APPENDICES

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Aquatic ecology impact assessment

OVEN MOUNTAIN PUMPED HYDRO STORAGE

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Aquatic Ecology Services

Oven Mountain Pumped Hydro Energy Storage Project: Aquatic Ecology Impact Assessment

Prepared for EMM Consulting Pty Ltd | March 2023

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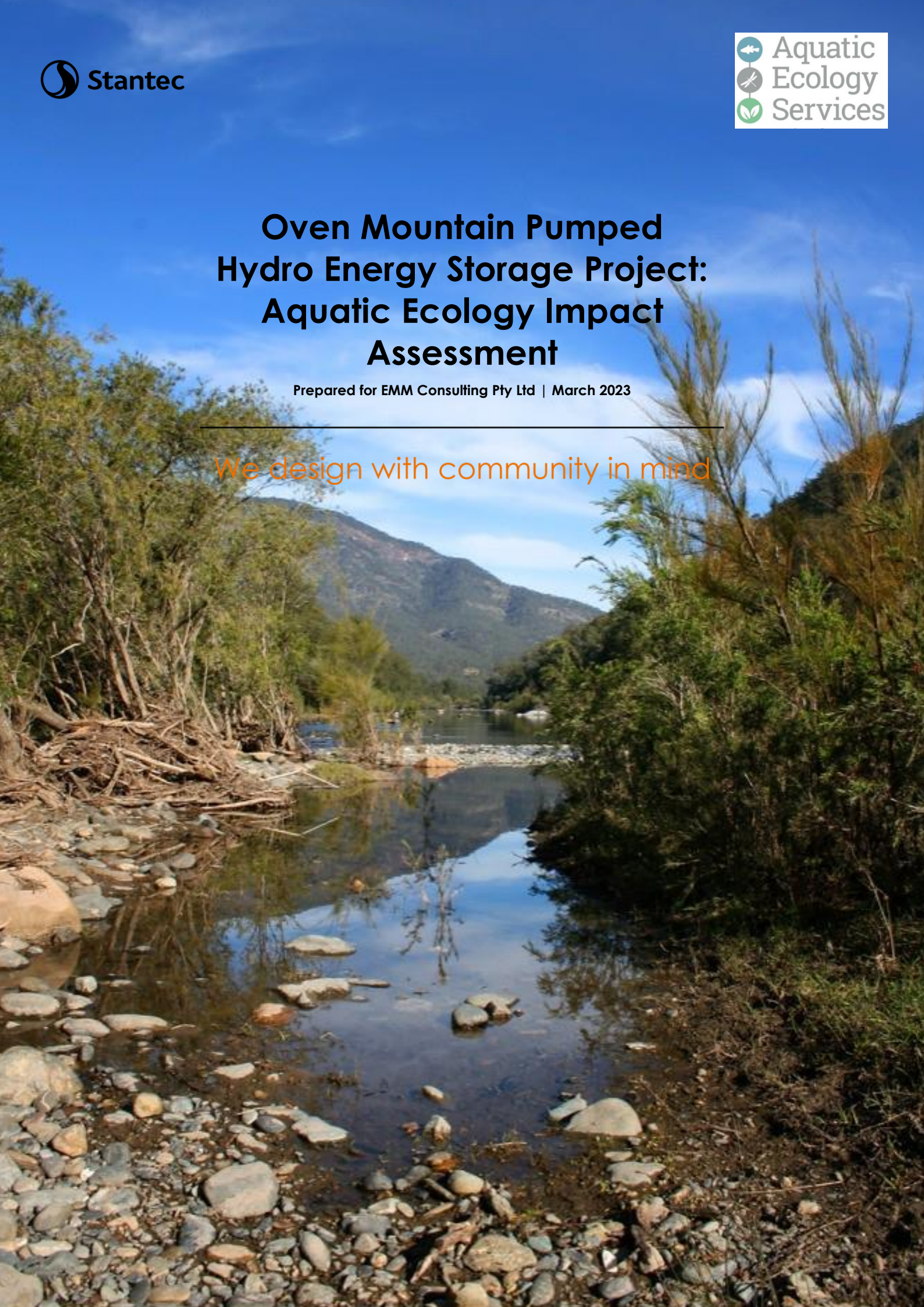

Quality Statement

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Executive Summary

OMPS Pty Ltd (OMPS) is proposing to develop the Oven Mountain Pumped Hydro Energy Storage Project (the Project), an off river pumped hydro energy storage system (referred to as the 'pumped hydro system') located approximately half-way between Kempsey and Armidale, adjacent to the Macleay River in northern New South Wales (NSW). The Project is located within the New England Renewable Energy Zone (REZ) and the Armidale Regional Local Government Area (LGA), proximate to its border with Kempsey Shire LGA. The Project will consist of upper and lower water reservoirs and an underground tunnel connecting them via a hydro-electric power station. The Project has been declared by the NSW Government to be critical State significant infrastructure (CSSI) under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The Project will utilise the highly favourable natural terrain of the site on which it sits to allow electrical energy from the main grid to be stored by pumping water from the Lower Dam and Reservoir to the Upper Dam and Reservoir. Energy can then be generated when needed by allowing water to flow back down to the lower dam and reservoir via the hydro-electric power station, effectively enabling the Project to act as a large battery.

The Project involves building two 'off river' water containment structures to create an upper and a Lower Dam and Reservoir (referred to as 'the upper dam and reservoir' and 'the lower dam and reservoir'), on an ephemeral tributary of the Macleay River. An underground hydro-electric power station complex will be connected to the reservoirs by infrastructure including a power waterway and tunnels. During operation, the water will enable the generation of electricity as it passes through the underground power station while moving from the upper to the Lower Dam and Reservoir, from where it is pumped back up via the same waterway in a 'closed-loop circuit'. The pumped hydro system will be connected to the existing transmission network via new overhead high voltage transmission lines. A detailed description of the Project and its strategic context is provided in the Project's EIS which should be read in conjunction with this report.

This aquatic ecology impact assessment (AEIA) report is an appendix to the Project's Environmental Impact Statement (EIS) and should be read in conjunction with it. It focusses on aquatic ecology values and provides an impact assessment and indicative offset approach in relation to the Project. An assessment of aquatic groundwater-dependent ecosystems (GDEs), consisting of groundwater-dependent wetlands, waterways, and subterranean ecosystems ("stygofauna"), is provided in a separate document. This AEIA has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued by the former Department of Primary Industry and Environment (DPIE), now the NSW Department of Planning and Environment (DPE), as of 10 June 2022, as well as considering relevant legislation, government assessment requirements, guidelines and policies, in consultation with the relevant government agencies.

The aim of the AEIA is to identify key fish habitat, listed habitat, threatened communities, populations or species that may be impacted by the construction and operation of the Project. The specific objectives were to:

- describe existing aquatic biodiversity values and existing environment;
- identify and assess the potential for occurrence of aquatic biodiversity values relevant to the Project, including threatened species, populations and communities listed under relevant legislation and associated policies and guidance material; and
- identify direct, indirect and cumulative impacts to aquatic biodiversity values that have the potential to occur as a result of the Project and assess these impacts.

To address the aim and objectives, the following tasks were undertaken:

- database searches and a literature review;
- aquatic ecology field survey of sites along the Macleay River and its tributaries, as well as waterways along proposed linear infrastructure, including:
    - assessment of key fish habitat using a combination of habitat sensitivity (waterway type) and water classification (waterway class) to determine if the Macleay River and associated waterways meet the definition of 'key fish habitat';
    - cataloguing of photographs at each site assessed along the waterways;
    - assessment of the suitability of identified habitats, including riparian vegetation, to support threatened aquatic species, communities or populations; and
    - collection of abiotic and biotic samples to aid in determining existing environmental values and documenting identified threatened communities, populations and species.
- laboratory analysis of abiotic and biotic samples collected during the March 2022 and June 202 field surveys, and associated data management; and
- preparation of this AEIA, incorporating key findings and undertaking impact assessment for the Project, with provision of recommendations, where required.

The March 2022 and June 2022 field surveys provided background data on the aquatic environments of the Macleay River and associated tributaries, upstream, within and downstream of the proposed Project. The field surveys comprised assessment and/or sampling of the following components; key fish habitat, water quality, sediment quality, aquatic invertebrates and aquatic vertebrates. Sampling effort was considered to be sufficient to assess habitat characteristics, key fish habitat, aquatic invertebrates and aquatic vertebrates. Results of the key fish habitat assessments ranged from Type 1 highly sensitive key fish habitat (nine sites) to Type 3 Minimally sensitive key fish habitat (26 sites), and Class 1 major key fish habitat (10 sites) to Class 4 unlikely key fish habitat (21 sites). Overall, the Macleay River was classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat. Many tributaries contained good structural habitat; however, they were generally ephemeral, although these waterways are likely to provide refuge for fish and other vertebrates from high water flow during flood, and they provide alluvium to the Macleay River. While the majority of waterways were considered to be in good condition, habitat for threatened species was generally limited. There was a proliferation of exotic plants at some sites, clearing of native vegetation (particularly overhanging riparian vegetation) was evident, and there was a lack of suitable habitat features (large woody debris and in-stream aquatic vegetation) available. There was also anthropogenic influences (pastoralism) and the presence of exotic fish fauna noted, likely impacting on waterway bank stability and native fish species.

Water and sediment quality differed between sites within the Macleay River and its tributaries with some sites charactersied by elevated nutrient and metal concentrations. Emergent macrophytes were found throughout the river and tributaries, considered typical of the region, but were not considered abundant or dense. The presence of several species of emergent macrophytes along tributaries indicated that a resident seed bank and sediment moisture has been sustained, even during historic drought conditions. No submerged macrophytes were observed. A total of 12 aquatic invertebrate orders comprising 36 aquatic invertebrate families and 20 aquatic vertebrate taxa (including two exotic species) were recorded across a maximum of 18 sites within nine waterways. Aquatic invertebrate communities were also considered typical of the region, and the macroinvertebrate community of the Macleay River catchment reflected good conditions, albeit pollution-sensitive. The fish assemblage was dominated by native species, and only two exotic species (*Eastern Gambusia[1] and *Goldfish or *Common Carp) were confirmed from several waterways. The fish community of the Macleay River is in relatively good condition due to its location within relatively undisturbed forested area (compared to other coastal catchments), lack of waterway regulation and good catchment condition in its upper reaches. The Platypus was recorded from the Macleay River (eDNA only) and although vertical banks with consolidated material were present, the prevalence of bedrock throughout the waterway suggests limited burrowing suitability. The presence of feral pigs, which were actively disturbing banks and floodplain areas, suggest that turtle recruitment is unlikely to be successful in the area due to the likelihood of egg predation. No threatened aquatic flora or fauna species were documented during the March 2022 and June 2022 field surveys. The Southern Purple-spotted Gudgeon, Manning River Helmeted Turtle and Bellinger River Snapping Turtle had the potential to occur within the local catchment; however, they are unlikely to be present, regardless of potential occurrence mapping data provided by the Department of Primary Industries and the Department of Planning and Environment, primarily due to a lack of recent species records within the catchment and overall lack of suitable habitat.

The primary ecological receptors identified by the findings of this AEIA, in relation to potential impacts resulting from the Project on the Macleay River and associated tributaries, comprise:

- key fish habitat, influenced by surface water volume, flow and quality;
- aquatic invertebrates, influenced by surface water volume, flow and quality;
- aquatic vertebrates, including threatened species and the Platypus, influenced by surface water volume, flow and quality (including elevated metal concentrations);
- native plants inhabiting the riparian zone of the Macleay River, influenced by surface water volume and flood regime;
- groundwater-dependent wetlands, influenced by surface expression of groundwater; and
- waterway baseflow ecosystems, influenced by surface expression of groundwater.

[1] ** indicates an exotic species.*

Project-related impacts to the Macleay River, associated tributaries and groundwater may influence ecological receptors, including significant taxa listed under relevant legislation. Project activities that have the potential to impact aquatic and groundwater-dependent ecology during construction and operation include:

- construction and operation of the Upper Dam and Reservoir/Lower Dam and Reservoir;
- construction and operation of the underground pumped hydro-electric power station, and water and access tunnels, including ground excavation;
- construction, operation and maintenance of other Project infrastructure;
- extraction of water from the Macleay River to fill the Upper Dam and Reservoir/Lower Dam and Reservoir and for intermittent top up;
- emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities;
- runoff, sedimentation and erosion as a result of construction, operation and maintenance earthworks activities;
- spoil storage;
- groundwater drawdown; and
- construction, operation and maintenance of bridge/road crossings and power transmission lines.

Direct impacts that may occur to ecological receptors as a result of Project activities include:

- Short-term minor decrease in surface water volume and flow within sections of the Macleay River and associated tributaries as a result of reservoir construction and filling.
- Aquatic and riparian habitat removal, disturbance and fragmentation within localised sections of the Macleay River and associated tributaries due to construction, operation and maintenance of infrastructure listed above, in particular the construction and filling of the reservoir(s).
- Disturbance of waterway beds and banks, short-term impediment of fish passage and impacts to potential Platypus burrow habitat as a result of the construction and installation of bridge/road crossings and power transmission lines.
- Aquatic fauna mortality attributed to extraction of water from the Macleay River.

Indirect impacts that may occur to ecological receptors as a result of Project activities and include:

- Short-term minor periodic decrease in surface water volume and flow within the Macleay River and associated tributaries as a result of water extraction.
- Initial and short-term periodic degradation in surface water quality (including breach of relevant water quality objectives; salinity, nutrients and/or metal concentrations) due to evapoconcentration within the Macleay River as a result of water extraction.
- Isolated, short-term thermal pollution of surface water within the Macleay River as a result of emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities.
- Erosion of the waterway within the zone of water extraction due to inappropriate extraction infrastructure design, operation and/or placement.
- Erosion, siltation, scouring and degradation of the riparian zone, including an increase in instability of waterway banks and beds, as a result of construction activities.
- Decrease in short to medium-term water and sediment quality as a result of runoff and sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.
- Decrease in short to medium-term water and sediment quality (including breach of relevant water quality objectives; salinity, nutrients and/or metal concentrations) as a result of unplanned discharge to waterways, or failure of surface water management systems as a result of inadequate rehabilitation and/or stabilisation methods, or rupture of water storage infrastructure.
- Increased local workforce potentially impacting upon aquatic species.
- Loss and /or reduced recruitment of native riparian plants, including potential loss of habitat and exacerbation of existing weed infestations, due to vegetation clearing, construction activities and water extraction during water extraction.

- Groundwater drawdown and host rock fracturing as a result of aquifer dewatering, potentially impacting groundwater-dependent wetlands and waterway baseflow ecosystems.

In terms of cumulative impacts related to aquatic ecology from surrounding projects, it is unlikely that identified projects will result in significant cumulative impacts in conjunction with the Project. However, cumulative impacts will still occur due to the overall contribution of the Project to relevant FM Act, BC Act and EPBC Act key threatening processes such as:

- degradation of native riparian vegetation along New South Wales water courses;
- installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams;
- removal of large woody debris from New South Wales rivers and streams;
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands;
- invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat);
- loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants; and
- predation by the Plague Minnow (*Gambusia holbrooki*).

This has the potential to influence water quality and aquatic biota on a State-wide scale. However, the disturbance footprint is localised and Project-specific management plans will be implemented to manage impacts.

In accordance with *NSW Biodiversity Offsets Policy for Major Projects. Fact sheet: Aquatic biodiversity*, aquatic offsets are required wherever direct or indirect impacts to key fish habitat occur (i.e. impacts to water quality, impediment to fish passage). It is not expected that the Project will result in significant broad-scale impacts to key fish habitat or aquatic biodiversity within the Macleay River and associated waterways because of the Project. However, consultation with the DPI Fisheries will occur as soon as practicable to discuss an approach to aquatic offsets, if considered necessary and where feasible for the Project to implement. Where avoidance is not feasible, direct and indirect impacts will be managed through the implementation of a variety of mitigation strategies and through ongoing consultation with relevant agencies and stakeholders.

Assessments were undertaken in accordance with relevant literature to determine whether the Project is likely to significantly impact listed habitats, communities, populations and/or species; however, it was determined that construction, operation and maintenance of the Project is unlikely to significantly impact significant species that have the potential to occur. In addition, a suite of mitigation measures are recommended to ensure impacts to aquatic ecology and significant species are minimised.

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1. Introduction

1.1. The Project

OMPS Pty Ltd (OMPS) is proposing to develop the Oven Mountain Pumped Hydro Energy Storage Project (the Project), an off river pumped hydro energy storage system (referred to as the 'pumped hydro system') located approximately half-way between Kempsey and Armidale, adjacent to the Macleay River in northern New South Wales (NSW). The Project is located within the New England Renewable Energy Zone (REZ) and the Armidale Regional Local Government Area (LGA), proximate to its border with Kempsey Shire LGA. Figure 1-1 and Figure 1-2 provide the regional and local context of the Project, respectively. The Project will consist of upper and lower water reservoirs and an underground waterway connecting them via a hydro-electric power station.

The Project has been declared by the NSW Government to be critical State significant infrastructure (CSSI) under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). Infrastructure projects are declared to be CSSI if, in the opinion of the NSW Minister for Planning, they are essential to the State for economic, environmental, or social reasons. By providing up to 900 MW of electricity generating capacity, the Project will aid in the transition of the National Energy Market (NEM) towards cleaner, more reliable and affordable electricity. It will also provide up to between eight and 12 hours of dispatchable energy at full generation to be stored and made available to the NEM through the New England REZ. The expected operational lifespan of the Project is in excess of 100 years.

The Project will utilise the highly favourable natural terrain of the site on which it sits to allow electrical energy from the main grid to be stored by pumping water from the Lower Dam and Reservoir to the Upper Dam and Reservoir. Energy can then be generated when needed by allowing water to flow back down to the lower dam and reservoir via the hydro-electric power station, effectively enabling the Project to act as a large battery.

1.2. Proponent

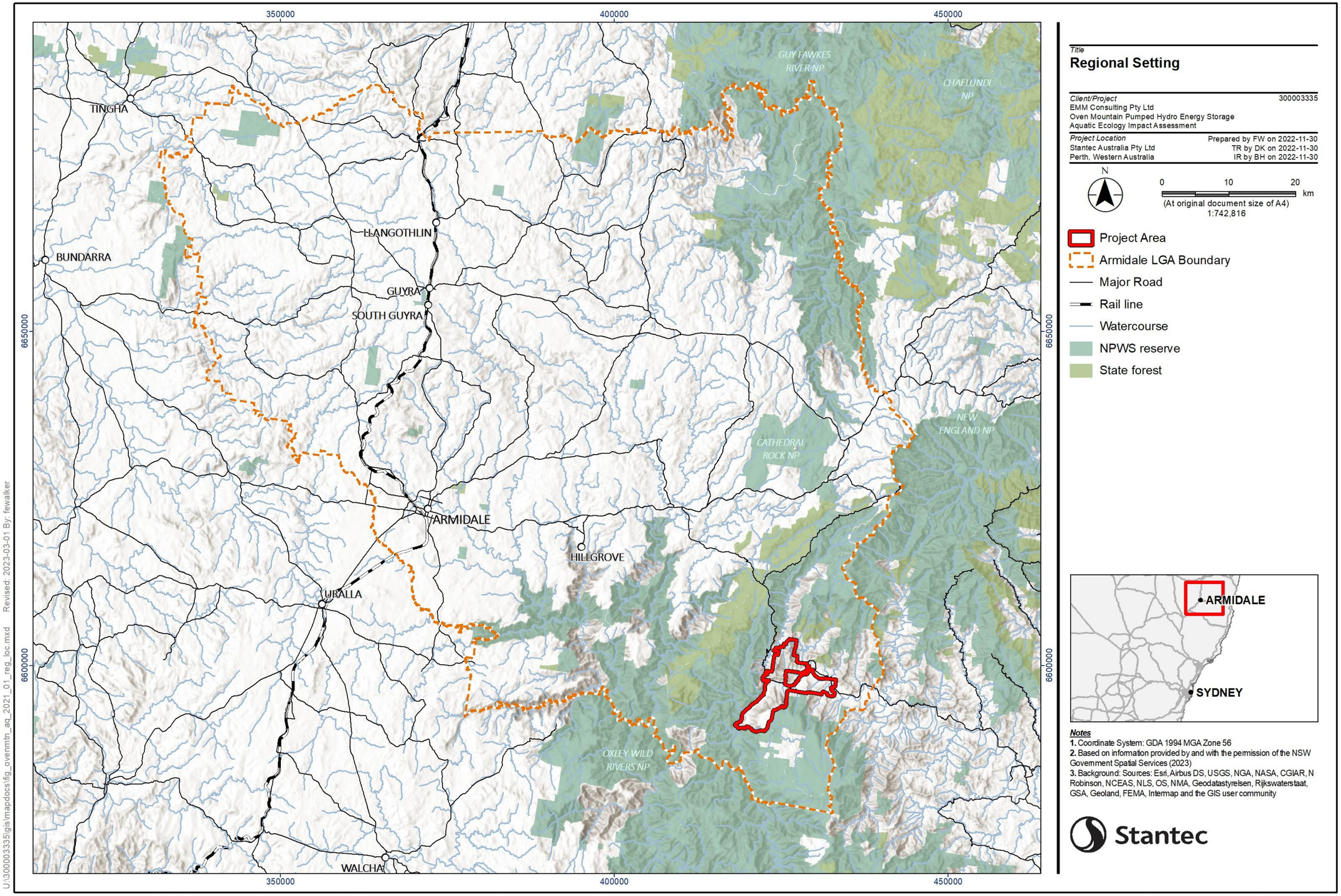
OMPS (ABN 22 160 259 174) is developing the Project and is located in Kempsey at 2/28 Clyde Street, Kempsey NSW 2440.

1.3. Purpose Of This Report

This aquatic ecology impact assessment (AEIA) report is an appendix to the Project's Environmental Impact Statement (EIS) and should be read in conjunction with it. It focusses on aquatic ecology values and provides an impact assessment and indicative offset approach, if required, in relation to the Project. An assessment of aquatic groundwater-dependent ecosystems (GDEs), consisting of groundwater-dependent wetlands, waterways, and subterranean ecosystems ("stygofauna"), is provided in EMM Consulting (2023).

This AEIA comprises the following sections:

- Introduction, Project Description and Legislative Context;
- Methods;
- Desktop Assessment Results and Discussion;
- Field Survey Results and Discussion;
- Ecological Values & Ecological Receptors;
- Potential Impacts;
- Impact Assessment;
- Recommendations;
- Indicative Aquatic Offset Approach; and
- References & Appendices.



Title

Regional Setting

Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

0 10 20 km

(At original document size of A4)
1:742,816

- Project Area
- Armidale LGA Boundary
- Major Road
- Rail line
- Watercourse
- NPWS reserve
- State forest

Notes

1. Coordinate System: GDA 1994 MGA Zone 56
2. Based on information provided by and with the permission of the NSW Government Spatial Services (2023)
3. Background: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

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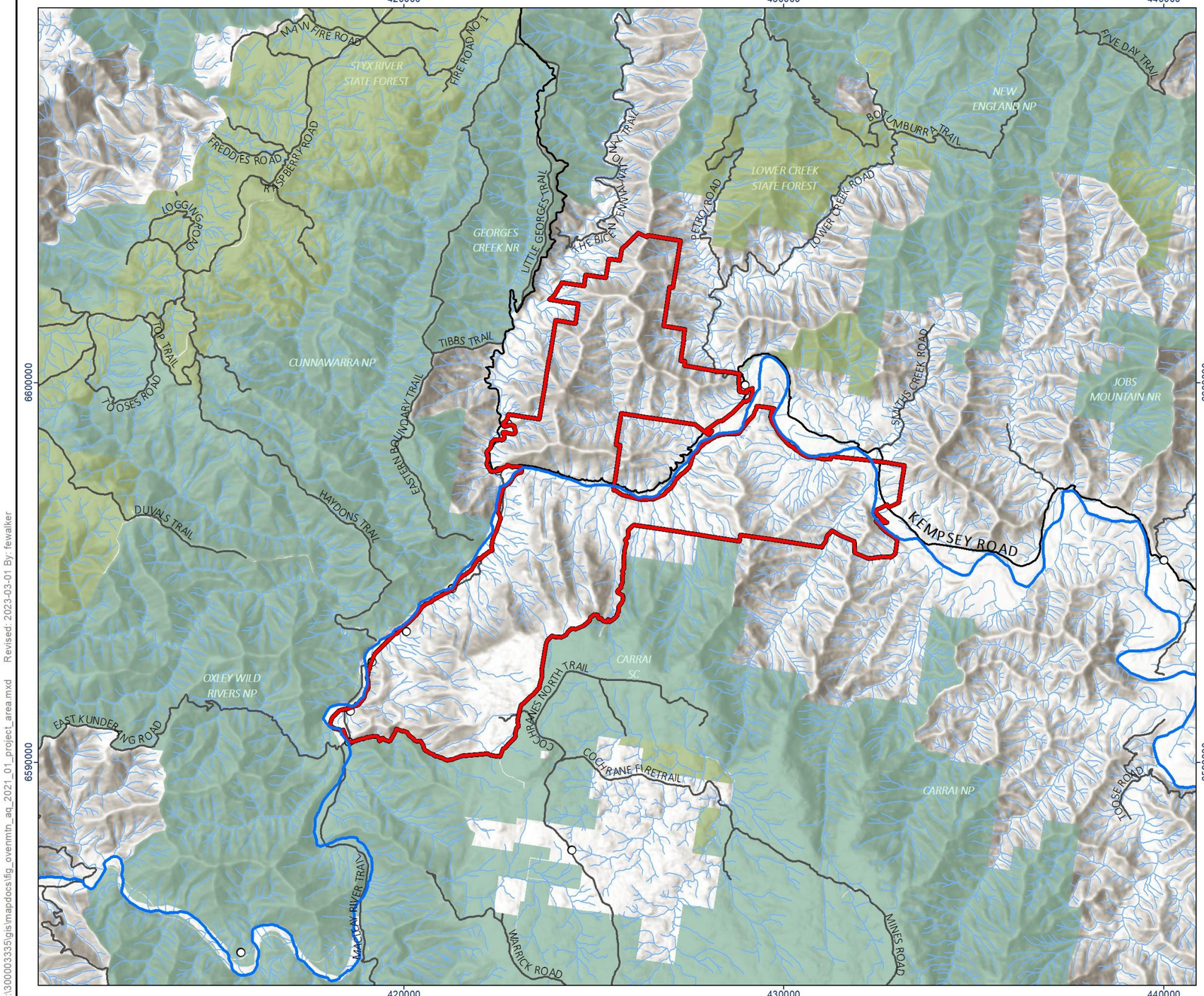
Figure 1-1: Regional setting.



Title

Project Area

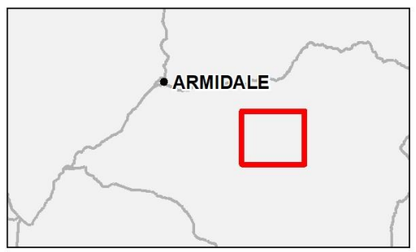
Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

0 2 4 km

(At original document size of A4)
1:150,000

- Project Area
- NPWS reserve
- State forest
- Macleay River
- Other Watercourse
- Major Road
- Minor Road



Notes

1. Coordinate System: GDA 1994 MGA Zone 56

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U:\300003335\gis\mapdocs\fig_ovenmtn_aq_2021_01_project_area.mxd Revised: 2023-03-01 By: fewalker

Figure 1-2: The local Project area.

1.4. Assessment Guidelines And Requirements

This AEIA has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued by the former Department of Primary Industry and Environment (DPIE), now the NSW Department of Planning and Environment (DPE), as of 10 June 2022. Table 1-1 lists the matters included in the SEARs, relevant to aquatic ecology, and where they are addressed in this report.

Table 1-1: Relevant matters raised in SEARs.

Requirement	Section Addressed
SEARs Key Issues	
Biodiversity: • an assessment of the biodiversity impacts of the project on terrestrial, aquatic and groundwater-dependent ecosystems, including listed Commonwealth and State threatened species and communities and listed Commonwealth migratory species, and impacts on National Parks and Reserves and World Heritage Areas), and Attachment A and; ○ an assessment of the likely impacts on listed aquatic threatened species, populations or ecological communities, scheduled under the Fisheries Management Act 1994, and a description of the measures to minimise and rehabilitate impacts,	Section 8 Appendix D EMM Consulting (2023)
• a strategy to offset the residual impacts of the project on these ecosystems	Section 12
Water: • an assessment of the impacts of the project on: ○ key water features on site, including potential impacts on riparian land;	Section 8
• a description of the likely changes to the hydrological regime of the Macleay River, and any associated biodiversity impacts;	Section 8 Appendix D
• where the project involves works within 40 metres of the high bank of any river, lake or wetlands (collectively waterfront land), identify likely impacts to the waterfront land, and how the activities are to be designed and implemented in accordance with the DPI Guidelines for Controlled Activities on Waterfront Land (2018) and (if necessary) Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (DPI 2003); and Policy & Guidelines for Fish Habitat Conservation & Management (DPI, 2013);	Section 8 Appendix D

This AEIA also considers relevant legislation, government assessment requirements, guidelines and policies, in consultation with the relevant government agencies, including:

- NSW *Fisheries Management Act 1994* (FM Act);
- NSW *Water Management Act 2000* (WM Act);
- NSW *Water Management (General) Regulation 2018*;
- NSW *Biodiversity Conservation Act 2016* (BC Act);
- NSW *Biosecurity Act 2015* (Biosecurity Act);
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- 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 under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment Water Heritage and the Arts 2010);
- NSW Biodiversity Offsets Policy for Major Projects. Factsheet: Aquatic biodiversity (Department of Primary Industries 2014);
- Matters of National Environmental Significance Significant impact guidelines 1.1 (EPBC Act) (Department of the Environment 2013);

- Revised provisional list of animals requiring urgent management intervention (Department of Agriculture Water and the Environment 2020);
- *Water Sharing Plan for the Macleay Unregulated and Alluvial Water Sources 2016*; and
- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*.

1.4.1. Other Relevant Reports

This AEIA has been prepared with reference to other technical reports prepared for the Project, as follows:

- Oven Mountain Pumped Hydro Energy Storage - material characterisation (EMM Consulting 2022a);
- Oven Mountain Pumped Hydro Energy Storage Project: Biodiversity Development Assessment Report (EMM Consulting 2022b);
- Oven Mountain Pumped Hydro Energy Storage Project: Groundwater Impact Assessment (EMM Consulting 2022d); and
- Oven Mountain Pumped Hydro Energy Storage Project: Surface Water Impact Assessment (EMM Consulting 2022e)(EMM Consulting 2023).

2. The Project Description

2.1. Project Overview

The Project involves building two 'off river' water containment structures to create an upper and a Lower Dam and Reservoir (referred to as 'the upper dam and reservoir' and 'the lower dam and reservoir'), on an ephemeral tributary of the Macleay River. An underground hydro-electric power station complex will be connected to the reservoirs by infrastructure including a power waterway and tunnels. During operation, the water will enable the generation of electricity as it passes through the underground power station while moving from the upper to the Lower Dam and Reservoir, from where it is pumped back up via the same waterway in a 'closed-loop circuit'. The pumped hydro system will be connected to the existing transmission network via new overhead high voltage transmission lines. A detailed description of the Project and its strategic context is provided in the Project's EIS which should be read in conjunction with this report.

2.2. Key Project Design Elements

Broadly, the Project has been categorised into three key components, which are further broken down into the Project's key elements in Table 2-1 and shown in Figure 2-2:

- pumped hydro-electric and generation works (PHGW) – including:
    - new upper and lower water storage dams and reservoirs;
    - a new underground pumped hydro-electric power station and transformer hall;
    - water tunnels, access tunnels, portals and adits;
    - tailrace;
    - intake and outlet structures; and
    - associated gates, shafts and screens.
- transmission connection works, including:
    - new electricity transmission lines to connect the PHGW to the existing electricity transmission network (Line 965);
    - new electricity transmission infrastructure; and
    - a new substation.
- ancillary development including, but not limited to:
    - access roads, tracks and bridge;
    - on-site quarries and related infrastructure;
    - utilities and communications infrastructure;
    - construction pads containing assets such as workshops, concrete batching plants (CBPs), and offices;
    - laydown and storage areas;
    - construction accommodation;
    - pumping infrastructure;
    - operational facilities such as offices, and camps for staff; and
    - construction and operational power supply.

Table 2-1: Key Project elements.

Project Element	Description
PHGW	

Underground power station complex	An underground pumped hydro-electric power station located below the upstream end of the pumped hydro system to optimise the hydraulic arrangement of the Project. The power station complex consists of:
	• two main caverns comprising;
	  ○ the machine hall; and
	  ○ the transformer hall; and
	• interconnecting tunnels, the transformer hall tunnel and isolated phase busbar (IPB) tunnels.

Dams and reservoirs	Two concrete faced rockfill dams (CFRD) and reservoirs, referred to as the upper dam and reservoir and lower dam and reservoir, with the following specifications:

Project Element	Description

	• Upper dam and reservoir:
	  ○ CFRD approximately 70 metres (m) high and 780 m long;
	  ○ reservoir covering a total area of approximately 20 hectares (ha) and an inundation extent of approximately 16.7 ha;
	  ○ reservoir height of 881 m Australian Height Datum (AHD) at full supply level (FSL) and 830 m AHD at minimum operating level (MOL); and
	  ○ reservoir storage capacity of around 5.1 gigalitres (GL) at FSL.
	• Lower dam and reservoir:
	  ○ CFRD approximately 70 m high and 280 m long;
	  ○ reservoir covering a total area of approximately 24.7 ha and an inundation extent of approximately 21.6 ha;
	  ○ reservoir height of 250 m AHD at FSL, 215 m at MOL and 205 m AHD at lowest operating level (LOL); and
	  ○ total reservoir storage capacity of around 6.5 GL at FSL.

Water intake structures	Two intake structures, one at each reservoir, including: • a morning glory, vertical-type intake structure situated at the upper dam and reservoir; and • a lateral intake structure, with head gates and stoplog slots, and an intake channel, at the lower dam and reservoir.
Spillway	Two concrete lined spillway chutes, one for each of the upper and lower dams and reservoirs. Both spillway crests will comprise of ungated ogee-shaped overflow weirs on the upstream ends of the spillway chutes.
Macleay River pump facility	A pump facility on the Macleay River, which will include duty and standby pumps for the first fill and for ongoing reservoir refills.
Tunnels	Three main tunnels comprising of: • two main access tunnels (MAT1 and MAT2); and • the emergency, cable, ventilation tunnel (ECVT). The MAT1 and MAT2 will provide loop access to the power station complex from the MAT portal. The ECVT will provide services access and egress between the switchyard portal and the transformer hall. The ECVT portal will contain the station switchyard, control rooms, ventilation and firefighting equipment, with blast walls separating important equipment.
Power waterway	The power waterway will consist of: • a 660 m long, 5.1 m diameter vertical pressure shaft; • 250 m concrete and steel lined high-pressure headrace tunnel; • three or more 80 m long penstock tunnels; • three or more 120 m long draft tube tunnels; and • a 1,825 m long concrete lined tailrace tunnel.
Transmission connection works	
Connection works	The connection works will consist of: • an approximately 15 km long transmission alignment comprising, at a maximum, double circuit single tower 330 kV overhead infrastructure and single circuit single tower 132 kV overhead infrastructure connecting to TransGrid Line 965; • up to 25 transmission tower sites (approximately 50 m x 50 m) containing the 132 kV and 330 kV infrastructure; and • a transmission easement width of a maximum of approximately 105 m. Note: The upgrade of existing Line 965 will be the subject of a separate application.

Project Element	Description
Sub-station	Construction of a substation and associated connection infrastructure of up to 330 kV rating.
Switchyard	A high voltage connection linking the connection transmission lines to the cables exiting the underground power station complex. The outdoor air insulated switchyard will likely include: • switchgear and control room; • cable potheads; • disconnector/earth switches; • capacitive voltage transformer (VT); • lightning protection; • security fencing, lighting and surveillance; and • surge arrestor.
Ancillary development (construction and operation)	
Access roads, access tracks and bridge	A variety of road works to improve existing access, and construction of new permanent roads to enable construction access, temporary establishment and use of construction sites, and general access to the Project area including transmission line infrastructure. The proposed main access will be via the construction of a new unsealed two-lane access road located to the east of the site. The main access road will interface with the existing Kempsey-Armidale Road and will require the construction of one new single or two lane low-level bridge crossing over the Macleay River. A temporary bridge may be utilised prior to the construction of the permanent bridge. There will be approximately 40 km of permanent roads connecting the dams, surface works, portals, transmission assets and spoil sites. Some of these roads are existing roads, however approximately 25 km will be newly constructed roads. The key road components include: • Main Access Road (approximately 4.7 km); • Eastern Access Road (up to approximately 11.4 km); • Lower Dam Access Road (approximately 3.6 km); • Upper Dam Access Road (approximately 7.1 km); • access to portals and underground works; and • Upper Dam Emergency Egress Road (approximately 2.2 km) Access to the transmission infrastructure north of the Macleay River will be via two roads accessed from the Kempsey-Armidale Road. These two roads include the: • Northern Transmission Access Road (approximately 15 km); and • Southern Transmission Access Road (approximately 2.3 km). To support access along the transmission line easement south of the Macleay River and to each of the tower sites, a network of interconnecting access and maintenance tracks will be constructed, to a large extent utilising existing access tracks.
Surface works pads and facilities	There are four main construction pads in addition to surface portals which will be used temporarily during construction for different services (workers camp, construction site offices, workshop area, and laydown storage). Construction works will require the establishment of the following ancillary support infrastructure and areas: • main accommodation camp(s), which will temporarily accommodate the majority of workers throughout the construction period; • temporary or fly camps, which will temporarily accommodate the majority of workers as required throughout the construction period; • two works areas including Works Area 1 and Works Area 2, which will contain ancillary facilities such as CBPs, mechanical and electrical workshops, a laboratory and various water treatment and wash areas; • spoil emplacement areas;

Project Element	Description
	• staging area; • stockpiling areas; and • temporary site offices to be used during construction.
Communications	Communication infrastructure, such as fibre optic cables, are required for the operation of the Project and will be located: • on an overhead line linking the upper and lower dams and reservoirs (in conjunction with the electrical line); and • buried in road corridors. The communication network will also include a communications tower near the upper dam and reservoir.
Utilities during construction	• Construction water will be supplied either via groundwater bores, or via pumping of water from the Macleay River to support camp operations, the CBP, dust suppressions and other activities across the site. • Construction power will be supplied primarily by use of portable diesel generators and supported where possible by leveraging off existing electricity distribution infrastructure running through the generation site.
Utilities for operation	Alignment and length of utilities (electricity, water, etc) will be combined into a single corridor (total length of about 5.4 km).
Water diversion and water treatment facilities	• Site drainage will include a combination of cross drainage culverts, drainage pits and pipe, open channels/open drains (vegetated, rock-lined or concrete), levees/bunds, and detention basins. • Various water treatment plants will be used for construction drainage and water treatment facilities – for the accommodation camp, temporary or fly camps, CBP, tunnel, etc. • Specific discharge locations are planned for stormwater and surface water runoff.
Laydown/Stockpile areas	Temporary laydown/stockpile areas will be utilised across the Project area, with a total allocated stockpile area of around 114,000 m^2 .
Spoil emplacement areas	To accommodate spoil generated through excavation of the underground caverns and tunnels, three permanent spoil placement locations have been identified with a capacity to store around 2 million cubic metres (Mm^3) of material. Dead storage space within the reservoirs will also be used for spoil placement, with a capacity to store approximately 300,000 m^3 – 400,000 m^3.
Ancillary operational facilities	Primary operation of the Project can be undertaken remotely and will require minimal onsite operational staff, other than for maintenance activities. Operational facilities include maintenance housing, work area, car parking, workshop and storage, control room and switchgear, water treatment plant, office area, heating, ventilation and air conditioning (HVAC), backup generators and Macleay River pump facility.
Other	
Construction	• Construction duration of around four to five years. • Construction workforce of over 600 to approximately 1,000 workers at construction peak.
Rehabilitation	Rehabilitation of areas disturbed during pre-construction and construction will be undertaken progressively during all stages and phases of the Project. Progressive rehabilitation will occur over about 70 ha including spoil emplacement areas and areas used for construction ancillary facilities no longer needed during operation. At the end of the Project's life, 192 ha in total will be rehabilitated to native ecosystem (including native vegetation and rock landscape). Approximately 138 ha will be retained permanently for the water storages and access roads, subject to agreement with relevant landowners/land managers.

Project Element	Description
Operation	• The Project will provide up to 900 MW of electricity generating capacity and up to eight hours of energy storage at full generating capacity. • Maintenance and operational activities will include power station operations, infrastructure inspections, maintenance to assets, vegetation management, auditing and compliance and other activities. • It is expected that the operation of the new power station will require around 30-50 full-time workers, as well as additional contractors for regular and ad hoc maintenance and repairs.
Hours of operation	• Construction of the Project will be 24/7 and 365 days per year. • Operation of the Project will be 24/7 and 365 days per year.
Project timeline	The Project will involve the construction and operational stages, and numerous phases which are outlined in the Project's EIS.
CIV	Estimated to be approximately $1.8 billion.

2.3. Project Area Terminology

Approval for the Project is being sought based on feasibility designs as is common for projects of this size and scale. To accommodate minor changes and amendments to the design as it progresses, a 'Project area', 'construction envelope', 'disturbance footprint' and 'operational footprint' approach is being adopted for the Project (Figure 2-2). This approach is aimed at ensuring environmental impacts are assessed as accurately as possible, while accounting for the current level of design and the likelihood of design refinements occurring as the Project progresses towards construction. This approach was adopted for the assessment of Snowy Hydro Limited's Snowy 2.0 Project. The *Project area* is the broader area within which the Project will be built and operated, and the extent within which direct impacts from the Project are anticipated (Figure 2-2). Importantly, the Project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments. The Project area has been further divided into different areas to facilitate the assessment of direct impacts from the Project.

The *construction envelope* represents the maximum extent of where disturbance may occur during the construction of the Project (Figure 2-2). In order to derive the construction envelope, buffers have been applied to the key Project elements and infrastructure. The buffers used to derive the final construction envelope area reflect the confidence around the current siting of the asset or infrastructure, and the likelihood that some minor amendments may be required prior to commencing the construction works as a result of the detailed design. The construction envelope for the Project covers an area of approximately 780 ha.

Located entirely within the bounds of the construction envelope sits the *disturbance footprint*, a smaller area that has been derived directly from the current level of design (Figure 2-2). The disturbance footprint represents the physical disturbance that can be expected as part of 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 as defined by the construction envelope. It is proposed that part of the disturbance footprint will be rehabilitated, and landformed at the completion of the Project, however, other parts will be retained post construction. These components are necessary for the ongoing operation and maintenance of the new power station (operational footprint). The disturbance footprint for the Project covers an area of approximately 330 ha.

Progressively, and at the end of construction, temporary components that are required to support the construction of the Project will be rehabilitated and returned to a state representing their previous use. The exceptions to this is the areas required for the permanent operation of the Project, which would be retained (referred to as the *operational footprint*). The operational footprint of the Project is around 285 ha. The Project area, construction envelope and disturbance footprint are shown in Figure 2-2.

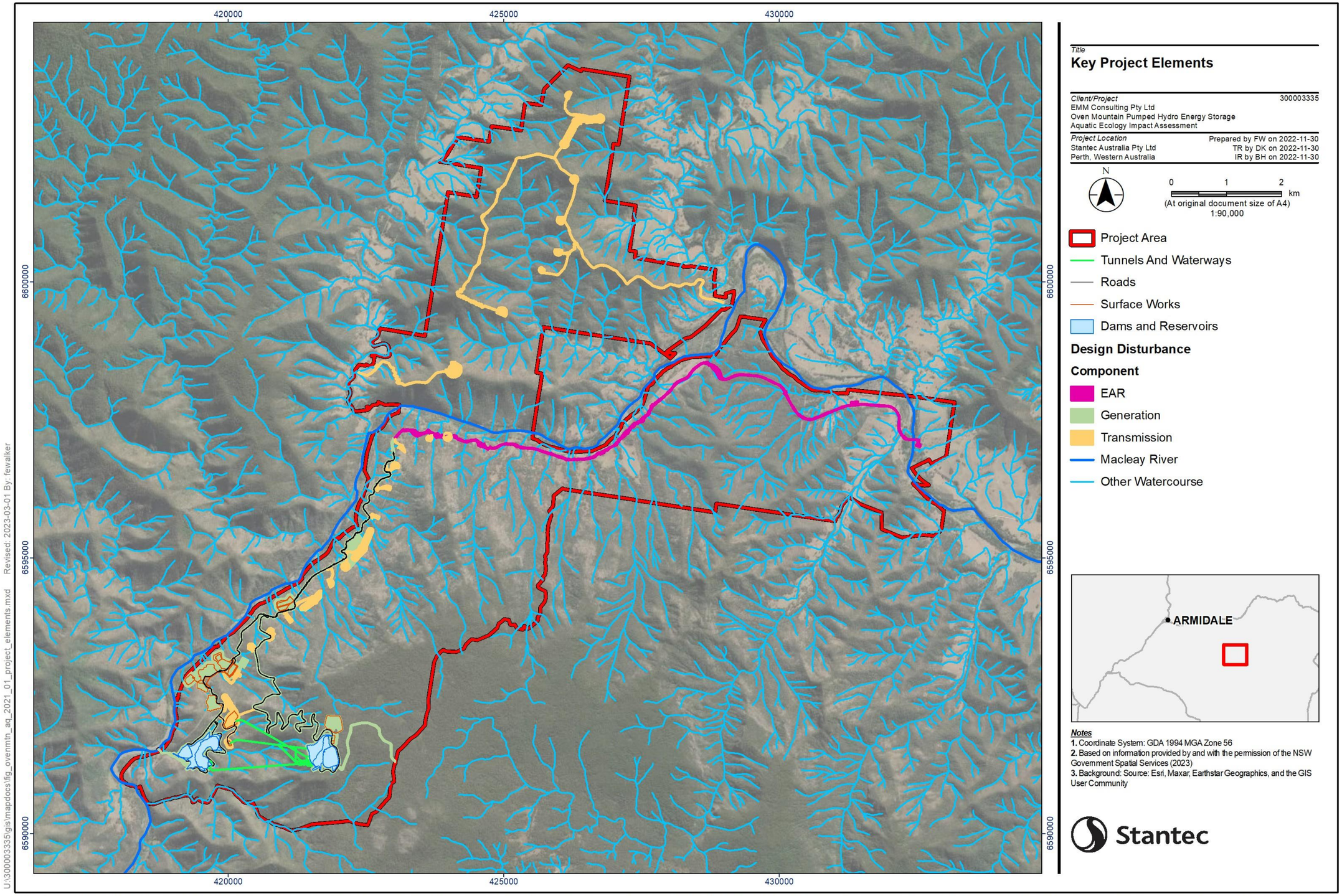

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Figure 2-1: Key Project elements.

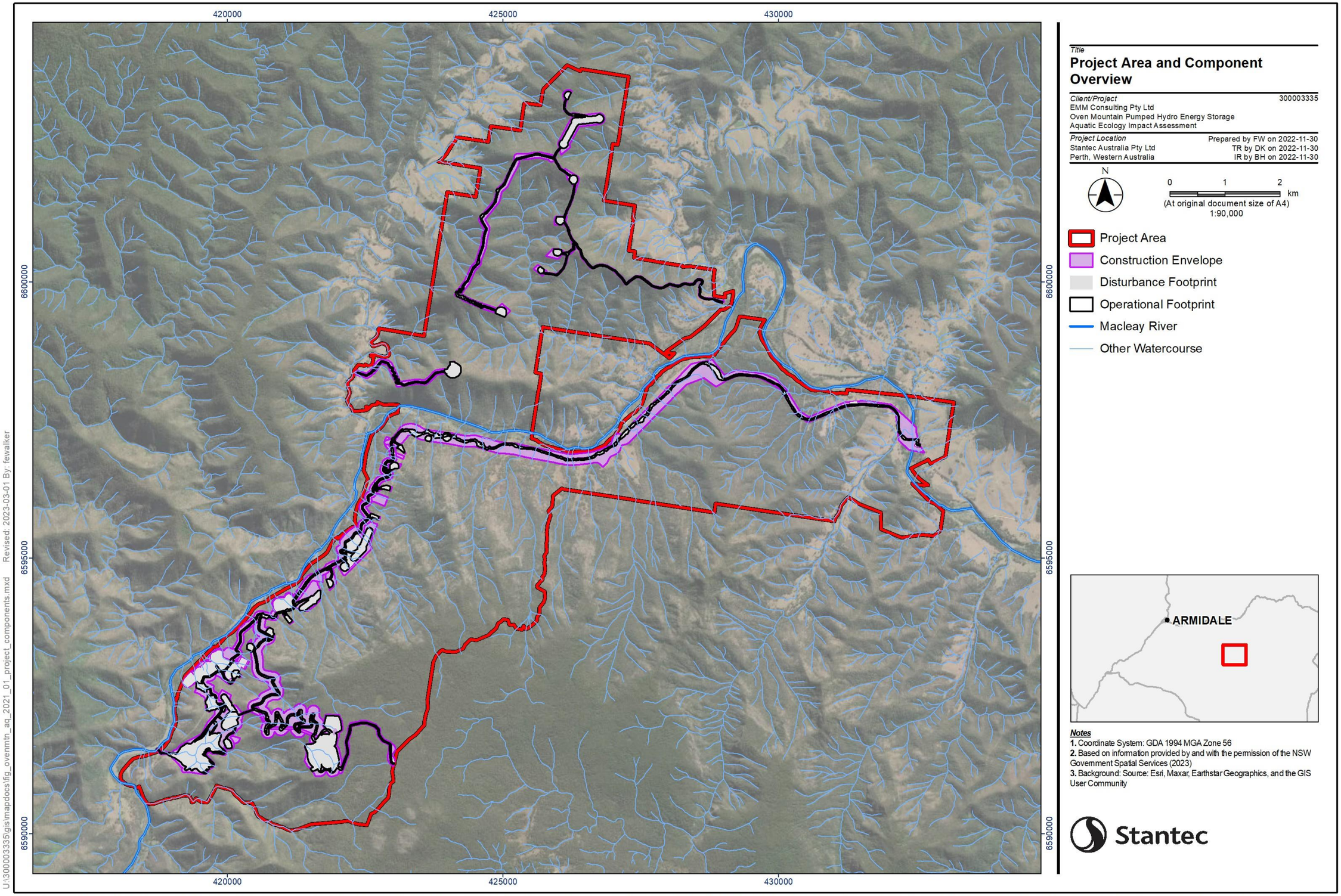

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Figure 2-2: Project areas overview.

3. Legislative Context

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

3.1. *Environmental Planning and Assessment Act 1979*

The EP&A Act was enacted to encourage the consideration and management of impacts of proposed development or land-use changes on the environment and the community. The EP&A Act is administered by the DPE. The EP&A Act provides the overarching structure for planning in NSW; however, it is supported by other statutory environmental planning instruments (EPIs) including State Environmental Planning Policies (SEPPs) and local environmental plans (LEPs). The Project is declared as CSSI under Part 5 Division 5.2 of the EP&A Act, which sets out the planning assessment and approval framework and process for CSSI. The NSW Minister for Planning is the determining authority for this Project and Part 2 Division 2.1 s 2.4(3)(b) of the EP&A Act prevents the delegation of this function by the Minister.

3.2. *Fisheries Management Act 1994*

The 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, key fish habitat, 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 s 220ZZ and s 220ZZA of the FM Act.

A key objective of the FM Act is to conserve key fish habitat. 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. Key fish habitat is defined in Section 3.2.1 and Section 3.2.2 of *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 systems (Department of Primary Industries 2013). Generally, 3rd order tributaries and above (Strahler 1952) are considered key fish habitat 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*".

