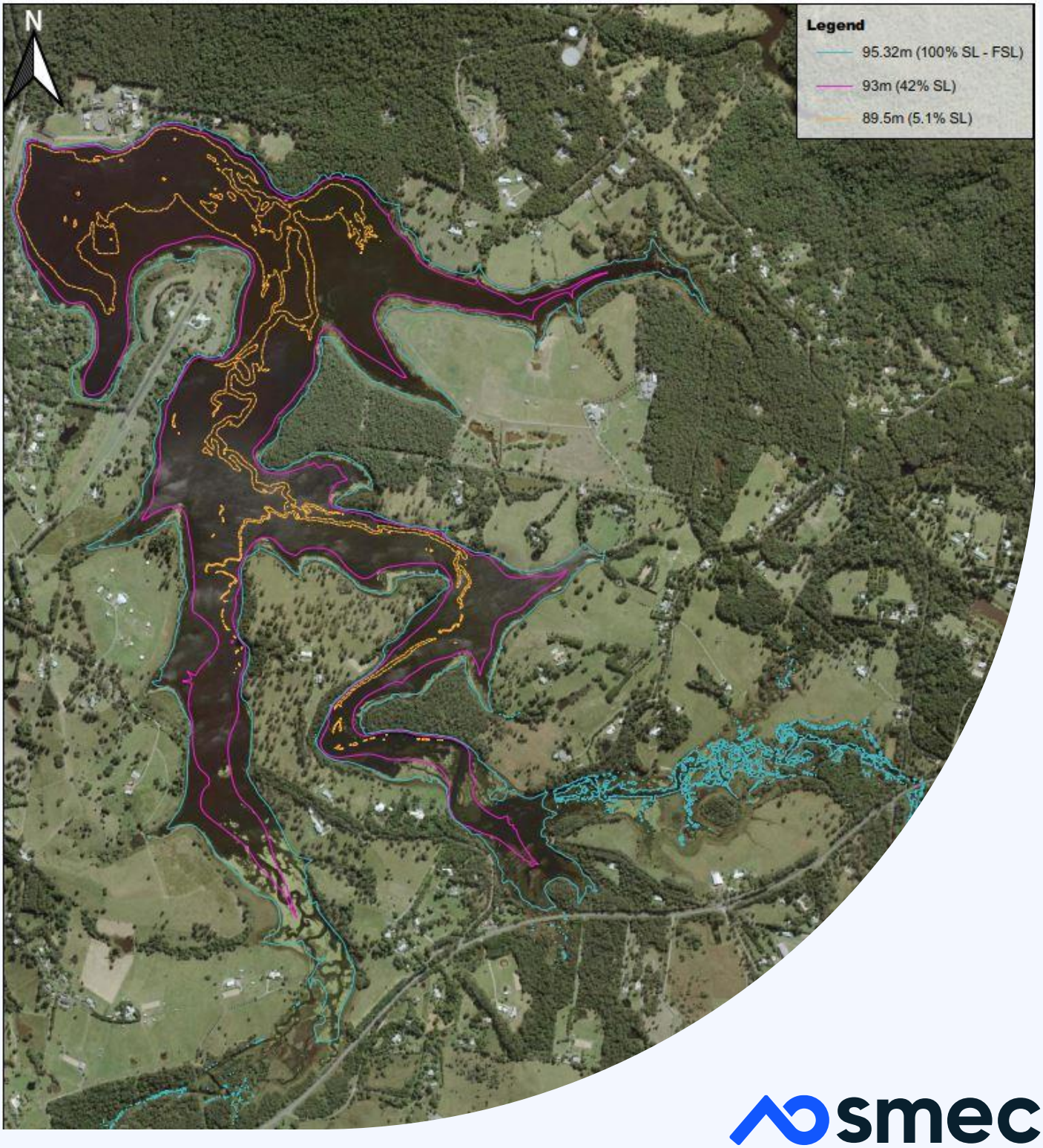
Report

LMDIP Water Quality Impact Assessment 2024

Prepared for: Seqwater
27 September 2024



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1. Introduction

1.1 Scope of impact assessment addendum

Lake Macdonald (Six Mile Creek) Dam is located on the Sunshine Coast in Noosa Shire and is one of two principal raw water sources that supply potable drinking water to the residents of Noosa Shire. The dam requires an upgrade to meet modern safety standards and the performance requirements of the Queensland dam safety regulations in the future. The upgrade will allow the dam to better manage severe weather and earthquake events. This includes improving the spillway discharge capacity and earthquake stability while maintaining water supply security. Studies have considered a range of options including decommissioning of the dam, retrofitting of strengthening works and new build options whilst allowing effective aquatic fauna salvage and relocation, and protection of habitat for endangered species that are known to inhabit the dam inundation area.

The previous assessment associated with drawdown involved identification of impacts and mitigation measures associated with a dam lowering to 5% Full supply level (FSL). Current project staging has identified that the intended operational drawdown (dam lowering) for works was altered from a current lowering to 5% FSL to 42% FSL potentially across an extended period, with construction staging occurring across 36-48 months.

- This report focuses on assessing the risks to the following key areas:Aquatic Habitats
- Water quality within and immediately downstream fo Lake Macdonald
- Aquatic Flora
- Aquatic Fauna
- Biosecurity
- Styogauna
- Matters of National Environmental Signficance.

This current report details, where required, specific impacts, risks and mtigiations for the 42% FSL drawdown methdology and is documented as an addendum, and truncates some details noted in the previous reports. This addendum report should be read in conjunction with supporting documentation including:

- Lake Macdonald (Six Mile Creek) Dam Improvement Project - Aquatic Ecology and Water Quality Assessment: September 2023 (frc environmental 2023)
- Lake Macdonald (Six Mile Creek) Dam Improvement Project - Aquatic Ecology and Water Quality Impact Assessment (frc environmental 2018)
- Lake Macdonald (Six Mile Creek) Dam Improvement Project - Adaptive Management Plan.

1.2 Site description

Lake Macdonald, located on Six Mile Creek about 10 km from Cooroy in the Noosa hinterland, was constructed in the early 1960s and raised in 1979. At full capacity, the dam holds 8,018 ML of water, spans a surface area of 260 ha, and has a catchment area of 49 km^2. The lake's location is depicted in Figure 1-1.

Primarily a water storage facility, Lake Macdonald does not have specific flood mitigation objectives, but it does offer some flood attenuation. The dam's water licence also includes requirements for environmental flow releases. The lake is a popular recreational area for the community, offering activities such as rowing, paddling, fishing, and foreshore recreation, including visits to the Noosa Botanical Gardens.

Several protected species are known or likely to inhabit the area around Six Mile Creek and Lake Macdonald. Among them are five species listed as Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES), which may be found in the lake and creek: the Mary River cod (*Maccullochella mariensis*), Australian lungfish (*Neoceratodus forsteri*), Mary River turtle (*Elusor macrurus*), white-throated snapping turtle (*Elseya albagula*), and giant barred frog (*Mixophyes iterates*). Additionally, the tusked frog (*Adelotus brevis*) and platypus (*Ornithorhynchus anatinus*), both MSES species, have been recorded within Lake Macdonald and its upper reaches, with the platypus also observed in Six Mile Creek.

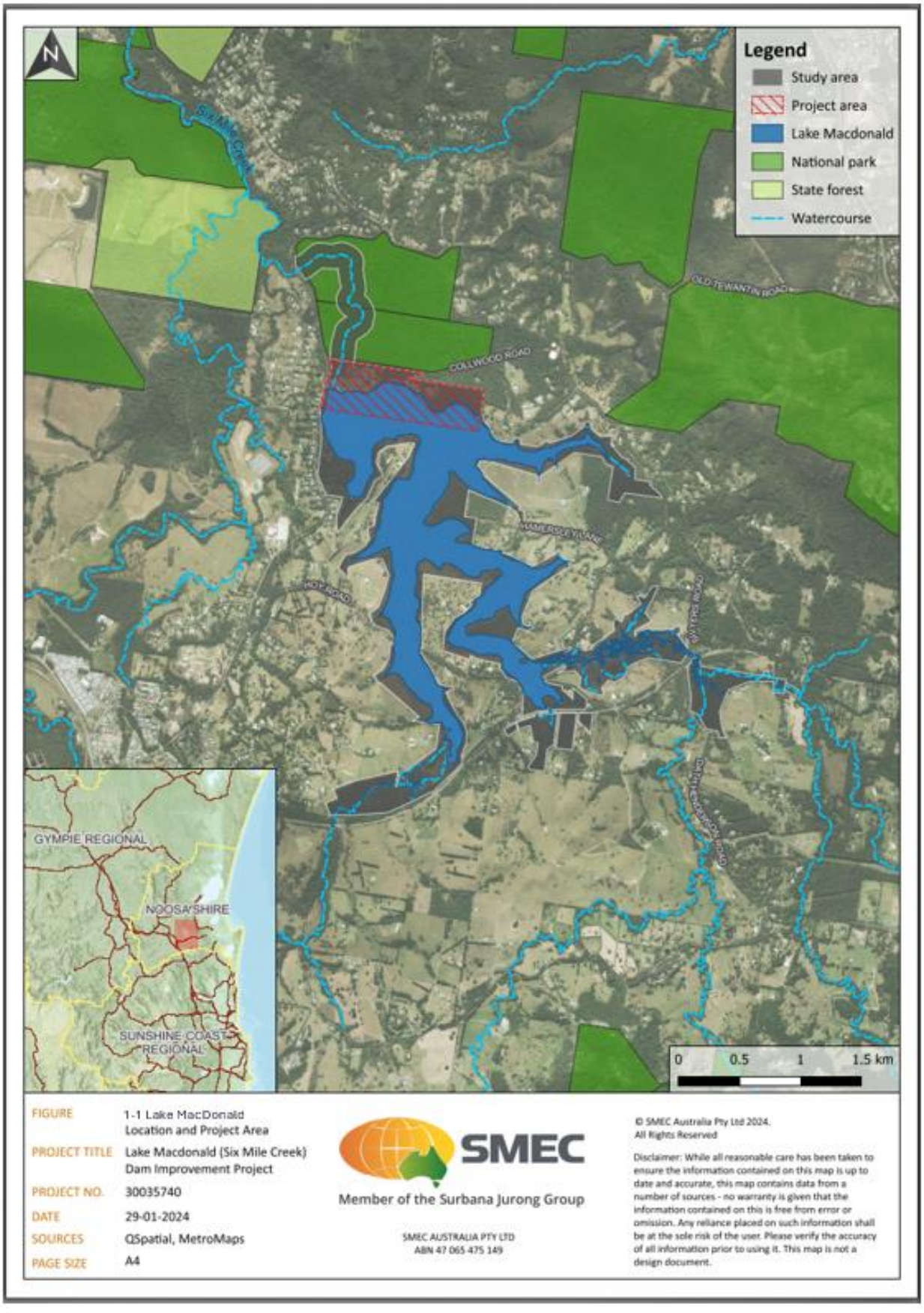

Figure 1-1. Lake MacDonald Location and Project Area

1.3 Relevant legislation

1.3.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act) establishes a legal framework to protect and manage nationally and internationally threatened species, ecological communities, and other Matters of National Environmental Significance (MNES), such as internationally important wetlands and heritage sites. The Act also regulates water resources related to coal seam gas, large mining projects, and nuclear actions.

The EPBC Act safeguards threatened species and ecological communities by listing them as threatened, developing conservation advice and recovery plans, maintaining a critical habitat register, recognizing key threatening processes, and requiring approval for activities likely to significantly impact MNES or other protected matters.

Within the Mary River and Six Mile Creek, four EPBC-listed species are present: the critically endangered white-throated snapping turtle (*Elseya albagula*), the endangered Mary River cod (*Maccullochella mariensis*) and Mary River turtle (*Elusor macrurus*), and the vulnerable Australian lungfish (*Neoceratodus forsteri*).

1.3.2 Queensland Environmental Protection Act 1994

The *Queensland Environmental Protection Act 1994* (EPA 1994) establishes the legal framework for promoting ecologically sustainable development in Queensland. It requires individuals, companies, and the government to take reasonable and practical measures to protect Environmental Values and prevent environmental harm. The Act includes mechanisms such as Environmental Protection Policies, which outline strategies for safeguarding these values.

1.3.3 The Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy 2009 (EPP Water) supports the Queensland Environmental Protection Act by:

- Identifying High Ecological Value (HEV) waters and Environmental Values (EVs).
- Setting water quality guidelines and Water Quality Objectives (WQOs) to protect these EVs.
- Establishing a decision-making framework for managing Queensland waters.
- Requiring monitoring and reporting on water conditions.

For Queensland waters, the EVs include protecting aquatic ecosystems. Specific components, like water quality, habitat, and biota, are outlined for protection under the EPP Water, particularly for the Mary River. A thorough assessment within this framework would also consider relevant protected matters under various environmental laws, including the EPBC Act, Queensland's *Nature Conservation Act 1992*, *Fisheries Act 1994*, and *Vegetation Management Act 1999*.

1.3.4 Queensland Nature Conservation Act 1992

The *Nature Conservation Act* (NCA) *1992* aims to conserve Queensland's natural environment by establishing and managing a network of protected areas, safeguarding threatened species and their habitats, regulating wildlife harvesting, and coordinating conservation efforts with Traditional Owners and other landowners. Various freshwater species are classified as protected wildlife under this Act.

Protected wildlife under the NCA 1992 must be shielded from threats, and critical habitats for these species should be preserved to the utmost extent.

1.3.5 Queensland Fisheries Act 1994

The *Fisheries Act 1994* governs the management and protection of fisheries resources, including the regulation of developments that may affect designated fish habitats and fish passage. Notably, several fish species, including the Australian lungfish, are listed as 'no take' species under this Act.

Fisheries resources, such as declared fish habitat areas, waterways that facilitate fish passage, and marine plants designated as Matters of State Environmental Significance (MSES), contribute to the Environmental Values of waterways and wetlands.

In the context of the current study, fish passage is a key consideration for assessable development. Development that may impact fish passage can be classified as either:

- Accepted development, where the infrastructure design strictly adheres to the Department of Agriculture and Fisheries' (DAF's) Accepted Development Requirements for Waterway Barrier Works (2017), or
- Assessable development, where the proposed development requires assessment by DAF (via SARA) and must demonstrate compliance with the State Development Assessment Provisions (SDAP State code 18).

1.3.6 Queensland Water Act 2000

The *Queensland Water Act 2000* ensures the sustainable management of water resources in Queensland. It requires permits for works within watercourses and supports the sustainable allocation of water, particularly for environmental flows that protect ecological functions in rivers. These requirements are often outlined in Resource Operations Plans (ROP) or Water Plans for specific catchments, detailing ecological goals and responsibilities for water licence holders or operators. Specific for this project, as the water licence holder for Six Mile Creek Dam, Seqwater is required to release specified environmental flows from the dam to achieve ecological outcomes in Six Mile Creek.

1.3.7 Queensland Biosecurity Act 2014

The *Biosecurity Act 2014* is designed to manage risks from exotic pests and diseases that impact industries like aquaculture, tourism, infrastructure, and the environment. It provides a framework to minimize biosecurity risks through a risk-based approach. The Act categorizes biosecurity matters into prohibited (not present in Queensland) and restricted (present in Queensland) matters and establishes a General Biosecurity Obligation (GBO). The GBO requires individuals and organizations who deal with biosecurity risks to take reasonable measures to prevent and minimize these risks.

Prohibited and restricted matters are detailed in Schedules 1 and 2 of the Act. Restricted biosecurity matters include aquatic pests such as pathogens, fish species like eastern Gambusia (*Gambusia holbrooki*), tilapia (*Oreochromis mossambicus*) and carp (*Cyprinus carpio*), and aquatic plants like salvinia (*Salvinia molesta*) and water hyacinth (*Eichhornia crassipes*). These species pose significant risks to the environment and industries, and the Act mandates actions to control their spread.

2. Lake Macdonald drawdown

2.1 Historic dam levels

The FSL of Lake Macdonald is at 95.3 meters above sea level, with a full supply volume (FSV) of 8,018 megalitres (ML). The Dam routinely spills across the current operational lifetime (refer Figure 2-1) and provides water to Six Mile Creek and the South-East Queensland water grid through regular operational releases through offtake and environmental flow releases. Dam volume has averaged at 95.17% between 01/07/2008 and 13/08/2024. Minimum volumes of 51.7% were recorded during March 2017. Median (50th percentile) volume for the Lake is 100.3%.

