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APPENDIX F – Environmental Impact Statement

Surface water assessment

Prepared for Lake Lyell Project Pty Ltd

Lake Lyell Pumped Hydro Energy Storage Project

Surface water assessment

Lake Lyell Project Pty Ltd

E221111 RP21

November 2025

Version	Date	Prepared by	Reviewed by	Comments
1	24 June 2025	Judy Herold & Chris Kuczera	Christopher Holloway	Draft
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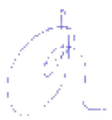

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Executive Summary

ES1 Background

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

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

ES2 Report purpose

This surface water assessment (SWA) supports the EIS for the project. It describes the existing surface water environment, the water management approach for construction and operation of the project and residual impacts. The assessment has been prepared to address the SEARs for the project, issued 17 November 2025, and considers relevant government and industry guidelines. This report references the following technical reports that also support the EIS for the project:

- Groundwater assessment (EMM 2025a) – this report describes the existing groundwater environment and groundwater impacts during construction and operation of the project.
- Excavated rock management strategy (EMM 2025b) – this report describes the excavated rock management strategy for the project, includes concepts for proposed permanent spoil emplacements (PSE) and describes the expected water quality profile of seepage from PSEs.
- Water licencing strategy (EMM 2025c) – this report addresses surface water and groundwater licensing requirements for the project under the NSW water regulatory framework.

ES3 Existing setting

The project is located within and near Lake Lyell, in the upper Coxs River catchment. The land-based components of the project will be constructed near the upstream portion of the Farmers Creek arm of Lake Lyell. Once operational, the project will utilise Lake Lyell as the lower reservoir for the PHES. The following water features and infrastructure are relevant to this assessment and are described in Chapter 4:

- Coxs River upstream of Lake Lyell
- Farmers Creek upstream of Lake Lyell
- watercourses within the construction envelope
- Lake Lyell, including the Farmers Creek arm of the reservoir
- the Coxs River Water Supply Scheme which supplies water from Lake Lyell to Mt Piper power station

- Coxs River downstream of Lake Lyell.

ES4 Water management during construction

ES4.1 Construction water management system

The project is estimated to take between four to five years to construct. A construction water management system will be operated to supply water to and manage water produced by construction activities. It will include the following key components:

- Clean water diversions to minimise the volume of water that requires management.
- A contaminated water system to manage potentially contaminated water generated from the following sources:
  - runoff (during construction) and seepage from PSEs
  - water pumped from subsurface excavations during construction
  - surface water from high intensity construction areas
- a stormwater system to manage runoff from areas disturbed by construction that have a low risk of producing contaminated water. These areas include:
  - roads and earthworks areas (excluding drill and blast areas)
  - accommodation camp (during construction and operation of the camp)
  - construction pads.

Treated water from the contaminated water and stormwater systems will be beneficially and preferentially used to supply non-potable water for construction purposes. Shortfalls may occur at the start of the project, if extended dry conditions occur during construction or if groundwater inflows into subsurface excavations are lower than predicted. Any shortfalls will be supplied from Lake Lyell or via groundwater extraction.

ES4.2 Waste water and potable water systems

The following options for potable water supply will be investigated at detailed design:

- Potable water is trucked to site.
- Treated water from Lake Lyell is used to supply potable water.
- Treated groundwater is used to supply potable water.

All wastewater (i.e. sewage) generated at the accommodation camp and construction site amenities will be treated onsite and trucked to a licensed facility unless a connection to an existing nearby sewer main is available. No onsite disposal of wastewater is proposed during construction.

ES4.3 Discharges and maximum water take

Table ES1 provides a summary of predicted system discharges and maximum water take.

Table ES1 Summary of discharges and maximum water take

Predicted system discharge	Description
Discharges	
Contaminated water system	• Surplus water will be treated and discharged to Lake Lyell. • The treated water quality will be similar to ambient water quality in Farmers Creek, which flows into the Farmers Creek arm of Lake Lyell.
Stormwater system – controlled discharges	• Following wet weather, water captured in sedimentation basins will be treated to remove suspended solids and discharged to Lake Lyell. • The treated water quality will be similar to ambient water quality in Farmers Creek.
Stormwater system – sedimentation basin overflows	• Sedimentation basins will overflow when the design capacity is exceeded. • Basin overflows may have elevated suspended solids concentrations and turbidity levels but are otherwise expected to have water quality that is similar to ambient water quality in Farmers Creek.
Water take	
Potable water supply	For assessment and water licensing purposes it has been conservatively assumed that 0.35 megalitres per day (ML/d) (equivalent to 128 megalitres per year (ML/yr)) of water is extracted from either Lake Lyell and/or the local groundwater system to supply potable water to the accommodation camp and construction site amenities.
Construction water supply	For assessment and water licensing purposes it has been conservatively assumed that 0.5 ML/d (equivalent to 183 ML/yr) of water is extracted from either Lake Lyell and/or the local groundwater system to meet shortfalls in the construction water supply.
Total (potable water and construction water supply)	The maximum water extraction volume from either Lake Lyell and/or the local groundwater system is 311 ML/yr.

ES5 Works on waterfront land

The *Water Management Act 2000* defines waterfront land as the bed of any river, lake or estuary and any land within 40 metres (m) of a riverbank, lake shore or estuary mean high water mark. The construction of the project will unavoidably require the following works on waterfront land:

- Temporary and permanent watercourse diversions.
- Watercourse crossings.
- Construction of the following works within Lake Lyell:
  - the inlet and outlet structure
  - the lake diversion
  - PSE 2 (infill pad) and PSE 3 (laydown pad)
  - temporary removal of one or more fusegates on the Lilyvale Dam spillway.
- Construction works within 40 m of watercourses and Lake Lyell.

Controls from works on waterfront land are described in Chapter 5

ES6 PHES operations

ES6.1 Operating principles

The PHES facility will be operated based on the electricity market demand. It is anticipated that standard operations will include either full or part cycles on most days. A full cycle will result in 9 ½ hours of pumping and 8 hours of discharging within a day. Pumping will generally occur during the day and generating will generally occur during the morning and evening peaks. The maximum pump rate is 190 metres cubed per second (m^3/s) and the maximum discharge rate is 210 m^3/s. During a full cycle, 5.3 gigalitres (GL) (equivalent to 16% of Lake Lyell total storage volume) will be transferred between Lake Lyell and the upper reservoir.

The following key operating principles will be applied:

- Lake Lyell will generally be maintained within the target PHES operating range (781.0 to 784.5 metres Australian Height Datum (mAHD) and will occasionally be within the maximum PHES operating range (780.0 to 786.0 mAHD). Lake Lyell will be 78% full (in terms of level) at the minimum PHES operating level of 780.0 mAHD.
- The PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD, which is the same as the Lake Lyell full supply level (FSL) or spill level. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows) and any associated downstream flood impacts.

A more detailed descriptions of the PHES operating principles is provided in Chapter 6.

ES6.2 Water take

The operation of the PHES facility will result in water take from Lake Lyell during the initial filling of the upper reservoir and due to ongoing system losses during operations. Table ES2 provides a summary of the predicted water take from these processes.

Table ES2 Summary of water take during operations

Process	Description	Estimated water take
Initial filling	The initial filling of the upper reservoir will occur gradually over multiple pump and discharge cycles during the commissioning phase of the project. The initial filling will be complete the first time the upper reservoir is filled to FSL.	6.3 GL
Net system losses	Once the initial filling is completed ongoing water losses will occur due to evaporation from the upper reservoir and seepage losses from the upper reservoir and tunnels. These losses will be partly or fully offset by direct rainfall and runoff into the upper reservoir (the net system loss).	• Dry year: 97 ML/yr loss • Median year: 47 ML/yr loss • Wet year: 5 ML/yr gain

ES6.3 Water management

The operational footprint of the project will be significantly smaller than the construction footprint. Notwithstanding, the following sources of water will require management during operations:

- stormwater runoff from permanent infrastructure areas
- stormwater runoff from sealed and unsealed permanent roads
- seepage from PSEs
- intercepted groundwater in the powerhouse and tunnels.

The proposed management approach is described in Chapter 6.

ES6.4 Wastewater management

During operations, an on-site wastewater system will be established to manage wastewater produced from site amenities. The system will be designed and operated in accordance with the methods described in *Designing and Installing On-Site Wastewater Systems* (WaterNSW 2023b).

ES7 Residual impacts

ES7.1 Construction phase

Chapter 7 describes predicted water cycle changes during the construction phase of the project. The key changes are:

- **Local watercourse** – some local watercourses will be unavoidably disturbed by construction.
- **Lake Lyell**:
  - Water levels – lake levels will be temporarily lowered during construction. No other changes to the existing lake operating approach or environmental releases are proposed.
  - Water quality – there is potential for increased suspended sediment concentrations and turbidity levels in the Farmers Creek arm of Lake Lyell during wet weather due to sedimentation basin overflows. No other material changes to water quality are expected in the Farmers Creek arm or other parts of the lake.
- **Coxs River downstream of Lake Lyell:**
  - Flow regime – there will be no change to environmental releases from the lake and no increase in flood risk downstream of the lake.
  - Water quality – due to the proposed water management measures and the water quality buffer provided by Lake Lyell, the construction phase of the project is expected to have a neutral effect on water quality in the Coxs River downstream of Lake Lyell. This means that the project would also have a neutral effect on water quality in Lake Burragorang, which is a major water supply dam for the Sydney metropolitan region that receives inflows from the Coxs River and is operated by WaterNSW.

ES7.2 Commissioning and operations phase

Chapter 8 describes predicted water cycle changes during the commissioning and operations phase of the project. The key changes are:

- **Lake Lyell:**
  - Water levels – Lake Lyell will continue to be maintained in a near full condition, the water level regime will change from moving slowly to fluctuating daily due to the PHES operation. The maximum rate of water level change will be 0.4 metres per hour (m/h) and the maximum change in water level over a full cycle will be 2.85 m. There will be no change to lake flood levels.
  - Water quality – PHES induced mixing will reduce stratification and improve water quality in the Farmers Creek arm and upper reaches of the lake which historically have had higher algae levels relative to the lower part of the lake.
  - Water quality – some scour in Farmers Creek arm may occur during the initial operating period. Scour has potential to generate suspended sediment and turbidity in Farmers Creek arm and the adjoining areas of Lake Lyell. The extent and magnitude of any impacts would decline overtime as the scour and depositional processes reach a new equilibrium.
- **Coxs River downstream of Lake Lyell:**
  - Flow regime – there will be no change to environmental releases from the lake and no increase in flood risk downstream of Lake Lyell.
  - Water quality – due to the proposed water management measures and the beneficial effect of the PHES operation on Lake Lyell water quality, the commissioning and operational phase of the project is expected to have a neutral to beneficial effect on water quality in the Coxs River downstream of Lake Lyell. This means that the project would also have a neutral to beneficial effect on water quality in Lake Burragorang, which is a major water supply dam for the Sydney metropolitan region that receives inflows from the Coxs River and is operated by WaterNSW.

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1 Introduction

1.1 Background

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

The project is located approximately 5 kilometres (km) west of Lithgow and 110 km west of the Sydney central business district, shown in Figure 1.1 and Figure 1.2. The project takes advantage of existing infrastructure (i.e. Lake Lyell) associated with Mt Piper power station which will be decommissioned in the coming decades and allows Lake Lyell to continue to serve a specific purpose in electricity generation (consistent with its existing use).

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

1.2 Report purpose and assessment requirements

This surface water assessment (SWA) supports the EIS for the project. It describes the existing surface water environment, the water management approach for construction and operation of the project and residual impacts. The assessment has been prepared to address the SEARs for the project, issued 17 November 2025, and considers relevant government and industry guidelines. This report references the following technical reports that also support the EIS for the project:

- Groundwater assessment (EMM 2025a) – describes the existing groundwater environment and groundwater impacts during construction and operation of the project.
- Excavated rock management strategy (EMM 2025b) – describes the excavated rock management strategy for the project, concepts for proposed permanent spoil emplacements (PSE) and the expected water quality profile of seepage from PSEs.
- Water licencing strategy (EMM 2025c) – addresses surface water and groundwater licensing requirements for the project under the NSW water regulatory framework.

Table 1.1 lists SEARs relevant to water and soil and notes where they are addressed in this report or other parts of the EIS.

Table 1.1 Assessment requirements

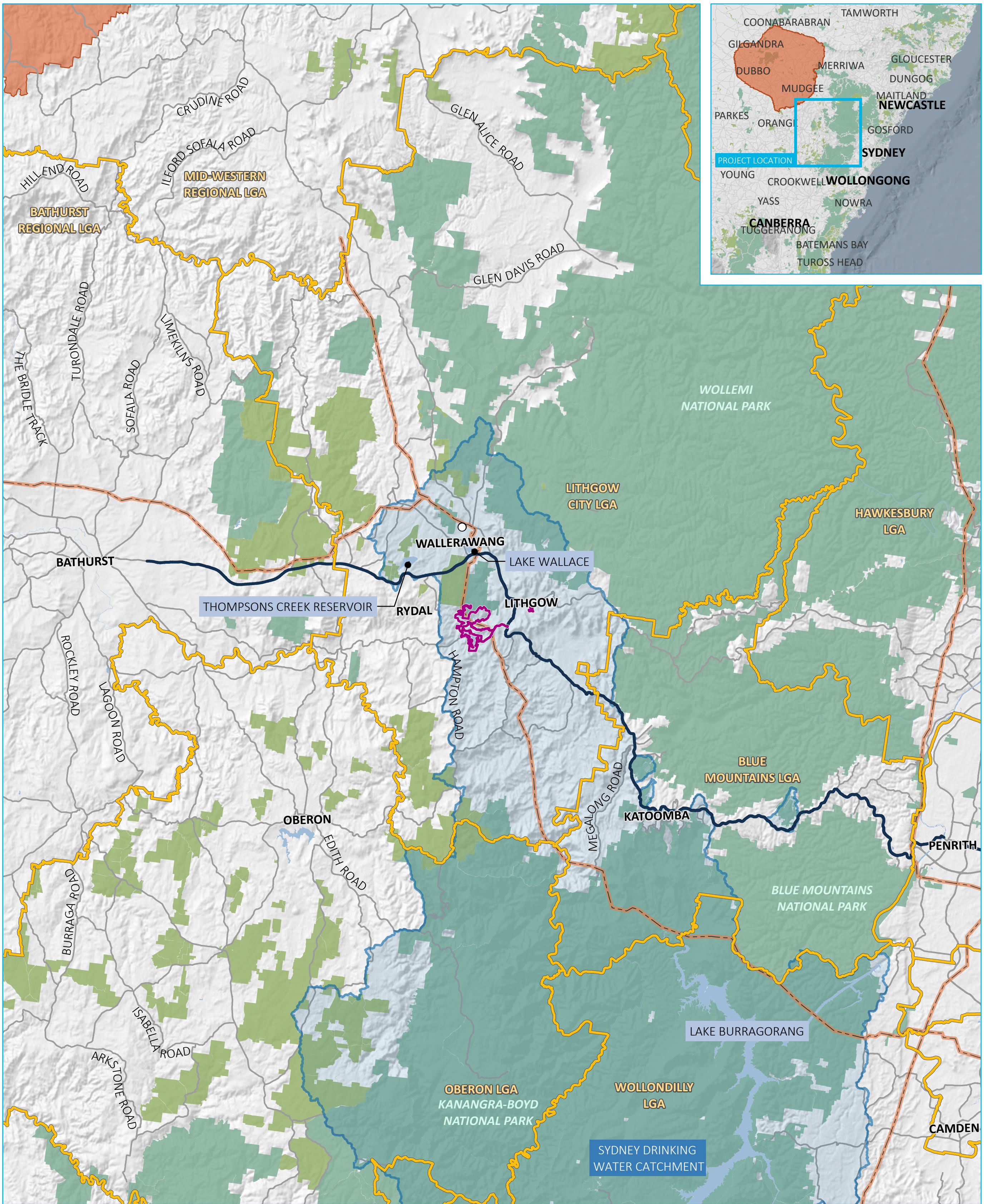
SEARs (Water and Soils)	Report section / EIS reference
A detailed site water balance for the project, including the water take from each surface and ground water source, any licensing requirements, and determine whether an adequate and secure water supply is available for the project.	• Estimates of surface water take are provided in Section 5.8 (construction phase) and Section 6.2 (commissioning and operational phase). • Estimates of groundwater take are provided in the groundwater assessment (EMM 2025a). • Surface water and groundwater licensing requirements for the project are addressed in the water licensing strategy (EMM 2025c).
A detailed description of the proposed water management system, water monitoring program, erosion and sediment control measures, and other measures to mitigate surface water and groundwater impacts.	• Construction phase water management is described in Chapter 5. • Operational phase water management and PHES operating principles are described in Chapter 6.
An assessment of the impacts of the project on: • the water catchment and quantity and quality of local and regional surface water and ground water resources, including Lake Lyell, Coxs River and Farmers Creek • water security for local downstream receivers including other dependent water industries • hydrological flows on site, including any potential flooding impacts • key water features on site, including potential impacts on riparian land • type and extent of any dredging or reclamation activities within 'water land' • water-related infrastructure, basic landholder rights and the entitlements of water users.	• Changes to key receiving surface waters are described in Chapter 7 (construction phase) and Chapter 8 (commissioning and operational phase). • Groundwater impacts are addressed in the groundwater assessment (EMM 2025a). • Surface water and groundwater licensing requirements for the project are addressed in the water licensing strategy (EMM 2025c).
A description of the likely changes to the hydrological regime of the Lake Lyell, Coxs River and Farmers Creek, and any associated biodiversity impacts.	• Changes to key receiving waters are described in Chapter 7 (construction phase) and Chapter 8 (commissioning and operational phase). • Terrestrial and aquatic ecology impacts are addressed in the aquatic ecology assessment and the biodiversity development assessment report which form part of the EIS.
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).	• Proposed controls for works on waterfront land are described in Section 5.10. • Impacts to waterfront land are described in Chapter 9. • Terrestrial and aquatic ecology impacts are addressed in the aquatic ecology assessment and the biodiversity development assessment report which form part of the EIS.
A strategy to manage spoil and enhance any new landforms created.	• This is addressed in the excavated rock management strategy (EMM 2025b).
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with Managing Urban Stormwater: Soils & Construction (Landcom 2004).	• The stormwater management system is described in Section 5.6.

SEARs (Water and Soils)	Report section / EIS reference
An assessment of the impacts of the project must: • identify, assess and describe any potential risks relating to all known and potential contaminants of concern (CoC) including nitrate that may be associated with any proposed blasting • describe mitigation and management options that will be used to prevent identified soil and water impacts associated with blasting. This should include an assessment of the effectiveness and reliability of the measures and any residual impacts after these measures are implemented and any associated impacts of these measures.	• Construction phase water management is described in Chapter 5. • This is further addressed in the excavated rock management strategy (EMM 2025b).

1.3 Report structure

This report is structured as follows:

- Chapter 2 describes the project.
- Chapter 3 describes regulations and government and industry guidelines that have been considered in this assessment.
- Chapter 4 describes the existing environment, as relevant to this assessment.
- Chapter 5 describes the construction water management approach for the project.
- Chapter 6 describes the operational water management approach for the project.
- Chapter 7 describes residual impacts to the surface water environment during the construction phase of the project.
- Chapter 8 describes residual impacts to the surface water environment during the commissioning and operational phase of the project.
- Chapter 9 describes impacts to waterfront land during and after construction.
- Chapter 10 provides a summary of management measures that are proposed in this assessment.



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

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KEY

- Project area
- Local government area
- Sydney Drinking Water Catchment
- Central West Orana Renewable Energy Zone

Existing environment

- Mt Piper Power Station
- Major road
- Great Western Highway
- 330 kV transmission line
- Named waterbody
- NPWS reserve
- State forest

INSET KEY

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

Regional context

Lake Lyell PHES
Surface Water Impact Assessment
Figure 1.1

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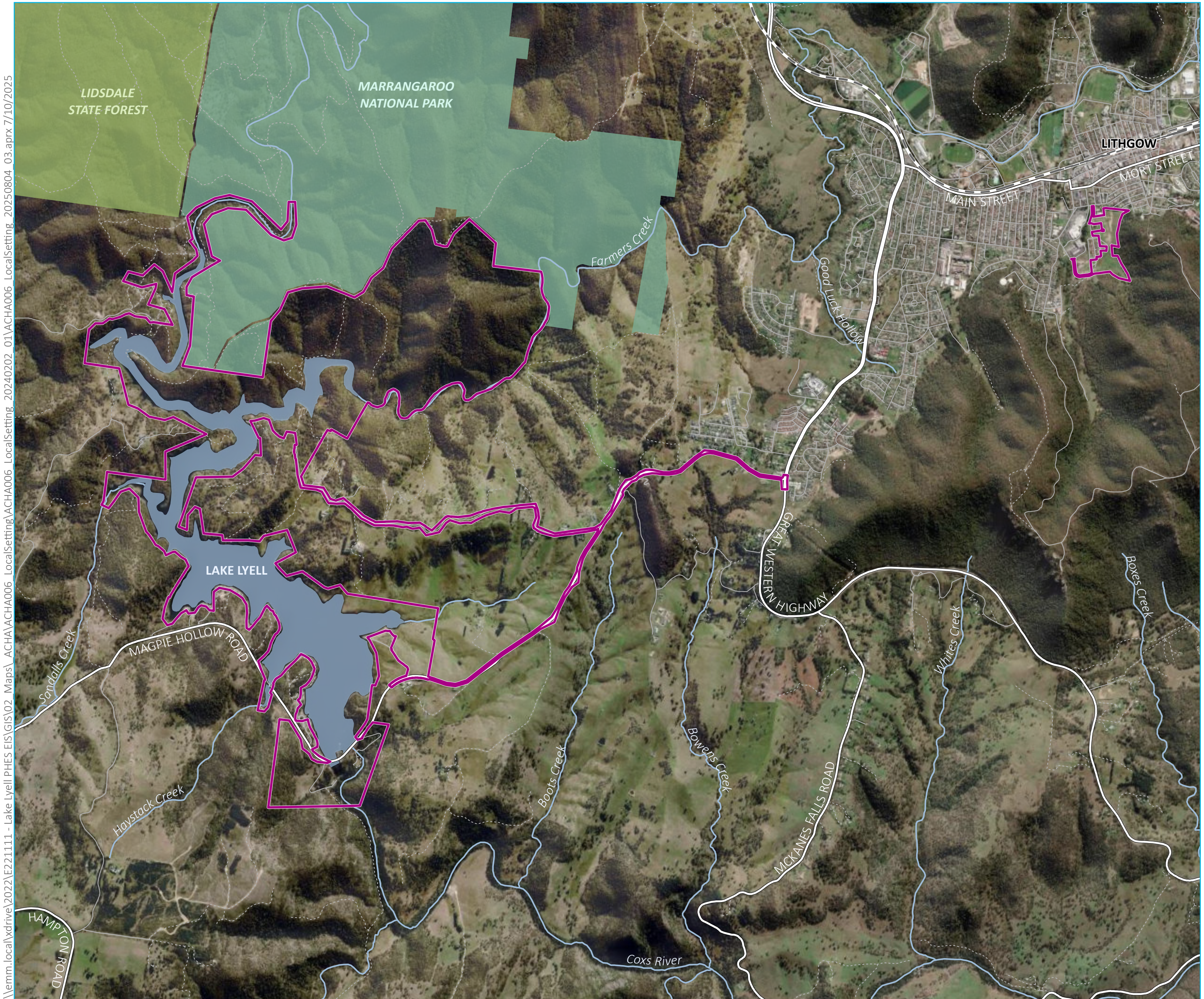

KEY

- Project area

Existing environment

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

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

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Local context

Lake Lyell PHES
Surface Water Impact Assessment
Figure 1.2

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2 Project description

2.1 Key project elements

A detailed description of the project, including an overview of its design, construction and operation is provided in the EIS (specifically Chapter 3 and Appendix B). A summary of the project's key elements is provided below.

The project design, as shown in Figure 2.1, can be broadly categorised into:

- pumped hydro generation components – including a 5.3 gigalitre (GL) upper reservoir to be constructed behind the southern ridge of Mount Walker, a 33.5 GL lower reservoir (existing Lake Lyell), inlet/outlet structures, and an underground powerhouse, surge shaft and waterway tunnels
- transmission connection components – including a new high voltage switchyard and connection to the existing 330 kilovolt (kV) transmission line that runs through the site
- site access and ancillary facilities – including upgrade of existing and construction of new access roads and bridges, a diversion and infill of a section of Lake Lyell, administration and utilities
- other construction components or works – including geotechnical investigations, temporary workforce accommodation, site work pads, laydown areas and facilities, and spoil management.

Construction will be completed in stages, including:

- pre-construction / enabling works – consisting of initial access works (internal and external roads), geotechnical investigations, site establishment and preparation of the worker's accommodation camp
- main works – consisting of all other construction activities needed to enable operation of the project.

During operation, the project will act as an electrical energy storage system. The project will provide services to the wholesale 'spot' market on the NEM, and support ancillary services used to manage the power system reliably.

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

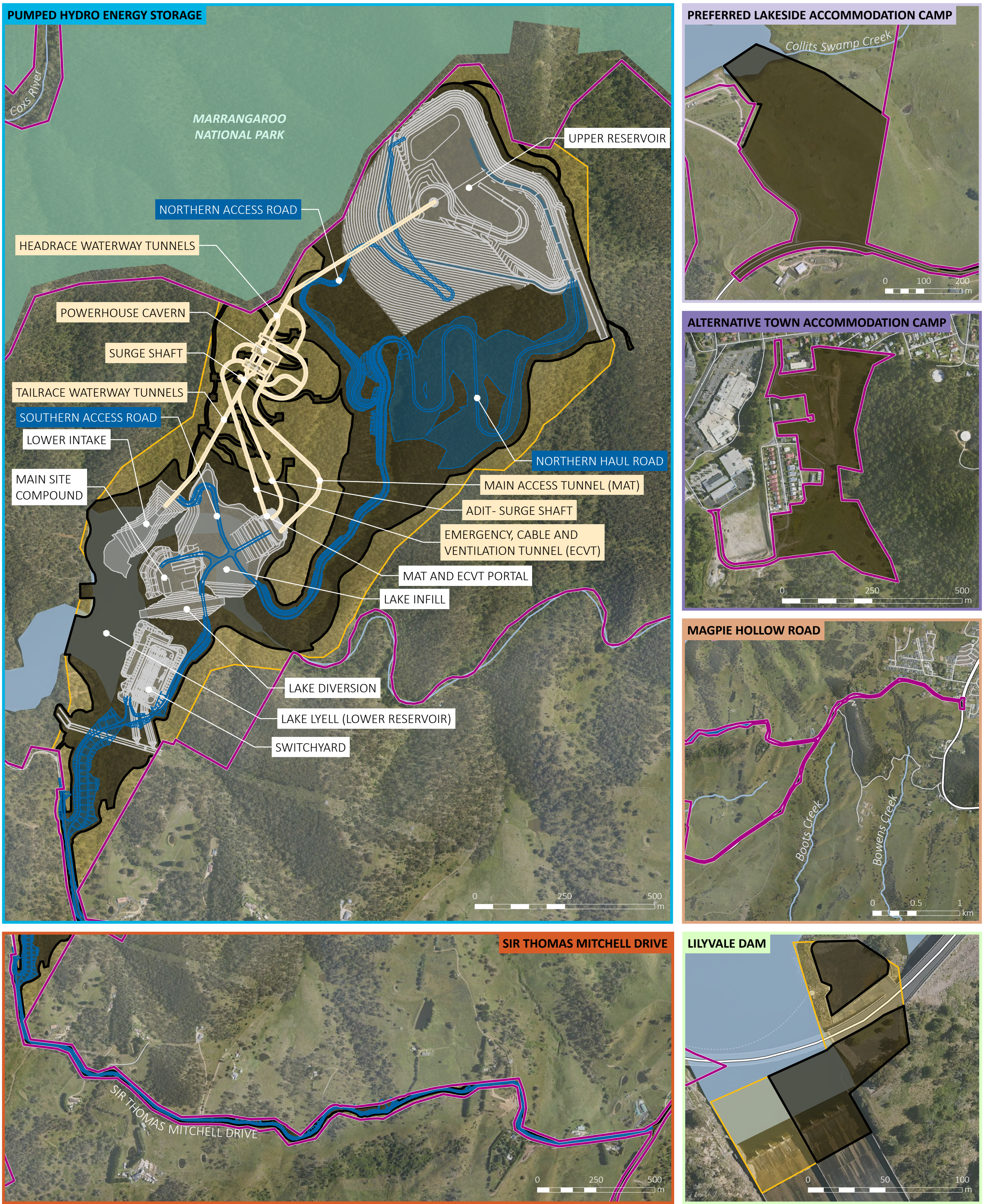
2.2 Project areas

The project is based on a concept design and therefore it is anticipated that ongoing refinements will occur as part of the detailed design. A concept design has been prepared by LLP to demonstrates project feasibility and provide sufficient detail to inform the preparation of the EIS and seek approval. The concept design layout is shown in Figure 2.1 and other figures in this report.

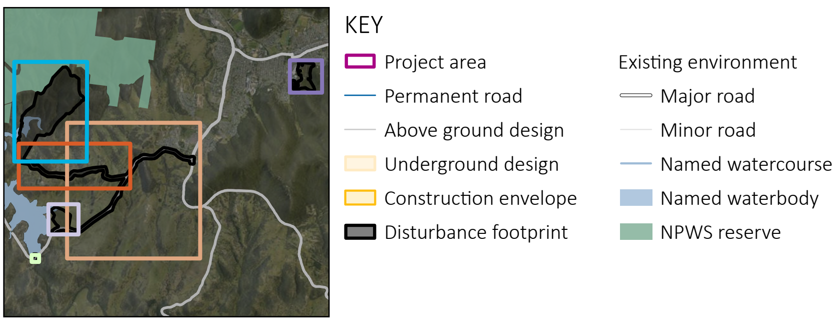
Table 2.1 describes the key terms that are used to describe the project areas in this assessment and the EIS.

Table 2.1 Project areas

Term	Description
Project area	The project area is a broader buffer around the project and represents the area that was investigated during the environmental assessments. The project area is largely confined to land owned by EnergyAustralia except for the primary access route on Lithgow City Council (Council) owned land and the alternative temporary accommodation camp site in Lithgow. The project area includes both the land that will be physically disturbed for the project (directly and indirectly) as well as land where no disturbance or impact will occur.
Construction envelope	The construction envelope represents the maximum extent of where disturbance may occur during the construction of the project. To derive the construction envelope, buffers have been applied around project infrastructure and work areas to provide a level of flexibility where required. Some areas have reduced buffers to indicate reduced flexibility due to environmental or design constraints to be avoided.
Disturbance footprint	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 defined by the construction envelope or vegetation clearing thresholds.



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



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Project overview

Lake Lyell PHES
Surface Water Impact Assessment
Figure 2.1

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3 Regulations and guidelines

This chapter describes regulations and guidelines that have been considered in this assessment.

3.1 NSW regulatory framework

3.1.1 NSW Water Management Act 2000

The primary legislation for managing water resources in NSW is the *Water Management Act 2000* (WM Act), which provides for sustainable and integrated management of the State's water for the benefit of both present and future generations. Relevant to the project, it sets the framework for sharing the State's water resources, statutory rights, licences and approvals that allow for taking and using of water, including surface water and groundwater. It also establishes the mechanisms for acquiring licences and approvals and for trading licences and the water allocations associated with these.

Water licensing requirements under the NSW water regulatory framework for the construction and operation of the project are addressed separately in the water licensing strategy (EMM 2025c). The water licensing strategy references the following information provided in this SWA:

- Descriptions of the construction water management system (refer to Chapter 5) and PHES infrastructure and operating principles (refer to Chapter 6).
- Estimates of surface water take during construction (refer to Section 5.8) and the commissioning and operational phase (refer to Section 6.2).

3.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities. Environment Protection Licences (EPLs) are administered by the NSW Environment Protection Authority (EPA) under the POEO Act. It is anticipated that the construction of the project will be regulated by an EPL.

3.2 Guidelines

The following government and industry guidelines have been considered in this assessment.

3.2.1 Stormwater management guidelines

The following guidelines are referenced when describing the surface water management approach for the construction phase of the project (refer to Chapter 5):

- Erosion and sediment control guidelines:
  - *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004)
  - *Managing Urban Stormwater: Soils and Construction Volume 2A*- Installation of services (DECC 2008)
  - *Managing Urban Stormwater: Soils and Construction Volume 2C* - Unsealed roads (DECC 2008)
  - *Managing Urban Stormwater: Soils and Construction Volume 2E* – Mines and quarries (DECC 2008).
- Bunding and spill management guidelines: Storing and Handling Liquids: Environmental Protection: Participant's Manual (DECC 2007) describes best practice storage, handling and spill management procedures for liquid chemicals.

3.2.2 NorBE guidelines

The project is located within the Sydney Drinking Water Catchment. Part 6.5 of State Environmental Planning Policy (Biodiversity and Conservation) 2021 requires that development in the Sydney Drinking Water Catchment demonstrates a Neutral or Beneficial Effect (NorBE) on water quality.

The following guidelines have been considered when addressing this requirement:

- *Neutral or Beneficial Effect on Water Quality Assessment Guideline* (WaterNSW 2022) – this guideline describes the assessment and approval process developed by WaterNSW for applying the principles of NorBE. Achieving a NorBE on water quality means any water introduced to an offsite water source will be comparable to or will have better quality than the receiving water body, thereby having no identifiable negative impact on the receiving water quality. Section 2.2.1 of the guidelines states that the guideline is for local development where the Council is the consent authority. Notwithstanding, the NorBE principles are addressed in this assessment.

- *Using MUSIC in Sydney Drinking Water Catchment* (WaterNSW 2023a) – this guideline describes MUSIC modelling approaches and assumptions that can be used to assess a project's NorBE on water quality.

- *Designing and Installing On-Site Wastewater Systems* (WaterNSW 2023b) – this guideline describes a best practice approach to designing, installing and operating on-site wastewater systems in Sydney drinking water catchments.

NorBE principles are addressed in Chapter 7 (construction phase) and Chapter 8 (commissioning and operational phase).

3.2.3 Water quality guidelines

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) provide a framework for:

- assessing and managing water quality for environmental values

- establishing water quality objectives

- establishing protection levels, water quality indicators and default guideline values (DGVs) for water quality indicators and toxicants.

ANZG 2018 includes frequent references to *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000). ANZG 2018 and (where relevant) ANZECC/ARMCANZ 2000 have been applied to establish water quality and environmental values for receiving watercourses based on DGVs for slightly-to-moderately disturbed upland river system and lake / reservoir. Information on the adopted DGVs for key water quality parameters is provided in Chapter 4.

3.2.4 Guidelines for works on waterfront land

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 metres (m) of a riverbank, lake shore or estuary mean high water mark. The following guidelines for works on waterfront land provide information on design and construction principles for works on waterfront land:

- *Controlled activities – Guidelines for riparian corridors on waterfront land* (DPE 2022).

- *Controlled activities – Guidelines for instream works on waterfront land* (DPE 2022).

- *Controlled activities – Guidelines for outlet structures on waterfront land* (DPE 2022).
- *Controlled activities – Guidelines for vegetation management plans on waterfront land* (DPE 2022).
- *Controlled activities – Guidelines for watercourse crossings on waterfront land* (DPE 2022).
- *Controlled activities – Guidelines for laying piped and cables in watercourses on waterfront land* (DPE 2022).

These guidelines are collectively referred to as the 'guidelines for works on waterfront land (DPE 2022)' in this report. Proposed controls for works on waterfront land are described in Section 5.10.

4 Existing setting

The project is located within and near Lake Lyell, in the upper Coxs River catchment. The land-based components of the project will be constructed near the upstream portion of the Farmers Creek arm of Lake Lyell. Once operational, the project will utilise Lake Lyell as the downstream reservoir for the PHES. The following water features and infrastructure are relevant to this surface water assessment:

- Coxs River upstream of Lake Lyell.
- Farmers Creek upstream of Lake Lyell.
- Watercourses within the construction envelope.
- Lake Lyell, including the Farmers Creek arm of the reservoir.
- The Coxs River Water Supply Scheme which supplies water from Lake Lyell to Mount Piper Power Station.
- Coxs River downstream of Lake Lyell.

This chapter describes each of the above water features and infrastructure as well as key water cycle processes. It is structured as follows:

- Section 4.1 describes rainfall and evaporation trends.
- Section 4.2 describes the above water features and infrastructure.
- Section 4.3 describes the water level regime in Lake Lyell and uses available stream gauge data to establish a conceptual water balance of seasonal inflows and outflows from the lake.
- Section 4.4 describes the water quality regime in the Coxs River, Farmers Creek and Lake Lyell.
- Section 4.5 uses available data to describe the limnological features and hydrodynamic processes in Lake Lyell.
- Section 4.6 provides a summary of the existing condition in key receiving waters.

This chapter presents and analyses data from multiple sources. The most complete data that is representative of current and near future conditions is from 1 July 2019 to 30 June 2024. This five-year period includes a range of dry, wet and average conditions and is referred to as the 'recent period' in this chapter.

Information from this chapter is used to inform the construction and operational water management approach (refer to Chapters 5 and 6) and description of the project's residual surface water impacts (refer to Chapters 7, 8 and 9).

4.1 Weather and climate

4.1.1 Rainfall and evaporation

The project is in the Central Tablelands region of NSW, which has a sub-humid temperate climate characterised by hot summers, cold winters and no dry season. Rainfall and evaporation characteristics are relevant to this assessment and are described in this section.

i Available data

Rainfall and evaporation data that is representative for the project area is available from the following sources:

- Local weather stations – the following Bureau of Meteorology (BoM) stations located within 15 km of the project and have long-term records: 63146 Cheetham Flats (Jundas), 63226 Lithgow (Cooerwull) and 63132 Lidsdale (Maddox Lane). The local weather stations are shown in Figure 4.3.

- Scientific Information for Land Owners (SILO) Australian climate database – The SILO database is a spatially and temporally complete climate database established by interpolated processing of climate records from BoM weather stations. Point rainfall and evaporation data was extracted from the upper reservoir location.

The following sections describe rainfall and evaporation regimes within the project area and the weather conditions over the recent period (1 July 2019 to 30 June 2024).

ii Rainfall and evaporation

a Annual trends

Table 4.1 provides key annualised rainfall statistics from the three local BoM stations and calculated statistics from SILO data. Annualised pan evaporation statistics calculated from the SILO data are also provided.

Table 4.1 Annual rainfall and evaporation

	Units	Local BoM stations (rainfall)			SILO data[1]	
		Cheetham Flats (Jundas)	Lithgow (Cooerwull)	Lidsdale Maddox Lane	Rainfall	Evaporation
Gauge information						
– ID		63146	63226	63132		
– Proximity to project[2]	km	7 km to SW	4 km to NE	12 km to N	Within the project area	
– Elevation	mAHD	1,060	900	890	918	
– Record period[3]		1959–2023	1878–1970 2007–2023	1959–2023	1889–2024	1889–2024
Statistics						
– Lowest	mm/yr	466	466	330	401	952
– 10th percentile	mm/yr	590	558	513	544	1,099
– Median	mm/yr	882	778	762	820	1,184
– 90th percentile	mm/yr	1,107	1,048	990	1,035	1,299
– Maximum	mm/yr	1,253	1,445	1,260	1,559	1,584

Notes:

1. The SILO data is point data extraction from the upper reservoir location (within the project area)
2. Distance calculated from Mount Walker.
3. The record period is the period used to calculate the statistics provided in this table.

b Monthly trends

Figure 4.1 compares the median, 10th and 90th percentile monthly pan evaporation rates to similar monthly rainfall statistics. The chart shows that:

- there are no significant seasonal trends in rainfall. However, higher rainfall tends to occur from late spring to early autumn (November to March), and mid-autumn to early spring (April to September) is generally drier
- the evaporation rate varies seasonally. Evaporation typically exceeds rainfall from September through to March, is similar to rainfall in May and August and is less than rainfall in June and July.

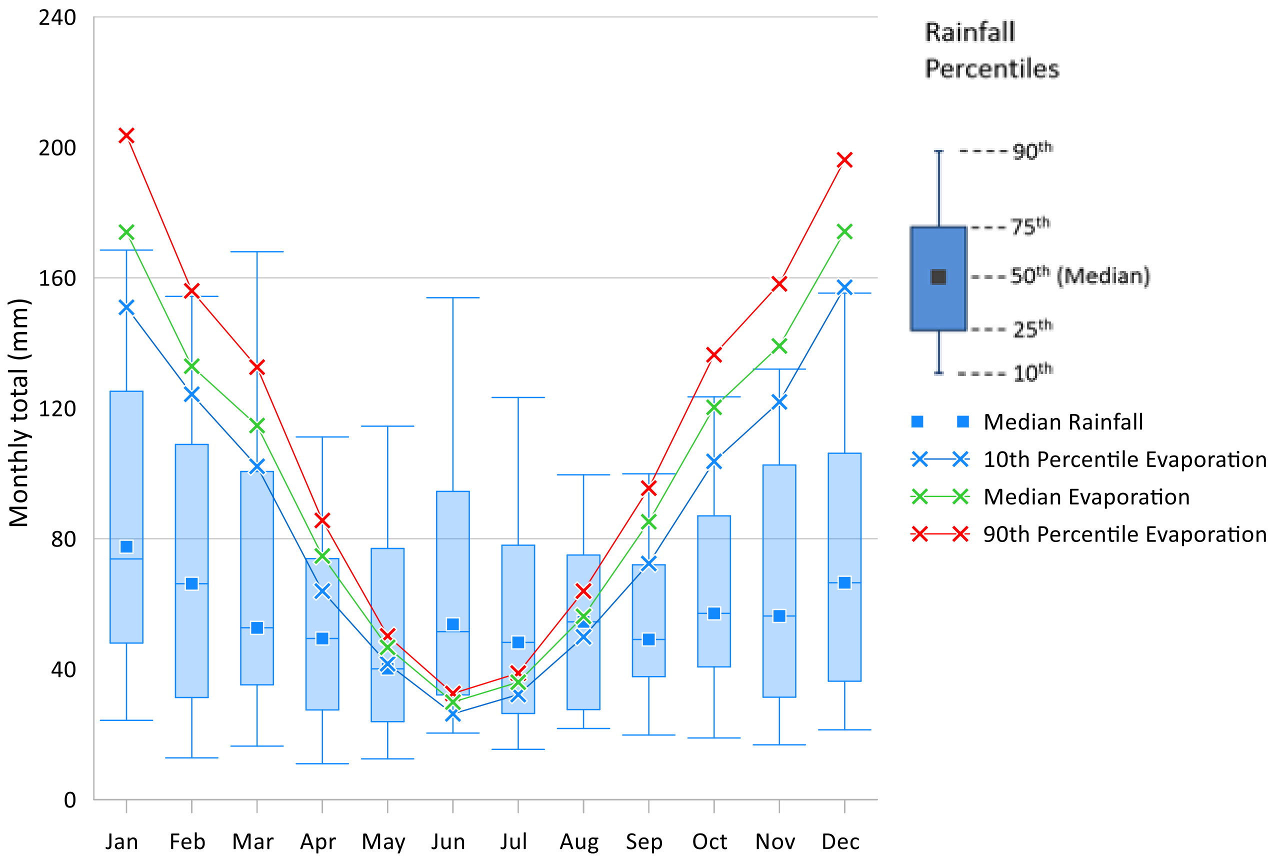


Figure 4.1 Monthly rainfall and evaporation

iii Recent rainfall

Figure 4.2 compares monthly rainfall over the recent period (1 July 2019 to 30 June 2024) to the 10th, 50th and 90th percentile monthly rainfall calculated from SILO data. This chart shows that the beginning of the recent period was characterised by below median rainfall from June 2019 to January 2020. During this time, monthly rainfall totals exceeded the median monthly rainfall in only one of eight months. This period coincided with the last few months of severe drought in NSW.

Three consecutive La Niña events occurred between September 2020 and March 2023 (31 months in total) (BoM 2024), with these events typically causing higher than average rainfall (particularly in winter-spring) in eastern Australia where the project is located (BoM 2016a). During this 31-month period, 24 months experienced higher than median rainfall with eight of these months recording rainfall close to or exceeding the 90th percentile monthly rainfall depths (refer Figure 4.2). Overall, 3,688 millimetres (mm) of rainfall was recorded, which is equivalent to the 97th percentile rainfall over a 31-month period (as calculated from the years 1900–2023 in the historical SILO data).

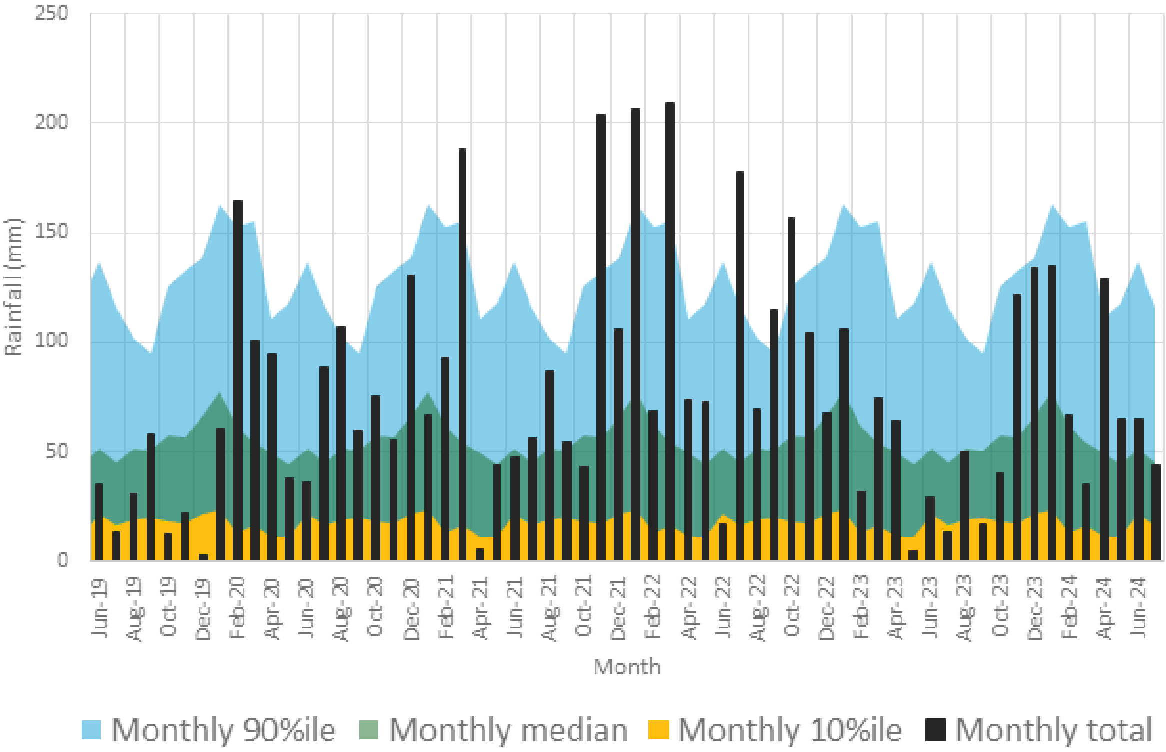


Figure 4.2 Monthly rainfall over the recent period (June 2019 to June 2024)

iv Design rainfall

Design rainfall information is used to calculate aspects of the stormwater management system. The following design rainfall information has been established for the project:

- Table 4.2 provides design rainfall depths for a range of exceedances per year (EY) and annual exceedance probability (AEP) events of varying durations. This information was sourced from the Design Rainfall Data System (BoM 2016b).
- Table 4.3 presents rainfall depths for 2, 5, 10 and 20-day rainfall events. This information was sourced from *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom 2004).

It is noted that when used for detailed design of the project, design rainfall depths are to be adjusted for climate change using the methodology described in Book 1, Chapter 6 Climate Change Consideration (Wasko, et all. 2024) of Australian Rainfall and Runoff 2019.

Table 4.2 Design rainfall depths

	Rainfall depths (mm)										
	4EY	**2EY**	**1EY**	**0.5EY**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.2%**
15 min	6	9	12	14	18	21	24	29	32	35	40
30 min	9	12	16	19	24	28	32	38	43	47	53
45 min	10	14	18	22	27	32	37	44	49	54	61
1 hour	11	15	20	24	29	35	40	48	53	58	66
2 hours	15	19	24	30	36	42	49	57	64	70	79
3 hours	17	22	28	34	41	48	55	65	72	79	88
6 hours	21	28	35	43	52	61	70	82	92	100	112
9 hours	25	33	41	51	61	71	82	97	108	117	131
12 hours	28	36	46	57	69	81	93	110	123	133	149
1 day	35	47	60	74	92	110	128	152	170	185	208
2 days	43	58	76	95	120	146	175	207	232	258	293
3 days	47	65	85	106	136	168	202	239	268	298	338
4 days	50	69	91	114	146	180	218	258	288	320	363
5 days	53	73	95	119	152	186	226	267	300	331	376
6 days	54	76	99	124	155	190	229	271	304	336	382
7 days	56	78	102	127	158	190	230	271	305	337	383

Source: Data sourced from Design Rainfall Data System (BoM 2016b).

Table 4.3 Design rainfall depths for frequent events

Percentile	**Rainfall duration**			
	2 days	**5 days**	**10 days**	**20 days**
80th percentile	14.0 mm	23.6 mm	38.9 mm	74.0 mm
85th percentile	18.3 mm	29.4 mm	47.5 mm	86.6 mm
90th percentile	24.2 mm	37.8 mm	60.7 mm	104.4 mm
95th percentile	35.3 mm	56.4 mm	84.4 mm	134.3 mm

Source: (Landcom, 2004) Table 6.3 – values for Lithgow

4.1.2 Wind

Wind shear is a key process that contributes to mixing in reservoirs such as Lake Lyell (discussed in Section 4.5). Long-term annual wind roses for Lithgow (BoM station 63224) for the period 1 August 1965 to 20 June 2006 were available from the BoM climate data portal and are presented in Annexure E. The annual wind roses for 9:00 am and 3:00 pm observations are similar, indicating the strongest winds are predominately from the west, followed by the north-west and south-east direction.

Recent daily wind data (9:00 am observations) is available from the BoM operated weather station at Lithgow (BoM station 63226) and a wind rose plot is also presented in Annexure E for the period 1 August 2023 to 22 September 2024. This data shows that the strongest winds (greater than 2 metres per second (m/s)) predominantly come from the north-west direction and the next prevalent directions are from the north and south-east direction. The main section of Lake Lyell is aligned on a north-west and south-east axis, hence there is potential for a reservoir longer wind fetch and significant transfer of energy to the lake via wind shear.

4.1.3 Climate change

The NSW Government provides information on projected changes to the climate in the Lithgow region by 2050 and 2090 for low and high emission scenarios (DCCEEW 2024). Table 4.4 provides a summary of the projected changes to temperature and rainfall. This information indicates that over the operational period of the project (which will likely be beyond 2090) there may be a reduction in annual rainfall and evaporation will likely increase due to higher temperatures. The implications of climate change on the operation of the PHES and associated residual impacts are discussed in Chapter 8.

Table 4.4 Projected changes to temperature and rainfall

	Low-emissions scenario (SSP1 - 2.6)	High-emissions scenario (SSP3 – 7.0)
2050 timeframe		
Temperature	• Mean temperatures are projected to rise by between 0.6 and 1.7°C. • The number of hot days (over 35°C) are projected to increase by between 4 to 25 days per year.	• Mean temperatures are projected to rise by between 1.1 and 2.9°C. • The number of hot days (over 35°C) are projected to increase by between 9 to 40 days per year.
Rainfall	• Changes to rainfall are projected in all seasons. Projected changes in annual rainfall range from a 23% decrease to a 18% increase. The mean predicted change is a 9% decrease.	• Changes to rainfall are projected in all seasons. Projected changes in annual rainfall range from a 36% decrease to a 7% increase. The mean predicted change is a 16% decrease.
2090 timeframe		
Temperature	• Mean temperatures are projected to rise by between 0.6 and 2.1°C. • The number of hot days (over 35°C) are projected to increase by between 6 to 32 days per year.	• Mean temperatures are projected to rise by between 2.9 and 5.7°C. • The number of hot days (over 35°C) are projected to increase by between 30 to 77 days per year.
Rainfall	• Changes to rainfall are projected in all seasons. Projected changes in annual rainfall range from a 22% decrease to a 24% increase. The mean predicted change is a 10% decrease.	• Changes to rainfall are projected in all seasons. Projected changes in annual rainfall range from a 41% decrease to a 59% increase. The mean predicted change is a 11% decrease.

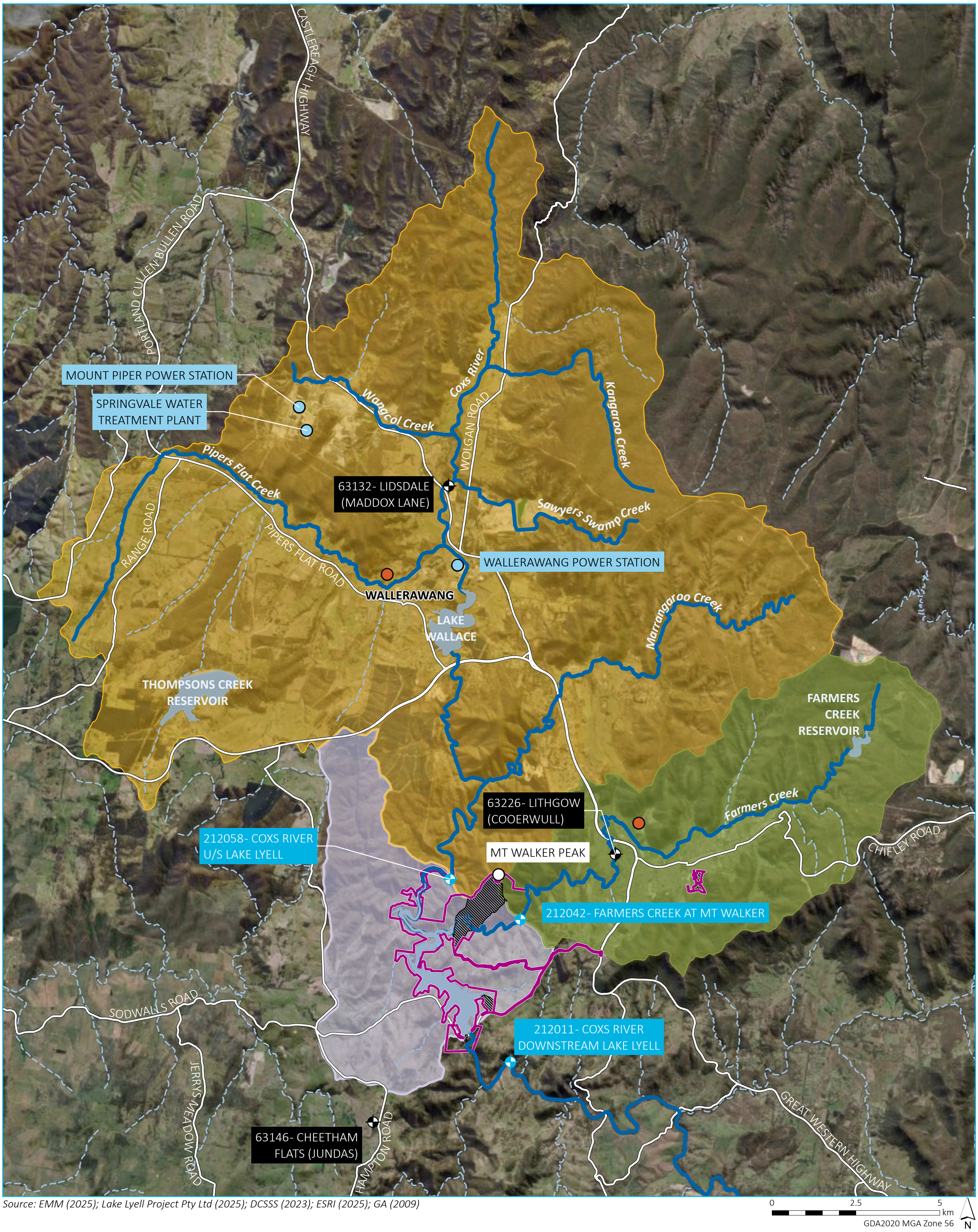
Source: Central West and Orana – Climate Change Snapshot (DCCEEW 2024)

4.2 Natural water features and infrastructure

This section describes the physical characteristics and functionality of the following natural water features and water infrastructure that are relevant to this SWA:

- Coxs River upstream and downstream of Lake Lyell.
- Farmers Creek upstream of Lake Lyell.
- Watercourses within the construction envelope.
- Lilyvale Dam and Lake Lyell.
- The Coxs River Water Supply Scheme.

Figure 4.3 shows the catchment area to Lilyvale Dam which includes the Coxs River upstream of Lake Lyell and Farmers Creek. The figure also locates some of the key features in each catchment that are discussed in this section. Each of the above-mentioned water features and water infrastructure is described in the following sections.



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

KEY

- Project area
- Construction envelope
- BOM weather station
- Stream gauge
- Wastewater treatment plant

Key water feature

- Key feature
- Coxs River water supply scheme infrastructure
- Key river and creek
- Reservoir

Catchment area

- Local catchments and lake waterbody (40 km^2)
- US of 212058- Coxs River upstream of Lake Lyell (275 km^2)
- US of 212042- Farmers Creek at Mount Walker (67 km^2)

Existing environment

- Major road
- Named watercourse

Lake Lyell- catchment area

Lake Lyell PHES
Surface Water Impact Assessment
Figure 4.3

EMM
creating opportunities

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4.2.1 Coxs River

The Coxs River is a major tributary to the Hawkesbury-Nepean system. The river flows generally in a southerly direction through parts of the Central Tablelands and Blue Mountains regions of NSW. It has a total catchment area of 1,450 kilometres squared (km^2) and ultimately flows into the northern arm of Lake Burragorang (also known as Warragamba Dam). Lake Burragorang is a major water supply dam for the Sydney metropolitan region and is managed by WaterNSW.

The project and Lake Lyell are in the upper portion of the river's catchment. The catchment area upstream of Lake Lyell is approximately 275 km^2 (refer to Figure 4.3) and is characterised by a series of valleys that are generally bound by rugged forested escarpments and have cleared valley floors. Key tributaries include Wangcol, Sawyers Swamp, Pipers Flat, Kangaroo and Marrangaroo creeks. Thompsons Creek and Lake Wallace reservoirs are upstream of Lake Lyell (refer to Figure 4.3). These reservoirs are part of the Coxs River Water Supply Scheme, which is described in Section 4.2.5.

The river is unregulated and has a variable streamflow regime. Baseflow is known to occur year-round, even during severe droughts such as the 2018 to 2020 drought (albeit at low rates). Seasonally, streamflow is highest in late winter and spring and lowest in late summer and autumn. The streamflow regime fits the definition of a permanent or perennial stream. Further information on the Coxs River streamflow regime is provided in Section 4.3.

The water quality in the Coxs River upstream of Lake Lyell is potentially impacted by the following anthropogenic influences in the catchment:

- direct and diffuse discharges from several active and decommissioned collieries
- direct and diffuse discharges from coal ash dams located near the former Wallerawang and current Mt Piper power stations
- discharges from the Wallerawang wastewater treatment plant (WWTP) (refer to Figure 4.3)
- stormwater runoff from urban areas including the townships of Wallerawang and Lidsdale
- runoff from agricultural lands within the catchment.

Section 4.4 describes the water quality characteristics of the Coxs River (upstream of Lake Lyell).

It is noted that prior to the recent period (1 July 2019 to 30 June 2024), discharges from Springvale and Angus Place collieries occurred upstream of Lake Wallace. These discharges are known to have altered streamflow and water quality regime in the Coxs River, especially during periods of low flow.

4.2.2 Farmers Creek

Farmers Creek is a major tributary of the Coxs River that flows into the north-eastern portion of Lake Lyell into what is referred to in this report as the Farmers Creek arm of the reservoir. The creek's catchment is approximately 67 km^2 (upstream of gauge 212042) and extends to the north-east of Lake Lyell (refer to Figure 4.3). The catchment is characterised by rugged forested escarpments and cleared valley floors. Farmers Creek flows through the township of Lithgow, which is located centrally in the catchment. Farmers Creek Reservoir is in the upper portion of the catchment, upstream of Lithgow. Farmers Creek Reservoir is one of the sources of potable water for the Lithgow region.

The water quality in Farmers Creek is potentially impacted by the following anthropogenic influences in its catchment:

- Direct and diffuse discharges from several active and decommissioned collieries.
- Legacy contamination from an iron and steel furnace, copper refinery and other heavy industry that historically operated in and around Lithgow (EMM 2025d).
- Discharges from the Lithgow WWTP (refer to Figure 4.3).
- Stormwater runoff from urban areas in Lithgow.
- Runoff from agricultural lands within the catchment.

The interface between Farmers Creek and Lake Lyell varies depending on the lake water level. The Lake Lyell full supply level (FSL) is indicated in Figure 4.5.

4.2.3 Local watercourses

There are twelve watercourses and five drainage lines that have catchments that are either partly or fully within the construction envelope (excluding the access road) and could therefore be potentially disturbed by the project. The term drainage line is used to describe material drainage features that are not shown as hydrolines in the Water Management (General) Regulation Hydro Line spatial database. Drainage lines will typically have similar characteristics to a 1st or 2nd order watercourse.

For the purposes of this report the watercourses are referred to as watercourses 1 to 12, from north to south and the drainage lines are referred to as drainage lines 1 to 5, also from north to south. Figure 4.4 shows the alignment, stream order and catchment area of each watercourse and drainage line. The construction envelope and Lake Lyell FSL (described in Section 4.2.4) are also provided for context. A description of each watercourse and drainage line is provided in Table 4.5. Figure 4.4 also indicates the lower reach of Farmers Creek that will receive runoff from watercourses and drainage lines that have catchments that are either partly or fully within the construction envelope. This reach is referred to as the Farmers Creek (lower reach) in this report. Residual impacts to each watercourse during the construction phase are described in Chapter 9.

As shown in Figure 4.4, the access road is located along a ridgeline and will not materially disturb any watercourses. Therefore, watercourses that have catchments within the construction envelope for the access road are not described.

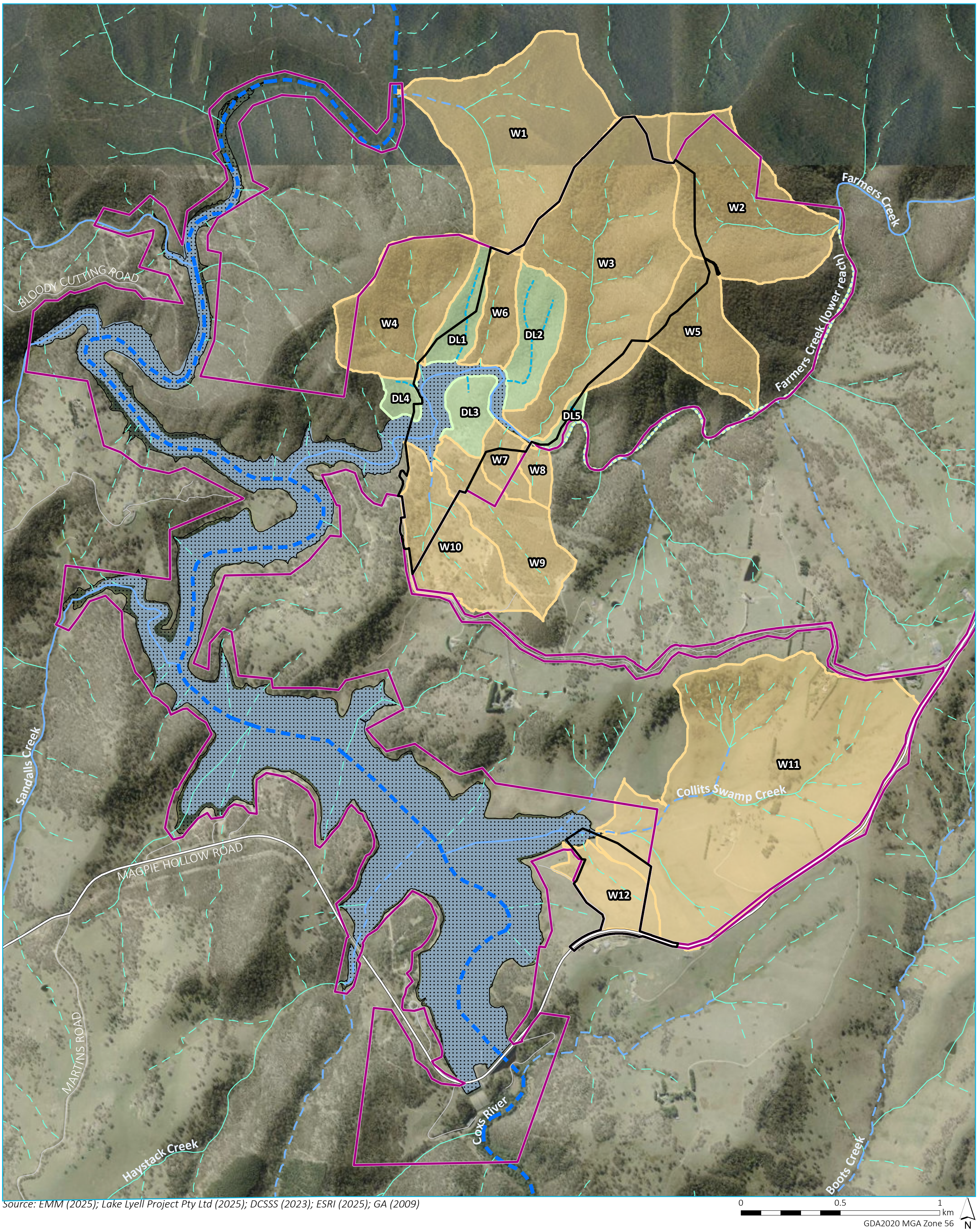
Table 4.5 Description of local watercourses and drainage lines

Name	Catchment area	Catchment characteristics	Stream order	Receiving water
Watercourse 1	62 ha	Steep forested terrain	3rd order	Coxs River, upstream of Lake Lyell
Watercourse 2	46 ha	Steep forested terrain	2nd order	Farmers Creek (lower reach)
Watercourse 3	77 ha	Steep forested terrain	2nd order	Farmers Creek arm of Lake Lyell
Watercourse 4	33 ha	Steep forested terrain	2nd order	Farmers Creek arm of Lake Lyell
Watercourse 5	23 ha	Steep forested terrain	1st order	Farmers Creek (lower reach)
Watercourse 6	10 ha	Partly cleared terrain	1st order	Farmers Creek arm of Lake Lyell
Watercourse 7	6 ha	Partly cleared terrain	1st order	Farmers Creek arm of Lake Lyell
Watercourse 8	4 ha	Partly cleared terrain	1st order	Farmers Creek (lower reach)

Name	Catchment area	Catchment characteristics	Stream order	Receiving water
Watercourse 9	23 ha	Partly cleared terrain	1st order	Farmers Creek arm of Lake Lyell
Watercourse 10	27 ha	Mostly cleared terrain	3rd order	Farmers Creek arm of Lake Lyell
Watercourse 11	136 ha	Mostly cleared terrain	3rd order	Lake Lyell
Watercourse 12	13 ha	Mostly cleared terrain	1st order	Lake Lyell
Drainage Line 1	9 ha	Steep forested terrain	Drainage line[1]	Farmers Creek arm of Lake Lyell
Drainage Line 2	14 ha	Steep forested terrain		Farmers Creek arm of Lake Lyell
Drainage Line 3	8 ha	Steep forested terrain		Farmers Creek arm of Lake Lyell
Drainage Line 4	4 ha	Steep forested terrain		Farmers Creek arm of Lake Lyell
Drainage Line 5	3 ha	Steep forested terrain		Farmers Creek (lower reach)

Notes:

1. ha = hectare
2. The term drainage line is used to describe material drainage features that are not shown as hydrolines in the Water Management (General) Regulation Hydro Line spatial database.



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

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KEY

- Project area
- Construction envelope
- Drainage line
- Lower Farmers Creek
- Full supply level

Potentially impacted catchment

- Drainage line (DL)
- Watercourse (W)

Strahler stream order (adjusted)

- 1st order
- 2nd order
- 3rd order
- 4th order
- 6th order

Existing environment

- Major road
- Minor road
- Named waterbody

Local watercourses

Lake Lyell PHES
Surface Water Impact Assessment
Figure 4.4

EMM
creating opportunities

4.2.4 Lake Lyell

Lake Lyell is an impounded water body located on the Coxs River. The lake was formed following the construction of the Lilyvale Dam in 1981/82. It is part of the Coxs River Water Supply Scheme (described in Section 4.2.5) and its initial purpose was to provide a reliable water supply to the Mt Piper and, the now retired, Wallerawang power stations. Currently, the lake provides water to the Mt Piper power station and is a popular recreational area used for water sports, fishing and camping. Lilyvale Dam and Lake Lyell are owned and operated by EnergyAustralia.

The lake receives inflows from the Coxs River, Farmers Creek and several smaller watercourses. Outflows from the lake occur via:

- the dam's outlet works which include three riparian valves to regulate outflows. Controlled releases are made from these riparian valves to meet environmental flow requirements
- the dam's spillway (when the lake level exceeds FSL)
- the Lilyvale pump station, which has capacity to transfer 95 megalitres per day (ML/d) into the Coxs River Water Supply Scheme.

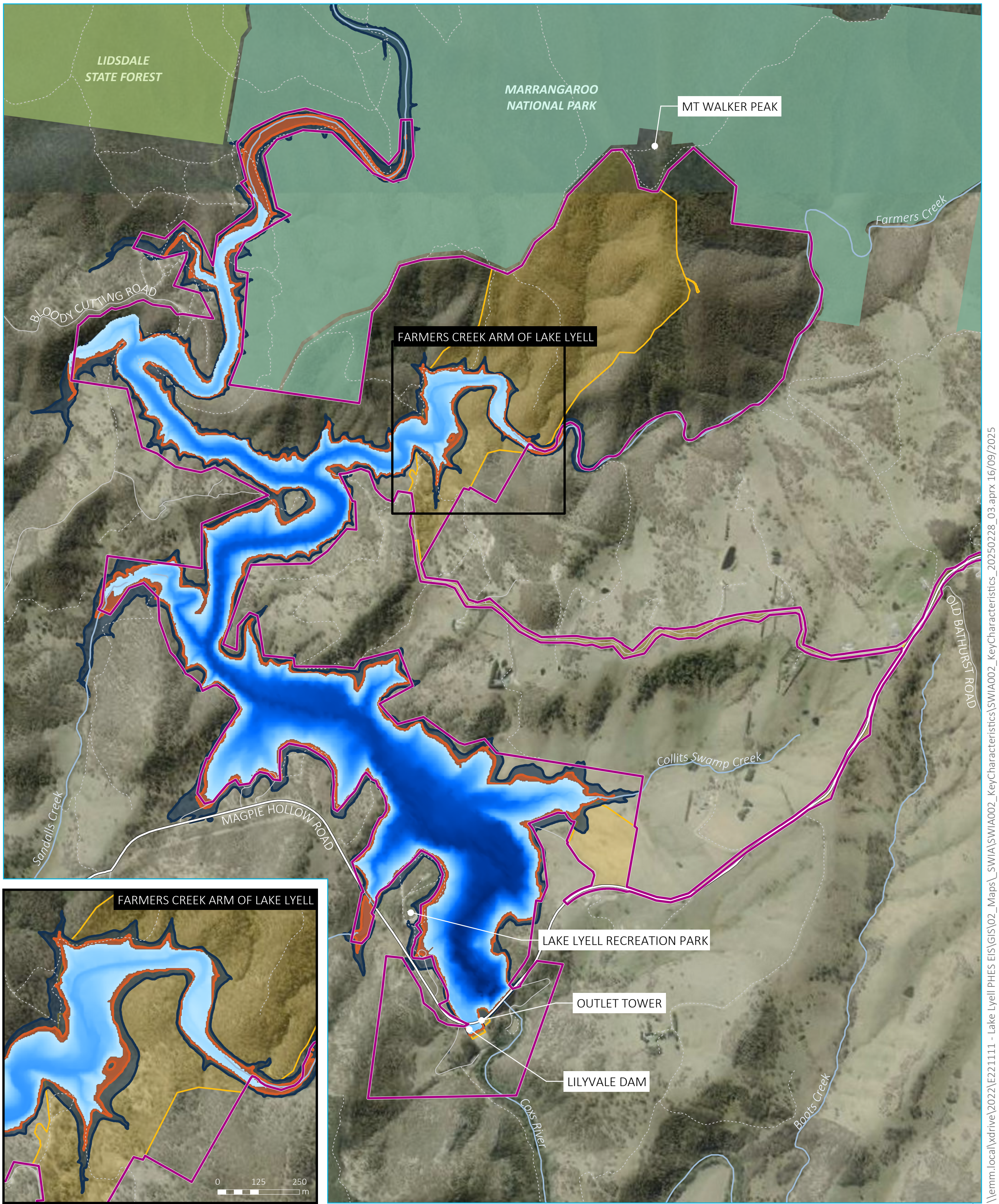
Table 4.6 provides a summary of the key attributes of Lilyvale Dam and Lake Lyell. Figure 4.5 shows the key features of Lilyvale Dam and Lake Lyell and shows the depth of the lake at FSL. The 1% AEP and probable maximum flood (PMF) extents are also shown. Environmental flow requirements and the lake management approach are described after Figure 4.5 in Sections 4.2.4i and 4.2.4ii.

Table 4.6 Lilyvale Dam and Lake Lyell – key attributes

Key attribute	Description
Lilyvale Dam	
Catchment area	The total catchment area to the Lilyvale Dam is 382 km^2, comprising: • Coxs River (upstream of Lake Lyell) – 275 km^2 (≈72% of total area) • Farmers Creek (upstream of Lake Lyell) – 67 km^2 (≈18% of total area) • local watercourses – 38 km^2 (≈10% of total area) • lake area – 2.3 km^2 (0.6% of total area).
Dam description	Lilyvale Dam (also known as Lyell Dam) has the following characteristics (EA, 2023a): • Conventional concrete faced rockfill embankment • Embankment height – 49.5 m • Embankment length – 200 m • Embankment crest width – 11 m • Embankment base width – 140 m • Embankment crest level – 795.5 metres Australian Height Datum (mAHD) • Upstream/downstream slope - 1.3H:1V

Key attribute	Description
Spillway	The spillway has the following characteristics (EA, 2023a): • 80 m long concrete dual ogee crest spillway and concrete channel / flip bucket. • Six fusegate control structures, each 9.75 m wide by 3.2 m high and constructed of reinforced concrete with stainless steel inlet wells. • Fusegate sill level – 782.3 mAHD. • Fusegate crest level – 785.5 mAHD (FSL). • Spillway crest level – 782.6 mAHD. • Spillway capacity – 6,789 metres cubed per second (m^3/s) (PMF) (HARC, 2019). • The fusegates are designed so that the first gate will not tip before a 1:20,000 AEP event and the last gate will tip for a 1:200,000 AEP event. This allows controlled overtopping and an incremental downstream impact. • The fusegates are single use, so once triggered are required to be reconstructed.
Outlet tower and riparian outlets	Discharge from the dam is via the outlet tower (when the dam is not spilling) and comprises the following: • Circular outlet tower with height 39.6 m and width 5.9 m. • Five vertical intake openings (with spacing of 5.5 m) at levels: 756.0, 761.5, 767.0, 772.5 and 778.0 mAHD • A 1,200 mm diameter pressure conduit beneath the dam wall connects the outlet tower to the downstream valve house. From the valve house, water can be diverted to the Lilyvale pump station or water can be discharged into the downstream Coxs River to provide riparian release or for dam emptying. The various outlets and control valves consist of the following: • At the upstream end of the pressure conduit, a 1,200 mm diameter electrically operated butterfly valve (guard valve) controls the overall water supply to downstream (i.e. closure stops all water supply). • Downstream of the butterfly valve there are the following: – Pump station feed pipeline (900 mm diameter). – Maintenance valve (1,000 mm diameter). – Riparian release #3 - fixed dispersion cone valve (control valve) for high volume releases (750 mm diameter). – Riparian release #2 - primary pipeline with flowmeter (300 mm diameter). – Riparian release #1 - secondary pipeline(s) (100 mm diameter) which is no longer used for riparian release purposes. • Riparian release #1, #2 and #3 are collectively referred to as the riparian outlet in the remainder of this document. The maximum capacity of the riparian outlet is 1,036 ML/d (equivalent to ≈12 m^3/s).
Lilyvale Pump Station	
Capacity	Up to 95 ML/d.
Operating range	Any water level above the MOL (761.3 mAHD).
Lake Lyell	
Surface area	2.34 km^2 (at FSL) (EA, 2023a).
Volume	Total capacity (at FSL) – 33.5 GL. Active capacity (between MOL and FSL) – 32.1 GL.
Maximum depth	Approximately 37.5 m (at FSL).
Minimum operating level (MOL)	761.3 mAHD.
Full Supply Level (FSL)	785.5 mAHD.