As the Project has been declared as CSSI, permits under the following sections of the FM Act are not required to be applied:

- s 201 Circumstances in which a person (other than a public or local government authority) may carry out dredging or reclamation;
- s 205 Marine vegetation—regulation of harm; and
- s 219 Passage of fish not to be blocked.

However, consideration has been given to these issues within this report, noting the following:

- With regard to fish passage (s 219 FM Act), works that may result in the temporary or permanent blockage of fish passage generally require a permit from DPI Fisheries. It should be noted, in alignment with the Department of Primary Industries (2013), that a temporary barrier is defined as one that is "*used for a short time only (generally less than 6-12 months) while the construction of a permanent barrier or waterway crossing is constructed*". It is expected, once a waterway crossing is completed, that the temporary barrier is removed. A permit is generally required for all barriers to fish passage across waterway of Type 1 to Type 3 key fish habitat (Table 4-3, Table 4-4), regardless of whether they are permanent or temporary. In addition,

any project that creates an obstruction to fish passage as a result of a pipeline crossing, is required to be assessed by the DPI Fisheries.

- The Department of Primary Industries (2013) also contains policy and guidelines for the management of riparian vegetation, as follows:
    - Riparian buffer zones are generally required to be established and maintained for developments or activities within, or adjacent to, waterways classified as Type 1 highly sensitive key fish habitat or Type 2 moderately sensitive key fish habitat and/or Class 1 major key fish habitat to Class 3 minimal key fish habitat (Table 4-3, Table 4-4); riparian buffer zones should be measured from the top of the bank/drainage depression along Class 1 to Class 3 waterways (Table 4-3, Table 4-4); several exceptions exist.
    - Riparian buffer zones must be designed to incorporate maintenance of lateral connectivity between aquatic and riparian habitat; installation of infrastructure, terraces, retaining walls, cycle ways, pathways and grass verges within the riparian buffer zone shall be avoided or minimised.
    - Proposals that aim to remove willows or other exotic trees or other weeds from a waterway, followed by rehabilitation with native species, will generally by supported by DPI Fisheries as long as stream stability is not compromised.

3.3. *Water Management Act 2000*

The WM Act, administered by the DPE Water, 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; and*
>
> *(b) a lake through which water flows; and*
>
> *(c) a channel into which the water of any such stream has been diverted; and*
>
> *(d) part of any such stream; and*
>
> *(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". However, as the project has been declared as CSSI, approval under the WM Act is not required (s 5.23 of the EP&A Act).

3.3.1. NSW Wetlands Policy

The NSW Wetlands Policy (Department of Environment Climate Change and Water 2010) provides for the protection, ecologically sustainable use, and management of NSW wetlands. A wetland is defined as an area of land that is wet by surface and/or groundwater for a sufficient period that plants and animals adapt to, and depend on, that moisture for at least part of their life cycle. Wetlands can be permanent or ephemeral. The policy contains 12 guiding principles focused on conservation, water and land management, sustainability, prioritisation of significant wetlands, recognition of wetlands' cultural significance, climate change, protection, and reporting.

3.4. *Biosecurity Act 2015*

The primary objective of the Biosecurity Act, administered by the DPI, is to provide a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers, or potential carriers. Other objectives include:

- to promote biosecurity as a shared responsibility between government, industry and communities;
- to provide a framework for the timely and effective management of a range of biosecurity issues;
- to provide a framework for risk-based decision-making in relation to biosecurity;
- to give effect to intergovernmental biosecurity agreements to which the State is a party; and
- to provide the means by which biosecurity requirements in other jurisdictions can be met, so as to maintain market access for industry.

3.5. *Environmental Protection and Biodiversity Conservation Act 1999*

The EPBC Act, administered by the Commonwealth Department of Climate Change, Energy, the Environment and Water (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 are:

- world heritage properties;
- national heritage places;
- wetlands of international importance;
- nationally threatened species and ecological communities;
- migratory species;
- Commonwealth marine areas;
- the Great Barrier Reef Marine Park;
- nuclear actions (including uranium mining); and
- a water resource, in relation to coal seam gas development and 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 DCCEEW for determination as to whether it is a controlled action. If deemed a controlled action, assessment occurs under the EPBC Act, and a decision is made as to whether to grant approval.

The Project was referred to the Commonwealth Minister for the Environment and was determined to be a controlled action on 1 February 2021 (EPBC 2020/8850, as varied 23 December 2023) and will be assessed in accordance with the State and Commonwealth bilateral agreement. The Secretary determined that the following controlling provisions apply:

- world heritage properties;
- national heritage places; and
- nationally threatened species and ecological communities.

Of these, one is directly relevant to aquatic ecology (nationally threatened species and ecological communities), and the remaining two may be indirectly relevant to aquatic ecology. This AEIA aims to evaluate whether these MNES are applicable. 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 Department of Agriculture Water and the Environment (2020) released a provisional list of animal species identified as requiring urgent management intervention following the 2019/2020 bushfire season in southern and eastern Australia (20 March 2020). Most of the species have potentially had at least 30% of their range burnt. The list includes several 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. The Eastern Freshwater Cod (*Maccullochella ikei*) and the Platypus (*Ornithorhynchus anatinus*) are included on this list, with the Platypus listed as "*species that are provisionally* included as high priority whilst more information is gathered" and has been included as a threatened species in this report.

4. Methods

4.1. Aim And Objectives

The aim of the AEIA is to identify key fish habitat, listed habitat, threatened communities, populations or species that may be impacted by the construction and operation of the Project. The specific objectives were to:

- describe existing aquatic biodiversity values and existing environment;
- identify and assess the potential for occurrence of aquatic biodiversity values relevant to the Project, including threatened species, populations and communities listed under the FM Act, the BC Act, and the EPBC Act and associated policies and guidance material; and
- identify direct, indirect and cumulative impacts to aquatic biodiversity values that have the potential to occur as a result of the Project and assess these impacts.

To address the aim and objectives, the following tasks were undertaken:

- database searches and a literature review (Section 4.2);
- aquatic ecology field survey of sites along the Macleay River and its tributaries, as well as waterways along proposed linear infrastructure, including:
    - assessment of key fish habitat using a combination of habitat sensitivity (waterway type) and water classification (waterway class) to determine if the Macleay River and associated waterways meet the definition of 'key fish habitat';
    - cataloguing of photographs at each site assessed along the waterways;
    - assessment of the suitability of identified habitats, including riparian vegetation, to support threatened aquatic species, communities or populations; and
    - collection of abiotic and biotic samples to aid in determining existing environmental values and documenting identified threatened communities, populations and species.
- laboratory analysis of abiotic and biotic samples collected during the March 2022 and June 2022 field surveys, and associated data management; and
- preparation of this AEIA, incorporating key findings and undertaking impact assessment for the Project, with provision of recommendations, where required.

4.2. Desktop Assessment

4.2.1. Database Searches

Database searches were undertaken by EMM Australia Pty Ltd (EMM) and Stantec to compile background information and to inform the likelihood of occurrence of threatened communities, species or populations that may inhabit waterways with the potential to be impacted by the Project (to within 50 km of the Project area). As part of the desktop assessment, the following databases and datasets were reviewed:

- Freshwater threatened species distribution maps (DPI Fisheries);
- Threatened species lists (DPI Fisheries);
- Australian Ramsar Wetlands: Internationally Important Wetlands (DCCEEW);
- Key Fish Habitat maps (DPI Fisheries);
- Groundwater Dependent Ecosystems Atlas (Bureau of Meteorology);
- Fisheries NSW Spatial Data Portal (DPI Fisheries);
- BioNet Atlas (DPIE);
- Protected Matters Search Tool (PMST) (DCCEEW);
- Provisional list of animals requiring urgent management intervention (DCCEEW);
- Directory of Important Wetlands: Nationally Important Wetlands (DCCEEW);
- Fish stocking (DPI Fisheries);
- WaterInsights portal (WaterNSW);
- NSW Fish Passage Database (DPI Fisheries); and
- Climate data online (Bureau of Meteorology).

4.2.2. Literature Review

A review of publicly available literature relating to aquatic 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, journals, and relevant government, university or regulatory publications. A limited number of aquatic studies (to within 200 km) have been undertaken in the vicinity of the Project.

4.3. Likelihood Of Occurrence Assessment

The criteria for assessing the likelihood of occurrence of threatened species included in Section 5.6.1 and summarised in Table 4-1. It should be noted that, while Commonwealth and State data sources indicate possible presence of species and habitats, local conditions should be considered when determining their actual likelihood of occurrence. Threatened habitats and/or communities that have the potential to be indirectly impacted by downstream effects are included in the assessment, as are populations and/or species that have the potential to occur within 50 km of a project and/or the Macleay River catchment. If the likelihood of occurrence of populations or species are identified as being unlikely or negligible, they have not been considered further than the desktop assessment.

Table 4-1: 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
Unlikely	• Based on data collected during the field survey, it was considered that the species was unlikely to occur or use the habitat encountered during the field survey. A species may utilise identified habitat on rare occasions .	No
Possible	• 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
Known	• 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

4.4. Field Survey Design

To aid in determining the ecological values of the Macleay River and associated waterways with the potential to be impacted by the Project, two field surveys were undertaken during March 2022 and June 2022. A total of 56 sites across 38 waterways were assessed upstream, within, and downstream of the Project area (Table 4-2, Figure 4-1). Sampling sites were selected based on the potential degree of impact (e.g. reservoir, road, discharge point) and stream order (Strahler 1952), with preference generally given to waterways 2nd order and above. The field surveys comprised undertaking sampling and assessment of a range of abiotic and biotic components, with biological sampling undertaken at waterways 4th order and above (Table 4-2, Figure 4-1), with the exception of:

- UW02-03 (2nd order) and UW02-04 (3rd order), which were located within the area proposed for the Lower Dam and Reservoir and will be directly impacted as a result of inundation. Both sites contained surface water during the March 2022 and June 2022 field surveys, due to preceding high rainfall events; therefore, they were included in biological monitoring; and
- PC01 (4th order), an accessible reach of Peach Tree Creek which was located upstream of a waterfall which flows into the Macleay River. However, due to the significance of the waterfall as a fish passage barrier, the site was not included in biological sampling.

Habitat characterisation and key fish habitat was assessed at all 56 sites, while sampling of abiotic and biotic components was completed at a subset of up to 14 sites during the March 2022 and June 2022 field surveys. This was due to a number of factors including stream order classification, site accessibility, habitat characteristics and fish passage barriers.

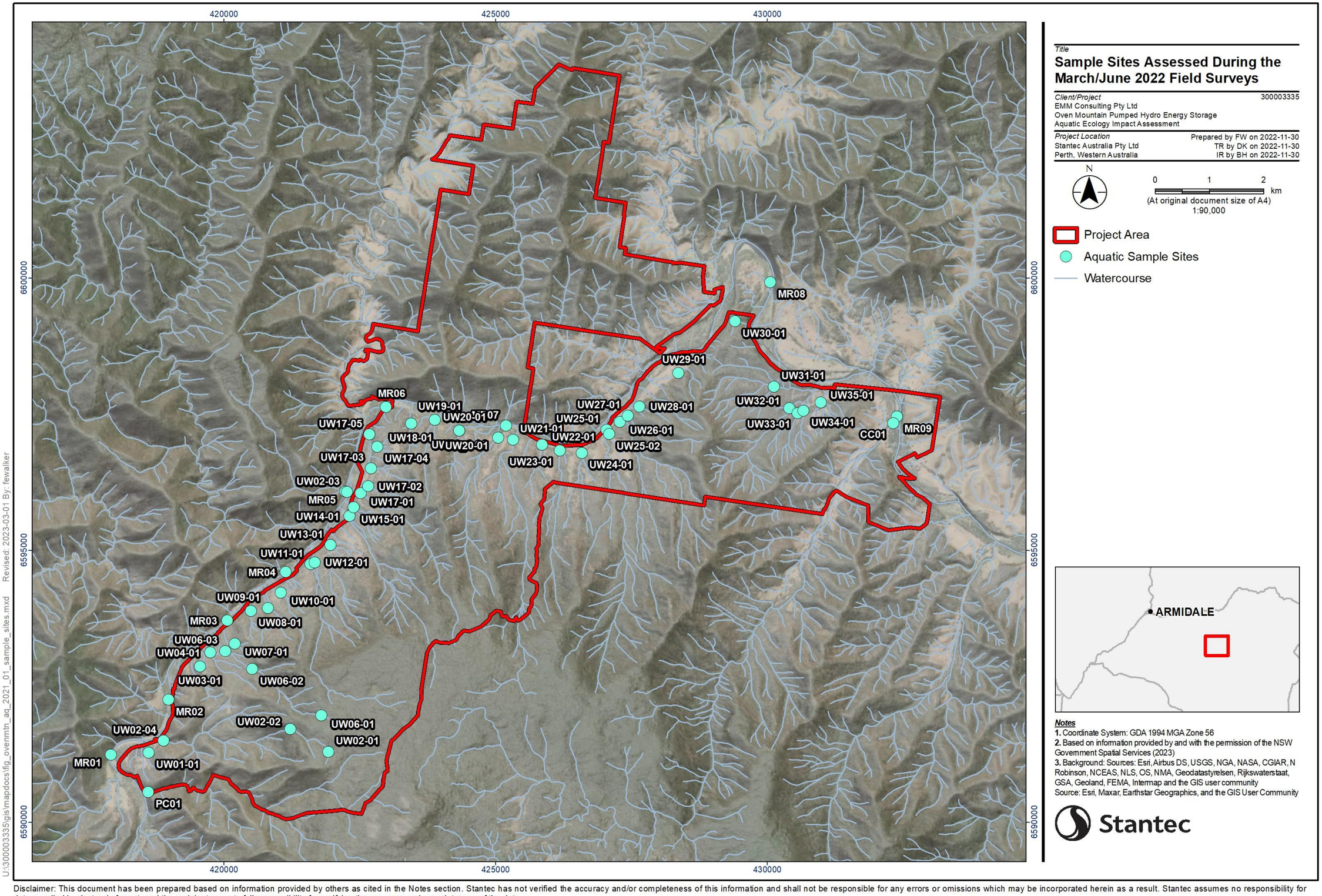
4.4.1. Field Team

The March 2022 and June 2022 field surveys were undertaken by Aquatic Ecology Services, comprising Tara Steele (Field Team Lead) and Terry Vallance (Field Team Support), with more than 30 years of combined experience in this discipline. Tara Steele is an Aquatic Ecologist with 12 years' experience in undertaking freshwater, groundwater-dependent and estuarine ecosystem assessments. She has worked extensively across Australia, undertaking fish, macroinvertebrate, water quality and stygofauna surveys for compliance monitoring and impact assessments. Terry Vallance's fields of expertise are fish biology, behaviour, and taxonomy. He has more than 25 years' experience in conducting aquatic ecology studies throughout Australia, largely in remote areas. Field sampling was undertaken in accordance with DPI Fisheries s 37 FM Act Scientific Collection Permit No P19/0025-1.0.

Table 4-2: Sampling site locations and components assessed during the March 2022 and June 2022 field surveys.

Project Area	Site	Latitude	Longitude	Potential Impact	Stream Order	Key Fish Habitat	Water Quality	Sediment Quality	eDNA	Aquatic Vertebrates	Macro-invertebrates
Macleay River	MR01	30.8091327	152.1418999	Reference site: no impact	9	June 2022	March 2022	March 2022	March 2022	June 2022	June 2022
	MR02	30.8000834	152.1530596	Pump station: water extraction	9	June 2022	-	-	-	June 2022	June 2022
	MR03	30.7870514	152.1644559	Downstream water extraction	9	June 2022	March 2022	March 2022	March 2022	June 2022	June 2022
	MR04	30.7790613	152.1757442	Water extraction	9	June 2022	March 2022	March 2022	March 2022	June 2022	June 2022
	MR05	30.7657944	152.1873576	Downstream water extraction / discharges	9	June 2022	March 2022	March 2022	March 2022	June 2022	June 2022
	MR06	30.7518159	152.1953029	Proposed bridge / road, downstream extraction / discharge	9	June 2022	-	-	March 2022	June 2022	June 2022
	MR07	30.7550662	152.2183669	Downstream of project	9	June 2022	-	-	-	June 2022	-
	MR08	30.7315370	152.2693285	Proposed bridge/road, downstream of project	9	June 2022	-	-	-	June 2022	June 2022
	MR09	30.7539758	152.2934717	Proposed bridge/road, downstream of project	9	June 2022	-	-	-	June 2022	June 2022
Upper Dam and Reservoir	UW02-01	30.8089515	152.1837262	Within Upper Dam and Reservoir	2	March 2022	-	-	-	-	-
	UW02-02	30.8051412	152.1764285	Downstream of Upper Dam and Reservoir	2	March 2022	-	-	-	-	-
	UW06-01	30.8029227	152.1824165	Spoil storage	1	March 2022	-	-	-	-	-
Lower Dam and Reservoir and Access Road	PC01	30.8153752	152.1489948	Groundwater drawdown	4	June 2022	-	-	-	-	-
	UW01-01	30.8088373	152.1491195	Groundwater drawdown	2	June 2022	-	-	-	-	-
	UW02-03	30.7658803	152.1876897	Within Lower Dam and Reservoir	2	June 2022	March 2022	March 2022	March 2022	June 2022	June 2022
	UW02-04	30.8068975	152.1520653	Within Lower Dam and Reservoir	3	June 2022	March 2022	March 2022	March 2022	June 2022	-
	UW03-01	30.7945970	152.1591327	Excavation spoil storage	3	June 2022	-	-	-	-	-
	UW04-01	30.7923284	152.1611404	Construction pads	2	June 2022	-	-	-	-	-
	UW06-02	30.7951120	152.1692090	Road	2	June 2022	-	-	-	-	-
	UW06-03	30.7920800	152.1640280	Road, construction pads	2	June 2022	-	-	-	-	-
	UW07-01	30.7908860	152.1658550	Road, construction pads	2	June 2022	-	-	-	-	-
	UW08-01	30.7854510	152.1690040	Road crossing	2	June 2022	-	-	-	-	-
	UW09-01	30.7850390	152.1722890	Road crossing	2	June 2022	-	-	-	-	-
	UW10-01	30.7824580	152.1748210	Construction pad	2	June 2022	-	-	-	-	-
	UW11-01	30.7778040	152.1805610	Road crossing	3	June 2022	March 2022	March 2022	March 2022	June 2022	-
	UW12-01	30.7774888	152.1813488	Road crossing	3	June 2022	March 2022	March 2022	March 2022	June 2022	-
	UW13-01	30.7746721	152.1844309	Road crossing	3	June 2022	-	-	March 2022	-	-
	UW14-01	30.7698583	152.1881177	Road crossing	3	June 2022	-	-	March 2022	-	-
	UW15-01	30.7684301	152.1889016	Road crossing	3	June 2022	-	-	March 2022	-	-
	UW17-01	30.7661138	152.1902743	Road crossing	2	June 2022	-	-	-	-	-
	UW17-02	30.7649412	152.1917289	Road crossing	1	June 2022	-	-	-	-	-
	UW17-03	30.7619503	152.1923311	Road crossing	2	June 2022	-	-	-	-	-
	UW17-04	30.7583934	152.1935332	Road crossing	3	June 2022	-	-	-	-	-
	UW17-05	30.7563339	152.1920736	Road crossing	4	June 2022	-	-	March 2022	-	-

Project Area	Site	Latitude	Longitude	Potential Impact	Stream Order	Key Fish Habitat	Water Quality	Sediment Quality	eDNA	Aquatic Vertebrates	Macro-invertebrates
Eastern Access Road	CC01	30.7550909	152.2927429	Proposed bridge/road crossing	5	June 2022	-	-	-	June 2022	June 2022
	UW18-01	30.7546096	152.2001025	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW19-01	30.7540004	152.2046128	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW20_1-01	30.7558070	152.2093224	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW20-01	30.7570044	152.2168131	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW20-01	30.7558070	152.2093224	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW21-01	30.7573924	152.2196358	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW22-01	30.7582404	152.2252652	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW23-01	30.7592532	152.2286402	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW24-01	30.7596573	152.2328640	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW25-01	30.7558449	152.2376835	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW25-02	30.7565365	152.2381102	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW26-01	30.7545674	152.2402132	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW27-01	30.7535307	152.2417708	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW28-01	30.7520277	152.2440308	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW29-01	30.7465068	152.2515230	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW30-01	30.7379779	152.2624957	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW31-01	30.7488552	152.2698588	Road crossing / proposed transmission line	4	June 2022	-	-	-	-	-
	UW32-01	30.7524865	152.2728413	Road crossing / proposed transmission line	4	June 2022	-	-	-	-	-
	UW33-01	30.7532800	152.2743625	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-
	UW34-01	30.7528925	152.2755305	Road crossing / proposed transmission line	2	June 2022	-	-	-	-	-
	UW35-01	30.7515813	152.2788595	Road crossing / proposed transmission line	3	June 2022	-	-	-	-	-



Title

Sample Sites Assessed During the March/June 2022 Field Surveys

Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

0 1 2 km

(At original document size of A4)
1:90,000

- Project Area
- Aquatic Sample Sites
- Watercourse

Notes

1. Coordinate System: GDA 1994 MGA Zone 56

2. Based on information provided by and with the permission of the NSW Government Spatial Services (2023)

3. Background: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Stantec

U:\300003335\gis\mapdocs\fig_ovenmtn_aq_2021_01_sample_sites.mxd Revised: 2023-03-01 By: fewalker

Figure 4-1: Sample site locations assessed during the March 2022 and June 2022 field surveys.

4.4.2. Habitat Characterisation

At all 56 sites across the two field surveys, 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;
- native riparian vegetation condition, cover and presence of introduced plants and weeds;
- waterway morphology and presence/absence/flow of surface water;
- refuge availability (snags, aquatic vegetation, rocks, surface water pools, etc.);
- amount of erosion, bank incision, and livestock impact;
- identification of sensitive habitat features as described by Department of Primary Industries (2013);
- identification of habitat preferred by listed species with the potential to occur; and
- any significant fish passage barriers.

Each site was assessed along the waterway for approximately 100 m in length. Sites on the Macleay River were assessed along approximately 500 m due to the higher stream order and greater waterway width. Photographs were taken at all sites to provide a record of habitat conditions (Appendix A) and a drone was deployed to assist assessment of difficult to access areas. Drone surveys were undertaken by an accredited operator and included photography of notable habitat features using a polarised filter.

The content of the AEIA is limited to aquatic and riparian habitat and does not address terrestrial ecology. Riparian vegetation is defined by the Department of Primary Industries (2005) as "*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 (groundcovers, understorey and canopy). Each waterway assessed has an existing order rank according to the Strahler (1952) method of stream ordering.

4.4.3. Key Fish Habitat

In accordance with *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries 2013), habitat sensitivity was assessed at the 56 sites during the field surveys by assigning a 'waterway type', while the functionality of the waterway as 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 AEIA, of the waterway types and waterway classes are summarised in Table 4-3 and Table 4-4, respectively, and are provided in full in Appendix B. Department of Primary Industries (2013) only recognises native aquatic plants for waterway type classification; where unknown, a conservative approach was taken, potentially overestimating the native vegetation component of waterway type classification.

Table 4-3: Waterway type definitions for habitat sensitivity.

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

Table 4-4: Waterway class definitions.

Classification	Characteristics of Waterway Class
Class 1 – Major key fish habitat	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 key fish habitat	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 key fish habitat	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 key fish habitat	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).

4.4.4. Water Quality

In situ physicochemical parameters were measured at a subset of eight sites during the field surveys using a multiparameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications. Water quality readings were taken at a depth of approximately 10 cm and recorded parameters included pH, electrical conductivity (µS/cm), dissolved oxygen (mg/L and %), turbidity (NTU) and temperature (°C) (Appendix C).

Surface water samples were collected at a subset of eight sites, using sterilised bottles provided by the NATA-accredited Australian Laboratory Group (ALS), containing preservative where required. Bottles were completely filled with water and sealed, excluding air from the samples where possible. Samples were then couriered to ALS Smithfield for analysis (Table 4-5). Holding times[2] were breached for turbidity (MR01, MR03, MR04, UW02-04, UW11-01) and organic carbon (total; MR01, MR03, MR04, MR05, UW02-03, UW02-04, UW11-01, UW12-01); therefore, these results should be considered indicative only.

Surface water quality data was compared to Foged (1978) for pH, categorising acidic water (4.5 to 6.5), neutral water (6.5 to 7.5), and alkaline water (>7.5). Salinity was compared to Hammer (1986), classifying surface water into freshwater (<3,000 mg/L), hyposaline (3,000 to 20,000 mg/L), mesosaline (20,000 mg/L to 50,000 mg/L) and hypersaline (>50,000 mg/L) categories. Basic water quality parameters and nutrient concentrations were compared to the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) guideline trigger values (also aligned with the water quality objectives (WQOs) in NSW) representative of slightly disturbed freshwater upland river ecosystems in south-east Australia (where available). Metal concentrations were compared to the Australian & New Zealand Guidelines (ANZG) for Fresh & Marine Water Quality (Water Quality Australia 2018) toxicant default guideline values (DGVs) for the protection of 95% of species in freshwater, representative of slightly to moderately disturbed ecosystems for south-eastern Australian upland rivers (where available).

4.4.5. Sediment Quality

Surface sediment samples were collected at the same eight sites as surface water samples during the field surveys (Table 4-2, Figure 4-1), 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 (Table 4-6). Holding times were breached for moisture content at sites MR01, MR03, MR04, UW02-03, UW02-04, UW11-01 and UW12-01; therefore, these results should be considered indicative only.

Sediment pH was compared to Hazelton and Murphy (2007), the classification of which ranges from very strongly acidic (<5.0) to very strongly alkaline (>9.0). Metal concentrations were compared to the sediment DGV and guideline value high (GV-High) (Water Quality Australia 2018), where available.

[2] *Sample holding time is generally defined as the time between sample collection and completion of analysis in a laboratory, with recommended holding times provided by the analytical laboratory to ensure accurate analytical results are provided.*

Table 4-5: Water quality parameters analysed from surface water during the March 2022 field survey.

Basic	Major Ions	Nutrients	Dissolved Metals and Trace Elements	
Total dissolved solids	Sodium	Nitrogen (total)	Arsenic	Lead
Turbidity	Calcium	Kjeldahl nitrogen (total)	Barium	Manganese
	Magnesium	Nitrite + Nitrate	Beryllium	Mercury
	Potassium	Phosphorus (total)	Boron	Nickel
	Chloride	Organic carbon	Cadmium	Selenium
	Bicarbonate	Organic carbon (total)	Chromium	Vanadium
	Sulphate		Cobalt	Zinc
	Carbonate		Copper	
	Hydroxide			
	Alkalinity (total)			

Table 4-6: Sediment quality parameters analysed during the March 2022 field survey.

Basic	Nutrients	Total Metals and Trace Elements	
Moisture content	Nitrogen	Aluminium	Lead
	Kjeldahl Nitrogen	Antimony	Manganese
	Nitrite + Nitrate	Arsenic	Mercury
	Phosphorus	Barium	Molybdenum
	Organic Carbon (%)	Beryllium	Nickel
		Boron	Selenium
		Cadmium	Silver
		Chromium	Strontium
		Cobalt	Vanadium
		Copper	Zinc
		Iron	

4.4.6. Aquatic Invertebrates

During the June 2022 field survey, macroinvertebrate samples were collected from a subset of 10 of the 56 sites assessed (Table 4-2, Figure 4-1). A 250 µm D-frame mesh net was used to sample macroinvertebrates, with riffles (fast-flowing, broken water over rocky substrate, including cobbles and boulders) predominantly sampled at the majority of the Macleay River sites, and composite samples (combined riffle and edge habitat) collected from sites within tributaries of the Macleay River. The collection of the riffle and composite samples followed methods outlined in Department of Environment and Conservation (2004) and was completed by an AUSRIVAS (Australian River Assessment System) accredited sampler.

Samples were live picked for a minimum of 40 mins in accordance with AUSRIVAS methods (Department of Environment and Conservation 2004). Macroinvertebrate samples were sent to an AUSRIVAS-accredited taxonomist for identification to genus level. River bioassessment scores were generated for each site where macroinvertebrate sampling took place, with the results providing an indication of habitat quality at each site in the context of suitability for macroinvertebrates. Raw macroinvertebrate data and bioassessment score calculations are presented in Appendix A.

4.4.7. Aquatic Vertebrates

During the June 2022 field survey, aquatic vertebrates were assessed at a subset of 14 sites (Table 4-2, Figure 4-1), using a number of methods to sample fish, the Platypus and turtles, including a backpack electrofisher, seine net, gill net, bait traps and eDNA water sampling. This combination of methods maximised the diversity of species captured, whilst not interfering directly with the habitat of any threatened species, consistent with the conditions of Aquatic Ecology Services' Scientific Collection Permit (P19/0025-1.0). All native fish were released in good condition. Non-native fish were euthanised. Fish sampling effort for each site is presented in Appendix A. It should be noted that boat-based electrofishing was not possible due to a lack of launch access, and that additional, deep-water habitats could have been targeted if this method could have been employed. Aquatic vertebrate (fish) nomenclature is reported in alignment with Allen *et al.* (2002), excluding the Dwarf Flathead Gudgeon (*Philypnodon macrostomus*), which was described by Hoese and Reader (2006), and the Eel-tailed Catfish (*Tandanus tandanus*), which is used by the Department of Primary Industries (2020).

4.4.7.1. Electrofisher

Electrofishing was undertaken at 13 sites to assess the presence of small-bodied fish, large-bodied fish and turtles. Electrofishing[3] involves passing an electrical current through water, stunning aquatic fauna so that they can be netted and identified. Water temperature was monitored concurrently 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. In areas of shallow water, a backpack electrofisher (Smith-Root LR20B) was used to maximise spatial coverage and sampling effort at each site, which enabled targeted sampling in pools and along undercut banks.

The timing (seconds) of electrofishing employed (also dependent on equipment type) was proportional to the amount of available habitat. 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 container fitted with an aeration system. Taxonomic verification was undertaken *in situ* at all sites using appropriate taxonomic literature. The first 20 individuals of each species caught per site were measured (fork length, or total length for species with convex or truncate caudal fins) and, once recovered, were gently returned to the same waterway in an area of slow flow near the bank. The electrofisher was cleaned before leaving each site to prevent transfer of specimens and pathogens.

4.4.7.2. Gill Net And Seine Net

A gill net was deployed in deeper water to target schooling fish. Mesh size was selected to exclude the capture of small-bodied fish. An unweighted gill net of 25 m in length, with a 3 m drop and a 6.35 cm mesh was set perpendicular to the waterway bank in still or slow-flowing water or angled downstream with increasing flow velocity. Sampling at dawn and dusk was avoided to reduce the likelihood of capturing the Platypus. The gill net was manned by a spotter to allow for clearance of bycatch. A 10 m long seine net with a mesh gauge of 5 mm, was also deployed by two people perpendicular to the waterway bank. In flowing water, seining was undertaken against the direction of water flow.

4.4.7.3. Bait Trap

Bait traps were deployed to target small-bodied fish. Entrance openings were small enough to avoid capture of larger animals such as the Platypus and turtles. Each trap was baited with cat biscuits secured in a pouch. The traps were deployed upon arrival at site and removed upon completion of all other sampling components at that site. Due to the large distances between sites, bait traps were deployed at each site for as long as practicable, considering travel distance between sites, accessibly, and landholder access requirements. Captured fish were processed on a flat area immediately adjacent to the site. If specimens were unable to be identified immediately on removal from the trap, they were transferred into a holding container fitted with an aeration system and held for a short period to undertake identification. Taxonomic verification was undertaken *in situ* at all sites using appropriate taxonomic literature. Bait traps were cleaned and dried before leaving each site to prevent transfer of specimens and pathogens.

[3] *Electrofishers are maintained and operated in strict accordance with Australian Code of Electrofishing Practice (1997).*

4.4.7.4. eDNA Sampling

Water samples for eDNA analysis were collected from 13[4] sites and subject to metabarcoding, to assess the presence of the Platypus, and fish species. At each site, water samples were collected in triplicate by passing up to 2,000 mL of water (average 962 ml) through a 1.2 µm syringe filter. Clean sampling protocols were employed to minimise contamination, with new sampling equipment at each site, avoiding entering the water, and taking care not to transfer soil, water or vegetation between sites. After filtering, a preservative (approximately 0.5 ml 10xTris-EDTA) was added to the filters to minimise DNA degradation. Filters were stored out of sunlight and kept at ambient temperature before being couriered to Enviro DNA in Parkville, Victoria, for analysis.

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 concentrations 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 at species from a site at that point in time; therefore, results should be considered indicative only. It should be noted that eDNA analysis did not distinguish between the *Common Carp[5] and the *Goldfish.

4.4.7.5. Opportunistic Observation

Opportunistic observations were made before, during and after entering the water to conduct aquatic vertebrate sampling by assessing waterway banks for areas of consolidated material that was suitable for Platypus burrowing, while feeding and transit habitat were also noted. Where suitable habitat for Platypus and/or turtles were observed, a more detailed search of banks for burrows and potential burrowing material was completed. No targeted surveys were conducted for turtles, but during all fish and macroinvertebrate surveys turtles were recorded were sighted, along with potential nesting habitat.

4.5. Data Management And Statistical Analysis

4.5.1. Water and Sediment Quality

4.5.1.1. Multivariate Statistics

Multivariate analysis involves the statistical analysis of more than one parameter at a time. Principal components analysis (PCA) was used to assess water and sediment quality. A PCA is an explanatory tool and was applied to the 2022 water and sediment quality data. Where values were recorded as below detection, a value equal to half the limit of reporting was substituted. Select parameters were transformed to reduce skewness (ensuring the data was normally distributed) and collinear variables (those that have a linear relationship) were removed during pre-treatment of the data. The results of the PCA have been shown in the form of a plot, with sites that are similar located closer together. Vectors radiate from the centre of the plot, representing the influence of each parameter, with higher concentrations tending to occur near the end point of the vector. The percentage variance is used to explain the strength of the PCA; presented over the first two axes of the plot. A value of more than 60% is considered a useful interpretation of the data (Clarke and Warwick 2001).

4.5.2. Aquatic Invertebrates

Standard metrics for macroinvertebrate communities were calculated as follows (Department of Environment and Conservation 2004):

- Taxa richness (Family and Genus) – Total number of taxa present at the site used as a measure of diversity of families (used for long-term data analysis).
- EPT richness – Total number of families from orders Ephemeroptera, Plecoptera and Trichoptera (EPT). EPT taxa are generally more sensitive to disturbance.
- SIGNAL-2 – A biotic index that allocates a value to each macroinvertebrate family based on their sensitivity to pollution and provides an average of those indices across the sample. Although this AEIA is not aiming to

[4] *Only 13 sites were sampled for eDNA during June 2022, as versus electrofishing at 14 sites in March 2022, as one site wasn't accessible during June 2022.*
[5] * *indicates an exotic species.*

understand the impact of point source pollution, the SIGNAL-2 score allows for a general understanding of the sensitivity of taxa inhabiting the Macleay River and associated tributaries.

Differences in the macroinvertebrate community structure was undertaken using non-metric multidimensional scaling (nMDS) ordination, which provides a representation of the relative similarity of sites based on the assemblage. The more similar sites are to each other based on composition, the closer they are located in the nMDS ordination space. The nMDS plots were used to display the similarity between sites along the Macleay River. A similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient was calculated. Stress, which is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions, was used to gauge the reliability of the patterns presented in the two-dimensional nMDS plots. Stress levels <0.20 have high reliability and are a good representation of site similarity (Clarke *et al.* 2014).

4.6. Limitations

Stantec has relied on information provided by third parties including EMM and Aquatic Ecology Services, to undertake this assessment. Errors or omissions in the provided data and/or reports could affect the validity of the assessment. Data pertaining to metal concentrations within the catchment and terrestrial environments was provided by EMM and results are not necessarily applicable to aquatic environments. Data informing the March 2022 and June 2022 field surveys and assessments was provided by Aquatic Ecology Services and not all raw data has been reviewed by Stantec. While some species have been assessed as having a low likelihood of occurrence, it is acknowledged that this does not indicate the species will never occur. Rather, it means that based on the desktop assessment and/or the field surveys 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; therefore, it is unlikely to be impacted by a proposed project. Further, aquatic ecology field surveys provide a sample of the conditions and species present at a site and point in time. However, not all of the predicted species may be recorded, due to their absence within the catchment/waterway, low abundance, variability in distribution within a catchment/waterway, seasonality and diurnal preferences, water temperature changes, and species activity at the time of sampling.

5. Desktop Assessment Results & Discussion

5.1. Biogeographical Context & Land Use

The Project area is located in the North Coast IBRA Bioregion (Figure 5-1), covering approximately 2,392 ha. This bioregion is one of the most diverse in terms of geology and geomorphology, and also supports a diverse range of flora and fauna. It is intersected by the Macleay River, with the Carrai National Park to the east, and the Cunnawarra National Park, Oxley Wild Rivers National Park and Carrai State Conservation Area proximate to the Project area. Much of the Project area contains undulating and steep terrain ranging in elevation from approximately 150 m to 1,000 m above sea level with vegetation coverage ranging from dense to cleared. The Project area is bordered to the south by Oxley Wild Rivers National Park, which forms part of the Gondwana Rainforests of Australia (GRA). The GRA is also nearby to the western border of the Project area where the Macleay River is situated between the Project area and the GRA (close to its western bank). Additionally, there are declared wilderness areas (under the NSW *Wilderness Act 1987*) proximate to the Project area.

Land use within the Macleay River catchment is diverse and includes fishing, cropping, grazing, mining, forestry, commercial applications, urban development and National Parks. The dominant land uses within the catchment are agricultural grazing (53%) and vegetated area (26%). Most of the vegetated area exists through the gorge and midland hill regions (Ryder et al. 2016). The Project area itself is zoned RU1 Primary Production under the Armidale Dumaresq Local Environmental Plan 2012 (the LEP). The Project area is predominantly freehold land and currently used for recreational purposes, logging and livestock agistment. Predominant land uses in the surrounding area include agriculture, forestry, national parks and reserves and rural residential development. There is no Biophysical Strategic Agricultural Land (BSAL) identified within the Project area; however, there is some BSAL identified north of the Project area, along Kempsey Road. BSAL is identified as land with high quality soil and water resources capable of sustaining high levels of agricultural productivity.

5.2. Climate & River Flow

The climate of the Macleay River catchment ranges from subtropical in the lower coastal areas, a sub-humid climate on the slopes, to temperate conditions in the higher elevation areas. A rainfall gradient exists from east to west following the topography of the catchment with lower rainfall experienced on the New England Tablelands and higher rainfall towards the coast. Average annual rainfall ranges from approximately 1,250 mm/year at Kempsey to 750 mm/year at Armidale (EMM Consulting 2022e). The majority of annual rainfall typically occurs during summer and early autumn; however, large rainfall events may occur at any time of the year (EMM Consulting 2022e). Summer and autumn rainfall increases towards the coastal areas of the catchment with monthly rainfall exceeding monthly evaporation from February to June. Greater rainfall deficits are experienced at higher elevations during summer and autumn compared to the location of the Project (EMM Consulting 2022e). However, rainfall is observed to marginally exceed evaporation during winter. The difference between monthly rainfall and evaporation totals is similar across the catchment in spring. Less of a rainfall deficit is experienced at elevation during spring compared to the rest of the catchment.

Seasonal flow duration curves for the Macleay River, downstream of Georges River Junction, indicate that streamflow is generally observed 100% of the time, with a perennial flow regime and constant baseflow contribution. The volume of streamflow generated per square kilometre of catchment generally increases from west to east corresponding with the rainfall gradient. The lowest streamflow occurs during spring when monthly rainfall totals are lower, and evaporation exceeds rainfall. During winter, streamflow is lower than summer, autumn and on an annual basis. However, low flows during winter exceed summer and annual low flow values, which may be a result of lower runoff and transmission losses due to reduced evaporation rates; particularly on plateau where average monthly rainfall exceeds average monthly evaporation during winter. The highest summer median daily streamflow ranges from 671 ML/day in January to 1,193 ML/day in March as a result of runoff from elevated rainfall (EMM Consulting 2022e). However, the January to March contribution to annual streamflow is highly variable and ranges from as little as 4% of annual streamflow up to 91% of annual streamflow, depending on annual rainfall distribution.

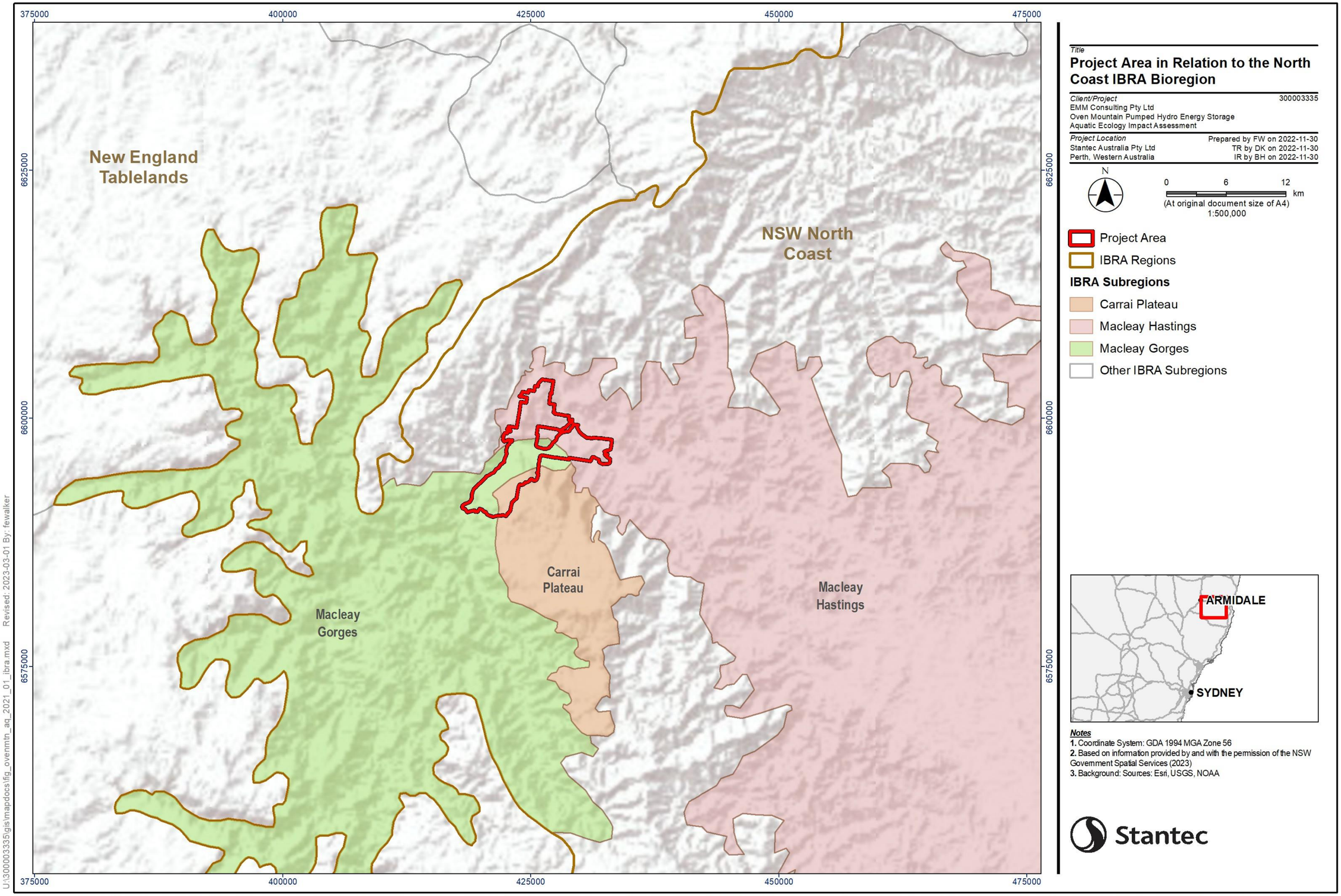


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Figure 5-1: Project area in relation to the North Coast IBRA Bioregion.

5.3. Geology

The Project lies within the New England Orogen[6] which extends approximately 2,000 km along the east coast of Australia from Townsville, QLD to Newcastle, NSW (EMM Consulting 2022d), and is bordered by the Sydney-Gunnedah-Bowen Basin to the west (EMM Consulting 2022d). Differing geodynamics in the early Permian to Triassic led to a series of linked pluton structures (known collectively as the New England Batholith), which intruded the sedimentary units of the Permian-aged Parrabel Beds and Carboniferous-aged Pee Dee Beds. The Triassic-aged Carrai Granodiorite; a plutonic structure outcropping over approximately 168 km^2, is the dominant geological unit occurring within the Project and is a product of the New England Batholith (EMM Consulting 2022d).

Deposits of alluvial and colluvial soils occupy the incised valleys which support the ephemeral waterways formed across the upper escarpment. The deposits become more substantial in the lower escarpment and plain area (further along the geomorphological profile of the streamline), reflecting the increased energy of the environment and wider catchment area, and generally comprise sub-rounded to rounded boulders, cobbles, gravel and sand. Further down the catchment, along the Macleay River and within the riparian zone, the surficial geology comprises of a relatively thin deposit of alluvium, comprising well rounded cobbles, gravel and sand (EMM Consulting 2022d).

5.4. Hydrogeology

Groundwater across the Project area generally flows from the higher elevations of the Carrai Plateau to the lower elevations of the Macleay River. The Macleay River is understood to recharge the adjoining alluvial and fractured rock groundwater systems during periods of high streamflow. The groundwater system releases water back into the Macleay River as baseflow under typical and dry conditions. Many of the ephemeral tributaries across the Project area also receive baseflow contributions from the shallow groundwater system. The surface water and groundwater systems across the Project area are connected via the following key mechanisms:

- Groundwater flows into the Macleay River as baseflow from the shallow fractured rock groundwater system when water levels in the river are low (i.e. during dry conditions).
- Streamflow from the Macleay River flows into the adjoining alluvial and shallow fractured rock groundwater systems when water levels in the river are high (i.e. during wet conditions).
- Groundwater flows into ephemeral streams via springs in the upper tributaries, eventually discharging to the Macleay River.

Localised groundwater systems in the upper reaches of the Project area flow into fens and eventually support the ephemeral stream system. This surface water-groundwater interaction occurs in small, isolated pockets across the Project area.

5.5. Hydrology, Aquatic Habitats & Key Fish Habitat

The Macleay River is a perennial waterway with a catchment area of approximately 11,400 km^2, extending from Armidale (on the Great Dividing Range of NSW) to Hat Head (on the east coast of NSW), more than 100 km to the east-southeast of the Project (Figure 5-2). The main sub-catchments of the Macleay River Basin include the Macleay, the Chandler and the Apsley sub-catchments (Figure 5-2). The river descends through a series of steep gorges before emerging into an area characterised by lower elevation hills downstream of Georges River. The Macleay River meanders a further 140 km before reaching the tidal limit at Belgrave Falls, 10 km upstream of Kempsey (Ryder et al. 2016). The catchment generally comprises relatively impervious rock at the ground surface, leading to rapid water level and streamflow responses in the Macleay River following rainfall. Most of the surface water within the catchment flows to the Macleay River via a series of waterways, including the perennial waterways listed below:

- Peach Tree Creek (within the Project) and Carrai Creek, originating in the upper escarpment and discharging to the Macleay River within the Macleay River floodplain;
- Kunderang Station Creek, originating (immediately southwest of the Project), originating in the upper western catchment and discharging to the Macleay River within the Macleay River floodplain; and
- Three Rock Plain Creek and Little Three Rock Plain Creek (south of the Project), originating in the eastern Carrai Plateau and discharging to the Macleay River to the east of the Project (Figure 5-2).

[6] *An Orogen is a belt of the earth's crust involved in the formation of mountains.*

Ephemeral streams discharge directly to the Macleay River or form upper tributaries to the perennial waterways. The ephemeral streams typically flow for periods proportional to recent duration and magnitude of rainfall (EMM Consulting 2022e), with relatively high flow events evident from the transported boulders and vegetation.

Numerous minor tributaries to the Macleay River traverse the Project area. Catchment characteristics across the Project area are generally uniform and primarily comprise steep bushland. The Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral tributary of the Macleay River which is classified at 2nd order in the vicinity of the upper dam and reservoir and 3rd order in the vicinity of the lower dam and reservoir (Figure 5-3). Fingerboard Crossing Creek has a catchment area of 3.3 km^2 and drains from the Carrai Plateau (Figure 5-2), which is situated to the east of the Project area, to the Macleay River. The waterways of the Macleay River catchment are largely unregulated, with only a small number of road crossings occurring, downstream of the Project area, across Lagoon Creek, Warbro Brook and several unnamed waterways (DPI Fisheries, unpublished data). However, several major dams are in operation within the broader catchment for domestic water use including the Malpas, Dumaresq and Puddledock dams.

Upland swamps occur in the upper reaches of some waterways, with two water-dependent communities of ecological significance identified to occur within vicinity of the Project area:

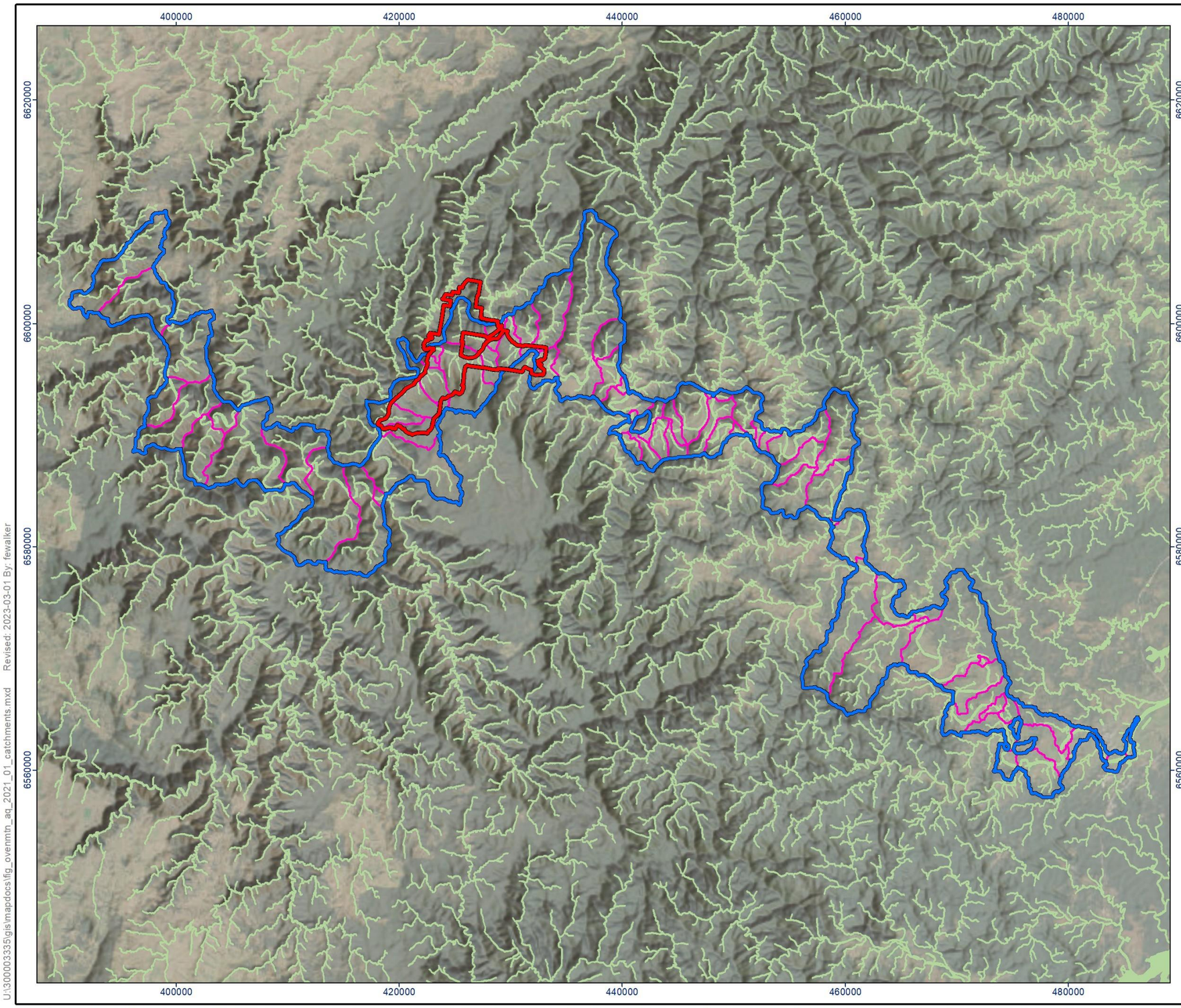
- Round Mountain Swamps (nationally important wetland) – Located more than 30 km northwest of the Project and not directly connected to the Macleay River; however, may be connected via groundwater (EMM Consulting 2022e).
- Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions endangered ecological communities (Montane Peatlands & Swamps EEC) – This EEC occurs at high altitudes on the Carrai Plateau in accumulated peaty or organic-mineral sediment on poorly drained areas at the headwater of waterways, with the potential to be impacted by Project activities (EMM Consulting 2022e).