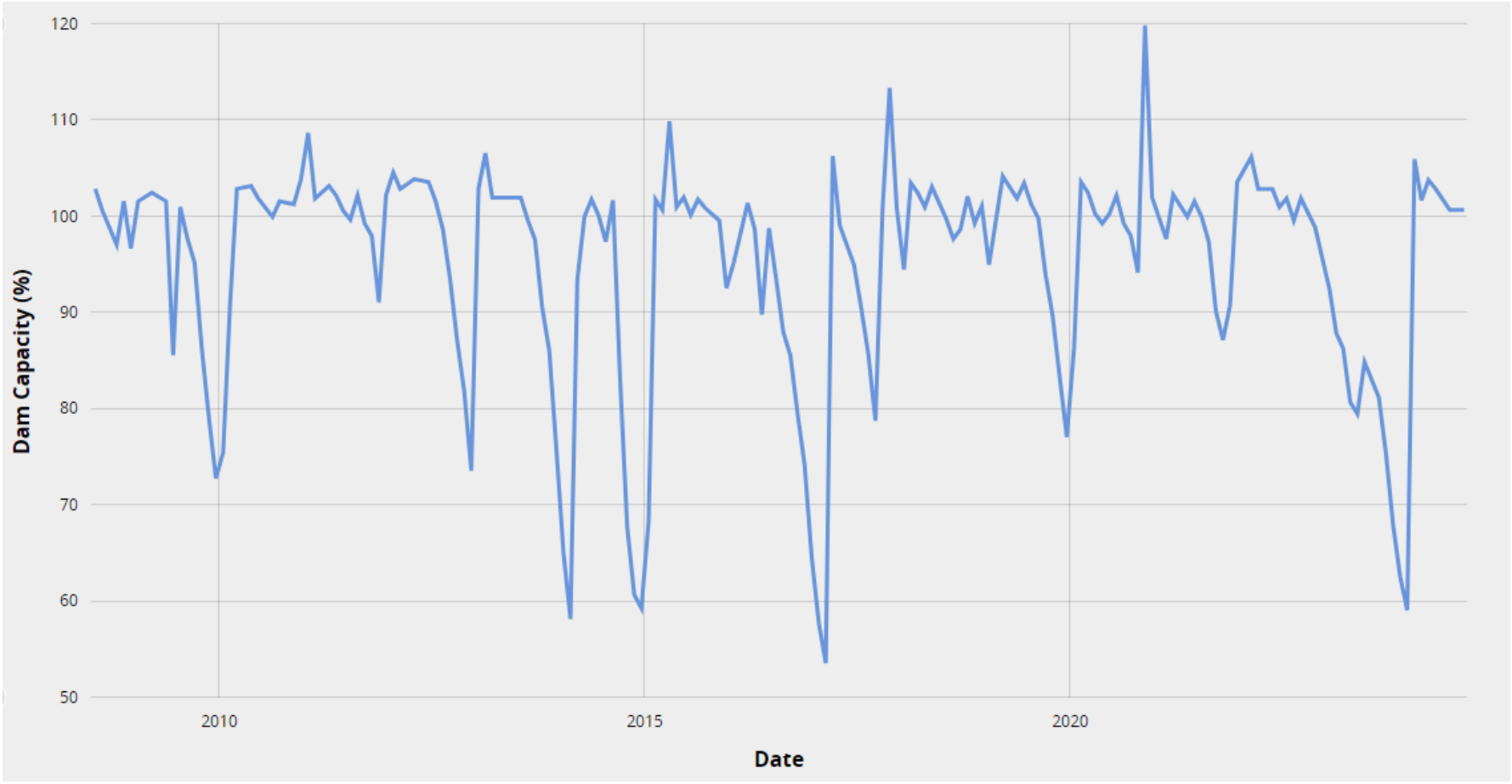

Figure 2-1 Lake Macdonald historic dam levels (2008-2024)

2.2 Reservoir drawdown

2.2.1 Drawdown level and water quantity

To construct a temporary cofferdam, the lake's water level will be lowered to RL 93.0 meters, reducing the volume to about 3,368 ML (42% of FSL) (refer Figure 2-2). The cofferdam will maintain this level during the construction of the new spillway and embankments, which will take 36 to 48 months. Figure 2-2 presents a relative indicator of remaining water volumes within the Lake and indicates minor changes to shore-line water encroachment between FSL and 42% of FSL, and significant increases in coverage in comparison to the earlier proposed 5% of FSL drawdown.

Water levels may fluctuate due to inflows, evaporation, and operational drawdown, potentially dropping to 91.5 meters (15% of FSL) in a worst-case scenario. Assuming Lake MacDonald is full at the initial time of water lowering, approximately 4,650 ML of water (plus inflows) will need to be removed before the cofferdam can be installed.

As such, the drawdown to 42% FSL is considered to be approximately 8% below the historic minimum FSL recorded within the lake.

2.2.2 Drawdown schedule

The initial lowering of Lake Macdonald cannot occur between September 1 and February 28 per conditions of approval for the Project (EPBC 2017/8078). This is to reduce impacts and protect the breeding seasons of threatened species under the EPBC Act. This schedule also avoids impacting breeding seasons of other threatened and common species. The lowering will take at least 4 weeks, ensuring a controlled and gradual process to minimize harm to aquatic fauna and allow for their capture and relocation. This approach also aims to minimize the impact on Six Mile Creek downstream and limit lakebed exposure. If natural inflows increase the lake level during the drawdown, the rate of lowering will be accelerated to maintain the 4-week schedule.

2.2.3 Initial drawdown rate

The initial drawdown of Lake Macdonald will aim to reduce approximately 11% of the lake's full supply volume each week. The volume of water discharged downstream will be set by the sum of:

- The required lake lowering requirement
- Plus inflow into the lake
- Minus operational water demand
- Minus evaporation and other losses.

The maximum practical release rate, as diverted flow around the cofferdam, is approximately 5 m^3/s.

2.2.4 Drawdown method

The drawdown of Lake Macdonald will be managed using pumps and/or siphons to achieve controlled and variable release rates. Screening requirements for intakes will ensure the safe operation of this equipment, and energy dissipation measures will be implemented to minimize erosion. Screening requirements for intakes are outlined in Table 5-2 of the ‘Adaptive Management Plan’ (SMEC, 2024). Discharged water will flow downstream through Six Mile Creek, with measures in place to minimize environmental impacts

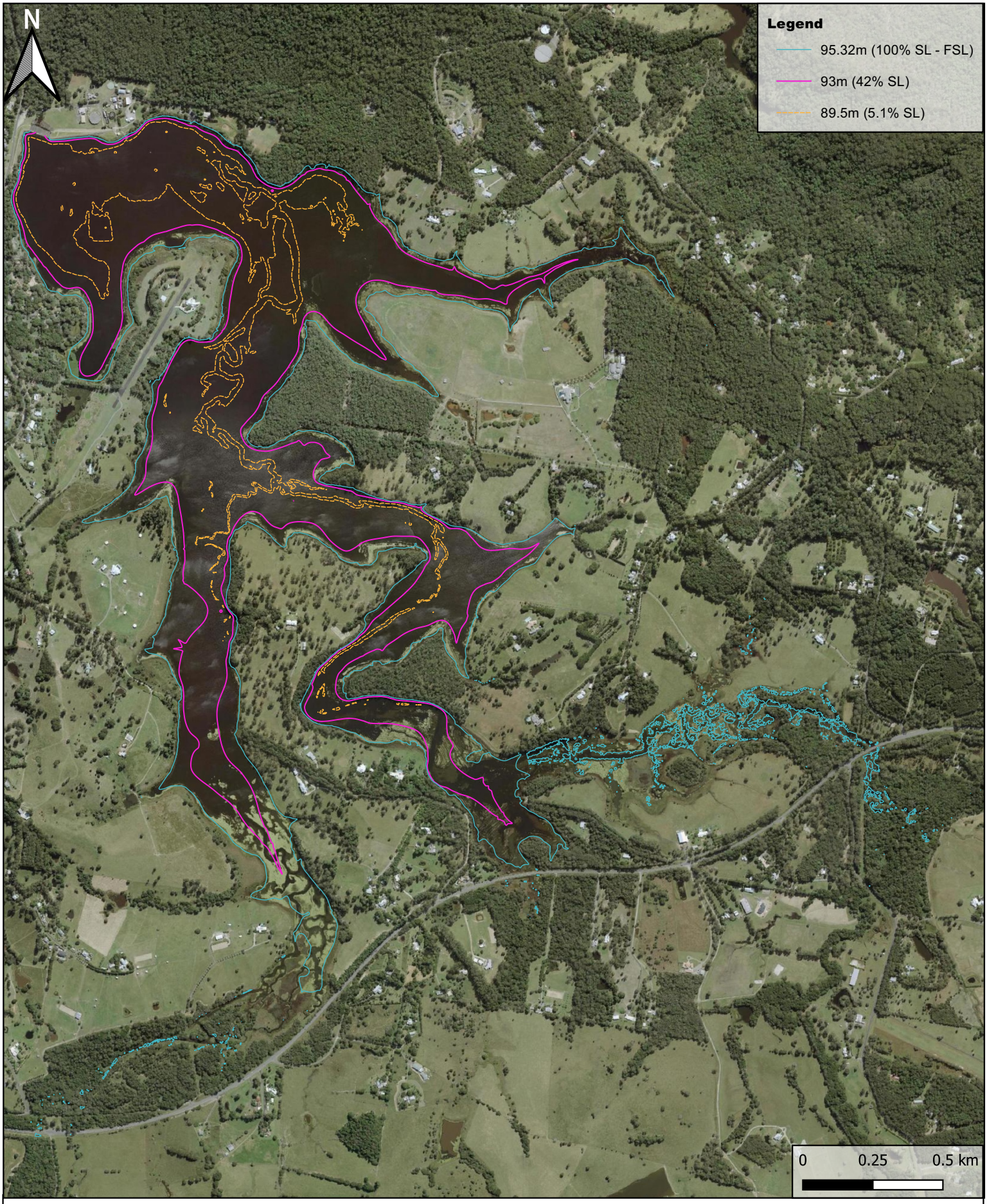

FIGURE	2-2: Relative indication of reservoir drawdown from FSL within Lake
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PROJECT NO.	30035740
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2.3 Post-drawdown maintenance of water level

Following the drawdown and during the construction of the new spillway and embankments, Lake Macdonald's water levels will be maintained at a temporary full supply level (FSL) of RL 93.0 meters (42% of normal full supply volume, FSV) using a 150m cofferdam with a crest at RL 93.5 meters. Part of the existing dam spillway will be lowered to 89.5 meters. The cofferdam will divert inflows up to 5 m^3/s around the construction area via pumps and siphons, matching the inflow rate when close to the temporary FSL. Excess inflows will discharge through the existing spillway.

To ensure regional and water security, the lake must remain operational (i.e. for consumptive water extraction) throughout construction, so water levels will vary based on inflows, consumption, and other losses. A small waterbody between the cofferdam and the construction site will occasionally need to be dewatered. This waterbody will have a large surface area (14,000 m^2 or 1.4 hectares), a depth of 2-3 meters, and will experience water flow through the cofferdam spillway and dam slot. It may also, periodically, have poor water quality and a moderate risk of fish kill.

Environmental management will focus on water quality and aquatic fauna monitoring and management (i.e. periodic dewatering and fish salvage). The cofferdam design will ensure safe access and working conditions for effective environmental and construction management.

2.4 Potential impact on aquatic ecological values

The project review has identified several potential impacts on the aquatic environmental values of Six Mile Creek and Lake Macdonald:

- Water quality impacts in the lake and downstream during drawdown, construction, and refill phases
- Aquatic habitat impacts in the lake and downstream during drawdown and construction phases
- Impacts on aquatic fauna in the lake during drawdown and construction phases
- Impacts on aquatic flora in the lake and downstream during drawdown and construction phases
- Spread of biosecurity issues downstream during drawdown and construction phase
- Impacts on stygofauna communities in shallow groundwater systems during drawdown and construction phases
- Impacts to Matters of National Environmental Significance.

3. Lake MacDonald and Six Mile Creek general ecological values

The current and previous assessments of the aquatic ecological values of Six Mile Creek and Lake Macdonald involved a comprehensive review of literature and databases, synthesis of existing data, field surveys, and expert consultations. Documents and databases such as the DNRM's Mary Basin Draft Water Resource Plan, the MNES Protected Matters Search Tool, the MSES search tool, the Department of Environment and Science's Wildlife Online database, and the Atlas of Living Australia were reviewed. Data from the Northern Pipeline Interconnector Stage 2 (NPI2) Aquatic Habitat Monitoring Program, baseline studies for the Six Mile Creek Dam Upgrade Project, and routine water quality monitoring by Seqwater were utilized. Additionally, a field survey was conducted to gather recent data on macroinvertebrates due to a knowledge gap in habitat condition. Expert consultations with academics, agency staff, and other stakeholders provided further insights.

Overall, aquatic ecology and water quality data have been gathered from 13 sites on Six Mile Creek and 2 sites on Lake Macdonald, along with additional data from 4 Seqwater sites. The baseline aquatic ecology study also included expert consultations and observations of platypus.

A total of 10 sites were surveyed from 4 to 9 September 2023, with watercourse sites being 100 m long and covering the full width of the channel, and reservoir sites covering 50 m^2. Of these 10 sites, 4 were in the upstream zone, 3 in the reservoir zone, and 3 in the downstream zone. The field survey assessed aquatic habitat, water quality, aquatic plants, macroinvertebrates, fish, turtles, and mammals (e.g., platypus). Results from the September 2023 survey were qualitatively compared to earlier surveys conducted for the Project, specifically from 13 sites on Six Mile Creek and 2 sites on Lake Macdonald. Previous observations of platypus were provided by SMEC, and a summary of previous survey results is presented in frc environmental (2018).

3.1 Aquatic habitats

3.1.1.1 Downstream sites

The downstream sites feature well-defined channels with high, steep banks and undercut areas. The substrate is primarily composed of clay and silt, with gravel riffles present near road crossings. Flow habitats exhibit high variation, including riffles, runs, and both shallow and deep pools. Aquatic flora is generally scarce, though site some submerged plants such as *Cabomba caroliniana* (Cabomba), *Salvinia molesta* (Salvinia), and *Nymphoides indica* (Water snowflake) are noted. The banks were lined with *Lomandra longifolia* (mat-rush), and there is an abundance of large woody debris and leaf packs. Riparian vegetation is in good condition, providing both shade and material. However, there are no suitable nesting or basking sites for the Mary River turtle and white-throated snapping turtle, though there is suitable habitat for the Mary River cod.

3.1.1.2 Lake MacDonald sites

At Lake MacDonald sites, the flow habitat was characterized by a single deep pool (i.e. the impoundment). The water level was low, which exposed undercut banks and dry bed margins. The aquatic flora was abundant, with submerged and floating plants such as *Cabomba caroliniana* (Cabomba), *Nymphoides indica* (Water snowflake), *Salvinia molesta* (Salvinia), and *Marsilea* sp. There was extensive emergent vegetation, including *Schoenoplectus mucronatus*, *Philydrum lanuginosum*, *Eleocharis* sp., *Ludwigia peploides, Persicaria* spp., and *Cyperus* spp. The substrate was primarily silt, with some sand near the banks. While there were no suitable nesting or basking sites for turtles, there was potentially suitable habitat for the Mary River cod, though no breeding habitat was present.

3.1.1.3 Upstream sites

For the Upstream sites, the channels were well-defined with high, steep, and undercut banks. Water levels were low, with flow habitats observed at Six Mile Creek sites, while Cooroy Creek had isolated pools. Aquatic flora was found in isolated patches, including *Cabomba caroliniana* (Cabomba), *Nymphoides indica* (Water snowflake), and *Myriophyllum aquaticum* in Cooroy Creek. Additionally, *Vallisneria nana*, *Ottelia ovalifolia*, *Potamogeton javanicus*, *Myriophyllum aquaticum* (parrots' feather), and *Salvinia molesta* (Salvinia) were found

in Six Mile Creek. One section was heavily covered by *Salvinia molesta* (Salvinia). Riparian vegetation was generally in good condition near the water but was cleared further from the bank for other land uses. There were limited suitable nesting habitats for turtles, although some basking sites were present, and the area had potentially suitable habitat for Mary River cod. Overall, it was noted that water levels were lower compared to earlier surveys, but physical habitat features, and plant-created habitats remained similar to those previously recorded.

3.2 Water quality

Four contemporary background water quality reports were generated for Lake MacDonald between 2023 – 2024. The initial survey was conducted in September 2023 with the following 3 completed between the months of March-May 2024. Section 3.2 will discuss the primary results found from each report and compare them against the trigger values and water quality objectives designated for Lake MacDonald.

Water quality was measured on-site for parameters such as temperature, pH, electrical conductivity, dissolved oxygen, and turbidity using a calibrated meter. Measurements were taken approximately 0.3 meters below the water surface at mid-channel locations for river sites, and at 1-meter intervals to create a depth profile for lake sites.

3.2.1 Water quality monitoring at Lake Macdonald (September 2023)

The September 2023 water quality results were compared against:

- The Water Quality Objectives (WQOs) for moderately disturbed lowland streams in the Upper Mary River, as outlined in the Environmental Protection (Water) Policy 2009 for the Mary River Environmental Values and Water Quality Objectives Basin No. 138, including all tributaries of the Mary River (DERM 2010).
- Water quality data from previous project surveys (frc environmental 2018) (refer to Appendix A).

3.2.1.1 Depth profiles

Depth profile results revealed that sites within Lake McDonald were generally not stratified at the time of the 2023 survey (refer to Appendix A). The Upstream Lake site displayed a slight water quality change with depth. Within these sites, dissolved oxygen decreased sharply below 1.5 meters, while turbidity increased below 3 meters. Electrical conductivity increased sharply below 4 meters. Temperature and pH showed no sharp changes across all depths.

3.2.1.2 Gauging station data results

The following results were taken from the gauging station for Six Mile Creek (refer to Appendix A):

- Temperature varied from 8.4 to 28.0 ºC throughout the year.
- Electrical conductivity consistently complied with the WQO.
- pH was generally within the WQO range (20th to 80th percentiles), but it occasionally fell outside this range, showing both minimum and maximum values.

pH was the only in-situ variable to display a range outside of the designated WQO's.