Key attribute	Description
1% AEP (1 in 100 year) flood level	788.4 mAHD (HARC 2019).
0.05% AEP (1 in 2,000 year) flood level	789.8 mAHD (HARC 2019).
PMF level	795.8 mAHD (HARC 2019).



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

KEY

Project area

Construction envelope

Flood level

1% AEP

Probable maximum flood (PMF)

Depth (m) from full supply level (785.5 m AHD)

0

37.6

Existing environment

Major road

Minor road

Vehicular track

Named watercourses

Named waterbody

NPWS reserve

State forest

Lake Lyell - key characteristics

Lake Lyell PHES
Surface Water Impact Assessment
Figure 4.5

EMM creating opportunities

i Environmental release requirements

Releases from Lake Lyell are made to maintain riparian health as part of environmental flow requirements specified by section 57H of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023* and the water supply work and water use approval 10CA117220 held by EnergyAustralia. The environmental flow release requirements for Lake Lyell are summarised as:

- when the total active storage of Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is 50,000 ML or more:
  - translucent flows – when the daily inflow into Lake Lyell is greater than 13.6 ML/d, the volume of water released is 13.6 ML/d plus 25% of the daily inflow volume above 13.6 ML/d
  - transparent flows – when the daily inflow into Lake Lyell is less than or equal to 13.6 ML/d, the volume of water released is equal to the daily inflow
- when the total active storage of Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is less than 50,000 ML (drought conditions):
  - the volume of water released is equivalent to the daily inflow up to a maximum of 9 ML/d
  - if the total active storage has been less than 50,000 ML continuously for at least six months, the volume of water released is equivalent to the daily inflow up to a maximum of 5 ML/d
- annual channel maintenance flow – within any continuous 12-month period, there must be at least one flow event of 800 ML/d or greater (for a minimum period of one hour) at the Coxs River at Lithgow gauge (212011) when not under drought conditions (i.e. total active storage of Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is greater than 50,000 ML). If this level of flow does not occur, an annual channel maintenance flow release must be made equal to the lesser of 800 ML/d or the maximum rate obtainable from the Lake Lyell outlet valves when fully open for a minimum continuous period of two hours.

ii Lake management approach

a Destratification system

A submerged diffuser system for aeration and artificial destratification of Lake Lyell is located on the reservoir bed near the dam wall. Air is supplied to the destratification pipeline from a compressor located in the Lilyvale pump station and isolation and pressure adjusting valves are located along the pipeline. The destratification system is operated under the following conditions:

- Annually between 1 October and 30 April.
- At any time when there is a blue-green algae alert more severe than green alert (algae alerts are discussed in Section 4.4.3).
- From September, whenever monthly measurements of dissolved oxygen at the surface and bottom of the lake indicate a difference greater than 5 mg/L, the destratification system is operated until April of the following year.

b Dam water level monitoring

The differential water level between the inside and outside of the outlet tower is measured by a submersible pressure transducer inside the outlet tower and a radar located at floor level of the tower. The two primary purposes of the water level monitoring system are obtaining a continuous record of the dam water level which is read at Mt Piper power station and protecting the pumps in the Lilyvale pumping station from low / no flow conditions. In the event the differential water level is more than 3 m, an alarm is triggered and automatically closes the 750 mm fixed dispersion cone valve to prevent further water loss from the tower and the pumps are shut down.

c Selective withdrawal

Discharge from the dam is via the outlet tower which is fitted with five vertical intake openings that are spaced 5.5 m apart (see Table 4.6 for levels). Solid bulkhead gates prevent water from entering the tower stem through the openings. An operational aim is to obtain vortex free, laminar flow into the tower stem and water that is generally fresh, oxygenated, of good colour and odour and free of debris. Selective withdrawal typically draws water from between 2 to 6 m below the water surface (depending on the bulkhead levels relative to surface water level).

4.2.5 Coxs River water supply scheme

Water required for the operation of Mt Piper power station is currently supplied from the Springvale water treatment plant (WTP), the Coxs River Water Supply Scheme and the Fish River Water Supply Scheme.

The Coxs River Water Supply Scheme was developed to ensure an adequate supply of water for the operation of the former Wallerawang and current Mt Piper power stations. The scheme comprises Lake Lyell, Lake Wallace on the Coxs River and Thompsons Creek Reservoir on Thompsons Creek, a tributary of the Coxs River, as well as several interconnecting pipelines and pumping stations. The framework of the scheme is shown in Figure 4.7.

Pumped transfers from Lake Lyell occur via the Lilyvale pump station, which has capacity to transfer 95 ML/d to a surge tank. From the surge tank, water is directed to Mt Piper power station or transferred to Thompsons Creek Reservoir, which acts as a buffer storage and is generally maintained at a level greater than 98% of capacity. Excess water can also be released from the surge tank to Lake Wallace.

The Springvale WTP commenced operation in 2019 and treats water from underground mine dewatering facilities at the nearby Springvale Colliery and Angus Place Colliery, enabling beneficial mine water reuse at Mt Piper power station.

The Fish River Water Supply Scheme is owned and operated by WaterNSW, supplying water to Oberon and Lithgow councils as well as Mt Piper power station. The scheme sources water from Oberon Reservoir and Duckmaloi Weir, located approximately 30 km south-west of Lake Lyell. EnergyAustralia has an 8,184 ML/yr contract allocation from the Fish River Water Supply Scheme. It is noted that the allocation may be restricted when the storage level in Oberon Reservoir drops below 50%, but also that unused allocation up to a maximum of 20% of contract volume that may be carried over from one water year to the next.

Table 4.7 and Figure 4.6 provides the annual water use at Mt Piper power station and a break-down of the water supply by source for the 2018/2019 to 2023/2024 water accounting years (which are the same as the financial accounting year). This information shows that water supply from the Springvale WTP has enabled reduced supply from the Coxs River and Fish River schemes.

Table 4.7 Mt Piper power station water usage and supply

Water year	Mt Piper power station water usage (ML/yr)	Water supply (ML/yr)		
		Springvale WTP	Coxs River Water Supply Scheme	Fish River Water Supply Scheme
2018/2019	9,705	0	6,047	3,658
2019/2020	7,259	3,434	2,631	1,194
2020/2021	11,470	6,557	3,782	1,130
2021/2022	6,686	4,955	1,188	543
2022/2023	6,654	5,169	1,172	313
2023/2024	10,886	6,842	3,114	930

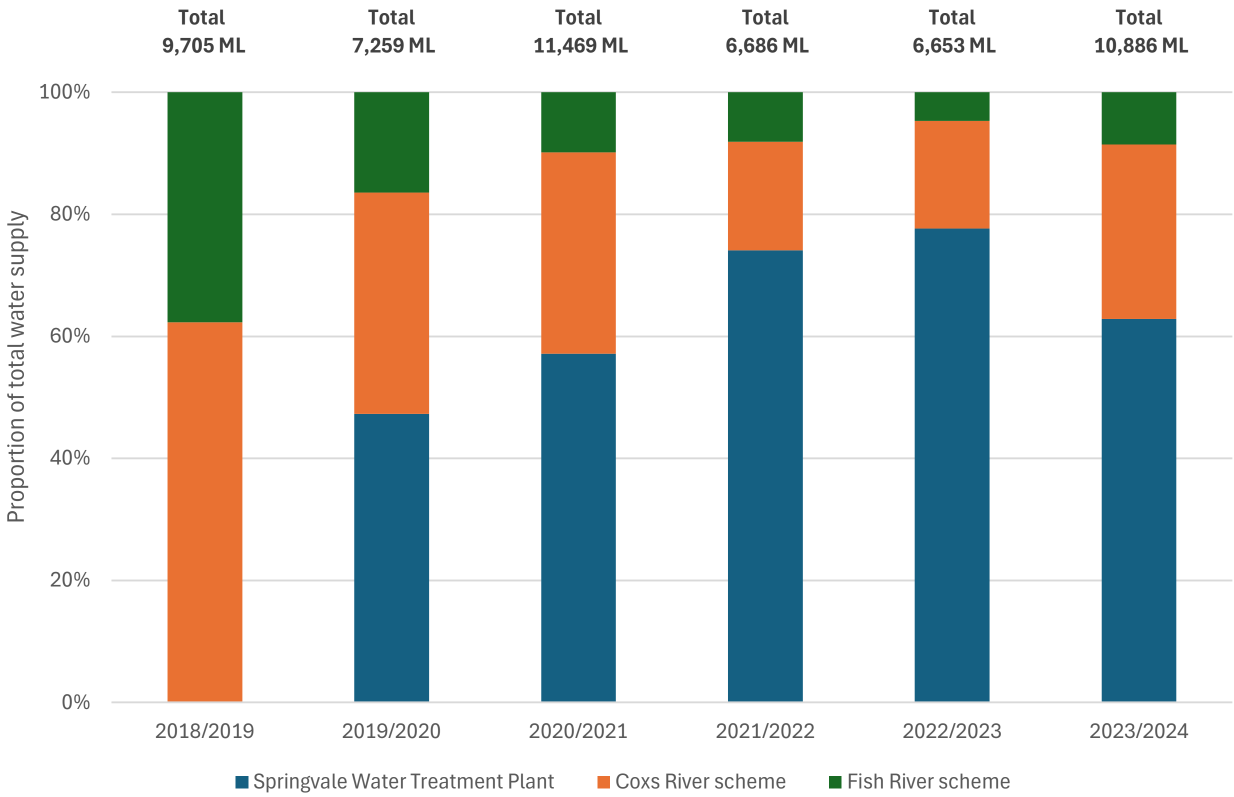
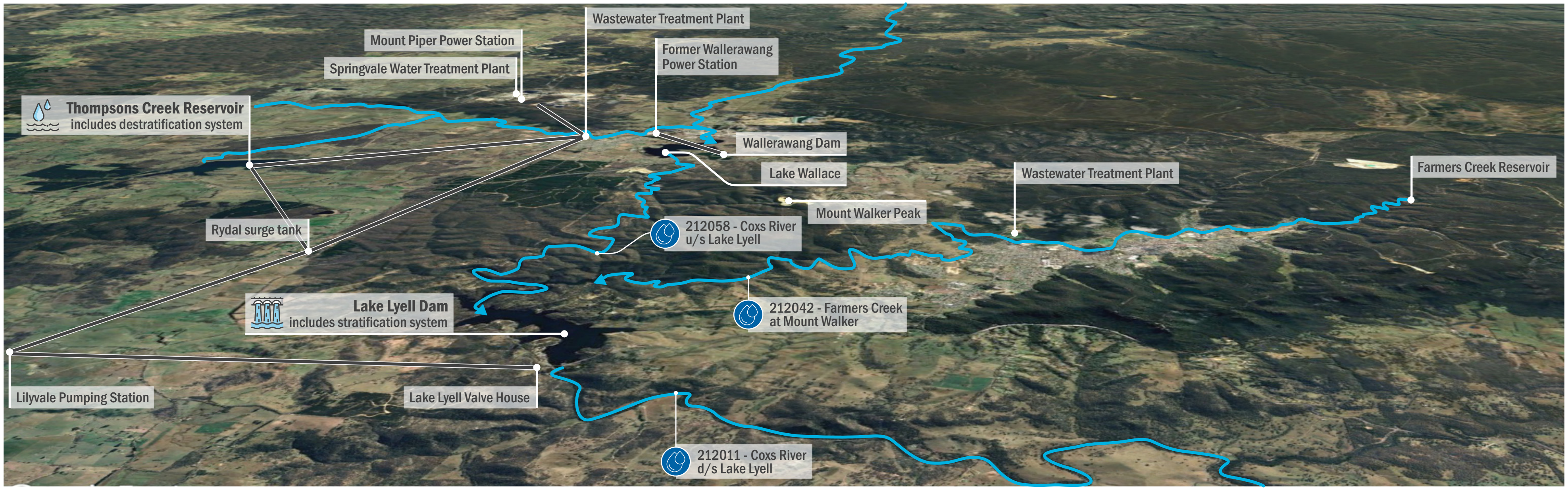
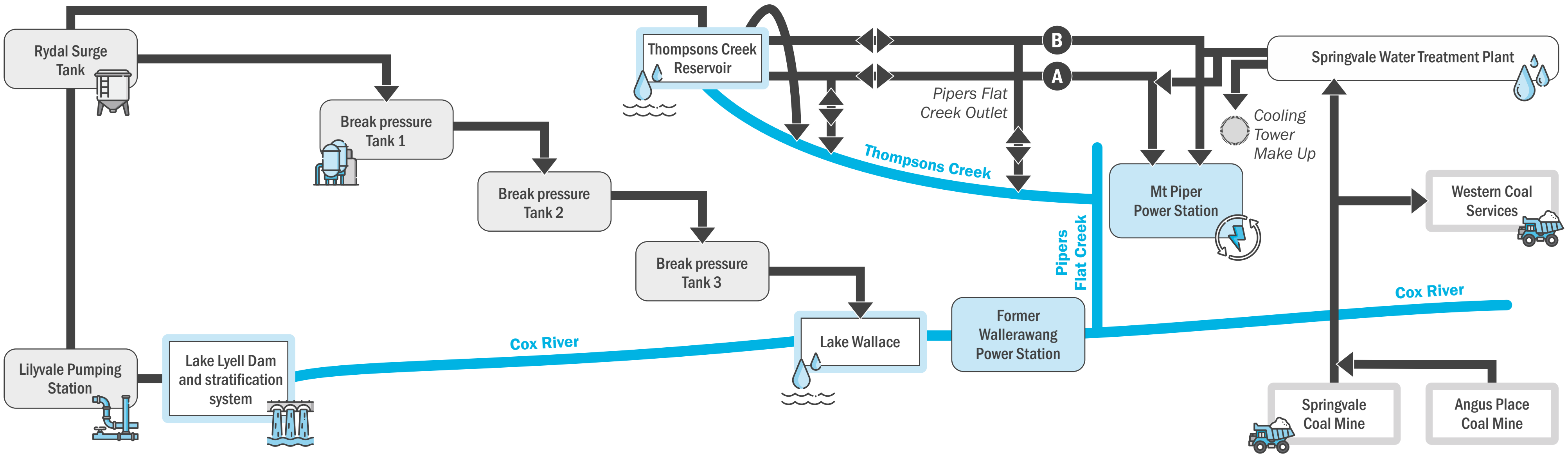


Figure 4.6 Mt Piper power station water usage and supply





Information presented is for general and illustrative purposes only, features are indicative only and are not to scale

Figure 4.7 **Coxs River Water Supply Scheme**

4.3 Streamflow and lake levels

4.3.1 Available data

Streamflow gauge data from the following WaterNSW operated gauges is used in this assessment to describe inflows and outflows from Lake Lyell:

- 212042 - Farmers Creek at Mount Walker.
- 212058 - Coxs River upstream of Lake Lyell.
- 212011 - Coxs River downstream of Lake Lyell.

Gauge locations are shown in Figure 4.10.

Lake Lyell daily water level (as measured at the outlet tower) and storage capacity data has also been provided by EnergyAustralia.

4.3.2 Streamflow regimes

Data from the three stream gauges is presented as follows:

- Figure 4.8 compares the seasonal stream flow volume at each gauge over the recent period (1 July 2019 to 30 June 2024).
- Table 4.8 provides the annual flows for each water year (same as the financial year) at each gauge during the recent period (1 July 2019 to 30 June 2024). The annual streamflow volumes are used to inform a conceptual water balance for Lake Lyell that is described in Section 4.3.4.
- Table 4.9 provides annual runoff volumes and volumetric runoff coefficients for the Coxs River and Farmers Creek catchments, upstream of Lake Lyell. This information was calculated using stream gauge data from 2003 to 2024 and is provided for 10th, 50th and 90th percentile streamflow conditions, which are representative of typical dry, median and wet years. These values are used to inform water balance calculations for the project.

It is noted that streamflow data from the recent period is not compared to earlier data as:

- prior to June 2019, discharges from mine operations upstream of Lake Lyell are known to have artificially increased baseflows in the Coxs River, upstream of Lake Lyell
- prior to June 2019 water take from Lake Lyell by the Coxs River Water Supply Scheme was higher than during the recent period due to a range of factors including: the closure of Wallerawang power station in 2014, water supply from the Springvale WTP (commenced in 2019) and a trend of declining power generation at Mt Piper power station.

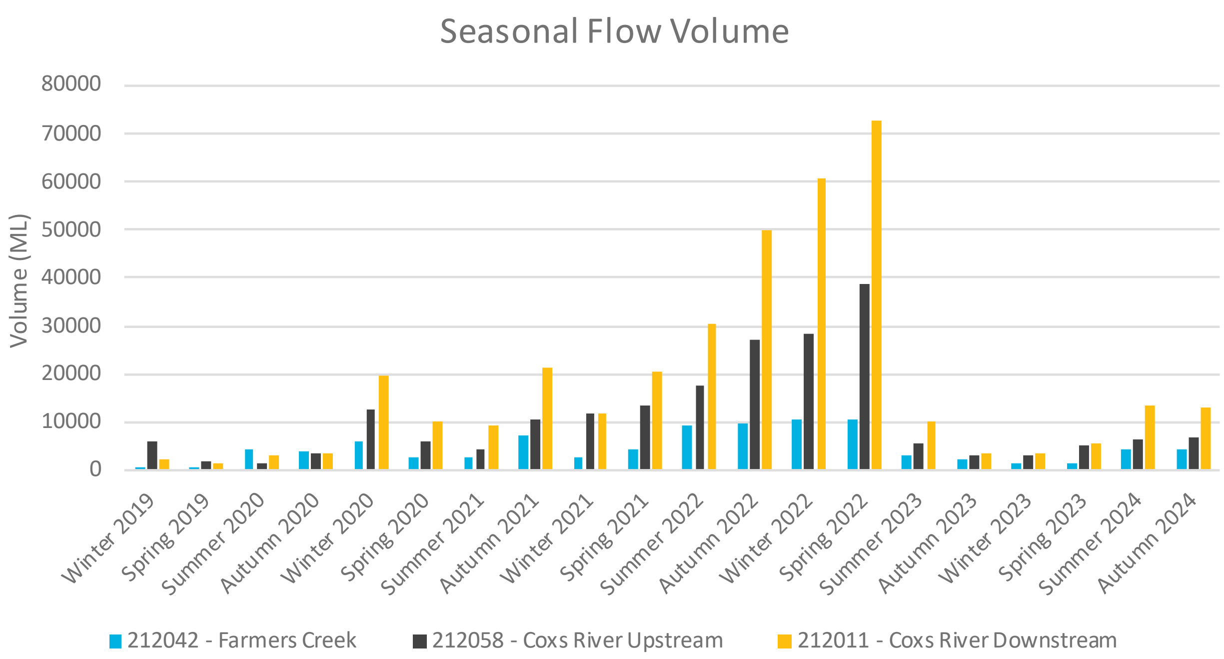


Figure 4.8 Seasonal stream flows over the recent period

Table 4.8 Annual stream flow volumes (GL) over the recent period (1 July 2019 to 30 June 2024)

Water year	Rainfall over period	Coxs River upstream of Lake Lyell (212058)	Farmers Creek at Mount Walker (212042)	Coxs River downstream of Lake Lyell (212011)
2019/2020	Below median	11.4	9.9	11.6
2020/2021	Above median	35.3	18.6	60.2
2021/2022	Above 90th percentile	71.1	26.5	116.9
2022/2023	Near 90th percentile	72.9	26.1	141.8
2023/2024	Above median	23.2	12.8	39.3
Total over recent period		213.8	93.9	369.7

Table 4.9 Runoff volumes and coefficients

	Units	Coxs River upstream of Lake Lyell (212058)			Farmers Creek at Mount Walker (212042)			Comments
		10th percentile	Median	90th Percentile	10th percentile	Median	90th Percentile	
Mean daily streamflow	ML/d	20.2	47.1	120.6	14.7	29.1	53.3	Calculated from stream gauge data from the 2003 to 2024 period.
Annual streamflow	ML/yr	7,389	17,186	44,026	5,380	10,626	19,472	Annual volume calculated from mean daily volume.
Catchment area	ha	27,500	27,500	27,500	6,700	6,700	6,700	Catchment areas and gauge locations are shown in Figure 4.3.
Streamflow to catchment ratio	ML/ha/yr	0.27	0.62	1.60	0.80	1.59	2.91	Calculated as *annual streamflow / catchment area.*
Streamflow expressed as equivalent runoff depth	mm/yr	27	62	160	80	159	291	Streamflow volume expressed as an equivalent runoff depth.
Rainfall	mm/yr	544	820	1,035	544	820	1,035	Values from Table 4.1.
Calculated volumetric runoff coefficient	Cv	0.05	0.08	0.15	0.15	0.19	0.28	Calculated as *streamflow / rainfall.* For comparison a mean Cv of 0.09[1] is used in WaterNSW's maximum harvestable right dam capacity calculator.

Notes:

1. A maximum harvestable right dam capacity (MHRDC) of 0.09 megalitres per hectare (ML/ha) was extracted near Mount Walker (-33.493005, 150.082841). The MHRDC is representative of 10% of the mean annual runoff volume. Therefore, a CV of 0.09 can be calculated from a MHRDC of 0.09 ML/ha by adjusting for area and scaling by a factor of 10 to apply to the total runoff volume.

4.3.3 Lake Lyell water levels

Figure 4.9 shows the water level in Lake Lyell between 1 July 2004 and 30 June 2024. For context the figure notes the closure of Wallerawang power station, the recent period (1 July 2019 to 30 June 2024) and the MOL and FSL of Lake Lyell. Streamflow in the Coxs River (at 212058) is also provided for context.

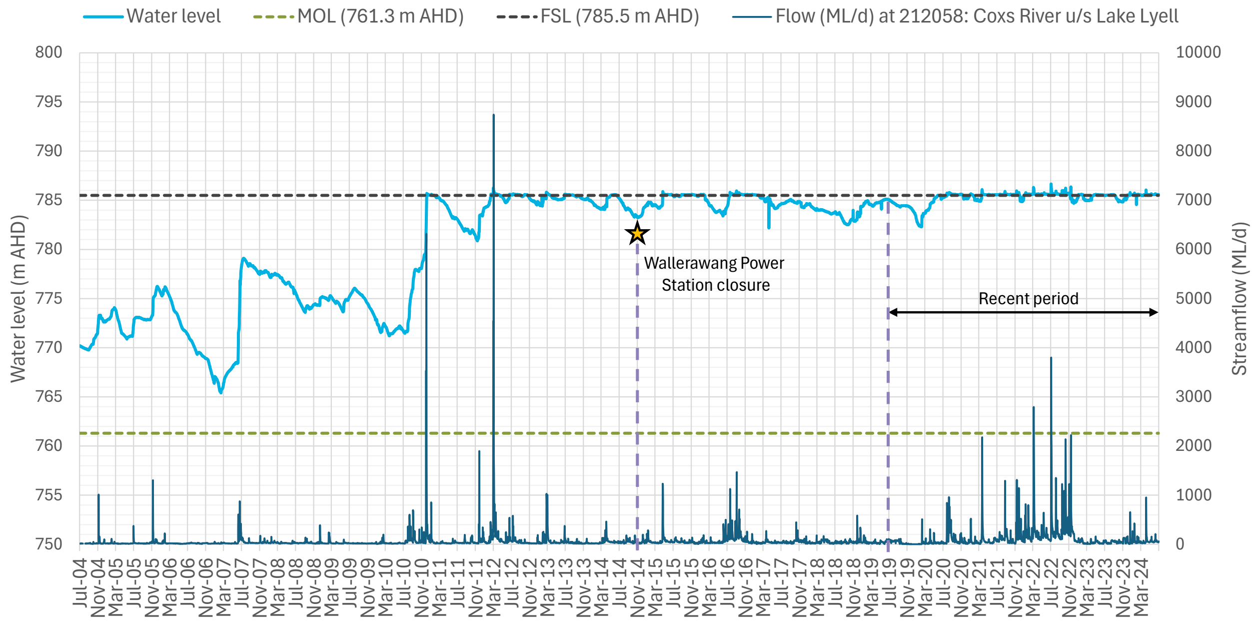


Figure 4.9 Lake Lyell water levels

The water level data shows that:

- for the period July 2004 to December 2010, Lake Lyell water levels were between 6 to 20 m below FSL, but always above MOL
- from December 2010 to the end of the recent period, water levels in the lake were maintained close to FSL. It is noted that a severe drought occurred in 2018 and 2019.

As described in Section 4.3.2, prior to the recent period Lake Lyell levels were influenced by the following anthropogenic activities:

- Discharges from mine operations are known to have artificially increased baseflows in the Coxs River, upstream of Lake Lyell.
- Water take from Lake Lyell by the Coxs River Water Supply Scheme was higher than during the recent period due to a range of factors including: the closure of Wallerawang power station in 2014, water supply from the Springvale WTP (commenced in 2019) and a trend of declining power generation at Mt Piper power station.

Due to the above activities the Lake Lyell water level regime prior to the recent period is not considered to be representative of future conditions.

4.3.4 Conceptual water balance

i Description

A conceptual water balance for Lake Lyell has been prepared to describe and contextualise the key lake inflows and outflows over the recent period (1 July 2019 to 30 June 2024). It includes:

- Inflows:
  - gauged inflows from the Coxs River and Farmers Creek (≈90% of the total catchment area to Lake Lyell)
  - calculated inflows from the ungauged portion of the Lake Lyell catchment (≈10% of the total catchment area to Lake Lyell)
  - calculated inflows from direct rainfall to Lake Lyell (0.6% of the total catchment area to Lake Lyell).
- Outflows:
  - gauged streamflow in the Coxs River downstream of Lake Lyell, which provides estimates of releases from the dam due to both riparian releases and spillway overflows
  - water extraction to supply Mt Piper power station
  - calculated evaporation losses from the lake.

Table 4.10 provides the annual volumes for each inflow and outflow. Refer to the table notes for calculation methodologies.

ii Discussion

The following conclusions can be made from the conceptual water balance calculations for the recent period:

- Lake inflows:
  - the Coxs River contributed approximately 58% of total inflows into Lake Lyell
  - Farmers Creek contributed approximately 25% of total inflows into Lake Lyell
  - runoff from ungauged catchments is estimated to have contributed approximately 14% of total inflows into Lake Lyell
  - direct rainfall to the lake is estimated to have contributed approximately 3% of total inflows and is therefore a minor process.
- Lake outflows:
  - the gauged streamflow downstream of Lake Lyell (370 GL) was similar to the estimated total lake inflows (372 GL)
  - evaporation losses from the lake are estimated to be approximately 2% of total lake outflows and is therefore a minor process
  - water extraction via the Lilyvale pump station for supply to Mt Piper power station was approximately 3% of the total outflows and is therefore a minor process.

Table 4.10 Conceptual Lake Lyell water balance over the recent period (1 July 2019 to 30 June 2024)

Water year	Rainfall over the period	Inflows (GL)					Outflows (GL)				
		Coxs River (212058)	Farmers Creek (212042)	Ungauged catchments[1]	Direct rainfall[2]	Total	Coxs River downstream of Lake Lyell (212011)[3]	Water extraction for Mt Piper power station[4]	Evaporation[5]	Total outflows	Difference (inflows – outflows)
Catchment area (% to Lilyvale Dam)		≈72%	≈18%	≈10%	0.6%						
2019/2020	Below median	11	10	6	1	28	12	3	2	17	12
2020/2021	Above median	35	19	11	2	67	60	4	2	66	1
2021/2022	Above 90th percentile	71	27	15	3	115	117	1	2	120	-4
2022/2023	Near 90th percentile	73	26	15	2	116	142	1	2	145	-29
2023/2024	Above median	23	13	7	2	45	39	3	2	44	1
Totals over recent period		214	94	53	11	372	370	12	9	392	-19
% of total[6]		58%	25%	14%	3%		94%	3%	2%		

Notes:

1. Inflow volume from ungauged catchments calculated as: (gauged flow at Farmers Creek (from Table 4.8) / catchment area to Farmers Creek gauge: 6,700 ha) x ungauged catchment area (3,779 ha, excludes lake area).
2. Direct rainfall volume calculated as annual rainfall (SILO data) x lake area (234 ha).
3. Stream gauge 212011 is located approximately 3 km downstream of Lilyvale Dam. Streamflow at the gauge is predominantly from Lake Lyell releases (both riparian releases and spillway overflows).
4. From Table 4.7.
5. Evaporation volume calculated as annual evaporation (SILO data) x lake area (234 ha) x 0.7 (pan coefficient).
6. Rounding approximation has been used in table (i.e.. % total for outflow = 99%).

4.4 Water quality

EnergyAustralia currently implement a water and algae monitoring program in the upper Coxs River basin. The program includes monitoring within Lake Lyell, Lake Wallace and Thompsons Creek Reservoir, several locations within the Coxs River (upstream and downstream of Lake Lyell) and Farmers Creek (upstream of Lake Lyell). The program includes the following types of monitoring:

- Algae monitoring that is used to inform algae alert levels in Lake Lyell.
- Water quality monitoring.
- Profile (water column) data at the Lake Lyell and Thompson Creek Reservoir outlet towers.

The following data from this program is used in this assessment to describe baseline conditions in Lake Lyell for the recent period (1 July 2019 to 30 June 2024):

- Data from seven monitoring locations within Lake Lyell.
- Data from one monitoring location on Farmers Creek upstream of Lake Lyell.
- Data from two monitoring locations on the Coxs River that are upstream of Lake Lyell and downstream of Lake Wallace.
- Data from two monitoring locations on the Coxs River downstream of Lake Lyell.

Water monitoring data for Thompson Creek Reservoir, Lake Wallace and Coxs River upstream of Lake Wallace was not used in this assessment for the following reasons:

- The construction and operation of the PHES will not impact Thompsons Creek Reservoir or Lake Wallace.
- Information on the water quality of Coxs River inflows into Lake Lyell is provided by the two monitoring locations on the Coxs River that are upstream of Lake Lyell and downstream of Lake Wallace.

Section 4.4.1 describes available data and notes the data that is used in this assessment, Section 4.4.2 describes the DGVs for the water quality analytes and monitoring results are presented and discussed in Sections 4.4.3 to 4.4.5. Information from this section is used to inform a conceptual water cycle processes model for Lake Lyell (refer to Section 4.5) and the assessment of residual impacts of the project (refer to Chapters 7 and 8).

4.4.1 Available data

i Water monitoring program

Table 4.11 describes the algae, water quality and profile monitoring programs and the data that is utilised in this assessment.

Table 4.11 Water monitoring program overview

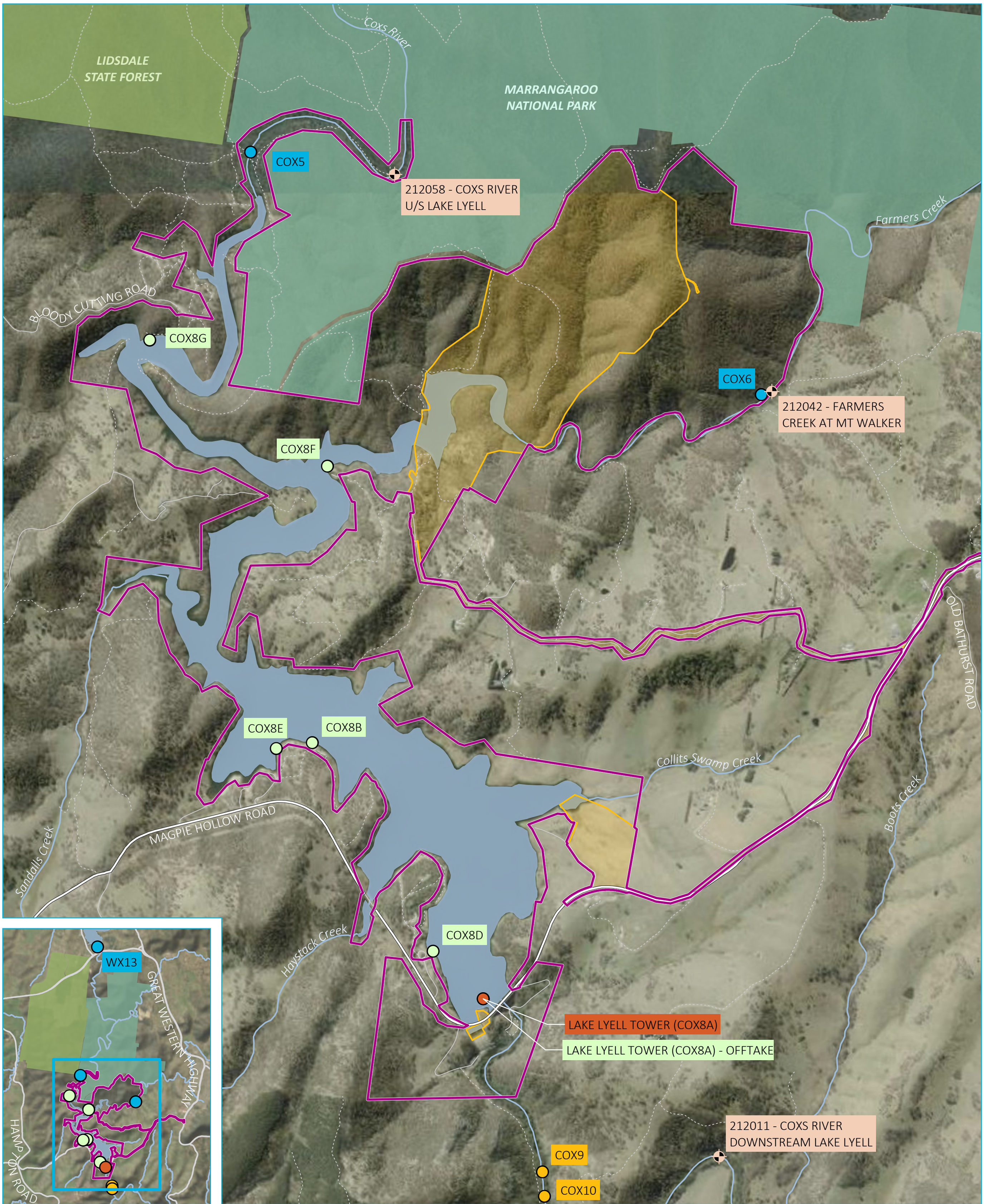
Program aspects	Description	Available data
Algae monitoring	EnergyAustralia conduct monthly algae monitoring, typically carried out during the first full week of the month. The frequency is dependent on the algae alert level, with the categories and corresponding increased sample frequency as follows (EA, 2023b): • NIL/green: monthly sampling • Amber: fortnightly sampling • Red: weekly sampling Algae monitoring is conducted at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell. Monitoring locations are described in Table 4.12.	The monitoring data and algae alert levels at the seven locations within Lake Lyell and two locations within the Coxs River were provided by EnergyAustralia as a daily time-series for the period 1/5/2019 to 31/7/2024. For the daily timeseries, the most recent sample reading is held constant until the next sample is obtained.
Water quality monitoring	EnergyAustralia monitor water quality at six monitoring locations that are within Lake Lyell and the adjoining reaches of Coxs River (both upstream and downstream) and Farmers Creek. Monitoring locations are described Table 4.12. Typically, monthly samples are taken, however more intensive monitoring is sometime undertaken for certain analytes. The full analyte suite and analysis methods are described in Table 4.13. It is noted that the full analyte suite was not applied to all monitoring.	Data from the six locations in Lake Lyell, Coxs River and Farmers Creek is available for the period 2/2016 to 8/2024. Only data for the recent period (1 July 2019 to 30 June 2024) has been used in this assessment. The number of samples (n) varies for both monitoring location and analytes and is indicated in the water quality summary tables in Annexure A and is also shown below result boxplots.
Conductivity-temperature-depth (CTD) monitoring	EnergyAustralia collect CTD profile (water column) data monthly at Lake Lyell tower. The data provides measurements of the following physio-chemical parameters with depth: temperature, pH, dissolved oxygen, electrical conductivity and turbidity.	Monthly profile data at the Lake Lyell tower for the period 1/2016 to 8/2024 was provided by EnergyAustralia. Only data for the recent period (1 July 2019 to 30 June 2024) has been used in this assessment.

ii Water monitoring locations

Table 4.12 describes all monitoring locations in EnergyAustralia's water and algae monitoring program and notes the applicability of this data for this assessment. All monitoring locations that are used in this assessment are shown in Figure 4.10.

Table 4.12 Water monitoring locations

ID		Description	Applicable to this assessment
Lake Wallace			
WX9	upstream to downstream	Coxs River upstream of Lake Wallace	No
COX3		Lake Wallace (western side)	No
WX13		Coxs River downstream of Lake Wallace	Yes (water quality)
Thompsons Creek reservoir			
TCR-water quality (or TCR1)		Thompsons Creek reservoir (north-west corner)	No
Thompsons Creek reservoir		Channel adjacent to reservoir (north side)	
Thompsons Creek Dam drain (seepage)		Channel adjacent to reservoir (north side)	
TCD-V notch 1		Channel adjacent to reservoir (north side)	
TCD-V notch 2		Channel adjacent to reservoir (north side)	
TCD-V notch 3		Channel adjacent to reservoir (north side)	
Lake Lyell			
COX5	upstream to downstream	Coxs River upstream of Lake Lyell (to north)	Yes (water quality)
COX6		Farmers Creek upstream of Lake Lyell (to east)	Yes (water quality)
COX8G		Lake Lyell algae monitoring location	Yes (algae alert)
COX8F		Lake Lyell algae monitoring location	Yes (algae alert)
COX8E		Lake Lyell algae monitoring location	Yes (algae alert)
COX8B		Lake Lyell algae monitoring location	Yes (algae alert)
COX8D		Lake Lyell algae monitoring location	Yes (algae alert)
COX8A/Lake Lyell tower		Lake Lyell tower (adjacent to the dam wall)	Yes (algae alert, water quality and profiles)
COX8A/Lake Lyell tower (offtake)		Lake Lyell algae monitoring location	Yes (algae alert)
COX9		Coxs River below (downstream) of Lake Lyell	Yes (algae alert and water quality)
COX10		Coxs River downstream of Lake Lyell	Yes (algae alert and water quality)



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

KEY

- Project area
- Construction envelope
- Stream gauge

Water monitoring location (by type)

- Algae
- Water quality
- Water quality, algae
- Water quality, algae and profile

Existing environment

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

Water monitoring locations

Lake Lyell PHES
Surface Water Impact Assessment
Figure 4.10

creating opportunities

iii Monitoring analytes and methods

Table 4.13 describes the water monitoring analytes and analysis methods for the water quality monitoring program. It is noted that full analyte suite in Table 4.13 was not applied to all samples. The number of samples (n) available for each location/analyte is indicated in the water quality summary tables in Annexure A and charts.

Table 4.13 Monitoring analytes and methods

Category	Analytes	Sampling and analysis methods
Physico-chemical parameters	pH, electrical conductivity, dissolved oxygen, temperature	Analysis was undertaken using a calibrated water quality meter.
	Total suspended solids Total dissolved solids Turbidity Total hardness and alkalinity (as $CaCO_3$) Ammonia, oxidised nitrogen (NOx), total Kjeldahl nitrogen (TKN) and total nitrogen Reactive (phosphate) and total phosphorus	Analysis was undertaken by a NATA-certified laboratory.
Anions	Chloride, fluoride, sulphate	Analysis was undertaken by a NATA-certified laboratory.
Cations	Sodium, potassium, calcium, magnesium	Analysis was undertaken by a NATA-certified laboratory.
Metals and metalloids (total)	Aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), strontium (Sr), vanadium (V) and zinc (Zn)	Analysis was undertaken by a NATA-certified laboratory.
Metals and metalloids (field filtered)	Aluminium (Al), arsenic (As), boron (B), iron (Fe), manganese (Mn), nickel (Ni), vanadium (V) and zinc (Zn)	Field filtered samples were filtered using a 0.45 µm filter. Analysis was undertaken by a NATA-certified laboratory.

4.4.2 Default guideline values

The National Water Quality Management Strategy (NWQMS) establishes water quality objectives for water resources using the *Australian & New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG 2018) framework. The following receiving waters and the associated DGVs are relevant to this assessment:

- **Coxs River, Farmers Creek and local watercourses –** DGVs for a slightly-to-moderately disturbed freshwater upland river apply.
- **Lake Lyell -** DGVs for a slightly-to-moderately disturbed freshwater lake or reservoir apply.

It is noted that the DGVs are water quality objectives and may not be representative of ambient water quality in Lake Lyell or watercourses.

Table 4.14 provides the DGVs for various water quality parameters for upland rivers and lakes and reservoirs. It is noted that there are some differences between the DGVs for an upland river and lakes and reservoirs. To simplify the results presentation and given that the water quality in Lake Lyell is influenced by and connected to the Coxs River and other watercourses, all water quality results are described relative to the DGVs for an upland river.

Table 4.14 Default guideline values for receiving waters

Parameter	DGV	Source
Chlorophyll a	Upland river: Not provided Lakes and reservoirs: 0.005 milligrams per litre (mg/L)	ANZECC (2000)
pH	Upland river: 6.5–8.0 Lakes and reservoirs: 6.5–8.0	
Electrical conductivity	Upland river: 350 microsiemens per centimetre (µS/cm) Lakes and reservoirs: 30 µS/cm	
Dissolved oxygen	Upland river: 90–110% saturation (For water temperature = 20°C, this converts to 8.2–10.0 mg/L) Lakes and reservoirs: 90–100% saturation (For water temperature = 20°C, this converts to 8.2–9.1 mg/L)	
Turbidity	Upland river: 25 NTU Lakes and reservoirs: 20 NTU	
Total phosphorus	Upland river: 0.02 mg/L Lakes and reservoirs: 0.01 mg/L	
Reactive phosphorous	Upland river: 0.015 mg/L Lakes and reservoirs: 0.005 mg/L	
Total nitrogen	Upland river: 0.25 mg/L Lakes and reservoirs: 0.35 mg/L	
NOx	Upland river: 0.015 mg/L Lakes and reservoirs: 0.01 mg/L	
Metals and other toxicants	Upland river and lakes and reservoirs: values for slightly-to-moderately disturbed freshwater ecosystems described in the ANZG (2018) guidelines.	ANZG (2018)

4.4.3 Algae alert data

i Data

EnergyAustralia undertake algae monitoring at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell (refer to Table 4.12 and Figure 4.10). The data is used to establish an algae alert level using the following algae total biovolume thresholds:

- Nil alert: ≤0.04 millimetres cubed per litre (mm^3/L).
- Green alert: >0.04 mm^3/L and ≤0.4 mm^3/L.
- Amber alert: >0.4 mm^3/L and ≤4 mm^3/L.
- Red alert: >4 mm^3/L.

Timeseries plots of daily total cyanobacteria biovolume and the corresponding algae alert levels have been prepared for the nine locations. Figure 4.11 illustrates the timeseries for surface water at mid-lake location COX8E for the period 1/5/2019 to 31/7/2024. Annexure B presents the timeseries for all locations. The coloured bands in the figures represent the corresponding algae alert level and the white bands represent a period of Nil alert.

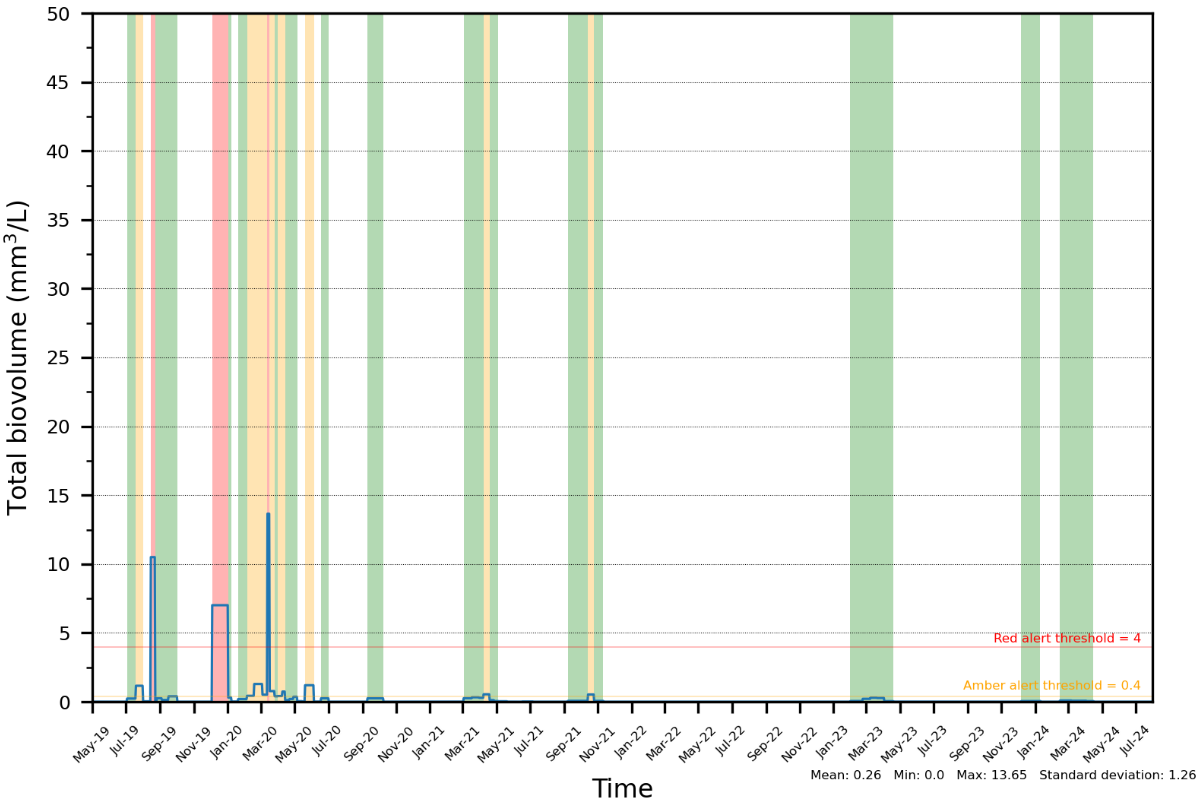


Figure 4.11 Location COX8E surface water algae alert timeseries

For each location and season, the percent of time spent in each algae alert level has been calculated and the results are shown in Figure 4.12. It is noted that the letters on the x-axis relate to calendar months (i.e. DJF = December, January and February).

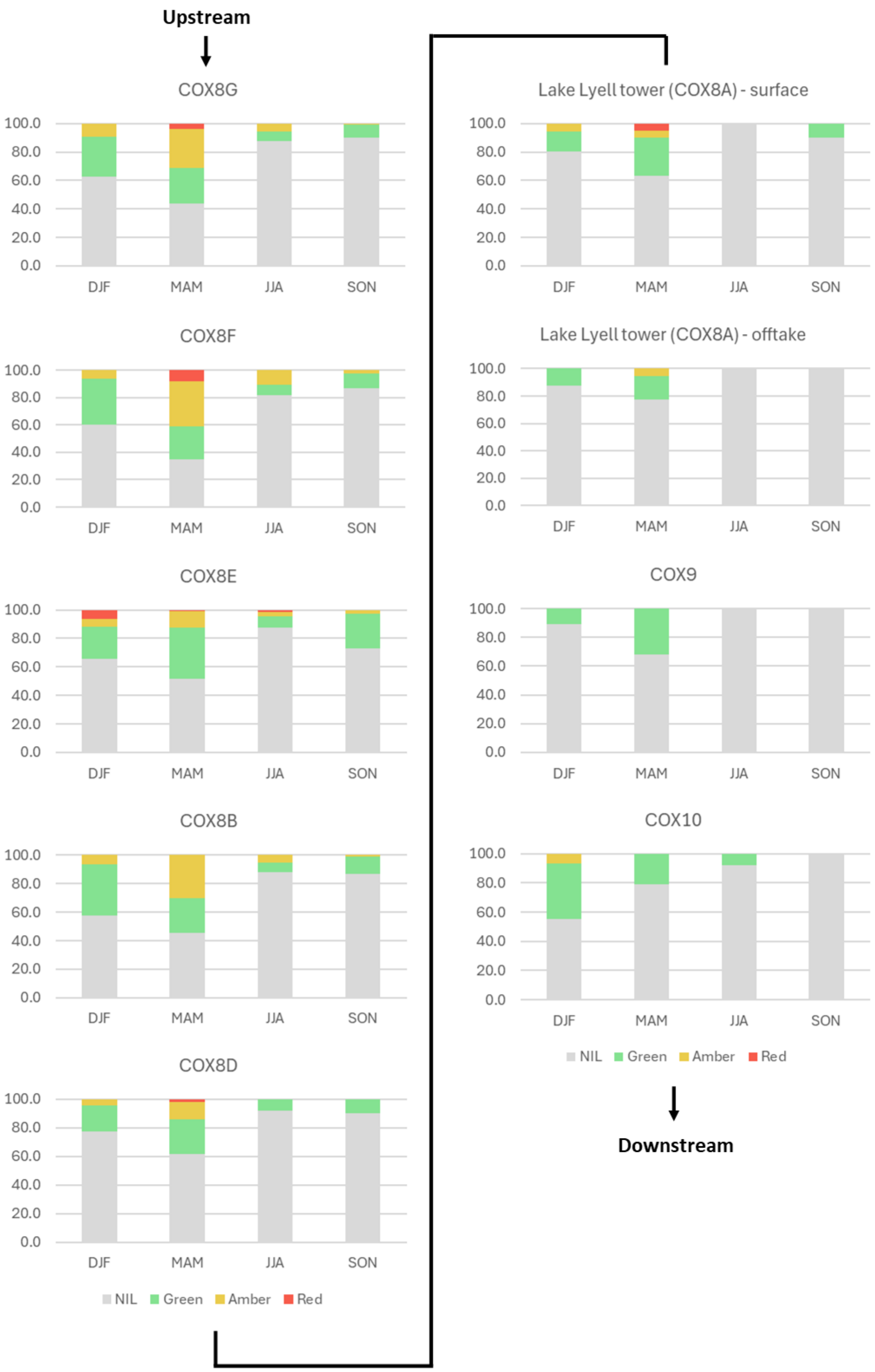


Figure 4.12 Percent of time in alert levels with season

ii Algae monitoring data conclusions

The following conclusions can made from the time-series and seasonal plots:

- Algae alerts (green to red) mostly occur in summer and autumn, with autumn displaying the higher percents in amber and red.
- The four most upstream locations (COX8G, COX8F, COX8E and COX8B) generally have higher algae concentrations and these conditions stretch into winter with some percent of time in amber alert. COX8F (located in the western portion of the Farmers Creek arm of Lake Lyell) had the highest percent of time in amber and red alert. This may be due to Farmers Creek inflows having higher nutrients than Coxs River inflows (discussed in Section 4.4.5).
- Generally, in winter and spring, location COX8D and downstream are predominantly in NIL alert, except for up to 10% of the time in green alert at COX8D, COX8A (surface) and COX10.
- At all locations, algae alerts generally occurred less frequently and at lower levels during the La Niña events that occurred between September 2020 and March 2023 (refer to Section 4.1.1iii) than at other times during the recent period that were characterised by average or dry conditions.
- Algae alerts generally occurred less frequently and at lower levels at Lake Lyell tower offtake (COX8A-offtake) and downstream Coxs River monitoring locations (COX9 and COX10) relative to the Lake Lyell tower surface (COX8A-surface) and upstream locations. This indicates that the selective withdrawal of water from several meters below the surface mitigates the release of algae from the reservoir into the Cox River.

4.4.4 CTD profile data

i Data

The monthly CTD profile data at Lake Lyell tower, provides understanding of the evolving vertical structure of the lake as it passes through both stratified and well-mixed homogenous (i.e. non-stratified) states. Monthly profile plots from 3/7/2019 to 5/6/2024 have been prepared and are presented in Annexure C. Examples of a typical stratified and non-stratified state at Lake Lyell tower are shown in Figure 4.13.

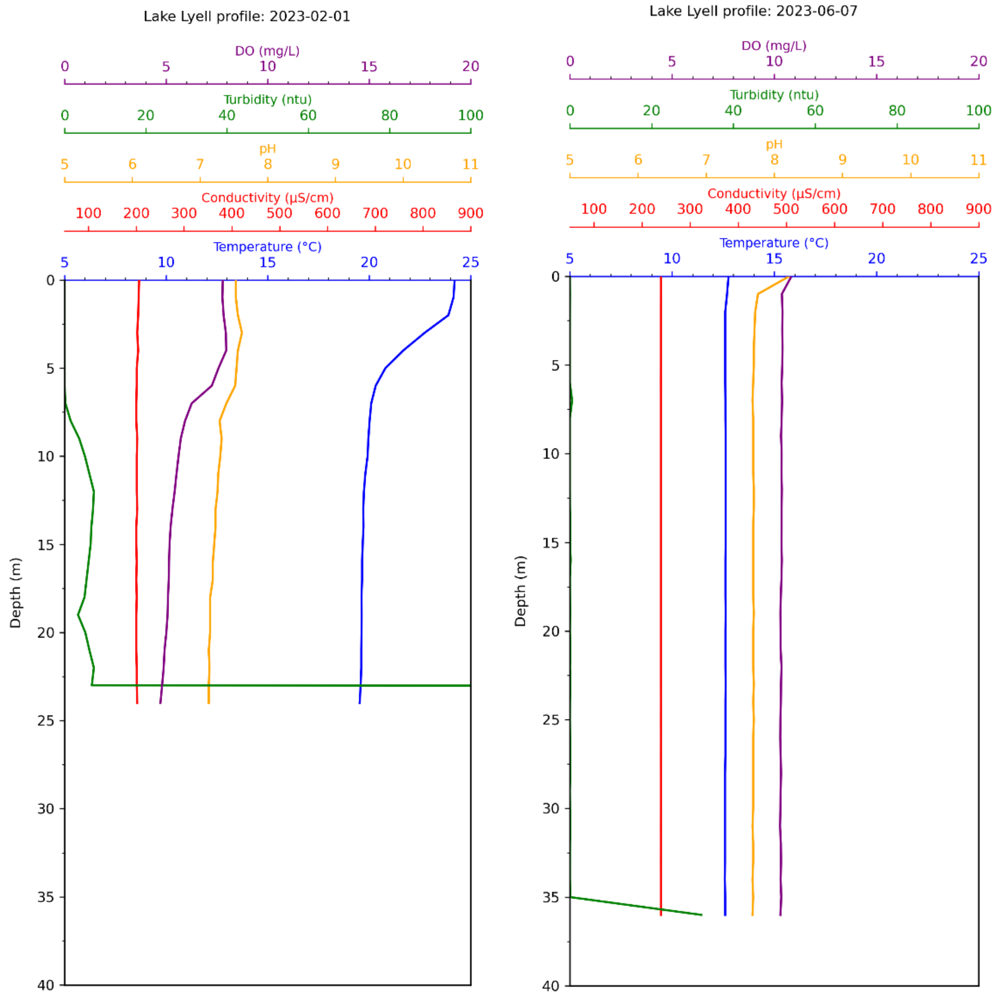


Figure 4.13 Lake Lyell CTD profile - typical stratified (left) and non-stratified state (right)

ii Profile data conclusions

The profile data over the five-year period typically shows the following characteristics:

- Temperature
  - Thermal stratification typically begins in October and breaks down to uniform temperatures from March to April. However, thermal stratification does not always occur during this period and can also break-down and reform within the period.
  - The strongest stratified state usually occurs in December to February when surface temperatures are around 22 to 24°C and a thermocline typically forms at 2 to 5 m depth. Temperatures below the thermocline are relatively uniform and typically range from 19 to 22°C (up to 5°C below surface temperatures).
  - Stratification will typically weaken in March. Unstratified conditions (uniform temperature with depth) are prevalent from April through to September. The lowest lake temperatures occur during winter in months July and August, with temperatures typically around 9 to 10°C.

- Dissolved oxygen (DO) – during periods when a thermocline is present, dissolved oxygen similarly exhibits a gradient with 8 to 10 mg/L at the surface and decreasing to around 4 mg/L in the lower lake. As thermal stratification breaks down, the DO gradient does not break down immediately and can persist. During July to August, DO peaks (up to 15 mg/L) and becomes uniform through the water column.

- Electrical conductivity (EC) - is shown to range from 100 to 850 µS/cm. The highest values occurred in 2019 during drought conditions and the lowest values occurred in winter months of 2022, following several years of above average rainfall associated with the La Niña events (refer to Section 4.1.1iii). Over different calendar years, the EC is shown to both increase and decrease and is relatively uniform with depth. During periods of stronger thermal stratification, a decrease in EC can be present at the surface, but this is not always evident.

- pH - generally is shown to remain in the range of 7 to 8 or 8 to 9, year to year.

- Turbidity - is generally clear to moderately turbid (0 to 25 NTU), however July to December 2019 (drought conditions) exhibited consistently high turbid conditions (25 to 100 NTU). This is possibly due to extensive bushfires in the region during that time.

iii Stratification status versus algae level

In Figure 4.14, the timeseries of daily total cyanobacteria biovolume at four Lake Lyell surface locations (COX8G, COX8F, COX8E and COX8A) are presented against the lake stratification status, which has been derived from the monthly temperature profile data.

The stratification status was derived based on the difference between the maximum and minimum temperature measured through the water column, according to the following:

- Unstratified: ΔT ≤1°C

- Transition: 1°C < ΔT <2°C

- Stratified: ΔT ≥2°C

Daily streamflow in Coxs River upstream of Lake Lyell (gauge 212058) is also included in Figure 4.14. The streamflow is presented as four quartile bins allowing periods of low and high discharge flow to be identified.

Figure 4.14 shows that high algae levels occurred between July 2019 and June 2020, which coincides with a period of severe drought in NSW, where inflows from the Coxs River were predominantly in the lowest quartile. Significant bushfires also occurred in parts of the catchment in December 2019. It is likely that abnormally high sediment and nutrient laden runoff from bush fire impacted areas occurred in the first half of 2020 and contributed strongly to the high algae levels that occurred in March 2000 to May 2020.

From June 2020 to June 2024, algae levels consistently spike annually during March and April at several monitoring locations. These months correspond to generally decreasing water temperatures in Lake Lyell (after the summer peak) and a stratification status of either unstratified or transition. It is noted that the algae levels in each year were an order of magnitude lower than the levels recorded in March to May 2020.

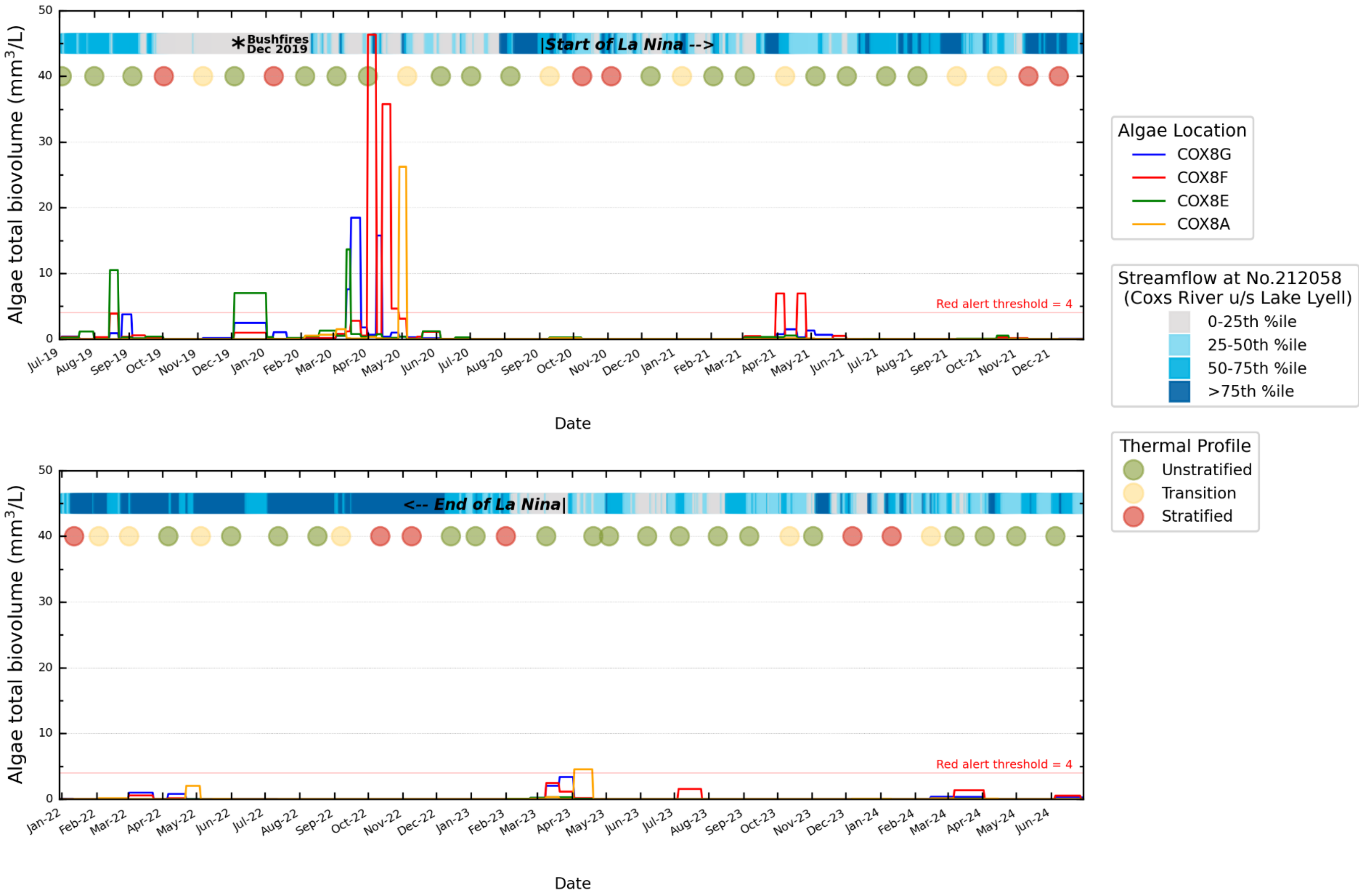


Figure 4.14 Timeseries of stratification status and algae level in Lake Lyell

4.4.5 Water quality monitoring

i Data

Water quality data from six monitoring locations is used in this assessment to establish baseline conditions (refer to Section 4.4.1). Three of the locations (WX13, COX5 and COX6) are located upstream of Lake Lyell. WX13 is just downstream of Lake Wallace and is about 7 km north of COX5 which is near the Coxs River inflow location to Lake Lyell. COX6 is in Farmers Creek upstream of Lake Lyell. Farmers Creek flows into the Farmers Creek arm of Lake Lyell where the PHES is proposed. These three sites provide a reference to characterise ambient water quality of inflows to Lake Lyell. COX8A (Lake Lyell tower) is the only monitoring site within the lake and is adjacent to Lilyvale Dam wall. COX9 and COX10 are located approximately 1 km downstream of Lake Lyell (COX10 further downstream by 150 m). These sites provide a reference of water quality in Coxs River due to flow releases from Lake Lyell. It is noted that samples at COX8A are collected near the water surface while water released from the lake is generally drawn from several meters below the water surface. Therefore, the water quality at COX8A is not always representative of water released from the lake, especially when the lake is in a stratified state.

The available water quality data has been described in Table 4.11. The following approach was applied to present the data for the recent period (1 July 2019 to 30 June 2024):

- Detailed results – key statistics are provided in table format in Annexure A for each monitoring location. All results are compared to DGVs (where available), and exceedances are classified as frequent or occasional using the following methodology:
  - An exceedance is described as frequent if the DGV is exceeded in 20% or more of samples.
  - An exceedance is described as occasional if the DGV was exceeded in at least one sample, but less than 20% of samples.
- Box and whisker plots (location comparison) – have been prepared to compare the monitoring results from all six locations along the Coxs River, Farmers Creek and Lake Lyell (from upstream to downstream). The box shows the 25th and 75th percentiles, the whiskers show the 20th and 80th percentiles and the outliers are data points that fall outside this range and include the minimum and maximum concentrations. The red horizontal line within the box depicts the median concentration. The plots identify changes in water quality along the reach, relative to DGVs. Plots have been prepared for the following key analytes:
  - pH, electrical conductivity, temperature and dissolved oxygen (refer to Figure 4.15).
  - Turbidity, total suspended solids, total dissolved solids and total phosphorus (refer to Figure 4.16).
  - Total nitrogen and oxidised nitrogen (refer to Figure 4.17).
- Box and whisker plots (seasonal comparison) – have been prepared to compare seasonal monitoring results from the following locations: COX5, COX6, COX8A and COX9. These sites provide representation of water quality upstream, within and downstream of Lake Lyell. Plots have been prepared for water temperature and dissolved oxygen and are included in Annexure D.
- Timeseries plots –have been prepared to describe temporal and spatial changes to water quality over the recent period. To demonstrate correlations between water quality and algae level, stream flows and stratification status, the plots include the algae levels at COX8E, lake stratification status (using the methodology described in Section 4.4.4iii) and daily streamflow in Coxs River upstream of Lake Lyell (gauge 212058).

The following plots have been prepared:

- EC - Figure 4.18 plots timeseries data for electrical conductivity (an indicator of water salinity) at COX5, COX6, COX8A and COX9.
- Temperature - Figure 4.19 plots timeseries data for water temperature at COX5, COX6, COX8A and COX9.
- DO - Figure 4.20 plots timeseries data for dissolved oxygen at COX5, COX6, COX8A and COX9.
- Turbidity - Figure 4.21 plots timeseries data for turbidity at COX5, COX6, COX8A and COX9.
- Total Nitrogen - Figure 4.22 plots timeseries data for total nitrogen at COX5, COX6, COX8A and COX9.
- Oxidised nitrogen - Figure 4.23 plots timeseries data for oxidised nitrogen at COX5, COX6, COX8A and COX9.
- Total Phosphorus - Figure 4.24 plots timeseries data for total phosphorus at COX5, COX6, COX8A and COX9.

• Nutrient balance calculations - for Lake Lyell have been undertaken to compare the median nutrient loads in lake inflows and outflows over the recent period. The calculations are provided in Table 4.15. Calculation methods and assumptions are described in the table notes.

The water quality data is discussed following the charts and tables.