A third water-dependent community of ecological significance occurs in coastal valleys and floodplains up to 250 m above sea level; Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion EEC. While primarily located closer to the coast, historically, the Macleay River is likely to have supported this EEC as well; therefore, it has the potential to occur within the Project area. Remnant areas may occur within floodplains across the lower slopes (DPIE 2020).

5.5.1. Key Fish Habitat

The key fish habitat map for the Armidale Regional LGA (Department of Primary Industries 2022e) indicates that, of the waterways that intersects Project disturbance footprint (primarily as a result of access road and transmission line infrastructure), more than 20 waterways are mapped as key fish habitat (Figure 5-2), including:

- the Macleay River (9th order waterway);
- Fingerboard Crossing Creek (2nd order to 3rd order) (as a result of upper and lower dam and reservoir construction);
- Georges Creek (6th order waterway);
- Pig Paddock Creek (3rd order waterway);
- Old Yard Gully;
- Chinaman Gully;
- Oaky Creek (3rd order waterway);
- Waterloo Creek;
- Needle Creek;
- Carrols Creek;
- one unnamed 4th order waterway; and
- approximately 10 unnamed 3rd order waterways.



Title

Macleay River Catchment and Sub-catchments with Key Fish Habitats

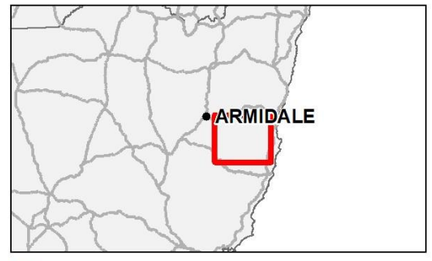
Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

0 6 12 km

(At original document size of A4)
1:500,000

- Project Area
- Key Fish Habitat
- Macleay River Catchment
- Macleay River Subcatchment



Notes

1. Coordinate System: GDA 1994 MGA Zone 56
2. Based on information provided by and with the permission of the NSW Government Spatial Services (2023)
3. Background: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Stantec

U:\300003335\gis\mapdocs\fig_ovenmtn_aq_2021_01_catchments.mxd Revised: 2023-03-01 By: fewalker

Figure 5-2: Macleay River catchment and sub-catchments showing DPI Fisheries key fish habitat classification of waterways.

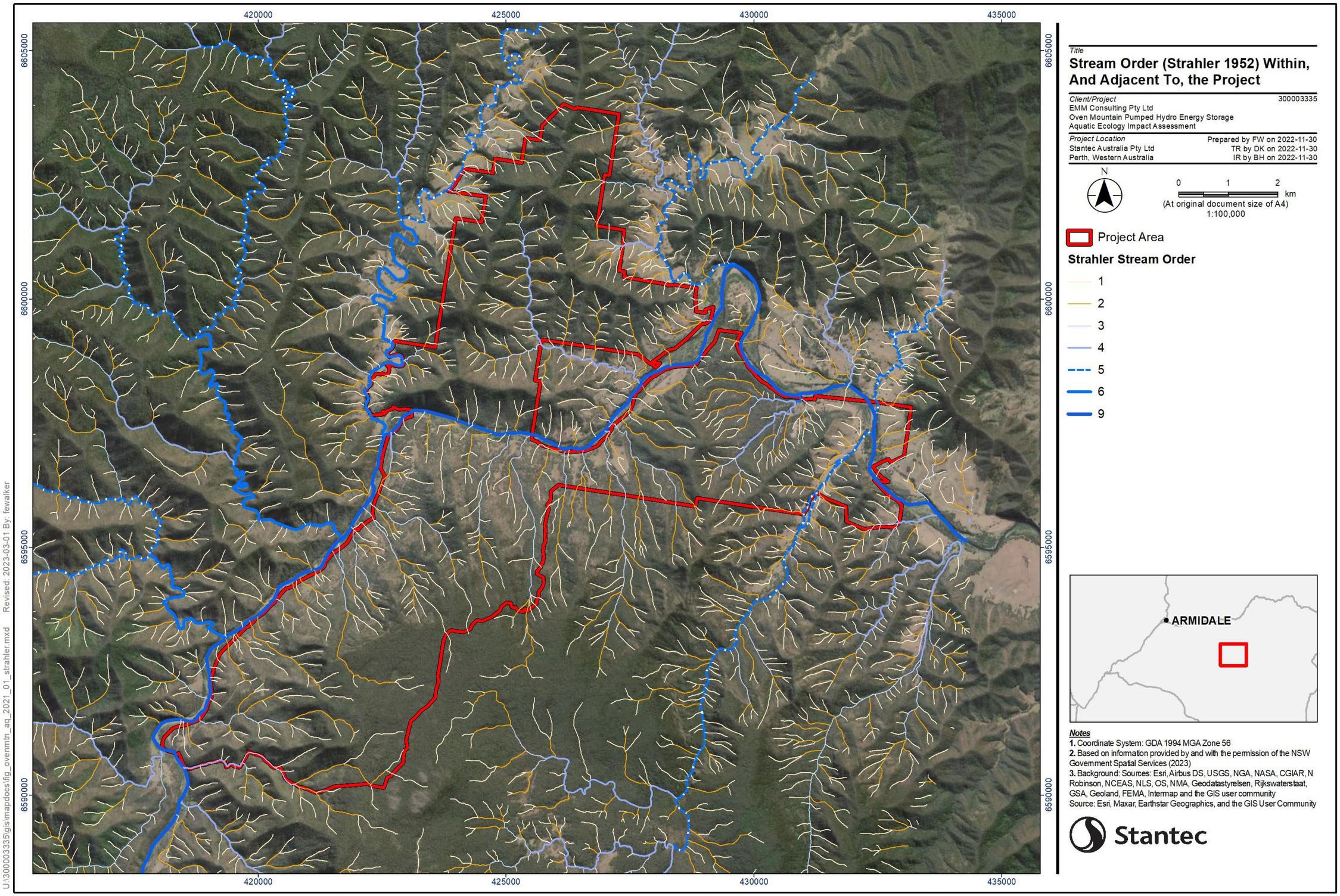


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Figure 5-3: Stream order (Strahler 1952) within, and adjacent to, the Project.

5.5.2. Water & Sediment Quality

Water quality across the Macleay River catchment varies both spatially and temporally with slightly poorer water quality, in comparison to the Macleay River, generally observed from the tributaries on the plateau, influenced by low dissolved oxygen, elevated pH, and high nutrient concentrations (Ryder et al. 2016). The main channel of the Macleay River typically displays good water quality compared to the plateau and associated tributaries; however, nutrient concentrations periodically exceed WQOs (EMM Consulting 2022e). Historic mining within the local catchment has resulted in elevated metal concentrations (e.g. arsenic, antimony), due to runoff occur from the mining area, occurring in the sediment and the water column of several major tributaries of the Macleay River, along with the Macleay River main channel and downstream floodplain (EMM Consulting 2022a;e). When compared to the local waterways across the Project area, the Macleay River is generally characterised by a neutral pH, lower turbidity, and lower dissolved metals concentrations.

5.6. Aquatic Flora & Fauna

No aquatic flora listed under the FM Act or the EPBC Act have been identified in proximity to the Project area. DPI Fisheries provides data on the condition of freshwater fish communities in terms of distribution, diversity and abundance of native and exotic species. The status of the Macleay River is 'good' along its length from its confluence in the northwest with the Chandler River to its confluence with the Belmore River towards the coast (Department of Primary Industries 2022f). Despite the 'good' classification, there has still been some degree of impact to native aquatic fauna within the Macleay River catchment, attributed to introduction of exotic fish, degradation of riparian vegetation and agricultural activities along its length. Several native fish species occur within the Macleay River catchment and/or in proximity to the Project including the Australian Smelt (*Retropinna semoni*), Marbled Eel (*Anguilla reinhardtii*), Freshwater Mullet (*Trachystoma petardi*), Striped Gudgeon (*Gobiomorphus australis*), Eastern Long-necked Turtle (*Chelodina longicollis*) and Macquarie River Turtle (*Emydura macquarii macquarii*) (Butler *et al.* 2015; Department of Planning and Environment 2022a). The Platypus has also been recorded within the catchment numerous times (Department of Planning and Environment 2022a).

The Australian Bass (*Macquaria novemaculeata*) is also known to occur, and this species has been recently stocked as fingerlings downstream of the Project in February 2022 (Department of Primary Industries 2022b). Other recreational fishing species have been stocked in some of the tributaries of the Macleay River, including Felters Creek and Dyke River where the Rainbow Trout (*Oncorhynchus mykiss*) has been released as recently as the 2020/2021 season (Department of Primary Industries 2022b). Other exotic fish species known from the catchment include the *Eastern Gambusia (*Gambusia holbrooki*) and the *Goldfish (*Carassius auratus*) (Department of Planning and Environment 2022a; Department of Primary Industries 2022b).

5.6.1. Threatened Aquatic Fauna

The results of the desktop assessment indicate that a total of five threatened species listed under the FM Act, BC Act and/or EPBC Act, and the Platypus have the potential to occur in waterways associated with the Macleay River catchment:

- Southern Purple-spotted Gudgeon (*Mogurnda adspersa*);
- Eastern Freshwater Cod (*Maccullochella ikei*);
- Western Sawshelled Turtle (*Myuchelys bellii*);
- Bellinger River Snapping Turtle (*Myuchelys georgesi*);
- Manning River Helmeted Turtle (*Myuchelys purvisi*); and
- Platypus.

An assessment was undertaken to evaluate the likelihood of each of these threatened species, and the Platypus, occurring within waterways intersecting, or downstream of, the Project area, based on the habitats likely to be present as well as existing literature and DPI Fisheries datasets (Department of Primary Industries 2022c). Habitat for several species of freshwater turtle was identified by EMM Consulting (2021) as part of the scoping study for the Project. Three threatened turtles listed under the BC Act and/or the EPBC Act identified as potentially occurring adjacent to the Project included the Western Sawshelled Turtle, Bellinger River Snapping Turtle and Manning River Helmeted Turtle (Table 5-1, Figure 5-4). The Southern Purple-spotted Gudgeon is listed as endangered under the FM Act, the Manning River Helmeted Turtle and the Bellinger River Snapping Turtle are listed as endangered and critically endangered under the BC Act, respectively, while the Bellinger River Snapping Turtle is also listed as critically endangered under the EPBC Act (Table 5-1). The Eastern Freshwater Cod is listed as endangered under both the FM Act and the EPBC Act. The Platypus is not listed under State or Commonwealth legislation, but was included in Department of Agriculture Water and the Environment (2020) following the 2019/2020 bushfire season. The most recent study of the Macleay River was conducted by NSW DPI (Butler et al. 2015) and incorporated sites in the vicinity of the Project, including a site at Georges Junction and tributaries of the Macleay River upstream and downstream.

Table 5-1: Threatened species with the potential to occur within, or adjacent to, the Project.

Family	Vernacular	Scientific Name	Conservation Status			LoO
			FM Act	BC Act	EPBC Act	
Fish						
Eleotridae	Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	E	-	-	Possible
Percichthyidae	Eastern Freshwater Cod	*Maccullochella ikei*	E	-	E	Negligible
Reptiles						
Chelidae	Western Sawshelled Turtle	*Myuchelys bellii*	-	E	V	Negligible
Chelidae	Bellinger River Snapping Turtle	*Myuchelys georgesi*	-	CE	CE	Possible
Chelidae	Manning River Helmeted Turtle	*Myuchelys purvisi*	-	E	-	Possible
Mammals						
Ornithorhynchidae	Platypus	*Ornithorhynchus anatinus*	-	-	PL	Known

Note: CE = Critically Endangered, E = Endangered, PL = LIST; LoO = likelihood of occurrence.

Of the six species identified above, four are known to occur within the Macleay River catchment, have occurred historically with the Macleay River catchment, and/or have the potential to occur with the vicinity of the Project area; Southern Purple-spotted Gudgeon, Manning River Helmeted Turtle, Bellinger River Snapping Turtle and the Platypus (Table 5-1). A summary of the ecology of the four species are provided in subsequent sections.

5.6.1.1. Southern Purple-spotted Gudgeon

The Southern Purple-spotted Gudgeon prefers slow-flowing or still water with a substantial amount of macrophyte coverage or a rocky benthos (Fish Base 2019), and is a benthopelagic feeder on larvae and small fish. This species is known to occur in quite shallow water; however, fluctuations in water volume/flow (affecting water level) as a result of river regulation have the potential to impact on important wetland habitat used for reproduction and recruitment. The Southern Purple-spotted Gudgeon requires a specific temperature range (19°C-34 °C) for spawning, with water releases a potential impact to its lifecycle if released during late winter or early spring (cold water pollution, turbidity). This species requires solid substrates near vegetation on which to lay their eggs. Recent population decline is attributed to competition for resources with exotic species, habitat degradation, river regulation, cold water pollution and fishing pressure, with the Southern Purple-spotted Gudgeon subject to competition from the Eastern Gambusia and predation by Redfin Perch (*Perca fluviatilis*) (Department of Primary Industries 2018). While the Department of Primary Industries (2018) indicates that this species has only been recorded once since 1983, and is currently considered to be extremely rare in inland NSW, the Atlas of Living Australia (2022) contains records from as recent as 2016. Further, EMM Consulting (unpublished data) has also documented a small population within the north of NSW; however, it is still unlikely that the Southern Purple-spotted Gudgeon occurs within the Macleay River catchment. Mapping for the Southern Purple-spotted Gudgeon (Department of Primary Industries 2022c) includes an approximately 15 km section of the Macleay River, upstream of the Project, as well as some of its tributaries including Georges Creek, Dyke River, Lagoon Creek, Five Day Creek, Pee Dee Creek, Gap Creek, Nulla Nulla Creek and Mackenzies Creek (Department of Primary Industries 2022c) to within approximately 20 km of the Project. However, the Southern Purple-spotted Gudgeon has not been recorded in any previous surveys carried out in the Macleay River (Harris and Gehrke 1997; Llewellyn 1983).

5.6.1.2. Manning River Helmeted Turtle

This medium sized, short-necked freshwater turtle is brown above and bright yellow below, with a distribution restricted to the middle and upper extent of the Manning River catchment (Department of Planning and Environment 2022c), although it is assumed that this distribution is severely fragmented. The Manning River Helmeted Turtle prefers relatively shallow, clear, continuously fast-flowing rivers with rocky and sandy substrates (Wells 2002) characterised by boulder beds and submerged logs. It is likely that the species is omnivorous (Allanson and Georges 1999; Wells 2002) but prefers to forage on benthic fauna and aquatic vegetation (Allanson and Georges 1999). Current potential habitat mapping for the species indicates that the Manning River Helmeted Turtle is likely to occur within the Project area (Figure 5-4) (Department of Planning and Environment 2022c), indicating that the species may not be restricted to the Manning River catchment. Further,

BioNet records indicate that the species occurs to the southwest of the Project (Department of Planning and Environment 2022a). Threats to the Manning River Helmeted Turtle include, but are not limited to, nest predation by foxes and pigs, poaching, agricultural and anthropogenic land use, elevated turbidity and nutrient concentrations, increased sedimentation of deep pools, removal of large woody debris, riparian zone degradation, waterway regulation, disturbance of suitable habitat, and potentially competition and hybridisation with native species (Department of Planning and Environment 2022c).

5.6.1.3. Bellinger River Snapping Turtle

This short-necked freshwater turtle species is endemic to the Bellinger River catchment on the north coast of NSW (Department of Planning and Environment 2022b) to the northeast of the Macleay River catchment. However, Department of Planning and Environment (2022b) maps "known" habitat of the species as occurring within tributaries of the Macleay River, to the west of the Project (Figure 5-4). The Bellinger River Snapping Turtle prefers moderate to deep pools with a rocky substrate, feeding on a wide variety of foods but with a tendency toward carnivory (Allanson and Georges 1999; Spencer *et al.* 2007). In early 2015, outbreak of a disease caused by a new virus resulted in decline in the population which was restricted to a 60 km stretch of the Bellinger River (Department of Planning and Environment 2022b). In addition, hybridisation may also occur with the Macquarie River Turtle. Other threats include predation on eggs and nesting females by foxes, poaching, riparian zone degradation, disturbance of suitable habitat, and potentially competition with native species (Department of Planning and Environment 2022b).

5.6.1.4. Platypus

The Platypus is a semi-aquatic mammal that depends entirely on freshwater systems, exhibiting a preference for aquatic habitats comprising a riparian zone with consolidated earth banks stabilised by large trees, overhanging vegetation, abundant in-stream organic matter, coarse woody debris, and coarse channel substrates, as well as a combination of wide stream sections and shallow pools (Bino *et al.* 2019). Foraging is undertaken in both low flow pools and high flow riffle habitat within streams, preferably at depths of less than 5 m and with coarse bottom substrates (Bino *et al.* 2019). Studies conducted by the Australian Platypus Conservancy (Serena and Williams 2010) indicates that a statistically significant relationship between platypus numbers and foraging activity and the presence of higher numbers of indigenous trees within the riparian zone exists. A similar relationship was demonstrated for the amount of cover provided by vegetation and lower-growing plants overhanging the water.

While the Platypus is not currently listed under the FM Act, BC Act or the EPBC Act, there is currently a lack of knowledge regarding species abundance at a local catchment level (Australian Museum 2019) 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 (Bino *et al.* 2019; Temple-Smith and Grant 2003). The Platypus was included on the Department of Agriculture Water and the Environment (2020) provisional list of animal species identified as requiring immediate urgent management intervention in February 2020, following the 2019/2020 bushfire season in southern and eastern Australia (20 March 2020). The Platypus has been observed within the Macleay River catchment on several occasions, including the Macleay River and near the confluences of associated tributaries including the Apsley River, Georges Creek, Lower Creek. Lagoon Creek and Pee Dee Creek, both upstream of, and within, the Project area (Figure 5-4) (Department of Planning and Environment 2022a). There is one recorded associated with the Carrai Plateau, 10 km southeast of the Project (Department of Planning and Environment 2022a).

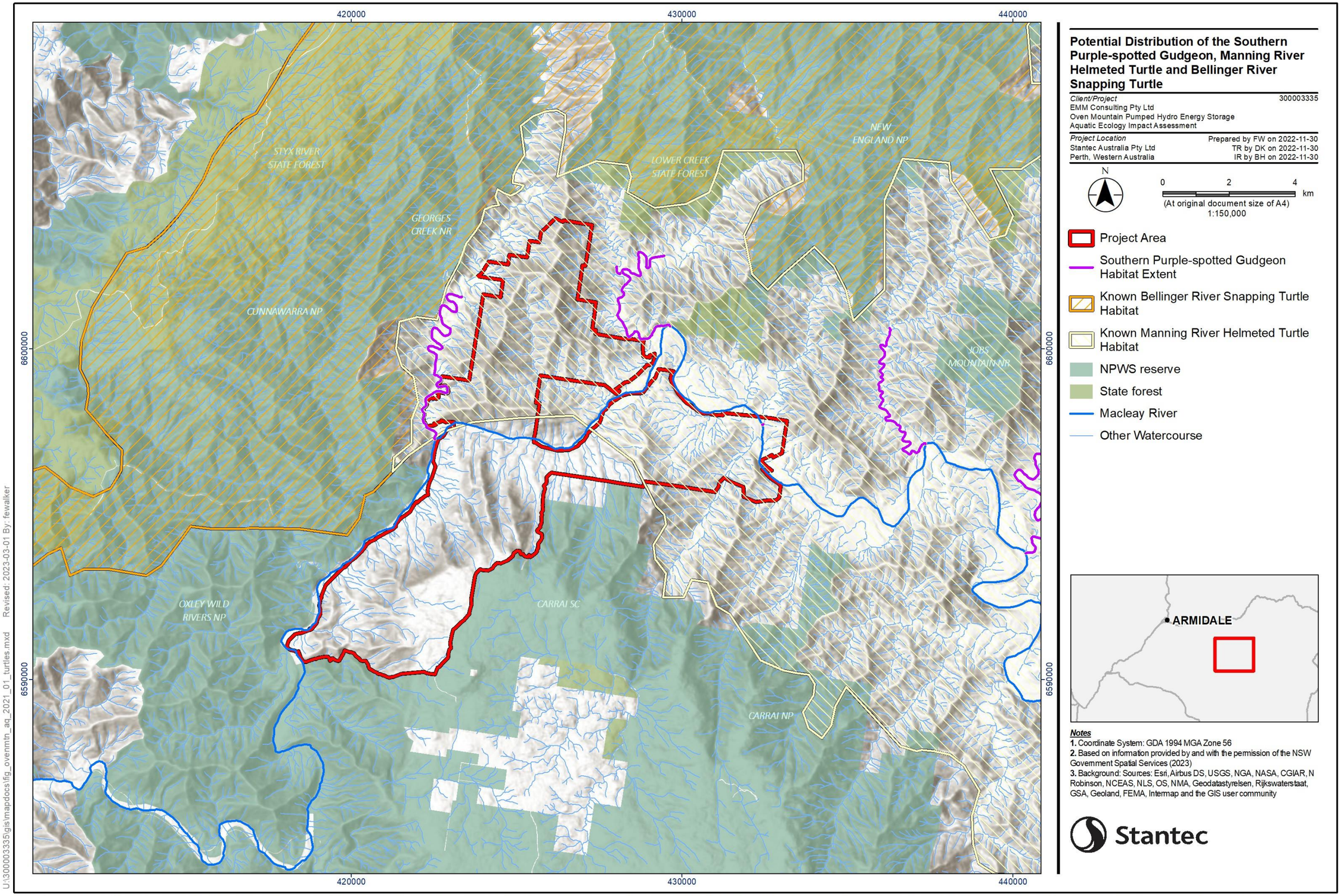

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Figure 5-4: Potential distribution of the Southern Purple-spotted Gudgeon, Manning River Helmeted Turtle and the Bellinger River Snapping Turtle.

6. Field Survey Results & Discussion

6.1. Flow Conditions

The first field survey undertaken in March 2022 was interrupted by rainfall and flooding in the Macleay River catchment. The second field survey undertaken in June 2022 was completed during a period of low rainfall characterised by decreasing flow conditions. River height data for the six years prior to early 2022 was analysed (Appendix A) and this indicated that the flooding that occurred during early 2022 was anomalous. Weather patterns associated with a La Niña event resulted in flooding and elevated river heights in the Macleay River since the beginning of 2020, which followed a year of particularly low flow. The natural flow pattern of the Macleay River for the years prior to 2019 were characterised by short spikes in river height, which are likely a result of the surrounding steep catchment and the same topographical features of its tributaries. The overall flow patterns observed reflect a dynamic river system that experiences fast elevations in flow but that also dissipates quickly; taking some time to reduce to a steady state river height. During the March 2022 field survey, all tributaries of the Macleay River that were assessed were flowing, and some were observed to have a high flow rate compared with the June 2022 field survey, when the majority of tributaries were flowing, but at much lower rate of discharge. Rainfall recorded at Turners Flat in the three months prior to each of the field surveys is presented in Figure 6-1, along with Macleay River height data (WaterNSW 2022) for the corresponding period.

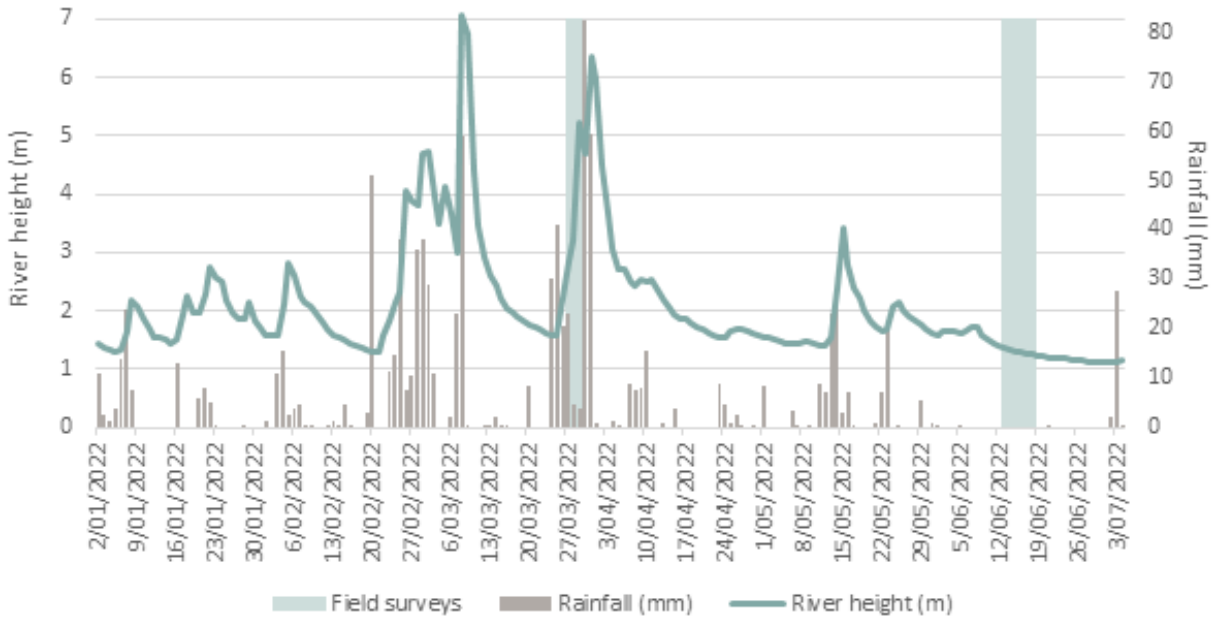


Figure 6-1: Rainfall at Turners Flat aligned with Macleay River height data at Georges Junction, January 2022 to July 2022.

6.2. Habitat Characterisation And Key Fish Habitat

6.2.1. Macleay River

The Macleay River is characterised as a steep valley, with a defined river channel. During the field surveys, where nine sites were assessed, riparian vegetation was discontinuous on both banks, and areas without shrubs and trees comprised predominantly a mixture of bedrock and sand benches. Riparian vegetation regeneration along the banks was evident, as was debris accumulating against trees in the flooded areas of the channel which were not regularly inundated. Beyond the waterway banks, vegetation comprised mostly native forest, with some cleared areas, and grazing within the riparian zone by cattle was evident (Plate 6-1). The dominant species within the riparian zone was Weeping Bottlebrush (*Callistemon viminalis*).

The substrate of the Macleay River compromised cobbles, with bedrock and boulders forming constrictions, cascades, and pools. Cobble, pebble, gravel, and coarse sand benches were also common (Plate 6-2). Downstream of George's Junction, deeper longer pools were observed, compared with upstream areas, and riffles were less frequent. At the majority of Macleay River field survey sites, riffles were found to be in excellent condition, often spanning the width of the river and creating riffle-pool sequences (Plate 6-3). There was some fine sediment accumulation noted at sites MR03 and MR04; both sites were located at constrictions in the river which had resulted in deposition across shallow areas after recent flooding.

Submerged macrophytes were not observed at any site along the Macleay River. During transit by helicopter the river was flown and no submerged vegetation was noted. Additionally, very few snags (woody debris) were observed. It is possible that recent flooding and high flows would have resulted in scouring and removal of fine sediment, macrophytes and large woody debris, causing scarcity of these habitat types.

There were no major obstructions to fish movement observed during the field surveys, with areas of low flow also noted, providing refuge and feeding areas for migratory fish. Instream structures were present in the form of large rocky outcrops and boulders. Small areas of fine sediment were observed in low flow areas downstream. Detritus was uncommon on the river bed, but was sparsely deposited in shallow, slow-flowing areas (Plate 6-4).

Turtle nesting habitat (sand benches) was observed at several sites, with the largest and most expansive areas located upstream of the Project at site MR01 and downstream near site MR08 (Figure 4-1). However, feral pigs were observed throughout the channel areas of the Macleay River and had caused instability of soft sediment and riparian vegetation as a result of digging. It is expected that turtle nesting would be substantially impacted by the presence of pigs in the area.

All sites along the Macleay River were classified as Type 1, Class 1 key fish habitat (Table 4-3, Table 4-4) due to the presence of gravel beds and, infrequent large woody debris, supported by Department of Primary Industries (2022e) key fish habitat mapping. A summary of key fish habitat attributes is presented in Table 6-1.

Plate 6-1: Cattle grazing in the riparian zone downstream of George's Junction.

Plate 6-2: Sand and cobble bench, cobble substrate, overhanging riparian vegetation at Macleay River site MR01, June 2022.

Plate 6-3: Riffle habitat at MR09.

Plate 6-4: Fine sediment and detritus deposited along the banks of the Macleay River, June 2022.

Table 6-1: Summary of key fish habitat features along the Macleay River, June 2022.

Waterway	Macleay River								
Site ID	MR01	MR02	MR03	MR04	MR05	MR06	MR07	MR08	MR09
Key Fish Habitat Waterway Type	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**
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	Present	Present	Present	Present	Present	Present	Present	Present	Present
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Present	Present	Present	Present	Present
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Present	Present	Present	Present	Present	Present	Present	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Absent	Present	Present	Absent	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Key Fish Habitat Waterway Class	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**
Class 1 – major key fish habitat	Present	Present	Present	Present	Present	Present	Present	Present	Present
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 4 – unlikely key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

6.2.2. Macleay River Tributaries – Upper Dam and Reservoir

Two Macleay River tributaries were surveyed within the proposed upper dam and reservoir area, one within the proposed spoil placement disturbance area (UW06-01; unnamed 2nd order waterway) and one within the Upper Dam and Reservoir (UW02-01). One site was located downstream of the Upper Dam and Reservoir (UW02-02) During the March 2022 field survey, both waterways contained surface water, attributed to recent heavy rain prior to the survey (Figure 6-1). The waterway located within, and downstream of, the proposed Upper Dam and Reservoir (UW02-01, UW02-02; unnamed 2nd order waterway) was flowing, whereas UW06-01 contained isolated pools but showed evidence of previous high flow (Plate 6-5).

Both waterways are expected to flow intermittently after rain and did not contain key fish habitat (Table 6-2). Their position on the Carrai Plateau above waterfalls makes the presence of fish or other aquatic fauna unlikely. Site UW02-01 was characterised by a defined channel and contained several species of emergent macrophytes such as *Cyperus* sp. and *Juncus* sp.. This indicates that water, or at least soil moisture, has been available along the waterway for some time. Neither waterways had a defined riparian zone or banks, and shading was high as a result of the closed canopy of the native forest comprising predominantly *Eucalyptus* species. While fish passage to the pool at the bottom of the waterfall at site UW02-02 was suitable; overall, the site did not meet the requirements of the Class 1 with the waterway unlikely to be permanently flowing or flooded.

Plate 6-5: Flattened grass, showing recent flow, within the waterway channel at site UW06-01.

Table 6-2: Summary of key fish habitat features at sites within the Upper Dam and Reservoir area, March 2022.

Project Area / Waterway	Unnamed Waterway		
Site ID	UW02-01	UW02-02	UW06-01
Key Fish Habitat Waterway Type	**Type 3**	**Type 2**	**Type 3**
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	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Present	Absent
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Absent	Present
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Absent	Present
Key Fish Habitat Waterway Class	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Present	Absent
Class 3 – minimal key fish habitat	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Present	Absent	Present

6.2.3. Macleay River Tributaries – Lower Dam and Reservoir and Access Roads

A total of 23 sites along Macleay River tributaries were assessed between the southern extent of the Project area (Peach Tree Creek) and George's Junction (Figure 4-1). Sites were assessed during March 2022 and June 2022, dependant on accessibility. Most sites were characterised by slow-flowing water in narrow channels (<0.3 m wide) or wide bedrock channels. Bedrock and boulders were a feature of many sites (Plate 6-7) and water flowed over steep and stepped surfaces, which were not conducive to fish passage by most species.

The accessible section of Peach Tree Creek (4th order) that was located upstream of a vertical drop of approximately 15 m created a waterfall, flowing into the Macleay River. It was not considered likely that fish could achieve passage into Peach Tree Creek without a flood much higher than any that had been recorded in the last five years. The other site with a higher stream order (UW17-05; 4th order) was inundated during the March 2022 field survey, but was dry during the June 2022 field survey, confirming that majority of the Macleay River tributaries, particularly in steeper topography, are unlikely to hold water for substantial periods of time.

Vegetation cover was variable with some areas cleared; however, the majority of sites were located in forested areas. Trees and shrubs dominated vegetation strata, with many waterways characterised by exotic plants such as *Crofton Weed (*Ageratina adenophora*), *Blackberry (*Rubus fruticosus*) and *Lantana (*Lantana camara*) (Photo 5). There were a number of dead trees along the waterways throughout the proposed Lower Dam and Reservoir and along proposed Access Roads, which appear to have burned. Despite some trees being devoid of leaves, most sites were shaded, which promoted the growth of moss and ferns on banks. Native grasses were common in cleared areas, as was the emergent macrophyte *Juncus* sp. which lined waterways where an overstorey was absent. Generally, waterways outside of the proposed Lower Dam and Reservoir (e.g. UW02) lacked remnant riparian vegetation, indicating surface water is unlikely to be permanent feature. However, soil moisture is expected to persist in the area due to extensive shading combined with groundwater discharge from several waterways.

Habitats within, and adjacent to, the proposed lower dam and reservoir ranged from a cobble-bed creek with intact riparian vegetation at UW02-03 (Plate 6-6), to a cascading creek characterised by boulders and large woody debris at UW02-04. Site UW02-04 is unnamed and represented the highest order of any waterway in this area. It contained multi-strata vegetation cover, complex habitats and suitable fish passage, below the waterfall. The waterway was flowing during the March 2022 field survey and the June 2022 field survey and, if not permanently flowing, is likely to maintain a moist hyporheic zone. Vegetation was different to other

waterways, and contained some riparian species found along the Macleay River, such as Weeping Bottlebrush (*Callistemon viminalis*) and Spiny-headed Mat-rush (*Lomandra longifolia*), but also patchy growth of Lantana. No lower dam and reservoir creek sites met the requirements of Type 1 key fish habitat (Table 4-3), as there were no gravel beds and very little structural habitat that was inundated and useful to fish.

Plate 6-6: Riparian vegetation and habitat at UW02-03.

Plate 6-7: Bedrock channel at site UW08-01.

Plate 6-8: Drone footage of waterfall and associated pool at UW02-02.

Plate 6-9: Looking upstream at UW11-01 which was infested with Crofton Weed and Lantana.

Table 6-3: Summary of key fish habitat features at sites within the Lower Dam and Reservoir and Access Roads, March 2022 and June 2022.

Project Area / Waterway	Peach Tree Creek	Unnamed Waterway									
Site ID	PC01	UW01-01	UW02-03	UW02-04	UW03-01	UW04-01	UW06-02	UW06-03	UW07-01	UW08-01	UW09-01
Key Fish Habitat Waterway Type	**Type 2**	**Type 3**	**Type 2**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 3**	**Type 3**	**Type 3**	**Type 3**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Present	Absent	Present	Present	Present	Present	Present	Present	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Absent	Absent	Present	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 2**	**Class 2**	**Class 2**	**Class 2**	**Class 4**	**Class 4**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Present	Absent	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Present	Absent	Present	Present	Absent	Absent	Absent	Present	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Absent	Present	Absent	Absent	Present	Present	Present	Absent	Present	Absent	Present

Table 6-4: Summary of key fish habitat features at sites within the Lower Dam and Reservoir and Access Roads, March 2022 and June 2022 (cont'd).

Project Area / Waterway	Unnamed Waterway										
Site ID	UW10-01	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW-17-01	UW17-02	UW17-03	UW17-04	UW17-05
Key Fish Habitat Waterway Type	**Type 3**	**Type 2**	**Type 2**	**Type 3**	**Type 2**	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Present	Present	Absent	Present	Present	Absent	Absent	Present	Absent	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Present	Present	Present	Present	Absent	Present	Absent	Present
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Present	Present	Present	Absent	Absent	Present	Absent	Present	Present
Key Fish Habitat Waterway Class	**Class 3**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 3**	**Class 4**	**Class 4**	**Class 4**	**Class 4**	**Class 2**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
Class 3 – minimal key fish habitat	Present	Present	Present	Absent	Present	Present	Absent	Absent	Absent	Absent	Absent
Class 4 – unlikely key fish habitat	Absent	Present	Absent	Present	Absent	Absent	Present	Present	Present	Present	Absent

6.2.4. Macleay River Tributaries – Eastern Access Road

The topography and the prevailing habitat characteristics of each site along the Macleay River tributaries in the vicinity of the proposed Eastern Access Road varied. The Eastern Access Road corridor is approximately 13 km in length and crosses 17 waterways of 3rd order or lower and included steep and stepped bedrock channels (Plate 6-10, Table 6-5, Table 6-6), cobble and gravel-lined creeks (Plate 6-11) and grassed swales (Plate 6-12). The hydroperiod of waterways ranged from completely dry to flowing. The size of the catchment of the waterway appeared to correlate with water presence at each site, with waterways originating further up the Carrai Plateau (larger catchments) generally flowing, and sites with smaller catchments generally not flowing. Surface water at a number of sites was sustained by groundwater, evidenced by flow observed further downstream from dry sites. Conversely, flow or seepage was also observed at some sites and further downstream the waterway was dry.

A number of sites that were dry at the time of the field surveys showed evidence of short duration high flow including debris trapped high in trees, and alluvial material deposition within the riparian zone, comprising predominantly Weeping Bottlebrush, and flood channel of the Macleay River, downstream of the tributary (Plate 6-13). This was common along the waterways traversed by the proposed Eastern Access Road and denotes the importance of these lower order streams as sources of alluvial material to the Macleay River. Emergent aquatic vegetation was present at a number of sites, comprising *Schoenaolectus mucronatus* and *Juncus* sp.. Of the Eastern Access Road waterways surveyed, only one of three 4th order and above waterways contained surface water at the time of the field surveys (Carrolls Creek; site CC01).

Plate 6-10: Stepped bedrock channel at site UW24-01.

Plate 6-11: Cobble substrate at site UW27-01.

Plate 6-12: Isolated pools within an exotic grass swale at site UW35-01, draining to the Macleay River.

Plate 6-13: Alluvial material transported from upstream to the Macleay River channel, downstream of site UW26-01.

Table 6-5: Summary of key fish habitat features at sites along the Eastern Access Road, June 2022.

Project Area / Waterway	Carrolls Creek	Unnamed Waterway								
Site ID	CC01	UW18-01	UW19-01	UW20-01	UW20_1-01	UW21-01	UW22-01	UW23-01	UW24-01	UW25-01
Key Fish Habitat Waterway Type	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 2**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Absent	Present	Present	Absent	Present	Absent	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 1**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Present	Present	Absent	Present	Absent	Present	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Present	Absent	Absent	Present	Absent	Present	Absent	Present	Present	Present

Table 6-6: Summary of key fish habitat features at sites along the Eastern Access Road, June 2022 (cont'd).

Project Area / Waterway	Unnamed Waterway										
Site ID	UW25-02	UW26-01	UW27-01	UW28-01	UW29-01	UW30-01	UW31-01	UW32-01	UW33-01	UW34-01	UW35-01
Key Fish Habitat Waterway Type	**Type 2**	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 2**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Present	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 4**	**Class 4**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Present	Absent	Present	Present	Absent	Present	Present	Present	Present	Present	Present

6.3. Water Quality

6.3.1. Analytical Results

Surface water samples were collected at eight sites along the Macleay River and its tributaries during the March 2022 field survey. Four sites were located along the Macleay River (MR01, MR03, MR04, MR05), and four sites were located in unnamed waterways (UW02-03, UW02-04, UW11-01, UW12-01). The salinity of surface water, measured as total dissolved solids (TDS), was classified as freshwater (<3,000 mg/L) according to Hammer (1986) and ranged from 56 mg/L (UW11-01, UW12-01) to 105 mg/L (MR03) (Table 6-7). Turbidity (measured in NTU) ranged from 1 NTU (UW11-01, UW12-01) to 4.1 NTU (MR04), with an average of 1.98 NTU. Surface water turbidity was below the ANZECC & ARMCANZ (2000) lower trigger value across all sites (Table 6-7). Salinity and turbidity were slightly higher in the Macleay River compared to the tributaries, supported by the PCA plot (Figure 6-2), with these sites clearly separated according to differences in these parameters.

During the March 2022 field survey, the composition of cations differed between Macleay River and its tributaries sites. The Macleay River sites were dominated by calcium, followed by sodium, magnesium and potassium and its tributaries were dominated by sodium, followed by calcium, magnesium and potassium, as evidenced by the PCA (Table 6-7, Figure 6-3). The dominance of anions was similar for all sites, with bicarbonate being dominant, followed by chloride and sulphate. Sites MR01 and MR03 were the exceptions, with sulphate having a higher concentration than chloride.

Nutrient concentrations were low across all sites, with the majority of the tributary sites close to or below the detectable limit of reporting (LoR) (Table 6-7). Concentrations of total nitrogen were low across all sites, with an average of 0.26 mg/L recorded. The lowest value, 0.1 mg/L (LoR), was recorded at three of the tributary sites; UW02-03, UW02-04 and UW11-01. The highest concentration of total nitrogen (0.5 mg/L) was recorded at a site on the Macleay River; MR01. Concentrations of total phosphorus were also low, ranging from <0.01 mg/L (UW11-01) to 0.09 mg/L (MR01) with an average of 0.041 mg/L. Similar to salinity and turbidity, differences between the Macleay River and tributary sites showed obvious separation on the PCA plot (Figure 6-2).

Concentrations of dissolved metals were below the analytical limit of reporting at most sites for the majority of metals analysed, with the exception of arsenic, barium, manganese and zinc. While detectable, concentrations of these metals were low and only zinc exceed the relevant DGV (0.008 mg/L) (Water Quality Australia 2018) at one Macleay River (MR01) and within one tributary (UW11-01) (Table 6-7). Where metals were detected, there was a clear trend of higher concentrations occurring within the Macleay River, compared to its tributaries, attributed to its function as the primary waterway in the local catchment.

6.3.2. *In situ* Results

In situ water quality was recorded at nine sites during the June 2022 field survey along the Macleay River (Table 4-2; Appendix C). The pH of surface water ranged from neutral (pH 7.86; MR06) to alkaline (pH 8.48; MR02, MR07) (Appendix C); however, all sites were alkaline except site MR06, which was neutral. The ANZECC & ARMCANZ (2000) upper trigger value for surface water pH was exceeded at all sites except site MR06 (pH 7.86). Higher pH values across the majority of sites indicates that surface water pH is naturally more alkaline within the Macleay River catchment, likely as a result of catchment geology.

In situ salinity was recorded during the June 2022 field survey, measured as electrical conductivity (µS/cm), and ranged from 164.08 µS/cm (MR06) to 185.73 µS/cm (MR03), with an average of 176.38 µS/cm (Appendix C). These results are classified as freshwater (<5 mS/cm) (Hammer 1986). The ANZECC & ARMCANZ (2000) trigger value for electrical conductivity were not exceeded at any site.

Turbidity was similar across all sites except for MR01, which was elevated (6.85 NTU). Low turbidity likely reflects stable water flow leading up to the survey. Dissolved oxygen (%) varied across sites along the Macleay River, ranging from 100.23% (MR04) to 109.17% (MR07). Faster flowing water was more aerated across shallow and undulating substrate (e.g. riffles). However, water quality was relatively homogenous across sites, due to the hydrological connection.

Table 6-7: Analytical water quality parameters recorded during the March 2022 field survey.

Water Quality Parameter		LOR	MR01	MR03	MR04	MR05	UW02-03	UW02-04	UW11-01	UW12-01	ANZECC & ARMCANZ (2000) triggers		Water Quality Australia (2018) DGVs	
			21-Mar-22	21-Mar-22	21-Mar-22	24-Mar-22	23-Mar-22	22-Mar-22	21-Mar-22	23-Mar-22	lower	upper	lower	upper
Basic	Total Dissolved Solids	1	103	105	97	104	98	97	56	56	-	-	-	-
	Turbidity (NTU)	0.1	1.6	2.6	4.1	1.9	1.9	1.8	1	1	-	25	-	-
Major Ions	Sodium	1	10	10	11	11	16	17	11	11	-	-	-	-
	Calcium	1	12	12	12	12	5	5	3	2	-	-	-	-
	Magnesium	1	6	6	5	6	3	3	1	1	-	-	-	-
	Potassium	1	2	2	2	1	1	2	1	1	-	-	-	-
	Bicarbonate	1	57	57	57	57	32	31	16	18	-	-	-	-
	Chloride	1	9	10	11	10	18	18	12	13	-	-	-	-
	Sulphate	1	10	11	9	10	8	8	<1	<1	-	-	-	-
	Carbonate	1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-
	Hydroxide	1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-
	Alkalinity (total)	1	57	57	57	57	32	31	16	18	-	-	-	-
	Cations (total) (meq/L)	0.01	1.58	1.58	1.54	1.6	1.22	1.29	0.74	0.69	-	-	-	-
	Anions (total) (meq/L)	0.01	1.6	1.65	1.64	1.63	1.31	1.29	0.66	0.73	-	-	-	-
Nutrients	Nitrogen (total)	0.1	0.5	0.4	0.4	0.3	<0.1	<0.1	0.1	0.2	-	-	-	-
	Kjeldahl Nitrogen (total)	0.1	0.4	0.3	0.3	0.2	<0.1	<0.1	0.1	0.2	-	-	-	-
	Nitrite + Nitrate	0.01	0.1	0.13	0.11	0.1	0.04	<0.01	<0.01	<0.01	-	-	-	-
	Phosphorus (total)	0.01	0.09	0.06	0.05	0.04	0.01	0.01	<0.01	0.03	-	-	-	-
	Organic Carbon	1	5	6	5	4	4	4	4	6	-	-	-	-
	Organic Carbon (total)	1	5	4	4	4	3	3	6	4	-	-	-	-

Water Quality Parameter		LOR	MR01	MR03	MR04	MR05	UW02-03	UW02-04	UW11-01	UW12-01	ANZECC & ARMCANZ (2000) triggers		Water Quality Australia (2018) DGVs	
			21-Mar-22	21-Mar-22	21-Mar-22	24-Mar-22	23-Mar-22	22-Mar-22	21-Mar-22	23-Mar-22	lower	upper	lower	upper
Dissolved Metals & Trace Elements	Arsenic	0.001	0.001	0.001	0.002	0.001	<0.001	<0.001	0.002	0.002	-	-	-	0.013
	Barium	0.001	0.011	0.011	0.012	0.012	0.007	0.007	0.008	0.007	-	-	-	-
	Beryllium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	Boron	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	0.94
	Cadmium	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	-	0.0002
	Chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	0.001
	Cobalt	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	Copper	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	0.0014
	Lead	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	0.0034
	Manganese	0.001	0.016	0.011	0.082	0.02	<0.001	<0.001	0.003	<0.001	-	-	-	1.9
	Mercury	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	-	0.0006
	Nickel	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	0.011
	Selenium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	0.011
	Vanadium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-
	Zinc	0.005	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	0.007	-	-	-	0.008

Note: All units in mg/L unless otherwise stated; red shading indicates exceedance of upper DVG (Water Quality Australia 2018) for protection of 95% of species in freshwater.

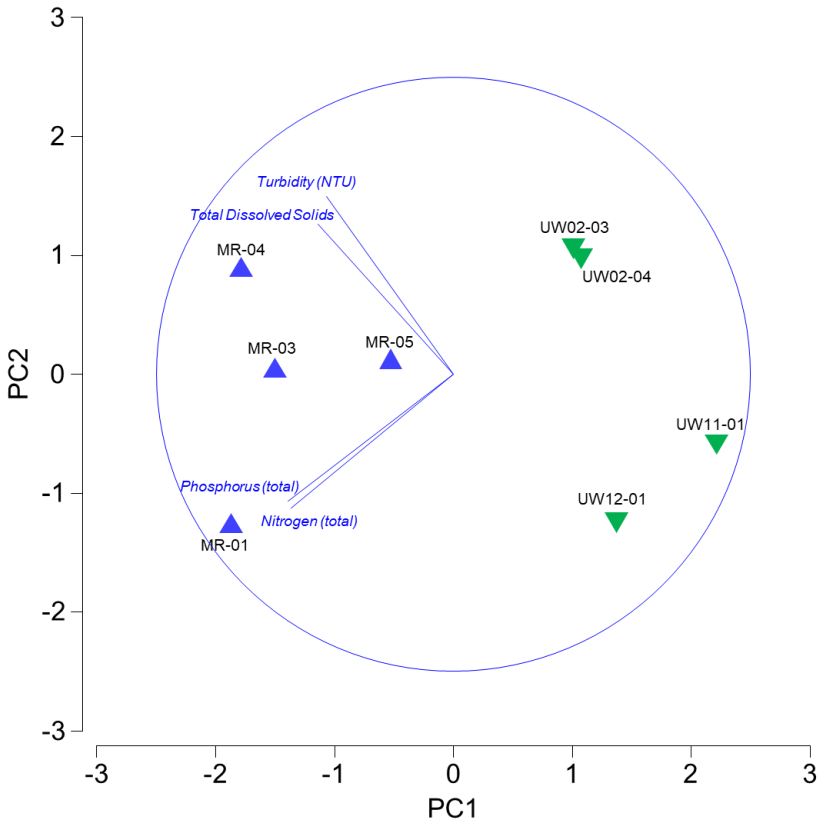


Figure 6-2: PCA of basic surface water quality and nutrients at sites along Macleay River (▲) and Unnamed waterways (▼) during the March 2022 field survey. A total of 87.7% variation in the data was explained by the first two axes.