3.2.1.3 In-situ survey data

Section 3.2.1.3 presents results of notable values identified during the 2023 survey:

- Electrical conductivity and turbidity complied with Water Quality Objectives (WQO) at all sites and reaches (refer to Appendix A**)**
- Temperature, electrical conductivity, and pH were frequently outside the 20th to 80th percentile range from previous surveys.
- Electrical conductivity and pH were higher than previous maximums at all sites within Lake MacDonald.
- Turbidity was higher than previous maximums at the Mid-Lake site.

- Dissolved oxygen did not comply with WQO at any site, being less than the WQO upstream and downstream of Lake MacDonald and higher than the WQO within the lake.
- pH was higher than both the WQO and the previous range at the US Lake site within Lake MacDonald.

The results indicated potential concerns with water quality surrounding Lake MacDonald. While electrical conductivity and turbidity generally met Water Quality Objectives (WQO) across all sites, there were significant deviations in other parameters. Temperature, electrical conductivity, and pH were frequently outside the expected ranges based on previous surveys, with electrical conductivity and pH levels reaching new maximums within Lake MacDonald. Additionally, turbidity exceeded previous maximums at the Mid-Lake site, and dissolved oxygen levels failed to meet WQOs at any location. These results were then compared to that of the following 3 reports conducted in 2024 (refer to Section 3.2.2).

3.2.2 Water quality monitoring at Lake Macdonald (March-May 2024)

Current monitoring of Lake Macdonald and downstream areas was carried out over the months of March, April, and May 2024. With the FSL drawdown level revisions for the Six Mile Creek Dam Safety Upgrade Project, further background water quality assessments to ensure environmental compliance and public safety were necessary.

3.2.2.1 Monitoring overview

The monitoring was conducted at eight key locations around Six Mile Creek Dam, both within Lake Macdonald and downstream. The sampling was done using a combination of remotely piloted aircraft (RPA) for difficult-to-access areas and traditional methods. Key water quality parameters, including temperature, pH, turbidity, dissolved oxygen, and concentrations of various nitrogen and phosphorus species, were consistently measured.

3.2.2.2 Monthly results summary and analysis

3.2.2.2.1 March 2024 results

Key observations:

- The data from March showed some minor exceedances of the proposed water quality triggers. These exceedances were not linked to significant rainfall events, despite consistent rainfall throughout the month.
- Notably, the turbidity and pH levels were within acceptable ranges, with minor fluctuations observed at downstream sites.

3.2.2.2.2 April 2024 results

Key observations:

- In April, there were notable exceedances of the proposed water quality triggers, particularly in pH levels on April 9. The exceedances were likely due to stratification in Lake Macdonald, where surface pH levels were higher compared to deeper waters.
- The use of an 8-meter sampling pole, as opposed to a drone, might have contributed to sampling at different depths, thereby influencing the pH results. However, for the remainder of April, pH levels did not exceed the triggers, even though the pole was used exclusively.
- The April exceedances highlight the potential impact of stratification and sampling methods on water quality results. The difference in pH across depths suggests that the lake's physical structure plays a significant role in water quality. The temporary nature of these exceedances, combined with the absence of further exceedances despite using the same sampling method, indicates that the issue may be localized or temporary. This underscores the need for continued monitoring and possibly revising the trigger values as more data is collected.

3.2.2.2.3 May 2024 results

Key observations:

- The monitoring data for May indicated minimal exceedances when compared to the criteria outlined in the Adaptive Management Plan (SMEC, 2024). The pH levels exceeded the threshold four times in the downstream areas and five times within Lake Macdonald.
- The reduction in exceedances compared to previous months, likely due to decreased rainfall, further emphasizes the role of external environmental factors such as runoff in influencing water quality.

3.2.2.3 March – May 2024 summary and recommendations

Over the three-month period, there was a noticeable trend in the water quality results. While March saw minor exceedances not linked to rainfall, April experienced more significant pH exceedances, likely due to lake stratification and variations in sampling depth. By May, the number of exceedances had decreased.

The data collected from March to May 2024 reveals that the lake's water quality is highly sensitive to natural variations such as stratification. The minor and temporary nature of most exceedances suggests that while the lake is responsive to changes, these fluctuations may not necessarily indicate long-term or significant environmental risks. However, the consistent exceedances in pH during April and May highlight the need for adaptive management strategies. The reports recommend that further monitoring focuses on understanding the impact of stratification and hydrophyte density on water quality. In conclusion, while the water quality in Lake Macdonald generally remained within acceptable ranges, the observed exceedances, particularly in pH levels.

3.2.3 Comparative analysis: Lake Macdonald March-May 2024 vs. 2023 water quality surveys

3.2.3.1 Stratification and depth profiles

The 2023 survey indicated a lack of significant stratification in Lake MacDonald, with sharp decreases in dissolved oxygen and increases in turbidity and electrical conductivity at specific depths. In contrast, the 2024 data from March to May suggested more variability in pH, likely due to stratification, particularly in April.

3.2.3.2 Water quality consistency

Both years highlighted concerns with elevated electrical conductivity and pH levels, particularly within Lake MacDonald. These consistent exceedances across different years indicate persistent underlying issues in water quality, likely due to inflow and effects occurring due to natural stratification.

3.2.3.3 Dissolved oxygen and turbidity

The 2023 survey showed widespread non-compliance with dissolved oxygen WQOs, a trend that continued in 2024, suggesting an ongoing issue with oxygen levels in the lake and its surroundings. Turbidity levels, while generally compliant, showed occasional exceedances, particularly at the Mid-Lake site, across sampling.

3.2.3.4 Overall water quality concerns

The persistent exceedances in pH and electrical conductivity, along with non-compliant dissolved oxygen levels, are likely an artefact of inflow and water quality, impoundment leading to increased hydraulic residence and natural stratification within Lake MacDonald. The data from both 2023 and 2024 indicates that these parameters frequently exceed management guidelines. In conclusion, the 2024 water quality surveys largely corroborate the findings from 2023, highlighting persistent background water quality.

3.2.4 Water quality monitoring of tailwater releases at Lake Macdonald

The water quality of the tailwater release were analysed and compared against the Water Quality Objectives (WQOs) for moderately disturbed lowland streams in the Upper Mary River, as outlined in the Environmental Protection (Water) Policy 2009 for the Mary River Environmental Values and Water Quality Objectives Basin No. 138, including all tributaries of the Mary River (DERM 2010)

The monitoring was conducted within the tailwater environmental release stream. Key water quality parameters, including temperature, pH, turbidity, dissolved oxygen, and concentrations of various nitrogen and phosphorus species, were consistently measured.

3.2.4.1 January 2024

Key Observations:

- The data from January showed some minor exceedances of the proposed water quality objectives. These exceedances were not linked to significant rainfall events, despite consistent rainfall throughout the month
- Turbidity was within acceptable ranges, with minor fluctuations observed
- pH and dissolved oxygen (% saturation) fluctuated outside of water quality objectives. Exceedances were never in the higher range, with points of low DO and pH observed across the month.

3.2.4.2 February 2024

Key observations:

- In February, there were exceedances of the proposed water quality objectives, particularly in turbidity on the 16th of February. >1000 NTU was measured, likely due to runoff and dam release from a high rainfall event (>50mm) on that date.
- pH and dissolved oxygen (% saturation) fluctuated outside of water quality objectives. Exceedances were never in the higher range, with points of low DO and pH observed over February.

3.2.4.3 March 2024

Key observations:

- For March, almost all values were consistently within an acceptable range
- pH was the only in-situ measurement value in exceedance, with heightened values in comparison to water quality objectives.

3.2.4.4 April 2024

Key observations:

- The monitoring data for April indicated a high exceedance in turbidity objectives. NTU reached >500 on the 4th of April, with no indicators of a large rainfall events surrounding this date
- pH and dissolved oxygen (% saturation) fluctuated outside of water quality objectives. Exceedances were not in the higher range of objectives, with points of low DO and pH observed over April.

3.2.4.5 May 2024

Key observations:

- The monitoring data for May indicated a consistent alignment with WQO's throughout the month with some lower objective exceedance in dissolved oxygen concentrations.

3.2.4.6 June 2024

Key observations:

- June displayed occasional minimal exceedances in dissolved oxygen, pH and turbidity. From the 25th-30th of June, pH consistently was recorded either in exceedance or close to the lower WQO value (pH<6.5). On the 25th was a recorded high rainfall event leading to the only, slight exceedance in turbidity.

3.2.4.7 July 2024

Key observations:

- All values recorded in July were within WQO's.

3.2.4.8 Summary

pH values were consistently low across all months, with exceedances occurring under the WQO's. Turbidity would often stay within range, to then display a spike during high rainfall events. 4th of April was an outlier, with NTU scaling high with no evidence of rainfall within the past 7 days. Dissolved Oxygen would fluctuate in and out of range but consistently staying above 70% saturation.

3.3 Aquatic flora

Overall, the aquatic plant diversity was low, with limited variety in species and growth forms. The highest diversity of aquatic plants in the water was observed upstream of Lake MacDonald, while the greatest diversity on the banks was within Lake MacDonald itself.

Due to low water levels, many plant species that were previously found in the water at Lake MacDonald were seen on the dry banks in September 2023. Generally, plant cover was low with isolated occurrences, except for a few notable exceptions: *Cabomba caroliniana* (Cabomba) and *Nymphoides indica* (Water snowflake) were present in Lake MacDonald; *Cabomba caroliniana* (Cabomba) was also observed upstream of Lake MacDonald; Lomandra was found on the banks both upstream and downstream of Lake MacDonald; and *Salvinia molesta* (Salvinia) was recorded upstream of Lake MacDonald (refer to Appendix A).

Salvinia molesta (Salvinia), a restricted invasive species, was found in all three reaches, with particularly high density 11km Upstream of Six Mile Creek. This species had not been recorded in previous surveys. No listed threatened aquatic plant species were observed, indicating the absence of such species in the Project area. Commonly recorded introduced species included *Cabomba caroliniana* (Cabomba), *Salvinia molesta* (Salvinia), and Parrot's Feather. Both *Cabomba caroliniana* (Cabomba) and *Salvinia molesta* (Salvinia) are restricted invasive plants and had not been recorded in previous surveys.

3.4 Aquatic fauna

3.4.1 Macroinvertebrates

The community composition was predominantly made up of non-biting midges (*Chironominae*, *Orthocladiinae*, *Tanypodinae*) and shrimp (*Atyidae*). At certain sites, there was an increase in the abundance of biting midges, damselflies, mayflies, and mites.

The macroinvertebrate communities exhibited variability depending on the site and location. Taxonomic diversity was generally lowest in bed habitats both upstream and downstream of Lake MacDonald, as well as in edge habitats within Lake MacDonald.

In terms of compliance with Water Quality Objectives (WQO), taxonomic richness and PET richness did not meet the WQO's at all sites. SIGNAL-2 scores fell short of WQO's at all sites except Mid Lake (bed habitat), Six Mile Creek (~6km U/S of spillway) (both habitats), and Six Mile Creek (~11km U/S of spillway) (bed habitat) (refer to Appendix A).

When compared to February 2018, taxonomic richness was generally lower, although there were some exceptions. PET richness was low but comparable to the levels recorded in February 2018 (refer to Appendix A). Sensitive taxa were mostly absent from most sites, with the exception of all Six Mile Creek sites, where their percentages were higher than those recorded in February 2018. Tolerant taxa comprised 38-73% of the taxa recorded and were most common at sites US Lake, Mid Lake, SMCUS03(Six Mile Creek; ~ 11 km US of spillway), and CC03 (Cooroy Creek; ~ 5 km US of the Lake Macdonald spillway) (refer to Appendix A).

3.4.2 Fish

Overall, a total of 26 native species, and five exotic species, are known or likely to occur in Six Mile Creek. In previous surveys, 20 native and three exotic species caught and recorded. Mary River cod and Australian lungfish are considered Matters of National and State Environmental Significance, while Eastern Gambusia and tilapia are restricted biosecurity matters under the Queensland Biosecurity Act 2014. Tilapia were recently noted downstream of Lake Macdonald but not in the lake or upstream.

During the survey, 13 native species were observed, none of which are listed as conservation significant under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act). No tilapia were found, suggesting they have not established a large population in the creek. The only new species recorded was the pest species platy at site CC01.

Key findings from the survey include:

- Native species diversity ranged from 5 to 9 per site, with the lowest diversity upstream of Lake MacDonald
- Native fish catch per unit effort (CPUE) varied from 48 to 3817, with highest CPUE generally near or within Lake MacDonald
- Common gudgeon was the most abundant species, followed by flyspecked hardyhead, Agassiz's glassfish, and crimson-spotted rainbowfish
- Exotic species were only found in the upper reaches of Six Mile Creek, with the highest CPUE at SMCUS01 and US Lake, and highest diversity at SMCUS02
- Fish were generally in high numbers and good health, though some showed signs of black spot disease, particularly in Lake MacDonald
- Fish length and weight data showed a linear relationship for common gudgeon and several other species, while others exhibited exponential relationships.

Three species of macrocrustacean were recorded, with freshwater shrimp being the most abundant and freshwater prawns the most commonly recorded. All macrocrustaceans were native but not conservation significant.

3.4.3 Turtles

The Mary River is home to a diverse range of freshwater turtles, including six species, with two being regionally endemic:

- **Mary River turtle** (*Elusor macrurus*): Endemic to the Mary River Basin.
- **White-throated snapping turtle** (*Elseya albagula*): Endemic to the Mary, Burnett, and Fitzroy River Basins.
- **Krefft's river turtle** (*Emydura macquarii krefftii*): Widespread.
- **Saw-shelled turtle** (*Wollumbinia latisternum*): Widespread.
- **Eastern long-necked turtle** (*Chelodina longicollis*): Widespread.
- **Broad-shelled river turtle** (*Chelodina expansa*): Widespread.

The Mary River turtle (endangered) and white-throated snapping turtle (critically endangered) are Matters of National and State Environmental Significance. Both species are known to inhabit permanent streams and large pools but are unlikely to be found near Lake MacDonald due to unsuitable breeding conditions, as confirmed by surveys.

In September 2023, four of the six turtle species were recorded in previous surveys and three in the recent survey:

- **Krefft's river turtle**: Most abundant in September 2023 (average CPUE of 1.4).
- **Saw-shelled turtle**: Most widespread (recorded at three sites).
- **Eastern long-necked turtle** and **Krefft's river turtle** were found in Lake MacDonald.
- **A single eastern snake-necked turtle** was also caught.

Turtles observed were generally in good health, with no shell damage.

3.4.4 Mammals

The platypus, classified as 'Special Least Concern' under the *Nature Conservation Act 1992*, is not nationally or state threatened. Records show platypus are present downstream, within, and upstream of Six Mile Dam, as well as in Lake Macdonald's arms (in contrast to the main impoundment body). However, no platypus were

observed during the September 2023 surveys. Suitable burrow habitat was noted upstream and downstream of Lake Macdonald but not within the lake.

3.4.5 Summary of aquatic fauna values

All fish species recorded in September 2023 were previously recorded except for the exotic platy, which was found upstream of the lake; tilapia was not recorded at any site, potentially due to low water levels at sampling.

Aquatic MNES, such as Mary River cod and Australian lungfish, along with platypus, are found in Six Mile Creek downstream of Lake Macdonald. Specifically, Mary River cod are known to breed in this area. It is also possible that Mary River turtle and white-throated snapping turtle inhabit the lower reaches of Six Mile Creek despite not being a suitable nesting or basking habitat for the species. MSES downstream of Lake Macdonald include fish passage waterways, various categories of regulated vegetation (e.g., category R and vegetation intersecting a watercourse), and HEV (watercourse) waters.

In Lake Macdonald and upstream areas, platypus are present and likely breed, while Mary River cod and Australian lungfish may occur but are unlikely to breed. Mary River turtle and white-throated snapping turtle are likely rare or absent in these areas. MSES upstream of Lake Macdonald include fish passage waterways, regulated vegetation (category R), and HEV (watercourse) waters.

Table 3-1. Site Ecological Values

Site	Aquatic Ecological Value
Six Mile Creek downstream of Lake MacDonald	Very High
Lake MacDonald	High
Six Mile Creek Upstream of Lake MacDonald	High
Groundwater ecosystems of the Project Area	Low (no habitat for conservation significant species)

3.5 Stygofauna

In the most recent survey, Stygofauna communities were not assessed with field sampling, however potential presence was previously examined in a desktop assessment conducted for the 2018 Aquatic Ecology and Water Quality Impact Assessment (frc environmental, 2018).

The assessment found that, in Queensland, 24 described families and 23 described genera of stygofauna have been recorded, including representatives from Southeast Queensland. This suggests that stygofauna may be present in the project area if the groundwater ecosystem habitat is suitable. The suitability of a groundwater ecosystem for stygofauna depends on factors such as geology, groundwater hydrology, and groundwater quality. Stygofauna are most common in geological units with sufficient pore space, such as alluvium, granite, gravel, sand, sandstone, silt, and volcanic rocks. They are less likely to occur in units with small pore spaces, such as mudstone, siltstone, and clays.