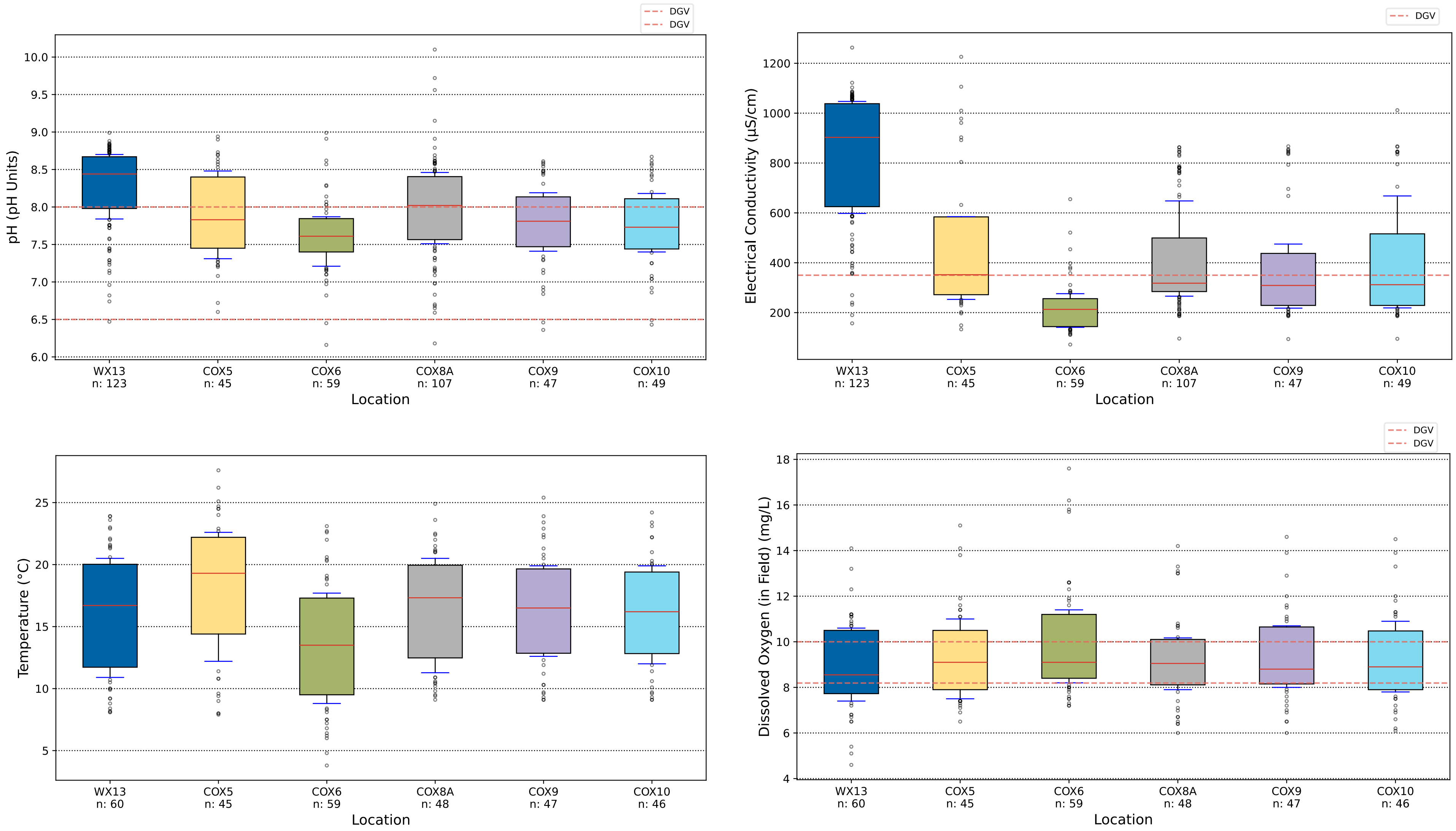


Figure 4.15 Box and whisker plots – sheet 1

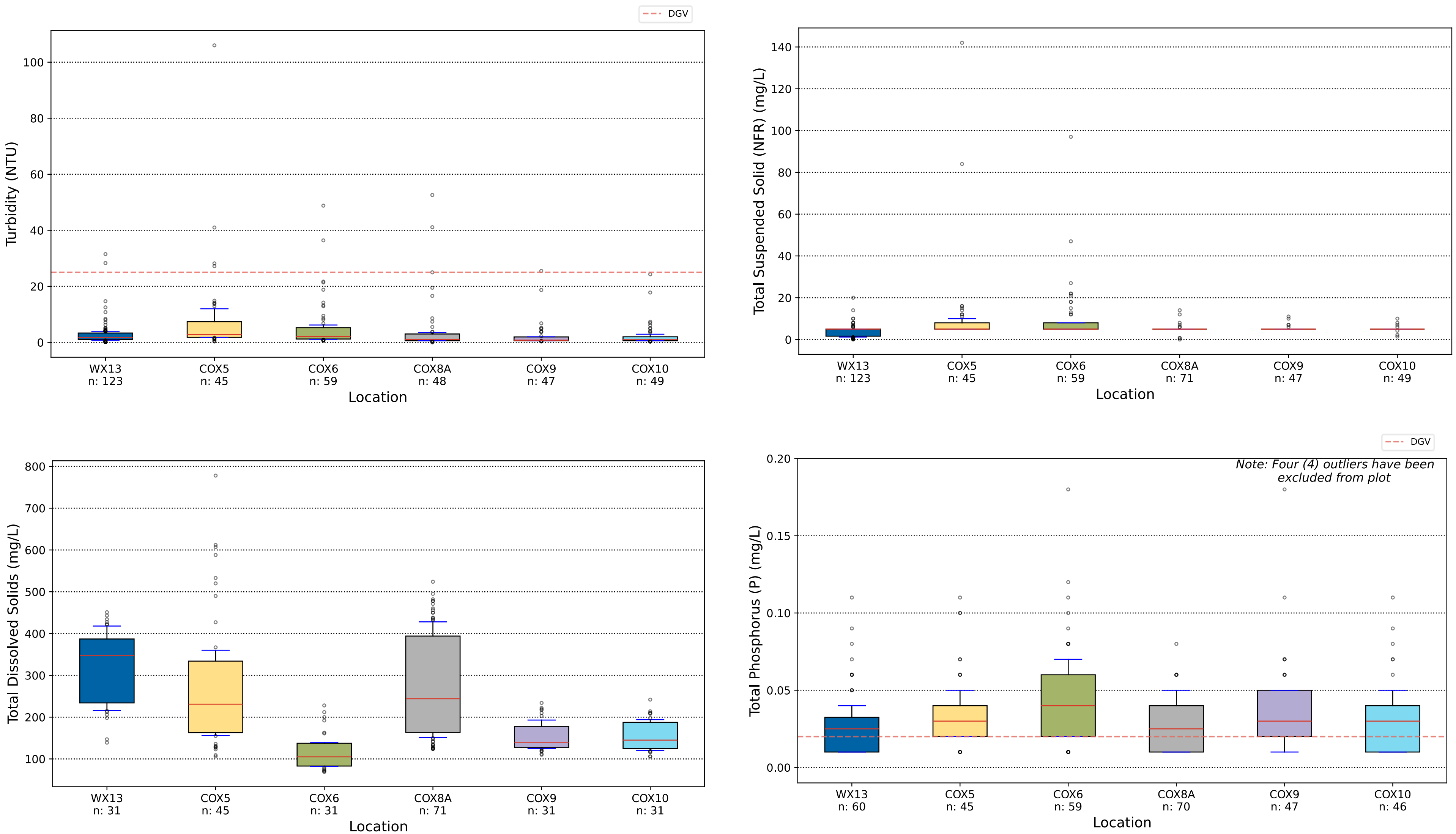


Figure 4.16 Box and whisker plots – sheet 2

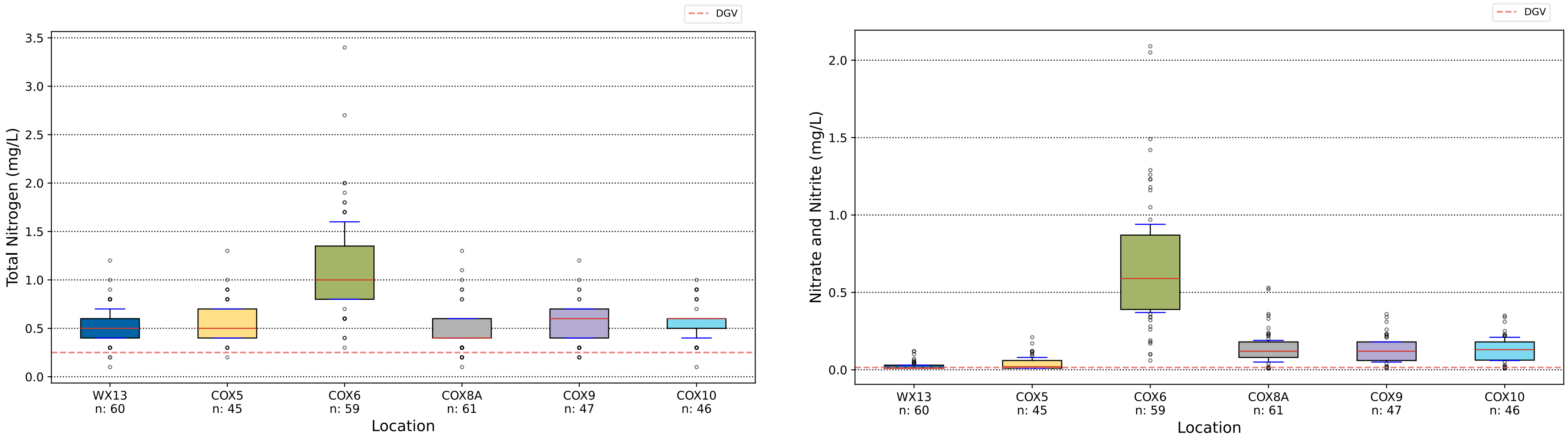


Figure 4.17 Box and whisker plots – sheet 3

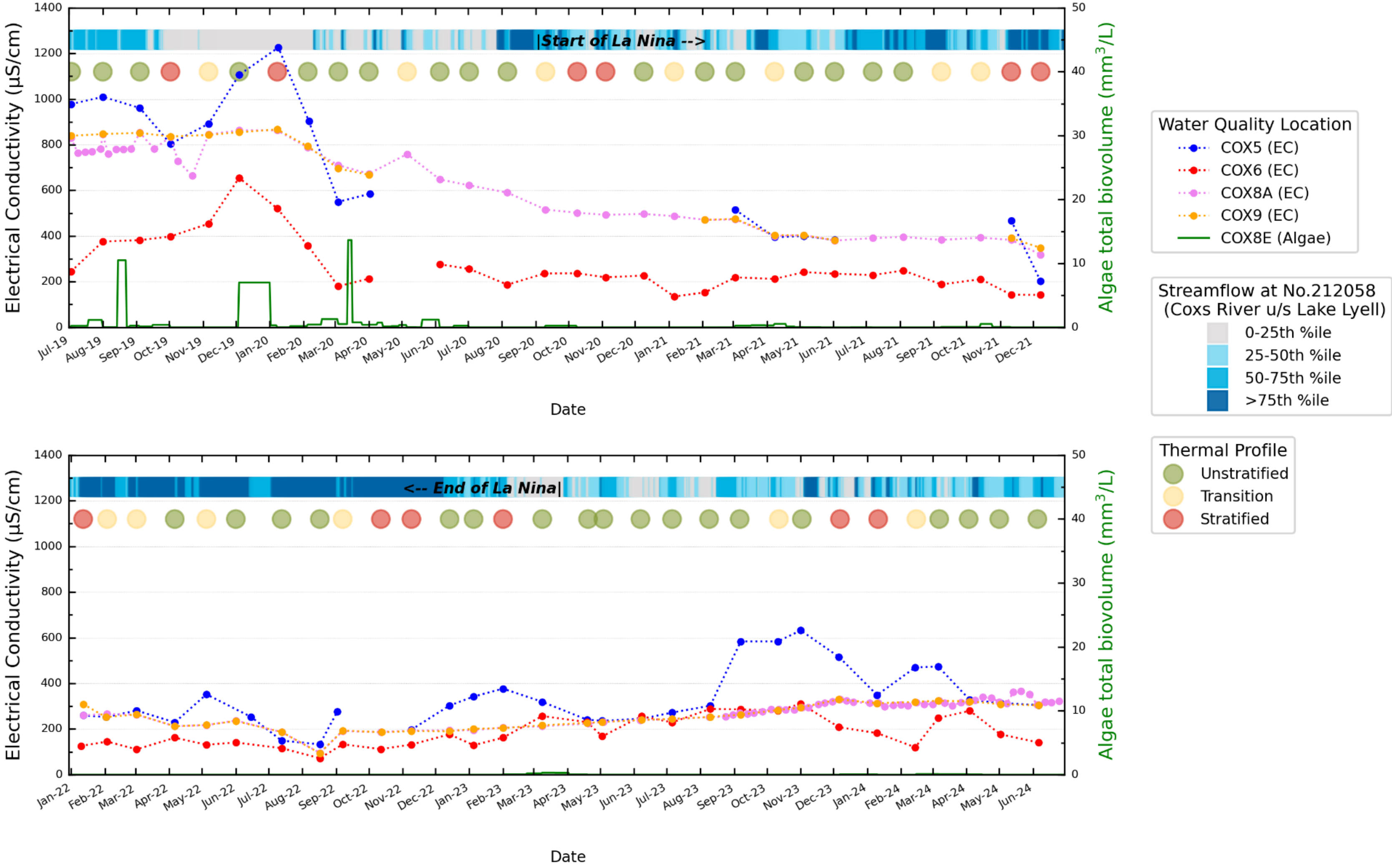


Figure 4.18 Timeseries of Lake Lyell electrical conductivity, algae level, stratification status and Coxs River upstream inflow

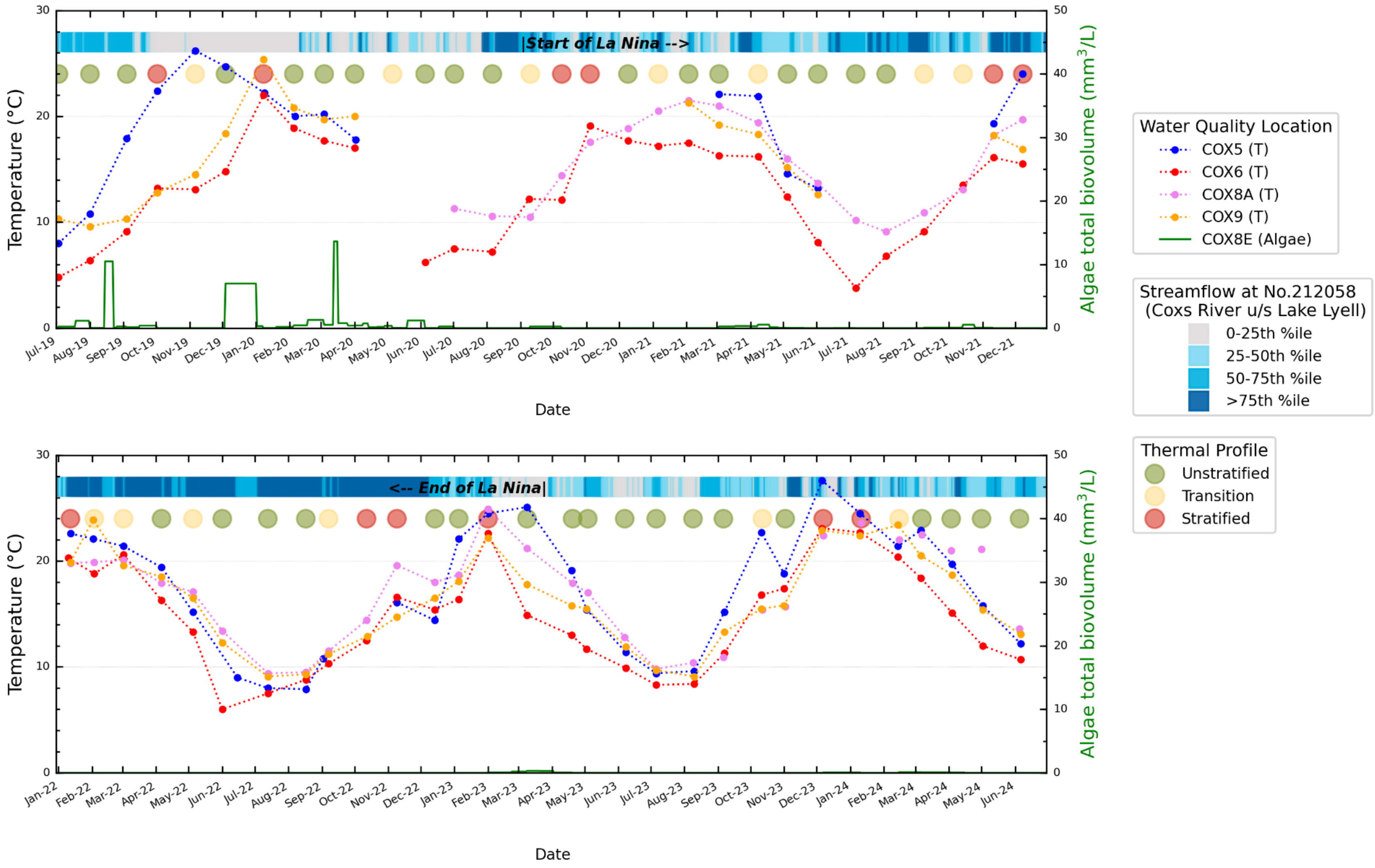


Figure 4.19 Timeseries of Lake Lyell temperature, algae level, stratification status and Coxs River upstream inflow

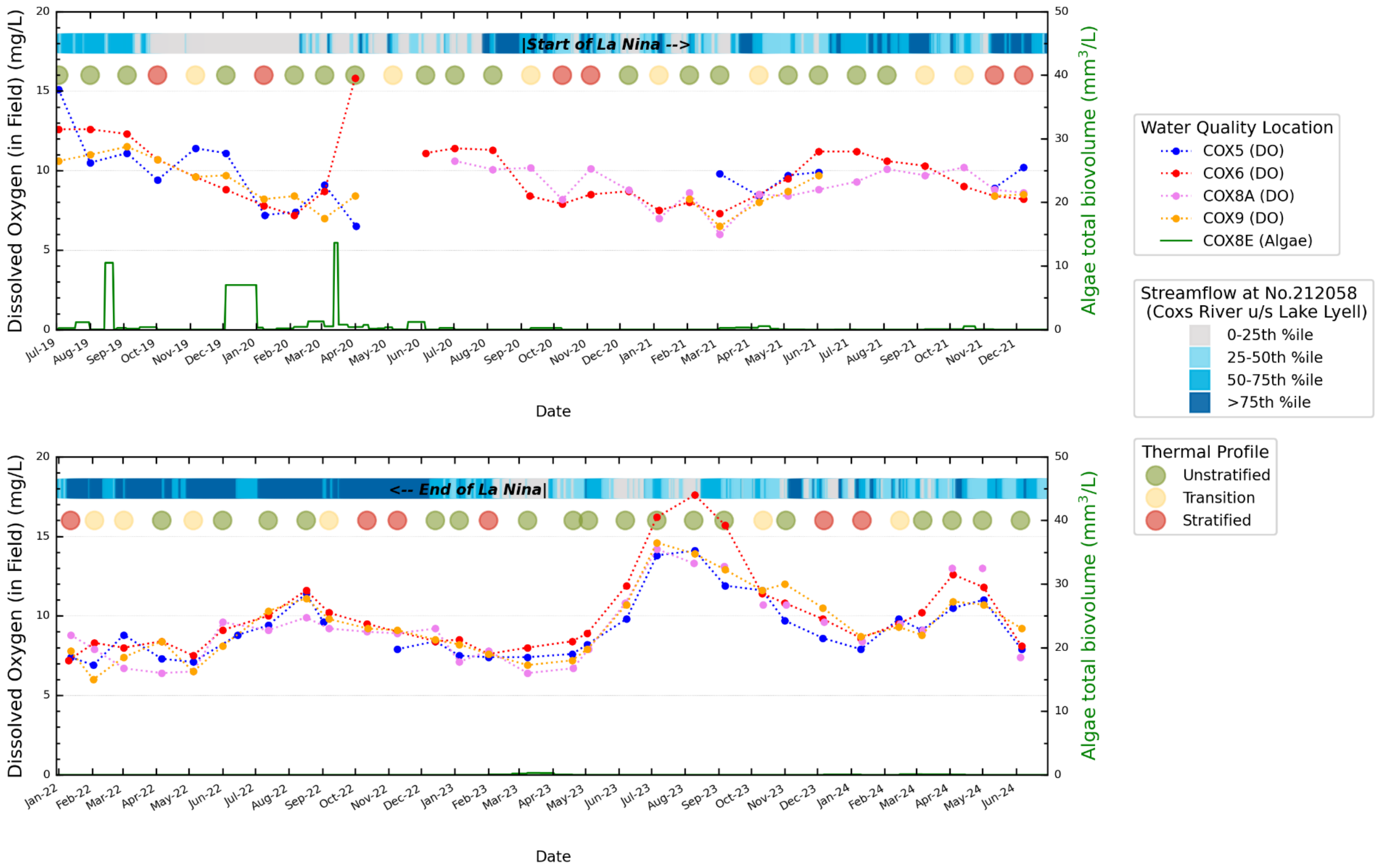


Figure 4.20 Timeseries of Lake Lyell dissolved oxygen, algae level, stratification status and Coxs River upstream inflow

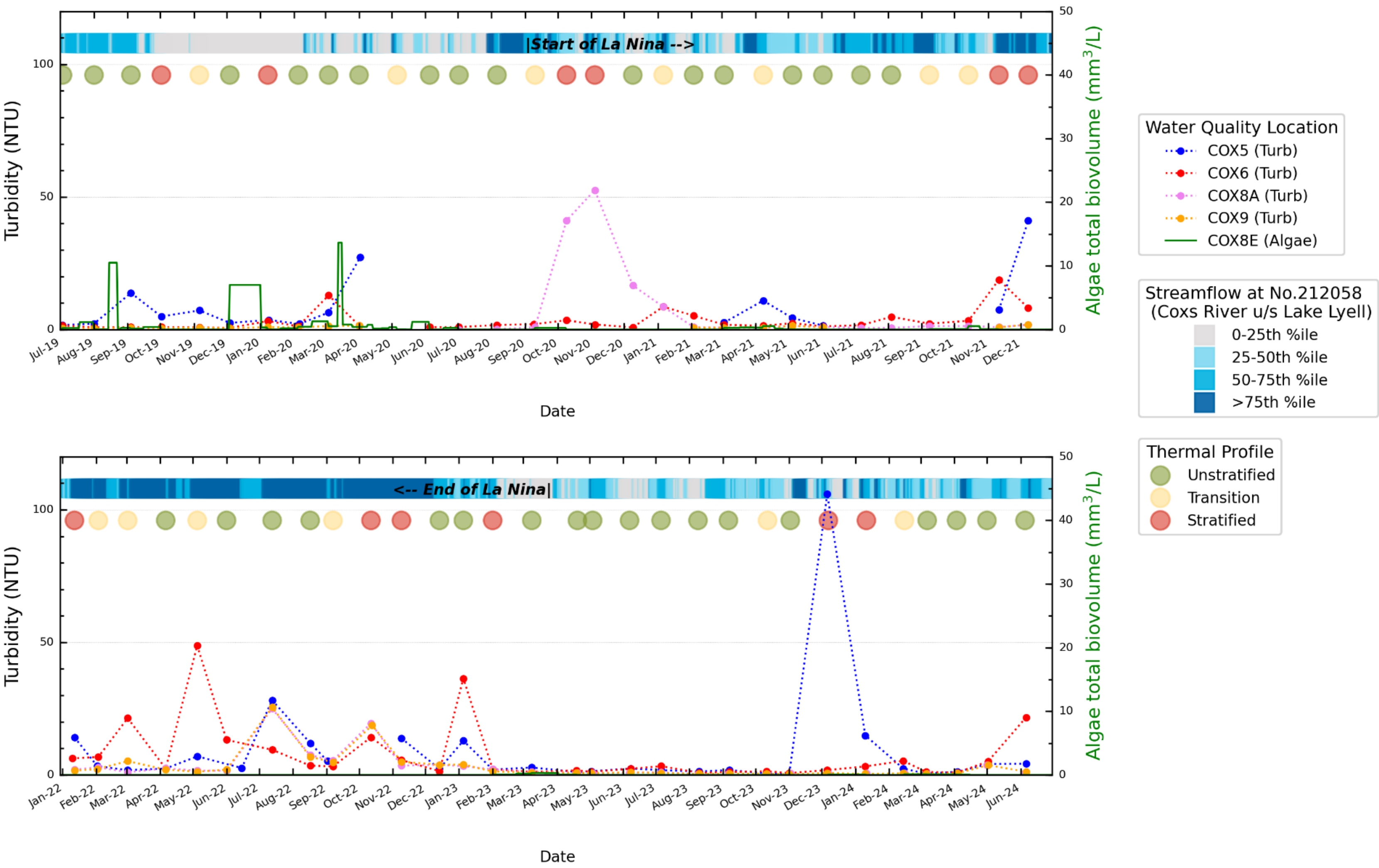


Figure 4.21 Timeseries of Lake Lyell turbidity, algae level, stratification status and Coxs River upstream inflow

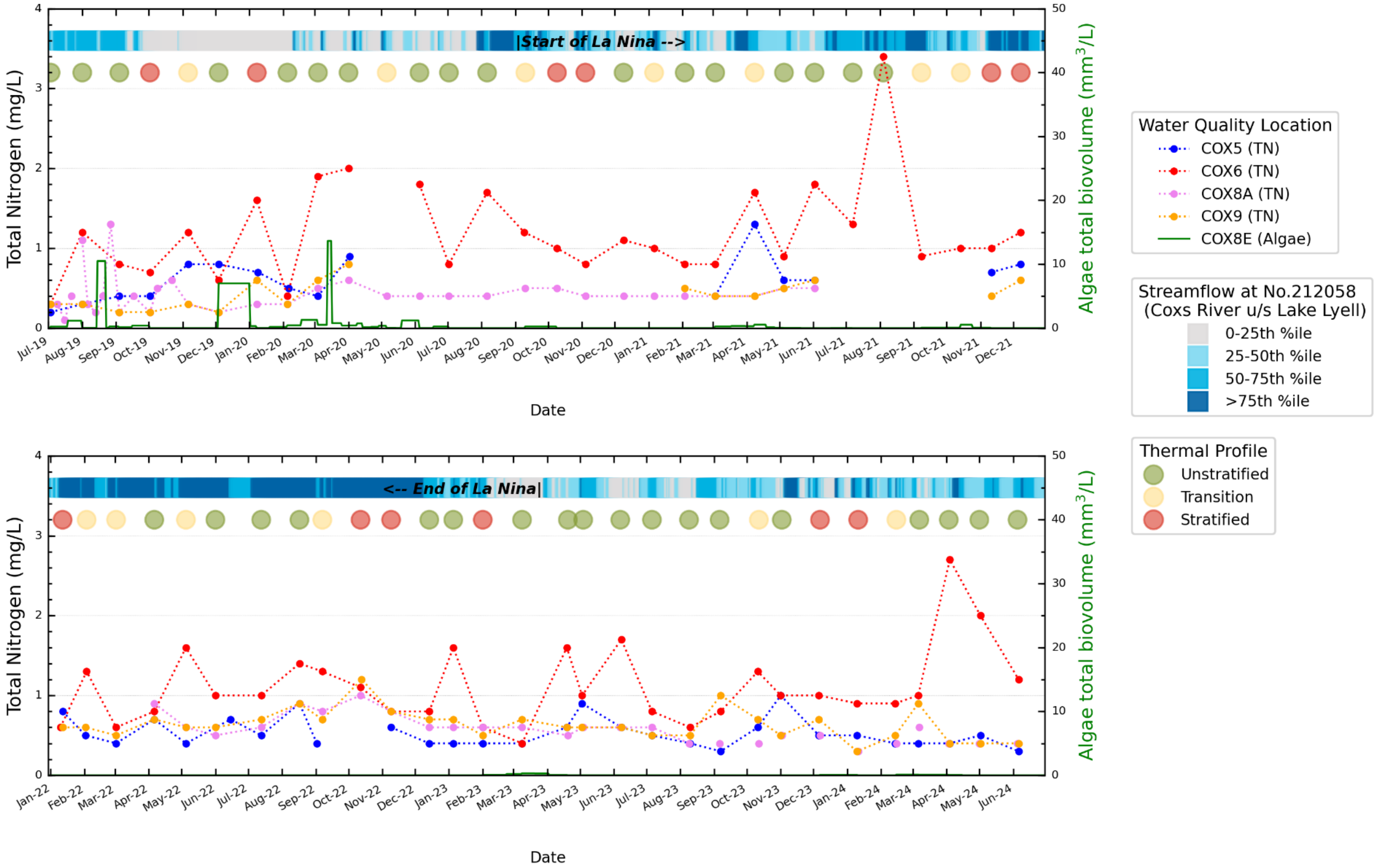


Figure 4.22 Timeseries of Lake Lyell total nitrogen, algae level, stratification status and Coxs River upstream inflow

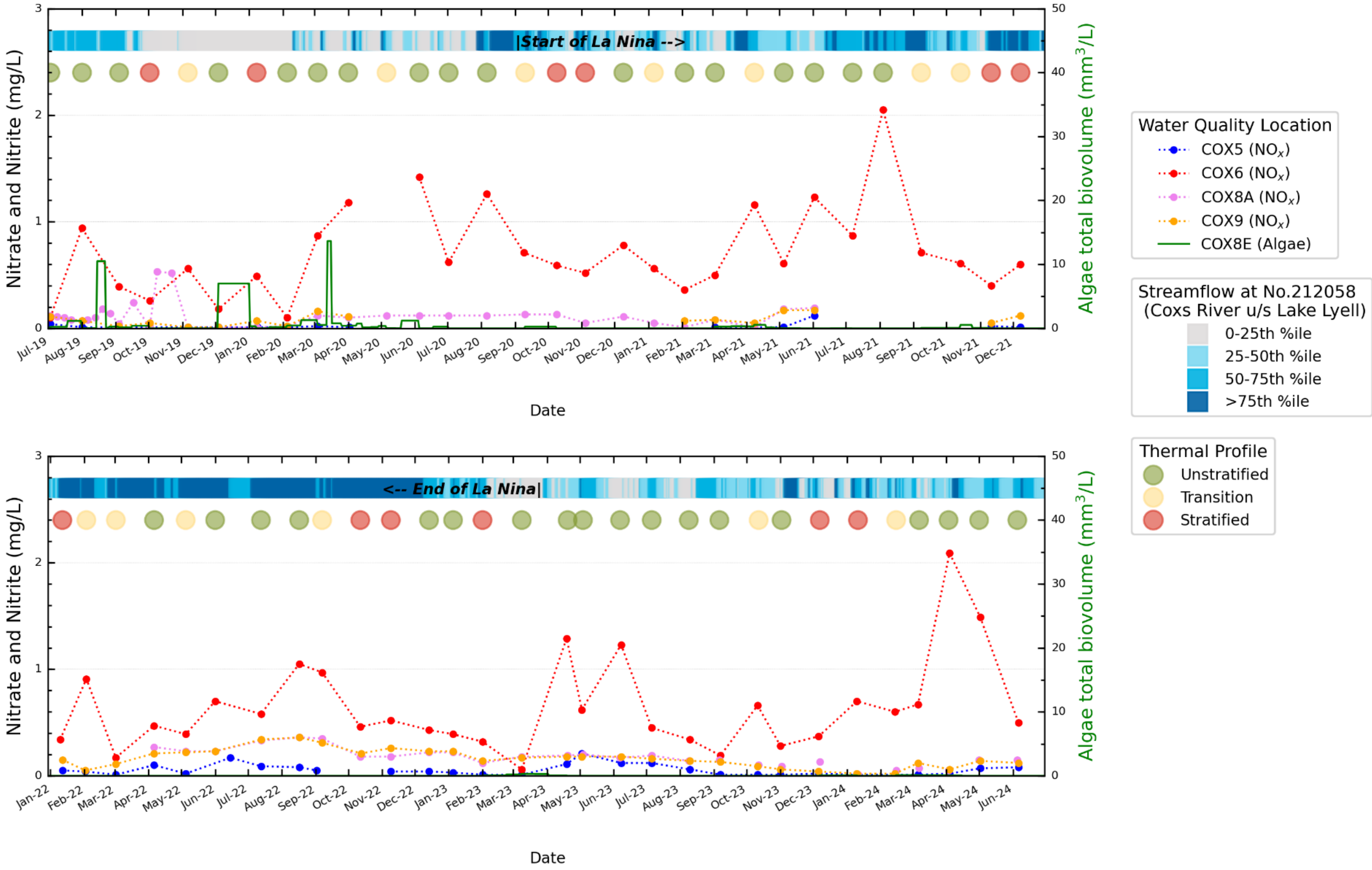


Figure 4.23 Timeseries of Lake Lyell oxidised nitrogen, algae level, stratification status and Coxs River upstream inflow

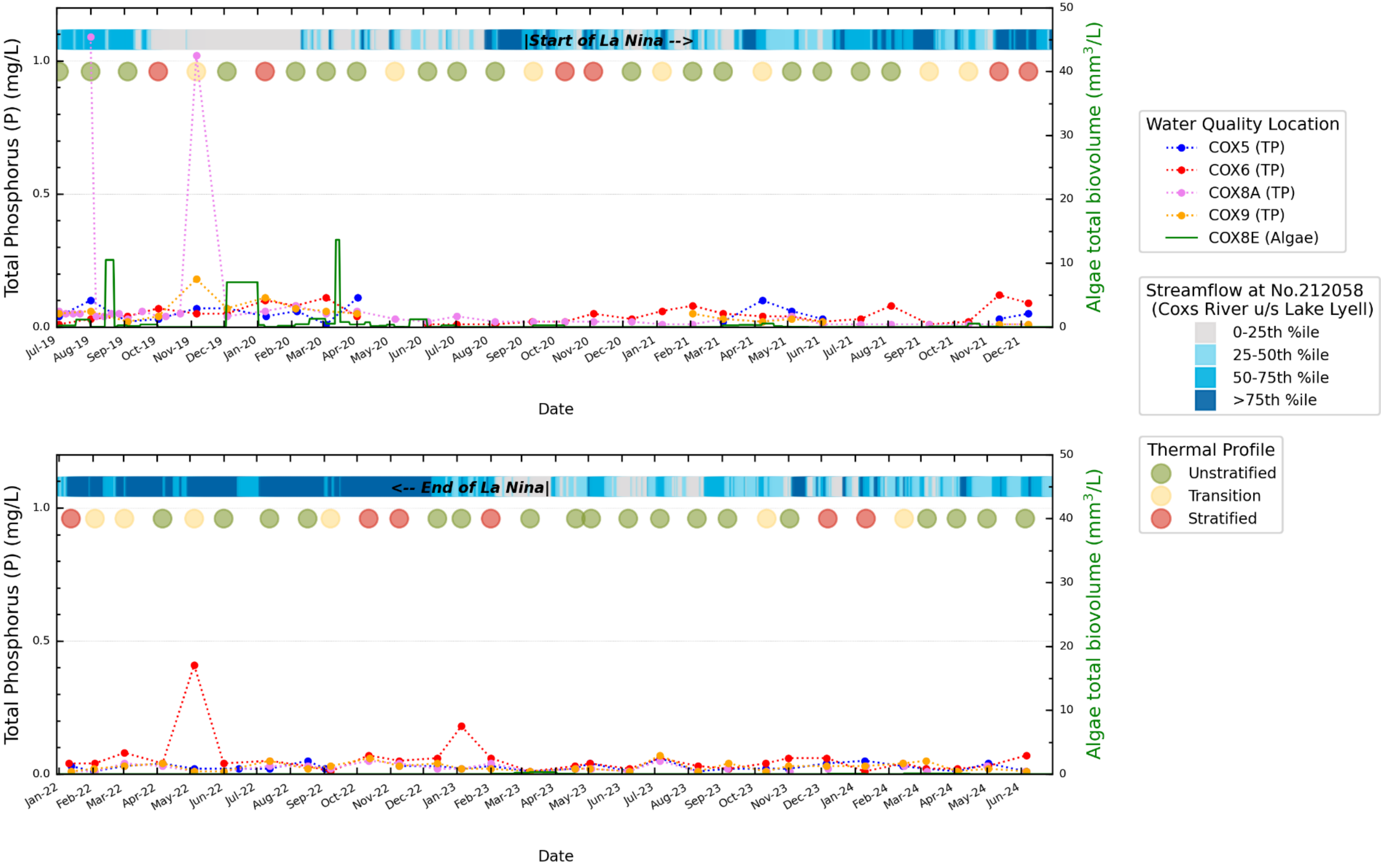


Figure 4.24 Timeseries of Lake Lyell total phosphorus, algae level, stratification status and Coxs River upstream inflow

Table 4.15 Lake Lyell nutrient balance calculations

		Oxidised Nitrogen		Total Nitrogen		Total Phosphorous	
	Median volume[1]	Median concentration[2]	Estimated load	Median concentration[2]	Estimated load	Median concentration[2]	Estimated load
Units	GL/yr	mg/L	kg/yr	mg/L	kg/yr	mg/L	kg/yr
Inflows							
– Coxs River	35	0.02	700	0.5	17,500	0.03	1,050
– Farmers Creek	19	0.59	11,210	1.0	19,000	0.04	760
– ungauged catchments[3]	11	0.02	220	0.5	5,500	0.03	330
– direct rainfall[3]	2	0.02	40	0.5	1,000	0.03	60
Inflows total	67	-	12,170	-	43,000	-	2,200
Outflows							
– Dam releases[4]	60	0.12	7,200	0.6	36,000	0.03	1,800
– Water extraction[5]	3	0.12	360	0.6	1,800	0.03	90
– Evaporation[6]	2	0.0	-	0.0	-	0.0	-
Outflows	65	-	7,560	-	37,800	-	1,890
Difference (inflows less outflows)	2 (3% reduction)		4,610 (38% reduction)		5,200 (12% reduction)		310 (14% reduction)

Notes:

1. Median volumes calculated for the recent period using the annual volumes in Table 4.10.
2. Median value from water quality tables in Annexure A.
3. Median concentration assumed to be similar to Coxs River inflows (COX5).
4. Median concentration values taken from COX 9 (Coxs River downstream of Lake Lyell).
5. Median concentration assumed to be the same as dam releases as Lilyvale pump station draws water from the outlet tower.
6. Assumed to be zero.

ii Water characterisation summary

Table 4.16 provides a summary of the water quality monitoring data for key parameters with reference to the water quality data described in Section 4.4.5i.

Table 4.16 Water characterisation summary

Parameter	Description
Physico-chemical parameter (excluding nutrients)	
EC – an indicator of water salinity	• The EC at COX8A (offtake tower surface) ranged from approximately 100 to 850 µS/cm, relative to a DGV of 350 µS/cm. The median value of EC over the recent period was 318 µS/cm, which is 32 µS/cm lower than the DGV (refer to Figure 4.15). The highest EC values occurred in December 2019, which was during a period of severe drought with upstream Coxs River inflows in the 0 to 25th percentile range (refer to Figure 4.18). The lowest EC values occurred in the winter months of 2022, which followed several years of above average rainfall associated with consecutive La Niña events (refer to Section 4.1.1iii). • The EC at COX5 (Coxs River inflows to Lake Lyell) ranged from approximately 150 to 1,200 µS/cm, with a median value of 352 µS/cm. It is noted that the EC declined substantially between WX13 (Coxs River downstream of Lake Wallace) and COX5 (refer to Figure 4.15). This is due to tributary inflows diluting higher salinity water in the upper Coxs River catchment that is known to receive diffuse and point source discharges from mines and coal ash dams. The change in EC between WX13 and COX5 demonstrates that the Coxs River water quality materially changes between Lake Wallace and Lake Lyell. • The EC at COX6 (Farmers Creek inflows to Lake Lyell) was lower than at COX5, with values ranging from approximately 70 to 650 µS/cm, with a median value of 213 µS/cm (refer to Figure 4.15). • The EC at COX9 and COX10 (Coxs River downstream of Lake Lyell) was similar to COX8A (offtake tower surface) which is expected (refer to Figure 4.15). • The total dissolved solids (TDS) data (refer to Figure 4.16) generally has similar trends to EC except the TDS at COX8A is generally higher than the TDS of inflows (COX5 and COX6) and outflows (COX9 and COX10). This is not consistent with expectations and may be due to the higher number of samples at COX8A (i.e. 71 compared to 31 at other locations).
pH	• The pH at COX8A (offtake tower surface) ranged from approximately 6 to 10, relative to a DGV range of 6.5 to 8 (refer to Figure 4.15). The median value of pH over the recent period was 8.0, which is the upper DGV limit. • The pH at COX5 (Coxs River inflows to Lake Lyell) ranged from approximately 6.5 to 9.0, with a median value of 7.8 (refer to Figure 4.15). It is noted that pH declined between WX13 (Coxs River downstream of Lake Wallace) and COX5 (refer to Figure 4.15). This is due to tributary inflows diluting higher alkaline water in the upper Coxs River basin that is known to receive diffuse and point source discharges from mines and ash dams. The change in pH between WX13 and COX5 demonstrates that the Coxs River water quality materially changes between Lake Wallace and Lake Lyell. • The pH at COX6 (Farmers Creek inflows to Lake Lyell) was generally lower than at COX5, with values ranging from approximately 6.0 to 9.0, with a median value of 7.6 (refer to Figure 4.15). • The pH at COX9 and COX10 (Coxs River downstream of Lake Lyell), was generally similar to pH at COX5 and slightly lower (closer to neutral) than pH at COX8A (refer to Figure 4.15).

Parameter	Description
Water temperature	• The water temperature at COX8A (offtake tower surface) ranged from approximately 9 to 25°C, with median value of 17.3°C (refer to Figure 4.15). As discussed in Section 4.4.4ii, the strongest stratified state usually occurred in December to February when surface temperatures are around 22 to 24°C and a thermocline typically forms at 2.5 to 5 m depth. Temperatures below the thermocline are relatively uniform and typically range from 19 to 22°C (up to 5°C below surface temperatures). Unstratified conditions are prevalent from April through to September, with lowest temperatures typically in July and August around 9 to 10°C. • The water temperature at COX5 (Coxs River inflows to Lake Lyell) ranged from approximately 8.0 to 27.5°C, with a median value of 19.3°C (refer to Figure 4.15). It is noted that water temperature increased between WX13 (Coxs River downstream of Lake Wallace) and COX5, likely due to warmer tributary inflows elevating temperature of cooler water being released from Lake Wallace. • The water temperature at COX6 (Farmers Creek inflows to Lake Lyell) was significantly lower than at COX5, with values ranging from approximately 4 to 23°C, with a median value of 13.5°C (refer to Figure 4.15). This is possibly due to a shorter residence time (i.e. the average period of time that water has been in a river) and the lack of riparian vegetation (i.e. less shading) in some reaches of the Coxs River. • The water temperature at COX9 and COX10 (Coxs River downstream of Lake Lyell) was in a similar range to water temperature at COX8A (offtake tower surface), however with lower median values of 16.5°C and 16.2°C respectively (compared to 17.3°C at COX8A). This is expected given that water released from Lake Lyell is selectively drawn from approximately 3 m below the water surface. • The seasonal boxplots in Annexure D compare water temperature statistics at COX5 (Coxs River inflows to Lake Lyell), COX6 (Farmers Creek inflows to Lake Lyell), COX8A (offtake tower surface) and COX9 (Coxs River downstream of Lake Lyell). While the small sample size of data should be noted, comparison of seasonal median temperatures of lake inflows (i.e. COX5 and COX6) to lake outflows (i.e. COX9) indicate that median water temperatures at COX9 are: – similar to water temperatures at COX5 but approximately 2.5°C higher than at COX6 in winter – approximately 1°C lower than at COX5 but approximately 2 to 3°C higher than COX6 in summer and autumn – approximately 4°C lower than at COX5 but similar to COX6 in spring. • The seasonal data indicates that the temperature of water released from Lake Lyell is generally within the range of temperatures in Coxs River and Farmers Creek upstream of the lake and that there is no clear indication that cold water pollution is occurring.
DO	• The DO at COX8A (offtake tower surface) ranged from approximately 6 to 14 mg/L, relative to a DGV range of 8.2 to 10 mg/L. The median DO over the recent period was 9 mg/L, which is in the middle of the DGV range (refer to Figure 4.15). As discussed in Section 4.4.4ii: – when the lake is stratified DO can exhibit a depth gradient with typical values of 8 to 10 mg/L at the surface, decreasing to around 4 mg/L in the lower lake – when the lake is unstratified DO will typically be uniform through the water column. • The DO at COX5 (Coxs River inflows to Lake Lyell) and COX6 (Farmers Creek inflows to Lake Lyell) was generally within the DGV range and was also similar to the DO at COX8A (refer to Figure 4.15). • The DO at COX9 and COX10 (Coxs River downstream of Lake Lyell), was also generally within the DGV range and was also similar to the DO at COX8A (refer to Figure 4.15). • From timeseries Figure 4.20, it is observed that peaks in DO occur in July and August and lowest DO levels occur from January through to April. This is because oxygen solubility and water temperature have an inverse relationship (i.e. oxygen solubility decreases as water temperature increases). The seasonal boxplots in Annexure D show a similar trend. The annual cycle of DO does not follow a consistent shape year to year (compared to water temperature). During the period of consecutive La Niña events with above average rainfall, the fluctuation between DO peak and trough was dampened. The use of the lake aerator to break down stratification also can affect the timing of increased DO levels. • The data indicates that in all seasons, water released from Lake Lyell has DO levels that are similar to the reservoir inflows and the DGV range and that there is no indication that low DO water is released from the lake.

Parameter	Description
Turbidity	• Turbidity is a measure of water clarity (i.e. how much light can pass through the water). Elevated turbidity can occur due to suspended sediment, algae and other organic matter in the water column. • Turbidity levels at all water quality monitoring locations were generally below the DGV of 25 NTU (refer to Figure 4.16), which means the water in Lake Lyell and upstream and downstream watercourses is generally clear. • Turbidity levels at COX5 (Coxs River inflows to Lake Lyell) and COX6 (Farmers Creek inflows to Lake Lyell) intermittently exceed the DGV value of 25 NTU, with most exceedances occurring during periods of higher streamflow (refer to Figure 4.21). • Turbidity levels at COX8A (offtake tower surface) were generally close to zero (the median value was 1 NTU and the 80th percentile value was 4 NTU - Table A.4) indicating that water in Lake Lyell is generally clear. Higher turbidity levels occurred from October 2020 to January 2021, with the highest levels occurring when the lake was in a stratified state (refer to Figure 4.21). • Turbidity at COX9 and COX10 (Coxs River downstream of Lake Lyell), was at or below the DGV of 25 NTU in all samples (Figure 4.16) and COX9 was also generally lower than levels in lake inflows (i.e. COX5 and COX6) and similar to levels at COX8A (refer to Figure 4.21). This indicates that Lake Lyell beneficially reduces turbidity and that releases from the lake have low turbidity even when turbid inflows occur.
Total suspended solids (TSS)	• The TSS results (Figure 4.16) are similar to the turbidity results.

Parameter	Description
Nutrients	
Nitrogen compounds	• The water monitoring program includes analysis of the following nitrogen compounds: – Ammonia is a bioavailable form of nitrogen. Median ammonia concentrations were elevated relative to the DGV of 0.013 mg/L at some located but were generally an order of magnitude lower than oxidised nitrogen concentrations and are therefore only provided in the tabulated results in Annexure A. – Oxidised nitrogen is the sum of nitrate and nitrite (NOx) and is also a bioavailable form of nitrogen. NOx results are provided in Figure 4.17 and Figure 4.23 as well as the tabulated results in Annexure A. – TKN is the sum of organic nitrogen (which is not readily bioavailable) and ammonia. TKN results are provided in Annexure A. – Total Nitrogen (TN) is the sum of NOx and TKN. TN results are provided in Figure 4.17 and Figure 4.22 as well as the tabulated results in Annexure A. – Nutrient balance calculations for NOx and TN are provided in Table 4.15. • The key results are: – TN concentrations at COX5 (Coxs River inflows to Lake Lyell) ranged from approximately 0.2 to 1.3 mg/L, with a median concentration of 0.5 mg/L (relative to a DGV of 0.25 mg/L). At WX13 (Coxs River downstream of Lake Wallace) which is upstream of COX5, TN concentrations were similar with a median of 0.5 mg/L. The median NOx concentration at COX5 was 0.02 mg/L (relative to a DGV of 0.015 mg/L). These results indicate that the TN is primarily in organic form. – TN concentrations at COX6 (Farmers Creek inflows to Lake Lyell) were higher than at COX5 with values ranging from 0.3 to 3.4 mg/L and median value of 1.0 mg/L (relative to a DGV of 0.25 mg/L). The median NOx concentration was 0.6 mg/L (relative to a DGV of 0.015 mg/L) which means the TN is primarily in NOx form (i.e. bioavailable). These results indicate that there is an anthropogenic (i.e. human induced) source of nitrogen in the Farmers Creek catchment, upstream of Lake Lyell. – TN concentrations at COX8A (offtake tower surface) were similar to COX5, ranging from 0.1 to 1.3 mg/L, with a median value of 0.4 mg/L (relative to a DGV of 0.25 mg/L). The median NOx concentration was 0.12 mg/L (relative to a DGV of 0.015 mg/L). – TN concentrations at COX9 and COX10 (Coxs River downstream of Lake Lyell), were slightly higher than COX8A (offtake tower surface), with a median value of 0.6 mg/L at both locations. The median NOx concentrations were 0.12 mg/L at COX9 and 0.13 mg/L and COX10, which were also similar to COX8A. • The nutrient balance calculations indicate that NOx and TN loads in lake outflows are lower than in lake inflows, with the calculated NOx load reducing by 38% and the calculated TN load reducing by 12% (refer to Table 4.15). The calculated NOx load reduction of 4,610 kg/yr is similar to the calculated TN load reduction of 5,200 kg/yr, which means that the TN reduction is primarily associated with the NOx reduction. • Overall, the water quality results and nutrient balance calculations indicate that bioavailable nitrogen (i.e. NOx) is beneficially removed in Lake Lyell via natural processes, potentially assisted by the destratification system that EnergyAustralia operate (refer to Section 4.2.4iia).

Parameter	Description
Phosphorus compounds	• The water monitoring program includes analysis of the following phosphorus compounds: – Phosphate (filtered) is a dissolved and readily available form of phosphorus. Phosphate (filtered) was included in the analyte suite and results are provided in Annexure A. It is noted that the laboratory analysis applied a limit of reporting (LOR) of 0.1 mg/L, which is nearly an order of magnitude higher than the DGV (0.015 mg/L) and typical values. This means that the phosphate results are of limited value as they are generally less than the LOR. – Total Phosphorus (TP) is the sum of all forms of phosphorus, including dissolved and particulate forms. TP results are provided in Figure 4.16 and Figure 4.24 as well as the tabulated results in Annexure A. – Nutrient balance calculations for TP are provided in Table 4.15. • The key results are: – TP concentrations at COX5 (Coxs River inflows to Lake Lyell) ranged from <0.01 to 0.11 mg/L, with a median concentration of 0.03 mg/L (relative to a DGV of 0.02 mg/L). At WX13 (Coxs River downstream of Lake Wallace) which is upstream of COX5, TP was similar with median of 0.025 mg/L. – TP concentrations at COX6 (Farmers Creek inflows to Lake Lyell) were slightly higher than at COX5, with values ranging from <0.01 to 0.4 mg/L and median value of 0.04 mg/L (relative to a DGV of 0.02 mg/L). – TP concentrations at COX8A (offtake tower surface) were similar to COX5 ranging from <0.01 to 1.1 mg/L, with a median value of 0.025 mg/L (relative to a DGV of 0.02 mg/L). In 2019 the TP concentration exceeded 1 mg/L in August and November. These results are outliers relative to other results at that time and may be associated with the bushfires that occurred in 2019 (refer to Figure 4.24). – TP concentrations at COX9 and COX10 (Coxs River downstream of Lake Lyell), were similar to TP concentrations at COX5, COX6 and COX8A, with a median concentration of 0.03 mg/L at both locations. – Overall, there is minimal variance in the TP concentrations between monitoring locations. • The nutrient balance calculations indicate that TP loads in lake outflows are lower than in lake inflows, with the calculated TP load reducing by 14%. • Overall, the water quality results and nutrient balance calculations indicate that Lake Lyell has a neutral to beneficial effect on phosphorus concentrations.
Metals and metalloids	
Results summary	• The water monitoring program includes analysis of the following metals and metalloids: – No metals were monitored at COX5 (Coxs River inflows to Lake Lyell). – Total aluminium, iron and manganese and filtered iron and manganese were monitored at COX6 (Farmers Creek inflows to Lake Lyell), COX9 and COX10 (Coxs River downstream of Lake Lyell). – The full metal suite described in Table 4.13 was monitored at COX8A (offtake tower surface) and the near full suite at WX13 (Coxs River downstream of Lake Wallace). • A summary of all results is provided in Annexure A. • The filtered metal and metalloids results at WX13 and COX8A identified the following DGV exceedances: – Filtered aluminium concentrations exceeded the DGV in less than 20% of samples at WX13 and more than 20% of samples at COX8A, the maximum exceedance was approximately 5x the DGV. – Filtered nickel concentrations exceeded the DGV in approximately 50% of samples at WX13, but were consistently below the DGV at COX8A. – Filtered zinc concentrations exceeded the DGV in less than 20% of samples at COX8A, the maximum exceedance was approximately 1.5x the DGV. • The total metal and metalloids results identified DGV exceedances of 80th percentile concentrations of aluminium, copper and nickel at some locations. Copper was not included in the filtered metal suite. • Overall, the limited available data did not identify any metals that have concentrations that are consistently above DGVs.

4.5 Conceptual water cycle processes model for Lake Lyell

Reservoirs are artificial waterbodies constructed by damming structures that obstruct natural river flows and therefore exhibit similar limnological features and processes that occur in naturally forming lakes. A conceptual water cycle processes model for Lake Lyell is shown in Figure 4.25. Figure 4.25 should be read in conjunction with Table 4.17 which describes the water cycle processes.

Table 4.17 Conceptual water cycle processes in Lake Lyell

ID	Description
1	Solar input - Solar radiation warms the surface layer of the reservoir.
2	Surface heat flux – Heat loss from the reservoir occurs through several heat transfer mechanisms including evaporation, conduction, convection and radiation.
3	Wind energy – The main body of Lake Lyell is aligned in a N-W / S-E direction, which is the axis of prevailing winds (refer to Section 4.1.2). Therefore, there is potential for a reservoir long wind fetch and significant transfer of energy to the reservoir via wind shear during prevailing wind events.
4	Coxs River inflow – The Coxs River flows into the northern upstream reach of Lake Lyell and contributes approximately 58% of total inflows into the lake (refer to Table 4.10). In addition to natural streamflow, the Coxs River inflow is potentially impacted by several anthropogenic influences which are discussed in Section 4.2.1.
5	Farmers Creek inflow – Farmers Creek flows into the Farmers Creek arm of Lake Lyell and contributes approximately 25% of total inflows into the lake. In addition to natural inflow, Farmers Creek inflow is potentially impacted by several anthropogenic influences which are discussed in Section 4.2.2. Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.
6	Kinetic mixing - Kinetic energy from wind shear (process 3) and upstream inflows (processes 4 and 5) drive hydrodynamic processes and turbulent mixing in the reservoir and contribute to developing the following conditions: • Generate surface currents and waves that drive circulation of the surface waters. • In turn, energy is transferred to greater depths where internal seiches, internal waves and inertial motions can develop and continue to transfer energy throughout the reservoir. • Kinetic energy cascades down to smaller and smaller scales, before eventually dissipating within the lake or at reservoir boundaries.
7 and 8	Thermal mixing - Central to a reservoir mixing regime is the natural heating and cooling cycle of the waterbody, specifically the development of the phenomenon of thermal stratification and its subsequent breakdown into a homogeneous water column (thermal destratification). Thermal stratification and destratification are described below.
7	Thermal stratification – Thermal stratification is a natural process which affects the vertical temperature and density gradient through the water column. A stratified system is characterised by a warm lower density surface layer (epilimnion) overlaying a cooler higher density bottom layer (hypolimnion), with an interfacing middle layer (metalimnion) which contains the sharp gradient in temperature called the thermocline (or the pycnocline for the density gradient). Profile data (refer to Section 4.4.4) indicates that stratification can occur between October and April, with the strongest stratified state usually occurring from December to February. During stratification, DO similarly exhibits a depth gradient as there is limited vertical mixing between the epilimnion (oxygen saturated surface water) and hypolimnion (lower oxygen water). Low DO levels in the hypolimnion can lead to anoxic conditions near the lakebed and sediments release soluble iron and manganese (by reducing metal oxides) and nutrients such as nitrogen and phosphorus that are stored in sediments. Once released, the soluble metals and nutrients can mix vertically when the stratification breaks down, resulting in poor water quality and a higher risk of algal blooms. As described in Section 4.4.4, stratification typically breaks down from March to April. Mechanical aeration can reduce the frequency and magnitude of low DO in the hypolimnion and the associated potential for metals and nutrients to be released from lakebed sediments. Figure 4.26 illustrates water quality processes under stratified conditions.

ID	Description
8	Thermal destratification – can occur due to: • kinetic mixing between the epilimnion and hypolimnion during high wind and/or runoff events (process 6) • convective mixing when water temperatures in the epilimnion cool and induce overturning such that the water column becomes uniform in temperature • artificial destratification (i.e. via the operation of a destratification system) can create upwards mixing between the hypolimnion and epilimnion and promotes the entrainment of deeper cooler water (discussed further in process 11). The destratification process is characterised by an initial deepening of the epilimnion and eventual homogenisation of the entire water column. Profile data (refer to Section 4.4.4) indicates that: • temporary destratification occurs during most summers due to artificial destratification and/or kinetic mixing • seasonal destratification typically occurs at the outlet tower between March to April (due to convective mixing and/or artificial destratification) and unstratified conditions are prevalent from April through to September. Figure 4.27 illustrates water quality processes under unstratified conditions.
9	Density currents (inflows) – Water density is a function of salinity and temperature. Density currents in reservoirs occur when inflows have a different density (due to temperature or salinity) to water in the reservoir. A more dense (i.e. cooler and/or more saline) inflow will sink deeper while a less dense (i.e. warmer and/or less saline) inflow will spread across the surface or have a higher intrusion. Density currents can influence the transport of nutrients within the reservoir and the distribution of dissolved oxygen.
10	Recreational activities – Recreational boating in Lake Lyell would have a local impact on lake hydrodynamics and water quality.
11	Mechanical aeration (diffuser system) – EnergyAustralia operate a submerged diffuser located on the reservoir bed near the dam wall (refer to Section 4.2.4iia). The system injects compressed air to the bottom of the reservoir to increase DO levels and induce upwards vertical mixing (i.e. from the hypolimnion to the epilimnion). The profile data (refer to Section 4.4.4) indicates that the operation of the diffuser system, does not always prevent stratification occurring. When the water column is stratified, DO similarly exhibits a gradient with higher levels of DO at the surface and decreasing DO with depth. Operation of the diffuser system would likely reduce the duration and magnitude of both stratification events and anoxic conditions occurring near the lakebed.
12	Dam spillway – The Lilyvale Dam wall and spillway are located at the southern end of Lake Lyell. The spillway operates when the lake level exceeds FSL.
13	Selective withdrawal – Controlled outflows from the lake occur through the multi-level offtake (MLO) outlet tower which is fitted with five vertical intake openings (bulk heads) at different levels (evenly spaced). EnergyAustralia operate the MLO to draw vortex free laminar flow into the tower that generally has high DO levels, good colour and is free of floating debris, such as algae. Selective withdrawal typically occurs approximately 3 m below the water surface. As described in Section 4.4: • the water quality in the Coxs River downstream of Lake Lyell generally has DO within the DGV range, low turbidity and algae levels that are well below levels in the reservoir • the temperature of water released from Lake Lyell is generally within the range of temperatures in Coxs River and Farmers Creek upstream of the lake which means there is no clear indication that cold water pollution is occurring. This indicates the selective withdrawal is effective in meeting the above-mentioned operational objectives.
14	Controlled discharge – Controlled discharge from Lake Lyell occurs via the outlet tower for the following purposes: • Water feed to Lilyvale pump station to supply the Mt Piper power station. The pumping station has capacity to transfer 95 ML/d. • Releases to the Coxs River via the riparian outlet to meet environmental flow requirements (refer to Section 4.2.4i) and for other purposes. The maximum capacity of the riparian outlet is 1,036 ML/d (equivalent to ≈12 m^3/s).

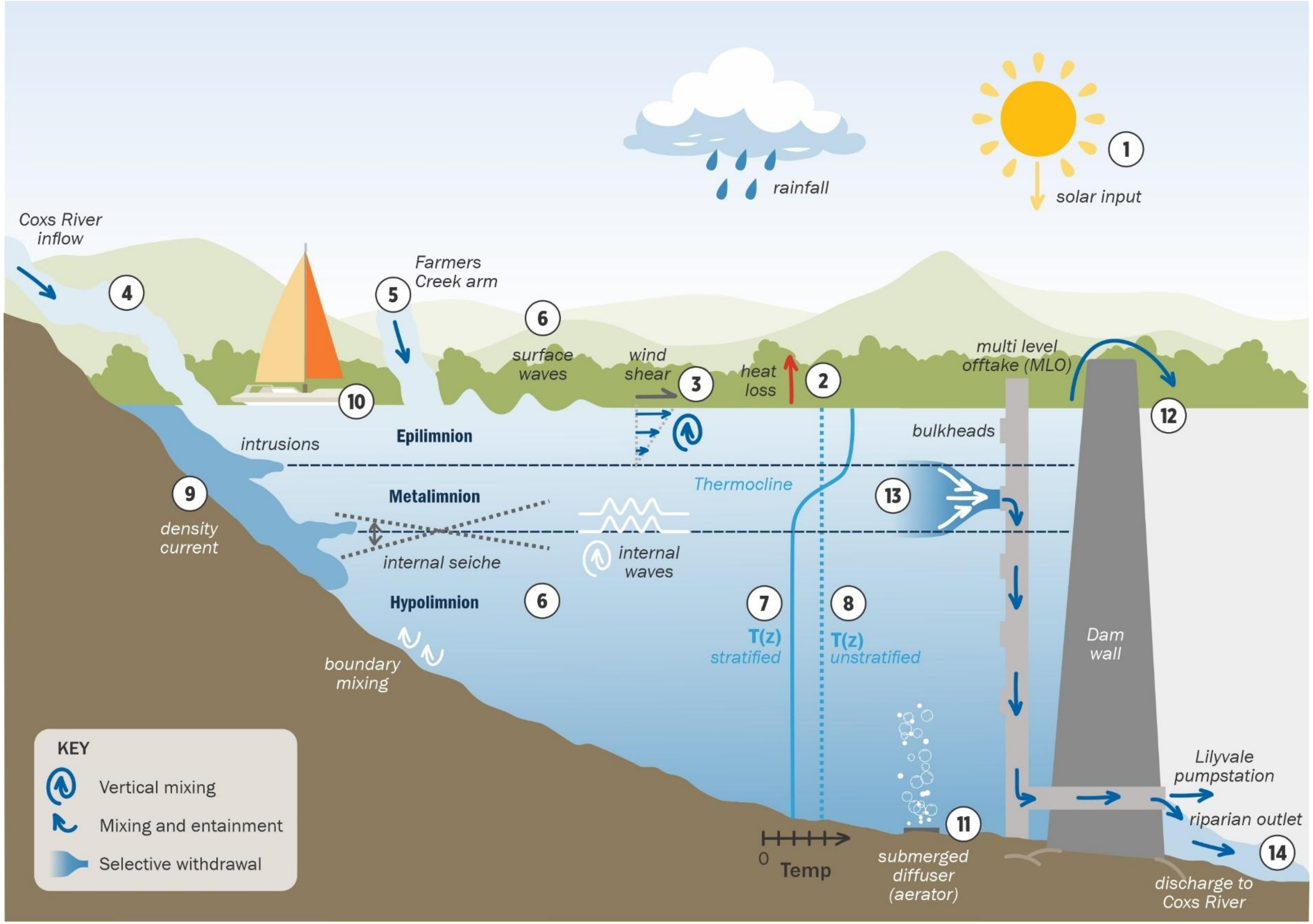


Figure 4.25 Conceptual water cycle processes model for Lake Lyell

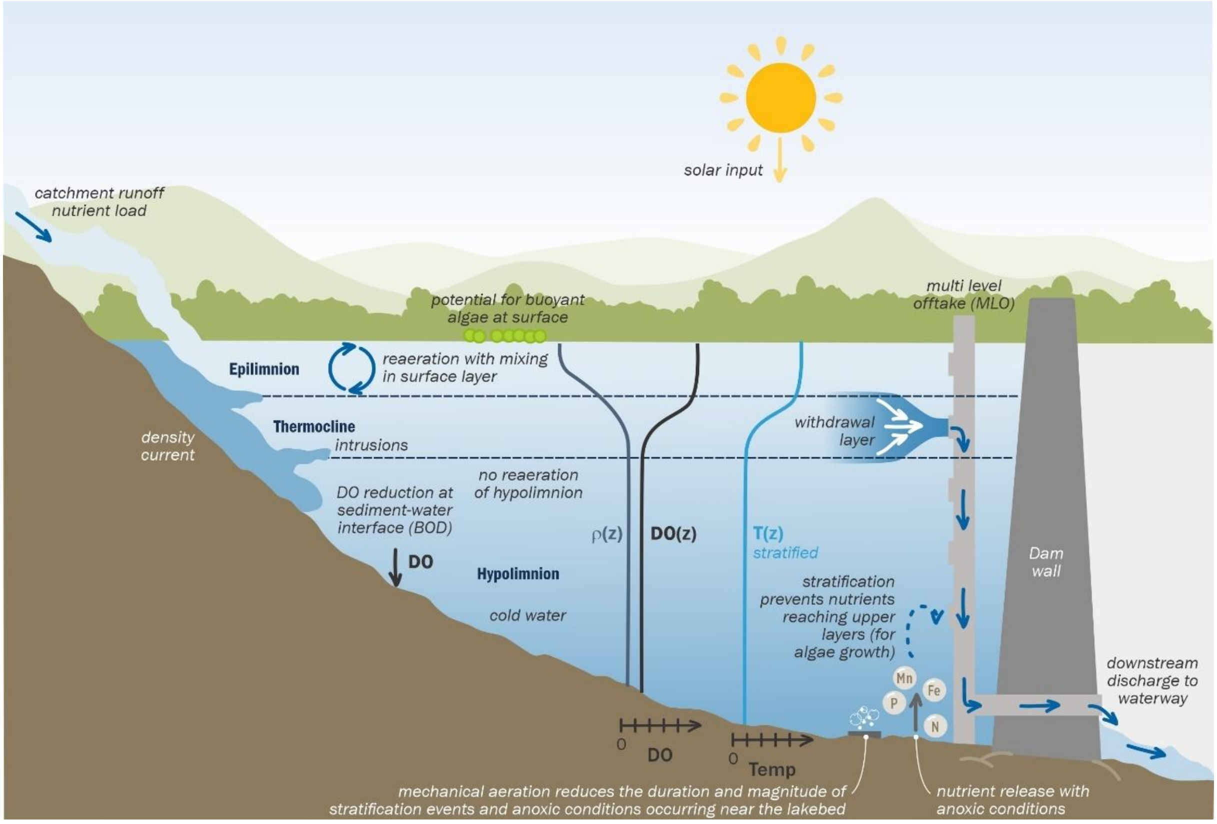


Figure 4.26 Water quality under stratified conditions

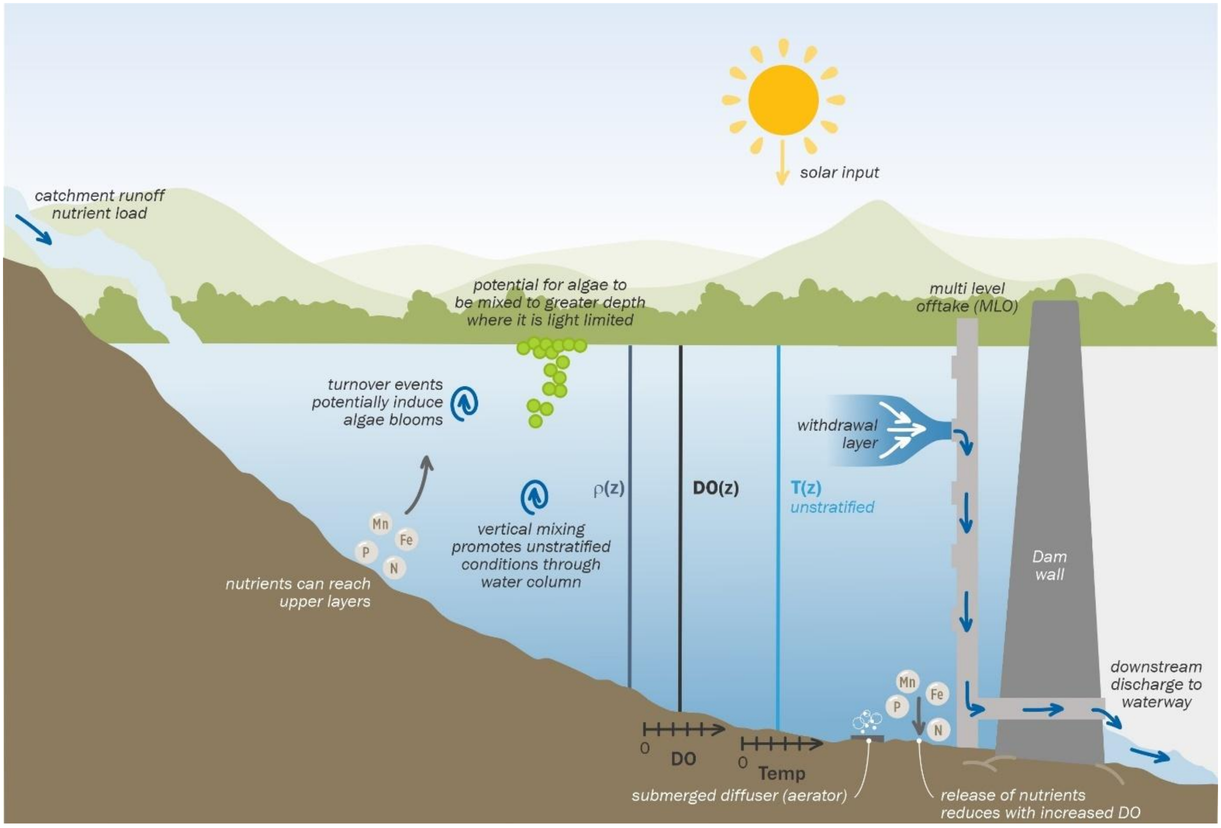


Figure 4.27 Water quality under unstratified conditions

4.6 Summary of existing condition in key receiving waters

The project will potentially discharge water into and interact with the lower reach of Farmers Creek that is upstream of Lake Lyell (Farmers Creek (lower reach)), Lake Lyell and the watercourses and drainage lines that are shown in Figure 4.4. Therefore, the project has potential to change the existing water quality and water cycle regimes in these immediate receiving waters. Lake Lyell releases water into the Coxs River (downstream), therefore any changes to Lake Lyell water quality or operating regime could also affect the Coxs River, downstream of Lake Lyell which means that this river reach is also a receiving water.

The project will not discharge water into or interact with the Coxs River upstream of Lake Lyell or Farmers Creek upstream of the Farmers Creek (lower reach). Therefore, these watercourse reaches are not receiving waters.

Table 4.18 provides a summary of the key water cycle and water quality conditions in the Farmers Creek (lower reach), Lake Lyell and the Coxs River downstream of Lake Lyell. A description of the watercourses and drainage lines that are shown in Figure 4.4 is provided in Table 4.5.

These descriptions are informed by the data and water cycle processes presented in this chapter for the recent period (1 July 2019 to 30 June 2024) and are used as the basis for describing potential changes to water quality and the water cycle during the construction and operational phase of the project. These changes are described in Chapters 7 and 8 (residual impacts).

Table 4.18 Summary of the existing condition in key receiving waters

Aspect	Summary of the existing condition
• **Farmers Creek (lower reach)**	
	• Farmers Creek (lower reach) refers to the lower 2,800 m reach of Farmers Creek that is upstream of Lake Lyell. This reach of the creek meanders through steep vegetated terrain and has well established riparian vegetation. • The creek receives runoff from a 67 km^2 catchment (refer to Figure 4.3). Its flow regime is impacted by water captured in the Farmers Creek Reservoir, runoff from urban areas in Lithgow and discharges from the Lithgow WWTP. It is estimated that Farmers Creek contributes approximately 25% of the total inflow to Lake Lyell (refer Table 4.10). • The creek water quality is characterised as having: – pH and EC that is generally within the DGV range – turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather – nutrient (TN and TP) concentrations that nearly always exceed DGVs and are elevated relative to concentrations in the Coxs River upstream of Lake Lyell. • There is insufficient data to identify if metals or other toxicants are present in Farmers Creek above DGV levels. • Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.
Lake Lyell	
Lake water level regime	• Lake Lyell is generally maintained in a near full condition, with water levels ranging from above FSL to 782.3 mAHD (a 4.4 m range) during the recent period. • Outside of significant wet weather events the lake water levels change slowly. • Under existing operating conditions EnergyAustralia source water from Lake Lyell to supply the Mt Piper power station. During the recent period the water extraction volumes were equivalent to approximately 3% of total outflows from the lake and was therefore a minor process. EnergyAustralia can extract greater volumes from Lake Lyell however this would only likely occur if there was reduced water availability from the Springvale WTP.

Aspect	Summary of the existing condition
Lake inflow regime	• Lake Lyell receives inflows from the Coxs River, Farmers Creek, several smaller watercourses that drain into the lake and direct rainfall. During the recent period inflows to the lake are estimated to have ranged from 28 to 116 GL/yr and originated from the following sources: – Coxs River upstream Lake Lyell – 58% – Farmers Creek upstream of Lake Lyell – 25% – inflow from smaller watercourses that drain into the lake – 14% – direct rainfall to the lake – 3%. • There are some anthropogenic activities in the Coxs River and Farmers Creek catchments that influence streamflow and water quality. During the recent period key activities include: the capture and use of water in Thompson Creek and Farmers Creek reservoirs, discharges from the Wallerawang and Lithgow WWTPs, discharges from mining operations and coal ash dams within the catchment. • Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.
Lake stratification cycle	• Central to Lake Lyell's mixing regime is the natural heating and cooling cycle of the waterbody, specifically the development of thermal stratification and its subsequent breakdown into a homogeneous water column (destratification). Water monitoring data (refer to Section 4.4.4) indicates that: – stratification can occur between October and April, with the strongest stratified state usually occurring from December to February – temporary destratification occurs during most summers due to artificial destratification and/or kinetic mixing induced by inflow or wind events – seasonal destratification typically occurs in March to April (due to convective mixing and/or artificial destratification) and unstratified conditions are prevalent from April through to September. • The following water quality conditions are associated with the stratification cycle: – low DO levels can occur in the lower lake (the hypolimnion) due to limited vertical mixing with oxygen saturated surface water in the epilimnion – low DO levels in the hypolimnion can lead to anoxic conditions near the lakebed and sediments release soluble iron and manganese and nutrients such as nitrogen and phosphorus that are stored in sediments. Once released, the soluble metals and nutrients can mix vertically when the stratification breaks down, resulting in poor water quality and a higher risk of algal blooms. • EnergyAustralia operate a submerged diffuser located on the reservoir bed near the dam wall. Operation of the diffuser system would likely reduce the duration and magnitude of both stratification events and anoxic conditions occurring near the lakebed.
Algae levels within Lake Lyell	• EnergyAustralia monitor algae at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell. The data is used to establish algae alert levels for the lake. The key conclusions from this data which is presented and analysed in Section 4.4.3 are: – algae alerts (green to red) mostly occur in summer and autumn, with autumn displaying the higher percents in amber and red. This aligns with the seasonal destratification that occurs in March and April – algae alerts are more likely to occur during dry conditions than wet conditions – algae concentrations are generally higher in upper reservoir monitoring locations then at the outlet tower – runoff from bush fire affected areas in the catchment can lead to abnormally high algae levels. • The following factors are assessed to contribute to algae growth: – high NOx (a bioavailable form of nitrogen) loads in Farmers Creek inflows create opportunities for algae growth – the seasonal destratification that occurs in March and April can supply nutrients to the epilimnion which can lead to algae growth in autumn – runoff from bush fire affected areas in the catchment can contribute abnormally high nutrient loads to the lake, creating opportunities for significant algae growth.

Aspect	Summary of the existing condition
Water quality of lake water	• The water quality of Lake Lyell is dependent on the water quality of the inflows and the limnological processes that occur within the lake (refer to Figure 4.25). Lake water quality is characterised as having: – pH that ranges between 6.0 and 10.0, relative to the DGV range of 6.5 to 8.0 – EC that ranges from 100 to 850 µS/cm, relative to a DGV of 350 µS/cm – DO that is generally within or above the DGV range at the surface but declines to below the DGV range at depth when the lake is stratified – turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather – nutrient (TN and TP) concentrations that nearly always exceed DGVs but are similar to concentrations in the Coxs River upstream of Lake Lyell. • The following additional conclusions are made from the water monitoring data and nutrient balance calculations: – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur. – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.
Coxs River downstream	
Streamflow regime	• Streamflow in the Coxs River downstream of Lake Lyell is controlled by releases from the lake which occur via: – controlled releases from the riparian outlet to meet environmental flow requirements (refer to Section 4.2.4i) and for other purposes. The maximum capacity of the riparian outlet is 1,036 ML/d (equivalent to ≈12 m^3/s) – discharges over the spillway when the water level in the lake exceeds the FSL. • A conceptual water balance of lake inflows and outflows over the recent period concluded that annual streamflow volumes in the Coxs River downstream of Lake Lyell are similar to lake inflow volumes.
Water quality	• Water quality in the Coxs River downstream of Lake Lyell is governed by the quality of water released from the lake via either controlled releases or spillway overflows. Controlled releases occur through the MLO outlet tower which is operated to draw vortex free laminar flow into the tower that generally has high DO levels, good colour and is free of floating debris, such as algae. Selective withdrawal typically occurs approximately 3 m below the water surface. Analysis of water monitoring data (refer to Section 4.4) concluded that the selective withdrawal approach is an effective mitigation method as: – the water quality in the Coxs River downstream of Lake Lyell generally has DO within the DGV range, low turbidity and algae levels that are well below levels in the reservoir – the temperature of water released from Lake Lyell is generally within the range of temperatures in Coxs River and Farmers Creek upstream of the lake which means there is no clear indication that cold water pollution is occurring. • The following additional conclusions are made from the water monitoring data (refer to Section 4.4) and nutrient balance calculations (refer to Table 4.15): – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur. – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.

5 Construction phase water management

5.1 Overview

The project is estimated to take between four to five years to construct. During construction a water management system will be operated to supply water to and manage water produced by construction activities. This chapter describes the construction water management system, it includes:

- proposed minimal harm discharge criteria that are used to describe the expected water quality within the construction water management system (refer to Section 5.2)
- a description of terminology used to describe the water management system (refer to Section 5.3)
- a description of the construction water management approach and systems (refer to Sections 5.4 to 5.7)
- a description of construction water and potable water supply systems (refer to Section 5.8)
- a description of the Lake Lyell operations during construction (refer to Section 5.9)
- a description of controls for works on waterfront land (refer to Section 5.10).

A summary of proposed measures is provided in Chapter 10.

Residual impacts associated with the construction phase of the project are described separately in Chapter 7.

Water licensing for the construction phase of the project is addressed in the water licensing strategy (EMM 2025c), using information from this chapter.

5.2 Proposed minimal harm criteria

In this chapter the expected water quality within the construction water management system is compared to minimal harm criteria that have been established based on DGVs and the ambient water quality of Farmers Creek inflows to Lake Lyell. Any discharge from the construction water system that meets the minimal harm criteria would not result in a material water quality impact as the discharge water quality would be similar to the water quality of Farmers Creek inflows into Lake Lyell. For context, Farmers Creek contributes approximately 25% of the total inflows into Lake Lyell (refer to Section 4.3.4) and is therefore the main contributor to water quality in the Farmers Creek arm of Lake Lyell and a key contributor to water quality in the greater lake.

Table 5.1 establishes the proposed minimal harm criteria. Refer to table notes for assumptions and explanations. It is noted that:

- EC is not included as discharge volumes from the construction water system will be minor compared to lake inflow volumes and therefore cannot materially change salinity levels in Lake Lyell.
- The TN and TP concentrations in the minimal harm criteria are based on the 80th percentile concentrations in Farmers Creek inflows. It is proposed that the minimal harm criteria will be an upper bound threshold which means that the concentrations in discharge that meet these criteria will generally be below the upper bound value.

The minimal harm criteria are used:

- to benchmark the expected water quality at different points in the construction water management system
- in the proposed water categorisation approach

- to inform the residual impact assessment that is discussed in Chapter 7.

Table 5.1 Proposed minimal harm water quality criteria

	Units	DGV[1]	Ambient water quality range in Farmers Creek[2]	Proposed minimal harm criteria
pH		6.5 to 8.0	7.2 to 7.9	6.5 to 8.0
Turbidity	NTU	25	<10	25
TN	mg/L	0.25	0.8 to 1.6	1.6
TP	mg/L	0.02	0.02 to 0.07	0.07
Metals and metalloids	varies	Values for slightly-to-moderately disturbed freshwater ecosystems described in the ANZG (2018) guidelines	Insufficient data[3]	DGVs occasionally exceeded for some metals[3]
Hydrocarbons	varies		Not monitored	Below laboratory detection concentrations

Notes:

1. DGVs for a slightly-to-moderately disturbed freshwater upland river that are described in Table 4.14.
2. The ambient lake water quality range is the 20th and 80th percentile values from COX6 (Farmers Creek upstream of Lake Lyell) that are provided in Table A.3 in Annexure A.
3. There is insufficient data to reliably characterise ambient concentrations of metals and metalloids in Farmers Creek. Based on the water quality data from other sites (i.e. WX13 and COX8A), it is expected that concentrations of some metals (i.e. aluminium, zinc and nickel) would occasionally exceed DGVs. In the water quality tables in Annexure A, exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples.

5.3 Terminology

The construction water management system will include separate systems to manage contaminated water and stormwater produced by construction activities and will supply non-potable to construction activities. In addition, a potable water and wastewater system will supply water to and manage wastewater produced at the accommodation camp and amenities within the main construction complex.

Table 5.2 provides an overview of each system and a reference to where it is described in this chapter. Table 5.3 describes the water categories that are used to describe the systems and notes the expected water quality.