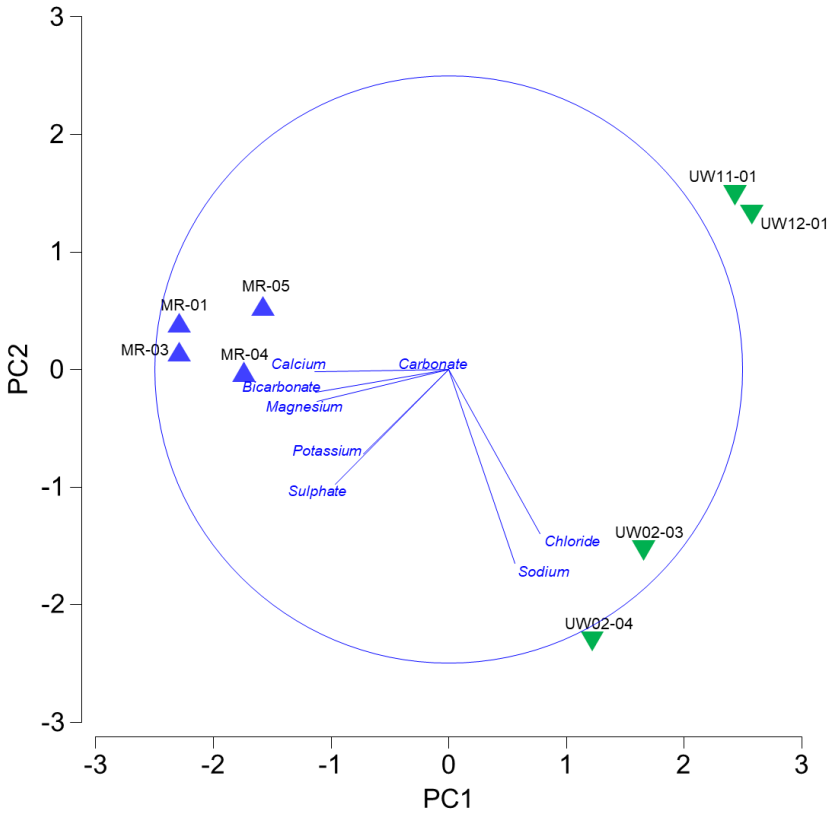


Figure 6-3: PCA of cations and anions at sites along Macleay River (▲) and Unnamed waterways (▼) during the March 2022 field survey. A total of 91.4 % variation in the data was explained by the first two axes.

6.4. Sediment Quality

Surface sediment samples were collected at eight sites along the Macleay River and its tributaries during the March 2022 field survey. Four sites were located along the Macleay River (MR01, MR03, MR04, MR05; Figure 4-1), and four sites were located in unnamed waterways (UW02-03, UW02-04, UW11-01, UW12-01; Figure 4-1). Sediment is an important component of aquatic ecosystems, supporting a wide range of benthic organisms (McKenzie et al. 2004; Pulford and Flowers 2006) and serving as a sink for contaminants which may influence biota (Simpson et al. 2005).

Nutrient concentrations varied across sites, with higher concentrations recorded at Macleay River sites compared to its tributaries (Table 6-8). Substantially higher nutrient concentrations were recorded at MR01 than all other sites. This was also evident on the PCA plot (Figure 6-4), with MR01 located on the far left and clearly distinct. Total nitrogen concentrations ranged from 150 mg/L at UW02-04 to 3,540 mg/L at MR01, with an average of 695 mg/L across all sites. Total phosphorus ranged from 95 mg/L at UW11-01 to 606 mg/L at MR01, with an average of 278.75 mg/L (Table 6-8). Site MR01 was located on a bend in the river, which is likely to slow the flow of water and result in the deposition of salts, nutrients and metals in the sediment.

Similar to water quality, the concentrations of metals were higher at Macleay River sites compared to its tributaries during the March 2022 field survey. Site MR01 had the highest concentrations of all metals compared to the other sites (Table 6-8), attributed to its location on a bend, supported by the PCA (Figure 6-5). While, several metal concentrations were elevated (e.g. arsenic, antimony), no concentrations exceeded DGV or GV-High triggers (Water Quality Australia 2018), where there were available. Many metal concentrations were below or close to the analytical detection limits with the exception of aluminium, barium, iron, manganese and zinc (Table 6-8). Site UW11-01 within an unnamed waterway had the lowest concentrations of aluminium, barium and iron (320 mg/L, 10.3 mg/L and 350 mg/L, respectively), while UW02-03 had the lowest concentrations of iron and manganese (28 mg/L and below detection limit, respectively) (Table 6-8).

Table 6-8: Sediment quality parameters recorded during the March 2022 field survey.

Water Quality Parameter		LOR	MR01	MR03	MR04	MR05	UW02-03	UW02-04	UW11-01	UW12-01	Water Quality Australia (2018) DGVs	
			21-Mar-22	21-Mar-22	21-Mar-22	24-Mar-22	23-Mar-22	22-Mar-22	21-Mar-22	23-Mar-22	DGV	GV-High
Basic	Moisture Content (%)	1	47.5	39.5	26.6	31.3	28.2	21.1	29.4	29.4	-	-
Nutrients	Nitrogen	20	3540	650	330	280	170	150	190	250	-	-
	Kjeldahl Nitrogen	20	3540	650	330	280	170	150	190	250	-	-
	Nitrite + Nitrate	0.1	0.7	0.3	0.1	0.4	0.2	0.2	0.3	0.2	-	-
	Phosphorus	2	606	325	574	220	162	117	95	131	-	-
	Organic Carbon (%)	0.5	6.3	0.6	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
Total Metals & Trace Elements	Aluminium	50	2400	1080	510	670	390	550	320	390	-	-
	Antimony	1	9.2	4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-
	Arsenic	1	5.3	2.5	1.2	1.6	<1.0	<1.0	1.7	2	20	70
	Barium	1	100	36	18.1	21.3	11.5	18.4	10.3	12.3	-	-
	Beryllium	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-
	Boron	50	<50	<50	<50	<50	<50	<50	<50	<50	-	-
	Cadmium	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	10
	Chromium	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	80	370
	Cobalt	0.5	7.7	2.8	1.2	1.3	<0.5	0.7	<0.5	<0.5	-	-
	Copper	1	11.6	3.4	1.4	1.7	<1.0	1.5	1.1	<1.0	65	270
	Iron	50	4740	1810	970	1200	450	530	350	420	-	-
	Lead	1	13.1	7	3.3	4.2	<1.0	1.1	1.1	1.4	50	220
	Manganese	10	1010	217	81	104	28	43	32	35	-	-
	Mercury	0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	1
	Molybdenum	5	<5	<5	<5	<5	<5	<5	<5	<5	-	-
	Nickel	1	5	1.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	21	52
	Selenium	0.5	1.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
	Silver	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1	3.7
	Strontium	5	53	15	6	6	<5	5	<5	<5	-	-
	Vanadium	2	9	2.8	<2.0	<2.0	<2.0	2	<2.0	<2.0	-	-
	Zinc	1	21.2	11	4.9	6.3	<1.0	1.1	1	1.4	200	410

Note: All units are mg/kg unless otherwise stated.

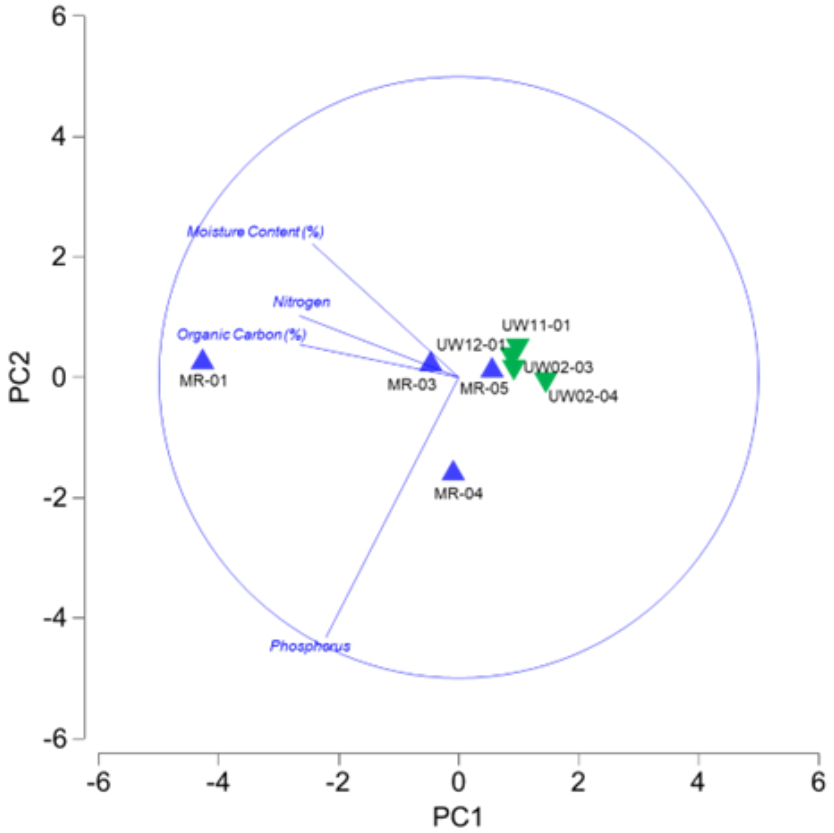


Figure 6-4: PCA of basic sediment quality and nutrients during the March 2022 field survey. A total of 94.7% of variation in the data was explained by the first two axes.

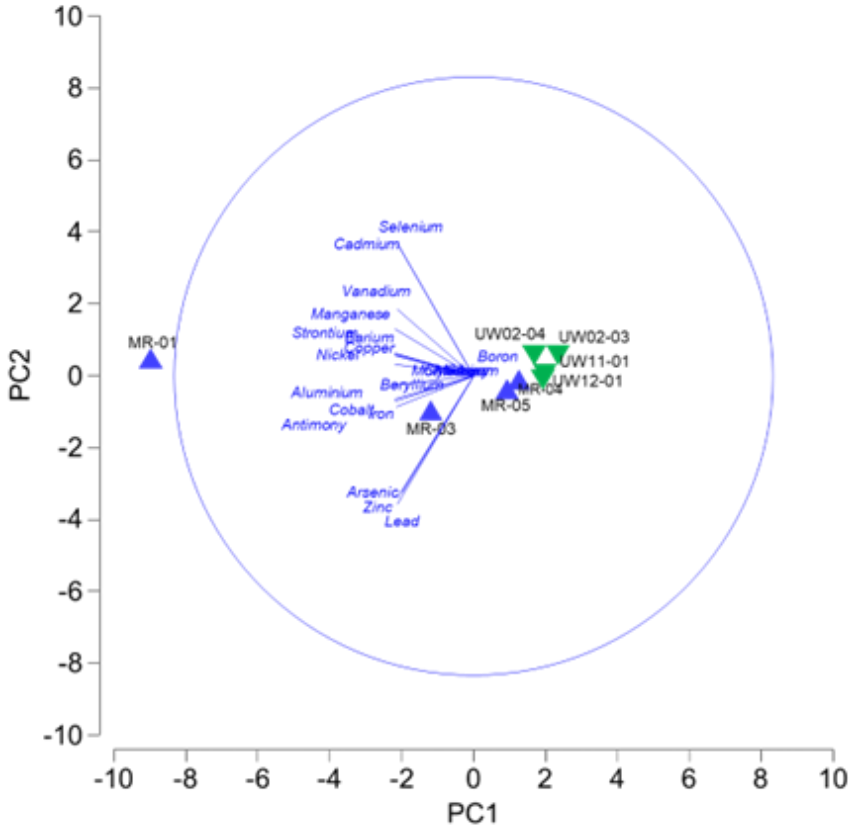


Figure 6-5: PCA of metal concentrations in sediment during the March 2022 field survey. A total of 97.9% of variation in the data was explained by the first two axes.

6.5. Macrophytes

Submerged macrophytes were not observed at any site in the Macleay River or its tributaries, most likely attributed to recent high flow events causing dislodgement of aquatic vegetation and/or colonisation of the waterway beds. Previous surveys of the Macleay River by Butler *et al.* (2015) did not note abundant aquatic vegetation beyond the coastal estuary. Emergent macrophytes were observed in several locations, mostly along tributaries. The most common macrophyte was a species of rush (*Juncus* sp.; Plate 6-14), which was observed at some tributary sites and in sparse patches on the banks of the Macleay River. Several species of sedge (Family: Cyperaceae) were observed in tributaries but were not flowering at the time of the March 2022 or June 2022 field surveys and could not be identified. *Schoenoplectiella mucronata* (Plate 6-15) was an exception and was observed at several sites along the Eastern Access Road. Many of the tributary sites along the Eastern Access Road, the Main Access Road and the Lower Dam Access Road contained minimal surface water; however, waterways with high soil moisture featured emergent macrophytes.

Plate 6-14: *Juncus* sp. growing at site UW29-01.

Plate 6-15: *Schoenoplectiella mucronata* growing at UW34-01.

6.6. Aquatic Invertebrates

A total of 58 genera were identified from the Macleay River and tributaries from a total of 10 sites during the June 2022 field survey (Table 4-2), comprising 12 orders and 36 families (Appendix A). Macroinvertebrate orders were dominated by EPT taxa, as well as Diptera (true flies). The diversity of orders was higher in the Lower Dam and Reservoir waterways (UW02-03, UW02-04) (Figure 6-6). This was likely due to the collection of composite samples which included a greater range of habitats compared with Macleay River sites, which were dominated by riffle habitat. Composite habitat was also sampled within Carrols Creek (site CC01); however, the diversity of orders was lower that at the Lower Dam and Reservoir sites. No threatened or exotic invertebrates were collected during the field survey.

There were no apparent trends between sites and there was limited variation in sampler, time and habitat type, with no existing impacts within the catchment. Therefore differences in composition were likely to be related to riffle characteristics at each site. The higher proportion of fine sediment in riffles at MR03 and MR04 is likely to have reduced interstitial spaces within rocky substrates and provided greater potential for suspension of sediment and smothering of filter feeding taxa. The absence of the family Simulidae (filter feeding black fly larvae) and Hyrdopsychidae (filtering collector caddis fly larvae) from both sites supports the incursion of fine silt, as these families were recorded from all other sites and in tributaries.

Sites MR03 and MR04 were the least abundant and diverse for macroinvertebrate communities. Sites MR06 and CC01 were also less diverse, compared to Lower Dam and Reservoir sites UW02-03 and UW02-04, which were more diverse. EPT diversity results followed a similar pattern to taxa diversity, and the high proportion of these taxa in each sample (Figure 6-7, Figure 6-9, Figure 6-10). Conversely, EPT taxa were less dominant in samples with a higher overall taxa diversity. Taxa diversity for all sites is presented in Figure 6-7, with Figure 6-8 demonstrating a high degree of similarity between sites, likely due to similarities in water quality and habitat. The exception was MR04 which had the lowest diversity of taxa of all sample sites (Figure 6-6).

Sensitivity of the macroinvertebrate community to pollution was calculated as a SIGNAL-2 score (Figure 6-9), which returned similar results across all Macleay River sites. The SIGNAL-2 scores were representative of a community with high sensitivity to pollution, including larvae of the Caddisfly (Family: Helicophydae), which has the highest possible sensitivity rating (SIGNAL-2 grade of 10) and a number of other taxa with SIGNAL-2 grades of 8 and 9. Lower Dam and Reservoir sites UW02-03 and UW02-04 returned lower scores, due to the more complex habitat profile of the sites, comprising backwaters and accumulated detritus that favours lower sensitivity taxa such as beetles (Coleoptera), worms (Oligochaeta) and true flies. Sites CC01, MR03 and MR04 returned SIGNAL-2 scores which were relatively inflated, given the low number of taxa used to calculate their average. However, it does corelate with the EPT results, with taxa that present representative of a high sensitivity grade.

The macroinvertebrate community of the Macleay River catchment reflects a waterway in good condition; however, one that is highly sensitive to an increase in sedimentation. The presence of feral pigs and cattle in the catchment are likely to have the greatest impact, mobilising fine sediment into the waterway. The dynamic flow regime observed over the last few years has also caused sediment flushing downstream. Higher rainfall has also resulted in the movement of coarse alluvial material into the Macleay River from its tributaries, which is likely to have resulted in the formation of riffles and gravel beds that allow for colonisation of rheophilic taxa (preference for flowing water). The macroinvertebrate community of the tributaries implies that shading and provision of organic material to waterways is key to ecological function. Consequently, the lack of riparian vegetation complexity has the potential to impact the community at site CC01.

Bioassessment scores were derived at all sites (Figure 6-10) and, although all sites were found to be in at least "good" condition, the comparatively lower scores at sites MR03 and MR04 were related to sediment accumulation and embeddedness. Sites along tributaries received similar bioassessment scores, likely attributed to the greater variety of habitat sampled. Backwaters, leaf packs, woody debris and trailing vegetation were all available. The key difference in habitat between CC01 and the other tributary sites was the greater vegetative cover and shade at the Lower Dam and Reservoir sites. This created more complex structural habitat and provided more organic material to the benthos compared with CC01, which was relatively free of detritus, but did have a number of large log jams and some grass trailing into the water.

No snails or bivalves were collected at any of the sites, though freshwater mussels (Family: Hyriidae) were observed outside of riffle areas on the Macleay River (Plate 6-16). A large number of broken mussel shells were observed along the water's edge in some areas of the Macleay River, likely consumed by pigs, as diggings in the area were extensive. Thousands of individuals of the Freshwater Prawn (*Macrobrachium australiense*) were observed at all sites where electrofishing took place, as a result of the pulsed electrical field. The absence of predators, such as Australian Bass due to seasonal migration, has allowed for prawn numbers to increase substantially.

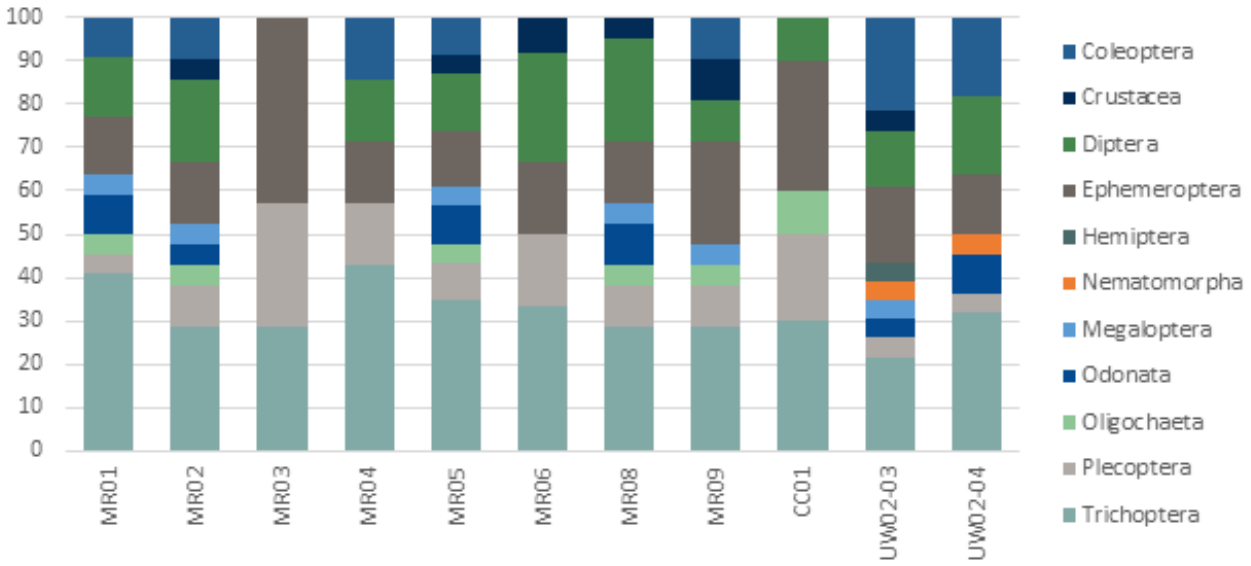


Figure 6-6: Composition of macroinvertebrate orders from samples collected during the June 2022 field survey.

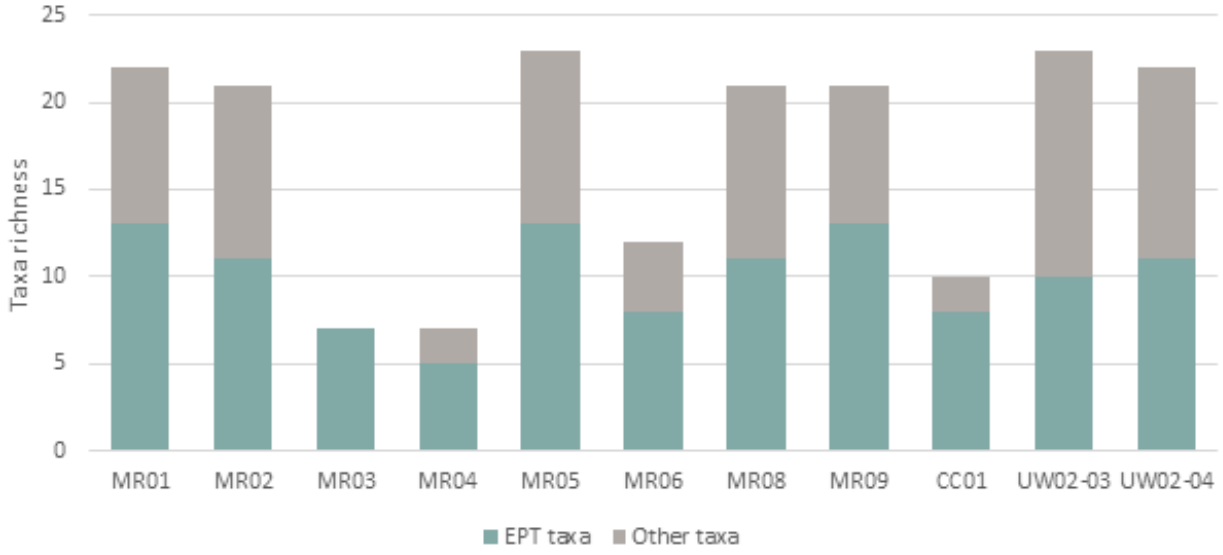


Figure 6-7: Genus-level taxa diversity per site demonstrating proportion of EPT taxa in each sample.

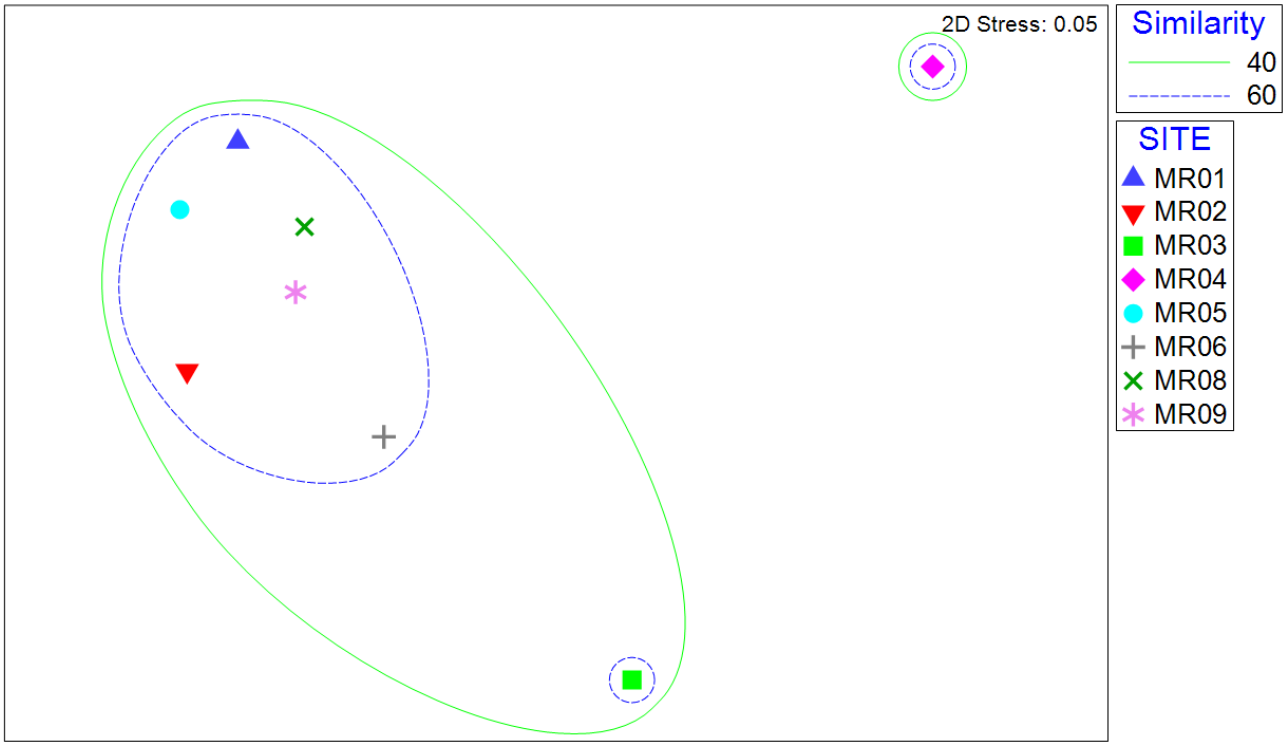


Figure 6-8: nMDS representing similarities in community composition at sites along the Macleay River during the June 2022 field survey.

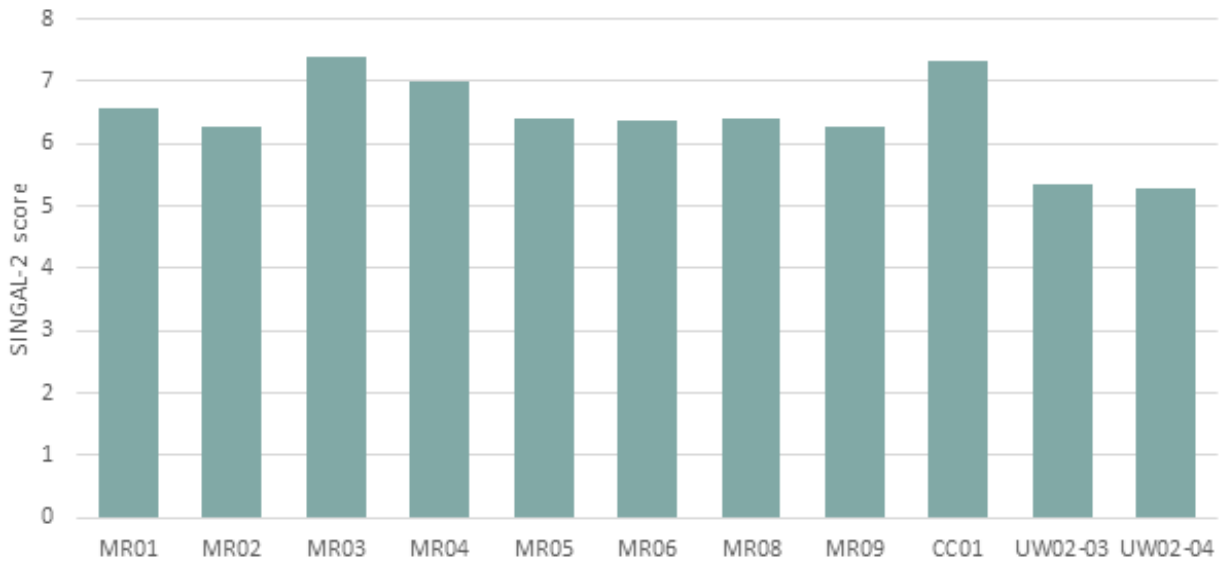


Figure 6-9: SIGNAL-2 scores of samples collected during the June 2022 field survey.

Figure 6-10: River Bioassessment Scores for all sites sampled for macroinvertebrates.

Plate 6-16: Freshwater mussels (Hyriidae) in fine substrate at MR05 during the June 2022 field survey.

6.7. Aquatic Vertebrates

A total of 21 aquatic vertebrate fauna species including at least 20 fish and one mammal were recorded from 14 sites during the June 2022 field survey (Table 4-2, Figure 6-12), belonging to 11 families (Table 6-9, Table 6-10). Of the 20 fish species, none were threatened species and two were exotic species (Table 6-9, Table 6-10). Class Actinopterygii (ray-finned fishes) was also recorded via eDNA at 13 of the 14 sites. However, these results are not discussed further as Actinopterygii represents a broad range of fish taxa. The Platypus was detected via positive (MR01, MR03, MR05) and equivocal (MR4, MR6) eDNA analysis at five sites across the Macleay River (Table 6-9). It is likely that the high abundance of the Freshwater Prawn, observed at a number of sites during electrofishing, is an important component of the life history of many fish migrating back to freshwater within the Macleay River, following spawning. The *Common Carp or *Goldfish was detected by eDNA analysis at eight sites, and the *Eastern Gambusia was recorded via collection as well as eDNA at four sites (Table 6-9, Table 6-10, Figure 6-11).

6.7.1. Threatened Aquatic Fauna

The Platypus was detected via eDNA analysis from five sites (three positive and two equivocal results) within the Macleay River (Table 6-9, Figure 6-11). As all records were confirmed using eDNA analysis, there is no additional context available on life history, population dynamics or habitat preferences, as the sampling locations may not necessarily correspond to the location of the individual animal. However, the broad pH, salinity and temperature ranges recorded at sites (Table 6-7; Appendix C) appeared suitable for supporting the species. The Macleay River provides sufficient suitable and variable habitat for the Platypus, including rocky substrate, deeper surface water pools, and shallow water connectivity at certain times of the year. In addition, it is likely that macroinvertebrates (e.g. Freshwater Prawn) inhabiting the waterway would provide a food source for the Platypus.

Species distributions for the Southern Purple-spotted Gudgeon, the Manning River Helmeted Turtle and the Bellinger River Helmeted Turtle indicate that these species have the potential to occur within, or immediately adjacent to, the Project area (Department of Planning and Environment 2022b;c; Department of Primary Industries 2018) and suitable habitat for these species was observed along the Macleay River. However, no threatened species listed under the FM Act, BC Act or EPBC Act were observed or recorded (via sampling or eDNA analysis) during the June 2022 field survey, and it is more likely that these species do not occur, or occurred historically (Department of Planning and Environment 2022c; Department of Primary Industries 2018), with the distributions generally based on extrapolated data (Department of Primary Industries 2018). The presence of exotic fauna including *Eastern Gambusia and feral pigs would potentially impact on threatened aquatic species, and aquatic fauna more broadly. However, at the time of the June 2022 survey, the abundance of exotic aquatic competitors/predators was limited, although disturbance from feral pigs had the potential to impact on turtle occurrence (Appendix A).

6.7.2. Introduced Species

The *Common Carp and *Goldfish are large, introduced freshwater fish that are common throughout most of NSW. The *Common Carp was recorded via eDNA analysis at sites MR01, MR03, MR04, MR05, UW02-03, UW02-04, UW11-01 and UW17-05. The species prefers still or low flow water at low altitudes, especially in areas where there is abundant aquatic vegetation. However, they can tolerate a wide variety of habitats and can endure highly degraded ecosystems (Department of Primary Industries 2022d). Maturity is reached as early as one year for males and two years for females and large numbers of eggs are produced at a time. Being omnivorous, the *Common Carp consumes an array of fauna including molluscs, crustaceans, insect larvae as well as seeds. Though they rarely eat other fish, the *Common Carp consume the fish eggs and larvae of other fish species. These, along with its other dietary sources are sucked up (along with mud and water) from the bottom and filtered out using gill rakers. This bottom-feeding method disturbs sediment which negatively impacts native fish habitat.

The introduced *Eastern Gambusia is widespread throughout NSW waterways and can tolerate a wide range of temperatures and water quality, thriving in low flow shallow waterways (Department of Primary Industries 2022a). This species was recorded via eDNA analysis at sites MR01, MR02, MR03 and MR05. After introduction into NSW during the 1920s, the *Eastern Gambusia has had direct impacts on several native threatened fish species through predation and competition. The species feeds on a wide variety of foods, including aquatic beetles and bugs, insects such as flies and ants, as well as other fauna. Eggs and juveniles of other fish species are also preyed upon. Reproduction can occur several times a year during warmer months where up to 50 young are born live after three to four weeks, reaching maturity in less than two months, leading to rapid growth of populations. The high reproductive rate and extended breeding season, along with its broad feeding habits, enables this species to overwhelm suitable habitats with juveniles and deplete food supplies.

Table 6-9: Aquatic vertebrate species presence/absence recorded from the Macleay River during the June 2022 field survey.

Common Name	Scientific Name	Macleay River								
		MR01	MR02	MR03	MR04	MR05	MR06	MR07	MR08	MR09
Fish										
Anguillidae										
Short-finned Eel	*Anguilla australis*	✓✓		✓✓				*		
Marbled Eel	*Anguilla reinhardtii*	✓✓✓	*	✓✓✓	✓✓	✓✓✓	✓✓✓	*		*
Clupeidae										
Freshwater Herring	*Potamalosa richmondia*				✓					
Cyprinidae										
*Goldfish or *Common Carp	*Carassius auratus* or *Cyprinus carpio*	✓✓		✓	✓	✓✓				
Eleotridae										
Striped Gudgeon	*Gobiomorphus australis*		*			*				
Cox's Gudgeon	*Gobiomorphus coxii*			*		*		*		
-	*Gobiomorphus* sp.	✓✓		✓✓✓	✓✓	✓✓	✓			
Empire Gudgeon	*Hypseleotris compressa*	*				*				
Western Carp Gudgeon	*Hypseleotris klunzingerii*	*	*		*	*	*	*	*	*
-	*Hypseleotris* sp.	✓✓✓		✓	✓✓✓	✓	✓✓✓			
Dwarf Flathead Gudgeon	*Philypnodon macrostomus*^			✓	✓	✓				
Eel-tailed Catfish	*Tandanus tandanus*		*	*	*	*	*	*		
Galaxiidae										
Mountain Galaxias	*Galaxias ornatus/olidus*	✓				✓✓				
Melanotaeniidae										
Crimson-spotted Rainbowfish	*Melanotaenia duboulayi*	✓			*					
Ornate Rainbowfish	*Rhadinocentrus ornatus*	*								

Common Name	Scientific Name	Macleay River								
		MR01	MR02	MR03	MR04	MR05	MR06	MR07	MR08	MR09
Mugilidae										
Sea Mullet	*Mugil cephalus*	✓✓		✓✓✓	✓✓	✓✓	✓✓✓			*
Freshwater Mullet	*Trachystoma petardi*	**✓✓**	*	✓✓	✓	**✓✓✓**	✓✓			
Percichthyidae										
Australian Bass	*Macquaria novemaculeata*	✓		✓✓	✓✓	✓✓	✓			
Poeciliidae										
Eastern Gambusia	*Gambusia holbrooki*	✓	*	✓		✓				
Retropinnidae										
Australian Smelt	*Retropinna semoni*	**✓✓✓**	*	✓✓✓	**✓✓✓**	**✓✓✓**	**✓✓✓**	*	*	*
Mammals										
Ornithorhynchidae										
Platypus	*Ornithorhynchus anatinus*	✓		✓	?	✓	?			

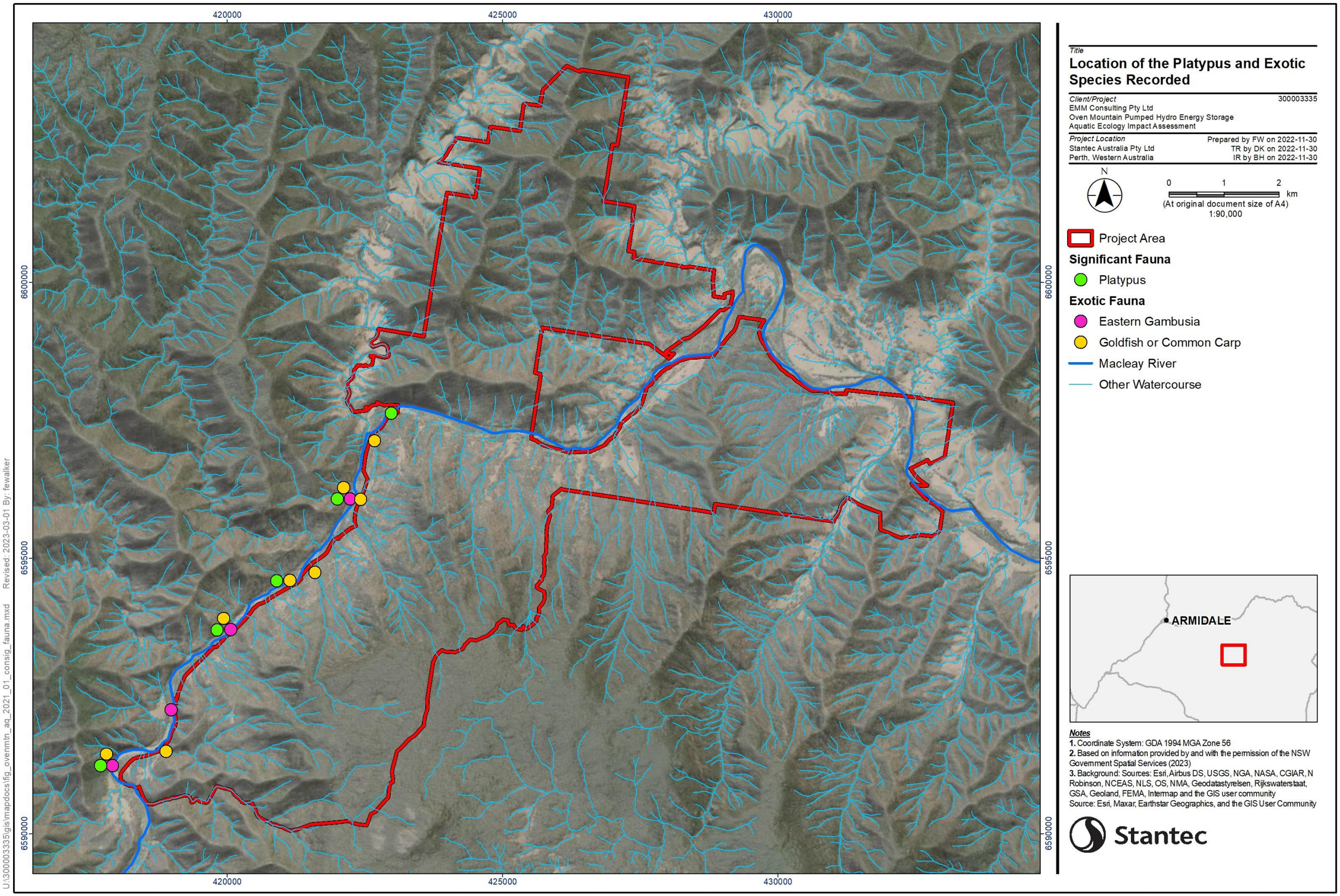
Note: Each tick mark demonstrates the number of positive eDNA replicates for each species; green bold ticks indicate where a species was also captured; an orange asterisk indicates where a species was captured; a question mark indicates an equivocal eDNA result.

Table 6-10: Aquatic vertebrate species presence/absence recorded from the Lower Dam and Reservoir, Access Roads and Eastern Access Road during the June 2022 field survey.

Common Name	Scientific Name	Lower Dam and Reservoir and Access Roads								EAR
		UW02-03	UW02-04	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW17-05	CC01
Fish										
Anguillidae										
Short-finned Eel	*Anguilla australis*				✓		✓			
Marbled Eel	*Anguilla reinhardtii*	✓	*	✓✓✓			✓✓✓	✓✓✓		*
Clupeidae										
Freshwater Herring	*Potamalosa richmondia*									
Cyprinidae										
*Goldfish or *Common Carp	*Carassius auratus* or *Cyprinus carpio*	✓	✓	✓✓					✓✓✓	
Eleotridae										
Striped Gudgeon	*Gobiomorphus australis*									*
Cox's Gudgeon	*Gobiomorphus coxii*	*								*
-	*Gobiomorphus* sp.									
Empire Gudgeon	*Hypseleotris compressa*									*
Western Carp Gudgeon	*Hypseleotris klunzingerii*									*
-	*Hypseleotris* sp.								✓✓	
Dwarf Flathead Gudgeon	*Philypnodon macrostomus*^									
Eel-tailed Catfish	*Tandanus tandanus*									*
Galaxiidae										
Mountain Galaxias	*Galaxias ornatus/olidus*									
Melanotaeniidae										
Crimson-spotted Rainbowfish	*Melanotaenia duboulayi*									

Common Name	Scientific Name	Lower Dam and Reservoir and Access Roads								EAR
		UW02-03	UW02-04	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW17-05	CC01
Ornate Rainbowfish	*Rhadinocentrus ornatus*									
Mugilidae										
Sea Mullet	*Mugil cephalus*									
Freshwater Mullet	*Trachystoma petardi*									
Percichthyidae										
Australian Bass	*Macquaria novemaculeata*									
Poeciliidae										
Eastern Gambusia	*Gambusia holbrooki*									
Retropinnidae										
Australian Smelt	*Retropinna semoni*	✓	✓✓	✓✓✓				✓✓✓	✓✓✓	*
Mammals										
Ornithorhynchidae										
Platypus	*Ornithorhynchus anatinus*									

Note: Each tick mark demonstrates the number of positive eDNA replicates for each species; green bold ticks indicate where a species was also captured; an orange asterisk indicates where a species was captured.



Title

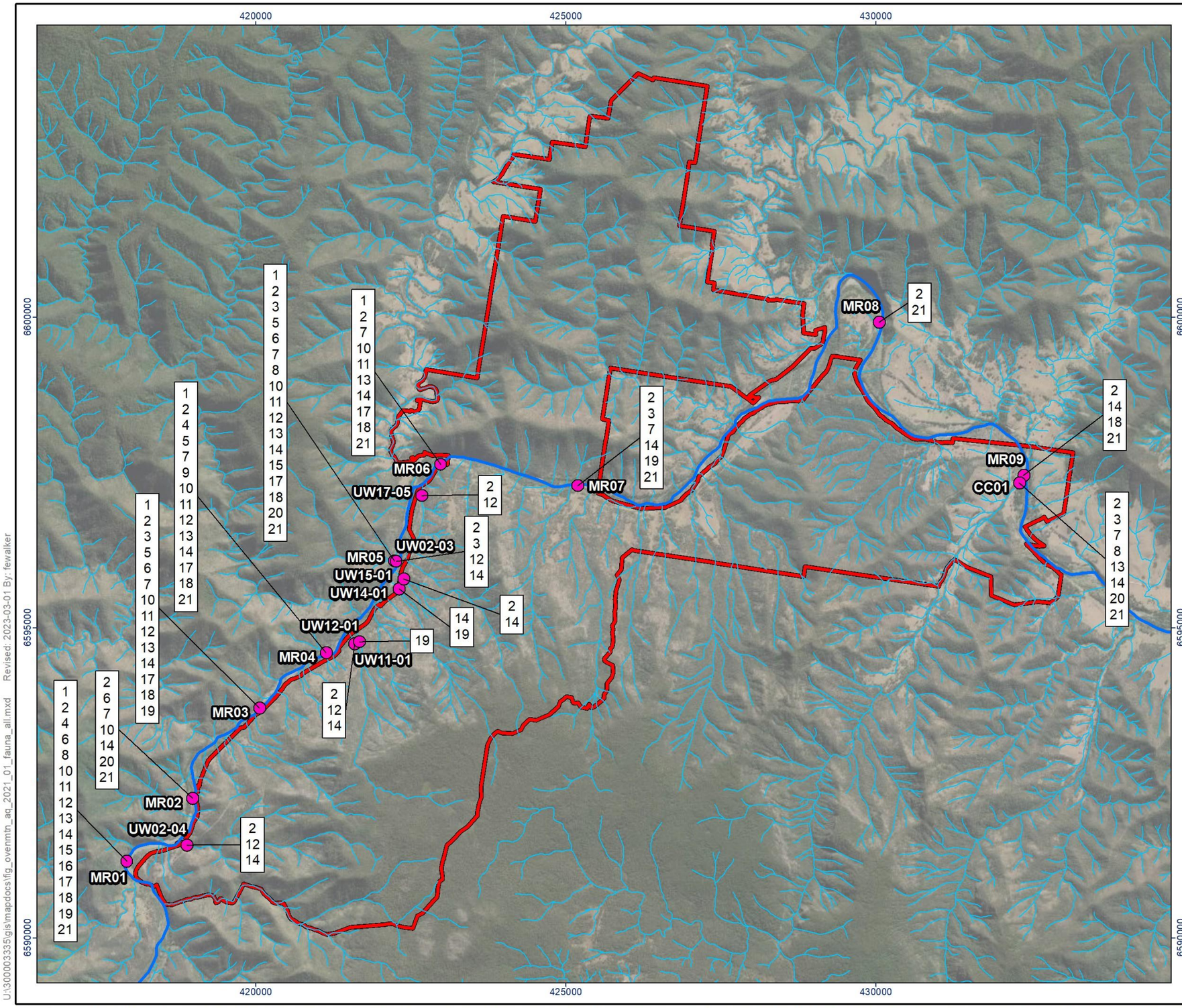
Location of the Platypus and Exotic Species Recorded

Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

U:\300003335\gis\mapdocs\fig_ovenmtn_aq_2021_01_consig_fauna.mxd Revised: 2023-03-01 By: fewalker

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 6-11: Location of the Platypus and exotic species recorded during the June 2022 field survey.



Title

Location of Recorded Fauna Species

Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

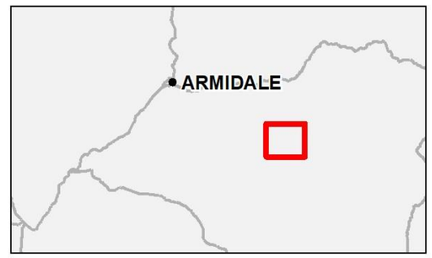
0 1 2 km

(At original document size of A4)
1:90,000

Project Area

Fauna Records

1 Australian Bass
2 Australian Smelt
3 Cox's Gudgeon
4 Crimson-spotted Rainbowfish
5 Dwarf Flathead Gudgeon
6 Eastern Gambusia
7 Eel-tailed Catfish
8 Empire Gudgeon
9 Freshwater Herring
10 Freshwater Mullet
11 Gobiomorphus sp.
12 Goldfish or Common Carp
13 Hypseleotris sp.
14 Marbled Eel
15 Mountain Galaxias
16 Ornate Rainbowfish
17 Platypus
18 Sea Mullet
19 Short-finned Eel
20 Striped Gudgeon
21 Western Carp Gudgeon



Notes

1. Coordinate System: GDA 1994 MGA Zone 56
2. Based on information provided by and with the permission of the NSW Government Spatial Services (2023)
3. Background: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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Figure 6-12: Location of all aquatic vertebrates recorded during the June 2022 field survey.

6.8. Migratory Status

The Macleay River fish population represents a community that is well adapted to the prevailing conditions, with free fish passage and unregulated flow allowing for seasonal migrations along with short-range movements. Species recorded during the June 2022 field survey as well as species recorded by Butler *et al.* (2015) are presented in Table 6-11, along with their migratory status. The Macleay River is largely unregulated; therefore, it supports species that migrate between freshwater and the ocean or coastal estuary. However, in the vicinity of the Project, the Macleay River generally lacks habitat requirements to support fish with anadromous life histories (species that undertake a migration to freshwater for spawning).

The migratory preferences of species like the Australian Bass, Freshwater Herring (*Potamalosa richmondia*) and the Sea Mullet (*Mugil cephalus*) meant that they were not captured during the June 2022 field survey but were detected during the March 2022 field survey via eDNA analysis. These catadromous species undertake winter migrations downstream to the ocean to spawn (Brooks *et al.* 2019; Industry and Investment NSW 2010). The individual Sea Mullet collected at MR09 was a juvenile (<200 mm), which accounts for its presence in freshwater of the Macleay River. No juvenile Australian Bass or Freshwater Herring were captured, but they are assumed to be present due to their detection via eDNA analysis. The Freshwater Mullet, also considered to be catadromous, were captured, likely because the June 2022 field survey occurred outside of their migratory period (January to March) (Fishes of Australia 2022).

The remaining species captured or recorded via eDNA analysis from the Macleay River comprised small-bodied potamodromous (freshwater species that migrate for spawning purposes over relatively shorter differences) (e.g. Eel-tailed Catfish; Plate 6-17) and short-range fish. The majority of these species are presumed to move locally during their adult life phase, and juveniles may be washed downstream and either migrate upstream or into inundated tributaries (Beumer 1996). These species are all excellent swimmers, and can adapt during high flow events, exploiting inundated and slower flowing areas. The Macleay River's instream connectivity and river morphology is well suited to these species, with many areas available for transit when the river is inundated.

Plate 6-17: Juvenile Eel-tailed Catfish collected from the Macleay River during the June 2022 field survey.

Table 6-11: Migratory status of species collected during the June 2022 field survey and species recorded by Butler *et al.* (2015).

Common Name	Scientific Name	Occurrence	Migratory Status/ Association
Anguillidae			
Short-finned Eel	*Anguilla australis*	C / D	Catadromous
Marbled Eel	*Anguilla reinhardtii*	C / D	Catadromous
Clupeidae			
Freshwater Herring	*Potamalosa richmondia*	D	Catadromous
Cyprinidae			
*Goldfish or *Common Carp	*Carassius auratus* or *Cyprinus carpio*	D / P	Potamodromous
Galaxiidae			
Mountain Galaxias	*Galaxias ornatus/olidus*	D	Potamodromous
Poeciliidae			
Eastern Gambusia	*Gambusia holbrooki*	C / D / P	Potamodromous
Eleotridae			
Striped Gudgeon	*Gobiomorphus australis*	C / D / P	Amphidromous
Cox's Gudgeon	*Gobiomorphus coxii*	C / D / P	Potamodromous
-	*Gobiomorphus* sp.	n/a	n/a
Empire Gudgeon	*Hypseleotris compressa*	C / D / P	Potamodromous (assumed)
Firetail Gudgeon	*Hypseleotris galii*	P	Potamodromous (short range)
Western Carp Gudgeon	*Hypseleotris klunzingerii*	C / D / P	Potamodromous (assumed)
-	*Hypseleotris* sp.	n/a	n/a
Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	U	Potamodromous (short range)
Dwarf Flathead Gudgeon	*Philypnodon macrostomus*^	C / D / P	Potamodromous (assumed)
Eel-tailed Catfish	*Tandanus tandanus*	C / P	Potamodromous (short range)
Melanotaeniidae			
Crimson-spotted Rainbowfish	*Melanotaenia duboulayi*	C / D / P	Potamodromous (short range)
Ornate Rainbowfish	*Rhadinocentrus ornatus*	C	Potamodromous (short range)
Mugilidae			
Sea Mullet	*Mugil cephalus*	C / D / P	Diadromous
Freshwater Mullet	*Trachystoma petardi*	C / D / P	Catadromous
Percichthyidae			
Australian Bass	*Macquaria novemaculeata*	D / P	Catadromous
Pseudomugilidae			
Pacific Blue-eye	*Pseudomugil signifer*	P	Amphidromous
Retropinnidae			
Australian Smelt	*Retropinna semoni*	C / D / P	Potamodromous

Note: C = collected; D = detected via eDNA; P = has the potential to occur; U = unlikely to occur.

7. Summary of Ecological Values

The March 2022 and June 2022 field surveys provided background data on the aquatic environment of the Macleay River and associated tributaries, upstream, within and downstream of the proposed Project. The field surveys comprised assessment and/or sampling of the following components; key fish habitat, water quality, sediment quality, aquatic invertebrates and aquatic vertebrates. Sampling effort was considered to be sufficient to assess habitat characteristics, key fish habitat, aquatic invertebrates and aquatic vertebrates.

Results of the key fish habitat assessments ranged from Type 1 highly sensitive key fish habitat (nine sites) to Type 3 Minimally sensitive key fish habitat (26 sites), and Class 1 major key fish habitat (10 sites) to Class 4 unlikely key fish habitat (21 sites) (Table 7-1, Table 4-3, Table 4-4). Overall, the Macleay River was classified as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat (Table 4-3, Table 4-4). Many tributaries contained good structural habitat; however, they were generally ephemeral, although these waterways are likely to provide refuge for fish and other vertebrates from high water flow during flood, and they provide alluvium to the Macleay River.

While the majority of waterways were considered to be in good condition, habitat for threatened species was generally limited. There was a proliferation of exotic plants at some sites, clearing of native vegetation (particularly overhanging riparian vegetation) was evident, and there was a lack of suitable habitat features (large woody debris and in-stream aquatic vegetation) available. There was also anthropogenic influences (pastoralism) and the presence of exotic fish fauna noted, likely impacting on waterway bank stability and native fish species.