Groundwater hydrology also plays a role; stygofauna are often found within 6 m of the water table and in areas where the water table is less than 15 m below ground, though they have been recorded from over 60 m deep. Water quality parameters, including electrical conductivity, dissolved oxygen, pH, and total dissolved solids (TDS), also influence stygofauna diversity and distribution.

The groundwater study for the Six Mile Creek Dam Upgrade Project (SLR 2018) indicated that the geological units underlying Lake Macdonald include quaternary alluvium with high clay content and weathered Triassic Myrtle Creek beds composed of sandstone. Outcrops of Triassic Kin Kin bedrock composed of shale and mudstone occur to the east of Six Mile Creek Dam. The alluvium has low hydraulic conductivity, while the underlying sandstone has higher conductivity. Groundwater quality parameters for the alluvium showed pH between 5.39 and 6.59, dissolved oxygen between 57.4 and 62.3 mg/L, electrical conductivity between 86 and 140 µS/cm, and TDS between 59 and 160 mg/L, with Kin Kin sandstone being considered potable to slightly brackish.

4. Risk assessment method

The potential risks and corresponding mitigation measures for each identified source of adverse impact on the Environmental Values of Six Mile Creek were assessed using a risk-based approach. The risk score for each potential impact was calculated by multiplying the impacts likelihood and consequence scores (refer Table 4-1, Table 4-2, Table 4-3). The 5 x 5 risk matrix (refer to Table 4-3) generates risk scores ranging from one to 15, with the risk levels categorized as follows:

- Low: score <5
- Medium: score >5 but <10
- High: score >10.

Potential impacts on the Mary River cod, Mary River turtle, Australian lungfish, and white-throated snapping turtle were further evaluated using the MNES Significant Impact Criteria Guidelines 1.1.

Table 4-1. Assessment ratings for likelihood of potential impacts.

Rating	Likelihood of occurrence
Highly Likely (5)	Is expected to occur
Likely (4)	Will probably occur during the period of approval
Possible (3)	Might occur during the period of approval
Unlikely (2)	Could occur period of approval but considered unlikely or doubtful
Rare (1)	May occur in exceptional circumstances

Table 4-2. Ratings used to assess the consequence of potential impacts (taken from AMP).

Rating	Consequence of occurrence
Critical (5)	The plan's objectives are unable to be achieved, with no evidenced mitigation strategies.
Major (4)	The plan's objectives are unlikely to be achieved, with significant legislative, technical, ecological and/or administrative barriers to attainment that have no evidenced mitigation strategies.
High (3)	High risk of failure to achieve the plan's objectives. Results in medium-long term delays to achieving plan objectives, implementing uncertain, high cost/effort corrective actions.
Moderate (2)	Moderate risk of failure to achieve the plan's objectives. Results in short term delays to achieving plan objectives, implementing well characterised, high cost/effort corrective actions.
Minor (1)	Minor risk of failure to achieve the plan's objectives. Results in short term delays to achieving plan objectives, implementing low cost, well characterised corrective actions.

Table 4-3. Environmental risk matrix, showing risk score and level of risk (green = low; amber = moderate, red = high).

Consequence		Likelihood				
		Rare (1)	**Unlikely (2)**	**Possible (3)**	**Likely (4)**	**Highly Likely (5)**
	Minor (1)	Low	Low	Low	Low	Medium
	Moderate (2)	Low	Low	Medium	Medium	High
	High (3)	Low	Medium	Medium	High	High
	Major (4)	Medium	High	High	High	Severe
	Critical (5)	High	High	Severe	Severe	Severe

5. Impact assessment

5.1 Water quality

5.1.1 Potential impacts

The drawdown of waterbodies can adversely impact water quality both at the discharge sites and downstream, as well as within the lake itself. It should be noted that bathymetric modelling does not indicate isolation of discrete waterbodies within the wider impoundment in a 42% drawdown, with the new water level remaining relatively contiguous (refer to Figure 2-2). Some minor contractions around the fingers and banks of the Lake are noted, relative to the 100% FSL.

Construction earthworks and runoff from soil stockpiles during construction can further degrade water quality. Additionally, the submersion of decomposing organic matter during the dam refill phases can lead to water quality deterioration and eutrophication.

Increased turbidity and total suspended solids can occur via the disturbance of bed sediments and erosion of beds and banks during drawdown and construction, as well as from the disturbance of earth and runoff from soil stockpiles during construction. Increased turbidity can negatively impact fish and macroinvertebrates by reducing respiratory and feeding efficiency, and it can adversely affect submerged aquatic plants by reducing light penetration required for photosynthesis. While small and brief increases in turbidity (consistent with natural flow events) are unlikely to have significant impacts, substantial increases, especially from fine silt and clay particles, could adversely affect the health, feeding, and breeding ecology of aquatic fauna.

A reduced pH can result from exposing or disturbing acidic soils during drawdown and construction, or from decomposing organic material (e.g., aquatic plants) reducing the pH of water. Additionally, increased pH levels may arise from two sources: the concrete batching plant and the large concrete cells used in spillway construction. Changes to pH can harm fish health by causing diseases (e.g., lesions and ulcers) and impacting metabolism and reproduction, with very low pH potentially causing fish kills. While the lower Mary River Basin's waterways are naturally acidic and stained with tannins, Six Mile Creek is not naturally acidic. Some variation in pH is tolerated by the aquatic biota of Six Mile Creek, but significant reductions in pH may adversely affect ecosystem health.

A reduced dissolved oxygen concentration can occur in the lake and downstream in Six Mile Creek if the waterbody becomes stratified or eutrophic, such as through the submersion of decomposing organic matter (e.g., decomposing *Cabomba caroliniana* (Cabomba)) during the refill phase. Dissolved oxygen is essential for respiration and metabolism by aquatic biota, and reduced levels can cause stress and potentially mass mortality. While some regional waterways naturally experience low dissolved oxygen, sustained periods of low dissolved oxygen will cause mortality in aquatic fauna.

There exists a probability of increased nutrient concentrations if drawdown exposes deep sediments below approximately 92.5 m AHD, which have higher nutrient content, and during refill if the lake becomes eutrophic from decomposing organic matter. High nutrient concentrations can lead to increased growth of phytoplankton, depleting dissolved oxygen, and promoting excessive algae and aquatic plant growth, which reduces in-stream habitat quality for some biota.

Increasing dissolved metal concentrations can occur during drawdown, construction, and refilling phases due to the mobilization and oxidation of lake sediments, lateral transport of sediment pore water, and ebullition fluxes. Drawdown exposing deep sediments below approximately 92.5 m AHD, which have higher metal content, increases the risk of adverse water quality impacts.

Spills of fuels, oils, or other chemicals from pumping equipment or other machinery/vehicles during drawdown and construction can be toxic to aquatic flora and fauna. Significant fuel spills can have a locally significant impact on both flora and fauna, with the size of the spill and the volume of water in the creeks influencing the length of the stream impacted.

These potential impacts necessitate robust management measures, including enhanced erosion and sediment control, continuous ecological monitoring, and stringent protocols for chemical management, as outlined in the Adaptive Management Plan.

5.1.2 Unmitigated risk assessment (low/medium/high/severe)

Provided with the specific drawdown and all potential risks identified above, the unmitigated risk assessment for each water quality criteria have been categorized below:

- **Turbidity and Total Suspended Solids (TSS):**

  Prolonged drawdown increases the likelihood of sediment resuspension, leading to elevated turbidity and TSS levels. The *unmitigated risk* for turbidity and TSS is considered ***medium.***

- **Dissolved Oxygen Levels:**

  Maintaining sufficient dissolved oxygen levels is critical, particularly during extended construction periods. The *unmitigated risk* for dissolved oxygen levels is considered ***high***.

- **Nutrient Concentrations:**

  Potential increases in nutrient concentrations could lead to eutrophication. The *unmitigated risk* for nutrient concentration is considered ***high***.

- **Mobilisation of metals:**

  Exposure of sediments and changes to surface water physico-chemical parameters (i.e. pH) may increase mobilisation of previously sediment-bound metals. The unmitigated risk for mobilisation of metals is considered ***medium***.

- **Introduction of contaminants from construction activities:**

  Works may introduce hydrocarbons or other chemical contaminants during spill events. The *unmitigated risk* for the introduction of contaminants from construction activities is considered ***medium***.

- **Reintroduction of poor water quality from stilling basin:**

  Works may introduce contaminants and poor water quality if stilling basin water is reintroduced to Lake MacDonald or Six Mile Creek. The *unmitigated risk* for the reintroduction of poor water quality from stilling basin is considered ***medium***.

5.1.3 Management measures

Appropriate mitigation measures should be implemented for the Project to achieve the following objective: prevent or reduce potential impacts to water quality. Based on the findings from " Aquatic Ecology and Water Quality Assessment: September 2023' and in alignment with the "Adaptive Management Plan". The suggested mitigation measures are as follows:

5.1.3.1 General measures

- Exposure of deep sediments should be minimized by avoiding lowering the water in Lake Macdonald below 93 m AHD to prevent exposure of sediments with high metal and nutrient concentrations.
- Real-time monitoring for key water quality parameters such as pH, dissolved oxygen, turbidity, TSS, and nutrients should be implemented. Objectives should be consistent with desired outcomes, and corrective actions should be triggered if these objectives are exceeded. Mitigation measure for concrete batching and cells will be outlined in the Construction Water Management Plan.
- Decomposing *Cabomba caroliniana* (Cabomba) should be removed from exposed lake surfaces during refill phases to reduce the risk of eutrophication and low dissolved oxygen levels.
- The likelihood of chemical spills or leaks should be reduced by storing fuels, oils, and other chemicals in bunded areas in accordance with Australian Standard 1940 (2004). Bunded areas should be established away from water bodies, preferably above the Q100 level. Refuelling should only occur in bunded areas, and spill kits should be available for rapid response to any spills.

5.1.3.2 Lake MacDonald

During Drawdown:

- The arrangement of dewatering equipment intakes should be such that suction does not disturb sediments on the lakebed. Intakes of dewatering equipment should be positioned to extract water from within the top half of the water column. The dewatering of the stilling basin should be directed back into the reservoir. Additionally, pontoon-based pump stations should be used to minimize disturbance of unconsolidated bed sediments.
- Biodegradable oils and lubricants should be utilized for mechanical equipment. Refuelling should be performed on land with suitable containment, and if refuelling near the lake is necessary, appropriate spill kits should be available to contain any spills.
- Fuels, oils, and other chemicals should be stored in bunded areas in accordance with Australian Standard 1940 (2004) – The storage and handling of flammable and combustible liquids.
- A risk-based assessment should be implemented for any exceedances of water quality trigger values to determine the potential for environmental harm. If environmental harm is determined, additional mitigations, such as aeration using the existing destratification unit, should be applied if the concentration of dissolved oxygen becomes concerning.

During Construction:

- Recommended continued use of biodegradable oils and lubricants for mechanical equipment. Refuelling should be done on land with suitable containment, and spill kits should be available for any necessary refuelling near the lake.
- Fuels, oils, and other chemicals should continue to be stored in bunded areas in accordance with the relevant standards.
- The construction erosion and sediment control plan and stormwater management plan should be complied with. Additionally, regular dewatering and treatment of poor water quality should be conducted when detected in the stilling basin.
- Dissolved oxygen levels should be maintained by using aeration units and ensuring turbulent release to the existing concrete apron.

5.1.3.3 Six Mile Creek downstream

During Drawdown and Construction:

- Release rates must comply with the mitigation measures outlined in the project's management plans.
- Aeration of water and erosion mitigation through energy dissipation, such as armoured discharge points or sprays, should be provided. An Erosion and Sediment Control Plan (ESCP) should be implemented in accordance with industry standards, and the efficacy of sediment and erosion control measures should be monitored. Water should be released to the existing concrete apron during drawdown.
- Refuelling or chemical use should be undertaken away from Six Mile Creek, in accordance with the relevant construction environmental management plan. Fuels, oils, and other chemicals should be stored in bunded areas in accordance with Australian Standard 1940 (2004).

By implementing these mitigation measures, the project can effectively manage and reduce potential impacts on water quality, ensuring the protection of aquatic ecosystems in Six Mile Creek and Lake Macdonald.

5.1.4 Residual risk assessment (low/medium/high/severe)

The risk assessment below discusses the risk of residual impact for each major water quality impact criteria after mitigation measures are in place.

- **Turbidity and Total Suspended Solids (TSS):**

  Management measures include the implementation of an adaptive monitoring program with clear trigger values and corrective actions and focus on limiting disturbance of sedimentation during extraction. After

these measures are implemented, the *likelihood* of turbidity and TSS impacts is considered *unlikely*. Subsequently, the *consequence* of impact is considered *minor*. The overall *residual risk* of turbidity and TSS is considered **low**.

- **Dissolved Oxygen Levels**:

  Aeration units and real-time monitoring systems will be deployed to ensure oxygen levels remain within acceptable limits. After these measures are implemented, the *likelihood* of dissolved oxygen impacts is considered *unlikely*. Subsequently, the *consequence* of impact is considered *moderate*. The overall *residual risk to* dissolved oxygen is considered *low*. After mitigation measures are in place, the overall *residual risk* of dissolved oxygen levels is considered **low**.

- **Nutrient Concentrations**:

  Active removal of decomposing organic matter and careful management of nutrient inputs is required and continued ongoing water quality monitoring of site. After these measures are implemented, the *likelihood* of nutrient concentration impacts is considered *unlikely*. Subsequently, the *consequence* of impact is considered *moderate*. After mitigation measures are in place, the overall *residual risk* of impacts caused by nutrient concentration is considered **low**.

- **Mobilisation of metals:**

  Prevention measures recommend avoiding lowering the water in Lake Macdonald below 92.5 m AHD to prevent exposure of sediments with high metals. Ongoing water quality monitoring of site will also be conducted. After these measures are implemented, the *likelihood* of impacts caused by the mobilisation of metals is considered *unlikely*. Subsequently, the *consequence* of impact is considered *low*. After mitigation measures are in place, the overall *residual risk* of impacts caused by the mobilisation of metals is considered **low**.

- **Introduction of contaminants from construction activities:**

  Prevention measures highlight the appropriate storage of contaminates and ongoing water quality monitoring of site. After these measures are implemented, the *likelihood* of impacts caused by the introduction of contaminants is considered *unlikely*. Subsequently, the *consequence* of impact is considered *moderate*. After mitigation measures are in place, the overall *residual risk to the* introduction of contaminants from construction activities is considered **low.**

- **Reintroduction of poor water quality from stilling basin:**

- Prevention measures recommend regular dewatering and treatment of poor water quality should be conducted when detected in the stilling basin and ongoing water quality monitoring of site. The dewatering of the stilling basin will be directed back into the reservoir, allowing poor water quality to be managed within a controlled environment, minimising environmental impact, and improving overall reservoir water quality through natural processes. After these measures are implemented, the *likelihood* of impacts caused by the reintroduction of poor water quality from stilling basin is considered *unlikely*. Subsequently, the *consequence* of impact is considered *moderate*. The overall *residual risk to the* reintroduction of poor water quality from stilling basin is considered **low.**

5.2 Aquatic Habitat

5.2.1 Potential impacts

Aquatic habitat in Lake Macdonald will be adversely affected by lowered water levels during the drawdown phase, reducing the aquatic habitat (i.e., volume of water) to about 3,368 ML (42% of FSV). The cofferdam will maintain this level for 36 to 48 months during the construction of the new spillway and embankments. Water levels may fluctuate due to inflows, evaporation, and operational drawdown, potentially dropping to 91.5 meters (15% of FSL) in a worst-case scenario. This temporary reduction in aquatic habitat will be reversed during the refill and operational phases of the project.

There may also be potential adverse impacts to aquatic habitat downstream of the lake due to sedimentation and hydrological changes during the drawdown and construction phases. Fine sediments that accumulate on the bed of reservoirs could be mobilized and deposited downstream during these phases, leading to

sedimentation. This sedimentation can smother benthic habitats, including infilling pools and interstitial spaces of coarse substrate such as gravels and cobbles, causing cascading impacts to primary producers (i.e., aquatic plants and benthic algae), macroinvertebrates, and fishes.

The frequency and duration of low flows will likely increase from current conditions during the construction period, as the reduced dam wall height provides less capacity to reduce or buffer outflows, leading to a greater proportion of inflows flowing downstream to Six Mile Creek. However, the magnitude, frequency, duration, and timing of large flows should not change substantially from current conditions because the natural condition of Lake Macdonald and its catchment are such that attenuation of high flows by the current dam is minimal.

The drawdown of Lake Macdonald and the construction phase of the project may impact aquatic flora and fauna in the lake through various mechanisms. These include impacts to water quality in the lake, the spread of aquatic biosecurity matters such as pest species, weeds, and disease, stranding of biota in workspace created by the cofferdam waterbody, and exposure to poor water quality. There is also a risk of injury or mortality of fauna from pumping equipment, which could make individuals susceptible to pathogens and disease. Alternatively, aquatic fauna may become fatally injured by pumping equipment or be trapped within it and consequently drown. The mitigations described below ensure that the risk is low.

As water levels decline during the drawdown of Lake Macdonald, there is a risk of stranding fauna in shallow isolated pools or burrows, which may increase predation (e.g., predation of smaller fish by larger fish and/or birds) and competition leading to crowding. Inflows may also wash fauna, particularly small fish and tadpoles, into the lake during drawdown and construction. Crowding may result in reduced dissolved oxygen concentrations in water, reduced food supply, and increased stress on fauna. In small, isolated pools that evaporate or areas that are rapidly dewatered, there is a risk that aquatic fauna could become stranded on dry areas. However, the risk associated with this potential impact is low because the rate and magnitude of dewatering is limited.

