-term impacts may influence a bottom-up trophic effect on the platypus’ diet, how the three main taxa of the Platypus diet are directly impacted by the water fluctuations and how water fluctuations influence the water temperature.

Annexure I – Bore water quality data

Table 66: Bore water quality from stygofauna survey 1 (03/05/2024)

Survey number	Bore ID	date	Time	Sample size (L)	Temp (°C)	mmHg	DO (%)	DO (mg/L)	Specific conductivity @ 25ºC (µS/cm)	Conductivity (µS/cm)	pH	ORP (mV)	Comments
Survey 1	MB2203B	3/05/2024	10:21		10.9	678.1	87.4	5.56	2205	1610	7.41		
	MB2201A												
	MB2201B						Pump Dry						
	MB2201B	3/05/2024	11:15		12	679.9	59.1	5.69	374.6	281.8	7.28		
	MB2202A	3/05/2024	14:04		13.8	690.9	103.7	9.74	492.4	387.1	7.56		
	MB2202B	3/05/2024	13:53		13.5	691	69	6.52	627.5	489.5	7.13		
	MB2204B	3/05/2024	12:33		13.8	685.1	52.4	4.87	940	739	7.57		
	MB2205B	3/05/2024	13:09		13.8	686.9	30.4	2.84	720	565	7.17		

Table 67: Bore water quality from stygofauna survey 2 (31/05/2024)

Bore ID	Date	Sample (L)	Temp (°C)	DO (%)	Specific Conductivity @ 25ºC (µS/cm)	Conductivity (µS/cm)	pH	ORP (mV)	Comments
MB2201A	31/05/2024					Not connected			
MB2201B	31/05/2024					Dry pump			
MB2202A	31/05/2024	0.2	13.8	72.7	396	311	6.69	-257.1	milky colour
MB2202B	31/05/2024					Dry pump			
MB2203A	31/05/2024					Dry pump			
MB2203B	31/05/2024	0.1	12.9	59.7	303.2	233.4	6.35	-228.5	
MB2204A	31/05/2024	1	14.1	40.4	279.7	221.3	7.09	-282.2	dark colour
MB2204B	31/05/2024	2	12.9	57.9	618.2	75.2	6.85	-245.6	clear
MB2205A	31/05/2024	1	13.3	25.5	383.8	297.9	7.13	-314.2	dirty water
MB2205B	31/05/2024	2	13.3	32.1	613.4	476.4	6.43	-299.3	
MB2206A	31/05/2024					No pump fitted			
MB2206B	31/05/2024					No pump fitted			

Table 68: Bore water quality from stygofauna survey 3 (04/07/2024)

Bore ID	Date	Sample (L)	Temp (°C)	DO (%)	Specific Conductivity @ 25ºC (µS/cm)	Conductivity (µS/cm)	Total Dissolved solids	pH	ORP (mV)	Comments
MB2201A	31/05/2024						Not connected			
MB2201B	31/05/2024						Dry pump			
MB2202A	31/05/2024						Dry pump			
MB2202B	31/05/2024	1.7	12.2	59.4	638	482	-	6.22	-45.1	
MB2203A	31/05/2024						Dry pump			
MB2203B	31/05/2024						Dry pump			
MB2204A	31/05/2024	1.2	11.2	17.3	349.6	257.7	-	5.7	61	dark colour
MB2204B	31/05/2024	2	9.2	72.9	750	523	-	7.11	-55.9	clear

Bore ID	Date	Sample (L)	Temp (°C)	DO (%)	Specific Conductivity @ 25ºC (µS/cm)	Conductivity (µS/cm)	Total Dissolved solids	pH	ORP (mV)	Comments
MB2205A	31/05/2024	1	11.7	26.1	538	401.8	-	6.97	152.8	dirty water
MB2205B	31/05/2024	1.8	12.1	9.9	733	552	-	5.79	-120.1	
MB2206A	31/05/2024						No pump fitted			
MB2206B	31/05/2024						No pump fitted			

Annexure J – Lake diversion design

Lake Diversion construction recommendations for fish and platypus friendly passage

The lake diversion has been proposed to:

1) minimise the impacts of sedimentation and debris on the operation of the lower inlet/outlet structure
2) improve the constructability of the lower inlet/outlet structure and tailrace tunnel
3) The diversion will comprise a waterway with a width of around 40 m with sides and berms that have an overall slope of 70 degrees
4) The diversion is designed to provide a pathway for flood debris to enter the lake downstream of the inlet / outlet structures and to allow aquatic animal passage.

It is expected that the final diversion will be constructed within a sandstone substrate. The concept design features of the lake diversion and construction are summarised below.

1) The lake diversion will involve excavation to a depth of approximately RL 783 to 780 m AHD.
2) The design of the diversion base includes a sequence of riffle, run and pool features to help replicate natural habitat conditions and to encourage passage of aquatic fauna.
3) The channel will be excavated, using traditional excavation methods including drill and blast with scrapers, excavators and trucks, leaving both ends in place until two cofferdams are established within the current section of the lake as shown in Figure 5. The detailed construction method will be advised by engineers and contractors.
4) The diversion will be approx. 230m long along the centre line, with a final grade of 1.3% (1V:77H).