While water and sediment quality differed between sites within the Macleay River and its tributaries, most sites were broadly similar, with the exception of site MR01, which was charactersied by elevated nutrient and metal concentrations (Table 7-1). Emergent macrophytes were found throughout the river and tributaries, considered typical of the region, but were not considered abundant or dense. The presence of several species of emergent macrophytes along tributaries indicated that a resident seed bank and sediment moisture has been sustained, even during historic drought conditions. No submerged macrophytes were observed.

A total of 12 aquatic invertebrate orders comprising 36 aquatic invertebrate families and 20 aquatic vertebrate taxa (including two exotic species) were recorded across a maximum of 18 sites within nine waterways. Aquatic invertebrate communities were also considered typical of the region, and the macroinvertebrate community of the Macleay River catchment reflected good conditions, albeit pollution-sensitive. Riffle habitat was generally in good condition; however, sediment accumulation appeared to impact the diversity of the macroinvertebrate community. The macroinvertebrate community of the Lower Dam and Reservoir was also in good condition, representative of the diverse habitat available at these sites.

The fish assemblage was dominated by native species, and only two exotic species (*Eastern Gambusia, *Goldfish or *Common Carp) were confirmed from several waterways (Table 7-1); unlikely to be having an impact on native fish populations. The fish community of the Macleay River is in relatively good condition due to its location within relatively undisturbed forested area (compared to other coastal catchments), lack of waterway regulation and good catchment condition in its upper reaches. The Platypus was recorded from the Macleay River (eDNA only) and although vertical banks with consolidated material were present, the prevalence of bedrock throughout the waterway suggests limited burrowing suitability. The Platypus has a large home range (Grant 2007); therefore, it is more likely that individuals use the Macleay River for feeding, transit and mating, with burrows located elsewhere along the waterway. Suitable nesting areas were present along the banks of the Macleay River; however, no evidence of turtles was observed. The presence of feral pigs, which were actively disturbing banks and floodplain areas, suggest that turtle recruitment is unlikely to be successful in the area due to the likelihood of egg predation.

No threatened aquatic flora or fauna species were documented during the March 2022 and June 2022 field surveys. The Southern Purple-spotted Gudgeon, Manning River Helmeted Turtle and Bellinger River Snapping Turtle had the potential to occur within the local catchment; however, they are unlikely to be present, regardless of potential occurrence mapping data provided by the Department of Primary Industries (2022c) and the Department of Planning and Environment (2022b;2022c), primarily due to a lack of recent species records within the catchment and overall lack of suitable habitat.

Based on the results of the desktop assessment and field surveys, the Macleay River is considered to be of high ecological value due to:

- its classification as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat (Table 4-3, Table 4-4);
- likely availability of permanent or semi-permanent refuge pools that persist during drought conditions;
- a current lack of waterway regulation, providing fish passage for migrating species; and/or
- potential transient use of the waterway by the Platypus.

Peach Tree Creek and Carrols Creek are considered to be of moderate ecological value (dependent on rainfall) due to:

- their classification as Type 2 and Class 2, and Type 2 and Class 1 (Table 4-3, Table 4-4), respectively;
- their potential to provide refuge during low rainfall conditions as a result of surface expression of groundwater, particularly Peach Tree Creek; and
- the presence of suitable key fish habitat features.

The remaining unnamed waterways are considered to be of lower ecological value as they are unlikely to hold surface water for prolonged periods, due to local topography and/or existing land disturbance, and their limited value as key fish habitat. However, it is possible that some of these waterways are sustained by groundwater, meaning that they may provide areas of refuge during low flow conditions.

Table 7-1: Summary of average habitat characteristics, aquatic biota, and ecological value based on the March 2022 and June 2022 field surveys.

Waterway / Site	Key Fish Habitat	Hydrology / Geology / Water Quality	Sediment Quality	Aquatic Biota	Notable Taxa	Ecological Value
Macleay River MR01, MR02, MR03, MR04, MR05, MR06, MR07, MR08, MR09	• Type 1 • Class 1	• Likely to contain areas of permanent water • Alkaline (pH 8.3 > ANZECC & ARMCANZ (2000) trigger) • Freshwater • Nitrogen (0.32 mg/L) > ANZECC & ARMCANZ (2000) trigger • Zinc (MR01; 0.012 mg/L) > Water Quality Australia (2018) DGV • Only MR01, MR03, MR04 and MR05 sampled	• Nitrogen and phosphorus relatively low, excluding nitrogen at MR01 which was elevated • Water Quality Australia (2018) DGVs for metals were not exceeded (where available) • Only MR01, MR03, MR04 and MR05 sampled	• 9 macroinvertebrate orders • 18 native aquatic vertebrate taxa • 2 introduced aquatic vertebrate taxa	• Platypus (MR01, MR03, MR04, MR05, MR06) • *Goldfish or *Common Carp (MR01, MR03, MR04, MR05) • *Eastern Gambusia (MR01, MR02, MR03, MR05)	• High • Likely to provide refuge to aquatic fauna during drought conditions • Currently unregulated; therefore, provides fish passage for migrating species • Exotic species recorded • Significant species recorded
Peach Tree Creek PC01	• Type 2 • Class 2	• Potentially contains areas of permanent water • Water quality data not collected	• Sediment quality data not collected	• Aquatic invertebrate data not collected • Aquatic vertebrate data not collected	• Nil	• Moderate (during flooded conditions) • Potential to provide refuge during low rainfall conditions • Contains suitable key fish habitat features
Carrols Creek CC01	• Type 2 • Class 1	• Potentially contains areas of permanent water • Water quality data not collected	• Sediment quality data not collected	• 5 macroinvertebrate orders • 7 native aquatic vertebrate taxa	• Nil	• Moderate (during flooded conditions) • Potential to provide refuge during low rainfall conditions • Contains suitable key fish habitat features
Unnamed Waterways (Lower Dam and Reservoir and Access Roads) UW01-01, UW02-03, UW02-04, UW03-01, UW04-01, UW07-01, UW08-01, UW09-01, UW10-01, UW11-01, UW12-01, UW13-01, UW14-01, UW15-01, UW-17-01, UW17-02, UW17-03, UW17-04, UW17-05	• Type 2 to Type 3 • Class 2 to Class 4	• Potential for some areas to contain permanent water as a result of surface expression of groundwater • Freshwater • Nitrogen and phosphorus < ANZECC & ARMCANZ (2000) trigger • Water Quality Australia (2018) DGVs for metals not exceeded • Only UW11-01 and UW12-01 sampled	• Nitrogen and phosphorus relatively low • Water Quality Australia (2018) DGVs for metals were not exceeded (where available) • Only UW11-01 and UW12-01 sampled	• 10 macroinvertebrate orders • 5 native aquatic vertebrate taxa • 1 introduced aquatic vertebrate taxa	• *Goldfish or *Common Carp (UW02-03, UW02-04, UW11-01, UW17-05)	• Low • Unlikely to hold surface water for prolonged periods • Limited value as key fish habitat
Unnamed Waterways (Upper Dam and Reservoir) UW02-01, UW02-02, UW06-01, UW06-02, UW06-03	• Type 2 to Type 3 • Class 3 to Class 4	• Potential for some waterways to contain permanent water as a result of surface expression of groundwater • Freshwater • Nitrogen and phosphorus < ANZECC & ARMCANZ (2000) trigger • Zinc (UW11-01; 0.011 mg/L) > Water Quality Australia (2018) DGV • Only UW02-03 and UW02-04 sampled	• Nitrogen and phosphorus relatively low • Water Quality Australia (2018) DGVs for metals were not exceeded (where available) • Only UW02-03 and UW02-04 sampled	• Aquatic invertebrate data not collected • Aquatic vertebrate data not collected	• Nil	• Low • Unlikely to hold surface water for prolonged periods • Limited value as key fish habitat
Unnamed Waterways (Eastern Access Road) UW18-01, UW19-01, UW20-01, UW20_1-01, UW21-01, UW22-01, UW22-01, UW23-01, UW24-01, UW25-01, UW25-02, UW26-01, UW27-01, UW28-01, UW29-01, UW30-01, UW31-01, UW32-01, UW33-01, UW34-01, UW35-01	• Type 2 to Type 3 • Class 3 to Class 4	• Potential for some waterways to contain permanent water • Water quality data not collected	• Sediment quality data not collected	• Aquatic invertebrate data not collected • Aquatic vertebrate data not collected	• Nil	• Low • Unlikely to hold surface water for prolonged periods • Limited value as key fish habitat

8. Ecological Impact Assessment

8.1. Ecological Receptors

The primary ecological receptors identified by the findings of this AEIA, in relation to potential impacts resulting from the Project on the Macleay River and associated tributaries, comprise:

- key fish habitat, influenced by surface water volume, flow and quality;
- aquatic invertebrates, influenced by surface water volume, flow and quality;
- aquatic vertebrates, including threatened species and the Platypus, influenced by surface water volume, flow and quality (including elevated metal concentrations);
- native plants inhabiting the riparian zone of the Macleay River, influenced by surface water volume and flood regime;
- groundwater-dependent wetlands, influenced by surface expression of groundwater; and
- waterway baseflow ecosystems, influenced by surface expression of groundwater.

8.2. Potential Impacts

Potential Project-related impacts to the Macleay River and associated tributaries are detailed in Appendix A of the SEARs. These impacts may influence ecological receptors, including significant taxa listed under the FM Act, BC Act and/or EPBC Act. Project activities that have the potential to impact aquatic ecology during construction and operation include:

- construction and operation of the Upper Dam and Reservoir/Lower Dam and Reservoir;
- construction and operation of the underground pumped hydro-electric power station, and water and access tunnels, including ground excavation;
- construction, operation and maintenance of other Project infrastructure;
- extraction of water from the Macleay River to fill the Upper Dam and Reservoir/Lower Dam and Reservoir and for intermittent top up;
- emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities;
- runoff, sedimentation and erosion as a result of construction, operation and maintenance earthworks activities;
- spoil storage;
- groundwater drawdown; and
- construction, operation and maintenance of bridge/road crossings and power transmission lines.

These activities may result in direct, indirect and/or cumulative impacts to ecological receptors and are discussed further below, followed by proposed mitigation measures to reduce such impacts.

8.2.1. Direct Impacts

Direct impacts that may occur to ecological receptors as a result of Project activities include:

- Short-term minor decrease in surface water volume and flow within sections of the Macleay River and associated tributaries as a result of reservoir construction and filling.
- Aquatic and riparian habitat removal, disturbance and fragmentation within sections of the Macleay River and associated tributaries due to construction, operation and maintenance of infrastructure listed above, in particular the construction and filling of the reservoir(s).
- Disturbance of waterway beds and banks, short-term impediment of fish passage and impacts to potential Platypus burrow habitat as a result of the construction and installation of bridge/road crossings and power transmission lines.
- Aquatic fauna mortality attributed to extraction of water from the Macleay River.

Construction of the Project will result in the impoundment of approximately 94% (3.1 km^2) of the Fingerboard Crossing Creek catchment. While all streamflow to the Macleay River from Fingerboard Crossing Creek will cease during the initial fill of the reservoirs, streamflow contributions from Fingerboard Crossing Creek are minor compared to flows within the Macleay River, comprising less than 0.1% of the overall Macleay River catchment (EMM, unpublished data). Following filling, streamflow that enters the Lower Dam and Reservoir may discharge downstream via a spillway (EMM Consulting 2022e). This has the potential to impact key fish habitat and aquatic habitat more broadly, as well as impeding fish passage. While these impacts are unavoidable in the area of the Upper Dam and Reservoir and the Lower Dam and Reservoir, it is unlikely that the ephemeral waterways in this area support persistent aquatic biota communities, particularly threatened aquatic species, although they may provide refuge habitat for aquatic biota during dry conditions within surface water pools sustained by groundwater. Impoundment also has the potential to reduce streamflow downstream of the structure(s); however, sufficient flow should still occur to minimise a reduction in flow from Fingerboard Crossing Creek, and groundwater mounding occurring during operation will contribute to streamflow within other waterways within the Project area (EMM Consulting 2022d). The water level of the Macleay River will also be subject to a minor decrease (modelled at 0.05 m), which is unlikely to affect the overall hydrological regime (EMM Consulting 2022e). Following implementation of appropriate mitigation, it is unlikely that significant direct impacts to aquatic ecology will occur as a result of a short-term minor decrease in surface water volume and flow within the Macleay River and associated tributaries as a result of reservoir construction and filling.

The removal and disturbance of aquatic and riparian habitat will occur as a result of construction of Project infrastructure, particularly the construction of the Upper Dam and Reservoir and the Lower Dam and Reservoir and the construction and installation of water extraction infrastructure in the Macleay River. Habitat fragmentation may also occur; however, this is likely to be limited to the areas of the Upper Dam and Reservoir and the Lower Dam and Reservoir, impacting on a limited area of ephemeral waterway, and less than 0.2 ha of the Macleay River (EMM Consulting 2022d). It is unlikely that Fingerboard Crossing Creek, above the waterfall, supports persistent aquatic biota communities, particularly threatened aquatic species, although it may provide refuge habitat for aquatic biota during dry conditions due to the intermittent surface expression of groundwater along its length. In terms of the Platypus, similarly to the above, ephemeral waterways along steeper sections of the escarpment are unlikely to support the species; however, these waterways may be used by the Platypus for foraging or refuge, supported by Department of Planning and Environment (2022a) which indicates Platypus presence within tributaries (Figure 6-11). It is anticipated that construction of water extraction infrastructure will only require a disturbance area of less than 0.2 ha, isolated to a localised area of the Macleay River, minimising impacts to the riparian zone. The installation and operation of water extraction infrastructure may further contribute to in-stream degradation of aquatic and riparian habitat, although the operation of water extraction infrastructure will primarily occur during the initial filling of the reservoirs, anticipated to take a minimum of three months. Erosion and sedimentation management will be implemented throughout the Project area to ensure that impacts to water quality, key fish habitat and the riparian zone are avoided or minimised during and after groundworks. All temporary disturbance areas will be rehabilitated to pre-disturbance conditions following completion of construction activities. Platypus burrow inspection and clearance surveys will be undertaken prior to any clearing and/or construction work being undertaken in areas of potential burrow habitat. A number of management and mitigation measures will also be implemented to minimise any impacts as part of Project-specific management plans. Following implementation of appropriate mitigation, it is unlikely that significant direct impacts to aquatic ecology will occur as a result of aquatic and riparian habitat removal, disturbance and fragmentation within the Macleay River and associated tributaries due to construction, operation and maintenance of infrastructure listed above, in particular the construction and filling of the reservoir(s).

It is anticipated that construction and installation of the bridge/road crossings and power transmission lines will require a disturbance area of less than 0.2 ha, isolated to minor localised areas, minimising impacts to waterway beds and banks. Similarly, impediment of fish passage may occur within several unnamed and named waterways including Oaky Creek, Waterloo Creek, Needle Creek and Carrolls Creek which will be intersected by the Eastern Access Road. The overhead transmission line will cross the Macleay River, Georges Creek, Middle Creek and the Dyke River catchments. However, it is anticipated that construction of this structure will be short-term and undertaken during dry conditions, as far as practicable, and is not expected to significantly impact the Macleay River. Similar to habitat disturbance, erosion and sedimentation management and Platypus burrow checks will be implemented at all waterway crossings to ensure that impacts are avoided or minimised wherever possible during and after installation of linear infrastructure, and that crossing sites are rehabilitated to pre-disturbance conditions, following completion of construction activities. Following implementation of appropriate mitigation, it is unlikely that significant direct impacts to aquatic ecology will occur as a result of disturbance of waterway beds and banks, short-term impediment of fish passage and impacts to potential Platypus burrow habitat as a result of the construction and installation of bridge/road crossings and power transmission lines.

Aquatic fauna mortality may occur via interaction with water extraction infrastructure, potentially impacting Platypus, fish and invertebrates. However, this will be mitigated by ensuring that design specifications of the extraction structure are "fish friendly" (Section 10.1), and by installing a gravity fed pipeline and wet well receptacle, to ensure fauna are not drawn towards water extraction infrastructure. The majority of aquatic fauna are also likely to be able to move away from extraction screens, given appropriate water extraction velocity is implemented. Following implementation of appropriate mitigation, it is unlikely that significant direct impacts to aquatic ecology will occur as a result of the potential for aquatic fauna mortality attributed to extraction of water from the Macleay River.

8.2.2. Indirect Impacts

Indirect impacts that may occur to ecological receptors as a result of Project activities and include:

- Short-term minor periodic decrease in surface water volume and flow within the Macleay River and associated tributaries as a result of water extraction.
- Initial and short-term periodic degradation in surface water quality (including breach of relevant WQOs; salinity, nutrients and/or metal concentrations) due to evapoconcentration within the Macleay River as a result of water extraction.
- Isolated, short-term thermal pollution of surface water within the Macleay River as a result of emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities.
- Erosion of the waterway within the zone of water extraction due to inappropriate extraction infrastructure design, operation and/or placement.
- Erosion, siltation, scouring and degradation of the riparian zone, including an increase in instability of waterway banks and beds, as a result of construction activities.
- Decrease in short to medium-term water and sediment quality as a result of runoff and sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.
- Decrease in short to medium-term water and sediment quality (including breach of relevant WQOs; salinity, nutrients and/or metal concentrations) as a result of unplanned discharge to waterways, or failure of surface water management systems as a result of inadequate rehabilitation and/or stabilisation methods, or rupture of water storage infrastructure.
- Increased local workforce potentially impacting upon aquatic species.
- Loss and /or reduced recruitment of native riparian plants, including potential loss of habitat and exacerbation of existing weed infestations, due to vegetation clearing, construction activities and water extraction during water extraction.
- Groundwater drawdown and host rock fracturing as a result of aquifer dewatering, potentially impacting groundwater-dependent wetlands and waterway baseflow ecosystems.

Short-term periodic decreases in surface water volume and flow within the Macleay River has the potential to occur as a result of water extraction during initial filling of the reservoirs and maintenance top-up of reservoir water. The initial extraction of water from the Macleay River for filling of the reservoirs will occur once and will be undertaken during high-flow events (above the 50th percentile flow) (EMM Consulting 2022e). The expected maximum annual volume extracted from the Macleay River is 6,865 ML, which represents less than 1% of streamflow in high-rainfall years ranging to approximately 7% of streamflow in low-rainfall years (EMM Consulting 2022e). The impact on annual streamflow volume is expected to decrease with distance downstream as runoff from the downstream catchment progressively forms a larger portion of observed streamflow, and input from waterways lower in the catchment is also likely to contribute to volume. In addition, groundwater mounding occurring as a result of presence of the reservoirs is expected to beneficially contribute to streamflow within ephemeral waterways, downstream of the reservoirs, contributing to surface water volume and flow within the Macleay River (EMM Consulting 2022d). Project-specific management plans will be implementation to ensure that surface water volume and flow are managed. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of short-term periodic minor decrease in surface water volume and flow within the Macleay River and associated tributaries as a result of water extraction.

Short-term periodic impacts to water quality may occur within the Macleay River as a result of evapoconcentration due to water extraction, including breach of relevant WQOs. Unplanned discharge to waterways, failure of surface water management systems, or rupture of water storage infrastructure may also contribute to impacts. It is unlikely that the extraction of water, or input of water, into the Macleay River will substantially influence evapoconcentration as the operation of water extraction infrastructure will primarily occur during high-flow events (above the 50th percentile flow) and will primarily only occur during the initial filling of the reservoirs (EMM Consulting 2022d). In addition, the transfer of water between the Lower Dam and Reservoir and the Upper Dam and Reservoir will result in substantial mixing, meaning that any unplanned discharge or failure of surface water management systems or water storage infrastructure is unlikely to substantially impact the Macleay River. Emergency and/or maintenance discharge of water is also likely to be isolated and short-term in nature, and a number of management and monitoring will be implemented as part of Project-specific management plans. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of the potential for short-term periodic degradation in surface water quality, due to evapoconcentration, within the Macleay River as a result of water extraction.

Further, construction, earthmoving, maintenance activities and inadequate post-construction rehabilitation and/or stabilisation methods have the potential to impact surface water quality as a result of mobilisation of sediment within the waterways adjacent to disturbed areas. Sedimentation and siltation, as well as exacerbation of runoff and erosion, have the potential to impact on water and sediment quality, the riparian zone, and stability of waterway banks and beds in the short to medium term. However, the construction envelope has been largely set back from the Macleay River and a number of mitigation and management strategies will be implemented to ensure that disturbed areas and waterway banks are stabilised during and after construction and during maintenance activities. Disturbed areas will also be progressively rehabilitated, where possible, in accordance with relevant Project-specific management plans. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of erosion, siltation, scouring and degradation of the riparian zone, including an increase in instability of waterway banks and beds, as a result of construction activities.

Elevated concentrations of metals have been recorded historically within the Macleay River catchment, including antimony, arsenic, copper and zinc, with most considered to occur naturally within the local catchment (EMM Consulting 2022a). Further, water and sediment sampling undertaken during the March 2022 field survey indicates that metals including aluminium, arsenic, barium, iron, manganese and zinc also occurred within the Macleay River, predominantly in areas of the waterway associated with wider bends where metals have the potential to accumulate in areas of lower flow (i.e. MR01, MR04; Section 6.3.1, Section 6.4). Therefore, while the construction and operation of the Project may contribute to elevated concentrations of metals within the water and sediment of waterways associated with the Project (particularly the Macleay River), it is more likely that this is a result of natural elevation of metals within the catchment, as well as potential runoff from existing disturbance sources (EMM Consulting 2022a). Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of a potential decrease in short to medium term water and sediment quality as a result of:

- unplanned discharge to waterways, or failure of surface water management systems as a result of inadequate rehabilitation and/or stabilisation methods, or rupture of water storage infrastructure; and/or
- runoff and sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.

Thermal (cold water) pollution occurring as a result of emergency dewatering from the low-level outlet, maintenance discharge of water from the Lower Dam and Reservoir via the spillway, and/or discharge from other water storage facilities has the potential to result in degraded water quality (e.g. dissolved oxygen, suspended solids, temperature, metal concentrations), impact upon the eggs and larvae of aquatic fauna, and interrupt the thermal breeding and migration cues for fish species. Thermal pollution is an artificial change in the temperature of a waterway as a result of thermal stratification and subsequent release of water via outlets located in the lower colder portions (i.e. the base) of reservoirs. Discharge from the Lower Dam and Reservoir has the greater potential to cause thermal pollution to Fingerboard Crossing Creek and the Macleay River. However, the transfer of water between the Lower Dam and Reservoir and the Upper Dam and Reservoir will result in substantial mixing of stored water, likely mitigating impacts associated with thermal pollution. Overflow from the spillway will likely have a lower risk to biota as spills would occur from the surface of the reservoir with the water likely being more similar temperature to the Macleay River. In addition, emergency and/or maintenance discharge of water is likely to be isolated and short-term in nature. During operation, the transfer of water will occur between the Lower Dam and Reservoir and the Upper Dam and Reservoir to store and generate energy, resulting in near complete mixing of stored water, expected to mitigate any impacts associated with cold water pollution. Further, mitigation and monitoring are proposed as part of Project-specific management plans. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of the potential for isolated, short-term thermal pollution of

surface water within the Macleay River as a result of emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities.

Inappropriate water extraction infrastructure design, operation and/or placement has the potential to result in erosion of the waterway within the zone of water extraction due to extraction velocity and extraction screen design. However, consultation with engineers will be undertaken during the detailed design phase to ensure that appropriate design is considered to reduce velocity and minimise erosion. Engineering design may consider, but is not to be limited to, ensuring water extraction infrastructure is raised off of the bed of the Macleay River to minimise erosion, positioning water extraction infrastructure in a section of the river where flow is relatively slow, and implementing Project-specific management plans, prior to Project construction. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of erosion of the waterway within the zone of water extraction due to inappropriate extraction infrastructure design, operation and/or placement within the Macleay River.

Construction, operation and maintenance of the Project may result in clearing and/or reduced recruitment of native riparian plants as well as the exacerbation of existing weed infestations. However, the disturbance footprint area within the riparian zone is limited to a localised area, reducing impact to riparian vegetation. In addition, the operation of water extraction infrastructure will only occur during high-flow events (above the 50th percentile flow), limiting the area of the riparian zone subject to drying. In terms of weed infestations, appropriate vehicle, machinery and soil/sediment checks will be undertaken to ensure weeds are not spread between construction areas and weed monitoring and management (e.g. chemical spraying) will be undertaken. Project-specific management plans will be implemented to manage activities within the riparian zone, as well as ensure soil hygiene practises are undertaken to reduce the spread of weeds. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to riparian vegetation will occur as a result of the loss and /or reduced recruitment of native riparian plants, including potential loss of habitat and exacerbation of existing weed infestations, due to vegetation clearing, construction activities and water extraction during water extraction.

Predicted impacts on streamflow have been assessed using flow statistics for the appropriate river flow objectives from available gauged records (EMM Consulting 2022e) in accordance with Department of Environment Climate Change and Water (2006). The net loss from surface water for the relevant waterways is then assumed to be a direct loss from prevailing flow. Maximum baseflow reduction to the Macleay River during construction of the Project is predicted to be approximately 193 ML/year; a 4% reduction from baseline baseflow conditions (EMM Consulting 2022d). However, during operation, water infiltration from Project infrastructure is predicted to increase baseflow contributions by approximately 400 ML/year; a 6% increase compared to baseline baseflow conditions (EMM Consulting 2022d). Overall, preliminary reduction in baseflow is not anticipated to have a significant impact on streamflow; therefore, it is also unlikely to impact aquatic ecology of the Macleay River and associated tributaries. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to waterway baseflow ecosystems will occur as a result of groundwater drawdown and host rock fracturing as a result of aquifer dewatering.

Additional pressure on aquatic fauna may occur as a result of the expected increase in the local workforce during the construction phase, resulting in increased fishing pressure. Construction employees should be prohibited from undertaking fishing activities while working on the Project, and should be educated as to fishery restrictions, as well as the status of local species, particularly threatened species, and the current threats to these species. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to aquatic ecology will occur as a result of the increased local workforce potentially impacting upon aquatic species.

The potential exists for construction, operation and maintenance of the Project to result in impacts to groundwater quality as a result of the precipitation of metals such as iron, or from leaching of surface spoil stockpiles or wastewater storage facilities. Introduction of blast chemicals may also impact groundwater quality. Prior to the application of mitigation, the risk to groundwater quality is considered low during construction and operation (EMM Consulting 2022d); therefore, it is likely that residual risk, particularly during operation, will be minor (EMM Consulting 2022d), with blast chemicals used only for a short period during construction of the tunnel. It is also anticipated that stockpiles and seepage will be mitigated and managed by appropriate measures to protect the groundwater resources as part of several Project-specific management and monitoring plans. Following implementation of appropriate mitigation, it is unlikely that significant indirect impacts to groundwater-dependent wetlands and waterway baseflow ecosystems will occur as a result of potential impacts to groundwater quality.

8.3. Cumulative Impacts & Key Threatening Processes

This section provides consideration of the Project's potential to generate cumulative impacts in the region related to aquatic ecology. The *Cumulative Impact Assessment Guidelines for State Significant Projects* (Department of Planning Industry and Environment 2021) are part of the Rapid Assessment Framework introduced in 2021, aimed at improving the assessment of major projects in NSW. The scoping phase for the Project preceded the implementation of these guidelines and, as such, a scoping assessment for cumulative impacts was not performed at the time. Therefore, the EIS has included a screening exercise of future projects, focusing on key matters that could be materially affected, to inform the cumulative impact assessment (EMM Consulting 2022c).

The Project is located within the Armidale Regional LGA. The cumulative impact assessment has considered other future projects (on the DPE Major Projects Planning Portal) that have the potential to interact with the Project, within the following spatial extent:

- within the Armidale Regional LGA;
- within Kempsey Shire LGA;
- within Walcha Council LGA; and
- within 70 km of the Project area.

The following projects (Figure 8-1) within the above domains were considered in the aquatic ecology cumulative impact assessment:

- Doughboy Wind Farm (SSD-9161599) – 30.5 km north of the Project area;
- Winterbourne Wind Farm (SSD-10471) – 37 km southwest of the Project area;
- Metz Solar Farm (SSD-7931) – 40.5 km north-west of the Project area;
- Stringybark Solar Farm (DA 112-2019) – 45.5 km northwest of the Project area;
- Olive Grove Solar Farm (DA 17-2020) – 46 km northwest of the Project area;
- Oxley Solar Farm (SSD-10346) – 47 km northwest of the Project area;
- Armidale Battery Energy Storage System (SSD-23515853) – 52 km northwest of the Project area;
- Armidale Solar Farm (DA 164-2019) – 54 km northwest of the Project area;
- New England Solar Farm (SSD-9255) – 61 km northwest of the Project area;
- Salisbury Solar Farm (SSD-10347) – 62 km west of the Project area;
- Thunderbolt Community Solar Farm (DA-8-2021) – 67.5 km west of the Project; and
- Tilbuster Solar Farm (SSD-9619) – 68 km northwest of the Project area.

8.3.1. Consideration of Cumulative Impacts Related To Aquatic Ecology

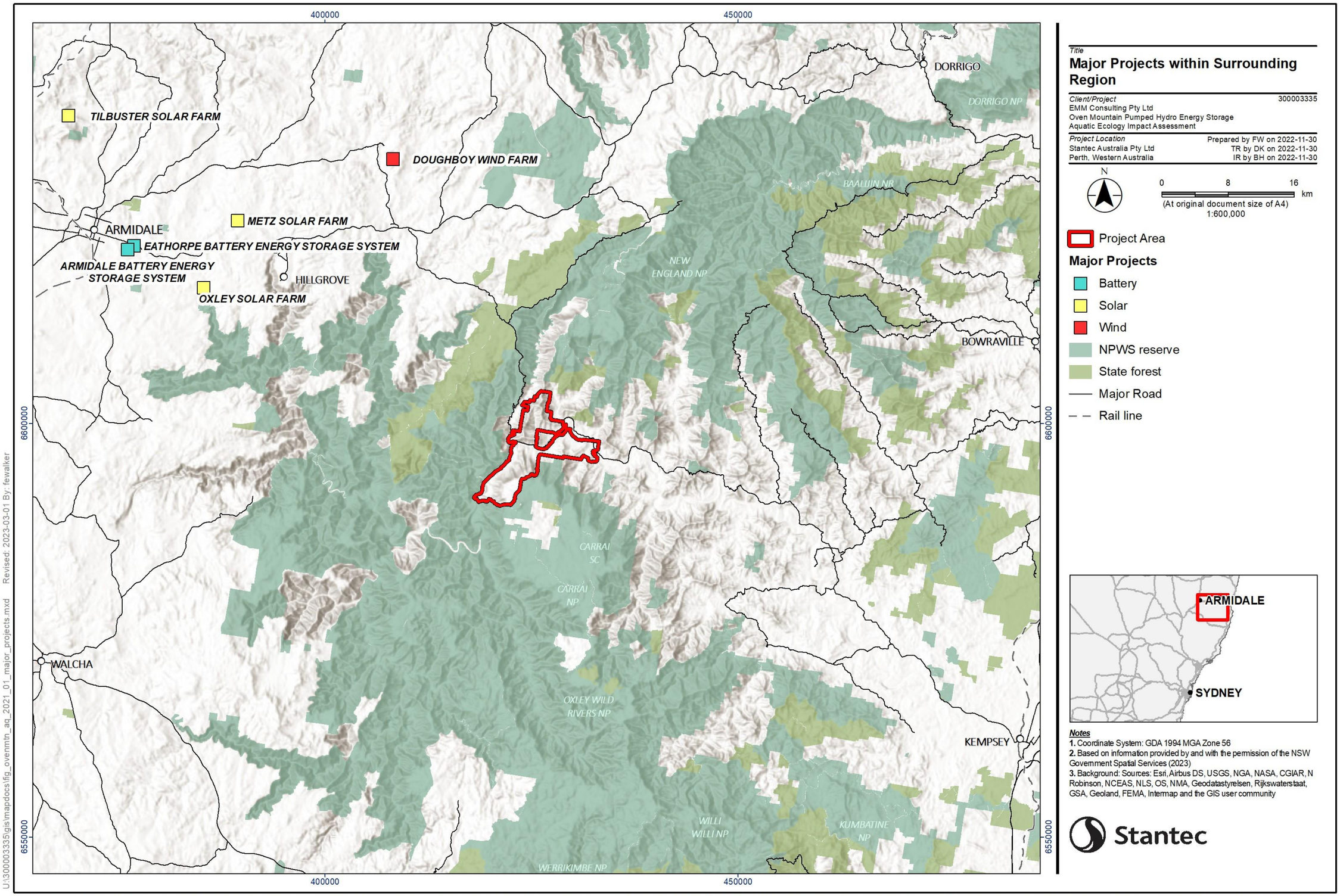
Following review of impacts related to aquatic ecology from surrounding projects within relevant domains, it is unlikely that the projects identified in Section 8.3 will result in significant cumulative impacts in conjunction with the Project. However, cumulative impacts will still occur due to the overall contribution of the Project to relevant FM Act, BC Act and EPBC Act key threatening processes such as:

- degradation of native riparian vegetation along New South Wales water courses;
- installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams;
- removal of large woody debris from New South Wales rivers and streams;
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands;
- invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat);
- loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants; and
- predation by the Plague Minnow (*Gambusia holbrooki*).

This has the potential to influence water quality and aquatic biota on a State-wide scale.

Construction, operation and maintenance of the Project may contribute to further deterioration of relevant key threatening processes including degradation of native riparian vegetation (e.g. construction activities and/or extraction of water), installation and operation of in stream structures altering natural flow (e.g. construction and operation of water extraction infrastructure), and invasion, establishment and spread of the introduced weed Lantana in the riparian zone (e.g. movement of soil from areas infested with *Lantana).

However, the disturbance footprint within the riparian zone is limited to a localised area, the operation of water extraction infrastructure will only occur during high-flow events (above 50th percentile), and Project-specific management plans will be implemented to ensure soil hygiene practises are undertaken to reduce the spread of weeds. As construction, operation and maintenance of the Project is anticipated to have only relatively minor impacts to aquatic ecology, it is unlikely that the cumulative impacts and key threatening processes, identified above will be exacerbated.



Title

Major Projects within Surrounding Region

Client/Project	300003335
EMM Consulting Pty Ltd	
Oven Mountain Pumped Hydro Energy Storage	
Aquatic Ecology Impact Assessment	
Project Location	Prepared by FW on 2022-11-30
Stantec Australia Pty Ltd	TR by DK on 2022-11-30
Perth, Western Australia	IR by BH on 2022-11-30

N

0 8 16 km

(At original document size of A4)
1:600,000

Project Area

Major Projects

- Battery
- Solar
- Wind

NPWS reserve

State forest

Major Road

Rail line

Notes

1. Coordinate System: GDA 1994 MGA Zone 56

2. Based on information provided by and with the permission of the NSW Government Spatial Services (2023)

3. Background: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

Stantec

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Figure 8-1: Major projects within surrounding region.

9. Significant Impact Assessment

In accordance with section 221ZV of the FM Act and *Matters of National Environmental Significance Significant impact guidelines 1.1 (EPBC Act)* (Department of the Environment 2013), an assessment was undertaken to determine whether the Project is likely to significantly impact listed habitats, communities, populations and/or species. Assessments of significant are presented in full in Appendix D. Species that were considered to be unlikely to occur have not been considered further. Assessments of significance have been provided for:

- Habitat and communities:
  - Nil.
- Populations and species:
  - Southern Purple-spotted Gudgeon (Endangered, FM Act; Appendix D).
  - Manning River Helmeted Turtle (Endangered, BC Act; Appendix D).

While the Platypus is not listed as a threatened species, a brief assessment has been provided below (Section 9.1.3).

9.1.1. FM Act

9.1.1.1. Southern Purple-spotted Gudgeon

Aspects of the Project that have the potential to impact the Southern Purple-spotted Gudgeon, if it occurs, include:

- reservoir construction and filling resulting in short-term minor decrease in surface water volume and flow within the Macleay River and associated tributaries;
- construction, operation and maintenance of infrastructure, particularly linear infrastructure, resulting in aquatic habitat (waterway beds and banks) removal, disturbance and fragmentation and short-term impediment of fish passage within the Macleay River and associated tributaries;
- extraction of water from the Macleay River resulting in aquatic fauna mortality;
- extraction of water from the Macleay River resulting in short-term periodic minor decrease in surface water volume and flow;
- initial and short-term periodic degradation of surface water quality (evapoconcentration of salinity, nutrients and/or metal concentrations) within the Macleay River as a result of water extraction;
- unplanned, emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities resulting in isolated, short-term thermal pollution of surface water within the Macleay River; and
- degradation of surface water quality within the Macleay River as a result of sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.

However, construction, operation and maintenance of the Project is unlikely to significantly impact the Southern Purple-spotted Gudgeon, if it occurs, justified as follows:

- It is unlikely that the Macleay River, or associated tributaries, support viable populations of the species.
- The species is unlikely to be present within the Project area. It is considered rare in inland water in NSW and, although Department of Primary Industries (2022c) distribution mapping suggests that its presence is possible within the broader region, there have been no sightings through field surveys since 1983.
- While habitat suitable to the Southern Purple-spotted Gudgeon may occur within the vicinity of the Project, the species was not confirmed as occurring within the Project area during any previous surveys carried out in the Macleay River.
- Overall, there is a general lack of extensive habitat for the Southern Purple spotted Gudgeon in the local area, and given the ephemeral nature of the catchment tributaries, it is unlikely that there is sufficient habitat to support the persistence of the species.
- The impacts of the Project on the Macleay River and its associated waterways have been minimised whereby:
  - the disturbance footprint is limited to 0.2 ha;
  - the operation of the water extraction infrastructure is considered to be temporary and/or short-term; and

    - the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the Department of Primary Industries (2022c) mapped distribution of the Southern Purple-spotted Gudgeon and unlikely to support aquatic biota communities.
- Appropriate management measures will be in place to ensure that impacts to water quality, key fish habitat and the riparian zone are avoided or minimised during and after groundworks, as far as practicable.

9.1.2. BC Act

9.1.2.1. Manning River Helmeted Turtle

Aspects of the Project that have the potential to impact the Manning River Helmeted Turtle, if it occurs, include:

- reservoir construction and filling resulting in short-term minor decrease in surface water volume and flow within the Macleay River and associated tributaries;
- construction, operation and maintenance of infrastructure, particularly linear infrastructure, resulting in aquatic habitat (waterway beds and banks) removal, disturbance and fragmentation and short-term impediment of fish passage within the Macleay River and associated tributaries;
- extraction of water from the Macleay River resulting in aquatic fauna mortality;
- extraction of water from the Macleay River resulting in short-term periodic minor decrease in surface water volume and flow;
- initial and short-term periodic degradation of surface water quality (evapoconcentration of salinity, nutrients and/or metal concentrations) within the Macleay River as a result of water extraction;
- unplanned, emergency and/or maintenance discharge of water from the Upper Dam and Reservoir/Lower Dam and Reservoir and other water storage facilities resulting in isolated, short-term thermal pollution of surface water within the Macleay River; and
- degradation of surface water quality within the Macleay River as a result of sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.

However, construction, operation and maintenance of the Project is unlikely to significantly impact the Manning River Helmeted Turtle, if it occurs, justified as follows:

- It is unlikely that the Macleay River, or associated tributaries, support viable populations of the species.
- The species is unlikely to be present within the Project area. Although known habitat distribution mapping suggests that its presence is possible within the broader region, the main area of impact of the Project is outside of this distribution.
- While habitat suitable to the Manning River Helmeted Turtle was observed within the vicinity of the Project, the species was not observed during the field survey.
- Overall, there is a general lack of extensive habitat for the Manning River Helmeted Turtle in the local area and, given the ephemeral nature of the catchment tributaries, it is unlikely that there is sufficient habitat to support the persistence of the species.
- The presence of exotic species and predators such as feral pigs pose a risk to survival and recruitment, as well as habitat quality and availability.
- The impacts of the Project on the Macleay River, and its associated waterways, have been minimised whereby:
    - the disturbance footprint is limited to 0.2 ha;
    - the operation of the water extraction infrastructure is considered to be temporary and/or short-term; and
    - the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the mapped distribution of the Manning River Helmeted Turtle (Department of Planning and Environment 2022c) and unlikely to support aquatic fauna.
- Appropriate management measures will be in place to ensure that impacts to water quality and the riparian zone are minimised during and after groundworks, as far as practicable.

9.1.3. Platypus

While the Platypus is not currently listed as threatened under State or Commonwealth legislation, there is currently a lack of knowledge regarding species abundance at a local catchment level (Australian Museum 2019). The Platypus is also subject to the same impacts and threats as for native fish species, including stream bank erosion, channel sedimentation, regulated waterways, barriers to water flow (e.g. dams and weirs), riparian zone degradation and loss of riparian vegetation (Bino *et al.* 2019; Temple-Smith and Grant 2003).

The Platypus is known to occur within the local catchment (Department of Planning and Environment 2022a), and the June 2022 field survey confirmed its presence along the length of the Macleay River (Table 6-9; Figure 6-11). It is possible that the Platypus may be impacted by the Project during construction and operation, attributed to infrastructure construction (habitat removal, fragmentation), operation of water extraction infrastructure (entrainment), and potential impacts to water volume, flow and quality. However, the species is known to persist in aquatic habitats lacking in key habitat features, including overhanging vegetation, riffle and run waterways sections, and solid earth banks, and is known to occur in degraded agricultural environments (Temple-Smith and Grant 2003). It is unlikely that the species uses the Macleay River for burrow construction, with the majority of the waterway characterised by bedrock.

Changes to the water volume, flow and quality, from the Project and associated fluctuations are expected to be minor, with initial water extraction to fill the reservoirs only occurring during high-flow events (above 50th percentile) (EMM Consulting 2022e); sufficient flow should occur to minimise low flow conditions and water quality impacts. It is predicted that river water level will only decrease by a maximum of 0.05 m (EMM Consulting 2022e), with this impact restricted to the vicinity of the water extraction infrastructure. In addition, the Platypus is substantially more mobile compared to fish and is able to move between surface water pools along waterways, further reducing the likelihood of impact to this species, particularly during emergency or planned discharge events. Regardless, Platypus burrow inspection and clearance surveys will be undertaken prior to any clearing and/or construction work being undertaken in areas of potential burrow habitat. A number of management and mitigation measures will also be implemented as part of Project-specific management plans to minimise any impacts.

10. Recommended Mitigation

A range of recommended mitigation will be implemented where feasible for the Project (Table 10-1).

Table 10-1: Mitigation measures for aquatic ecology impacts.

ID#	Impact / Risk	Recommended Mitigation	Timing	Responsibility
AE01	Potential impacts on the Southern Purple-spotted Gudgeon and the Manning River Helmeted Turtle	• Undertake further field sampling to document the presence/absence of the Southern Purple-spotted Gudgeon and the Manning River Helmeted Turtle (e.g. targeted habitat sampling, eDNA sampling) to expand their known range, reducing impact on the overall population.	Prior to construction	OMPS and contractor
AE02	Short-term minor decrease in surface water volume and flow within the Macleay River and associated tributaries as a result of reservoir construction and filling.	• The baseflow of the Macleay River should be maintained during dry conditions in accordance with the relevant licensing provisions (SPAL) approved for the Project. • Surface water , flow and quality should be monitored upstream and downstream of the water extraction site within the Macleay River, prior to, during and post-construction to detect changes outside of expected ranges and in accordance with the relevant licensing provisions (i.e. the SPAL). • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Prior to, during and post-construction	OMPS and contractor
AE03	Initial and short-term periodic degradation in surface water quality (including breach of relevant WQOs; salinity, nutrients and/or metal concentrations) due to evapoconcentration within the Macleay River as a result of water extraction.	• Sediment control devices should be used around construction areas (e.g. silt fences in areas where construction runoff may enter waterway). • Surface water , flow and quality triggers should be established for the Macleay River to detect changes in salinity and other parameters relevant to aquatic ecology, particularly during initial filling of the reservoirs, and to further inform monitoring programs. • Surges of water after rainfall naturally flush waterways to prevent stagnation; therefore it is recommended that the SPAL considers filling of the reservoirs should be delayed post-initial flush, where feasible. • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Prior to construction	OMPS and contractor
AE04	Aquatic fauna mortality attributed to extraction of water from the Macleay River.	• Water extraction infrastructure should be designed, constructed and operated in alignment with Boys (2021) and Boys *et al.* (2021), and "fish friendly" end-of-pipe screens (Section 10.1) should be selected to minimise	Prior to, during and post-construction	OMPS and contractor

ID#	Impact / Risk	Recommended Mitigation	Timing	Responsibility
		mortality of fish, Platypus, amphibians and turtles, and to prevent infrastructure damage.		
AE05	Disturbance of waterway beds and banks as a result of water extraction.	• Ensure water extraction infrastructure is raised off the sediment to minimise erosion of the benthos.	Prior to, during and post-construction	OMPS and contractor
AE06	Disturbance of waterway beds and banks, decrease in short to medium term water and sediment quality, short-term impediment of fish passage and impacts to potential Platypus burrow habitat as a result of the construction and installation of bridge / road crossings and power transmission lines.	• Ensure all waterway crossings comply with *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003) and *Policy and guidelines for fish habitat conservation and management* (Department of Primary Industries 2013); • Ensure Project management plans contain provisions for managing impacts and monitoring water quality, key fish habitat and fish passage during Project construction, in particular, bridge/road and transmission line waterway crossing installation. • Ensure the sections of waterway to be impacted by Project construction (i.e. bridge / road crossings, water extraction infrastructure installation) are surveyed for Platypus burrows and individuals and, if Platypus are located, that relocation surveys are undertaken prior to clearing and construction works. • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Prior to and during construction	OMPS and contractor
AE07	Additional surveys and monitoring to identify any potential Project-specific impacts to aquatic vertebrate fauna species not yet identified from the Macleay River within the Project area.	• If practical, undertake follow up aquatic vertebrate fauna monitoring using a boat electrofisher as some areas with deeper water couldn't be accessed due to lack of boat access at the time of the field surveys. • Alternatively, purchase historic monitoring data from the DPI Fisheries.	Prior to construction	OMPS
AE8	Erosion, siltation, scouring and degradation of the riparian zone, including an increase in instability of waterway banks and beds, as a result of construction activities.	• Ensure Project-specific management plans and relevant licenses contain provisions for managing water quality, water flow, aquatic habitat and riparian habitat, and include erosion and sediment management and mitigation measures such as silt fencing and sediment capture downslope of construction areas. Ensure construction staff use specific tracks when accessing and moving through riparian corridors.	Prior to and during construction	OMPS and contractor

ID#	Impact / Risk	Recommended Mitigation	Timing	Responsibility
		• Fence off areas of riparian vegetation to exclude cattle and livestock. • Ensure Project-specific management plans are prepared and implemented, prior to construction.		
AE9	Decrease in short to medium term water and sediment quality as a result of Project activities adjacent to the Macleay River.	• Ensure Project-specific management plans contain provisions for the management of construction pollutants (i.e. hydrocarbons, chemicals) to ensure that no contamination of waterways (or nearby soil) occurs. • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Prior to and during construction	OMPS and contractor
AE10	Decrease in short to medium term water and sediment quality as a result of runoff and sedimentation attributed to inadequate post-construction rehabilitation and/or stabilisation methods.	• Ensure Project-specific management and rehabilitation plans contain provisions for managing water and sediment quality, downslope of constructed areas, post-Project construction. • Undertake periodic monitoring or inspection of adjacent aquatic and riparian habitat during and post-construction. • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Construction	OMPS and contractor
AE11	Loss and /or reduced recruitment of native riparian plants, including potential loss of habitat and exacerbation of existing weed infestations, due to vegetation clearing, construction activities and water extraction during water extraction.	• Ensure that aquatic and riparian zones are progressively rehabilitated, where necessary, and managed in accordance with Project rehabilitation plans, and that adjacent disturbed areas are also rehabilitated (weed management, native vegetation planning, erosion control / prevention, fencing of waterways, etc.), where practicable. • Ensure Project-specific management plans contain provisions for managing water quality, water flow, aquatic habitat and riparian habitat, and include erosion and sediment management and mitigation measures such as silt fencing and sediment capture downslope of construction areas. Ensure construction staff use specific tracks when accessing and moving through riparian corridors. • Fence off areas of riparian vegetation to exclude cattle and livestock. • Ensure Project-specific management plans are prepared and implemented, prior to construction.	Construction and post-construction	Contractor

ID#	Impact / Risk	Recommended Mitigation	Timing	Responsibility
AE12	Decrease in short to medium term water and sediment quality	• Consider developing site-specific water and sediment quality criteria for use in future monitoring.	Prior to and during construction	OMPS and contractor
AE13	Risk of a lack of understanding and subsequent challenging by relevant regulatory departments and stakeholders of management approaches and aquatic offset strategy.	• Consultation with relevant regulatory departments should be undertaken as soon as practicable to ensure management of the Project, in relation to aquatic ecology, aligns with expectations, including but not limited to the DPI Fisheries and the Natural Resources Access Regulator (NRAR). • Consult with the DPI Fisheries regarding the implementation of an aquatic offset package, if necessary and feasible, for the Project in alignment with *NSW Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity* (Department of Primary Industries 2014).	Prior to and during construction	OMPS and contractor

10.1. End-of-pipe Screens

It is also recommended that "fish friendly" end-of-pipe screens are selected to minimise mortality of fish, Platypus, amphibians and turtles, and to prevent infrastructure damage (Boys 2021; Boys *et al.* 2021). Several factors are presented below for consideration.

- Screens may comprise a box, drum or plate affixed around or to the end of the pipe, and can be constructed from punched steel plate, wire mesh or wedge wire.
- Screen selection should account for fauna species, size and nearby habitat, as well as water harvest rate, screen material, maintenance and cleaning methods, and be no more than a maximum of 3 mm in aperture.
- The water harvest rate should account for the swimming mode of the potentially affected fauna species, with a maximum of 0.1 m/sec approach velocity (measured 8 cm in front of the screen).
- Inclusion of an automated cleaning system (e.g. air purge) to allow finer screens to be cleaned and may also be operated to scare aquatic fauna away prior to start up, with velocity increasing gradually to allow more sedentary aquatic fauna to escape.
- If an automated cleaning system is not installed, the mesh extraction screen will need to be manually cleaned periodically during and after water extraction.
- Screens should be situated in areas and depths of water with low concentrations of fish during high flow periods and should be away from structures that attract fish that are migrating, spawning, or in rearing habitat.
- Screens should face the direction of water flow (i.e. downstream) and should be located at such a height above the substrate so that entrainment of sediment and benthic fauna is avoided.
- Where possible, screens should be positioned in river sections where flow is relatively slow, to minimise potential for erosion.
- Screens should not have any additional openings that are less than the screen opening dimensions and structural support should be in place to prevent sagging/collapse of the structure.
- Additional cages or "trash screens" can be installed around the screen for protection, particularly during high flow events where vegetative debris may be present in large quantities.
- Consideration should be given to regular removal, inspection, and cleaning of screens to prevent fouling and entrainment of fish, with the wet well pump turned off at this time.
- Fish friendly screening methods can be costly, so it is recommended that an analysis of options is undertaken as early in the design phase as possible. The cost of regular maintenance should also be considered.
- Discussion with the design engineers should be undertaken as soon as practicable to ensure that the above considerations are incorporated into the detailed design phase. Stantec and/or EMM would be available to assist in this discussion to ensure that ecological considerations are addressed.

11. Conclusion

This AEIA has been prepared for the Project and includes a thorough desktop assessment and field survey program (completed in March 2022 and June 2022) to inform the habitat characteristics, aquatic biota, and the ecological value of the construction envelope and broader Project area. Project activities that have the potential to directly or indirectly impact the ecological receptors of the Macleay River, associated tributaries and groundwater during construction and operation have been assessed. It is concluded that, following implementation of appropriate mitigation, where impacts occur, it is unlikely that significant direct or indirect impacts to aquatic ecology will occur because of the Project's activities. Additionally, assessments of significance were undertaken for the Southern Purple-spotted Gudgeon and the Manning River Helmeted Turtle. It was concluded the Project is unlikely to significantly impact these species.