Turtles may be injured or killed in construction workspaces and on the spillway of the existing dam, which they may use for basking. Similarly, turtles moving downstream during spilling events may be injured or killed on the spillway. The release of water downstream to Six Mile Creek during the drawdown of Lake Macdonald may impact aquatic flora and fauna via impacts to downstream water quality, changes in downstream flow conditions, and the spread of aquatic biosecurity matters such as pest species, weeds, and disease.

The release of water into Six Mile Creek during the drawdown may impact aquatic fauna through the creation of a high flow event that could transport fauna downstream or trigger behaviour that would usually occur at another time, such as breeding migration. However, limiting the initial drawdown to a minimum four-week period ensures that this potential impact has a low risk. The release of contaminated water from the cofferdam waterbody could adversely impact aquatic biota in downstream Six Mile Creek. Habitat condition and availability may also be impacted where water released from Lake Macdonald leads to erosion or sedimentation, disturbance of physical habitat structures, and high flows or prolonged inundation at times when they would not otherwise occur, all of which have a low level of risk.

5.2.2 Unmitigated risk assessment (low/medium/high/severe)

Provided with the specific drawdown and all potential risks identified above, the unmitigated risk assessment for each aquatic habitat criteria have been categorized below:

- **Temporary loss of aquatic habitat:**

  The *unmitigated risk* assessed for the temporary loss of aquatic habitat is considered ***high*** in impact. The rating was assessed based upon the risks of water extraction and the loss of habitat for Mary River cod and platypus within Lake MacDonald.

- **Changes to downstream flows:**

  Releasing during the drawdown may impact aquatic fauna via transportation during the potential high flow events. Additionally, the drawdown may cause fluctuations in dam depth and flow velocity across the impact area. The *unmitigated risk* assessed for the changes in downstream flows impacts is considered **medium.**

- **Sedimentation**:

During the drawdown and construction phases, fine sediments that accumulate on the bed of reservoirs could be mobilized and deposited downstream. This potential sedimentation could smother benthic habitats putting fauna and flora species at risk. The unmitigated risk assessment for sediment is considered ***medium.***

5.2.3 Management measures

For the Project, appropriate mitigation measures should be implemented to prevent or reduce potential impacts on aquatic habitat.

In Lake Macdonald, it is essential to apply management measures for water quality, erosion, sediment control, and aquatic fauna as outlined in the AMP (SMEC, 2024).Vegetation outside the designated clearing area defined in the IAR should not be removed. During construction, efforts should be made to augment aquatic habitat where possible, by either adding physical habitat structures or controlling aquatic weeds, to enhance the long-term value of Lake Macdonald. Measures to minimize sedimentation include using a pontoon-based pump station to reduce disturbance and downstream sediment transfer, stabilizing exposed sediments with non-invasive grasses, and managing potential erosion with potentially an ESCP and physical barriers.

For Six Mile Creek, similar management measures for water quality, erosion, sediment control, and aquatic fauna should be implemented. It is crucial to control the drawdown release rate as specified and avoid vegetation clearing outside the approved areas. The initial drawdown should not be completed in less than four weeks, and changes to hydrology should be avoided during the breeding seasons for MNES and MSES species, specifically from September 1 to February 28. Vegetation clearing or excavation should only occur after a suitably qualified person has assessed the area for threatened fauna and breeding habitat, with a 3 m x 3 m exclusion zone established if necessary. Post-construction, re-establishment or supplementation of aquatic habitat should be carried out where monitoring indicates it is needed.

To address potential hydrological impacts, releases should be avoided during natural low flow periods, and major pulse flow events should be managed by controlling discharge rates. The existing flow regime should be maintained by allowing inflows to pass the construction area and pumping water downstream at a rate consistent with inflows.

5.2.4 Residual risk assessment (low/medium/high/severe)

The risk assessment below discusses the risk of residual impact for each major aquatic habitat impact criteria after mitigation measures are in place.

- **Temporary loss of aquatic habitat:**

  The temporary loss of aquatic habitat in Lake Macdonald is assessed as *high* in *consequence*. This is due to the presence of non-breeding habitat for Mary River cod and habitat for platypus within the lake. However, the impact on habitat is reversible, and efforts will be made to enhance long-term habitat values during the project. The *likelihood* of this temporary habitat loss is *possible*, with an expected loss of approximately 58% of the lake's aquatic habitat (42% FSL - measured by volume). This results in a ***moderate*** level of overall *residual risk*, therefore requiring additional mitigation measures, specifically: An aquatic fauna salvage plan (See Section 5.2.3).

- **Changes to downstream flows**

  After the mitigation measures are in place, the impact of changes in downstream flows is considered *minor* in *consequence*. The most significant hydrological change will be a short-duration event during the drawdown phase, which is planned to occur outside the breeding season of Mary River cod and Australian lungfish, the MNES species found in Six Mile Creek downstream of the dam. The *likelihood* of altered hydrology is *possible* due to a sustained 4-week release during drawdown and potentially increased flow frequencies past the construction site, which may temporarily benefit the downstream environment. The overall *residual risk to the* impacts caused by changes to downstream flow is considered ***low***.

- **Sedimentation**

  The impact of water release on the downstream creek is reversible, with large flows expected to naturally flush out sediment after construction. With the addition of using a pontoon-based pump station to reduce disturbance and downstream sediment transfer, non-invasive grasses, and managing erosion with an ESCP

and physical barriers, the *likelihood* of impacts caused by sedimentation is considered *unlikely*. Furthermore, the *consequence* of impact is considered *moderate*. The overall *residual risk to the* impacts caused by sedimentation is considered ***low***.

5.3 Aquatic Flora

5.3.1 Potential impacts

Dewatering could expose aquatic plants above 93m AHD, likely causing the death of species that rely on standing water in these areas. Mobilization of sediments during the drawdown and construction phases could lead to their deposition downstream. This sedimentation has the potential to cover benthic habitats, which could impact aquatic plants and benthic algae. Changes in flow conditions might also result in the disturbance and potential loss or degradation of aquatic plants.

5.3.2 Unmitigated risk assessment (low/medium/high/severe)

Provided with the specific drawdown and all potential risks identified above, the unmitigated risk assessment for the primary aquatic flora criteria has been categorized below:

- **Loss of aquatic flora:**

  The initial unmitigated risk impact of dewatering on aquatic plants is considered ***low*** because no known threatened aquatic plant species were identified in the area. The plant community in Lake Macdonald is predominantly Salvinia and *Cabomba caroliniana* (Cabomba), which are labelled as restricted biosecurity concern (refer to Section 5.5).

5.3.3 Management measures

Water in Lake MacDonald will largely be retained above93 m AHD, providing refugee habitat for aquatic plants. Mobilizing of sediments and changes to flow condition will be managed as per the Adaptive Management Plan (SMEC, 2024).

5.3.4 Residual risk assessment (low/medium/high/severe)

The risk assessment below discusses the risk of residual impact for the major aquatic flora impact criterium after mitigation measures are in place.

- **Loss of aquatic flora:**

  To mitigate loss, water will largely be maintained in Lake Macdonald above 93 m AHD, and aquatic plants have strong dispersal abilities that will facilitate their recolonization during the refill and operation phases. The *likelihood* of impact from dewatering is *unlikely,* with the adjoining *consequence* of impact considered *moderate* after implementing mitigation measures. While some native plants can survive in saturated sediments, several species will die in dewatered areas. However, this impact is expected to be reversed once refilling begins and during the operational phase. Overall, the *residual risk* of impact is ***low***.

5.4 Aquatic fauna

5.4.1 Potential impacts

The drawdown of Lake MacDonald and the construction phase of the Project may have several impacts on aquatic flora and fauna. During the drawdown phase, aquatic fauna might suffer injuries from pumping equipment, which could lead to increased susceptibility to pathogens and disease or result in fatal injuries. They may also become trapped and drown. Additionally, injuries could occur in the low flow notch during construction and over the spillway during the refill and operation phases.

As water levels decrease, aquatic fauna in Lake MacDonald may become stranded in small, isolated pools. This could happen both during the drawdown phase and after large flow events during construction, when water

levels rise and then fall. Stranding increases the risk of predation by larger fish or birds and can lead to crowding. Crowding may reduce dissolved oxygen levels, increase competition for food and shelter, and heighten stress on the fauna. As pools dry up or areas are dewatered rapidly, fauna may end up stranded on dry land and potentially perish. Turtles and platypuses might struggle to reach available water due to exposed sediments and vegetation. Some turtle species may attempt to leave the waterbody as levels drop, but they might not find nearby water sources or could encounter hazards like roads during their movement.

Other potential impacts include the spread of aquatic biosecurity issues such as pest species and the stranding of biota in areas created by the coffer dam, leading to exposure to poor water quality. Injury or mortality from pumping equipment could cause fauna to become susceptible to pathogens or drown. As Lake MacDonald is lowered, stranding in shallow pools could lead to increased predation and competition, though the risk is minimized due to controlled dewatering rates.

Turtles might be injured or killed in construction areas and on the dam's spillway, which they might use for basking. They could also be affected during downstream movements during spilling events. The release of water into Six Mile Creek could impact aquatic flora and fauna by altering water quality, flow conditions, and spreading biosecurity issues. High flow events created by the release could transport fauna downstream or trigger unusual behaviour, but limiting the drawdown period to a minimum of four weeks reduces this risk. Contaminated water from the cofferdam could also adversely affect downstream aquatic biota. Habitat conditions and availability may be affected by erosion, sedimentation, disturbance of habitat structures, and changes in flow patterns. This in turn could affect the breeding capabilities of aquatic fauna.

5.4.2 Unmitigated risk assessment (low/medium/high/severe)

Provided with the specific drawdown and all potential risks identified above, the unmitigated risk assessment for the primary aquatic fauna criteria has been categorized below:

- **Fauna injury and mortality:**

  The major potential risk of injuries and mortality to aquatic fauna are primarily during releases and pumping. The risks arise from getting caught in pumping equipment, in the low flow notch during construction and over the spillway during the refill and operation phases. Aquatic fauna could also be affected by downstream movements during spilling events. Overall, the *unmitigated risk* to fauna injury and mortality is considered ***medium***.

- **Stranding of fauna:**

  As water levels in Lake MacDonald decrease, aquatic fauna risk becoming stranded in small, isolated pools, especially during the drawdown phase and after large flow events. This stranding increases the threat of predation, crowding, and stress due to reduced oxygen, food, and shelter. If pools dry up or water recedes quickly, fauna may be left on dry land and perish. Turtles and platypuses may also struggle to access remaining water due to exposed sediments and vegetation. The overall *unmitigated risk* for stranding of fauna is considered ***high***.

- **Facilitated impacts to breeding:**

  The proposed works may have a significant impact on the breeding seasons for aquatic fauna, causing potentially higher stress levels and increased mortality for juveniles and maternal species. Six Mile Creek was the only suitable breeding habitat for aquatic fauna of significance. For other sites there is no applicable risk as there is no suitable breeding habitat. For specifically Six Mile Creek, the initial unmitigated risk is considered ***high***, due to potential breeding consequences for protected species (i.e. Platypus and Mary River Cod).

5.4.3 Management measures

Before Drawdown

Before the drawdown of Lake Macdonald, an evaluation survey should be conducted with a focus on the upper reaches. This survey will include assessments of large-bodied fish, specifically MNES species, with the salvage of these species;

- small-bodied fish - recording species and their abundance

- platypus - initially using eDNA sampling to inform locations for setting up camera traps in and around active burrows to monitor ongoing presence
- turtles - both MNES listed and common species, using methods outlined in DSEWPC (2011)
- tadpoles - identifying and recording the abundance of barred frog tadpoles (genus *Mixophyes*) caught incidentally using fish and turtle survey methods. If *Mixophyes* tadpoles are detected, species determination should be undertaken.

The evaluation survey may be modified to include activities such as the evaluation of biomass and pre-drawdown commencement of aquatic fauna salvage and relocation.

5.4.3.1 Lake MacDonald

During Drawdown

The initial lowering of the lake from FSL (RL 95.3 m AHD) to approximately 42% FSL (RL 93 m AHD) should occur gradually over a period of no less than four weeks to allow fauna to adapt to the reduced water level. The drawdown program should begin outside the platypus breeding season (August to October) and avoid hot conditions, such as summer months. Water quality should be managed as described in the AMP (SMEC, 2024) and intake exclusion screens of suitable design (less than 20 mm aperture) should be used to prevent aquatic fauna from being entrained into drawdown equipment, ensuring the approach velocity is no more than 0.1 m/s.

A salvage plan should be implemented to prevent crowding and stranding, with platypus not being relocated unless necessary. The existing destratification unit should be maintained and on standby to respond to water quality triggers or signs of fish distress. Frogs should not be handled unless relocation is necessary or they appear stranded, and if handling is necessary, protocols in section 8.2.4 of the AMP should be followed.

During Construction

During construction, where physical conditions in the lowered lake are suitable, habitat and waterholes for platypus within their home range in the Lake Macdonald footprint should be maintained, considering natural behaviours. Aquatic biota salvage from the cofferdam waterbody should be implemented as needed. The presence of turtles basking in the workspace and dam spillway areas should be monitored, and if deemed to present an issue, specialist advice should be sought on how to best manage their exclusion. Frogs should not be handled unless relocation is necessary or they appear stranded, and if handling is necessary, the protocols in section 8.2.4 of the AMP should be followed.

5.4.3.2 Six Mile Creek

During Drawdown

During the drawdown of Six Mile Creek downstream, the release rate should be tailored to achieve the initial drawdown over a period of not less than four weeks to minimize artificial impacts associated with elevated flow velocity and depth. The initial drawdown should avoid releases during the breeding seasons for Mary River cod, platypus, and giant barred frog, which are known to be in Six Mile Creek downstream of the dam, by conducting the initial drawdown between March and October. Water quality and aquatic habitat should be managed as described in Sections 3 and 6 of the AMP respectively (SMEC, 2024).

A visual monitoring of sites should be conducted weekly where fauna have been relocated, including observations of mortality and measurement of in situ water quality, focusing on dissolved oxygen.

During Construction

During construction, inflows should be allowed to pass downstream, and water quality and aquatic fauna should be managed as described in Section 5.4.3.1.These measures are aimed at preventing or reducing potential impacts to aquatic fauna, particularly listed threatened species, and ensuring the effective management of aquatic habitats throughout the project.

5.4.4 Residual risk assessment (low/medium/high/severe)

The risk assessment below discusses the risk of residual impact for each major aquatic fauna impact criteria after mitigation measures are in place.

- **Fauna Injury and Mortality:**

  The *likelihood* of such injury or mortality is *unlikely when* appropriate mitigations are implemented, as they help prevent species from becoming trapped in equipment, reduce the risk of stranding, and minimize the potential for injury or death over the spillway and in plunge pools. The *consequence* of injury or mortality to aquatic fauna is considered *moderate* with the proposed mitigation measures in place. These measures are designed to prevent significant harm, such as the death of large numbers of threatened and other aquatic species in Lake Macdonald. The overall *residual risk* of fauna injury and mortality is considered ***low***.

- **Stranding of Fauna:**

  The *consequence* of fish and turtle stranding is *high*. Appropriate mitigation measures will minimize significant stranding of aquatic fauna. The lake will be drained over a period of 4-weeks giving aquatic fauna time to adapt to the new levels and a fish salvage plan will be utilised to relocate any stranded fauna. It will also be ensured that refugial habitat will remain throughout the construction period. The *likelihood* of stranding is *unlikely* when these measures are in place. Despite this, the mitigated risk of fish and turtle stranding remains ***moderate***.

- **Facilitated Impacts to Breeding**

  The initial drawdown should avoid releases during the breeding seasons for Mary River cod, platypus, and giant barred frog by conducting the initial drawdown between March and October. The *likelihood* of impact is therefore mitigated, and considered *rare*, whilst the *consequence* of impact is still considered *high*. The overall *residual risk* is considered ***low***.

5.5 Impacts from spread of biosecurity issues

5.5.1 Potential impacts

Invasive species are those that, beyond their natural range, pose significant threats to environmental, agricultural, or societal resources. In Queensland, such species are classified under the Biosecurity Act 2014 as either prohibited matters, which are not yet present, or restricted matters, which are currently found in the region.

The potential impacts of biosecurity risks associated with the lowering of Lake MacDonald include:

Impacts associated with present competitive Invasive species, like eastern gambusia (*Gambusia holbrooki*) and tilapia (*Oreochromis mossambicus*). These species have the potential to out-compete native species, leading to declines or threats to native populations. Similarly, aquatic weeds such as water hyacinth (Eichhornia crassipes), Salvinia (*Salvinia molesta*) and *Cabomba caroliniana* (Cabomba) can displace native aquatic plants.

The identified invasive species are also known for degrading habitats that support native species. Aquatic weeds can choke waterways and lower dissolved oxygen levels, while tilapia (*Oreochromis mossambicus*) can disrupt benthic habitats through their breeding behaviours. *Salvinia molesta* (Salvinia), a category 3 restricted biosecurity matter under the Biosecurity Act 2014, was recorded in all three reaches (and in high density at site SMCUS03), but not recorded in previous surveys. This suggests its abundance is recent, highlighting the need to further control and mitigate.