Table 5.2 Water management system

System	Description	Section reference
Construction water system	Refers to the overall water management system that includes a contaminated water system, stormwater system and construction water supply system.	See below
Contaminated water system	In this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria (refer to Table 5.1). The contaminated water system will manage potentially contaminated water generated from construction activities to minimise pollution of the stormwater system and receiving surface and groundwater systems.	Section 5.5
Stormwater system	The stormwater system will manage surface water runoff that is not contaminated water from areas disturbed by construction. The stormwater system will be separated from the contaminated water system.	Section 5.6

System	Description	Section reference
Construction water supply system	The construction water supply system will supply water to construction activities. The system will beneficially and preferentially use water from the contaminated water and stormwater systems following treatment (if required).	Section 5.8.2
Potable water supply system	The potable water system will supply water that is suitable for human consumption to the accommodation camp and amenities within the main construction complex.	Section 5.8.1
Wastewater system	The wastewater system will manage wastewater (i.e. sewage) produced at the accommodation camp and amenities within the main construction complex.	Section 5.7

Table 5.3 Water categories

Term	Description
Clean water	Refers to surface water runoff from areas that are either undisturbed by construction activities or rehabilitated following disturbance. Where practical, clean water will be diverted around disturbance areas to minimise the volume of stormwater or contaminated water that requires management. Clean water can be diverted into a receiving water without treatment.
Lake water	Refers to water in Lake Lyell. The ambient water quality of lake water is described in Table 4.18. The minimal harm discharge criteria (refer to Table 5.1) are also representative of the ambient water quality of Farmers Creek inflows into Lake Lyell, which account for approximately 25% of total inflows into Lake Lyell.
Groundwater	Refers to groundwater in the regional groundwater systems that are near the project. Groundwater systems and quality are described in the groundwater assessment (EMM 2025a).
Stormwater	Refers to stormwater runoff from areas disturbed by construction activities. Stormwater may have elevated suspended solids concentrations and turbidity levels but is otherwise expected to have water quality that is similar to the minimal harm discharge criteria (refer to Table 5.1) (i.e. ambient water quality in Farmers Creek).
Treated stormwater	Treated stormwater is stormwater that has been captured and treated for suspended solids. The water quality of treated stormwater is expected to be similar to the minimal harm discharge criteria (refer to Table 5.1) (i.e. ambient water quality in Farmers Creek).
Potentially contaminated water	Potentially contaminated water refers to water produced by construction activities that may have concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria. A procedure informed by regular water quality monitoring will be used to categorise potentially contaminated water as being either stormwater or contaminated water.
Contaminated water	In this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria (refer to Table 5.1). Contaminated water will be managed separately to stormwater.
Nitrogen laden water	Refers to contaminated water that has high concentrations of nitrogen compounds.
Wastewater	Refers to wastewater produced by the onsite amenities (i.e. sewage).
Potable water	Refers to water that is suitable for drinking.
Construction water	Refers to water that has been treated to a suitable standard for use in construction activities. Construction water will have low suspended solids and near neutral pH.

5.4 Construction water management approach

The construction water management system will supply water to and manage water produced by construction activities. It will include separate systems to manage contaminated water and stormwater water. Overall, the systems will be designed, constructed and operated to achieve the following objectives:

1. Where practical, clean water will be diverted around stormwater management areas to minimise the volume of stormwater that requires management.

2. Potentially contaminated water will be separated from stormwater to minimise stormwater contamination and the volume of contaminated water that requires management following wet weather. For parts of the contaminated water systems that will unavoidably receive stormwater ingress, diversion systems will be constructed upstream of contaminated water storages to divert surplus inflows into the stormwater system when storages are full. This will only occur during intense rainfall events when most of the inflows are stormwater and will minimise overflows from the contaminated water storages.

3. The contaminated water system will:

    a) capture and contain contaminated water to minimise spills into the stormwater system

    b) beneficially use captured water in construction to minimise the need for and volumes of discharge

    c) treat surplus water to meet the minimal harm criteria prior to discharge to Farmers Creek arm of Lake Lyell.

4. Stormwater will be managed in accordance with the methods described in Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004).

This assessment describes two approaches for the contaminated water system:

- Option 1 (source control approach) – applies a combination of targeted management of nitrogen laden water, beneficial reuse, controlled irrigation and water treatment to manage contaminated water.

- Option 2 (centralised approach) – applies fewer source controls and relies on beneficial reuse, controlled irrigation and water treatment to manage contaminated water.

The preferred water management system approach for each phase of construction will be established at detailed design in consultation with regulators and will be documented in a Construction Water Management Plan that will be prepared post approval in accordance with relevant consent conditions.

Figure 5.1 and Figure 5.2 show the framework of the construction water system for Option 1 (source control approach) and Option 2 (centralised approach) respectively.

Figure 5.3 shows a conceptual layout of the construction water system that identifies indicative clean water diversion systems, stormwater management areas and sources of potentially contaminated water.

The contaminated water and stormwater and systems are described in Sections 5.5 and 5.6 respectively.

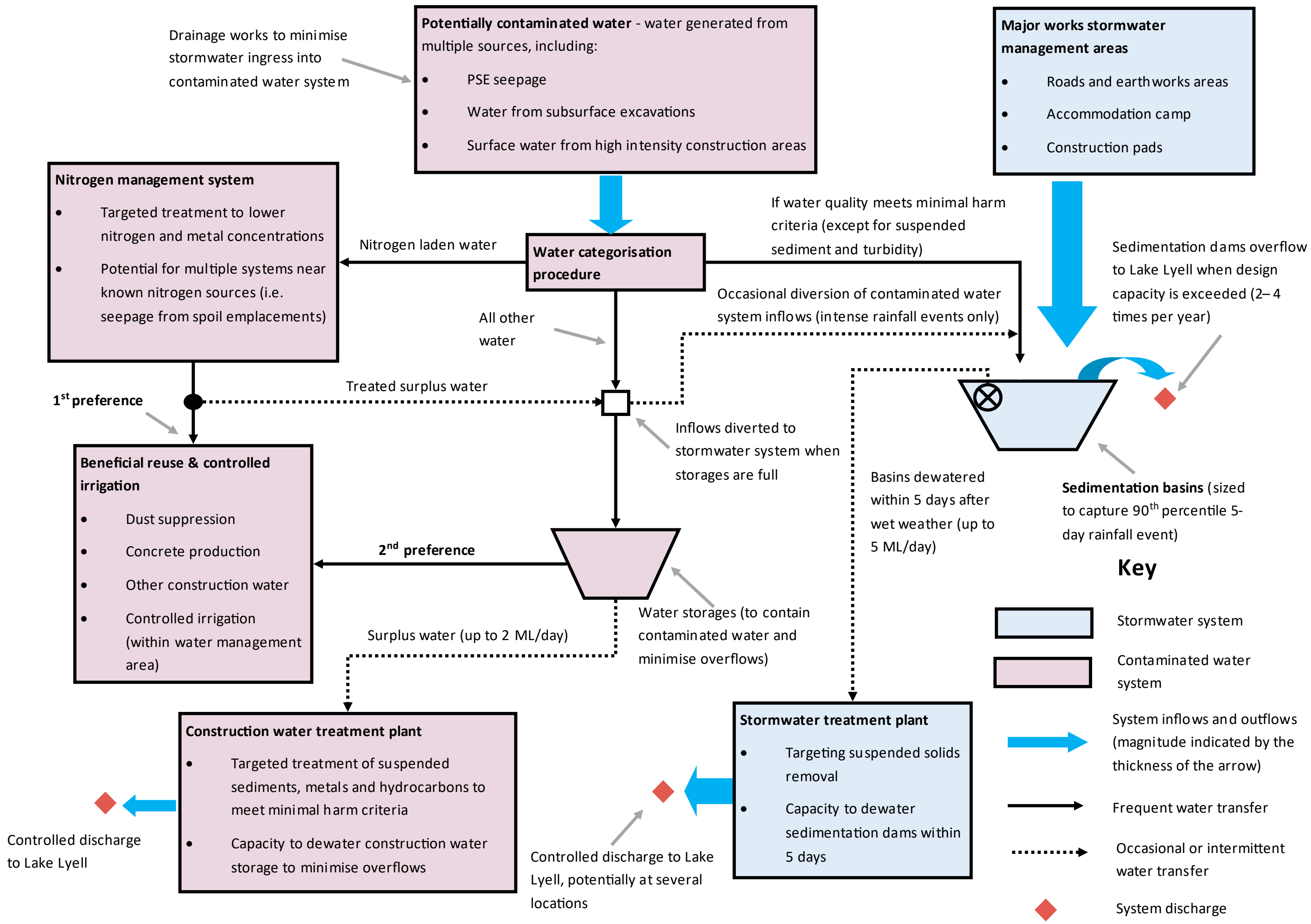


Figure 5.1 Construction water management system framework – Option 1 (source control approach)

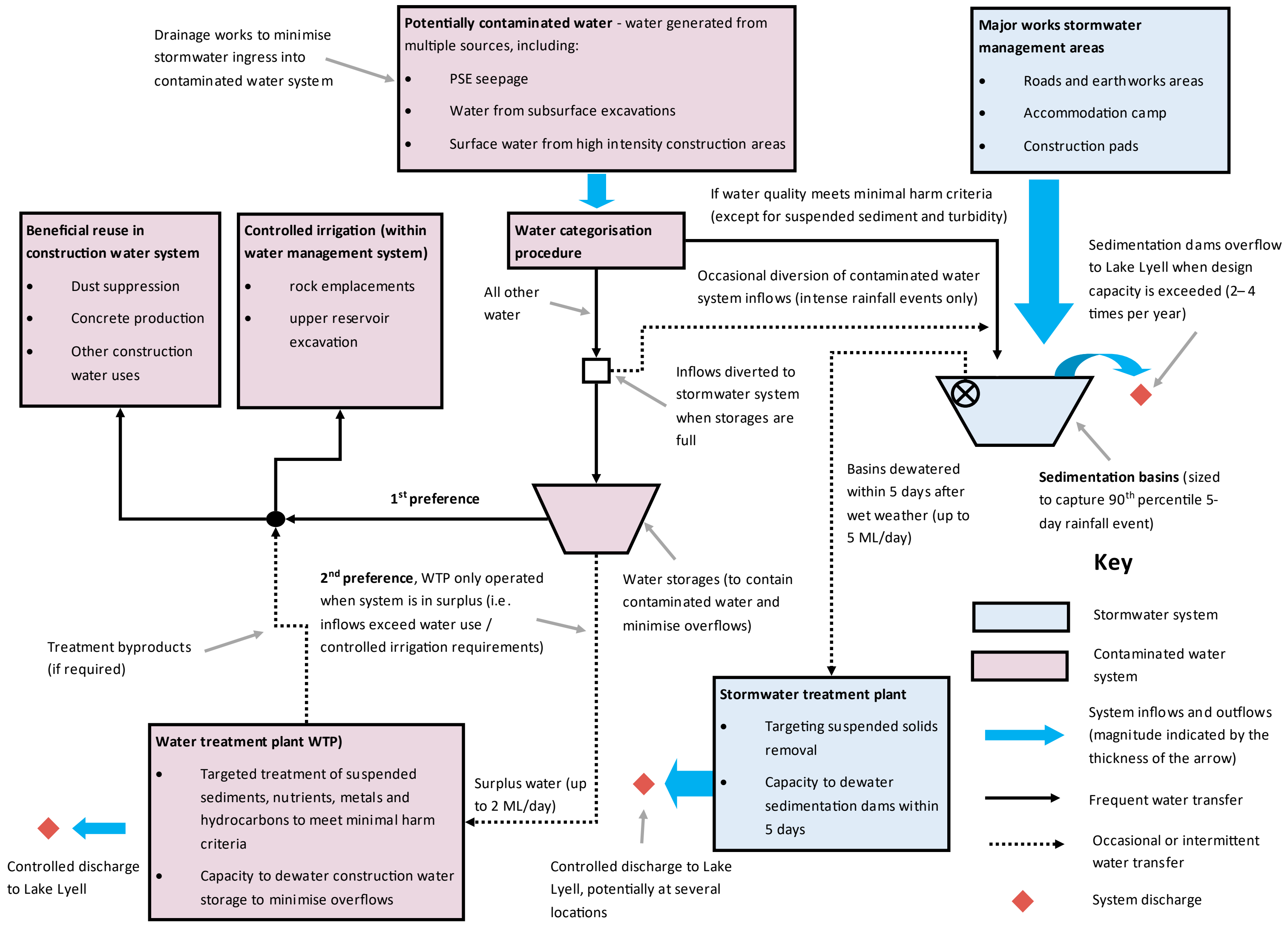
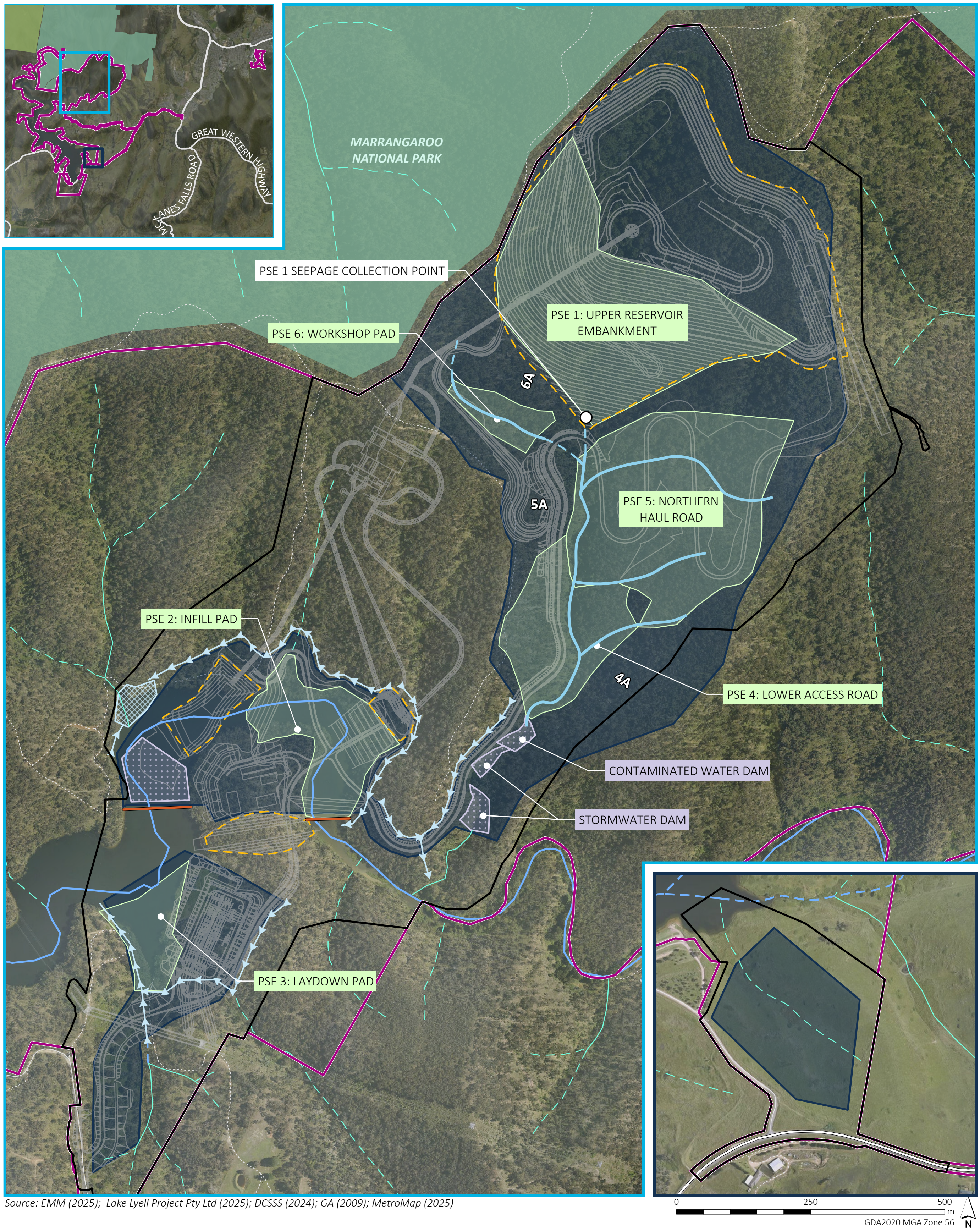


Figure 5.2 Construction water management system framework – Option 2 (centralised approach)



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

KEY

- Construction envelope
- Project area
- Seepage collection point
- Project layout
- Coffer dam
- Subsurface drainage
- Surface drainage
- Clean water diversion
- Clean water dam
- High intensity construction area
- Permanent spoil emplacement
- Water management dam
- Stormwater area (major works)

Strahler stream order (adjusted)

- 1st order
- 2nd order
- 3rd order
- 4th order

Existing environment

- Major road (refer to inset)
- Minor road
- Vehicular track
- NPWS reserve
- State forest (refer to inset)

Conceptual layout of construction water management system

Lake Lyell PHES
Surface Water Impact Assessment
Figure 5.3

EMM creating opportunities

The conceptual water system layout will be further developed at detailed design and may vary from the layout shown.

5.5 Contaminated water system

5.5.1 Overview

In this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria (Table 5.1). The contaminated water system will manage potentially contaminated water generated from construction activities to minimise pollution of the stormwater system and receiving surface and groundwater systems.

As described in Section 5.4, this assessment describes two possible approaches for the contaminated water system:

- Option 1 (source control approach) – applies a combination of targeted management of nitrogen laden water, beneficial reuse, controlled irrigation and water treatment to manage contaminated water. A system framework for this approach is shown in Figure 5.1.
- Option 2 (centralised approach) – applies fewer source controls and relies on beneficial reuse, controlled irrigation and water treatment to manage contaminated water. A system framework for this approach is shown in Figure 5.2.

Both options would achieve similar outcomes in terms of minimising pollution of the stormwater system and receiving surface and groundwater systems.

The preferred approach for each construction phase will be established at detailed design in consultation with regulators and will be documented in the construction water management plan (CWMP).

The following sections describe the sources of potentially contaminated water and the key components of the Option 1 and Option 2 systems. A table form summary of Option 1 and Option 2 and associated discharge characteristics is provided at the end of this section.

5.5.2 Sources of potential contaminated water

Sources of potentially contaminated water will vary over the construction program and may continue post construction. The key sources are:

- runoff (during construction) and seepage (during and after construction) from permanent spoil emplacements (PSEs)
- water pumped from subsurface excavations during construction
- surface water runoff from high intensity construction areas.

i Runoff and seepage from PSEs

The construction of surface and subsurface infrastructure for the project will require the excavation of significant quantities of rock. Most excavated rock will be beneficially used to construct the upper reservoir embankment, construction pads and roads. Due to potential water quality risks associated with excavated rock emplacements, the upper reservoir, access road landforms and construction pads are described as being PSEs in the EIS. Six PSEs are proposed. These PSEs are divided into the following categories:

- Embankment constructed using excavated rock – PSE 1 will be the embankment for the proposed upper reservoir
- In-reservoir PSEs - PSE 2 and 3 will be partially below the Lake Lyell FSL

- Land-based PSEs - PSE 4, 5 and 6 will be land-based emplacements.

The location and footprint of each PSE is indicated in Figure 5.3.

The excavated rock management strategy (EMM 2025c) includes:

- a description of excavated rock sources and proposed PSEs
- a description of the geochemical characteristics of excavated rock and the potential water quality risks from excavated rock emplacements
- design principles and concepts for each PSE.

The following key information from the excavated rock management strategy (EMM 2025c) is relevant to construction water management:

- During construction surface water runoff and seepage from each PSE will be potentially contaminated water.
- The upper reservoir embankment (PSE 1) and land-based PSEs (PSE 4, 5 and 6) will be constructed in the Watercourse 3 catchment. Each emplacement will include subsurface drainage to facilitate drainage through the landforms to the water management dams that will be in the lower portion of the Watercourse 3 catchment. The indicative layout of the subsurface drainage and water management dams is shown in Figure 5.3. Further information on subsurface drainage is provided in the excavated rock management strategy (EMM 2025c).
- The water quality of PSE runoff (during construction) and seepage will be influenced by the geochemistry of the rock (which is variable) and the excavation method. Table 5.4 describes the interpreted water quality of PSE runoff (during construction) and seepage.

PSE runoff (during construction) and seepage will be collected and managed in the contaminated water system until water quality monitoring demonstrates that water quality meets the minimal harm criteria. Routine monitoring of seepage quality and volume will be undertaken and ongoing treatment after the construction phase of the project may be required (discussed in Section 6.3).

Table 5.4 Interpreted water quality of PSE runoff (during construction) and seepage

Source	Description
Geochemistry related	LLP commissioned a geochemistry characterisation study to identify and characterise rock geochemistry and associated water quality risks. The study utilised rock samples from geotechnical and hydrogeological drilling programs that were undertaken to inform the project's concept design and EIS and is documented in the Geochemical Characterisation Report, which is provided as Annexure A of the excavated rock management strategy (EMM 2025c). The study results indicate that the excavated rock will: • not pose a significant acid metalliferous drainage risk • not pose a significant saline drainage risk • large-scale mobilisation of metals and metalloids other than aluminium is unlikely if acidification risks can be managed • there is a low likelihood of excavated rock containing Naturally Occurring Asbestos (within the range of lithologies and depths investigated).

Source	Description
Construction related	Due to rock conditions, drill and blast methods will be required to construct most of the proposed subsurface and major surface and excavations. The use of ammonium nitrate fuel oil (ANFO) explosives is a known source of nitrogen contamination of water in construction areas where blasting is used and seepage from stockpiles of drill and blast generated material. The release of nitrogen can occur due to: • leaching from explosives prior to detonation • leaching from undetonated explosives after detonation • nitrogen residue in blasted material after detonation. Nitrogen residual in blasted material is bound to the surface of rock fragments. Given that nitrogen compounds including ammonium and nitrate are highly soluble, leaching of residual nitrogen is expected to occur in the short to medium term following blasting. The timeframes for leaching are expected to be variable based on a range of factors including PSE construction timeframes, blasting intensity, types of explosives used, exposure of blasted material to weather and water prior to placement, the design of PSEs and water exposure of the material following placement. It is anticipated that the leaching rate can be accelerated by irrigating excavated rock during construction of emplacements. The excavated rock management strategy assumed that drill and blast generated material may leach nitrogen at concentrations that are elevated relative to the receiving waters. The rate of leaching will be highest immediately after placement (which could occur for several years for some PSEs) and will decline overtime. It is noted that controls to manage nitrogen laden water are discussed in Section 5.5.3ii.

ii Water from subsurface excavations during construction

The tunnels, powerhouse cavern and surge shaft will be excavated using a combination of drill and blast and raise bore methods. Most of the excavations will be below the groundwater table which means that groundwater inflows into the excavations will occur during and after construction. During construction groundwater inflows will be collected in sumps and pumped to the surface to maintain construction access.

Groundwater inflows into subsurface excavations during construction are described in the groundwater assessment (EMM 2025a) and are reproduced in Table 5.5.

Table 5.5 Predicted groundwater inflows during construction

Construction year	Groundwater inflows[1] (ML/yr)
Year 1	22.4
Year 2	31.9
Year 3	61.9
Year 4	56.6
Range	22.4 to 61.9

Notes: 1. Results are from Table 9.1 of Groundwater Assessment (EMM 2025a) and relate to 90th percentile results.

The quality of water pumped from subsurface excavations during construction will be a function of the quality of groundwater inflows and influences due to construction activities. The groundwater assessment (EMM 2025a) characterises ambient groundwater quality using data provided by EnergyAustralia from 13 monitoring bores. Table 5.6 compares the groundwater quality range at these bores to DGVs and the minimal harm criteria. The available data indicates that the water quality of groundwater inflows will have salinity levels that are similar to ambient levels in Lake Lyell and potentially concentrations of several metals that exceed DGVs.

Table 5.6 Water quality of groundwater inflows to subsurface excavations

	Units	DGV[1]	Proposed minimal harm criteria	Ambient groundwater quality range[2]
pH		6.5 to 8.0	6.5 to 8.0	5.8 to 8.9
Turbidity	NTU	25	25	ND[2]
EC	µS/cm	350	See note 3	240 to 1,000
TN	mg/L	0.25	1.6	ND[2]
TP	mg/L	0.02	0.07	ND[2]
Metals and metalloids	varies	values for slightly-to-moderately disturbed freshwater ecosystems described in the ANZG (2018) guidelines	DGVs occasionally exceeded for some metals	Available data indicates that concentrations of As, Cu, Fe, Ni and Zn may exceed DGVs
Hydrocarbons	varies		Below laboratory detection concentrations	ND[2]

Notes:

1. DGVs for a slightly-to-moderately disturbed freshwater upland river that are described in Table 4.14.
2. The groundwater quality range is the range shown in the box and whisker plots in Figure 6.5 and 6.6 of the groundwater assessment (EMM 2025a). ND indicates that no data is provided for the given analyte.
3. EC is not included in the minimal harm criteria. For context ambient electrical conductivity levels in Lake Lyell ranged from 266 to 661 µS/cm at COX8a (outlet tower).

Construction activities such as blasting, the use of concrete and grout and operation of plant and equipment have potential to introduce other pollutants such as suspended sediment, nitrogen, metals and hydrocarbons to water that is pumped from subsurface excavations.

Available information indicates that:

- intercepted groundwater that is not impacted by construction activities is likely to be similar to the minimal harm criteria except the concentrations of some metals may exceed DGVs

- intercepted groundwater that is impacted by construction activities may have concentrations of suspended sediment, nitrogen, metals and hydrocarbons that exceed the minimal harm criteria and will therefore be managed in the contaminated water system.

iii Surface water from high intensity construction areas

The term high intensity construction is used to describe surface construction activities that use blasting to assist excavation, require large scale concreting or grouting works and/or require intensive use of plant and equipment. Surface water runoff from these areas may have concentrations of suspended sediment, nitrogen, metals and hydrocarbons that exceed the minimal harm criteria and will therefore be managed in the contaminated water system. It is noted that potential for these water quality risks would only occur during construction works. Following construction surface water runoff from these areas would be stormwater or clean water.

The construction of the lake diversion, inlet and outlet structure, MAT portal and the upper reservoir will be high intensity construction works. Approximate areas of these works are indicated in Figure 5.3. Table 5.7 describes the key construction activities and indicative surface areas.

Table 5.7 High intensity construction areas

High intensity construction work	Construction activities	Indicative area
Lake diversion	Blasting and intensive earthworks	1.2 ha
Inlet and outlet structure	Blasting, intensive earthworks, large scale concreting	2.9 ha
MAT Portal	Blasting, intensive earthworks, large scale concreting	0.5 ha
Upper reservoir	Blasting and intensive earthworks	27.0 ha
Total		**31.6 ha**

Surface water runoff from high intensity construction areas will be managed in the contaminated water system. Where practical, drainage works will be implemented to divert clean water and stormwater around high intensity construction areas to minimise the volume of contaminated water that requires treatment during and after wet weather.

5.5.3 Contaminated water system Option 1

The Option 1 approach is to manage contaminated water through a combination of targeted treatment of nitrogen laden water, beneficial reuse of contaminated water in construction, controlled irrigation and treatment of surplus contaminated water to meet the minimal harm criteria. The framework for this approach is described in Figure 5.1. Key system components are described in the following sections.

i Water categorisation procedure

As indicated in Figure 5.1, a water categorisation procedure will be implemented to categorise potentially contaminated water as being either stormwater or contaminated water. Contaminated water will be further categorised to identify nitrogen laden water, which is contaminated water that contains high nitrogen concentrations. Nitrogen laden water will be managed in the nitrogen management system that will include targeted nitrogen treatment. Surplus contaminated water (that is not nitrogen laden water) will be treated in the construction water treatment plant prior to discharge.

The implementation of a water categorisation procedure will achieve the following objectives:

- The water quality of key potentially contaminated water sources will be progressively categorised to enable the most effective management approach to be implemented.
- The volumes of contaminated water will be minimised by separating contaminated water from stormwater.
- The separation of high and low nitrogen concentration water will enable targeted management of nitrogen laden water and a less complex treatment process for the contaminated water treatment plant.

The water categorisation procedure will be included in the Construction Water Management Plan. It will include:

- a concentration threshold for nitrogen laden water based on dilution in the system and the nitrogen treatment efficacy of the contaminated water treatment plant. The overall objective will be to ensure that high concentration nitrogen water is treated in the nitrogen management system so that the nitrogen concentration in discharge meets the minimal harm criteria of 1.6 mg/L
- a water monitoring procedure that specifies monitoring locations, frequencies and analytes

- a methodology for categorising water as being stormwater, nitrogen laden water and contaminated water (low nitrogen concentration). The methodology will apply a conservative approach to categorising potentially contaminated water as being stormwater. For example, potentially contaminated water will not be categorised as stormwater (i.e. appropriate for discharge) until monitoring data from recent samples can clearly demonstrate that future water quality will be consistent with stormwater quality.

ii Nitrogen management strategy

Due to rock conditions, drill and blast methods will be required to construct some of the proposed surface and subsurface excavations. As described in Table 5.4, ANFO explosives are a source of nitrogen. The following sections describe controls to minimise the release of nitrogen and to manage nitrogen laden water from construction areas.

a Controls to minimise the release of nitrogen

The release of nitrogen cannot be avoided but can be reduced by:

- measures to minimise the release of nitrogen prior to detonation
- optimisation of blasting activities to minimise the overall use of explosives
- measures to locate and remove unexploded explosives post detonation.

A nitrogen management plan will be prepared as part of the CWMP. The nitrogen management plan will include protocols for storing, handling and using explosives to minimise the release of nitrogen from explosives use.

b Management of nitrogen laden water

Water from construction areas where blasting is used and seepage from stockpiles of drill and blast generated material may have elevated concentrations of nitrogen. On other similar projects the nitrogen has been primarily in nitrate form (a bio-available form of oxidised nitrogen) and typically has concentrations between 5 to 20 mg/L.

The treatment of nitrate to low concentrations can be challenging in high-capacity water treatment plants and typically requires an advanced water treatment system.

The Option 1 approach is to avoid the need for advanced water treatment systems by separating the relatively small volumes of nitrogen laden water from other contaminated water and applying targeted biological treatment to treat the nitrogen laden water. This approach aligns with the general principle that biological based treatment systems are more effective at treating smaller volumes of water with higher nutrient concentrations than larger volumes of water with lower nutrient concentrations.

The nitrogen management systems will be developed at detailed design but could include:

- Management using closed loop irrigation – Nitrogen laden water could be managed using a closed loop irrigation and nitrogen treatment system. The key components are micro-nutrient supplements (i.e. dissolved carbon and phosphorus and reactive silica) would be added to nitrogen laden water to enable biofilm growth, the dosed water would be irrigated to either a rock face (i.e. an exposed wall in the upper reservoir) or a pile of rocks to promote nitrogen removal via biofilm growth on the rocks as well as evaporation losses. Runoff from the irrigation area would be collected in a sump and recirculated. This approach would promote removal of nitrogen via biofilm growth on the rock media and manage water accumulation in the system via evaporation. Wood chips could potentially be used to provide a source of carbon and promote denitrifying processes.

- Biological treatment using algae-based systems - These systems are effective at removing nutrients and metals to low concentrations. The key components are targeted diatoms (which are species of algae that naturally occur in waterways), micro-nutrient supplements to enable algae growth (i.e. dissolved carbon and phosphorus and reactive silica), a treatment system that creates favourable conditions for algae growth (i.e. high DO, near neutral pH, low turbidity and adequate residence time). Effective treatment will typically require one to two weeks of residence time which means that this approach would only be suitable for managing relatively small volumes of nitrogen laden water, such as seepage from a PSE. Treated water could be beneficially used in construction, blended into the contaminated water system, or (if water quality is suitable) released into the stormwater system.

Figure 5.4 illustrates concepts for the above systems.

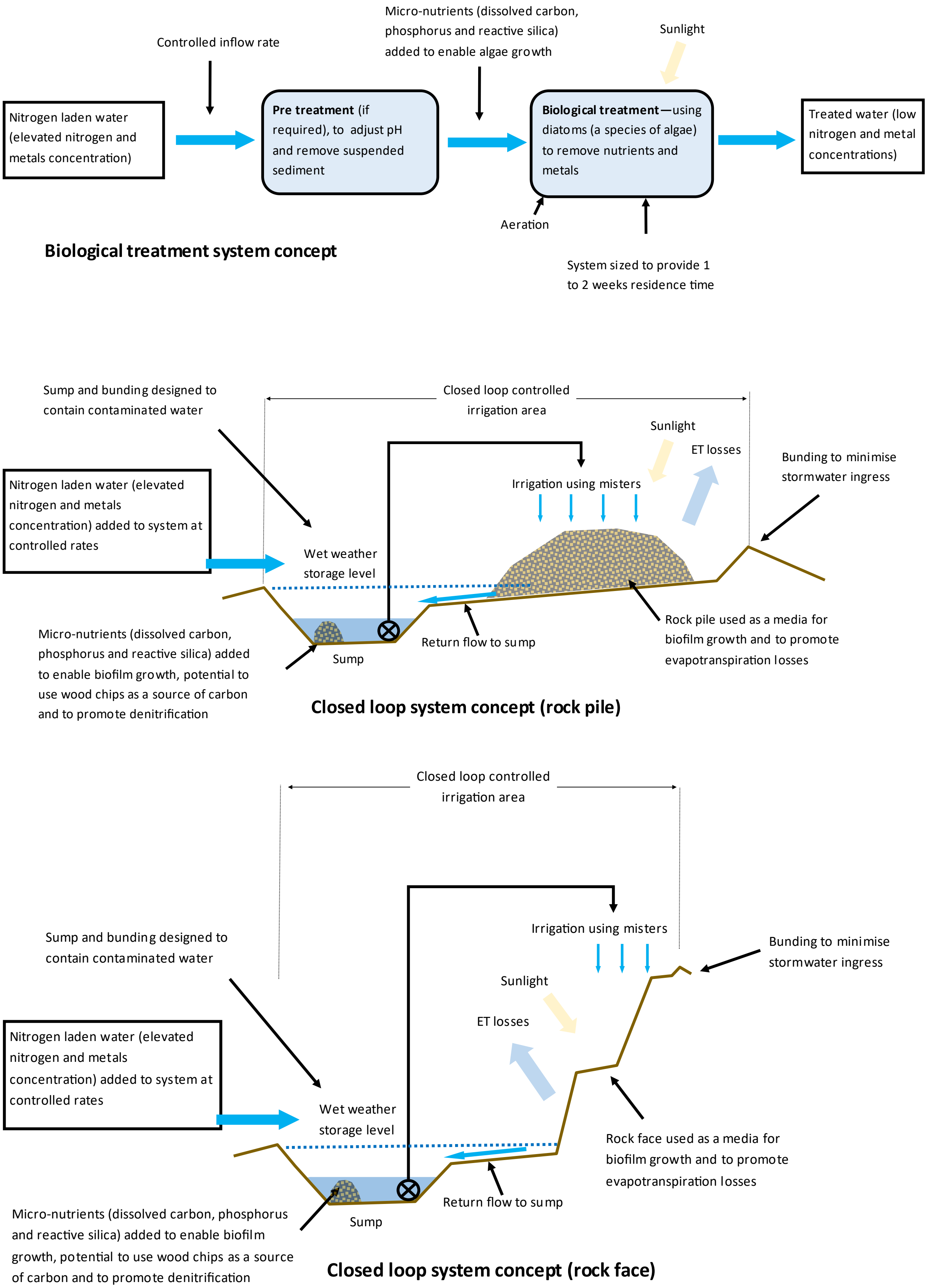


Figure 5.4 Concepts for nitrogen management systems

iii Construction water treatment plant

A construction water treatment plant would treat surplus water from the contaminated water system. As nitrogen laden water would be managed in the nitrogen management system the treatment system would target removal of suspended solids, metals and hydrocarbons to meet the minimal harm criteria (refer to Table 5.1). The system would be designed at detailed design but is expected to be a modular system that can be expanded and modified as required, have a capacity of between 1 to 2 ML/d and discharge treated water into the Farmers Creek arm of Lake Lyell.

5.5.4 Contaminated water system Option 2

The Option 2 approach is for a centralised system that manages contaminated water via a combination of:

- beneficial reuse in construction
- controlled irrigation within the contaminated water system area
- treatment and discharge of surplus water.

The framework for Option 2 is described in Figure 5.2.

The key difference between Option 1 and Option 2 is that Option 2 will have more reliance on water treatment to manage nitrogen in contaminated water. This would likely mean that a more advanced water treatment system is required.

Key system components are described in the following sections.

i Water categorisation procedure

The water categorisation procedure would be similar to the Option 1 procedure (refer to Section 5.5.3i) except it would only categorises water as being stormwater or contaminated water.

ii Nitrogen management strategy

A nitrogen management plan will be prepared as part of the CWMP. The nitrogen management plan will include protocols for storing, handling and using explosives to minimise the release of nitrogen from explosives use.

Nitrogen laden water would be combined with other contaminated water and treated in the centralised system.

iii Water treatment plant

A construction water treatment plant would treat surplus water from the contaminated water system. The preferred treatment approach will be established at detailed design but is expected to be a modular system that can be expanded as required, have a capacity of between 1 to 2 ML/d and discharge treated water into the Farmers Creek arm of Lake Lyell. The treated water quality would meet the minimal harm criteria (refer to Table 5.1).

5.5.5 Comparison of Options 1 and 2

Table 5.8 compares the management approach and system discharge characteristics for Options 1 and 2.

Table 5.8 Comparison of Options 1 and 2

Aspect	Option 1 (source control approach)	Option 2 (centralised approach)
Management approach		
System description	A semi-centralised system that uses a combination of targeted management of nitrogen laden water, beneficial reuse, controlled irrigation and water treatment to manage contaminated water.	A centralised system that uses beneficial reuse, controlled irrigation and water treatment to manage contaminated water.
Key controls	• Controls to minimise the release of nitrogen due to explosives use. • Water categorisation procedure to separate stormwater, nitrogen laden water and low nitrogen concentration contaminated water. • Targeted treatment of nitrogen laden water to reduce nitrogen concentrations in the contaminated water system. • Beneficial reuse and controlled irrigation to reduce the frequency and magnitude of discharges. • Treatment and discharge of surplus contaminated water to meet minimal harm criteria.	• Controls to minimise the release of nitrogen due to explosives use. • Water categorisation procedure to separate stormwater and contaminated water. • Beneficial reuse and controlled irrigation to reduce the frequency and magnitude of discharges. • Treatment and discharge of surplus contaminated water to meet minimal harm criteria.
System discharges		
Receiving water	Farmers Creek arm of Lake Lyell.	
Regime	Intermittent discharges when system inflows exceed construction water use and controlled irrigation rates. Discharges are more likely during and after wet weather, during cooler months when evaporation rates are lower and during construction years 3 and 4 when groundwater inflows are higher.	
Volumes	The maximum discharge rate is estimated to be between 1 to 2 ML/d.	
Water quality	Discharge quality to meet minimal harm criteria (refer to Table 5.1).	

5.6 Stormwater system

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

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

The stormwater system will also manage water from the contaminated water system that is categorised as stormwater using the water categorisation procedure (refer to Section 5.5.4i) and any high flow diversions from the contaminated water system that may occur during intense rainfall events (refer to Section 5.4).

There are three key components to the stormwater system:

- Clean water diversions – The stormwater system will include several temporary and permanent clean water systems to divert clean water runoff either around or through construction areas. Indicative locations of temporary and permanent systems are shown in Figure 5.3.
- Stormwater management for minor works – applies to construction of roads, service trenches and minor works where construction will disturb a small portion of a catchment for a short period (i.e. typically less than three months).
- Stormwater management for major works – applies to construction works that will disturb a moderate to large portion of a catchment for a longer period of time (i.e. more than three months). Major works stormwater management areas are indicated in Figure 5.3 and include construction pads and the accommodation camp. The total stormwater management area for major works is approximately 100 ha.

Table 5.9 describes the proposed controls for these stormwater system components.

Table 5.9 Stormwater system – proposed measures

ID	Measure	Proposed controls	Outcomes
SW 1	**Clean water diversions –** applies to any clean water diversion around or through construction areas. Key temporary and permanent diversions are indicated in Figure 5.3**.**	• Where practical, clean water will be diverted around or through construction areas. Runoff from clean water areas that cannot be diverted will be accounted for in the design of stormwater systems. • Clean water drainage will be designed to have non-erosive hydraulic capacity. The design event will be established based on disturbance duration, flood risks and other relevant factors. • Where practical, clean water diversions will seek to avoid increasing flow rates in adjoining catchments and watercourses. • Further controls for temporary and permanent watercourse diversions are provided in Section 5.10	• Clean water ingress into the stormwater and contaminated water systems will be minimised, which will reduce the volume of water that requires management during and following wet weather.
SW 2	**Stormwater management for minor works -** applies to construction of roads, service trenches and minor works where construction will disturb a small portion of a catchment for a short period (i.e. typically less than three months).	An Erosion and Sediment Control Plan (ESCP) will be prepared for each construction area. Each ESCP will: • apply the methods and principles provided in Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004) and where relevant Volume 2A – Installation of services (DECC 2008) and Volume 2C – Unsealed roads (DECC 2008) • consider local soil characteristics, topography and environmental constraints and proposed construction methods • all temporary drainage and sediment control measures will be designed to have non-erosive hydraulic capacity and be structurally sound for a design event. The design event will be established based on the disturbance duration and other relevant factors • consider all practical erosion control and rehabilitation methods and apply the most appropriate method • consider all practical methods to stabilise small temporary stockpiles and apply the most appropriate method • apply enhanced erosion controls where significant risks are identified • be progressively amended as required during construction.	• Best practice erosion and sediment controls will be applied to minor works areas.

<table>
<tr><th>ID</th><th>Measure</th><th>Proposed controls</th><th>Outcomes</th></tr>
<tr><td>SW 3</td><td>Stormwater management for major works – applies to construction works that will disturb a moderate to large portion of a catchment for more than three months. Major works stormwater management areas are indicated in Figure 5.3.</td><td>The stormwater system in each major works area will be described in the Construction Water Management Plan. Each system will include the following controls:
• The following source controls will be applied (where relevant):
– Potentially contaminated water will be managed separately in the contaminated water system.
– Activities that have potential to contaminate stormwater runoff (i.e. concrete batching plant) will be isolated from the stormwater system by covering (i.e. by a building or roof) and/or bunding. Potentially contaminated water produced by these activities will be managed separately to stormwater via either reuse or in the contaminated water system.
– Chemical products, including fuels and oils will be stored and handled in accordance with relevant Australian Standard AS1940:2004 and the bunding and spill management guidelines: Storing and Handling Liquids: Environmental Protection: Participant's Manual (DECC 2007).
• An erosion sediment control plan (ESCP) will be prepared for each disturbance area. The ESCP will consider all practical erosion control and rehabilitation methods for disturbed areas. The most appropriate methods will be applied to minimise sediment laden runoff and progressively rehabilitate disturbed areas.
• All temporary drainage and sediment control measures will be designed to have non-erosive hydraulic capacity and be structurally sound for a design event. The design event will be established based on the disturbance duration and other relevant factors.
• Where practical, all runoff from disturbance areas will be directed to Type D sedimentation basins sized to capture runoff from a 5-day 90th percentile rainfall event (37.8 mm[1])[1]
• Water captured in the sedimentation basins will be either beneficial used in construction (i.e. for dust suppression) or treated and discharged to Lake Lyell.
• Stormwater treatment systems will have capacity to treat captured water within five days and will target suspended sediment removal. The quality of treated water is expected to be similar to the minimal harm criteria (refer to Table 5.1).
• Water quality monitoring will be undertaken at all controlled discharge points.
The framework of the proposed stormwater controls for major works areas is shown in Figure 5.1 and Figure 5.2.</td><td>• Source controls will manage point sources of contamination within stormwater management areas.
• Best practice erosion and sediment controls will be applied to minimise sediment laden runoff.
• Captured water in sedimentation basins will be either beneficially used in construction (i.e. for dust suppression) or treated and discharged to either Lake Lyell or Farmers Creek. The quality of treated water is expected to be similar to the minimal harm criteria (refer to Table 5.1).
• Sedimentation basins will overflow when the design rainfall event is exceeded. The water quality of overflows is expected to be similar to the minimal harm criteria (refer to Table 5.1) except for suspended sediment and turbidity, which may be higher.
• Residual impacts associated with stormwater system discharges are described in Chapter 7.</td></tr>
</table>

Notes:

1. Basin sizing in accordance with the methods in Table 6-1 of Managing Urban Stormwater: Soils and Construction Volume 2E (DECC 2008). Assumes standard receiving water, greater than three-year disturbance and applies the 5-day 90th rainfall depth from Table 5.9.

5.7 Waste water management

All wastewater generated at the accommodation camp and construction site amenities will be treated and trucked to a licensed facility unless a connection to an existing nearby sewerage main is available. No onsite disposal of wastewater is proposed during construction.

5.8 Water supply during construction

5.8.1 Potable water

The maximum potable water usage at the accommodation camp and construction site amenities is approximately 230.5 kilolitres per day (KL/d). The following options for potable water supply will be investigated at detailed design:

- Potable water is trucked to site.
- Treated water from Lake Lyell is used to supply potable water.
- Treated groundwater that is extracted near the accommodation camp.

For assessment and water licensing purposes it has been conservatively assumed that 350 KL/d (equivalent to 128 ML/yr) of water is extracted from either Lake Lyell or the local groundwater system to supply potable water to the accommodation camp and construction site amenities.

5.8.2 Construction water

Non-potable water will be used in construction for a range of purposes including dust suppression, concrete production, drilling and underground works and washdown. The use rate is expected to vary based on construction activity and intensity, seasonality and due to weather. The highest use rates would likely occur when warm dry conditions occur during peak construction periods as dust suppression use will be at its highest. The highest typical daily use rate is approximately 0.5 ML/d.

Treated water from the contaminated water and stormwater systems will be beneficially and preferentially used to supply non-potable water for construction purposes. It is anticipated that supply from this system will meet demand some of the time as the contaminated water system will manage surface water from high intensity construction areas, PSE seepage and groundwater inflows into subsurface excavations.

Shortfalls may occur at the start of the project (prior to commencement of subsurface excavations) or if extended dry conditions occur during construction. Any shortfalls will be supplied from Lake Lyell or via groundwater extraction.

For assessment and water licensing purposes it has been conservatively assumed that 0.5 ML/d (equivalent to 183 ML/yr) of water is extracted from either Lake Lyell and/or the local groundwater system to meet shortfalls in the construction water supply.

5.8.3 Total water supply requirements

It is proposed that water will be extracted from either Lake Lyell or via groundwater extraction to supply:

- up to 128 ML/yr to the potable water system
- up to 183 ML/yr to the construction water system.

The maximum water extraction volume is 311 ML/yr. This volume is equivalent to 0.4% of lake outflows, which averaged 74 GL/yr over the recent period (refer to Table 4.10) and is therefore negligible from a catchment scale water balance perspective.

5.9 Changes to Lake Lyell

5.9.1 Lake Lyell operations during construction

During construction EnergyAustralia will regulate lake levels using riparian releases from the dam and pumping to Thompson Creek Reservoir (refer to Section 4.2.5). One or more fusegates on the Lilyvale Dam spillway will also be temporarily removed to lower the FSL by 3.2 to 782.3 mAHD (the construction phase FSL). Removal of the fusegates would result in lower reservoir flood levels as the spillway would be engaged once lake levels exceed the construction phase FSL. The revised flood levels have not been calculated as part of this EIS. The fusegates will be restored at the end of construction.

During the initial construction period, lake levels will be reduced to and maintained at around 772 mAHD to enable construction of the coffer dam and other in lake works. Once these initial works are completed the lake levels will be allowed to rise to the construction phase FSL.

Higher water levels may occur for short periods during high lake inflow events.

Aside from the temporary changes to the management of lake water levels described above, no changes to the existing lake operating approach or environmental releases are proposed.

5.9.2 Lake diversion

To protect the permanent inlet/outlet infrastructure from floods, water borne debris and sedimentation, the Farmers Creek arm of Lake Lyell will be permanently diverted before its junction with the natural extent of Farmers Creek. The diverted path of the Farmers Creek arm will comprise a waterway that will be constructed within the parent bedrock. The invert (i.e. bottom) of the drain will be between 783 to 780 mAHD (several metres below the Lake Lyell FSL of 785.5 mAHD) and will be graded east to west, in the Farmer Creek flow direction. The floor of the diversion will be the parent rock and the walls will be benched rock batters. The diversion will be within the FSL extent of Lake Lyell and will be sized to allow passage of a Farmers Creek PMF. The location and extent of the division is shown in Figure 5.3.

During construction, the diversion works area will be a high intensity construction area which means that surface water runoff from the works area will be managed in the contaminated water system. Coffer dams will be used at both ends to prevent the ingress of lake water into the construction works area.

5.9.3 Coffer dam

Two coffer dams are required to allow the construction of the inlet / outlet structure which will require works below the Lake Lyell FSL. The location of the coffer dams is indicated in Figure 5.3. The following approach will be applied to construct the coffer dams and achieve construction access to the inlet / outlet structure area:

- Lake Lyell will be lowered to around 772 mAHD via riparian releases or pumping to Thompson Creek Reservoir (refer to Section 5.9.1).
- The lake diversion will be constructed to permanently divert Farmers Creek flows around the inlet / outlet structure.
- The coffer dams will be constructed. The construction of coffer dams may disturb lakebed sediments but should otherwise not impact water quality.

- Once the coffer dams are installed, any remaining lake water behind the coffer dams will be pumped into the lake once any turbidity from disturbance has cleared.
- Once construction commences the area behind the coffer dams will be a high intensity construction area and surface water runoff will be managed in the contaminated water system. Clean water diversions will be constructed to minimise clean water ingress into the system from upgradient areas to the north and east. Key clean water diversions are indicated in Figure 5.3.

5.10 Works on waterfront land

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of a riverbank, lake shore or estuary mean high water mark. The construction of the project will unavoidably require the following works on waterfront land:

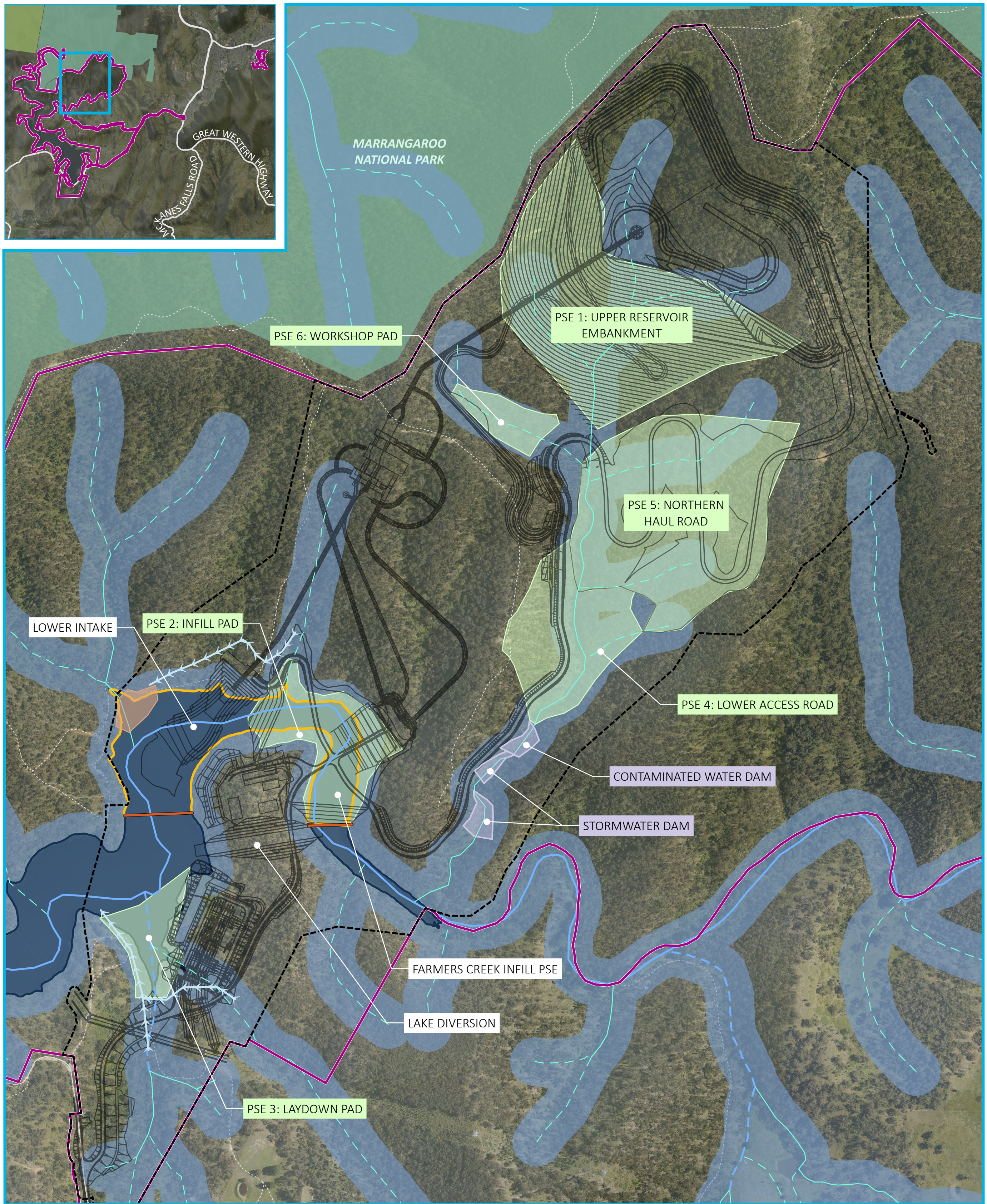
- Construction of the upper reservoir and PSEs 4 (main access road), PSE 5 (northern haul road) and PSE 6 (workshop pad).
- Temporary and permanent watercourse diversions.
- Watercourse crossings.
- Construction of the following works within Lake Lyell:
  - the inlet and outlet structure
  - the lake diversion
  - PSE 2 (infill pad) and PSE 3 (laydown pad)
  - temporary removal of one or more fusegates on the Lilyvale Dam spillway (refer to Section 5.9.1).
- Construction works within 40 m of watercourses and Lake Lyell.

Figure 5.5 shows the indicative extent of waterfront land, the location of temporary and permanent watercourse diversions and proposed works within Lake Lyell. Table 5.10 describes proposed measures for works on waterfront land.

Table 5.10 Proposed controls for works on waterfront land

ID	Measure	Proposed controls	Outcomes
WFL 1	**Temporary watercourse diversions** – applies to any watercourse that will be temporarily diverted during construction. Indicative temporary diversions are indicated in Figure 5.5.	• Controls for clean water diversion that are described in Table 5.9 (ID SW1) apply. • Temporary diversions will be removed following construction, and any disturbed watercourse reaches will be reinstated. Reinstated watercourses will be designed and constructed as a physically stable naturalised watercourse that has similar environmental values to the pre-disturbed watercourse.	Best practice approach that is consistent with the guidelines for works on waterfront land (DPE 2022).
WFL 2	**Permanent watercourse diversions** – applies to any watercourse or watercourse reach that will be permanently diverted. Indicative permanent diversions are indicated in Figure 5.5.	• Controls for clean water diversion described in Table 5.9 (ID SW1) apply. • Any watercourse that will be permanently diverted around permanent infrastructure will: – be a piped and/or surface drainage system – be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for a design event. The design event will be established based on a risk assessment that considers environmental risks, flood risks and other relevant factors – have adequate scour protection at the system inlets and outlets. • During detailed design a risk assessment will be undertaken to identify risks associated with by-pass flows that may occur because of system blockage or an event greater than the design event. If significant risks are identified (such as embankment failures or entrainment of materials that could pollute the receiving environment), overland flow paths will be established to manage by-pass flows. • Where practical, surface drainage systems will be established as physically stable naturalised watercourses that have similar environmental values to the pre-disturbed watercourse.	Risk based approach applied to the design and construction of permanent watercourse diversions.
WFL 3	**Land based PSEs** – applies to reaches of watercourse 3 and its tributaries that are within the footprints of PSE 1, 4, 5 and 6.	• Proposed controls and design concepts for PSEs 1, 4, 5 and 6 are provided in the excavated rock management strategy (EMM 2025b).	Stable and free draining landforms.
WFL 4	**Watercourse crossings** – applies to transverse drainage (i.e. road culverts) and bridges.	• The design of watercourse crossings will apply the principles described in the guidelines for watercourse crossings on waterfront land (DEP 2022) and where relevant, *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPI 2003).	Best practice approach that is consistent with the guidelines for works on waterfront land (DPE 2022) and other relevant guidelines.

ID	Measure	Proposed controls	Outcomes
WFL 5	**PSEs within Lake Lyell** – applies to the PSE 2 (infill pad) and PSE 3 (laydown pad) PSEs (refer to Figure 5.5).	• Proposed controls and design concepts for the PSE 2 (infill pad) and PSE 3 (laydown pad) are provided in the excavated rock management strategy (EMM 2025b).	Risk based approach applied to the design and construction of PSEs within Lake Lyell.
WFL 6	**Lake Diversion**	• The design concept for the lake diversion is described in Section 5.9.2.	The lake diversion will protect the inlet and outlet structure from debris and allow Farmers Creek to freely drain into Lake Lyell.
WFL 7	**Inlet and outlet structure**	• The inlet and outlet structure will be designed to be to have non-erosive hydraulic capacity and be structurally sound for the proposed PHES flows. • The proposed design concept is described in the project description of the EIS.	The inlet and outlet structure will be fit-for-purpose.



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

0 250 500 m

GDA2020 MGA Zone 56

N

KEY

- Construction envelope
- Project area
- Project layout
- Coffer dam
- Permanent watercourse diversion
- Permanent spoil emplacement (PSE)
- Temporary clean water dam
- Lake Lyell full supply level
- Lake Lyell area behind coffer dam
- Water management dam
- Waterfront land

Strahler stream order (adjusted)

- 1st order
- 2nd order
- 3rd order
- 4th order

Existing environment

- Major road (refer to inset)
- Minor road
- Vehicular track
- NPWS reserve
- State forest (refer to inset)

Works on waterfront land

Lake Lyell PHES
Surface Water Impact Assessment
Figure 5.5

EMM
creating opportunities

The conceptual water system layout will be further developed at detailed design and may vary from the layout shown.

6 Operational phase water management

This chapter describes the water management approach during the commissioning and operational phase of the project. It includes a description of the PHES operating principles (refer to Section 6.1), a conceptual water balance for the PHES operations (refer to Section 6.2) and a description of the stormwater, wastewater and contaminated water management approach (refer to Section 6.3). A summary of proposed management measures is provided in Chapter 10.

Residual impacts associated with the operational phase of the project are described separately in Chapter 8.

6.1 PHES operating principles

LLP will be the operator of the PHES facility and Lake Lyell. This section describes the PHES and Lake Lyell operating principles. Changes to the Lake Lyell water level and water quality regimes and residual impacts associated with the operation of the PHES are discussed separately in Chapter 8.

PHES and Lake Lyell operating protocols will be documented in an operations management plan that will be prepared post approval in accordance with relevant consent conditions.

6.1.1 Key elements

Table 6.1 describes the key elements of the PHES facility that are relevant to this assessment.

Table 6.1 PHES facility – key elements

Project element	Key elements
Upper reservoir	**Operating levels** • FSL: 1,050 mAHD • MOL: 1,010 mAHD • Operating water level range (between MOL and FSL): 40 m • Median operating level: approximately 1,035 mAHD (equivalent to the storage being 50% full) **Storage volume and area** • Total storage volume (between empty to FSL): 6.3 GL • Operating storage volume (between MOL and FSL): 5.3 GL • Water surface area (at FSL): 16.5 ha • Water surface area (at median operating level): 12.9 ha **Catchment area** • 25.4 ha (includes water storage surface area) **Spillway** • The upper reservoir will have an emergency spillway that will be engaged if the water level in the reservoir reaches 0.8 m above FSL. Spillway overflows will discharge into Watercourse 5 (refer to Figure 4.4), which flows into Farmers Creek (lower reach). The purpose of the spillway is to prevent the embankment from overtopping if water levels in the upper reservoir exceed the FSL due to either rare or extreme rainfall or an over-pumping event. An over-pumping event would require multiple system failures and is therefore unlikely to occur. **Lining** • The upstream face of the embankment will be lined with a PVC geomembrane liner. • The floor and northern and eastern walls of the reservoir will be the parent bed rock, which has a low permeability. Any fractures identified during construction will be grouted to minimise permeability. Seepage losses from the upper reservoir are estimated in the Groundwater Assessment (EMM 2025a). Figure 6.1 is a conceptual layout of the upper reservoir that shows the above-mentioned features.

Project element	Key elements
Lower reservoir (Lake Lyell)	**Existing reservoir operating range** • FSL: 785.5 mAHD • MOL: 761.3 mAHD • Operating volume (i.e. between MOL and FSL): 32.1 GL **Target PHES operating range** • Target PHES operating range: 781.0 to 784.5 mAHD • Target PHES operating volume: 7.0 GL **Maximum PHES operating range** • Maximum PHES pump level: 786.0 mAHD • Maximum PHES discharge level: 785.5 mAHD (at the FSL) • Minimum PHES operating level: 780.0 mAHD • Maximum PHES operating volume (i.e. between 780 and 785.5 mAHD): 11.2 GL • Lake Lyell storage between 784.5 and 785.5 mAHD (i.e. between FSL and the target PHES operating range): 2.2 GL **Lake Lyell water releases** • No change to existing spillway and riparian outlet (described in Table 4.6). • No change to environmental release requirements from Lake Lyell (described in Section 4.2.4i).
PHES operations	**Energy generation and storage** • The project will have the capacity to store up to 3,080 MWh of energy and generate 385 MW for 8 hours or up to around 440 MW for a shorter period. **Operating approach** • The PHES facility will be operated based on the electricity market demand. It is anticipated that standard operations will include either full or part cycles on most days. A full cycle will result in 9 ½ hours of pumping and 8 hours of discharging within a day. Pumping will generally occur during the day and generating will generally occur during the morning and evening peaks. Further information on the typical operating regime is provided in the project description of the EIS. • EnergyAustralia will seek to maintain Lake Lyell water levels within the target PHES operating range (781.0 to 784.5 mAHD). This will be achieved when the upper level (784.5 mAHD) is not exceeded at the end of a discharge cycle and the lake level does not drop below the lower level (781.0 mAHD) at the end of a pump cycle. • When Lake Lyell water levels exceed the target PHES operating range water can be released from the lake via the riparian outlet, which has a 1,036 ML/d capacity. The operating approach during high inflow events is discussed in Section 6.1.2. • If Lake Lyell water levels drop below the target PHES operating range the PHES can continue to operate to the minimum PHES operating level of 780.0 mAHD. The operating approach during drought conditions is discussed in Section 6.1.3. **Pump and discharge rates** • PHES facility will comprise two synchronous fixed speed reversible Francis type pump-turbine generation units which can operate at variable rates. • Maximum pump rate: 190 m^3/s • Maximum discharge rate: 210 m^3/s

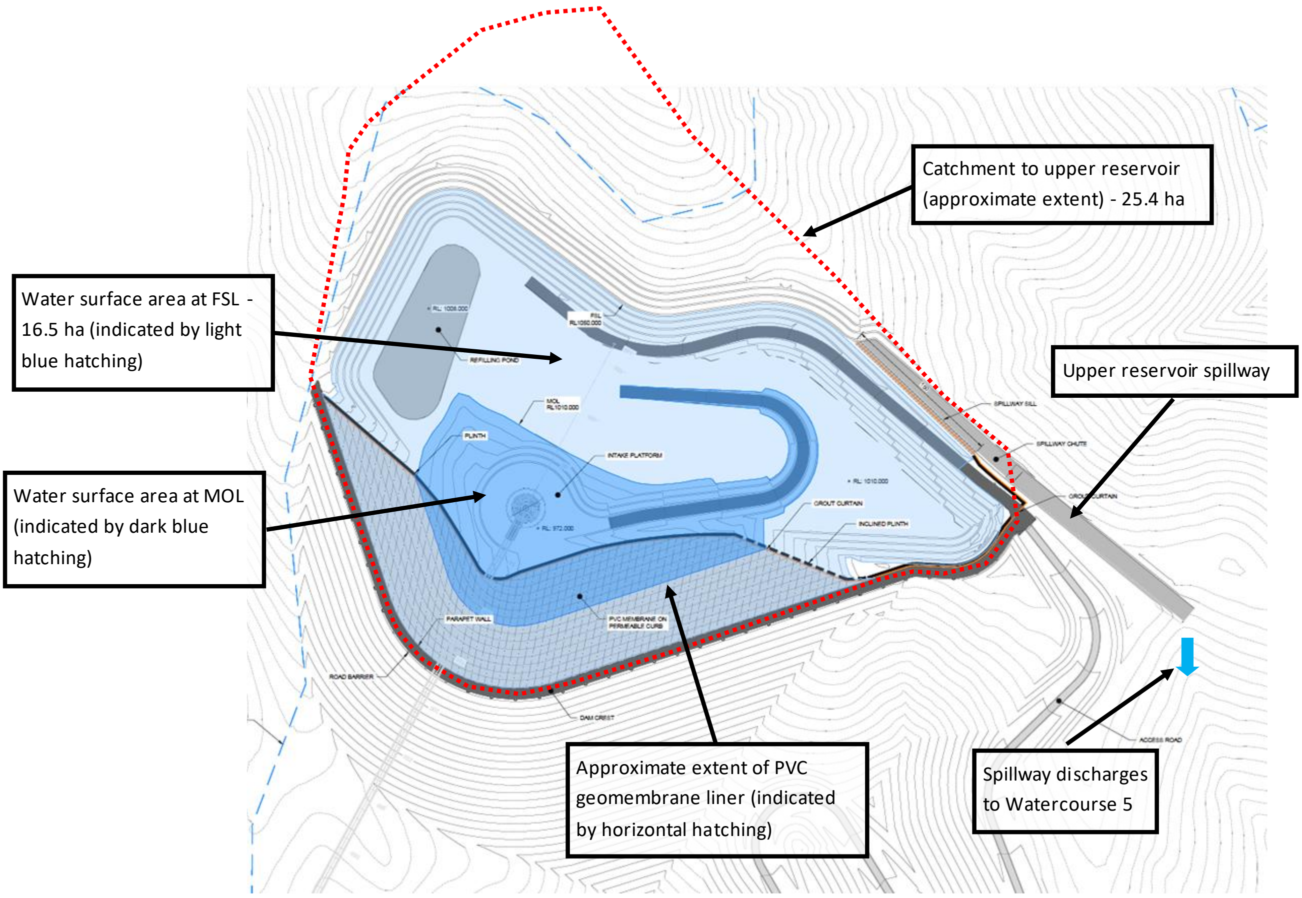


Figure 6.1 Upper reservoir conceptual layout

6.1.2 Operations during high inflow events

Lake Lyell has a contributing catchment area of 382 km^2 and periodically receives high inflows during wet weather events. High inflows could lead to the lake water level rising above the target operating range of 781.0 to 784.5 mAHD and in some cases spills from the reservoir.

As described in Table 6.1 the PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD, which is the same as the Lake Lyell FSL or spill level. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows) but will also mean that the PHES operations can be restricted during high inflow events.

During high inflow events the PHES facility and Lake Lyell will be operated to:

- avoid PHES generation and associated discharges from the upper reservoir to Lake Lyell when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD
- minimise restrictions on the PHES operation.

Table 6.2 describes the operating approach that will be applied during high inflow events to achieve these objectives.

Table 6.2 PHES and Lake Lyell operating approach during high inflow events

	Typical Lake Lyell conditions	Operating approach
Prior to a forecast high rainfall event	• Lake water levels within the target operating range (refer to Table 6.1), at least 1 m below FSL. • Lake inflow rate less than riparian outlet capacity (1,036 ML/d) which means that riparian releases can be used to reduce water storage and levels in the lake.	• LLP will monitor streamflow conditions, Lake Lyell water levels and forecast rainfall. • Water levels in Lake Lyell can be lowered via riparian releases to increase the water storage volume in the lake prior to an anticipated high inflow event.
During a high inflow event	• Lake inflow rate is greater than the riparian outlet capacity (1,036 ML/d) resulting in water accumulation in the lake and upper reservoir. • Lake spills occur when the water level exceeds FSL.	• LLP will monitor streamflow conditions, Lake Lyell water levels and forecast rainfall. • Riparian releases can occur to minimise water accumulation in Lake Lyell and the upper reservoir. • The PHES facility can operate while Lake Lyell water levels are within the maximum operating range (refer to Table 6.1). However, LLP will seek to avoid filling the upper reservoir prior to an anticipated Lake Lyell spill, which will occur when lake levels exceed the FSL. • PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows). • PHES pumping can occur while Lake Lyell water levels are at or below the maximum PHES pump level of 786.0 mAHD. However, LLP will seek to minimise filling the upper reservoir during a high inflow event so that there is capacity to fill the upper reservoir after the high inflow event when lake inflows are less than the riparian outlet capacity.

	Typical Lake Lyell conditions	Operating approach
After a high inflow event	• Lake levels may be above FSL. • Lake inflow rate less than riparian outlet capacity (730 ML/d) which means that riparian releases can be used to reduce water storage and levels in the lake.	• PHES pumping can occur (subject to capacity in the upper reservoir) to rapidly lower Lake Lyell water levels to below the FSL. • PHES generation can occur when the Lake Lyell water level is below the maximum PHES discharge level of 785.5 mAHD. • Lake water levels will be restored to the target operating range via riparian releases. If the upper reservoir is empty approximately 2.1 GL (refer to Table 6.1) will need to be released, which will take approximately 3 to 5 days depending on lake inflow rates. If the upper reservoir is full approximately 7.4 GL (i.e. 2.1 + 5.3 GL) will need to be released, which will take approximately 10 to 15 days depending on lake inflow rates.

6.1.3 Operations during droughts

During drought conditions EnergyAustralia will continue to operate Lake Lyell to meet the environmental flow requirements (described in Section 4.2.4i) and to supply water to the Mount Piper Power Station until its closure. This could result in a gradual reduction in the volume of water stored in Lake Lyell and the upper reservoir. As described in Table 6.1 the minimum PHES operating level is 780.0 mAHD, which is equivalent to the reservoir being 65% full (from a storage volume perspective). Therefore, there is a risk that the operation of the PHES facility could be temporarily restricted during drought conditions if the lake level drops below 780.0 mAHD. It is noted that the Lake Lyell water level has been consistently above 780.0 mAHD since November 2010 (refer to Figure 4.9). Prior to this lake water levels were generally lower than 780.0 mAHD as Lake Lyell was the primary supplier of water to both Mt Piper and the now closed Wallerawang power stations.

EnergyAustralia have assessed the drought risk to the PHES facility to be low due to the following reasons:

- Environmental flow requirements do not require a net release of water from Lake Lyell (i.e. daily release volumes are equal to or less than daily inflow volumes). This means that environmental releases will not reduce the volume of water stored in Lake Lyell.
- Following the commencement of the Springvale WTP in 2019 the water supply volume to Mt Piper power station from the Coxs River scheme (which includes Thompson Creek Reservoir and Lake Lyell) ranged from 1.2 to 3.8 GL/yr. These volumes are minor compared to the maximum PHES operating volume (11.2 GL) which means that any water supply to Mt Piper power station would only result in a gradual reduction in the volume of water stored in Lake Lyell.
- The operation of the PHES facility will not materially increase water losses from Lake Lyell, with net system losses during operations calculated in Section 6.2.2 to be equivalent to 0.12% of lake outflows.

The drought risk would increase if the Springvale WTP ceased to operate before Mount Piper Power Station closes as there could be an increased reliance on Lake Lyell to supply water to Mount Piper Power Station. If this were to occur EnergyAustralia could consider the following options to reduce drought risk to the PHES facility:

- The current operating approach of the Coxs River Water Supply scheme could be adjusted so that Thompson Creek Reservoir is initially drawn down to supply Mt Piper power station and Lake Lyell is used as the contingency storage.
- There could be a greater reliance on EnergyAustralia's 8,184 ML/yr contract allocation from the Fish River Water Supply Scheme, noting that the allocation may be restricted according to storage level when Oberon Reservoir drops below 50%, but also that unused allocation up to a maximum of 20% of contract volume may be carried over from one water year to the next.
- Alternative water supplies for Mt Piper power station could be investigated.

To mitigate the risk of drought to the PHES operation EnergyAustralia will seek to maintain water levels in Lake Lyell as full as possible when drought conditions are forecast.

6.2 Conceptual water balance for PHES operations

The operation of the PHES facility will result in water take from Lake Lyell during the initial filling of the upper reservoir and due to ongoing system losses during operations. Water take estimates for each of these mechanisms are provided in the following sections. The water licencing approach and requirements for initial filling and net system losses are described separately in the water licensing strategy (EMM 2025c) using information from this section.

6.2.1 Upper reservoir initial filling

The initial filling of the upper reservoir will occur gradually over multiple pump and discharge cycles during the commissioning phase of the project. The initial filling will be complete the first time the upper reservoir is filled to FSL. The initial filling process will remove 6.3 GL (the total storage volume from Table 6.1) of water from Lake Lyell. Once initial filling has been completed subsequent filling and emptying of the upper reservoir will be approximately in balance which means there will be no additional net water take from Lake Lyell aside from net system losses (discussed in Section 6.2.2).

6.2.2 Net system losses

Once the initial filling is completed ongoing water losses will occur due to evaporation from the upper reservoir and seepage losses from the upper reservoir and tunnels. These losses will be partly or fully offset by direct rainfall and runoff into the upper reservoir (the net system loss).

The net system loss calculations account for direct rainfall and runoff into the upper reservoir. As runoff from this catchment currently contributes runoff to Lake Lyell (via Watercourse 3 and Farmers Creek (lower reach) the loss of runoff from this catchment also needs to be accounted for when calculating the net change due to the project from a catchment scale water balance perspective. Therefore, the net change is the sum of net system losses and the loss of runoff from the upper reservoir catchment (the net change). Table 6.3 provides annualised calculations for net system losses and net change due to the project for a dry (10th percentile), median and wet (90th percentile) year. Assumptions and calculation methods are noted in the table.

The calculated net system losses range from a 97 ML/yr loss (dry year) to a 5 ML/yr gain in a wet year with a median value of a 47 ML/yr loss.

The calculated net change due to the project ranged from a 117 to 69 ML/yr reduction, with a median reduction of 88 ML/yr. This means that in a median year, the operation of the PHES will take (either directly or indirectly) approximately 88 ML/yr of water from Lake Lyell relative to a no project scenario.

For context:

- the median net system loss of 47 ML/yr is equivalent to 0.13 ML/d which is 0.002% of the 5,300 ML that would be circulated daily during a full pump and discharge cycle and is therefore a negligible loss from a system efficiency perspective

- the median net change of a 88 ML/yr reduction is equivalent to approximately 4% of the annual evaporation losses from Lake Lyell, which are calculated in Section 4.3.4 to be approximately 2 GL/yr. The conceptual water balance for Lake Lyell that is also described in Section 4.3.4 concluded that evaporation losses from Lake Lyell are equivalent to approximately 2% of outflows from the lake. Therefore, the net change would be equivalent to 0.08% of lake outflows and is therefore negligible from a catchment scale water balance perspective.