In accordance with *NSW Biodiversity Offsets Policy for Major Projects. Fact sheet: Aquatic biodiversity* (Department of Primary Industries 2014), aquatic offsets are required wherever direct or indirect impacts to key fish habitat occur (i.e. impacts to water quality, impediment to fish passage). It is not expected that the Project will result in significant broad-scale impacts to key fish habitat or aquatic biodiversity within the Macleay River and associated waterways because of the Project. However, consultation with the DPI Fisheries will occur as soon as practicable to discuss an approach to aquatic offsets, if considered necessary and where feasible for the Project to implement. Where avoidance is not feasible, direct and indirect impacts will be managed through the implementation of a variety of mitigation strategies and through ongoing consultation with relevant agencies and stakeholders.

12. Indicative Aquatic Offset Approach

It is not expected that the Project will result in any significant broad-scale impacts to key fish habitat or aquatic biodiversity within the Macleay River and associated waterways as a result of the Project. However, it is recommended that consultation occurs with the DPI Fisheries as soon as practicable to discuss an approach to aquatic offsets, if considered necessary and where feasible for the Project to implement. In accordance with *Biodiversity Offsets Policy for Major Projects Fact sheet: Aquatic biodiversity* (Department of Primary Industries 2014), aquatic offsets are required wherever direct or indirect impacts to key fish habitat occur (i.e. impacts to water quality, sediment).

A summary of the key features of an aquatic offset strategy are provided below, relative to aquatic biodiversity, if an aquatic offset package is required. The aquatic offset strategy should be implemented:

- within the Macleay Rivers catchment;
- within "like-for-like" habitat;
- within the same or a similar habitat in the same catchment that is more threatened than the habitat being impacted; and
- as part of an offset site, as versus implementing supplementary measures.

In the event that the above criteria cannot be met, then funds may be provided towards implementing supplementary measures which provide additional flexibility in fulfilling offset requirements. These may include:

- implementing actions outlined in relevant threatened aquatic species recovery plans or Priorities Action Statement in the absence of threatened aquatic species recovery plans;
    - e.g. Priorities Action Statement – Actions for the Southern Purple spotted Gudgeon.
- implementing actions that contribute to threat abatement plans;
    - e.g. Threat Abatement Plan – large woody debris.
- undertaking biodiversity research and survey programs identified by the DPI Fisheries; and/or
- rehabilitating degraded aquatic habitat.

Where aquatic habitat is currently degraded and fragmentation exists, it is possible that supplementary measures would form a key part of any offset strategy. For example, funding could be provided to existing habitat mapping programs within the broader region, aquatic and riparian habitat rehabilitation could be implemented, and/or existing barriers to fish passage could be removed. In the event that a monetary contribution is proposed in place of offsets occurring within the same, or a similar habitat, to that being impacted, then the area of key fish habitat loss would be calculated for impacted waterways.

Department of Primary Industries (2014) requires that a minimum 2:1 offset occurs for Type 1 to Type 3 key fish habitats (Table 4-3) to redress both the direct and indirect impacts of development, based on a calculation of impacted area; however, the key fish habitat area calculation process should be undertaken in close consultation with DPI Fisheries. In addition, it should be noted that:

- any offset strategy shall be developed in consultation with the DPI Fisheries, and relevant technical staff, to determine whether on-site improvement or contribution to priorities identified by DPI Fisheries is the preferred option; and
- the offset strategy is likely to be developed following approval of the Project.

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Appendices

We design with community in mind

Appendix A Aquatic Ecology Services (2022)

Oven Mountain Pumped Hydro Energy Storage Project

Aquatic Ecology Final Report

Aquatic Ecology Services

This report has been prepared for EMM as a technical document to inform an EIS. Aquatic Ecology Services prepared this report in consultation with EMM.

The opinions, conclusions and any recommendations in this report are based on information obtained from a field survey undertaken at or in connection with specific sample points under the flow conditions at the site. As a result, not all relevant site features and conditions may have been identified in this report.

Rainfall and river height data were obtained from external sources. Aquatic Ecology Services has made the assumption that all data has been validated and is correct.

Version	Prepared by	Reviewed by	Review Date
1.0	T Steele	T Vallance	1/08/2022
1.1	T Steele	E McIntosh, B Hay	15/08/2022
2.0	T Steele		

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1. Introduction

1.1 Background

The Oven Mountain Pumped Hydroelectricity (OMPH) Energy Storage project (The Project) t is an 'off river' development located adjacent to the Macleay River between Armidale and Kempsey. The project will provide clean energy generation and storage capabilities, ensuring a reliable, resilient, and renewable future energy supply for NSW.

The Project will include upgrades to the existing electricity transmission network enabling ready transport of power to the grid. It will also include upgrades to existing local and regional roads, allowing for safe construction and operation access. Work on The Project will include delivering an underground pumped hydro-electric power station complex, lower and upper reservoir and intakes, spillways, new and upgraded roads to allow ongoing access and maintenance along with power and communication infrastructure. Construction will also require delivering temporary infrastructure such as water stores; pumps and pipes; on-site borrow pits and concrete batching plants; construction power supply; and accommodation camps.

As an 'off river' scheme, The Project will have little additional need for water over its operational life once the dam infrastructure has filled. Water from the Macleay River will be used for the initial fill – a one-off event during the construction period. During operation, discharges to the receiving environment will also be required. Both of these activities, and the construction footprint of The Project have the potential to impact aquatic ecosystems, and so studies of the existing environment were required.

1.2 Scope

EMM engaged Aquatic Ecology Services to undertake an assessment of the aquatic ecology values of the Macleay River and its tributaries at the site of, and downstream of the proposed works to inform an EIS. This was achieved through the following:

- Desktop assessment of aquatic ecological values, including review of available literature
- Field survey of sites along the Macleay River and its tributaries, as well as waterways along proposed linear infrastructure.
- Processing of biological samples (eDNA, macroinvertebrates, stygofauna)
- Provide a technical report characterising the aquatic ecosystems within and surrounding the OMPH footprint

The following report presents the findings of a field surveys undertaken between March and June 2022.

1.3 Study Area

The Macleay Basin is the located in the north-east of NSW and covers an area of ~11,450 km2. The Basin is formed by the Great Dividing Range at its western and north-western boundaries, by the Snowy Ranges and the Macleay Hills along its north-eastern boundary, and the Banda Banda Plateau and the hills of the Maria River State Forest to the south (White 2000). The rivers and streams of the Macleay Basin remain largely unregulated, with a small number of weirs, dams and road crossings throughout the smaller headwater tributaries. The OMPH Study Area is located near Lower Creek, and spans along the Macleay River from Peacock Creek to the south-west, to Carroll's Creek in the east, and includes tributaries of the Macleay River that flow from the Carrai Plateau.

1.4 Threatened species

Threatened species identified by EMM during the Scoping Study (EMM 2021) as predicted to occur or known to occur in the vicinity of the study area are presented below in Table 1. The most recent study of the Macleay River was conducted by NSW DPI (Butler *et al.* 2015) and incorporated sites in the vicinity of the Study Area, including a site at George's Junction and tributaries of the Macleay River upstream and downstream. Southern Purple-spotted Gudgeon and Eastern Freshwater Cod were not recorded during these surveys and have not been recorded in any previous surveys carried out in the Macleay River (Llewellyn 1983; Harris and Gherke 1997). The scoping study used desktop tools which spanned a radius of 50km, which included nearby catchments in which both species have been found. Current potential habitat mapping for Southern Purple Spotted Gudgeon (DPI 2022a) does include reaches of the Macleay River within the study area, and so this species is considered to have a greater potential to occur than Eastern Freshwater Cod.

Habitat for several species of freshwater turtle was also identified in the Scoping Study.

Table 1 – Listing status of threatened species predicted to occur in the vicinity of the study area

Scientific name	Common Name	EPBC Act	FM Act	BC Act
Mogurnda adspersa	Southern Purple-spotted Gudgeon	-	Endangered	-
Maccullochella ikei	Eastern Freshwater Cod	-	Endangered	-
Myuchelys purvisi	Manning River Helmeted Turtle	-	-	Endangered
Myuchelys bellii	Western Sawshelled Turtle	Vulnerable	-	Endangered
Myuchelys georgesi	Bellinger River Snapping Turtle	Critically Endangered	-	Critically Endangered

1.5 Fish Stocking

Recreational fishing species have been stocked in the Macleay River and its tributaries historically. The most recent stocking events included the release of fingerlings downstream of the Study Area in February 2022 (Kempsey Shire Council 2022) and the stocking of Felters Creek and Dyke River with Rainbow Trout over consecutive years since 2010 and 2013 respectively (NSW DPI 2022b).

1.6 Project Team

The project was undertaken by Aquatic Ecology Services. The project team are provided below in Table 2. Our team offered over 30 years of combined experience in aquatic ecology surveys.

Table 2 - Project Team

Team Member	Experience	Description	Role
Tara Steele	12 years	Tara is an Aquatic Ecologist, with over ten years' experience in freshwater, groundwater dependent and estuarine ecosystems. She has worked extensively in across Australia, undertaking fish, macroinvertebrate, water quality and stygofauna surveys for compliance monitoring and impact assessments.	Field team leader, reporting
Terry Vallance	25 years	Terry's fields of expertise are fish biology, behaviour, and taxonomy. He has more than 25 years' experience conducting aquatic ecological studies throughout Australia, largely in remote areas. His clients include water authorities, mining companies, NRM bodies, universities, government entities and fish stocking groups.	Field team member

2. Site selection

As The Project is made up of several components (e.g., reservoirs, roads, discharge points etc.) sites were selected based on potential impact. Stream order was an additional site selection factor, with streams of Strahler Stream Order 2 and above assessed for key fish habitat. Additionally, biological sampling was carried out at waterways of stream order 4 and above. A full list of sites visited during fieldwork are presented below in Table 3, including the methods employed at each site. The location of each site is also presented in Figure 1.

Although two sites within the lower reservoir (UW02-03 and UW02-04) are below stream order 4, there was the greatest potential for direct impact to the watercourse beyond the Macleay River. Combined with the water available for sampling at the time of the survey, these sites were included in biological monitoring.

The accessible reach of Peacock Creek (PC-01) was located upstream of a waterfall which flowed almost directly into the Macleay River. Due to the significance of this fish passage barrier, the site was not included in biological sampling, despite being stream order 4.

Table 3 – Survey site locations.

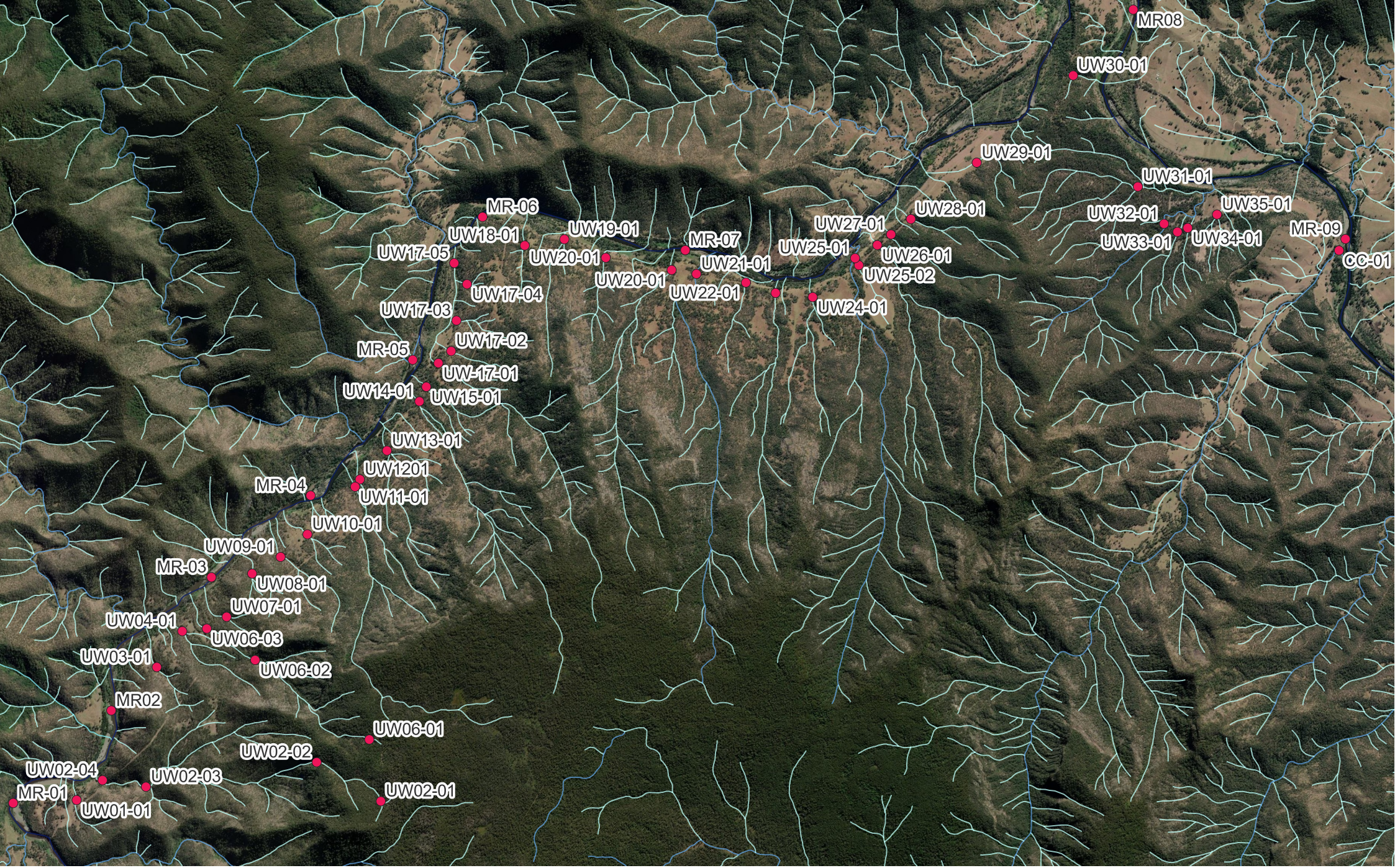
Site Code	Latitude	Longitude	Potential Impact	Stream order	Key Fish Habitat	eDNA	Fish sampling	Macroinvertebrates
MR-01	30.8091327	152.1418999	Reference site – no impact	9	✓	✓	✓	✓
MR-02	30.8000834	152.1530596	Pump station: water extraction	9	✓		✓	✓
MR-03	30.7870514	152.1644559	Downstream water extraction	9	✓	✓	✓	✓
MR-04	30.7790613	152.1757442	Water extraction	9	✓	✓	✓	✓
MR-05	30.76579438	152.1873576	Downstream water extraction/discharges	9	✓	✓	✓	✓
MR-06	30.7518159	152.1953029	Proposed bridge/road, downstream extraction/discharge	9	✓	✓	✓	✓
MR-07	30.75506617	152.2183669	Downstream of project	9	✓		✓	
MR-08	30.73153695	152.2693285	Proposed bridge/road, downstream of project	9	✓		✓	✓
MR-09	30.75397584	152.2934717	Proposed bridge/road, downstream of project	9	✓		✓	✓
CC-01	30.75509085	152.2927429	Proposed bridge/road crossing	5	✓		✓	✓
PC-01	30.8153752	152.1489948	Groundwater drawdown	4	✓			

Site Code	Latitude	Longitude	Potential Impact	Stream order	Key Fish Habitat	eDNA	Fish sampling	Macroinvertebrates
UW01-01	30.8088373	152.1491195	Groundwater drawdown	2	✓			
UW02-01	30.80895149	152.1837262	Within Upper Reservoir	2	✓			
UW02-02	30.80514119	152.1764285	Downstream of Upper Reservoir	2	✓			
UW02-03	30.76588028	152.1876897	Within Lower Reservoir	2	✓	✓	✓	✓
UW02-04	30.8068975	152.1520653	Within Lower Reservoir	3	✓	✓	✓	
UW03-01	30.794597	152.1591327	Excavation spoil storage	3	✓			
UW04-01	30.7923284	152.1611404	Construction pads	2	✓			
UW06-01	30.8029227	152.1824165	Spoil storage	1	✓			
UW06-02	30.795112	152.169209	Road	2	✓			
UW06-03	30.79208	152.164028	Road, construction pads	2	✓			
UW07-01	30.790886	152.165855	Road, construction pads	2	✓			
UW08-01	30.785451	152.169004	Road crossing	2	✓			

Site Code	Latitude	Longitude	Potential Impact	Stream order	Key Fish Habitat	eDNA	Fish sampling	Macroinvertebrates
UW09-01	30.785039	152.172289	Road crossing	2	✓			
UW10-01	30.782458	152.174821	Construction pad	2	✓			
UW11-01	30.777804	152.180561	Road crossing	3	✓	✓	✓	
UW12-01	30.7774888	152.1813488	Road crossing	3	✓	✓	✓	
UW13-01	30.7746721	152.1844309	Road crossing	3	✓	✓		
UW14-01	30.7698583	152.1881177	Road crossing	3	✓	✓		
UW15-01	30.7684301	152.1889016	Road crossing	3	✓	✓		
UW-17-01	30.7661138	152.1902743	Road crossing	2	✓			
UW17-02	30.76494119	152.1917289	Road crossing	1	✓			
UW17-03	30.7619503	152.1923311	Road crossing	2	✓			
UW17-04	30.75839343	152.1935332	Road crossing	3	✓			
UW17-05	30.7563339	152.1920736	Road crossing	4	✓	✓		

Site Code	Latitude	Longitude	Potential Impact	Stream order	Key Fish Habitat	eDNA	Fish sampling	Macroinvertebrates
UW18-01	30.75460961	152.2001025	Road crossing/proposed transmission line	2	✓			
UW19-01	30.7540004	152.2046128	Road crossing/proposed transmission line	2	✓			
UW20-01	30.7570044	152.2168131	Road crossing/proposed transmission line	2	✓			
UW20-01	30.75580696	152.2093224	Road crossing/proposed transmission line	2	✓			
UW20_1-01	30.75580696	152.2093224	Road crossing/proposed transmission line	3	✓			
UW21-01	30.7573924	152.2196358	Road crossing/proposed transmission line	3	✓			
UW22-01	30.7582404	152.2252652	Road crossing/proposed transmission line	2	✓			
UW23-01	30.7592532	152.2286402	Road crossing/proposed transmission line	3	✓			
UW24-01	30.75965733	152.232864	Road crossing/proposed transmission line	3	✓			
UW25-01	30.75584494	152.2376835	Road crossing/proposed transmission line	3	✓			
UW25-02	30.75653654	152.2381102	Road crossing/proposed transmission line	2	✓			
UW26-01	30.75456738	152.2402132	Road crossing/proposed transmission line	3	✓			

Site Code	Latitude	Longitude	Potential Impact	Stream order	Key Fish Habitat	eDNA	Fish sampling	Macroinvertebrates
UW27-01	30.75353069	152.2417708	Road crossing/proposed transmission line	2	✓			
UW28-01	30.75202773	152.2440308	Road crossing/proposed transmission line	2	✓			
UW29-01	30.74650679	152.251523	Road crossing/proposed transmission line	2	✓			
UW30-01	30.73797793	152.2624957	Road crossing/proposed transmission line	2	✓			
UW31-01	30.74885522	152.2698588	Road crossing/proposed transmission line	4	✓			
UW32-01	30.75248652	152.2728413	Road crossing/proposed transmission line	4	✓			
UW33-01	30.75327995	152.2743625	Road crossing/proposed transmission line	3	✓			
UW34-01	30.75289247	152.2755305	Road crossing/proposed transmission line	2	✓			
UW35-01	30.75158133	152.2788595	Road crossing/proposed transmission line	3	✓			



Aquatic Ecology Services

Oven Mountain Pumped Hydro Storage Project

0 1 2 km

Figure 1 - Aquatic ecology sampling locations

Source: ESRI Satellite (ArcGIS/World Imagery): https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/tile/{z}/{y}/{x}

4. Methods

4.1 Water quality

In situ physical and chemical parameters were measured at each site using a multi-parameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications. Water quality readings were taken at around 10cm from the waters surface. The following parameters were recorded:

- Temperature (°C)
- pH
- Electrical conductivity (EC) (µS/cm)
- Dissolved oxygen (mg/L and %)
- Turbidity (NTU)

4.2 Habitat assessment

Key Fish Habitat (KFH) is mapped in the Macleay River and its major tributaries throughout the study area (DPI 2022). Each site was assessed along the waterway for approximately 100m in length. Sites on the Macleay River were assessed along approximately 500m due to the higher stream order and much greater width. A drone was deployed to assist with a robust assessment of available habitat in areas that were less accessible on foot. Drone surveys were undertaken by an accredited operator and included photography of notable habitat features using a polarised filter. Aquatic habitat assessments included the following at each site:

- Photographs of the site and any important habitat features or notable disturbance
- Identification of sensitive habitat features as described in "Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update)" – (DPI 2013) ()
- Identification of habitat specific to any of the listed species above
- Recording of any significant fish passage barriers
- Riparian zone characterisation and condition

River bioassessment scores were generated for each site where macroinvertebrate sampling took place. The scores are a method of understanding the quality of habitat at each site in the context of suitability for macroinvertebrates.

Table 4 - Waterway type definitions for habitat sensitivity

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

Table 5 - Waterway class definitions

Classification	Characteristics of waterway class
Class 1 – Major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (eg river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
Class 2 – Moderate key fish habitat	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 key fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats.
Class 4 – Unlikely key fish habitat	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 (eg dry gullies, shallow floodplain depressions with no aquatic flora).

4.3 Fish sampling

Surveys for fish were undertaken using a number of methods that were used in combination to maximise the diversity of species captured, whilst not interfering directly with the habitat of any threatened species. This approach is consistent with the conditions of Aquatic Ecology Services' Scientific Collection Permit (P19/0025-1.0). Methods utilised at each pool site included:

- Boat and backpack electrofishing
- Fyke netting
- Gill netting
- Seine netting
- Bait trapping

All native fish were released in good condition. Non-native fish, were euthanised. Fish sampling effort for each site can be found in Appendix F

4.3.1 Electrofishing

Electrofishers are maintained and operated in strict accordance with the Australian Code of Electrofishing Practice (1997). The seconds of electrofishing by each type of gear was proportional to the amount of available habitat. At each site deeper habitat which was identified as appropriate for sampling using a boat electrofisher was identified, but access to the water for launch was not possible, and several Macleay River sites were only accessible by helicopter.

Sites contained areas of shallow water, and backpack electrofishing was utilised to maximise spatial coverage and sampling effort at each site. A Smith-Root LR20B backpack electrofisher was used for sampling and enabled for more targeted sampling in shallow pools and along undercut banks. Immobilised fish were collected in nets and transferred to an aerated bucket to recover. Fish were identified, measured and released back to the water where appropriate. Data collected included fork lengths (or total lengths for species with convex or truncate caudal fins) of the first 20 individuals of each species caught per site.

4.3.2 Seine netting

Deploy the seine net perpendicular to the stream bank between two people with each person holding the foot rope against the substrate (usually with their foot) as firmly as practical and holding the head rope (usually in the hand) so that it lies along the water surface. In flowing waters, seining should be undertaken against the direction of water flow.

Haul the extended seine along the desired section of stream as quickly as possible to reduce the likelihood of fish avoiding or escaping the net. The escape of fish can often be reduced by ensuring the seine net maintains a "U" shape. It may be useful to have a person walking behind the net to quickly clear the net from any obstructions during seining, otherwise it may be required to stop seining and start again if the net gets caught. Complete seining by having the person holding the shoreward end of the seine stop so

that the person holding the other end can swing towards the shore so that the seine forms a loop with both ends at the water's edge.

4.3.3 Gill netting

As schooling fish that were likely to occupy deeper habitats (mullet) were identified through eDNA sampling, gill nets were deployed at Macleay River sites to target these species. Mesh size was selected to exclude the capture of small-bodied fish. An unweighted gill net was used and dawn and dusk were avoided, as platypus are known to be in the Macleay River. A gill net 25m in length, 3m drop, with 2.5" mesh was used. The gill net was always manned by a spotter to allow for clearance of bycatch. There were no incidents where any unintended fauna were caught in nets.

A weight was attached to the float line of the net before deploying in order to limit movement of the net during its deployment. The gill net was set perpendicular to the bank in still or slow-flowing water, or increasingly angled downstream with increasing flow velocity.

4.3.4 Bait Trapping

Bait traps primarily capture smaller fish and it is common to set traps overnight to favour the collection of nocturnal and crepuscular (active at dawn and dusk) species. Accessibility of sites reduced the ability for return visits to sites, and so bait traps were set for the duration of visit at each biological sampling site.

4.4 Platypus observations

At each site, banks were scanned for areas of consolidated material that was suitable for burrowing, and feeding and transit habitat were also noted. At the site of each of the two options a more detailed search of banks for burrows and potential burrowing material was completed.

4.5 Turtle observations

No targeted surveys were conducted for turtles, but during all fish and macroinvertebrate surveys observations of turtles (if any) were recorded. Where nesting habitat for turtles was observed this was also recorded at each site.

4.6 eDNA sampling

Water samples for eDNA analysis were collected from all sites during the field survey and to assess the presence of Platypus, as well as a general assay for fish species. At each site, water samples were collected in triplicate by passing up to 2000 ml water (average 962 ml) through a 1.2 µm syringe filter. Clean sampling protocols were employed to minimise contamination including new sampling equipment at each site, not entering water, and taking care not to transfer soil, water or vegetation between sites. A preservative (approx. 0.5 ml 10xTris-EDTA) was added to the filters after filtering to minimise DNA degradation. Filters were stored out of sunlight and kept at ambient temperature before being couriered to Enviro DNA in Parkville ,Victoria, for analysis.

DNA was extracted from the filters using a commercially available DNA extraction kit (Qiagen Power Soil Pro) that minimizes compounds that can inhibit PCR reactions. Real-time quantitative Polymerase Chain Reaction (qPCR) assays were used to amplify the target DNA, using species-specific markers targeting a small region of the platypus mitochondrial DNA, previously developed and assessed for specificity and sensitivity by Enviro DNA (e.g. Lugg *et al.* 2018).

In addition, fish biodiversity assessments were performed on all samples using a universal Fish assay targeting a small region of the 12S mitochondrial DNA (McColl-Gausden *et al.* 2020). Library construction involved two rounds of PCR whereby the first round employed gene-specific primers to amplify the target region and the second round incorporated sequencing adapters and unique barcodes for each sample-amplicon combination included in the library. Negative controls were also included during library construction. Negative controls consisted of the extraction negative as well as PCR negatives where nuclease-free water was used in place of DNA during both rounds of PCR. Sequencing was carried out on an Illumina iSeq 100 machine.

Positive and negative controls were included for all assays as well as an Internal Positive Control (IPC) to detect inhibition (Goldberg *et al.* 2016). Assays were performed in triplicate on each sample. At least three positive qPCR assays (out of nine assays undertaken for the site) were required to classify the site as positive. To minimise false positives, sites were considered equivocal if only one or two assays returned a positive result, indicating very low levels of target DNA. While trace amounts of DNA may indicate the species is actually present in low abundance, it may also arise from sample contamination through the sampling or laboratory screening process (minimised through strict protocols and negative controls), facilitated movement of DNA between waterbodies (i.e. water birds, recreational anglers, water transfers, predator scats), or dispersal from further upstream.

4.7 Macroinvertebrates

4.7.1 Field sampling

Macroinvertebrates were sampled at a number of sites as specified in Section 2. Macroinvertebrates are a widely sampled community used to demonstrate aquatic ecosystem health. Riffles (fast-flowing, broken water over rocky substrate, including cobbles and boulders) were observed to be a feature of most Macleay River sites visited during sampling, and as these habitats can be particularly susceptible to changes in flow regimes (Chessman 2015). In tributaries of the Macleay River, composite samples (combined riffle and edge habitat) were collected. The collection of the riffle and composite samples followed methods outlined in Turak *et al.* (2004) and was completed by an AUSRIVAS accredited sampler.

Samples were live-picked in accordance with AUSRIVAS methods (Turak *et al.* 2004), with live-picking completed for each sample for a minimum of 40 minutes. Macroinvertebrate samples were sent to an AUSRIVAS accredited taxonomist for identification to genus level.

4.7.2 Data analysis

Standard metrics for macroinvertebrate communities were calculated:

- Taxa richness (Family and Genus) – Total number of taxa present at the site used as a measure of diversity of families (used for long-term data analysis).
- EPT richness – total number of families from orders Ephemeroptera, Plecoptera and Trichoptera. EPT taxa are generally more sensitive to disturbance.
- SIGNAL-2 – a biotic index that allocates a value to each macroinvertebrate family based on their sensitivity to pollution, and provides an average of those indices across the sample. Although this study is not directly aiming to understand the impact of point source pollution, the SIGNAL-2 score allows for a general understanding of the sensitivity of taxa inhabiting The Macleay River.

In addition to univariate analysis of metrics, an assessment of differences in the macroinvertebrate community composition will be undertaken. NMDS Ordination provides a representation of the relative similarity of entities (i.e., samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar sites are to each other, the closer they are located in the NMDS ordination space. In this study, NMDS plots were used to display the similarity between sites along the Macleay River A similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient was calculated. Stress, which is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions, was used to gauge how reliable the patterns presented in two-dimensional NMDS plots are. Stress levels above 0.20 indicate a poor representation of inter-sample similarity and, as such, the NMDS results with stress values of this order require interpretation with caution (Clarke *et al.* 2014).

5. Results and Discussion

5.1 Site conditions

Rainfall recorded at Turners Flat leading up to field surveys and Macleay River height data for the corresponding period is presented in Figure 2. Field surveys were carried out over two occasions. The first survey in March was interrupted by rainfall and flooding in the Macleay River catchment, whereas the second survey event in June was completed during a period of low rainfall and stable, decreasing flow conditions.

In order to understand whether the flooding that occurred during the early period of 2022 was anomalous, river height data for the previous six years was viewed (Appendix A). Weather patterns associated with a La Niña event resulted in elevated river heights (flooding) in the Macleay River since the beginning of 2020, which followed a year particularly low flow. The natural flow pattern in the Macleay River for the years prior to 2019 was short-lived spikes in river height, which are likely a result of the surrounding steep catchment and the same topographical features of its tributaries. The overall flow patterns observed reflect a dynamic

river system that experiences fast elevations in flow that also dissipate quickly, but can take some time to reduce to a steady state river height.

During the March survey all creeks feeding the Macleay River were flowing, and some were observed to have a high flow rate compared with a return visit in June, when the majority of tributaries were flowing, but at much lower rates of discharge.

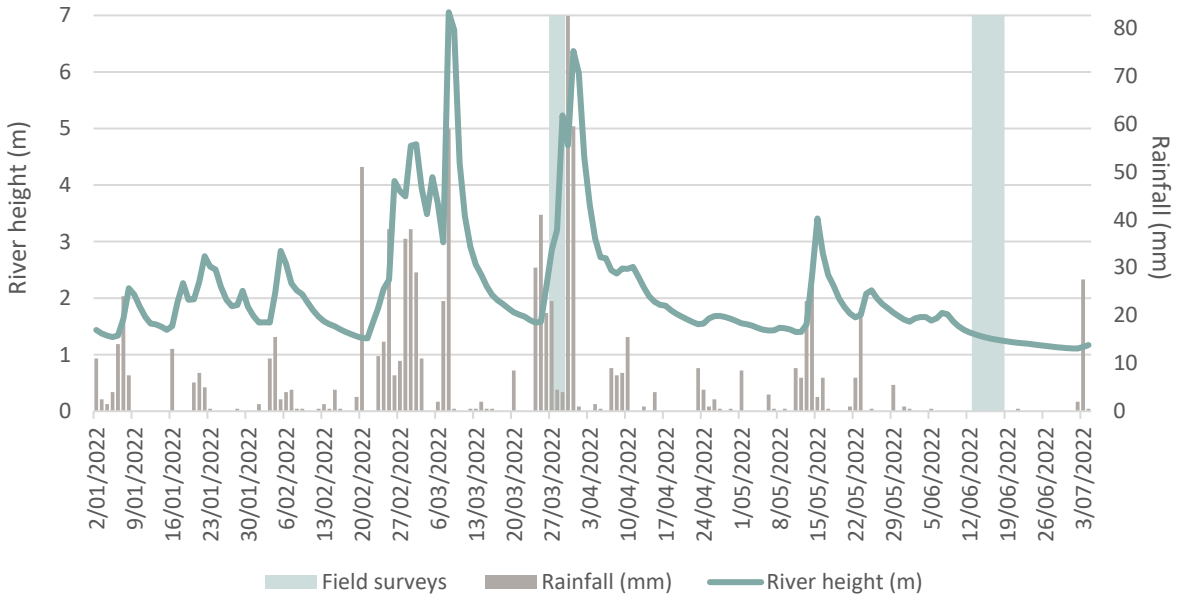


Figure 2 – Rainfall for the period January-July 2022 (Turners Flat) aligned with Macleay River height data (George's Junction). Data from Water NSW (2022)

5.2 Water quality

In situ water quality results for Macleay River sites are presented in Table 6, and the remaining water quality readings for tributaries can be found in Appendix B. Default guideline values have been applied (where available) for slightly disturbed ecosystems in NSW lowland rivers (ANZECC 2000). The following observations were made in relation to water quality in the Macleay River:

- Given the proximity of the sites to each other, hydrological connection and very few differences in land use between sites, there was not expected to be a great deal of difference between results from each site.
- Temperature varied at sites aligning with the time of day that readings were taken. Temperatures were indicative of colder ambient temperatures experienced during the winter months.
- Readings for pH were outside of guideline values at all but one site on the Macleay River in June, consistently higher readings indicate that pH is likely to be naturally higher than the guideline range.
- Electrical conductivity decreased marginally with distance downstream on the Macleay River. The majority of tributaries were recorded as having lower conductivity results compared with sites on the Macleay River, and it is therefore likely that dilution of dissolved salts is taking place over distance downstream with increased contributions from feeder creeks and rivers.
- Dissolved oxygen varied at each site on the Macleay River, with no clear pattern. Throughout the Study Area, the Macleay River is characterised by riffle, run and pool sequences. Faster flowing water was likely aerated across shallow and undulating substrate, and was therefore more saturated by oxygen at some sites, compared with others.
- At all but one site on the Macleay River, turbidity was below the guideline range., which is indicative of a stable flows leading up to sampling.

Table 6 – In situ water quality data collected at survey sites, June 2022 (Guideline exceedances in bold)

Site Code	Time	Temp (°C)	pH (units)	EC (µS/cm)	Dissolved oxygen (%)	Turbidity (NTU)
GV (ANZECC 2000)		-	**6.5-8.0**	**125-2200**	**85-110**	**6-50**
MR-01	8:49	9.44	**8.37**	183.03	100.75	6.85
MR-02	14:49	10.70	**8.48**	183.94	104.08	**2.98**
MR-03	16:38	9.93	**8.35**	185.73	103.09	**2.95**
MR-04	10:49	9.66	**8.30**	182.24	100.23	**1.83**
MR-05	14:51	12.38	**8.28**	179.39	106.66	**3.00**
MR-06	13:19	11.65	7.86	164.08	101.82	**1.70**
MR-07	16:38	11.62	**8.48**	172.21	109.17	**2.85**
MR-08	15:19	10.75	**8.16**	168.80	100.96	**2.50**
MR-09	11:39	9.94	**8.24**	167.99	102.01	**2.37**

5.3 Habitat characterisation

Habitat descriptions of each site are provided along with site photos in Appendix C., and a full list of KFH results are available in Appendix D.

5.3.1 Macleay River

The Macleay River is characterised as a steep valley, with a defined river channel. Riparian vegetation was not continuous on both banks, and areas without shrubs and trees were mostly a mixture of bedrock and sand benches. Riparian vegetation regeneration along the river banks was evident, as was debris stacked against trees in the flooded areas of the channel which were not regularly inundated. Beyond the banks, vegetation was mainly native forest, with some areas cleared and grazed by cattle. Downstream of George's Junction cattle were observed grazing in the riparian zone regularly (Photo 1).

The substrate of the Macleay River is majority cobbles with bedrock and boulders forming constrictions, cascades and pools. Benches made of a mixture of cobbles, pebbles, gravel and coarse sand were also common (Photo 2). Beyond George's Junction, deeper and longer pools were found compared with upstream areas, and riffles were less frequent.

Submerged macrophytes were not observed at any site on the Macleay River. During transit by helicopter the river was flown and no submerged vegetation was noted. Additionally, very few snags were observed along the river, which was interesting given the densely forested areas beyond the river banks. Recent flooding is likely to have caused scouring and removal of fine sediments, aquatic vegetation and large woody debris, causing scarcity of these habitat types.

There were no major obstructions to fish movement observed during the surveys, with numerous areas of low velocity allowing for rest and feeding for migratory fish. Instream structure was present in the form of large rock outcrops and boulders. Small pockets of fine sediment were observed in low velocity areas, namely downstream of boulders, vegetation etc. Detritus was uncommon on the substrate of the Macleay River, likely because of the flooding and scouring processes, but was found sparsely deposited in shallow, slow-flowing areas (Photo 3).

All sites along the Macleay River were classified as Type 1, Class 1 habitat due to the presence of gravel beds, and in rare instances, large woody debris. A summary of key fish habitat attributes are presented in Table 7. The entirety of the Macleay River is classed as key fish habitat by DPI Fisheries (2022), which was confirmed by the surveys.

Turtle nesting habitat (sand benches) were found at several sites, with the largest and most expansive upstream of The Project footprint at MR-01 and downstream near MR-08.

Photo 1 - Cattle grazing in the riparian zone downstream of George's Junction

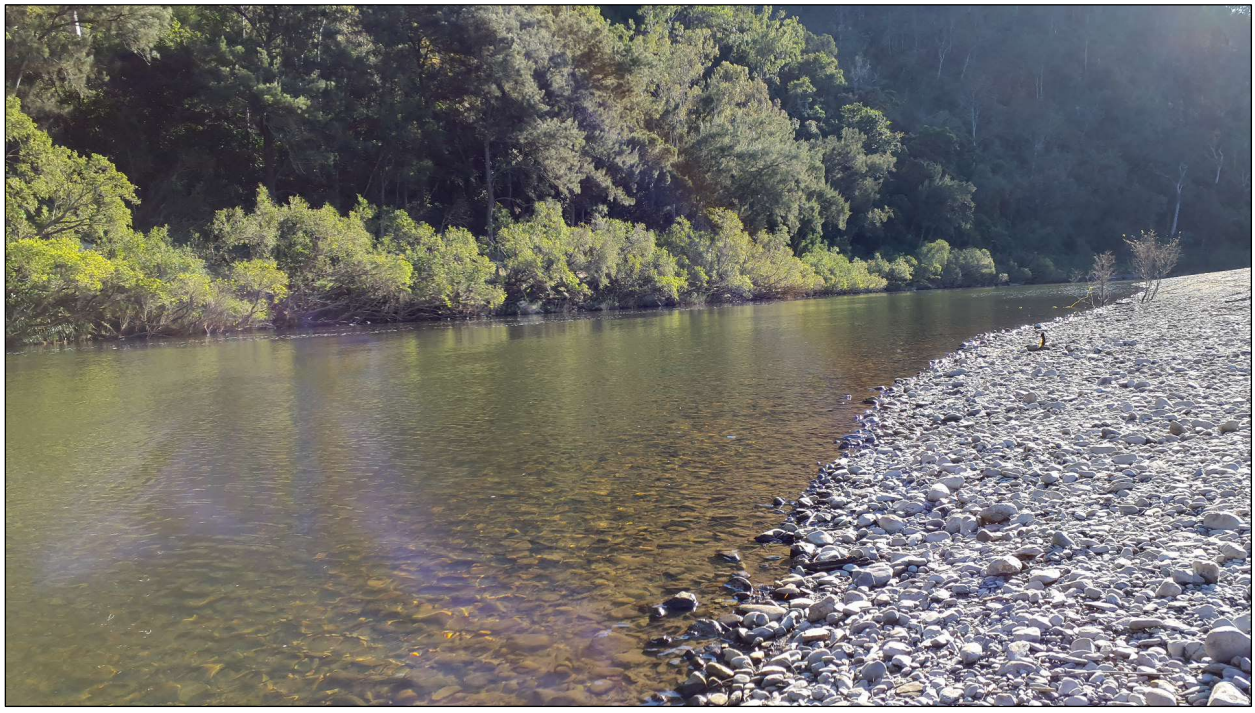


Photo 2 –Sand and cobble bench, cobble substrate, overhanging riparian vegetation at Macleay River site MR-01, June 2022

Photo 3 – fine sediment and detritus deposited along banks, Macleay River, June 2022

Table 7 – Summary of Key Fish Habitat features at Macleay River surveyed in June 2022

Region/waterway:	Macleay	Macleay	Macleay	Macleay	Macleay	Macleay	Macleay	Macleay	Macleay
Site ID:	**MR-01**	**MR-02**	**MR-03**	**MR-04**	**MR-05**	**MR-06**	**MR-07**	**MR-07**	**MR-08**
Key Fish Habitat Waterway Type	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**	**Type 1**
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	Present	Present	Present	Present	Present	Present	Present	Present	Present
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Present	Present	Present	Present	Present
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Present	Present	Present	Present	Present	Present	Present	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Absent	Present	Present	Absent	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Key Fish Habitat Waterway Class	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**	**Class 1**
Class 1 – major key fish habitat	Present	Present	Present	Present	Present	Present	Present	Present	Present
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 4 – unlikely key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

5.3.2 Macleay River Tributaries – Lower Reservoir and Access Road

A total of 23 sites were assessed between the southern boundary of the Study Area (Peacock Creek) and George's Junction. Sites were visited in March and June of 2022, depending on accessibility. Most sites were flowing, with the majority flowing very gently through narrow channels (<0.3m wide) or across wide bedrock channels. Bedrock and boulders were a feature of many sites (Photo 4), where water flowed over steep and stepped surfaces which were not conducive to fish passage by most species. Peacock Creek, a Strahler order 4 site was not surveyed for fish or sampled for eDNA. The accessible section of creek was located upstream of a vertical drop of around 15m that created a waterfall, flowing almost directly into the Macleay River. It was not considered likely that fish could achieve passage into Peacock Creek without a flood much higher than any that had been recorded in the last five years. The other site with a creek of higher Strahler order (UW17-05) was sampled for eDNA in March, and upon a return visit in June, was completely dry and so biological sampling was not completed.

Vegetation cover was variable, some areas were cleared, but the majority of the sites were located in forested areas. Trees and shrubs dominated vegetation, with many creeks lined and shrouded by exotic plants such as Crofton weed (*Ageratina adenophora*), Blackberry (*Rubus fruticosus*) and Lantana (*Lantana camara*) (Photo 5). There were a number of dead trees along creek lines throughout the Lower Reservoir and access track areas, which appear to have burned. Despite some trees being devoid of leaves, most sites were heavily shaded and promoted the growth of moss and ferns on banks. Native grasses were common in cleared areas, as was emergent macrophyte *Juncus sp.* lining creeks where an overstorey was not present. For the most part, creeks outside of the Lower Reservoir creek (UW02) lacked remnant riparian vegetation that suggested permanency of surface water. Soil moisture is expected to persist due to high shading and groundwater discharge, as many creeks that were continuing to seep in June, after a period without rain.

Lower Reservoir sites ranged from a steep waterfall at UW02-02 (Photo 6), a cobble-bed creek with intact riparian vegetation at UW02-03 (Photo 7) to a cascading creek filled with boulders and large woody debris at UW02-04. This creek is unnamed and represented the highest order of any creek in this part of the Study Area. It contained a multi-storey vegetative cover, complex habitats and good fish passage (below the waterfall). The creek was flowing well during visits in March and June, and if not permanently flowing, is very likely to maintain a moist hyporheic zone. The vegetation was different to other creeks, and contained some riparian species found along the Macleay River, such as Bottlebrush (*Callistemon viminalis*) and Spiky matrush (*Lomandra longifolia*), but also patchy growth of lantana. No Lower Reservoir creek sites met the requirements of Type 1 key fish habitat, as there were no gravel beds and very little structural habitat that was inundated and useful to fish. Passage to the plunge pool at the waterfall (UW02-02) was good, but signified a Class 2 rating when compared with habitats available in the Macleay River.

Photo 4 – Bedrock channel at site UW08-01

Photo 5 – Looking upstream at UW11-01, covered by Crofton weed and Lantana

Photo 6 – Waterfall and plunge pool at UW02-02, photo taken via drone

Photo 7 – Riparian vegetation and habitat at UW02-03

Table 8 - Summary of Key Fish Habitat features at site in the Lower Reservoir and access track area surveyed in March and June 2022

Region/waterway:	Peach Tree Creek	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay
Site ID	**PC-01**	**UW01-01**	**UW02-02**	**UW02-03**	**UW02-04**	**UW03-01**	**UW04-01**	**UW06-03**	**UW07-01**	**UW08-01**	**UW09-01**
Key Fish Habitat Waterway Type	**Type 2**	**Type 3**	**Type 2**	**Type 2**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 3**	**Type 3**	**Type 3**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Present	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Present	Absent	Absent	Present	Present	Present	Present	Present	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Absent	Absent	Absent	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 2**	**Class 2**	**Class 3**	**Class 2**	**Class 2**	**Class 4**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Present	Absent	Present	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Present	Absent	Present	Present	Present	Absent	Absent	Present	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Absent	Present	Absent	Absent	Absent	Present	Present	Absent	Present	Absent	Present

Region/waterway:	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay
Site ID	**UW10-01**	**UW11-01**	**UW12-01**	**UW13-01**	**UW14-01**	**UW15-01**	**UW-17-01**	**UW17-02**	**UW17-03**	**UW17-04**	**UW17-05**
Key Fish Habitat Waterway Type	**Type 3**	**Type 2**	**Type 2**	**Type 3**	**Type 2**	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Present	Present	Absent	Present	Present	Absent	Absent	Present	Absent	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Present	Present	Present	Present	Absent	Present	Absent	Present
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Present	Present	Present	Absent	Absent	Present	Absent	Present	Present
Key Fish Habitat Waterway Class	**Class 3**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 3**	**Class 4**	**Class 4**	**Class 4**	**Class 4**	**Class 2**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
Class 3 – minimal key fish habitat	Present	Present	Present	Absent	Present	Present	Absent	Absent	Absent	Absent	Absent
Class 4 – unlikely key fish habitat	Absent	Present	Absent	Present	Absent	Absent	Present	Present	Present	Present	Absent

5.3.3 Macleay River Tributaries – Upper Reservoir

Two creeks were surveyed in the upper reservoir area. One is located in the proposed construction footprint, and the other is within the upper reservoir. Both creeks were visited in March 2022, and contained water, which was expected given rain prior to the survey (Figure 2). The creek located within the proposed upper reservoir area (UW02-01) was flowing, whereas the other (UW06-01) contained isolated pools but showed evidence of previous high flows (Photo 8). Both creeks are expected to flow intermittently after rain and did not contain key fish habitat (Table 9). Their position on the plateau above waterfalls makes the presence of fish or other aquatic fauna very unlikely.

Site UW02-01 was much more defined than UW06-01, and contained several species of emergent macrophytes, which the other site did not. This indicates that water, or at least soil moisture, has been available along the watercourse for some time. Both creeks did not have a defined riparian zone or banks, and shading was high as a result of the closed canopy of the native forest that the creeks are found in.

Photo 8 – Site UW06-01, flattened grass in creek channel indicating recent flow

Table 9 - Summary of Key Fish Habitat features at site in the Upper Reservoir area surveyed in March 2022

Region/waterway:	Unnamed tributary, Macleay	Unnamed tributary, Macleay
Site ID	**UW02-01**	**UW06-01**
Key Fish Habitat Waterway Type	**Type 3**	**Type 3**
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	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Absent
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present
Key Fish Habitat Waterway Class	**Class 4**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Absent
Class 4 – unlikely key fish habitat	Present	Present

5.3.4 Macleay River Tributaries – Eastern Access Road

The topography and therefore prevailing habitat characteristics of each site along the proposed Eastern Access Road (EAR) varied. The EAR covers a corridor of approximately 13km and crosses 17 creeks of order 3 or lower, which included steep and stepped bedrock channels (Photo 9), cobble and gravel-lined creeks (Photo 10) and grassed swales (Photo 11). Creeks were in varied hydrological states, from completely dry to flowing. The length of the catchment appeared to correlate with the water available at the site, with sites originating further up the plateau generally flowing, and those with short catchments not flowing.

There were a number of sites where flow was sourced from groundwater. This was evidenced by dry conditions at a given site, but flow being observed further downstream on the same creek line. Conversely, flow or seepage was also observed at some sites and further downstream the creek bed was dry.

A number of sites that were dry at the time of the survey showed signs of short, sharp flow events in the form of debris stuck high in trees, and aprons of alluvial material transported to the Macleay River riparian zone and flood channel (Photo 12). This was very common along the creeks of the EAR and denotes the importance of these lower order streams as sources of alluvial material to the Macleay River.

Emergent aquatic vegetation was present at a number of sites, which was mostly made up of *Schoenaolectus mucronatus and Juncus sp.* Of the creeks surveyed in the EAR, only one of three waterways

of stream order 4 or above contained water at the time of the survey, and so this was the only site at which biological surveys were completed.

Photo 9 - Site UW24-01, stepped bedrock channel

Photo 10 – Site UW27-01 cobble substrate

Photo 11 – Site UW35-01, isolated pools in a grass swale draining to the Macleay River

Photo 12 – Downstream of UW26-01, alluvial material transported from upstream to the Macleay River channel

Table 10 - Summary of Key Fish Habitat features at sites along the EAR surveyed in June 2022

Region/waterway:	Carrolls Creek	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay
Site ID	**CC-01**	**UW18-01**	**UW19-01**	**UW20-01**	**UW20_1-01**	**UW21-01**	**UW22-01**	**UW23-01**	**UW24-01**	**UW25-01**	**UW25-02**
Key Fish Habitat Waterway Type	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 2**	
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present	Absent
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Absent	Present	Present	Absent	Present	Absent	Absent	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 1**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 4**
Class 1 – major key fish habitat	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Absent	Present	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Absent
Class 4 – unlikely key fish habitat	Present	Absent	Absent	Present	Absent	Present	Absent	Present	Present	Present	Present

Region/waterway:	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay	Unnamed tributary, Macleay
Site ID	**UW26-01**	**UW27-01**	**UW28-01**	**UW29-01**	**UW30-01**	**UW31-01**	**UW32-01**	**UW33-01**	**UW34-01**	**UW35-01**
Key Fish Habitat Waterway Type	**Type 2**	**Type 3**	**Type 3**	**Type 2**	**Type 3**	**Type 2**	**Type 3**	**Type 3**	**Type 3**	**Type 2**
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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present
Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present
Key Fish Habitat Waterway Class	**Class 4**	**Class 3**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**	**Class 3**	**Class 4**
Class 1 – major key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2 – moderate key fish habitat	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3 – minimal key fish habitat	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent	Present	Absent
Class 4 – unlikely key fish habitat	Absent	Present	Present	Absent	Present	Present	Present	Present	Present	Present

5.4 Fish community

5.4.1 eDNA

eDNA sampling was carried out in March 2022 at 13 sites, including five sites on the Macleay River and eight lower reservoir and access track sites. Sites sampled reflected access at the time of the survey. Flood damage to the EAR at the time made access unavailable. Further sampling was not performed in June, as analysis timeframes at the eDNA laboratory would not meet reporting deadlines for the project. It is expected that the spread of sites sampled provides a representation of both the Macleay River and tributaries across the Study Area.