Operations associated with the Project could exacerbate biosecurity issues, particularly:

- **Spread of restricted biosecurity matters:** The lowering of Lake Macdonald could facilitate the upstream movement of invasive species like tilapia (*Oreochromis mossambicus*), especially during large flow events that overtop the coffer dam. Additionally, aquatic plant fragments could spread during the fauna relocation phase.
- **Introduction of new biosecurity matters:** The lowering of the lake might spread biosecurity concerns such as aquatic weeds and pest species, or introduce new biosecurity matters if not properly managed.

Specific potential impacts include:

- **Downstream spread:** Lowering Lake Macdonald may increase the transport of restricted matter like *Cabomba caroliniana* (Cabomba) and Gambusia downstream to Six Mile Creek. Water transferred from the lake could have higher concentrations of these matters, impacting downstream aquatic communities. If

Chytrid fungus is present in Lake Macdonald, it may also spread to Six Mile Creek via contaminated equipment, machinery, or workers.

- **Fauna relocation sites:** The fauna salvage and relocation program could inadvertently spread biosecurity matters from Lake Macdonald to relocation sites. This includes pest fish and aquatic weeds, which could be transported in water or on the fauna themselves. Additionally, pathogens or diseases like Chytrid fungus may be introduced to new areas, although Chytrid is already widespread.

5.5.2 Unmitigated risk assessment (low/medium/high/severe)

- **Spread of restricted biosecurity matters:**

  As stated in Section 5.5.1, the lowering of Lake Macdonald could facilitate the upstream movement of invasive species, especially during large flow events. Additionally, aquatic plant fragments could spread during the fauna relocation phase. The unmitigated risk for the spread of restricted biosecurity matters is considered ***medium***.

- **Introduction of new biosecurity matters:**

  As stated in Section 5.5.1, the lowering of the lake might spread biosecurity concerns such as aquatic weeds and pest species, or introduce new biosecurity matters if not properly managed. The resulting unmitigated risk is considered ***high***.

5.5.3 Management measures

Biosecurity Mitigation Measures for this section applies to both Lake Macdonald and Six Mile Creek Downstream:

Before Drawdown

Hydrological monitoring will identify conditions that may facilitate upstream fish movement and establish thresholds for corrective actions. Cofferdam design will involve consultation with fisheries biologists to ensure it prevents the upstream movement of pest fish, particularly tilapia (*Oreochromis mossambicus*).

During Drawdown and Construction

Actively manage the lake's water level to minimize the risk of drown-out or overtopping, considering weather conditions. If the cofferdam is overtopped, conduct a fish salvage event targeting tilapia (*Oreochromis mossambicus*) when conditions are safe, which may involve lowering the lake level to consolidate biomass for effective sampling. Humanely euthanize pest fish during aquatic salvage or sampling activities.

Filter (screen) all water to be used to hold and transport fauna for relocation to reduce potential of transport of weeds. All vehicles used for fauna relocation to be inspected and washed before leaving site if they have entered Lake Macdonald or margin areas where aquatic plants are exposed.

Biosecurity Management Plan

Ensure that project activities do not increase the distribution of pests or existing pest populations. Avoid using water from Six Mile Creek downstream of the dam for construction purposes to prevent transferring biosecurity matters like tilapia (*Oreochromis mossambicus*) into Lake Macdonald. Require all vehicles and equipment, including boats, to have weed hygiene certification before entering Lake Macdonald. Provide pest identification training to all relevant personnel.

Salvage and Relocation

Ensure personnel involved in fauna salvage and relocation are trained in pest identification. Euthanize any pest fish or turtles caught during salvage activities using ethics-approved methods and dispose of them appropriately. Filter all water used for holding and transporting fauna to reduce the potential transport of tadpoles. Assess the condition of fauna and do not relocate individuals with impaired condition or visible parasites, lesions, or fungi.

Return impaired fauna to the lake or euthanize them, except for MNES species, which should be transported to a qualified wildlife carer. Wash down vehicles and equipment used in fauna relocation according to weed washdown protocols before returning to the project area to remove attached sediment or mud. Clean and

disinfect footwear used for fauna relocation following the Hygiene protocols for the control of diseases in Australian frogs (Murray et al., 2011).

Additional Mitigation Measures

Reduce opportunities for tilapia (*Oreochromis mossambicus*) to move upstream during lake lowering and construction by managing water levels to prevent drown-out and avoid using water from Six Mile Creek downstream of the dam for construction purposes. Humanely euthanize pest fish in accordance with animal ethics-approved methods during any salvage effort. Install cane toad traps to control potential increases in cane toad populations. Remove invasive aquatic plants like Hydrophilia, *Salvinia molesta* (Salvinia) and *Cabomba caroliniana* (Cabomba) (as identified in the survey) from Lake Macdonald during the construction phase. Implement pest identification training for construction personnel, only relocate aquatic fauna to water bodies already infested with *Cabomba caroliniana* (Cabomba), and subject all vehicles, machinery, equipment, and temporary infrastructure to weed hygiene protocols.

5.5.4 Residual risk assessment (low/medium/high/severe)

The risk assessment below discusses the risk of residual impact for each major biosecurity impact criteria after mitigation measures are in place.

- **Spread of Restricted Biosecurity Matters:**

  Management measures to prevent the spread of restricted biosecurity matters include monitoring water levels, designing a cofferdam to block pest fish movement, and actively managing the lake's water during construction. Efforts also involve humane euthanising of pests, rigorous vehicle and equipment hygiene protocols, and training personnel in pest identification. Additional steps include installing cane toad traps, removing invasive aquatic plants, and ensuring that relocated fauna do not spread diseases or pests. The *likelihood* of impact is considered *rare* after implementation of mitigation measures. The *consequence* of impact is considered *high*. The overall *residual risk* rating is considered ***low***.

- **Introduction of New Biosecurity Matters:**

  The consequence of establishing or spreading biosecurity matters is *high*, as it would result in significant environmental impact and non-compliance with the *Biosecurity Act 2014*. Establishment of invasive species is typically irreversible. However, the *likelihood* of this occurring is *rare* when appropriate mitigation measures are implemented. Therefore, the *residual risk* of impact from the spread and establishment of biosecurity matters is ***low***.

5.6 Stygofauna communities in shallow groundwater systems

5.6.1 Potential impacts

The results of the desktop assessment (refer to Section 3.5) suggests that the high clay content and low hydraulic conductivity of the alluvium in the project area makes the habitat it unsuitable for stygofauna.

5.6.2 Unmitigated risk assessment (low/medium/high/severe)

The overall *unmitigated risk* is considered ***low***.

5.6.3 Management measures

There is no identifiable requirement to provide management measures for Stygofauna as the site is not considered a suitable habitat.

5.6.4 Residual risk Assessment (low/medium/high/severe)

Due to the proposed area not being a suitable ecosystem for Stygofauna, the *likelihood* of Stygofauna is considered *rare,* and the *consequence* of impact is considered *minor*. The overall *residual risk* is considered ***low***.

5.7 Summary of impact assessment

Table 5-1 presents a summary of the unmitigated risk of impact, general summation of management measures and residual risk assessment. This section should be read in conjunction with the relevant sections as:

- Water quality – Section 5.1
- Aquatic habitat – Section 5.2
- Aquatic flora – Section 5.3
- Aquatic fauna – Section 5.4
- Impacts from spread of biosecurity issues – Section 5.5
- Stygofauna communities – Section 5.6.

A more detailed list of mitigations for the whole stage of impacts associated with drawdown, construction and re-fill are noted in the sister reports identified in Section Scope of impact assessment addendum.

Table 5-1. Summary of risk-based impact assessment

Environmental Attribute	Potential Impacts	Initial Risk	Management Measures	Residual Risk		
				Likelihood	Consequence	Risk
Water Quality	**Turbidity and Total Suspended Solids**	**Medium**	• An adaptive monitoring program with clear trigger values and corrective actions • Focus on limiting disturbance of sedimentation during extraction	**Unlikely**	**Minor**	**Low**
	Dissolved Oxygen	**High**	• Aeration units and real-time monitoring systems will be deployed to ensure oxygen levels remain within acceptable limits	**Unlikely**	**Moderate**	**Low**
	Nutrient Concentrations	**High**	• Active removal of decomposing organic matter • Careful management of nutrient inputs is required. • Continued ongoing water quality monitoring of site.	**Unlikely**	**Moderate**	**Low**
	Mobilisation of Metals	**Medium**	• Avoid lowering the water in Lake Macdonald below 93 m AHD to prevent exposure of sediments potentially high in metals. • Ongoing water quality monitoring of site will also be conducted.	**Unlikely**	**Moderate**	**Low**

Environmental Attribute	Potential Impacts	Initial Risk	Management Measures	Residual Risk		
				Likelihood	Consequence	Risk
	Introduction of contaminants from construction activities	**Medium**	• Appropriate storage of contaminates. • Ongoing water quality monitoring of site.	**Unlikely**	**Moderate**	**Low**
	Reintroduction of poor water quality from stilling basin	**Medium**	• Regular dewatering and treatment of poor water quality should be conducted when detected in the stilling basin. • Ongoing water quality monitoring of site.	**Unlikely**	**Moderate**	**Low**
Aquatic Habitat	**Temporary loss of aquatic habitat**	**High**	• An aquatic fauna salvage plan. • Augment aquatic habitat where possible, by adding physical habitat structures or controlling aquatic weeds. • Post-construction, re-establishment or supplementation of aquatic habitat should be carried out where monitoring indicates it is needed. • Suitably qualified persons to assess vegetation before clearing	**Possible**	**High**	**Medium**
	Changes to downstream flows	**Medium**	• The short-duration event during the drawdown phase is planned to occur outside the breeding	**Possible**	**Minor**	**Low**

Environmental Attribute	Potential Impacts	Initial Risk	Management Measures	Residual Risk		
				Likelihood	Consequence	Risk
			season of the MNES species found in Six Mile Creek. • Planned sustained 4-week release during drawdown limiting significant change to flow and associated impacts			
	Sedimentation	**Medium**	• Use of a pontoon-based pump station to reduce disturbance and downstream sediment transfer. • Non-invasive grasses to hold sediment. • Managing erosion with an ESCP and physical barriers	**Unlikely**	**Moderate**	**Low**
Aquatic Flora	**Loss of aquatic flora**	**Low**	• Water will be maintained in Lake Macdonald largely above 93 m AHD, • Identified aquatic plants have strong dispersal abilities that will facilitate their recolonization during the refill and operation phases	**Unlikely**	**Moderate**	**Low**
Aquatic Fauna	**Fauna injury and mortality**	**Medium**	• Exclusion and relocation plans to prevent any injury or mortality of aquatic species on spillway, plunge pool or caused by umping equipment.	**Unlikely**	**Moderate**	**Low**

Environmental Attribute	Potential Impacts	Initial Risk	Management Measures	Residual Risk		
				Likelihood	Consequence	Risk
	Stranding of Fauna	**High**	• Water will be drained over a period of 4-weeks providing aquatic fauna time to adapt to the new level. • A fish salvage plan will be utilised to relocate any stranded fauna.	**Likely**	**Moderate**	**Medium**
	Facilitated impacts to breeding	**High**	• The initial drawdown will avoid releases during the breeding seasons for Mary River cod, platypus, and giant barred frog by conducting the initial drawdown between March and October.	**Rare**	**High**	**Low**
Biosecurity Risks	**Spread of restricted biosecurity matters**	**Medium**	• Monitoring water levels • Designing a cofferdam to block pest fish movement. • Actively managing the lake's water during construction. • Humane euthanising of pests • High standard vehicle and equipment hygiene protocols, and training personnel in pest identification. • Installing cane toad traps, removing invasive aquatic plants, and ensuring that	**Rare**	**High**	**Low**

Environmental Attribute	Potential Impacts	Initial Risk	Management Measures	Residual Risk		
				Likelihood	Consequence	Risk
			relocated fauna do not spread diseases or pests.			
	Introduction of new biosecurity matters	**High**	• Consistent pest identification surveys and implementing removal strategies if present.	**Rare**	**High**	**Low**
Stygofauna	**Presence of Stygofauna**	**Low**	• Habitat not suitable for Stygofauna based upon desktop assessment	**Rare**	**Minor**	**Low**

6. Matters of National Environmental Significance

Previous assessments have been conducted for the previous drawdown methodology (to 5% FSL) for the following species:

- Mary River cod
- Mary River turtle
- White-throated snapping turtle
- Australian lungfish.

The assessments were based on a moderate to high degree of confidence based on an understanding of potential impacts and survey data was considered in currency. The previous assessments identified the following, in reference to assessment against significant impact criteria based on a 5% FSL drawdown and a time impact of 18-24 months:

- Mary River cod – **No significant impact** from action
- Mary River turtle - **No significant impact** from action
- White-throated snapping turtle - **No significant impact** from action
- Australian lungfish - **No significant impact** from action.

The current assessment methodology has reduced the drawdown impact from 5% FSL drawdown level to 42% FSL drawdown. Time of drawdown has increased from 18-24 months to 36-48 months. As such, the increase in time of impact may result in a change to the previous assessment, specifically the significant impact criteria for *'Disrupt the breeding cycle of a population'*. A reassessment of this specific significant impact criteria has been undertaken which on this significant impact assessment as below:

- Mary River cod – The population within Lake Macdonald is not considered a breeding population and is not expected to result in impact. Impact within Six Mile Creek is not expected due to result in an impact where initial drawdown releases are managed to avoid influencing breeding in Six Mile Creek. No significant impact which will disrupt the breeding cycle of a population is considered from the varied drawdown methodology activities.
- Mary River turtle -No breeding habitat for this species is known from either Lake Macdonald or Six Mile Creek and as such, no significant impact which will disrupt the breeding cycle of a population is considered as a result from the varied drawdown methodology.
- White-throated snapping turtle - No breeding habitat for this species is known from either Lake Macdonald or Six Mile Creek and as such, no significant impact which will disrupt the breeding cycle of a population is considered as a result from the varied drawdown methodology.
- Australian lungfish – The population within Lake Macdonald is not considered a breeding population and is not expected to result in impact. Impact within Six Mile Creek is not expected due to result in an impact where initial drawdown releases are managed to avoid influencing breeding in Six Mile Creek. No significant impact which will disrupt the breeding cycle of a population is considered from the varied drawdown methodology activities.

Overall, in reference to assessment against significant impact criteria based on a 42% FSL drawdown and a time impact of 36-48 months:

- Mary River cod – **No significant impact** from action
- Mary River turtle - **No significant impact** from action
- White-throated snapping turtle - **No significant impact** from action
- Australian lungfish - **No significant impact** from action.

7. Conclusion

The newly proposed 42% FSL drawdown and construction phases at Lake Macdonald pose several environmental risks, including impacts on water quality, aquatic habitat, flora, and fauna, as well as biosecurity concerns.

Water quality could be adversely affected by increased turbidity, decreased pH, reduced dissolved oxygen, elevated nutrient levels, and the mobilization of metals. These changes might harm aquatic life, leading to potential disease and oxygen depletion. Unmitigated risks are medium to high, particularly for dissolved oxygen and nutrient concentrations. To mitigate these risks, measures include minimizing sediment exposure, real-time monitoring of water quality, removing decomposing organic matter, and preventing chemical spills. After implementing these measures, residual risks to water quality were considered *low*. It is recommended that updated water quality trigger values be established by utilising current/contemporary water quality data. This approach ensures that the revised values are representative of current environmental conditions.

The Aquatic habitat is at risk from reduced water levels, which may harm significant species like the Mary River cod and platypus and affect downstream habitats due to sedimentation. The unmitigated risk of temporary habitat loss is *high*, while changes in downstream flows and sedimentation present a *medium* risk. Management strategies involve controlling drawdown rates, stabilizing sediments, enhancing habitats, and avoiding disturbance during critical breeding seasons. After mitigation, residual risks are reduced to *moderate* or *low* levels.

Aquatic Flora could be impacted by dewatering, which might expose and kill aquatic plants and cover benthic habitats with sediment. The unmitigated risk is *low*, as the affected flora mainly includes restricted species like *Salvinia molesta* (Salvinia) and *Cabomba caroliniana* (Cabomba). Management includes retaining water below 93m AHD to protect plants and managing sediment and flow according to water quality plans. The residual risk after mitigation remains *low*.

Aquatic fauna faces risks such as injury, mortality, stranding, and poor water quality, with specific concerns about breeding impacts. The unmitigated risk is medium to high for injuries and stranding, and high for breeding impacts. Management measures involve pre-drawdown surveys, gradual drawdown, maintaining habitat, monitoring water quality, and implementing protective measures. Residual risks after mitigation are low for injuries and mortality, moderate for stranding, and rare for breeding impacts.

Biosecurity risks include the potential spread of invasive species and introduction of new biosecurity matters. Management measures involve hydrological monitoring, designing cofferdams, careful water level management, and strict hygiene protocols for vehicles and equipment. After mitigation, the residual risk of spreading restricted biosecurity matters is low, but introducing new biosecurity matters remains a high concern if not properly managed.

Stygofauna are not expected to be impacted due to unsuitable habitat conditions.

For all nationally significant species like the Mary River cod and Australian lungfish, no significant impact is anticipated from the current drawdown methodology based on updated assessments.