To achieve the best possible outcomes for fish and platypus passage the following design principles are recommended. The design principals below are typical for a natural river/waterway and are based on details and contemporary rock fishway experience as described in Stuart et. al. 2024. The conceptual design principals have been provided and the potential for these to be integrated within the constraints of the lake diversion footprint and the geology which is sandstone bedrock.

Table 69: Recommended concept design specifications for rock fishways and suitability of the current design to support them

Recommended design inputs	Are design principals achievable at Farmers Ck?
Construct the diversion with a riffle, pool sequences and designed for fish passage with objectives relevant to the local small-bodied native fish species, platypus and hydrology.	There is suitable length (230m) and grade (1.3%; 1V:77H) to include pool and riffle sequences to support fish passage.
Match existing lateral (bank-to-bank) slope.	Not achievable based on the topography.
A low fishway longitudinal slope of 1V:20H to 1V:30H to maintain relatively low water velocities and meet current best-practice.	The current diversion has a grade of less than 3V:230H (1.3%) and is below the minimum grade recommended.
Construct pools below the current invert of the lake bypass provides a fish resting area and helps maintain low turbulence. Pools should be 0.4 m deep.	Possible to achieve with designs
No drop to occur over weir crest, the crest should be essentially drowned out (e.g. >0.1 m depth over crest).	Achievable within the current design location – design required
Promote high hydraulic diversity	Achievable within the current design location – design required
Include deeper pools within the lake diversion below the invert level that will collect sediment and small debris to provide habitat	Achievable within the current design location – design required
The fishway steps are constructed by a series of boulders, either as a 'boulder garden' or in regular rows to create a series of step-pools for fish ascent	Not recommended based on the bedrock substrate Design principle could be incorporated into the bedrock design
Maintain existing depth (0.25 to 0.4 m) within the fishway.	Achievable within the current design location – design required
Random stream margin placement of large angular ridge-rocks (e.g. 0.8 m diameter), in roughly horizontal lines but with variable gaps, to create backwatering. These rocks to protrude 0.2 to 0.3 m above water surface and be embedded into the river bed at least half their diameter.	Not recommended based on the bedrock substrate Design principle could be incorporated into the bedrock design

Recommended design inputs	Are design principals achievable at Farmers Ck?
Large angular toe rocks (e.g. 1.0-1.2 m diameter) to provide greater structural stability, to be embedded into the bypass.	Not recommended based on the bedrock substrate Not necessary in a bedrock design
The rocks on the stream margins should be set at varying levels and extending up the river banks, to provide fish passage as river flows increase.	Not recommended based on the bedrock substrate but may be incorporated into the bedrock design
To avoid common maintenance issues of debris build up In rock fishways, the most upstream rocks should have a 'V'-shaped cross-sectional profile and rocks that have low water emergence	May be achievable within the current design location – design required
Consider Farmers Creek hydrology and lower flow periods as overdesign of the Lake diversion for capacity only could result in undesirable outcomes for fish and platypus passage with shallow flows during low flow periods. A 40m wide channel may need to be designed with a low flow channel 5-10m wide to maintain adequate depths for fish and platypus passage.	Yes

To achieve the best outcomes for the project the design of the lake diversion will need to have a concept design prepared followed by a detailed design. To prepare a concept design the following expertise and information will be required:

1) Assemble the appropriate team of personnel including:
    a. Ecologists (fishway designers)
    b. Engineers
    c. Geotechnical specialists
    d. Hydraulic modellers
    e. Construction experts.
2) Survey – Feature survey around the inlet and outlet areas will be required.
3) Hydraulically modelled performance of the design will be required to ensure it meets the required hydraulic outcomes (e.g. water velocity, turbulence, operating range, sedimentation).
4) Farmers Creek flow data for hydraulic performance modelling.

Concept Design Features for Consideration

Geotechnical constraints

Given the constraints of the geotechnical site conditions (sandstone bedrock) it is recommended that the design of the lake diversion and the fish passage features are created within the in-situ bed rock rather than the addition of rock to create the desired hydraulic features and conditions.

Pools and riffle sequences

The total length of the lake diversion is 230m and the total fall over the diversion is 3 m vertically which results in an overall grade of 1.3%. The preferred design guidelines specify that there should be no more than a 0.1 m drop over each step/drop. Larger drops of 0.2 m and 0.3 m could be achieved by aggregating the drops and rock features into small riffle sections such as those pictured in Figure 36. Increasing the vertical drops at each riffle sequence may require more horizontal distance to achieve the required hydraulic conditions than small individual drops but it is important for any final design to include regular pools for fish to rest.

Figure 36: East Barham full-width lateral-ridge rock fishway in temperate Victoria (Stuart, et al., 2024)

Pool depth

Increasing the pool depth below the channel invert of the diversion will allow for deeper pools to be created. Any increase in pool depth will likely result in periodic concentration of silt and organic material in the pools. The deposition of silt and organic material may enhance the ecological value of the lake diversion and support greater macroinvertebrate compared to bare bed rock. However, it is expected that this material will be scoured from the pools during high flows. The existing features at the Farmers Creek arm of Lake Lyell suggest that there is a large volume of silt, sand and organic material that is discharged from the catchment.

Modelling of the benefits of deeper and longer pools in the lake diversion will need to be considered as larger and longer pools support greater deposition. This could create a barrier to fish passage and expose vulnerable species (i.e. platypus) to risks of predation if the pools fill and become shallow during extended low flow periods.

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