For each site, three replicate samples were tested and the results of eDNA analysis are presented in Table 11, with each tick mark demonstrating the number of positive replicates for each species. Although detections were recorded, three sites (UW02-03, UW02-04 and UW17-05) recorded low-level detections that were below a detection threshold, which determines those results to be equivocal. Several sites that were sampled for eDNA were not sampled using electrofishing (UW13-01, UW14-01, UW15-01), as the prevailing riparian vegetation and channel form suggested they were ephemeral. Upon revisiting sites in June 2022, this was confirmed, as most sites were either damp or flowing only slightly, not allowing for fish passage, but most retaining isolated pools.

Recent flooding in late 2021 and early 2022 may have provided inundation of channels and increased fish passage, allowing for movement of small fish into to tributaries, where their presence was detected. Sites located on tributaries of the Macleay River that returned positive results all contained eels, which are known to be excellent migrators (Beumer & McDowall 1996). The detections in creeks that flow intermittently indicates that strong-swimming fish (such as eels, gudgeons and carp) use them opportunistically and are likely to be found for most of their life in the Macleay River or beyond during migration.

Galaxias were detected at two sites on the Macleay River, despite previous sampling not detecting them. Butler *et al.* (2015) noted that Climbing galaxias were not likely to be found in the Macleay River, as Galaxias prefer steep and forested headwater streams, of which many were present and flowing. It is possible that DNA had washed from tributaries to the Macleay River, where it was found.

Sampling using eDNA has shown the sensitivity of the method for smaller streams when compared with electrofishing results for the same tributaries below. Further explanations of eDNA results are available in Appendix E.

Table 11 – Results of eDNA analysis for fish species

Scientific Name	Common Name	MR-01	MR-03	MR-04	MR-05	MR-06	UW02-03	UW02-04	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW17-05
Actinopteri	Ray-finned fishes	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Anguilla australis	Australian shortfin eel	✓✓	✓✓							✓		✓		
Anguilla reinhardtii	Australian longfin eel	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓		✓✓✓			✓✓✓	✓✓✓	
Carassius auratus or Cyprinus carpio	Goldfish or carp	✓✓	✓	✓	✓✓		✓	✓	✓✓					✓✓✓
Galaxias ornatus/olidus	Mountain galaxias	✓			✓✓									
Gambusia Holbrooki	Eastern gambusia	✓	✓		✓									
Gobiomorphus sp.	Australian gudgeon genus	✓✓	✓✓✓	✓✓	✓✓	✓								
Hyseleotris sp.	Carp gudgeons	✓✓✓	✓	✓✓✓	✓	✓✓✓								✓✓
Melanotaenia duboulayi	Crimson-spotted rainbowfish	✓												
Mugil cephalus	Sea mullet	✓✓	✓✓✓	✓✓	✓✓	✓✓✓								
Percalates novemaculeata	Australian bass	✓	✓✓	✓✓	✓✓	✓								
Philypnodon macrostomus	Dwarf flathead gudgeon		✓	✓	✓									
Potamalosa richmondia	Australian freshwater herring			✓										
Retropinna semoni	Australian smelt	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓	✓✓✓				✓✓✓	✓✓✓
Trachystoma petardi	Freshwater mullet	✓✓	✓✓	✓	✓✓✓	✓✓								

5.4.2 Sampling results

The number of fish caught at each site are presented in Table 12 and raw data for fish captures are available in Appendix F. A total of 533 fish were captured during sampling comprising of 13 species. All but one species were native, and the majority of species collected were detected by eDNA sampling. The most commonly sampled species were Australian longfin eels, collected at 11 sites, and the most abundant species (Australian smelt) was found at ten sites, and made up almost 60% of all fish recorded. Electrofishing and seine netting captured all fish recorded during the surveys. Bycatch of freshwater shrimp (Family Atyidae) was common, with large schools being found at all sites along the Macleay River.

The results of eDNA analyses did not correspond directly at all sites, but it is acknowledged that some time had passed between sampling of water for eDNA and fish sampling in the Macleay River. Tributary sites were sampled when eDNA samples were taken, and there were a number of instances where results of the two sampling techniques were not consistent.

Although not present in eDNA results, Freshwater catfish were common at sites on the Macleay River. Habitat conditions were considered to be favourable for Freshwater catfish. Gravel and cobble beds were common, providing material preferred for nest building (Pollard et al. 1996). This was confirmed, as adult and juvenile Eel-tailed Catfish were captured, with juveniles dominating the catch (Photo 13). Recruitment of juveniles is likely to be the result of high flows in the catchment over the previous year (Ye et al. 2015). The sedentary nature of Eel-tailed catfish denotes that home-ranges are small and available spawning habitat is of significance to their presence and successful reproduction in the Study Area.

As previously mentioned in Section 5.4.1, Galaxias were not found at any site, including tributaries sampled that contained habitat conducive to several species that have the potential to be present. This result matches the results of targeted Galaxias surveys by Raadik (2014), that did not capture a single Galaxias in the Macleay River catchment. The presence of eDNA confirms that they are present, but as Butler et al. (2015) predicted, likely only to be present in small numbers and in steep catchments, such as those present in the area within, surrounding and upstream of the Project Area.

One result, which appeared to be consistent across both sampling methods was the prevalence of eels in both the Macleay River and its higher order tributaries. Both Long-fin and Short-fin eels were detected in eDNA samples and captured during electrofishing, Longfin eels being more consistently captured throughout. Although eels are common throughout east coast catchments, there remains few that retain the condition of the Macleay River, whose upper freshwater reaches have remained relatively undeveloped and well vegetated. The size range of Longfin eels captured indicates post-recruitment migration to the Macleay River, which again highlights the importance of the river as a feeding and growth zone for eels.

Photo 13 - Juvenile Freshwater catfish collected in the Macleay River, June 2022

5.4.3 Southern purple-spotted gudgeon

Occupying a wide variety of habitat types, including submerged vegetation, snags, rocks and undercut banks (Lintermans 2009), the Southern purple-spotted gudgeon was predicted as likely to occur by DPI (2022). Habitat identified by Lintermans (2009) was present at the site, yet no individuals were captured during surveys. Predation by Eastern Gambusia and habitat disturbance by European Carp are an identified cause of decline of the species (DPI 2017). Both exotic species were detected in eDNA sampling, but either captured in low numbers or not captured at all.

Previous surveys, which included several tributaries of the Macleay River, which may be more favourable to Southern purple-spotted gudgeon also did not detect the species. Given the survey effort on a number of occasions which targeted the habitat expected to house the species, and no results returned through eDNA sampling, Southern purple-spotted gudgeon may have historically inhabited the catchment, but is likely to be either extremely sparsely distributed or not inhabiting the waters of the Macleay River within the Study Area.

5.4.4 Eastern freshwater cod

There were no eDNA detections of Eastern Freshwater Cod, which concurred with information from previous surveys that have not captured the species in the Macleay River. The previous surveys employed boat-mounted electrofishing (Butler *et al.* 2015), which can access deep water habitats not able to be reached in this study which is likely to be more preferrable to larger-bodied fish. Much of the Macleay River contains the structural habitat noted as preferrable to Eastern freshwater cod (Butler *et al.* 2014), but the separation of the catchment by an estuary and high, steep mountains precludes any migration to The River. It is therefore not considered to be present in the catchment of the Study Area.

Table 12 – Fish sampling results from surveys conducted in March and June 2022. Highlighted cells indicate corresponding positive detection of eDNA at the site

Species	Common Name	MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-07	MR-08	MR-09	CC-01	UW02-03	UW02-04	UW11-01	UW12-01
Anguilla australis	Australian Shortfin Eel							1							
Anguilla reinhardtii	Australian Longfin Eel	5	1	6	7	7	4	4		10	8	2	2		
Gambusia holbrooki	Eastern Gambusia		2												
Gobiomorphus australis	Striped Gudgeon		1			1					10				
Gobiomorphus coxii	Cox's Gudgeon			2		3		6			1	3			
Hypseleotris compressa	Empire Gudgeon	1				2					6				
Hypseleotris klunzingerii	Carp Gudgeon	1	1		3	1	8	9	6	4	10				
Melanotaenia duboulayi	Crimson-spotted Rainbowfish				2										
Mugil cephalus	Sea Mullet									1					
Philypnodon macrostomus	Dwarf flathead gudgeon			1											
Retropinna semoni	Australian Smelt	75	16		47	46	48	9	7	5	67	1			
Rhadinocentrus ornatus	Ornate Rainbowfish	1													
Tandanus tandanus	Freshwater Catfish		2	1	1	1	1	5			1				
Trachystoma petardi	Freshwater Mullet	10	13			42									
Total		**93**	**36**	**10**	**60**	**103**	**61**	**34**	**13**	**20**	**97**	**5**	**2**	**0**	**0**

5.4.5 Migratory status

The Macleay River fish population represents a community that is well adapted to the prevailing conditions, namely free fish passage and unregulated flow allowing for seasonal migrations along with short-range movements.

Detections in eDNA and fish collected during sampling, along with species collected at George's Junction by Butler et al. (2015) are presented in Table 13, along with their migratory status. The unregulated condition of the Macleay River means that it favours fish with a migratory status that includes passage requirements to the estuary or sea, but potentially lacks the habitat requirements in the Study Area to attract fish with anadromous life histories (species that undertake a migration to freshwater for spawning).

The migratory patterns of certain species, such as Australian bass, Freshwater Herring and Sea mullet meant that they were not captured in the June survey, but were detected at sites in March of 2022 when eDNA was collected. These catadromous species undertake winter migrations downstream to spawn (Brooks et al. 2019; NSW I&I 2010; NSW DPI 2022c). The individual sea mullet collected at MR-09 was a juvenile (<200mm), which accounts for its presence in the freshwater section of the Macleay River. No juvenile Australian bass or Freshwater Herring were captured, but they are assumed to be present. Freshwater mullet, also considered catadromous were captured, as the sampling of the Macleay River fell outside of their migratory period of January to March.

Beyond the species that undertake migrations to the estuary or ocean, a number of small-bodied potamodromous and short-range fish species have been detected or collected in the Macleay River. The majority of these species are presumed to move locally during their adult life phase, and juveniles may be washed downstream and either migrate upstream and into tributaries (Beumer and McDowall 1996). A commonality is that these species are excellent swimmers, often adapted to movement during high flow events, exploiting inundated and slower flowing areas. The Macleay River's instream connectivity and river morphology is well suited to these species, with many areas available for transit when the river is inundated.

One observation made at all sites where electrofishing took place was the high abundance of freshwater prawns. Freshwater invertebrates are affected by the pulsed electrical field, which resulted in thousands of freshwater prawns being observed at some sites. The absence of larger predators, such as Australian Bass has allowed for their numbers to grow significantly. This abundance of prey is likely to be an important component of the life history of many migrating fish in the Macleay River, which would feed on freshwater prawns readily after spawning and subsequent migration back to freshwater.

Table 13 -Migratory status of collected and expected species of the Macleay River

Scientific Name	Common Name	Captured/ Detected/ Expected	Migratory Status/Association
Anguilla australis	Australian shortfin eel	C D	Catadromous
Anguilla reinhardtii	Australian longfin eel	C D	Catadromous
Carassius auratus/Cyprinus carpio	Goldfish or carp	D E	Potamodromous
Galaxias ornatus/olidus	Mountain galaxias	D	Potamodromous
Gambusia Holbrooki	Eastern gambusia	C D E	Potamodromous
Gobiomorphus australis	Striped gudgeon	C D E	Amphidromous
Gobiomorphus coxii	Cox's gudgeon	C D E	Potamodromous
Hypseleotris compressa	Empire gudgeon	C D E	Assumed Potamodromous
Hypseleotris galii	Firetail gudgeon	E	Potamodromous (short range)
Hypseleotris klunzingerii	Carp gudgeon	C D E	Assumed Potamodromous
Melanotaenia duboulayi	Crimson-spotted rainbowfish	C D E	Potamodromous (short range)
Mogurnda adspersa	Southern purple-spotted gudgeon	NE	Potamodromous (short range)
Mugil cephalus	Sea mullet	C D E	Diadromous
Percalates novemaculeata	Australian bass	D E	Catadromous
Philypnodon macrostomus	Dwarf flathead gudgeon	C D E	Assumed Potamodromous
Potamalosa richmondia	Australian freshwater herring	D	Catadromous
Pseudomugil signifer	Southern blue eye	E	Amphidromous
Retropinna semoni	Australian smelt	C D E	Potamodromous
Rhadinocentrus ornatus	Ornate Rainbowfish	C	Potamodromous (short range)
Tandanus tandanus	Freshwater Catfish	C E	Potamodromous (short range)
Trachystoma petardi	Freshwater mullet	C D E	Catadromous

C = captured, D = detected, E = expected, NE = not expected

5.5 Platypus

5.5.1 eDNA

eDNA sampling was carried out in March 2022 at 13 sites, including five sites on the Macleay River and eight lower reservoir and access track sites. Sites sampled reflected access at the time of the survey. Flood damage to the EAR at the time made access unavailable. Further sampling was not performed in June, as analysis timeframes at the eDNA laboratory would not meet reporting deadlines for the project. It is expected that the spread of sites sampled provides a representation of both the Macleay River and the lower order tributaries across the Study Area.

Testing of water samples for platypus eDNA resulted in positive and equivocal results at Macleay River sites, and there were no detections in tributaries sampled. Table 14 summarises eDNA analysis results for platypus. Equivocal results represent low detection rates for eDNA.

Table 14 – Platypus eDNA sampling results

Site Code	Waterway	Positive Assays	Result
MR-01	Macleay	4 of 9	Positive
MR-03		3 of 9	Positive
MR-04		2 of 9	Equivocal
MR-05		6 of 9	Positive
MR-06		1 of 9	Equivocal
UW02-03	Unnamed tributary	0 of 9	Negative
UW02-04		0 of 9	Negative
UW11-01		0 of 9	Negative
UW12-01		0 of 9	Negative
UW13-01		0 of 9	Negative
UW14-01		0 of 9	Negative
UW15-01		0 of 9	Negative
UW17-05		0 of 9	Negative

5.5.2 Habitat

Habitat preferential to platypus feeding and transit, such as overhanging riparian vegetation and riffle-pool sequences were ubiquitous throughout the Macleay River. During bank searches, no burrows were seen. It should be noted that burrows can be positioned below the waters surface and so their presence cannot be ruled out. Vertical banks with consolidated material were present, but the prevalence of bedrock throughout the waterway suggested that burrowing prospects would be poor. Platypus have large home ranges (Grant 2013), it is very likely that platypus utilise the study area for feeding, transit and mating, with burrows located elsewhere along The River. Detections in eDNA confirm that platypus are present in the Macleay River, but were not utilising tributaries in March 2022, when these were flowing and connected to The River.

5.6 Non-target fauna observations

There were no turtles observed during either visit to the Macleay River, but areas of gently sloping sand along banks are considered to be good nesting material, should turtles be present. Feral pigs were seen throughout the channel areas of the Macleay River, and had caused damage through diggings in soft sediments and around riparian vegetation. It is expected that turtle nesting would be significantly impacted by the presence of pigs in the area. A large number of broken mussel shells were observed along the waters edge in some sections of the Macleay River. The mussels appear to have been consumed by pigs, as diggings in the area were extensive. Some mussels did survive, (Family: Hyriidae, Photo 14).

Photo 14 - Freshwater mussels (Hyriidae) in fine substrate at MR05, June 2022

5.7 Aquatic vegetation

Submerged macrophytes were not observed at any site in the Macleay River or its tributaries. It is unclear if this is due to the rocky nature of the majority of river substrate that does not support or promote submerged vegetation growth, or that recent high flow events have resulted in scouring and removal of vegetation from the river bottom. Previous surveys of the Macleay River by Butler *et al.* (2015) did not note aquatic vegetation of value beyond the estuary. Emergent macrophytes were found in several locations, mostly along tributaries. The most common macrophyte was Jointed rush (*Juncus sp.*, Photo 15), which was observed at both tributary sites and in sparse patches on the banks of the Macleay River. Several species of sedge (Family: Cyperaceae) were observed in tributaries but were not flowering at the time of the surveys and could not be identified any further. Roughseed bulrush (*Schoenoplectiella mucronata*, Photo 16) was observed at several sites along the EAR. Many of the tributary sites along the EAR and the track to the Lower Reservoir that contained little water. Channels containing soil moisture featured emergent macrophytes indicating that soil moisture had been present for some time and a resident seed bank existed.

Photo 15 - Juncus sp. growing at site UW29-01, June 2022

Photo 16 - Schoenoplectiella mucronata growing at UW34-01

5.8 Macroinvertebrates

5.8.1 Habitat characteristics

Sampling was completed after a period of relative stability in the Macleay River catchment (see Section 5.1). At the majority of Macleay River sites, riffles were found to be in excellent condition, often spanning the width of the river and creating riffle-pool sequences (Photo 17). There was no riffle present at or near site MR-07 and therefore a sample was not collected. There was some fine sediment accumulation noted at sites MR-03 and MR-04, both sites were located at constrictions in the river which had resulted in deposition across shallow areas after recent flooding. Bioassessment scores were derived at all sites (Figure 3) and although all sites were found to be in at least "good" condition, the lower scores at sites MR-03 and MR-04 were related to sediment accumulation and embeddedness.

Sites on tributaries received similar bioassessment scores, and a greater variety of habitat was sampled. Backwaters, leaf packs, woody debris and trailing vegetation were all available. The key difference in habitat between CC-01 and the other creek sites was the greater vegetative cover and shade at the Lower Reservoir sites, this created more structural habitat and provided more organic material to the benthos compared with CC-01, which was relatively free of detritus, but did have a number of large log jams and some grass trailing into the water.

Bioassessment score calculations are available in Appendix H.

Photo 17 – Riffle habitat at MR-09**Error! Not a valid link.**

Figure 3 – River Bioassessment Scores for all sites sampled for macroinvertebrates

5.8.2 Sampling results

A total of 58 genera were identified from the Macleay River and tributary sites, comprising of 12 orders and 36 families. Raw macroinvertebrate data is available in Appendix H. There were no threatened or exotic invertebrates collected during sampling.

The composition of macroinvertebrate orders is presented in Figure 4, demonstrating the dominance of EPT taxa in all samples, along with True flies (Diptera) which were found at all but one site. There were a more diverse number of orders collected in Lower Reservoir creeks (UW02-03 and UW02-04), this is likely due to the collection of composite samples, which included a greater range of habitats compared with Macleay River sites that where riffle habitat was targeted. Surprisingly, composite habitat was sampled at CC-01, but did not result in the same diversity of orders as Lower Reservoir sites. There were no snails or bivalves collected at any site, though freshwater mussels were observed outside of riffle areas on the Macleay River (Photo 14).

Figure 5 provides further demonstration of community composition using nMDS ordination at sites on the Macleay River. As there was little variation in sampler, time and habitat type combined with no apparent point source pollution in the catchment, differences in community composition are likely to be related to characteristics of riffles at each site. The higher proportion of fine sediments in riffles at MR-03 and MR-04 would reduce interstitial spaces and provide greater potential for suspension of sediment and blanketing of filter feeding taxa. The absence of Simulidae (filter feeding black fly larvae) and Hyrdopsychidae (filtering collector caddis fly larvae) from both sites is a good example of fine silt incursion, as the taxa were found at all other sites and in tributaries.

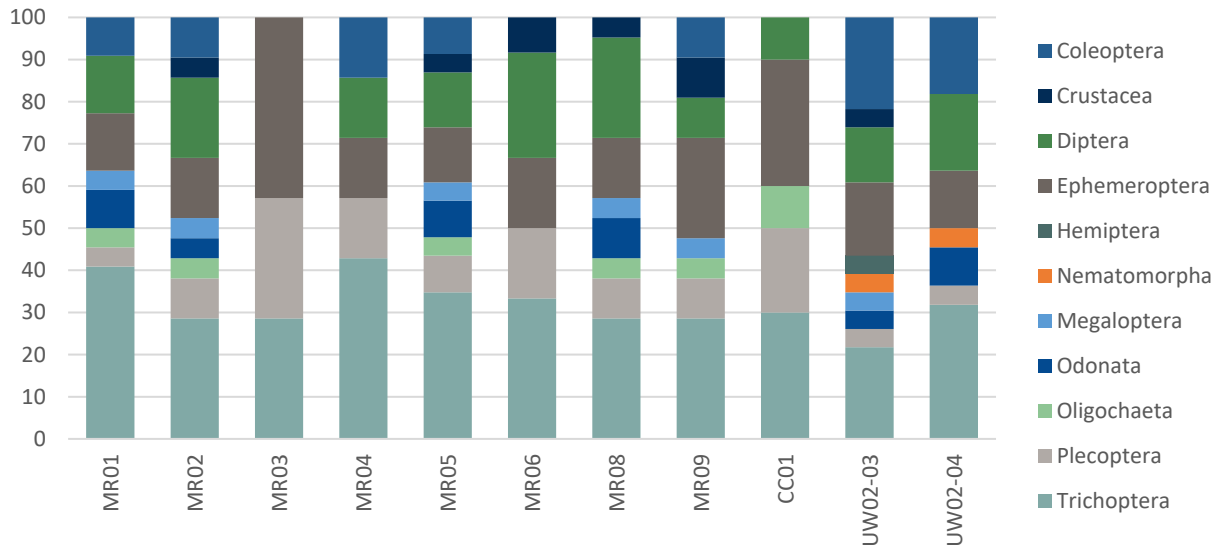


Figure 4 – Composition of macroinvertebrate orders from samples collected in the Study Area

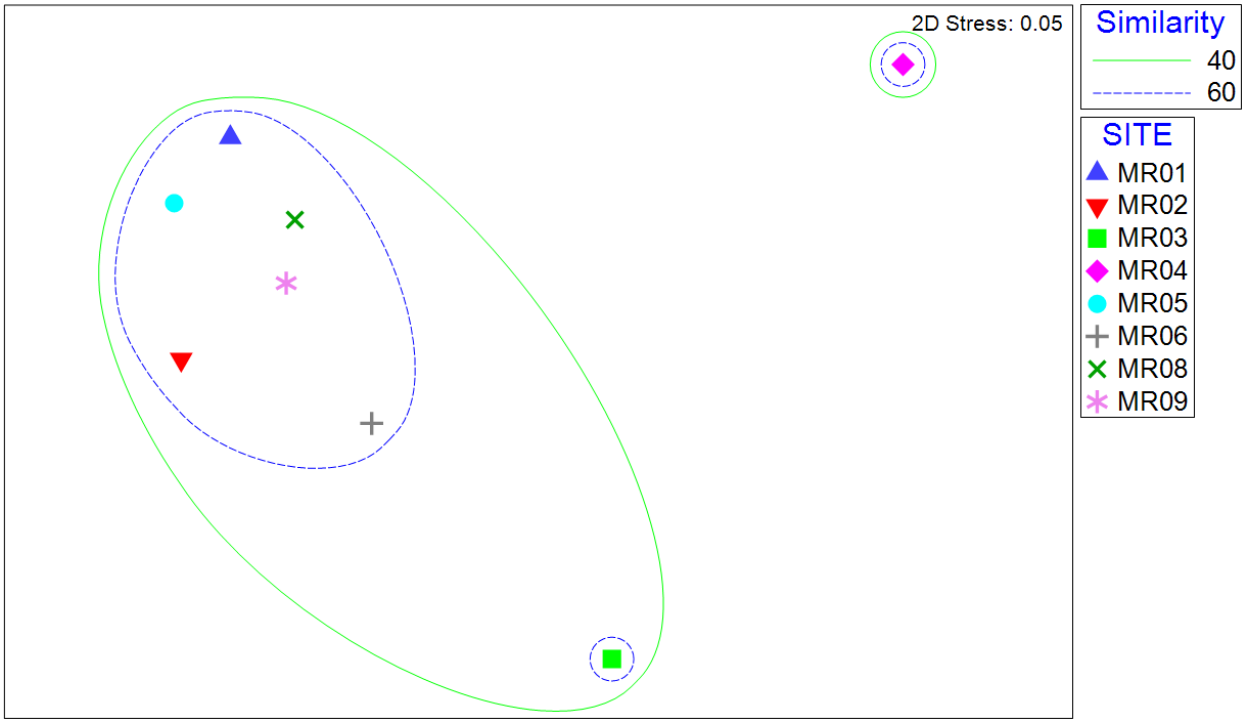


Figure 5 – nMDS representing similarities in community composition of sites on the Macleay River

Taxa richness for all sampled sites is presented in Figure 6. Differences in taxa richness at sites in the Macleay River are thought to be the result of differences in riffle characteristics at each site. There was no pattern to discern from this data, but it did appear that the two sites noted to contain a higher amount of fine sediment (MR-03 and MR-04) returned the poorest results and were the least diverse. Sites MR-06 and CC-01 also contained less taxa than other sites, and Lower Reservoir sites UW02-03 and UW02-04 contained a relatively high number of taxa. EPT richness results followed a similar pattern to taxa richness, and the high proportion of these taxa in each sample can clearly be seen. For example, in samples with

low overall taxa richness consisted of all or almost all EPT taxa. Samples with a higher overall taxa richness were more balanced.

Sensitivity to pollution was calculated as a SIGNAL-2 score (Figure 7), which returned similar results across all Macleay River sites. The SIGNAl-2 scores are considered to represent a community of high sensitivity to pollution, including the collection of a Caddisfly (Family: Helicophydae) with the highest possible sensitivity rating (SIGNAL-2 grade of 10) and a number of other taxa with SIGNAL-2 grades of 8 and 9. Lower Reservoir creek sites UW02-03 and UW02-04 returned lower scores, which is related to the more complex habitat profile of the sites, that includes backwaters and accumulated detritus that favour lower sensitivity taxa such as Beetles (Coleoptera), Worms (Oligochaeta) and True flies. Sites CC-01, MR-03 and MR-04 returned SIGNAL-2 scores which were somewhat inflated, given the low number of taxa used to calculate their average. It does however agree with the EPT results, that taxa that were present were still of a high sensitivity grade overall.

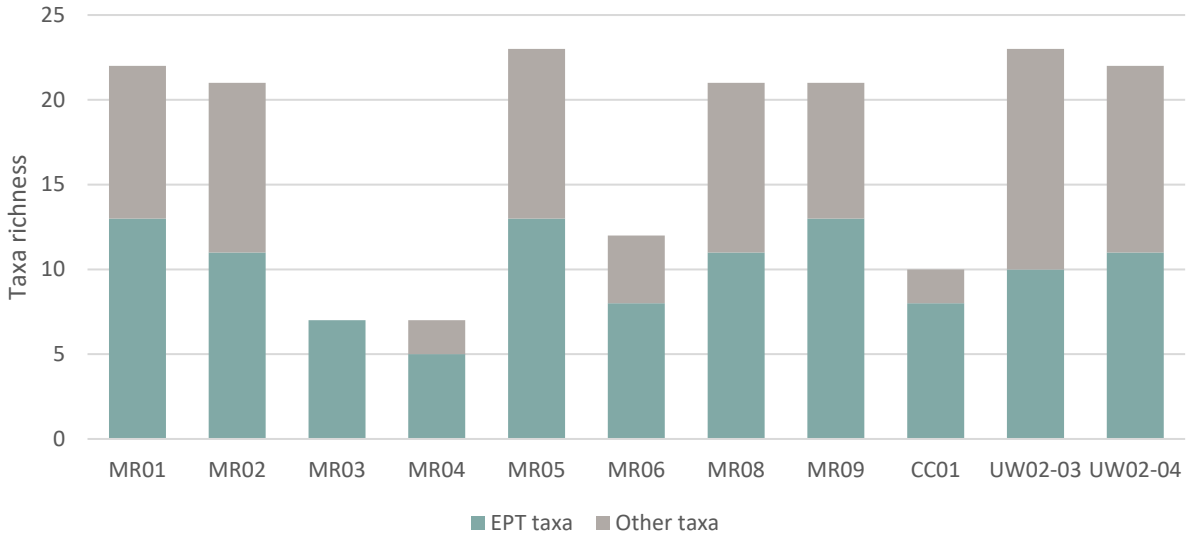


Figure 6 – Genus-level taxa richness of each site demonstrating proportion of EPT taxa in each sample

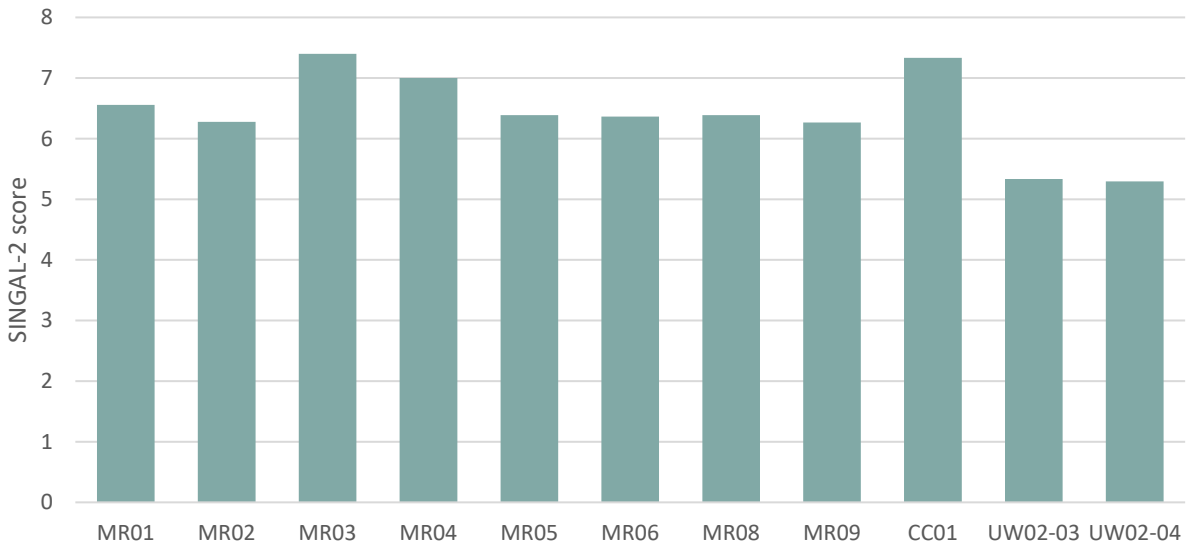


Figure 7 – SIGNAL-2 scores of samples collected in the Study Area

The macroinvertebrate community of the Macleay River catchment is considered to be in good condition, but highly sensitive to changes in sediment accumulation. The presence of feral pigs and cattle in the catchment are likely to be having the greatest impact on sediment mobility, which is probably allowing fine sediment to be washed to the riverbed above what would be considered natural. The dynamic flow regime observed in the past few years has resulted in sediment flushing downstream, and little of the sediment appears to be accumulating outside of constrictions. Higher rainfall has also resulted in movement of coarse alluvial material to the Macleay River from its tributaries, which is likely to have resulted in formation of riffles and gravel bars that allow for colonisation of rheophilic taxa. The macroinvertebrate community of the tributaries sampled implies that shading and provision of organic material to creeks is important. The lack of riparian vegetation complexity may be impacting the community at CC-01.

6. Conclusions

Field surveys were successful in characterising aquatic habitat throughout the Study Area, and sampling effort was considered to be sufficient to assess fish community, macroinvertebrates and habitat characteristics. The following conclusions can be made in relation to the study area:

- Surveys of the study area have classified key fish habitat throughout the Macleay River as Type 1, Class 1. Although many tributaries contained good structural habitat, they were ephemeral, or flowed rarely. Tributaries are likely to be a good source of refugial habitat for fish during floods, and provide alluvium to the Macleay River during high flows.
- Although habitat within the study area is in good condition, anthropogenic influences are apparent. The presence of exotic flora and fauna and pastoralism have had some impact on bank stability and are likely resulting in predation of native species.
- The fish community of the study area was dominated by native species, but several exotic species were detected. The fish community of the Macleay River is in relatively good condition due to its isolation, lack of regulation and good catchment condition in its upper reaches. Exotic species are in low numbers within the study area and are likely to be having little impact on native fish populations at this stage.
- Neither of the identified threatened species were detected during the surveys, and previous work by DPI Fisheries states that although potentially historically present, Southern purple-spotted gudgeon is highly unlikely to be present. Eastern freshwater cod have not been captured in the catchment historically and were not detected in eDNA. The species is not considered to be present in the Macleay River.
- There were no observations of turtles during surveys. Nesting areas were present along the banks of the Macleay River, but the presence of a large number of feral pigs who were actively disturbing banks and floodplain areas suggested that recruitment is unlikely to be successful in the area due to the likelihood of egg predation.
- Emergent macrophytes were found throughout the Macleay River and its tributaries, but rarely grew densely. A resident seed bank and sustained moisture was indicated by the presence of several species of emergent macrophyte along tributaries. There were no submerged macrophytes observed.
- The macroinvertebrate community of the Macleay River catchment is considered to be in good condition and pollution sensitive. Riffle habitat was in good condition at mist sites, and sediment accumulation appeared to impact the diversity of the macroinvertebrate community significantly. Macroinvertebrates of the Lower Reservoir were also in good condition, and were representative of the diverse habitat available at the sites.

7. References

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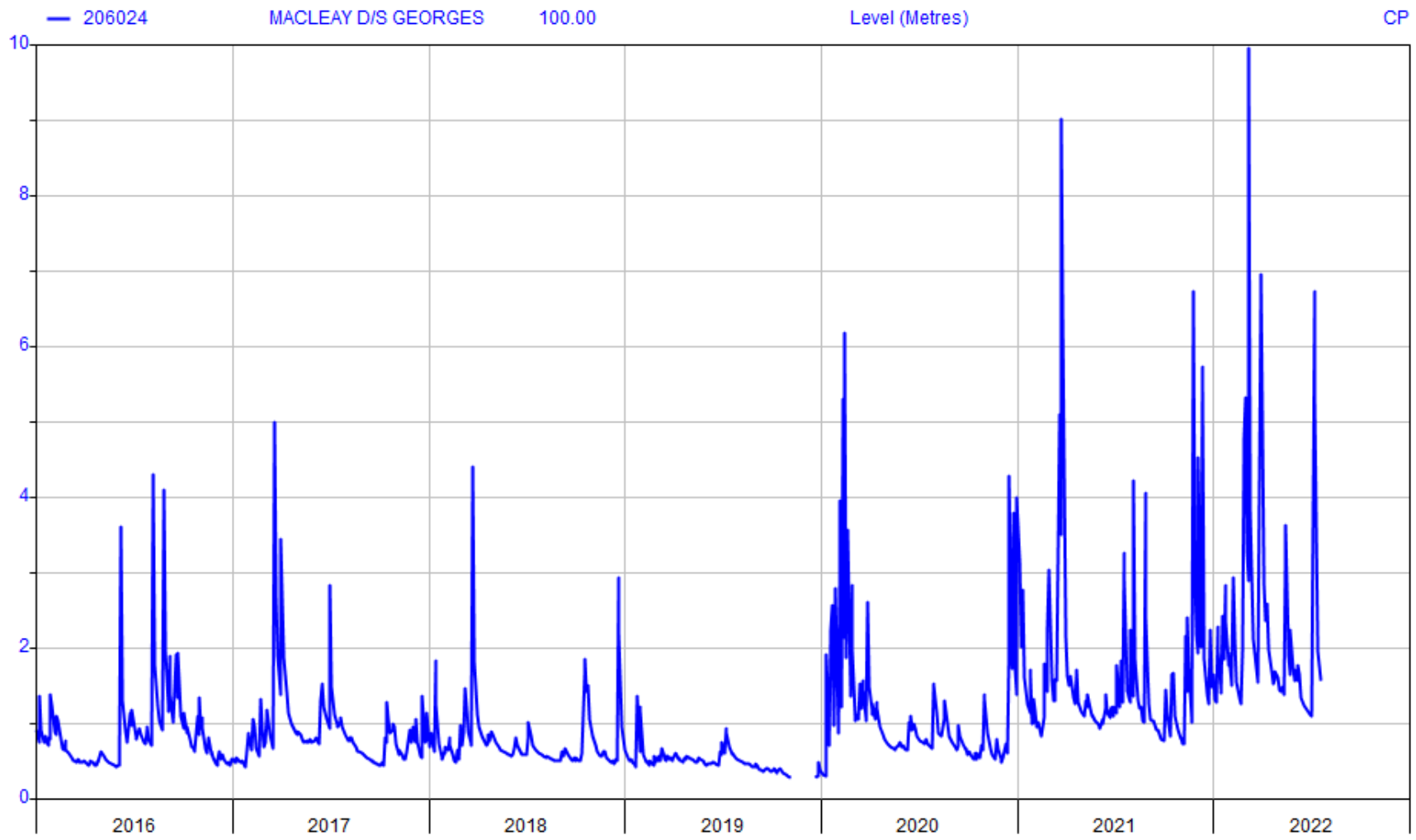
Appendix A. River height data at George's Junction 2016-2022

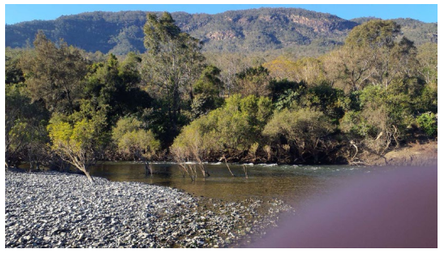


Appendix B. *In situ* water quality readings

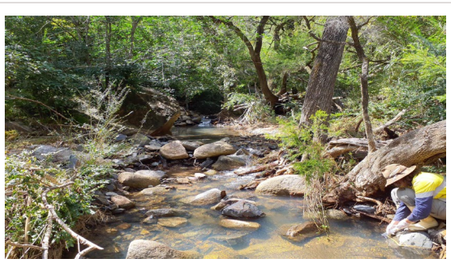
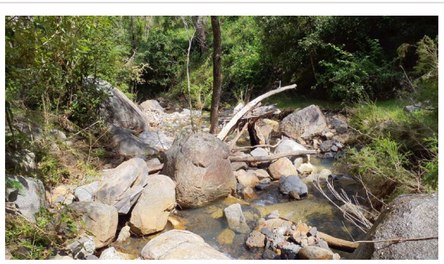
Site Code	Time	Temp (°C)	pH (units)	EC (µS/cm)	Dissolved oxygen (%)	Turbidity (NTU)
GV (ANZECC 2000)		-	**6.5-8.0**	**125-2200**	**85-110**	**6-50**
CC-01	2:07:00	10.82	7.86	**63.39**	102.19	**1.98**
PC-01	23:18:00	17.9	7.83	**90.1**	85.9	**0.8**
UW01-01	1:17:00	Dry				
UW02-01		22.7	**8.14**	**69.3**	**71.3**	**1.1**
UW02-02	1:57:00	N/A	N/A	N/A	N/A	
UW02-03	3:35:00	21	7.76	**124.8**	**80.6**	N/A
UW02-04	2:01:00	20.7	7.53	**124.3**	**70.8**	**2.4**
UW03-01		N/A	N/A	N/A	N/A	N/A
UW04-01	4:27:00	23.8	**8.14**	132.5	**81.9**	1
UW06-01	12:01:00	18.95	**8.02**	**45.3**	**50.12**	1
UW06-02		N/A	N/A	N/A	N/A	N/A
UW06-03	23:04:00	13.26	7.59	**68.8**	100.64	3.45
UW07-01	23:38:00	13.38	7.97	280.27	100.05	32.28
UW08-01	0:01:00	13.98	7.85	175.35	96.3	2.69
UW09-01	0:14:00	Too	shallow			
UW10-01	0:30:00	15.1	**5.47**	222.4	**78.68**	2.23
UW11-01	0:52:00	4.4	6.64	**39.24**	95.46	
UW12-01	5:31:00	21.1	7.68	**67.9**	**74**	2.8
UW13-01	5:19:00	22.6	7.39	154.3	**71.3**	1.6
UW14-01	21:37:00	20.7	7.68	**83.5**	**77.2**	1.9
UW15-01	22:21:00	20.5	7.29	**112.5**	**78.8**	0.5
UW17-01	23:53:00	21.6	7.97	196	89.8	
UW17-02	4:12:00	15.58	**6.21**	182.37	**48.4**	2.36
UW17-03	0:16:00	22	**8.04**	140.8	**98.8**	
UW17-04	3:08:00	15.43	6.58	133.92	**83.89**	2.47
UW17-05	2:49:00	Dry				
UW18-01	3:39:00	Dry				
UW19-01	4:48:00	17.51	7.38	**117.53**	94.94	2.1
UW20-01	5:30:00	14.1	7.32	152.49	97.32	1.71
UW20-01	4:27:00	16.4	7.49	147.76	90.56	2.12
UW21-01	5:13:00	14.77	7.57	**110.15**	97.66	1.83
UW22-01	4:51:00	14.22	7.69	144.76	95.09	1.9
UW23-01	4:26:00	15.2	**8.42**	131.81	99.89	2.45
UW24-01	3:50:00	17.7	**8.16**	151.89	**112.82**	2.13
UW25-01	3:27:00	15.52	**8.16**	136.69	100.22	2.14

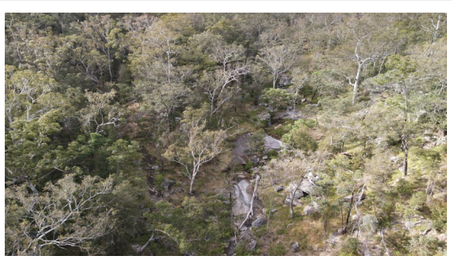
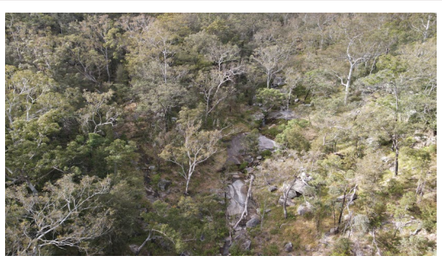
Site Code	Time	Temp (°C)	pH (units)	EC (µS/cm)	Dissolved oxygen (%)	Turbidity (NTU)
UW25-02	2:57:00	13.31	7.51	185.92	95.17	5.46
UW26-01	2:36:00	1.35	7.84	195.29	102.96	2.4
UW27-01	1:43:00	Dry				
UW28-01	1:24:00	12.27	7.58	308.5	**77.09**	1.98
UW29-01	1:05:00	Dry				
UW30-01	22:55:00	9.59	6.77	**88.69**	**48.93**	61.29
UW31-01	0:38:00	9.74	**4.48**	153.88	**77.29**	16.88
UW32-01	0:21:00	Dry				
UW33-01	0:06:00	10.28	7.34	125.09	**82.68**	56.69
UW34-01	23:43:00	10.82	7.67	216.5	**66.9**	19.2
UW35-01	4:52:00	12.19	6.89	**118.48**	**21.9**	9.5

Appendix C. Site Descriptions and Photos

Site code and description	Upstream	Downstream	Stream bed	Bank
MR-01 Habitat type: Pool Hydroperiod: Flowing Water colour: Clear Banks: Clay,Sand,Gravel,Cobbles,Bedrock Sediment: Pebbles,Cobbles,Gravel,Clay,Sand				
MR-02 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Gravel,Pebbles,Boulders,Bedrock, Clay,Sand Sediment: Sand,Gravel,Pebbles,Cobbles				
MR-03 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Gravel,Pebbles,Cobbles,Sand Sediment: Gravel,Pebbles,Cobbles,Sand				
MR-04 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Mud,Boulders,Cobbles Sediment: Gravel,Pebbles,Cobbles,Boulders				
MR-05 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Cobbles,Boulders,Pebbles,Gravel,Sand Sediment: Bedrock,Boulders,Cobbles,Gravel, Pebbles,Sand				

Site code and description	Upstream	Downstream	Stream bed	Bank
MR-06 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Cobbles,Boulders,Pebbles,Gravel,Sand., Bedrock Sediment: Bedrock,Boulders,Cobbles,Pebbles,Gravel, Sand				
MR-07 Habitat type: MR-07 Hydroperiod: Run Water colour: Flowing Banks: Clear Sediment: Clay,Sand, Cobbles				
MR-08 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Boulders,Cobbles,Clay,Sand Sediment: Gravel,Pebbles,Cobbles,Sand				
MR-09 Habitat type: Riffle Hydroperiod: Flowing Water colour: Clear Banks: Cobbles,Pebbles,Gravel,Sand Sediment: Sand,Cobbles,Pebbles				
CC-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Sand,Cobbles,Pebbles,Other Sediment: Sand,Gravel,Pebbles,Cobbles				

Site code and description	Upstream	Downstream	Stream bed	Bank
PC-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Tannins Banks: Boulders,Cobbles,Pebbles,Gravel,Sand, Bedrock Sediment: Sand,Gravel,Pebbles,Cobbles,Boulders				
UW01-01 Habitat type: Creek (dry) Hydroperiod: Intermittent Pools Water colour: Clear Banks: Bedrock,Clay,Pebbles,Cobbles Sediment: Gravel,Pebbles,Cobbles,Boulders				
UW02-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Clay, Sand, Cobbles Sediment: Clay, Cobbles				
UW02-02 Habitat type: Waterfall, plunge pool Hydroperiod: Flowing Water colour: Clear Banks: Bedrock, Boulder, Clay Sediment: Bedrock, Boulder, Cobbles, Pebbles				
UW02-03 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Clay Sediment: Bedrock,Cobbles,Sand, Clay				

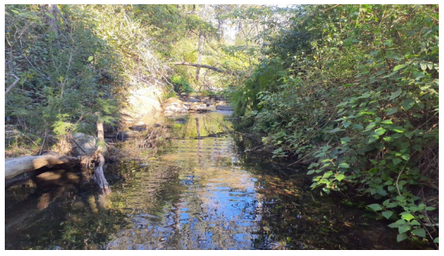
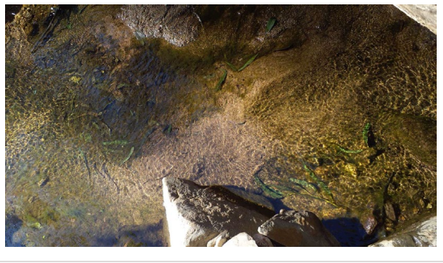
Site code and description	Upstream	Downstream	Stream bed	Bank
UW02-04 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Boulders,Cobbles,Clay Sediment: Boulders,Cobbles,Pebbles,Gravel				
UW03-01 Habitat type: Channel Hydroperiod: Intermittent Pools Water colour: Tannins Banks: Bedrock Sediment: Boulders,Bedrock				No Photo
UW04-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Clay,Sand,Gravel Sediment: Bedrock,Sand				
UW06-01 Habitat type: Channel Hydroperiod: Intermittent Pools Water colour: Clear Banks: Clay Sediment: Cobbles, Clay				
UW06-02 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Bedrock, Clay Sediment: Bedrock, Boulder				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW07-01 Habitat type: Gully Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Boulders,Sand,Clay Sediment: Bedrock,Boulders,Sand,Gravel				
UW08-01 Habitat type: Gully Hydroperiod: Flowing Water colour: Clear Banks: Clay,Gravel,Cobbles,Boulders,Bedrock Sediment: Boulders,Cobbles,Pebbles,Gravel,Sand				
UW09-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Sand,Clay,Gravel Sediment: Bedrock				
UW10-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Boulders,Clay,Gravel,Cobbles Sediment: Sand,Clay,Mud,Cobbles,Boulders				
UW11-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Clay,Boulders,Cobbles,Bedrock Sediment: Gravel,Pebbles,Boulders,Bedrock				

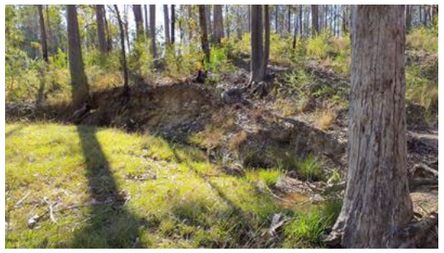
Site code and description	Upstream	Downstream	Stream bed	Bank
UW12-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Tannins Banks: Bedrock,Boulders Sediment: Bedrock,Boulders,Cobbles,Pebbles, Sand				
UW13-01 Habitat type: Other Hydroperiod: Flowing Water colour: Tannins Banks: Sand,Gravel,Clay Sediment: Sand,Gravel,Pebbles,Cobbles, Boulders				
UW14-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Boulders,Clay,Sand Sediment: Sand,Clay,Gravel,Pebbles,Cobbles, Boulders,Bedrock				
UW15-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Boulders,Clay,Sand,Gravel Sediment: Bedrock,Cobbles,Gravel,Sand				
UW17-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Sand,Clay,Gravel,Cobbles Sediment: Sand,Gravel,Pebbles,Cobbles, Boulders				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW17-02 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Sand,Gravel,Pebbles,Cobbles Sediment: Sand,Gravel,Pebbles,Cobbles, Boulders				
UW17-03 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Boulders,Sand,Clay,Cobbles Sediment: Sand,Gravel,Cobbles,Boulders				
UW17-04 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Bedrock Sediment: Bedrock,Sand				
UW17-05 Habitat type: Pool Hydroperiod: Dry Water colour: Other Banks: Clay Sediment: Clay, Silt				
UW18-01 Habitat type: Creek Hydroperiod: Dry Water colour: Other Banks: Sand,Clay Sediment: Sand,Gravel				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW19-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Boulders,Bedrock Sediment: Bedrock,Boulders,Sand				
UW20-01 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Clay,Bedrock,Boulders,Cobbles Sediment: Sand,Gravel,Pebbles,Cobbles,Bedrock				
UW20_01-01 Habitat type: Other Hydroperiod: Flowing Water colour: Clear Banks: Clay,Boulders,Bedrock Sediment: Sand,Gravel,Cobbles,Boulders,Bedrock				
UW21-01 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Clay,Sand,Gravel,Cobbles Sediment: Sand,Clay,Mud,Gravel,Pebbles,Cobbles,Boulders,Bedrock				
UW22-01 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Mud,Sand,Clay Sediment: Sand,Clay,Gravel,Mud				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW23-01 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Clay,Sand,Gravel Sediment: Sand,Gravel,Clay				
UW24-01 Habitat type: Run Hydroperiod: Flowing Water colour: Clear Banks: Clay,Bedrock Sediment: Bedrock				
UW25-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Sand,Cobbles,Clay,Bedrock Sediment: Sand,Gravel,Cobbles,Boulders				
UW25-02 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Sand,Clay,Gravel Sediment: Clay,Sand,Gravel				
UW26-01 Habitat type: Creek Hydroperiod: Flowing Water colour: Clear Banks: Bedrock,Clay,Gravel,Pebbles Sediment: Sand,Gravel,Pebbles,Cobbles, Boulders				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW27-01 Habitat type: Creek Hydroperiod: Dry Water colour: Other Banks: Clay,Cobbles,Boulders,Bedrock Sediment: Sand,Clay,Gravel,Pebbles,Cobbles, Bedrock				
UW28-01 Habitat type: Creek Hydroperiod: Intermittent Pools Water colour: Clear Banks: Bedrock,Clay Sediment: Sand,Gravel,Pebbles,Cobbles,Boulders, Bedrock				
UW29-01 Habitat type: Swamp Hydroperiod: Dry Water colour: Other Banks: Clay,Mud Sediment: Clay,Mud				
UW30-01 Habitat type: Gully Hydroperiod: Intermittent Pools Water colour: Turbid Banks: Clay,Cobbles,Boulders,Bedrock Sediment: Clay,Gravel,Cobbles,Boulders,Bedrock				
UW31-01 Habitat type: Pool Hydroperiod: Intermittent Pools Water colour: Turbid Banks: Bedrock,Clay Sediment: Clay,Sand,Gravel,Cobbles,Bedrock				

Site code and description	Upstream	Downstream	Stream bed	Bank
UW32-01 Habitat type: Creek Hydroperiod: Dry Water colour: Other Banks: Bedrock Sediment: Gravel,Pebbles,Cobbles,Sand				
UW33-01 Habitat type: Creek Hydroperiod: Intermittent Pools Water colour: Turbid Banks: Gravel,Pebbles,Clay Sediment: Clay,Gravel,Pebbles,Cobbles,Sand				
UW34-01 Habitat type: Creek Hydroperiod: Intermittent Pools Water colour: Turbid Banks: Clay Sediment: Clay,Gravel				
UW35-01 Habitat type: Pool Hydroperiod: Intermittent Pools Water colour: Tannins Banks: Mud,Clay Sediment: Clay,Mud				

Appendix D. Key fish habitat features

Site Code:	Habitat Description	MR-01	MR02	MR-03	MR-04	MR-05	MR-06	MR-07	MR08	MR-09
Type 1	*Posidonia australis* (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and *Ruppia* species of seagrass beds >5m^2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m^2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Present	Present	Absent	Present	Present	Present	Present	Present	Present
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Present	Present	Absent	Absent	Absent	Absent	Present	Present	Absent
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m^2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Present	Present	Present	Present	Present	Present	Present	Present

Site Code:	Habitat Description	MR-01	MR02	MR-03	MR-04	MR-05	MR-06	MR-07	MR08	MR-09
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Absent	Present	Absent	Absent	Absent	Absent	Absent	Present
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	CC-01	PC-01	UW01-01	UW02-02	UW02-03	UW02-04	UW03-01	UW04-01	UW06-03
Type 1	Posidonia australis (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	CC-01	PC-01	UW01-01	UW02-02	UW02-03	UW02-04	UW03-01	UW04-01	UW06-03
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Present	Absent	Present	Present	Present	Absent	Absent	Absent	Absent
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Present	Absent	Absent	Present	Present	Present	Present	Absent

Site Code:	Habitat Description	UW07-01	UW08-01	UW09-01	UW10-01	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01
Type 1	Posidonia australis (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	UW07-01	UW08-01	UW09-01	UW10-01	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Present	Absent	Absent	Present	Present	Absent	Present	Present
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Present	Absent	Present	Present	Absent	Present	Present	Present
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Present	Present	Present	Present	Present	Present	Absent

Site Code:	Habitat Description	UW17-01	UW17-02	UW17-03	UW17-04	UW17-05	UW18-01	UW19-01	UW20-01	UW20-01
Type 1	Posidonia australis (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Absent	Absent	Present	Absent	Present	Absent	Absent	Present	Absent
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	UW17-01	UW17-02	UW17-03	UW17-04	UW17-05	UW18-01	UW19-01	UW20-01	UW20-01
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Absent	Present	Absent	Present	Present	Absent	Present	Present
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Absent	Present	Absent	Present	Present	Present	Present	Present	Present

Site Code:	Habitat Description	UW21-01	UW22-01	UW23-01	UW24-01	UW25-01	UW25-02	UW26-01	UW27-01	UW28-01
Type 1	Posidonia australis (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	UW21-01	UW22-01	UW23-01	UW24-01	UW25-01	UW25-02	UW26-01	UW27-01	UW28-01
Type 1	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Absent	Absent	Present	Absent	Present	Absent	Absent
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Present	Absent	Present	Present	Present	Absent	Absent	Absent	Absent
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Present	Present	Present	Present	Present	Present	Present

Site Code:	Habitat Description	UW29-01	UW30-01	UW31-01	UW32-01	UW33-01	UW34-01	UW35-01
Type 1	Posidonia australis (strapweed) present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh >5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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	Absent	Absent	Absent	Present	Absent	Absent	Absent
	Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mound Springs	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Site Code:	Habitat Description	UW29-01	UW30-01	UW31-01	UW32-01	UW33-01	UW34-01	UW35-01
Type 1	Zostera, Heterozostera, Halophila and Ruppia species of seagrass beds <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Mangroves present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal saltmarsh <5m2 in area	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Marine macroalgae	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Estuarine and marine rocky reefs	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	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)	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 2	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1	Present	Absent	Absent	Absent	Absent	Absent	Absent
	Weir pools and dams up to full supply level where the weir or dam is across a natural waterway	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Type 3	Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna	Absent	Absent	Absent	Absent	Absent	Absent	Absent
	Coastal and freshwater habitats not included in TYPES 1 or 2	Absent	Absent	Absent	Absent	Absent	Present	Absent
	Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation	Present	Present	Present	Present	Present	Present	Present

Class	Class description	MR-01	MR02	MR-03	MR-04	MR-05	MR-06	MR-07	CC-01	PC-01	UW01-01
Class 1	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'.	Present	Present	Present	Present	Present	Present	Present	Present	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
Class 3	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.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present

Class	Class description	MR-01	MR02	MR-03	MR-04	MR-05	MR-06	MR-07	MR-08	MR-09	CC-01
Class 1	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'.	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3	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.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Class	Class description	PC-01	UW01-01	UW02-03	UW02-03	UW02-04	UW03-01	UW04-01	UW06-03	UW07-01	UW08-01
Class 1	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'.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Present	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3	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.	Present	Absent	Absent	Present	Present	Absent	Absent	Present	Absent	Present
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Absent	Present	Absent	Present	Absent	Present	Present	Absent	Absent	Absent

Class	Class description	UW09-01	UW10-01	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW17-01	UW17-02	UW17-03
Class 1	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'.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3	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.	Absent	Present	Present	Present	Absent	Present	Present	Absent	Absent	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Present	Absent	Present	Absent	Present	Absent	Absent	Present	Present	Present

Class	Class description	UW17-04	UW17-05	UW18-01	UW19-01	UW20-01	UW20-01	UW21-01	UW22-01	UW23-01	UW24-01
Class 1	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'.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3	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.	Absent	Absent	Absent	Present	Present	Absent	Present	Absent	Present	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Present	Absent	Present	Absent	Present	Present	Absent	Present	Present	Present

Class	Class description	UW25-01	UW25-02	UW26-01	UW27-01	UW28-01	UW29-01	UW30-01	UW31-01	UW32-01	UW33-01
Class 1	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'.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Class 3	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.	Present	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Absent	Present	Absent	Present	Present	Absent	Present	Present	Present	Present

Class	Class description	UW34-01	UW35-01
Class 1	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'.	Absent	Absent
Class 2	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.	Absent	Absent
Class 3	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.	Present	Absent
Class 4	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).	Present	Present

Appendix E. eDNA Results Report

Project number 2005CR10
July 11, 2022

Project J210465 - Investigating the occurrence of threatened fish and platypus with environmental DNA.