Table 6.3 Net system losses during PHES operation

	Units	Dry (10th percentile) year	Median rainfall year	Wet (90th percentile) year	Source / assumptions
Calculation assumptions					
– Evaporation	mm/yr	1,299	1,184	1,099	From Table 4.1
– Rainfall	mm/yr	544	820	1,035	From Table 4.1
– Volumetric runoff coefficient (Cv)	-	0.15	0.19	0.28	From Table 4.9
Predevelopment condition					
– Runoff from predevelopment catchment	ML/yr	20	40	74	Upper reservoir catchment area (Table 6.1) x Cv x rainfall
Operational system					
System losses					
– Evaporation from upper reservoir	ML/yr	111	107	99	Water surface area (at median operating level) (Table 6.1) x evaporation x pan factor (0.7)
– Net seepage losses from upper reservoir and tunnels	ML/yr	66	66	66	Groundwater assessment (EMM 2025a) - results from Table 9.1, relate to a 90th percentile scenario
Total losses	**ML/yr**	**177**	**173**	**165**	
System gains					
– Direct rainfall into upper reservoir	ML/yr	70	106	134	Water surface area (at median operating level) (Table 6.1) x rainfall
– Runoff to upper reservoir	ML/yr	10	20	36	Upper reservoir catchment area - water surface area (at median operating level) (Table 6.1) x Cv x rainfall
Total gains	ML/yr	**80**	**126**	**170**	
Net system losses	ML/yr	**97 (loss)**	**47 (loss)**	**5 (gain)**	
Net change due to project	ML/yr	**117 (reduction)**	**88 (reduction)**	**69 (reduction)**	Net system loss + runoff from predevelopment catchment

6.3 Water management during operations

The operational footprint of the project will have a significantly smaller area than the construction footprint. Notwithstanding, the following sources of water will require management during operations:

- Stormwater runoff from permanent infrastructure areas including the switchyard and infill pad
- Stormwater runoff from sealed and unsealed permanent roads
- Seepage from PSEs
- Intercepted groundwater in the powerhouse, MAT and ECVT
- Wastewater from amenities.

Table 6.4 describes the proposed controls for each of these sources. The proposed systems will be established at detailed design and will be documented in an operations water management plan that will be prepared post approval in accordance with relevant consent conditions.

Table 6.4 Water management during operations

ID	Measure	Proposed controls	Outcomes
WM1	**Stormwater management for infrastructure areas** – applies to the switchyard, infill pad and any other permanent infrastructure areas.	• All hazardous chemicals and hydrocarbon products will be stored in bunded areas in accordance with relevant Australian Standard AS1940:2004 and other relevant guidelines. • Transformers will be in bunded areas in accordance with Australian Standard AS1940:2004 and other relevant guidelines. • A stormwater system for each area will be established that is consistent with best practice for the proposed land use and activities. The system will include stormwater controls that meet WaterNSW's NorBE assessment criteria.	Stormwater systems that are consistent with best practice and meet WaterNSW's NorBE criteria
WM2	**Stormwater management for sealed roads –** applies to all permanent sealed roads.	• Runoff from sealed roads will be managed in roadside swales.	Stormwater systems that are consistent with best practice
WM3	**Stormwater management for unsealed roads –** applies to all permanent unsealed roads.	• Runoff from unsealed roads will be managed in accordance with the methods in Managing Urban Stormwater: Soils and Construction Volume 2C – Unsealed roads (DECC 2008).	Stormwater systems that are consistent with best practice
WM4	**Management of seepage from PSEs** – applies to seepage from all PSEs. Each PSE will have a seepage collection system that will separate seepage from surface water runoff.	• The water quality and volume of PSE seepage will be monitored. If the water quality does not meet the minimal harm criteria (Table 5.1) seepage will be treated prior to discharge. The most appropriate treatment method will be established once the volumes and water quality of seepage are known. • Monitoring and active management of PSE seepage will cease once water quality monitoring demonstrates that seepage water quality is similar to the minimal harm criteria (refer to Table 5.1).	Long term management of PSE seepage
WM5	**Management of intercepted groundwater –** groundwater inflows into the powerhouse, MAT and ECVT will be pumped to the surface. As described in Section 5.5.2ii, the water quality of groundwater inflows is expected to be similar to the minimal harm criteria (refer to Table 5.1) except the concentrations of some metals may exceed DGVs.	• Source controls and procedures will be implemented to minimise the risks of water pollution due to leaks and spills and maintenance in underground operational areas. • Collected water will be treated in an oil and grease separator to remove hydrocarbons. • The water quality of water pumped from the powerhouse, MAT and ECVT will be monitored prior to discharge into Lake Lyell. Water quality controls such as treatment will be implemented if required.	Management of water quality risk in water pumped from the powerhouse, MAT and ECVT
WM6	**Wastewater management –** small volumes of wastewater will be generated from site amenities.	An on-site wastewater system will be established to manage wastewater (i.e. sewage) produced from site amenities. The system will be designed and operated in accordance with the methods described in *Designing and Installing On-Site Wastewater Systems (WaterNSW 2023b).*	Best management practice applied

7 Construction phase residual impacts

7.1 Overview

This chapter describes predicted water cycle changes during the construction phase of the project, during which the water management principles and measures that are described in Chapter 5 will be implemented. Section 7.2 describes discharges from the construction water management system and Section 7.3 provides a summary of changes to receiving waters. Impacts to waterfront land during construction and operation are described separately in Chapter 9.

7.2 Discharges from the construction water management system

The project is estimated to take between four to five years to construct. During this time, a construction a water management system will be operated to supply water to and manage water produced by construction activities. The construction water management system is described in Chapter 5. This section describes the predicted discharges from the construction water management system. Ambient streamflow and water quality conditions in Farmers Creek are used to contextualise the discharges from the construction water system and describe potential changes to water quality in the Farmers Creek arm of Lake Lyell.

7.2.1 Ambient conditions in Farmers Creek

In Chapter 5, the expected water quality within the construction water management system is compared to minimal harm criteria that was established based on DGVs and the ambient water quality of Farmers Creek inflows to Lake Lyell. Any discharge from the construction water system that meet the minimal harm criteria would not result in a material water quality impact as the discharge water quality would be similar to the water quality of Farmers Creek inflows into Lake Lyell. For context, Farmers Creek contributes approximately 25% of the total inflows into Lake Lyell (refer to Section 4.3.4) and is therefore the main contributor to water quality in the Farmers Creek arm of Lake Lyell and a key contributor to water quality in the greater lake.

Table 7.1 describes ambient streamflow and water quality conditions in Farmers Creek for typical drought, dry weather, after material and significant wet weather and during material and significant wet weather conditions. Material and significant wet weather is defined in the table notes. This information is used to contextualise the discharges from the construction water system.

Table 7.1 Typical conditions in Farmers Creek

Conditions	Streamflow (ML/day)[1]	Typical water quality
Drought conditions	0 to 13 ML/d (minimum to 20^{th} percentile)	Similar to minimal harm criteria except nutrient concentrations may be higher
Dry weather	13 to 66 ML/d (20^{th} to 80^{th} percentile)	Similar to minimal harm criteria
Minor wet weather or after material[2] or significant[3] wet weather[2]	66 to 104 ML/d (80^{th} to 90^{th} percentile)	Similar to minimal harm criteria
During material wet weather[2]	104 to 302 ML/d (90^{th} to 98^{th} percentile)	Similar to minimal harm criteria, except turbidity and suspended sediments may be higher due to runoff from disturbed areas in the catchment
During significant wet weather[3]	>302 ML/d (>98^{th} percentile)	

Notes:

1. Streamflow rates calculated from 212042 - Farmers Creek at Mount Walker.
2. Material wet weather refers to rainfall events that generate surface runoff in a catchment. Typically, several material wet weather events would occur in most years that are not drought years.
3. Significant wet weather refers to rainfall events that result in near-bank full streamflow. Significant wet weather events will occur every one or two years on average.

7.2.2 Discharge regimes and quality

The construction water management system will include separate systems to manage contaminated water and stormwater water. Table 7.2 describes the key features and discharge mechanisms from these systems and the expected discharge regime and water quality.

Table 7.2 Construction water system discharges

System description		Expected discharge regime	Expected water quality
Stormwater system discharges			
Clean water diversions applies to any clean water diversion around or through construction areas. Key temporary and permanent diversions are indicated in Figure 5.3. Proposed controls for clean water diversions are provided in Table 5.9.		Similar to runoff regime.	Consistent with clean water.
Stormwater system (minor works) - applies to construction of roads, service trenches and minor works where construction will disturb a small portion of a catchment for a short period (i.e. typically less than 3 months). Proposed controls for clean water diversions are provided in Table 5.9.		Stormwater runoff is expected on most wet weather days.	Stormwater runoff may have elevated suspended solids concentrations and turbidity levels but is otherwise expected to have water quality that is similar to the minimal harm discharge criteria (refer to Table 5.1).
Stormwater system (major works) applies to construction works that will disturb a moderate to large portion of a catchment for a longer period of time (i.e. more than three months). Major works stormwater management areas are indicated in Figure 5.3 and include construction pads and accommodation camp. The total stormwater management area is approximately 100 ha. The following discharges from this system are proposed.			
Controlled discharge of treated water	• Water captured in the sedimentation basins will be either beneficially used in construction (i.e. for dust suppression) or treated and discharged to Lake Lyell. • Stormwater treatment systems will have capacity to treat captured water within five days and will target suspended sediment removal.	Intermittent discharges that will typically occur for several days following wet weather. The maximum discharge rate is estimated to be up to 5 ML/d[1].	The quality of treated water is expected to be similar to the minimal harm criteria (refer to Table 5.1)[3].
Sedimentation basin overflows	• Sedimentation basins will be sized to capture runoff from a five-day 90th percentile rainfall event. • The basins will overflow when the design capacity is exceeded.	The average overflow frequency from a basin sized to capture the five-day 90th percentile rainfall event is between 2 to 4 overflows per year[2]. More frequent overflows would occur in wet years.	Basin overflows may have elevated suspended solids concentrations and turbidity levels but are otherwise expected to have water quality that is similar to the minimal harm discharge criteria (refer to Table 5.1)[3]

System description	Expected discharge regime	Expected water quality
Contaminated water system discharges		
Controlled discharge of treated water in this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria (refer to Table 5.1). The contaminated water system will manage potentially contaminated water generated from construction activities to minimise pollution of the stormwater system and receiving surface and groundwater systems. Section 5.5 describes two possible approaches for the contaminated water system. Both approaches include the treatment and discharge of surplus water to Lake Lyell.	Intermittent discharges will be required when system inflows exceed construction water use rates. Discharges are more likely during and after wet weather, during cooler months when evaporation rates are lower and during construction years 3 and 4 when groundwater inflows are higher. The maximum discharge rate is estimated to be between 1 to 2 ML/d.	The quality of treated water is expected to meet the minimal harm criteria (refer to Table 5.1).

Notes:

1. Calculated as the estimated combined sedimentation basin volume for a 100 ha stormwater management (major works) area (25 ML) divided by five days.
2. From Table 6-2 in Managing Urban Stormwater: Soils and Construction Volume 2E – Mines and quarries (DECC 2008).
3. Assumes that inflows from the contaminated water system are limited to the diversion of high flows during intense rainfall events (see Section 5.4).

7.2.3 Potential water quality impacts in Farmers Creek arm of Lake Lyell

The construction water system for the main construction area will discharge water into the upper portion of the Farmers Creek arm of Lake Lyell. Therefore, the Farmers Creek arm is the immediate receiving water. Under the existing condition, the water quality in the Farmers Creek arm is predominately influenced by inflows from Farmers Creek, which are described Section 7.2.1 for a range of weather conditions (i.e. drought to significant wet weather).

Table 7.3 describes the likely discharge regimes from the construction water system for each of the five weather conditions and the potential for water quality impacts in Farmers Creek arm to occur. The key conclusions from this table are:

- No change to water quality in the Farmers Creek arm is expected during drought conditions, dry weather, minor wet weather and after material and significant wet weather as discharges from the system would be predominately limited to the controlled discharges of treated water from the contaminated water and stormwater systems which will have similar water quality to Farmers Creek inflows (i.e. the minimal harm criteria).

- During material and significant wet weather, overflows from sedimentation basins and runoff from stormwater (minor works) areas may contribute to elevated suspended sediment and turbidity in the Farmers Creek arm. No material increases in nutrient or metal loads are expected as key sources of these pollutants will be managed in the contaminated water system.

Receiving water impacts are discussed further in Section 7.3.

Table 7.3 Potential water quality impacts in Farmers Creek arm of Lake Lyell

Conditions	Typical conditions in Farmers Creek (from Table 7.1)	Typical discharge regime	Potential water quality impact in Farmers Creek arm of Lake Lyell
Drought conditions	**Streamflow**[1] - 0 to 13 ML/d **Water quality -** similar to minimal harm criteria except nutrient concentrations may be higher	• It is unlikely that discharges will be required as construction water requirements would exceed system inflows (i.e. the system would be in water deficit) most of the time.	• No change to water quality expected as any controlled discharges will have similar water quality to Farmers Creek inflows (i.e. the minimal harm criteria).
Dry weather	**Streamflow**[1] - 13 to 66 ML/d **Water quality -** similar to minimal harm criteria	• Some controlled discharge of treated water from the contaminated water system may occur if non-rainfall dependant inflows (i.e. water pumped from subsurface excavations) exceeds construction water requirements.	• No change to water quality expected as controlled discharges will have similar water quality to Farmers Creek inflows (i.e. the minimal harm criteria).
Minor wet weather or after material[2] or significant[3] wet weather	**Streamflow**[1] - 66 to 104 ML/d **Water quality -** similar to minimal harm criteria	• Controlled discharges of treated water from the stormwater and contaminated water system – up to 7 ML/d. • Sedimentation basins overflows are unlikely as design capacity would not be exceeded. • Some runoff from stormwater (minor works) areas expected.	• No change to water quality expected as controlled discharge will have similar water quality to Farmers Creek inflows (i.e. the minimal harm criteria) and the runoff from stormwater (minor works) areas would be minor compared to Farmers Creek inflows.

Conditions	Typical conditions in Farmers Creek (from Table 7.1)	Typical discharge regime	Potential water quality impact in Farmers Creek arm of Lake Lyell
During material wet weather[2]	**Streamflow[1]** - 104 to 302 ML/d **Water quality -** similar to minimal harm criteria, except turbidity and suspended sediments may be higher	• Some overflows from sedimentation basins expected during rainfall. • Runoff from stormwater (minor works) areas expected. • Controlled discharges of treated water from the stormwater and contaminated water system – up to 7 ML/d.	• Potential for increased suspended sediment and turbidity due to sedimentation basins overflows and runoff from stormwater (minor works) areas. • No material increases in nutrient or metal loads are expected as key sources of these pollutants will be managed in the contaminated water system.
During significant wet weather[3]	**Streamflow[1]** - >302 ML/d **Water quality -** Similar to minimal harm criteria, except turbidity and suspended sediments may be higher	• Significant overflows from sedimentation basins expected during rainfall. • Runoff from stormwater (minor works) areas expected. • Controlled discharges of treated water from the stormwater and contaminated water system – up to 7 ML/d.	

Notes:

1. Streamflow rates calculated from 212042 - Farmers Creek at Mount Walker.
2. Material wet weather refers to rainfall events that generate surface runoff in a catchment. Typically, several material wet weather events would occur in most years that are not drought years.
3. Significant wet weather refers to rainfall events that result in near-bank full streamflow. Significant wet weather events will occur every one or two years on average.

7.3 Summary of changes to receiving waters

Section 4.6 establishes that Farmers Creek (lower reach), Lake Lyell and the Coxs River downstream of Lake Lyell are the key receiving waters for the project. Table 4.18 provides a summary of the key water cycle and water quality conditions in each of these key receiving waters for the existing condition. Table 7.4 provides a summary of predicted changes to these conditions during the construction phase of the project. The table reproduces the descriptions of the existing condition from Table 4.18 and explains the changes with reference to the existing condition, information in this chapter and Chapter 5. For each aspect, a conclusion is made regarding the residual impact.

A key conclusion in Table 7.4 is that due to the proposed water management measures and the water quality buffer provided by Lake Lyell, the construction phase of the project is expected to have a neutral effect on water quality in the Coxs River downstream of Lake Lyell. This means that the project will also have a neutral effect on water quality in Lake Burragorang, which is a major water supply dam for the Sydney metropolitan region that receives inflows from the Coxs River and is operated by WaterNSW.

Table 7.4 Summary of changes to existing conditions in key receiving waters – construction phase

Aspect	Summary of the existing condition	Changes due to construction of the project
1. Farmers Creek (lower reach)		
	• Farmers Creek (lower reach) refers to the lower 2,800 m reach of Farmers Creek that is upstream of Lake Lyell (indicated in Figure 4.4). This reach of the creek meanders through steep vegetated terrain and has well established riparian vegetation. • The creek receives runoff from a 67 km^2 catchment (refer to Figure 4.3). Its flow regime is impacted by water captured in the Farmers Creek Reservoir, runoff from urban areas in Lithgow and discharges from the Lithgow WWTP. It is estimated that Farmers Creek contributes approximately 25% of the total inflow to Lake Lyell (refer to Table 4.10). • The creek water quality is characterised as having: – pH and EC that is generally within the DGV range – turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather – nutrient (TN and TP) concentrations that nearly always exceed DGVs and are elevated relative to concentrations in the Coxs River upstream of Lake Lyell. • There is insufficient data to identify if metals or other toxicants are present in Farmers Creek above DGV levels. • Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.	• No material changes to the streamflow regime in Farmers Creek (lower reach) are expected as discharges from the construction water system will be minor compared to streamflow in Farmers Creek. • Some construction disturbance may occur in the upper catchments of Watercourses 2 and 5, which drain to Farmers Creek (lower reach) – see Figure 4.4. Runoff from construction disturbance areas will be managed in the construction water system (refer to Chapter 5). No material changes to the water quality in Farmers Creek (lower reach) are expected as any discharges from this system (i.e. due to sedimentation dam overflows) would be minor compared to the natural streamflow in Farmers Creek. **Residual impact:** *Negligible change*

Aspect	Summary of the existing condition	Changes due to construction of the project
2. Lake Lyell		
a) Lake water level regime	• Lake Lyell is generally maintained in a near full condition, with water levels ranging from above FSL to 782.3 mAHD (a 4.4 m range) during the recent period. • Outside of significant wet weather events the lake water levels change slowly. • Under existing operating conditions EnergyAustralia source water from Lake Lyell to supply the Mt Piper power station. During the recent period the water extraction volumes were equivalent to approximately 3% of total outflows from the lake and was therefore a minor process. EnergyAustralia can extract greater volumes from Lake Lyell however this would only likely occur if there was reduced water availability from the Springvale WTP.	• During construction EnergyAustralia will temporarily remove one or more fusegates on the Lilyvale Dam spillway to lower the FSL by 3.2 m to 782.3 mAHD (the construction phase FSL). The temporary removal of the fusegates would also result in lower reservoir flood levels as the spillway would be engaged once lake levels exceed the construction phase FSL. The revised flood levels have not been calculated as part of this EIS. The fusegates will be restored at the end of construction. • During the initial construction period, lake levels will be reduced to and maintained at around 772 mAHD to enable construction of the coffer dam and other in lake works. Once these initial works are completed the lake levels will be allowed to rise to the construction phase FSL. • Aside from the temporary changes to the management of lake water levels described above, no changes to the existing lake operating approach or environmental releases are proposed. **Residual impact:** *Lake levels will be temporarily lowered during construction*

Aspect	Summary of the existing condition	Changes due to construction of the project
b) Lake inflow regime	• Lake Lyell receives inflows from the Coxs River, Farmers Creek, several smaller watercourses that drain into the lake and direct rainfall. During the recent period inflows to the lake are estimated to have ranged from 28 to 116 GL/yr and originated from the following sources: – Coxs River upstream Lake Lyell – 58% – Farmers Creek upstream of Lake Lyell – 25% – inflow from smaller watercourses that drain into the lake – 14% – direct rainfall to the lake – 3% • There are some anthropogenic activities in the Coxs River and Farmers Creek catchments that influence streamflow and water quality. During the recent period key activities include: the capture and use of water in Thompson Creek and Farmers Creek reservoirs, discharges from the Wallerawang and Lithgow WWTPs, discharges from mining operations and coal ash dams within the catchment. • Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.	• No material changes to lake inflow regimes are expected as discharges from the construction water system will be negligible compared to lake inflows. • The construction water management system (refer to Chapter 5) will include best practice standard controls to manage potentially contaminated water, stormwater and wastewater. Discharges from this system will be into the upper portion of the Farmers Creek arm of Lake Lyell. The following changes to the water quality of inflows into Farmers Creek arm are anticipated due to the operation of this system: – No changes are expected during drought conditions, dry weather, minor wet weather and after material and significant wet weather as discharges from the system would be predominately limited to the controlled discharges of treated water from the contaminated water and stormwater systems which will have similar water quality to Farmers Creek (i.e. the minimal harm criteria). – During material and significant wet weather overflows from sedimentation basins and runoff from stormwater (minor works) areas may contribute to elevated suspended sediment concentrations and turbidity levels in inflows. No material increases in nutrient or metal loads are expected as key sources of these pollutants will be managed in the contaminated water system. **Residual impact:** *Negligible change to lake inflow volumes, potential for increased suspended sediment concentrations and turbidity levels in inflows to Farmers Creek arm during wet weather due to sedimentation basin overflows, no other material changes to water quality expected.*

Aspect	Summary of the existing condition	Changes due to construction of the project
c) Lake stratification cycle	• Central to Lake Lyell's mixing regime is the natural heating and cooling cycle of the waterbody, specifically the development of thermal stratification and its subsequent breakdown into a homogeneous water column (destratification). Water monitoring data (refer to Section 4.4.4) indicates that: – stratification can occur between October and April, with the strongest stratified state usually occurring from December to February – temporary destratification occurs during most summers due to artificial destratification and/or kinetic mixing induced by inflow or wind events – seasonal destratification typically occurs in March to April (due to convective mixing and/or artificial destratification) and unstratified conditions are prevalent from April through to September. • The following water quality conditions are associated with the stratification cycle: – low DO levels can occur in the lower lake (the hypolimnion) due to limited vertical mixing with oxygen saturated surface water in the epilimnion – low DO levels in the hypolimnion can lead to anoxic conditions near the lakebed and sediments release soluble iron and manganese and nutrients such as nitrogen and phosphorus that are stored in sediments. Once released, the soluble metals and nutrients can mix vertically when the stratification breaks down, resulting in poor water quality and a higher risk of algal blooms. • EnergyAustralia operate a submerged diffuser located on the reservoir bed near the dam wall. Operation of the diffuser system would likely reduce the duration and magnitude of both stratification events and anoxic conditions occurring near the lakebed.	• No changes to the lake stratification cycle will occur during construction as the construction activities will not affect any of the processes that drive stratification and destratification. • EnergyAustralia will continue to operate the submerged diffuser located on the reservoir bed near the dam wall as required. **Residual impact:** *Neutral change*

Aspect	Summary of the existing condition	Changes due to construction of the project
d) Algae levels within Lake Lyell	• EnergyAustralia monitor algae at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell. The data is used to establish algae alert levels for the lake. The key conclusions from this data which is presented and analysed in Section 4.4.3 are: – algae alerts (green to red) mostly occur in summer and autumn, with autumn displaying the higher percents in amber and red. This aligns with the seasonal destratification that occurs in March and April – algae alerts are more likely to occur during dry conditions than wet conditions – algae concentrations are generally higher in upper reservoir monitoring locations then at the outlet tower – runoff from bush fire affected areas in the catchment can lead to abnormally high algae levels. • The following factors are assessed to contribute to algae growth: – high NOx (a bioavailable form of nitrogen) loads in Farmers Creek inflows create opportunities for algae growth – the seasonal destratification that occurs in March and April can supply nutrients to the epilimnion which can lead to algae growth in autumn – runoff from bush fire affected areas in the catchment can contribute abnormally high nutrient loads to the lake, creating opportunities for significant algae growth.	No changes to the extent and magnitude of algae levels in Lake Lyell are expected during construction of the project as: • discharges from the construction water system will not materially increase nitrogen loads to Lake Lyell as key sources of nitrogen will be managed in the contaminated water system • no changes to the lake stratification cycle are predicted. **Residual impact:** *Neutral change*

Aspect	Summary of the existing condition	Changes due to construction of the project
e) Water quality of lake water	• The water quality of Lake Lyell is dependent on the water quality of the inflows and the limnological processes that occur within the lake (refer to Figure 4.25). Lake water quality is characterised as having: – pH that ranges between 6.0 and 10.0, relative to the DGV range of 6.5 to 8.0 – EC that ranges from 100 to 850 µS/cm, relative to a DGV of 350 µS/cm – DO that is generally within or above the DGV range at the surface but declines to below the DGV range at depth when the lake is stratified – turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather – nutrient (TN and TP) concentrations that nearly always exceed DGVs but are similar to concentrations in the Coxs River upstream of Lake Lyell. • The following additional conclusions are made from the water monitoring data and nutrient balance calculations: – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.	• The construction water management system (refer to Chapter 5) will include best practice standard controls to manage potentially contaminated water, stormwater and wastewater. The following changes to the water quality of Farmers Creek arm of Lake Lyell are anticipated due to the operation of this system: – No changes are expected during drought conditions, dry weather, minor wet weather and after material and significant wet weather as discharges from the system would be predominately limited to the controlled discharges of treated water from the contaminated water and stormwater systems which will have similar water quality to Farmers Creek (i.e. the minimal harm criteria). – During material and significant wet weather overflows from sedimentation basins and runoff from stormwater (minor works) areas may contribute to elevated suspended sediment concentrations and turbidity levels in the Farmers Creek arm. No material increases in nutrient or metal loads are expected as key sources of these pollutants will be managed in the contaminated water system. • Any elevated suspended sediment concentrations and turbidity levels would be confined to the upper (eastern) portion of the Farmers Creek arm as the suspended material will settle out of the water column via sedimentation processes in the slow-moving water in Farmers Creek arm. No material changes to water quality are expected in other parts of the lake. **Residual impact:** P*otential for increased suspended sediment concentrations and turbidity levels in the Farmers Creek arm of Lake Lyell during wet weather due to sedimentation basin overflows, no other material changes to water quality are expected in the Farmers Creek arm or other parts of the lake.*

Aspect	Summary of the existing condition	Changes due to construction of the project
3. Coxs River downstream		
a) Streamflow regime	• Streamflow in the Coxs River downstream of Lake Lyell is controlled by releases from the lake which occur via: – controlled releases from the riparian outlet to meet environmental flow requirements (refer to Section 4.2.4i) and for other purposes. The maximum capacity of the riparian outlet is 1,036 ML/d (equivalent to ≈12 m^3/s) – discharges over the spillway when the water level in the lake exceeds the FSL. • A conceptual water balance of lake inflows and outflows over the recent period concluded that annual streamflow volumes in the Coxs River downstream of Lake Lyell are similar to lake inflow volumes.	During construction there will be minimal change to the streamflow regime in the Coxs River downstream of Lake Lyell as: • no changes to the existing riparian outlet or environmental release requirements from Lake Lyell are proposed • conservative estimates of water extraction from the lake to supply the construction water system and potable water are equivalent to 0.4% of lake outflows and are therefore negligible from a catchment scale water balance perspective (refer to Section 5.8.3). This means that there will be a negligible change to the volume of water released from Lake Lyell due to extraction for construction water supply • the temporary removal of the fusegates will lower the FSL of the lake but will not increase the flood risk downstream of Lake Lyell as the lake will only spill when the FSL is exceeded due to inflows (as per the existing arrangement). **Residual impact:** *Neutral change*

Aspect	Summary of the existing condition	Changes due to construction of the project
b) Water quality	• Water quality in the Coxs River downstream of Lake Lyell is governed by the quality of water released from the lake via either controlled releases or spillway overflows. Controlled releases occur through the MLO outlet tower which is operated to draw vortex free laminar flow into the tower that generally has high DO levels, good colour and is free of floating debris, such as algae. Selective withdrawal typically occurs approximately 3 m below the water surface. Analysis of water monitoring data (refer to Section 4.4) concluded that the selective withdrawal approach is an effective mitigation method as: – the water quality in the Coxs River downstream of Lake Lyell generally has DO within the DGV range, low turbidity and algae levels that are well below levels in the reservoir – the temperature of water released from Lake Lyell is generally within the range of temperatures in Coxs River and Farmers Creek upstream of the lake which means there is no clear indication that cold water pollution is occurring. • The following additional conclusions are made from the water monitoring data (refer to Section 4.4) and nutrient balance calculations (refer to Table 4.15): – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur. – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.	No changes to the water quality in the Coxs River downstream of Lake Lyell are predicted during construction as: • the construction water management system (refer to Chapter 5) will include best practice standard controls to manage potentially contaminated water, stormwater and wastewater • changes to water quality in Lake Lyell are limited to potential elevated suspended sediment concentrations and turbidity levels in the Farmers Creek arm during wet weather. No other material changes to water quality are expected in the Farmers Creek arm or other parts of the lake • Lake Lyell will continue to beneficially reduce turbidity levels, suspended sediment and bioavailable nitrogen concentrations. **Residual impact:** *Neutral change*

8 Operational phase residual impacts

8.1 Overview

This chapter describes predicted water cycle changes during the commissioning and operational phase of the project, in which the operational phase water management principles and measures that are described in Chapter 6 will be implemented. Sections 8.2 to 8.5 describe key changes due to the operation of the PHES and Section 8.6 provides a summary of changes to receiving waters. Impacts to waterfront land during construction and operation are described separately in Chapter 9.

8.2 Lake Lyell water level regime

The PHES operating principles are described in Section 6.1. The following elements are relevant to changes to the Lake Lyell water level regime:

- The PHES facility will be operated based on the electricity market demand. It is anticipated that standard operations will include either full or part cycles on most days. A full cycle will result in 9 ½ hours of pumping and 8 hours of discharging within a day. Pumping will generally occur during the day and generating will generally occur during the morning and evening peaks. The maximum pump rate is 190 m^3/s and the maximum discharge rate is 210 m^3/s. During a full cycle, 5.3 GL (equivalent to 16% of Lake Lyell total storage volume) will be transferred between Lake Lyell and the upper reservoir.

- EnergyAustralia will seek to maintain Lake Lyell water levels within the target PHES operating range (781.0 to 784.5 mAHD). This will be achieved when the upper level (784.5 mAHD) is not exceeded at the end of a discharge cycle and the lake level does not drop below the lower level (781.0 mAHD) at the end of a pump cycle. When lake water levels exceed the target PHES operating range water will be either released from the lake via the riparian outlet (which has a 1,036 ML/d capacity) or pumped to Thompson Creek Reservoir via the Lilyvale Pump Station (which has a 95 ML/d capacity). The operating approach during high inflow events is described in Section 6.1.2. The minimum operating level is 780 mAHD.

Table 8.1 provides the maximum rate of water level change and the maximum total change in Lake Lyell water levels over a full cycle. Figure 8.1 shows the extent of the PHES operating range that is below the FSL (i.e. 780 to 785.5 mAHD) relative to the lakebed levels. The lake shoreline (or ponded water extent) will fluctuate within this area when the PHES is operating.

Table 8.1 Maximum water level change in Lake Lyell

Aspect	Description
Maximum rate of water level change	0.3 to 0.4 m/hr (depending on lake water level[1])
Maximum water level change over a full pump/discharge cycle	2.30 to 2.85 m (depending on lake water level[1])

Notes:

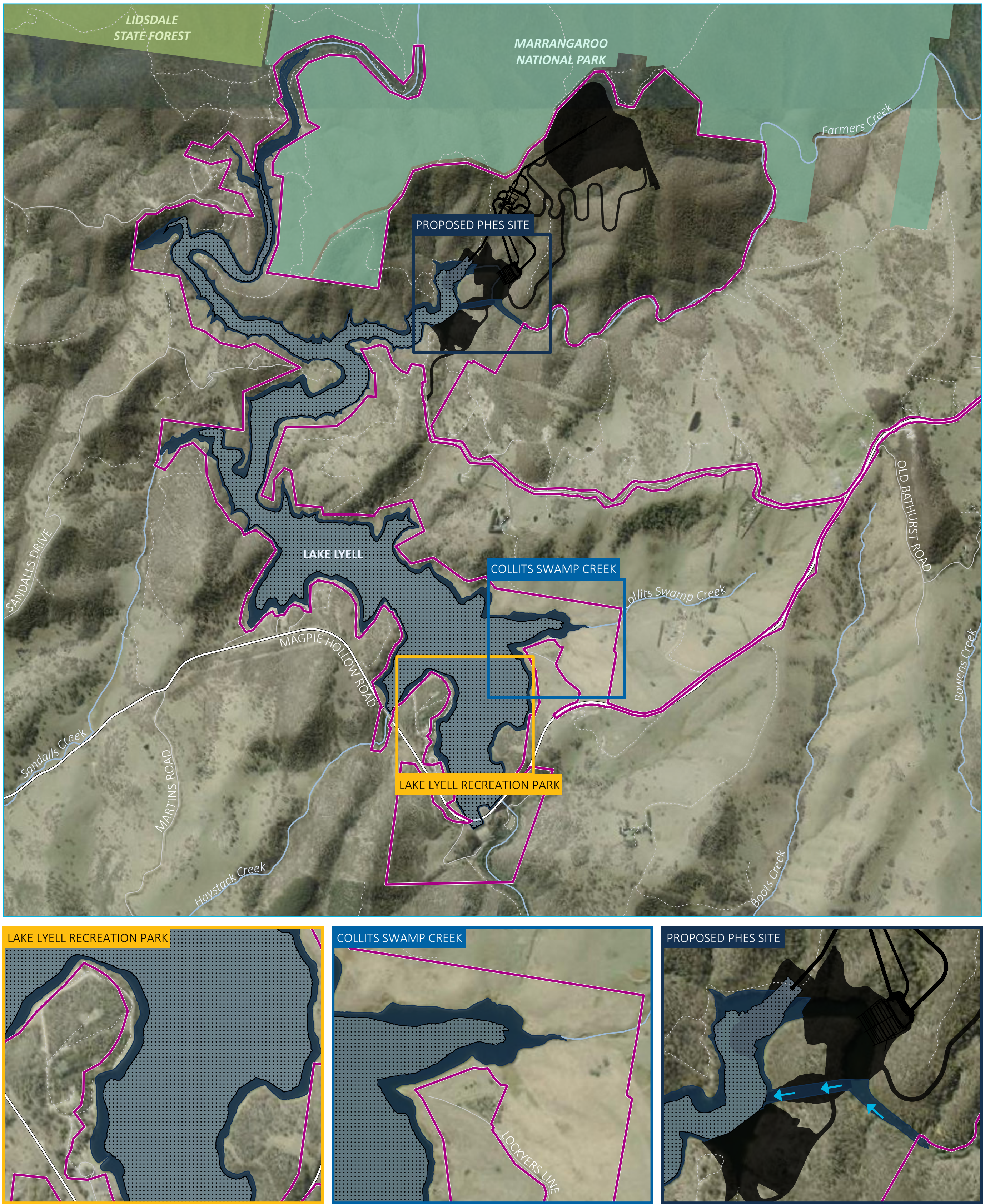
1. The rate of water level change due to PHES operations is variable as the Lake Lyell storage to surface area ratio reduces with depth. The higher rates of change will occur when the Lake Lyell water level is near the lower end of the PHES operating range and the lower rates will occur when Lake Lyell water level is near the upper end of the PHES operating range.

Table 8.2 provides a summary of changes to the Lake Lyell water level and spill regime due to the PHES operation.

Table 8.2 Changes to Lake Lyell water level and spill regimes

	Existing condition (from Table 4.18)	Changes due to PHES operation
Changes to lake water levels	• Lake Lyell is generally maintained in a near full condition, with water levels ranging from above FSL to 782.3 mAHD (a 4.4 m range) during the recent period. • Outside of significant wet weather events the lake water levels change slowly.	• Lake Lyell will generally be maintained within the target PHES operating range (781.0 to 784.5 mAHD) and will occasionally be within the maximum PHES operating range (780.0 to 786.0 mAHD). Lake Lyell will be 78% full[1] at the minimum PHES operating level of 780.0 mAHD. • Lake water levels will fluctuate daily due to PHES operations. The maximum rate of water level change will be 0.4 m/hr and the maximum change in water level over a full cycle will be 2.85 m. • Figure 8.1 shows areas where the lake shoreline (or ponded water extent) will fluctuate due to the PHES operation.
Changes to lake spill frequencies	• During high inflow events Lake Lyell is generally allowed to fill to FSL then spill.	• The frequency of water levels exceeding the Lake Lyell FSL and spills from the lake will decrease as EnergyAustralia will seek to maintain lake water levels within the target PHES operating range using riparian releases.

Notes: 78% full refers to the water level between the Lake Lyell MOL (761.3 mAHD) and FSL (785.5 mAHD)



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

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KEY

- Project area
- Farmers creek flow direction
- Operational footprint
- Lake inundation extent at minimum PHES operating level (780.0 m AHD)*
- PHES operating range to FSL (780.0 to 785.5 m AHD)*

Existing environment

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

*The 780 m AHD contour was derived using bathymetry data provided by Energy Australia. The 785.5 m AHD contour was derived using a 1 m DEM obtained from the ELVIS portal.

Proposed PHES operation levels

Lake Lyell PHES
Surface Water Impact Assessment
Figure 8.1

EMM
creating opportunities

8.3 Potential scour in Farmers Creek arm of Lake Lyell

The PHES facility will use Lake Lyell as the lower reservoir. During pumping and discharge, water will flow between Lake Lyell and the inlet and outlet works via the Farmers Creek arm of Lake Lyell. The maximum flow rates for discharging and pumping are 210 m^3/s and 190 m^3/s respectively. For context these flows are greater than the daily maximum flow rate (184 m^3/s) recorded at Farmers Creek at Mount Walker (gauge 212042) over the 44-year period from 1 October 1980 to 30 September 2024. The pumping and discharge flow rates have potential to cause scour or erosion of sediments at the lakebed and along banks in the Farmers Creek arm of Lake Lyell.

A qualitative assessment of scour risks is provided in Annexure G. This assessment concluded the following:

- There is potential for scour of sediments at the lakebed and along banks, as calculated average velocities at all the cross-sections exceed at least one erosion velocity threshold for clay, silt, sand and gravel. The assessment identified areas within the Farmers Creek arm of Lake Lyell that may have a higher erosion risk. These areas include:

  - The lakebed and bank inundated at the lower end of the maximum PHES operating range (i.e. below 781 mAHD). For water level at 781 mAHD, more sediment types have the potential to erode (clay, silt, sand and gravel) compared to at the higher water level of 784.5 mAHD (silt and sand only). This is because the available flow conveyance area reduces as the water level drops, resulting in higher velocities and increased potential for scour.

  - Parts of Farmers Creek arm that have a narrower channel. Cross-sections 4, 6, 7 and 8 (refer to Figure G.1 in Annexure G) have smaller cross-sectional areas compared to the other cross-sections. The flow velocity and scour potential would be higher in the narrower parts of the channel that have less flow conveyance area

  - Parts of Farmers Creek arm that have channel bends. There are three bends between cross-section 4 to 11 (refer to Figure G.1 in Annexure G) that would likely have a higher erosion risk relative to the straighter parts of the channel. This is due to the likely presence of concave banks (which are more susceptible to scour) and recirculating currents that increase turbulence and flow velocities along channel banks.

  Annexure G provides more detailed information on the potential for scour in Farmers Creek arm.

- If scour does occur it is expected that:

  - the extent and magnitude of scour will decline overtime as the lakebed and banks will adjust to a new scour and depositional equilibrium

  - most of the scoured material will be deposited in and around the western portion of the Farmers Creek arm of Lake Lyell where flow velocities will be lower due to increased cross-sectional area.

- The use of rock armouring would be an effective mitigation against bank or shoreline erosion provided that the armouring is appropriately designed to prevent undermining.

The risk of scour occurring is a function of the flow velocities against the bed and banks and the ground conditions. There is negligible potential for scour where shallow bedrock is present. Ground conditions within Farmers Creek arm have not been assessed.

Further assessment will be undertaken at detailed design. This assessment will be informed by a numerical model and will be used to inform the design of the inlet and outlet structure and identify the need for and inform the design of shoreline armouring.

8.4 Potential for thermal heating

The PHES project will have capacity to generate 3,080 MWh of electricity over a full cycle. Energy losses in the system will occur at the reversible turbines and as friction losses in the tunnels and inlet and outlet works. Most of the energy loss in the system will manifest as heat. The heat will be absorbed by water moving through the turbines and tunnels and would also be dissipated within the turbine enclosure.

Thermal heating assumptions were undertaken using conservative assumptions to assess the potential for the operation of the PHES to result in heating of Lake Lyell. The calculations are provided in Annexure F and concluded:

- the potential thermal heating of water transported over the full cycle is 0.13°C. This increase in water temperature is negligible, as air temperature and solar radiation result in daily lake water temperature changes that are an order of magnitude greater

- there will not be a build-up of heat in Lake Lyell, as the discrete volume of water transported over a full cycle (16% of Lake Lyell total volume) will dilute with lake water and the lake water temperature is continually adjusting through heat exchange with the atmosphere, gradually moving toward thermal equilibrium.

The overall conclusion is that the operation of the PHES will not result in any material heating of Lake Lyell.

8.5 Changes to Lake Lyell water cycle processes and quality

The operation of the PHES will introduce the following key changes to Lake Lyell:

- **Water circulation** - A full cycle will circulate 5.3 GL of water between Lake Lyell and the upper reservoir. This volume is equivalent to 16% of Lake Lyell total storage capacity (33.5 GL), up to the FSL. Water discharged from the upper reservoir into the Farmers Creek arm will be fully mixed and oxygenated which means it will have a homogeneous temperature, density and water quality and high DO levels.

- **Increased kinetic mixing** - pumping and discharging will introduce new currents and kinetic mixing in Lake Lyell. The currents will be strongest in the Farmers Creek arm of Lake Lyell and in the upper (northern) extent of Lake Lyell which is narrower and shallower than the lower (southern) extent of the lake.

Section 8.5.1 describes a conceptual water cycle processes model for Lake Lyell with PHES operations. Changes to the stratification cycle, algae levels and water quality in Lake Lyell are discussed in Section 8.6.

8.5.1 Conceptual water cycle processes model for Lake Lyell with PHES operation

Section 4.5 describes a conceptual water cycle processes model for Lake Lyell for the existing condition. These processes are expected to continue however some of the processes will be less dominant in the proposed condition. Figure 8.2 shows the additional processes that will be introduced by the operation of the PHES facility. Figure 8.2 should be read in conjunction with Table 8.3, which describes the new processes and Section 4.5, which describes the existing processes.

Table 8.3 Additional water cycle processes in Lake Lyell due to PHES operation

ID	Description
15	**Upper reservoir** – The upper reservoir active storage is 5.3 GL which equates to 16% of Lake Lyell total storage volume at FSL (33.5 GL).
16	**PHES pumping and discharges –** The PHES facility will be operated based on the electricity market demand. It is anticipated that standard operations will include either full or part cycles on most days. A full cycle will result in 9 ½ hours of pumping and 8 hours of discharging within a day. Pumping will generally occur during the day and generating will generally occur during the morning and evening peaks. The maximum pump rate is 190 m^3/s and the maximum discharge rate is 210 m^3/s. During a full cycle, 5.3 GL (equivalent to 16% of Lake Lyell total storage volume) will be transferred between Lake Lyell and the upper reservoir.
17	**PHES water level rise and fall –** Lake water levels will fluctuate daily due to PHES operations. The maximum rate of water level change will be 0.4 m/hr and the maximum change in water level over a full cycle will be 2.85 m.
18	**PHES induced currents (Farmers Creek arm)** – Water will be drawn from and discharged into Lake Lyell at the inlet and outlet works, which will be located at the eastern end of the Farmers Creek arm of Lake Lyell. The maximum flow rates for discharging and pumping are 210 m^3/s and 190 m^3/s respectively. Water discharged from the upper reservoir into the Farmers Creek arm will be fully mixed and oxygenated which means it will have a homogeneous temperature, density and water quality and high DO levels.
19	**PHES induced mixing (Lake Lyell) –** Pumping and discharging will introduce new currents and kinetic mixing in Lake Lyell. The currents will be strongest in the Farmers Creek arm and in the upper (northern) extent of the lake which adjoins the Farmers Creek arm where it is narrower and shallower than the lower (southern) part of the lake. The increased currents and mixing are expected to reduce the extent and magnitude of lake stratification relative to the existing condition. These changes will be more prevalent in the upper portion of the lake than the lower portion.
20	**Increased riparian releases** - EnergyAustralia will seek to maintain lake water levels within the target PHES operating range (781 to 784.5 mAHD) using riparian releases. This will mean that the frequency and magnitude of spills from the lake will decrease as utilisation of the riparian outlet will increase. No material change to the overall volume of water released from Lake Lyell is expected.

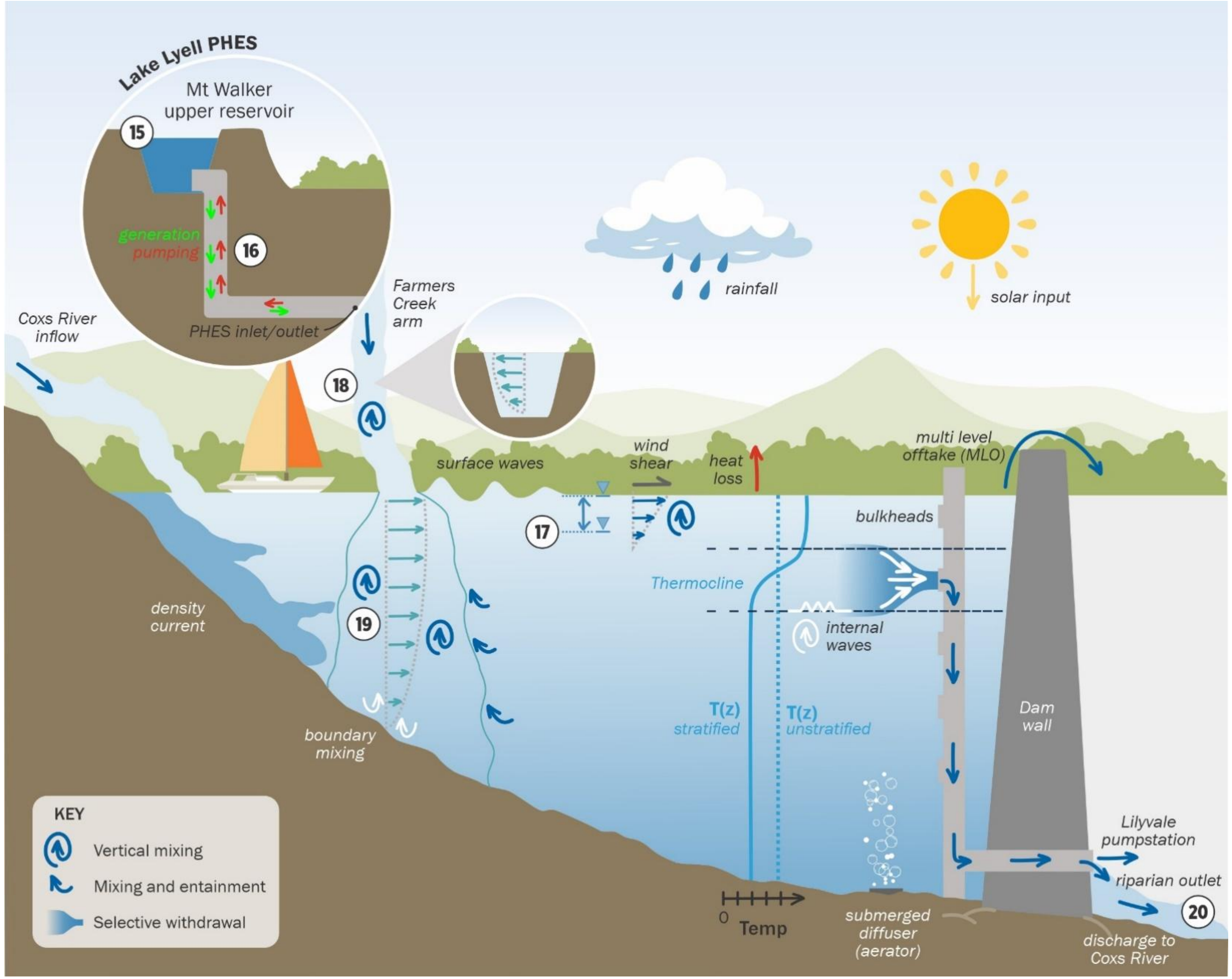

Figure 8.2 Additional water cycle processes in Lake Lyell due to PHES operation

8.6 Changes to key receiving waters

Section 4.6 establishes that Farmers Creek (lower reach), Lake Lyell and the Coxs River downstream of Lake Lyell are the key receiving waters for the project. Table 4.18 provides a summary of the key water cycle and water quality conditions in each of these key receiving waters for the existing condition. Table 8.4 provides a summary of predicted changes to these conditions due to the operation of the PHES facility. The table reproduces the descriptions of the existing condition from Table 4.18 and explains the changes with reference to the existing condition, information in this chapter and Chapter 6. For each aspect, a conclusion is made regarding the residual impact.

A key conclusion in Table 8.4 is that due to the proposed water management measures and the beneficial effect of the PHES operation on Lake Lyell water quality, the commissioning and operational phase of the project is expected to have a neutral to beneficial effect on water quality in the Coxs River downstream of Lake Lyell. This means that the project would also have a neutral to beneficial effect on water quality in Lake Burragorang, which is a major water supply dam for the Sydney metropolitan region that receives inflows from the Coxs River and is operated by WaterNSW.

Table 8.4 Summary of changes to existing conditions in key receiving waters

<table>
<tr><th>Aspect</th><th>Summary of the existing condition</th><th>Changes due to operation of the PHES facility</th></tr>
<tr><td colspan="3">1. Farmers Creek (lower reach)</td></tr>
<tr><td></td><td>
• Farmers Creek (lower reach) refers to the lower 2,800 m reach of Farmers Creek that is upstream of Lake Lyell. This reach of the creek meanders through steep vegetated terrain and has well established riparian vegetation.
• The creek receives runoff from a 67 km^2 catchment (refer to Figure 4.3). Its flow regime is impacted by water captured in the Farmers Creek Reservoir, runoff from urban areas in Lithgow and discharges from the Lithgow WWTP. It is estimated that Farmers Creek contributes approximately 25% of the total inflow to Lake Lyell (refer to Table 4.10).
• The creek water quality is characterised as having:
– pH and EC that is generally within the DGV range
– turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather
– nutrient (TN and TP) concentrations that nearly always exceed DGVs and are elevated relative to concentrations in the Coxs River upstream of Lake Lyell.
• There is insufficient data to identify if metals or other toxicants are present in Farmers Creek above DGV levels.
• Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.
</td><td>
No material changes to the streamflow regime or water quality in the Farmers Creek (lower reach) are expected as:
• Farmers Creek (lower reach) is upstream of Lake Lyell and will therefore not be impacted by the operation of the PHES facility
• the operational water management system (Section 6.3) will include best practice standard controls to manage:
– stormwater runoff from permanent infrastructure areas including the switchyard and infill pad
– stormwater runoff from sealed and unsealed permanent roads
– seepage from PSEs
– intercepted groundwater in the powerhouse, MAT and ECVT
– wastewater from amenities.
Residual impact: Neutral change
</td></tr>
</table>

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
2. Lake Lyell		
a) Lake water level regime	• Lake Lyell is generally maintained in a near full condition, with water levels ranging from above FSL to 782.3 mAHD (a 4.4 m range) during the recent period. • Outside of significant wet weather events the lake water levels change slowly. • Under existing operating conditions EnergyAustralia source water from Lake Lyell to supply the Mt Piper power station. During the recent period the water extraction volumes were equivalent to approximately 3% of total outflows from the lake and was therefore a minor process. EnergyAustralia can extract greater volumes from Lake Lyell however this would only likely occur if there was reduced water availability from the Springvale WTP.	• Lake Lyell will generally be maintained within the target PHES operating range (781.0 to 784.5 mAHD and will occasionally be within the maximum PHES operating range (780.0 to 786.0 mAHD). The lake will be 78% full (in terms of level) at the minimum PHES operating level of 780.0 mAHD. • Lake water levels will fluctuate daily due to PHES operations. The maximum rate of water level change will be 0.4 m/hr and the maximum change in water level over a full cycle will be 2.85 m. • Figure 8.1 shows areas where the lake shoreline (or ponded water extent) will fluctuate due to the PHES operation. • No changes to lake flood levels will occur as: – the PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows) and any associated flood impacts – no changes to the existing spillway or riparian outlet are proposed. **Residual impact:** *Lake Lyell will be maintained in a near full condition, the water level regime will adjust from changing slowly to fluctuating daily due to the PHES operation. There will be no change to lake flood levels.*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
b) Lake inflow regime	• Lake Lyell receives inflows from the Coxs River, Farmers Creek, several smaller watercourses that drain into the lake and direct rainfall. During the recent period inflows to the lake are estimated to have ranged from 28 to 116 GL/yr and originated from the following sources: – Coxs River upstream Lake Lyell – 58% – Farmers Creek upstream of Lake Lyell – 25% – inflow from smaller watercourses that drain into the lake – 14% – direct rainfall to the lake – 3% • There are some anthropogenic activities in the Coxs River and Farmers Creek catchments that influence streamflow and water quality. During the recent period key activities include: the capture and use of water in Thompson Creek and Farmers Creek reservoirs, discharges from the Wallerawang and Lithgow WWTPs, discharges from mining operations and coal ash dams within the catchment. • Water quality data and nutrient balance calculations (refer to Table 4.15) indicate that there is an anthropogenic source of nitrogen in the Farmers Creek catchment (upstream of Lake Lyell) and that Farmers Creek inflows contribute more than 90% of the total NOx load and 45% of the total TN load in inflows to Lake Lyell.	No material changes to the lake inflow regime are expected as: • the operation of the PHES facility will not change the existing lake inflow regimes • the operational water management system (refer to Section 6.3) will include best practice standard controls to manage: – stormwater runoff from permanent infrastructure areas including the switchyard and infill pad – stormwater runoff from sealed and unsealed permanent roads – seepage from PSEs – intercepted groundwater in the powerhouse, MAT and ECVT – wastewater from amenities. **Residual impact:** *Neutral change*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
c) Lake stratification cycle	• Central to Lake Lyell's mixing regime is the natural heating and cooling cycle of the waterbody, specifically the development of thermal stratification and its subsequent breakdown into a homogeneous water column (destratification). Water monitoring data (refer to Section 4.4.4) indicates that: – stratification can occur between October and April, with the strongest stratified state usually occurring from December to February – temporary destratification occurs during most summers due to artificial destratification and/or kinetic mixing induced by inflow or wind events – seasonal destratification typically occurs in March to April (due to convective mixing and/or artificial destratification) and unstratified conditions are prevalent from April through to September. • The following water quality conditions are associated with the stratification cycle: – low DO levels can occur in the lower lake (the hypolimnion) due to limited vertical mixing with oxygen saturated surface water in the epilimnion – low DO levels in the hypolimnion can lead to anoxic conditions near the lakebed and sediments release soluble iron and manganese and nutrients such as nitrogen and phosphorus that are stored in sediments. Once released, the soluble metals and nutrients can mix vertically when the stratification breaks down, resulting in poor water quality and a higher risk of algal blooms. • EnergyAustralia operate a submerged diffuser located on the reservoir bed near the dam wall. Operation of the diffuser system would likely reduce the duration and magnitude of both stratification events and anoxic conditions occurring near the lakebed.	The operation of the PHES facility will beneficially reduce the extent and magnitude of lake stratification as: • pumping and discharging will introduce new currents and kinetic mixing in Lake Lyell. The currents will be strongest in the Farmers Creek arm and in the upper (northern) extent of the lake which adjoins the Farmers Creek arm where it is narrower and shallower than the lower (southern) part of the lake. The increased currents and mixing are expected to reduce the extent and magnitude of lake stratification relative to the existing condition. These changes will be more prevalent in the upper portion of the lake than the lower portion • water discharged from the upper reservoir into the Farmers Creek arm will be fully mixed and oxygenated which means it will have a homogeneous temperature, density and water quality and high DO levels. This will beneficially reduce the extent and magnitude of stratification which requires a thermal gradient to develop within the water column • EnergyAustralia will continue to operate the submerged diffuser located on the reservoir bed near the dam wall if required. **Residual impact:** *Beneficial change*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
d) Algae levels within Lake Lyell	• EnergyAustralia monitor algae at seven locations within Lake Lyell and two locations on the Coxs River, downstream of Lake Lyell. The data is used to establish algae alert levels for the lake. The key conclusions from this data which is presented and analysed in Section 4.4.3 are: – algae alerts (green to red) mostly occur in summer and autumn, with autumn displaying the higher percents in amber and red. This aligns with the seasonal destratification that occurs in March and April – algae alerts are more likely to occur during dry conditions than wet conditions – algae concentrations are generally higher in upper reservoir monitoring locations then at the outlet tower – runoff from bush fire affected areas in the catchment can lead to abnormally high algae levels. • The following factors are assessed to contribute to algae growth: – high NOx (a bioavailable form of nitrogen) loads in Farmers Creek inflows create opportunities for algae growth – the seasonal destratification that occurs in March and April can supply nutrients to the epilimnion which can lead to algae growth in autumn – runoff from bush fire affected areas in the catchment can contribute abnormally high nutrient loads to the lake, creating opportunities for significant algae growth.	The operation of the PHES facility will beneficially reduce the extent and magnitude of algae blooms in Lake Lyell as: • the PHES induced mixing and circulation will create less favourable conditions for algae growth which thrive in still and calm conditions • less lake stratification will reduce the release of nutrients to the epilimnion during the seasonal destratification that typically occurs (for the existing condition) in March and April and is associated with the highest annual algae levels • the operational water management system (refer to Section 6.3) will include measures to manage nitrogen laden water such as PSE seepage and wastewater. **Residual impact:** *Beneficial change*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
e) Water quality of lake water	• The water quality of Lake Lyell is dependent on the water quality of the inflows and the limnological processes that occur within the lake (refer to Figure 4.25). Lake water quality is characterised as having: – pH that ranges between 6.0 and 10.0, relative to the DGV range of 6.5 to 8.0 – EC that ranges from 100 to 850 µS/cm, relative to a DGV of 350 µS/cm – DO that is generally within or above the DGV range at the surface but declines to below the DGV range at depth when the lake is stratified – turbidity levels that are generally below the DGV but intermittently exceed the DGV, typically after wet weather – nutrient (TN and TP) concentrations that nearly always exceed DGVs but are similar to concentrations in the Coxs River upstream of Lake Lyell. • The following additional conclusions are made from the water monitoring data and nutrient balance calculations: – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur. – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.	The following aspects of the operation of the PHES facility will have a neutral to beneficial effect on Lake Lyell water quality: • Less lake stratification will reduce opportunities for the release of nutrients and metals from lake sediments that occur with anoxic conditions. • The PHES induced mixing will improve water quality in the Farmers Creek arm and upper reaches of the lake which historically have had higher algae levels relative to the lower part of the lake. • The operational water management system (refer to Section 6.3) will include measures to manage nitrogen laden water such as PSE seepage and wastewater. The following aspects of the operation of the PHES facility may temporarily impact Lake Lyell water quality: • Scour in Farmers Creek arm may occur during the initial operating period. Scour has potential to generate suspended sediment and turbidity in Farmers Creek arm and the adjoining areas of Lake Lyell. The extent and magnitude of any impacts would decline overtime as the scour and depositional processes reach a new equilibrium. **Residual impact:** *Neutral to beneficial change, however there is potential for increased turbidity during the initial operating period if scour of Farmers Creek arm occurs.*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
3. Coxs River downstream		
a) Streamflow regime	• Streamflow in the Coxs River downstream of Lake Lyell is controlled by releases from the lake which occur via: – controlled releases from the riparian outlet to meet environmental flow requirements (refer to Section 4.2.4i) and for other purposes. The maximum capacity of the riparian outlet is 1,036 ML/d (equivalent to ≈12 m^3/s) – discharges over the spillway when the water level in the lake exceeds the FSL. • A conceptual water balance of lake inflows and outflows over the recent period concluded that annual streamflow volumes in the Coxs River downstream of Lake Lyell are similar to lake inflow volumes.	The operation of the PHES facility will result in a minimal change to the streamflow regime in the Coxs River downstream of Lake Lyell as: • no change to existing spillway and riparian outlet or environmental release requirements from Lake Lyell are proposed • PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows) and any associated flood impacts • EnergyAustralia will seek to maintain lake water levels within the target PHES operating range using riparian releases. This will mean that the frequency and magnitude of spills from the lake will decrease as utilisation of the riparian outlet will increase • the following direct and indirect water take from Lake Lyell will occur: – The initial filling of the upper reservoir will occur gradually over multiple pump and discharge cycles during the commissioning phase of the project. The initial filling process will take 6.3 GL of water from Lake Lyell (refer to Section 6.2.1). This will result in a commensurate reduction in the volume of water released to the Coxs River overtime – once initial filling has been completed subsequent filling and emptying of the upper reservoir will be approximately in balance which means there will be no additional net water take from Lake Lyell aside from net system losses. Net system losses due to the operation of the PHES facility are equivalent to 0.08% of lake outflows and are therefore negligible from a catchment scale water balance perspective (refer to Section 6.2.2). This means that there will be a negligible change to the volume of water released from Lake Lyell following the initial filling process • it is noted that the water licencing approach and requirements for initial filling and net system losses are described separately in the Water Licensing Strategy (EMM 2025c). **Residual impact:** *No change to environmental release requirements, minimal change to streamflow regimes, negligible change to streamflow volumes except for a one-off 6.3 GL reduction due to initial filling, no increase in flood risk downstream of Lake Lyell.*

Aspect	Summary of the existing condition	Changes due to operation of the PHES facility
b) Water quality	• Water quality in the Coxs River downstream of Lake Lyell is governed by the quality of water released from the lake via either controlled releases or spillway overflows. Controlled releases occur through the MLO outlet tower which is operated to draw vortex free laminar flow into the tower that generally has high DO levels, good colour and is free of floating debris, such as algae. Selective withdrawal typically occurs approximately 3 m below the water surface. Analysis of water monitoring data (refer to Section 4.4) concluded that the selective withdrawal approach is an effective mitigation method as: – the water quality in the Coxs River downstream of Lake Lyell generally has DO within the DGV range, low turbidity and algae levels that are well below levels in the reservoir – the temperature of water released from Lake Lyell is generally within the range of temperatures in Coxs River and Farmers Creek upstream of the lake which means there is no clear indication that cold water pollution is occurring. • The following additional conclusions are made from the water monitoring data (refer to Section 4.4) and nutrient balance calculations (refer to Table 4.15): – Lake Lyell beneficially reduces turbidity levels and suspended sediment concentrations in that releases from the lake generally have low turbidity and suspended sediment even when turbid inflows occur. – Lake Lyell beneficially removes bioavailable nitrogen (i.e. NOx) with calculated loads of NOx in lake inflows reducing by 38% in lake outflows over the recent period.	The operation of the PHES facility will have a neutral to beneficial effect on the water quality in the Coxs River downstream of Lake Lyell as: • a neutral to beneficial effect on lake water quality is predicted (see Item 3b) • no heating of Lake Lyell is predicted (refer to Section 8.4) • no changes to the riparian outlet or environmental release requirements from Lake Lyell are proposed • the PHES induced mixing may inhibit potential for algae growth and settlement of suspended solids in Farmers Creek arm and the upper portion of Lake Lyell. Notwithstanding these processes will continue to occur in the lower (southern) portion of the lake where the PHES induced mixing currents will be substantially lower. Therefore, Lake Lyell will continue to beneficially reduce turbidity levels, suspended sediment and bioavailable nitrogen concentrations in lake inflows. **Residual impact:** *Neutral to beneficial change*

9 Impacts to waterfront land

9.1 Overview

This chapter describes impacts to waterfront land during both construction and operations. As described in Section 5.10, the WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of a riverbank, lake shore or estuary mean high water mark. The construction of the project will unavoidably require the following works on waterfront land:

- temporary and permanent watercourse diversions
- watercourse crossings
- construction of the following works within Lake Lyell:
  - the inlet and outlet structure
  - the lake diversion
  - PSE 2 (infill pad) and PSE 3 (laydown pad)
  - temporary removal of one or more fusegates on the Lilyvale Dam spillway (refer to Section 5.9.1)
- construction works within 40 m of watercourses and Lake Lyell.

Figure 5.5 (in Chapter 5) shows the indicative extent of waterfront land, the location of temporary and permanent watercourse diversions and proposed works within Lake Lyell and on waterfront land. Table 5.10 (in Chapter 5) describes proposed measures for works on waterfront land, including descriptions of proposed works in Lake Lyell.

9.2 Changes to watercourses

Section 4.2.3 established that there are twelve watercourses and five drainage lines that have catchments that are either partly or fully within the construction envelope (excluding the access road) and could therefore be potentially disturbed by the project. The term drainage line is used to describe material drainage features that are not shown as hydrolines in the Water Management (General) Regulation Hydro Line spatial database. These drainage lines have similar characteristics to a 1st or 2nd order watercourse.

Table 9.1 provides a summary of changes to watercourses and drainage lines during the construction and operation of the project. The location and pre-development catchment area of each watercourse and drainage line is shown in Figure 5.5 (in Chapter 5).

Table 9.1 Summary of changes to watercourses

Name	Catchment area	Stream order	Temporary impacts during construction	Permanent changes
Watercourse 1	62 ha	3rd order	• The upper portion of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The construction envelope does not intersect with watercourses or riparian zones within the catchment. Therefore, there will be no direct impacts to watercourses or riparian corridors.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.
Watercourse 2	46 ha	2nd order	• The upper portion of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• The upper portion of the catchment (approximately 3 ha or 7% of the catchment area) will be permanently diverted into the upper reservoir. Therefore, there will be a minor reduction in runoff volumes from this catchment. No changes to the runoff regime (i.e. when runoff does and doesn't occur) are predicted as runoff will still occur from the remaining catchment area. • Any construction disturbance in the catchment will be rehabilitated.
Watercourse 3	77 ha	2nd order	• The Watercourse 3 catchment will be disturbed by the construction of the upper reservoir, access roads and PSEs 1, 4, 5 and 6. During construction runoff from this catchment will be managed in the construction water system, which will include water management basins in the lower part of the catchment.	• The upper portion of the catchment (approximately 23 ha or 30% of the catchment area) will be permanently diverted into the upper reservoir. Therefore, there will be a reduction in runoff volumes from this catchment. • The upper reservoir embankment (PSE 1) and land-based PSEs (PSE 4, 5 and 6) will be constructed in the Watercourse 3 catchment. Each PSE will include subsurface drainage to facilitate drainage through the landforms. The extent of each PSE is indicated in Figure 5.5.
Watercourse 4	33 ha	2nd order	• During construction, runoff from Watercourse 4 will be collected in a clean water dam and pumped into Lake Lyell (indicated in Figure 5.5). • The clean water dam will be removed when construction of the inlet and outlet works is finished and Watercourse 4 will be reinstated.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.

Name	Catchment area	Stream order	Temporary impacts during construction	Permanent changes
Watercourse 5	23 ha	1st order	• The upper portion of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• The upper reservoir spillway will discharge into this catchment. As described in Table 6.1, the purpose of the spillway is to prevent the embankment from overtopping if water levels in the upper reservoir exceed the FSL due to either rare or extreme rainfall or an over-pumping event. An over-pumping event would require multiple system failures and is therefore unlikely to occur. Any non-minor spill has potential to cause scour and erosion in Watercourse 5. • Any construction disturbance in the catchment will be rehabilitated.
Watercourse 6	10 ha	1st order	• Most of this catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The lower reach of this watercourse will be permanently diverted around the inlet and outlet structure (indicated in Figure 5.5).	• Any construction disturbance in the catchment will be rehabilitated. • The lower reach of this watercourse will be permanently diverted around the inlet and outlet structure (indicated in Figure 5.5).
Watercourse 7	6 ha	1st order	• The lower part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.
Watercourse 8	4 ha	1st order	• A minor part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.
Watercourse 9	23 ha	1st order	• The lower part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The lower reach of this watercourse will be permanently diverted around or under the switchyard (indicated in Figure 5.5).	• The switchyard and other permanent infrastructure will be in the lower portion of the catchment. • The lower reach of this watercourse will be permanently diverted around or under the switchyard (indicated in Figure 5.5).
Watercourse 10	27 ha	3rd order	• The lower part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The lower reach of this watercourse will be permanently diverted around PSE 3 (indicated in Figure 5.5).	• The PSE 3 and other permanent infrastructure will be in the lower portion of the catchment. • The lower reach of this watercourse will be permanently diverted around PSE 3 (indicated in Figure 5.5).

Name	Catchment area	Stream order	Temporary impacts during construction	Permanent changes
Watercourse 11 (Collits Swamp Creek)	136 ha	3rd order	• A minor part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The construction envelope does not intersect any watercourses or riparian zones within the catchment. Therefore, there will be no direct impacts to watercourses or riparian corridors.	• The accommodation camp and access roads will be in the catchment.
Watercourse 12	13 ha	1st order	• The construction of the accommodation camp will require the removal of most of this 1st order watercourse.	• The construction of the accommodation camp will require the removal of most of this 1st order watercourse.
Drainage Line 1	9 ha	Drainage Line[1]	• The lower part of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • During construction drainage line 1 will be integrated with the Watercourse 4 clean water diversion system.	• The lower reach of this drainage line will be permanently diverted around the inlet and outlet structure (indicated in Figure 5.5).
Drainage Line 2	14 ha		• All of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur. • The lower reach of this drainage line will be permanently diverted around PSE 2 (indicated in Figure 5.5).	• Any construction disturbance in the catchment will be rehabilitated. • The lower reach of this drainage line will be permanently diverted around PSE 2 (indicated in Figure 5.5).
Drainage Line 3	8 ha		• All of the catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• The main site compound and other permanent infrastructure will be in this catchment.
Drainage Line 4	4 ha		• During construction, part of this catchment will be integrated with the Watercourse 4 clean water diversion system.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.
Drainage Line 5	3 ha		• A minor part of catchment is within the construction envelope. Therefore, some construction activities within the catchment may occur.	• No permanent changes as any construction disturbance in the catchment will be rehabilitated.

Notes: 1. The term drainage line is used to describe material drainage features that are not shown as hydrolines in the Water Management (General) Regulation Hydro Line spatial database.

10 Summary of management measures

Table 10.1 provides a summary of management measures described in this assessment.

Table 10.1 Summary of management measures

ID	Management measure	Report reference
Prior to construction		
D1	**Assessment of scour potential in Farmers Creek arm of Lake Lyell** Further assessment of scour potential in Farmers Creek arm of Lake Lyell will be undertaken at detailed design. This assessment will be informed by a numerical model and will be used to inform the design of the inlet and outlet structure and identify the need for and inform the design of shoreline armouring.	Section 8.3
During construction		
C1	**Construction water management plan** This plan will be prepared post approval in accordance with relevant consent conditions. It will: • describe the contaminated water, stormwater and wastewater management systems • describe how water will be managed to achieve compliance with consent and EPL conditions • establish surface water quantity and quality monitoring requirements.	Section 5.4
C2	**Nitrogen management plan** This plan will be prepared post approval in accordance with relevant consent conditions. It will: • describe protocols for storing, handling and using explosives to minimise the release of nitrogen from explosives use.	Section 5.5.3ii
C3	**Contaminated water management** In this assessment the term contaminated water is used to describe water produced by construction activities that has concentrations of nutrients, metals or other pollutants that exceed the minimal harm discharge criteria (refer to Table 5.1). The contaminated water system will manage potentially contaminated water generated from: • PSE runoff (during construction) and seepage • water pumped from subsurface excavation areas during construction • surface water from high intensity construction areas. The system will: • separate potentially contaminated water from clean water and stormwater systems • capture and contain contaminated to minimise spills into the stormwater system • beneficially use water for construction purposes to minimise discharge • treat surplus water to meet the minimal harm criteria (refer to Table 5.1) prior to discharge to Lake Lyell or Farmers Creek.	Section 5.5
C4	**Stormwater management** • Stormwater refers to runoff from roads and earthworks areas (excluding drill and blast areas), accommodation camp (during construction and operation of the camp), construction pads. • Stormwater will be managed in accordance with the approach described in Table 5.9, which is generally in accordance with the methods described in Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom 2004).	Section 5.6
C5	**Waste water management** All wastewater generated at the accommodation camp and construction site amenities will be trucked to a licensed facility unless a connection to an existing nearby sewer main is available. No onsite disposal of wastewater is proposed.	Section 5.7

ID	Management measure	Report reference
C6	**Lake Lyell operations during construction** EnergyAustralia will continue to operate Lake Lyell to meet the environmental flow requirements specified in section 57H of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023* and the water supply work and water use approval 10CA117220 held by EnergyAustralia.	Section 5.9
C7	**Works on waterfront land** • Works on waterfront land refers to works that are within 40 m of a watercourse or Lake Lyell. The construction of the project will unavoidably require the following works on waterfront land: – temporary and permanent watercourse diversions – watercourse crossings – construction of works within Lake Lyell, including: the inlet and outlet structure, the lake diversion, PSE 2 (infill pad) and PSE 3 (laydown pad) – construction works within 40 m of watercourses and Lake Lyell – temporary removal of one or more fusegates on the Lilyvale Dam spillway. • Works on waterfront land will be undertaken in accordance with the approach described in Table 5.10.	Section 5.10
During operations		
O1	**Environmental releases from Lake Lyell** EnergyAustralia will continue to operate Lake Lyell to meet the environmental flow requirements specified in section 57H of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023* and the water supply work and water use approval 10CA117220 held by EnergyAustralia.	Section 6.1
O2	**PHES operations during high inflow events** PHES generation and associated discharges from the upper reservoir to Lake Lyell will cease when the lake water level reaches the maximum PHES discharge level of 785.5 mAHD, which is the same as the Lake Lyell FSL. This will avoid PHES discharges while Lake Lyell is spilling (due to inflows).	Section 6.1.2
O3	**Lake Lyell and PHES operations management plan** This plan will be prepared post approval in accordance with relevant consent conditions. It will: • describe operating protocols for Lake Lyell and the PHES for normal, high inflow events and drought conditions • include a water and algae monitoring plan.	Section 6.1
O4	**Water management during operations** The following sources of water will require management during operations: • stormwater runoff from permanent infrastructure areas including the switchyard and infill pad • stormwater runoff from sealed and unsealed permanent roads • seepage from PSEs • intercepted groundwater in the powerhouse, MAT and ECVT • wastewater from amenities. Water management systems for each of these sources will be established in accordance with the controls in Table 6.4.	Section 6.3
O5	**Operations water management plan** This plan will be prepared post approval in accordance with relevant consent conditions. It will: • describe the water management systems (from Measure O4) • include a water monitoring plan.	Section 6.3

References

ANZECC and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council) 2000, Australian and New Zealand guidelines for fresh and marine water quality.

ANZG 2018, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Governments and Australian state and territory governments, https://www.waterquality.gov.au/anz-guidelines.