In conclusion, while robust management measures will mitigate many risks associated with the 42% drawdown, careful attention to water quality, habitat protection, and biosecurity is essential to minimise environmental impacts effectively.

8. References

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Appendix A – General ecological value details

A-1 Water quality assessments

A-1-1 Water quality assessment (September 2023)

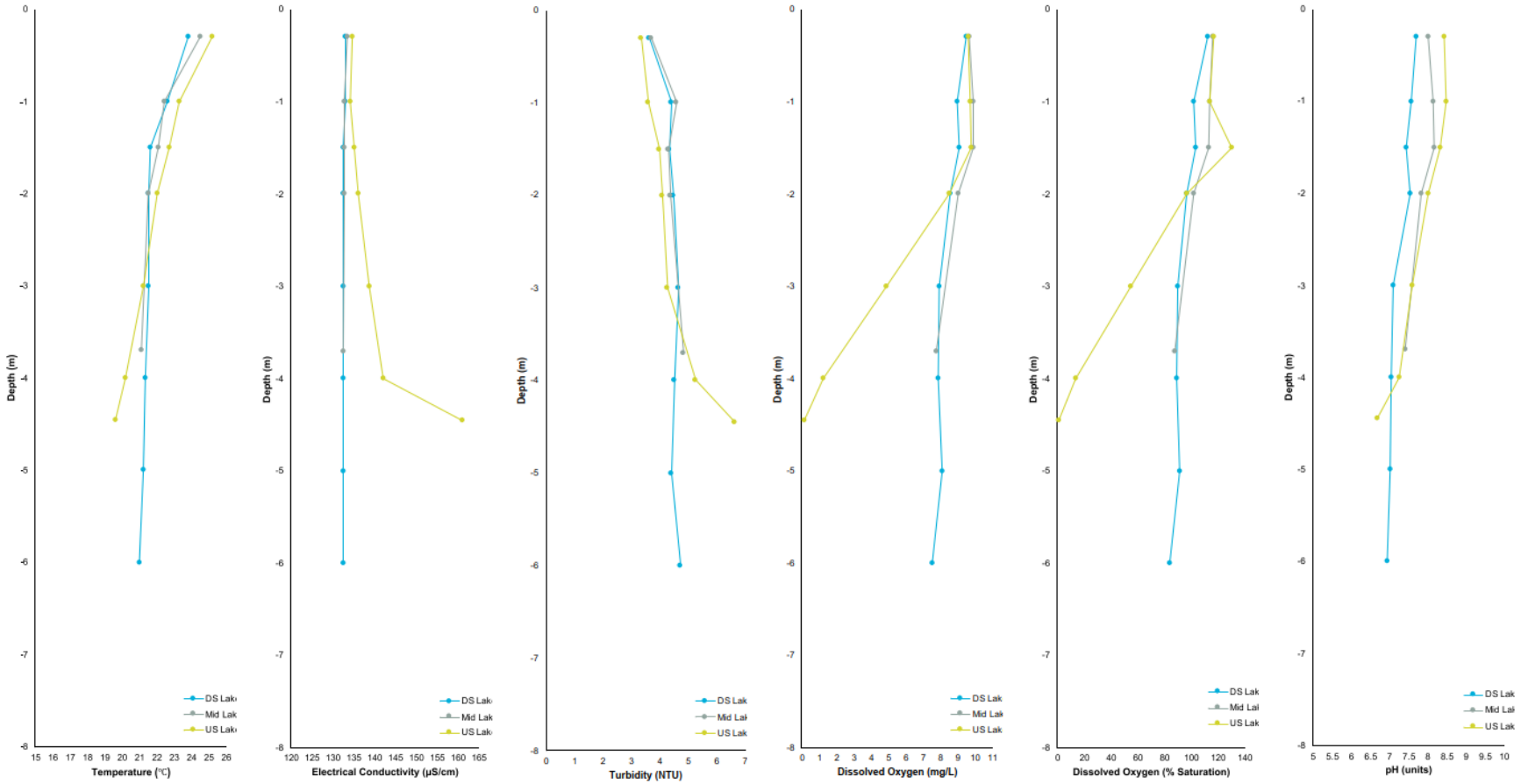

Figure A-1 Water quality depth profiles at Lake MacDonald site

Table A-1 Summary of mean daily water quality since November 1998 measured at gauging station 138107B on Six Mile Creek at Cooran.

Summary Statistic	Temperature (°C) [a]	Electrical Conductivity (µS/cm)	pH (unit)
WQO	–	**626**	**6.5–8.0**
Minimum	8.4	29	6.0
20th Percentile	15.0	143	6.6
Median	19.7	173	6.9
80th Percentile	23.1	204	7.1
Maximum	28.0	315	8.5

grey shading denotes results that did not comply with the WQO.

Table A-2 Summary of surface water quality measured at sites downstream of Lake MacDonald compared to the WQO and data from previous surveys.

Parameter	Units	WQO	Previous Surveys		September 2023 Survey		
			20-80th %iles	Full Range	SMCDS03	SMCDS02	SMCDS01
Temperature	°C	–	19.0–24.5	17.7–26.6	17.5	17.6	19.9
Electrical conductivity	µS/cm	626	114–180	76–244	210	206	139
pH	unit	6.5–8.0	6.2–7.2	5.6–7.4	7.2	7.3	6.4
Dissolved Oxygen	mg/L	–	3.0–5.7	2.0–7.9	4.6	5.3	5.3
Dissolved Oxygen	% saturation	85–110	34–65	24–93	48	56	58
Turbidity	NTU	50	5–11	3–16	5	5	12

blue shading denotes results outside the 20-80th percentile range from previous surveys.

light grey shading denotes results that do not comply with the WQO but are within the range from previous surveys.

Table A-3 Summary of surface water quality measured at sites within Lake MacDonald compared with WQO's of previous surveys

Parameter	Units	WQO	Previous Surveys		September 2023 Survey		
			20-80th %iles	Full Range	DS Lake	Mid Lake	US Lake
Temperature	°C	–	23.2–28.0	22.9–28.8	23.8	24.5	25.2
Electrical conductivity	µS/cm	626	53–92	42–103	133	133	135
pH	unit	6.5–8.0	6.8–7.3	6.7–7.5	7.7	8.0	8.4
Dissolved Oxygen	mg/L	–	7.7–9.9	4.2–10.0	9.5	9.7	9.6
Dissolved Oxygen	% saturation	85–110	99–117	55–120	112	116	117
Turbidity	NTU	50	4–6	3–6	5	8	6

gold shading denotes results outside the full range from previous surveys.

light grey shading denotes results that do not comply with the WQO but are within the range from previous surveys.

dark grey shading denotes results that do not comply with the WQO or the range from previous surveys.

Table A-4 Summary of surface water quality measured at sites upstream of Lake MacDonald compared to the WQO and data from previous surveys.

Parameter	Units	WQO	Previous Surveys		September 2023 Survey			
			20-80th %iles	Full Range	CC01	CC03	SMCU S01	SMCU S03
Temperature	°C	–	18.9–24.0	17.4–29.8	18.2	18.1	18.0	18.1
Electrical conductivity	µS/cm	626	89–142	59–189	147	142	155	139
pH	unit	6.5–8.0	6.3–7.1	5.8–7.6	7.0	6.6	6.8	6.9
Dissolved Oxygen	mg/L	–	3.1–7.3	2.1–8.9	4.1	3.6	1.7	4.5
Dissolved Oxygen	% saturation	85–110	34–92	25–110	43	38	17	47
Turbidity	NTU	50	6–14	5–15	14	15	9	6

blue shading denotes results outside the 20-80th percentile range from previous surveys.

light grey shading denotes results that do not comply with the WQO but are within the range from previous surveys.

A-1-2 Water quality assessments (Mar-Jun 2024)

Table A-5 March results from field water testing

Date	Parameter	Field Testing DS04	DS03	DS02	I1	I3	I4	I5	7-day Prior Average Rainfall (mm)
8/03/2024	Temp (degC)	24.98	23.45	26.85	27.01	26.72	26.39	26.01	10.6
	EC (us/cm)	111	140	137	89	91	82	71	
	Sal(ppt)	0.05	0.07	0.06	0.04	0.04	0.03	0.03	
	pH	6.82	7.05	6.99	7.23	7.27	7.53	7.23	
	ORP (mV)	744	694	692	677	632	685	589	
	Turb(ntu)	13.2	14.5	6.7	7.4	7.7	12.7	14.7	
	DO (mg/L)	3.52	4.65	4.01	3.48	3.23	4.85	3.91	
14/03/2024	Temp (degC)	24.77	23.64	25.85	26.14	25.66	25.22	25.65	15.2
	EC (us/cm)	103	127	91	85	108	77	80	
	Sal(ppt)	0.05	0.06	0.04	0.04	0.05	0.03	0.04	
	pH	6.37	6.39	6.78	7.07	7.25	6.89	6.7	
	ORP (mV)	776	707	743	709	574	652	738	
	Turb(ntu)	14.7	14.7	6.8	7.5	7.1	23	23.3	
	DO (mg/L)	4.01	4.31	4.1	4.01	3.91	3.58	3.32	
21/03/2024	Temp (degC)	24.81	24.95	25.52	24.58	25.33	23.5	23.89	25.1
	EC (us/cm)	116	105	94	83	83	80	84	
	Sal(ppt)	0.06	0.05	0.04	0.04	0.04	0.04	0.04	
	pH	7.1	7.08	7.09	6.88	6.94	6.94	6.75	
	ORP (mV)	526	642	681	689	6.94	742	743	
	Turb(ntu)	13	10.9	7.4	8.6	7.9	9.9	20	
	DO (mg/L)	3.76	4.24	4.59	4.06	3.92	4.77	3.75	
26/03/2024	Temp (degC)	22.61	22.87	23.89	24.2	24.16	23.22	23.43	23.8
	EC (us/cm)	109	96	85	88	86	86	86	
	Sal(ppt)	0.06	0.05	0.04	0.04	0.04	0.04	0.04	
	pH	7.42	7.25	7.28	7.02	7.24	6.86	6.72	
	ORP (mV)	585	682	707	700	687	706	706	
	Turb(ntu)	28.2	26.9	9.2	7.8	7.2	15.2	18.3	
	DO (mg/L)	4.34	4.78	4.38	3.85	4.43	4.05	3.38	

** Green highlights represent a value below (low) the trigger and the yellow highlights represents a value that exceeds (high) the trigger.*

** Rainfall is based on a 7-day average prior to water monitoring*

Table A-6 March ALS Laboratory Results, Suspended Solids (SS), Total & Dissolved mercury, Total N & P

Date	Parameter(mg/L)	DS04	DS03	DS02	DS01	I1	I3	I4	I5	7-day Prior Average Rainfall (mm)
8/03/2024	Total Suspended Solids (TSS)	13	11	6	8	8	13	13	12	10.6
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Kjeldahl Nitrogen	0.7	0.8	0.8	0.9	0.9	0.8	1.2	1.1	
	Total Phosphorus	0.02	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	
14/03/2024	Total Suspended Solids (TSS)	11	12	9	7	8	<5	10	12	15.2
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Kjeldahl Nitrogen	0.6	0.9	1	1.2	0.8	0.9	0.8	0.6	
	Total Phosphorus	0.03	0.03	0.04	0.06	0.07	<0.05	0.04	0.06	
21/03/2024	Total Suspended Solids (TSS)	7	8	8	12	8	12	9	16	25.1
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Kjeldahl Nitrogen	0.6	0.7	0.7	0.9	0.9	0.8	0.8	1.1	
	Total Phosphorus	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.08	
26/03/2024	Total Suspended Solids (TSS)	15	18	6	7	7	<5	<5	8	23.8
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Kjeldahl Nitrogen	0.8	0.7	0.8	1	0.8	0.8	0.8	1	
	Total Phosphorus	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.05	

Table A-7 April Results from water quality field testing

Field Testing										
Date	Parameter	DS04	DS03	DS02	DS01	I1	I3	I4	I5	7-days Prior Average Rainfall
3/04/2024	Temp (degC)	24.38	24.06	24.86	28.07	26.79	29.19	30.64	30.97	
	EC (us/cm)	108	101	0	80	83	79	72	76	
	Sal(ppt)	0.05	0.05	0	0.03	0.03	0.03	0.02	0.02	
	pH	6.92	6.96	6.81	6.84	7.00	6.89	7.13	6.88	6.9
	ORP (mV)	614	665	836	680	675	611	614	677	
	Turb(ntu)	13.2	13.9	171.9	9.2	11.5	9.7	12.7	17	
	DO (mg/L)	3.56	3.87	5.25	4.14	4.74	4.31	4.68	4.02	
9/04/2024	Temp (degC)	24.42	24.48	25.1	26.08	28.75	28.55	28.24	26.49	
	EC (us/cm)	102	103	83	80	85	71	73	75	
	Sal(ppt)	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	
	pH	7.38	7.38	7.23	7.22	7.32	7.71	7.53	7.41	10.0
	ORP (mV)	571	616	656	679	621	442	694	687	
	Turb(ntu)	14.8	17.2	7.6	8.5	9.2	11.4	8.6	8	
	DO (mg/L)	3.66	4	3.74	4.31	4.67	5.23	4.7	4.89	
17/04/2024	Temp (degC)	21.82	22.35	22.38	23.87	24.6	24.83	24.87	25.69	
	EC (us/cm)	316	184	184	117	94	87	89	87	
	Sal(ppt)	0.17	0.1	0.1	0.06	0.05	0.04	0.04	0.04	
	pH	7.3	7.21	7.19	7.04	7.02	6.97	6.94	7.08	0.0
	ORP (mV)	487	565	568	635	631	632	636	555	
	Turb(ntu)	12.3	14.1	13.7	6.4	8	6.9	7.1	8.2	
	DO (mg/L)	4.34	4.54	4.44	3.61	4.52	3.83	3.4	4.11	
24/04/2024	Temp (degC)	21.6	21.76	22.5	23.69	24.56	25.62	25.54	25.39	
	EC (us/cm)	101	97	86	83	82	77	74	82	
	Sal(ppt)	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.04	
	pH	6.81	6.89	6.77	6.83	6.82	7.32	7.06	6.91	21.2
	ORP (mV)	629	673	721	695	696	684	648	694	
	Turb(ntu)	18.4	15.7	7.1	6.8	6.2	13.4	25.6	5.8	
	DO (mg/L)	4.89	5.1	5.11	5.48	4.97	6.89	4.81	5.05	

** Green highlights represent a value below (low) the trigger and the yellow highlights represents a value that exceeds (high) the trigger.*

** Rainfall is based on a 7-day average prior to water monitoring*

Table A-8 April Laboratory Results, Suspended Solids (SS), Total & Dissolved mercury, Total N & P

Laboratory Results, Suspended Solids (SS), Total & Dissolved mercury, Total N & P										
Date	Parameter(mg/L)	DS04	DS03	DS02	DS01	I1	I3	I4	I5	7-days Prior Average Rainfall (mm)
24/04/2024	Total Suspended Solids (TSS)	<5	6	<5	<5	<5	<5	10	9	
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Ammonia as N	0.03	0.05	0.12	0.08	0.09	0.06	0.03	0.05	21.2
	Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Nirate as N	0.04	0.05	7.10	0.03	<0.01	<0.01	<0.01	<0.01	
	Nitrite plus Nirate as N (NOx)	0.04	0.05	7.10	0.03	<0.01	<0.01	<0.01	<0.01	
	Total Kjeldahl Nitrogen	0.4	0.5	0.6	0.6	0.6	0.6	0.8	0.9	
	Total Nitrogen as N (TKN + NOx)	Missing from ALS Results								
	Total Phosphorus	0.05	0.04	0.20	0.04	0.04	0.04	0.06	0.07	

Table A-9 May Results from Field Water Testing

		Field Testing								
Date	Parameter	DS04	DS03	DS02	DS01	I1	I3	I4	I5	7-day Prior Average Rainfall (mm)
1/05/2024	Temp (degC)	21.01	21.07	21.84	22.62	23.06	23.02	24.76	24.55	
	EC(us/cm)	127	110	85	83	86	80	76	82	
	Sal(ppt)	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	
	pH	7.08	7.18	7.01	6.95	6.98	7.14	7.34	7.14	7.8
	ORP(mV)	614	561	623	681	716	719	678	686	
	Turb(ntu)	11.4	9.6	5.9	6.9	7.7	6.8	10.4	10.7	
	DO(mg/L)	4.8	4.95	4.73	5.22	4.87	5.39	5.83	5.4	
10/05/2024	Temp (degC)	20.66	20.66	21.28	21.92	22.58	21.55	23.06	22.38	
	EC(us/cm)	117	104	97	93	93	85	89	105	
	Sal(ppt)	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.05	
	pH	7.41	7.4	7.5	7.46	7.28	7.31	7.94	7.55	4.3
	ORP(mV)	504	612	618	622	613	635	576	597	
	Turb(ntu)	11.1	9.8	7.8	6.7	6.9	7.1	4.7	9.4	
	DO(mg/L)	5.1	5.37	5.49	5.79	5.3	5.54	7.49	5.34	
16/05/2024	Temp (degC)	20.15	20.47	21.16	22.02	22.82	22.47	23.83	22.88	
	EC(us/cm)	129	116	86	84	85	85	86	107	
	Sal(ppt)	0.07	0.06	0.04	0.04	0.04	0.04	0.04	0.05	
	pH	7.36	7.24	7.13	7.18	7.11	7.15	7.65	7.24	1.0
	ORP(mV)	518	615	665	631	629	657	640	661	
	Turb(ntu)	10.8	9.7	5.9	6.1	6.4	5.8	5.7	8.7	
	DO(mg/L)	4.64	5	4.83	5.58	5.27	5.57	6.86	5.49	