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Summary

A key challenge for biodiversity conservation is the ability to detect species. Determining the presence or absence of a species is integral to making informed management decisions. Unfortunately, detecting species, particularly in an aquatic environment, can be difficult, time consuming, expensive, and often highly invasive. Analysis of environmental DNA (eDNA) is a relatively new, cheap, quick and non-invasive method for detecting species (Rees *et al.* 2014; McColl-Gausden *et al.* 2019; Thomsen and Willerslev 2015). As the name suggests, eDNA refers to the genetic material that an organism leaves behind in its environment. Quantitative comparisons with traditional sampling methods indicate that eDNA methods can be superior in terms of sensitivity and cost efficiency, particularly for 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), enabling effective detection of species at low densities.

During March 2022, water samples were collected from 13 sites by Aquatic Ecology (subcontractor) staff following sampling protocols developed by EnviroDNA. At each site, water samples were collected in triplicate by passing up to 2000 ml water (average 962 ml) through a 1.2 μm syringe filter. Filtration was undertaken on-site to reduce DNA degradation that may occur during transport of whole water samples (Yamanaka *et al.* 2016). Clean sampling protocols were employed to minimise contamination including new sampling equipment at each site, not entering water, and taking care not to transfer soil, water or vegetation between sites. A preservative (approx. 0.5 ml 10xTris-EDTA) was added to the filters after filtering to minimise DNA degradation. Filters were stored out of sunlight and kept at ambient temperature before being transported to the laboratory for processing.

DNA was extracted from the filters using a commercially available DNA extraction kit (Qiagen Power Soil Pro) that minimizes compounds that can inhibit PCR reactions. Real-time quantitative Polymerase Chain Reaction (qPCR) assays were used to amplify the target DNA, using species-specific markers targeting a small region of the platypus mitochondrial DNA, previously developed and assessed for specificity and sensitivity by EnviroDNA (e.g. Lugg *et al.* 2018; Weeks *et al.* 2015). Positive and negative controls were included for all assays as well as an Internal Positive Control (IPC) to detect inhibition (Goldberg *et al.* 2016). Assays were performed in triplicate on each sample. At least three positive qPCR assays (out of nine assays undertaken for the site) were required to classify the site as positive for the presence of platypus. To minimise false positives, sites were considered equivocal if only one or two assays returned a positive result, indicating very low levels of target DNA. While trace amounts of DNA may indicate the target species is actually present in low abundance, it may also arise from sample contamination through the sampling or laboratory screening process (minimised through strict protocols and negative controls), facilitated movement of DNA between waterbodies (i.e. water birds, recreational anglers, water transfers, predator scats), or dispersal from further upstream. If greater confidence is required, further sampling is recommended at equivocal sites to confirm the presence or absence of the target species. Repeat sampling is

also recommended to help determine the tenure of the species at a site (i.e. resident or transient).

In addition, fish biodiversity assessments were performed on all samples using a universal Fish assay targeting a small region of the 12S mitochondrial DNA (McColl-Gausden *et al.* 2020). Library construction involved two rounds of PCR whereby the first round employed gene-specific primers to amplify the target region and the second round incorporated sequencing adapters and unique barcodes for each sample-amplicon combination included in the library. Negative controls were also included during library construction. Negative controls consisted of the extraction negative as well as PCR negatives where nuclease-free water was used in place of DNA during both rounds of PCR. Sequencing was carried out on an Illumina iSeq 100 machine.

Following quality control filtering to remove primer sequences, truncated reads and low-frequency reads, DNA sequences were clustered into Operational Taxonomic Units (OTUs) on the basis of sequence similarity. Taxonomic assignment was performed with VSEARCH software (Rognes et al. 2016) whereby each OTU cluster was assigned a species identity using a threshold of 95% by comparing against a reference sequence database. Where a species could not be assigned (i.e. reference database was deficient and/or taxa were poorly-characterised), taxonomic assignments were manually vetted by first obtaining a list of possible species through BLASTN searches against the public repository Genbank (www.ncbi.nlm.nih.gov), then eliminating species on the basis of their geographic distribution using information from the Atlas of Living Australia (ALA). In cases where an OTU could not be adequately resolved to a single species (due to shared haplotypes for instance), either a list of multiple species was included, or it was assigned to the lowest taxonomic rank without further classification. Similar to the interpretation of qPCR results above, detection of species in multiple replicates from a site increases the confidence that the eDNA detection represents actual presence of the species. Detection of a species in a single replicate may indicate species presence at low abundance but can also arise from site level (in field) or sample level (sampling or laboratory protocols) contamination (Darling *et al.* 2021).

Results from the qPCR analysis for platypus are summarised below (Table 1). Platypus eDNA was positively detected at three sites with another two sites returning Equivocal results, all in the Macleay River. Without location details for sites, it is impossible to determine any previous database or eDNA records for platypuses in the area.

A summary of the fish species detected from the metabarcoding analysis is provided in Table 2. A total of 14 taxa were identified across all sites including 12 native and 2 introduced taxa. Species richness at the site level varied from 1 to 13 with a clear difference between sites with the MR designation and sites with UW designation. Unidentified fish reads were common across all sites indicating there are one or more species present that are not represented in the reference database and therefore genetic sequences from samples could not be assigned.

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Carp gudgeons (*Hypseleotris* sp.) were detected at several sites throughout the study area with a number of haplotypes identified. Haplotypes aligned most closely with known sequences from *H. compressa* and Midgley's carp gudgeon (*Hypseleotris* sp) but it is difficult to confidently assign to species due to high intraspecific variation within species and hybridization. Similarly, the mountain galaxias complex comprises up to 15 closely related species with some shared haplotypes. Sequences here most closely aligned with known sequences for *G. olidus* and *G. ornatus*.

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Table 1. Results for eDNA analysis of water samples for platypus (*Ornithorhynchus anatinus*).

Site Code	Waterway	Latitude	Longitude	Date sampled	Positive assays	Test Result
MR-01	Macleay River	not provided	not provided	22/3/22	4/9	**Positive**
MR-03	Macleay River	not provided	not provided	21/3/22	3/9	**Positive**
MR-04	Macleay River	not provided	not provided	21/3/22	2/9	Equivocal
MR-05	Macleay River	not provided	not provided	24/3/22	6/9	**Positive**
MR-06	Macleay River	not provided	not provided	24/3/22	1/9	Equivocal
UW02-03		not provided	not provided	23/3/22	0/9	Negative
UW02-04		not provided	not provided	22/3/22	0/9	Negative
UW11-01		not provided	not provided	21/3/22	0/9	Negative
UW12-01		not provided	not provided	21/3/22	0/9	Negative
UW13-01		not provided	not provided	23/3/22	0/9	Negative
UW14-01		not provided	not provided	24/3/22	0/9	Negative
UW15-01		not provided	not provided	24/3/22	0/9	Negative
UW17-05		not provided	not provided	22/3/22	0/9	Negative
Neg1	N/A			N/A	0/3	Negative
Neg2	N/A			N/A	0/3	Negative
Neg3	N/A			N/A	0/3	Negative

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Table 2. Summary of results from the FISH biodiversity assay for each site with explanatory footnotes below.

Scientific names	Common names	MR-01	MR-03	MR-04	MR-05	MR-06	UW02-03*	UW02-04*	UW11-01	UW12-01	UW13-01	UW14-01	UW15-01	UW17- 05*
Actinopteri - not classified further		+++	+++	++	+++	+++	+++	++	+++	+++	++	+++	+++	+++
Anguilla australis	Australian shortfin eel	++	++							+		+		
Anguilla reinhardtii	Australian longfin eel	+++	+++	++	+++	+++	+		+++			+++	+++	
Carassius auratus or Cyprinus carpio	goldfish or carp	++	+	+	++		+	+	++					+++
Galaxias ornatus/ olidus (1)	mountain galaxias	+			++									
Gambusia holbrooki	Eastern mosquitofish	+	+		+									
Gobiomorphus sp.	genus of Australian gudgeons	++	+++	++	++	+								
Hypseleotris sp.	genus of carp gudgeons	+++	+	+++	+	+++								++
Melanotaenia duboulayi	crimsonspotted rainbowfish	+												
Mugil cephalus	flathead grey mullet, sea mullet	++	+++	++	++	+++								
Percalates colonorum or P. novemaculeata	estuary perch or Australian bass	+	++	++	++	+								
Philypnodon macrostomus	dwarf flathead gudgeon		+	+	+									
Potamalosa richmondia	Australian freshwater herring			+										
Retropinna semoni	Australian smelt	+++	+++	+++	+++	+++	+	++	+++				+++	+++
Trachystoma petardi	pinkeye mullet	++	++	+	+++	++								
Number of taxa detected		**13**	**12**	**11**	**12**	**8**	**4**	**3**	**4**	**2**	**1**	**3**	**3**	**4**

+ indicates number of replicate samples the species was detected

* Indicates very low reads from the site, below 0.1% threshold level

Notes:

1 The mountain galaxias complex may comprise up to 15 species, including G. ornatus (ornate galaxias) and G. olidus.

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Appendix F. Fish Raw Data

CC-01

Species	ANG REI	GOB AUS	GOB COX	HYP COM	HYP KLU	RET SEM	TAN TAN
1	623	104	84	75	71	65	66
2	320	110		60	42	65	
3	834	75		71	58	58	
4	272	108		75	38	41	
5	610	76		60	58	56	
6	802	90		48	40	55	
7	435	108			48	52	
8	495	102			38	60	
9		84			46	40	
10		81			40	41	
11						60	
12						51	
13						34	
14						44	
15						40	
16						56	
17						41	
18						39	
19						42	
20						50	
Tally						47	

MR-01

Species	RET SEM	ANG REI	HYP COM	RHA ORN	HYP KLU
1	48	230	38	74	41
2	45	224			
3	43	210			
4	42	286			
5	47	271			
6	52				
7	48				
8	46				
9	46				
10	42				
11	37				
12	46				
13	46				
14	43				
15	44				
16	43				
17	41				
18	37				
19	43				
20	38				
Tally	55				

MR-02

Species	ANG REI	GAM HOL	GOB AUS	HYP KLU	MYX PET	RET SEM	TAN TAN

1	1020	45	33	29	105	48	138
2		28			88	38	71
3					74	39	
4					82	44	
5					92	48	
6					88	46	
7					89	46	
8					86	40	
9					103	40	
10					86	50	
11					87	46	
12					114	48	
13					95	42	
14						37	
15						50	
16						48	
17							
18							
19							
20							
Tally							

Mr-03

Species	GOB AUS	RET SEM	ANG REI	GOB COX	PHI MAC	TAN TAN
1	92	48	850	38	55	72
2	84	34	543	62		
3		54	625			
4		54	263			
5		37	458			
6		42	921			
7		38				
8		43				
9		37				
10		46				
11		48				
12		51				
13		32				
14		38				
15						
16						
17						
18						
19						
20						
Tally						

Mr-04

Species	RET SEM	ANG REI	MEL DUB	HYP KLU	TAN TAN
1	38	256	38	68	133
2	29	548	34	39	
3	35	721		36	
4	36	850			
5	40	272			
6	39	358			
7	28	685			
8	36				
9	32				
10	33				
11	29				
12	33				
13	28				
14	29				
15	33				
16	32				
17	33				
18	35				
19	39				
20	34				
Tally	27				

Mr-05

Species	ANG REI	GOB AUS	GOB COX	HYP COM	HYP KLU	MYX PET	RET SEM	TAN TAN
1	650	90	75	72	78	184	56	60
2	340		51	67		142	60	
3	375		54			127	65	
4	820					110	51	
5	650					152	57	
6	425					128	62	
7	300					106	58	
8						118	48	
9						111	58	
10						100	65	
11						105	57	
12						137	50	
13						127	70	
14						115	60	
15						110	64	
16						106	49	
17						173	53	
18						153	42	
19						152	54	
20						181	61	
Tally						22	26	

Mr-06

Species	RET SEM	TAN TAN	HYP KLU	ANG REI
1	56	65	37	845
2	38		30	151
3	40		32	270
4	41		36	420
5	37		30	
6	42		34	
7	37		74	
8	40		33	
9	42			
10	41			
11	45			
12	34			
13	44			
14	40			
15	41			
16	50			
17	38			
18	46			
19	40			
20	70			
Tally	28			

Mr-07

Species	ANG AUS	ANG REI	GOB COX	HYP KLU	RET SEM	TAN TAN
1	155	420	74	46	57	56
2		550	40	38	57	72
3		140	50	45	56	64
4		125	38	39	50	74
5			52	41	54	66
6			58	40	48	
7				50	46	
8				32	39	
9				31	43	
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
Tally						

Mr-08

Species	RET SEM	HYP KLU
1	44	37
2	55	45
3	44	38
	42	34
5	39	36
6	57	38
7	45	
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
Tally		

Mr-09

Species	RET SEM	ANG REI	HYP KLU	MUG CEP
1	50	322	45	147
2	55	720	34	
3	44	842	42	
4	49	921	41	
5	42	825		
6		382		
7		381		
8		252		
9		230		
10		195		
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Tally				

UW02-03

Species	GOB COX	ANG REI
1	55	350
2	60	390
3	63	
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
Tally		

UW02-04

Species	ANG REI
1	320
2	190
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
Tally	

Appendix G. Fish sampling effort

Settings	Seconds	V	Hz	%
MR-01	954	400	120	15
MR-02	498	400	120	15
MR-03	578	400	120	15
MR-04	976	400	120	15
MR-05	1127	400	120	15
MR-06	1198	400	120	15
MR-07	820	400	120	15
MR-08	854	400	120	15
MR-09	901	400	120	15
CC-01	936	250	120	15
UW02-03	447	500	120	15
UW02-04	365	700	120	15
UW11-01	412	500	120	15
UW12-01	151	500	120	15

Appendix H. River Bioassessment Scores

Site		MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-08	MR-09	CC-01	UW02-03	UW02-04
Habitat variable	**Scale**											
Bottom substrate	0-20	18	18	14	14	17	17	18	18	14	12	12
Embeddedness	0-20	19	19	11	10	16	18	18	18	12	15	15
Velocity and depth category	0-20	16	18	17	18	18	17	18	19	12	15	10
Channel alteration	0-15	11	14	12	11	10	11	11	10	7	9	12
Bottom scouring and deposition	0-15	13	13	10	8	12	12	11	12	9	9	8
Pool/riffle, run/bend ratio	0-15	14	13	10	11	14	12	14	14	12	12	10
Bank stability	0-10	9	9	9	9	8	8	10	9	8	6	7
Bank vegetation and stability	0-10	9	9	7	8	9	9	7	7	6	9	9
Streamside cover	0-10	8	8	8	8	8	8	8	8	10	10	10
Totals	**0-135**	**117**	**121**	**98**	**97**	**112**	**112**	**115**	**115**	**90**	**97**	**93**
Habitat score category*		**Excellent**	**Excellent**	**Good**	**Good**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Good**	**Good**	**Good**

Appendix I. Raw Macroinvertebrate Data

Order	Family	Lowest taxon	MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-08	MR-09	CC01	UW02-03	UW02-04
COLEOPTERA	DYTISCIDAE	DYTISCIDAE	0	0	0	0	0	0	0	0	0	0	1
COLEOPTERA	DYTISCIDAE	Hyphydrus	0	0	0	0	0	0	0	0	0	1	0
COLEOPTERA	DYTISCIDAE	Necterosoma	0	0	0	0	0	0	0	0	0	1	1
COLEOPTERA	DYTISCIDAE	Rhantus	0	0	0	0	0	0	0	0	0	0	0
COLEOPTERA	ELMIDAE	Austrolimnius	1	1	0	7	0	0	0	0	0	0	0
COLEOPTERA	GYRINIDAE	Macrogyrus	0	0	0	0	0	0	0	0	0	2	1
COLEOPTERA	HYDRAENIDAE	Hydraena	0	0	0	0	0	0	0	0	0	1	0
COLEOPTERA	HYDROPHILIDAE	Berosus	0	0	0	0	1	0	0	1	0	0	0
COLEOPTERA	HYDROPHILIDAE	Enochrus	0	0	0	0	0	0	0	0	0	0	1
COLEOPTERA	PSEPHENIDAE	Sclerocyphon	1	0	0	0	2	0	0	1	0	0	0
COLEOPTERA	SCIRTIDAE	Scirtidae larvae	0	1	0	0	0	0	0	0	0	1	1
CRUSTACEA	ATYIDAE	Australatya	0	1	0	0	0	1	0	1	0	0	0
CRUSTACEA	ATYIDAE	Parataya	0	0	0	0	1	0	2	2	0	1	0
DIPTERA	ATHERICIDAE	Dasyomma	0	0	0	1	0	0	3	0	0	0	0
DIPTERA	CHIRONOMIMIDAE	VELIIDAE	0	0	0	0	0	0	0	0	0	0	0
DIPTERA	Chironominae	Polypedilium	0	0	0	0	0	0	0	0	0	2	2
DIPTERA	Chironominae	Tanytarsini	0	0	0	0	0	0	1	0	0	0	0
DIPTERA	CULICIDAE	Orthocladinae	0	0	0	0	0	0	0	0	0	0	0
DIPTERA	DOLICHOPODIDAE	Dolichopodidae	0	1	0	0	0	0	0	0	0	0	0
DIPTERA	Orthocladinae	Cricotopus	1	2	0	0	2	4	2	1	0	0	0
DIPTERA	SIMULIIDAE	Austrosimulium	1	5	0	0	1	4	3	1	0	0	0
DIPTERA	SIMULIIDAE	Paracnephia	0	0	0	0	1	0	0	0	1	4	4
DIPTERA	SIMULIIDAE	Simulidae	0	0	0	0	0	0	0	0	1	0	0
DIPTERA	SIMULIIDAE	Simulium	0	0	0	0	0	0	0	0	0	1	1

Order	Family	Lowest taxon	MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-08	MR-09	CC01	UW02-03	UW02-04
DIPTERA	Tanypodinae	Ablesmyia	0	0	0	0	0	0	0	0	0	0	1
DIPTERA	TIPULIDAE	Tipulidae	1	1	0	0	0	2	5	0	0	0	0
EPHEMEROPTERA	AMELETOPSIDAE	Mirawara	1	0	0	0	1	0	3	1	0	0	0
EPHEMEROPTERA	BAETIDAE	BAETIDAE	1	0	0	0	2	0	5	0	0	1	2
EPHEMEROPTERA	BAETIDAE	Bungona	0	0	0	0	0	0	0	0	0	1	0
EPHEMEROPTERA	BAETIDAE	Offadens	5	3	1	6	10	8	10	3	5	1	2
EPHEMEROPTERA	LEPTOPHLEBIIDAE	Atalophlebia	0	0	0	0	0	0	0	1	0	0	0
EPHEMEROPTERA	LEPTOPHLEBIIDAE	Austrophleboides	12	8	5	0	6	4	9	4	4	4	3
EPHEMEROPTERA	LEPTOPHLEBIIDAE	Jappa	0	2	0	0	0	0	0	0	0	0	0
EPHEMEROPTERA	LEPTOPHLEBIIDAE	LEPTOPHLEBIIDAE	3	3	1	0	2	0	5	1	0	0	1
EPHEMEROPTERA	LEPTOPHLEBIIDAE	Nousia	0	0	1	0	0	0	0	0	1	1	2
EPHEMEROPTERA	LEPTOPHLEBIIDAE	Thraulophlebia	0	0	0	0	0	0	0	3	0	0	0
HEMIPTERA	VELIIDAE	Microvelia	0	0	0	0	0	0	0	0	0	2	0
HYDRACARINA	ORBATIDAE	Orbatidae	0	0	0	0	0	0	0	0	0	0	0
MEGALOPTERA	CORYDALIDAE	Archichauliodes	1	1	0	0	2	0	1	1	0	1	0
NEMATOMORPHA	GORDIOIDEA	Gordioidea	0	0	0	0	0	0	0	0	0	2	1
ODONATA	DIPHLEBIIDAE	Diphlebia	1	0	0	0	0	0	0	0	0	0	0
ODONATA	GOMPHIDAE	Gomphidae	0	2	0	0	0	0	0	0	0	1	1
ODONATA	GOMPHIDAE	Hemigomphus	2	3	0	0	3	0	2	0	0	0	0
ODONATA	LIBELLULIDAE	Libelluliade	0	0	0	0	0	0	0	0	0	0	1
ODONATA	TELEPHLEBIIDAE	Spinaeschna	0	0	0	0	2	0	2	0	0	0	0
OLIGOCHAETA		Oligochaeta	6	2	0	0	2	0	10	2	5	0	0
PLECOPTERA	GRIPOPTERYGIDAE	GRIPOPTERYGIDAE	1	0	0	0	0	0	0	0	0	0	0
PLECOPTERA	GRIPOPTERYGIDAE	Illesoperla	3	4	2	1	4	3	4	2	3	1	2
PLECOPTERA	GRIPOPTERYGIDAE	Trinotoperla	0	1	1	0	1	1	5	2	7	0	0
TRICHOPTERA	CALAMOCERATIDAE	Anisocentropus	1	0	0	0	0	0	0	1	0	1	2
TRICHOPTERA	GLOSSOSOMATIDAE	Agapetus	0	1	0	0	0	0	0	0	0	0	0

Order	Family	Lowest taxon	MR-01	MR-02	MR-03	MR-04	MR-05	MR-06	MR-08	MR-09	CC01	UW02-03	UW02-04
TRICHOPTERA	HELICOPHIDAE	Helocabbus	2	2	0	0	3	2	4	2	2	0	0
TRICHOPTERA	HELICOPSYCHIDAE	Helicopsyche	0	0	0	0	1	0	0	0	0	0	0
TRICHOPTERA	HYDROBIOSIDAE	Apsilochorema	1	0	0	0	0	0	0	0	0	0	1
TRICHOPTERA	HYDROBIOSIDAE	Taschorema group	2	3	2	0	4	1	1	3	3	3	3
TRICHOPTERA	HYDROBIOSIDAE	Ulmerochorema	0	0	0	0	0	0	0	0	1	0	0
TRICHOPTERA	HYDROPSYCHIDAE	Asmicridea	0	0	0	0	2	0	0	0	0	0	0
TRICHOPTERA	HYDROPSYCHIDAE	Cheumatopsyche	3	10	0	0	1	1	7	1	0	0	0
TRICHOPTERA	HYDROPSYCHIDAE	HYDROPSYCHIDAE	1	1	0	0	0	0	0	0	0	0	0
TRICHOPTERA	LEPTOCERIDAE	Notalina	1	0	0	8	3	0	2	1	0	0	0
TRICHOPTERA	LEPTOCERIDAE	Oecetis	1	0	0	0	1	0	0	0	0	1	1
TRICHOPTERA	LEPTOCERIDAE	Triaenodes	0	0	0	0	0	0	0	0	0	0	1
TRICHOPTERA	LEPTOCERIDAE	Triplectides	1	1	0	1	0	2	1	3	0	6	7
TRICHOPTERA	PHILOPOTAMDAE	Chimarra	3	2	1	2	2	2	1	4	0	4	0
TRICHOPTERA	TASIMIIDAE	Tasiagma	0	0	0	0	0	0	0	0	0	0	1

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Appendix B DPI Fisheries Key Fish Habitat Assessment Proforma

Table B-1: Key fish habitat – waterway type assessment.

Component	Present?	Component	Present?	Component	Present?
Type 1 - Highly sensitive key fish habitat		Type 2 – Moderately sensitive key fish habitat		Type 3 – Minimally sensitive key fish habitat	
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 >5m2 in area		Mangroves		Coastal and freshwater habitats not included in TYPES 1 or 2	
Coastal saltmarsh >5m2 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 key fish habitat: • First and second order streams on gaining streams (based on the Strahler method of stream ordering) • Farm dams on first and second order streams or unmapped gullies • Agricultural and urban drains • Urban or other artificial ponds (e.g. evaporation basins, aquaculture ponds) • Sections of stream that have been concrete-lined or piped (not including a waterway crossing) • Canal estates	
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			
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)			
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			
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			
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			
Mound springs		Weir pools and dams up to full supply level where the weir or dam is across a natural waterway			

Table B-2: Key fish habitat – waterway class assessment.

Classification	Characteristics of waterway class	Present?
Class 1 – major key fish habitat	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 key fish habitat	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 key fish habitat	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 key fish habitat	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).	

Appendix C Water Quality Data, March 2022

Table D-1: *In situ* water quality recorded during the March 2022 field survey.

Water Quality Parameter	MR01	MR02	MR03	MR04	MR05	MR06	MR07	MR08	MR09	ANZECC & ARMCANZ (2000) triggers
pH (units)	8.37	8.48	8.35	8.3	8.28	7.86	8.48	8.16	8.24	6.5 – 8.0
EC (µS/cm)	183.03	183.94	185.73	182.24	179.39	164.08	172.21	168.8	167.99	125 – 2,200
Turbidity (NTU)	6.85	2.98	2.95	1.83	3	1.7	2.85	2.5	2.37	6 – 50
DO (%)	100.75	104.08	103.09	100.23	106.66	101.82	109.17	100.96	102.01	85 – 110
Temp. (°C)	9.44	10.7	9.93	9.66	12.38	11.65	11.62	10.75	9.94	-
Time	8:49	14:49	16:38	10:49	14:51	13:19	16:38	15:19	11:39	n/a

Note: Red shading indicates values below or above the lower or upper limit of the ANZECC and ARMCANZ (2000) trigger values for slightly disturbed south-eastern Australian upland rivers.

Table D-2: Total metals analysed from surface water samples during the March 2022 field survey.

Water Quality Parameter		LoR	MR01	MR03	MR04	MR05	UW02-03	UW02-04	UW11-01	UW12-01
Total Metals & Trace Elements	Arsenic	0.001	0.002	0.003	0.003	0.002	0.002	0.002	0.003	0.002
	Barium	0.001	0.032	0.015	0.015	0.014	0.009	0.008	0.009	0.007
	Beryllium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Boron	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Cadmium	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Cobalt	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper	0.001	0.004	<0.001	0.004	<0.001	0.009	<0.001	<0.001	<0.001
	Lead	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese	0.001	0.016	0.018	0.081	0.023	<0.001	<0.001	0.003	<0.001
	Mercury	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Nickel	0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Vanadium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.005	0.027	<0.005	<0.005	<0.005	0.008	<0.005	<0.005	<0.005

Appendix D FM Act Significant Impact Assessment

Table E-1: Significant impact criteria (endangered species) – Southern Purple-spotted Gudgeon.

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	The Southern Purple-spotted Gudgeon is currently considered to be extremely rare in inland NSW and has only been recorded once since 1983. While the Department of Primary Industries (2022c) mapping for the Southern Purple-spotted Gudgeon indicates that it is possible that it is present within the vicinity of the Project and/or within the Macleay River more broadly, this distribution within the Macleay River is upstream of the Project, and some of its tributaries to within approximately 20 km of the Project. Furthermore, the Southern Purple-spotted Gudgeon has not been recorded during any previous surveys carried out in the Macleay River (Harris and Gehrke 1997; Llewellyn 1983). Overall, it is unlikely that the Project will have an adverse effect on the life cycle of the Southern Purple-spotted Gudgeon such that a viable local population of the species is likely to be placed at risk of extinction, because a viable local population is likely absent from the vicinity of the Project area.
(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,	Not applicable
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity-- **(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**	Not applicable
(d) in relation to the habitat of a threatened species, population or ecological community-- **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**	The removal and disturbance of aquatic and riparian habitat will occur as a result of construction of Project infrastructure, particularly the construction of the Upper Dam and Reservoir and the Lower Dam and Reservoir and the construction and installation of water extraction infrastructure in the Macleay River. However, the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the Department of Primary Industries (2022c) mapped distribution of the Southern Purple-spotted Gudgeon. In addition, it is unlikely that the ephemeral waterways in this area support persistent aquatic biota communities, particularly threatened aquatic species, although the waterways may provide refuge habitat for aquatic biota during dry conditions within surface water pools sustained by groundwater. It is anticipated that construction of water extraction infrastructure in the Macleay River will only require a disturbance footprint of less than 0.2 ha, isolated to a localised area, which will minimise impacts to the riparian zone.

Criteria	Discussion
	Although the installation and operation of water extraction infrastructure may further contribute to in-stream degradation of aquatic and riparian habitat, the operation of water extraction infrastructure will primarily occur during the initial filling of the reservoirs, anticipated to take a minimum of three months. Overall, it is unlikely that the Southern Purple-spotted Gudgeon is present within habitat directly impacted by the development of the Project in the first instance. Where habitat will be removed or modified as a result of the proposed Project, the extent of this has been minimised in size of disturbance footprint (0.2 ha) and duration, in relation to initial filling of the reservoirs (anticipated to take a minimum of three months), such that it is unlikely the Southern Purple-spotted Gudgeon will be significantly affected by the impacts of the Project on habitats, if present.
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	Given the ephemeral nature of the waterways within the Project area, it is unlikely that aquatic biota communities are stable and persistent, although the waterways may provide refuge habitat for aquatic biota during dry conditions. While the water level of the Macleay River will be subject to a decrease, this will be minor (modelled at 0.05 m) and unlikely to affect the overall hydrological regime. The expected maximum annual volume extracted from the Macleay River is 6,865 ML, which represents less than 1% of streamflow in high-rainfall years ranging to approximately 7% of streamflow in low-rainfall years (EMM Consulting 2022e). In consideration of the impacts of the Project to the ecological aquatic community, there will be minimal additional risk of drying due to the development of the Project compared to natural fluctuations in the hydrological regime.
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,	The Southern Purple-spotted Gudgeon prefers slow-flowing or still water with a substantial amount of macrophyte coverage and/or a rocky benthos. While the Macleay River and its associated tributaries may contain habitat suitable to this species, within the vicinity of the Project, it is more likely that the lack of suitable habitat and the ephemeral nature of its tributaries prevent the species from permanently colonising the waterways. Based on the results of the desktop assessment and field surveys, the Macleay River is considered to be of high ecological value due to its classification as Type 1 highly sensitive key fish habitat and Class 1 major key fish habitat; likely availability of permanent or semi-permanent refuge pools that persist during drought conditions; and a current lack of waterway regulation, providing fish passage for migrating species. However, it is anticipated that construction of water extraction infrastructure will only require a disturbance footprint of less than 0.2 ha, isolated to a localised area of the Macleay River, minimising impacts to aquatic habitat. In addition, the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the Department of Primary Industries (2022c) mapped distribution of the Southern Purple-spotted Gudgeon. While the Project poses risk of habitat fragmentation, there is an overall lack of contiguous riparian habitat along the Macleay River and its tributaries, which suggests that habitat fragmentation is already present in the local region.
(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),	There is no declared critical habitat listed under the FM Act for the Southern Purple-spotted Gudgeon.
(f) whether the proposed development or activity is consistent with a Priorities Action Statement,	There are a number of recovery actions stipulated for the Southern Purple-spotted Gudgeon, with two potentially being of relevance to the Project: • *Allocate and manage environmental water flows in regulated rivers to restore natural seasonal flow patterns, and to reduce the impact of cold water downstream of dams (High priority)* ○ The Project will result in short-term minor periodic decreases in volume and flow of the Macleay River, in particular during the initial filling of the reservoirs and maintenance top-up of reservoir water, which will

Criteria	Discussion
	be undertaken during high flow events (above the 50th percentile flow). ○ The expected maximum annual volume extracted from the Macleay River is 6,865 ML, which represents less than 1% of streamflow in high rainfall years ranging to approximately 7% of streamflow in low rainfall years (EMM Consulting 2022e). The water level will be subject to a minor decrease (modelled at 0.05 m), which is unlikely to affect the overall hydrological regime (EMM Consulting 2022e). ○ The transfer of water between the two reservoirs will result in substantial mixing of stored water, likely mitigating impacts associated with cold water pollution. ○ Project-specific management plans will be implemented to ensure that surface water volume and flow are managed appropriately. • *Undertake work to identify, restore and protect known and potential…habitats and address key threats such as habitat degradation and water quality decline from expanding development (High priority)* ○ Erosion and sedimentation management will be implemented throughout the Project area to ensure that impacts to water quality, key fish habitat and the riparian zone are minimised during and after groundworks. Temporary disturbance areas will be rehabilitated to pre-disturbance conditions following completion of construction activities, as far as practicable. ○ It is unlikely that the extraction of water from, or input of water into, the Macleay River will substantially influence water quality as a result of evapoconcentration as the operation of water extraction infrastructure will primarily occur during high-flow events (above the 50th percentile flow) and will primarily only occur during the initial filling of the reservoirs (EMM Consulting 2022d). Emergency and/or maintenance discharge of water is also likely to be isolated and short-term in nature, and a number of management and monitoring actions will be implemented as part of Project-specific management plans. The Project will be implemented in a manner that does not contradict relevant Priorities Action Statements, as far as practicable.
(g) whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	Of the key threatening processes listed under the FM Act, two may be relevant to the project with regard to the Southern Purple-spotted Gudgeon: • *Degradation of native riparian vegetation along New South Wales water courses* ○ While the Southern Purple-spotted Gudgeon uses native riparian habitat, the species relies more on in-stream aquatic flora. ○ Overall, habitat for the Southern Purple-spotted Gudgeon is generally limited within the Macleay River catchment. There was a proliferation of exotic plants at some sites, clearing of native vegetation (particularly overhanging riparian vegetation) was evident, and there was a lack of suitable habitat features (large woody debris and in-stream aquatic vegetation) available. Within the tributaries, no waterways within the Project area had a defined riparian zone or banks. Generally, waterways outside of the proposed Lower Dam and Reservoir (e.g. UW02) lacked remnant riparian vegetation. ○ The disturbance footprint for the water extraction infrastructure within the riparian zone is limited to 0.2 ha and isolated to a localised area, reducing impact to riparian vegetation. In addition, the operation of water extraction infrastructure will only occur during high-flow events (above the 50th percentile flow), limiting the area of the riparian zone subject to drying. ○ Erosion and sedimentation management will be implemented throughout the Project area to ensure that impacts to water quality, key fish habitat and the riparian zone are minimised during and after groundworks, as far as practicable.

Criteria	Discussion

	• *Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams*
	  ○ The installation and operation of instream structures altering natural flow will relate only to the construction and operation of water extraction infrastructure within the Macleay River. The operation of water extraction infrastructure will primarily occur during the initial filling of the reservoirs, anticipated to take a minimum of three months.
	  ○ The Project will result in short-term minor periodic decreases in volume and flow of the Macleay River, in particular during the initial filling of the reservoirs and maintenance top-up of reservoir water, which will be undertaken during high flow events (above the 50th percentile flow). The expected maximum annual volume extracted from the Macleay River is 6,865 ML, which represents less than 1% of streamflow in high-rainfall years ranging to approximately 7% of streamflow in low-rainfall years (EMM Consulting 2022e). The water level will be subject to a minor decrease (modelled at 0.05 m), which is unlikely to affect the overall hydrological regime (EMM Consulting 2022e).
	  ○ The risk of mortality to aquatic species from the instream infrastructure will be mitigated by ensuring that design specifications of the extraction structure are "fish friendly" (Section 10.1), and by installing a gravity fed pipeline and wet well receptacle, to ensure fauna are not drawn towards water extraction infrastructure. The majority of aquatic fauna are also likely to be able to move away from extraction screens, given appropriate water extraction velocity is implemented.
	  ○ Project-specific management plans will be implemented to ensure that surface water volume and flow are managed.
	The Project will be implemented in a manner that will not result in an increased impact of the key threatening processes identified.

Conclusion	Construction, operation and maintenance of the Project is unlikely to significantly impact on the Southern Purple-spotted Gudgeon, if it occurs, justified as follows:
	• It is unlikely that the Macleay River, or associated tributaries, support viable populations of the species.
	• The species is unlikely to be present within the Project area. It is considered rare in inland water in NSW and, although Department of Primary Industries (2022c) distribution mapping suggests that its presence is possible within the broader region, there have been no sightings through field surveys since 1983.
	• While habitat suitable to the Southern Purple-spotted Gudgeon may occur within the vicinity of the Project, the species was not confirmed as occurring within the Project area during any previous surveys carried out in the Macleay River.
	• Overall, there is a general lack of extensive habitat for the Southern Purple-spotted Gudgeon in the local area, and given the ephemeral nature of the catchment tributaries, it is unlikely that there is sufficient habitat to support the persistence of the species.
	• The impacts of the Project on the Macleay River and its associated waterways have been minimised whereby:
	  ○ the disturbance footprint is limited to 0.2 ha;
	  ○ the operation of the water extraction infrastructure is considered to be temporary and/or short-term; and
	  ○ the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the Department of Primary Industries (2022c) mapped distribution of the Southern Purple-spotted Gudgeon and unlikely to support aquatic biota communities.
	• Appropriate management measures will be in place to ensure that impacts to water quality, key fish habitat and the riparian zone are avoided or minimised during and after groundworks, as far as practicable.

Appendix E BC Act Significant Impact Assessment

Table E-1: Test for determining whether proposed development or activity likely to significantly affect threatened species or ecological communities, or their habitats – Manning River Helmeted Turtle (Endangered, BC Act).

Criteria	Discussion
(a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,	Although the distribution of the Manning River Helmeted turtle is restricted to the middle and upper extent of the Manning River catchment (Department of Planning and Environment 2022c), current potential habitat mapping for the species indicates that the Manning River Helmeted Turtle is likely to occur within the Project area (Department of Planning and Environment 2022c), indicating that the species may not be restricted to the Manning River catchment. That said, although suitable habitat for these species was observed along Macleay River, the species was not observed during the 2022 field survey. It is considered more likely that this species does not occur, with the distributions generally based on extrapolated data (Department of Planning and Environment 2022c), or is present periodically. Suitable nesting habitat for turtles (sand benches) was observed at several sites, with the largest and most expansive areas located upstream of the Project at site MR01 and downstream near site MR08. However, feral pigs were observed throughout the channel areas of the Macleay River and had caused instability of soft sediment and riparian vegetation as a result of digging. It is expected that turtle nesting would be substantially impacted by the presence of pigs in the area. The main impact of the Project is the construction and operation of the two reservoirs, proceeding with the impoundment of Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River. This area of disturbance is outside of the known distribution of the Manning River Turtle habitat. In addition, the Manning River Helmeted Turtle favours relatively shallow, clear, continuously fast-flowing rivers with rocky and sandy substrates and, given the ephemeral nature of the tributary and intermittent flow, it is unlikely that the species would be present in this area. Overall, it is unlikely that the Project will have an adverse effect on the life cycle of the Manning River Helmeted Turtle such that a viable local population of the species is likely to be placed at risk of extinction, because a viable local population is likely absent from the vicinity of the Project area.
(b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity— **(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**	Not applicable
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,	Not applicable
(d) in relation to the habitat of a threatened species or ecological community— **(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity,**	The Manning River Helmeted Turtle prefers relatively shallow, clear, continuously fast-flowing rivers with rocky and sandy substrates (Wells 2002) characterised by boulder beds and submerged logs. It is likely that the species is omnivorous (Allanson and Georges 1999; Wells 2002) but prefers to forage on benthic fauna and aquatic vegetation (Allanson and Georges 1999). The main impact of the Project is the construction and operation of the two reservoirs, proceeding with the impoundment of Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River. This tributary is outside of the known Manning River Helmeted Turtle habitat; therefore, the extent

Criteria	Discussion
	to which the habitat is likely to be affected by the Project is negligible. Furthermore, the ephemeral nature of the tributary is not a preferable habitat to the species compared to fast flowing streams. It is anticipated that construction of water extraction infrastructure in the Macleay River will only require a disturbance footprint of less than 0.2 ha, isolated to a localised area. Although the installation and operation of water extraction infrastructure may further contribute to in-stream degradation of aquatic and riparian habitat, the operation of water extraction infrastructure will primarily occur during the initial filling of the reservoirs, anticipated to take a minimum of three months. Overall, it is unlikely that the Manning River Helmeted Turtle is present within habitat directly impacted by the development of the Project in the first instance. Where habitat will be removed or modified as a result of the Project, the extent of this has been minimised in size of disturbance footprint (0.2 ha) and duration, in relation to initial filling of the reservoirs (anticipated to take a minimum of three months), such that it is unlikely the species will be significantly affected by the impacts of the Project on habitats, if present.
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and	The distribution of the Manning River Helmeted Turtle within the Manning River catchment is assumed to be substantially fragmented (Department of Planning and Environment 2022c). Within the Macleay River catchment, while the known habitat of the species is within the vicinity of the Project, no recordings of the species were observed during field studies and it is considered unlikely to be present persistently. Given the ephemeral nature of the Fingerboard Crossing Creek where habitat impacts will occur, the likelihood of fragmentation of habitat already exists for the area. Overall, the Project is unlikely to lead to habitat fragmentation or isolation because habitat fragmentation for the species already occurs. The exacerbation of habitat fragmentation from the Project is also unlikely as the main impact area of the Project is outside of the known habitat distribution of the species and is considered unfavourable.
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality,	Although habitat for the Manning River Helmeted Turtle was observed during surveys, the habitat for the species was generally limited and fragmented. There was a proliferation of exotic plants at some sites, clearing of native vegetation (particularly overhanging riparian vegetation) was evident, and there was a lack of suitable habitat features (large woody debris and in-stream aquatic vegetation) available. There was also anthropogenic influences (pastoralism) and the presence of feral pigs noted, likely impacting turtle nesting sites, recruitment and resulting in sediment disturbance. The main impact of the Project is the construction and operation of the two reservoirs, proceeding with the impoundment of Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River. This tributary is outside of the known Manning River Helmeted Turtle habitat; therefore, the importance of the habitat to the species that will be affected by the proposed development is negligible. Furthermore, the ephemeral nature of the tributary is not a preferable habitat to the species compared to fast flowing streams. The amount of habitat affected by the Project, such as the water extraction infrastructure, is considered minimal and will be managed appropriately to prevent mortality. Overall, the habitat to be removed, modified or fragmented by the Project is of low importance to the species, if it is present in the area in the first instance.
(d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),	Not applicable

Criteria	Discussion

(e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.	Of the key threatening processes listed under the BC Act, five may be relevant to the Project with regard to the Manning River Helmeted Turtle:
	• *Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (as described in the final determination of the Scientific Committee to list the threatening process):*
	  ○ The Project will result in short-term minor periodic decreases in volume and flow of the Macleay River, in particular during the initial filling of the reservoirs and maintenance top-up of reservoir water, which will be undertaken during high flow events (above the 50th percentile flow).
	  ○ The expected maximum annual volume extracted from the Macleay River is 6,865 ML, which represents less than 1% of streamflow in high rainfall years ranging to approximately 7% of streamflow in low rainfall years (EMM Consulting 2022e).. The water level will be subject to a minor decrease (modelled at 0.05 m), which is unlikely to affect the overall hydrological regime (EMM Consulting 2022e).
	  ○ The transfer of water between the two reservoirs will result in substantial mixing of stored water, likely mitigating impacts associated with cold water pollution.
	  ○ Project-specific management plans will be implemented to ensure that surface water volume and flow are managed.
	• *Predation by Gambusia holbrooki Girard, 1859 (Plague Minnow or Mosquito Fish) (as described in the final determination of the Scientific Committee to list the threatening process):*
	  ○ *Eastern Gambusia was recorded from four sites within the Macleay River during field surveys; however, as the Project transfers water via a "closed loop circuit" there is no opportunity for the introduction of this species into the Macleay River, or for the Project to exacerbate existing exotic species populations.
	• *Predation, habitat degradation, competition and disease transmission by Feral Pigs, Sus scrofa Linnaeus 1758*
	  ○ Feral pig activity was observed within the Project area and implementation of the Project has the potential to increase activity. However, the Manning River Helmeted Turtle is unlikely to be present in the Project area, despite presence of habitat, due to the lack of contiguous and favourable habitat due to the ephemeral nature of waterways.
	• *Removal of dead wood and dead trees:*
	  ○ The disturbance footprint for the water extraction infrastructure within the riparian zone is limited to 0.2 ha and isolated to a localised area, reducing impact to riparian vegetation.
	  ○ Within areas of potential turtle habitat along the Macleay River, there will be no requirement to remove dead wood and dead trees.
	The Project will be implemented in a manner that does not contradict key threatening processes, as far as practicable.

Conclusion	Construction, operation and maintenance of the Project is unlikely to significantly impact the Manning River Helmeted Turtle, if it occurs, justified as follows: • It is unlikely that the Macleay River, or associated tributaries, support viable populations of the species. • The species is unlikely to be present within the Project area. Although known habitat distribution mapping suggests that its presence is possible within the broader region, the main area of impact of the Project is outside of this distribution. • While habitat suitable to the Manning River Helmeted Turtle was observed within the vicinity of the Project, the species was not observed during the field survey. • Overall, there is a general lack of extensive habitat for the Manning River Helmeted Turtle in the local area and, given the ephemeral nature of the catchment tributaries, it is unlikely that there is sufficient habitat to support the persistence of the species.

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	• The presence of exotic species and predators such as feral pigs pose a risk to survival and recruitment, as well as habitat quality and availability.
	• The impacts of the Project on the Macleay River, and its associated waterways, have been minimised whereby:
	  ○ the disturbance footprint is limited to 0.2 ha;
	  ○ the operation of the water extraction infrastructure is considered to be temporary and/or short-term; and
	  ○ the Project reservoirs will impound Fingerboard Crossing Creek, an ephemeral 2nd order to 3rd order tributary of the Macleay River, which is outside of the Department of Planning and Environment (2022c) mapped distribution of the Manning River Helmeted Turtle and unlikely to support aquatic fauna.
	• Appropriate management measures will be in place to ensure that impacts to water quality and the riparian zone are minimised during and after groundworks, as far as practicable.

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