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Beutel et al. (2008), Effects of aerobic and anaerobic conditions on P, N, Fe, Mn, and Hg accumulation in waters overlaying profundal sediments of an oligo-mesotrophic lake, Water Research, Vol 42, Issues 8-9, April 2008, pages 1953-1962

BoM 2016a, Climate updates webpage http://www.bom.gov.au/climate/updates/articles/a020.shtml

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BoM 2025, Climate data online webpage http://www.bom.gov.au/climate/averages/tables/cw_063224.shtml

DECC 2007, Storing and handling liquids: environmental protection participant's manual. NSW Department of Environment and Climate Change

DECC 2008, Managing Urban Stormwater: Soils and Construction Volume 2E: Mines and quarries. NSW Department of Environment and Climate Change

DECCEEW 2024, Central West and Orana: Climate Change Snapshot

DPE 2022, guidelines for works on waterfront land refers to the following suite of guidelines:

- Controlled activities – Guidelines for riparian corridors on waterfront land (DPE 2022)
- Controlled activities – Guidelines for instream works on waterfront land (DPE 2022)
- Controlled activities – Guidelines for outlet structures on waterfront land (DPE 2022)
- Controlled activities – Guidelines for vegetation management plans on waterfront land (DPE 2022)
- Controlled activities – Guidelines for watercourse crossings on waterfront land (DPE 2022)
- Controlled activities – Guidelines for laying piped and cables in watercourses on waterfront land (DPE 2022)

DPI 2003, Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings

Earle, 2019, Physical Geology, BCcampus, https://opentextbc.ca/physicalgeology2ed/

EA 2023a, Lyell Dam Databook – Mount Piper Power Station, June 2023

EA 2023b, Lyell Dam Operations and Maintenance Plan – Mount Piper Power Station, July 2023

EMM 2025a, Lake Lyell Pumped Hydro Project – Groundwater Assessment

EMM 2025b, Lake Lyell Pumped Hydro Project – Excavated Rock Management Strategy

EMM 2025c, Lake Lyell Pumped Hydro Project – Water licencing strategy

EMM 2025d, Lake Lyell Pumped Hydro Project Contamination Preliminary Site Investigation

HARC 2019, Hydrology, Dambreak and Consequence Assessment – Lyell, Thompson Creek and Wallerawang Dams, Report version 1, September, 2019

Krueger et al. (2020), Iron and manganese fluxes across the sediment-water interface in a drinking water reservoir, Water Research, Vol 182, September 2020.

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Ryan et al. (2001), Status of cold water releases from Victorian Dams, Department of Natural Resources and Environment, State Government of Victoria.

WaterNSW 2022, Neutral or Beneficial Effect on Water Quality Assessment Guideline

WaterNSW 2023a, Using MUSIC in Sydney Drinking Water Catchment

WaterNSW 2023b, Designing and Installing On-Site Wastewater Systems

Wasko, et all. 2024, Book 1 Chapter 6 Climate Change Considerations, Australian Rainfall and Runoff: A Guide to Flood Estimation

Abbreviations

AEP	annual exceedance probability
AMD	acid and metalliferous drainage
ANFO	Ammonium Nitrate Fuel Oil
BoM	Bureau of Meteorology
CSSI	Critical State Significant Infrastructure
Cv	volumetric runoff coefficient
D&B	drill and blast (refers to a method for excavating rock)
DGV	default guideline values
DPHI	NSW Department of Planning, Housing and Infrastructure
EDFA	EDF power solutions Australia
EIS	environmental impact statement
EMM	EMM Consulting Pty Limited
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
EY	exceedances per year
FSL	full supply level
GL	gigalitres
KV	kilovolt
LOR	limit of reporting
MOL	minimum operating level
MW	Megawatts
MWh	megawatt hours
NorBE	neutral or beneficial effect
NAG	net acid generation
NAF	non-acid forming
NEM	National Electricity Market
NOA	naturally occurring asbestos
the project	the Lake Lyell Pumped Hydro Energy Storage Project
PHES	pumped hydro energy storage
PMF	probable maximum flood
POEO Act	*Protection of the Environment Operations Act 1997*
PSEs	permanent spoil emplacements

SEARs	Secretary's Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
WWTP	wastewater treatment plant

Annexure A

Water quality data summary tables

EMM

creating opportunities

A.1 Water quality data summary tables

Table A.1 Water quality data summary table – Location WX13

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		60	4.6	7.4	8.6	10.6	14.1	Yes	-	-	-
EC	µS/cm	350		123	157	592	903	1051	1263	Yes	-	2.5x	3x
pH	pH units	6.5-8		123	6.5	7.8	8.4	8.7	9	Yes	-	-	-
Temperature	deg C			60	8.1	10.9	16.7	20.5	23.9	-	-	-	-
TSS (NFR)	mg/L		5	123	<5	<5	<5	<5	20	-	-	-	-
Turbidity	NTU	25		123	0.1	0.8	1.8	3.9	31.5	-	Yes	-	-
TDS	mg/L			31	139	216	347	418	451	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			36	30	65	109	119	319	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			31	30	55	103	114	142	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	50	<0.01	<0.01	0.02	0.04	0.3	Yes	-	2x	3x
Nitrate and Nitrite	mg/L	0.015	0.01	60	<0.01	<0.01	0.01	0.03	0.12	Yes	-	-	2x
TN	mg/L	0.25		60	0.1	0.4	0.5	0.7	1.2	Yes	-	2x	3x
TP (P)	mg/L	0.02	0.01	60	<0.01	<0.01	0.03	0.04	0.11	Yes	-	1.5x	2x

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
TKN	mg/L		0.1	60	<0.1	0.4	0.5	0.6	1.1	-	-	-	-
Phosphate (PO4) Filtered	mg/L	0.015	0.1	39	<0.1	<0.1	<0.1	<0.1	0.18	Inconclusive	Inconclusive	-	-
Anions													
Fluoride	mg/L		0.01	31	0.052	0.12	0.198	0.227	0.307	-	-	-	-
Chloride	mg/L			46	9.7	17.2	24.8	31.3	44	-	-	-	-
Sulphate	mg/L			95	40.8	126.4	178.1	263.2	377.6	-	-	-	-
Cations													
Sodium	mg/L			5	118	120	162	183	223	-	-	-	-
Potassium	mg/L			5	10.1	11	12.8	13.1	13.6	-	-	-	-
Calcium	mg/L			5	16.2	16.2	19.2	24.9	33.5	-	-	-	-
Magnesium	mg/L			5	13.1	14.8	16.5	18.9	23.2	-	-	-	-
Metals and metalloids (total)													
Aluminium	mg/L	0.055	0.01	75	<0.01	<0.01	0.02	0.05	0.75	Yes	-	-	-
Barium	mg/L		0.001	5	0.021	0.026	0.029	0.032	0.034	-	-	-	-
Copper	mg/L	0.0014	0.001	15	<0.001	<0.001	<0.001	0.002	0.006	Yes	-	-	1.5x
Iron	mg/L		0.05	8	<0.05	<0.05	0.12	0.23	0.3	-	-	-	-
Manganese	mg/L	1.9	0.001	8	0.05	0.057	0.09	0.134	0.192	-	-	-	-
Arsenic	mg/L	0.013	0.001	15	<0.001	0.003	0.004	0.007	0.008	-	-	-	-
Silver	mg/L	0.0005	0.001	5	<0.001	<0.001	<0.001	<0.001	<0.001	Inconclusive	Inconclusive	-	-
Boron	mg/L	0.94	0.05	15	0.08	0.11	0.13	0.15	0.16	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Cadmium	mg/L	0.0002	0.0001	5	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-	-	-
Mercury	mg/L	0.00006	0.00004	5	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	-	-	-	-
Molybdenum	mg/L	0.034	0.001	5	0.008	0.012	0.014	0.02	0.021	-	-	-	-
Nickel	mg/L	0.011	0.001	15	0.007	0.008	0.011	0.014	0.032	Yes	-	-	1x
Lead	mg/L	0.034	0.001	5	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Selenium	mg/L	0.005	0.0002	15	<0.0002	0.0002	0.0002	0.0003	0.0004	-	-	-	-
Zinc	mg/L	0.008	0.005	15	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	-	-
Chromium	mg/L	0.001	0.001	5	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Metals and metalloids (filtered)													
Iron filtered	mg/L		0.05	75	0.01	0.02	0.05	0.07	0.5	-	-	-	-
Manganese filtered	mg/L	1.9	0.001	75	0.001	0.01	0.032	0.097	0.5	-	-	-	-
Aluminium filtered	mg/L	0.055	0.01	15	<0.01	<0.01	<0.01	<0.01	0.09	-	Yes	-	-
Zinc filtered	mg/L	0.008	0.005	15	<0.005	<0.005	<0.005	<0.005	0.005	-	-	-	-
Arsenic filtered	mg/L	0.013	0.001	15	<0.001	0.003	0.004	0.007	0.008	-	-	-	-
Boron filtered	mg/L	0.94	0.05	15	0.08	0.1	0.13	0.14	0.15	-	-	-	-
Nickel filtered	mg/L	0.011	0.001	15	0.007	0.008	0.011	0.013	0.017	Yes	-	-	1x

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)

3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80th percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Table A.2 Water quality data summary table – Location COX5

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		45	6.5	7.5	9.1	11	15.1	Yes	-	-	-
EC	µS/cm	350		45	133	253	352	594	1226	Yes	-	1x	2x
pH	pH units	6.5-8		45	6.6	7.3	7.8	8.5	8.9	Yes	-	-	-
Temperature	deg C			45	7.9	12	19.3	22.6	27.6	-	-	-	-
TSS (NFR)	mg/L		5	45	<5	<5	<5	10.2	142	-	-	-	-
Turbidity	NTU	25		45	0.3	1.8	2.8	12.2	106	-	Yes	-	-
TDS	mg/L			45	106	156	231	361	778	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			30	18	45	59	83	113	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			30	18	42	59	83	113	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	40	<0.01	<0.01	0.01	0.02	0.06	Yes	-	-	2x
Nitrate and Nitrite	mg/L	0.015	0.01	45	<0.01	<0.01	0.02	0.08	0.21	Yes	-	1x	5x
TN	mg/L	0.25		45	0.2	0.4	0.5	0.7	1.3	Yes	-	2x	3x
TP (P)	mg/L	0.02	0.01	45	<0.01	0.02	0.03	0.05	0.11	Yes	-	2x	3x
TKN	mg/L		0.1	45	0.2	0.4	0.5	0.7	1.3	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Phosphate (PO4) Filtered	mg/L	0.015	0.1	34	<0.1	<0.1	<0.1	<0.1	0.13	Inconclusive	Inconclusive	-	-
Anions													
Fluoride	mg/L		0.01	30	0.042	0.089	0.114	0.168	0.212	-	-	-	-
Chloride	mg/L			30	9.8	11.9	13.5	16.4	27.4	-	-	-	-
Sulphate	mg/L			45	32.8	54.6	75.4	116.8	186	-	-	-	-

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)
3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80th percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Table A.3 Water quality data summary table – Location COX6

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		59	7.2	8.2	9.1	11.4	17.6	Yes	-	-	-
EC	µS/cm	350		59	72	141	213	278	655	-	Yes	-	-
pH	pH units	6.5-8		59	6.2	7.2	7.6	7.9	9	Yes	-	-	-
Temperature	deg C			59	3.8	8.6	13.5	17.7	23.1	-	-	-	-
TSS (NFR)	mg/L		5	59	<5	<5	<5	9.6	97	-	-	-	-
Turbidity	NTU	25		59	0.6	1.1	2.1	6.4	48.8	-	Yes	-	-
TDS	mg/L			31	69	82	105	139	228	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			31	18	31	40	54	65	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			31	18	31	40	54	65	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	49	<0.01	<0.01	0.02	0.04	0.36	Yes	-	2x	3x
Nitrate and Nitrite	mg/L	0.015	0.01	59	0.06	0.37	0.59	0.95	2.09	Yes	-	39x	63x
TN	mg/L	0.25		59	0.3	0.8	1	1.6	3.4	Yes	-	4x	6x
TP (P)	mg/L	0.02	0.01	59	<0.01	0.02	0.04	0.07	0.41	Yes	-	2x	4x
TKN	mg/L		0.1	59	0.2	0.3	0.4	0.6	1.4	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Phosphate (PO4) Filtered	mg/L	0.015	0.1	39	<0.1	<0.1	<0.1	0.14	0.82	Yes	-	-	9x
Anions													
Fluoride	mg/L		0.01	31	<0.02	0.057	0.075	0.12	0.234	-	-	-	-
Chloride	mg/L			31	7	7.7	9.7	15.3	19.9	-	-	-	-
Sulphate	mg/L			31	11.4	16.9	22.6	42	63.6	-	-	-	-
Metals and metalloids (total)													
Aluminium	mg/L	0.055	0.01	59	0.01	0.05	0.09	0.25	1.44	Yes	-	2x	5x
Iron	mg/L		0.05	8	0.11	0.17	0.23	0.38	0.61	-	-	-	-
Manganese	mg/L	1.9	0.001	8	0.012	0.019	0.024	0.039	0.057	-	-	-	-
Metals and metalloids (filtered)													
Iron filtered	mg/L		0.05	59	<0.05	0.08	0.11	0.17	0.61	-	-	-	-
Manganese filtered	mg/L	1.9	0.001	59	0.005	0.012	0.02	0.03	0.068	-	-	-	-

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)
3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80th percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Table A.4 Water quality data summary table – Location COX8A

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		48	6	7.8	9.1	10.2	14.2	Yes	-	-	-
EC	µS/cm	350		107	96	266	318	661	863	Yes	-	-	2x
pH	pH units	6.5-8		107	6.2	7.5	8	8.5	10.1	Yes	-	-	-
Temperature	deg C			48	9.1	11.1	17.3	20.8	24.9	-	-	-	-
TSS (NFR)	mg/L		5	71	<5	<5	<5	<5	14	-	-	-	-
Turbidity	NTU	25		48	0	0.6	1	3.6	52.6	-	Yes	-	-
TDS	mg/L			71	124	151	244	428	524	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			106	28	56	64	245	311	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			66	28	48	60	64	73	-	-	-	-
Calcium Hardness (as CaCO3) filtered	mg/L			6	29	31	33	36	37	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	61	<0.01	<0.01	0.02	0.03	0.1	Yes	-	1.5x	2x
Nitrate and Nitrite	mg/L	0.015	0.01	61	<0.01	0.05	0.12	0.19	0.53	Yes	-	8x	13x

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
TN	mg/L	0.25		61	0.1	0.4	0.4	0.6	1.3	Yes	-	2x	2.5x
TP (P)	mg/L	0.02	0.01	70	<0.01	0.01	0.03	0.05	1.09	Yes	-	1.5x	2.5x
TKN	mg/L		0.1	56	0.1	0.2	0.3	0.4	1.2	-	-	-	-
Phosphate (PO4) Filtered	mg/L	0.015	0.1	39	<0.1	<0.1	<0.1	<0.1	0.18	Inconclusive	Inconclusive	-	-
Anions													
Fluoride	mg/L		0.01	105	<0.01	0.102	0.14	0.293	0.563	-	-	-	-
Chloride	mg/L			106	5.7	12	14.4	18.4	41.8	-	-	-	-
Sulphate	mg/L			106	23.7	54.4	66.6	86	99.9	-	-	-	-
Cations													
Sodium	mg/L			106	17	28	36	114	177	-	-	-	-
Potassium	mg/L			106	4	5	5.7	8.6	11.1	-	-	-	-
Calcium	mg/L			106	10	13.7	15.2	16.3	22.2	-	-	-	-
Magnesium	mg/L			106	5.1	7.3	8.3	9.6	11.3	-	-	-	-
Metals and metalloids (total)													
Aluminium	mg/L	0.055	0.01	106	<0.01	0.01	0.02	0.05	0.74	-	Yes	-	-
Barium	mg/L		0.001	106	<0.001	0.014	0.016	0.018	0.034	-	-	-	-
Copper	mg/L	0.0014	0.001	106	<0.001	<0.001	0.001	0.002	0.03	Yes	-	-	1.5x
Iron	mg/L		0.05	106	0.01	0.05	0.05	0.11	0.96	-	-	-	-
Manganese	mg/L	1.9	0.001	106	<0.001	0.006	0.009	0.023	0.236	-	-	-	-
Strontium	mg/L		0.001	106	<0.001	0.076	0.085	0.093	0.499	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Arsenic	mg/L	0.013	0.001	106	<0.001	<0.001	<0.001	0.003	0.005	-	-	-	-
Silver	mg/L	0.0005	0.001	106	<0.001	<0.001	<0.001	<0.001	<0.001	Inconclusive	Inconclusive	-	-
Beryllium	mg/L		0.001	106	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Boron	mg/L	0.94	0.05	106	<0.05	<0.05	0.06	0.08	0.15	-	-	-	-
Cadmium	mg/L	0.0002	0.0001	106	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	-	Yes	-	-
Mercury	mg/L	0.00006	0.00004	79	<0.00004	<0.00004	<0.00004	<0.00004	0.00015	-	Yes	-	-
Molybdenum	mg/L	0.034	0.001	106	<0.001	0.001	0.002	0.01	0.014	-	-	-	-
Nickel	mg/L	0.011	0.001	106	<0.001	0.004	0.004	0.005	0.012	-	Yes	-	-
Lead	mg/L	0.034	0.001	106	<0.001	<0.001	<0.001	<0.001	0.054	-	Yes	-	-
Selenium	mg/L	0.005	0.0002	106	<0.0002	<0.0002	<0.01	<0.01	<0.01	Inconclusive	Inconclusive	-	-
Vanadium	mg/L	0.006	0.01	106	<0.01	<0.01	<0.01	<0.01	<0.01	Inconclusive	Inconclusive	-	-
Zinc	mg/L	0.008	0.005	106	<0.005	<0.005	<0.005	0.007	0.192	-	Yes	-	-
Antimony	mg/L	0.009	0.001	43	<0.001	<0.001	<0.001	<0.001	0.003	-	-	-	-
Cobalt	mg/L	0.0014	0.001	43	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Chromium	mg/L	0.001	0.001	105	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Metals and metalloids (filtered)													
Iron filtered	mg/L		0.05	54	0.01	0.05	0.05	0.17	0.32	-	-	-	-
Manganese filtered	mg/L	1.9	0.001	54	<0.001	0.001	0.003	0.011	0.058	-	-	-	-
Aluminium filtered	mg/L	0.055	0.01	54	<0.01	<0.01	0.01	0.06	0.25	Yes	-	-	1x

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Zinc filtered	mg/L	0.008	0.005	54	<0.005	<0.005	<0.005	<0.005	0.011	-	Yes	-	-
Arsenic filtered	mg/L	0.013	0.001	54	<0.001	<0.001	<0.001	0.001	0.004	-	-	-	-
Boron filtered	mg/L	0.94	0.05	54	<0.05	<0.05	0.05	0.07	0.09	-	-	-	-
Nickel filtered	mg/L	0.011	0.001	54	0.001	0.004	0.004	0.005	0.006	-	-	-	-
Vanadium filtered	mg/L	0.006	0.01	54	<0.01	<0.01	<0.01	<0.01	<0.01	Inconclusive	Inconclusive	-	-

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)
3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80th percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Table A.5 Water quality data summary table – Location COX9

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		47	6	7.9	8.8	10.7	14.6	Yes	-	-	-
EC	µS/cm	350		47	94	216	309	629	867	Yes	-	-	2x
pH	pH units	6.5-8		47	6.4	7.4	7.8	8.3	8.6	Yes	-	-	-
Temperature	deg C			47	9.1	12.4	16.5	20	25.4	-	-	-	-
TSS (NFR)	mg/L		5	47	<5	<5	<5	<5	11	-	-	-	-
Turbidity	NTU	25		47	0.3	0.5	0.8	2.2	25.5	-	Yes	-	-
TDS	mg/L			31	110	125	140	193	234	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			31	27	38	51	60	68	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			31	27	38	51	60	68	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	41	<0.01	<0.01	0.01	0.03	0.1	Yes	-	-	2x
Nitrate and Nitrite	mg/L	0.015	0.01	47	<0.01	0.05	0.12	0.2	0.36	Yes	-	8x	14x
TN	mg/L	0.25		47	0.2	0.4	0.6	0.7	1.2	Yes	-	2x	3x
TP (P)	mg/L	0.02	0.01	47	<0.01	0.01	0.03	0.05	0.18	Yes	-	1.5x	2.5x
TKN	mg/L		0.1	47	0.2	0.3	0.4	0.5	1	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20^{th} %ile[4]	Median[4]	80^{th} %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80^{th} %ile[7]
Phosphate (PO4) Filtered	mg/L	0.015	0.1	35	<0.1	<0.1	<0.1	<0.1	0.15	Inconclusive	Inconclusive	-	-
Anions													
Fluoride	mg/L		0.01	31	0.047	0.077	0.097	0.123	0.157	-	-	-	-
Chloride	mg/L			31	9.4	10.3	11.8	14.1	18.2	-	-	-	-
Sulphate	mg/L			31	35.6	39.6	48.5	63.2	76.4	-	-	-	-
Metals and metalloids (total)													
Aluminium	mg/L	0.055	0.01	47	<0.01	0.01	0.02	0.08	0.66	Yes	-	-	1.5x
Iron	mg/L		0.05	6	<0.05	0.06	0.11	0.26	0.29	-	-	-	-
Manganese	mg/L	1.9	0.001	6	0.004	0.011	0.017	0.033	0.043	-	-	-	-
Metals and metalloids (filtered)													
Iron filtered	mg/L		0.05	47	0.01	0.05	0.05	0.2	0.31	-	-	-	-
Manganese filtered	mg/L	1.9	0.001	47	0.001	0.004	0.008	0.015	0.047	-	-	-	-

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)
3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80^{th} percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Table A.6 Water quality data summary table – Location COX10

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Physico-chemical parameter (excluding nutrients)													
DO (in Field)	mg/L	8.2-10		46	6.1	7.8	8.9	10.9	14.5	Yes	-	-	-
EC	µS/cm	350		49	95	218	312	683	1012	Yes	-	-	2x
pH	pH units	6.5-8		49	6.4	7.4	7.7	8.2	8.7	Yes	-	-	-
Temperature	deg C			46	9.1	12	16.2	19.9	24.2	-	-	-	-
TSS (NFR)	mg/L		5	49	<5	<5	<5	<5	10	-	-	-	-
Turbidity	NTU	25		49	0.3	0.6	1.1	3.1	24.3	-	-	-	-
TDS	mg/L			31	106	120	145	194	242	-	-	-	-
Alkalinity as Carbonate (CaCO3)	mg/L			31	25	39	52	59	69	-	-	-	-
Bi-Carbonate Alkalinity	mg/L			31	25	39	52	59	69	-	-	-	-
Physico-chemical parameter (nutrients)													
Ammonia	mg/L	0.013	0.01	41	<0.01	<0.01	0.01	0.03	0.07	Yes	-	-	2x
Nitrate and Nitrite	mg/L	0.015	0.01	46	<0.01	0.06	0.13	0.21	0.35	Yes	-	9x	14x
TN	mg/L	0.25		46	0.1	0.4	0.6	0.6	1	Yes	-	2x	2x
TP (P)	mg/L	0.02	0.01	46	<0.01	<0.01	0.03	0.05	0.48	Yes	-	1.5x	2.5x
TKN	mg/L		0.1	46	0.1	0.3	0.4	0.5	0.8	-	-	-	-

Parameter	Units	DGV[1]	LOR[2]	Results summary[8]						Exceedance frequency		Exceedance magnitude	
				No. of samples	Min[3]	20th %ile[4]	Median[4]	80th %ile[4]	Max	Frequent [5]	Occasional [6]	median[7]	80th %ile[7]
Phosphate (PO4) Filtered	mg/L	0.015	0.1	35	<0.1	<0.1	<0.1	<0.1	0.1	Inconclusive	Inconclusive	-	-
Anions													
Fluoride	mg/L		0.01	31	0.035	0.077	0.104	0.126	0.166	-	-	-	-
Chloride	mg/L			31	9.3	10.2	11.9	14.2	16.4	-	-	-	-
Sulphate	mg/L			31	35.9	39.5	49.5	62.9	80.1	-	-	-	-
Metals and metalloids (total)													
Aluminium	mg/L	0.055	0.01	49	<0.01	0.01	0.03	0.1	0.74	Yes	-	-	2x
Iron	mg/L		0.05	6	<0.05	0.07	0.1	0.13	0.3	-	-	-	-
Manganese	mg/L	1.9	0.001	6	0.005	0.007	0.012	0.03	0.04	-	-	-	-
Metals and metalloids (filtered)													
Iron filtered	mg/L		0.05	49	0.01	0.05	0.05	0.18	0.31	-	-	-	-
Manganese filtered	mg/L	1.9	0.001	49	0.001	0.004	0.008	0.016	0.258	-	-	-	-

Notes:

1. DGV = Default guideline value as described in Section 4.4.2
2. LOR = Limit of reporting, this is the minimum measurable concentration by laboratory techniques (taken as <value in data)
3. Minimum value or <LOR value (occasionally a value recorded which is less than LOR and has been left unchanged)
4. Summary statistics
5. Exceedances are described as frequent if the DGV was exceeded in 20% or more of samples
6. Exceedances are described as occasional if the DGV value was exceeded in at least one sample, but in less than 20% of samples
7. Magnitude of exceedance of the median and 80th percentile value compared to the DGV (provided as x times)
8. bold text denotes DGV exceedance

Annexure B
Algae alert timeseries

EMM
creating opportunities

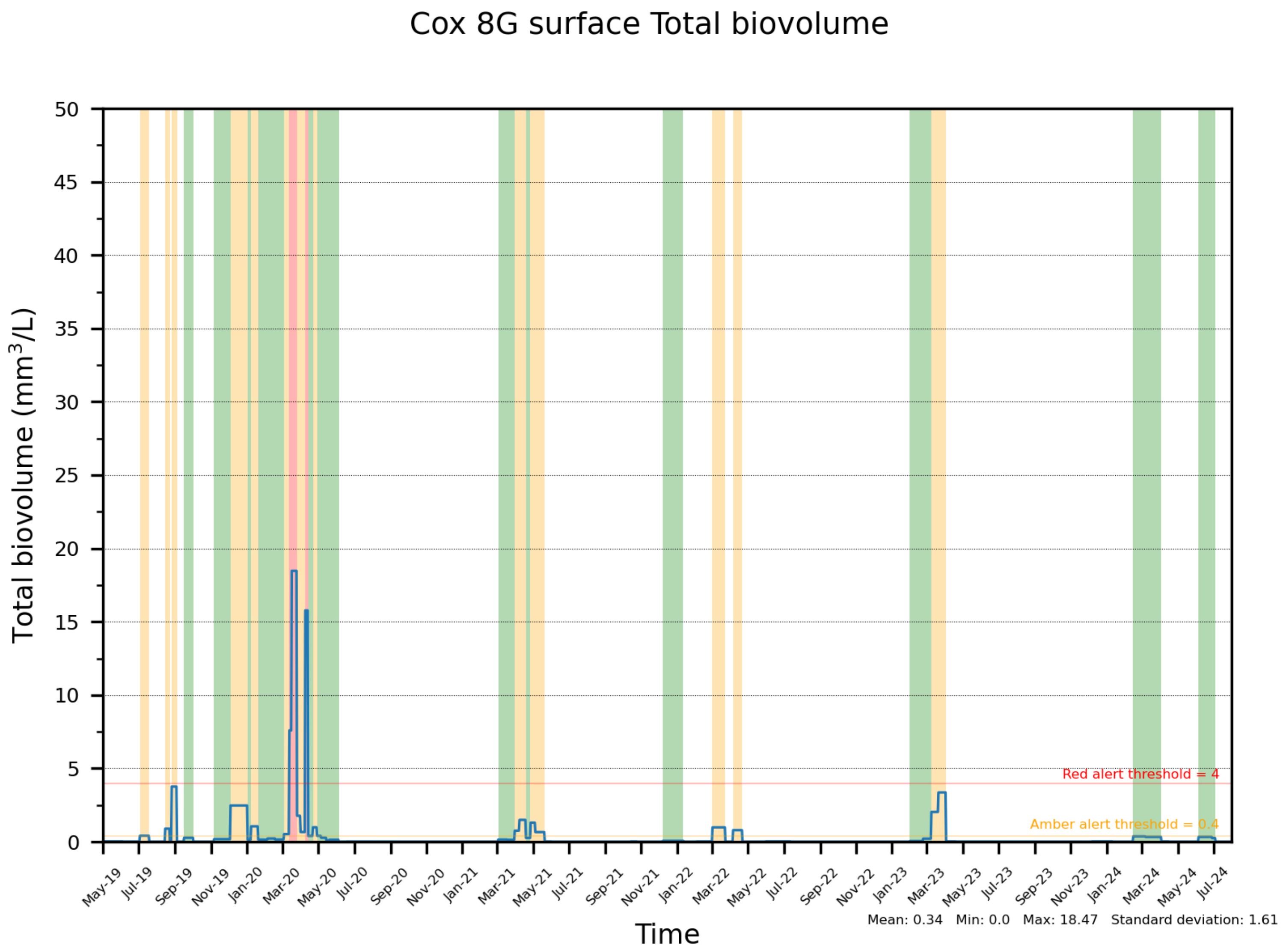


Figure B.1 **Algae alert timeseries at COX8G**

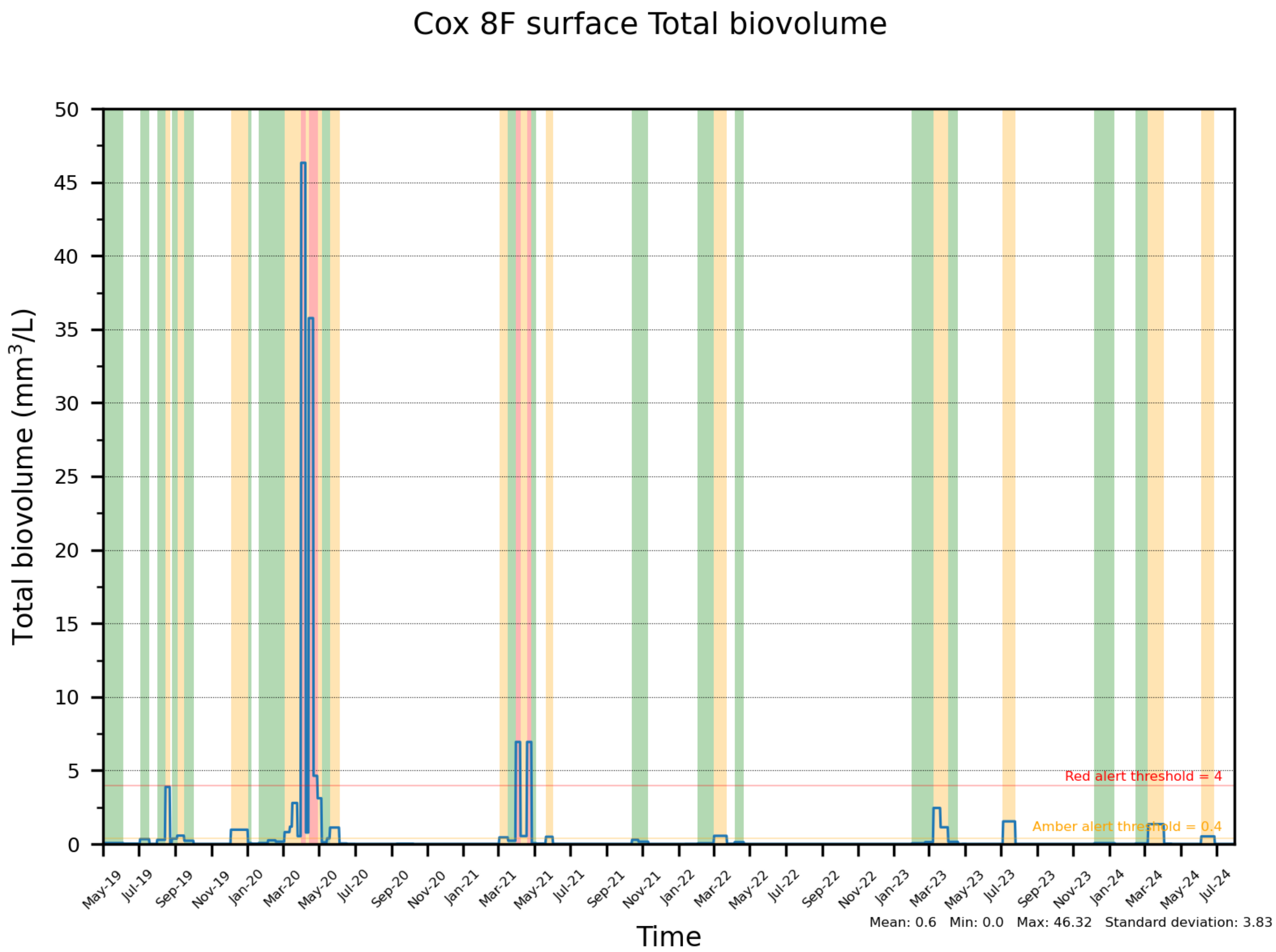


Figure B.2 Algae alert timeseries at COX8F

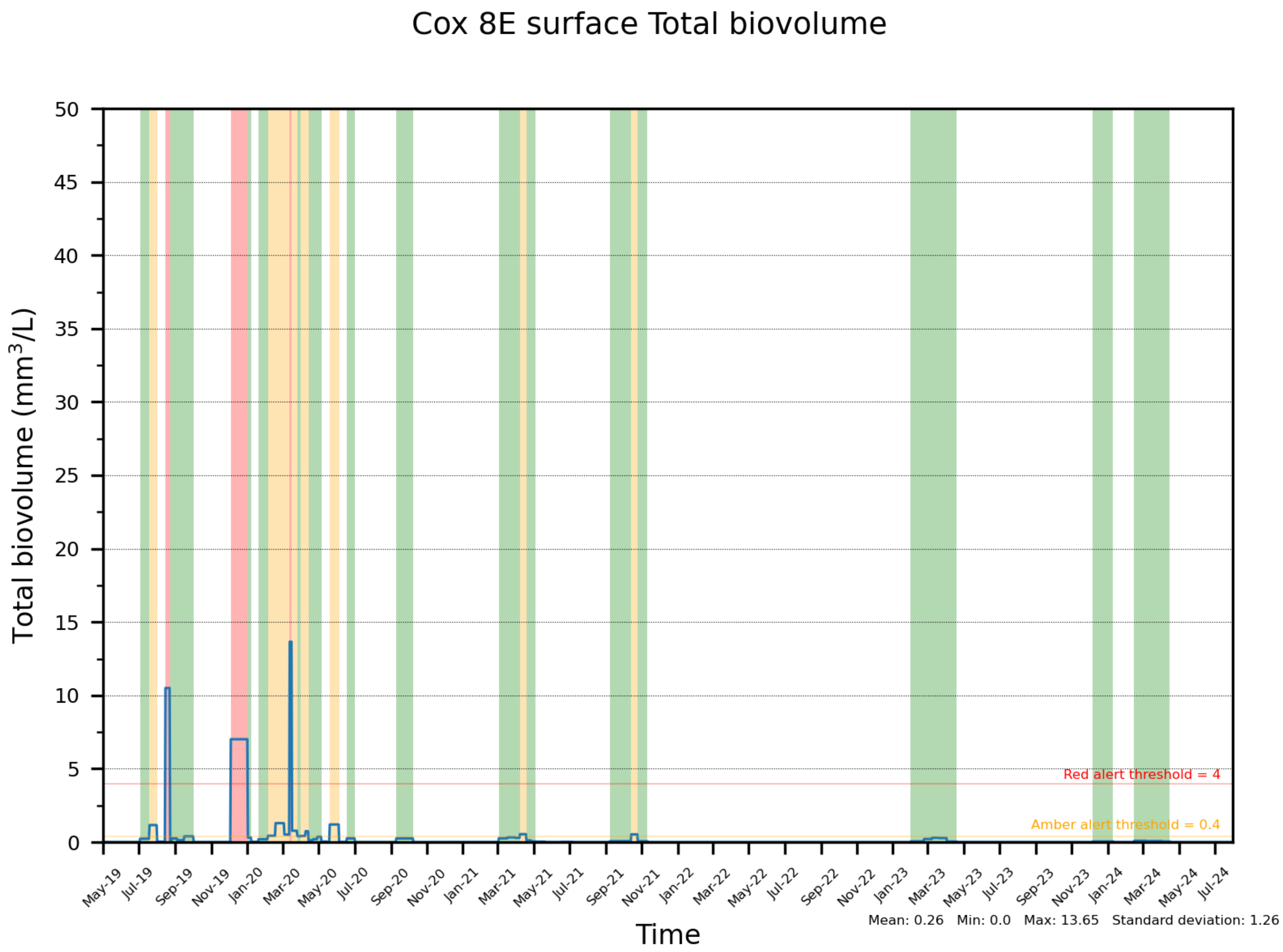


Figure B.3 **Algae alert timeseries at COX8E**

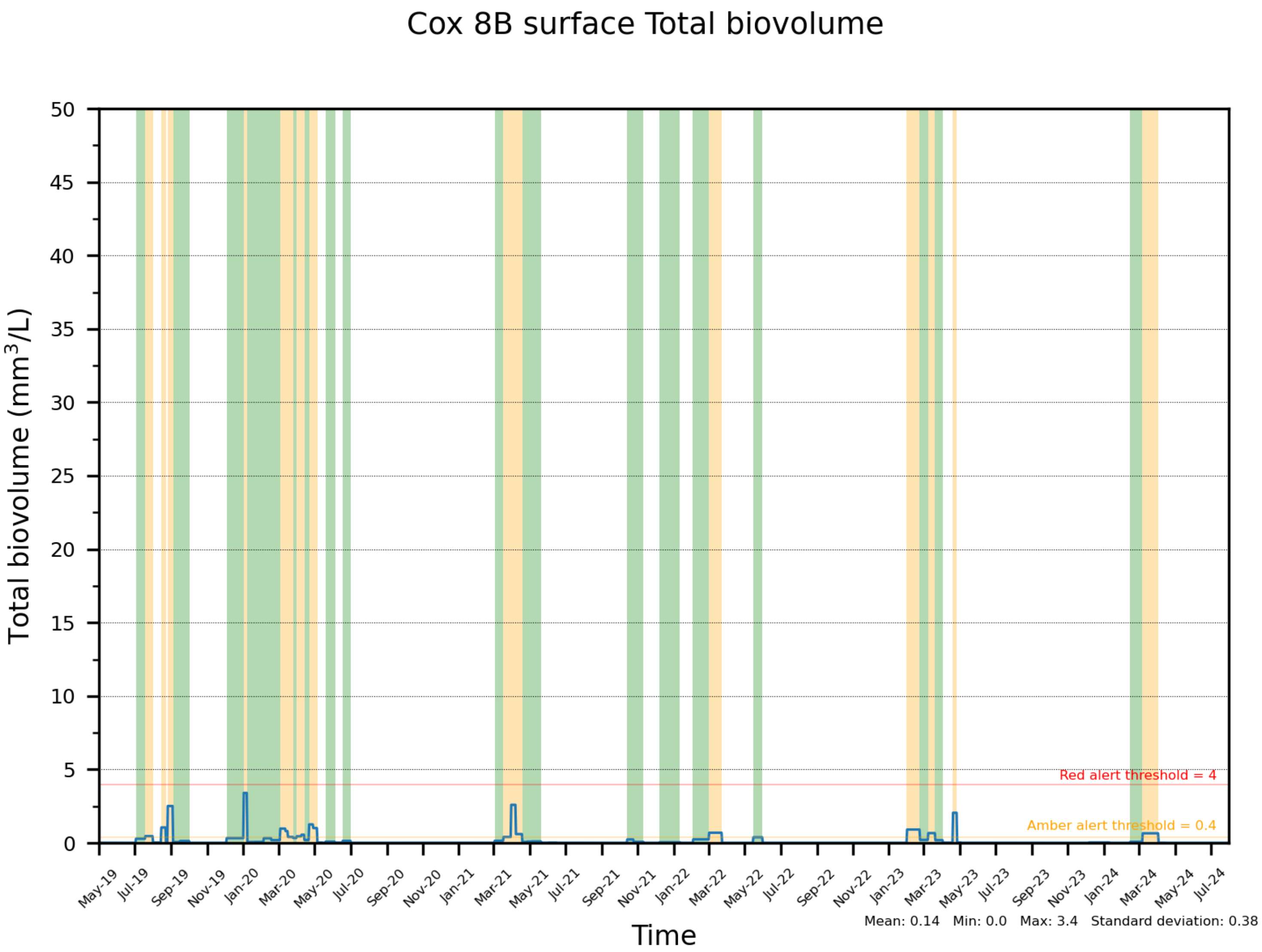


Figure B.4 **Algae alert timeseries at COX8B**

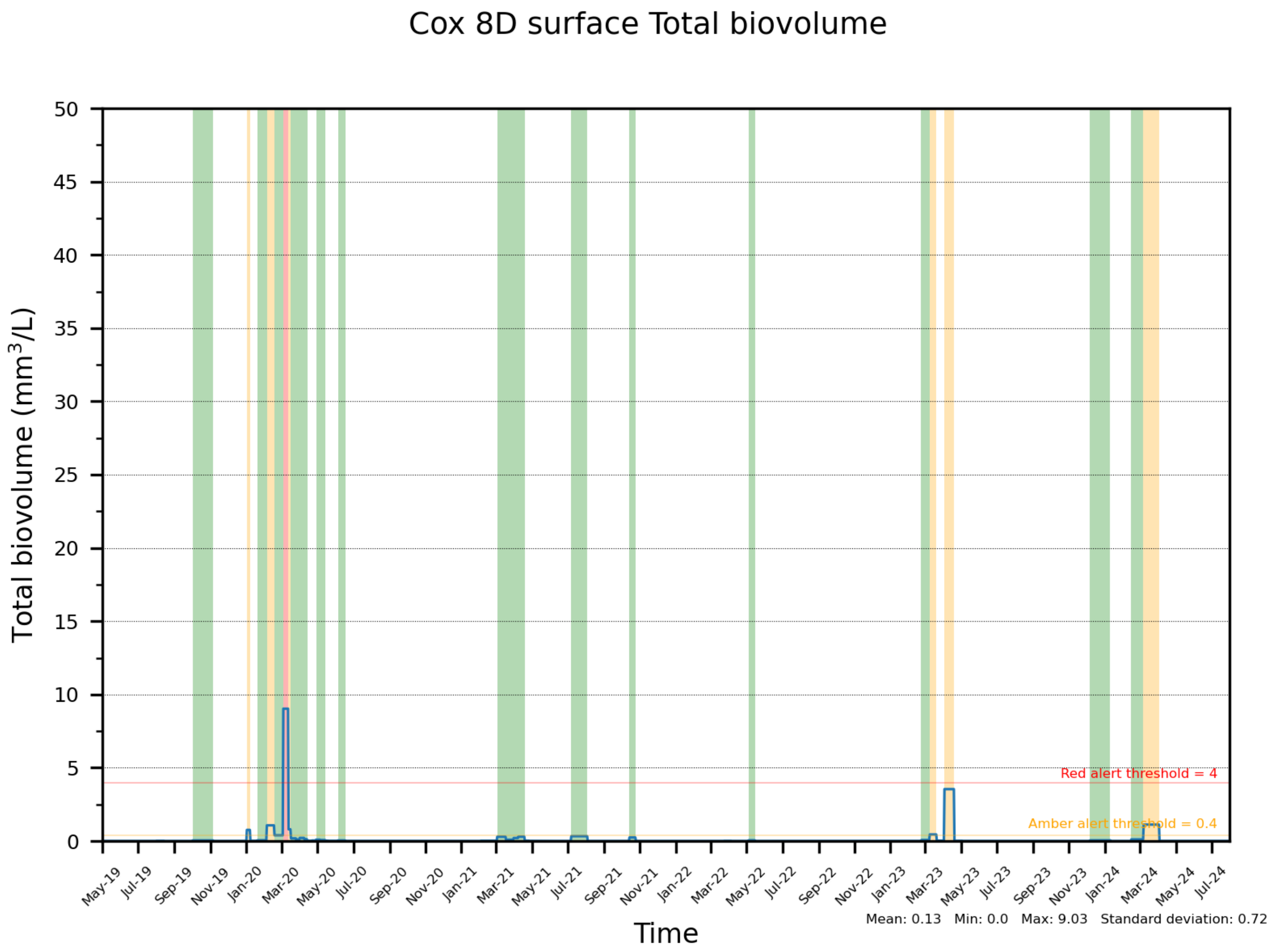


Figure B.5 Algae alert timeseries at COX8D

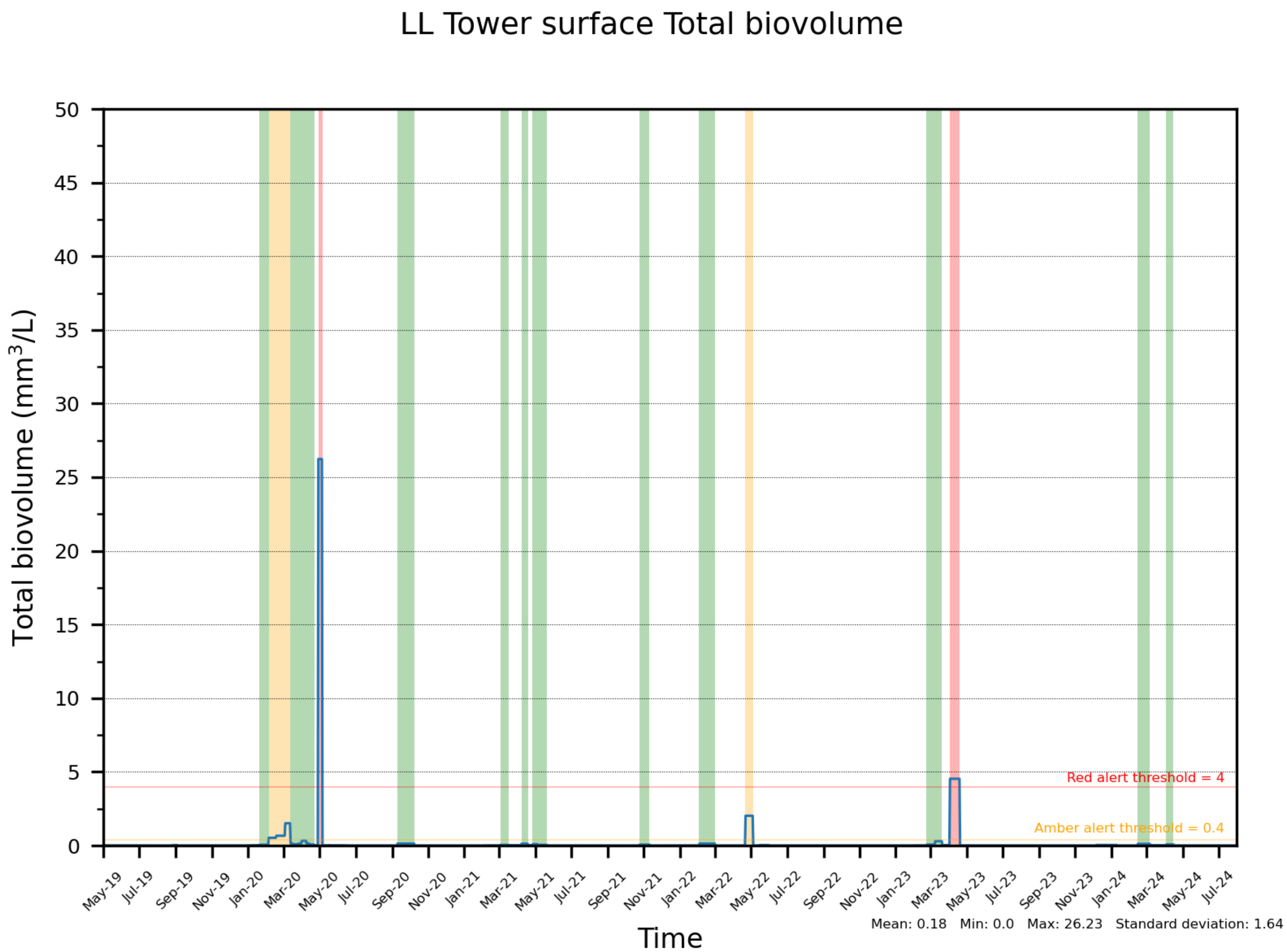


Figure B.6 Algae alert timeseries at Lake Lyell tower (surface)

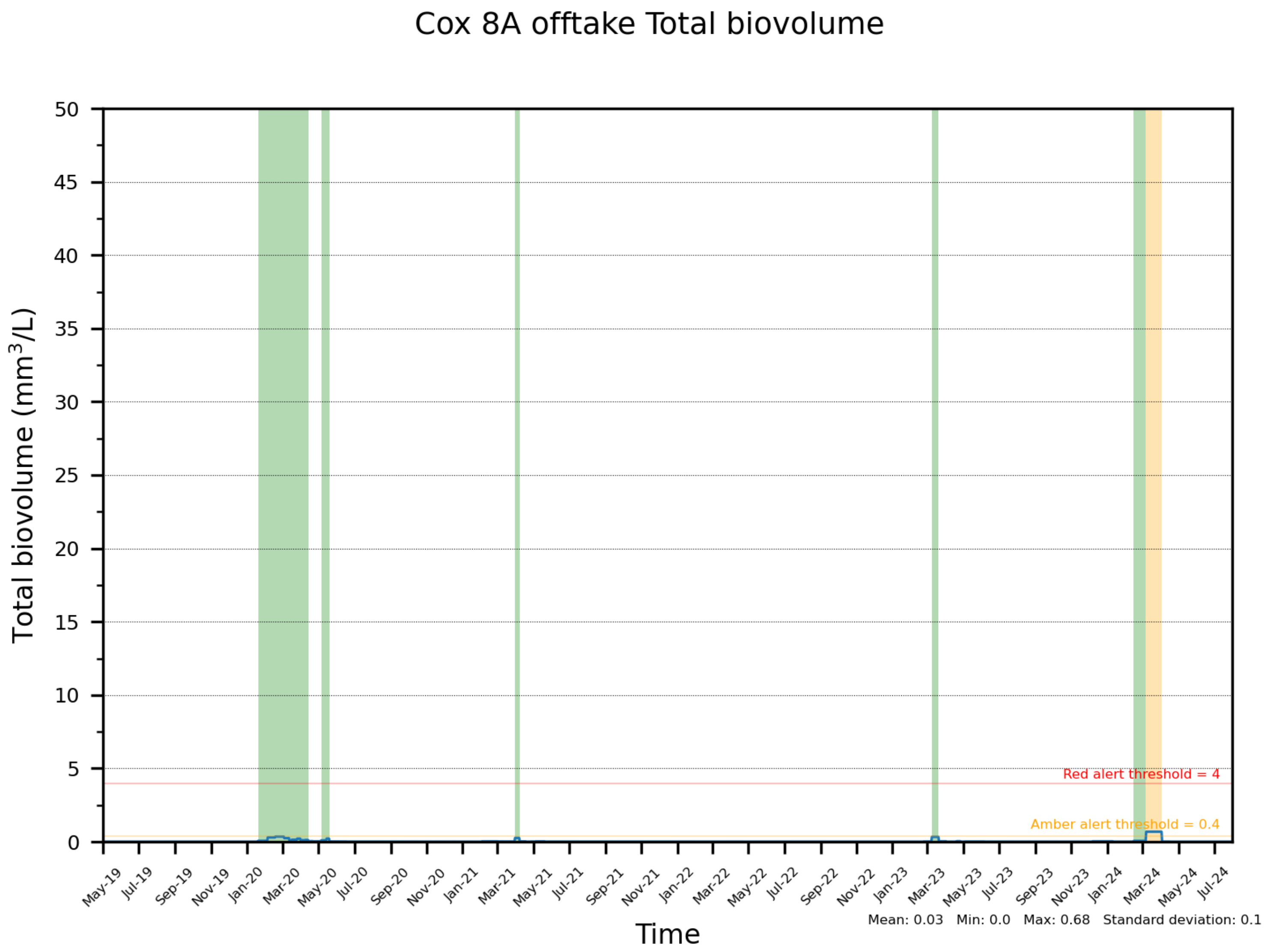


Figure B.7 Algae alert timeseries at COX8A (Lake Lyell tower) (offtake)