** Green highlights represent a value below (low) the trigger and the yellow highlights represents a value that exceeds (high) the trigger.*

** Rainfall is based on a 7-day average prior to water monitoring*

Table A-10 May ALS Laboratory Results, Suspended Solids (SS), Total & Dissolved mercury, Total N & P

Date	Parameter(mg/L)	DS04	DS03	DS02	DS01	I1	I3	I4	I5	7-day Prior Average Rainfall (mm)
1/05/2024	Total Suspended Solids (TSS)	<5	<5	<5	<5	6	6	10	6	
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Ammonia as N	0.13	0.05	0.07	0.09	0.08	0.06	0.02	<0.01	
	Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	7.8
	Nirate as N	0.10	0.09	0.07	0.01	0.01	0.01	<0.01	<0.01	
	Nitrite plus Nirate as N (NOx)	0.1	0.09	0.07	0.01	0.01	0.01	<0.01	<0.01	
	Total Kjeldahl Nitrogen	0.6	0.5	2.4	0.8	0.8	0.6	0.9	0.6	
	Total Phosphorus	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	
10/05/2024	Total Suspended Solids (TSS)	<5	<5	<5	<5	<5	<5	<5	<5	
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Ammonia as N	0.12	0.03	0.08	0.08	0.07	0.06	<0.01	0.02	
	Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	4.3
	Nirate as N	0.08	0.09	0.07	0.01	0.05	0.01	<0.01	<0.01	
	Nitrite plus Nirate as N (NOx)	0.08	0.09	0.07	0.01	0.05	0.01	<0.01	<0.01	
	Total Kjeldahl Nitrogen	0.7	0.5	0.7	0.8	1.0	0.9	0.6	0.6	
	Total Phosphorus	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.03	
16/05/2024	Total Suspended Solids (TSS)	7	6	<5	<5	<5	<5	<5	8	
	Dissolved Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Total Recoverable Mercury by FIMS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
	Ammonia as N	0.01	0.01	0.04	0.06	0.03	0.06	<0.01	<0.01	
	Nitrite as N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.0
	Nirate as N	0.11	0.12	0.1	0.03	0.02	0.02	0.08	<0.01	
	Nitrite plus Nirate as N (NOx)	0.11	0.12	0.1	0.03	0.02	0.02	0.08	<0.01	
	Total Kjeldahl Nitrogen	0.1	0.3	0.4	0.4	0.3	0.3	0.2	0.2	
	Total Phosphorus	0.03	0.03	0.05	0.05	0.03	0.03	0.02	0.05	

** Green highlights represent a value below (low) the trigger and the yellow highlights represents a value that exceeds (high) the trigger.*

A-2 Aquatic flora

Table A-11 Results of Aquatic Plant Survey

Species	Common name	Growth form	Six Mile Creek DS		Lake Macdonald		Six Mile Creek US	
			Previous Surveys	Sep-23 Survey	Previous Surveys	Sep-23 Survey	Previous Surveys	Sep-23 Survey
Plants in water (in-stream)								
Azolla sp.	Azolla	floating					I	
Cabomba caroliniana	Cabomba [c]	submerged	I [a]	I [a]	D	D	S	S
Eleocharis sp.	spikerush	emergent			I [b]	I [b]		
Lemnoideae	duck weed	floating					I	
Ludwigia peploides	water primrose	emergent			I [b]		I	
Marsilea sp.	nardoo	floating-attached				I [b]		
Myriophyllum aquaticum	parrots' feathers [c]	submerged-emergent						I
Nymphaea caerulea	cape waterlily [c]	floating- attached			I			I
Nymphoides indica	water snowflake	floating-attached	I [a]	I [a]	S	S	I	I
Ottelia ovalifolia	swamp lily	floating-attached						I
Philydrum lanuginosum	frogsmouth	emergent			I [b]			
Potamogeton javanicus	Javan pondweed	submerged			I			I
Salvinia molesta	salvinia [c]	floating		I [a]		I		D
Vallisneria nana	ribbonweed	submerged						I
Typha sp.	bullrush	emergent			I [b]			
Plants not in water (banks)								
Carex spp.	sedge	–	I					
Cyperus spp.	flat-sedge	–	I	I	I	I	I	I

Species	Common name	Growth form	Six Mile Creek DS		Lake Macdonald		Six Mile Creek US	
			Previous Surveys	Sep-23 Survey	Previous Surveys	Sep-23 Survey	Previous Surveys	Sep-23 Survey
Eleocharis sp.	spikerush	–				I		
Lomandra spp.	mat-rush	–	D	D	I	I	S	S
Ludwigia octovalvis	willow primrose	–			I	I		
Ludwigia peploides	water primrose	–				I		
Marsilea sp.	nardoo	–				I		
Myriophyllum aquaticum	parrots' feathers [c]	–						I
Nymphoides indica	water snowflake	–				I		
Persicaria spp.	smartweeds	–	I		I	I	I	I
Philydrum lanuginosum	frogsmouth	–				I		
Schoenoplectus mucronatus	mucronate club-rush	–	I			I		I

I = isolated; S = scattered; D = dense cover

[a] Cabomba was found in Six Mile Creek downstream of Lake Macdonald, but only within several hundred meters of the dam. In-stream aquatic plants (including Cabomba) were absent from most sites downstream of Lake MacDonald.

[b] these emergent species only occurred in shallow water along the edge of Lake Macdonald

[c] denotes an exotic species

A-3 Aquatic Fauna

A-3-1 Macroinvertebrates survey results

Table A-12 Macroinvertebrate indices at sites downstream of Lake MacDonald compared to the WQO and results from the December 2018 survey

Macroinvertebrate Indices	WQO	Edge Habitat				Bed Habitat			
		Feb-18 Range	SMCDS03	SMCDS02	SMCDS01	Feb-18 Range	SMCDS03	SMCDS02	SMCDS01
Abundance	–	123–232	129	117	154	153–190	67	89	52
Taxonomic Richness	≥ 22	14–25	13	10	16	8–19	7	8	3
PET Richness	≥ 4	3–5	3	2	2	1–5	2	2	0
SIGNAL-2 Score	≥ 4	3.60–4.06	4.33	4.05	3.38	3.40–4.12	3.55	4.21	3.27
% Sensitive Taxa	–	0–7%	8%	20%	0%	0–11%	14%	13%	0%
% Tolerant Taxa	–	33–47%	46%	30%	56%	28–50%	43%	38%	67%

blue shading denotes results outside the range from the previous survey.
light grey shading denotes results that do not comply with the WQO but are within the range from the previous survey.
dark grey shading denotes results that do not comply with the WQO and are outside the range from the previous survey.

Table A-13 Macroinvertebrate indices at sites within Lake MacDonald compared to the WQO and results from the December 2018 survey

Macroinvertebrate Indices	WQO	Edge Habitat				Bed Habitat			
		Feb-18 Score	DS Lake	Mid Lake	US Lake	Feb-18 Score	DS Lake	Mid Lake	US Lake
Abundance	–	163	34	52	140	131	65	103	104
Taxonomic Richness	≥ 22	15	4	7	11	10	6	10	7
PET Richness	≥ 4	4	0	0	1	2	1	2	1
SIGNAL-2 Score	≥ 4	3.31	3.36	3.14	2.95	3.83	3.44	4.18	3.47
% Sensitive Taxa	–	0%	0%	0%	0%	0%	0%	0%	0%
% Tolerant Taxa	–	49%	50%	67%	73%	30%	50%	40%	57%

grey shading denotes results that do not comply with the WQO.

Table A-14 Macroinvertebrate indices at sites upstream of Lake MacDonald compared to the WQO and results from the December 2018 survey

Macroinvertebrate Indices	WQO	Edge Habitat					Bed Habitat				
		Feb-18 Score	CC01	CC03	SMCUS01	SMCUS03	Feb-18 Score	CC01	CC03	SMCUS01	SMCUS03
Abundance	–	126	181	170	115	77	204	201	111	70	123
Taxonomic Richness	≥ 22	17	21	18	10	9	13	19	9	6	5
PET Richness	≥ 4	1	2	1	2	2	1	1	0	1	0
SIGNAL-2 Score	≥ 4	3.45	3.22	3.54	3.83	3.69	3.59	3.34	3.15	3.94	3.57
% Sensitive Taxa	–	0%	0%	0%	10%	0%	0%	0%	0%	17%	0%
% Tolerant Taxa	–	63%	57%	56%	40%	38%	58%	47%	67%	50%	40%

grey shading denotes results that do not comply with the WQO.

A-3-2 Fish survey results

Table A-15 Fish species known from, or likely to occur in Six Mile Creek.

Species	Common Name	Caught in Previous Surveys	Caught in Sep-23
Native Species			
Ambassis agassizii	Agassiz's glassfish	✓	✓
Ambassis marianus	estuary glassfish	–	–
Anguilla australis	southern shortfin eel	✓	–
Anguilla reinhardtii	longfin eel	✓	✓
Craterocephalus marjoriae	silverstreak hardyhead	–	–
Craterocephalus stercusmuscarum	flyspecked hardyhead	✓	✓
Glossamia aprion	mouth almighty	✓	–
Gobiomorphus australis	striped gudgeon	–	–
Hypseleotris compressa	empire gudgeon	–	–
Hypseleotris spp.	common gudgeon	✓	✓
Leiopotherapon unicolor	spangled perch	✓	–
Maccullochella mariensis	Mary River cod	✓	–
Macquaria ambigua	yellowbelly	✓	–
Melanotaenia duboulayi	crimsonspotted rainbowfish	✓	✓
Mogurnda adspersa	southern purplespotted gudgeon	✓	✓
Mugil cephalus	sea mullet	–	–
Nematolosa erebi	bony bream	✓	✓
Neoceratodus forsteri	Australian lungfish	✓	–
Neosilurus hyrtlii	Hyrtl's tandan	–	–
Notesthes robusta	bullrout	–	–
Percolates novemaculeata	Australian bass	✓	✓
Philypnodon grandiceps	flathead gudgeon	✓	–
Philypnodon macrostomus	dwarf flathead gudgeon	✓	✓
Pseudomugil signifer	Pacific blue eye	✓	✓
Retropinna semoni	Australian smelt	✓	✓
Scleropages leichardti	southern saratoga	✓	–
Tandanus tandanus	freshwater catfish	✓	✓
Trachystoma petardi	pinkeye mullet	–	–

Species	Common Name	Caught in Previous Surveys	Caught in Sep-23
Exotic Species			
Gambusia holbrooki	eastern Gambusia	✓	✓
Oreochromis mossambicus	tilapia	✓ [a]	–
Poecilia reticulata	guppy	–	–
Xiphophorus maculatus	platy	–	✓
Xiphophorus hellerii	swordtail	✓	✓

[a] observed only.

Table A-16 Fish Catch Per Unit Effort (CPUE) at each site during the September 2023 field survey

Latin Name	Common name	Downstream of Lake MacDonald			Lake MacDonald			Upstream of Lake MacDonald			
		SMCDS03	SMCDS02	SMCDS01	DS Lake	Mid Lake	US Lake	CC01	CC03	SMCUS01	SMCUS03
	Effort	***152.16***	***143.06***	***100.06***	***64.66***	***57.87***	***61***	***59***	***39.74***	***109.98***	***115.06***
Native Species											
Ambassis agassizii	Agassiz's glassfish	4.6	1.4	2.0	479.4	105.4	483.6	84.7	–	0.9	11.3
Amniataba percoides	barred grunter	–	–	–	94.3	121.0	136.1	–	–	–	–
Anguilla reinhardtii	longfin eel	0.7	2.8	4.0	6.2	–	14.8	–	–	–	–
Craterocephalus stercusmuscarum	flyspecked hardyhead	–	–	3.0	641.8	406.1	713.1	–	–	–	–
Hypseleotris spp.	common gudgeon	23.7	49.6	1649.0	2428.1	3086.2	532.8	1249.2	676.9	219.1	57.4
Macquaria novemaculeata	Australian bass	–	0.7	2.0	–	–	4.9	–	–	–	–
Melanotaenia duboulayi	crimsonspotted rainbowfish	15.1	24.5	28.0	68.0	–	13.1	516.9	213.9	2.7	91.3
Mogurnda adspersa	southern purplespotted gudgeon	0.7	–	–	–	–	–	3.4	5.0	–	6.1
Nematalosa erebi	bony bream	–	–	–	52.6	43.2	167.2	–	–	–	–
Philypnodon macrostomus	dwarf flathead gudgeon	–	–	1.0	–	–	–	–	2.5	1.8	0.9
Pseudomugil signifer	Pacific blue eye	2.0	–	–	–	–	–	–	–	–	–
Retropinna semoni	Australian smelt	1.3	–	–	–	–	–	11.9	7.5	48.2	2.6
Tandanus tandanus	freshwater catfish	–	–	11.0	46.4	8.6	14.8	–	–	1.8	1.7
Native Species CPUE		**48.0**	**79.0**	**1700.0**	**3816.9**	**3770.5**	**2080.3**	**1866.1**	**905.9**	**274.6**	**171.2**
Native Species Richness		**7**	**5**	**8**	**8**	**6**	**9**	**5**	**5**	**6**	**7**

Latin Name	Common name	Downstream of Lake MacDonald			Lake MacDonald			Upstream of Lake MacDonald			
		SMCDS03	SMCDS02	SMCDS01	DS Lake	Mid Lake	US Lake	CC01	CC03	SMCUS01	SMCUS03
Exotic Species											
Gambusia holbrooki	eastern Gambusia	–	–	–	–	–	–	–	5.0	–	1.7
Xiphophorus hellerii	swordtail	–	–	–	–	–	–	–	–	19.1	–
Xiphophorus maculatus	platy	–	–	–	–	–	14.8	1.7	–	–	7.8
Exotic Species CPUE		–	–	–	–	–	–	**14.8**	**1.7**	**5.0**	**19.1**
Exotic Species Richness		**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**2**

– none caught

A-3-3 Macrocrustacean survey results

Table A-17 Macrocrustacean CPUE at each site during the September 2023 field survey.

Latin Name	Common name	Downstream of Lake MacDonald			Lake MacDonald			Upstream of Lake MacDonald			
		SMCDS03	SMCDS02	SMCDS01	DS Lake	MID Lake	US Lake	CC01	CC03	SMCUS01	SMCUS03
	Effort	***152.16***	***143.06***	***100.06***	***64.66***	***57.87***	***61***	***59***	***39.74***	***109.98***	***115.06***
Cherax dispar	slender yabby	25.0	2.1	1.0	–	–	1.6	10.2	5.0	44.6	35.6
Macrobrachium sp.	freshwater prawn	146.6	35.0	35.0	34.0	3.5	93.4	67.8	78.0	62.7	21.7
Paratya sp.	freshwater shrimp	2008.4	179.6	80.0	–	–	11.5	1191.5	218.9	425.5	326.8
Macrocrustacean CPUE		**2179.9**	**216.7**	**115.9**	**34.0**	**3.5**	**106.6**	**1269.5**	**302.0**	**532.8**	**384.1**
Richness		**3**	**3**	**3**	**1**	**1**	**3**	**3**	**3**	**3**	**3**

– none caught

A-3-4 Turtle survey results

Table A-18 Turtle species known from, or potential to occur in Six Mile Creek

Species	Common name	Previous Surveys			September 2023		
		Six Mile Creek DS	Lake Macdonald	Six Mile Creek US	Six Mile Creek DS	Lake Macdonald	Six Mile Creek US
Chelodina expansa	Broad-shelled river turtle	–	–	✓	–	–	–
Chelodina longicollis	Eastern long-necked turtle	–	✓	✓	–	✓	–
Elseya albagula	white-throated snapping turtle	–	–	–	–	–	–
Elusor macrurus	Mary River turtle	–	–	–	–	–	–
Emydura macquarii krefftii	Krefft's river turtle	–	✓	✓	–	✓	–
Wollumbinia latisternum	Saw-shelled turtle	✓	–	✓	✓	–	✓

Table A-19 Turtle CPUE at each site during the September 2023 field survey

Latin Name	Common name	Downstream of Lake MacDonald			Lake MacDonald			Upstream of Lake MacDonald			
		SMCDS03	SMCDS02	SMCDS01	DS Lake	MID Lake	US Lake	CC01	CC03	SMCUS01	SMCUS03
	Effort	***84***	***76***	***70***	***89***	***78***	***82***	***82***	***59.34***	***57***	***60***
Chelodina longicollis	eastern snake-necked turtle	–	–	–	1.1	–	–	–	–	–	–
Emydura macquarii krefftii	Krefft's river turtle	–	–	–	10.1	–	3.7	–	–	–	–
Wollumbinia latisternum	saw-shelled turtle	–	1.3	2.9	–	–	–	2.4	–	–	–
Turtle CPUE		**–**	**1.3**	**2.9**	**11.2**	**–**	**3.7**	**2.4**	**–**	**–**	**–**
Richness		**0**	**1**	**1**	**2**	**0**	**1**	**1**	**0**	**0**	**0**

– none caught

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