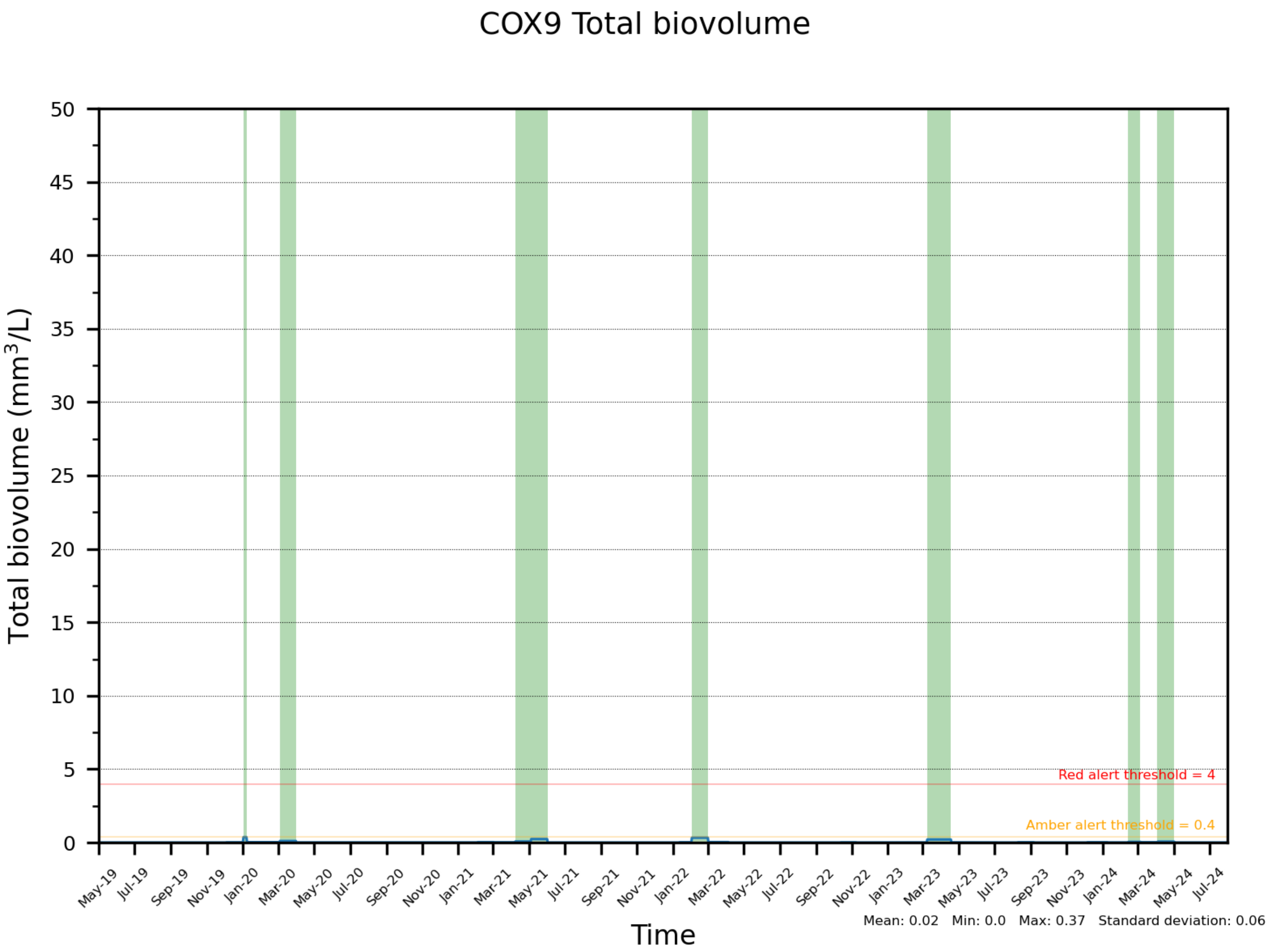


Figure B.8 Algae alert timeseries at COX9

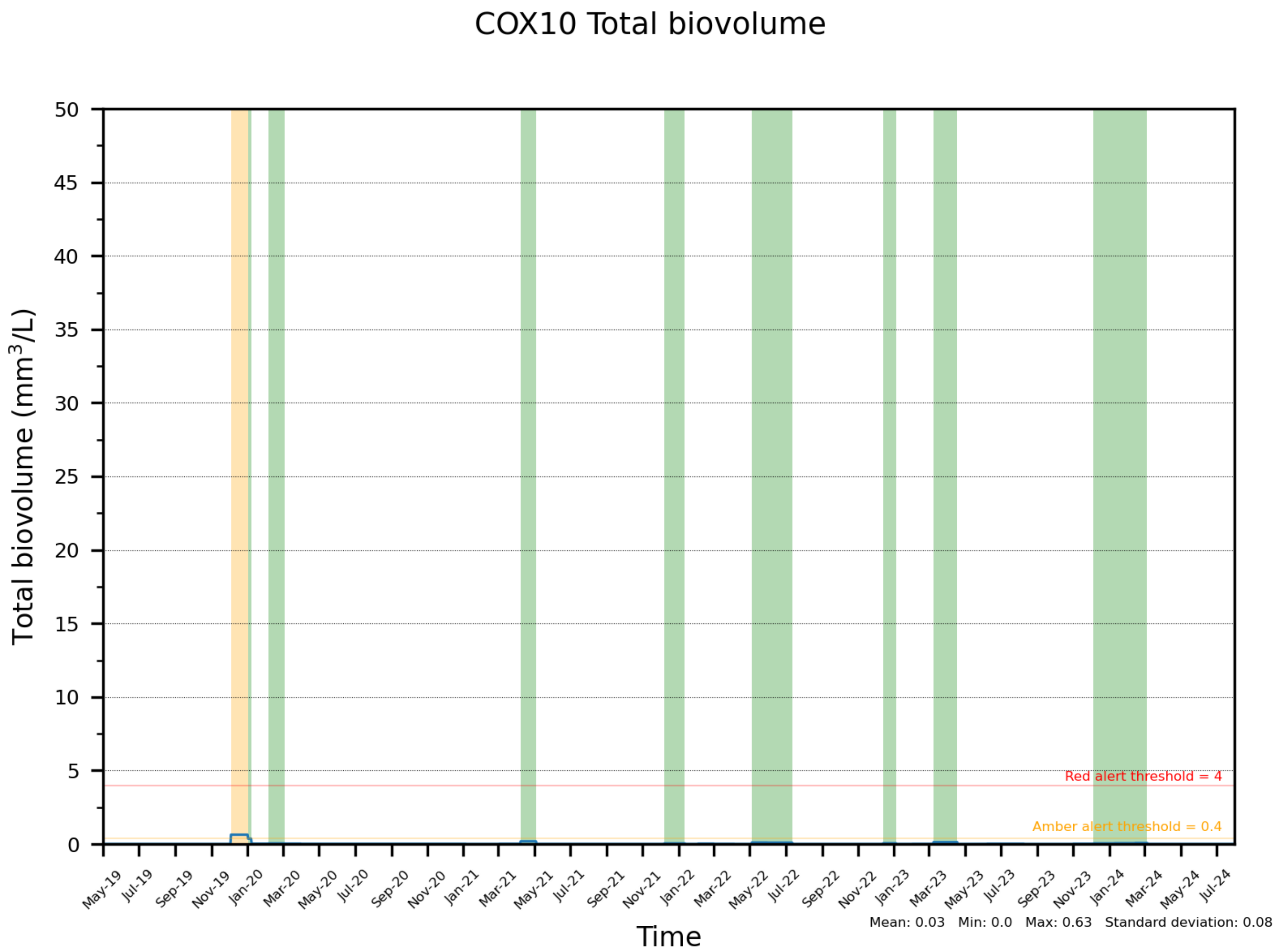


Figure B.9 Algae alert timeseries at COX10

Annexure C

Lake Lyell monthly profiles

EMM
creating opportunities

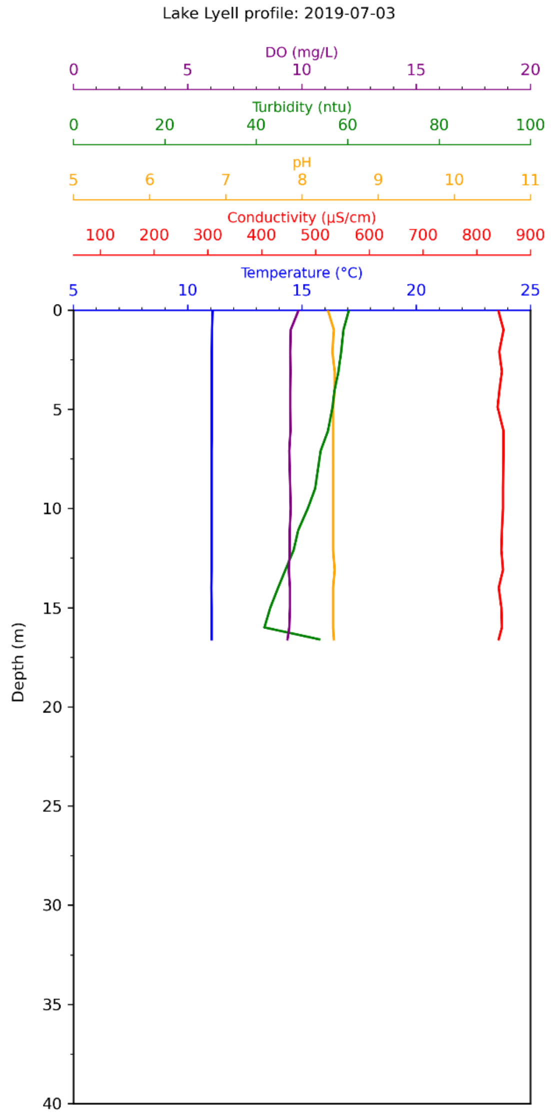


Figure C.1 Lake Lyell profile 3/7/2019

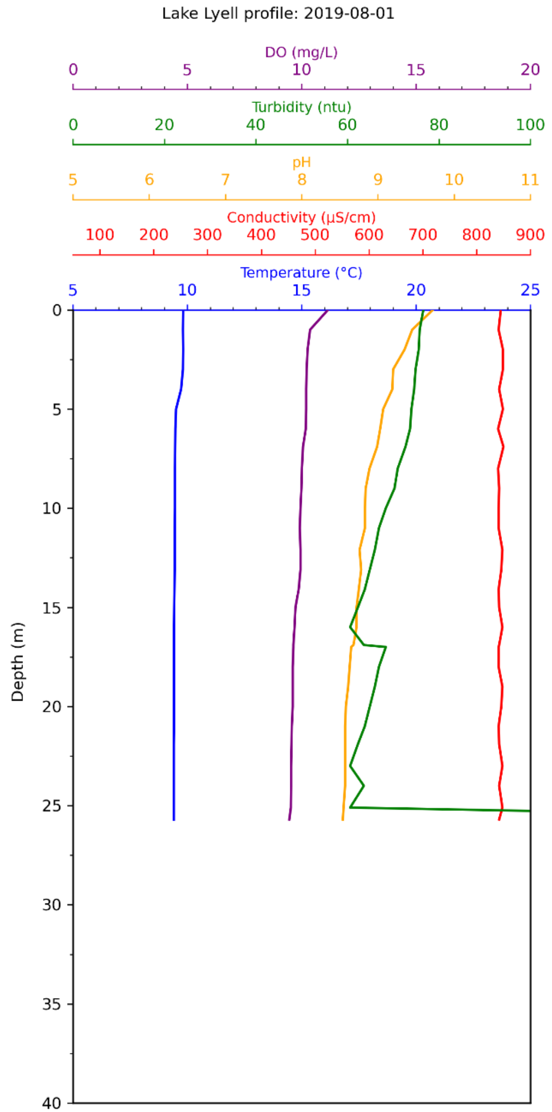


Figure C.2 Lake Lyell profile 1/8/2019

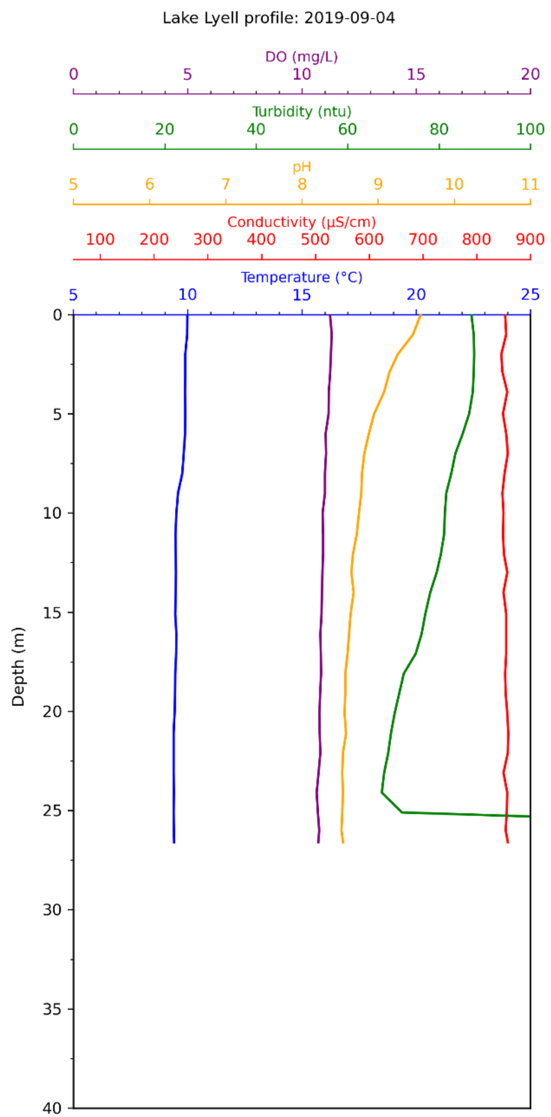


Figure C.3 Lake Lyell profile 4/9/2019

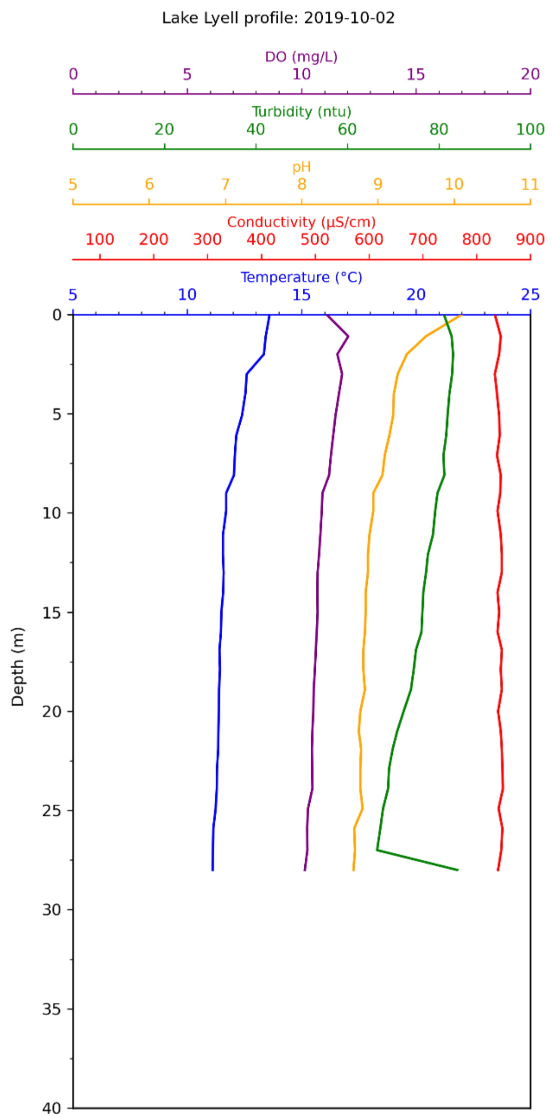


Figure C.4 Lake Lyell profile 2/10/2019

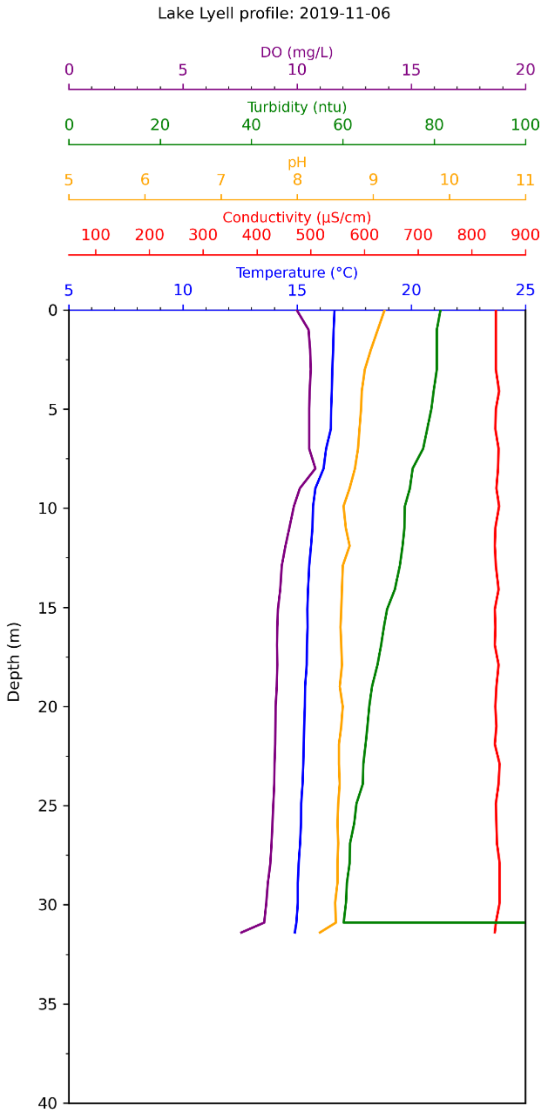


Figure C.5 Lake Lyell profile 6/11/2019

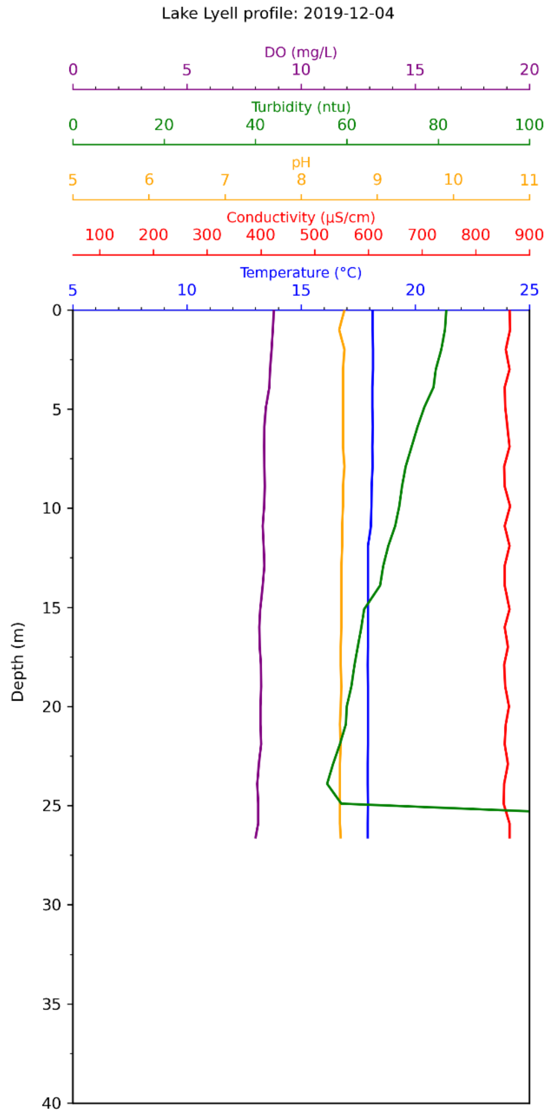


Figure C.6 Lake Lyell profile 4/12/2019

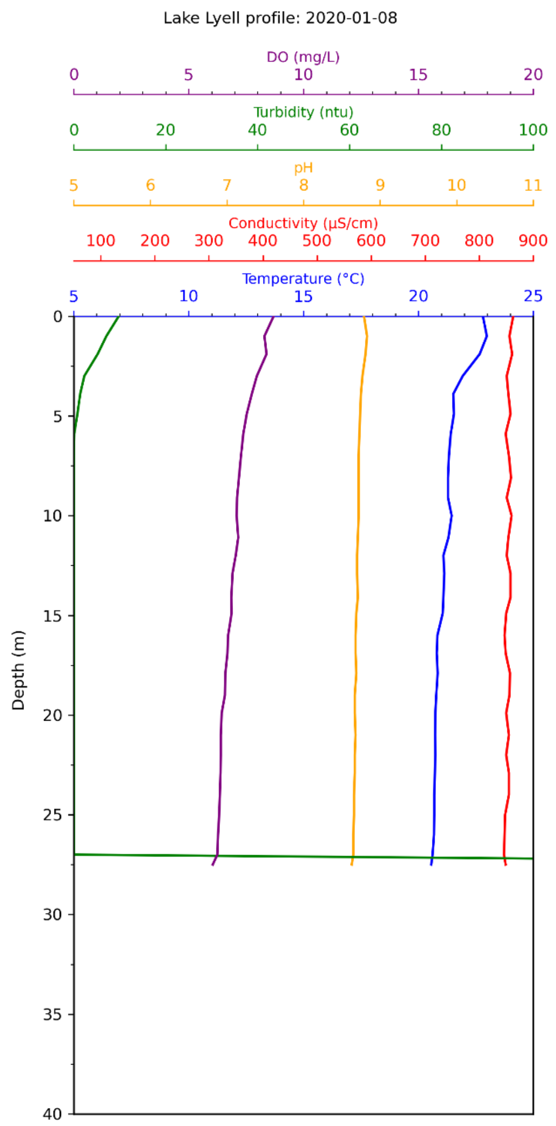


Figure C.7 Lake Lyell profile 8/1/2020

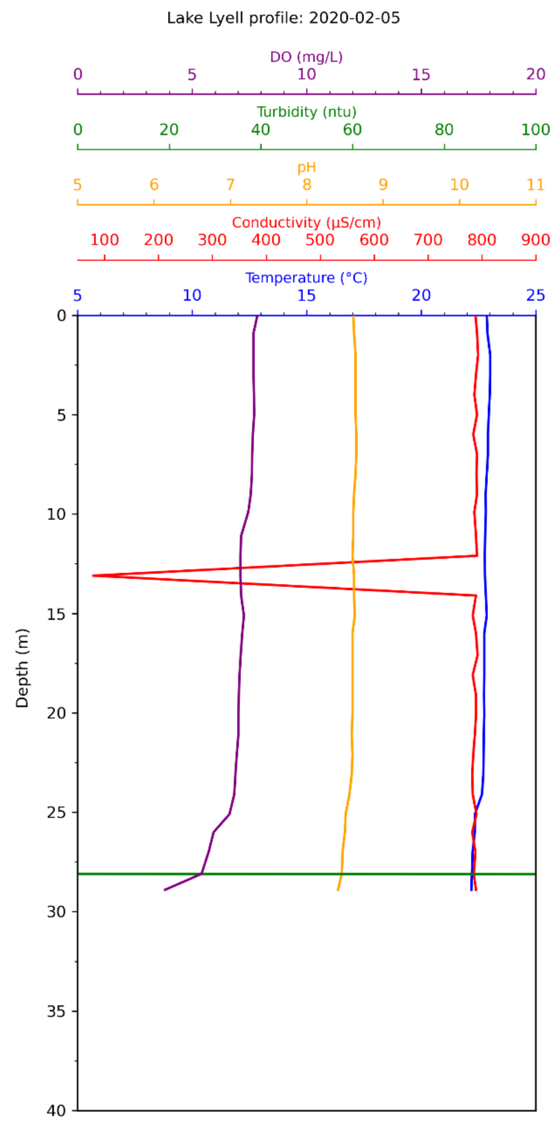


Figure C.8 Lake Lyell profile 5/2/2020

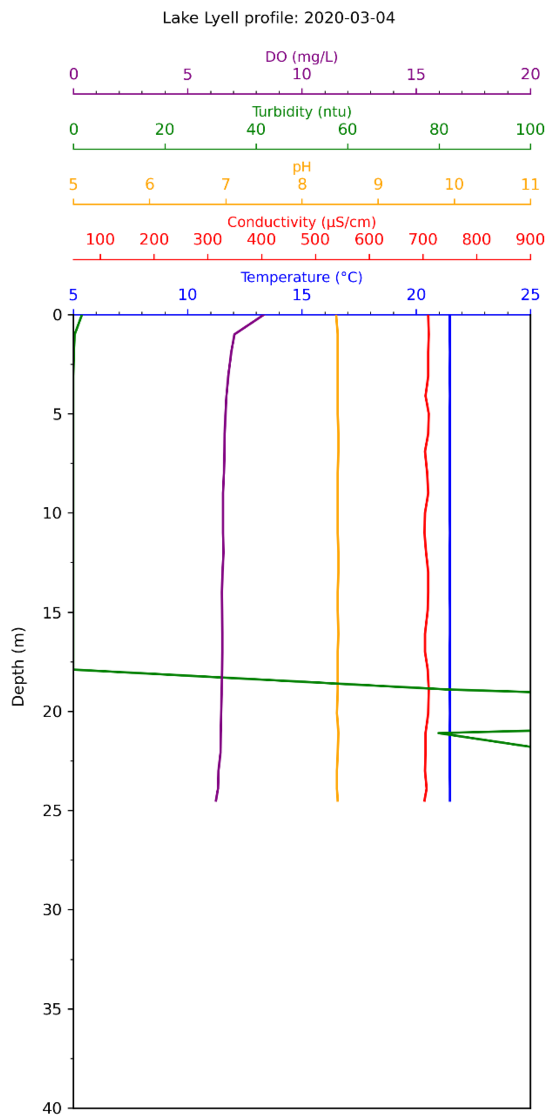


Figure C.9 Lake Lyell profile 4/3/2020

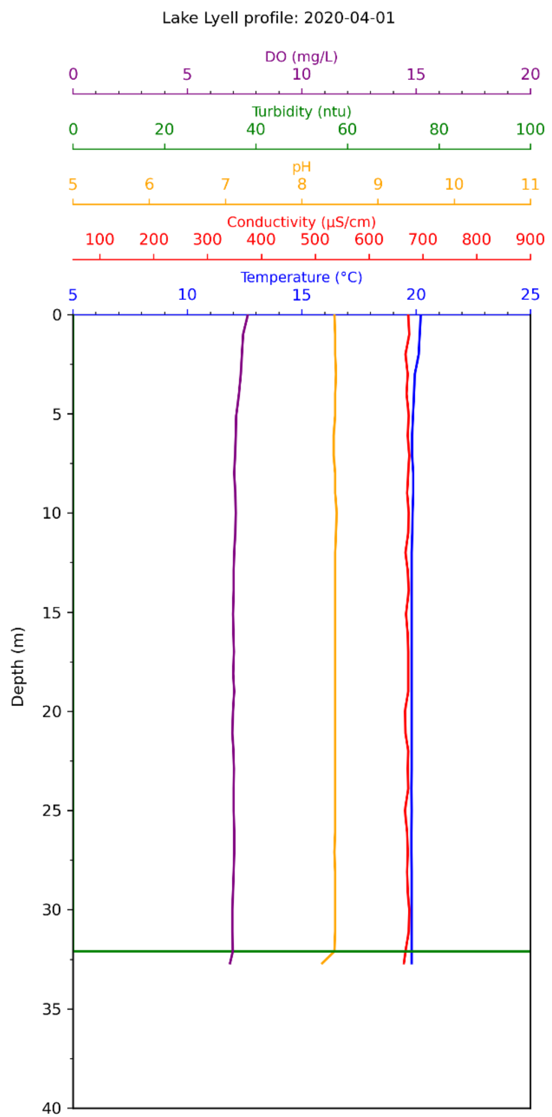


Figure C.10 Lake Lyell profile 1/4/2020

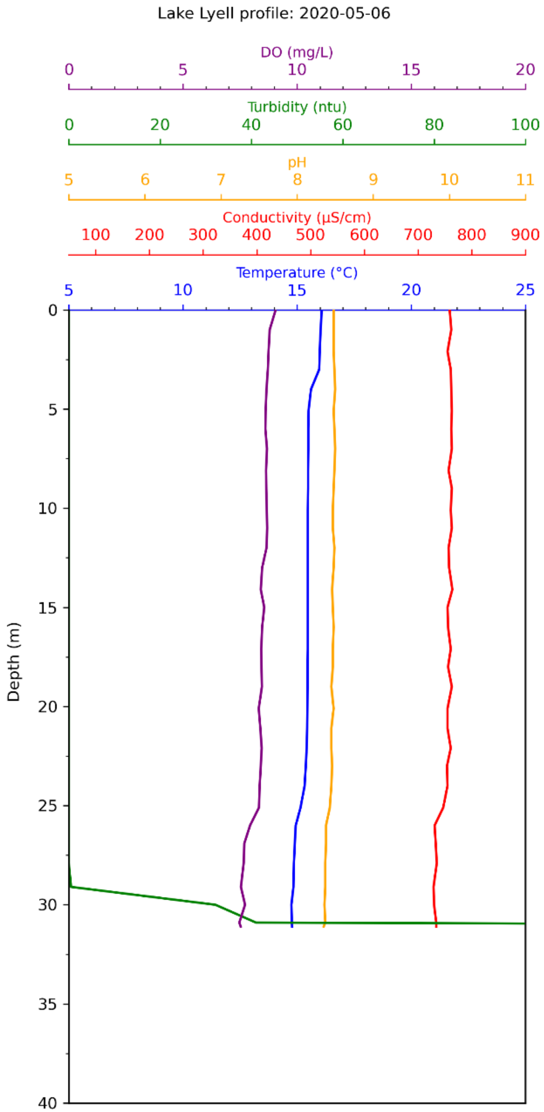


Figure C.11 Lake Lyell profile 6/5/2020

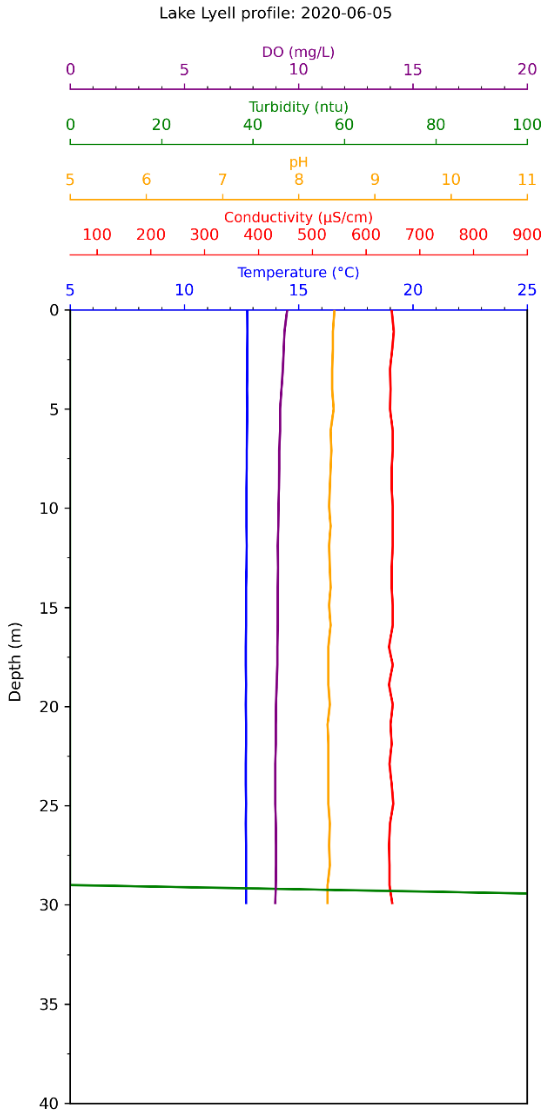


Figure C.12 Lake Lyell profile 5/6/2020

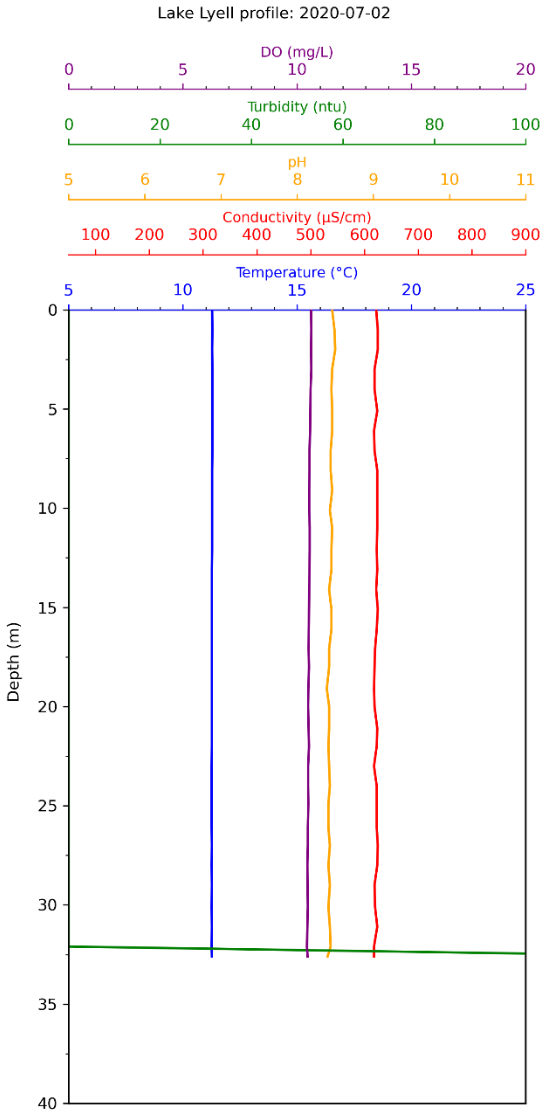


Figure C.13 Lake Lyell profile 2/7/2020

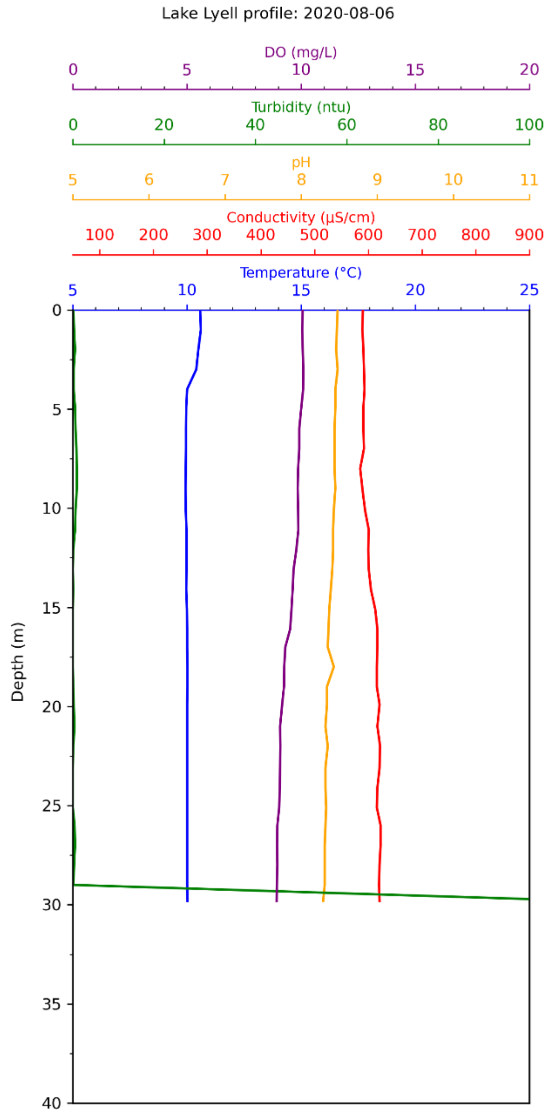


Figure C.14 Lake Lyell profile 6/8/2020

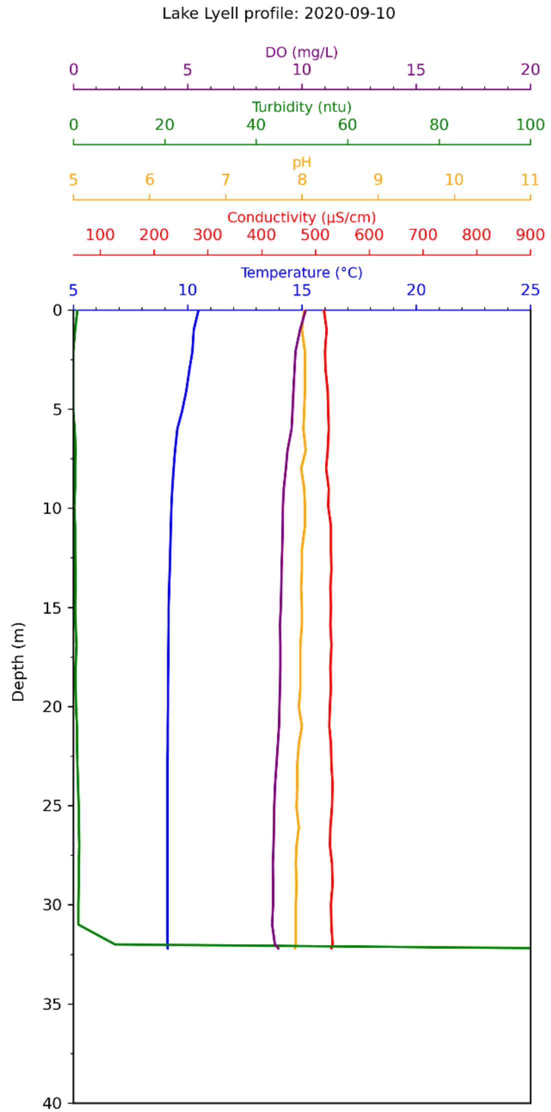


Figure C.15 Lake Lyell profile 10/9/2020

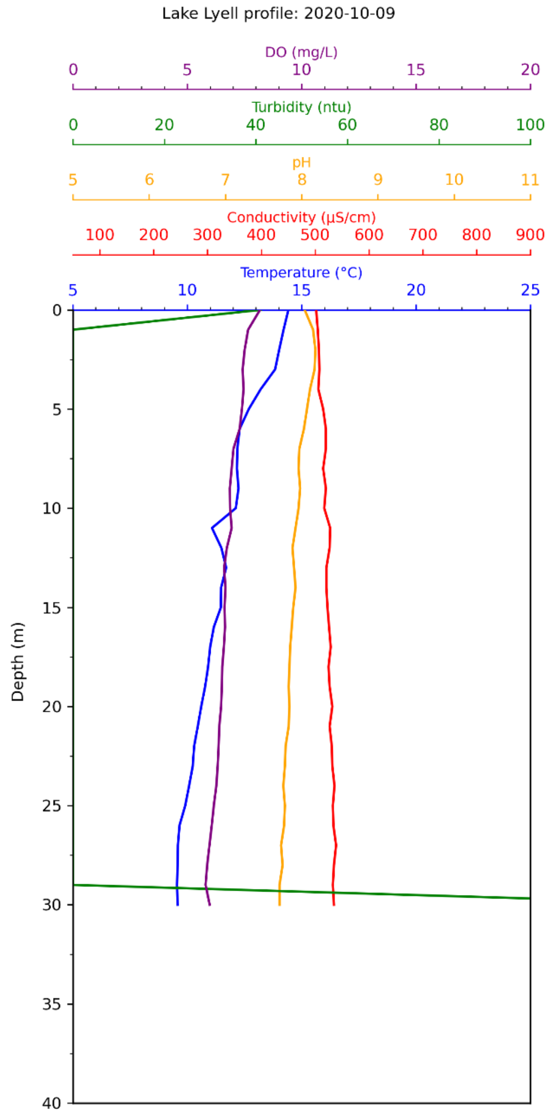


Figure C.16 Lake Lyell profile 9/10/2020

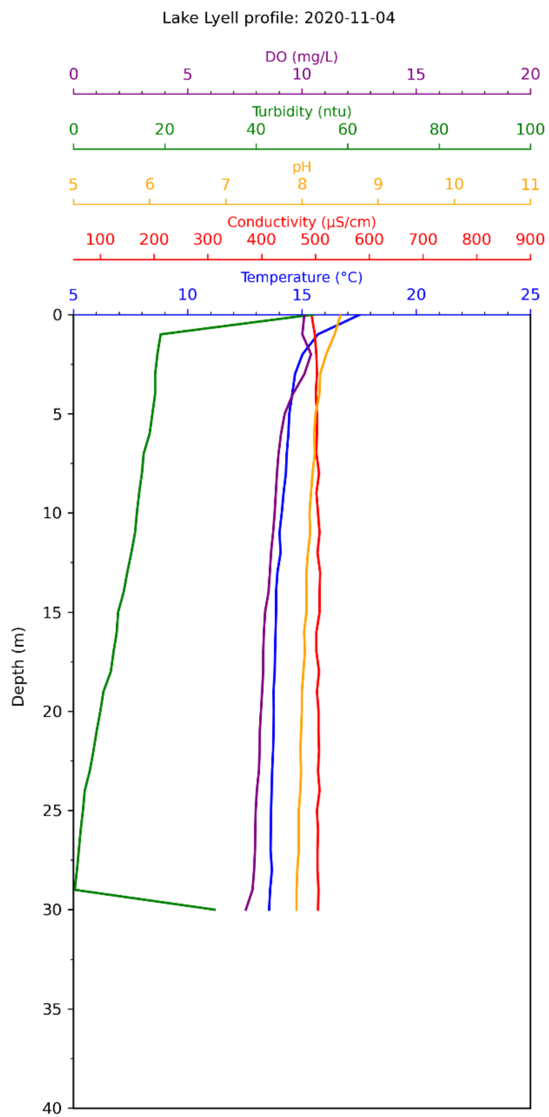
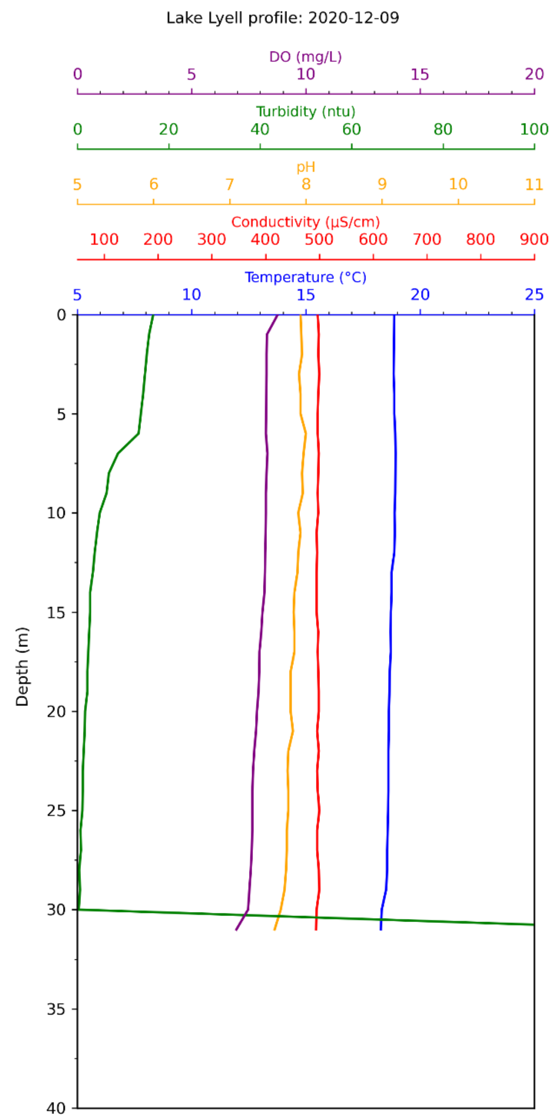


Figure C.17 Lake Lyell profile 4/11/2020



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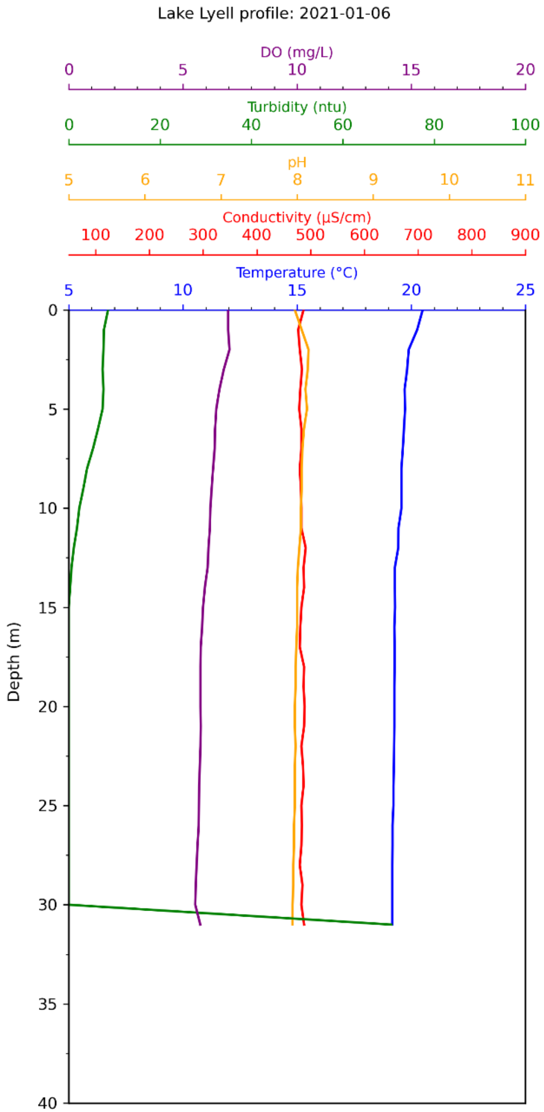


Figure C.19 Lake Lyell profile 6/1/2021

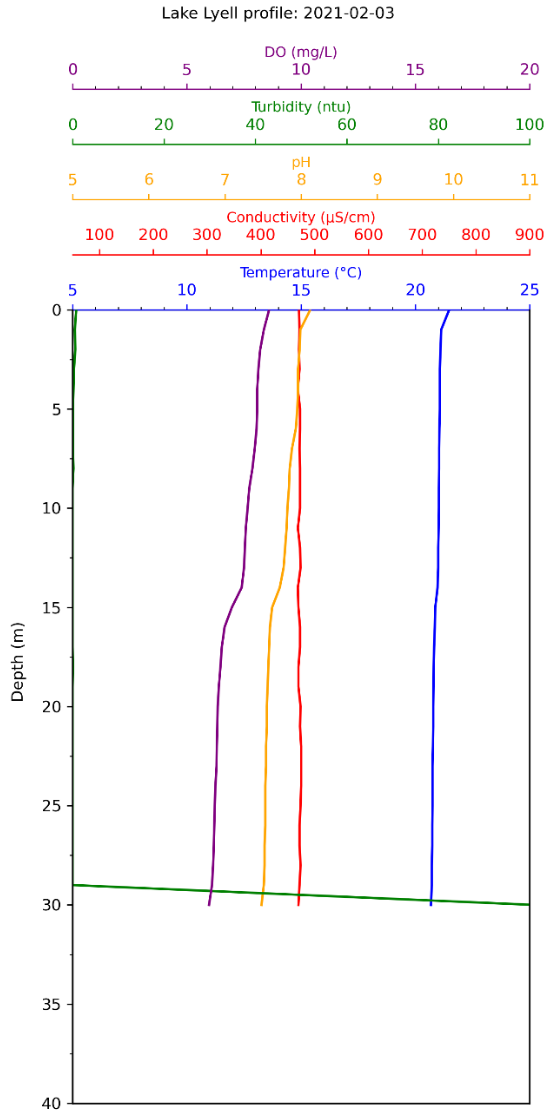


Figure C.20 Lake Lyell profile 3/2/2021

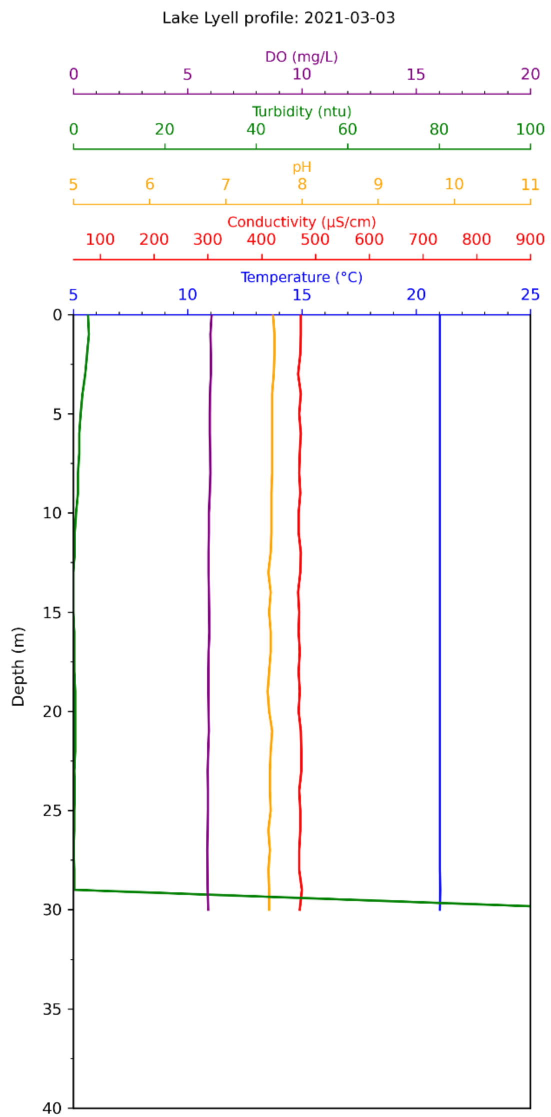


Figure C.21 Lake Lyell profile 3/3/2021

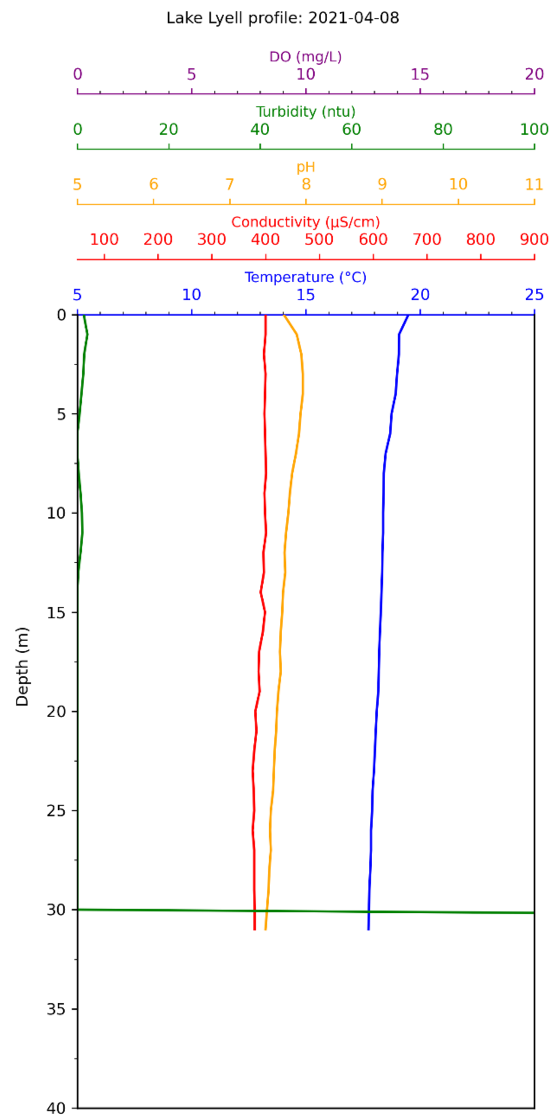


Figure C.22 Lake Lyell profile 8/4/2021

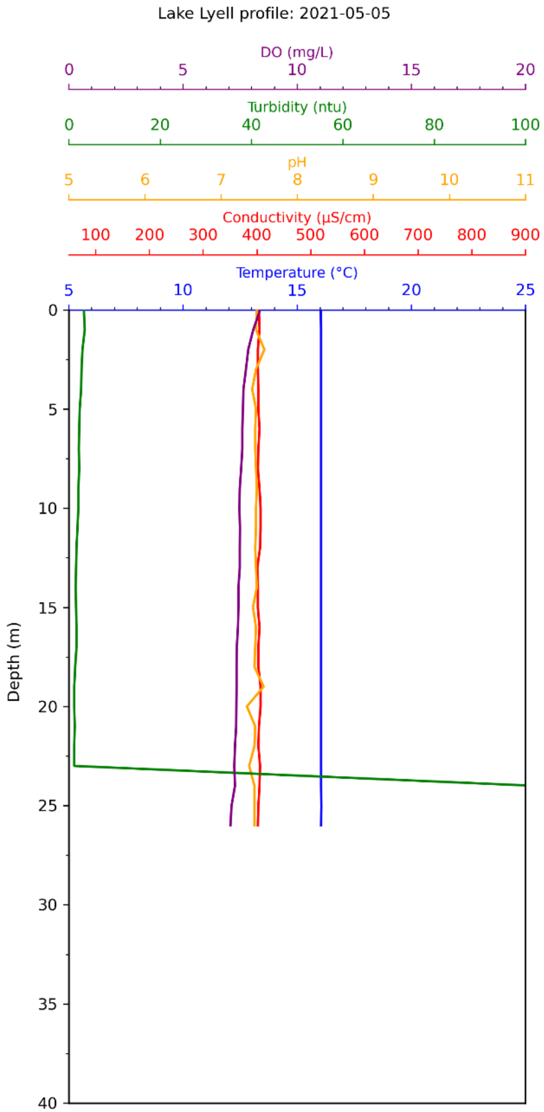


Figure C.23 Lake Lyell profile 5/5/2021

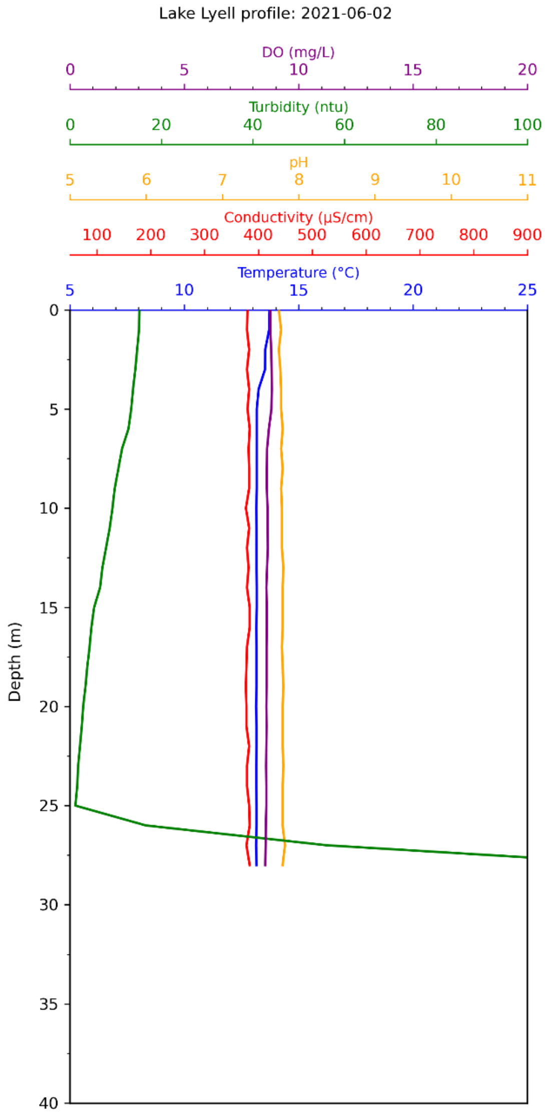


Figure C.24 Lake Lyell profile 2/6/2021

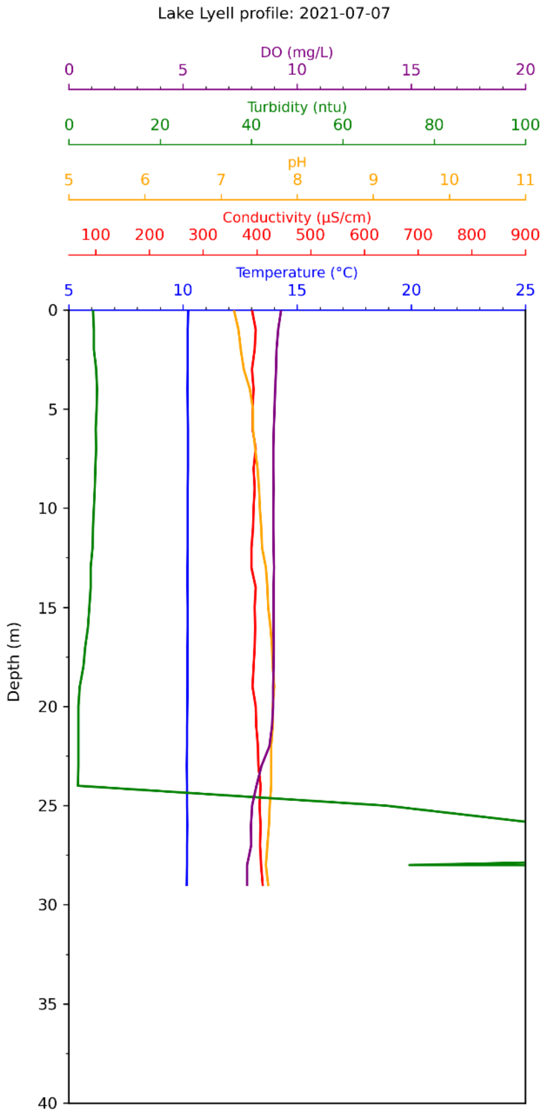


Figure C.25 Lake Lyell profile 7/7/2021

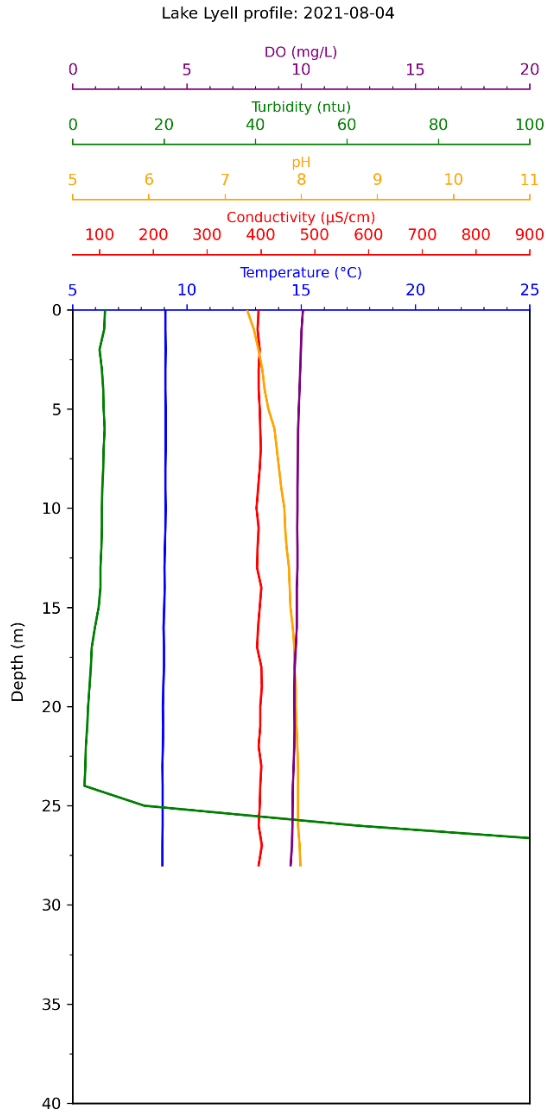


Figure C.26 Lake Lyell profile 4/8/2021

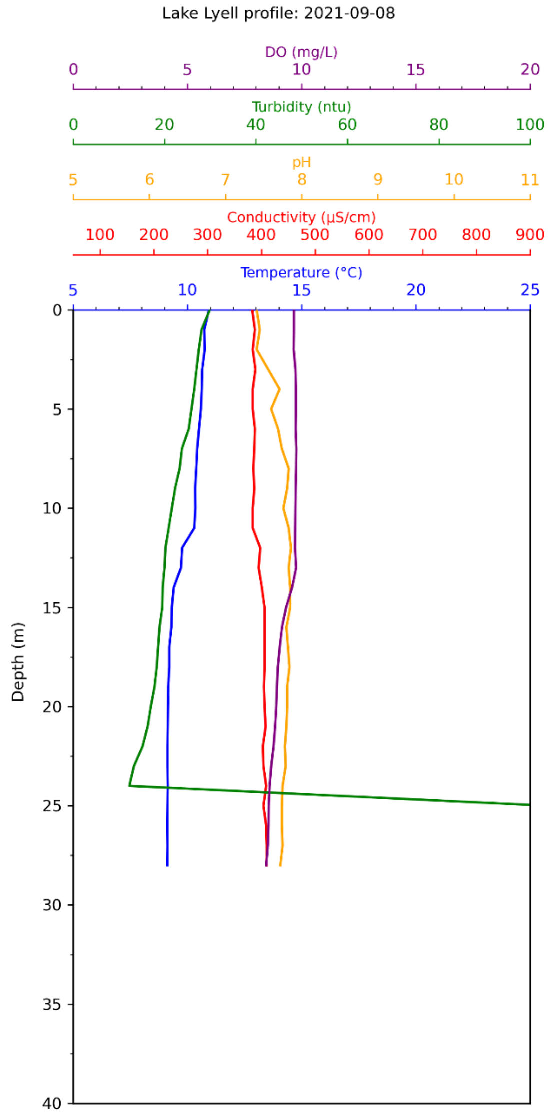


Figure C.27 Lake Lyell profile 8/9/2021

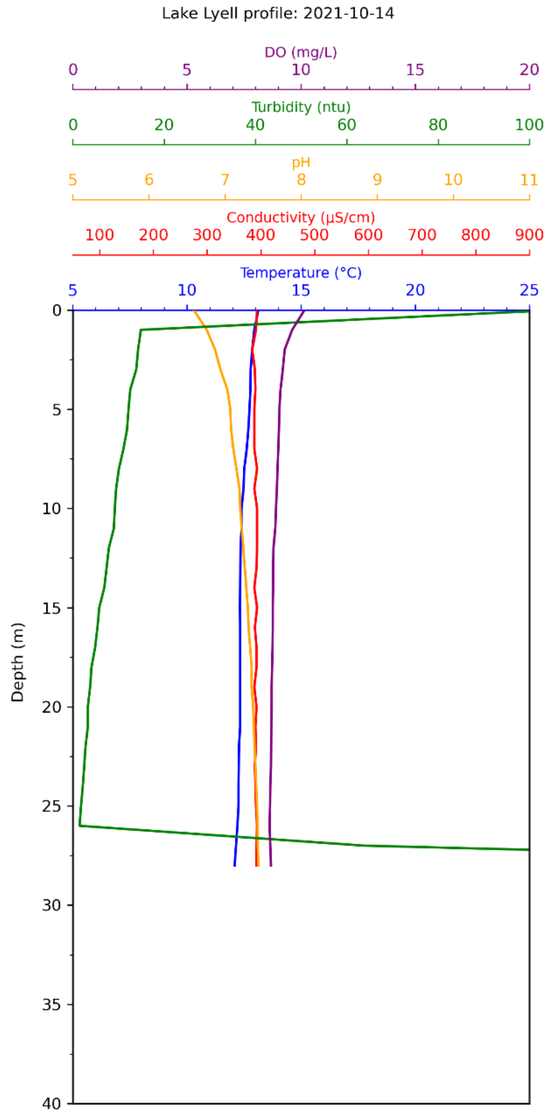


Figure C.28 Lake Lyell profile 14/10/2021

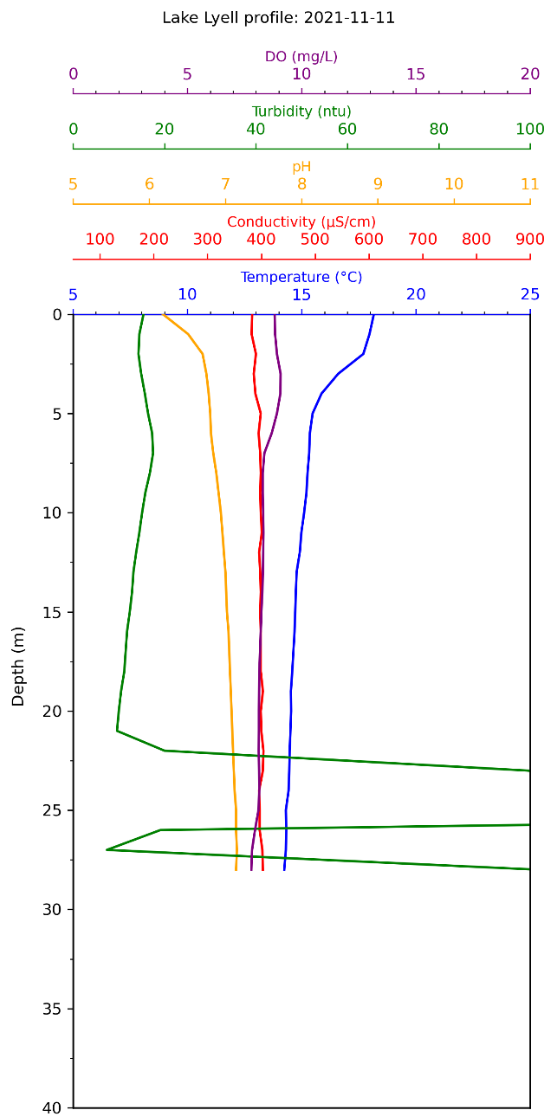


Figure C.29 **Lake Lyell profile 11/11/2021**

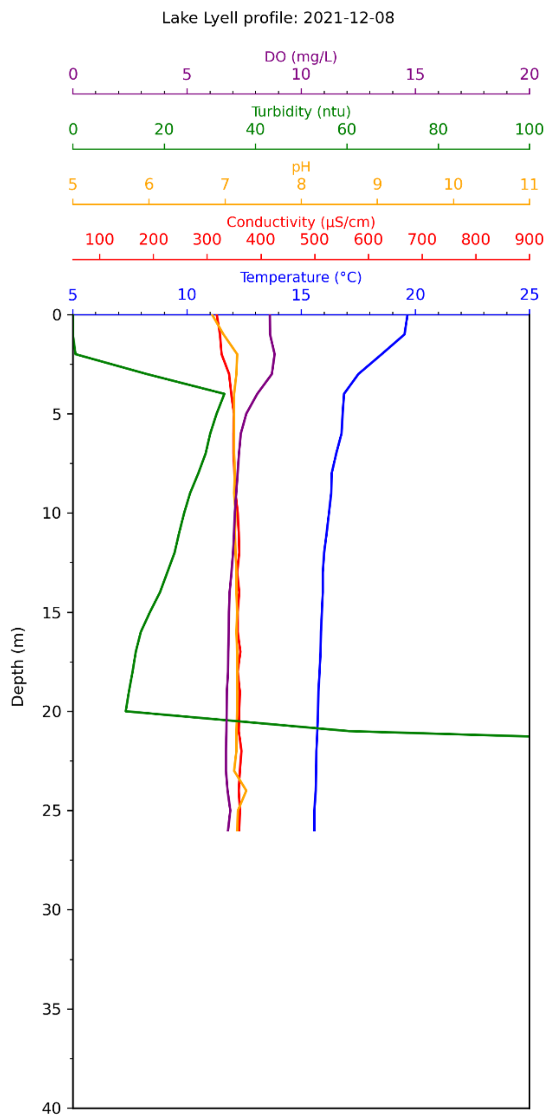


Figure C.30 **Lake Lyell profile 8/12/2021**

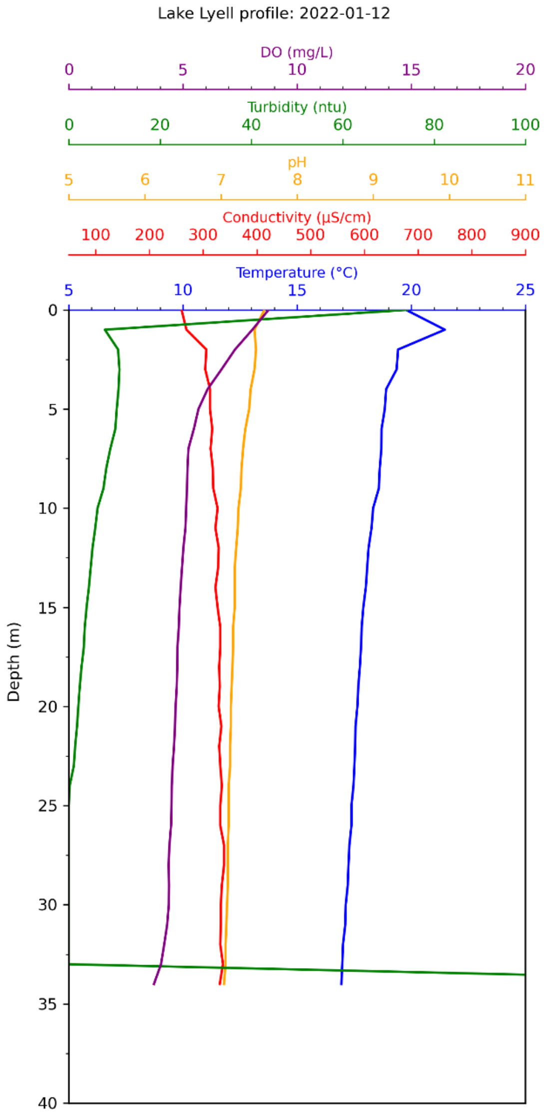


Figure C.31 Lake Lyell profile 12/1/2022

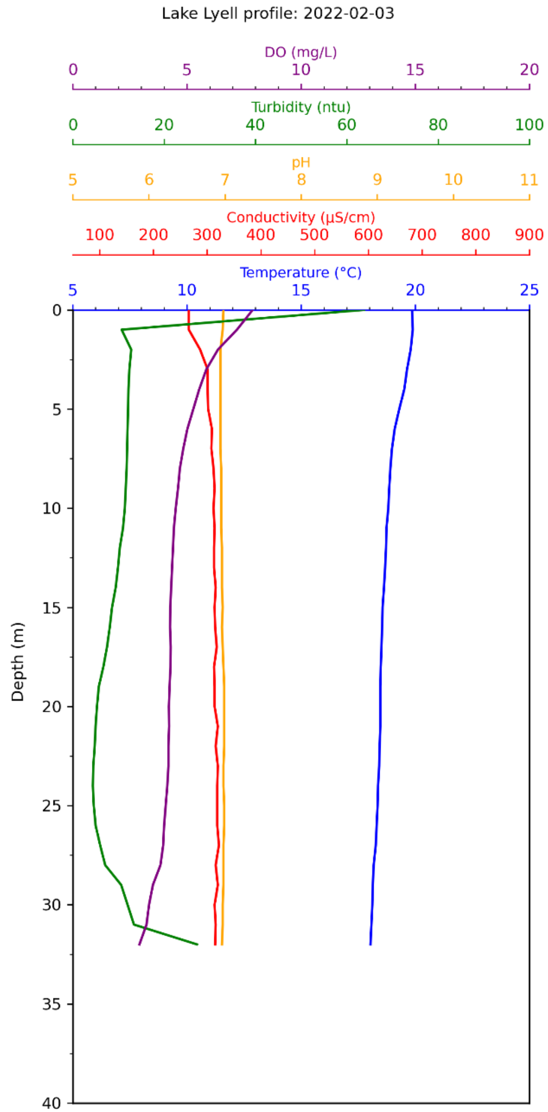


Figure C.32 Lake Lyell profile 3/2/2022

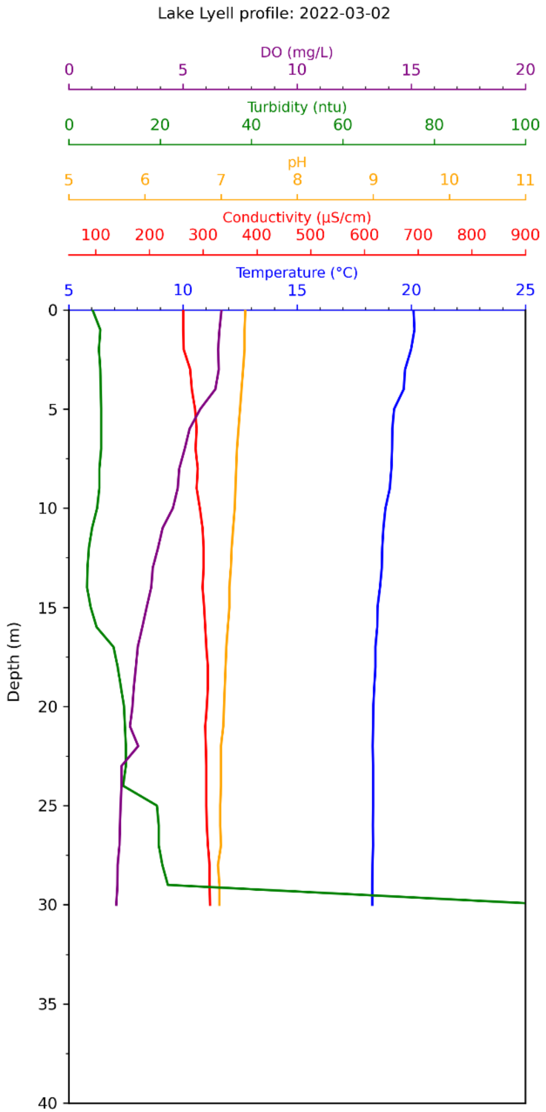


Figure C.33 Lake Lyell profile 2/3/2022

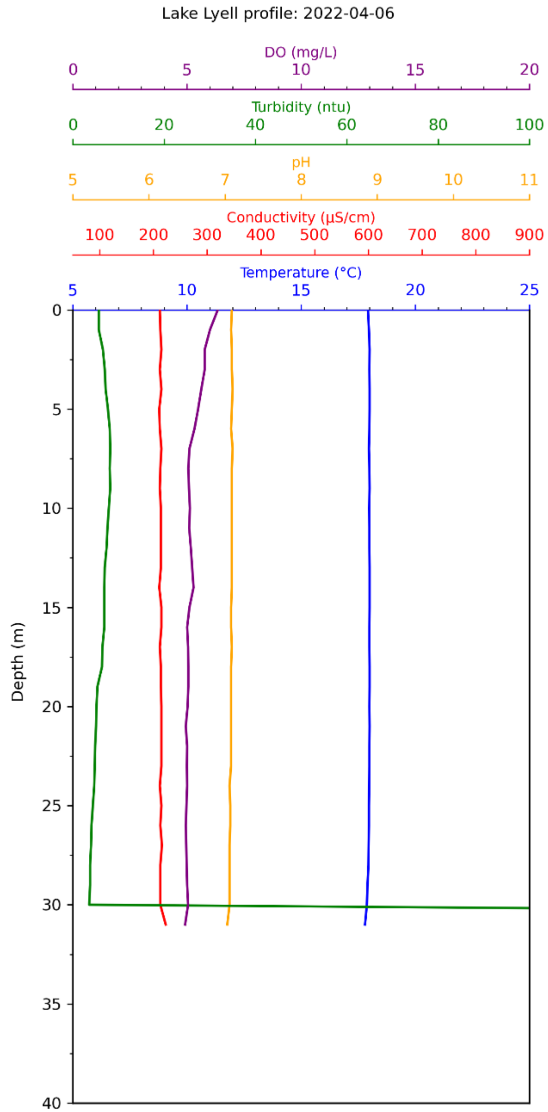


Figure C.34 Lake Lyell profile 6/4/2022

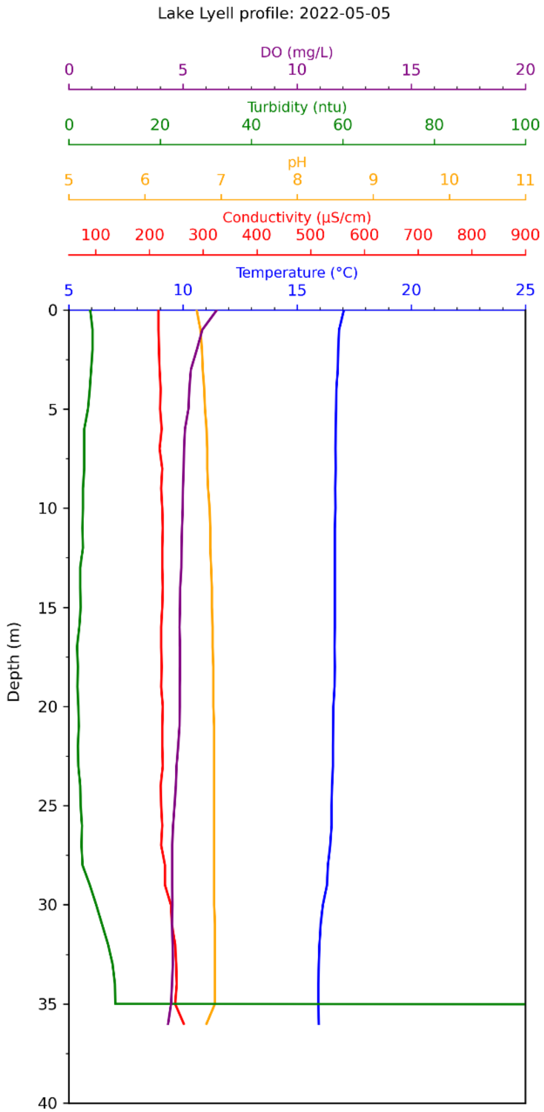


Figure C.35 Lake Lyell profile 5/5/2022

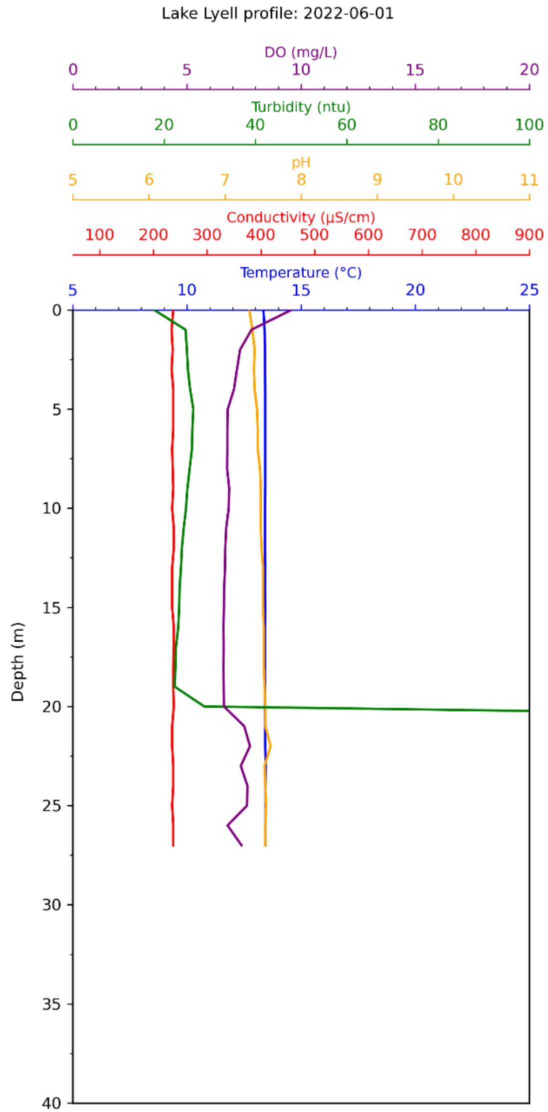


Figure C.36 Lake Lyell profile 1/6/2022

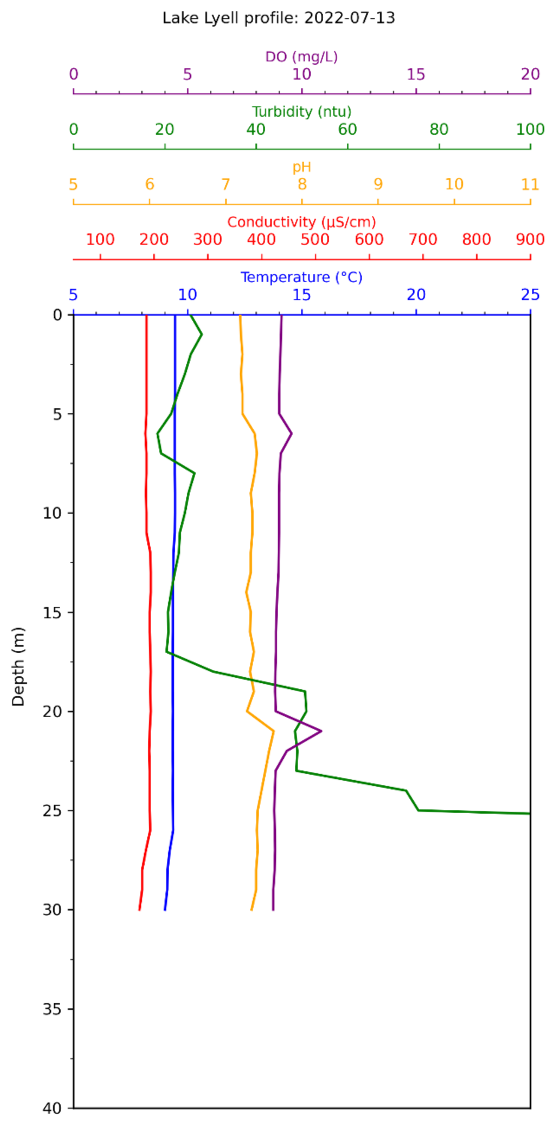


Figure C.37 Lake Lyell profile 13/7/2022

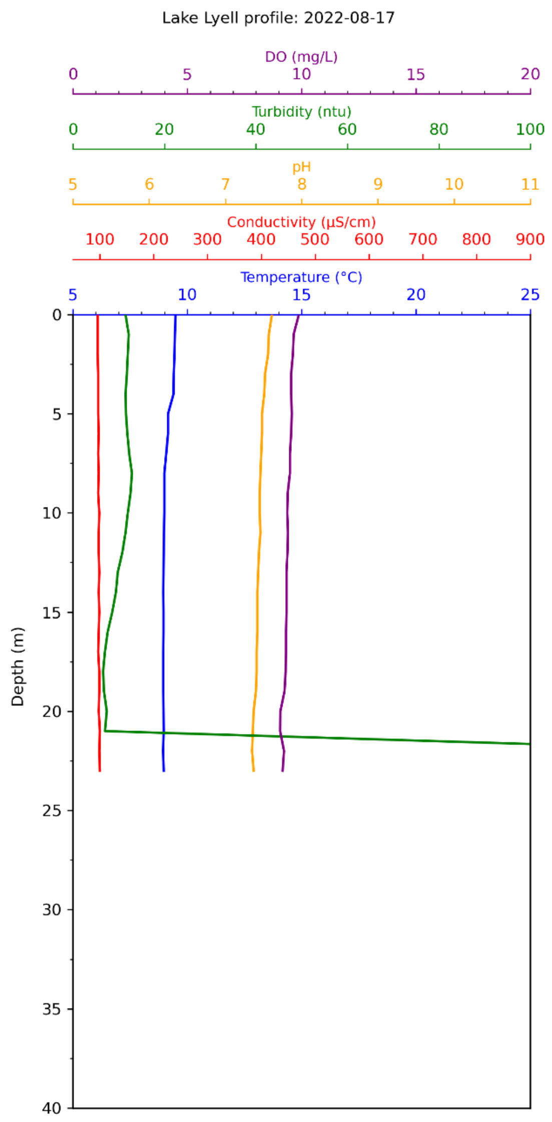


Figure C.38 Lake Lyell profile 17/8/2022

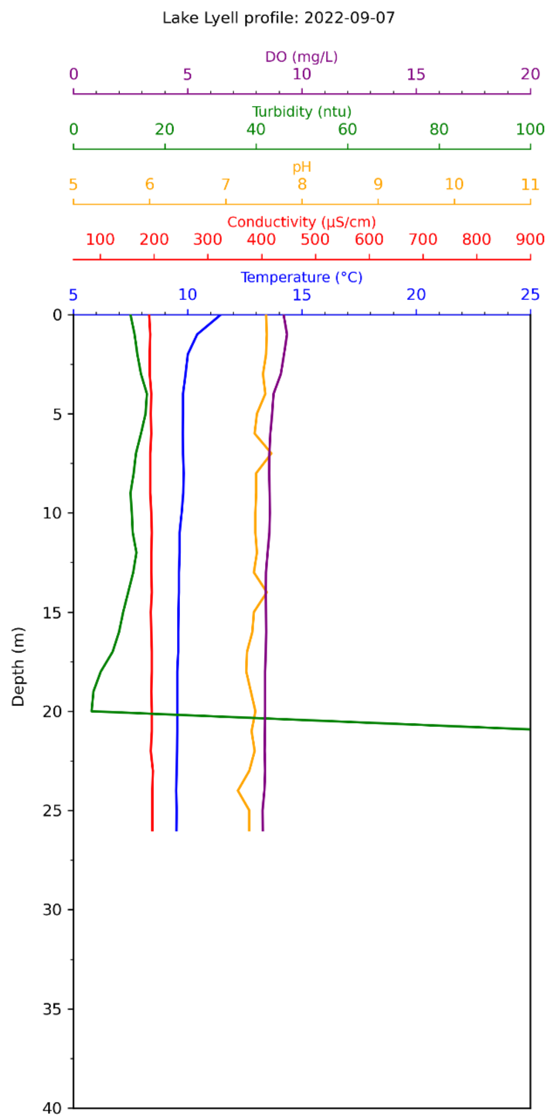


Figure C.39 Lake Lyell profile 7/9/2022

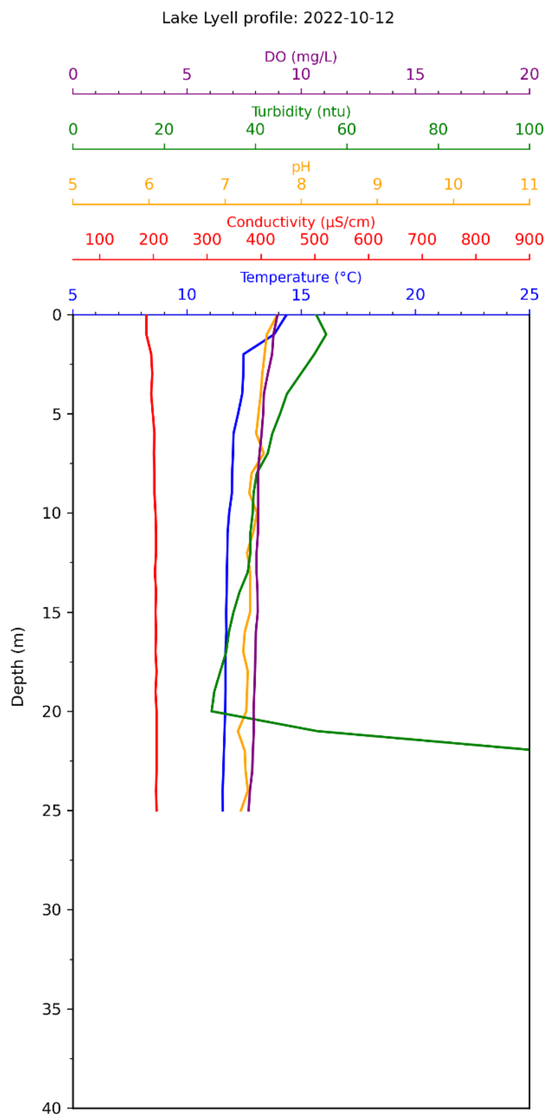


Figure C.40 Lake Lyell profile 12/10/2022

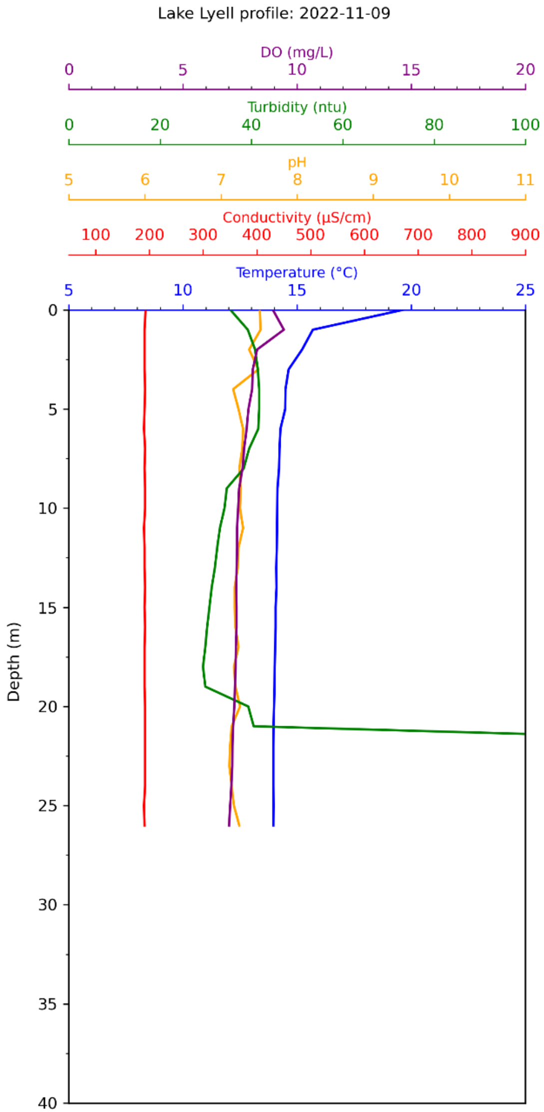


Figure C.41 Lake Lyell profile 9/11/2022

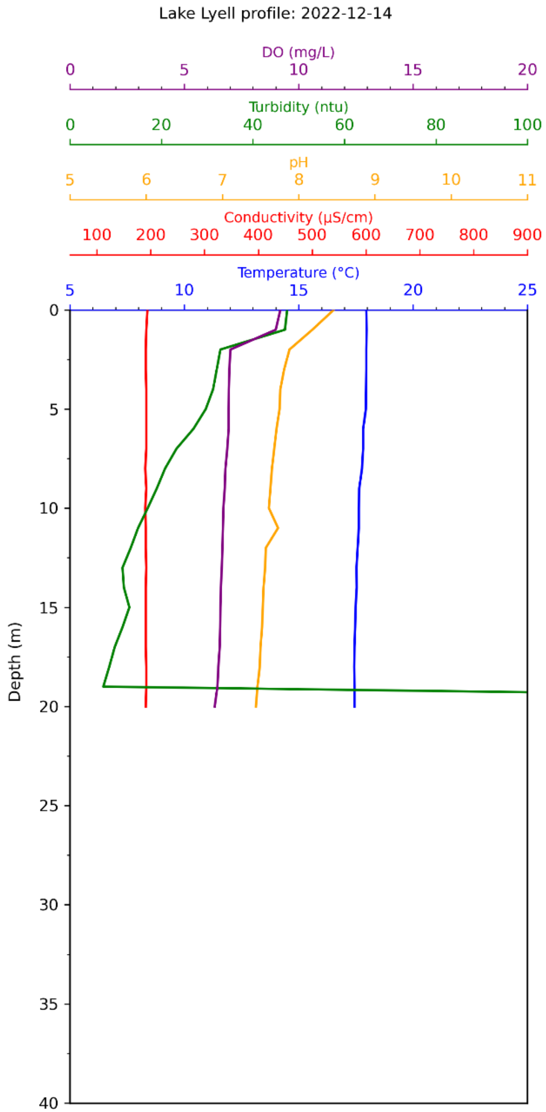


Figure C.42 Lake Lyell profile 14/12/2022

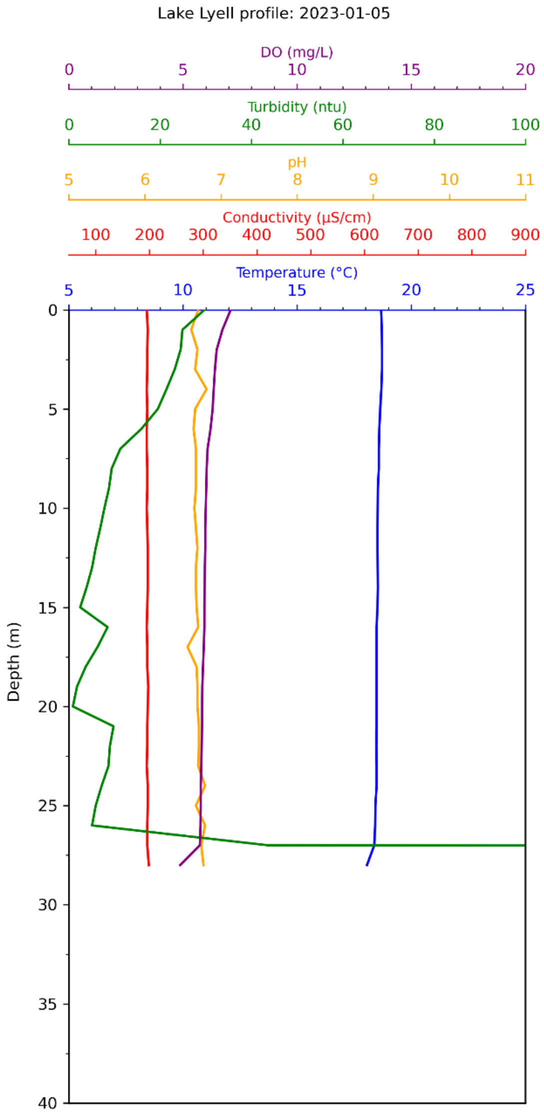


Figure C.43 Lake Lyell profile 5/1/2023

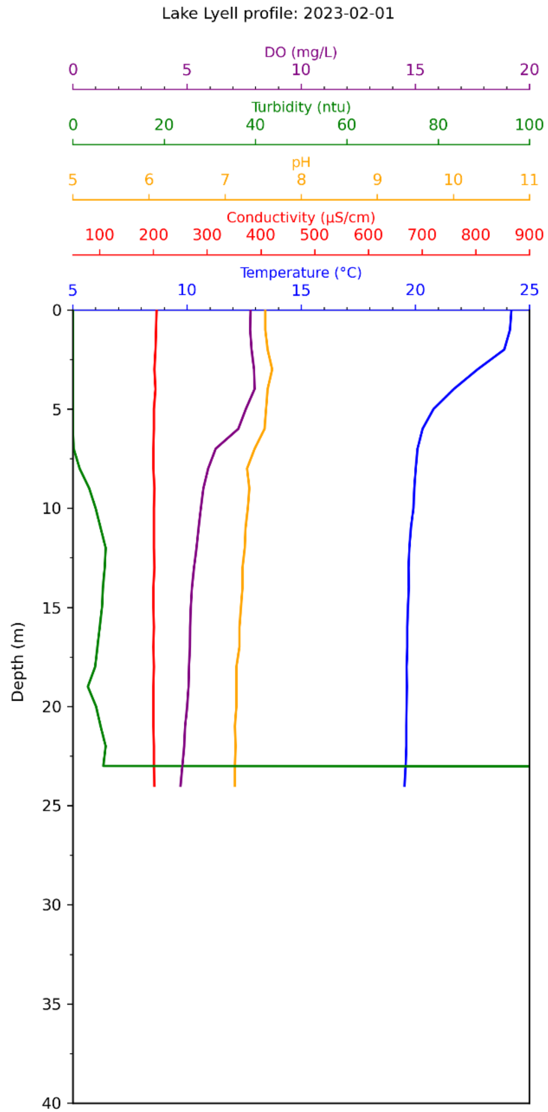


Figure C.44 Lake Lyell profile 1/2/2023

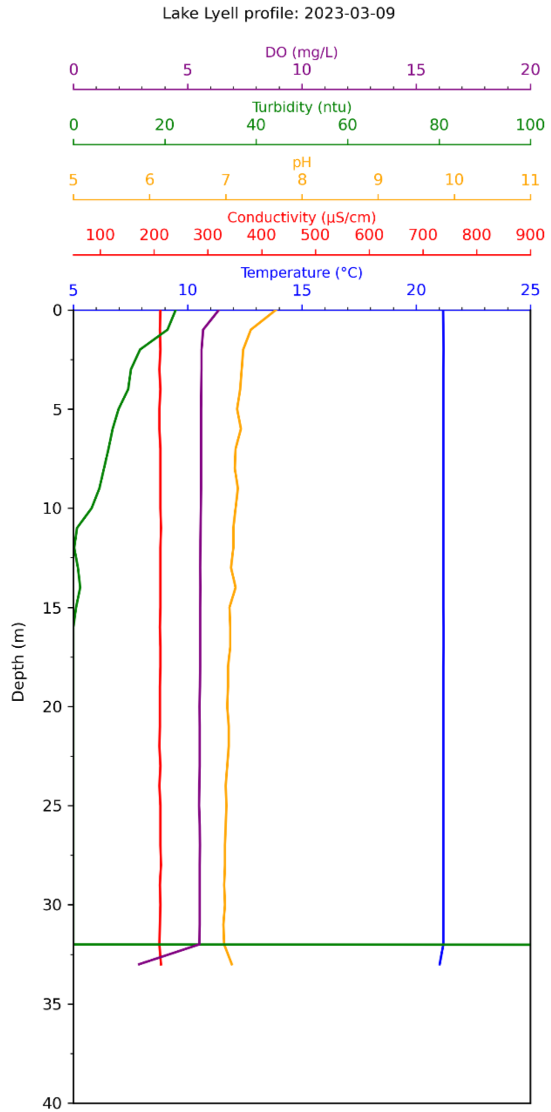


Figure C.45 Lake Lyell profile 9/3/2023

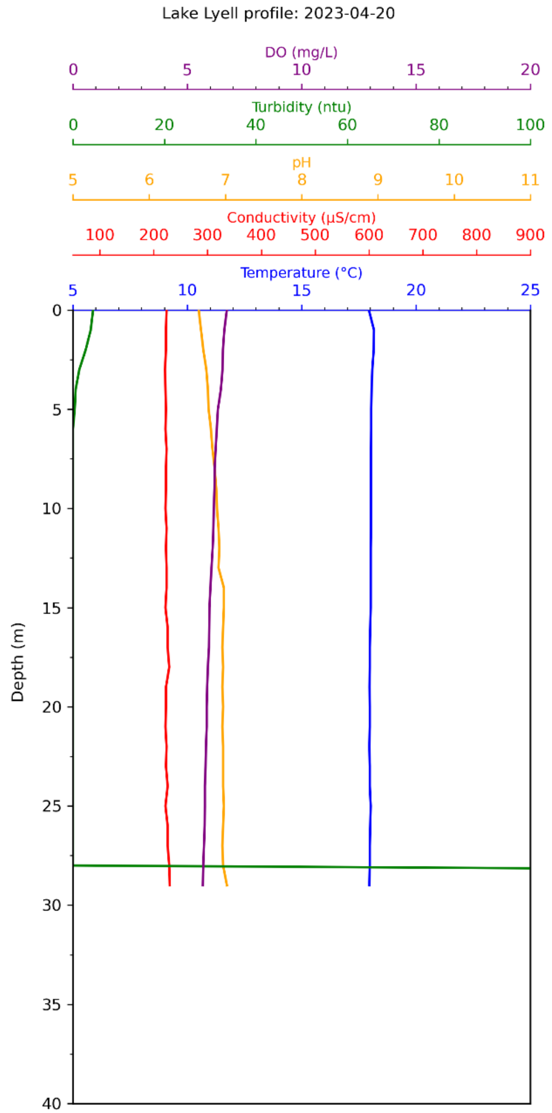


Figure C.46 Lake Lyell profile 20/4/2023

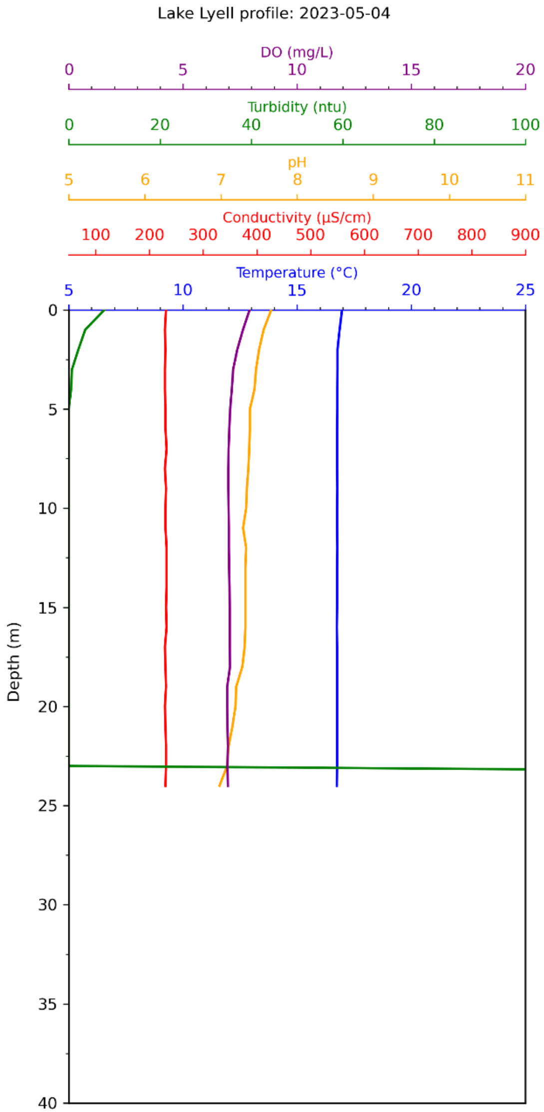


Figure C.47 Lake Lyell profile 4/5/2023

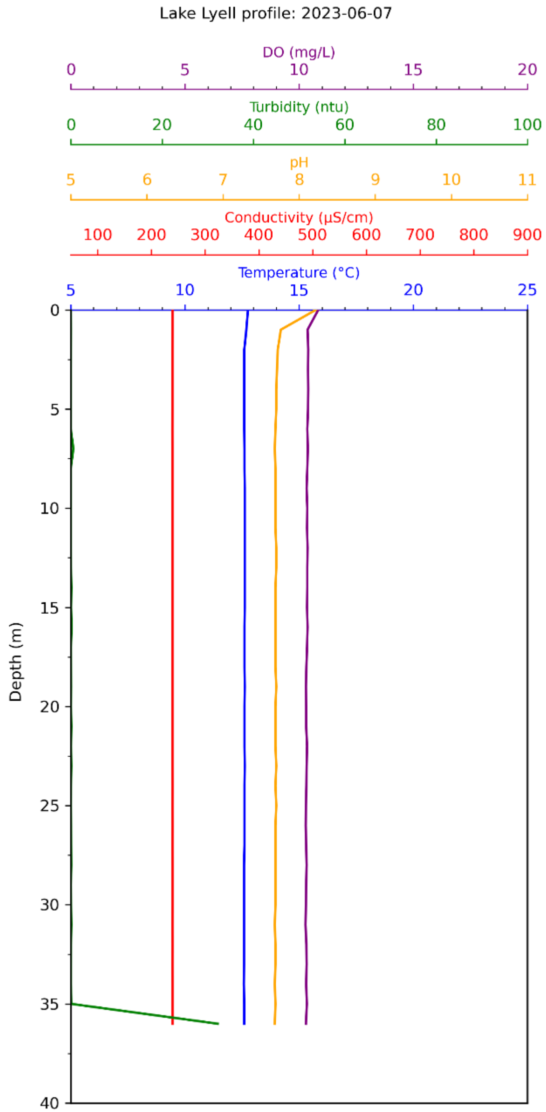


Figure C.48 Lake Lyell profile 7/6/2023

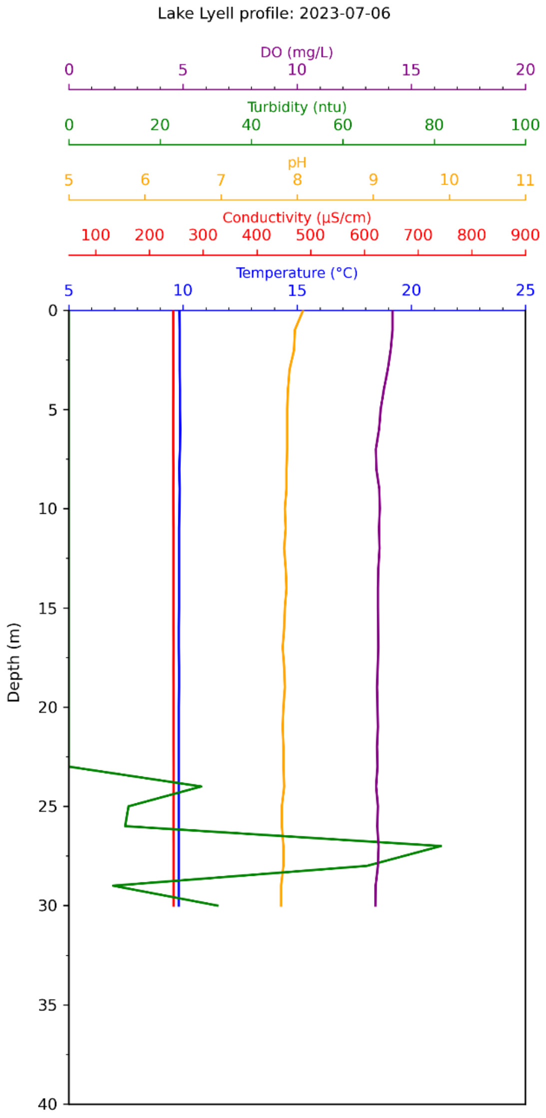


Figure C.49 Lake Lyell profile 6/7/2023

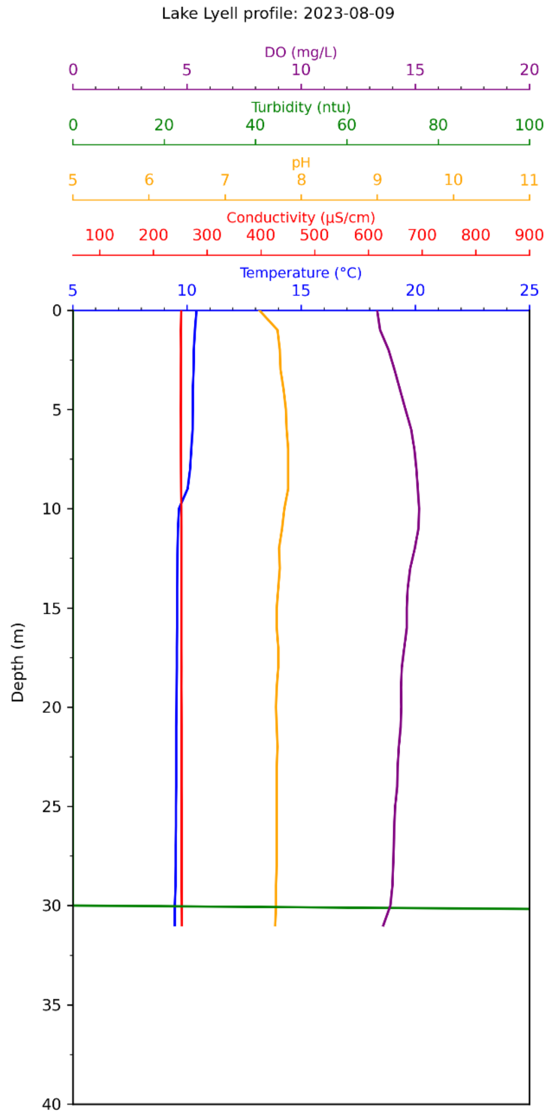


Figure C.50 Lake Lyell profile 9/8/2023

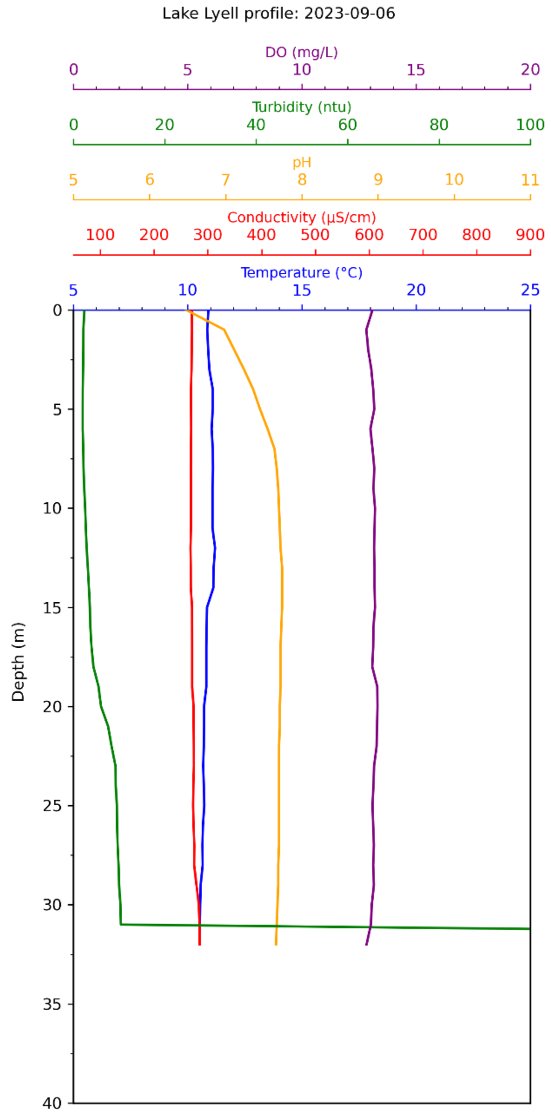


Figure C.51 Lake Lyell profile 6/9/2023

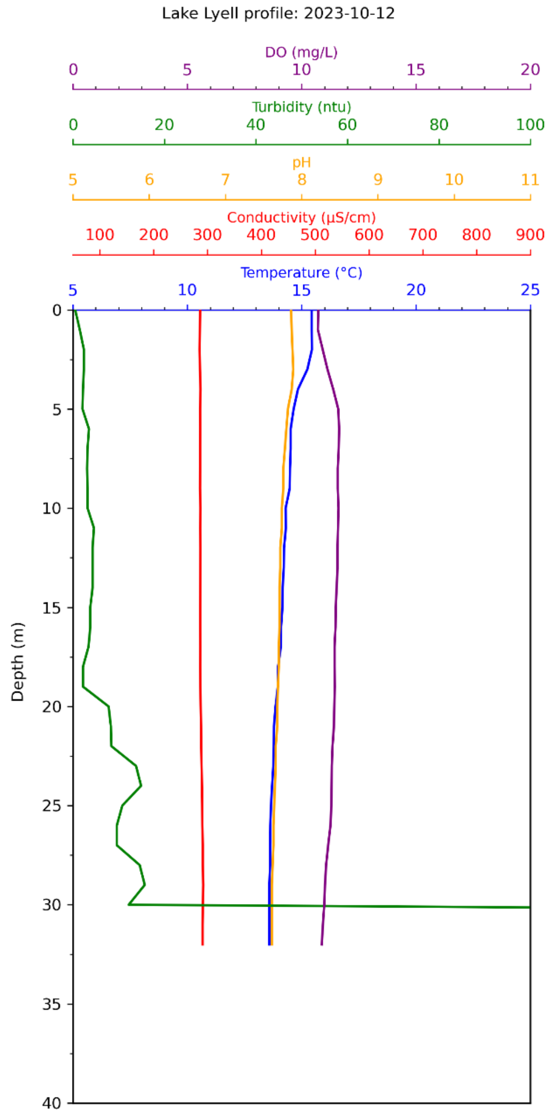


Figure C.52 Lake Lyell profile 12/10/2023

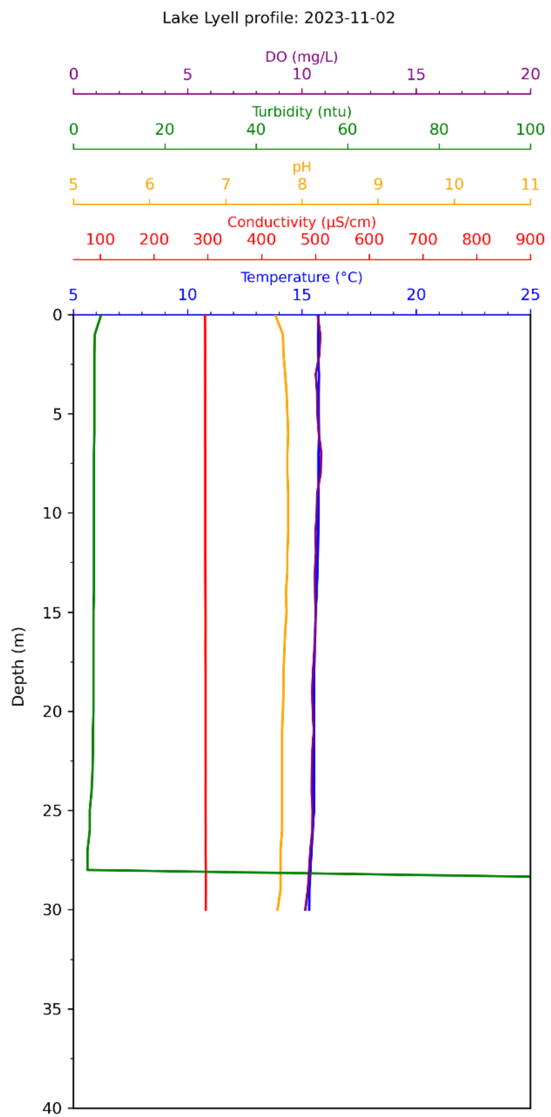


Figure C.53 Lake Lyell profile 2/11/2023

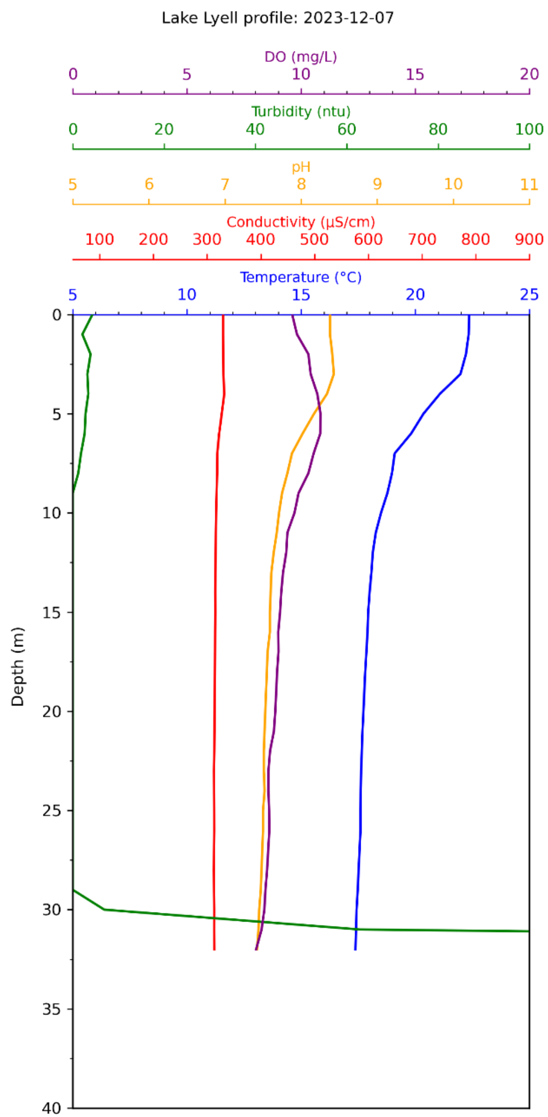


Figure C.54 Lake Lyell profile 7/12/2023

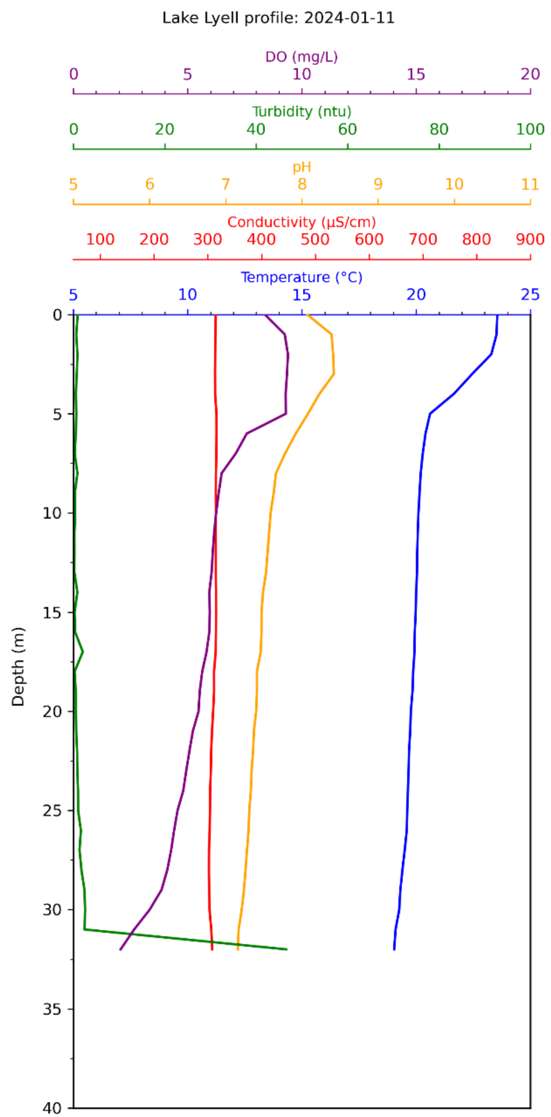


Figure C.55 Lake Lyell profile 11/1/2024

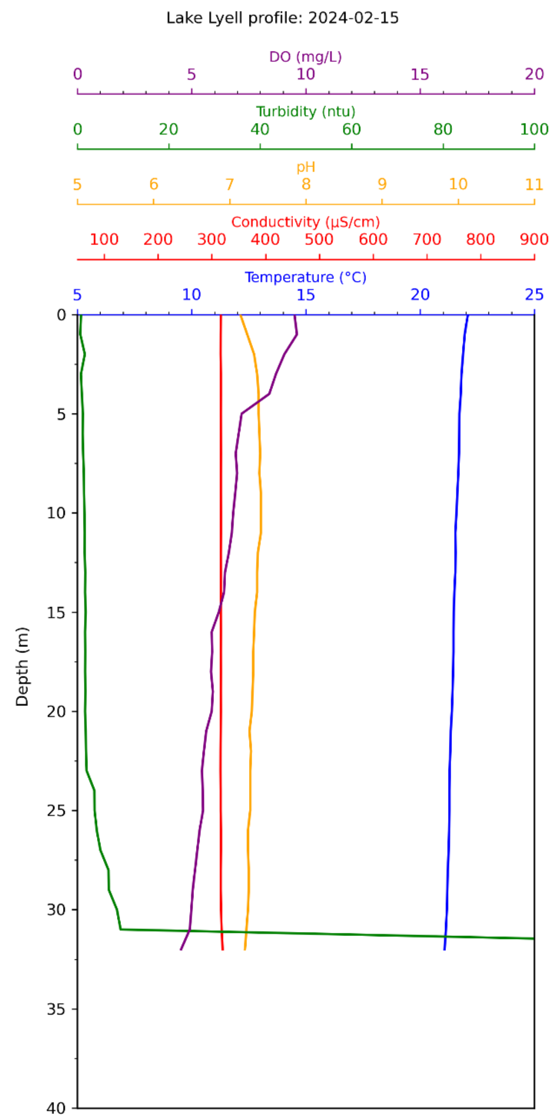


Figure C.56 Lake Lyell profile 15/2/2024

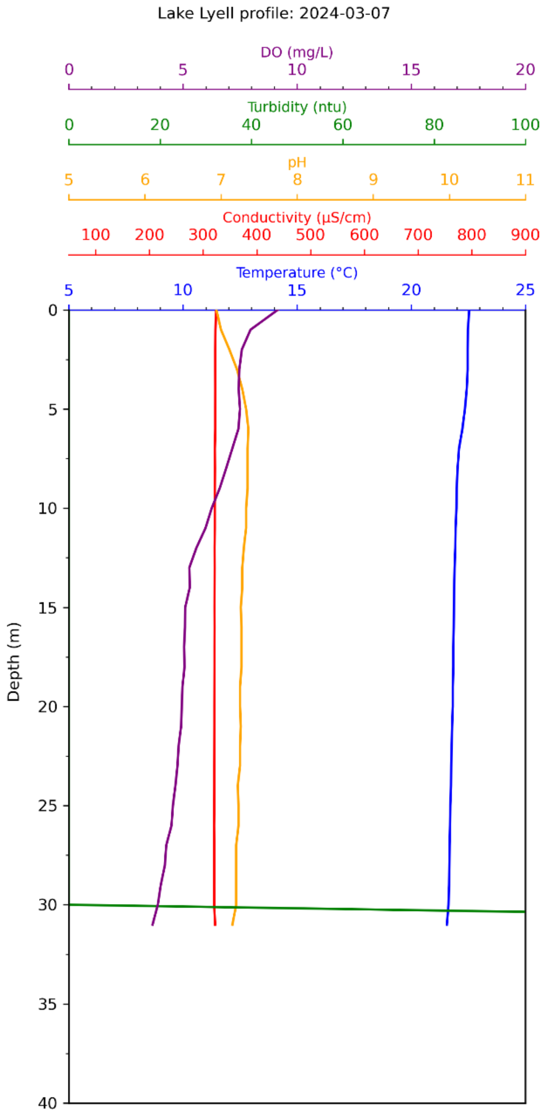


Figure C.57 Lake Lyell profile 7/3/2024

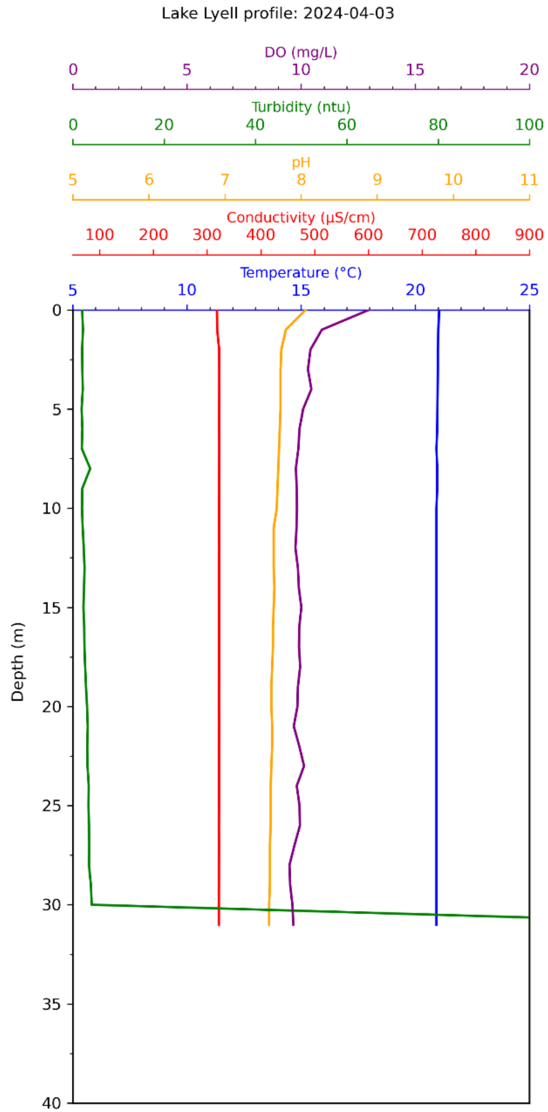


Figure C.58 Lake Lyell profile 3/4/2024

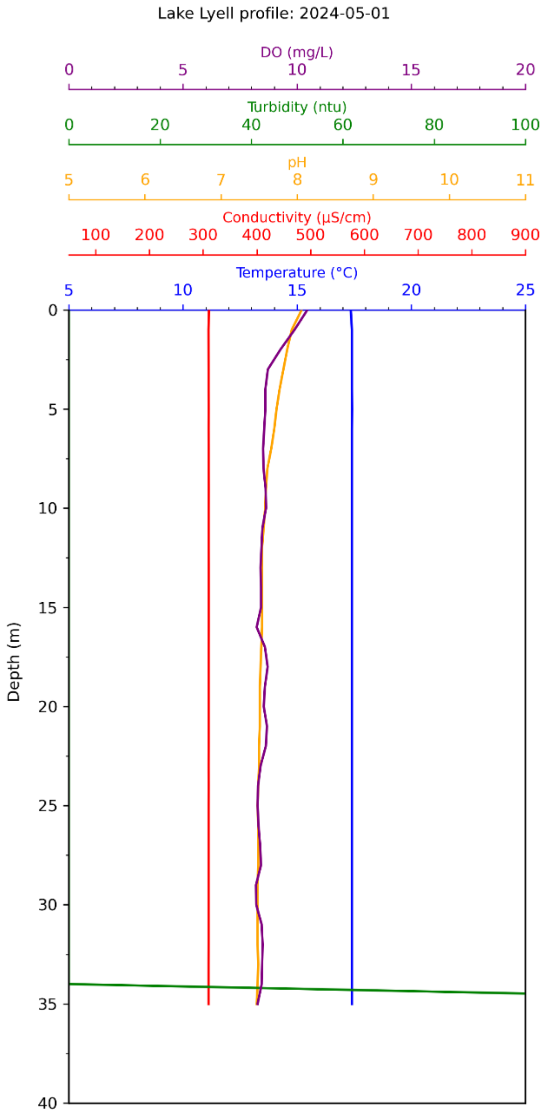


Figure C.59 Lake Lyell profile 1/5/2024

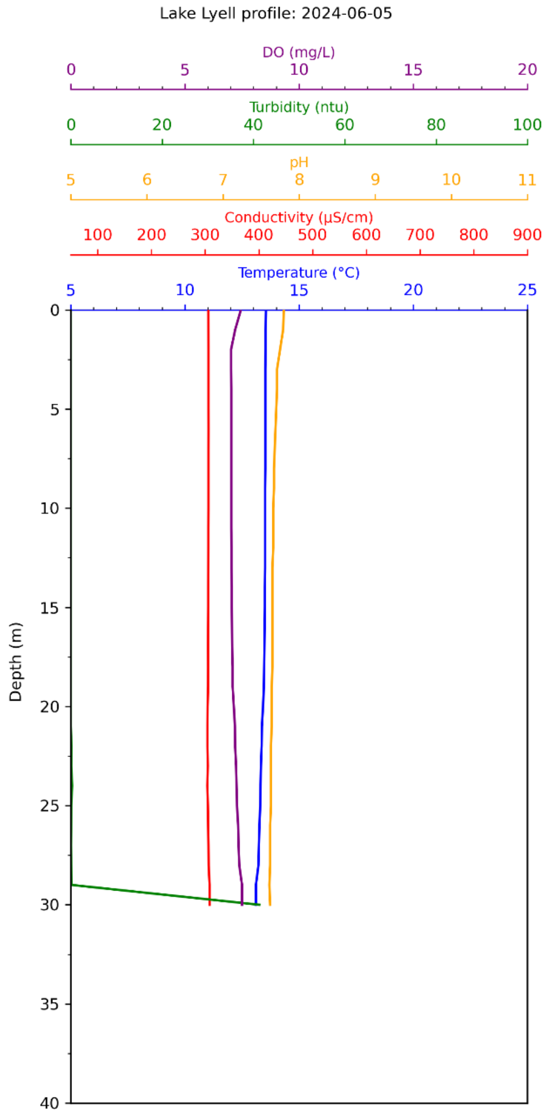


Figure C.60 Lake Lyell profile 5/6/2024

Annexure D

Seasonal boxplots

EMM
creating opportunities

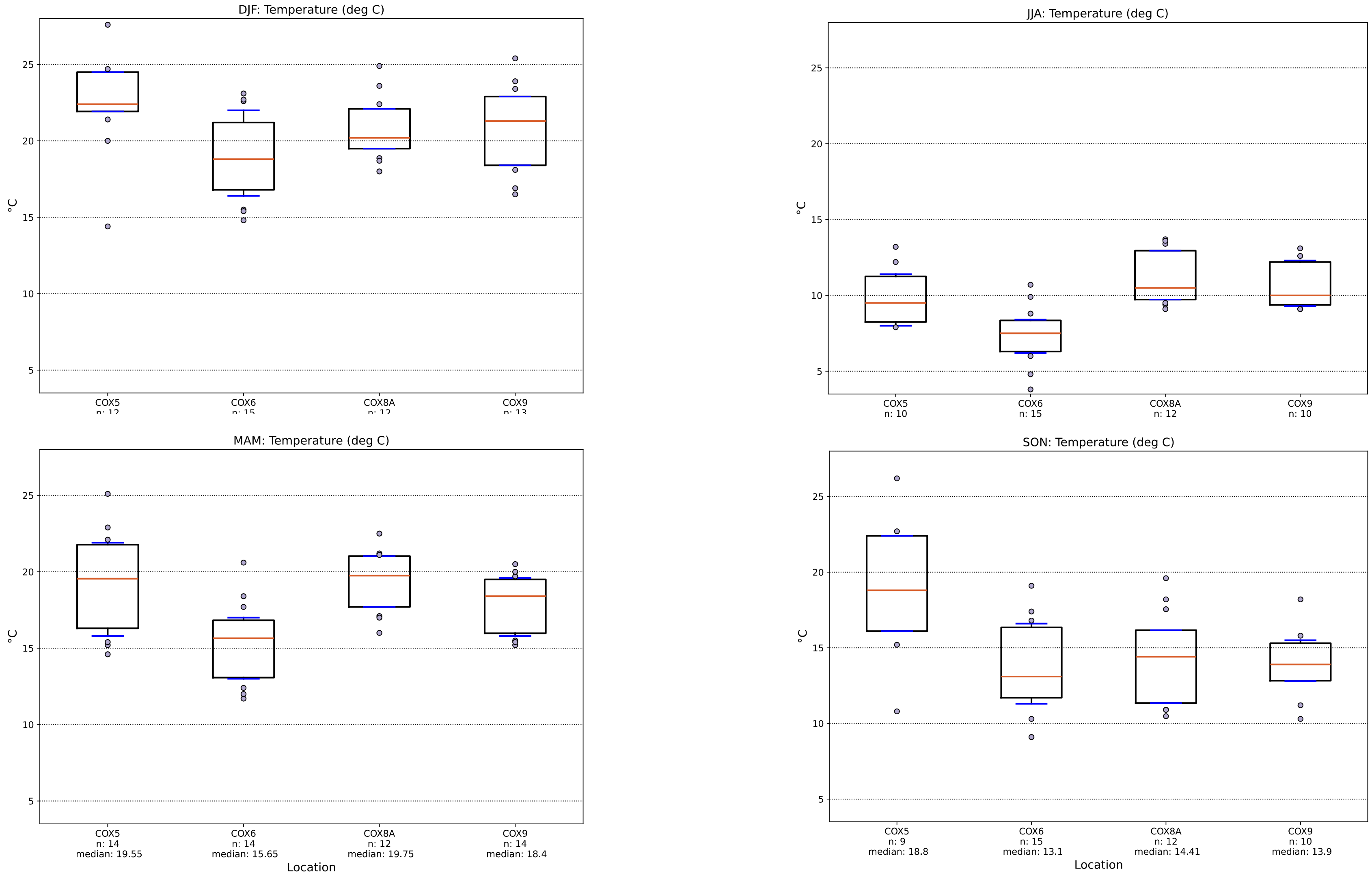


Figure D.1 Seasonal boxplots - Temperature

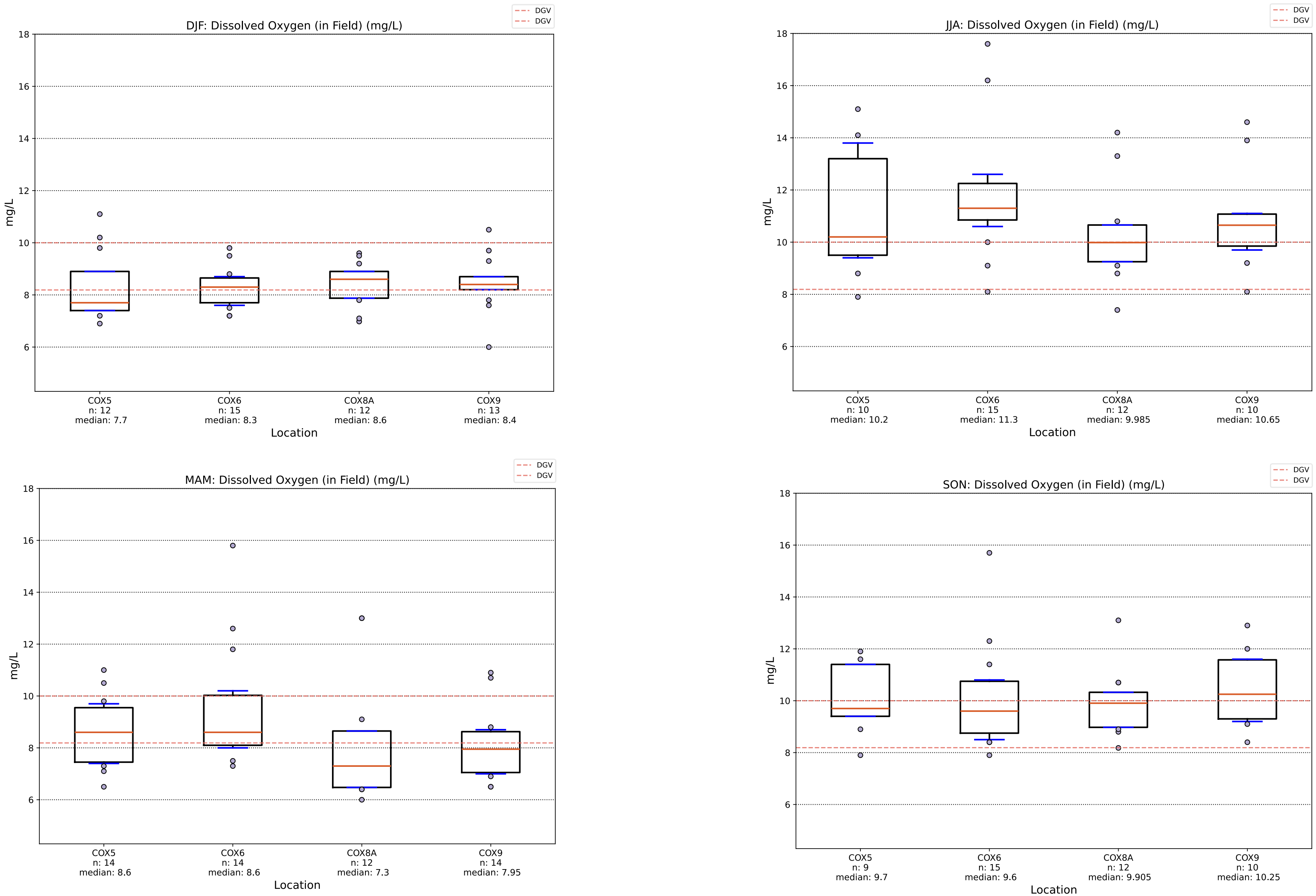


Figure D.2 Seasonal boxplots – Dissolved oxygen

Annexure E

Meteorological data

creating opportunities

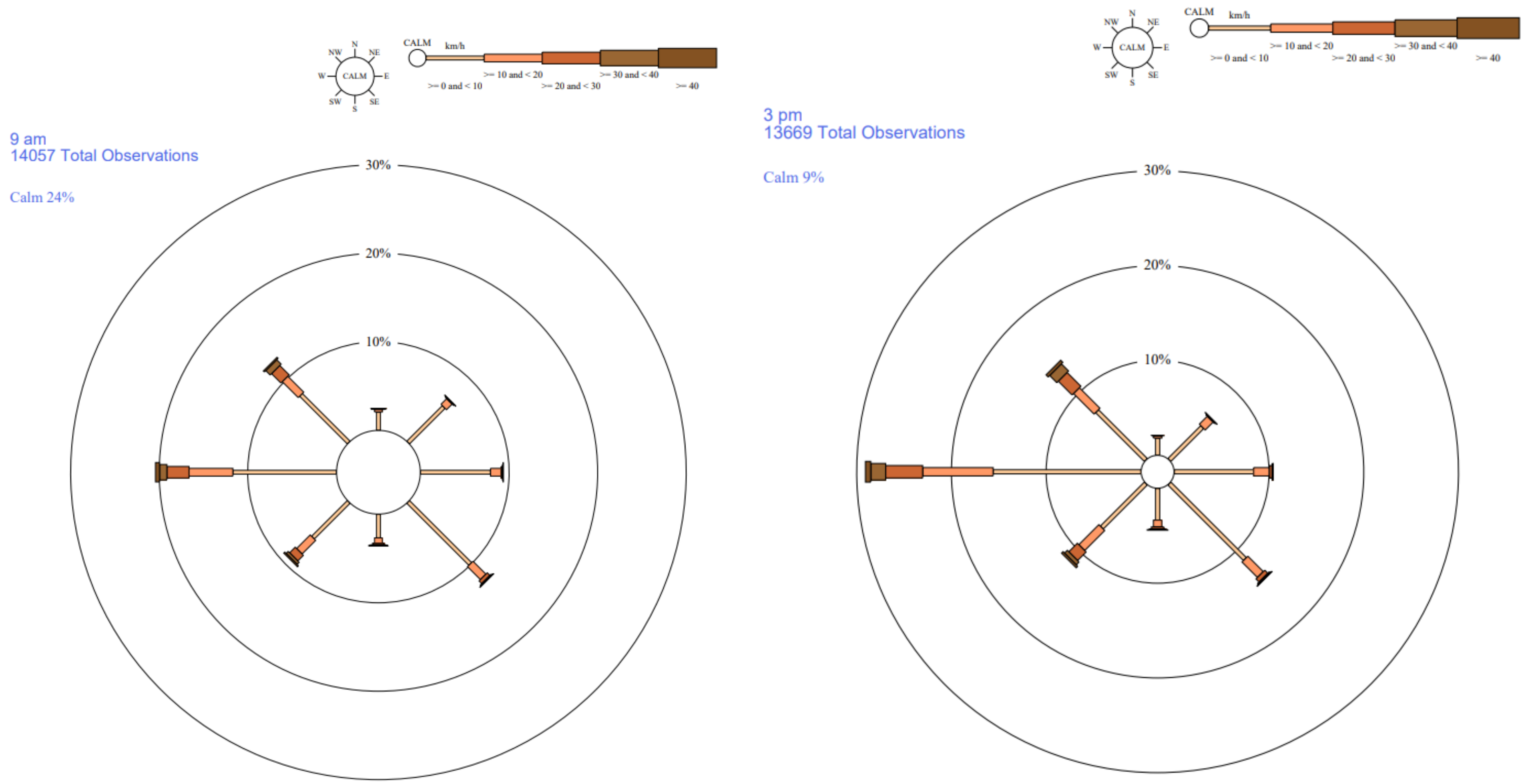


Figure E.1 **Annual wind rose for 9 am (left) and 3pm (right) observations at Lithgow (station 63224) for 1 August 1965 to 20 June 2006 (BoM, 2025)**

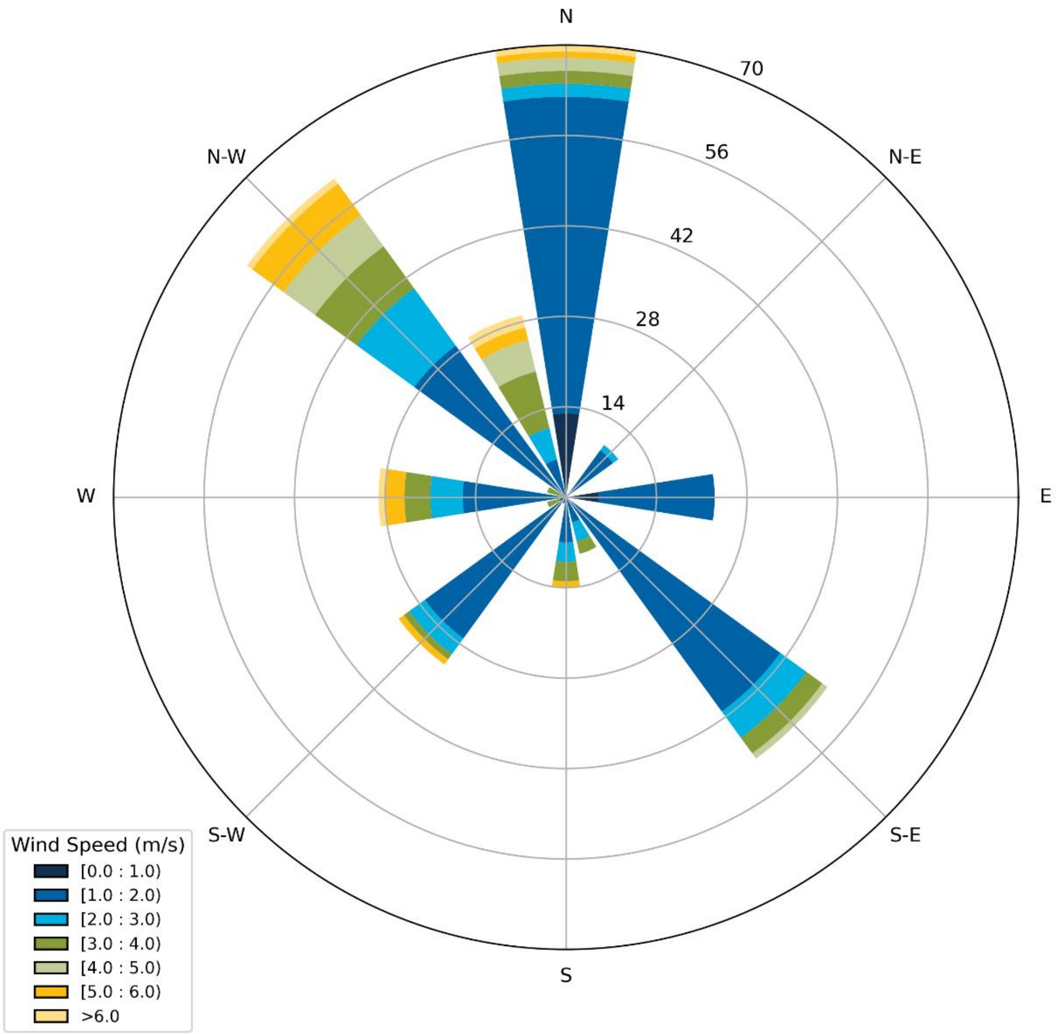


Figure E.2 Wind rose of daily wind observations (9 am) at Lithgow (station 63226) for 1 August 2023 to 22 September 2024

Annexure F

Lake Lyell PHES thermal heating calculation

EMM
creating opportunities

F.1 Introduction

The Lake Lyell PHES scheme will generate electricity as water from the upper storage is released and runs through the turbines to the lower lake. Water will then be pumped back up to the higher elevation storage which effectively recharges the PHES system. This PHES cycle is illustrated in Figure F.1. The turbines are less than 100% efficient, with a portion of energy put into the turbines lost as heat. The heat is both absorbed by the water moving through the turbines and dissipated within the turbine enclosure. The following potential thermal heating calculation uses the conservative assumption that all lost energy will be absorbed by the water.

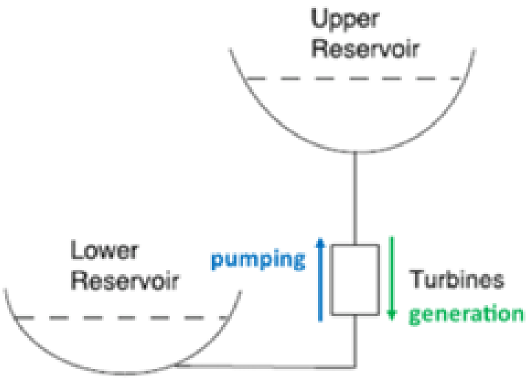


Figure F.1 Simple schematic of PHES operation

F.2 Data

The potential thermal heating calculation is based on the project information and parameters provided in Table F.1.

Table F.1 Parameters used for calculation

Parameter	Symbol	Value
Energy generated to grid during the discharge phase (per day)	$E_{generated}$	385 MW for 8 hours = 3080 MWh
Upper reservoir active storage	V	5.3 GL
Efficiency of PHES round-trip (as fraction)	$\eta_{round\text{-}trip}$	0.8 (Blakers et al., 2021)
Efficiency of PHES generation phase (as fraction)	$\eta_{generation}$	0.9 (Blakers et al., 2021)
Fraction of total energy loss that contributes to water heating		1.0 (conservative assumption)
Density of water	ρ	1000 kg/m³
Specific heat capacity of water (Note: 4186 J is needed to raise the temperature of 1 kg of water by 1 °C)	c	4186 J/kg°C

F.3 Equations

Efficiency equation:

$$Efficiency = \frac{Energy\ output}{Energy\ input}$$

... (1)

Overall round-trip efficiency:

$$\eta_{round-trip} = \eta_{generation} \times \eta_{pumping}$$

... (2)

Specific heat capacity equation:

$$\Delta E = mc\Delta T$$

$$\Delta T = \frac{\Delta E}{mc}$$

... (3)

ΔE = change in energy (J)

m = mass (kg)

c = specific heat capacity (J/kg°C)

ΔT = change in temperature (°C)

F.4 PHES potential thermal heating

F.4.1 Calculation of E_{stored}, $E_{pumping}$ and check on $\eta_{round-trip}$

Using equation 1 and 2, the following are calculated:

- E_{stored} = the potential energy stored in the upper reservoir (MWh)
- $E_{pumping}$ = the energy used during the charging phase of the system (MWh)

Using $\eta_{generation}$ = 0.9 and $E_{generated}$ = 3080 MWh,

$$\eta_{generation} = \frac{E_{generated}}{E_{stored}} = \frac{3080}{E_{stored}} = 0.9$$

$$E_{stored} = 3422\ MWh$$

Using $\eta_{round-trip}$ = 0.8,

$$\eta_{round-trip} = \frac{E_{generated}}{E_{pumping}} = \frac{3080}{E_{pumping}} = 0.8$$

$$E_{pumping} = 3850\ MWh$$

Therefore,

$$\eta_{pumping} = \frac{E_{stored}}{E_{pumping}} = \frac{3422}{3850} = 0.888$$

-> $\eta_{round-trip} = \eta_{generation} \times \eta_{pumping} = 0.9 \times 0.888 = 0.8$

-> checks

F.4.2 Calculation of change in temperature (ΔT) over generation phase

E_{stored} = 3422 MWh = 3422 x10^6 Wh (1 Wh = 3600 Ws)

= 1.232 x 10^{13} J (1 Ws = 1 J)

Using $\eta_{generation}$ = 0.9 => factor = 0.1

$$\Delta E = 1.232x10^{13} \times 0.1 = 1.232x10^{12}\ J$$

Using upper reservoir active storage volume = 5.3 GL (assuming total volume emptied/filled) and ρ = 1000 kg/m^3,

$$m = 1000 \times 5300000 = 5.3x10^9\ kg$$

Therefore, using equation 3,

$$\Delta T = \frac{1.232x10^{12}}{5.3x10^9 \times 4186}$$

-> $\Delta T = 0.06\ °C$

-> negligible heating

F.4.3 Calculation of change in temperature (ΔT) over pumping phase

$E_{pumping}$ = 3850 MWh = 3850 x10^6 Wh (1 Wh = 3600 Ws)

= 1.386 x 10^{13} J (1 Ws = 1 J)

Using $\eta_{pumping}$ = 0.888 => factor = 0.111

$$\Delta E = 1.386x10^{13} \times 0.111 = 1.54x10^{12}\ J$$

As above,

$$m = 1000 \times 5300000 = 5.3x10^9\ kg$$

Therefore, using equation 3,

$$\Delta T = \frac{1.54x10^{12}}{5.3x10^9 \times 4186}$$

-> $\Delta T = 0.07\ °C$

-> negligible heating

F.5 Discussion

The effect of the PHES operations, with the conservative assumption that all energy loss will be absorbed by the water is the following:

- $\Delta T_{generation}$ = +0.06 °C
- $\Delta T_{pumping}$ = +0.07 °C

With PHES generation and pumping occurring in the same day, the complete cycle has the potential of thermal heating up to 0.13 °C.

This calculated potential thermal heating is negligible and would typically be less considering a portion of energy loss dissipating via turbine footings to the surrounding rock and into the air of the pump chamber. Both ρ and c are a function of water temperature and sensitivity testing of these values does not change the result.

The water passing through the turbines will mix with water in the lower lake during the generation phase, which will dilute any noticeable effect. It is not expected that the additional heat would build up over time, as atmospheric effects will consistently apply on the lake surface, causing water temperatures to trend towards the daily average air temperature. The effect of air temperature and solar radiation will result in daily lake temperature changes an order of magnitude greater than the effect of the PHES operations.

F.6 Conclusion

From the PHES thermal heating calculation, the following conclusions can be made:

- The potential thermal heating of water transported over the full cycle is 0.13°C. This increase in water temperature is negligible, as air temperature and solar radiation result in daily lake water temperature changes that are an order of magnitude greater.
- There will not be a build-up of heat in Lake Lyell, as the discrete volume of water transported over a full cycle (16% of Lake Lyell total volume) will dilute with lake water and the lake water temperature is continually adjusting through heat exchange with the atmosphere, gradually moving toward thermal equilibrium.

References

Blakers et al. (2021), A review of pumped hydro energy storage, Progress in Energy 3, March 2021

Annexure G
Cross-section average velocity calculation

EMM
creating opportunities

G.1 Introduction

The Lake Lyell PHES scheme will typically consist of a daily cycle, made up of a generation phase in which water is discharged to Lake Lyell and a recharge phase in which water is pumped out of Lake Lyell to the upper reservoir. The proposed peak flow rates for discharging and pumping from Farmers Creek arm of Lake Lyell are 210 m^3/s and 190 m^3/s respectively. These flow rates have the potential to cause erosion of sediments at the lakebed and along banks.

To understand the potential erosion risk and potential velocities that could occur within Farmers Creek arm, this appendix presents the calculation of average velocities (uniform) across numerous cross-sections in Farmers Creek arm, for the maximum PHES flow of 210 m^3/s. The calculation is an approximation based on the maximum PHES flow and approximate measurement of cross-sectional area. It is important to note that across the cross-section, flow velocities will vary, with values both lower and higher than the calculated average due to cross-sectional shape and boundary friction effects.

Generally, channel flow is fastest where it is deepest, has fewer obstructions and less friction. Across a straight section of channel with a relatively uniform depth cross-section, higher velocities tend to be in the centre of the channel in the upper surface waters. In a meandering channel bend, higher velocities are expected on the outside of the bend where the cross-section deepens, with lower velocities occurring in the shallower inner bend (Earle, 2019; Klingeman et al., 1984).

G.2 Cross-sections

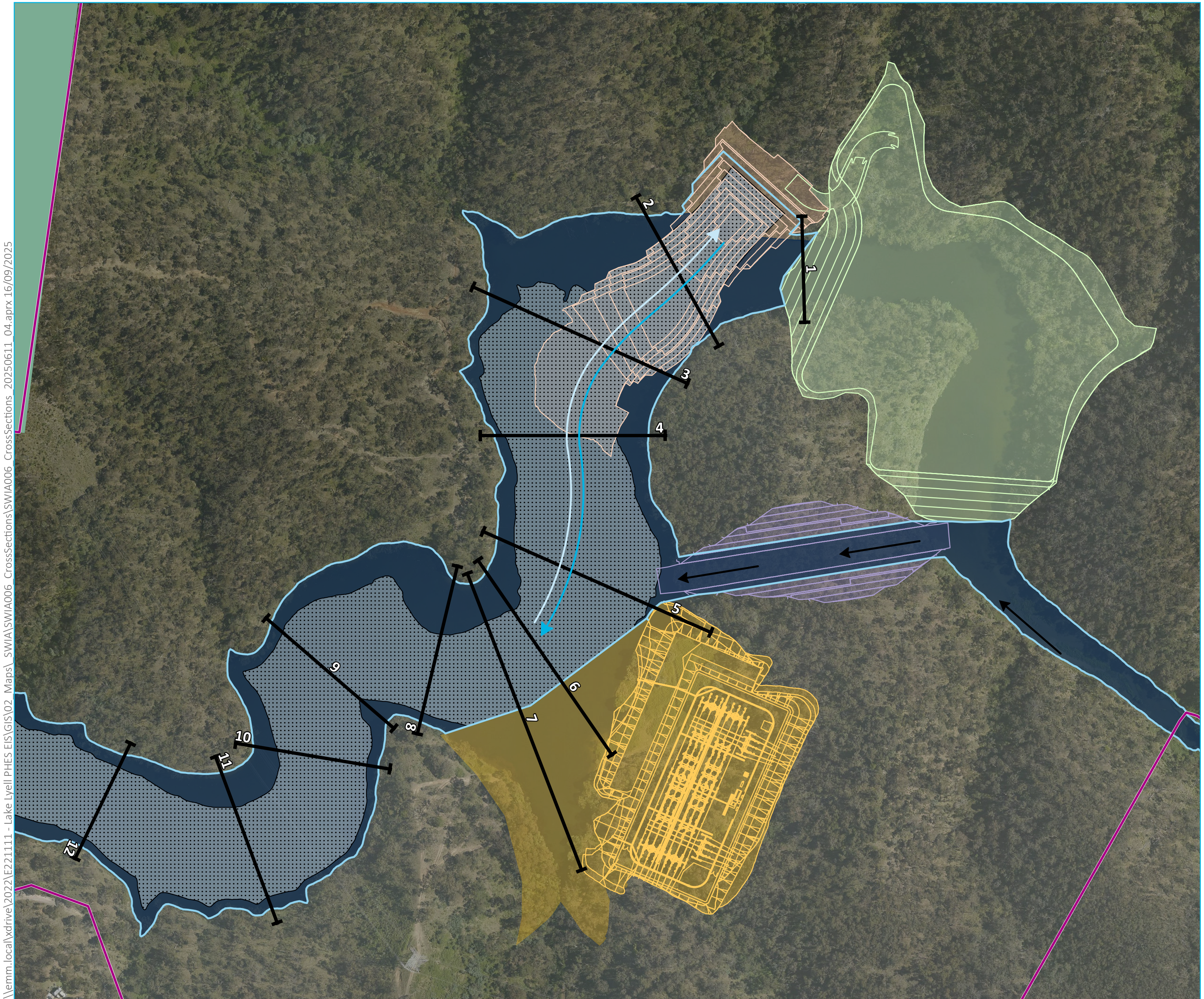
G.2.1 Data

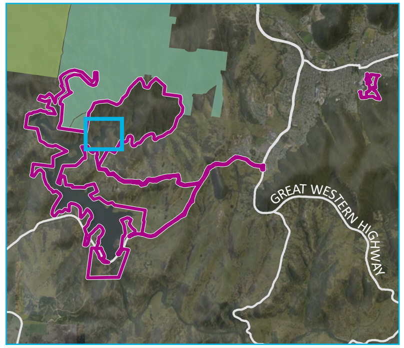
To estimate the area of cross-sections along Farmers Creek arm, the lake bathymetry dataset (provided by EA) was merged with the 50 cm LiDAR data (provided by Aerometrex). At the merge of the two datasets around 784.5 mAHD, minimal processing artefacts are present, hence the calculated areas should be considered approximate.

G.2.2 Locations

The indicative locations where cross-sectional area has been calculated in Farmers Creek arm are shown in Figure G.1. The location of cross-section 4, is approximately at the head of the inlet channel and considering the natural undeveloped channel, has the smallest calculated cross-sectional area compared to all the downstream cross-sections (5 to 12).

For the average velocity calculations in this appendix, the proposed project laydown infill has been considered (approximated by a vertical wall) which reduces the channel cross-sectional area calculated at cross-sections 5, 6 and 7. Only the cross-sections at the head of the inlet channel and downstream have been considered for the average velocity calculation (cross-section 4 to 12). In Figure G.2 and Figure G.3, cross-section 1 to 3 represent the natural undeveloped channel cross-sections of Farmers Creek arm.





KEY

Project area

Cross section*

Generation flow direction

Pumping flow direction

Farmers creek flow direction

Lake Lyell operational extent

Lake inundation extent at minimum PHES operating level (780.0 m AHD)

PHES operating range to FSL (780.0 to 785.5 m AHD)

Project layout

Lake diversion

Infill permanent spoil emplacement

Lower inlet/outlet

Laydown permanent spoil emplacement

Existing environment

NPWS reserve

State forest (refer to inset)

*A merged raster was developed using bathymetry data provided by Energy Australia and a 0.5m DEM provided by Aerometrex over Mt Walker, in order to extract cross-sections from Farmers Creek Arm. Due to the merge of two different datasets around 784.5 m AHD, minimal artefacts are present and the cross-sections should be considered as approximate.

Indicative cross-section locations

Lake Lyell PHES
Surface Water Impact Assessment
Figure G.1

creating opportunities

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

0 50 100
m
GDA2020 MGA Zone 56
N

G.2.3 Profiles and approximate cross-sectional areas

The extracted profiles for the 12 cross-sections (for PHES minimum operating level of 780 mAHD) are shown in Figure G.2 and the approximate cross-sectional areas are shown in Figure G.3 for a range of lake levels. It should be noted that these figures represent the natural undeveloped cross-sections, except for cross-section 5, 6 and 7 which consider the proposed project laydown infill.

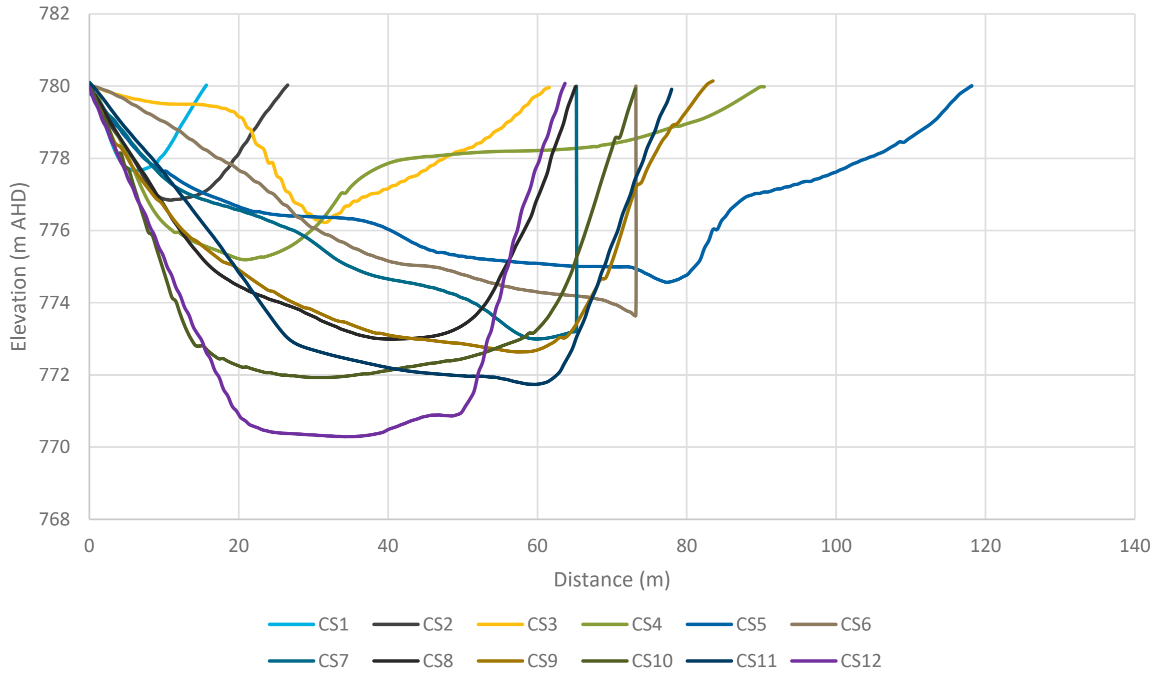


Figure G.2 Profiles of cross-sections (facing upstream and left to right) for minimum PHES operating level (780 mAHD)

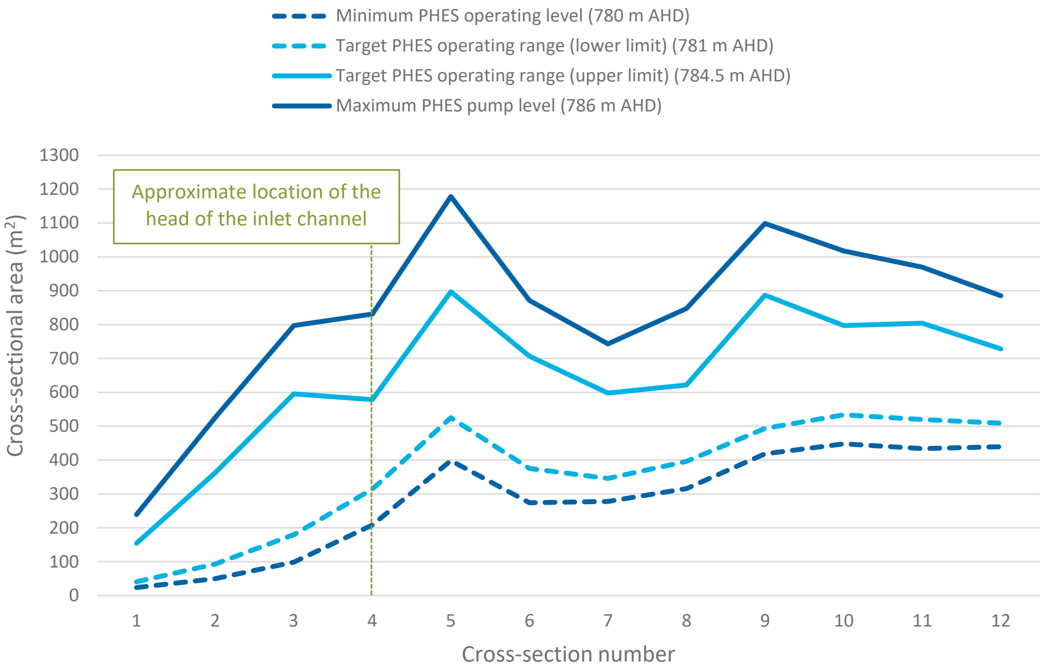


Figure G.3 Approximate cross-sectional areas within PHES operating range

G.3 Calculated average velocity

For the proposed PHES peak flow of 210 m^3/s, the cross-sections with the various PHES operating levels, have the calculated average velocities shown in Table G.1. Cross-section 4 and 7 tend to have the smallest cross-sectional areas and hence highest average velocities (highlighted).

Table G.1 Cross-section average velocities

Cross-section	Area (m^2)	Average velocity (m/s)
Maximum PHES range (lower: 780 mAHD)		
4	208	1.0
5	399	0.5
6	274	0.8
7	278	0.8
8	316	0.7
9	418	0.5
10	448	0.5
11	434	0.5
12	439	0.5
Typical PHES range (lower: 781 mAHD)		
4	314	0.7
5	525	0.4
6	375	0.6
7	346	0.6
8	396	0.5
9	494	0.4
10	534	0.4
11	519	0.4
12	509	0.4
Typical PHES range (upper: 784.5 mAHD)		
4	578	0.4
5	897	0.2
6	707	0.3
7	598	0.4
8	622	0.3
9	886	0.2
10	797	0.3

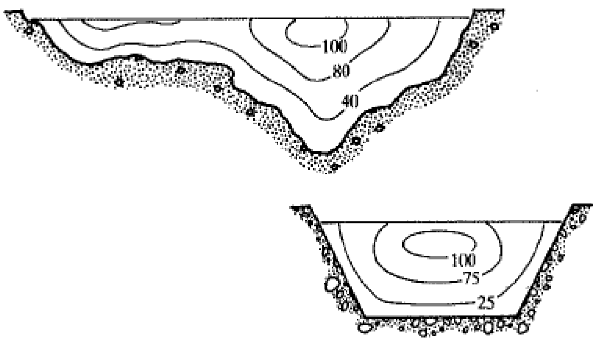
Cross-section	Area (m²)	Average velocity (m/s)
11	804	0.3
12	728	0.3
Maximum PHES range (upper: 786 mAHD)[1]		
4	831	0.3
5	1178	0.2
6	871	0.2
7	743	0.3
8	848	0.2
9	1099	0.2
10	1018	0.2
11	969	0.2
12	885	0.2

Note: The average velocities (rounded to 1 decimal place) calculated using 190 m^3/s are almost identical to 210 m^3/s. Velocities using 210 m^3/s are retained to be slightly more conservative.

G.4 Velocity variation and potential maximum

Flow velocity is not uniform across the cross-section of open channels. Velocities vary continuously across the cross-section, both below and above the calculated average velocity due to cross-sectional shape and friction effects at the boundary and at the free surface. Velocity is decreased by boundary friction, so the slowest moving water is at the channel bed and banks, with the fastest moving water in the deeper interior and at the surface. The maximum point velocity occurs just below the free surface due to air frictional effects.

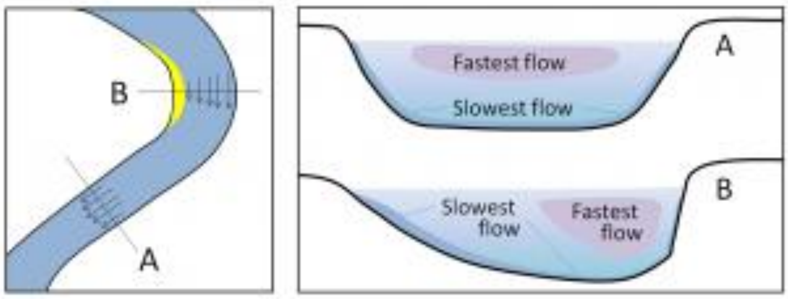
From the literature, maximum velocity within a cross-section of flow is typically around 1.2 to 1.4 times the average velocity, however field observations have reported this factor to be as high as 1.8 (Chow, 1959; Klingeman et al., 1984). In Figure G.4, typical velocity distributions are shown for a regular and irregular channel shape, where the contour values indicate a percentage of the maximum velocity and hence support these factors.



Source: Chow (1959)

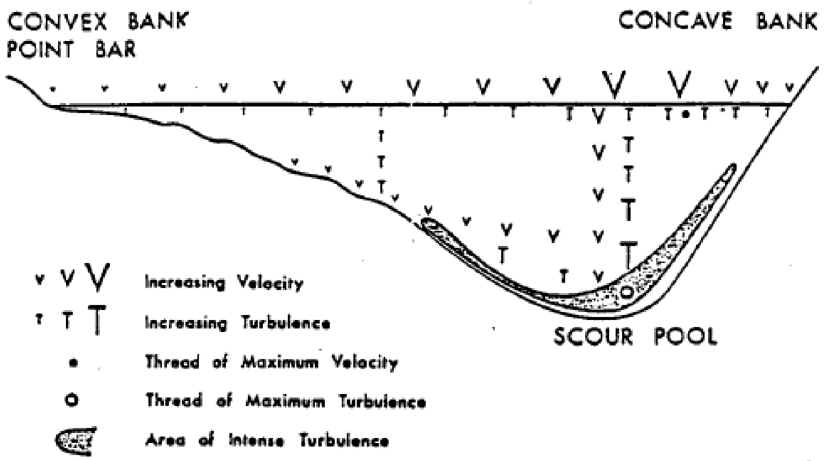
Figure G.4 Typical velocity distribution for different channel shapes

Across straight sections of channel with a relatively uniform depth cross-section, higher velocities tend to be central and within the upper surface waters. In a meandering channel bend, higher velocities are expected on the outside of the bend (concave bank) where the cross-section deepens. These higher velocity zones are illustrated in Figure G.5 and Figure G.6. The concave banks of bends in meandering waterways are generally locations of increased risk of bank erosion.



Source: Earle (2019)

Figure G.5 Velocity variation over a straight and curved channel



Source: Klingeman et al. (1984)

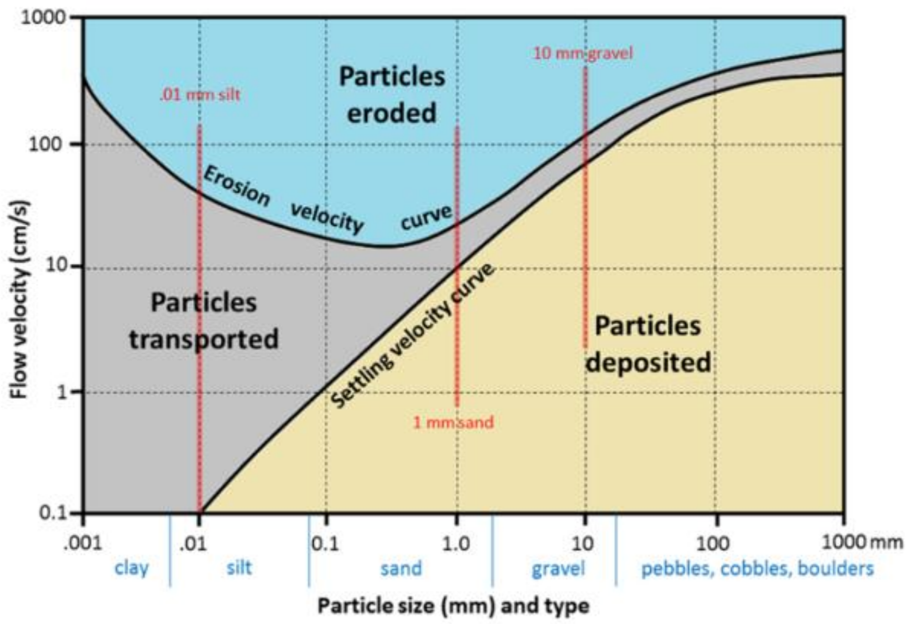
Figure G.6 Velocity and turbulence in a river bend

G.5 Potential for erosion

The potential for erosion and scour to occur in a watercourse depends on several factors in addition to flow velocity, including:

- flow characteristics (duration and frequency of high flow velocities)
- sediment characteristics (type, size, shape, density, cohesion and compaction)
- local environment conditions

Erosion occurs when the shear stress exerted by the flow exceeds the critical shear stress for erosion of the sediment. Earle (2019) presents the Hjulström-Sundborg diagram (refer to Figure G.7) which shows the relationship between particle size and the tendency for particles to be eroded, transported or deposited under different flow velocities.



Source: Earle (2019)

Figure G.7 The Hjulström-Sundborg diagram

To help with interpretation of Figure G.7, the flow conditions under which potential erosion can occur at the channel bed and along banks are summarised in Table G.2. It is important to note that within each particle type, size variation affects potential erosion.

Table G.2 Potential flow conditions for erosion

Particle type	Flow velocity for potential erosion	Flow velocity for transportation/deposition
Clay	Greater than 0.6 m/s	Less than 0.6 m/s, particles are likely to be in suspension and transported.
Silt	Greater than 0.2 m/s	Less than 0.2 m/s, particles are likely to be in suspension and transported. Less than 0.009 m/s, particles potentially have the ability to settle.
Sand	Greater than 0.15 m/s	Less than 0.15 m/s, particles are likely to be in suspension and transported. Particles potentially settle from 0.2 m/s (larger particles) to 0.009 m/s (smaller particles).
Gravel	Greater than 0.4 m/s	Particles potentially settle from 1.0 m/s (larger particles) to 0.2 m/s (smaller particles).
Pebbles, cobbles, boulders	Greater than 2 m/s	Particles potentially settle from 4.0 m/s (larger particles) to 1.0 m/s (smaller particles).

Using the calculated average velocities, together with Figure G.7 and Table G.2, sediment type with the potential for erosion are summarised in Table G.3. The cross-sections representing the highest and lowest calculated average velocity are included in Table G.3.

Table G.3 Sediment type with potential for erosion based on calculated average velocity

Cross-section	Average velocity (m/s)	Sediment type with potential for erosion
Maximum PHES lower limit (780 mAHD)		
Cross-section 4	1.0	Clay (medium to large particles) Silt (all sizes) Sand (all sizes) Gravel (small to medium particles)
Cross-section 5, 9 to 12	0.5	Silt (medium to large particles) Sand (all sizes) Gravel (small particles)
Typical PHES lower limit (781 mAHD)		
Cross-section 4	0.7	Clay (large particles) Silt (all sizes) Sand (all sizes) Gravel (small to medium particles)
Cross-section 5, 9 to 12	0.4	Silt (medium to large particles) Sand (all sizes)
Typical PHES upper limit (784.5 mAHD)		
Cross-section 4 and 7	0.4	Silt (medium to large particles) Sand (all sizes)
Cross-section 5 and 9	0.2	Sand (small to medium particles)
Maximum PHES upper limit (786 mAHD)		
Cross-section 4 and 7	0.3	Silt (medium to large particles) Sand (all sizes, except largest particles)
Cross-section 5, 6, 8 to 12	0.2	Sand (small to medium particles)

G.6 Conclusion

From the qualitative assessment presented in this appendix, the following conclusions can be made:

- There is potential for scour of sediments at the lakebed and along banks, as calculated average velocities at all the cross-sections exceed at least one erosion velocity threshold for clay, silt, sand and gravel.
- Where scour does occur it is expected that:
  - the extent and magnitude of scour will decline overtime as the lakebed and banks will adjust to a new scour and depositional equilibrium
  - most of the scoured material will be deposited in and around the western portion of the Farmers Creek arm of Lake Lyell where flow velocities will be lower due to increased cross-sectional area
- The use of rock armouring would be an effective mitigation against bank or shoreline erosion provided that the armouring is appropriately designed to prevent undermining.

The qualitative assessment identified areas within the Farmers Creek arm of Lake Lyell that may have a higher erosion risk. These areas include:

- The lakebed and bank inundated at the lower end of the maximum PHES operating range (i.e. below 781 mAHD). For water level at 781 mAHD, more sediment types have the potential to erode (clay, silt, sand and gravel) compared to at the higher water level of 784.5 mAHD (silt and sand only). This is because the available flow conveyance area reduces as the water level drops, resulting in higher velocities and increased potential for scour.

- Parts of Farmers Creek arm that have a narrower channel. Cross-sections 4, 6, 7 and 8 have smaller cross-sectional areas compared to the other cross-sections. The flow velocity and scour potential would be higher in the narrower parts of the channel that have less flow conveyance area.

- Parts of Farmers Creek arm that have channel bends. There are three bends between cross-section 4 to 11 that would likely have a higher erosion risk relative to the straighter parts of the channel. This is due to the likely presence of concave banks (which are more susceptible to scour) and recirculating currents that increase turbulence and flow velocities along channel banks.

References

Chow, V.T. (1959), Open-channel hydraulics, McGraw-Hill, New York

Earle (2019), Physical Geology, BCcampus, https://opentextbc.ca/physicalgeology2ed/

Klingeman et al. (1984), Streambank erosion protection and channel scour manipulation using rockfill dikes and gabions, WRRI-98, Water Resources Research Institute, Oregon State University, Oregon

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